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and the Future

VOLUME THREE



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MINISTRY OF FUEL AND POWER

**FUEL
AND THE FUTURE**

**The Proceedings of a Conference held in London
on October 8th, 9th and 10th, 1946 under the
Auspices of the Fuel Efficiency Committee**

VOLUME THREE

**LONDON
HIS MAJESTY'S STATIONERY OFFICE
1948**

PREFACE

The general need for efficiency in British industry has never been greater than it is to-day. Fuel efficiency is an integral part of production efficiency, and correct fuel utilisation is now, and will be in the future, essential in every factory, establishment and home. For this reason, the Fuel Efficiency Committee of the Ministry decided in March, 1946, to convene a conference at which both the present state of development of fuel utilisation and its future trends could be freely discussed by experts in each individual field in an informative manner for the general guidance of all fuel users, industrial and domestic.

Nearly five thousand industrialists and members of domestic organisations interested in fuel usage attended the conference on 8th, 9th and 10th October, 1946.

After a joint opening session at which those assembled were addressed by prominent members of the Government, Industry and Trade Unions, the conference divided into eight sections meeting simultaneously in different places, each section holding three sessions consecutively. The sections dealt with the following subjects :

- Section " A "—The Generation of Steam.
- Section " B "—Steam Utilisation.
- Section " C "—Heat for Drying.
- Section " D "—High Temperature Processes.
- Section " E "—The Carbonisation and Chemical Industries.
- Section " F "—Special Industrial Sessions.
- Section " G "—Modern Heating and the Architect.
- Section " H "—The Home and its Fuel Services.

Two joint sessions were then held simultaneously, one dealing with the Sizing and Grading of Coal, and the other with District Heating, after which there was a closing session presided over by the Rt. Hon. Emanuel Shinwell, M.P., Minister of Fuel and Power, and addressed by the Rt. Hon. Sir Stafford Cripps, K.C., M.P., President of the Board of Trade, at which also the sectional chairman summarised the conclusions of their meetings.

The proceedings of the conference have been printed in three volumes, of which this book comprises the third. It is devoted to sections G and H on modern heating and the architect, and the home and its fuel services, together with the joint session on district heating. In addition, it includes an abridged account of the opening and closing sessions.

Considerations of space have made it necessary to curtail most of the communications to a greater or lesser extent by abridgement, summarisation or condensation as best fitted the subject. Every care has been taken to avoid the omission or distortion of any essential matter, and the authors are thanked for submitting to this unfortunately necessary operation.

Where requested, acknowledgments have been formally made in the text of this publication. In addition, the Ministry wish to express their thanks to all those who have contributed to the success of this conference and without whose aid it could not have been held.

Finally, it should be pointed out that the fact of publication of these proceedings must not be held to imply that all the views expressed therein are necessarily in every respect those of the Ministry of Fuel and Power.

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FUEL AND THE FUTURE

OPENING SESSION

Chairman : Dr. E. S. GRUMELL, C.B.E.

(CHAIRMAN, FUEL EFFICIENCY COMMITTEE OF THE MINISTRY OF FUEL AND POWER)

The speeches given during this session by the Chairman, The Minister of Fuel and Power, Sir Clive Baillieu, Lord Citrine, together with a summary of the speech by Alderman Key, will be found in Volume I of the Proceedings. The speeches of the Minister and of Alderman Key are reproduced here in full for the benefit of non-industrial readers who may not wish to secure copies of Volumes I and II.

THE Rt. Hon. Emanuel Shinwell, M.P. : Ladies and Gentlemen, on behalf of the Ministry of Fuel and Power I extend to all the assembled delegates a cordial welcome. Many of you have travelled a long way to attend this Conference, no doubt at some inconvenience to yourselves, and are now to consider and report upon the various aspects of fuel efficiency. In so doing, you are rendering the whole nation a considerable service.

No subject is so far-reaching, nor, indeed, so beneficial, in its ultimate consequences, as that of how to promote the efficient use of fuel. It is, of course, directly associated with the present fuel shortage, but it is more than a short-term problem ; it concerns the industrial and, therefore, the social future, not only of this country, but of people all over the world. Unless we can promote the highest efficiency in the use of our fuel resources and make the necessary changes in the technique of industry, we shall not be able in the coming years to maintain our prestige in the industrial field, nor can we provide a high standard of living.

We are at the beginning of another industrial revolution with far greater opportunities than those that faced the people 150 years ago. There is more technical skill and general knowledge at our command ; our industrial organisation, while in many respects defective, is vastly superior, and I am glad to inform the representatives of other nations that the ability of our scientists and technicians will bear favourable comparison.

But if the opportunities are greater so is the need. We must conform to modern standards of living and even improve them. The needs of the people in the aftermath of a devastating war, the risks associated with international competition, our dependence on imports of raw material and food-stuffs are a sharp and constant challenge to us all—whether we are technicians or politicians, or, for that matter, just ordinary people. Therefore, we must not any longer misuse our resources, rather should we exercise our ingenuity and skill in removing all forms of waste—using our raw materials and reduced manpower in the most effective fashion.

In this matter we must promote the utmost co-operation between the politicians and the technicians. I suspect that in the past the fuel engineers have been regarded as “ back-room boys ”, doing important jobs no doubt,

but never seen and rarely heard. Perhaps they have been far too bashful to speak of their capabilities, much less of their needs. As I have a strong conviction that politicians cannot succeed without the assistance of the technicians, I am glad that this Conference has attracted the attention it deserves, and may thus serve the purpose of bringing our fuel engineers out of the back-rooms and into the Board-rooms where their opinions can, and should, be adequately ventilated.

Now there is one politician who will be grateful for your assistance ; it is, as you may expect, the Minister of Fuel and Power.

One of your number recently startled me by contradicting a statement that has been made everywhere since I became Minister. He said " We do not want more coal ". However, he added this important qualification—" We want more efficiency in its utilisation." The search for that higher efficiency is the purpose of this Conference.

Most people in the country, for one reason or another, misuse the coal they get. I regret it should be so and we must endeavour to break down prejudices before we succeed in applying those splendid ideas about fuel efficiency which you have evolved and which you wish to apply with speed.

In a period of improvisation, it is not easy to determine the right policy. We are now in this phase of improvisation. Although we are about to embark on a plan for the coal industry we must also adapt ourselves to existing needs. There is a shortage of manpower and material. We must plan for the future, but not all our plans are capable of immediate application. Therefore, while the short-term position is acute, we must improvise. Our problem is to harmonise that improvisation with the plans and policy which are essential in the long run.

I shall not dwell on the matter of improvisation for long this morning, for the title of this Conference is " Fuel and the Future " and you are met to consider plans for a period of five or seven years ahead. How long the period of improvisation will last I cannot say, but we can surely be optimistic enough to place its duration at much less than seven years.

Meanwhile, we cannot escape the difficulties of transition from war to peace, so that what I must say on the period of improvisation, though brief, is of the utmost importance. We have to address ourselves to the problem of how we can get through the coming winter, without dislocation of our national life—how we are to avoid a shortage of domestic fuel and the curtailment of industrial production.

This is not the occasion to deal with the efforts that have been made on the production side—the improvement in mineworkers' conditions, the stimulus to recruitment, or the development of open-cast mining. Without those efforts the position would undoubtedly be graver than it is. We can claim to have arrested the rot and that is all to our advantage.

Nevertheless, we must recognise that the manpower in the coalmining industry is declining. Without emergency measures to repair the wastage and secure recruitment from new sources, this decline must continue. Mechanisation in the form of power loading is on the increase, but it is still in its infancy and affects only about 1 per cent. of the annual output. It must be some years before intensive mechanisation of this type can play any large part in increasing production. Therefore, the crucial problem at the moment is how to make the most efficient use of the manpower below ground that is at present available to the industry.

Meanwhile, in order to assist in meeting the gap between production and consumption, we have improvised by arranging to bring substantial quantities of heavy fuel oil into this country. And I should like to pay tribute to those who have agreed to change over from coal to oil. I am sure that they will follow with special attention the addresses to be given at the Session of the Conference on "Oil Firing". It is regrettable that with our vast coal resources conversion from coal to oil, even on a limited scale, should be necessary, but this is almost entirely attributable to the process of deterioration that has characterised the industry in recent years.

However, there are limits to the relief to be found from importing and using oil. These limits, to quote only two, are set by shipping space and the availability of oil-burning equipment. I take this opportunity of saying publicly that the limits of the present conversion programme have been reached. The new commitments already undertaken, added to our existing requirements, will absorb all the heavy oil for which equipment can be guaranteed within a reasonable period of time. All commitments undertaken will, of course, be honoured, but in considering further applications we should, I think, give priority to those processes where there is special advantage to be gained from oil firing, where the maximum quantity of coal can be replaced by the minimum of oil. So that if any industrialist is hesitating today about bringing his coal-burning equipment to the peak of efficiency, in case he may later be called upon to convert to oil firing, I suggest that he owes it to himself, no less than to the nation, to hesitate no longer.

Making every allowance for possible increases in production, and after arranging to reduce our distributed stocks to the lowest limit that we dare, we run a very grave danger of breakdown. In the public utilities, there is one additional danger, arising from lack of plant. Neither the gas nor the electricity industry has had sufficient opportunity to overtake its wartime arrears of maintenance, let alone make adequate provision for the increased loads that are being thrust upon it.

We have already experienced the consequences. There have been periods when power stations have shed their load and when gasworks have reduced pressure. Fortunately, up to now, those periods have been of short duration. But when I tell you that, in the case of electricity, the normal load is expected to be 8 per cent. greater this winter than it was last, and the peak demand, even at the present time, is 15-20 per cent. higher, you can appreciate the situation that we face.

Therefore, we must seek for a reduction in consumption. The alternatives are to step up at once our efforts to economise, or to face, in the depths of the coming winter, a breakdown in supplies. I know you will agree with me there is but one choice between these alternatives.

I am obliged to set a target for this effort, and to ask for an all-round voluntary saving in consumption of at least 10 per cent. I believe I am not asking the impossible, for I know how dramatic have been the results of your previous efforts. I recall how great were the savings made in 1944 and 1945, when it became essential to impose economies by Direction.

This saving of 10 per cent. is needed in coal, gas and electricity, and must apply to all consumers, not only in industry, but also in the home and in public and commercial undertakings.

Lest there be any misunderstandings, let me say at once, I am not proposing to reduce the allocations of coal to domestic consumers. I look to them for

savings in the form of gas and electricity. And since domestic consumption of gas was 26 per cent. higher in 1945 than it was in 1938, while with electricity the increase was 65 per cent., I feel sure the domestic consumer can and will respond.

However, I must remember that I am addressing an audience that is thoroughly fuel-conscious. I must avoid preaching too much to the converted. And, while the situation demands the maximum effort by everyone to save more fuel, it would obviously be unwise to expect additional savings from those who have already co-operated fully in the fuel efficiency campaign.

I turn from the short-term prospects to the long-term, from the period of improvisation to that of planning. I doubt whether, as a long-term policy, fuel efficiency requires either explanation or justification. It is an end in itself, for waste in any form is an evil thing.

Until 1914 the availability of good quality coal at low prices in the United Kingdom had resulted in little attention being paid to its efficient use, and judged by present standards there was a great waste of fuel. But with the war of 1914-1918 there came a fundamental change in the position.

Inland coal consumption (exclusive of colliery fuel and miners' coal) reached its peak in 1916 with 179 million tons. The drive for fuel efficiency then began to tell and its effects continued to be felt throughout the inter-war period. As a result, the consumption in the inter-war years barely exceeded that in 1913, and the peak consumption in 1937 was only 171 million tons as compared with 167 million tons in 1913.

During this period the population increased by 10 per cent., the use of power and heat in manufacturing processes was widely extended to secure increased production, new industries came into being and the standard of domestic comfort was raised considerably. In spite of all these developments the inland consumption of coal had not increased.

In many industries there was a clear trend of a decrease in the amount of fuel required per unit of industrial output, as shown by the following figures :

In 1920 coal consumption per unit of electricity generated was 3·74 lb.

By 1929 this had decreased to 1·5 lb. per unit, and by 1937-38 only 1·43 lb. per unit was required. In the White Paper on the Iron and Steel Industry the following figures for fuel consumption per ton of pig iron were given :

1913	..	..	..	..	41 cwt. per ton pig iron
1937	..	..	..	..	33 cwt. per ton pig iron

In 1939, Sir Harold Hartley, in addressing the British Commercial Gas Association on "The Conservation of the Nation's Resources", said that he had made a rough calculation of the savings effected by the technical improvements in the case of gas, electricity, railways, iron and steel, and collieries. If the efficiencies of these industries had remained at the 1920 levels, in 1937 they would have required about 47 million tons more coal, or 58 per cent. of their 1937 consumption.

Subsequent analyses of the inter-war years indicate that the fuel economies were mainly the result of the installation of new plant and equipment which was considerably more efficient in its use of fuel. But the replacement of capital equipment is usually slow (boilers, for example, have lives of 25 to 50 years) and in industries where fuel costs are a small proportion of their

total costs, there was little incentive to replace equipment on grounds of fuel economy alone, particularly with the low price of coal in the inter-war period.

On the outbreak of war a Committee was set up under the Chairmanship of Sir William Bragg to review the fuel position in the light of war conditions. The Committee was doubtful as to the scope for further economies in view of the progress made in recent years. In 1941, however, when the fuel position became critical owing to the increased demand for coal for the munition factories and the falling output from the mines, a second Committee was appointed under the Chairmanship of Dr. E. S. Grumell, to review the recommendations of the 1940 Committee and to report on immediate measures of economy with a view to alleviating the now serious shortage in supplies.

The investigations carried out by the Committee showed that in general, the standard of fuel efficiency in industry was still low, in spite of the economies effected since 1914. This was due to inefficient practice and to the existence of much old-fashioned and inefficient plant. Even in the best managed works it was possible to suggest ways in which fuel could be saved by improved methods, and it was estimated that the visits to factories resulted in an average increase of efficiency of 10 per cent.

During the war it was not possible to replace obsolete plant on any large scale, but 2,490 licences were granted by the Government to firms for the purchase of such fuel-saving plant and appliances as were estimated to save the capital cost of installation by the fuel saving obtained within two and a half years. In many cases this economy was obtained in an even shorter period, and it is estimated that nearly three-quarters of a million tons of coal were saved in this way.

Thus in the inter-war years two conflicting tendencies were at work. The growth of new industries, like the motor-car industry, and the development of new uses for fuel and power increased the demand for coal. On the other hand, there grew up an appreciation of the importance of using coal properly which the wartime work of the Fuel Efficiency Committees has hastened so much.

Up to now these two tendencies have roughly balanced one another. At the moment it is clear that, although production is rising, consumption is outstripping it by far. It will be interesting to see whether this balance is regained. Reference has been made to the diversity of the uses of fuel, and the Programme of this Conference shows that new demands are already appearing. Who, for example, would have expected, a few years ago, that farming would be found among the major fuel-consuming industries? Yet that is now its position. Moreover it is clear that the heat and power needs of the ordinary household are going to rise very rapidly. The fascinating report of the Fuel and Power Advisory Council, which two sections of this Conference will discuss, describes the British home, in cold weather, as the "smallest in the civilised world". All the functions of family life are confined to "a narrow half circle of warmth" in front of the sitting-room fire. Shall we remain content with this condition of affairs?

In industry, the policy of full employment, the drive for greater mechanisation, the demands for better standards of lighting, heating, and ventilating the factory all require more fuel.

It is clear that there will be full employment for the fuel technologists also. Indeed, they will have to work overtime to increase efficiency if all these new benefits are to be secured. There will be no room for absenteeism. I can

assure you that they will have the full support of the Ministry of Fuel and Power, not merely as a statutory duty but as a matter of firm conviction. I shall do everything to promote co-operation and happy relations between fuel consumers and the Ministry, which have been built up on the magnificent voluntary work so many of you have performed on Fuel Efficiency Committees, and which, I am sure, you will continue.

But the fuel engineer will need other help besides mine. In industry he must have the support of management and labour. On the domestic side, he must carry with him the architects, the housing authorities, and most of all, the housewives.

The success of fuel efficiency is conditioned by the measure of co-operation we receive. It calls for the active support and encouragement of all sorts and conditions of men—and, I hasten to add, of women—who, at any rate in the domestic sphere, can do much to mitigate the harshness of the short-term problem. Much depends on this conference: on its vigour, its capacity for direction, and above all on its courage in departing from the bad old ways.

There will be many speakers of repute who will address the conference. I wish I could stay and hear them all, but that is impossible in present circumstances. However, I shall have the opportunity of attending the final session when the reports of the respective chairmen will be heard.

I shall, therefore, be able to leave you this morning with the deep conviction that you are ready to proceed with your discussions with enthusiasm, and that your sole desire is to place your skill and knowledge at the service of the nation.

Alderman C. W. Key, M.P. (Parliamentary Secretary, Ministry of Health) : My task is to talk of fuel requirements in connection with the housing programme, and housing is such a many-sided activity, involving so many different industries and occupations, that if I were to attempt to deal with the fuel requirements of the housing programme in all its different aspects, always supposing that I were competent to do so, and without undue modesty I readily admit I am not, I should have to speak for a very long time, and I am afraid I should leave little for those who were to follow me to discuss. I propose, therefore, to leave the whole question of the fuel requirements necessary to the industries concerned with the building of houses to others more competent than I am to deal with, and to speak only of the fuel services that are necessary to the completed house to keep it warm and to provide hot water and cooking facilities. This is a side of the problem which most of us appreciate, because we get the importance of it thrust upon us at first hand as consumers if not as producers, and it is one in which my Department has a particular interest. Nor is the demand for fuel for domestic purposes by any means an insignificant section of the nation's total demand. The report of the Fuel and Power Advisory Council on domestic fuel policy reminded us that in 1938 the consumption of coal in Britain for domestic purposes amounted to over one-third of the total consumption, so that it is obvious that in considering how to make the best use of our limited fuel supplies—and I think the Minister of Fuel and Power has made the necessity for doing this sufficiently clear this morning—we must pay very special attention to the domestic aspect. This is also necessary from another point of view. In spite of the enormous amount of coal consumed on domestic heating in the past, the resultant heating services have in many ways been really lamentably inadequate. Most houses have, I suppose, reasonably adequate cooking facilities, but space-heating and water-heating arrangements, particularly in low-cost houses, have left a very great deal to be desired not only as

regards the efficient and economical use of fuel but also as regards the comfort and health of the householders. It is this second aspect in which my Department is especially interested, and there can be no doubt that it is so closely linked with the fuel economy aspect as to make our interests practically identical with those of our friends at the Ministry of Fuel and Power. Improved fuel services mean not only economical use of fuel but also greater comfort and better health to the householder, and we are therefore wholeheartedly in support of everything that is done to achieve such improvement. Moreover, the housing need itself presents us with an outstanding opportunity of gaining this end. Already the rate of house building is gathering speed ; families are being re-housed at the rate of some 5,000 a week, a large proportion of them in new houses, permanent or temporary, and in these next few years we should see new houses growing up faster than ever before. Moreover, most of these new houses are being built by local authorities, and will therefore come within the scope of intelligence and thoughtful planning and design (laughter)—well, that is true—so that we have an immense opportunity to break with the past and get our people housed in properly and economically heated dwellings. I therefore welcome this Conference for the contribution that it can make to this end. We have already had a most valuable contribution in the report of the Fuel and Power Advisory Council on domestic fuel policy, and ways and means of implementing its recommendations are being actively considered. The opportunity in this Conference for the exchange of ideas and the discussion on the problems will be immensely valuable. As I see it there are three different though closely-linked fields for improvement in domestic fuel services—the appliance, the house and the estate—and it would perhaps be appropriate for me to give some idea of what is in our minds in the Ministry of Health with regard to each of these.

First, the appliance. I think it is generally accepted that as far as gas and electric appliances are concerned the position is entirely satisfactory. There is, of course, always room for improvement, but enough was achieved during the years between the wars to put reasonably efficient appliances on the market and within the reach of the lower income groups. But the story with regard to solid-fuel appliances is a very different one, and it is on improvement here that we need to concentrate. Details of what is being done I can no doubt leave to those who speak for the industries concerned, but I simply say that we, for our part, will do all in our power to urge the local authorities to instal such improved appliances as have been fully tested and approved by the Government. I may say that we only recommend appliances which we are satisfied that local authorities can afford. While we cannot ask them to incur disproportionate expenditure in this way, we have made it possible, by general subsidies, for them to provide much better equipment than in the past, and, moreover, we are not blind to the consideration that improved appliances, though their initial cost may be high, should pay for themselves many times over by the resulting economy in fuel ; not only will the household benefit directly but so will the nation by the overall saving. In any case, let me make it quite clear that, much as we are concerned to keep housing costs down, we would not dream of cutting out an improved appliance from a local authority's plans merely on account of the additional cost. There is, however, one note of warning that I must sound. Our desperate need at present is for houses, and nothing must be allowed to interfere with the progress of house construction. The chief difficulty about improved solid-fuel appliances is that of quick

production, and cast-iron appliances generally are so scarce that in June last we had, to our very great regret, to ask local authorities in normal urban areas to instal only one space heating, solid-fuel appliance in each of their houses. We will withdraw that instruction as soon as supplies are available. Change-over from old to new appliances takes time and house building must not be delayed because of that. It has, therefore, been necessary for production of pre-war models to be continued for a time, but as production capacity increases it will no doubt be possible to complete the change-over without slowing up housing programmes and this is the object at which I hope manufacturers will aim.

Before I leave the question of appliances, I should like to remind you of the improvement of smoke abatement, if only from the standpoint of public health. I should also like to say a word about the importance of remembering in the design of appliances a point of view which sometimes tends to be forgotten in that, as in other things connected with a house, and that point of view is the point of view of the housewife. To direct attention to that, the Minister has appointed a special Sub-Committee of his Central Housing Advisory Committee to consider appliances from this angle. The Committee, under the Chairmanship of Lady Reading, who, I see, is also Chairman of the section of this Conference which is to deal with "The Home and Its Fuel Services" and includes among its members a number of housewives. The Committee will have an increasingly valuable part to play as development of new appliances proceeds, and I am confident that manufacturers will co-operate in doing all they can to implement its recommendations.

I come now to the design of the house, and its relation to fuel efficiency and economy. This is a matter which will principally concern the architectural section of this Conference, and I am sure their discussion will be of great value. All I wish to say now is that the Ministry of Health has already asked local authorities to pay particular attention to methods of thermal insulation in design, and has already recommended that increased provision should be made for fuel storage. There is, I know, a great deal more than this that can be done for fuel services by improved design, in particular by design for the delivery of heat so as to avoid wastage and we shall await with interest the conclusions of this Conference in that connection.

Lastly, I must say something about the very important matter which is to be discussed at the second Joint Session of the Conference—"District Heating". This is a side of domestic heating on which we in this country have much to learn, and my Department is very anxious to encourage the making of experiments which will increase our knowledge. It is a big subject with many implications, but we must not be afraid of that, for it offers great possibilities both for comfort in the home and fuel economy. If we can get sufficient district heating schemes at reasonable cost to the tenant we shall have made a great step forward in the domestic heating field. Only by experiment can costs be fully ascertained, and the Inter-Departmental Committee which has been appointed for this purpose is examining several projects by local authorities to undertake such experiments. We hope that there will be more still to follow.

Now to sum up : We, in the Ministry of Health, welcome whole-heartedly the new interest in domestic heating, child of necessity though it be, which is now growing up in this country, and the opportunity afforded by this Conference to discuss these matters in detail. We feel that the very best technical knowledge

ALDERMAN C. W. KEY, M.P.

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and advice should be available to local authorities in their great task of providing high standard accommodation for the people. I am sure this Conference will provide the means for doing this, and if for no other reason than that we give it our sincere good wishes for its great success.

SECTION G

MODERN HEATING AND THE ARCHITECT

Chairman: Mr. M. HARTLAND THOMAS, F.R.I.B.A.

SESSION I. Domestic Heating Requirements

Chairman of Session: MR. L. H. KEAY, PRESIDENT, R.I.B.A.

THE CHAIRMAN, having welcomed the members of the conference, said that there should be close collaboration between those who planned buildings and those who designed equipment for them. He would not object to losing a little in efficiency to ensure that a building was properly planned and planned primarily for the comfort of those who occupied it. The open coal fire, he believed, would die very hard in this country, especially among those who worked in the open air. If it were true that one-third of the country's coal consumption was for domestic purposes, then probably at least one-quarter of the whole was used in buildings which were inadequately heated. In these buildings other coal-using appliances were by no means highly efficient. The problem was thus to see how the limited supplies of coal could be used in the most effective manner. He wished to issue a warning that the limit of cost for housing in this country had been reached and that the people who occupied small houses could not afford to spend any larger proportion of their weekly wages on light, heat and power. It was often argued that if more money were spent on the equipment, the subsequent running and maintenance costs would be reduced, but that did not appeal very strongly to a person going into a house or to the person providing it. He believed that the running and maintenance costs could be reduced and he hoped that as the result of the conference those who were in a position to do so would apply their minds to the planning of more efficient equipment which would be run and maintained at a very much lower cost.

1. The Fuel Position and Prospects

by HUGH GAITSKELL, M.P.

PARLIAMENTARY SECRETARY TO THE MINISTER OF FUEL AND POWER

Mr. Gaitskell said that his task was to provide the background for the discussions and to indicate what fuels were available. Whether heat was provided by raw coal, coke, gas or electricity, it was all derived from coal, except for the very small fraction of power generated by water. During the last seven years the situation had changed—since 1938 the output of coal in this country had fallen by about 25 per cent. This was due partly to a reduction in manpower of some 10 per cent., partly to reduction in output per man-shift and, to a very small extent, to a very small reduction in the number of shifts

worked per man. The decline in output per man-shift followed very much the same course during and after the war of 1914-1918. It had not been until 1927 that the output per man-shift reached the 1913 figures again. This development was probably not unconnected with war and had its roots fairly deep in the changes created by war conditions. During this war the output per man-shift had not fallen so far as it did during the first world war and it was already beginning to recover. There had, however, been a big fall in output which was almost entirely met by reduction in exports and to a small extent by an increase produced by open-cast mining. The consumption of coal last year for inland purposes had been about the same as in 1939, but this year it was rather more.

The coal consumed directly for domestic purposes had fallen since 1938 by no less than one-third. The reduction may have been forced upon consumers but there appeared to be already beginning some change in people's habits in this connection. With regard to electricity, the opposite was the case, the amount of coal used for generating having increased by 50 per cent. since 1939. There had been a small increase in the amount of coal used for gas production but a considerably larger increase—about 20 per cent.—in gas consumption, the discrepancy being due to the more efficient manufacture of gas. There had been an increase in the use of anthracite and coke for domestic purposes but both increases were relatively small. In considering the future, it was necessary to make a sharp distinction between the long and short periods. The short period was naturally present in our minds but architects were much more concerned with the long-term aspect. Even a prefabricated house had a fairly long life, whilst we could assume that a permanent house would last at least 60 years. Therefore he proposed to discuss the long-term fuel prospect.

Mr. Gaitskell went on to say : I suppose you really want to ask me a series of questions such as the following : We have heard a great deal about fuel efficiency and we know that much has been done in recent years to improve that efficiency, owing to the shortage of coal, but should we have in mind a continuing need for fuel efficiency over a long period ? We are building houses to last for sixty years. Have we to think of the need for fuel efficiency continuing for anything like that period of time ? Are we to expect a continuing coal shortage for so many years ? Ought we to plan for all-electric or all-gas rather than for direct coal consumption ? The President has referred to what he thinks people feel about the open coal fire, and I agree with him. I think there is a great deal in what he says, but at least there is the possibility that one might say : ' Well, we really must consider some alternative.'

The first observation that I wish to make on the group of questions which I have mentioned is that when we speak of fuel efficiency we are apt to confuse two rather different meanings of the term. We may mean getting a better result in the sense of more heat from a particular quantity of coal without any additional expense, or we may mean getting a better result at a certain cost ; it may be at any cost, but, at any rate, cost enters into the matter. With regard to the first, I have nothing to say. It is clearly a matter of great technical importance, and no doubt other speakers will deal with it. If you can find ways and means of providing more heat from the same quantity of basic material without any extra cost, nobody is likely to argue about the matter, and anyone who can do that will clearly be a benefactor. I suppose, however, that although there may be developments in that direction we should be fortunate if we found that the scientists could from time to time suggest

ways of providing more heat which involved extra cost, and it is that case—the case in which greater efficiency can be obtained but at an additional cost—which I think we ought to consider.

Mr. Gaitskell then said that the scarcity of coal at the moment was partly the reflection of the fact that it was an article whose distribution and price were fairly carefully controlled. If there were no control there would be the alternative of very much higher prices. To the ordinary person, then, the scarcity would not be of coal in the direct sense, but of money with which to buy it ; when we were thinking in terms of ten and forty years the question was not whether coal was going to continue to be scarce but whether the price of coal was likely to be higher in relation to other costs. That was the real issue that architects would have to consider and which would determine how much incentive there would be to economise.

Under the scale of values of different commodities the price of coal had certainly gone up substantially since before the war. Reference had been made to an increase of 120 per cent. which was certainly above the general level of prices. The price of coal before the war was artificially low ; it was low only because the wages of miners were low and the wages of miners remained low only because there were not sufficient alternative jobs for the miners. As soon as there was a state of full employment the wages went up and he thought that this would have happened even if there had not been a war. Since labour costs were about 70 per cent. of the production cost of coal there was bound to be a reaction on prices.

We could expect to see in the industry in the course of the next five years or ten years, very remarkably substantial technical changes and he saw no reason to doubt that these changes would increase to a considerable extent the productivity of the mines. That in itself did not indicate that coal was likely to become cheaper again but he had heard some technicians in the industry speaking of reducing the pit-head price of coal by these economies, by about 10s. per ton. They had to balance against that the question whether the price that we paid to get people to go down the pits now was an adequate one in the sense of being sufficient to induce people to do so. The matter was a complicated one but he would go so far as to say, with great caution, that it would be rash to assume, in the present state of recruitment to the industry, that the wage differentiation as between coalmining and other occupations had necessarily reached equilibrium. He would emphasise that this was only his personal opinion and that it was not in relation to other things. He was not talking about the absolute level of prices, which depended on the value of money, but of the relative level.

Should gas and electricity be preferred to coal ? Although both were derived from coal, the coal was subjected to a number of subsequent processes and an analysis of the cost of production of a unit of electricity or cubic foot of gas, showed that the element of coal cost was small. Therefore a rise in the price of coal favoured the use of something produced from coal rather than the use of coal itself. We could not, however, conclude from this that there should be a compulsory switching over to gas or electricity in the home. The reasons for that were very fully set out in what was generally known as the Simon Report, the Report of the Advisory Council on Domestic Fuel Policy.* The report pointed out that any attempt to do this would involve an enormous

* Cmd. 6762. H.M.S.O. price one shilling.

expansion in the load which had to be carried and could only be done at the cost of building a vastly greater number of generating stations and gasworks. He thought that the arguments of the report were quite conclusive and that the capital costs would be such as to make it clear that the winter load would continue and must continue to be met primarily by solid fuel.

The importance of avoiding pollution of the atmosphere by smoke and sulphurous gases was emphasised. Smoke resulted in a heavy material and social cost which must be taken into account in planning. The arguments in favour of smokeless fuel were very strong indeed, but he foresaw difficulties in meeting the demand for a few years ahead, though the necessary supplies of smokeless fuel might well be available in 20, 30 or 40 years' time. There was a tendency for the price of coal in relation to other commodities to continue at a fairly high level, and there was therefore a tendency for people to use what might be called the more developed forms of coal rather than coal in the raw state. Although there might be expected to be a gradual transition to smokeless fuel, that could not be expected to take place quickly. Therefore both houses and appliances should for the time being allow for burning both smokeless fuels and bituminous coal.

2. Basic Domestic Heating Requirements

By PROF. SIR ALFRED EGERTON, SEC.R.S.

CHAIRMAN OF THE HEATING AND VENTILATION (RECONSTRUCTION) COMMITTEE
OF THE BUILDING RESEARCH BOARD OF THE D.S.I.R.

I should like to divide my remarks under three headings : first, the need for efficiency in the use of fuel ; secondly, the need for the architect's help ; and, thirdly, the need for looking ahead.

The holding of this conference is a real sign that in this country we have awakened to the fact that our methods of using fuel for purposes of the home have in the past been grossly inefficient. Since domestic heating forms the largest single use of coal, unless we do something to get all we can out of coal for this purpose our general national economy will always be under a serious drag. It is surely hard enough to get the coal. Why throw it away ?

Before the war we used about 60,000,000 tons of coal a year for household purposes, including what was used for the purposes of supplying electricity, coke and gas. The 60,000,000 tons of coal were about one-third of the total coal used for all the country's activities and about one-third more per head than is used in continental countries where the winters are far more severe than they are in this country. Furthermore, the heat was provided in such a way that our houses were far less well heated.

The committee of which I had the honour to be chairman studied the subject of domestic heating from three aspects, one leading to another. First, we needed to arrive at some indication of the average requirement for comfort in the home ; for instance, what sort of temperature is necessary in the various parts of the house, how much ventilation, how much hot water and at what temperature. All these things needed close study from many different aspects, including the medical aspect. I say " average " because some people's idea of a comfortable temperature is very different from that of others, and it is

necessary to try to measure the average requirement. We attempted to set out the standards, and I am glad to say that they have been generally accepted as a basis on which to work. I must refer you to the report*, which probably most of you have seen, for the various details. It has been accepted as the basis for the work of the Simon committee and for obtaining some measure of agreement on the question of domestic fuel policy. That study led to the working out of the heat requirements for an average house or flat for a family of four in order to provide these desirable conditions. That involved the study of the effects of insulation in conserving the heat, and I am very glad to find that a whole meeting of this conference is being devoted to the question of insulation. It also involved studying the effect of internal wall coatings to shorten heating-up periods in rooms, and, to conduce to general comfort, the need to lag pipes and tanks to conserve the heat put into hot water. The total amount of heat needed to meet the standard requirements worked out at between 350 and 530 therms per house per annum, of which about 180 therms would be for water heating. The needs of hot water in the house were set out in the report. The questions of the number of baths, how much water was required for washing, and so forth, were gone into, and an average figure of about 250 gallons per week was arrived at. That study led in turn to a consideration of the means of providing the heat requirement in relation to economy and all the other factors—smoke abatement, labour saving, adaptability and convenience—which enter into the choice of means of providing the heat.

The problem of heating is a dual one. On the one hand, we need to improve the standard of heating. We need to make use of the whole house, which must be warm enough everywhere for its purpose and not chilly and cavernous in the bedrooms. If one member of the family wishes to do his or her homework in a room upstairs, that room should be capable of being warm enough to prevent him or her getting chilly and perhaps developing a cold. Chilliness has a very serious economic disadvantage.

It has been pointed out in several reports that our houses are larger in area than houses in other countries for the same income groups, yet the area properly warmed is smaller than in any other civilised country. The principle of background heating helps to overcome this difficulty. Many people do not like the home to be uniformly heated throughout, and in this climate, which is very variable, that is understandable. It is better to maintain the whole house off the chill, so that damp can never condense, and then to bring it up to temperature where and when required. This is the principle of background heating with topping up as desired. It is a system which allows flexibility, choice of ways and means, and it is generally accepted as a fairly wise way to start improving our standards of heating as well as allowing perhaps for more economy than the system of full heating does.

Improved standards of heating mean more fuel spent, unless the efficiency of methods can be improved. Therefore not only have we to improve efficiency to reduce the total quantity of fuel needed for domestic purposes, but we must improve it still more because we also need to improve the standards of heating. We cannot do with less than an all-round doubling of the average efficiency of the use of fuel for domestic purposes. If before the war the average efficiency was about 20 per cent., it must in the future become at least an all-round 40 per cent. Instead of one-fifth of the coal being utilised, two-fifths of it must

* Post War Building Studies. No. 19. Heating and Ventilation of Dwellings. H.M.S.O. price 2s. 6d.

now be used. If we are to achieve national economy as well as new standards of heating, instead of putting 1,500 therms into a house, as we on the average were accustomed to doing before the war, and using only 300 of those 1,500 therms, we must now put in less than 1,200 therms and use at least 500 to 600 of those therms. Can this be done? It cannot be done without your help. In new housing it should be quite possible, but new housing will be only a part of the total housing; there will still be a greater number of existing houses fitted with old wasteful appliances. If, with rising standards of heating, these methods are still used, we shall not get the general reduction in the use of coal for domestic purposes which is necessary for the nation's welfare, so I urge all those who can help to see that new methods are introduced to renovate the heating arrangements and improve the insulation of old as well as new housing. This is just as important as ensuring that all new housing is built with satisfactory thermal insulation and fitted with efficient and convenient new appliances.

In new plans it is essential that the house and its heating services should be considered as a unit. The first cost may be high, but, in view of the savings in fuel and maintenance over a period of years, the overall cost should be considerably lower than that for a less well-planned house. I do not intend to try to tell you how to build the house—you know that much better than I do—but I do hope that, as a result of our report on the house and its heating services, all the new houses will be designed as a whole unit. Their whole structure should be considered from the point of view of how they will behave thermally. In our report the necessary approximate calculations are indicated, so that the behaviour of the houses can be estimated beforehand in relation to the climate and the properties of walls, windows, floors, ceilings and so on. Make sure by calculation that the house will need less than a gross 1,200 therms and that half is usefully employed.

I am sure that in the design of houses for rural and urban districts much thought has been given by builders and architects, gas and electrical engineers and solid-fuel appliance makers to ensure, first, that the houses will be insulated so that heat is conserved. Both our report and the publication of the Ministry of Fuel show what amount of insulation is worth while. Our ancestors were sensible in that they built their houses with thick walls and then panelled the insides or hung tapestries. With modern capabilities and materials, we can get the same results with less difficulty and at a fairly low cost. Secondly, the house should not be littered with appliances. As few as possible should be used to supply heating and hot water requirements. Each appliance has its own wastage; therefore as small a number as possible should be used. By clever design and positioning, architects are able not only to reduce the labour needed in attention to appliances and to increase amenities but also to eliminate expensive chimneys.

It can be left to the experts, women particularly, to discuss just how they can best get those numerous amenities that are needed in the home—the good supply from a 35-gallon or a 40-gallon tank of 250 gallons of hot water per week at 140° F., the laundry and drying facilities, the warm cupboard for airing or keeping clothes nice and warm before going out (a subject on which Rumford, our first heating expert, expatiated 150 years ago), efficient cooking stoves and well shaped pots and pans. The particular industries—gas, electric and solid fuel—will say what they can do. Let us have collaboration and let us have combination of utilities where such combination can help. In this country we must lead in the design of appliances and methods of heating, so that, instead

of being considered the most backward of countries in regard to heating, we shall surpass what others can do and export our heat services and methods to the peoples abroad.

The problem of heating a house is to convey heat from the appliance in which the fuel is burned at high efficiency, either in or outside the house, and to convey it to the places in the house where it is wanted. That can be done by the use of air or hot water as the medium. We are still backward in the design of convenient, low cost, central-heating equipment, and more attention should be given to this. It is one particular point that I wish to stress. It should be possible to design appliances which will burn raw coal and have a high efficiency.

At present much of the heating of industrial and community buildings is effected by numerous separate central-heating plants heating individual buildings. The efficiency is probably not far from 50 per cent., which is quite fair. The average consumption of heat per head of population is probably about 40 per cent. for these community and industrial buildings and 60 per cent. for housing, but these figures vary quite considerably from town to town. Much could be done towards achieving efficiency of heating if all types of building could be served from larger grouped central sources of high efficiency. Modern boiler plant can be easily operated at 70 to 80 per cent. efficiency, and the loss in distribution over short distances should not be more than 10 to 15 per cent., so that by grouping there is a certain gain in total efficiency as well as a considerable saving of labour.

If there is to be a move towards heating from central sources, it is of considerable importance, as I have already said, that attention should be paid to appliances—radiators, calorifiers, etc.—which can be fitted in houses, particularly as there are great possibilities in still larger schemes. Our committee has been considering the subject of district heating, a term which I think should be reserved for areas of at least 5,000 inhabitants. Our working group, under the chairmanship of Mr. Stubbs, has now produced a very formidable report which has not yet been issued. The working group went into the subject very thoroughly. It took a hypothetical town of 250,000 inhabitants, with heat distributed as hot water from a station generating heat and electricity together. Such a station would have an overall thermal efficiency of 70 per cent., instead of the 25 per cent. of existing straight electrical generating stations. The increase in efficiency over separate straight electrical generation and straight hot-water distribution from a central boiler plant providing the same electrical and heat output would be raised from 52 per cent. to 70 per cent. The adoption of a scheme such as has been studied would reduce the fuel consumption of the population served by 48 per cent. and at the same time would give 32 per cent. more heat than is at present obtained from the 277,000 tons of solid fuel which would be consumed by present methods for a population of 250,000. The capital cost is great—about £45 per head—but the over all cost to the consumer is encouraging.

That is the case for district heating. There are many considerations which come into the question, and by way of caution our committee has set down in an interim report, available to the conference, the various considerations which enter into the subject and which make it somewhat difficult to implement. I hope, however, that this conference will urge that some district heating scheme, on a large enough scale, should be started in some place, with a view to its extension at a later date, in order that experience may be gained in this country

of this method of heat supply, which does provide a great opportunity for fuel saving.

We are behindhand in methods of really large-scale heating. In Russia and the United States schemes have been operating for many years, and our great urban districts are surely very suitable for such developments, particularly in these times of reconstruction. Looking ahead still further, with rising prices of coal and possibilities of utilising nuclear energy we shall need to have a large-scale system of distributing heat. Why not make preparations for such developments now? This reconstruction period is surely the time to make a start. What I have tried to suggest is that, although we may not be able to introduce the most desirable methods of full heating at once, we should have them always in mind and in our designs ensure that our houses can be adapted to new methods. That is why I should like to see small individual central-heating devices developed which can be adapted to group heating from grouped central sources or later even from district heating schemes. There are other technical developments which have come on the scene—the gas turbine in its relation to power plant and the heat pump as an adjunct for special heating purposes—helping perhaps to balance the loads between heat and power. These are interesting days, in which great improvements can be made in clearing away past debris and launching out on well considered plans which will help in setting this country in a good sound economic position, with its basic needs efficiently satisfied.

3. Domestic Fuel Policy and the Simon Report.

By SIR REGINALD E. STRADLING, C.B., M.C., D.S.C., F.R.S.
CHIEF SCIENTIFIC ADVISER, MINISTRY OF WORKS

The acceptance of the recommendations of the report on Domestic Fuel Policy involves a coming together of all interested in construction and a frank facing of the fact that we have to change our methods, in particular our method of approach to the design of a building. This is honestly difficult in a human activity at any time, but it is particularly so in one which for many generations has been almost entirely dependent upon expert craftsmanship.

The impact of modern conditions both in its changing demands upon buildings and in the provision of new types of facilities for building, uncatered for in the traditional development of the industry, has brought about considerable confusion and irritation. Recently cries have even been heard which reflect this in the extreme form of an appeal to slow up research because certain portions of the industry cannot keep pace. Such an appeal seems to me a counsel of despair, for the true requirement is a speeding up of the collection of information and an intensive drive to get this knowledge incorporated in practice.

As I see it, the problem before this conference is just the one that I have outlined, and I will summarise it as follows. We have a new requirement, peculiar to present-day conditions. It is being demanded by the nation from the building industry. Whereas in the past we had a cheap and plentiful fuel supply, at any rate for certain sections of the community, the nation now demands that the heat supplies shall be greatly improved for all, and this at a time when fuel supplies are more difficult than ever before. That is the first

point. Secondly, two important committees have been at work bringing together a statement of the requirements and also to a large extent the basic data on which the supplying of the demands must be built, and, thirdly, further information is available, based on other investigations, and efforts are being made by the Government to create the supply conditions essential if the industry is to do the job required.

I should like now to deal with one or two of these points. I do not want to say anything about Sir Alfred Egerton's report, except that the basic standards of heat requirements laid down by Sir Alfred's committee were adopted by Sir Ernest Simon's committee. In that way the two reports are linked together.

Professor Mackintosh (on page 50 of the Simon report) said : " In cold weather the British home is the smallest in the civilised world, although its total space compares favourably with what is provided in most countries." That expresses briefly the present-day dissatisfaction with the traditional methods of heating. It refers, of course, to the fact that in the homes of the lower income groups it has not been possible to have more than one fire and that the only living space possible in cold weather is the small area of the house immediately around the fire. Investigations have shown how very wasteful is the traditional open fire and how very efficient the modern designs of heating units can be. A further idea is also implied in Professor Mackintosh's statement. That further idea is the one which Sir Alfred Egerton outlined when, using the jargon which has grown up in this kind of work, he spoke about background heating and the advantage of that from the point of view of the inhabitants of the house, and the facility it provides for topping up in various parts of the house for special work, so that the children can have some privacy for doing their home work and for living their own lives, which, it seems to me, is extraordinarily difficult under some of our living conditions at the present time.

To enable such improved conditions to be provided, not only must properly designed heating appliances be adopted but they must be installed in buildings suitably designed to enable the appliances to work efficiently. This must entail serious consideration of the problem by the designer. The day has gone when the architect can show a more or less standard symbol for the fireplace and leave it to the building craftsman to fix the exact sizes necessary to fit a fire unit chosen more for its appearance than for its efficiency. Further, the whole house has now to be heated probably from one fire unit, and thus heat losses from the house itself have very seriously to be considered in the design. A recent circular* issued by the Ministry of Health draws special attention to this aspect of the problem. It is of vital importance and necessitates the most careful study if the problem before us is really to be tackled.

Therefore, as I see it, the fact that the designer of small houses has now to face is that, instead of it being a simple job which anybody can do (that is how it has too often been regarded in the past), it is a comparatively complicated one, requiring the best technical knowledge which is available. Let us face the further fact that all of us have not yet attained the necessary facility in handling the new data required for efficient design. Some complaints have already been made that these extra human requirements of our time are restricting the architect. Surely these complaints are due to a refusal to face

* M.O.H. Circular 170/46.

the facts of modern life. The opposite attitude, which I have no doubt will be exemplified at this conference, is the right one, that these new demands on the skill of the designer will be met joyfully as a real challenge that it is worth while accepting, because it means helping to provide the improved living conditions for our people which we are all so anxious to see brought about.

Except for one item, I have now completed my part in the programme of the conference. That item is to mention briefly what is being done to implement the other recommendations in the report of Sir Ernest Simon's committee. Following the presentation of the report in March, 1946, the Ministers of Fuel and Power, Health and Works appointed an Interdepartmental Committee, under the chairmanship of Sir Guy Nott-Bower, Deputy Secretary of the Ministry of Fuel and Power, to do everything possible to carry out the recommendations. I can honestly say that I do know from inside how very much has been done, how very seriously this report has been taken and what a tremendous effort has been made to endeavour to implement the recommendations of this report. With the help of the Ministry of Supply, the whole appliance field is being tackled. Blanket orders are being placed for approved solid-fuel appliances and also for gas and electric cookers. The help of the Department of Scientific and Industrial Research, chiefly through the Fuel Research Station, has been enlisted, together with the testing stations of the Gas Light and Coke Company and the Ministry of Supply, to test the appliances, whilst the Building Research Station, together with the Ministry of Works, is doing everything possible to advise on and settle the various building problems which arise. The Health Departments are encouraging local authorities to pay serious attention to the whole problem by circulars on the heat insulation of buildings and the use of the newer heating appliances. Further, a bulletin on district heating, which was mentioned by Sir Alfred Egerton, has been prepared by the Ministries of Works and Fuel and Power, and this also has been issued to the local authorities.

4. Domestic Fuel Policy and the Architect

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The programme for this session is intended to be a summary of the Egerton and Simon reports in so far as they affect the architect. I propose to consider what the architect must have in mind before he can come to any detailed consideration of the appliances or, in fact, before he can even produce a sketch plan.

Space heating, cooking and water heating must obviously be considered together eventually, but it is simpler to begin by taking space heating separately.

The two reports contain a good deal of detail about the requirements of space heating. The present position seems to me to be that everyone agrees that we must have something a great deal better than we had before the war, and the policy at the moment appears to be in favour of some degree of background heating plus topping up in certain rooms when it is necessary. We must, of course, take it for granted that we agree about the need for better insulation of the structure and more efficient appliances.

Background heating plus topping up is excellent so far as it goes, but I think there is one big danger that we architects have to watch. I am afraid that we may become so immersed in the day-to-day details of trying to obtain and then finding out the best way of putting into the houses the new appliances that are coming along at the moment that we may lose sight of what the ultimate object of the heating system should be. For example, at the moment an enormous amount of interest is being taken in the development of the open fire and the use of convection systems in conjunction with the open fire or the openable stove, but I think it would be unfortunate if, in getting immersed in the details of how to put those things into the house in the best way, which type of appliance to choose, etc., we lost sight of the fact that none of those things can be regarded as more than the first stage in an improvement on our pre-war state of barbarism.

It might be useful, therefore, to get a clear picture of what the ultimate objective is, and I think we might sum it up as "Comfort, convenience, cost and coal." I deliberately put comfort and convenience first, because I think that householders are really interested in comfort and convenience. Cost and coal are a kind of nuisance that have to be put up with and that we have to deal with, but the ultimate object of the heating system is surely comfort and convenience.

A good deal is said about comfort in both the reports and in Professor Mackintosh's appendix to the Simon report, to which reference has been made this afternoon. It is well recognised now that it is not enough simply to provide a certain amount of warmth ; it is almost equally important to provide warmth of the right kind ; in other words, we have to have good quality as well as good quantity. Certain factors leading to that are fairly clearly established. For example, we know that the air temperature alone is not even a true guide to whether we feel warm, and it is certainly not a true guide to whether we feel comfortable. We have to take into account radiation losses to surrounding walls or radiation from a heat source. We are told that in a living room the surface temperature of surroundings ought to be about the same as and preferably higher than the air temperature. We know that high temperature gradients in a room are a bad thing, particularly when they occur vertically from floor to head level. We are also warned against excessive radiation to the head, but I think on that subject we need rather more information. We are also told that we should have some air movement but no cold draughts. There is also the question of ventilation, with which I will deal later.

Where do all these things lead us ? One immediate conclusion which might possibly be drawn is that a system of heating which relies entirely on convection would be bad, because it probably would not satisfy the first of the conditions that I mentioned, namely, the walls being as warm as or warmer than the air. In spite of the things that we are told in the reports it is rather difficult to get a clear picture of the sort of positive conditions that we want for comfort.

Architects usually find it easier to understand a drawing or a graph than a written statement or a formula, and it might help if I could present, at any rate as a subject for discussion, a sort of pictorial statement of good heating.

I suggest that there is a very close relationship between the sense of seeing and the sense of warmth appreciation. First, in lighting it is now very well recognised that we must have good quality as well as good quantity. I have

already mentioned that that is the case in heating, and I think there would be no argument about that. To go into more detail, some time ago there was a fashion for indirect lighting, but I think that, after a certain amount of experience, it was fairly generally agreed that indirect lighting alone gave a very dull and rather monotonous and dead effect. Quite often now indirect lighting is used, but it is supplemented with some sparkle or bright spots in the form of direct lighting. I wonder whether there is not something rather similar in the case of heating and whether in fact the way in which some people react to the ordinary central-heating system, saying that it is wrong in one respect or another, is not in fact due to the lack of sparkle from the all-over central heating at normal times. The practical implication of that might be that we should introduce some high-temperature radiant heat sources to be used in conjunction with our central heating, or possibly some small high-temperature radiant source to be used in conjunction with low temperature radiant heating as a background. Someone will probably say that the Americans have used a considerable amount of panel heating recently in some of their larger houses, that everybody likes it very much and that they do not in fact add any high-temperature radiant sources. I think my reply to that would be that when the Americans have used a low-temperature panel heating system they have almost invariably done so in houses which have large south windows and in a climate which has a very high sunshine record in winter, and I suggest that this gives the sparkle which brightens up the system and makes it so apparently satisfactory.

In lighting, although the need for some bright spots is recognised, it is also very well known that you must not have glare. The naked light bulb is a most uncomfortable thing to look at, and that suggests to me the reason why I personally cannot sit comfortably in the direct beam of a high-temperature radiant fire. Incidentally, I might mention here one system of heating which was tried out in Portland, Oregon, and which seemed to give very satisfactory results indeed. The living rooms were heated by at least two sources, placed on different walls, each source giving a fairly considerable convection component together with a dull red radiant heat. I think that satisfied the sort of conditions that are suggested by a good lighting system.

We might compare temperature gradient requirements for heating with the known fact that a big gradient in lighting is also a bad thing, and I think we could go further still. What I have tried to do is to suggest a sort of pictorial sense of what comfortable heating might perhaps be.

Ventilation is a subject upon which people differ a great deal. It is obvious, of course, that on the ground of economy we should not have more cold air passing through a room than is absolutely necessary for health and comfort. The Egerton report suggests that, from the point of view of airborne infection, cleanliness of the home and person is more important than air change and that the determining factor in assessing ventilation rates is the need to reduce unpleasant odours, and for that a figure of 600 cubic feet per person per hour has been suggested. In terms of the normal living room, that means about one and a half air changes per hour, which is a great deal less than we used to get with the pre-war open fire, and the difference is just so much waste heat if the air is allowed to go through the room and has to be warmed up in doing so. The suggestion has been made that the additional air required to satisfy the chimney pull should be taken along a by-pass route from outside the house to a point near the fireplace, and no doubt that suggestion will be dealt with

at the session of the conference tomorrow morning. We still do not know what is the minimum ventilation requirement for comfort. Many people argue against any reduction of ventilation on the ground that the room will be stuffy. Both the reports mention the need for air movement ; probably air movement is the answer to stuffiness and ventilation is not necessarily so important. Again I should like to refer to America. In the colder districts there the architects and the householders go to a good deal of trouble to prevent any air coming into the house, because it is so very cold when it does come in. They use weather-stripping round the windows and they have storm windows, but I think it is noticeable that, in spite of the fact that they obviously get a very small air change, their rooms are not in fact stuffy. I know some people will say that they are stuffy. I agree that they are overheated by our standards and that we may be uncomfortable in them because they are overheated, but I do not agree that they are stuffy. I think the reason is that they have more air movement, as a rule, although they do not have more ventilation. I have made rather a point of this, because it brings me to one of the things which affects architects very much indeed. I suggest that the Americans have more air movement in their houses because of their typical open type of plan, and therefore, if we are to change our standards of ventilation, we have to think of the plan in conjunction with the ventilation rate, or, if we are to change our type of plan for any reason, we have to bear in mind what we may or may not be able to do with our ventilation rate and still get comfort.

That brings me to the planning question in other respects. I have so far discussed only the conditions required for comfort in a room. There is the difficult question of how much of the house is to be heated and to what extent it is to be heated. The present tendency and policy are in favour of a slight degree of background warming throughout the house with topping up locally to give comfort conditions when and where needed. There are three arguments in favour of background heating. The first is the fact that background heating reduces condensation and keeps the house and its furnishings in better condition. Secondly, it makes the hall and the bedrooms slightly more comfortable, and, thirdly, it makes possible the raising of the temperature of the bedrooms reasonably quickly to reach comfort conditions by means of local topping up. I should like to suggest again that we should not lose sight of the ultimate ideal although we are faced with certain particular circumstances at the moment. I do not think that, if you could really have your own way, you would be satisfied with a certain amount of background heat in a room and then topping it up rather than getting full heating wherever you wanted it and when you wanted it from one main system, and I feel fairly certain that the general public will come to that conclusion in time. It may be argued that full heating in a house is a bad thing because we do not want all the rooms warm all the time. The answer to that is that if you have a good heating system that does heat all the rooms you can turn it off in some of the rooms if you want to do so. I know the other argument will be that full heating is fantastically costly. I cannot go into that now, but Mr. Dufton will deal to some extent tomorrow with the cost of background heating plus topping up as compared with the cost of full heating.

From the architect's point of view, the really important point on the question of how much heat should be provided throughout the house is the effect it may have on the planning. I do not propose to enter into a discussion of the merits or demerits of different types of house plan and I am not suggesting

that a particular type is right, but it is important to appreciate that the type of heating that we put into a house does vitally affect the possibilities of planning. So long as we had only an open fire in the living room, that room had to be fairly restricted in size, enclosed by walls and fitted with doors which were usually kept shut, and, in fact, we were confined to the small semi-circle of space round the fire to which reference has been made. If we provide continuous heating in that room the possibilities of the plan are somewhat changed. We could probably have a larger room and we might open up the plan to the extent of having the living room and the dining room combined in some way. If we have a really warm hall, not just a little background heating, we can open up the hall into the living room-dining room area without feeling uncomfortable. If we do all that and produce a completely open plan downstairs, I think we must consider what effect it will have on the planning of the rest of the house, because clearly, if we break up the normal pre-war arrangement of separate rooms downstairs and make one room there, we shall lose a certain amount of the privacy and quiet which were possible at any rate in the two usable rooms that most of the houses had. The answer that has been given to that is that we should use the bedrooms, and I suggest that if we have the open type of plan downstairs we shall be forced to make more use of the bedrooms for purposes of study and so on. That may possibly affect the economics of background heating of bedrooms, because presumably whether it is economic to have background heating or some other form depends on how often we are going to use the background heating. Therefore I think that, if we adopt the open type of plan downstairs which becomes possible when we raise our heating standards, we have to realise that there is an effect on the heat installation upstairs which must be considered.

There is one point with regard to insulation which I think should be mentioned here. We hear a great deal about the importance of considering the economic value of insulation as a balance between the first cost of the insulation and the saving in fuel, but I think it is important to throw into the balance in favour of insulation the fact that it plays quite a large part in increasing comfort. A well insulated wall will enable us to get more easily the cool air and warm wall effect for which we have been asked. The comfort value of insulation is very well recognised in the colder countries, where insulation is widely used.

Finally, we have obviously to choose those appliances with a high working efficiency. That is bound to mean that we shall tend to use a more expensive appliance, and in that connection we have to consider the important point to the householder, which is not the first cost of the appliance but the interest rate on the first cost of the appliance plus the annual expenditure on fuel and maintenance.

There is one point about hot water that I should like to mention. Sir Alfred Egerton referred to the new standard recommended in his report, namely, 250 gallons of hot water per family per week. The argument has been used against a central hot-water supply system (this I think applies to flats and district heating rather than to individual houses) that people would be wasteful if they got unlimited supplies, but there is a very considerable amount of evidence, from measurements in a large number of houses and flats on different estates in America, which suggests that that is not the case, at any rate not to an unreasonable extent. Admittedly the usage of hot water increases where people are provided with an unlimited supply for a fixed charge, but

the figures show that, whereas in the house where the tenant pays for his hot water by heating the water himself the average consumption (taken over a large number of houses) was 230 gallons per family per week, it went up to 350 gallons when people were given an unlimited supply. Admittedly that is a fairly considerable increase, but it is not an outrageous increase such as some people have suggested would occur if we provided unlimited supplies. It was fairly common to get a consumption higher than 350 gallons per family per week for a short time after the system had been installed, but people soon became tired of the novelty of leaving taps running and settled down fairly generally to the average figure of 350 gallons.

We have to make things as convenient as possible for the housewife, and I think it is clear that we are all trying to do that, but, as a glimpse into the future, I think the situation will be somewhat as follows. At the moment we are involved in getting some heat into the house, and the next stage presumably will be the refinement of that heat, getting real comfort conditions as opposed to mere temperature. When we have achieved that, I think we shall have the full force of the householder's demands turned on us in terms of convenience, and I think we should bear that in mind now, so that we shall not be taken by surprise later on."

Discussion

Mr. Robert K. Thulman, of the U.S. Federal Housing Administration, who spent three months in examining domestic heating appliances and equipment in this country last winter, wrote : The conference which you are holding covers so many parts of the overall house-heating question that it is difficult to condense my own comments within the few short paragraphs which I feel are all that I should inflict upon you and at the same time cover the ground fully. It is now six months since I left Britain, during which a great deal of my own time has been taken up with the heating problems connected with our own comprehensive housing programme, but I have been constantly reminded of the identity of the heating problems here with those which I was privileged to study in your country. It is for this reason—that heating of houses in the United States poses many of the same problems that confront you—that I do not feel apologetic in presuming to comment on your programme. Also, the genuine interest in American methods which architects, engineers, Government officials and manufacturers expressed to me during my visit prompts comments which might appear otherwise to be presumptuous. I believe our efforts and yours to improve the comfort and habitability of houses are faced with the same or similar problems, and that those problems can be solved only after a frank and open discussion of them.

The two reports, "Domestic Fuel Policy" and "Heating and Ventilation of Buildings", are an appropriate combination for a single meeting. The first report endorses the standards set up in the second, and it is these standards and the implications they generate that I question. The concept of "background heating plus topping up" seems to require the installation of two methods of heating, two systems of heating, or one system plus a number of individual heating devices, while the same performance standard—45–50° F. "background" with "topping up" to a full comfort temperature—can readily be accomplished with a single system adequate to provide full comfort and with controllability to accomplish any degree of discomfort the occupant of the house may choose to inflict upon himself. Perhaps it is necessary to warm up

the British people gradually and, if this be the case, the two-stage standard may be an interim standard of some value. On the other hand, it is my firm opinion, based on conversations with people in all walks of life in Britain, that the single system, with means to shut off at will the heat in unused rooms, would be a quite welcome improvement. The single system has the added advantage of lower initial cost. The operating cost of the single system is also likely to be less and it certainly cannot be more.

The single system with capacity to heat the entire house requires that the system be designed to operate at efficiencies far higher than the efficiencies of your high-temperature radiant devices if it is to be economically practical. The house, too, must be designed to provide the greatest practicable degree of resistance to the escape of heat, and your discussion of insulation should be most important. I suggest that it embrace, in addition to its relation to more economical heating services, its relation to greater comfort.

Heating of the entire house and insulation break down barriers to freedom in planning. The architect is released from the necessity of planning a ground floor consisting of a number of separate cubicles and free to utilise each square foot of floor area fully and economically. Some of your architects are now developing plans along this line. The results in terms of economy, comfort—both of which can be predicted—and public acceptance, which is not predictable, will be most interesting.

The many large-scale housing developments now being planned and under construction in Britain provide an opportunity to effect economies and provide improvement in comfort through the use of district heating schemes. I would recommend that you encourage more consideration of this method on the part of architects and engineers. To realise the greatest degree of economy it will probably be necessary to forego the fireplace and it is with some fear and trepidation that I even mention it. I recognise that the Britisher's rights to make a lot of work for his wife (rarely for himself) by clinging to a rather messy open fire and to deposit a generous layer of soot over his beautiful countryside are just as inalienable as his right to freeze himself. But I am firmly convinced that your people are not too different from ours and that, given a good job of heating the entire house, they will not use the fireplace even if they have one.

I have a recommendation to make which bears on the question of public acceptance of heating of the entire house and the architectural plans that result. We have in this country a sizeable segment of British womanhood known categorically as G.I. brides. They have come from all walks of life in the United Kingdom and are now in an equal variety of circumstances here. By next spring they will have experienced an American winter and will have experienced a variety of American heating devices and systems. An inquiry both by questionnaire and by personal interview of a selected sample of G.I. brides to determine their reactions to heating the whole house should be of considerable value in charting the future course of British house heating. I therefore recommend the formation of a party to carry on the investigation described.

In conclusion, may I repeat what I told you before I left England, how impressed I am with the progressive attitude and forthright approach which the Ministry of Fuel and Power has shown and which are exemplified by the comprehensive scope of the present conference? I should also like to mention that the same progressive attitude and approach of some of your manufacturers

—even some of those whose principal product is the much maligned open fire—have been followed up by personal investigation of American methods here and augur well for the future comfort of the British public. I feel sure that Government and manufacturer progressiveness of this kind cannot fail to accomplish the objectives you seek.

Mr. J. C. Pritchard said he was very much encouraged by the letter which had been read from Mr. Thulman, because it was very much in line with his personal views. In the main the burden of the Heating and Ventilation Report was the subject of background heating and topping up, which, as Mr. Thulman said, seemed to provide a duplicate system of heating when both were perhaps a little inadequate. He would like to know what were the relative efficiencies of high-temperature radiant heating of any kind. He believed they were very much less than when heat was provided from controlled appliances. The fact that the Simon committee accepted those heating conditions was rather disappointing, because it encouraged manufacturers, with a few exceptions, to concentrate on trying to improve appliances which in themselves, he believed, were outmoded.

He had been very disappointed to hear the Parliamentary Secretary to the Minister of Health say that morning that the heating efficiency in terms of coal with gas and electricity was more or less satisfactory. He could not help feeling that the policy indicated was a very shortsighted one, and he would like to hear from the technical people what was the coal efficiency of gas and electricity in the form of high-temperature radiant heating.

On page 126 of the Egerton Report it was stated that 34 per cent. of the people interviewed were in favour of central heating and only 21 per cent. were against it. He thought that was rather significant. The chief objection made by the 21 per cent. was lack of cheerfulness, but he thought that architects could provide cheerfulness in other ways.

At a very interesting exhibition held in Birmingham two years ago and organised by the Ministry of Fuel and Power and the Ministry of Works, showing the implications of heating on the house plan, he had listened to the comments of housewives and had been a little disappointed, because a large number of the women—chiefly elderly women—seemed to demand drudgery as a right and liked stoking their dirty open fires. There was, however, an important proportion of young women who were strongly opposed to that inefficient and dirty form of heating, and he thought it would be well to take notice of their views also. He thought the authorities should be urged to try to have at least some proportion of houses heated in the most efficient manner possible. Experiments had been carried out at Coventry and more would be carried out in other places.

Much of the opposition to central heating was due to a lack of appreciation of what could be done about it. It need not be stuffy. There was no need to keep a house at a temperature of 80° all the time, and there was no need to have all the rooms heated all the time. In fact, most of the objections could usually be eliminated.

Mr. R. H. Rowse said that Sir Alfred Egerton and Mr. Handisyde had referred to heating in America and he wished to give a very brief sketch of the American practice and background conditions.

North America was a vast country and the conditions varied considerably throughout the thousands of miles of its length and breadth, but the majority of its inhabitants lived in the colder regions, where the temperature often fell

in winter to 30° F. or 40° F. below freezing point but where there was very often much more sunshine during the winter months than there was in this country. It was, however, significant that the heating arrangements demanded by climatic conditions in those regions were, to a large extent, used in other parts of the country where the climate was similar to that in England. Fuels in America were abundant in quantity and in variety, but, in spite of large hydro-electric developments and the availability of natural gas, in some places at only a few pence a therm, and vast supplies of home-produced oil, most of the house heating was done by means of coal, wood and anthracite. There were, of course, considerable local variations.

The general requirements for heating during the winter were that houses should be heated throughout for twenty-four hours a day. In all new houses the heating system was designed to enable a controlled air temperature of about 70° F. to be obtained downstairs, even during the coldest weather, and perhaps a slightly lower temperature upstairs, but the heating was under control by the occupier and lower temperatures could be used if desired. The heating upstairs could be cut off entirely, but if there was no heating upstairs the temperature might fall far below freezing point. In many of the older houses the heating system was not so refined, but, even so, the heating appliance was kept alight continuously to keep the living room hot and to give some warmth to the rest of the house.

As the outside air was so cold it was essential, in the interests of comfort and health, to eliminate draughts, and it was necessary, in the interests of fuel economy, to limit the amount of cold air flowing into the house, in order to conserve heat. In fact, as Mr. Handisyde had mentioned, houses were made as airtight as possible, but, because of the open plan, whereby there was a free connection between the rooms on the ground floor, there was an amazing absence of stuffiness. He should emphasise that he was referring to small domestic dwellings.

The American attitude towards ventilation was worth consideration, especially in comparison with that in this country, where there was a considerable flow of air through the house, caused by the open fire chimneys and by the numerous ventilators, cracks and crevices. Some experience in America with the open fire in houses with complete heating had shown that the amount of fuel used on the furnace was increased instead of decreased when the open fire was lit, because of the cooling effect of the increased quantity of air flowing through the house.

As to the appliances and the methods of heating, many of the older houses were heated by means of heating stoves situated in the living room and as far as possible in a central position in the house. Those stoves were kept alight continuously during the winter. They heated the living room by convection and the warm air circulated through open doorways to the rest of the house. No attempt whatever seemed to have been made to provide stoves in which the fire was made visible either by means of transparent panels or by doors that could be kept open. The heating stove was regarded as being only moderately satisfactory. The chief disadvantages were that it was not under automatic control, the warming of the rest of the house was not positive, and the living room was cold at floor level.

In more modern houses heating was done by warm air or hot water, and steam heating was sometimes used in blocks of apartments. When warm air heating was used, the furnace was usually situated in the basement and the

air was distributed throughout the house by means of ducts. There were two kinds of system, the gravity system and the forced warm-air system. In the gravity system, the warm air circulated under the influence of natural convection, whilst in the forced warm-air system circulation was induced by means of a small fan. In the gravity system there were very small forces causing a movement of air ; that gave rise to considerable design difficulties and even the heating engineer did not always find it easy to heat the whole house uniformly in this way. There were a number of bad installations. Forced warm-air systems, on the other hand, if properly designed, generally gave a much more even temperature distribution, owing to the more positive distribution of air by the fan, and there seemed to be no prejudice against having a fan in the system. The hot water central-heating systems were in the main similar to those used in this country, but some interesting developments were taking place in connection with the use of concealed skirting-board radiators. In most houses the hot water was obtained from a furnace in the basement, but in some cases it was taken from district heating mains.

He had not referred to the open fire, because it was not generally regarded as a main source of heat. He thought it was regarded as such in less than 7 per cent. of the houses, and most of those houses were in the Southern States. It was generally looked upon as an expensive luxury and was used only occasionally. It was interesting to note that nowhere in North America did there seem to be any demand for high-temperature radiant heating. The public did not appear to want it, architects and heating engineers did not generally provide it, and the physiologists had not, up to the present, found any virtue in it. He should add that the sunshine record of North America in winter was much better than it was in this country. The sunshine in the winter months in Washington was about ten times more than in Manchester.

With regard to hot water, the provision of an ample quantity of hot water had long been considered essential in all American houses, and, in fact, nearly all American houses in urban areas had a piped hot-water supply.

A study of American heating methods showed how very closely house planning and heating were inter-related. If that relationship and its implications were not appreciated, the success of any new heating systems in this country might be immeasurably restricted.

He had mentioned that the heating furnace for central-heating systems was usually located in the basement. In addition, the basements were used for such purposes as fuel storage, clothes washing and, in bad weather, clothes drying, but were invariably non-habitable. Basement accommodation was often cheap to provide in the colder regions, as the foundations had to go below the depth of frost penetration and excavating might cost no more than trenching.

The importance of insulation of the structure of a building was fully appreciated from the point of view of fuel economy in the winter and comfort throughout the year. This appreciation was not confined to architects and heating engineers ; it was shared by members of the public and by the Administration, which prescribed for all Government-sponsored houses a minimum degree of insulation of the structure, depending upon the prevailing climatic conditions of the locality.

The general attitude towards heating and heat services was that a complete heating system, providing continuous and controlled warmth throughout the house, was essential.

Mr. G. L. Rough said that he had listened very carefully to everything that had been said at the meetings that morning and afternoon. Being a layman, he could not use technical language, but he was concerned about the facts, and he thought that so far the technicians, the architects and the heating engineers were merely trying to find out where they were going. In view of that, he thought that further experiments should be made in district heating and in the heating of houses and that they should be made in many of the new housing schemes that were being developed at the present time by local authorities. The local authorities were not so much concerned about the insulation of houses, the radiation of heat in houses, and so on ; they were concerned about the cost and its effect on the rent when the houses were let to working-class people, and so far not one speaker had touched on that very important aspect of the question. It had been admitted by all the technicians that the cost of district heating or any other type of group heating would be very high indeed, involving an average increase in rent of about 4s. 6d. per week. That was a very heavy increase for a local authority to consider and certainly a very large sum for the ordinary worker to pay out of his wages.

Professor J. D. Bernal said that Mr. Rough had said nearly all that he had intended to put before the meeting. He believed it was necessary to ascertain the facts to which Mr. Rough had referred, and the matter was actually in hand ; a good deal of the work had been done, though a report on it had not yet been issued. Groups of houses were being built at the present moment in order to test the various methods of heating at full scale and with adequate costing. The various scientific committees were not quite as much in the clouds as Mr. Rough had implied. The question of capital cost and running cost taken together over a period of years was the criterion for a heating system, and he thought it would be found that in the future suitable appliances and suitable insulation would be regarded not as a luxury but as basic necessities in a house.

Mr. A. H. T. Broderick said that the section of the report of the Egerton Committee dealing with the insulation of buildings, in his opinion, was very unfortunate. The tone and the content of it, he feared, would do what they were not intended to do. In the first paragraph of chapter 4 of the report reference was made to the importance of insulation, and the keynote for the rest of that chapter was given in the last sentence of the first paragraph, which read as follows : "The higher the thermal efficiency and the less expensive the fuel, the less will be the saving attainable by means of insulation." That attitude, unfortunately, went right through the chapter.

Having established this half-price criterion, the committee applied it in a way which he was afraid might convince most people who read the report that insulation was a very hazardous sort of thing and a luxury which was likely to be very expensive, but, of course, that was quite contrary to the facts.

Unfortunately the committee did not touch on the fact that insulation should not be regarded as something which must be added to the structure at additional cost but should be regarded as something which could be used sometimes as part of the structure, without adding to the expense. If insulating board was used for the ceiling instead of plasterboard, insulation would be achieved and would cost almost nothing. Therefore he submitted that the wise thing to do, when a certain amount of insulating board was used, was to use it for the ceiling of the first floor, using the plasterboard for the ceiling of the ground floor, where insulation did not matter so much.

Mr. E. G. Fowler said that as the Ministry of Fuel and Power had convened the conference he had expected that much greater stress would be laid on the subject of fuel. A great deal had been said and written about the heating of houses and many tests had been tabulated, but in the ultimate reckoning there could be no case whatever for burning coal in an open grate at an efficiency of 20 per cent. or for using an electric stove or immersion heater at an overall efficiency of 18 per cent. or a gas fire at an overall efficiency of 25 per cent. (those figures were taken from the Egerton Report) when coal could be burned in a solid fuel appliance in the house, under automatic control, at an efficiency of 70 per cent. In 1938, 45,000,000 tons of coal were burned in houses, and the efficiency, according to the report, was 20 per cent. If that could be raised to 40 per cent., the Minister of Fuel and Power would have 22,000,000 tons, which, he was sure, would make a great difference to the Minister's economy.

Mr. A. L. Roberts said that no reference had been made to the difference in the calorific value of fuels when the quantities used before the war and to-day had been compared, and he submitted that figures which did not take into account the heating power within the fuel which was supplied might be misleading.

He also wished to draw attention to the fact that the fuel supplied to-day was not always of an economic size for the heating apparatus or the fire in which it had to be burned. He himself used coke and anthracite, and the coke came in much too small a size, with the result that it burned through in a domestic boiler much more quickly than the proper size of coke would do.

Mr. D. E. E. Gibson said that he agreed with Sir Alfred Egerton on the need for dealing with the heating of old houses. As the conference was a fuel conference it should deal with the question of economies in fuel, and it was obviously far more important that the existing houses should be put right than that the smaller number of new ones, which were going to be built should be built properly. What was the use of building a relatively small number of good houses that did not pollute the atmosphere if the old houses continued to do so? How could the old houses be dealt with? He could not imagine any private owner taking out fittings which his tenants were prepared to go on using unless there was some inducement offered to him to do so. In certain areas in blitzed cities the matter could probably be dealt with under the 1944 Act dealing with compulsory acquisition, whereby all the properties would become leasehold to one building owner, and if a central-heating plant was put down its use could probably be made compulsory. In other cases, unless there was a special subsidy or some inducement in the form of an income tax rebate for improvement of dwellings of specified types, he did not see how the old houses could be dealt with, and he thought that point should be emphasised.

The same remarks applied, he thought, to the new houses. The local authority in Coventry—no doubt like other local authorities—had set out with the best of good intentions to follow the recommendations in the Egerton and Simon reports, but they had then been faced by the Ministry of Health with bringing the cost down to 21s. 6d. per sq. ft. of floor area, and the very things that had been discussed at the present meeting and ought to be included had had to be cut out. He had been very interested and pleased to hear Mr. Key's statement that the Ministry would in fact support the introduction of things which would save fuel, and he would like that to be noted, because there might be some difference between the directorate of the Ministry and the officers who had to carry out the policy. Insulation, for instance, was

obviously an important matter and it could be introduced easily and without great expense, but there was a certain amount of expense to be met, and he thought that either an additional subsidy should be given for it or the local authorities should be told that they must not introduce it and the reason why.

There was one point that he wished to make on the question of the temporary house programme. It had been noticed in Coventry that many tenants were not using the right fuels, such as coke or anthracite. It seemed to him that there should be some tightening up in that connection and that very definite instructions should be given to the tenants and also to the coal merchants. The tenants were told what fuel they ought to use, but the coal merchants, he thought, very often put them off with other fuels and the tenants used those fuels. That caused trouble in connection with the flues, and, moreover, the tenants were not getting the right efficiency out of their appliances and were making the atmosphere more dirty than they should.

In the housing schemes that were now being carried out he found that under-floor ventilation was seldom used. Cavity walls continued to be ventilated, and he did not think that ought to be done, as it reduced the wall to a 4½-in. brick wall straight away. The possibility of getting some warmth into the solid floors that were now being used owing to the timber shortage should be considered. He suggested the use of no-fines concrete or the use of empty bottles and broken hollow clay partition blocks from the manufacturers' yards, to be mixed loosely with concrete in order to get air cells underneath. He thought that in the rooms where electric heating was used the place for the electric heater was on the ceiling, pointing downwards. That made for the flexible planning of the room and placing of the furniture.

In Coventry, twelve months' running of an experimental house, experimentally planned and also experimentally heated, had now been completed. In that house solid fuel was used for the fire in the living room and for water heating, and the heat was taken to the bedrooms for background heating, which was topped up with radiators. The total cost, including electricity for lighting, for the radio, for the vacuum cleaner and the refrigerator, gas for topping up in the bedrooms and an immersion heater for summer-time use, worked out at an average of 9s. 6d. per week over the whole year, the fuel costs being as follows: coke, 60s. per ton; gas, 10d. per therm; and electricity, 3d. per unit. That result would be published shortly and it showed that it could be an economical proposition to get really good background heating all over the house in that way. There must be many estates where the complete heating of houses by district heating could not be done, and the method adopted in the experimental house at Coventry presented a good second best.

Mr. A. C. Hazel, speaking as one who still preferred an open fire, cautioned the meeting against accepting American practice. He hoped that this country would not automatically copy America, but rather maintain its own way of life. The efficiency of the openable solid-fuel stove was given in the report on Domestic Fuel Policy as 45 per cent.; he personally liked to see the flickering flames from this stove and pointed out that it had a thermal efficiency which was three times that of the electric fire.

Mr. R. K. A. Still mentioned that houses in the Cotswolds were built of stone. Wood and not coal was used for heating since coal was too expensive. He noted that the Ministry of Works was installing openable stoves in some of the prefabricated houses now being erected. In many rural districts neither gas nor electricity was available.

SECTION G. MODERN HEATING AND THE ARCHITECT—*continued*

SESSION II. New Appliances and Architectural Design

Chairman of Session: MR. J. H. FORSHAW, M.C., F.R.I.B.A.
CHIEF ARCHITECT TO THE MINISTRY OF HEALTH

THE CHAIRMAN, in opening the session, said that in 1914 when coal supplies were abundant, the accepted slogan was "Burn more Coal". To have sought efficiency by lower coal consumption in those days, especially in the domestic market, would have been to depress business and to increase unemployment. Consequently, in the parallel industries—the foundries—appliances were produced to burn the generous supplies of those days in large open fires. Today the position was reversed and the point had been reached at which it had become expedient, whether we liked it or not, to make drastic economies in our use of coal. Our only choice was to plan to reduce its consumption in the open domestic hearth. That was another example of circumstances forcing a revolution on us.

The subject under discussion at this session covered but one section of a field in which, until recent years, at any rate, neither the skilled designer nor the qualified scientist had been called to work, and certainly not together. He believed, however, that by this new approach to a problem of everyday concern and because of the urge arising from our present tribulations we should enjoy the comforts and conveniences which science had in store for us perhaps ten, fifteen or twenty years earlier than would otherwise have been the case.

In the art of industrial design progress today was rapid and vigorous; it was of our own time and belonged to our everyday life. The danger of flooding the country with large quantities of inferior products was a real one, although it was held in check partially because of the scarcity of raw materials. It was essential to fight against cheap and low-standard fittings if we were not again to see a progressive decline, and the conference would, therefore, welcome the action taken by the Council of Industrial Design in drawing the attention of manufacturers and of the public to the importance of good design. He had mentioned good design in a general sense, but the conference was concerned with efficiency, cost and convenience of operation and cleaning as well as with appearance.

The building and equipment of new homes would be the major task before the country for the next ten years and in consequence the demand for heating appliances would be vast and urgent. Light, durable and inexpensive equipment was essential, and by "inexpensive" he did not mean cheap, although cost would be the ruling factor. In whatever was designed or planned the tenant's needs had to be kept foremost in the designer's mind and full account taken of the requirements of the work of installation, maintenance and repair. By seeing that those requirements were fulfilled, much would be done for the housewife and for her family.

1. New Types of Solid Fuel Domestic Heating Appliances and Systems

By J. S. HALES

The improvement of domestic heating with solid fuel presents two more or less distinct problems, one concerned with existing houses and the other with new houses yet to be built. Although the increased efficiency of modern solid-fuel appliances will provide a higher standard of heating and reduced fuel consumption when installed in both existing and new houses, considerably more scope for improvement is possible with the latter since the location of the appliance, the design of flue and hot water service can all be properly designed around the solid-fuel appliances to give the highest efficiency and service to the user.

The various improvements in post-war designs as compared with pre-war types, may be summarised under the following headings :—

(1) More accurate control over combustion, giving more certain performance and reduced fuel consumption when required.

(2) Increased thermal efficiency.

(3) Provision in many cases for continuous burning with low overnight fuel consumption, thus giving the advantage of heating throughout the 24 hours with elimination of labour for lighting fires.

(4) Ability to burn a wider range of fuels, including many smokeless fuels.

(5) Improved multi-duty of solid-fuel appliances, whereby one fire will give more than one service, for example, space heating and hot water supply or cooking and hot water supply, or again a combination of all three services. This multi-duty service may include the provision of background warming to other rooms by means of warm air or hot water coils or radiators.

(6) Improved appearance of solid-fuel appliances.

Most modern solid-fuel space heating appliances have closeable open fires whereby the pleasing features of a cheerful open fire are combined with the efficiency and convenience of the closed stove. Where there is no specific arrangement for closing the fire, provision is made for rapid and easy ignition of the fuel by means of a gas burner built into the appliance. There are three main types of improved open fire type space heaters, namely :—(a) The open-close stove. (b) The closeable open fire. (c) The smokeless-fuel open fire.

The *open-close stove* is now made in a variety of designs, incorporating new features which aim at improved control while ensuring good appearance. In some models, the fire doors are arranged to disappear out of sight when the stove is used as an open fire, while in others special doors with permanently transparent windows are used. Most of these stoves will burn coke and other smokeless fuels for which they are primarily designed, and in some cases the firebox is so arranged as to reduce smoke emission when burning bituminous coal. The open-close stove gives the larger proportion of its heat in the form of warm air (convection heating) and in some cases this may be used for warming other rooms. Care is needed, however, to ensure that sufficient heat is allowed

to flow into the room in which the stove is placed in order to ensure satisfactory heating of that room, and for this reason in some designs only a proportion of the warm air can be diverted into other rooms.

The *closeable open fire* differs from the open-close stove in that the emphasis is more on the open fire appearance with a closure lid or plate to cover the fire when the room is unoccupied or for overnight burning. As in the case of the open-close stove, a high efficiency can be obtained by use of warm air heating (convection heating) to supplement the normal radiation from the open fire. The main advantages of this type of fire as compared with pre-war stool-bottom and hearth grates are the ability to obtain continuous heating at higher efficiency with more accurate control over burning and the consequent wider range of fuels which may be successfully used.

The *smokeless-fuel open fire* derives its effectiveness by the design of grate, accuracy of air control and provision for easy ignition. Although primarily designed for burning coke, from which a high radiant efficiency is obtained, a wide range of other fuels can be used, including anthracite and bituminous coal. Some designs of the smokeless-fuel open fire also provide warm air heating from the outer casing of the fire thus giving an additional source of heat which may be used either in the room in which the fire is situated or elsewhere in adjacent rooms.

COMBINED SPACE HEATING AND WATER HEATING APPLIANCES

Nearly all solid-fuel space-heating appliances can be arranged to incorporate a boiler which supplies either the domestic hot-water supply or additional space heating by hot water radiators. When correctly installed, with compact and well insulated hot water tank and plumbing, such a combined system of space heating and water heating provides one of the most economical methods of giving the two services for the small house during all but the warmer weeks of the year. The efficiency and effectiveness of this arrangement, however, depends ultimately on the layout and insulation of the hot water system and this point cannot be too strongly emphasised.

WATER HEATING APPLIANCES

In addition to the many modern space-heating appliances giving water heating as just noted, there is a variety of independent boilers of improved design which give a high efficiency of water heating. In addition these boilers provide a measure of space heating direct from the appliance itself, and, if required, by hot water radiators.

Owing to the present shortage of sized smokeless fuels, the extensive use of the independent boiler is not being encouraged for the time being, but where its installation can eliminate other forms of space heating, it can be both efficient and effective. As with other modern developments, the improvements in independent boilers centre round the certainty of control to give reliable continuous heating combined with better design to reduce labour for cleaning.

COOKING APPLIANCES

For the small house it is usually more economical to combine water heating with the cooking appliance if this is of the solid-fuel continuous-burning type. Such a combination, given proper plumbing layout, gives a good continuous supply of hot water as well as full cooking facilities. Improvements include better thermal insulation of the cooker with more rapid hot-plate heating, and

in some cases the elimination of oven flues by the use of warm-air oven heating. Accurate combustion control enables a variety of fuels to be burned economically with the minimum of labour for attention.

COMBINED COOKING, SPACE HEATING AND WATER HEATING APPLIANCES

The latest designs of multi-duty appliances (usually referred to as combination grates) whether these are of the side oven or back-to-back types, provide the three services of cooking, space heating by an open or openable fire, and hot water supply. As with other appliances giving water heating combined with other services, the need for compact and thermally insulated hot-water systems is of vital importance if efficiency and fuel economy are to be fully realised.

Improvements in these multi-duty appliances cover a wide range including such features as closeable fires designed for continuous burning and air-heated ovens. All provide more accurate control which enable the three functions of cooking, space heating and water heating to be separately regulated to suit the needs of the particular installation. The increased use of some form of closeable fire avoids excess space heating in the living room or kitchen living room when this is not required, and in some multi-duty appliances auxiliary heating either by gas or electricity is incorporated in the appliance for use in the warmer weeks of the year.

COMPLETE HOUSING UNITS

The increased use of prefabricated methods of house construction have had their counterpart in the design of complete house heating systems using solid fuel appliances as the basis for heating. The various units which have been designed all aim at centralising the plumbing and flue system, but naturally vary from one unit to another as to the completeness or otherwise of the equipment included. In all cases the house is built around the central system, although the construction of the house is usually not required to be of special form.

The advantages of such systems are of two possible kinds, firstly the saving of site man-hours by the installation of plumbing, flue and ducting as a prefabricated unit, and secondly, the increase in heat utilisation from the fuel appliance and its associated flue resulting from compactness of design and proper co-ordination of the working parts.

The services supplied vary with the particular system and type of appliance used. For example, general space heating and hot water supply is provided in one case by an independent boiler with auxiliary heating as required for living room and an independent gas or electric cooker. In another example, the combined service of space heating and hot water supply is given by an open-close stove in which warm air is fed to upstairs rooms. In yet another example, the three services of space heating, cooking and hot water supply are provided by a back-to-back grate arranged in a single unit incorporating the flue, plumbing, tanks and electric auxiliaries.

PROVISION OF CHIMNEYS AND DUCTING

Unlike most other fuels, solid-fuel appliances require for their satisfactory working, efficient flues and in some cases ducting for the admission of cold air and the transfer of warm air to other parts of the house. Many new developments in flues are being tried and, as already indicated, it is possible to extract

a certain amount of additional heat from their outer surfaces, heat which would otherwise be mostly lost. The methods of construction and materials used in these flues are rather outside the scope of the present paper, but correct flue design is vital to the proper working of modern improved appliances. The provision of ducting for the circulation of air to and from some of the appliances designed for convection heating also calls for care in planning and emphasises again the need for correct location of the appliance in the house if the optimum results are to be obtained.

BACKGROUND WARMING FROM SOLID-FUEL APPLIANCES

In the brief description of the various types of improved solid-fuel appliance, reference has already been made to the multi-duty nature of many of them. The use of background heating for rooms other than that in which the appliance is fixed is, of course, no new development, but the increasing use of heat extracted from the outer surfaces of many modern appliances, heat which would otherwise be wasted, introduces fresh methods for the more effective heating of the small house.

The amount of heat available is usually sufficient for warming one or two rooms, auxiliary heating by gas or electricity being used for topping-up as required. Appliances of the continuous burning type are the most suitable for supplying background heating since they are capable of giving a steady flow of heat throughout the 24 hours.

FUTURE DEVELOPMENTS

Great though the improvements in solid-fuel appliances have been during the last year or two it must be remembered that until fairly recent times solid fuel has been plentiful and cheap in this country and little incentive was given to develop appliances of high efficiency. All that is now changed, however, and the rate of progress of further developments and improvements in solid-fuel appliances is likely to accelerate at an ever increasing rate in order to utilise the reduced supplies of coal to the utmost.

The production of larger quantities of smokeless fuel of both the manufactured and natural types which has been forecast will find a ready use in the improved appliances now being designed, many of which give their highest thermal efficiency on these fuels. Alongside these developments one may expect single appliances to burn bituminous coal with greatly reduced smoke emission, whilst the use of centralised systems with pre-formed plumbing and complete house-heating services are likely to be of special interest.

From the point of view of the householder the correct combination of the three fuels, solid fuel, gas and electricity, offers the best opportunity for a satisfactory heat service which combines the efficient use of the nation's coal with convenience and low cost to the user.

2. New Gas Appliances and Architectural Design

By J. WHITE

The general purpose of this paper is to review briefly the recent improvements in various types of domestic gas appliances, and to direct attention to the modern conception of the gas heating installation as a whole, which

marches with the architectural conception of the functional design of a house as a place for living. Functional design connotes not only an appreciation of materials, their clean handling and appropriate application, but also a clear apprehension of the specific activities which centre in the dwelling house, and which grouped together form the home life of the family. In so far as these activities involve the use of fuel, the gas industry can, I think, offer a considerable contribution to their understanding as they affect families of the various income groups and occupations, of varying sizes and compositions, and of different "methods of living", as the Housing Manual puts it.

Among the industries concerned with the production and distribution of fuel and of the appliances for using it, the gas industry has almost unique opportunities for studying the whole matter. It not only supplies a measured amount of a particular fuel to almost every urban household in the country, but it supplies and fixes, or prescribes the appliances, and has for many years co-operated with the appliance makers in their development. In most cases it maintains the appliances after installation, and is in close touch with the users. Because of its wide and long experience it can be of considerable service to the architect.

Production difficulties have so far severely restricted the output of the new appliances, but some are coming through the works, and others are well forward in the immediate pre-production stages. Improvements take the form of an increase in thermal efficiency, easier maintenance and cleaning, more and better automatic control, and better æsthetic design. This applies to a wide range of space heaters, cookers, water heaters, and home laundry appliances. Gas fires are now being made which, in addition to the radiant heat from the brightly glowing open fire, give a further portion as convected heat in the form of a stream of warm air projected into the room and this without appreciably affecting the ventilating effect of the fire although the over-all thermal efficiency is very considerably increased. At the same time the fireclay radiants have been made stronger, and the burners simplified in such a way as to cut down maintenance requirements to a minimum. The gas industry places high importance upon trouble-free service and this theme is very evident in the new types coming forward.

The gas cooker, in its fundamental principles, is not susceptible to radical change. For many years its cooking performance has been such as to give satisfaction alike in the kitchen at home and in the high temples of the culinary art. Improvements in format, in detail, and in appearance in respect of both "in-built" and free standing appliances, have, however, been made, and the post-war cooker is right up to the highest standard of post-war kitchen equipment. The greater use of enamelled outer casings, improved heat-resisting enamels which have made it possible to extend this finish over the hotplate, coupled with a general cleaning up of design, have made the cooker more attractive in appearance and easier to keep clean. Complete thermostatic control capable of infinite variation over the entire temperature range is now fitted as standard on domestic cookers; accessibility, simplicity, and reliability, already of a high order, have been further improved. Models with a more convenient positioning of the oven and hotplate, and in some cases incorporating hot cupboards and utensil cupboards, are somewhat held up by the present severe restrictions as to kitchen space and cost, but the designs are there ready for production when circumstances permit.

Some improvements in water heaters, in existing types and in new designs coming on to the market, have been directed towards the diminishing of maintenance requirements, others to make them more adaptable to the modern idea of fitted kitchen equipment. Methods for their incorporation as an integral component of the planned hot-water supply of the small dwelling have been worked out, and schemes have been developed for a complete hot-water service, thus avoiding the limitations imposed by the dual purpose solid-fuel space and water heater—further, schemes for the complete summer service, for which the dual purpose heater is manifestly unsuitable, and for a variety of supplementary hot-water services, are equally available, and it is important to note that the proposals available are not the result of slide rule approximations as is too often the case in fuel requirement calculations, but are based upon massive district testing under widely different conditions in many parts of these islands. Time does not permit of a detailed presentation of these various systems, but I would urge that the hot water system for the small dwelling should be considered as a whole, remembering that it is in use winter and summer, and that a careful comparison of local fuel prices should be made before a decision is taken, and that the convenience of the housewife should be taken into account. Most men have helped with the washing of dishes in the evening, but not so many are familiar with the washing of the breakfast dishes, and have therefore missed the blank misery of a hot water system that at that particular moment is not what its name suggests.

Our long experience of the housewife's problems, reinforced by many recent discussions between our Home Service staffs and representative groups of women, leads me to put in a special plea for adequate provision of home laundry facilities. Women's opinion in my own district is overwhelmingly in favour of the provision of a separate wash-house—call it a utility room if you like. Have you noticed how often, in houses of slightly more generous accommodation than those at present building, the garage, if it does not house a car, or if it has a few feet of spare space, is made to serve as a wash-house, which is fair on neither housewife nor car?

Gas wash-boilers have been improved in thermal efficiency, and gas washing machines in design and appearance, but the development of the latter is hindered by the heavy incidence of the purchase tax. Especially in hard water districts, the washing machine with agitator and wringer is a very much better proposition than the wash boiler, and despite the fact that in the past a wringer has always been provided by the tenant and not by the landlord, the present tendency to provide more complete kitchen equipment might well be extended to cover it. In any case, either wash boiler or washing machine is worthy of a better fate than to be housed under the draining board.

The outstanding contribution, however, that the gas industry can make to the post-war home laundry, and through it to the amenities of the whole household, is the gas-heated clothes dryer. Gas clothes dryers have been successfully used for many years, but chiefly in large households and institutions. Now their mass production is in hand in sizes and finishes which will fit in with the new standard kitchen fitments—safe for use on either rayons, woollens, or cottons. They are fitted with thermostatic control, which has enabled the rate of drying of a full load of wet clothes to be speeded up to under the hour. The result is that the family washing can be ironed and put away within the one day, and need not be found draping the living room the following day—in fact we have a slogan "Out of the way in one day." It should be noted,

and this is a serious matter, that from 8 to 12 lb. of water may have to be evaporated from a complete washing for a family, and provision must therefore be made by flueing or adequate ventilation for the removal of the steam. In the process of studying a great many designs of clothes dryers and of the houses in which they are to be installed I have been astonished to observe how little thought appears to have been given to the ultimate resting place of this not inconsiderable quantity of water. The gas-heated dryer of today recognises the problem and solves it so far as the design of the dryer is concerned, but thereafter the final problem of the transport of the water to the outside atmosphere is, I submit, a matter for co-operation between the architect and the gas undertaking.

Almost within the present century, water supply, water carriage sewage, gas supply, and electricity supply, have progressed from the position of being added extraneously to the plan of the house to being an integral part of the design. Probably the group of services which we class together rather clumsily as telecommunications is making a similar progress. But there is still a good deal of planning and thought required before the functions, the appliances, and the installations are properly correlated with each other and with the working of the household and the general design of the house. The inter-war period houses were certainly an improvement in many cases upon the earlier houses in which scullery, bathroom, etc., were located on the outer wall of a hideous offshoot. Now we have arrived at the stage of the kitchen unit and the plumbing unit. These are excellent things in suitable circumstances, but they are not necessarily a short cut to good planning on all occasions. Integration should be accomplished without loss of flexibility and a house should give its occupants opportunity for different ways of living, and not expect them to conform to a preconceived pattern.

We may recognise that certain fuel equipment and provision for its installation is fundamental, but we cannot pick out certain designs of appliances and say that they will persist as long as (we hope) the house will last. It is obvious that the cooker, water heater and refrigerator are fundamental to the kitchen, and the washing machine and clothes dryer to the home laundry. Gas fires are, or will be, essential to the sitting room, the bedroom-study, the sick room, and the old people's bedroom. Improvements in design and installation methods have solved the related problems of heating and ventilating these rooms. Their layout need no longer be governed by the multiflued chimney stack carried from the foundations straight through to the roof. The new panel fires can be fixed flush upon the wall at any convenient height. They are silent, cannot "light back", and are unaffected by dust and fluff. The method of fixing them to the wall has been simplified and is in the process of being standardised. They can be flued by a 30 sq. in. area concrete block flue in the thickness of the wall, which can be placed in any convenient position (the corner position in a bedroom is often particularly convenient), and continued by asbestos cement flue pipe across the roof space to a convenient stack or ridge tile. It should be noted that a flue or ventilating shaft of 30 sq. in. area is the method of ventilating bedrooms recommended in the B.S. Code of Functional Requirements for Dwellings.

A broader view of the fuel-using installation as a whole will result in a better deal for the housewife and a fuller and freer home life for the family. Nor should it be forgotten that the complete abolition of smoke is essential to restoring and preserving the beauty of our land.

3. New Types of Electrical Domestic Heating Appliances and Systems

By J. I. BERNARD, B.SC., M.I.E.E.

CHIEF TECHNICAL OFFICER, BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION

Although dependent so far mainly on fuel-burning power stations, electricity itself is a form of energy. As such it can be instantly transformed into heat by the simple process of passing a current through a wire. Every unit of electricity must produce a definite amount of heat, irrespective of the size of the apparatus, and practically any temperature can be developed depending upon the proportions of the heating element. This flexibility in design explains why electric heating is usually applied in separate appliances, each made for a specific purpose and for installation in the most convenient position chosen by the architect. Electricity therefore imposes no restrictions on architectural design; in effect it gives the greatest possible freedom in planning.

Electric heating appliances work at very high efficiencies—in many cases 100 per cent.—and this efficiency of utilisation is of greater importance than the “coal economy” efficiency which takes no account of the kind of coal used; power stations generally burn the poorest grades of fuel which virtually cannot be used for any other purpose.

MODERN ELECTRIC SPACE-HEATING APPLIANCES

Electric fires, both of the portable and wall-mounted types, are being produced in an increasing variety of patterns, their high-temperature elements giving out a large proportion of radiant heat of the kind that is so popular in our relatively damp climate. Some new reflector type electric fires are designed to radiate their heat over a wide arc— 120° in plan—so that persons sitting at the side are warmed as well as those in front of the fire. Wall-mounted fires are designed for fixing on the wall without the need for a recess or cutting away and the convection air currents are thrown forward so as to avoid staining the wall surface above the fire. Electric convectors, i.e. the type of heater in which the elements run at a relatively low temperature and most of the heat is used to warm the air, are made in both freestanding and inset types. They should preferably include a built-in thermostat since automatic control is always desirable when non-luminous elements are used. Tubular heaters, also low-temperature wall panels, are available for cases where lateral distribution of warmth is required, as under large windows to stop down-draughts and check the sense of chill.

The choice between the different kinds of electric heater depends to a large extent upon personal preference. Electric fires are generally satisfactory provided that the house is well built from the point of view of low heat losses, which should be taken as meaning not only insulation up to the values of $U = 0.15 - 0.20$ recommended in Code of Practice, Chapter VIII, but also that insulation should be applied, or the interior wall surfaces finished, in such a way as to reduce the thermal capacity, thus enabling conditions of comfort to be attained in the shortest possible time. If, however, additional “background” heating is needed, electric convectors or other low-temperature

heaters are a very simple means of solving the problem. In small houses, a convector of $1\frac{1}{2}$ –2 kW standing in the hall provides a measure of central heating for the whole house during the coldest months.

ELECTRIC WATER HEATING

The types of installations for small houses can be conveniently divided according to whether electricity is the sole source of heat or used in conjunction with a solid-fuel fired system.

All-Electric Systems.—A factory-made electric water heater, which consists of a well-insulated storage vessel fitted with heating element and thermostat for automatic control, should be used in conjunction with an efficient layout of piping.

A new type of electric water heater made by a number of manufacturers under various names has been produced specially as a contribution to the post-war housing programme. It is made in two sizes, 20 and 30 gallons capacity, and is fitted with two heating elements; one near the top keeps hot sufficient water, about 6 gallons, for ordinary domestic purposes, while the second element at the bottom of the cylinder is switched on when larger quantities of water are needed for hot baths or on washing day. The optional reduction in the quantity of hot water stored when the demand is low ensures the lowest possible consumption of electricity.

One heater has been specially designed with a diameter of 20 in. and a height of 33 in. for fixing under the standard kitchen draining board—a convenient out-of-the-way position, which has the great advantage of cutting down the length of pipe to the sink tap. As this is the most frequently used tap, appreciable economy in pipe losses is effected and the user finds that the water runs hot immediately.

Coal-Electric Systems.—If electric heating is to work in conjunction with a solid-fuel fired boiler, supplying all the hot water in summer-time and supplementing solid fuel when required, the whole arrangement becomes more complicated and care is needed to obtain economical results with electricity. The cardinal principle is to design the dual system so that it is efficient from the electrical point of view in which case the heat losses are bound to be less when the coal fire is in use. The general layout should include the following points :—

(i) The electrically-heated storage vessel must be fixed at a sufficient height above the solid-fuel boiler to ensure that the boiler-to-storage circulation will not reverse when electric heating is in use, so causing electrically-heated water to be circulated through the cold boiler, which would cause excessive heat loss.

(ii) Any circulating loops to radiators, towel rail, etc., should have their flow pipe branched off just above the boiler and not taken from the top of the storage which would permit electrically-heated water to circulate, causing unwanted and probably large waste of heat. This applies irrespective of whether the hot water system is of the "direct" or "indirect" type.

(iii) No draw-off piping, e.g. to the kitchen tap, should be connected to the boiler flow pipe. Such connections which were sometimes used in the past either to save piping or with the idea of getting hot water more

quickly after lighting the fire, are definitely unsuitable when electric heating is used because, being below the level of the hot storage, only cold or luke-warm water will be obtained at the taps so connected.

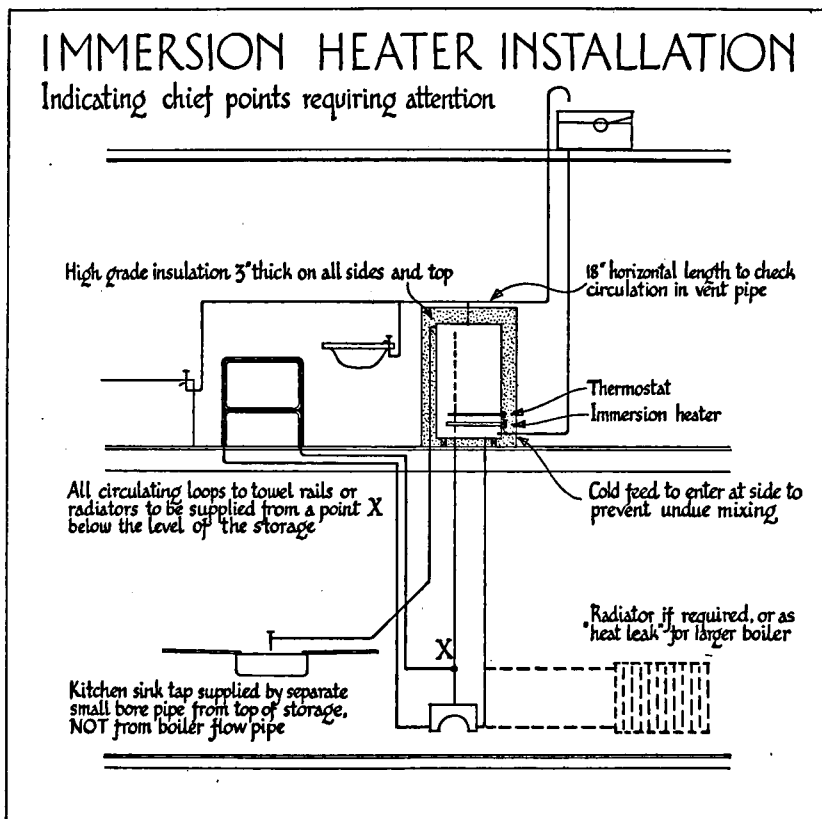


FIG. 1

Immersion Heater.—In converting a storage tank by fitting an immersion heater as an alternative to a solid-fuel boiler, expert advice should be obtained as there are a number of pitfalls which may trap the plumber or hot water fitter, who is inexperienced in electric water-heating technique. A mistake in a single house may not be costly to rectify, but in these days, when hundreds or thousands of houses are being built to a standard design, it is more than ever desirable that the architect should provide adequate space—at least 3 in. on all sides and on top of the tank or cylinder—for effective heat insulation and make sure that the layout of the piping has been approved from the electrical point of view. Electricity supply authorities can give valuable advice, including experience of the effect of local water, whether hard or soft. Properly designed electric water-heating installations require a negligible amount of maintenance and give an automatic, constant hot-water service with standing losses so low that the consumption of electricity is practically in direct proportion to the amount of hot water used.

ELECTRIC COOKERS

New models which have been designed since the war are notable for a number of improvements introduced mainly as a result of surveys of user opinion. They include : thermostatic control of oven temperature ; a quicker heating-up of the oven ; rapid boiling plates ; simmering controls for the boiling plates ; increased grilling and warming space.

The electric cooker with its flat top has always been easy to keep clean, but in post-war models attention has also been paid to the elimination of corners, ridges and beadings so as to increase still further the ease of cleaning. This greater simplicity of outline is being aided by the greater use of pressed steel in place of castings. An added refinement for those who desire it is a time-switch which allows the housewife who has to go out for the morning or afternoon to put a meal in the oven and set the time-switch to switch on at a predetermined time and also, if necessary, to switch off when the meal is cooked.

Post-war cookers of the vertical type are being made to conform to the standard dimensions of kitchen fittings, namely, 21 in. wide, 21 in. deep and 36 in. high ; they will have flush sides so that if necessary they may be inset between counters or cupboards, thus assisting the architect still further to improve the utilisation of space and eliminate gaps which are difficult to clean between fittings. From a kitchen planning point of view, it may be noted that oven doors are usually hung on the left-hand side and an electric cooker can be placed anywhere in the kitchen, its installation merely involving the provision of the necessary wiring and its operation being unaffected by draughts or other external conditions.

In order to meet the user demand for an oven at a higher level to avoid stooping, an increased number of post-war cookers will be available in either the side-by-side or buffet type, the dimensions of which will be 44 in. wide by 21 in. deep.

The maintenance of post-war cookers will be greatly facilitated by replacement parts such as boiling plates, etc., being made by all manufacturers to a common interchangeability specification sponsored by the Electrical Development Association.

REFRIGERATORS

New designs include an inset model of family size (4 cu. ft.) intended to be fitted in a range of storage cupboards at waist height so that all the contents can be easily inspected without stooping. The standard dimensions will be 24 in. wide, 19 in. deep and 42 in. high. The compressor unit is mounted above the cabinet so that it can be removed complete with the freezing chamber for ease of maintenance. With a refrigerator of adequate size and suitable accommodation for vegetables (which may take the form of a ventilated cupboard under the inset refrigerator) there is really no need for the conventional larder since other foods are mainly groceries which are more conveniently kept in suitable dry storage cupboards in the kitchen. If, however, a larder is thought necessary, it can be much smaller and planned so as not to encroach on kitchen space which is at a premium in small houses.

LAUNDRY APPLIANCES

Electric washing machines and wash-boilers are being standardised in size so that they can be accommodated under a draining board and if necessary

used in that position in order to simplify the washing process. The latest designs of washing machine avoid the need for a wringer by running the tub at high speed to remove most of the water by centrifugal force. An automatic model has been produced in which the whole sequence of operations, soaking, washing, rinsing, and partial drying is carried out with no more trouble to the housewife than the setting of a control dial.

In many parts of the country where outdoor drying of clothes is often spoiled by rain or a smoky atmosphere, there is a demand for indoor facilities. There are freestanding drying cupboards of steel available, but there is no necessity to instal such an expensive article in new houses ; a drying cupboard can be constructed approximately 2 ft. square on plan, either 6 ft. 6 in. or 8 ft. high, the interior finish being smooth, hard plaster. The inside of the door, floor and ceiling can be lined with glazed asbestos sheeting or similar material and the cupboard should be ventilated top and bottom so as to permit air circulation, the damp air being preferably discharged to the outside by means of an extract fan. The base of the cupboard is fitted with a suitable electric heating unit controlled by a three-heat switch to allow the drying rate to be varied according to the load ; on low heat, it can also be used for drying off wet outer clothing.

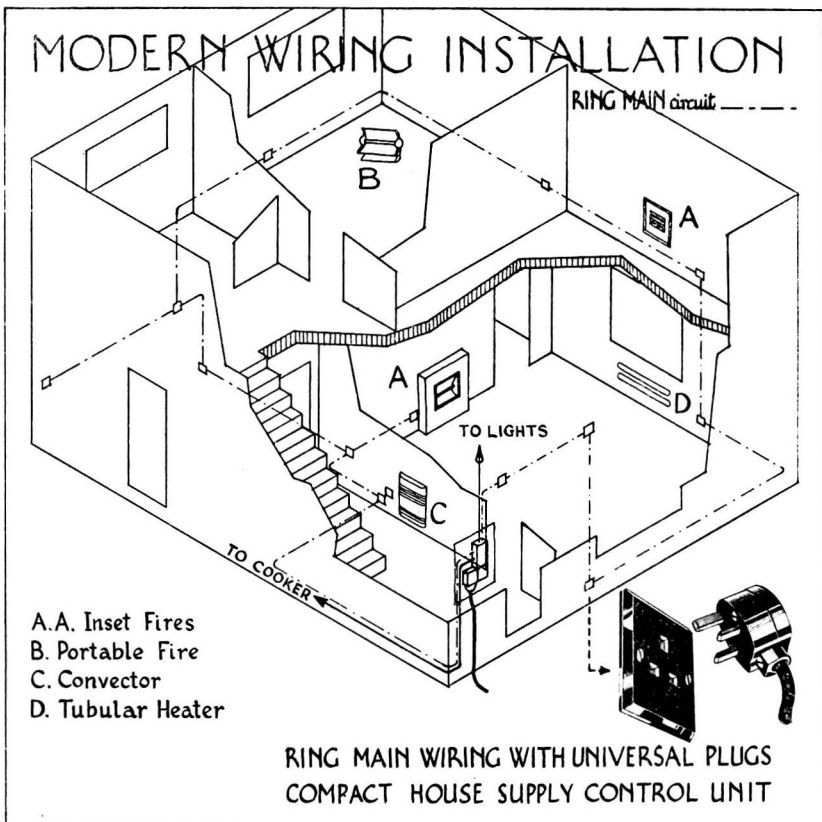


FIG. 2

NEW WIRING SYSTEMS

It is now generally recognised that convenience and, in some cases, economy in the domestic use of electric light, heat and power was seriously hampered by the lack of plug points in small houses built before the war. Much thought has therefore been given to the development of wiring systems which provide better facilities without serious increase in cost. The most notable departure from pre-war practice is the connection of a number of plug points to a single wiring circuit which is fed from both ends, thus doubling the effective size of conductor and obtaining the greatest possible diversity in loading. "Ring main" wiring as it is called has been officially approved in the 1946 Supplement to the Wiring Regulations of the Institution of Electrical Engineers which permits at least ten socket outlets in small houses not exceeding 1,000 sq. ft., to be connected to a ring main having a certain size of conductor which was previously permitted to supply only one heating socket.

A UNIVERSAL PLUG

The ring main system of wiring can only give the greatest convenience to the user if all the socket outlets are of the same size and suitable for supplying every kind of domestic apparatus from lamps and clocks, which only take a small amount of current, to the largest electric fire. In order to afford proper protection against overload or short circuit, the plugs for attachment to the flexible cords of the lamps or appliances, are each fitted with a separate fuse; this has the further advantage to the user that the effect of a blown fuse will be confined to the faulty piece of apparatus, instead of cutting off the supply of current to a number of sockets. The new fused plug designed to supply up to 3 kW will, therefore, be more convenient in every way.

NUMBER OF PLUGS

In view of the reduction in cost of installing a larger number of plug points, there is no reason why even the smallest house should not be provided with an installation adequate for the use of all the electrical appliances which will be employed during the life of the house. As a general rule, a minimum of three plug points should be installed in every living room and double bedroom, two in single bedrooms, and additional connections where needed for water heating, refrigerator and laundry appliances. Wiring for an electric cooker should be provided as a separate circuit on account of the heavier load (6-8 kW) all the other points consisting of the new 3 kW socket outlet.

4. The Influence of New Appliances and Systems on Architectural Design

By J. PINCKHEARD, A.R.I.B.A.

In the past we have always been rather prone to consider small houses as relatively simple and uncomplicated problems. Today, when perhaps more intensive research into the design of houses is going on than ever before, we are discovering how little in fact we know. Some of us perhaps heard a well-known scientist observe recently that we hadn't found a really satisfactory definition for "fresh air." Domestic heating in particular is one of those things which architects have taken for granted. Today the impact of a serious fuel

shortage and the appearance of new non-traditional forms of construction are forcing us to think much more seriously about domestic heating and about thermal insulation.

A very great deal of work has already been done by the scientists and by industry. Architects now, thanks to the work of the Egerton Committee, have for the first time a clearly stated programme of heating requirements. At the same time we now have a range of heating appliances with an efficiency often far in excess of anything available before the war. I want to say a little about the influence of these new standards and these improved technical resources on the work of architects. The method of heating has had a tremendous, and I think often unsuspected, influence on the evolution and development of the house—and even on its interior decoration and furnishing. The changes in heating technique today—in particular in the case of solid fuel burning appliances—we can be certain will be reflected unmistakably in the houses of the immediate future.

Technical innovations are likely to succeed each other at an ever-increasing pace ; architects more than ever in the past will continually be having to adapt their designs to take account of these changes. We should be making a very great mistake if we were to regard our new standards and new appliances as in any sense static. Nevertheless, while the architect must keep his eye on the future and watch the direction in which technique is moving, he must also master the detailed implications of the contemporary advances in building practice. I make no apology therefore for plunging into some of the more detailed problems with which architects are faced today.

It is possible to single out several aspects of the new domestic heating practice—the heating practice, that is, which is recommended by or implicit in the Egerton Report—each of which will, I think, have its effect on post-war domestic architecture. In particular I would select the following :—

- (1) The conception of background heating.
- (2) The trend towards the use of a single appliance for the main space-heating and water heating load.
- (3) The use of convected air for heating.
- (4) The controlled introduction of fresh air for combustion.
- (5) The introduction of new types of flue construction.

I am for the moment regarding all these factors from the rather narrow standpoint of our immediate housing problems.

BACKGROUND HEATING

The recommendations of the Egerton Report are based on the acceptance of a method of heating which is familiarly described as “ background heat plus topping up ”. The main effect of background heating will be to increase the usable area of the house. The practice of limiting adequate space heating to one or two rooms meant in effect that family life became restricted to that part of the house—often only to the living room or that part of the living room nearest to the fire. Such a state of affairs is socially objectionable, apart from the obvious waste of space. The family which has hitherto been concentrated into a single small area in the living room by the attraction of the one and only adequately heated zone will be able to spread out over the whole area of the house.

With heating throughout the house, and a draught-free heating appliance (to which I shall refer later) we can expect to see an opening up of the main

living area of the plan on the ground floor level. And parallel with, and complementary to, this tendency will be an extension of the functions of the upstairs rooms, to satisfy the needs of privacy, and to provide for work and study as well as for sleeping.

THE SINGLE MULTI-DUTY APPLIANCE

The second aspect about which I want to speak is very closely related to the question of background heating. One of the most noticeable changes in the plans of post-war houses—apart from the improved standards of floor space—arises from a general trend towards the use of a single multi-duty heating appliance operating on solid fuel. This is a trend which is reflected in many of the type plans circulated by the Ministry of Health, in the recent official restriction on the use of more than one solid-fuel burning appliance per house, and, of course, in the production of prefabricated heating units designed to give a complete heat service.

THE ECLIPSE OF THE OPEN FIRE

One of the more unpopular implications of the single solid-fuel appliance is, of course, the tendency to replace the open fire by the openable stove. The closed stove (or the openable stove) delivers more useful heat for a given quantity of fuel than does the open fire—even including the new improved designs—and in the present national fuel situation this advantage may prove decisive, notwithstanding the deep-rooted preference for the traditional open fire. It will be interesting to see how far people are prepared to sacrifice a warm house for the sake of the local warmth and the visual stimulation of the open fire. Architecturally, the effect of the eclipse of the open fire would be, I think, to deprive the room of its customary focus and to stimulate the creation of some alternative centre of interest quite dissociated from the source of heat. Perhaps the television set will fill this need.

LOCATION OF THE MULTI-DUTY APPLIANCE

The multi-duty appliance will frequently be required to provide space heating up to full comfort conditions in the room in which it is situated, with background heating to the adjacent ground-floor room, background heating by warm air to the two main bedrooms and an adequate supply of domestic hot water. The fulfilment of these requirements is best achieved when the appliance is located centrally in the house. The typical pre-1939 plan with its familiar fireplaces ranged against the party wall, beloved by local authorities and speculative builders alike, is a particularly unsuitable one for heating from a single main source, and it seems likely that this type of plan will be largely superseded by one with a central stack.

MEANS OF ACCESS

With this type of installation the question of access becomes of special importance. Access is required to the back boiler and the plumbing connections, and to the auxiliary water-heating appliance which may frequently be placed in the space behind the main appliance. Once again, the centrally placed stack has the advantage since it facilitates easy access to the appliance from the rear.

WATER HEATING

The incorporation of water heating with the main appliance has encouraged the adoption of a more efficient layout and more efficient insulation for the domestic hot-water system, and in particular has resulted in bringing the

cylinder close to the boiler in order to minimise the length of flow and return pipes. Admittedly this arrangement may result in longer draw-off pipes but generally the heat losses from the draw-offs are more than balanced by the saving effected by a short flow and return. There is a tendency, therefore, for the cylinder to be fixed on the ground floor rather than the first floor, in which case it can be conveniently installed in a cupboard adjoining the main stack.

Some means of auxiliary water heating are highly desirable, especially in the summer months, and either an electric immersion heater or a gas circulator can be provided. If a gas circulator is adopted it can often be fitted into the space behind the main appliance or it can share the cupboard with the hot water cylinder.

CHIMNEY SWEEPING

The question of chimney sweeping is one which requires careful attention, especially where closed stoves are used. Sweeping from the front may be difficult, especially if the stove has a flue adaptor which is much offset or where the stove itself is low down. The provision of means of access to the back of the stove previously referred to suggests the possibility of sweeping from the rear.

THE USE OF WARM AIR FOR HEATING

Where a single multi-duty appliance is installed, warm air will be the normal means of supplying background heat to the upper floors. The influence of the single appliance on the small house plan has already been considered and the use of warm air as a supplementary means of heating underlines the arguments already advanced in favour of the central stack. The main vertical warm-air duct, associated with the stack, becomes an essential element in the plan and more and more the tendency is for the house to be designed with the heating system rather than the heating being added to a previously determined plan.

TYPICAL LAYOUT

In a typical installation the heating appliance is surrounded—except at the front—by a shrouding. The enclosed space constitutes a convection chamber where air drawn in at the base is warmed by contact with the hot surfaces of the heating appliance. A vertical duct—frequently formed by the shrouding to the main flue—conducts the warmed air to the bedrooms above. A well-designed installation on these lines will be cheaper in first cost than a hot water heating system, it can be highly efficient in operation, and it requires a minimum of materials which are now in short supply.

AVOIDANCE OF EXCESSIVE AIR CHANGE

It is important to remember that the forces causing the warm air to rise in the ducts are very small in comparison with those due to wind pressure and chimney draughts. For this reason the design of the ducting, the placing of the inlet and outlet grilles and the avoidance of excessive air change are matters requiring the most careful consideration. Where the source of heat is an open fire it is highly desirable that at least part of the air required to feed the flue is drawn from a source outside the room. I shall deal later in more detail with this question in considering the implications of the open fire.

INTAKE DUCT

The air used in the warm air ducts may be either fresh air drawn in from outside, or partially warmed air drawn from inside the house. The objection

to drawing in outside air is that it will be unnecessarily cold and that to allow this air to enter the house an equal volume of warmed air must be discharged to waste. A further objection is that with an intake on an outside wall the circulation is much more liable to interference by wind pressure.

The alternative system where air is drawn from inside the house largely avoids these objections. It would be a mistake to suppose, however, that the same air is continually recirculated. A proportion of the warm air delivered to the bedrooms is being continually dissipated through flues, cracks, air bricks and so on ; and, of course, must be if adequate ventilation is to be maintained. The most that it is safe to claim in this respect for the internal intake is that it probably reduces the rate of air change as compared with the intake from outside the house. The recommended situation for an internal intake is in the hall. Here the air is less likely to be laden with cooking and tobacco smells, and also the risk of draughts is less objectionable here than in other parts of the house. The intake duct should deliver cool air at the lowest point in the convection chamber and if possible immediately under the hot base of the heating appliance.

DELIVERY DUCTS AND OUTLET GRILLES

The ducts from the convection chamber delivering warmed air should be always vertical. Horizontal ducts are to be avoided. Experience with horizontal ducts has been conspicuously disappointing.

Generally speaking, the duct will not supply two or more grilles simultaneously at different levels. The higher grille will tend to rob the lower. It is essential that the grilles are closeable at will by a hit-and-miss device so that warm air can be directed as required. In the typical three-bedroom plan grilles can normally be provided to two out of the three bedrooms. They should be kept away from windows and fireplaces, and as low down to the floor as practicable, providing always that where fireplaces exist the grille is above the level of the fireplace opening.

There should be always a warm air outlet in the room in which the heating appliance is situated, so that the occupier can deflect the whole of the available heat from the appliance into one room. If this is not done, there may be hardship where the tenant is unable to buy sufficient fuel to provide background heating throughout the whole house.

The problem of sound transference through ducts is one of the most difficult to overcome. Not only may sound travel across the duct between rooms on the same level but also up the duct from the ground-floor rooms to the bedrooms, unless careful baffling arrangements are incorporated. This is one of the aspects on which research is needed and one on which I hope the Building Research Station will soon be in a position to give us some guidance.

MATERIALS AND CONSTRUCTION

Ducts can be constructed of any incombustible material not likely to corrode. Galvanised steel, asbestos cement, brick or concrete block are all suitable. Fibre board, black steel, plywood or timber are not suitable.

THE CONTROLLED ADMISSION OF AIR FOR COMBUSTION

The controlled admission of fresh air for combustion has particular relevance for the type of installation we have just been discussing, but it is an advantage in connection with almost any solid-fuel burning appliance. It has always been the practice in the past for the solid-fuel burning appliance—generally the open fire—to draw the air necessary for combustion from the room in which the

appliance is situated. As a result a large volume of warmed air is continually drawn up the flue, to be replaced, of course, by an equal volume of cool air which finds its way into the room.

The open fire, which has always been commended as a highly efficient means of ventilation, is now recognised as a particularly bad offender in inducing excessive and unnecessary air change in the room. An open fire in a typical living room will induce some five air changes per hour. The normal requirements of ventilation will be met by roughly $1\frac{1}{2}$ air changes, so that warm air is being extracted from the room three times as fast as is actually necessary for proper ventilation. The importance of preventing this continuous discharge to waste will be appreciated when it is remembered that air change is normally responsible for about a quarter of the total annual heat loss.

There is a second consideration also to which we should pay attention—though it is not one to which a precise cash value can be attached; that is, the prevention of draughts. Architects have always been aware of the connection between open fires and draughts—an awareness which is reflected in house plans, in the placing of the fireplace away from doors and windows. It is highly questionable whether the placing of the fireplace can *prevent* draughts; the best that planning can do, within the limits of traditional practice, is to localise them. If the fire is to burn, then somehow air must find its way from the outside of the house to the inside. No amount of curtaining or draught excluders can provide a remedy.

The problem for the architect is to conduct a stream of fresh air to a point close to the fireplace without permitting it to pass at high velocity past the legs and ankles of the occupants. The satisfactory solution of this problem will, I think, have an influence on placing of the fireplace. Once we have achieved the draught-proof fireplace we shall have a greater freedom in positioning it. We shall not be influenced by the positions of door and windows. The fireplace with its own independent guaranteed air supply can be located in the rooms irrespective of the position of other openings—free standing in the middle of the room, for example—without any fear of discomfort of the occupants.

One of the difficulties encountered in providing fresh air ducts arises from wind pressure, and in particular from variations in the pressure of the air on opposite sides of the house. Let us assume that a duct is led from a point close to the fire, under the floor and terminating in a grille in an external wall. If the wind is blowing in the direction of the inlet grille, the net result may be the introduction of a large volume of cold air into the room. If the wind is blowing in the opposite direction, the pocket of low-pressure air induced on the lee side of the house may produce the reverse effect and cause air to be extracted from the room.

The obvious answer to this difficulty is for the duct to run continuously from side to side of the house with inlet grilles located in opposite external walls. A tee branch from the main duct is then arranged to deliver air close to the fireplace. By this arrangement the varying effects of wind are balanced out and a steady air supply is ensured for the fire.

From the point of view of preserving flexibility in planning there is no doubt that such ducts are best out of the way and below floor level. The traditional suspended timber floor, of course, provides a ready-made void in which to run ducting, and in such floors the constructional difficulties are few. To-day, however, the suspended timber ground floor is rather out of favour, and the

solid concrete floor, which is the only practicable alternative, does offer difficulties when it comes to putting in ducts. Where there is no alternative to putting the fresh-air duct below floor level a six-inch concrete or stoneware pipe can be laid just below the top of the concrete raft.

While the planning advantages of keeping the duct work below floor level will readily be appreciated there are several points deserving careful attention. First the construction of the foundation slab is made more complicated. This may not always matter, but in a large proportion of prefabricated houses the foundation slabs are sub-contracted and there is every advantage in keeping them as simple and straightforward as possible and concentrating all the more complicated items of construction in the superstructure. Second, difficulties may arise in arranging inlet grilles to the under-floor duct so that they are clear of the ground. Third, the possibility exists of water finding its way into the duct, and finally there is a risk of ducts becoming choked with rubbish during construction.

It will be seen that from the point of view of construction there are sound reasons for keeping ducts above the concrete level. It is not easy to keep such ducts unobtrusive. A boxed-out skirting is a possible expedient but it is always an awkward projection in a room. A better solution perhaps is to run a duct of flat cross-section in the thickness of a projecting dado. There is one other possibility which may be worth mentioning, and that is running the duct in the inter-floor space at first-floor level, and having a tee branch extending downwards to deliver near the fireplace opening.

The exact positioning of the grille at the delivery end of the duct—that is, near the fireplace opening—requires some consideration. Horizontal grilles in the hearth itself should not be used as they allow dust and ashes to be swept into the duct. If a built-in kerb forms part of the hearth the grille can sometimes be arranged in the vertical face of the kerb towards the appliance. This brings the air in at the right place but the construction around the hearth is apt to get rather involved. An alternative position and one simpler in construction is in the surround itself at the side of the appliance, and kept down fairly low.

NEW METHODS OF FLUE CONSTRUCTION

One of the features associated with many contemporary domestic heating installations is the free standing flue—generally of cast iron but it may also be of solid drawn steel, precast aluminous cement concrete pipes, glazed stoneware pipes or asbestos-aluminous cement pipes if and when they are commercially available. It may be mentioned that glazed stoneware pipes have the disadvantage that owing to their smoothness internally they favour sudden and possibly dangerous falls of soot. The flue pipe should have an internal diameter of 8 in., notwithstanding the fact that the appliance which it serves has a flue outlet of less diameter.

Among the factors that have contributed to this type of flue are, first, the prevailing shortage of traditional material ; second, the search for dry methods of building, especially in connection with factory-made houses and, third, the possibility of extracting waste heat from the flue by allowing a stream of air to come into contact with the hot flue pipe. Flues of this type must, of course, be adequately shrouded. The shrouding frequently—as in the M.O.W. heat service unit—constitutes the vertical duct supplying warm air to the upper floor.

Most bye-laws require that timber shall be kept a minimum distance of 9 in. from the inside of the flue. Adherence to this requirement results in a rather bulky shrouding and there are reasons for thinking the distance of 9 in. can be safely reduced. The M.O.W. unit, for example, is often installed so that the flue pipe is considerably closer to the surrounding timber than the statutory 9 in. This is again a case for a clear official ruling, and the anticipated recommendations of the Code of Practice Committee on flues will be awaited with considerable interest.

The support of the flue pipe will frequently call for a certain amount of constructional ingenuity. It is necessary to support the flue so that there is no possibility of its weight being transferred on to the heating appliance and at the same time to allow freedom for thermal expansion. It is particularly important to ensure that the flue pipe has completely air-tight joints and there should be adequate supervision on the job to see that jointing is properly carried out. If this is not done there is a risk of smoke leaking into the house when the fire is lit, and later, when the flue is warmed up, of warm air being drawn into the flue through the defective joints.

Access to the flue pipe must be provided, since it may be necessary within the life of the house to replace the flue pipe.

CHIMNEY TERMINALS

One of the biggest headaches for the architect who uses cast iron or other flue pipes is what to do when the pipe emerges above the line of the roof. This is entirely an architectural problem, and if we could reconcile ourselves to a naked little pipe poking out through the roof there would be no need to worry any further. A really satisfactory chimney terminal has yet to be designed. The function of such a terminal, which is in effect a shrouding to that part of the flue pipe above the roof, is to protect the flue pipe against corrosion from the weather and to provide a satisfactory weather-tight and smoke-tight seal between the flue pipe and the roof covering.

One design for a thoroughly orthodox brick chimney stack balanced on top of a light steel framework hidden in the roof space has been produced, but I think that better solutions will be found by avoiding such obvious shams. The brick chimney is the natural extension of the brick fireplace and stack, but if we dispense with solid brick inside the house we should surely dispense with it outside. The solution must, I think, be along the lines of a terminal unit that embodies the same lightness and absence of mass as the rest of the construction. Such a unit would be light enough to be carried on the roof structure without any additional support from below. Several materials in addition to the ubiquitous asbestos cement have been suggested—notably light precast concrete, glazed stoneware and even heavy gauge copper—the latter, incidentally, in connection with a sheet copper roof.

HEATING AS A PRIMARY FACTOR IN THE EVOLUTION OF THE HOUSE

Before closing I want to stress again the critical influence which heating technique has had and will have on the development of the house. Even in the period since 1920 changes in heating practice—in particular the almost universal adoption in urban areas of gas or electricity for cooking—have produced conspicuous changes in small house plans.

Of the innovations to which I have referred by far the most significant for domestic buildings is the introduction of warm-air heating. At present warm air is no more than a supplementary means of heating, but its use may well

be greatly extended. It is clearly impossible to predict with any certainty repercussions of such a change in architectural design. In America, where warm-air heating for houses is a long-established practice, the more open domestic plan is largely attributable to the use of forced warm air. So far as this country is concerned it is safe, at any rate, to say that the wider adoption of warm-air heating, by creating a comfortable climate throughout the whole house, will increase the usable area of the plan. It may lead us, as it has the Americans, to the adoption of a more open type of plan. In this direction lie the most interesting developments architecturally.

Finally I would underline two essential preconditions for the successful adoption of these new ideas in heating. First is the need for more information on the technicalities of the problems involved. I mean particularly information which is intelligible to and usable by the building industry. Architects are already much indebted to scientists, but if we are not to progress by the painful process of trial and error there are a lot more urgent questions we want answered. Second, and last of all; if the new heating standards are to be adopted and put into practice in every house there must be a widespread appreciation of the desirability and practicability of these standards. Selling the idea is clearly the Government's job, but architects by the nature of their work are in a position to help raise the low heating standards current today. I hope that some of the things I have said may stimulate architects to interest themselves in this task.

5. Summary of the Domestic Appliance Position

By DR. A. PARKER, C.B.E.
DIRECTOR OF FUEL RESEARCH, D.S.I.R.

It is my task in the limited time at my disposal to review the position, taking into account all types of fuels, appliances and systems, with the object of directing the attention of architects and others concerned with housing to some of the principal factors to be considered in planning and equipping the house or dwelling so that as the centre of family life it provides the comfort and amenities desirable at reasonable overall cost.

As a starting point, let us consider what was the position in Great Britain during the inter-war years 1919 to 1939. It was then common practice to aim at certain minimum standards for number and type of rooms, floor area, and cubic capacity, which should be provided for the family of average size. But insufficient attention was given to the provision of heating services which would be adequate, efficient in the use of fuel, and economical in overall cost, and the possibilities of insulating the building to avoid any unnecessary large loss of heat to the surrounding atmosphere were almost entirely neglected.

Houses and flats cannot properly be planned and equipped to serve the many needs of the family unless the provision of heating and other services is fully considered at the outset. In the past, the usual procedure has been to plan the house, provide a few flues and chimneys, and think about the heating services afterwards as a kind of accessory. Costs must clearly be taken into account, but overall costs, including capital, maintenance and repairs, and operation, are not merely first cost. Hitherto many items of heating equipment have been chosen because their initial cost has been low. Often this has led to very inefficient use of fuel with high fuel costs and unsatisfactory service.

DOMESTIC FUEL CONSUMPTION

What quantities of the different fuels are ordinarily used in Great Britain and what services are obtained from them? Since 1939 conditions have been abnormal. For this reason, it is best to take as a basis the figures for fuel consumption for the three complete years 1936 to 1938. During this period the total amount of coal used within this country, that is excluding coal exported and used for ships' bunkers, for all industrial and domestic purposes was about 180 million tons per annum. Of this total home consumption, 50 million tons of coal and anthracite (including miners' coal) were supplied direct to domestic consumers. In addition, large quantities of the gas and coke made at gasworks and coke ovens, and considerable amounts of electricity were supplied for domestic purposes. From the estimates that have been made, it seems that to the 50 million tons of coal and anthracite supplied as such, there should be added at least 10 million tons to allow for the coal used in producing the fuel or energy supplied in the form of gas, coke and electricity, making a total annual consumption, direct and indirect, of roughly 60 million tons of coal for domestic heating services. This is one-third of the total home consumption of coal, and it means that domestic consumers must have spent at least £150 million a year on fuel during 1936 to 1938. The same amount of fuel at the present time, if it were available, would cost domestic consumers about £250 million a year—an amount obviously of sufficient importance to justify real thought in planning houses and their heating services.

EFFICIENCY OF USE OF FUEL BEFORE THE WAR

What did the householders of Great Britain get from the consumption of this 60 million tons of coal a year? Before the war there were between 12 million and 13 million dwellings for a population of 46 millions. This means an average of nearly 5 tons of coal per annum for each household, or nearly 1½ tons per person per year. If the coal could have been used with 100 per cent. efficiency, there would have been available an average for each dwelling of about 1,500 therms of heat a year. From the data available for other countries it has been estimated that the corresponding figure for the U.S.A. was 1,700 therms and for Germany 880 therms. Houses in the U.S.A. are kept warmer and more uniformly heated than in this country, and in general there are longer periods of colder weather. In spite of these differences, the amount of fuel used in relation to the number of dwellings and the size of population was not much greater than here. In Germany before the war, the houses were, in general, kept at least as warm as in Great Britain, but the relative fuel consumption was much lower though the climate is colder. Many factors accounted for these differences, but the main factors were more efficient appliances used in the U.S.A. and Germany, as in certain other countries, and the greater attention given to the construction of houses to prevent excessive loss of heat to the outside air.

It is not possible from available data to give accurate figures for the efficiency of utilisation of coal for the various domestic services under average household conditions in this country before the war. To obtain accurate figures would involve an enormous number of measurements in a large number of occupied dwellings with varied family requirements, and over long periods to cover different weather conditions. It is less difficult to determine the efficiency of appliances for space heating and the provision of hot water under test-bench conditions in the laboratory. But under such conditions the rate of supply of

fuel and other factors are under constant scientific supervision and control, which are impracticable under ordinary conditions. Further, accurate allowance cannot be made for the fact that the appliances in ordinary use during many parts of the day or year, particularly with our variable climate, may be providing more radiant heat or convected heat or more hot water than is required, and to that extent the fuel is wasted. The rough estimates of fuel efficiency under everyday working conditions that can be made, however, do serve as a useful guide.

In Great Britain the usual appliances have been the traditional open fire for space heating and the kitchen range with an open fire for space heating and cooking, and often also for the provision of hot water, with the addition of a gas or electric cooker. The overall efficiency of the open coal fire under average household conditions has probably been less than 20 per cent. For the general purpose appliance in which coal is used for space heating, hot water and cooking, the corresponding figure is somewhat greater, because of the heat taken up by the water. But it can be taken that the overall efficiency in use of the 50 million tons of raw coal for domestic purposes has not been more than about 20 per cent. ; in other words, only about one-fifth of the heat value of the coal has been usefully employed.

With coke for the open domestic fire with a grate designed for burning this fuel, the efficiency under average conditions is roughly 25 per cent., on the basis of the calorific value of the coke. In making coke and gas at gasworks and coke ovens, heat is expended in carbonising the coal from which they are derived. The efficiency of the carbonisation process is about 75 per cent. When related back to the original coal, therefore, the overall or coal economy efficiency in using coke in the open fire is no more than about 20 per cent. It is somewhat greater if the coke fire also provides hot water. In closed stoves and boilers of the domestic type, the efficiency of using coke is in the region of 40 to 50 per cent., equivalent to a coal economy efficiency of 35 to 40 per cent.

The efficiency of gas appliances in general is higher than that of the appliances using coal and coke. Modern pre-war gas fires have an efficiency of 40 to 50 per cent. under average conditions, or a coal economy efficiency of 30 to 40 per cent. Electrical appliances for space heating and for providing hot water are highly efficient in the use of the electrical energy supplied to them and have an overall efficiency in the region of 80 to 100 per cent., but the average efficiency of generation and distribution of electricity is low, only about 20 per cent. This means that the coal economy efficiency in using electricity for domestic heating is only in the region of 15 to 20 per cent. It should be stressed, however, that all these figures refer to conditions of use over long periods of many hours each day. For short periods of only a few hours the average efficiencies of appliances burning coal and coke are not so great as for long periods, with the result that for short-period intermittent heating, gas and electrical appliances may be more efficient and no more costly than solid fuel, and they have the advantages of greater convenience and cleanliness.

ATMOSPHERIC POLLUTION

In addition to the great waste of coal that has occurred with the methods of domestic heating generally adopted in this country, there has resulted gross pollution of the atmosphere. The smoke emitted from the 50 million tons of coal annually burnt in domestic appliances before the war carried into the atmosphere more than one million tons of tarry and sooty matter. The effects

of pollution of this kind include detriment to health, damage to agriculture, and damage to structure and materials, involving extra labour of cleaning and consequent waste of fuel, in addition to the direct waste represented by unburnt carbonaceous matter in the smoke. It is impossible to give an accurate figure for the cost of atmospheric pollution from the burning of raw coal in domestic appliances, but from the estimates that have been made it is certain that the money equivalent of the damage to buildings and materials and agriculture, together with the direct waste of fuel, is many millions of pounds per year. Considerable expenditure would be justified in reducing or preventing pollution of the atmosphere.

IMPROVEMENTS IN DOMESTIC HEATING

During recent years, as explained by previous speakers, more efficient heating appliances have been developed for use in individual houses in this country. There have been improvements not only in gas and electrical space heaters, water heaters, and cookers, but also in appliances using solid fuel to provide similar services. For example, there have been developed and placed on the market, closed stoves which are highly efficient for space heating and water heating, and several cookers of the heat-storage type. These appliances have the advantage not only of high efficiency, at least twice as efficient as open coal fires, but they can be kept burning continuously overnight at low rates of consumption. In addition they do not draw into the house excessive quantities of cold air which carry away heat up the chimney and cause cold draughts. Some of the stoves are suitable for the circulation of hot water through radiators to provide full central heating or to give partial background heating. In general they require smokeless solid fuels such as anthracite, low volatile steam coal, or coke of a suitable grade of size. These fuels have the advantage of not producing smoke, but the quantities of smokeless solid fuels so far available would be insufficient if all houses were fully equipped with stoves of these types.

There is one difficulty to be overcome, even if the necessary smokeless fuels become available, before closed stoves will be adopted generally in this country. We are accustomed to the open fire, burning coal, with its ever-changing flames and cheerful appearance, and it is not easy to persuade householders to dispense with open fires and replace them by closed stoves. Recently, with the object of overcoming this difficulty, there have been designed open fires which burn coal with a production of less smoke than from open fires of the older type. Some of these new designs can be closed by a cover to allow for slow continuous burning during the night or at other times as required. There can also be provision for heating water and for heating air which can be carried by ducts into the same room or into other rooms. With provision for water heating and convection heating by warm air, especially if this air and some of the air for burning the coal is drawn directly from outside instead of through the room, these new fires are much more efficient than the traditional open coal fire. It should be pointed out, however, that no small domestic appliance suitable for an individual house has yet been designed which will burn bituminous coal without producing an appreciable quantity of smoke.

Another recent development is the openable stove so designed that doors at the front can be opened to give the appearance of the open fire or closed to serve more as a closed stove. Some of these stoves include a boiler for hot water and arrangements for warming air for circulation into the same room or

other rooms. The boiler can also be used to circulate hot water through radiators. With these stoves, it is, in general, preferable to use graded smokeless fuel rather than bituminous coal. There are also designs which provide for cooking, water heating and space heating. These latest appliances of the several types for solid fuel are at least twice as efficient in the use of fuel under ordinary household conditions as the older appliances with open coal fires.

On grounds of cost, the main load for space heating and water heating in the winter in the majority of houses in this country will be carried by appliances burning solid fuel, with gas or electricity for much of the cooking load, some of the water heating load, and for short-period intermittent space heating, particularly in the milder weather. The relative division between solid fuel, gas and electricity will be dependent partly on local custom and preferences, and partly on the relative prices of solid fuel, gas and electricity.

Improvements are also being made in domestic appliances using oil fuels. The amount of oil likely to be used in domestic appliances, however, will probably remain very small in relation to the quantity of coal used direct or indirect as coke, gas and electricity.

INSULATION

Even if the individual fuel-burning appliance uses the fuel with high efficiency, the heating installation as a whole cannot give maximum working efficiency if insufficient attention is given to the possibilities of preventing dissipation of heat, where it is not required or is undesirable, by the judicious application of insulating material. Hot water pipes should obviously be insulated and hot water tanks should always be lagged. Often the appliances themselves, particularly cookers, require effective lagging to prevent wasteful dissipation of heat. The position and extent of lagging must be properly planned in relation to the heating unit and the house.

VENTILATION

From the health standpoint, there should be adequate ventilation of all parts of the house ; but in most cases in the past the ventilation has been excessive, with consequent great waste of heat and much discomfort from draughts. Often doors and windows have been badly made and fitted and many open fires and flues have been such that when the fire is burning in very cold weather, it has drawn vast quantities of cold air from outside through the house to be heated and carried away up the chimney. In many instances the quantity of cold air drawn in this way has been such that the heating effect of radiation from the fire has in large measure been offset by the cooling effect of the extra quantities of cold air from outside. With the best type of closed stoves and openable stoves, there is adequate but not excessive ventilation, and this draught-producing effect of the usual type of open fire is avoided.

STANDARDS OF HEATING

The heating and ventilation of buildings have been considered in some detail by the Heating and Ventilation (Reconstruction) Committee of the Building Research Board of the Department of Scientific and Industrial Research. In its published report, the committee has recommended standards of heating and facilities for hot water supplies and for cooking, which are higher than have been practicable hitherto in the vast majority of houses. It is believed that these higher standards can be reached, or at least approached, at reasonable overall cost with new houses, provided that the houses are suitably designed and constructed, and equipped with the most effective heating installations.

Another condition is that there must be available fuels suitable for the selected appliances. With the object of keeping down capital costs, heating units are now being developed which can be made by mass production methods and form part of the house construction. With better insulation of houses and more efficient heating installations, the capital cost may be somewhat greater, but the average pre-war standard of heating could be obtained with a lower consumption of fuel or a much higher standard could be obtained with the same consumption of fuel.

If for a time it is necessary to instal some open fires, they should be so designed as to be suitable for burning smokeless fuel such as coke, and not suitable only for bituminous coal. A change-over to solid smokeless fuel could then easily be made when the necessary supplies of such fuels become available.

In one session, it is obviously impossible to deal with this important subject of domestic heating and domestic heating appliances in detail. The main object has been to draw attention to the defects of the past and to show in what direction it is practicable to increase the comfort of our houses, and at the same time use fuel much more efficiently and with less pollution of the atmosphere. Attention has been drawn to the new appliances and systems that are becoming available.

Further developments and improvements are to be expected. At the present time investigations and developments are being undertaken, not only by the Fuel Research and Building Research establishments of the Department of Scientific and Industrial Research, but also by industrial research associations and by many industrial firms. All these research units are working in the closest co-operation, and there is no doubt that as these investigations are continued and intensified, the results will be applied and further improvements will be effected in the heating, insulation and ventilation of our houses.

Discussion

Mr. A. L. Roberts, Hon. Secretary the R.I.B.A., said he had had over 45 years' experience as an official architect. Having regard to that experience and to his contact with architects in private practice, he thought he could speak for the whole of the profession in assuring the conference that architects were very conscious of the defects in the appliances which were available to them in the past and that they were examining with keen interest the developments which were now taking place in order to meet the Government's difficulties and with a view to increasing the efficiency of services in the home.

Architects prided themselves on their adaptability in planning to meet all requirements ; that, after all, was their job. It should be realised, however, that the architect worked for clients, if he were in private practice, and for a committee if he were in the local government service, and that both clients and committees had a very awkward habit of asking questions which the architect was expected to answer ! It would be appreciated, therefore, that when an architect put forward a scheme he had to be prepared to deal with its snags as well as with its advantages. It was significant, he thought, that Mr. Pinckheard was the only speaker who had mentioned a snag in connection with one of the new appliances. It was only by looking at the matter from that point of view that the architect could safeguard himself. The architectural profession gratefully acknowledged the assistance it was now getting from the scientists (indeed it could not do without it), but the scientists' theories had to stand the acid test of use and practice, and there was, as everyone knew,

frequently a great difference between theory and practice. In that connection the question of capital cost could not be disregarded.

Turning to the use of warm air ducts, he appealed to the scientists and to those who were developing the idea to ensure that the parts of the flues in which the air flowed were accessible for cleaning purposes. Air, unfortunately, took other things with it, and those who had experience of air ducts knew how filthy they became.

Mr. Pinckheard had suggested that the intake might be from the hall. In small houses, however, probably the door from the kitchen to the hall would be open when cooking or washing was in progress, and the steam generated in the kitchen might ascend to the bedrooms, possibly to such an extent as to cause mildew.

It was useless to put things in the home which depended too much on the human element, and it was not an economic arrangement to instal appliances which could not be used because the tenant could not afford to use them. A little sociology was involved in the problem and should not be overlooked.

Mr. Knapp said he had recently been told by the representative of a manufacturing firm that the plugs for use in connection with ring mains were the subject of a patent in which that firm held all the rights. He asked whether that was so. If it was, it precluded their use generally for housing because of the difficulty of maintenance and replacement.

Mr. J. I. Bernard replied that whilst certain patented designs of plugs had been produced by individual manufacturers, the position generally was that a British Standards specification was about to be issued and the plug would be made by all manufacturers.

Mr. Robson said he understood Mr. Pinckheard to say that it was practicable to bring in a duct at first-floor level, down to the convection chamber and up to the other points. He had been taught that a draught increased or decreased between the inlet and the outlet, and that if the inlet were raised the current of air was slowed.

Mr. J. Pinckheard replied that he could not give a definite answer because he did not know of any such duct having been installed. The question arose because—as he had tried to make clear in his paper—it was sometimes very difficult to bring in a duct at ground-floor level. If the duct were brought in at first-floor level, with a downward pointing “T”, it was possible that there would be a sufficiently strong pull on the flue to draw air from the inlet duct located in front of the fireplace opening, in the surround or wherever it was put. He agreed that if the downward leg of the duct became sufficiently hot (if it were put tight up against the flue, for example) conditions might easily obtain which would be the reverse of those desired, but provided that could be obviated, possibly by insulating the downward branch against the heat of the stack, there seemed to be a good possibility that the pull of the flue would pull air in from the open grating.

Mr. Hooper asked the Government officials present to urge the War Damage Commission to incorporate the excellent systems which were now going into the houses built under the State housing scheme in the rebuilding of cost of works houses.

THE CHAIRMAN, Mr. J. H. Forshaw, answered that he was quite sure, so far as his Minister was concerned, that he would be most anxious, provided the apparatus were available, to encourage the War Damage Commission to permit

that. It had been clearly indicated in the speeches yesterday that the problem was not only one of installing new apparatus, where it would effect a saving in fuel in new houses but also in reconstructed houses.

Mr. Mayson enquired as to the possibility of discoloration taking place round the outlets of hot air ducts. He had seen instances of heating columns attracting dirt to their surfaces and to surrounding surfaces, and it was his impression that there was a grave risk of discoloration taking place round the mouth of the outlet in a room.

Mr. J. Pinckheard said there were two sorts of discoloration to watch for around outlet grilles. First of all, there was the possibility of air coming out between the grille and the plaster face, thus causing localised black marks, and secondly, there might be a general darkening of the wall over the opening.

The first difficulty could be overcome by the provision of a proper gasket between the grille and the plaster face, making an air-tight joint and thus avoiding localised staining. The problem of the general darkening might be met to some extent by designing the louvres in such a way as to throw the air outwards into the room. The velocity of the air from the duct, however, was, relatively, so low that even the provision of louvres to deflect it outwards might not prevent it from turning back and crawling up the wall. If the air were moving at a high velocity, that device might be effective, but it was not possible to give a positive assurance that with the grilles available at the moment, that there would not be a general staining above them.

Mr. Foster pointed out that there had been no mention of radiators. Much had been said about ducts, but ducts were a headache in a small house and a worse one in flats. At the moment it might be better, instead of spending money on ducts, to instal two radiators worked from a boiler behind an open fire. The open fire, he understood, would be sufficient for two radiators and a hot water system. That would help to solve one of the housewife's problems, i.e., airing; she could not air on the outlet from a hot air duct but she could on a radiator.

Mr. J. S. Hales said the suggestion was a good one in that it was an alternative where the boiler capacity was adequate for the purpose. There were quite a number of difficulties in a hot air system, and in some circumstances the radiator had its points and could certainly be used as a substitute.

Mr. Ford and **Mr. Hazel** also spoke.

Dr. Parker said that **Mr. Roberts** had spoken about warm air ducts and the danger of their absorbing dust and odours from the rest of the house. The authors realised—and had done for some time—that there were problems connected with the use of those ducts and agreed that those points required to be watched carefully.

Mr. Roberts had also made the point that tenants should not be provided with appliances which depended too much on the human element, which meant, he supposed, appliances needing an enormous amount of regulation and requiring almost a trained scientist to operate them. The conference, however, could rest assured that those at the Fuel Research Station who had the task of testing new appliances had that point very much in mind. As a scientist, he would have no difficulty in designing an appliance with a working efficiency of something like 70 to 75 per cent., but it might have half a dozen dampers and half a dozen screws for regulation. When he got home at night he would not want to be bothered with an appliance like that, and neither

would the ordinary householder. The Fuel Research Station also watched the flexibility of appliances. It was all very well to instal a multi-purpose appliance which could be used for space heating, water heating, cooking and so on, but it was not much use if, just because the user wanted a certain amount of space heating, he had at the same time to provide so much hot water that he had to run it off frequently to stop it boiling. The Research Station aimed at guiding manufacturers, when they needed guidance, towards flexibility and simplicity, and he was prepared to sacrifice a certain amount of test bench efficiency to get what he called better working efficiency. At the Research Station appliances were tested under all sorts of practical conditions for a long time.

Dealing with the question of whether tenants could afford appliances, he said the aim was to encourage those appliances which were flexible in use and which worked at higher efficiencies. It was admitted that in most cases the capital cost would be rather higher, but the running costs would be such that the pre-war degree of comfort could be obtained at a lower cost in the matter of fuel, or, if the tenants could afford it, more comfort could be provided at no greater cost. The change in the value of money, of course, had to be taken into account, but that was allowed for in wages. We could not get coal at the same price as in pre-war days.

Solid fuel was bound to be the main means of heating in households for many years to come. It had the advantage that it took the peak load in winter and that adequate storage capacity could be provided for it. A reserve of solid fuel could be built up, but that could not be done in the case of the other fuels; the electricity companies could not store electricity at all, and the gas companies could only store gas for about 24 hours. They had to bring in stand-by equipment to meet peak loads. Solid fuel, by carrying the heavy winter load, kept down the cost of gas and electricity, because if those undertakings had to carry an enormous amount of stand-by plant which could not be operated in the summer the over all costs of gas and electricity would rise.

SECTION G. MODERN HEATING AND THE ARCHITECT—*continued.*

SESSION III. The Insulation of Buildings: Methods, Costs and Influence on Design

Chairman of Session: DR. F. M. LEA, O.B.E., D.SC.
DIRECTOR OF BUILDING RESEARCH, D.S.I.R.

THE CHAIRMAN said that from the two previous sessions of this section there had emerged two points which would be firmly fixed in the mind of everyone present. One was that the English home was the smallest in the world, and the other that the ratio of the comfort obtained in the home in this country to the fuel consumed was almost the lowest in the world. Those two statements were a real challenge that had to be faced.

During Session No. II the conference had been told what the appliance designers and manufacturers were doing to meet that challenge and the problems confronting the architect in the installation of modern heating appliances were discussed. There was, however, another side to that picture; it was not enough to put in heating appliances which would give a large amount of useful heat in the house in relation to the fuel they consumed if the houses were so constructed as to allow that heat to escape wastefully. This second aspect of the subject was their problem in the present session—the problem of insulation. It was a problem about which something could be done and from which there would be immediate results.

Intimately connected with the problem of insulation, which concerned the overall heat losses from the house, was the question of providing low-capacity linings on the inside of the walls. For that reason it was imperative to consider intermittent heating in addition to continuous heating.

1. Heat Conservation in Small Houses

By A. F. DUFTON, M.A., D.I.C.
BUILDING RESEARCH STATION

In its report on "Heating and Ventilation" the committee under the chairmanship of Sir Alfred Egerton, which was appointed by the Building Research Board to make recommendations for practice in post-war building, expressed the opinion that the utmost importance should be attached to the conservation of heat in the building of houses, and pointed out that improvements in the insulation of buildings would, in general, reduce both the fuel bill of the occupant, and the amount of coal which had to be mined. A typical small house was examined by way of example, and a balance arrived at as to the expenditure on insulation, additional to the normal cost of the building, which could justifiably be incurred on account of the saving in the heating cost.

Eight houses have been built at the Building Research Station for the joint purpose of research in house construction and full-scale tests of the heat requirements of houses insulated to different standards. The objective was to obtain experimental evidence which would help in assessing the amount of insulation which is worth while and to ascertain how the heating of a house insulated to the committee's standard compares with that of an "uninsulated" house. The recommendations of the committee were conservative and so, in view of the possibility that a higher standard of insulation than that proposed might be envisaged, the houses were designed to provide the four distinct grades of insulation shown in the table. Grade A (Table I) represents the ordinary pre-war house and grade C the standard recommended by the committee.

TABLE I

THERMAL TRANSMITTANCE, B.T.H.U. PER SQ. FT. PER HR. PER DEG. F.

	A	B	C	D
External walls	0.30	0.25	0.20	0.15
External walls, living room	0.30	0.20	0.15	0.10
Windows	1.0	1.0	1.0	0.5
Windows, living room	1.0	1.0	0.5	0.5
Ground floor	0.35	0.20	0.15	0.10
Roof and top-floor ceiling	0.56	0.30	0.20	0.15

The houses were designed by an architect to give the required insulation without any more assistance than is given by the booklet on "The Computation of Heat Requirements" published by the Institution of Heating and Ventilating Engineers. Samples of the composite walls used were tested at the National Physical Laboratory which confirmed the computed figures, and the computed heat losses for the houses as a whole agree very well with the amount of heat which had to be provided to offset these losses.

The heating system installed is one of the various combinations considered by the Egerton Committee, and was selected because it is an experimentally convenient example of an installation using solid fuel. Background heating is provided by embedded ceiling panels in the living room and the parlour, which serve also as floor panels for the two main bedrooms; and the living room is "topped-up" by an electric fire. Hot water for the panels is supplied, through a heat interchanger, by a hot-water supply boiler, which also provides the domestic hot water. It was decided to include experiments in two more houses in grade A and grade C in order to ascertain whether it would be advantageous to eliminate the topping up and to warm the living room solely by the central-heating installation.

A thermostatically-controlled magazine boiler, suitable for burning anthracite grains, has been installed in the kitchen of each house. The thermostat brings into operation a fan, which supplies air to the fire and promotes vigorous combustion. When the thermostat switches the fan off, the fire slumbers under the natural draught of the chimney. The boiler heats a hot-water tank in the linen cupboard indirectly and, through a specially designed heat interchanger, which serves as a towel warmer in the bathroom, supplies hot water to invisible ceiling panels in the living room and in the parlour.

In two houses the ceiling panels serve to keep the living rooms comfortably warmed night and day and to provide background warmth in the parlour and bedrooms. In the other four houses the panels supply only background heating. An inset electric fire in the living room was used for extra heating and in each house a time-switch turned the fire on between the hours of 7 a.m. and 8.30 a.m.; noon and 1.30 p.m.; and 4 p.m. and 10.30 p.m., corresponding to the typical usage suggested by the Egerton Committee. In these houses eupatheostats served to limit the heating of the rooms during these topping-up periods by switching the fires off and on so as to maintain an equivalent temperature 65° F. when that temperature was attained. The electricity for the fires was metered independently of the other consumption in the houses. In order to utilise heat which would otherwise be lost, a duct is provided round the boiler flue-pipe and this serves to supply heated air to the landing on the first floor.

Provision for ventilation has been made in accordance with the recommendations of the Egerton Committee. Air is admitted to the living room, the parlour and the three bedrooms from the hall and landing through specially designed louvres above each door and is withdrawn from each room by means of a flue. The flue has a cross-sectional area of 30 sq. in. and is suitable for a gas fire. The main ventilation intake is via the tool-shed, whence the air passes through a grille into the hall. Provision was made for warming the incoming air by means of a radiator, but it was found to be superfluous as the heat from the lower part of the flue, which passes through the tool-shed, proved to be fully sufficient to temper the air.

Apart from eupatheostats in the living room, no other room-temperature controls were used. A maximum-and-minimum thermometer was hung on the wall of each room, the hall and the landing, with its bulbs 5 ft. from the floor. The location of the thermometer was the same in any room from house to house and was chosen to minimise any effects of radiation on the thermometer. The thermometers were read and reset each morning. The equivalent of 250 gallons of hot water at 140° F. was drawn off in each house every week. This was done by running up ten baths of approximately 25 gallons each, one every morning and one in the afternoons of Monday, Wednesday and Friday.

The daily fuel consumption of the boilers was determined by weighing. The magazines have wide mouths and so special narrow-mouthed hoppers were inserted so as to make it easy to fill up to a definite level each day. The only other attention required by the boiler was the removal of clinker from the fire-beds. This was not a daily operation but was carried out regularly after a hundredweight of fuel had been burned on the cleaned fire-bed.

The experiment commenced with all the panels of each topped-up house turned off. When, as the weather turned cold, the minimum temperature in any of the parlours or two principal bedrooms fell below 50°, the panels of that house were put into service by closing a by-pass valve in the linen cupboard.

When the minimum temperature in the rooms rose above 55°, as it did when there was a spell of warm weather, the by-pass valve was reopened until such time as background heat was again required.

The installations were designed to give substantially equivalent conditions in the various houses, despite the differences in insulation, and were operated to do so as closely as possible. Care was taken to ensure that the houses with the higher grades of insulation were no less warm than the less well-insulated houses. This equivalence is shown by the average daily minimum temperature for each house (the mean minimum of all the rooms) taken for the period

1 November to 31 March. The average mean temperature of each house was approximately $1\frac{1}{2}^{\circ}$ higher than the average minimum temperature.

The fuel consumption for the six winter months have been plotted to illustrate the progressive reduction as the grade of insulation rises from A to D (see Fig. 3). The grades have been set out so as to give a straight-line graph for background heating. This is convenient as it enables interpolation to be made for grade B, and extrapolation for grade D, on the graph for continuous warming.

The electricity required for topping up was virtually independent of the grade of insulation and the amount was substantially the same in each house—about 1,800 kWh for each living room for the winter six months. The reason for this is believed to be that the requirement depends more upon the intensity of radiation provided by the fire than upon the increase in the rate

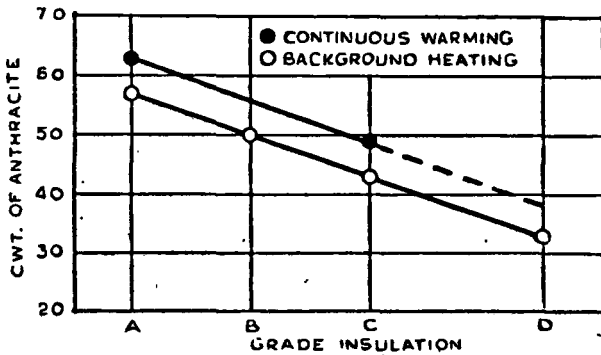


Fig. 3.

of heat loss due to the increased warming of the room. By a horizontal beam of 40 B.Th.U. per sq. ft. per hour the equivalent temperature is raised about 7° F., irrespective of the general warming of the room. As the topping-up was independent of the grade of insulation of the various houses, the saving of fuel due to insulation can be appraised in terms of the fuel required to provide the background warmth and the hot-water supply.

With grade A, the pre-war standard, as datum, the savings found for grades B, C and D are as shown in Table II, which lists both the annual saving of fuel and also its monetary value, reckoned at £4 4s. per ton. The saving found

TABLE II

Grade of Insulation	Saving of fuel	Monetary Value
	cwt.	£ s. d.
B	7.2	1 10 3
C	14.4	3 0 6
D	24.2	5 1 8

for grade C, from experiments in the houses in which the living rooms were kept comfortably warmed, amounted to 15.3 cwt., valued at £3 4s. 3d. On these fuel savings one could justify an additional initial cost of £60 of a grade C house over a grade A house, and this figure also underlies the suggested maximum values of thermal transmittance put forward by the Egerton Committee.

The boiler used in these experiments was an efficient one and only 20 per cent. of the potential heat of the fuel escaped from the chimney or was left in the clinker. If a less efficient appliance had been used a somewhat greater saving would have been found; but it would be difficult to justify higher insulation costs on the ground that inefficient appliances are to be used.

As mentioned earlier, two houses, one grade A and the other grade C, were duplicated in order to ascertain whether it would be advantageous to eliminate the topping-up and to warm the living room solely by the central-heating installation. In the six winter months, in a grade A house 7.9 cwt. more fuel sufficed to keep the living room comfortably warmed at all times, and in a grade C house 6.8 cwt. This extra fuel has to be set against the 1,800 kWh required for the six months topping-up of a living room.

Now, as £1 17s. 6d. will purchase either 1,800 units of electricity at $\frac{1}{2}$ d. per unit or 9 cwt. of anthracite grains at £4 4s. per ton, it is clear that it is advantageous to eliminate the topping-up and to warm the living room solely by the central-heating installation unless electricity can be obtained for a farthing a unit. And even so the warmth provided by the electric fire is less generous and less equable than that afforded by the central-heating installation. In a house with a less efficient central-heating installation, a proportionately higher price for electricity would naturally be considered as justifiable.

In the Egerton Report, an estimate is given of the fuel consumption for a house at Kew of "medium" insulation (intermediate between grade A and grade C, and substantially equivalent to grade B) of floor area 768 sq. ft., the centre house of a terrace. It is of interest to compare these figures with the values obtained in the present experiments in detached houses, of floor area 1,050 sq. ft., heated by a similar combination of appliances.

The range of values given in the Egerton Report for the solid fuel requirements corresponds to various assumed boiler efficiencies and even the maximum appliance efficiency assumed is below that obtained from the boiler installed in the present houses. The comparison, which is conveniently made on the basis of the fuel consumption for the six winter months, from 1st October to 31st March, is set out in Table III. The average outside temperature for the period was 42.9° F., substantially equal to 42.6° F., the normal figure for Kew.

TABLE III

Service	House in Egerton Report	Present Experiments		
		Grade B	Grade A	Grade A
Heating and hot water supply	68-112 cwt.	49.6 cwt.	56.8 cwt.	64.7 cwt.
Topping up living-room	1,550 kWh	1,924 kWh	1,607 kWh	Nil

When it is remembered that the average daily *minimum* temperatures in the relatively large, detached, experimental houses were as high as 56°, 56° and 59° F. respectively, it is clear that the comparison reveals that an important further saving of fuel, over and above that estimated in the Egerton Report, can be obtained. And the figures in the last two columns refer to “uninsulated” houses. It is practicable, with less fuel than that estimated by the committee for a terrace house, to heat to an even higher degree a larger, detached, uninsulated house.

CONCLUSIONS

I would like to draw three conclusions from these experiments. The experiments confirm the view of the Egerton Committee that an expenditure on insulation can justifiably be incurred, additional to the normal cost of building, on account of the substantial saving in the heating cost. They confirm that, if the additional initial cost does not exceed £60 for a small house, the maximum values of thermal conductance put forward by the committee are reasonable, and that still lower values are to be preferred where they can be obtained economically.

The *dictum* of the committee, that those responsible for the choice of methods of heating of new houses need to make a careful study of the relative costs of the various systems available in any district, is lent added emphasis by the investigation into the advantage of eliminating topping-up by an electric fire and of warming the living room solely by the central-heating installation.

The experiments show that it is practicable to heat a house with an economy of fuel even greater than is apparent in the Egerton Report. It is hoped that this demonstration will lead to increased economy and efficiency for the individual user and to a more economical utilisation of the national fuel resources.

2. Methods and Costs of Insulation

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INTRODUCTION

The problem of the right choice of the amount of insulation to provide in a new building is a complex one. There are three quantitative factors operative at any given time—the insulating value of structures—the cost of structures erected complete—the cost of fuel. Only the first of these factors remains stable and the other two fluctuate in relation to other economic factors in the national life. To some slight extent, however, the last two may be expected to show similar trends over long periods of time. It follows, therefore, even if it were possible to lay down an exact balance of values to suit all three factors, that this balance would only be correct for the particular time at which it was formulated.

Despite the difficulties, however, it is usually possible to make a sane decision even at a time like the present, and there are various authoritative recommendations which can be followed. To those who have been working on the scientific aspects of the heat insulation of buildings for a great many

years it must be very gratifying to find that at long last heat insulation is recognised as one of the major desiderata. I refer particularly to Mr. Dufton, Dr. Griffiths and other members of the staff of D.S.I.R. As a result of their labours during the last twenty years it is possible to estimate the heat insulating value of almost any projected form of construction with sufficient accuracy for all normal design purposes. This is a huge step forward and it means that the enormous programme of building which lies before the country can be tackled with the firm assurance that reliable values of heat insulation are easily predictable. The values of heat insulation which are quoted in this paper were provided by the Building Research Station and this, it may be added, at very short notice.

THE PROBLEM

To come now to the problem of heat insulation of buildings as it affects the designer. It can be considered under the following headings :—

- (1) Layout and planning of buildings as a means of avoiding excessive heat loss.
- (2) How much thermal insulation to provide in the structure.
- (3) How to provide the amount of thermal insulation indicated under (2) above.
- (4) What is the cost involved in providing the required heat insulation.

LAYOUT AND PLANNING OF BUILDINGS TO MINIMISE HEAT LOSS

As a first simplification it is assumed that the whole of the interiors of buildings are warmed and that the main problem is to prevent unduly rapid escape of heat through the outer shell. There are all sorts of complications when different parts of buildings are heated to different temperatures, but it is probably sufficient for practical purposes to deal with the outer shell only.

Purely from the point of view of conservation of heat the best shape for a building is the one which encloses the maximum of space with the minimum area of external shell. If curvilinear figures were admissible the sphere or hemisphere would be the most efficient. In rectangular shapes the cube is best. A town of cubes and spheres might be uninteresting but it should be remembered that long, thin, straggling buildings must tend to be expensive to heat and will be more wasteful of heat than the more compact arrangements.

The next factor is orientation. Heat flow is greatest where the temperature difference between inside and outside is greatest. There is a marked difference between the coldness of the exterior of buildings on north facing and south facing aspects. The northerly winds are colder and the sun's heat, whether direct or reflected from clouds, is greatest on the south side. Consequently the rooms which are most used and where warmth is provided more regularly should be placed on the south facing sides of our buildings. When we consider the important question of the gain of heat from the sun through windows of our buildings this question of orientation assumes a major importance. To provide large windows of a living room or working kitchen facing anywhere between north-west and east should be regarded as a crime.

HOW MUCH THERMAL INSULATION TO PROVIDE

Owing to the major importance of housing at the present moment, and because housing is in many ways the most difficult type of building from the point of view of heating and heat insulation, it is proposed to deal specifically

with housing in this paper. The data which are assembled are, however, equally applicable to other buildings and the problem is basically the same for all buildings.

There is an abundance of literature on the subject of the requirements for thermal insulation in the construction of buildings. Perhaps more than should be current at any particular time. The following publications in particular might be mentioned :—

(1) The Housing Manual, issued by the Ministry of Health and Ministry of Works.* The Manual lays down irreducible minima for the thermal insulation of the structure of houses though, in fact, it would be desirable, wherever possible to work to higher standards of insulation.

(2) Post-war Building Studies Report No. 1—House Construction. Standards of thermal insulation are recommended which in the main are specified in :—

(3) Post-war Building Studies Report No. 19—Heating and Ventilation of Dwellings. This report contains what are in fact the most authoritative recommendations on the subject and the reasons for adopting the values set out are indicated. It should be noted, however, that the recommendations laid down in this report are most conservative and that higher values of insulation could easily be justified.

The report by the Fuel and Power Advisory Council on Domestic Fuel Policy endorses the recommendations of the Egerton Committee, so that for the time being there are the strongest reasons for following them. It is to be expected, however, that in the near future the standards of heat insulation will be codified in the form most suitable for universal adoption in the British Standard Code of Practice, Code of Functional Requirements for Building, which is now in course of preparation.

PROVIDING APPROPRIATE STANDARD OF THERMAL INSULATION

If the designer is to follow the recommendations laid down in the documents enumerated above it is necessary to be able to assign a figure for the heat insulating value of the elements of most of the common types of structure which he will normally have to use. From the point of view of the architect this is an important step to recognise. The subject must be dealt with quantitatively and to use the figures intelligently it is desirable to have an understanding of the principles involved. Fortunately the principles are reasonably simple and only the simplest arithmetic is necessary in the day-to-day computations which are likely to be called for. Equally fortunately the subject is dealt with comprehensively and in a form convenient for use in a booklet "The Computation of Heat Requirements for Buildings", published by the Institution of Heating and Ventilating Engineers. With the aid of this book it is possible to assign a value for the heat insulating value of almost any normal form of structure which is likely to be dealt with in day-to-day practice. Where the necessary data cannot be found for some unusual combination of materials it would be desirable to address an enquiry to the Building Research Station.

In the notes which follow the values of heat insulation quoted are in terms of estimated "thermal transmittance"—termed "U"—which is the over-all

* H.M.S.O., 1944, price 2s.

heat transmittance from interior air to external air, taking account of all surface effects and is the figure appropriate for average external conditions. The values are given in terms of the heat flow through the structure expressed in British Thermal Units flowing through each square foot of the structure per hour for every degree Fahr. difference in temperature between inside and outside air.

It is proposed to examine briefly the thermal transmittance "U", and the cost of various elements of the outer shell of buildings and to deal with them under the headings of external walls, roofs and ground floors. The costs are given as a range which is believed to be reasonably representative of current prices and are prime costs of materials and labour to which must be added the appropriate amounts for overheads, profit, etc.

EXTERNAL WALLS

The Egerton Committee recommend that the thermal transmittance "U" should not exceed 0.20 B.Th.U./sq. ft./hr./° F. for any part of a house and should not exceed 0.15 for the walls of the warmed living room where there is controllable heating apparatus. The costs and "U" values in Table I are for various common traditional types of external wall.

TABLE I

Wall construction	Range of cost for a typical house of about 1,000 sq. ft. floor area	Thermal Transmittance "U" B.Th.U./sq. ft./hr./° F.
(i) 9 in. brickwork, rendered and rough cast externally, plastered internally.	£ 156-165	0.41
(ii) As (i) but with ½-in. fibre board on wood battens in lieu of internal plaster.	175-185	0.22
(iii) As (i) but with 1-in. wood wool slab finished skim coat plaster stuck to brick with bitumen in lieu of internal plaster.	184-195	0.25
(iv) As (i) but 14-in. brickwork in lieu of 9-in.	210-220	0.34
(v) 11-in. cavity wall, 4½-in. facings, 2-in. cavity, 4½-in. common brick, 2 coats plaster internally.	165-175	0.34
(vi) As (v) but with 3-in. clinker concrete slab in lieu of inner leaf of 4½-in. brickwork.	150-160	0.27
(vii) As (v) but with 4-in. clinker concrete slab in lieu of inner leaf of 4½-in. brickwork.	157-167	0.24
(viii) As (vii) but with ½-in. fibre board on timber battens in lieu of 2 coats plaster internally.	176-185	0.15

The 9 in. solid brickwork has a thermal transmittance twice as great as the recommended value and should be ruled out. It can be improved, however, by the substitution of a fibre board internal lining on battens in lieu of two coats of plaster for a moderate increase in cost. Unfortunately the supply position is not such as to encourage the wider use of any type of wall board at the present time, so that the 9 in. solid wall seems to be ruled out for the moment. The 14 in. solid wall is expensive and does not approach the desired value of thermal insulation.

The normal cavity wall is seriously deficient in thermal insulation but is very much improved by the substitution of an insulating concrete slab for the inner leaf of brick. The cost also is reduced when a clinker concrete slab is used and all in all it seems reasonably clear that this type of construction is the most advantageous for current conditions. When foamed slag aggregate becomes more widely available at an economic price a combination of facing brick exterior leaf and foamed slag concrete slab inner leaf would be almost ideal. The fact is that under existing supply conditions it is very difficult to get the traditional construction down to the values of insulation set out in the Egerton report.

(b) *Poured Concrete Types*.—No-fines concrete has been an important means of economy in skilled labour and is likely to be extensively developed in the near future. Table II gives costs and thermal transmittances for various mixes.

TABLE II
POURED CONCRETE WALLS

Wall construction of no-fines concrete	Range of cost for a typical house of about 1,000 sq. ft. floor area	Thermal Transmittance "U" B.Th.U./sq. ft./hr./° F.
(i) 8-in. thick clinker aggregate, render and rough cast externally, 2 coats plaster internally.	£ 136-145*	0.30
(ii) As (i) but 10 in. thick	145-155*	0.25
(iii) As (i) but 12 in. thick	154-165*	0.22
(iv) 8 in. thick, ballast aggregate render and rough cast externally, plaster 2 coats internally.	137-147*	0.45
(v) As (iv) but 10 in. thick	147-157*	0.40
(vi) As (iv) but 12 in. thick	156-166*	0.36
(vii) As (iv) 8 in. thick but with ½-in. fibre board in lieu of internal plaster.	160-170*	0.27
(viii) As (iv) 8 in. thick but with 1-in. wood wool slab and plaster skim in lieu of internal plaster.	169-180*	0.23

* If constructed by specialist firm.

Looking at the data in Table II it is evident that the choice of aggregate is all-important in no-fines concrete. Clinker aggregates can give a wall with reasonably good insulation and it is likely that "clean" clinker aggregates will be marketed in the near future. Ballast concrete no-fines walls cannot be brought down to reasonable values of thermal transmittance by thickening up, but they can be considerably improved by lining the shuttering with insulating boards and will still be very economical in cost. When the supply position for insulating boards improves, the lined no-fines concrete wall in a dense aggregate will be a very good choice ; in the meantime the clinker no-fines in a fairly thick wall is good. Dense foamed slag concrete walls can give very good insulation at a moderate price. Thus an 8 in. thick wall will have a thermal transmittance of $U = 0.18$ for a cost of the order of £130-140.

(c) *Framed Walls (post and panel types)*.—Generally speaking, the framed walls, which are characteristic of many of the prefabricated and partially prefabricated house types now under development, can easily be brought down to the recommended values of thermal transmittance because it is possible to introduce a layer of highly insulating material within the thickness of the wall. The costs tend to be on the high side owing to the high cost of prefabricated elements, but there is often a saving in skilled labour on sites and speed of completion which may in some part counter-balance the higher cost. Table III gives some typical values of costs and thermal transmittances for walls of this type.

TABLE III
FRAMED WALLS

Construction	Range of cost for a typical house of about 1,000 sq. ft. floor area	Thermal Transmittance "U" B.Th.U./sq. ft./hr./° F.
(i) Light timber framework, covered externally with painted steel sheet, lined internally with plasterboard, 1-in. fibreglass quilt in cavity.	£ 175-200	0·15
(ii) Concrete posts, with concrete slab externally and plasterboard internally, 1-in. fibreglass quilt in cavity.	170-200	0·15
(iii) As (ii) but with 2-in. clinker concrete slab internally and sheet of aluminium foil on paper backing in cavity.	196-220	0·23
(iv) Pre-cast foamed-slag concrete panels, 8 in. thick, mechanically erected, tile facing externally and skim coat plaster internally.	150-180	0·20

The conclusion is that the commendably low values of thermal transmittance are due to the facility with which highly insulating materials such as fibreglass or slag wool can be incorporated in the framed structure. Incidentally these materials are themselves relatively inexpensive.

(d) *Windows*.—Windows form an important proportion of the area of the walls of any building and merit special consideration since they account for a high proportion of the total heat loss from a warmed building. As has already been mentioned the windows have a notable effect on the total heat balance by virtue of the admission of the sun's heat but obviously this effect only occurs when the sun is sufficiently high above the horizon. The heat loss through the windows at night is very high, the thermal transmittance through the glass being of the order of $U = 0·88$ as compared with the recommended value for walls of $U = 0·20-0·15$. The cost of wooden or metal windows complete with frames, glazing and painting is roughly of the order of half that of the corresponding area of walls for the cheaper wall construction. In order to minimise the high loss through the windows at night it is necessary to use reasonably heavy, tight-fitting curtains which will effect an important reduction

METHODS, COSTS AND INFLUENCE ON DESIGN

or, alternatively, the use of double glazing may well be justified. Double glazing has become standard practice in many countries which are little, if any, colder than the colder parts of Great Britain.

2. ROOFS

(a) *Pitched Types.*—The position with pitched roofs is that the normal pre-war practice gave a roof with a very poor thermal insulation. It is very easy, however, to improve this to the recommended standards and the cost of doing so is very moderate. The Egerton Committee recommended as standard for rooms that thermal transmittance "U" should not exceed 0.2–0.3 B.Th.U./sq. ft./hr./° F. Table IV gives appropriate costs and thermal transmittances for various types of pitched roofs.

TABLE IV
PITCHED ROOFS

Construction	Range of cost for a typical house of about 1,000 sq. ft. floor area	Thermal Transmittance "U" B.Th.U./sq. ft./hr./° F.
(i) Plain tiling on battens, felt, rafters, purlins, with plasterboard ceiling, plaster skimmed.	£ 85–100	0.43
(ii) As (i) but with 1-in. fibreglass or slag wool laid over ceiling joists.	90–105	0.18
(iii) As (i) but with fibreboard in lieu of plasterboard ceiling.	87–102	0.15
(iv) Asbestos cement sheeting on timber purlins and light board trusses with plasterboard ceiling.	65–75	0.43
(v) As (iv) but fibreboard ceiling	67–77	0.25
(vi) As (iv) but 1-in. fibreglass or slag wool over ceiling joists.	74–84	0.15

In examining the above figures it is obvious that the modest extra cost of adequate thermal insulation is abundantly justified. There is the question where to put the insulation. By placing it over the ceiling joists instead of on the roof slope the quantity of material required is significantly less, and fixing is much simplified. Storage tanks and water pipes can and should be individually insulated to protect them against frost.

(b) *Flat Roofs.*—Table V gives some approximate costs and thermal transmittance values for various types of flat roof.

The conclusion is that the flat roof can easily be brought down to the required standards of insulation but that the concrete roof cast *in situ* is not quite so easy to deal with economically as the other types.

TABLE V

FLAT ROOFS

Construction	Range of cost for a typical house of about 1,000 sq. ft. floor area	Thermal Transmittance "U" B.Th.U./sq. ft./hr./° F.
(i) 7-in. × 2-in. timber joists, 1-in. nominal wood boarding firred to falls, finished 2 layers 3-ply bitumen felt, bitumen coated and topped, 1-in. macadam, plasterboard ceiling under.	£ 70-75	0·29
(ii) As above but fibreboard ceiling in lieu of plasterboard.	72-77	0·22
(iii) As (ii) above but with aluminium foil on paper draped over joists.	77-82	0·16
(iv) 5-in. reinforced concrete slab, plastered ceiling, finished 2 coats 3-ply bitumen felt, coated bitumen and gritted.	85-90	0·52
(v) As (iv) but fibreboard ceiling laid on shuttering .	90-95	0·33
(vi) As (v) but with 2-in. average foamed slag concrete screed below bitumen felt.	98-105	0·25
(vii) As (iv) but with r.c. and hollow tile slab in lieu of solid r.c.	100-105	0·44
(viii) Pre-cast reinforced concrete joists, 2½-in. foamed slag concrete slab over with 2-in. average foamed slag concrete screed covered 2 layers 3-ply bitumen felt, bitumen coated and gritted, ceiling of plasterboard on timber fillets attached to joists with necessary noggings.	100-105	0·20

3. GROUND FLOORS

The main problem with the ground floor (Table VI) is the choice between the normal ventilated timber floor and the solid floor direct on a concrete slab. So far as costs are concerned the problem is complicated by the amount of under building required. On reasonably flat sites the solid floor direct on the concrete slab is the cheaper. On sloping sites the timber joist floor on sleeper walls has the advantage in cost. With the present shortage of timber and with the superior insulation of the solid type of floor it is reasonable to swing the balance over rather more towards the latter type.

Here again, it can be seen that the recommended standards can readily be obtained and on a reasonably level site without additional cost.

TABLE VI
GROUND FLOORS

Construction	Range of cost for a typical house of about 1,000 sq. ft. floor area	"U" B.Th.U./ sq. ft./ hr./° F.
(i) 4-in. x 2-in. timber joists on honeycomb sleeper walls, 1-in. nominal t. & g. boarding ventilated under, including excavating hardcore and oversite concrete.	£ 55-60	0.35
(ii) As (i) but with building paper covered both sides aluminium foil draped over joists.	60-65	0.20
(iii) As (i) but with 1-in. fibreglass or slag wool quilt draped over joists.	63-68	0.16
(iv) 1-in. nominal t. & g. boarding on 1½-in. x ½-in. dovetail fillets embedded in surface of concrete slab, with 10 lb. per sq. yd. pitch coating applied hot over surface of concrete and fillets including excavation and hardcore under.	51-60	0.15
(v) As (iv) but with ½-in. wood block laid in bitumen in lieu of boarding.	62-66	0.15
(vi) As (iv) but with granolithic finish in lieu of boarding.	40-45	0.20
(vii) As (iv) but with pitch mastic in lieu of boarding.	44-50	0.20

Discussion

THE CHAIRMAN, Dr. F. M. Lea, announced that a written question had been received from Mr. A. H. Broderick (Barnet) which he would ask Mr. Fitzmaurice to read and answer.

Mr. R. Fitzmaurice said that Mr. Broderick's question related to the Egerton Report. The first paragraph of the letter read :—

" Officially recommended standards of thermal resistance for post-war housing have been set up and are beginning to be fairly widely accepted. How does the Egerton Committee justify their suggestion that such standards should be adopted only if they can be attained at a cost equal to half their true value reckoned in monetary savings in heating cost ? (Chapter 4, Section 4.2.1.)"

The idea at the back of the Egerton Report was to preach the gospel of better insulation and to start off by being very conservative about it. At the time it was drafted the idea that one should thermally insulate buildings was not really an accepted fact and the committee thought it good to be conservative and capitalise on half the quantity of saving.

Mr. Broderick's second question was :—

" As a result of their own half-price criterion the committee appear to prove that insulation in many forms is unjustifiable economically. In Table 4 (1) they suggest lining an 11-in. cavity wall with 1-in. fibreboard on battens and say that the ' allowable increase in cost ' is 6d. per sq. ft. (4s. 6d. per sq. yd.) for the whole house or 9d. per sq. ft. (6s. 9d. per sq. yd.) for the living room only. In Table 4 (3) they suggest an allowable increase of 2d. per sq. ft. (1s. 6d. per sq. yd.) for laying insulating

board above ceiling joists, beneath boarding and tiles and over a plaster or plasterboard ceiling. The control price of $\frac{1}{2}$ -in. insulating board is 2s. 9 $\frac{5}{8}$ d. per sq. yd. equivalent to 5s. 7 $\frac{1}{2}$ d. per sq. yd. for 1-in. The reader is therefore bound to conclude that these forms of insulation are quite uneconomic and unjustifiable. Examples could be multiplied. Does the Egerton Committee consider that in publishing this they are helping the cause of insulation, or don't they believe in it themselves?"

Mr. Broderick had pointed out that those figures were not strictly justifiable because the price of insulating board was higher than the price taken in the Egerton Committee's report. Anyone who tried to argue about costs of thermal insulation was on dangerous ground because costs were slipping away all the time. In the interim between the writing of the Egerton Report and its publication costs had risen. He was grateful to Mr. Broderick for pointing out the flaw which had come into the argument. Mr. Broderick suggested that the committee would have done insulation a better service if they had pointed out that, instead of adding to the cost of the roof structure by adding insulating board on top of the joists, the substitution of insulating board for the plaster and plasterboard as the ceiling and another layer of $\frac{1}{2}$ -in. insulating board instead of the roof boarding would effect a reduction of the thermal transmittance to 0.19 and at the same time save money. He thought one must agree that that would be the case. He himself had suggested such a substitution in his own paper.

Mr. Nelson Haden said that a long time ago he had been one of the signatories of the Egerton Report. He would like to take the opportunity to say that since its completion, and in the light of further work and investigation, he had come to accept the arguments, some of which had been put forward at the present conference, in favour of full and continuous heating at least for the living room or, for the whole house, a much higher degree of background heating than recommended in the Egerton Report. The Egerton Committee, after all, had started by putting forward a very revolutionary idea, that of background heating for houses of the class with which they were concerned and then they examined a large number of combinations of apparatus which could be used. But for various reasons it was not possible then for them to put down the present-day value costs against those various combinations. If they had been able to do so, however, it was his personal opinion that they would have recommended a much higher degree of background heating than they did.

He had been concerned with the design of the houses which Mr. Dufton had shown and it was interesting to see that his opinions were borne out by Mr. Dufton's results. It needed special emphasis, however, that Mr. Dufton's tests were carried out during the previous winter, long after the Egerton Report was completed. The Egerton Report was concerned with a fairly long-term point of view. It therefore behoved everyone to get all the heating possible from the ordinary domestic boiler or back-boiler which was used for hot water supply.

It might be of some interest to the conference if he mentioned an experiment which had been made. The trend of the industry lately in the design of small boilers was to increase the size of the firepot, to provide a high standard of air tightness of doors, better draught control and finely graduated dampers in conjunction with the general use of rocking bars. Those objects were exemplified in the new British Standard Codes. He suggested that that was wrong

and that their object could be achieved more efficiently by depending for control on ash removal or disturbance with a different type of grate. If refractories were added and a special grate put in for the small domestic boiler its efficiency could be improved and the amount of attention required reduced. The brief results of a test which was still proceeding showed what could be done on those lines to produce hot water and background warmth with a small quantity of fuel. A boiler serving a 30-gallon storage tank and a large radiator of 60 sq. ft., equivalent to something more than 2 kW, was lit at 2 p.m. on Monday and a short while afterwards fully charged with coke. At that time the flue damper was completely closed. No further manipulation of the dampers was necessary. The test was still in progress with the dampers in the original position. At 10 p.m. on the same day the boiler was re-fuelled but no ash was removed. The next morning lightly disturbing the ash caused the fire to revive rapidly. The temperature of the water in the storage tank was 130° F.

Throughout Tuesday the only other attention given was ash removal and re-fuelling at 9 a.m. and 3 p.m. and charging the boiler at night at 10 o'clock. The CO₂ content was maintained at 10 per cent. The radiator was pulling its weight all day in spite of the withdrawal of 30 gallons of water. Those results were possible with modest rates of fuel consumption. The procedure resulted in a consumption of between 1½ and 1¼ lb. of fuel an hour during the day and ¼ lb. during the night. The weekly consumption of fuel was 1½ cwt. For that amount of fuel not only was 250 gallons of hot water obtained but some measure of radiator heating.

This technique could be applied to open fireplaces by fitting a small firepot at the back of the grate. The capacity was less than ¼ cu. ft. and there was a fire capacity of 6 lb. of coke, but it would keep alight all night and provide heat for a 30-gallon storage tank. No dampers were provided, control being effected by removal or disturbance of ash.

Mr. A. H. T. Broderick said that the shortage of insulating material was largely imaginary and it had probably been brought about by the operation of controls. To take one material alone—insulating board—the annual supply from mills in this country, Canada and Scandinavia was probably in the region of 250,000,000 sq. ft. If 1,000 sq. ft. were allowed per house for insulating the roof in the manner which he had suggested, namely, using ¼-in. insulating board as roof boarding under the tiles and another ¼-in. as a ceiling it would be seen that that one material alone would provide adequate roof insulation giving thermal transmittance at a figure of 0.19 for about 250,000 houses per annum. Vast quantities of slag wool, glass silk, aluminium foil and other forms of insulating material were also available.

One reason why architects did not specify insulating materials was that insulation, being normally one of the things which added neither to the appearance nor to the stability of a structure, was one of the easiest things to cut out and often had been cut out to reduce the cost of the building.

Col. F. C. Temple said he wished to talk about the subject of insulation in India because he had spent 30 years in trying to keep people cool. He thought that almost everywhere they had gone through a period of moving in the wrong direction to the extent that as they had improved building materials and methods and had used thinner walls they had lost something which they were only now beginning to replace. In a country where there

were sun temperatures of 130° F. something pretty good was required. The old mud wall of the Indian bungalow, which had to be 2 ft. thick to stand, was a very good insulating material and so was the old thatch roof. A 14-in. brick wall was not too bad with mud in the joints. When lime was added it became less insulating.

Mr. E. G. Fowler said that he had found the conference very interesting and he thought that there was a great deal of technical unanimity. Mr. Dufton's paper, however, suggested that there were differences about the conclusions reached in the Egerton and Simon Reports, both of which advocated background heating and topping up. Mr. Dufton had carried out tests which indicated that full central heating was more economic. He did not think that the conference should leave the matter there.

Mr. R. F. B. Grundy asked for more information about the proposed method of insulating ceilings. From discussion of the matter he was not sure whether the suggestion was that the blanket should go over the ceiling joists with the secondary difficulty that it would conceal the electric conduit and the water pipes and make them difficult of access or whether it was proposed to lay it in strips between the joists, which had obvious advantages from the point of view of laying and preservation.

The Solid Fuel Installations, Post-War Studies No. 10, 1944, stated that modifications to the hearth construction would be necessary for supplying air for combustion but that the additional building costs would not be likely to be serious. Standard hearths of a suitable type might be sold with those appliances which required hearth combustion. In 1945 the Institution of Heating and Ventilating Engineers Study No. 19 had an excellent drawing of the construction of a hearth but there was no sign of any air inlet to that hearth and presumably the air was drawn from the room. From the figures which he had got out it would appear that the heat losses in the living room, when merely consuming the air for the necessary change of ventilation, amounted to 22·4 therms per annum. But the annual heat loss owing to the extra volume of air drawn in for combustion of the fire added up to 56·4 therms. Therefore, for the luxury of having cold air round one's feet it was necessary to pay for another 43 therms per annum, which was about 10 per cent. of the total fuel for the whole year for the whole house.

Mr. R. Fitzmaurice said that the question of blankets would be a matter rather of when one could get the job done. If strips could be obtained, all well and good, but they were not easy to get; when obtainable they should be placed between the joists. He did not know off-hand what it would cost to get the strips cut but that might be an important issue.

Mr. Clothier said that Mr. Haden's suggested method of using controlled boilers put out of date the beautiful examples of stove which were to be seen and also effected a considerable saving in machinery. He would like to have more details on that subject and he would also like to know whether it was applicable to space-heating units.

Mr. J. S. Hales said it was quite true that the loss of heat caused by excessive ventilation was a serious matter and the suggestion made in certain reports for bringing in some of the air for combustion from outside rather than through the room itself would save a good deal of fuel and add to the comfort. There were, however, two methods of overcoming the difficulty. One was to bring the air in from outside and the other was to so design the fire that the

volume of air drawn through was considerably reduced. He believed he was right in saying that the example quoted by Mr. Grundy, in which there was no outside air connection shown, was explained by the fact that the throating of that fire was reduced with the intention of correspondingly reducing the volume of air drawn through the room. He was not sure that that was a complete answer but it might throw some light on the reason why in one case air was recommended and in another not.

With regard to the question of using ash as a means of control there was no doubt an increase in the number of appliances which were using that method and Mr. Haden had mentioned the independent boiler as a case in point. It was an effective method. It had possible advantages also in that grates were usually bad where shale and stone were concerned and the grateless appliances overcame that objection to a certain extent. There was one possible difficulty, namely, that with some fuels and some ash characteristics their operation was sometimes not quite so reliable. There was a possibility of considerable development in that method of firing.

Mr. J. Creese asked why a flat roof was chosen for the experimental houses referred to by Mr. Dufton. He also wished to know whether it was considered better to put an insulating material on top of the rafters rather than on top of the ceiling joists.

Mr. S. M. Sternfeldt pointed out that double glazing must have considerable effect on transmission and he thought that a number of those present would like to know whether any experiments had been carried out on that subject. He realised that glass was difficult to obtain and therefore it was rather a question for the future.

Mr. R. Fitzmaurice said that the experimental houses were built not only for experiments in heating but for structural experiments. The houses were interesting in that the whole of the structural loads were carried by $4\frac{1}{2}$ in. of brickwork. To make such a building stable it was necessary to have a strong, rigid diaphragm and that had been achieved by means of a flat roof.

On the question of whether it was best to place insulating material at the ceiling level, or on the rafters, he personally preferred the ceiling level because it required less insulating material. It followed from that that the cost was lower. There were objections, however, to putting it on the ceiling.

As building technique advanced he would expect to see Great Britain going the same way as many other countries and double glazing becoming universal. A number of countries with climates rather similar to that of Great Britain did, in fact, use double glazing and would not contemplate putting up any building without it. He regretted that he had no reliable data as to the cost of double glazing. It was known that double glazing would almost reduce heat losses by half. In Switzerland double glazing was estimated to cost 30 per cent. to 40 per cent. more in the glazing costs. The cost of glazing was roughly speaking half the cost of the wall it replaced. The area of windows could be increased and double glazing could be used which would reduce the heat losses, and result in a greater solar gain.

The Chairman said he would like Mr. Dufton to say something about the savings effected by applying insulation to a hot water supply. He would also be interested to know what the heat losses were with unlagged pipes and tanks.

Mr. A. F. Duffton said that he would have liked more notice of the question because it was not altogether a matter of saving. His mind was carried back some 18 years to an experiment he had carried out in his own home. The hot water supply was provided by a combination grate in the kitchen. The hot water system was not compact. There was 50 ft. of piping and a 20-gallon storage tank, all entirely unlagged. The result was that there was no hot water and he had therefore altered the layout. He had not been able to bring the bath any nearer to the grate but he had been able to get the tank vertically over the grate. He had installed a 40-gallon tank which was quite a large storage for a small fire in a combination range and he had insulated that well with cork. Thereafter he had had hot water. The combination grate, which was not a domestic hot-water supply boiler at all, was an adjunct to a cooker. It burned 18 lb. of fuel a day and it gave not less than two baths of hot water besides its function of cooking and warming the kitchen. It was that aspect of insulation which was probably more important than the saving of fuel because the loss of heat from a hot water system did not necessarily go out of the house.

Mr. Hartland Thomas said that he would like to know the coal consumption required to produce various building materials.

The Chairman said that that was a problem of long-term implication. If it was going to be necessary to economise on fuel on a long-term basis, it might be necessary to consider the quantities of fuel required to produce different building materials. Any values which could be given were, of course, averages of figures which varied over a fairly wide range from one works to another. Taking first 9 in. solid thickness of Fletton bricks built in 1 : 3 cement mortar, with $\frac{1}{2}$ in. 1 : 1 : 6 rendering on the external face, the amount of coal required would be 27 lb. per sq. yd. If the external rendering were eliminated but the same material used, the amount of coal required came down to 25 lb. per sq. yd. Using the same thing but with colliery shale bricks, the amount of coal required went up to 37 lb. per sq. yd. and if common bricks were substituted the amount went up to 88 lb. per sq. yd. Using sand-lime bricks the amount was 37 lb. per sq. yd. and using foamed slag concrete cored blocks 18 in. by 9 in. by 9 in. in cement mortar with $\frac{1}{2}$ in. 1 : 1 : 6 rendering the amount required was 23 lb. per sq. yd. Using the same thing in clinker concrete the amount required was 25 lb. per sq. yd. Those materials gave different degrees of insulation. The thermal transmittance of 11 in. cavity brick was 0.34. Foamed slag concrete cored blocks had a thermal transmittance of 0.25.

Mr. Hartland Thomas said that he thought it could fairly be said that as a profession they were insulation conscious and they had been that for a good deal longer than many other people. For an even longer period of time they had been very particular about the efficiency of equipment and efficiency in the method of installation.

The bringing of an architectural section into the present conference indicated that a long-term view was wanted as well as a short-term view. Obviously, architects could do very little indeed about the immediate problem of this winter or next winter. The most they could do was to choose efficient methods for the particular buildings which were being put up—a very small factor. The long-term prospects were much more their business. On the long-term prospects it seemed to him that it was the feeling of the conference

METHODS, COSTS AND INFLUENCE ON DESIGN

that the standards of comfort from the point of view of heating inside houses required very radical reconsideration. Whichever way they went in the topping-up controversy, he felt sure that they would not be content with that sort of thing on a long-term basis.

He thought it could be claimed that during the war years those architects who were still concerned with building had co-operated very willingly and had worked in accordance with the standards of wartime building. They had used bricks when they wanted to use timber and had used steel sparingly. Now they could not use bricks for anything but houses.

He wondered whether the fuel situation, on a long-term basis, was really so acute or so important. He wondered if it would be public policy for the architects to be given a lead in the choice of building materials from the fuel point of view. In other words, was it going to be one of the most important pieces of costing to cost building materials in terms of coal utilisation? It was with that in mind that he had asked a question on the subject. Should the architects ask for a lead of that kind? If they obtained such a lead he felt confident that the architects would follow it.

He thought he was correct in assuming that the question of extra cost of insulation should be included in the extra cost of installing apparatus. Unless a lead were given as to how much local authorities could spend in supplying improved apparatus it was impossible for them to so much as suggest such things.

Mr. M. D. Robinson proposed that the conference might suggest to the Ministry concerned that the controlled figures of £1,200 and £1,300 should be increased to cover some of the items which were apparently of value to the nation at large.

Dr. Macfarlane said that those who had been present at the opening Session must have been very pleased to have had a categorical statement on the subject of costs from the Parliamentary Secretary to the Minister of Health, **Alderman Key**, who had said that "much as the Government was concerned to get costs down, improved appliances would not be cut out of local authorities' plans merely on account of additional costs."

Section H was no less alive to it than Section G. **Miss Evelyn Sharp**, until recently Under-Secretary in the Ministry of Health in charge of housing, had amplified **Alderman Key's** statement.

Mr. F. R. Steele thought that the conference had arrived at two general conclusions. It had condemned the open fire in the distant future when non-bituminous coal would be more obtainable, and it had generally decided that houses should be heated as a whole from a central source. There were two things which would have to be done before that could be brought about. First they had to get a satisfactory focal point in the house to take the place of the fireplace and the television set suggested did not fill the bill because it was well outside the financial scope of the majority of the public. Secondly, they had got to battle against the old-established British custom of opening windows and he personally would not like to do that.

A speaker remarked that it was most important to educate the public in the use of new appliances, particularly the housewife.

Another speaker stressed the importance of impressing on the Minister of Fuel and Power and the Minister of Health that it was important that in fitting new appliances and insulation the cost should not be borne by the tenant, especially in Council houses. The Minister of Health should give the local authorities a larger subsidy to prevent a rise in rents.

FINAL SUMMARY

At the Closing Session of the Conference, the Chairman of Section G, **Mr. Hartland Thomas, M.A., F.R.I.B.A.**, summarised the main conclusions to be drawn from the discussions as follows :

Our discussions naturally at the present time have concentrated around the housing problem but we also bore in mind the heating needs and practices for other buildings. I have three highlights from our section—they are different in kind—but I must put them in this way. First, we regard as very important, and we welcome with the greatest pleasure, the undertakings that came to us several times from the Minister of Health to the effect that considerations of costs were not going to be put above more efficient heating apparatus and more efficient insulation auxiliaries. Secondly, there is something of a controversy at the present time between the advantages of background heating plus topping-up over full heating. I have to report that very important and good evidence was brought to our section in favour of the view that background heating and topping up was not so efficient as full heating. The third important matter I want you to treat seriously, though it may at first seem frivolous, that is, we want to suggest that a questionnaire or Gallup poll, is conducted amongst the G.I. brides in the U.S.A., in order to give us a comparison between housewives' opinions of British and American heating systems. From having brought architects into this conference it is clear you want us to consider the long-term aspect. As architects there is nothing in our work we can do that is going to make an important saving this winter, or even next. We considered fully the comfort of the human being. It was clear to us that the heating problem related to the human being is not the heating problem at all but the control of the cooling of the human body. Nevertheless, we have to look far ahead, for planning is the architect's job. We are very conscious of the importance of thermal insulation and very conscious of the importance of working efficiency in the apparatus we select for our buildings and we regard the present housing programme as an opportunity to increase the trend of improvement in those respects. I bring to you an offer from the architects to yourself as Minister of Fuel and Power. In the past six years we architects have been accustomed to make considerations of public policy a major factor in our work of planning buildings. We have worked with the Minister of Works' standards and wartime building regulations beside our drawing boards. That is something rather new and if you choose to give us a similar line from the coal utilisation point of view I can assure you we will follow it as readily as we have played ball with the Minister of Works in matters of wartime building. To be more specific, there are two aspects of this offer. One, as between different materials, some require more coal to make them than others.

As between two kinds of brick, you can have a brick that takes three times as much coal to make as another brick. If you will give us a lead that you want us to choose materials from that point of view, please, Mr. Minister of Fuel and Power, consult the Minister of Works and give us that lead. The other aspect is that we in the past have been offered more than one medium for providing heat in buildings, namely, gas, electricity and solid fuel. Before the war we had absurdities like the all-electric house. We noticed with pleasure that the experts concerned with the different heating media are no longer in this extensive competition, but they were suggesting to us, to our great pleasure, combined apparatus using heat from fuel in the best way. We think this is a sign of the times, and we want from you, if you care to make a ruling, guidance as to where we should use the different forms of heating media. For instance, will you tell us that heating by electricity is something we should avoid specifying or something we should promote ?

SECTION H

THE HOME AND ITS FUEL SERVICES

Chairman:
THE DOWAGER MARCHIONESS OF READING, G.B.E.
CHAIRMAN OF THE W.V.S.

SESSION I. Better Fuel Services: The Need For Them

THE CHAIRMAN, having welcomed those attending the meeting, pointed out that planning was very necessary in the transition from war to peace. To achieve the very best for the future, there must be long-term planning in connection with housing, and this must include the provision of adequate fuel services. Plans must be formulated and put into effect with courageous vision, and we must not be shackled by the past. At the same time there was the immediate problem of conserving fuel, and the conference must examine how to avoid a shortage of domestic and industrial fuel during the coming winter. The Minister of Fuel and Power had emphasised that, in that saving, housewives had a large part to play.

1. The Objectives of Domestic Fuel Policy

By SIR ERNEST SIMON
CHAIRMAN OF THE FUEL AND POWER ADVISORY COUNCIL

Having lived in Manchester for the last 60 years, I feel most strongly about the curse of the smoke nuisance and the old-fashioned coal fire which is the origin of so much of it. The average consumption of fuel in the average house is about $3\frac{1}{4}$ tons a year, 3 tons of which is bituminous coal, and in burning it produces nearly 2 cwt. of smoke, i.e. tar and oil, and 2 cwt. of sulphuric acid. Those two between them are destructive of life and beauty and buildings, and of everything else that makes civilised city life worth while. The open coal fire is not only dirty and destructive; it is also very wasteful indeed. The efficiency is about 20 per cent., whereas with closed stoves, or central heating, efficiencies two and three times as great can be obtained. Moreover, it only heats a small portion of the house. As against this dirty, wasteful and ineffective way of heating, there are in America, Germany and Sweden, methods of heating by burning coal in closed stoves or by central heating which are twice as efficient and give, in much colder climates, warmer houses than we have here. In the temporary houses now being erected, scientists, engineers, architects and designers have installed the best that is known in the way of space heating, water heating and cooking. It is efficient; there is very little labour, and it is economical. It is very encouraging that after all these years we begin to think about applying science to domestic heating.

I want to summarise very briefly the Egerton Report and the report of the Fuel and Power Advisory Council on Domestic Fuel Policy. These reports deal with what can be done over the next twenty years.

My council's report starts by saying what should be the objectives of domestic heating. We accept the standards laid down by the Egerton Report for space heating and water heating and for cooking ; those will be dealt with by Professor Mackintosh. Certain objectives must be achieved. The first is to secure the standards laid down. The second is to secure them in a way which is satisfactory to the householder who requires low cost, convenience and cleanliness. The third is to secure them in a way that conforms with the national interest, i.e. without burning coal unnecessarily or spending unnecessary capital, e.g. on power stations, gasworks, coke ovens, etc. The fourth objective is to abolish smoke.

The next point is—what fuels are available ? I do not propose to mention oil and wood or peat because they are all minor fuels, so we are left with the solid fuels—coal, or solid products of coal—on the one hand, and gas and electricity on the other. Gas and electricity are admirably clean and convenient fuels, and in the inter-war period they practically captured the whole cooking load between them. They had begun to make progress in the heating of water ; there is an immense field to be captured by gas and electricity there still. They have made a small beginning in space heating, and it is a little uncertain what they will achieve there. They have begun well. Much research and development are undertaken in both those industries and their appliances are good. The story of the solid-fuel appliances is very different. There was no initiative in developing solid-fuel appliances between the wars. The old-fashioned coal grate and the old-fashioned kitchen range still continued, although the kitchen range was improved. The real trouble was that the old-fashioned coal grate was so cheap (and coal was so cheap) that people just put it in without thought. The solid-fuel appliance makers for the most part did very little research. One or two first-rate appliances were developed, notably the slow-combustion cooker, and the coke-fired water heater. These showed what could be done ; but, on the whole, little was done and the bad old appliances were still being made and installed in all the houses built after the end of the last war.

In using solid fuel, it is obvious that smokeless solid fuels are needed. It has always been clear that until we can get a good smokeless solid fuel we can never solve the domestic heating problem, and in the early part of our enquiry it seemed to us that the only hope was coke. There was a very limited amount of anthracite. Coke supplies had been steadily increasing and it seemed likely to be necessary, if we were going to get the smokeless solid fuel we wanted, for there to be a very great increase in coking, which might lead to awkward questions as between the gas and electricity industries. Then the Fuel Research Coal Survey staff informed us that in their view there was no difficulty in increasing the supply of smokeless coal of the anthracite type by another 20 million tons a year. That, of course, will obviously revolutionise the whole position. We can get more coke, and if we want it and take the necessary steps we can secure an additional 20 million tons of good smokeless solid fuel.

Having that information, we then set to work to consider our next point—how is the heating load to be divided among the available fuels ? There are two kinds of heating load. The first is water heating and cooking, which are fairly steady right through the year. In addition there is the space-heating

load, which in winter actually is about twice as much as the others added together. There is thus this steady load going on all the time and in the winter there is this tremendous peak, the top of the peak for space heating alone being three times as high as the total summer load. It seems to us quite clear that the cooking load is already largely taken by gas and electricity, and there is no reason why they should not take more of it unless such good solid-fuel cookers are produced that people prefer them. There is plenty of room for gas and electricity to increase their load very much in water heating. Space heating, which only extends for a few months at its full load, could not all the year round be taken efficiently by gas or electricity. One reason is that, according to our view, to provide continuous space heating by gas or electricity costs the householder considerably more than by solid fuel. A second reason is that if during cold snaps in winter, the additional space-heating load were superimposed on the normal gas and electricity load, the full load could not be met without tremendous storage capacity. The only way of storing-fuel so as to have it ready for a cold snap is to store solid fuel. We recommend that there should be storage for a ton of fuel, if possible, in every house. If ten million houses stored a ton of fuel each, that ten million tons of coal could be got in the summer, when the mines are slack, and would be used in the winter, thus helping to even out the load on the mines over the year. Thus we come to the conclusion that the winter space-heating load must be taken by solid fuel.

The position at the present time is that about 85 per cent. of the fuel burnt is coal, about 10 per cent. gas and about 5 per cent. electricity. The guess we made was that gas and electricity were likely steadily to increase. We have taken a period of twenty years. We think they will steadily increase and that, perhaps, at the end of that twenty years 30 per cent. of the load might be taken by gas and electricity as against 15 per cent. now. That would still leave 70 per cent. of the load to be taken up by solid fuel. We hope, and we have recommended, that every effort should be made to secure an additional one million tons of smokeless solid fuel—coke or smokeless briquettes or anthracite—every year for the next twenty years, and that by the use of good appliances it ought to be possible on the average to get an efficiency of at least 40 per cent. and possibly rather more. That means that the target is, in twenty years, to replace the fifty million tons of bituminous coal which are now being burned, with an efficiency of only 20 per cent., by a much smaller amount of solid smokeless fuel burned with an efficiency of 40 per cent. or 50 per cent. That is our recommendation. If that is done, in twenty years you are going to double the efficiency of your domestic heating and you are going to abolish domestic smoke. That, and we are unanimous about it, we regard as a perfectly practicable programme.

It could be achieved in two ways. The amount of useful heat in every house could be doubled. All the cooking ; a really good supply of hot water so that everybody could have a bath when he wanted one ; the main room properly heated ; and bedrooms heated up to a background level of about 50° F. (topping up to a higher temperature when required), could be secured by doubling the amount of useful heat in the house without any greater consumption of coal than now, and at very little extra cost to the householder, reckoned at pre-war prices.

Probably most people would not want to go quite as far as that, and an alternative would be to increase the useful heat in the house by 50 per cent.,

with reduced cost to the householder and a saving of ten million tons of coal a year. That would probably be quite sufficient, especially if some of the improved insulating materials were applied to the house.

Those results are, of course, completely revolutionary. They are possible for one reason and for one reason only, that the old method of using the open coal fire is such an inefficient way of using fuel. It is used in no other country in the world. It is so incredibly inefficient that if you will obtain the appliances, which are perfectly well known, and if you will get smokeless fuel, you can secure those completely revolutionary results within twenty years.

To get that result there are certain lines of action which have to be taken by the Government, with vision and increasing vigour. The local authorities are, of course, an absolutely essential link and every housewife and every worker must co-operate. Obviously the industries have to produce the appliances and must do a great deal of research.

There are two main recommendations. One is, of course, the production of efficient appliances. Already, we know enough to make those very good appliances which are installed in the temporary houses ; but they are far from perfect, and everybody knows that in both solid-fuel appliances and gas and electrical appliances there is still undoubtedly room for substantial improvement ; further research is required. But much more important than research is that the best types of known appliances should be made in large numbers as quickly as possible, and that as soon as possible British Standards should be laid down for those different appliances. We have very strongly recommended that those standards should be made compulsory.

The next step clearly is that those standard appliances should be mass-produced at the lowest possible prices and installed in the new houses. Then, of course, the next stage would be gradually to replace the bad old appliances in existing houses by those new appliances.

The second recommendation is the production of an additional one million tons of smokeless solid fuel each year. That is a matter for the National Coal Board. I hope that between them the Government and the Coal Board will put their whole hearts into this, because anthracite, as we all know, is a magnificent fuel. It has been produced at very high cost in the past. We are told that technically there is no reason why the cost should be high, and that if the pits are reorganised and new pits are sunk, anthracite ought to be no dearer than other coal.

Another recommendation is that there should be Government Information Centres, for the guidance of local authorities, architects and planners, on the whole question of what are the best appliances and the best fuels for all sorts of different purposes. That is a highly technical matter, which has never been satisfactorily dealt with. In Manchester the Gas Committee has a most cheerful showroom at one end of the building, where you can learn all the virtues of gas appliances ; and at the other end of the building the Electricity Committee has another beautiful showroom where the staff are perfectly convinced that any sensible person never installs anything except electricity. There are showrooms where solid-fuel appliances are shown. But there is no one place to which anybody can go and find a showroom with all the different heating appliances, with an independent technical staff who will advise him which are the right appliances and which are the right fuels for certain purposes. Government Information Centres and showrooms might very well be run in conjunction with the local authorities, with probably one centre with a very

high-grade staff in London and branches in all the main towns. While the whole thing is developing as quickly as it is, while appliances are changing, and while fuels are changing, no architect can get all the necessary information.

The prospect is exhilarating. In Manchester, we have produced a magnificent plan. Just below and around the University, on a site of 300 acres, is to be built a cultural centre with a large University campus, staff buildings, hospitals and teaching schools. That will take twenty years or more. I hope, in the meantime, if we all work together under the vigorous guidance of the Ministry of Fuel and Power, we shall during that same period, if we get that twenty million tons of smokeless solid fuel, abolish domestic smoke—industrial smoke is a relatively easy job—so that it will become practical politics to clean up the air of Manchester and the air of Sheffield and of all the other places too. I feel perfectly certain it can be done, and we could get conditions to live in which would be such that, whereas now the whole urge has been to get out of Manchester and go and live in Cheshire, there would be a flight from Cheshire back to Manchester and people coming in to live in Manchester just as they come in to live in Copenhagen or Stockholm, where they get all the advantages and amenities of civilisation.

I hope this conference marks a turning point in what has hitherto been the extraordinarily unfortunate history of domestic heating in this country. The worst use of fuel—I shall be corrected if I am going too far—for domestic purposes in any industrial country in the world has been that of Britain. What has been worked out for the temporary houses is possibly the best in the world. We are entering a period of almost revolutionary change. I do not think there is any doubt about the whole-hearted co-operation of the housewives and the individual workers and the local authorities, and I am sure there is going to be vigorous research by the industry. The prime essential in this matter is the leadership of the Ministry of Fuel and Power which has given us its preliminary blessing, and I look forward to hearing assurances from Sir Guy Nott-Bower later in this session of the continued vigour and scope of their work.

2. Comfort Requirements in the Home

By J. M. MACKINTOSH, M.D., F.R.C.P.

DEAN, LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

In the modern house we look upon water and drainage as normal ; we get them fitted and we more or less forget about them. In the matter of comfort, we are still in this country at the stage of looking at warmth rather shyly as an accessory and a luxury. The real object of the report on Domestic Fuel Policy, which I will call for short, the Simon Report, is to enable us as a long-term policy to turn on the tap of comfort in the home. That is why the first recommendation reads : “ The provision of fuels and appliances of qualities and at prices that will enable householders in general to afford conditions of full health and comfort for all members of the household, with a minimum of dirt and labour.” I would like to emphasise two particular points in that recommendation—“ . . . full health and comfort ” and “ . . . all members of the household.”

We hear a great deal about mother. I am going to have something to say about father and the children as well. Let us just for a few minutes put aside the architects and the engineers, and even the politicians. Come with me and look over the shoulder of Mr. and Mrs. Smith and the three children. Who are the Mr. and Mrs. Smith we are interested in? First, they are not the people who want to occupy the houses of yesterday. They are people of less than thirty. Mr. Smith is just back from the war and they are looking forward to occupying the house of tomorrow, and don't let us forget that they are going to be there a much longer time than the older ones of us today. They are going to bring up children in that house, and they have still to create the sentiments and loyalties and traditions of the home that have lighted so many happy homes in England in the past. But surely we do not want Smith and his wife to stick to the past when it comes to comfort? We want them to look forward with clear eyes to the future. What do they need for the new home? Something more than shelter. We want their home to be designed for specialised functions, for privacy, to begin with, in married life. That means freedom from outside noise, such as the radio and the windy spasms of gurgling pipes and babies in the house next door. We want them to have an opportunity for rest and sleep without disturbance. We want them to be able to have their meals properly cooked and served in a comely way. Above all, in winter at any rate, we want them to have warmth where and when required—not only when, but also where, in the house. Lastly, we want to give them real opportunity for the care of their children in favourable conditions of companionship and supervision.

British homes, I think it is fair to say, lead the world in space, but space is of little use unless it is usable space—living space. The secret of living space, and there is only one, is warmth. Do not forget when we talk about colder countries like Canada and Sweden that our great enemy is just as great as their's—damp as well as cold. If Mr. Smith and his family are to be confined perpetually to a fireplace in one room, the rest of the house will be cold and cheerless; that will promote friction in the family life.

Here is your problem: how to provide for Mr. Smith to stretch himself in the evening in front of a cheerful fire and knock his pipe out in the ashes, and for Mrs. Smith to get away from her work, away from the sights and smells of cooking, even if it means only a change from the sink to the work-basket. If the children are small, how very important it is for them to have warmth in undressing. It is really just as important as for them to have the windows open after they are tucked up in bed. Both are equally valuable. Then when there is a baby in the house, of what enormous value it is to be able to change and feed it upstairs, without making a mess in the living room—to get the chance of some source of heat that you can turn on and off when you want it.

Then there are the aged. So many people in this ageing community have older relatives, and there is a very real need for their comfort. They feel chills more when they get on in life. The same is true of the sickroom. Some people think that a sickroom ought to have a fire burning all day, but that is really a fallacy. The great point is to be able to have some sort of heating that can be turned on or off as required, i.e. when the doctor comes or the patient requires to be nursed or dressed or changed.

Not only that, but as the children grow up they should have a room of their own, where they can bring their friends, a study/bedroom where they can

do their lessons, where they can have fun and kick about and play the flute and do what they like without disturbing father or mother, and without being disturbed by father or mother.

We are not concerned only with the evenings. Day by day the housewife has to go about her ordinary work. Do we want her perpetually to go about with blue fingers and creaking bones? Again, is there anything more depressing in winter in this country than for the housewife to go to a cupboard and find that the clothes and the linen are damp? Lastly, there is the toddler. You know what a wide range the baby and the toddler have, and you have noticed that the greater part of it is on the floor. Are you going to have the floor always cold for the baby's bottom, or are you going to have it unchilled a little?

These, very briefly, are the needs. How are we going to provide them? I would tell Smith that much as I like the ordinary open fire it is the most expensive form of heating he can have, except in its first cost. Sir Ernest Simon has told you the reasons for that expensiveness—the waste, the smoke and dirt, the ash-carrying and the sweeping, and so on. But Smith and I would like to have a fire very often that we can sit by, and yet a fire that will do its job during the day and during the night when we are not there. The representatives of the local authorities are going to listen to architects and engineers who will tell them about these heating appliances, and I am not going into detail about them at the moment, but I would like to suggest to you one or two questions to ask yourselves and them. You can no doubt think of many other questions yourselves.

Take the fire first. Ask yourselves, does this appliance take over during the night without having to be re-lighted and without great expense in fuel? If it does not then there is something the matter with its design. Does it create a draught that races across the floor and meets your heels and gives you chilblains? If so, there is something the matter with the design. Does it mean dust and ashes, not to mention the sackcloth you have to kneel on to clean it out every morning? Does it mean raking and the collection of clinker, or can you get rid of the clinker easily? Is it adaptable to something less than the perfect fuel?

Then, ask yourself about the pipes. Do you ever go into that storage place by a stupid little door in the ceiling which leads to an attic? Have you ever seen the welter of pipes careering around there, most of them just under the eaves, where they freeze at the first touch of winter? Have you examined the hot water system to find out two things: firstly, does it give enough water for both Mary and Jean to have a bath, or does it just give enough water for one bath and then cool down for the rest of the night; and, secondly—which is part of the same thing—is it protected by lagging against the waste of heat? Further, does the house itself act as a holder of heat or does it just pour it out through the walls? In other words, is the house properly insulated? It is very gratifying to see that the Ministry of Health have recently issued a circular to local authorities, which I hope you will have noticed, specially urging the importance of the insulation of walls.

Lastly, ask yourselves, is there some good method of heating water in the summer when the rest of the heating has to be turned off? There are plenty of good modern appliances which fulfil the need for both space and water heating, not to give, of course, tropical heat as in American hotels, but to give a reasonable amount of comfort which you can increase to the full scale when

and where you want it. That is what we have been accustomed to call "topping up". Look out for these things.

I want to say just a word about quality. In the report there is a very striking reference to standards, that a house should be so built and equipped as to make it possible to provide the standards of heating which have been recommended. The report goes on to deal with installations, and in another recommendation it says that minimum standards should be established as soon as possible for all types of appliances, and that the Government should take steps to bring those standards into operation. I do not want you to be confused about that word "standards". Think in terms first of standards of quality and performance. Every one who is interested in housing wants first-class standards of quality and performance, but that does not mean dull, uniform standardisation of the apparatus. The word "standards" does not refer to uniformity of what you see but of quality and efficiency in action.

So, when we come to the service behind the walls, if I may put it that way, the service in the attic and so on, we want standardised parts. In a motor car, for example, there is nothing more troublesome than inability to get a part of the engine replaced. Correspondingly, in the interests of economy and efficiency, we want a standardised heat service unit.

All these standards demand a tremendous amount of research to get efficiency and to make an efficient machine, but that is by no means all. Research into the mechanical side is not enough. *People* live in houses and we need to study human nature. Under the ægis of the Industrial Research Council there is a keen and active Committee which is dealing with the physiological aspect. What are the needs for health and comfort? What is the ideal temperature for the human body?

Through the Ministry of Health and the Ministry of Works, various types of equipment are being tested under actual living conditions. At the Fuel Research Station, apparatus is being tested. The most important of all the human experiments, however, is "in the field", that is to say, the extended trials now being made in large numbers of houses up and down the country. These are being carried out by the Ministry of Works, and they are being made by ordinary folk living and working and helping the experts by criticising, correcting and improving. All those tests, which you will come across in Scotland and in England, are not experiments *on* the people; they are experiments *with* the people and with their enthusiastic assistance.

There is no one test of that kind. It needs continuous testing—in different climates, with different types of apparatus, with different conditions of living. What Manchester says today is not necessarily suitable for London tomorrow.

I have touched only upon the fringe of these things, but I do want to underline the great need for further research and investigation into housing. The Ministry of Fuel and Power and other Ministries are keenly engaged in doing that work. I have not touched upon either central heating or district heating because I have been talking about immediate needs. I believe myself that there is an advance and a revolution just round the corner, although it may be two years or three years or five years ahead. In the study of the houses of today we must be ready for this revolution, and the local authorities particularly must see that the apparatus that goes into the houses of today, particularly the heat service units and the fittings behind the fire, are appropriate for those great advances that are to come; because, to use Shakespeare's words: "If it be not now, yet it will come: the readiness is all."

3. Improved Fuel Services and Housing Design

By MISS JUDITH LEDEBOER, M.A., A.R.I.B.A.

You have been told that we shall require everyone to save fuel, and Professor Mackintosh has told you that everybody requires an enormous amount of warmth. Presumably you will require me to reconcile those two statements. I cannot help thinking that perhaps the best thing to do would be to try to build a house for Mr. and Mrs. Smith here and now, and get you to help me to make the various necessary compromises, taking into account the problems which are involved.

We will presume it is a local authority house, and that it has to conform to the Housing Manual standards of today. There are two main ways by which the fuel services of the house can be improved—insulation and improved appliances.

Let us take insulation first. Insulation conserves coal by applying certain materials in particular ways so as to prevent the loss of heat. The Ministry of Health have recently issued a circular which makes one or two suggestions as to how this should be done. It refers first to the walls, and suggests a method for improving the insulation value of the walls. It goes on to suggest that you also need similar insulating effect in the ceiling. In fact it suggests that you should lay a sort of eiderdown on top of the house, and it goes on to suggest that you should also do something of the same kind to the floor, so that you have in fact an eiderdown round the whole of your house, made in various ways, but necessary in order to keep as much cold as possible out of the house and to keep the heat in. That, I am quite certain, is going to be the greatest improvement we can possibly make in the design of houses, going even beyond the improvement that can be made in the appliances. If you have a well-insulated house you are bound to feel comfortable in it. It is like going into some of those older houses which have panelling, where a certain amount of warmth has already got into the building and you feel a warmth in the place to start with. Now that is an aim which we should be able to achieve. The Smiths would very much appreciate it, and certainly it would lead to reduced consumption of fuel, and will mean that all their visitors will come into a house that is pleasantly warm in winter and cold in summer.

Now we come to appliances. Mr. and Mrs. Smith live out in the country where there is no gas or electricity. He is a farm labourer, and may prefer to be able to settle down in the kitchen and have his meals straight away, probably at an odd hour when the children have not turned up. There are some practical appliances—in fact some of the greatest improvements have taken place here—for this purpose. The old range has gone, and you will be able to acquire a combination grate which will look cheerful, but which still conserves the heat and which does the cooking and provides the hot water. Alternatively, there are insulated cookers. Some have been rather expensive; we hope that cheaper ones will be available soon. Those combination grates heat the room, they do the cooking and supply hot water as well. A three-in-one service is a real trial of any appliance, so that there may be shortcomings in a device of that kind. It cannot necessarily always be cooking at the same time as it does the heating of the water. Some of these appliances have been made so that they stay in all night, which is the

ideal requirement for a solid-fuel appliance. This cooker should be put in the centre of the kitchen where it gives the greatest heat.

All this presupposes that electricity or gas are not available. Let us now suppose that the Smiths inhabit a house in a town, where they can get gas and electricity. Mrs. Smith undoubtedly wants her own little working kitchen where there is a sink and a gas cooker or an electric cooker and everything is beautifully arranged. She has a living room with probably a dining recess or she has a recess in the kitchen for serving meals. She will probably want one or the new openable stoves for heating, or she may like an open fire which can be closed down so that she can keep the fire in all day and all night. She probably thinks it is best that this stove should heat the water.

Constant hot water is one of the requirements laid down by the Simon Report. Mrs. Smith must get it in the best possible way. If she is going to take her hot water off the fireplace then certain things must be taken into consideration which affect the plan of the house. Most plans show the living room fireplace immediately opposite the door and usually against the party wall, so that the next-door neighbour can hear you poking the fire. This position for the fireplace is very convenient for sitting around, because father's chair can be put on one side, mother's chair on the other and the children round the table. But, to get good hot water supplies off the living-room fire, your hot water cylinder should be very close to your fireplace and to the kitchen or the bathroom, which so often, by reason of planning round the hall, is right on the other side of the house.

Therefore, where hot water is to be provided from the living room fire, the fireplace should be moved towards the centre of the house. That is not the usual place to find it in this country, although it is common abroad. The central stack is frequently a prerequisite of a good and efficient hot water supply. That, I think, is the most obvious move or change in planning resulting from the attempt to get these three services done efficiently from one appliance.

If a heat service unit is used, which is a prefabricated system containing the hot water and the space-heating services, it obviously requires positioning in the centre of the house because access is required from both sides.

There are one or two difficulties ; it may not be possible to solve every problem fully, and it may be necessary to compromise between giving everybody comfort round the fire and providing everybody with good heat right through the house.

Now let us go upstairs. Are the provisions which you hope to be able to make for the Smiths and their children going to affect your plan in any way ? How are you going to get background heating ? At present the heat service units and other equipment are built into the house, and hot air ducts encourage the hot air around the flues to come out, so that if the fire is maintained fairly constant you should get a considerable rise in temperature upstairs. You will require facilities for topping up in these rooms. I do not think this is going to affect that plan very much ; the central duct is still required because you will want to convey the heat to each bedroom, and obviously you cannot do that if you have your units at the side wall.

I do not think that in any other respect your bedroom plan is likely to be altered, except where we can build houses larger, and when the Ministry allows us to increase the size of bedrooms and the size of the bathroom.

Finally, I do not think there will be any really sound revolution in planning until there is complete central heating. For example, in a centrally heated

American house there is no hall ; you walk straight into the living room. Though you may find all the doors open, there is no draught. When central heating or other over-all method of heating becomes general, then we may see the development of new house planning arrangements.

Discussion

Sir Hector McNeill (Lord Provost of Glasgow), speaking as a representative of local authorities, prefaced his remarks by a quotation from the late Sir Oliver Lodge : "The earth is beautiful in the extreme in places where nobody lives but in places where people have decided that they wish to live in large numbers together for social purposes, for business purposes, for businesses of all kinds, they have taken no precautions to keep the earth beautiful, they have made it ugly. There they have spoiled the peace of the earth."

The speaker pointed to the great advances made in the supply and utilisation of gas and electricity, but in view of the care and attention devoted in most homes to ensuring a pleasant æsthetic environment, asked that there should be an improvement in the quality of domestic coal. The capacity of domestic grates was limited so that the use of high-ash coal restricted the amount of heat available, increased smoke pollution, reduced the thermal efficiency of utilisation and involved extra labour in handling and in keeping the house clean.

Alderman Miller (Plymouth), also speaking as a local authority representative, discussed the measures necessary for immediate saving of fuel. While the average Briton relied for his heat upon the traditional open fire, the speaker recognised its inefficiency. It seemed to him to be based on an unholy alliance between the builder, who installed an inefficient coal grate and flue, and the coal merchant who thereupon reaped his profit from the consumption of as much fuel as possible. He advocated an open fire which could be closed when desired, like the Continental types with flues passing through every room. These flues have glazed tile fronts which retain the heat and transmit it gradually to the rooms. In Plymouth, where 941 new houses were now occupied, with a similar arrangement only 1 cwt. of fuel a week was used in 95 per cent. of the houses for space heating and water heating. The fuel used was a mixture of coal and coke. Another system much in demand was the normal open fire with back boiler and well-insulated cylinder, fitted with a flue supplying heat throughout the house. More information was needed concerning available appliances.

4. What Needs to be Done

By **SIR GUY NOTT-BOWER**

DEPUTY SECRETARY, MINISTRY OF FUEL AND POWER

It is my misfortune but not my fault that the facts which I have to lay before you are not all that you would wish to hear. You will not be surprised at that because frustration is the order of the day at present. I think everybody realises that we are grappling with outside facts which at the moment we are not able entirely to control. May I say, also, that we at the Ministry of Fuel and Power are all enthusiasts for fuel efficiency.

The Simon Report is in our view something of a classic. It is in a way almost an advantage that we have been brought by the circumstances of war to a position in which we can at last contemplate a really revolutionary change in the whole of our domestic heating arrangements. If it had not been for the war it is possible that we should have continued to muddle along in the same old way, and nobody would have been sufficiently moved to take the action which is now about to be taken and has, indeed, already commenced.

I want to tell you, as shortly as I can, what has been done. If you say afterwards that it is not enough, I shall agree. It is not nearly enough, and we have to get on and do more, and do that more quickly. We are fully alive to that necessity.

Immediately after the Simon Council issued their Domestic Heating Report, the Ministers primarily concerned, that is the Minister of Fuel and Power, the Minister of Health and the Minister of Works, met personally, and after that meeting gave an assurance to Sir Ernest Simon and his colleagues that they accepted in principle the recommendations of the report. There is thus no question as to the report being in debate : it has been accepted by the Government and the only question at issue is how well, and how quickly, effect can be given to its recommendations.

Following upon the meeting of the Ministers, an Inter-Departmental Committee was set up, of which I am the Chairman, consisting of representatives of the Ministry of Fuel and Power, the Ministries of Health, Works, and Supply, the four Departments principally concerned with this problem. We have held a number of meetings and we have divided into sub-committees. I want to tell you very briefly the point we have now reached.

There are certain activities of this committee with which I am not going to deal. One is district heating, which is to be discussed in detail at the second Joint Session of the Conference.

When we tackled our problem we found from the outset that we were up against two principal difficulties. The first difficulty is the shortage of coal generally, and the second difficulty was the shortage of appliances for the immediate housing programme. I am going to say a good deal more about the appliances question in a few moments.

On the question of fuel, I can only say that this is primarily a matter for the National Coal Board, and at the commencement of our revolution we are necessarily up against a transitional period of very great difficulty. The National Coal Board are engaged in examining the main problems, and we hope that they will be in a position not long after the vesting date to let us know a little more of what they can do and hope to do in relation to the problem with which we are chiefly concerned, and that is, of course, the supply of much larger quantities of solid smokeless fuel.

On the question of appliances we have taken quite a considerable amount of preliminary action in consultation with the Ministry of Supply, who are responsible for the manufacturing arrangements and relations with manufacturers.

A preliminary list of approved appliances which are now in manufacture, or will be in manufacture shortly, has been prepared, and the Ministry of Supply are giving manufacturers every encouragement to produce these appliances. A Ministry of Health circular to all local authorities has drawn attention to the necessity of installing them in subsidised houses and we hope they will be adopted as far as supplies permit. The difficulties in the way of

speeding up their production are many. There is a very acute shortage of labour in the foundry industry now, and a special campaign of recruitment is to be undertaken. These appliances are a very great advance on anything we have had in the past. It is very important to realise that although we have not got everything we shall want in the future, we must press on with the utmost speed in getting better appliances installed wherever it is possible.

Let us always remember, however, that we are not dealing entirely, or even mainly, with the problem of supplying new appliances to new houses only. The new housing programme, however well it goes and however fast it develops, will be for a long time to come only a comparatively small fraction of the total housing capacity of this country. There are something like 12 million or 13 million existing houses, the majority of which have not got anything approaching efficient fuel-burning appliances, and which have to be tackled before we can say that we are anything like out of the wood. That is, as I say, the problem which has to be faced as soon as possible after the problem of the new houses.

Alderman Key, in his speech at the opening of the conference, said that while the first cost must be a consideration in the minds of the Ministry of Health, they were not going to stop local authorities from having efficient fuel appliances simply on grounds of first cost. Alderman Key referred to "the desperate need for houses", which compels us, for the time being, to put into some houses appliances which are not yet up to the standards we desire, and also to allow only one solid-fuel appliance in each new house. But these are passing difficulties.

Another very important problem, which has already been touched upon, is insulation. This is a matter of very great interest to local authorities in planning their housing estates. Sufficient types of insulating materials are already in good supply, and there is no reason why they should not be used immediately in houses now being built. The dividend in fuel saving from the reduction of fuel losses is quite remarkable in return for the very small expenditure of money, and we ought to make quite sure that no houses will be put up in the future without at least some measure of scientific insulation.

The design of the house, again, is conditioned by passing difficulties. A great deal of experimentation is being carried out, and some local authorities have already made remarkable strides in innovations of design. Miss Ledebor has already touched on the work which is being done in that field, and we at headquarters are particularly interested to hear of any development which individual local authorities may be putting forward on their own.

District and central heating are not matters on which I want to touch but, as has already been said, they are undoubtedly going to have a very great effect on future domestic heating in this country. A number of schemes are already in an advanced stage, and we are now in possession of sufficient basic statistical information to enable us to decide quite definitely where district heating is practicable in the broadest sense, and where it is not. Obviously, where new housing estates and new flat housing estates are being put up there is very large scope for experiments in district heating.

The National Coal Board have the supply of smokeless fuel in the forefront of their programme, but the anthracite coalfield in West Wales is probably more in need of re-organisation than almost any other part of the coalfields. Wholesale re-organisation of most of the existing pits, and also the sinking of new pits are necessary. These, as you may readily imagine, are not things

which can be done overnight, they require the most careful engineering considerations, and the employment of a large amount of capital. Therefore I cannot offer you much hope of large increases in the supplies of solid smokeless fuels in the very near future ; but do not, for that reason, hesitate to put in these new appliances. The appliances now being put on the market, and which will come on the market in the next year or two in large numbers, are what we call non-selective, that is to say they will burn a very large range of fuels and are not dependent on the supply of solid smokeless fuel. The Siesta Stove, for example, which is now installed in fairly large numbers, will, if used properly, burn bituminous coal and various blends of coal quite economically. Therefore it is important that you do not wait until solid smokeless fuel is available in large quantities before you put in new appliances.

On the testing of fuel appliances, the Ministry of Fuel and Power and the Department of Scientific and Industrial Research have worked out performance standards for domestic heating appliances. Here again we are up against one of those temporary difficulties, shortage of premises and shortage of staff. Our Regional Fuel Engineers provide liaison with the appliance manufacturers and carry out a limited amount of preliminary testing in the laboratories of those manufacturers who already have testing facilities. In addition, testing facilities are available on a limited scale at the Fuel Research Station at Greenwich, and we are using the testing laboratories of the Gas Light and Coke Company at Watson House, and the research laboratories at the British Coal Utilisation Research Association, all of whom are carrying out full appliance tests on behalf of the Ministry of Fuel and Power to the performance standards laid down. The test results are considered by the Domestic Heating Committee and as far as possible the modifications of appliances recommended as the result of the tests are passed on to manufacturers and they give effect to them.

The appliances are being tested according to British Standards, when these are available, and in order that these Standards may be adequately reviewed and new ones prepared for appliances burning different kinds of fuel, an inter-departmental Standards Sub-Committee is already in action.

It is absolutely essential that the new fuel appliances conform at least to minimum standards of efficiency and performance, and we are quite satisfied that that will be achieved.

We are also doing what we can in the way of having large-scale user trials of these new appliances. The Ministry of Works have erected experimental prefabricated houses, built by different methods, with varying plans and systems of heating, in different parts of the country. There are fifty of these houses on each site. Records of fuel consumption and standards of comfort achieved will be made by observer-tenants. At the suggestion of the Scientific Advisory Committee of the Ministry of Works a large-scale sociological experiment in this field is also being carried out.

The Simon Council laid great stress on the importance of education. It is no use providing modern and technically efficient fuel-burning appliances if the people in whose homes they are installed do not understand how to use them. It is astonishing how quite intelligent people will quite often ignore the instruction cards which are sent out with these appliances.

This educational part of the new fuel efficiency drive is of vital importance. Our own Domestic Fuel Efficiency Organisers have already done a good deal in this field and we are enlisting the help of women's organisations and local

authorities. We are finding that even in the prefabricated temporary houses with the Siesta appliance the housewife still needs a lot of explanation in its use. It is astonishing how bad even a modern appliance can be if it is not used in accordance with the directions issued with it.

That, I think broadly, is the factual information which I am in a position to give. I have tried to make no excuses but merely to tell you facts, and I am quite certain that when we have got over this transitional period, progress will be very rapid.

The quality of coal is engaging the very close attention of the National Coal Board, and we hope that in future not only will there be far larger quantities of smokeless solid fuel, but that coal will be much more carefully graded and that the whole price structure of coal will be related much more closely to its calorific value. We shall know what we are getting, and shall be quite certain that we can buy coal with the same assurance of quality and service as we can now buy gas and electricity.

The upshot of my appeal to you is just this. We want everybody today to be a fuel efficiency expert, and there is no reason why everybody should not be.

Lady Reading : I wonder if you would agree if I suggested to Sir Guy that we should all understand the rules and regulations which come with appliances better if they were written for the ignorant and not for the intelligent? I find that I have to work an appliance for several days before I understand what is written on the card, because that is always written by someone who understands the thing very well. If the instructions could be written with the people in mind who will have to use the appliance, I think it would help very much.

QUESTIONS

A number of written questions were handed in, answers to which were given by the principal speakers. (Other questions were subsequently answered in writing, and are not included.)

Answers by Prof. Mackintosh

Question : Does the Ministry of Health consider that central heating is as satisfactory from the health point of view as the open coal fire ?

Answer : Speaking in general terms, so far as we know there is no difference whatever between good central heating and any other good form of heating. Health is so extraordinarily complex, involving human factors such as overcrowding, food, ventilation, etc., that it is impossible to be sure that a particular thing has a particular effect.

Question : We have been told of the desirability of changing over the heating of the home from the open coal fire to patent appliances using gas or electricity to be turned on or off at will. The necessity for insulation has been stressed. This affects the structural details of our future house. The use of patent appliances will probably result in very much smaller flues or no flues, and the insulation will possibly tend to reduce window space. Must not ventilation and light be considered alongside these proposals? Is not the average flue one of our best means of ventilation? What are the alternatives?

Answer : The first sentence is based on a misunderstanding. It is not proposed to abolish the open fire but to improve it. The open coal fire tends

to over-ventilation, i.e. draught. With a good roaring fire there is approximately three times as much ventilation air going across the floor and up the chimney as is needed for health ; the smaller flue therefore does not affect health but reduces draught. The reduced flue of a gas fire, for example, gives a little more ventilation than that recommended by physiologists on both sides of the Atlantic. Ventilation is thoroughly satisfactory when these new appliances are used.

Answers by Miss Ledeboer

Question : What would it cost to insulate an ordinary house ?

Answer : This is a difficult question because the insulation can be incorporated by degrees. The standard of insulation recommended by the Ministry of Health's circular is not likely to cost a very considerable amount extra.

Question : Is the incorporation of insulating material likely to restrict the size of the house ?

Answer : No, particularly if the insulating materials are structural. The Ministry of Health circular suggests a 4-in. coke-breeze lining be built into the house. This would be effective without reducing the size of the house at all.

Answers by Miss Sharp (Deputy Secretary, Ministry of Town and Country Planning ; late Under-Secretary in charge of Housing, Ministry of Health).

Question : Will the Ministry adjust the ceiling price they work to in checking local authorities' proposals to allow for the additional cost of the new appliances and the insulation ?

Answer : The standards of cost to which the Ministry work in looking at proposals are being constantly adjusted in the light of current prices and wages. Alderman Key gave the assurance at the Opening Session of the conference that the necessary capital cost envisaged in the question would be allowed.

Question : Should there be any financial help, subsidy, etc., to enable householders of small means to instal new and efficient equipment or to exchange their old, inefficient equipment for new equipment ?

Answer : This question is really one for the Ministry of Fuel and Power. Possibly with Government assistance and bulk purchasing the cost will be brought within the reach of everyone. It is generally assumed that the new appliances will be very expensive, but unless they are at a cost that will be within people's means, they will not be what we want.

Question : Who is expected to bear the cost of replacing old types of appliances by new types when these are available ?

Answer : If there is to be a general replacement in local authority houses, the cost will fall on the local authorities' maintenance funds. This fund is derived from minor and small adjustments of rents. The new appliances should be so much more economical in running that there should be a good saving to the tenant which will enable the authority to build up its maintenance fund.

Answers by Sir Guy Nott-Bower

Question : What will be done to ensure that rural areas have modern appliances at reasonable cost ?

Answer : There must be some delay before appliances can be put into existing houses on a large scale, but it must be done, and rural areas must

have preferential treatment. The Minister attaches great importance to schemes of rural electrification.

Question : How can the efficient use of fuel be secured in mining areas while the miners get one ton of coal a month ?

Answer : Free, or assisted-price, coal which the miners receive is and always has been part of their wages. When the National Coal Board considers the whole wage structure of the mining industry, it is likely that this problem will be tackled by them in conjunction with the National Union of Mineworkers.

Question : Is it reasonable that on a housing estate in a mining area which is to have district heating, the miners who get free coal should be required to pay for district heating ?

Answer : Since free coal is part of the miner's wages, it is clear that some adjustment will have to be made. It would not be fair that miners should be required to pay for district heating and forego their supplies of free coal.

SECTION H. THE HOME AND ITS FUEL SERVICES—*continued*

SESSION II. Better Fuel Services: Can We Provide Them?

Chairman of Session:

THE DOWAGER MARCHIONESS OF READING, G.B.E.

THE CHAIRMAN said that this session would be devoted to the immediate practical side of the problems discussed in the first session. A great deal had already been done toward future planning and while being proud of that we should not be depressed if appliances were not forthcoming as quickly as they were needed. The rate of production was growing, however. As temporary houses ceased to be erected, the materials used in them would be diverted to permanent houses. Whilst Section H was largely devoted to long-term planning, in the present session practical people would indicate the scope and the availability of appliances.

1. Improved Fuel-Burning Appliances: Solid Fuel

By G. L. SCOTT

VICE-CHAIRMAN, SOLID FUEL INSTALLATIONS COMMITTEE ;
DIRECTOR IN CHARGE OF RESEARCH, ALLIED IRONFOUNDERS, LTD.

The outstanding difference between pre-war and post-war designs primarily concerns the greater degree of accurate control over combustion and therefore over the performance obtained from the appliance.

Another feature resulting from improved control is the satisfactory manner in which smokeless fuels can be burned in many appliances which previously were limited to bituminous coals—especially the open fire.

Generally speaking, the measures which have brought about this improvement consist in preventing uncontrolled air from reaching the fire either by improved fitting of firebox components, frets, ash doors, etc., or by providing optional means for enclosing the fire, in designs which hitherto had a permanently open fire.

The ability to burn a wide range of fuels, especially smokeless fuels, is intimately connected with improved firebox insulation, especially the insulation of frets fitted to open fires.

Inevitably these measures have tended towards increased first costs, but their desirability is difficult to question in view of the need for national fuel economy.

The general improvements in combustion control, therefore, can be regarded as the keynote, and the factor most responsible for today's improvements: any additional cost is well worth paying for, so also is the advantage of being able to burn a wide range of fuels, according to availability.

There are many secondary benefits which arise from the present character of development, which are not directly concerned with economy or efficiency. They are the sort of things, however, which matter a very great deal to the

ordinary user. For example, improved combustion means less flue cleaning. It is very doubtful whether the real benefits from constant burning are as yet fully appreciated. This practice permits an appliance to be ready for use at extremely short notice and without any preliminary labour. It means also that appliances can be left unattended for long periods. As a result, there is a considerable reduction in the time and labour required to obtain satisfactory operation. Furthermore, this practice removes the need for "boosting" and bursts of acceleration, which are not only the primary cause of excessive consumption, but also bring about clinking, which is the principle cause of erratic and unreliable performance.

It is quite erroneous to suggest that constant burning necessarily involves a higher overall consumption than intermittent burning: the contrary is invariably the case given proper use. So much for the general design side.

There have been some extremely intelligent advances in application—largely due to improved methods of heat exchange, especially in the field of space heating. An obvious example is the open fire, the latest practice being to provide an air space round the sides and back, and by convection air currents to make additional heat available either to the room in which the appliance is placed, or by ducts to other rooms. Hitherto this heat passed into the structure of the building, and its benefits largely dissipated without tangible benefit. By this method some 15 to 20 per cent. more heat can be made directly available to the user.

In other designs water takes the place of air, as a medium of heat exchange. It is sometimes argued that this method is more costly, but it is perhaps easier of effective application, being undisturbed by any question of air pressure differences, which arise from windows being opened on the side of the house against which the wind is blowing.

It is now possible to combine two services in one appliance, either cooking and water heating, or space and water heating, without the disadvantage previously associated with such combinations. The net gain is a substantial increase of overall efficiency, and where constant burning cookers are concerned, a very reliable source of hot water supply, with a reduction in personal labour and attention.

Most modern solid-fuel appliances, particularly dual-purpose appliances, lend themselves extremely well to intelligent combinations of gas or electric auxiliaries, since the basic load can be very economically carried by solid fuel, and any special requirements taken care of by additional help from gas or electricity.

While these new appliances make possible greatly improved heat services to the user, it is necessary to remember that the appliance by itself will not be a guarantee of better service, without certain specific care in installation and some necessary information to the user on how to obtain the best results. It may be perhaps useful, therefore, to refer to some of the precautions necessary to successful operation.

CONTROL

Perhaps the first and most important point is one of information to the user.

In the past the majority of solid-fuel appliances were primarily controlled by a flue damper or dampers. This method was inevitable where fireboxes or grates were wholly or partly open to the atmosphere, or when closure was, for mechanical reasons, of by no means an airtight character.

The constructional improvements already referred to make it both possible and preferred to control rates of burning by some form of airvalve, which controls the volume of air entering the ash chamber. It is therefore essential to make certain that users are informed how each appliance is controlled : otherwise excessive fuel consumption, or overheating of the appliance, may well result.

PLUMBING

The full benefits of fuel economy which are to be obtained from modern designs will only be realised if it is appreciated that hot water systems must be much more carefully planned and insulated than was considered necessary in the past. It is absurd to go to a great deal of trouble and expense to insulate an appliance, and then allow a large proportion of the heat generated and passed to water, to be quite uselessly dissipated.

When most, if not all, these modern designs were evolved, it was realised that quite substantial fuel savings were possible by the use of relatively low powered boilers, providing that the hot water system was properly lagged : in consequence, some new ideas have been introduced in dual-purpose appliances, in which water heating is incorporated. These new measures can be really effective, but only when combined with satisfactory insulation, short flow and return, and hot water cylinders of appropriate size. There is a good deal of evidence that a cylinder of about 30 gallons capacity, placed not more than 15 ft. away from the appliance, gives a high average of satisfaction. A relatively small cylinder has the virtue of ensuring that the water will be really hot, which discourages the wasteful practice of leaving the hot tap running while washing or washing up. Also these small cylinders are eminently suited for coupling up to gas or electric auxiliaries when this practice is favoured. While it is realised that larger cylinders can in some cases be used to greater advantage, it is essential in such cases to avoid undue mixing of the replacement cold water with hot water in the tank. Since this question of mixing is influenced by pipe sizes and position, water pressure, and in particular the relative width to height of cylinders, considerable care must be used if larger tanks are to be successful. Owing to the number of variables involved, it has been considered wiser to recommend somewhat smaller storage capacity.

APPLIANCE SELECTION AND DUTY

A review of a great many housing schemes reveals a tendency towards overloading some of the dual-purpose appliances which are proposed for installation. Overloading in two directions, first, as regards what the appliance can reasonably effectively and efficiently perform : secondly, as regards what the appliance can perform on the permitted fuel allowance. It does not suffice merely to fit gas or electric auxiliaries without also informing the user what service they can reasonably expect from the solid-fuel appliance, since the pre-war habit of "boosting" a solid-fuel fire appears still to be an accepted method of standard operation.

It cannot be too strongly stressed that as far as dual-purpose appliances are concerned, the balance of heat service has been very carefully arranged for in the design, and any attempt to plus up any service, be it space heating or water heating, can quite easily result in destroying the balance, and will in any case lead to excessive consumption.

Virtually every case of complaint which the author has investigated has been traced to faulty estimates as to the duty which the appliance could

reasonably be asked to perform, or an ignorance of the amount of fuel required to give the desired and intended service.

It is difficult to exaggerate the importance to everyone concerned of giving some real thought to this much neglected aspect of domestic heat service. It would be less important if the fuel situation was easier ; the fact remains that it is anything but easy.

FLUE CLEANING AND FUEL

In spite of widespread wishes and recommendations to use smokeless fuels where possible, it must be realised that a very large volume of bituminous fuel will have to be used for some time to come. Perhaps one of the most important factors in this case is to realise the greater frequency and need for effective chimney cleaning, than would be the case where smokeless fuels were used. It is to be regretted that a great many installations already in use possess completely insufficient provision for this necessary job to be done either easily or effectively. These precautions are obviously more important where totally enclosed cookers or openable stoves of the inset type are concerned, especially when the flue pipes are exposed or partially exposed in a duct intended to carry hot air for remote heating, the main flue thereby being difficult of direct access, since it is enclosed and screened by the hot air duct. The problem is most acute with inset stoves, because of the difficulty in inserting a flue brush long enough to sweep the entire chimney.

DUCT HEATING

While it is a matter of great interest to note the developments made in the use of ducted hot air for remote or background heating, there still appears to be in some quarters a dangerous lack of appreciation of the problems involved and the limitations associated with the practice as now being developed in this country. In colder countries where this system has been used with much success, the winter air temperature is usually so low that windows are seldom, if ever, open for any period of time, or even at all during the cold season.

In this country the practice is otherwise, and it should be noted and remembered that when natural circulation or unassisted hot-air flow is the intended method in contra-distinction to a power fan, the flow of hot air can be reduced, stopped or even reversed, should a window be open on the side of the house against which a wind is blowing. Some educative instruction is therefore essential on this matter if users are not to be disappointed.

It is beyond the scope of this paper to review the numerous technical considerations affecting the cross section of ducts, position and size of air ports, etc., and it is only possible to suggest that first class technical advice be sought while the planning of the dwelling is still fluid.

This matter, like that of appliance selection, deserves and repays a good deal of clear thinking and painstaking planning. After all, the more generally used method of remote or central heating by hot water, demands quite specialised skill for satisfactory operation, and yet cases are known of hot air systems which have been installed with much optimism but obviously little expert knowledge.

It only remains to say that although the fuel situation today must inevitably greatly influence all planning of heat services, it is to be hoped that those responsible will take the longer view of installing appliances which will give them the heat service they would like to see provided, against the time when the fuel situation permits really improved services to be realised to the full.

It must also be appreciated that bulk supplies involve an inevitable absence of close contact between manufacturer and user. When this circumstance is also allied to the fact that most users will be unfamiliar with new designs, it is more than ever necessary to tie up the advisory service essential to satisfactory use.

In conclusion, a few observations may be made on measures leading to an immediate saving in fuel consumption. Taking first the open fire, where control is obviously not very exact, one rather elementary precaution is often to reduce the size of the firebox by putting in refractory brick, or alternatively not to fill the firebox completely. A recent experience shows that a reduction in fuel consumption of one-fifth was obtained by this method. This was on a cooking stove ; the practice had been to fill it right up before starting to cook, but as cooking was completed well before the fuel was consumed, the remainder of the fuel burnt away uselessly as the fire died out.

Another step is to avoid "boosting" the fire. That often arises from want of forethought as to when the hot water, or whatever it is, is needed. By starting up the fire a little sooner, or opening the dampers a little sooner, the fuel burns slowly and with a markedly higher efficiency.

Most chimneys or flues provide rather more draught than is needed, particularly for hot water boilers and stoves. Fuel can be saved by installing some form of flue damper, e.g. a small section of sheet metal inserted into a flue pipe, or opening slightly a door leading into the flue, the object being to reduce the natural draught. This will result in a very much lower consumption of fuel.

2. Improved Fuel-Burning Appliances : Town Gas

By G. C. HOLLIDAY, B.A., M.INST.GAS E. F.INST.F.

THE GAS LIGHT AND COKE COMPANY

There are no technical difficulties in providing improved fuel services in the home and in view of the urgent need for conserving our fuel resources it is imperative that this improved service should be obtained with increased economy of fuel.

The attainment of better fuel service in the home depends not only on the efficiencies of the fuel appliances themselves but also on the design, layout and structure of the house, the planning of the fuel service as a whole, and to an increasing extent on the housewife's understanding of the function and most economical use of appliances.

THE HOUSE

It is when the house is being built that utility services can be incorporated at lowest cost. If they are not provided then, the tenant is often unable to afford the cost of subsequent installation and is denied the benefit of labour-saving and fuel-saving equipment.

The standard of insulation of structure and hot water system will affect the family's fuel bill and the degree of comfort it obtains.

More attention should be given to the Egerton Committee recommendations on these matters and on ventilation, especially the ventilation by flues of kitchens and bedrooms.

These factors, which are being discussed at other sessions of this conference, do, however, have an important bearing on the problem of providing better fuel services, quite apart from the efficiencies of the fuel appliances themselves.

THE GAS INDUSTRY'S CONTRIBUTION

The gas industry is in a unique position in that it supplies in addition to gas and the well-known by-products, tar, benzole, fertilisers, etc., some 10 million tons of smokeless solid fuel—coke.

Much research and development work has been directed to the domestic uses of gas and coke, to the improvement of appliances burning both fuels, and to the best ways of using them in combination to give improved heat service especially in low income group houses.

If the Simon Council's recommendations are accepted, then coke is best used for the bulk of the winter space heating and winter water heating, and it is our view that gas should be used where it is available for all-the-year-round cooking, laundry and refrigeration, for mild weather and intermittent space heating and for the whole of the summer water heating.

This combination of two smokeless fuels not only gives the housewife a high degree of labour-saving service throughout the year but also allows her to dispense entirely with solid fuel during the summer months.

Further, owing to the high efficiency of gasworks' processing, gas and coke give these heat services with minimum expenditure of raw coal, and thus represent a major contribution to national fuel conservation.

Mr. Scott has dealt with the higher efficiencies now obtainable from modern solid-fuel appliances including those burning coke.

It is important to remember, however, that whereas for instance a single solid fuel appliance used for room warming and water heating may have a high overall efficiency in winter, its useful efficiency drops substantially in summer when no room heating is required. This, quite apart from convenience to the housewife, is one justification for providing alternative services by gas.

THE GAS APPLIANCES

(A) *Space heating*

(i) *Background heating.*—One of the most important recommendations of the Egerton Committee is that the temperature of the house should not fall below 45° to 50° F. This is, of course, not full central heating which would require a temperature of about 65° F. To attain 45° to 50°, background heating in the South of England would be required for 7 to 14 weeks. Where the solid-fuel installation does not provide the whole of this background heat, a low-consumption gas background heater in the hall can make a useful contribution during the seven coldest weeks.

An appliance consuming less than one-thirtieth of a therm per hour will give 1,000 cu. ft. of warmed air per hour and much of the heat from it when fitted in a hall will assist in keeping the upper storey warm.

(ii) *Gas fires.*—The main development in gas fires is in the use of stronger radiators and a different type of burner, both of which should lead to reduced attention for maintenance.

Flues for gas fires need only be about 30 sq. in. in area and will still ensure adequate ventilation in the room. Special flues are available to fit in readily and cheaply with different forms of building construction.

The normal gas fires would mainly be used for bedroom heating.

(iii) *Convecting gas fires* not only give radiant heating but also warmed air. They have a total efficiency substantially higher than that of the normal type of gas fire resulting in a saving in gas of up to 30 per cent. They are recommended where required for long or longish period heating when full benefit of the warmed air is obtained, e.g. in meals rooms. It has also been suggested that a fire of this type should be installed in one bedroom as being more economical to run in case of sickness or where the room is used by children for homework.

(iv) *Portable fires*.—In mild weather or on chilly evenings when the space-heating requirements are relatively low, a portable type of gas fire will give all the heat required with low consumption of gas and it is recommended that a gas point be provided by the side of the living room fireplace, where it can not only be used for this type of appliance but also for ignition of the solid-fuel appliance in winter.

(B) *Water heating*

The Egerton Committee rightly recommends provision for ample supplies of hot water. Only a very small proportion of families, however, at present use as much as the recommended 250 gallons (140° F.) per week and until hot baths are taken more frequently the weekly usage will fall far short of this figure.

In the past, small quantities of hot water for sink use and for ablutions were frequently obtained from a kettle on the cooker. This was economical but is inconvenient for the amounts of hot water now regarded as desirable.

Gas appliances can meet the varying intermittent demands for hot water economically, with certainty and with great speed. Housewives should have the labour-saving facilities for obtaining complete hot water service by gas in summer, especially where a coke or other solid-fuel appliance with back boiler is used in the living room for winter space heating and water heating. A service of 160 gallons at 140° F. per week, normally adequate for low income group houses, can be given for 2½ to 3½ therms a week and at present prices in most areas at no greater running cost than when using solid fuel, and with considerable national saving of coal.

Let me give a simple illustration : Two hot baths are wanted on a summer's day. To obtain this from the back boiler of my living room fire I would have to use about 15 lb. of solid fuel, which at 4s. per cwt. would cost me 6½d. If I use a gas water-heater I would burn less than one-third of a therm which would cost me 3½d. to 4½d., there would be no fuelling, no overheating of my living room, and there would be a national saving of 10 lb. of coal.

This kind of argument applies to all the purposes for which gas is recommended in this paper.

(i) *Sink heaters*.—For small quantities at the sink this type of heater has the lowest gas consumption. One type of appliance also gives boiling water if desired. Other types recently produced can be used as small multipoint heaters for supplying, for example, sink and bathroom wash-basin, or kitchen sink and utility-room sink.

(ii) *Bath heaters*.—These being fitted over the bath and delivering directly into it give the lowest gas consumption for bath use. They can also supply hot water to an adjoining wash basin.

The combination of sink heater and bath heater would normally give the lowest gas consumption for low income group usages.

(iii) *Instantaneous multipoint heaters*.—With these, sink, wash-basin and bath can be served by one appliance. The consumption is slightly more than when using a separate sink heater and bath heater. For most economical running this type of heater should be fitted close to the kitchen sink, i.e. the point most frequently used.

(iv) *Circulators*.—These supply hot water to a storage cylinder which is normally the storage tank of a solid-fuel system. Water is heated to the required temperature in one passage through the thermostatically controlled heater so that hot water is available from the top of the tank before that at the bottom has begun to be heated at all. This enables the circulator to be used intermittently when small quantities of hot water only are required. There is substantial saving as compared with continuous heating. The circulator can also be used to act as a “ booster ” to the solid-fuel boiler in winter. Consumptions for low income group usages are somewhat higher with circulators than with the other systems, but use of a sink heater for sink, and circulator for bath and washing days, would reduce consumption for the 160 gallon usage to about $2\frac{1}{2}$ therms per week.

(v) *Storage heaters* are similar in principle to the circulator but since the storage cylinder is an integral part of the appliance and as the whole unit is compact and well insulated, this results in lower running cost.

Storage heaters can be run intermittently with economy in gas consumption and can serve as the storage cylinder of a solid-fuel hot water installation.

A type of heater has just been designed for fitting under the draining board and incorporates a circulator and 15-gallon tank. It is provided with controls which enable either 5 gallons to be heated or the full 15 gallons for baths, as desired. The whole system is compact and being placed near the sink, heat losses in the draw-off pipe are reduced to a minimum.

Each of these heaters or combinations of them will give full hot water service and the best choice depends very much on such factors as capital cost, layout of house, and the type of service required.

All these appliances have high thermal efficiencies but new developments are active to reduce consumption under normal conditions of household use, and to reduce capital and maintenance costs. For example, a single appliance which can be used as an instantaneous sink heater and as a circulator for baths is being designed. Simple methods of direct heating of back boilers and storage cylinders by gas for baths in summer may also soon be available. New methods of “ topping up ” tepid water from solid-fuel heaters, combined gas and coke boilers so that one appliance can give hot water service with either or both fuels, and new designs and controls of circulators and storage systems to improve performance when used intermittently, are in hand.

(C) *Cooking*

Roughly half the gas produced in this country is used for cooking.

From the point of view of fuel conservation, a gas cooker, providing complete cooking for a family of four, uses up only $\frac{1}{2}$ ton of coal a year, a remarkably low figure.

Improvements in performance and design are being steadily incorporated. For example, new designs of grills combine considerable economy in gas consumption with more even grilling and toasting. New and more efficient burners, improved facilities for simmering, standard thermostat settings and standardisation of overall dimensions, are already being introduced. Finishes,

resistant to heat and to the action of spilled food, and ease of cleaning oven and hotplate are being progressively improved. Kettles incorporating finned bases will soon be available in quantity and these use about 20 per cent. less gas than the normal plain kettle and also give similar increase in speed.

(D) *Laundry*

(i) *Clothes washing*.—A gas wash-boiler with a normal capacity of 8 gallons is adequate for clothes washing. Finning of the base or other means of increasing the efficiency of heating saves 30 per cent. or more gas and speedier boiling is possible.

Some portable types are now fitted with lugs for attachment of a wringer. Fixed wash-boilers are preferable from the housewife's point of view if provision can be made for a waste pipe.

An alternative to a wash-boiler is a high-efficiency heated sink which should soon be available and is provided with a lid for use during boiling operations. It can also be used as a normal sink when not required for laundry purposes, or for fruit bottling or boiling Christmas puddings.

Washing machines incorporate an agitator and wringer. The agitator may be hand operated or the agitator and wringer electrically driven.

(ii) *Clothes drying, airing and ironing*.—More attention is now being paid to indoor clothes drying and suitable cabinets are available in which a full load of clothes is dried to ironing stage in about an hour. It is essential that kitchen ventilation should be to the standards recommended by the Egerton Committee.

Small gas units for airing, similar in principle to background heaters with very low gas rates are available for linen cupboards which do not house the hot water cylinder.

New gas irons of improved design are being developed.

(E) *Refrigeration*

Refrigerators are likely to be used to an increasing extent in low income group houses following their adoption in the temporary house.

Developments in gas refrigerators are aimed at reduction in capital costs and at still lower maintenance costs than pre-war.

ANNUAL FUEL CONSUMPTIONS

In a house in the South of England of normal pre-war construction with 11-in. cavity walls using coke for living room heating, winter water heating and some background heating, and using gas for bedroom and auxiliary heating, cooking, clothes washing and complete summer water heating, to the full Egerton Committee standard, including 250 gallons of hot water per week, can be obtained with a consumption of 2 tons of coke and about 230 therms of gas ; from the fuel conservation point of view about 3½ tons of coal only would be required. For colder regions, e.g. in the North, about 20 per cent. should be added to these figures.

Improved standards of house insulation would reduce these consumptions or, alternatively, give a still higher standard of comfort.

RESEARCH AND DEVELOPMENT

I have indicated some of the newer appliances and the improvements effected in recent years.

In less than two decades before the war, gas appliances had been improved to such an extent that 4 therms could do the work previously done by 5 therms and further improvements are actively in hand on all types of gas and coke appliances not only to reduce running costs still further but also to reduce

capital, maintenance and installation costs. This work will be reflected in still better appliances and better heat service for our consumers.

CONCLUSIONS

In conclusion, I would repeat that better fuel service is now possible without incurring high fuel consumptions, and in giving this service the importance of using gas for the purposes mentioned is stressed, not only as giving a high degree of labour-saving but also as preventing unnecessary waste of fuel.

As the Egerton Committee states, if provision is not made at the time of building for adequate gas and electricity services it is much more costly to provide them afterwards. When, as now, so many permanent houses are being planned and built it is important that the various factors affecting fuel running costs should be fully understood. It is false economy to deprive houses of facilities which would ensure both low running costs and reduced consumption of the country's fuel.

3. Improved Fuel-Burning Appliances: Electricity

By PHILIP HONEY, A.M.I.E.E.

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION

The electrical industry is confident that it can play its part in providing better conditions in the homes of the future.

Although its manufacturing capacity was almost entirely devoted during the war to the production of armaments and materials completely alien to its peacetime programme, it is now largely re-organised for the manufacture of electrical appliances and machinery both for home use and for export.

ELECTRICAL APPLIANCE DESIGN

The design of electrical equipment differs from other domestic appliances in that it makes use of a versatile and remarkable form of energy. The problem, therefore, is not merely to apply electric heat to traditional types of cooker or heater but to design the appliances with due regard to the unique advantages which that energy possesses.

The manufacturer has no difficulties regarding heat production and can concentrate, then, on efficient utilisation. The fact that electric heat can be produced without requiring air and without having to get rid of products of combustion makes it possible to design appliances in which the efficiency of utilisation approaches 100 per cent.

The absence of combustion problems gives the electrical appliance a mobility which is of considerable assistance to the architect, who is free to consider the siting of appliances more from the user's point of view, and is not handicapped by other considerations.

ELECTRICAL APPLIANCES

Cooking.—The design of the post-war electric cooker continues as before, features which made it so popular in pre-war days, such as smooth easily cleaned surfaces, flat hob top and combined griller space and warming cupboard.

In addition, speedier operation has been achieved on the boiling plates and faster pre-heating of the oven. The control of each part of the cooker has also

been improved by the introduction of a new type of switch giving a much wider variation in cooking temperatures. All post-war electric cookers have thermostatic oven control marked in degrees fahrenheit, which has now been standardised by every manufacturer.

HEATING

Whilst it is suggested in the report of the Fuel and Power Advisory Council that solid fuel should carry the base load of heat required in the home, it is clear that their recommendation for better heat insulation in houses and flats will encourage the greater use of easily controllable energy such as electricity for the total domestic heat requirements, particularly when thermostatic control is applied and the temperature of various rooms is maintained at different levels.

At the same time, a considerable scope for national fuel economy lies in the use of electricity for intermittent heating in the home. For periods of use less than, say, four hours, it requires a smaller amount of coal at the power station to heat a living room than from the household cellar when an open fire is used.

Developments in the design of electric fires are mainly in the direction of better heat distribution and this has been achieved by a more scientific approach to the shaping of reflectors, the use of better quality resistors permitting higher temperature and higher radiant efficiency. A further feature is the greater use of air warmers. The latter are being made in several types with built-in thermostatic control. Low-temperature radiators made of plastic or in the form of the conventional steel radiator are post-war innovations, the latter being filled with a special oil which distributes over a wide area the heat produced by a comparatively small element.

ELECTRIC WATER HEATING

In flats and certain types of houses it is sometimes difficult to provide a hot water installation which requires a flue of appreciable length. Where the situation is cramped, too, the need for a compact water heating system is apparent.

A recent design of electric water-heater which has been produced caters particularly for this requirement. It is designed to stand under the draining board or in some other convenient position from which all hot water taps can be supplied. The new heater has an upper and a lower heating element, each with thermostatic control, one or both of which can be used at will. Normally the upper heater only is sufficient for slack periods, the lower heater being switched on when baths, etc., are required.

The use of electric immersion heaters for the auxiliary supply of hot water in solid-fuel installations is well recognised and from a fuel economy point of view it should be known that less coal is required at the power station to produce sufficient electricity to provide an individual bath. Provision for the fitting of an immersion heater has been made in the new Ministry of Works Heat Service Unit, and in several prefabricated units which have been specially designed. Expert advice, however, should always be sought before fitting immersion heaters to other installations.

ELECTRIC LAUNDRIES

Where it is possible to provide full facilities for clothes washing in each dwelling—as is generally required in housing estates—the ideal, of course, would be to instal an electric washing machine, a separate wash tub, and an

electrically-heated drying cupboard. Restricted space and other considerations in blocks of flats, however, often prevent such full equipment being supplied for each tenant. This difficulty is being overcome in some cases by providing a communal laundry which is, in fact, a complete break-away from the traditional municipal wash-house. Privacy for the tenant is assured by the provision of cubicles, each equipped with the latest type of electric washing machines and hot and cold running water. Clothes are then dried in either heated drying rooms or electrically operated "tumbler" dryers. Several all-electric laundries of this kind have been built since 1939, where tenants on an adjoining estate have the use of these facilities for a number of hours weekly, ironing being done in the tenant's own home. Some of the latest washing machines are automatic in action and proposals have been made by municipalities to instal them in communal laundries where tenants can operate them by placing a coin in a slot. The control of these appliances is of particular interest as each operation can be accurately timed to ensure the best results. Failing these amenities, new types of electric wash-boilers with standardised over-all dimensions are available for home use.

REFRIGERATION

The provision of refrigeration in the kitchen is acknowledged by all authorities as essential for good health. The British electrical refrigeration industry has standardised one size of cabinet of 4 cu. ft. for post-war housing, giving ample facilities for food storage, rapid freezing speeds and the preparation of home-made—and safe—ice cream. With the greater sale of frozen foods in prospect, a refrigerator in each home is surely a great advantage.

THE ELECTRICAL INSTALLATION

The new appliances now being produced for post-war households all call for a greater availability of electric plug points in the modern home. To ensure inter-changeability the electrical industry has agreed to standardise on one type of plug and socket which can be used for lighting, heating or other appliances as desired. A system of "ring main" wiring has also been introduced which makes it possible to instal a large number of plug points all over the house at comparatively low cost. The controls at the meter end, too, have been simplified, a standard type of house service unit having been designed to reduce the number of fuses controlling the circuits and eliminating unsightly wires.

LIGHTING

Increasing use of fluorescent lighting grows daily and with the introduction of lower wattage types (4 ft. in length and under) the door is open for a more general use of this type of lighting in the home. Fluorescent lamps (which provide more than double the light for a given current consumption) are particularly desirable for long-hour use in living rooms where softer lighting is essential.

These are some of the advances which have been made in the design of electrical appliances, some of which no doubt may be suitable for the better fuel service which we are all striving to produce.

Perhaps the term "fuel service" does not strictly apply to electricity, as it is an energy service, combustion of fuel having already taken place at the power station. The electrical industry, however, presents its case in the knowledge that it can supply its product at an economic figure without

trespassing on the fuel requirements of other industries. To utilise the low-grade fuel resources of the country for the generation of electricity is a wise policy, to say nothing of the possibility of district heating increasing efficiency still further.

COSTS

The question will be asked, Can we afford these better fuel services ? Speaking for electricity, I would unhesitatingly answer in the affirmative, especially in view of the fact that wartime increases in fuel costs have been largely offset by savings in other directions. Electricity is still available in many places at little more, or no more, than its pre-war price.

Whilst figures of cost based on laboratory tests have their value, the electrical industry places more faith in records obtained from housing estates all over the country where electricity is used exclusively for the essential services in the home—cooking, hot water, clothes washing, etc. Improved designs of appliances tend to reduce costs of operation which tenants were well able to afford before the war. The large sale of electric fires during the past twelve months proves that most people are not afraid of the running cost of electric heat.

The majority of local housing authorities will agree that most tenants prefer to pay for their lighting and heating at short intervals, usually once a week or once a month, to correspond as far as possible with the influx of income. A large proportion of householders today purchase their electricity on the popular two-part tariff which consists of a fixed charge based on the rateable value or size of the house plus a low rate of one penny per unit or less.

Although the collection at short intervals of electricity accounts based on this tariff might seem to be difficult, several ways have been introduced which find considerable favour with local housing authorities. In many cases arrangements have been made for the electricity fixed charge to be collected with the rent by the housing authority, together with hire charges for appliances rented by the tenant. The unit charge for consumption of electricity is collected in that case by an ordinary pre-payment meter.

FUTURE POSSIBILITIES

Whilst not anticipating unduly the hopes which are being entertained today that power stations working on atomic energy may become an established fact in the near future, it is clear to many that a source of light, heat and power which does not have to rely on our coal resources will have numerous advantages. At the same time, mention may be made of other researches which are nearer finality and from which successful results have been obtained.

Of these, perhaps the most interesting is the heat pump with which heat energy from a low-grade source such as a river can be upgraded to heat, say, a block of municipal flats.

The use of cheap electricity during slack periods, especially at night, has already been proved as a practical proposition when, by heat storage, warmth and hot water are available on tap throughout the day. The development of control by means of superimposed currents on the town's electricity mains has simplified the operation of these plants.

The generation now faced with the problem of obtaining, furnishing and running a home, has just emerged victoriously from a mechanised war. They have seen how electricity entered very largely into its every phase and will expect to use that same energy as freely as possible in their homes.

4. Improved Fuel-Burning Appliances: Petroleum

By J. S. JACKSON, B.SC., F.R.I.C., F.INST.P.

Petroleum fuels which are available for use in the home include "bottled gas" and kerosene, popularly known as paraffin oil. A review in course of preparation by the Institute of Petroleum will deal fully with petroleum fuels and the appliances available for their use.

The consumption of bottled gas is admittedly comparatively small, but it is of interest to know that there is already available a full range of appliances of modern design, including fires, hot-plates, ovens, geysers, etc.; so that bottled gas provides a very acceptable substitute in country districts where coal gas is not available.

The consumption of kerosene increased by as much as 50 per cent. in the period between, say, 1921 and 1928. There are, in fact, 2,500,000 kerosene heaters and 1,000,000 kerosene cookers in use. Kerosene is economical in use and is making a considerable contribution towards domestic heating.

The war created many special demands and has led to a certain number of developments which are of interest. For instance, there is now an increased use of wickless burners which incorporate incombustible kindlers; there have been further developments of space heaters, and burners operated by thermostatic control devices have been perfected. Among typical appliances which have been made possible by these developments, may be mentioned a space heater with a short drum wickless burner fitted with an incombustible kindler. This burner incorporates a radiant element which is capable of converting about 30 per cent. of the heat into radiant heat. The burner is controlled by a valve operating three positions, high, low and off. Appliances of this kind are odourless in use and completely portable.

Another new appliance is a simple form of water heater operated by a thermostatically-controlled kerosene burner, which is capable of providing hot water to meet the requirements of a normal small dwelling. This appliance offers many advantages over the more usual domestic water heater, operated on solid fuel. A water storage system has been designed operated again by a thermostatically-controlled burner which will supply from 5 to 20 gallons of water. In one arrangement of a kerosene-operated cooker, the oven can be raised to either a high or a medium position.

5. The Best Use of Appliances

By MRS. IRENE BARCLAY, F.R.I.C.S.

MEMBER OF THE EGERTON COMMITTEE

Previous speakers have dealt with the requirements, design and the practical programme; others have described the provision we can make for heating, cooking, hot water supplies and other amenities in the house which depend on the use of fuel. A very full and clear picture has been given of the details of fuel-burning appliances. It seems as if there is nothing more to be said, and the next thing to do is to mine the coal, to generate the electricity, to manufacture the goods, and to build factories and houses, and instal the appliances.

We all know what to do with the apparatus when we get it. We have visions of a glorious achievement. There is certainly plenty of hard work to be done, and we cannot disregard Mr. Shinwell's warning; but if we do all the work the achievement is certain.

Despite the wealth of information and advice given to us, there is perhaps a little more to be said, and I must ask you to bear with me if I seem for a few minutes to be going a little wide of my rather limited subject in order to get you right into the plan. The angle from which we must begin thinking now and go on thinking, is the needs of people in their own homes. Professor Mackintosh gave us the viewpoint from which we must start in the use of appliances, otherwise our work will very largely be wasted. We must beware of paper planning.

We have gone on far too long with unscientific appliances ; science and inventive genius have been used for war and destruction, and for travel and amusement, for production, and for nearly every department of life, before coming to the home. We have had the most primitive appliances in our homes, mediæval grates and cookers. In setting out to revolutionise our houses it is not only a question of avoiding too sharp a break with tradition: we must consider how far tradition has been right. Women are much too accustomed to putting up with things, but now the tide has turned. We, and I believe people in general, are often at our best in invention when we have to overcome difficulties, and that is our present position.

The introduction of new heating methods in our homes is very far from easy. The temptation is to copy other countries where the use of fuel is much more efficient, to listen to experts from abroad. But we must not just copy. We must consider the differences in climate and ways of living as between this country and other countries. We have been told often about America and various parts of Europe where heating is so very much more efficient, and the use of fuel is so much more efficient and economical, and we are told the advantages of making the window the centre of the house rather than the fireplace. We certainly want to use our fuels to much better advantage ; but we must consider our climate. The chief point about our climate is its variability. We can have an appalling summer or we can have a mild winter. We can have frost in the morning, and a bright, hot afternoon. We do not have winter setting in on a given date.

The skies here are so grey for most of the year ; it is so dull, so I am going to talk for a moment about the old controversy of the open coal fire. We know the pros and cons of the open coal fire, but a point that is not sufficiently emphasised is that the open coal fire is cheerful on a dull day. You do not catch people sitting round a radiator in the same way as they sit around a coal fire. When a man comes in from having worked on the roads all day, or working in an office, what he wants is the cheerfulness and the brightness, and the glow of an open fire. It is often the most comforting thing in the house, the thing which means so much good cheer.

That is not a plea for burning bituminous coal, because I think we have all to be converted in these days to the use of smokeless fuels. We were told by Sir Ernest Simon that it will be 20 years before we have enough smokeless fuel in this country to meet our needs, and we have at present to go on making and improving the grates which will burn the smokeless fuel in the future, and

which will burn a certain amount of bituminous coal, too, in the new planning system.

For our immediate planning we must accept the open fire, which is also closable and continuous burning, and here I will give an illustration. About 16 or 18 years ago we put into most of our council houses, in the living rooms, a coke-fired cooker. Nowadays I think most of us feel pretty discontented with that piece of apparatus ; we look at it with disgust, but at the time I think we were perfectly right in putting that in because people were extremely poor. There were the inventions and improvements we now have, we were beginning to have improved gas and electric cookers, but they were too expensive for these people, who needed a coal fire in the living room, and they needed to be able to use it for cooking in the winter. During the 'thirties, when many districts suffered so much from the slump, people were again extremely poor, and I found that even the coke-fire range was too extravagant; it burnt too much coke, and people crowded round the little bedroom grates. Certainly they did so in the London flats, horrid little bedroom grates, costing about 10s. 6d. apiece, and when they were used every day the bottom, fell out, and they smoked and came away from the wall bringing plaster with them. They were utterly unsuitable for use but people had to use them because they could not afford anything else. That is an illustration ; we must think about the way people live, and what they can afford, and what they need, and not merely plan on paper.

In the choice of appliances there are many factors to take into account. The difference between town and country, the difference between north and south, and the normal requirements and the customary ways of living. There are, however, certain essentials. The first is the insulation of buildings to the extent at least as recommended in the Egerton Report. I think most of you know that is carefully worked out in the Egerton Report. The case is completely made for the insulation of buildings. Secondly, adequate background heating of the whole house. There, again, I think the case is proved up to the hilt. Thirdly, the necessity for a supply of hot water. Fourthly, the need for a fire which is continuous burning, if possible a dual-purpose fire, which is economical in fuel, and is labour saving. Fifthly, adequate provision for cooking, washing and drying and airing clothes.

In considering how to achieve these objects, there are many alternatives before us, and personally I am converted entirely to district heating. I think there is no doubt at all that we want hot water just as we have cold water, by turning on a tap, and I see no reason why houses and flats should not be supplied from a central source. We can learn how to do it, and we do not need terrific steam heat such as they have in America and other very cold countries, but we do need a supply of hot water which will heat a couple of radiators as well as heat the water for the baths, and other uses. There is a great deal to be said for a grate with a back boiler. In formulating the ideal arrangements for cooking and working in the kitchen, the needs of the family and the way people live in their homes must be considered. A separate dining room recess is often an advantage, though there has been, of course, a movement between the two wars for a small kitchen. It is considered very backward for people to have meals in their kitchens, but there is a good deal to be said for it, at any rate for allowing enough room for snacks in the kitchen which will not interfere with the working of the rest of the house. A man may get up at

four or five o'clock in the morning, and he wants a meal before he goes out to work. It is better to make provision for having snack meals in the kitchen. There is a good deal to be said for having a dining room recess off the kitchen, and a good-sized living room. That is a point to take into account in planning our kitchens.

Then there is the question of clothes washing and drying. People in this country do not yet entirely accept the idea of communal laundries. There is room for a lot more experiment, but personally I do not think women should have to do heavy washing, such as sheets and blankets, at home. I think a good municipal laundry is a service which should be given. We do, however, want to leave room in the home for the baby washing and what we nowadays call the "smalls", but I do not think that should be done in the kitchen; I am all against washing in the kitchen.

Cooking facilities are extremely important. Heating, too, should be adequate, and it should be well-placed. It is no good expecting people to use bedroom heating if the bedclothes are likely to be scorched because the fire is too near to the bed, or there is no room to have a fire, or if the bedside lamp is too far away from the fire. There are many problems involved in accepting these standards and considerations. For example, if we have heating in our homes, what about the ventilation? On the subject of ventilation I endorse the views expressed in the Egerton Report.

Having decided on our appliances we must make sure they are suitably placed. I want to emphasise just one point. Miss Ledeboer hinted that we had perhaps to compromise to some extent in order to get our fireplace into the centre of the building, to use economically the centre of the building, a proposal which certainly has many advantages from the point of view of economy and useful planning. But make sure you can all sit round your coal fire when you have it. It is difficult to plan a house with a central fireplace and be able to get from one place to another without having too many doors in the sitting room, but it is worth sacrificing something for this ideal.

If the planners and the architects have all done their parts, what more remains to secure the best use of planning? It is no insult to say that some education is necessary in the matter of management. There is economy to be gained in having advice on management from qualified people. I believe in the skilled management of housing estates. It is a job which should be tackled from two points of view equally: the highly-skilled technician with experience in building and maintenance and kindred problems must run the estate generally. But housing must also be regarded as a piece of social service and the housing manager must also understand good housing.

I have got one of the new appliances in my own home, a continuous-burning open fire. We are not particularly dense and slow in my family, in fact we are quite normal—one of us is an engineer—but it took us a little time to find out the best way of using our grate to get the best out of it. We have all to get used to the idea that it does take a little trouble, and it is worth a little trouble, to learn how to use them. In spite of all that has been said about exhibitions, lectures, booklets, and so on, instruction in the home is what is wanted, so I am pleading for qualified management, not just in connection with building, but in advising on the layout, in advising on everything connected with housing. Skilled management is essential, it is part of the management's work to introduce a fresh, live person who will give some help and advice, which will be welcomed, on the use of fuel management.

6. Education in the Use of Fuel

By MISS CAROLINE HASLETT

DIRECTOR, THE ELECTRICAL ASSOCIATION FOR WOMEN

The keynote of much of this session has been co-operation. Unless the women who must use the appliances that have been discussed understand them, the efficiency campaign cannot succeed.

The British housewife is a very wonderful woman, and during the war she has been called upon to do more than ever. She has had to adapt, she has had to improvise, she has had to do her work under the greatest possible difficulties. That perhaps is a situation which we put up with during the war ; but Mr. Shinwell, the Minister of Fuel and Power, has told us, and the whole of this conference indicates the same thing, that we are about to enter on a great new fuel revolution. The economy of the future must be quite different. Not only industry must change its methods, become more efficient, but the woman in the home, too, is being asked to co-operate.

In industry—and I know this from my own experience—when we are about to change our methods, to put in new appliances, we make great preparations, we employ highly-skilled technicians to help us ; a great deal of money is spent on doing the job in the best possible way. I should like to suggest that the same attitude must be applied to the home if this fuel efficiency campaign is to be a success. It is not only knowledge that we want. It is a new mental outlook, and therefore it will mean a great educational campaign throughout the country, greater than we have ever had before, if this is going to be a success.

The women of the country will co-operate, and co-operate very readily, since there is now a prospect of better homes, of better tools in the home, and an easier way of doing all the jobs that women must do to keep their families warm and fed and clean. But local authorities must realise what they perhaps have not realised before, how essential it is to undertake this great educational campaign which can not only assist in fuel efficiency and saving, but will give the women of the country a more hopeful outlook on the task of running their homes than they have ever had before. To do this work qualified, well-trained help must be employed.

I would like to stress the importance of educating and helping the housewife to understand this new technique in which there are so many extraordinary terms. I have said jokingly to my men colleagues in the engineering world : “ You are bringing out great instruments for women to use in the home, but, gracious me, how you talk to us ; you talk to us about watts and volts and amperes, and those are all new things to us.”

In his speech the Minister said : “ Waste in any form is an evil thing.” How much waste of human energy, which is the most precious possession we have, there has been in the homes of the past ! If we co-operate as women in this fuel efficiency campaign, which is forcing the technical world to produce these better appliances, we at last come within sight of the elimination of unnecessary human effort in the home. This increase of efficiency is one which women should welcome.

There is one further and most important point on the long-term issues : while it is important that we women today should begin to understand the

import of all that this fuel revolution is going to mean, this work should really be done in our schools. It should be done immediately. One can hear some of the school teachers perhaps saying " Oh, dear, another subject ", but I do not think it should be another subject. It should be integrated into the whole of our educational system. It should be found in the teaching of efficiency and the elimination of waste in our Domestic Science Centres. It should be found in our geography lessons, because we must know more and more about the fuel resources of the world and realise that countries behave as they do largely because of their fuel situation.

We can learn a good deal about it even in our history lessons. We have to understand that in the country that was built up on its wonderful and almost unlimited supply of coal, a new era is dawning which is going to alter the whole of our economic outlook. We could even do it in our arithmetic lessons, because with our new efficiency we shall know more exactly how many units or therms we are going to need in our homes. So let the children begin to do practical arithmetic of that sort at school to help them when they go home.

We cannot put over this education unless we give a great deal of help to our teachers. Many of our teachers have been trained under the old economy, the old approach towards fuel efficiency. Suddenly a whole world of new knowledge comes and they must be given help with refresher courses ; they must be helped with films, charts, textbooks and demonstrations. If there is to be a revolution in our outlook and attitude towards the use of fuel, then education is the main thing we have to think of ; it must start in the schools and it must be taken up as vigorously as any other subject we have in the curriculum.

Discussion

Mrs. Hamilton Brown: Speaking as a housewife, there is one request I should like to make. May we, as housewives, have more instructive pamphlets ? All the housewives to whom I have spoken who have used such pamphlets have been most enthusiastic about them.

To go back to solid fuel, in the past in this country the housewife has accepted the daily drudgery of cleaning grates and laying fires and cleaning rooms made dirty by those fires and, worst of all, the periodical visits of the sweep, because she felt there was no alternative. She also accepted a wasteful, inadequate system of getting hot water, very often no system at all. But in recent years, as a result of scientific research, a much higher standard of solid-fuel heating, both space heating and water heating, has been made possible. Everybody in this room knows that and so also do many housewives in the country. These appliances are on show at exhibitions. Moreover, women have seen these appliances in use and have seen the high standard of heating in the prefabricated houses, both temporary and permanent, which local authorities are now erecting. The housewife now knows that there are stoves which burn throughout the day and night so that she can come down in the morning to a room which has already a pleasant background of warmth and where it is not necessary to start the day with the unpleasant job of cleaning the grate and lighting a fire. She knows, too, that it is possible to have ash removal once a week and that the ash is collected cleanly and does not spread into the atmosphere. She also knows that for cooking as well as space heating there are appliances which are far better than those in use in the past and

already demands are beginning to come in from the tenants of old houses for the new equipment. Now that the women have seen what can be done, they will no longer be content with the old, wasteful, and inefficient methods.

The co-operation of the housewives has been asked for. From my own experience and information, I entirely agree with Miss Haslett that the housewife is only too willing to co-operate. I feel, however, that, from the point of view of the local authorities, this equipment is not available in sufficient supply nor quickly enough to enable the local authorities who are responsible for the urgent completion of large housing programmes to instal them in the new houses which are at present under construction or which are being considered for the near future. They are therefore faced with the alternative of putting in the old type of equipment which they can get fairly easily, or waiting for the new. No housing authority in this country can afford to wait in these days of extreme urgency.

Again, the Ministry of Health has asked the local authorities to incorporate some of these up-to-date methods in their new houses, but although they are more efficient and more economical over a period of time, both to the householder and also to the fuel resources of the country, as we all know they are more expensive in initial outlay. I was indeed very reassured to hear from Alderman Key that in future the Ministry of Health will take these considerations into account.

The Housing Committee, of which I am a member, is really anxious to do all it can on this question of fuel efficiency and we were hoping to put some of the most modern equipment into our new houses—permanently burning fires and a very modified form of central heating so that the heat was spread out over the house and there would be no dead space for twelve out of the twenty-four hours as happens in so many houses at present. However, owing to the maximum price laid down, we have been forced to cut down our plans very considerably indeed and until research makes possible a great reduction in the price of these appliances, we shall not be able to incorporate them. It is disappointing.

Our Housing Committee considered the circular from the Ministry of Health on insulation and realised, as everybody does, the advantages to be gained from such a construction in preventing the loss of heat from external walls. But insulation is bound to increase the cost of construction and it is difficult to see how this added expenditure can be brought within the limit imposed upon local authorities by the Ministry of Health. No local authority has done it at the present time, but I feel sure they are only too willing to co-operate on this question of better fuel services if they can have some assistance from the Department and some assurance about the increased cost of construction of houses.

Mr. T. Paterson (Ayr Town Council) said that he had been disturbed by the apparent assumptions (1) that local authorities had learned nothing from their 25 years' experience of housing and (2) that what suits one part of the country will suit others. He felt that his Scots colleagues and those local authorities in whose areas most of the population is restricted to the storage of 1 cwt. of solid fuel must have registered surprise when they heard from Sir Ernest Simon that each household should have a storage capacity of 1 ton.

Mr. Paterson proceeded: Miss Ledeboer has stressed the importance of making the best possible use of convection-heating appliances. I have visited some of the houses where convection heating is being applied and I have seen

a room where the blackened condition of the walls and ceiling were such that I had great difficulty in ascertaining whether I was looking at the delivery end of a heating duct or the end of an open-cast coalmine. I suggest that is not going to mean any easement of the housewife's labours.

I want strongly to support the point of view advanced by Sir Henry MacNeil, that irrespective of the type of solid-fuel appliance that we adopt, the quality of the solid fuel we introduce into it is the governing factor. In this investigation, to which I have already referred, we were taken to one house built under one scheme where there was the modern openable stove. As far as one could see, it had been effectively handled by the housewife, but absolutely no space heating was coming from the appliance at all, while in a neighbouring town, with the same appliance, the heating could be felt immediately you entered the room. The only explanation of that is that in the first house the quality of the fuel used was not of a standard to give the heat required, and yet the appliance was just the same.

Professor Mackintosh certainly shocked me. He had apparently learned something of what has been happening in those houses in the North where, owing to the insistence of the Department in reducing over-all costs, fireplaces were cut out of all bedrooms. He referred to damp clothes in the cupboards. The experience of those local authorities who were forced into that position is that not only have we damp clothes in the cupboards but we have mildewed clothes in the cupboards, and that, in my judgment, arises only from the elimination of the ventilating flue which the open fire provides. I am not arguing that we should all have open fires in the bedrooms, but when, in reply to a question, Professor Mackintosh stated that in his experience, which was an extensive one, it did not matter what sort of ventilation you had, and he told us that he had been into twenty-eight different houses, with all due deference I want to suggest that he never lived long enough in any one house to determine whether its heating installation or its ventilation was good and, not only that, but it is absolutely contrary to what is reported in the report of the Reconstruction Committee of the Building Research Board where in chapter 8 is definitely demonstrated the efficiency of the open flue for purposes of ventilation.

Local authorities are being urged to use all the new appliances that are being developed in this short-term policy. That practice was followed after the 1914-1918 war, and today we are just in the position we were in at that stage. What is the result today ? The local authorities who carried out that practice find that they had so many different appliances in the new houses built in the inter-war years that it is utterly impossible for the engineer's department to carry the necessary replacements for those appliances.

Mr. J. C. Pritchard : Mr. Paterson has severely criticised air flues, saying that they make the room black. There are, I think, something like 122 million people living in America and they all seem very comfortable. In all the houses I saw, and I have been travelling about and seeing quite a large number of houses and talking to housewives, there was not one case of discoloration of walls due to the use of air flues. We found about two houses where an oil burner was leaking and that had naturally made some dirt.

Another point raised was about open fires and I would just love to answer that one because, speaking as a husband, and a lazy one at that, I hate having to clean the mess from open fires and whereas so many of you women seem to take on the drudgery as a right, I personally do not. Therefore, I think the

open fire as a means of heating is a vicious thing. As a means of amenity, as a luxury, I think it is a grand thing and I certainly would prefer not to be without it, but to say that you have to have all that inconvenience just to get ventilation seems to be going rather a long way round when you can do it in so many other ways. Ventilation and heating can be provided so much more efficiently than by means of an open fire, or any other kind of fire.

Miss W. M. Whiskin (Housing Manager, Swansea Borough Council) : This conference is most exhilarating. So many of us who are concerned with housing spend all our time making do. We make do with houses which are really quite unfit for occupation now. We make do with outworn appliances. It is difficult to keep up standards. To spend two days considering what is really the best in appliances and in methods of construction and hearing in so much detail of the actual progress that is being made is, consequently, of the greatest encouragement.

I should like to add one further word of cheer, from my experience of the use of the equipment which has been put into the temporary bungalows. Most of the tenants who have moved into the temporary bungalows had practically no facilities for either cooking or for heating water where they have been living before ; so many of them have been living in one room and have had to do any cooking or heating of water over one open fire. It is, I think, enormously to their credit that they have so readily adapted themselves to this very new equipment.

It has been suggested that we should supply an alternative, either gas or electricity, and that would seem to be a helpful way of ensuring that any tenant who moved in would have a choice of using the fuel in which they were most experienced. In temporary bungalows that is impossible, as the equipment is on such a small and compact scale that it has to be neatly fitted in. Our experience is that, with a certain amount of help, the majority of the tenants very quickly adapt themselves and make very good use of the equipment.

When a tenant moves in to one of the bungalows in Swansea, she is shown how to use the Siesta stove, and they have the card of instructions to refer to. Lady Reading said yesterday that she thought the card of instructions was worded in a not very easily understandable way, and I quite agree that without some personal introduction and explanation, it is not very helpful, but it is useful to them to have it there for reference and to refresh the memory.

A demonstrator from the Electricity Department then goes round and visits each tenant and explains the use of the electric equipment, and she then goes round again a week later to read the meter and to answer any further queries, and we find that that helps the majority of tenants enormously.

Mrs. Barclay said she thought it was help in the home that was needed rather than general demonstrations, and I think that is completely true. Demonstrations tend to be attended by those who are already interested, who know what the difficulties are, and who would probably make quite good use of the equipment in any case ; so their value is limited. The other tenants, those who perhaps find using the equipment more difficult, who find it difficult perhaps to regulate their work and to do one thing at a time and who are easily distracted, are the ones who need much more help, but they would not think of attending a demonstration or a lecture about it. Their reaction to a cooker that didn't do exactly what they wanted on first trial would be that it was a bad cooker and one of the things they had to put up with. They would probably put up with it without very much complaint. Those are the tenants

whom the Housing Manager can help on her general rounds. She knows a few of the difficulties and she can give them help at times when she is on the spot and can make general enquiries to see how the equipment is being used. It is a great encouragement to know that the first equipment that is going into these bungalows is being used extremely efficiently and with good results.

Councillor Mrs. Godsell: There is one form of heating which has not been mentioned at this conference and which is not mentioned, as far as I know, in any Government circular, i.e. the sun. It is of vital importance in planning the layout that your house should be sited so that you get the maximum amount of sun. Any woman knows that sun is essential in the rearing of children. I brought this question before an official of the Ministry of Health some time ago and he informed me that there was a special Joint Committee of the Ministry of Health and the Ministry of Town and Country Planning on this subject. All I can say is that the Committee keeps its information to itself. It does not reach the local authorities. I raised this subject with the Ministry of Town and Country Planning at Reading and they were not the least interested in arguing with me as to whether it was really necessary to have the sun.

I built my own house and I designed it. I designed it with the particular idea of the conservation of heating. In order to get conservation of heat, I sited it so that I get the sun on four sides of the house for six months of the year so that there is always a warm place and on many days I do not require a fire when most other houses have to light one.

My Council is also paying a good deal of attention to the siting of houses. We have two Housing Managers qualified for this work and they are instructed by the Council that they must design houses so that the living rooms and the bedrooms get the sun. We do not have the house facing the road if it is north ; we then put the living room and the bedrooms on the garden side, and the living room does not necessarily face the road. That may be very revolutionary, but I feel it is essential that in modern planning that should be considered.

I know it is not possible for every house to be perfectly sited. In a rural district such as I come from, it is much easier, of course, but it is possible to see that in every house certain rooms get the sun. My experience is that the officials of the Ministry are far more concerned to see that the house is level with the road or level with the fence. That attitude, to my mind, is entirely out of date and we must now move on rather different lines. Your house can be made perfectly well sited and will look quite well if you do not bother too much about your parallel lines ; those can be kept right in the layout of the garden with its trees.

I would like to support previous speakers on the importance of putting the chimney in the middle of the house. People constantly remark when they come into my house on the warmth. I also have vita-glass, which I know helps in this matter, but I can keep my domestic water hot in the summer for forty-eight hours with no fire and in the winter for twenty-four hours with no fire. That is done by a cylinder which is lagged, but not according to the official instructions. It is a 60-gallon cylinder which is insulated, first by an open space, then seven layers of corrugated paper, and completely enclosed. I only have to put on the electric heater at night and the water remains hot all day. The electricity is costing about the same as the solid fuel in a modern range.

QUESTIONS

A number of written questions were handed in, which were answered by the principal speakers. The name of the speaker answering each group of questions is given at the head of the group.

Answers by the Chairman, Lady Reading

Question : Mrs. Barclay suggested that measures might be taken to obtain advice on the use of new appliances and their advantages. Could one arrange an informal meeting in one's own home with this end in view ?

Answer : This has already been done with the Siesta stove. Because there is insufficient trained staff for this purpose, volunteers are endeavouring on a neighbourly basis to show the best way of using this appliance.

Question : Mrs. Barclay and Miss Haslett stressed the need for qualified women to educate housewives in the use of appliances and for teaching in the schools. As it will be some time before these qualified women can be produced and before the children can be brought up with a new outlook, should not the local authorities now invite competent volunteers to do some training and advice in the immediate future—persons with their expenses paid ?

Answer : I do not know about their expenses being paid, but I do know that this suggestion is being carried out in certain regions and I am quite sure the Ministry of Fuel and Power would be grateful if it could be carried out in all regions.

Answers by Mr. C. L. Scott

Question : With an open fire, surely a large fire banked down with slack would last for hours and really heat the room and be more economical than a fire of small area which does not heat the room ?

Answer : Certainly, if slack is available and if there is someone who will bother to apply it at the right time.

Question : Will local authorities not find it too expensive to instal the necessary kitchen equipment for solid fuel in new housing schemes ?

Answer : The over-all first costs are not greatly dependent on the type of fuel for which the appliances are installed.

Question : Do you not consider central heating unnecessarily extravagant in our variable climate ? A portable electric fire can be used more cheaply and conveniently.

Answer : Background heating is generally agreed to be essential to any economical heating scheme and there is evidence that background heating can be as economically applied by solid fuel as by any other method.

Question : All speakers have emphasised the necessity for the insulation of hot water storage tanks to economise in fuel. This cuts across the housewife's need for closed airing cupboards. Is it a practicable proposition for a small heater similar to a towel rail to be carried on the cylinder which is fitted with these cylinder jackets ? Many housewives move the jacket because they have been deprived of the means of airing their clothes.

Answer : Most people exaggerate the amount of heat necessary to keep linen aired. There is a distinction between airing and drying. My own experience is that if one square foot of the exposed cylinder surface is left unlagged the result is generally satisfactory.

Answers by Mr. G. C. Holliday

Question : How is it possible to avoid the smell and fumes from a portable gas fire when the local supply is not of very good quality ?

Answer : Properly designed and adjusted appliances should not give any fumes at all. There have, in the past, been a number of inferior appliances sold which do not conform to the British Standards. It is important that they should conform to these standards. That question is being watched carefully by the gas industry, and the British Standards are now being revised. There are one or two alterations which should help a great deal in restricting appliances which do not properly conform to that specification.

Question : I have a great admiration for the efficiency of the gas water heater I use, but the smell it emits unless it is cleaned at least every three months is very unpleasant. Is this just my bad luck or is it general ?

Answer : Without some knowledge of the appliance, I cannot answer that question very well, but there is absolutely no reason why an appliance should require attention every three months in normal use. Our objective in developing all these modern gas appliances is to dispense with maintenance for at least two or three years, and I can only suggest that in that particular case the appliance may have too high a gas rate and is therefore requiring attention more frequently.

Answers by Mr. P. C. Honey

Question : Why has no reference been made by the speaker to the comparatively high consumption of coal in the use of electric appliances ?

Answer : This means, of course, that the transformation of coal into electricity represents a high consumption at the power station. The amount of fuel used in a modern power station like Battersea is round about 1 lb. per unit of electricity produced. It is true that the efficiency is not very high ; in fact, the maximum efficiency at the Battersea Station is not more than 30 per cent. The point is the kind of fuel which is used. The electricity industry uses low-grade fuel. As this fuel cannot be used for domestic purposes the power station can claim to make the best possible use of it.

Question : Is it possible to make an electric storage cooker on lines similar to the Aga ?

Answer : Yes. Two types of electric storage cooker have been made. The most recent is quite large and works on thermo-storage lines. The electricity is kept on permanently and it runs throughout the whole twenty-four hours.

Question : If one of the amenities to which the working classes are entitled is a refrigerator, is it the intention of the electrical industry to lower the cost of this amenity and so bring it within the range of the working-class pocket ?

Answer : Yes, that is the intention. It is only by mass production that these goods will come down in price, but I would ask you to remember two things : (1) that there is a very big export programme to which we have to work, and (2) that there is a big Government order for temporary and other housing for that type of electric refrigerator which is occupying manufacturers at the present moment practically to their fullest extent.

Answers by Mrs. Irene Barclay

Question : Should wash-boilers not be eliminated in new houses ? Is the boiling of soiled linen a proved scientific necessity ?

Answer : I think the time is coming when we can eliminate wash-boilers in small private houses, but it is not a thing that can be done very quickly. We have not yet proved that people are willing to do without them. They will only put a bucket on the gas stove or the electric cooker if we do not give them wash-boilers at present. We have to educate them and they are slowly being educated.

Question : Is there any evidence that municipal laundries would do the work better than private laundries ?

Answer : I hope I did not imply that there was. That was not quite what I meant. People cannot afford the high prices of the private laundries to do all their work in these days, but there are increasing numbers of people using the services of the bag-wash ; and the bag-wash is a bit too rough. As the work cannot be done cheaply enough by private firms, I suggest that this is a service which can be performed by the municipality, to take the place of the rather cheap and rough bag-wash. I am not criticising the bag-wash people ; they have to make a profit out of it, but it is all rather uneconomical.

Miss Caroline Haslett : I have no questions to answer, but I have here a very nice statement which I think some people would like to hear. One member of the audience says :

My mother at ninety-two has ordered a new stove as the old one is falling to pieces, and (to quote her own words) " she cannot possibly go on using it year after year ".

Then I would like to put in another statement :

In view of the importance of the fuel economy drive, would it be possible to train suitable women in an advisory capacity to the women who will be doing the job ?

I should like us not to make up our minds too quickly that we cannot get these women. I believe we could get them if we started a training scheme and paid them properly. I do not want to feel that this job is going to be done for too long by amateurs. I think the fuel economy drive is so important that we ought to find means of getting the women with the best training and putting them into this job as quickly as possible.

SUMMING-UP

Miss E. Sharp (until recently Under-Secretary for Housing, Ministry of Health ; Deputy-Secretary, Ministry of Town and Country Planning) : Before I start summing up I would like to answer two questions which have come the way of my old Department, especially one about the ceiling price, namely :

In view of the fact that a ceiling price is put upon these houses, how can we possibly afford all these appliances ?

I think there is some misunderstanding concerning what the Ministry do about this ceiling price. What they do, in the course of administration, is to try to settle in the different parts of the country what is the approximate price at which, in that part of the country, a fully up-to-standard house fitted with all the approved appliances can be built, given keen tendering, and, in doing that, they are largely relying upon their experience of the prices they are getting from local authorities. Mr. Bevan has given an assurance many times that he does not want to cut prices by cutting any of the approved appliances, equipment and fittings which are going into the houses. The Ministry, as you

probably know, have published a complete Housing Manual, and they will, of course, bring it up to date with all the approved new fuel appliances as they come along.

What I am afraid happens is that when a local authority puts a price in and the Minister says "This is too high", and the local authority has difficulty in getting the builder to come down on the hundred-and-one minor items going into the house, they compromise by saying "Leave out this £20 item and make it up in that way", but that is not the intention of the Minister and it is not what should be done. Mr. Key gave an assurance at the Opening Session that the cost of these new appliances will be allowed, and so it will, every time. If you find them being cut out, that is wrong and you should complain, but that does not let you out of the necessity of getting your over-all cost of the house down to what is reasonable on current costs.

A second complaint is that the Ministry have refused consent to instal refrigerators.

The fact is, I think I am right in saying, that at the moment there are no really reasonably priced refrigerators available. They will come with standardised production and bulk orders. What the Ministry will do every time is to allow you to put in the point or whatever it is and to leave the space for the refrigerator so that it can be very easily installed when we get a really low-priced refrigerator.

I am supposed to sum up the discussion, but I do not think I can do that ; what I would much prefer to do would be just to say what is my own impression and the feeling left in my mind by it.

I was very sorry when I left the Housing Division of the Ministry of Health only a month ago, and I feel sorrier than ever today because I would very much like to hurry straight off to the Ministry and start to do something about the things we have been hearing. However, I do see scattered round the hall inconspicuously some of the members of the Ministry, and I feel sure they will take the message home.

I would like to use your platform to send a parting message to my old Ministry, and that is this. When I got to the Housing Division of the Ministry only a year ago, I went there full of enthusiasm for the very sort of things we have been talking about. I was completely ignorant, I did not know the position, but what was really in my mind was the enormous importance and necessity of comfort and convenience as well as standards of design in housing. I, personally, have very strong feelings on this question of heating and warmth in houses.

But when I had been at the Ministry for a year and had done a lot of work on day-to-day administration, the result was that I had become absolutely swamped by the day-to-day difficulties in building houses at the present time. We were so taken up with the difficulty of getting bricks and mortar, and this, that, and the other thing, and in keeping our heads above water at all, that I know this side of it very much slipped into the background of my mind. I feel sure that the local authorities are finding the same thing. Therefore, the problem is really how we can be sure of getting hold of the sort of thing this Conference has given us, and an assurance that enormously better standards of heating and comfort can be provided in houses ; how to avoid losing the enthusiasm given us by these two days of discussion, and to do something about it.

Looking at it from the Government end, I feel sure that the thing we have to get hold of and not lose is the immense importance of better information to all of you ; I am thinking there of the local authorities, but it applies to the housewives and to people generally. The trouble is that we hear about these new appliances and know that these new appliances are on the market, or, if not on the market, are coming ; that there is going to be this, that, and the other way of doing things, and so on, but it is all very vague in our minds. We do not really know what is the best to use in our own particular local conditions. I feel that what the Ministry of Health, in collaboration with the other Ministries, must do is to see that everyone—the public, and particularly the local authorities—is kept fully and adequately informed of what is available ; what is good in different circumstances, so that you really know what is going on, and are kept up to date and given that information which will enable you to make an adequate and efficient choice. That is my parting message to my old Department and I hope, if they do not produce the stuff you need, you will harry them ; from my own experience, I am sure you will.

SECTION H. THE HOME AND ITS FUEL SERVICES—*continued.*

SESSION III. Better Fuel Services: Can We Afford Them?

Chairman of Session:

THE DOWAGER MARCHIONESS OF READING, G.B.E.

1. The Costs of Fuel Services

By HUGH GAITSKELL, M.P.

PARLIAMENTARY SECRETARY, MINISTRY OF FUEL AND POWER

I want to express my admiration at the outset for both the Simon Report and the Egerton Report. I am not going to say that I would necessarily subscribe to every word of the Simon Report, and I know perfectly well that on some of the technical aspects there is a good deal of disagreement—I heard it severely criticised in Section G by experts—but I do not think it would be denied that that report has crystallised attention on the problem of domestic fuel policy in a way which has never happened before, and it has made an ever wider circle of people in this country conscious of the desirability of making up their minds on this subject. If that is all that it has done, quite apart from its material recommendations—and I think there will be general agreement on a good many of them—it is something of which those who contributed to it should really be proud.

The interest which is being shown in fuel policy is no doubt partly based on the fact that it is not very easy to get coal. Therefore, whether we like it or not, fuel economy is forced upon us. If that is the case, it may be that the shortage of coal has done some good. But I want to say at once that I do not think we should take as the background to our discussions on this problem the present coal situation. Naturally the Ministry is only too anxious to get people to economise in coal consumption. Nothing would please us better than to have someone come and wave a wand and produce a result which enabled everybody to get twice as much heat out of the same amount of coal. But there is, of course, no prospect of that, and what we are discussing here is the domestic fuel policy over a much longer period. We all know that the most obvious application of any decisions that we make will be in relation to the new houses. We all know that even when it comes to putting in new appliances, discussing whether new appliances should be put into existing houses, the appliances have a relatively long life, the houses even longer, and we are looking ahead, thinking in terms not of this year or next year or five or ten years ahead, but so far as decisions are concerned they are decisions which will be effective over a large number of years. Therefore it would obviously be quite inappropriate to make our decisions on the basis of a temporary absolute shortage of coal such as we face today.

The particular subject of this afternoon's discussion is "Can we afford better fuel services?" That is a very appropriate question to ask. Sometimes, even the greatest experts seem to me to be in danger of falling into a fallacy. They sometimes speak as though economy in fuel were an end in itself. One

has often heard people say, "When we burn coal in an open grate we only get 10 per cent. or 15 per cent., it may be 20 per cent., heat out of it as compared with what we might get in other ways". Sometimes they go on to conclude from that that any appliance in any circumstances which increases the efficiency with which coal is consumed is bound to be good in itself. I would not deny for a moment that you may have an invention of a particular appliance which involves no greater cost and gives far more heat for the same amount of coal. In so far as that is concerned it would clearly be desirable to introduce it ; but except when this is the case we have to be a good deal more careful, and we have to consider the costs on the other side. If I emphasise this point you will perhaps forgive me, because I do find sometimes that it tends rather to be overlooked. Supposing you knew that you could get far better efficiency from burning coal in the same old open grate by the housewife working much harder, by some process shall we say of sifting the ashes or what not, I think most of us would at once scratch our heads and say, "Is it really worth while, all this further going down on hands and knees ; is it not better to stick to the old 10 per cent. or 20 per cent. ?" But just because no one is, in fact, suggesting that we are going to have extra labour we are sometimes inclined to assume that we need not worry about the extra cost, because it is not an immediate labour cost. Of course it is an extra cost in an indirect sense in most cases. I think that Sir Clive Baillieu put his finger on it when he said that by and large what we are really looking for—he was speaking, I admit, rather more on the industrial side—is whether we should substitute some labour of workers in the steel industry, in the foundries, manufacturers' plant, for mining labour, and it is just as well to bear that point in mind. We have to make a full comparison when we ask the question "Can we afford the services ?" we want to know exactly what is involved on both sides, the gains on one side and the disadvantages on the other.

Having said that, let me at once turn to one aspect of better fuel services which need not detain us very long. The Simon Report refers in one short but notable chapter to smoke abatement, and here I think we can all agree that we have a rather remarkable situation. People who burn coal in an open grate and thereby pollute the atmosphere are, in fact, imposing on the rest of the community a social cost, a cost which the rest of the community pays in extra washing, in ill-health and in various other ways. The total cost of it is estimated in the Simon report at £20,000,000 a year. It is paid willy-nilly by other people, not by the people who burn the fire in grates except in so far as they have also to suffer from it. I remember when a student of economics many years ago reading what is a very well known textbook by a man who was Professor of Economics at Cambridge, and this business of the pollution of the atmosphere with smoke was given by him as a very good example of where, in effect, the ordinary working of the price system did not produce the best results. We had all this pollution because it was worth the while of no-one to tackle the problem, and yet from the point of view of the community it cost us £20,000,000 a year. The money represents expenditure in manpower and raw materials and so on, and if as a community we can invest that £20,000,000 a year in getting rid of the smoke and pollution, we shall have done a good turn for ourselves. That is one pretty important point to bear in mind when looking at fuel policy. Again, this matter has been referred to in previous reports, but nothing has been done. My Professor of Economics would, in fact, have recommended a tax on open firegrates which would discourage people

from polluting the atmosphere. Politically I think that might be difficult, there are too many open grates, and I notice the Simon Report rather suggests a subsidy to get rid of the open grate. I am not sure the Chancellor of the Exchequer would be so very favourable to that, but it is essentially a political problem rather than a technical one.

When we balance the pros and cons of these better fuel appliances, ought we not to take into account the drudgery of the housewife ? I do not suppose there will be much doubt about the answer to that. Obviously we should, but what I really mean is, in so far as the individual consumer is the person who chooses in this matter, so long as the housewife is really master in her own home it will be taken into account, we can be sure of that, but there is always the risk that she is not ; though perhaps no more than a slight risk !

Having got those points out of the way, let us look at the comparison, let us see " Can we afford these better appliances ? "

One is faced with a pretty complicated sum. First of all you naturally ask the question, " What are the alternatives ? " We have on the one side what is sometimes called the traditional method of heating the home with an open fireplace, with perhaps a little electricity or gas, and on the other hand various alternatives. Let me at once dispose of one of them on which I think I am on pretty strong ground. That is the use of electricity only for supplying the whole of both the winter and summer space and water heating needs. Some people like the idea of all-electric houses, but you come up against the great difficulty that the amount of heat we require varies so enormously in different seasons of the year that in order to have electricity to carry the whole of the winter load you would need an immense extension of generating capacity, and you would have a much bigger peak figure by a long way than you have today, between the peak load imposed on the power station and the normal load, and that would be very heavy in capital cost which would be reflected in the charges which would have to be made to the consumer.

That is all set out very well in the Simon Report, and their arguments are pretty conclusive. One hesitates to be too dogmatic, but I myself must confess with one qualification which I come to in a moment, that I must admit the argument is a very strong one.

The qualification is this. In the section dealing with district heating—perhaps in others as well—reference has probably been made by some speakers to the possibility of using atomic energy as a source of power, and one hears all sorts of talk from time to time on the possibilities in this field. One thinks of it primarily as a source of power to generate electricity. Frankly, I do not know enough about the technique, and perhaps still more the economic aspects, of this to say whether it would have any great bearing on that decision between the all-electric house and something else. I leave it in the air, therefore, and simply say that we must watch that position carefully. It may be we shall see remarkable developments in this field, and that would have a great bearing.

Having ruled out that particular alternative, let me take the Simon Report proposals. I assume that most of you by now, if you have not read the report, will have heard a good deal about it in these discussions, and you have a fair idea of what is advocated there. It is, broadly speaking, that in place of the present normal system of heating by the open firegrate, with similar open fires in bedrooms occasionally, there should be a system of background heating by improved solid-fuel burning appliances, and that that should be topped up from time to time when the temperature requires it by additional electricity

or gas. I think that is a fair statement of the Simon Committee proposals. Now let us see what they involve in terms of cost—and here I am going to give you some figures that may interest you. I am advised that the pre-war type of appliance, if we go on in that way, is likely to involve an average weekly expenditure of 8s. 1d. Let me add one qualification: this assumes that people get as much coal as they want for this purpose and burn—how lovely it sounds—four and a quarter tons of solid fuel per annum. That was about the quantity burned by many people before the war.

Now let us turn to the comparison in improved appliances. It is set out in the Simon Report, and in greater detail in the Egerton Report. One can take two or three standards here. Using the kitchen as a living room, the figure is less, and the ordinary weekly expenditure is 6s. 7d.; but with the rather higher standard house the figure is 7s. 10d. So we have 8s. 1d., 6s. 7d. and 7s. 10d. finally, one other minor variation, with a higher proportion of gas 8s. 2d.

This latter alternative first of all involves consuming slightly less solid fuel. It involves giving, on the basis of these reports to which I have referred, about twice as much comfort as before. In other words, the improved appliances are supposed to be able to provide a standard of heat and warmth and comfort and convenience, so that for roughly the same weekly expenditure you get the desired results. I say roughly, because I would not like to be tied down to a penny here or there. The point is that these figures are fairly close.

There is one other thing we have to take into account. I said that was the weekly expenditure, but of course you will say "These additional appliances, better fuel appliances, cost more to produce and perhaps to instal". In terms of the capital cost, when we regard that as a sum, I am advised again that at present-day prices the difference is, in fact, no more than about £10, perhaps possibly £20—say £10 to £20. Now the weekly cost will depend on a number of factors. It depends on the life of the appliance and various other things, but I think we should be safe in saying it is not going to increase the weekly cost by more than, say, 3d. My expert advisers gave me a lower figure but I want to be on the safe side. That is pretty remarkable—better comfort, more convenience, and—let me make it quite clear in case there is a misunderstanding—I have taken everything into account, the extra electricity required for topping up the bedrooms, and so on; all that is taken into account, and we get the comforts, convenience and less drudgery on the whole though we still have a fire instead of turning on a switch. And the extra weekly cost is very small.

Before we come to any final conclusion we ought, I think, just to take a look at what is likely to happen in the future to the various factors which make up these relative costs. Here let me make one fairly fundamental point. Coal is the basis of all these different methods of heating, and you might think, therefore, that any change in the price of coal would have the same sort of effect on all these different methods of heating; but that is not so. An increase in the price of coal makes relatively more expensive the direct burning of coal in an open grate as compared with indirect use in other forms. The exact difference, of course, depends on those other forms. Of the total costs of producing one unit of electricity which is attributable to coal, the proportion is much less than producing the same equivalent of heat by direct burning of coal. It follows, therefore, as the price of coal goes up the balance swings in

favour of indirect methods of heating. The price of coal has gone up substantially, and that is no doubt one reason why people are much more interested in this sort of thing than they used to be.

What is likely to happen if the price of coal were likely to go down again very sharply in relation to other things ? We might have to reconsider the figures I have given you. It would certainly produce different results, perhaps not very startling, but different. One is on very difficult ground here, if one attempts to prophesy, and the world is full of uncertainties, so that all I can say is that we do expect in the next few years there will be very striking developments in the coal industry on the technical side, and I think we can look with confidence to a substantial increase in productivity. It may be that as the result of that a reduction in the price of coal will become possible. It may be.

But we have to bear in mind one other thing. You all know that at the moment we are having something of a struggle on the manpower issue in the coal industry because we are short of miners. I do not think we need go into the matter in great detail, but you have all to ask yourselves one question : " Why do not people send their sons to work in the mines in larger numbers ? Why do they prefer alternative occupations, as many do ? " The reason is partly the conditions, but if we are to have miners to get the coal we may be able to improve the conditions, and that will make a difference, though it will cost money, too. It will have an effect, perhaps, on the cost of coal, but we may also have to see—and I express this as a personal view only—that the wage differential in favour of the miner, the man who does the unpleasant work which other people do not want to do, has got to be higher. You have to reckon with that. It was frankly, in my opinion, much too low before the war, and we got our coal much too cheaply. Let us face it. We got it cheaply only because we had not a state of full employment and because there were no alternative occupations available for people in the mining areas.

I leave that with you as something which you have to reckon with, and giving my own view again we cannot anticipate that an increase in the price of coal is something temporary ; I think we have to reckon with the relative price of coal being higher than it was before the war.

There is one other thing for the future that we must keep an eye on. That is capital costs. I said earlier that obviously these new fuel appliances involve heavier capital expenditure. They do. It is not very great, but it is there. One reason why I think they are to be favoured nowadays is that again, as compared with before the war, the rate of interest is lower. Those of you who come from local authorities interested in housing will no doubt be fully aware of the considerable significance that it has in the rents which have to be charged for the houses, and it has a significance, of course, in the weekly cost of these installations. Here again we need not bother to look into the future. If you are making a decision now and the rate of interest is low, it does not matter to you if it goes up later on. It would perhaps be different if you thought it was going to come down. So I think we have many things in favour of these appliances.

I have only one more point. There is a good deal of reference in the Simon Report to smokeless fuel, and from the things I have said earlier you will see how very desirable I regard that, but I must issue a warning here, I am afraid. It is no good expecting to be able to get very rapidly all the increased quantities of smokeless fuel which would be necessary if the programme recommended were to be carried out. If we were to substitute for 10 per cent.

of the coal consumed directly now its equivalent of anthracite, we should need an increase in the production of anthracite in this country of 140 per cent. You see the proportion. It is not easy to get a change like that quickly. We can look to the Coal Board to develop anthracite production, and we can expect the development of other smokeless fuel, but do not imagine that the supplies would just be there for you automatically if everywhere we introduced appliances of this kind. Therefore we must conclude, I think, that at the moment the kind of appliance we want to introduce is an appliance which can burn not merely smokeless fuel but also ordinary bituminous coal, and burn it with as little smoke as possible.

My last word—and I speak as a domestic consumer like everybody else—is that I feel one of the most valuable things we could have is experiment, and I would like to see different parts of the country engaged in house experiments under the supervision perhaps of the local authority and the Ministry if they cared to take part, just to see how people get on with the different appliances.

2. The Cost of Fuel Services with Particular Reference to Insulation

By J. WEST, D.SC., F.INST.P.

DEPUTY CHIEF SCIENTIFIC ADVISER, MINISTRY OF WORKS

INTRODUCTION

In 1938 the average housewife of a small terraced house of area about 770 sq. ft. (the typical house considered in the Egerton Report) bought, in effect, some 4 tons of coal per year to obtain 225 useful therms of heat. Actually, the amount of raw coal was usually less than this, the remainder being in the form of gas or electricity.

This provided space heating for one room, possibly an occasional fire in the parlour, and limited hot water (about 100 gallons per week). In addition, the coal provided labour and dirt.

For cooking purposes, either a further supply of raw coal was used, or its equivalent in gas or electricity (of the order of about three-quarters of a ton).

Of these 225 useful therms of heat, about 175 therms were used for space heating and 50 for water heating. To reach the Egerton standards, it is estimated that this house would require some 220 therms for space heating and some 165 therms for hot water (250 gallons per week).

Today, instead of the 1938 terraced house of 770 sq. ft., a semi-detached house of about 1,000 sq. ft. is being provided for the same household. Its corresponding space-heating requirement for the Egerton standards is estimated to be 290 therms. The water heating requirement remains the same, viz., 165 therms. Thus, through change of house and change of standards of comfort, the requirements for a housewife in 1946 have increased from 220 to 455 therms per year.

THE PROBLEM

How can we, without an increase in coal consumption, bridge the gap between 220 therms and 455 therms ?

THE SOLUTION

Any method leading to a solution must either reduce the heat requirement by better house planning and construction, or increase the useful heat output per ton of coal by using better appliances—or by both.

HOUSE PLANNING AND CONSTRUCTION

Let us consider the first alternative—house planning and construction. This involves :—

- (a) Better planning in relation to heat services and house orientation, e.g.,
 - (i) No fires on external walls.
 - (ii) Compact water heating arrangements.
 - (iii) Minimum sized windows consistent with adequate lighting and house orientation. Double glazing instead of single glazing would to some extent modify this requirement.
- (b) Better construction, e.g.,
 - (i) Better insulation of the house shell.
 - (ii) Better insulation of the water heating system. Heavy insulation of the storage cylinder is of particular importance when gas or electricity is used.
 - (iii) Better fitting windows and doors, and avoidance of cracks in components generally, to reduce unnecessary ventilation—which can be one of the major causes of heat loss in a house.

THE PROBLEM OF INSULATION

Poor insulation is perhaps the most significant factor in heat losses. Let us consider what improvements might be made, and at what cost, in the semi-detached house of traditional construction of the type we are discussing.

(a) *External walls.*—Normally, these are 11-in. cavity walls with two brick leaves. The outer leaf is of facing brick and the inner leaf is of common brick with two coats of plaster. The thermal transmittance, $U = 0.34$.

If we substitute 4-in. thick clinker concrete block for the inner leaf, we can reduce the U value to about 0.20, and incidentally, release 5,000 bricks for other purposes.

This substitution should entail no extra cost ; in fact, it would not be unreasonable to expect a saving of about £5 per house.

(b) *Ground floor.*—Normally, this is ventilated boarding on timber joists on sleeper walls. The U value is 0.35.

If we substitute tongued and grooved boarding on dovetailed fillets set on a waterproof membrane on oversite concrete, the U value will be reduced to 0.20 or less. Alternatively, we may lay pitch mastic on oversite concrete.

The relative costs of these methods of construction will depend on the site falls. Assuming, however, a reasonably level site, there should be a slight extra cost of about £2 per house by using the wood floor on fillets and a slight saving of about £2 per house by using pitch mastic.

(c) *Top floor ceiling (roof).*—In the case of a pitched roof it is normal to have rafters and tiles with a plaster or plasterboard ceiling. The U value is 0.56.

If we add a blanket 1-in. thick of glass wool or slag wool over the ceiling the U value will be reduced to 0·20.

The extra cost is £6 to £8 per house.

In the case of a flat roof it is normal to have timber joists on boarding covered with two layers of 3-ply bitumen-felt-bitumen coated with 1-in. macadam topping. A plasterboard ceiling is placed below. The U value is 0·52.

If we substitute $\frac{1}{2}$ -in. fibreboard for the plasterboard the U value will be reduced to 0·20.

The extra cost is £1 per house.

(d) *Summary.*—The estimated total effect of these changes in insulation in a house built on a reasonably level site is a saving of some 90 therms of heat for an addition of not more than about £5 to the capital cost of the house.

By attention to the other constructional factors mentioned earlier, we can reasonably hope to save at least 30 more therms. Even the close drawing of curtains at night can help considerably. Some recent experiments by the Building Research Station suggest that the wise use of curtains with singly glazed windows can reduce heat losses through windows by some 25 per cent.—equivalent to a saving of about 10 therms.

These considerations in sum reduce the total heat requirements from 455 to 335.

BETTER APPLIANCES

Let us now turn to our second alternative—to increase the useful heat output per ton of coal.

This question has already been discussed, and you are aware that there are now more improved heating appliances with an efficiency of 30 per cent. instead of the pre-war 20 per cent. and that the additional cost involved is of the order of £20. This increase in efficiency is sufficient to bridge the final gap in our requirements.

Thus, combining both methods we see that, for an outlay of about £25, we can hope to reach the Egerton standards of comfort in a semi-detached house of substantially traditional type and of area 1,000 sq. ft. with the pre-war consumption of coal unchanged at 4 tons per year and incidentally with less labour and dirt.

This outlay corresponds to a weekly charge of about 5*d.*—less than the price of one cigarette per house per day.

EXPERIMENTS AT THE BUILDING RESEARCH STATION ON INSULATED BUILDINGS

These general conclusions are substantially justified by some important experiments now in progress at the Building Research Station, and from which some very interesting results have already been obtained.

One object of the experiments was to study the effect of different standards of insulation on the heat requirements of a house of the type we have been considering ; and, thereby, to determine to what extent increased insulation is worth while.

Eight houses were built to satisfy separately the pre-war standard of insulation, the Egerton standard, a standard intermediate between the first two and a standard higher than the Egerton standard. High-efficiency heating appliances and suitable thermal measuring apparatus were installed.

In the first stage of the experiment, covering the last cold season from October to March, the houses were not occupied, thus avoiding the complication of the human factor. Instead, the customary heating activities of the household were simulated.

The general conclusion was that a standard of insulation beyond that recommended in the Egerton Report is an economical proposition.

A very recent Ministry of Health circular on this subject suggests that an addition of £80 to the capital cost of a house to raise the standard of insulation and heating to improve pre-war conditions is worth while.

NON-TRADITIONAL PERMANENT HOUSES

So far, we have considered the house of substantially traditional type.

During the last year or two, in order to provide houses more quickly without at the same time making heavy demands on certain building materials in short supply, and on certain types of skilled craftsmen (e.g., bricklayers), attention, as you know, has been given to non-traditional types of construction. Some of these houses, e.g., the Airey and B.I.S.F., are already in production; and very recently ten further types have been approved by the Ministry of Health for production.

I have gathered in a convenient form some relevant data about these houses, and it is interesting to study the choice and treatment of insulating materials and the resulting heat transmittance values. (See Appendix.)

On the whole, the Egerton standards of insulation are reached: in a few cases they are even surpassed. In some cases, however, the insulation values are somewhat below the Egerton standards although inside the requirements of the Housing Manual. No doubt when considering these house types, local authorities will take the insulating factor into serious account and may even, in view of its importance, require additional insulation.

These various house types provide excellent opportunities to study the relationship between heating requirements and comfort, and their dependence on heating appliances and insulation when the houses are occupied by the normal household.

With the collaboration of the local authorities, the Ministry of Works hopes to examine this relationship by using the services of observer-tenants selected by the local authorities. These observer-tenants, with the help of simple apparatus and by exchange of experiences with their neighbours, will be in a position to gather a considerable amount of important information.

Combined with the experimental work already described to you by Professor Mackintosh during this conference, and assisted by appropriate Social Surveys, one can hope to assess more accurately the various factors involved, and thereby design the most economic house to meet the householder's real needs.

FURTHER IMPROVEMENTS

Any further steps we can afford to take to increase the efficiency of our appliances or the heat-conserving properties of our houses will lead to an actual reduction in our estimated effective coal requirements—a matter now of extreme importance.

Present indications are that we can afford to provide standards of insulation higher than the Egerton standards.

With regard to the improved appliances operating at 30 per cent., we might hope, by arranging for some degree of selective control over the separate

activities of these multi-purpose units to increase the efficiency to 40 per cent., saving thereby a ton of coal out of our 4 tons.

A promising development lies in thermostatically-controlled heating appliances. One or two such appliances are likely shortly to be on the market. One such type—a thermostatically-controlled magazine boiler—was used in the Building Research Station experiments referred to earlier. This appliance has a slow minimum rate of burning. Its burning rate depends on the demand and there is little excess heating in mild weather. Most appliances give excessive heating in these conditions—a major source of waste. The estimated efficiency of the magazine boiler was about 80 per cent.

There remain, of course, communal methods of heating such as those envisaged in district heating. The relative merits of such schemes are dealt with elsewhere during this conference.

COOKING.

I have so far confined myself to space and water heating. With regard to cooking, of which a considerable amount is done by the use of gas or electricity, I might mention two major factors responsible for waste.

The first is poor insulation of the oven—cheap appliances are usually cheap because of their poorly insulated ovens, and are, in fact, not cheap in the long run.

The second factor is the choice of inappropriate cooking utensils for particular purposes or for particular heaters. Some housewives, for example, habitually use a small pan on a large gas ring. There is something to be said for some degree of dimensional standardisation of cooking equipment in relation to the sizes of heat sources.

THE HUMAN FACTOR

Finally, all the improvements we have mentioned—particularly in appliances (unless perhaps thermostatically controlled)—will be comparatively useless unless the housewife is knowledgeable and willing to take the fullest advantage of them.

The provision of some simple written explanatory instruction, some simple demonstrations in the home itself, and some guidance from time to time after the newer appliances have been installed, will go a long way towards meeting this final requirement.

APPENDIX

Type	External walls	Ground floor	Ceiling and roof	Remarks
Airey Urban	Vibrated precast concrete slabs $1\frac{1}{8}$ in. thick. Internal lining of plasterboard with (a) Aluminium foil membrane, $U = 0.18$ (b) $\frac{3}{8}$ -in. fibreboard membrane, $U = 0.21$	Sandwich type concrete slabs finished with wood blocks with a damp course membrane of bitumen felt, $U = 0.15$	Flat roof of 1-in. timber boards on joists covered with 3-ply bitumen felt with a sand finish. An aluminium foil membrane is incorporated, $U = 0.15$	—
B.I.S.F., Type A	Cavity construction. Ground floor : $4\frac{1}{2}$ brick facing, a 5-in. cavity and an inner leaf of 2-in. of breeze or foamed slag. Plaster finish. U : with breeze filling, 0.29. U : with foamed slag filling, 0.26. First floor : facing is of ribbed steel with a $\frac{1}{4}$ -in. fibreboard backing. U = with breeze filling, 0.23. U = with foamed slag filling, 0.22.	Solid concrete incorporating a damp proof membrane, $U = 0.20$	Ceiling of plaster on expanded metal. Roof of corrugated protected metal sheets backed with $\frac{1}{4}$ -in. insulating board, $U = 0.26$	
B.I.S.F., Type B	Cavity construction Ground floor external cladding is of rendering on dovetailed sheeting. The internal lining of $\frac{1}{2}$ -in. plasterboard to which is glued $\frac{1}{4}$ -in. insulating board. Finished with a skim coat of plaster, $U = 0.26$ First floor external cladding of ribbed steel sheeting, $U = 0.27$ With an aluminium membrane in cavity, $U = 0.16$	Solid concrete finished with mastic asphalt on screed, $U = 0.20$	Ceiling of insulating board fixed to battens on joists. Roof covering is corrugated protected metal backed with insulating board, $U = 0.25$ With a glass silk quilt, $U = 0.16$	

APPENDIX—continued

Type	External walls	Ground floor	Ceiling and roof	Remarks
British steel construction	<p>Factory made units of foamed slag concrete faced with burnt clay tiles.</p> <p>Ground floor walls 8 in. thick, U = 0.20</p> <p>First floor walls 6 in. thick, U = 0.27</p>	<p>Reinforced concrete raft finished with a screed of foamed slag concrete 2-in. thick on which "Granwood" block flooring is laid, U = 0.15</p>	<p>Ceiling of reinforced plaster units faced with $\frac{3}{8}$-in. plasterboard faced with hessian scrim and finished with a plaster gauged lime coat. Roof of light steel trusses with a plane tile covering supported by light-weight concrete slabs 2 in. thick, U = 0.31</p>	—
Cussins . . .	<p>External cladding of foamed slag concrete faced with $1\frac{1}{4}$-in. clay tiles. Internal lining of 2-in. wood wool slabs covered with plaster, U = 0.18</p>	<p>Wood joists covered with $\frac{7}{8}$-in. t. & g. boarding, U (base) = 0.40, U (covered with lino) = 0.35.</p>	<p>Ceiling two coats of plaster on $\frac{3}{8}$-in. plasterboard. Roof: single lap concrete tiles on battens with a felt underlay, U = 0.43</p>	—
Dyke clothed concrete .	<p>Formed of precast concrete cladding units. External rendering of two coats of mortar. Internal cladding burnt clay hollow tiles aluminium foil dividing the cavity, U = 0.21</p>	<p>Concrete on hardcore with pitchmastic finish, U = 0.20</p>	<p>Ceiling: $\frac{1}{2}$-in. fibreboard. Roof: normal timber construction covered with tiles on battens with a felt underlay, U = 0.30 — 0.33</p>	—
Easiform . . .	<p>9-in. concrete cavity walls. Outer skin $3\frac{1}{2}$-in. gravel concrete. Inner skin $3\frac{1}{2}$-in. breeze concrete, U = 0.26</p>	<p>$3\frac{1}{2}$-in. concrete on hardcore, with pitchmastic finish, U = 0.20</p>	<p>Ceiling: plasterboard, with glass fibre quilt. Roof: pitched timber with tiles and felt underlay, U = 0.18</p>	—
No-fines (Wimpey)	<p>Back and side walls of No-fines concrete 12-in. thick, U = 0.31</p> <p>Front wall, 11-in. cavity brick, U = 0.30</p>	<p>Wood wool plates on wood joists covered with 1-in. floor boards on aluminium foil, U = 0.20</p>	<p>$\frac{3}{8}$-in. plasterboard ceiling on joists. Roof: tiles with felt underlay, U = 0.43</p>	—

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	Outer leaf of dense concrete. Inner leaf of foamed slag concrete. Internal finish a single coat of plaster, $U = 0.27$	covered with $\frac{3}{4}$ -in. layer of insulating material of cork and foamed slag. A further $\frac{1}{4}$ -in. layer of cement mortar screed and $\frac{1}{4}$ -in. mixture of reclaimed rubber latex and cement with hardwood chippings, $U = 0.15$	battens. Roof: Flat concrete covered with 2-in. screed of foamed slag concrete finished with two layers of 2-ply bitumen felt, $U = 0.29$	
Scottwood	$3\frac{1}{2}$ -in. thick, consisting of inner and outer skins of plywood each $\frac{3}{4}$ -in. thick. Cavities filled with glass-wool between bitumen paper, $U = 0.12$	6 in. deep, consisting of upper layer of $\frac{3}{4}$ -in. plywood and lower layer of $\frac{1}{4}$ -in. plywood. Cavity filled with glass-wool, $U = 0.10$	Roof is flat and similar in construction to the floor. Top ply $\frac{1}{4}$ -in. thick, lower ply $\frac{1}{4}$ -in. thick. Roof covered with bituminous roofing, $U = 0.10$	Complies with Fire Code of Practice. Heat capacity very small.
Steane, Type B	Factory made panels of clay tiles backed by 1-in. of cement concrete. Internal lining of plywood backed with aluminium foil, $U = 0.28$	Reinforced concrete raft. Kitchen, scullery and hall finished in Terazzo, $U = 0.20$ Remainder finished with wood blocks laid in bitumen. $U = 0.15$	Ceiling of $\frac{3}{4}$ -in. plywood with brush applied plaster finish faced with aluminium foil on upper side. Roof covered with asbestos cement sheets on wood battens, $U = 0.35$ With felt underlay, $U = 0.20$	—
Unity	Covered externally with slabs of medium weight concrete (115 lb./c. ft.) and internally with slabs of light weight concrete (90 lb./c. ft.), $U = 0.33$	Concrete raft with a waterproof membrane and a 2-in. cement and sand screed on which are laid softwood fixing blocks. Floor covered with $\frac{3}{4}$ -in. t. & g. boarding, $U = 0.15$	Ceiling consists of a 2-in. \times 1-in. timber frame covered on one side with $\frac{1}{2}$ -in. asbestos cement sheets. Pitched roof of wooden rafters with asbestos trays to carry concrete tiles. A glass silk blanket is incorporated, $U = 0.19$	—
Wates	Formed of pre-cast vibrated concrete blocks. Internal lining of timber frames faced with $\frac{1}{2}$ -in. plasterboard backed with $\frac{1}{2}$ -in. glass-wool blanket, $U = 0.21$	4-in. reinforced concrete on hard-core with $\frac{1}{2}$ -in. pitch-mastic finish, $U = 0.20$	Ceiling of $\frac{3}{4}$ -in. plasterboard on joists. Roof covered with single lap concrete tiles, $U = 0.43 - 0.56$ (with 1-in. slag wool $U = 0.30$)	—

Note

The above values of U are based on the known thermal conductivities of the materials employed. Since account has not been taken of detailed structural features such as the presence of framing members, the U values in actual practice may differ slightly from those calculated and tend to be somewhat greater.

As the development groups associated with various types of house progress, certain modifications in detail are from time to time introduced. After approval by the Ministry of Health further modifications are sometimes judged necessary in localities where a shortage of particular materials has occurred. It is, however, important when considering substitute materials to take into account the resulting effect on the thermal characteristics of the house.

The Ministry of Health has given general approval to all of the above types of house construction ; some of these are mentioned in Ministry of Health Circular No. 175/46. Many other types not mentioned above are being studied.

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Professor Zuckerman (Member of the Scientific Advisory Committee, Ministry of Works) said that he had been asked to discuss the question : “ Can we afford not to have better fuel services ? ” If the Simon Report were accepted, the answer must clearly be in the negative. If the question were propounded to him as a scientist he would be bound to confess that the problem contained too many variables to admit of a scientific solution. If better fuel services were not provided, would the health of the nation suffer ? Did the quality of mental work depend upon the temperature and degree of comfort provided ?

By good standards of domestic heating he understood the provision of fuels and appliances of qualities and at prices which would enable conditions of full health and comfort to be enjoyed by all members of the household with the minimum of dirt and labour, accepting the standards prescribed in the Egerton Report. That was one objective of a national fuel policy. Another was that these services should be secured at low cost to the householder and with the maximum of convenience, that involved high-efficiency appliances and insulation. Yet another objective was to conserve the nation's reserves of coal. Finally, smoke must be abolished. All these objectives were technically desirable.

A contribution that the scientist could make was in regard to standards. The Fuel and Power Advisory Council accepted the standards laid down by the Egerton Committee. Those standards were different from those accepted in the U.S.A. and there was no certainty about them. It was not known whether the higher temperatures favoured in the U.S.A. were necessarily productive of greater human energy, of better health, or whether there are other psychological effects. It was known that health was improved by improved living conditions but it was not known what were the optimum living conditions. The determination of these conditions was important. If a lower temperature than the 65° F. usually recommended for sedentary work in this country could be used, less fuel would be needed for space heating.

The speaker said that his positive contribution to the discussion was to press for research into all these problems. It was essential to know at what temperature to aim in space heating, and whether comfort is associated with health and energy or with a lack of these qualities.

The real question was not “ Can we afford not to have better fuel services ? ” but “ Dare we afford not to ? ” The scientist in turning his attention to standards and needs provided the fine adjustment to a screw that was already turning.

Finally, in discussing fuel and the future in relation to scientific work, it must not be forgotten that we were on the brink of a social revolution brought about by a major scientific discovery, atomic energy. Already it had been announced in the U.S.A. that the cost per kWh of electricity provided by atomic fission would not be very much greater than that provided by other known standard methods. What would be the position in this country twenty years hence, in view of the higher cost of coal here and the smaller reserves of fuel ?

His recommendations would be to instal better domestic fuel services, to embark upon more social research into standards for space and water heating and to look to other, new, sources of energy.

QUESTIONS

A number of written questions were handed in, answers to which were given by the principal speakers. The name of the speaker answering each group of questions is given at the head of the group.

Answers by Mr. Hugh Gaitskell, M.P.

Question : Does the 3d. a week mentioned as the increased cost of the new appliances include interest on capital ?

Answer : Yes.

Question : Will costs of electrical and gas services be standardised nationally so that more sparsely-populated regions will not have to pay much more per unit or per therm than more densely-populated regions ?

Answer : This is a thorny problem. It is the desire of the Government to reduce the price of electricity especially in rural areas, and it is hoped to do this as a result of nationalisation, but it is not decided whether the policy will be to have a single national charge.

Question : Mr. Gaitskell mentioned only anthracite as smokeless fuel. Surely the carbonisation industries provide more smokeless fuel as coke and gas, and as coke was exported in large quantities pre-war would this source not provide the necessary smokeless fuel for domestic purposes ?

Answer : It is quite true I did not refer to coke. The position now, whatever it may have been before, is that we would certainly not export any coke, I think, or only a trickle of coke, at the moment. The domestic coke consumption has actually risen from two and a half million tons in 1939 to nearly three and a half million in 1943, which is the latest figure I have. The difficulty is that the supplies of coke really depend largely on the production of gas, and as the gas industry expands and the demand for gas continues to expand, greater supplies of coke become available. All I was trying to point out was not that we should not get more smokeless fuel in time, but it was no good expecting to be able to turn out enough anthracite at the same cost as coke in a matter of a year or two to enable everybody to change over to smokeless fuel.

Question : I learn with regret that it will be a long time before sufficient smokeless fuels are available for the open fire. What are the difficulties in increasing the manufacture of smokeless solid fuels such as coalite ?

Answer : That is another form of carbonisation, and there is the same difficulty as far as the immediate position is concerned as with gas ; that is, lack of carbonising plant.

Answers by Dr. J. West

Question : Is it not rather late in the day to talk of standards ?

Answer : It is never too late ; standards are continually changed with changing conditions.

Question : Is it not rather late to talk of standards when designs for new houses have already been accepted and houses built ? Houses are already up. Why was it not brought forward earlier, before the scheme was formulated ? These new houses will be out of date before they are completed, and our housing programme built before the appliances are available in country districts.

Answer : We cannot wait for the perfect solution. A good deal of co-operation on the part of the local authorities is involved, and these attempt to

find out by trial in the houses themselves that have been put up with people in them what are the real needs and what are the reactions to the various appliances and improvements made. If we can find a solution to that we should act as soon as we could, but we cannot wait for the perfect solution. We have first to put up the houses as quickly as we can with the data available, and then take all the steps we can to get fresh data to make sure that the houses still to go up will be an improvement on those that went up last. The houses going up today have quite good insulation, but if from knowledge of what materials have gone in you know that the standards are below the Egerton standard, you can often improve them. For instance, ceilings can be additionally insulated by putting a 1-in. layer of slag wool or glass wool above the top floor ceiling. That will cut down the heat losses very considerably, and the price of that, if it is glass wool, is of the order of £5 and if of slag wool £8.

Question : Does the insulation of a house lessen or increase the fire risks ?

Answer : In general it will lessen it. There is no reason for increasing it unless it uses material which is itself inflammable. Glass wool and slag wool are not inflammable, they improve the fire risk, and in fact fires are often caused because appliances are not insulated, for example, the flue pipes from the stoves.

Question : Was the £8 mentioned in the discussion inclusive of material and labour for fixing ?

Answer : It includes the labour for fixing.

Question : If bitumastic is used for floors, would not there be complaints of cold feet by tenants ?

Answer : This is a very good example of what was said previously about people's reactions. We want to find out to what extent these reactions occur. I cannot say off-hand what would happen.

Answers by Mr. Symon, Ministry of Health

Question : Is any standard of insulation insisted on by the housing Ministry or is the adequacy left to the discretion of local authorities ?

Answer : It is the primary responsibility of local authorities to look after the housing in their own areas. The Ministry of Health have not come to the stage yet, or have passed it, when it dictates too strongly to people like local authorities. Full guidance and directions are given, such as have already been issued on insulation, and local authorities are asked to advise the Ministry how they are getting on.

Question : Is the standard insulation system approved by the Ministry now being incorporated in Council houses ?

Answer : The answer is : Gradually, yes. Our powers of persuasion we believe are being effective, and we ask the local authorities to let us know how they are getting on, and to what extent they want to use the materials which are sometimes required, so that we can increase production and make some more readily available.

Question : The shortage of appliances must make the permanent Council houses a nightmare to fuel economists for the next 50 years. Should the Government urge local authorities to concentrate on prefabricated bungalows and Swedish wooden houses in which convected-air methods of heating are embodied ?

Answer : There are about 13 million houses already in this country and the number of houses that we can build within the next year or so can only be a very small proportion of that 13 million. I do not think, therefore, that the new houses that might be building today and tomorrow, in which we can incorporate these appliances, will make very much difference to the headache of the fuel economist. That there is no reason whatever why these new appliances should not be incorporated in many of the traditional types and certainly many of the new types, quite apart from prefabricated bungalows and Swedish wooden houses. Prefabricated bungalows and Swedish wooden houses are merely an example of what we can do when we really get going.

3. Review of the Discussions in Section H

Sir Guy Nott-Bower : Probably most of us, at the end of discussions like these, are inclined to put together something in the nature of a profit and loss account. When I addressed the meeting I was careful not to be too cheerful. Possibly I was too careful, but I did think that at the beginning at any rate of a conference of this kind, honesty was the essential policy. It is no good merely drawing rosy pictures of things which are just round the corner. If I was less than optimistic I know you will forgive me, but having considered what has transpired at this meeting, and having made in my own mind my own profit and loss account, I am perfectly certain that the general impression left on all our minds is one of great cheerfulness and hope.

There are one or two things which are not too good on the debit side of the account. We have learned, for example, that the provision of the full quantity of solid smokeless fuels which the Simon Report calls for is likely to be delayed for some little time because of the necessity of large-scale re-organisation in the coalmining industry, and the addition of fresh plant in the carbonising industries. That is, of course, something in the nature of a debit in our accounts.

There is also on the debit side the fact that the present transition conditions, with the shortage of labour and materials, confront us for a short time with a lack of some of these appliances. The Government have already placed large orders for some of the latest types with manufacturers of domestic fuel appliances. The work is going forward at full speed on these large orders, but there, to a less degree, we have to face a certain amount of temporary and passing frustration. We shall be very soon round that corner, and these new appliances will, in the comparatively near future, be available in large quantities. That is the debit side of the account.

On the credit side of the account, we have heard perhaps a most interesting and inspiring address from Dr. West. It is perfectly clear that we can go a long way now immediately to bridge the gap between the old fuel standards of the house and the new ones by methods of insulation and by new methods of building construction. That is a very hopeful aspect of the question, particularly from the point of view of local authorities who, I am sure, have also put into practice many of Dr. West's precepts.

In addition to that, on the credit side, we think we can fairly say that the holding of this conference is itself an enormously encouraging factor. This is the first time in the history of this country that very large numbers of people have

become fuel efficiency minded. One of the difficulties of the past, as any one will realise at once who looks over the history of fuel in this country, has been that we have had a great deal of coal, coal has been wasted prodigally, and it has been no-one's business to think of fuel efficiency. We have been told, for example, that the problem of smoke pollution has not been tackled simply because it was to no-one's interest to do it. This conference and the other signs of awakening interest which we see all over the country now, are an enormous asset in tackling the problem which lies before us today, and when this conference breaks up and when the many people who have given up time to attend it, go back to their homes and start spreading the gospel which we have been trying to spread here, the result will be a very rapid step forward.

I would therefore like to take this opportunity of thanking all who have come, particularly to the meetings of this section, for the interest they have displayed and for the trouble they have taken. I have already paid my tribute to the local authorities, and I should like also to pay a very warm tribute to the women's organisations who are so largely represented here today, and who have already rendered enormous service to the Ministry of Fuel and Power in the voluntary help they have given our domestic fuel organisers in spreading education and information.

We have, as Mr. Shinwell said in his opening address, to face a problem of very great seriousness, but we ought not to allow that problem to obsess our minds. The thing which is of abiding interest to all of us is the future of fuel efficiency in this country. Anybody can use fuel but it takes a wise man to use it properly, and nothing is clearer than that the industrial future and supremacy of this country in the face of world competition must depend on how many people take an interest in fuel efficiency, and how determined the man in the street is to see that never again shall we go back to the old haphazard methods.

I would like to draw the attention of everybody here to the service which the Ministry of Fuel and Power can offer you in the Regions. I have had to tell you that so far, owing to shortage of staff and accommodation, it has not been possible to implement the Simon Committee's recommendation that we should have centres of information all over the country. It is obviously necessary that that should be done at the first possible moment, and you can rely on us to do it, but in the meantime I would like those of you who did not know it to realise that we have allotted domestic fuel organisers to each of our twelve regions, and they are working in close contact with our fuel efficiency engineers also at our regional headquarters. Anybody who wants help or advice in all these matters should in the first instance go to our regional offices and consult our fuel organiser, and if necessary the regional engineer.

I should also like to thank the Domestic Fuel Efficiency Committees, to whose success women's organisations have so largely contributed.

I do not want to say anything more about the present problem, because Mr. Shinwell has already dealt with it fully, but questions have been asked during the sessions of this section as to what can be done by people today to get a greater amount of fuel economy to meet the short-term problem. The answer to this again is that our regional organisers will provide literature, films and advice to anybody sufficiently interested, and I hope that everybody will take full advantage of that.

The Chairman: During the last eight years I have worked a great deal with local authorities, and during that time my respect and admiration for them has grown. I have learned a great deal from them, and I think one basic

thing which is not always realised centrally is that local authorities live with and on their problems ; they never escape the people for whom they work ; they are at the doorstep of those people and therefore their practicalness is imprinted on them even more strongly than it would be otherwise. For that reason local authorities are keen to know the most modern and best appliances in order to get the most up-to-date and best information. During these two days they have had a great deal of fuel for thought, quite apart from the other sort of fuel.

As many speakers have said, we are on the brink of a great fuel revolution, and unlike most revolutions it has taken place in Great Britain. It is one to be anticipated and looked forward to and gone into with our eyes open. The success of anything ahead of us will depend on our courage in abandoning the bad ways of the past and in being ready with receptiveness for anything good that there is ahead.

I do want to adjure everybody—men, women and children—to have an open mind towards the future, so that we can get the very best there is.

In Great Britain we are queer creatures ; we do not understand ourselves, but certainly no-one else understands us. For that reason we have an opportunity to seize any new idea that comes and make it what we will, and by attendance and by the interest shown the informed part of the community that has come here is going back with a greater awareness of what is possible and practical.

I have finished being in the chair, and so I now feel at liberty to say this to local authorities. Do not behave yourselves. Go on attacking and attacking for what you want, and in the end you will get it. Keep on asking for the things you want. Demand information. It is the only way to get it. Keep on attacking for improved and tried appliances. We do not want an appliance which we are told is good without knowing what its trials have been. We want to know not only that it is better than the last, but more effective. Let us keep on reminding everybody, because it is terribly important to all of us that appliances should be at a cost within the pocket of the mass. We are not talking about the individual who can afford something, we are talking of something which should be available to Mr. and Mrs. Smith; Mr. and Mrs. Jones, Mr. and Mrs. Brown. Ask for advice ; we want the answers quickly.

I would like to urge the establishment of advice centres. The local authorities implement central legislation, but the centre is very snowed under with work, and therefore it is important to remember the Portuguese proverb : " Call on your aunt, but not every day ".

Remember to urge more education. We have had ample evidence of the lack of education, but in urging more education remember that the persons you are urging may not be as intelligent as you are yourself, and therefore tell them what sort of information you want.

We must not let new ideas go to sleep in our heads. We have to apply them and plant them. This is the right time of the year for planting anything that is going to last some time, and we have to keep on improving.

From the local authority angle we want to urge the incorporation of utility services in all new houses as they are being built, not afterwards, not putting off to the day after tomorrow, but immediately, even if all appliances cannot be connected immediately.

Above all, we want to preach the gospel of insulation, and we want to practise it also.

We want to urge so far as possible on local authorities and all other people who have the power to adopt it, experimentation of all kinds under supervision, experiments which will bring us more information in regard to social research and in other directions. In that way we shall see that example as well as precept come into it seriously. The day-to-day use of equipment is obviously the best way to use equipment to advantage. It is also the best way to implement the things that we have not talked about at all, which is a very big responsibility. In Great Britain we believe that people have a duty, and that they see that duty without it being constantly pushed under their noses. We accept the individual contribution towards the community, and I think perhaps the greatest tribute which has been paid to all delegates today is that nobody has kept on saying "What are you going to do about the immediate six months? How are you going to save what Mr. Shinwell asked you to save yesterday morning?" The greatest tribute to the individual here is that it is taken for granted that he or she will extract from what they have heard the best use of the information in order to put it to immediate service.

To the voluntary organisations, who are naturally very close to my heart, I say that I know the volume of work you can do. The first thing that you have to do is to examine how you are going to make use of the wealth of information that they have had during these last few days.

The tribute paid to you was no mere lip service; real pleasure is felt by all your colleagues at the immense amount of work put in by all the voluntary organisations.

On the short-term six months, quite obviously we all of us who are in voluntary organisations must apply ourselves and devise methods by which we can do the very best job possible. We have done it before, and we can do it again.

On the long-term five or seven years, we have to think not on a saving basis but a thrift basis—a word that everybody hates, but a word which should be more popular because it leads to something worth while. We want to think in terms of fuel watchers, fuel housewives. We want in future to bring it down to the very lowest common denominator, so that the person who is the actual practical user will also be the practical saver.

We want to help that work by short training wherever we can get it, short training which will have a relation to being qualified, in the same way as a first-aid course has a relation to nursing. We want to do all we can to help, and I believe we can do it. I believe that by definite undertaking, definite resolution, even today after we have had a long and tiring time during the years behind us, we can undertake a difficult task and carry it through. The reason I believe that is because we have a vision ahead of us, and we know that through a morass we are trying to reach a place where a better life will be available to us and to those who come after us.

If a thing has a spiritual idea behind it it has greater strength than anything else to carry it through, and in closing this session I would like to say that I think there is more than just the practical thing that we are thinking of in all this work. There is something deeper. It is our urge to make improvements, and in making improvements we want to ensure the happiness and contentment of those who come after us in the future.

At the Closing Session of the Conference, the Chairman of Section H, **Lady Reading, G.B.E.**, gave the following summary of the principal conclusions that could be drawn from the three Sessions :

The section over which I had the honour to preside took full opportunity of the conference and made certain recommendations.

The first of these recommendations was that their very great desire that the need for utility services to be placed on an exactly balanced basis and incorporated into all houses as they are being built and not being left till later should be well remembered.

Secondly, that in regard to appliances, improved and tried appliances should be provided, and that such appliances should be within the purchasing power of the masses. It was the strong recommendation of all those attending the conference that the Government should give every encouragement for the speedy production of such proved appliances.

They also wish to make it very clear that in their view it is absolutely essential that there should be availability of cheaper appliances throughout the country. They were very insistent on the fact that the investigation of appliances, with special regard to the easing of strain and fatigue, should be watched.

They also asked whether it would be possible for consideration to be given to the suggestion that instructions in regard to such appliances should in future be given in language understood by the masses, and not merely by technicians.

They asked strongly that a good deal of experimentation should be undertaken, and that such experimentation should in every case be under supervision so as to gain maximum efficiency.

They strongly advised that hot water should be piped and become a public utility service in the same way as cold water is.

They felt strongly that if the value of central deliberations was to be disseminated at local level education was very important.

They advocated a big campaign of efficiency as a long-term programme and a short-term campaign as regards the present critical outlook and the immediate implications on that basis.

They also urged that if the future problem of fuel is to be given the best implementation by local endeavour, education should be carried into the home and into the school.

They asked that consideration should be given by those in the centre to ensure that in future better information be given from the centre to local authorities, with applied evidence and without vague generalities.

They also asked that Fuel Advice Centres throughout the country should be made available at the technical level ; and also at the man-in-the-street level ; and in general they asked that an investigation into the costs of continuous-burning appliances should be considered with special regard to draught regulation and labour-saving capacity.

JOINT SESSION II.

DISTRICT HEATING

Chairman: SIR PATRICK DOLLAN

CHAIRMAN OF THE SCOTTISH REGIONAL FUEL EFFICIENCY COMMITTEE

THE CHAIRMAN, in opening the session, said that he hoped that many of the expedients advocated in the domestic section of the conference would be rendered unnecessary by the rapid development of district heating during the next 20 years, in both new housing estates and also in the older houses. The electrical industry, with its maximum power station efficiency of little more than 30 per cent., may sometimes be using inferior fuel, as was claimed by speakers at the conference, but it was also using capital that could be utilised in erecting plant giving some 70 or 80 per cent. of the thermal value of the coal. All this waste must be eliminated and had been eliminated in New York and some European cities.

At least three minor schemes of this character had been put into effect in Scotland. One, at Craigie, was based on a continuous supply of hot water to over 200 tenants; one, at Troon, was applied to a group of 100 houses; and one semi-industrial company, operated by Michael Nairn and Co., linoleum manufacturers, of Kirkcaldy, catered for an old estate and for 35 years had operated with an efficiency of 67 per cent. Industrial firms who had surplus steam would be well advised to study the Kirkcaldy scheme. When the efficiency of this station was compared with the 30 per cent. efficiency of a modern power station such as Battersea, it was realised that lamentable waste must be taking place all over the country that called for immediate examination.

At Dundee, where there was the only communal heating scheme in Britain, 520 houses had been heated by a district scheme since 1924. Those who lived in the houses were highly satisfied; during the war the tenants of these two and three-apartment houses were getting their space heating and hot water for 3s. 6d. and 4s. 6d. a week, respectively, now raised to 4s. 9d. and 6s. 6d. For this they had an equable temperature day and night, with saving of work and increased convenience. The open fire was unnecessary, though used occasionally for the benefit of visitors.

It had been asked why the Dundee scheme had not been extended to other areas and why it had not been duplicated in Dundee. The attitude of tenants, especially in the lower income groups, was that district heating involved paying 4s. 9d. or 6s. 6d. a week extra, but this ignored the saving of 7s. to 8s. a week on coal. The speaker suggested that wherever district heating schemes were installed the charge should be collected weekly and collectors should explain that district heating was a substitute for coal, not an additional charge upon the rent. Two other local authorities had decided to experiment with the Dundee plan. At Glasgow, 560 houses of four or five apartments, with public buildings, were to be heated at an estimated cost of 4s. 6d. a week for each house; here it was thought that the larger the scheme the greater would be the economy. But at a Midlothian mining village, Bonnyrigg, a scheme

to heat 182 houses had been estimated to cost the tenant* 8s. 9d. a week. Other schemes were projected or in course of construction, including Manchester, Salisbury, Birmingham and Urmston.

1. District Heating as a Public Service

By A. STUBBS, B.SC., M.I.MECH.E., M.I.E.E.

1. District heating as a public service may, for the purpose of this discourse, be conveniently considered as the supply of heat for space heating and hot water in the form of a public utility service, comparable in scope with existing electricity, gas and water services. It may be provided for communities differing widely in size from housing estates to large cities. It is, however, to be regarded as distinct from the supply of heat to consumers or groups of consumers of one specific type, such as may be found in many large central-heating schemes. For present purposes it is convenient also to disregard the supply of heat for manufacturing processes, which practice is already fairly well understood. The possibility of including process heat may be reserved for the particular example as being something supplementary which is going to add to the case for district heating in that instance.

2. District heating regarded in this way deals with the major heat requirements of the people, but it presents problems outside present experience in this country, nor can experience abroad be accepted without interpretation and qualification.

3. A detailed study of an illustrative large district heating scheme has been made for the District Heating Sub-Committee of the Heating and Ventilation (Reconstruction) Committee of the Department of Scientific and Industrial Research, the chairman of which is Sir Alfred Egerton. This scheme will be fully described in a comprehensive report on district heating being prepared by the sub-committee. In the meantime some of the figures relating to the scheme will be used in the following paragraphs by way of illustration. Any prices quoted relate to the year 1937, when the Board of Trade index figure for intermediate products was around 100 per cent.

4. One of the first things to establish is the thermal load characteristic of district heating, and since experience does not present suitable records it is necessary to examine the various types of heat load and the manner in which these are likely to be integrated so as to form a complete whole.

There are three main types :—

(a) Industrial and commercial buildings.

(b) Community buildings, including schools, hospitals, churches and the like.

(c) Housing, including flats.

5. The particular points of importance in relation to the thermal load curves are the maximum heat demand and the summated or average demand, although it is also of interest to know the load curve shape when estimating

* The original scheme for Bonnyrigg has since been revised, with a substantial reduction of the weekly charge.—Ed.

the plant which is to be reserved as standby, or when considering district heat generation in relation to another service such as electricity generation.

The heating loads of industrial and commercial buildings, as well as of community buildings, can be estimated from existing central-heating experience, although the integration of the various loads does require special consideration. The heat load for small houses needs separate examination in view of its being a substantial part of the total load, and because there is not experience available with this type of load when connected to a district heating service.

6. In the illustrative scheme already mentioned, houses considered collectively have been estimated to have an annual consumption of :—

182 therms for hot water
393 therms for space heating
<hr style="width: 20%; margin: 0 auto;"/>
575 therms total
<hr style="width: 20%; margin: 0 auto;"/>

whilst the maximum demand per house has been estimated as :—

3,000 B.Th.U./hour for hot water
12,000 B.Th.U./hour for space heating
<hr style="width: 20%; margin: 0 auto;"/>
15,000 B.Th.U./hour total
<hr style="width: 20%; margin: 0 auto;"/>

In determining these figures it is considered that it would not be desirable to assume that the ordinary householder would be prepared to pay more for space heating and domestic hot water supply from a district system than he does at the moment for heat obtained from burning solid fuel for the same purpose.

The solid-fuel requirement per house for space heating and hot water may be taken as 4 tons per annum, which, at 60s. per ton, would be £12 per annum, and would give 330 therms per annum effective heat.

The maximum demand of 12,000 B.Th.U. per hour represents the heat emitted from 75 sq. ft. of hot water radiator surface. For a normal two-storey house of 500 sq. ft. ground floor area this would be sufficient for continuous heating to 65° F. in the living room in severe weather, with a small amount of heating in the kitchen and upstairs.

It has been assumed that the district heating service would be suitable for the supply of heat to installations of normal design, using hot water as a heating medium at temperatures normally employed in this country. Also for the purpose of hot water supply a calorifier would be necessary.

Hot water may be chosen as the medium for distribution of district heat. This choice incidentally permits of a centralised control such that the heat supplied to houses would be in reasonable relation to requirements dictated by external weather conditions. This inherent feature of the system makes house metering unnecessary, which is a matter of practical advantage.

7. As already stated district heat may be supplied to a small community, a large town or city. An examination of the large scale application involves most of the problems of the small scale application. The build-up of the complete load will in all cases depend upon the proportions of the various types of load.

The study of a typical town presented the following interesting figures :—

Area of town	25 square miles.
Population of town	250,000
Population served	60 per cent.
Developed area (acres) :	
Industrial and commercial	1,355
Community	1,475
Housing	5,700
	<hr/>
Total	8,530
	<hr/>
Maximum demand, therms/hour :	
Industrial and commercial buildings	7,680
Community buildings	2,440
Housing	6,180
	<hr/>
Total	16,300
	<hr/>

Load factor:

Industry and commercial	20·4
Community	20·0
Housing	43·7
Overall	29·3

Interest in the housing load is increased because of the relatively high load factor.

8. Large-scale applications approaching full development may be expected to have the same features as are found with other services, such as electricity supply, viz., central generation, the main distribution and the sub-distribution.

The main and sub-distribution will be by pipe systems installed underground, the pipes being suitably insulated and protected. In the generating station and the sub-stations pumps will be operated to deal with the heat conveying medium.

In the case of the typical town with 60 per cent. development, the total electrical energy absorbed by the pumps is $35·4 \times 10^6$ kWh per annum. The heat losses per annum are :—

Sub-distribution system	$5·366 \times 10^6$ therms
Main distribution system	$3·184 \times 10^6$ therms

which total heat losses correspond to 17·3 per cent. of the total heat sent out from the generating station.

9. Heat required for district heating is relatively low grade, much lower grade, in fact, than that which may be used in the ordinary power generation cycle. This remark is applied to the steam turbine cycle, but it would also apply to the Diesel cycle and the gas turbine cycle.

The heat for district heating may be generated most simply direct in a boiler plant ; the steam generated being used in calorifiers to transfer the heat, to the transmitting medium. In many small schemes this may well be the practice adopted and even in the larger schemes a considerable proportion of the heat would be dealt with in this manner through peak heaters, but there is still a large proportion of heat which may be generated under conditions which involve a compromise between the straight heat cycle and the power cycle.

10. The study of this compromise leads to the thermal-electric station. The study is complex for it involves not only the thermo-dynamic features and the apportionment of the heat costs between district heat and power, but also the proper use of the capital invested and the apportionment of the capital charges in a similar manner.

The net result, in the case of the typical town with its 60 per cent. development, is to reduce the cost per therm to the consumer by approximately 20 per cent. when heat is generated at a combined thermal-electric station, as compared with the cost of heat generated at a straight heat station.

11. The cost of heat supply for the typical town with 60 per cent. development, and with the generation at a combined thermal-electric station, is shown in the following figures :—

Consumers' maximum demand—16,288 therms/hour.

Annual fixed costs—£39·5 per therm/hour maximum demand.

Annual consumption at consumers— $41\cdot81 \times 10^6$ therms.

Running costs—0·93 per therm.

Over-all cost per therm at consumers—4·62*d.*

This over-all cost is distributed as

Generation	1·44 <i>d.</i> per therm.
Main distribution	1·18 <i>d.</i> „ „
Sub-distribution	2·00 <i>d.</i> „ „
	<hr/>
Total	4·62 <i>d.</i> „ „
	<hr/>

An examination of the distribution of costs between the various types of load seemed to indicate that it would be reasonable to regard the total average of 4·62*d.* per therm as applicable to the housing load. This somewhat unexpected result arises from the high load factor of the housing load which serves to off-set the greater spread of the housing load, which, by itself, increases the distribution costs.

12. The fuel economy to be obtained by the use of a district heat service to the typical town in its 60 per cent. developed stage is shown by the following figures :—

Total annual coal consumption allocated to the supply of heat—145,000 tons.

The corresponding fuel consumption with existing practice would be :—

41,385 houses served at 4 tons per house = 165,000 tons/annum.

Industrial, commercial and community = 112,000 „ „

Total	277,000 „ „
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Giving a total annual saving of 132,000 tons/annum.

13. District heating offers the prospect of a very large saving in fuel. For every million people who receive the service there is the prospect of a saving in coal of $0\cdot8 \times 10^6$ tons per annum. The advancement of the art of power generation is not likely to remove this potential saving, for district heat generation may be coupled with the most advanced power generation contemplated at least for some years to come.

2. District Heating in Relation to Town and Country Planning

By W. G. HOLFORD, A.R.I.B.A., M.T.P.I.

LEVER PROFESSOR OF CIVIC DESIGN AT LIVERPOOL UNIVERSITY

Town and country planning is a co-ordinating activity which covers the various developments and uses to which land may be put. It is concerned with estimating and controlling—in the public interest—the amount and rate of development produced by building demand, agriculture, and mineral working ; and it is also concerned with the social consequences that arise from the adoption of a particular plan or programme.

District heating, as a comparatively new element in this picture, is of particular interest to the town planner for two reasons ; first, because, as a service, it offers immense opportunities for improvement in amenity, convenience and public health ; and secondly, because it sets certain physical and economic problems which require something more than good engineering to solve them. These problems are serious because they are relatively permanent in character and affect the distribution of homes, offices, and factories as between town and country. It stands to reason that a public utility provided at high capital cost, taking a long time to construct, requiring rights of way under the streets for its distribution, and mass-consumption for its economic operation, will be a long-term investment and will tend to stabilise the layout of the houses or factories which it serves. This involves questions of location, of plan-forms, of building, and of rent ; and therefore the subject is one in which planner, engineer, architect and housing manager must co-operate.

First, then, let me outline very briefly the advantages of district heating from the planning point of view. I shall leave it to others to deal with a most important one, namely, the more efficient use of the nation's coal resources. I shall deal mainly with the consumer, the housewife, the worker, the citizen, the person whom planning is intended to benefit.

The main advantages which the public would derive from rational and efficient large-scale heating systems, are the indirect ones, and these are the most difficult to assess in terms of cost. The greatest is probably the reduction of fog and smoke. Town planners look with envy at the sites of new towns in the Mediterranean area because they are free from atmospheric pollution ; architects see their buildings reduced to drabness within their own lifetimes owing to the effects of black smoke and sulphur dioxide ; and the average householder no longer reckons smoky chimneys as signs of prosperity, but associates them with black towns, and depressed areas, and tries to find a house where the curtains will not need cleaning every week. But these likes and dislikes are nothing compared with the toll of disease, discouragement, and death which is all the time being paid in the background. There are towns where the death rate and the incidence of fog are equally high from the middle of November, to the middle of January. There are whole regions of Britain in which a prolonged damp season reduces health and impairs efficiency. On the other hand, I know of a damp valley in County Durham where fog has been practically eliminated through the centrally-heated factories and offices. A little heat in winter, and fresh air and sunlight all the year round, are the greatest amenities which a town planner could wish to secure, both in the

development of new towns and residential neighbourhoods, and in the re-development of slums and derelict areas.

Next comes the interesting question of zoning. One of the problems of planning is to group similar activities and uses together for the sake of convenience, common services, and protection from conflicting types of development, and at the same time to prevent such huge segregations of houses or factories that workers have to travel a long way from their homes, and the districts themselves become monotonous and unsociable. So we usually try to avoid the indiscriminate mixture of factories and houses (such as you see, for example, at Stoke-on-Trent or in parts of London), and at the same time bring the factory zone as near to the residential zone as possible. If you look at some of the French garden cities, such as Châtenay Malabry, or at the provisional plan for the new town of Stevenage in Hertfordshire, you will see compact residential neighbourhoods with schools, public buildings, and small shops and workshops in each, but you will also notice well-defined shopping and factory areas close by.

To achieve this kind of planning you need clean factories—even when the houses are situated to windward of them; and both the industrial estate and the residential neighbourhoods with community buildings should be of a size and character to take full advantage of a central source of power which would provide space heating, hot water and possibly process steam as well. It is true that factories are so quickly altered and extended that a district heating scheme may prove too inflexible for economy; but each case should be at least considered on its merits. It is worth noting that the final report of the New Towns Committee* under the Chairmanship of Lord Reith, basing its recommendations on information supplied by the District Heating Subcommittee of the main Heating & Ventilating Committee of the D.S.I.R. says that:—

“ . . . district heating may be already accepted as entirely practicable in a commercial or industrial area. We think this may apply also to a domestic area with a density as low as 10 houses to the acre. In our view the time has arrived for a full scale test . . . in one of the first new towns ”.

The next advantage that calls for consideration from a town planning point of view is the simplification of coal supplies and deliveries in built-up areas, and the reduction of the space at present devoted to fuel storage and individual heating systems. Central heat on a metered or a rental basis, supplied from a thermal or thermal-electric station which is strategically located, would eliminate the need for a considerable number of lay-bys, loading docks, chutes, hoppers and fuel bins, boilerhouses, chimneys and flues, stokers and cleaners. It would rid the narrower streets of the obstruction caused by coal carts and fuel lorries which are usually slow and bulky and which waste time and manpower in their unloading.

The economy in building is also considerable, where background heating is provided from a central source, and flues are required only for ventilation, or for small apparatus used for topping up. This is particularly true of large office buildings, though the reduction in brickwork or masonry in the chimney breasts and flues of small houses is also considerable.

Anyone who has had the misfortune over the last few years to work in an office which depends for its heat on the regular stoking of a bituminous-coal

* Cmd. 6876 H.M.S.O., price 1s. 3d.

fire and on its raking out and relaying every winter morning, or who has herself had to perform this operation at home, will not need telling of the disadvantages of the system : the dust and grit, the time-consuming drudgery, the irritation it entails. Demands on our productive capacity are increasing, so is our own demand for leisure and for social and civic activities ; domestic service is completely different from what it was before the war, and millions of families are in need of new houses. In such a situation, convenience and labour-saving methods become increasingly important ; and a planning scheme which does not contemplate adding to water supply, sewerage, and power supply, the additional service of district heating and clean air, is one which is looking backward instead of forward.

Although I have not quoted figures in support of these arguments, I think there can be little doubt that on the grounds of economy, convenience and amenity this method of heat supply has everything to commend itself to the town and country planner. But now let me say something of the problems with which it confronts him.

In the first place, and in common with all improvements in the standard of living, this new service has not only a high capital cost but will impose a constant addition to rent and rates in the form of standing charges. Where a poor householder could make desperate economies by denying himself a coal fire altogether, he will not be able, in any particular week or month, to turn off the district heating. There must be general acceptance of the service in the area of operation ; and if there is a strike or a breakdown—and such things are not unknown in the best regulated systems—all the consumers suffer together. But this is the price of progress, and to advance these as reasons *against* the adoption of a district heating system would be a policy of bankruptcy. Moreover, as Mr. Donald Smith remarked, in a paper to the Royal Sanitary Institute in 1944 :—

“ . . . So far from being a burden, a correctly designed system can give more heat at less cost than any other system, and can be operated at a profit. In fact, if the real cost of housing is to be reduced, this method, on account of the annual savings obtained, is equivalent to a subsidy of from £100 to £220 per house ”.

Nevertheless, the capital cost is high, and interest and sinking funds have to be met. There is no sense in not facing up to this fact, which is of course common to all large-scale enterprises and not incommensurate with its benefits. The scheme outlined by Mr. Stubbs, for a town of a quarter of a million inhabitants, would cost £10,000,000, but would supply heat at about 5*d.* per therm at 1937 price levels, and would save 48 per cent. of the present fuel consumption of such a town on heating and hot water supply for buildings of all types.

The second problem is one of distribution. Mr. Margolis will tell you of actual examples on the Continent where heat has been economically transmitted from a station six miles outside the area of supply. It is reasonable to suppose that in a well-designed system it could be conveyed up to two miles with a loss of only about 2 per cent. But whether the source is central or outside the town, the distributing mains must pass under a considerable length of verge or pavement before they reach the house, or office, or factory of the consumer. In a few old towns, for example, in some streets of the City of London, there are short lengths of duct capable of carrying these mains without further negotiation or tunnelling ; but in the majority of towns, especially in those

where clearance due to war damage, slums or obsolete property, is not complete, one of the greatest difficulties is likely to be the routing of these mains and the actual provision of space for the pipes and their insulation in conduits or tunnels.

The moral is clear. If heat is to be seriously considered along with other essential services in re-development schemes, the layout, density and detailed site-planning of the area should not be settled without reference to the heating engineer. If this is true in new schemes, where great economies can be effected by the adoption of a layout which is equally satisfactory from the planning and the heating point of view, it is equally necessary in rebuilding schemes in the central areas of towns, where the problem is more difficult and technical co-operation is absolutely essential. You will hear shortly that it is already taking place at Birmingham, at Manchester, at Coventry, and in the City of London.

A further difficulty is the acquisition, in large built-up areas and in towns of high architectural and historical importance, of suitable sites for the power stations, particularly for large thermal-electric stations with chimneys perhaps three hundred feet high. From all points of view, physical, economic and æsthetic, it is the problem of *re*-development and the adaptation of a new system to existing streets and buildings, that is the more difficult of the two. But it is by no means insoluble. A power station functionally designed, built in pleasing materials, and with its coal-handling plant carefully sited to avoid unnecessary dust and disturbance, can be an architectural asset. But if its size and character are clearly incompatible with the development of the area it is intended to serve, the cost of placing it further away and of increasing the length of the distributing mains must be squarely faced. Amenity is something which we must be prepared to pay for wherever we consider it really worth while.

As for re-development in stages, there will obviously be a loss of efficiency in several small thermal stations as compared with one large station, and more fuel is likely to be consumed proportionately. But the linking up of several stations, each designed to serve in turn a section of the whole area to be re-developed, may be the only practicable method in our older towns.

* * * * *

There are, of course, many other problems of technique, administration, cost and maintenance which will be raised by other speakers in this conference, and in discussion. I should like to end by referring again to what seems to me to be the central factor common to modern methods of space heating and to modern ideas of town and country planning : it is the factor of scale.

It is evident to everyone that some services can be provided efficiently and cheaply for a large unit of building, under one ownership or management, whereas they are usually uneconomic for small units operating independently. The great 18th century landlords, for example, were able to lay out estates of some size and dignity, both in town and country, with good accommodation and services, and a high architectural and landscape quality. Without creating monotony they nevertheless made use of standardisation, up to a point ; and some of the contracts were carried through with considerable speed.

Local authorities, by virtue of the Housing and the Town and Country Planning Acts (particularly the Planning Act of 1944), are now placed in more or less the same position to carry out large-scale development. In the centres

of existing towns, they are faced with the task—and the opportunity—of promoting under unified ownership and control the national and efficient development of hitherto unrelated properties. It is not unusual to find 20 to 30 buildings on an acre of ground each with its own staircases, passages, light wells, entrances and chimneys. On the same acre could be erected a building, individually designed but harmonious with its neighbours, containing the same or greater floor space, with better light, more direct circulation, improved resistance to fire, and even space for car-parking and a row of trees.

The whole tendency of planning legislation is towards comprehensiveness and the raising of standards all round. The significant detail can often receive greater attention at the hands of someone concerned with mass-production or large-scale development, than at the hands of the small owner or lessor with fewer resources.

The same principle must, I think, apply to such an essential service as heating. The individual should be better served, the community better housed, and the national resources better used, if heating is organised on the scale of the town or district rather than on the scale of the single building and the single inefficient open fire.

3. Continental Practice

By A. E. MARGOLIS, Dipl. Ing.

I. GENERAL REVIEW

The development of district heating on the Continent after the war of 1914–18 has been facilitated by the shortage and high cost of coal. In 1921, the Hamburg Electricity Company and a leading heating firm formed a company for public heat supply. The success of this company encouraged many towns in the following years to take up district heating. Many plants were on a small scale, owing to the economic limitations of district heating at that time.

The predominant method of heating on the Continent is by slow combustion stoves with a thermal efficiency of 40 to 50 per cent. as compared with 20 to 25 per cent. for open coal fires in this country. In consequence of this, the saving that can be attained by the introduction of central-heating installations is less than would be the case in this country. Moreover, the installation of central heating in an existing building involves many difficulties, and as a rule a district heating plant had to be designed for the heat supply of existing central-heating plants only. Evidently, heat could not be distributed in streets where only one out of ten buildings could take the supply. No service, even electricity supply, could be run under such conditions. It is also obvious that a district heating service could only be successful if the heat was supplied at a lower rate than the cost from central-heating boilers.

This explains why the district heating service had at first to be limited to favourable areas of a town with an adequate proportion of central-heating installations. The conditions improved steadily because central heating, partly due to district heating, became more popular in the following years. All new office buildings and almost all new blocks of flats were fitted with central-heating systems.

According to my experience as manager of the District Heating Company in Hamburg and as the engineer responsible for many other schemes in Germany and other countries, the new service has been appreciated everywhere for its convenience, cleanliness, low cost and reliability. During my management of the District Heating Company for 12 years, it happened only once that the supply to a few consumers had to be interrupted, owing to the flooding of the basements. The Fire Brigade isolated the section because of the escaping vapour from one basement due to the flood water vaporising where in contact with the steam main. It would have been much worse if the old central-heating boilers had been kept in service.

According to a report of the Association of Electricity Undertakings, there were in Germany in 1936, 28 district heating plants for public supply of heat. This figure does not include numerous central station heating plants for housing estates. The heat distribution systems were as follows :—

	<i>Plants.</i>
Steam	16
High pressure hot water	3
Low pressure hot water	3
Steam and hot water	6

In 1936, the total heat sent out amounted to 5.14×10^{12} B.Th.U.

The success of district heating in Germany can be judged from the data published by a well known authority—Dr. Wellmann, V.D.I., Journal, 15th November, 1941, according to which new district heating plants for four towns were sanctioned and partly carried out for an annual supply of 30.5×10^{12} B.Th.U., about six times as much as from all pre-war plants.*

The development of district heating in the Soviet Union has been even more remarkable. It was started on a very small scale, with only two consumers, in Leningrad in 1924–25. In 1938 the total heat-distribution system of Leningrad had already been extended to 44 miles, and the heat sent out in that year amounted to 3.3×10^{12} B.Th.U. At the beginning of 1939 the total capacity of generating sets with heat supply for space heating and process work in the U.S.S.R. amounted to 1,747,000 kW, and the total heat sent out in 1939 was 87.5×10^{12} B.Th.U.

According to the Five Years' Plan of 1938–42, which was interrupted by the war, the capacity of all thermal power stations had to be increased by 7 million kW, of which 5 million kW were to be installed with back-pressure or extraction turbines for heat supply. The heat-electric capacity would then have been 47.5 per cent. of the total steam-driven electric generating capacity in the U.S.S.R.

In 1939, the total number of district heating plants in the U.S.S.R., including industrial plants with heat supplied to outside buildings, amounted to about 160. It is often said that the extent of these district heating plants is comparatively small. True, the length of the heat distribution systems and the number of consumers is very small indeed. According to the data on district heating for the ten leading cities† the total length of their heat-distribution systems amounted to 136 miles, out of which about 120 miles were by means of hot water. The total number of consumers was only 1,063, although the number

* The Growth of District Heating in Russia and Germany, by A. E. Margolis—Engineering, October 8th, 1943.

† District Heating in Russia, by A. E. Margolis. The Steam Engineer. February and March, 1941.

of connected buildings was much greater. This shows that the supply of heat is still limited to large buildings and factories. On the other hand, it shows how great is the demand for low-grade heat, and it indicates the wide scope for the future development of district heating.

District heating has also been adopted in other countries, such as Denmark, Holland, France and Czechoslovakia. The heat-electric station at Brno is of special interest, as it supplies steam to the majority of the textile and chemical factories of the town and to many buildings, for process work and heating.* The Vatican City should also be mentioned as the only city on the Continent with a centralised heat supply throughout, and supplied from a heat-electric station.

2. COMBINED HEAT AND POWER GENERATION

The rate of growth of district heating on the Continent in recent years has been much greater than in the U.S.A. It is due first of all to the fact that the cost of plant, especially of the heat transmission and distribution systems, and the cost of labour as well, are lower on the Continent and the cost of coal is generally higher than in the U.S.A. The main reason is, however, that American plants are operating as a rule with straight steam supply. In contrast to Continental practice, combined heat and power generation is seldom applied in the U.S.A.

The growth of district heating in the U.S.A. in the eighties and nineties of the last century coincided with the erection of numerous light and power stations which, at that time, were built with exhaust steam engines. It was a comparatively easy job to make use of the available exhaust steam for heating buildings in the neighbourhood of the power station. There was no need for returning the condensate, and the balancing of the heat and power loads was a simple matter. With the rapid growth of the electric power demand at the beginning of this century, the old primitive stations were hopelessly outpaced by large condensing stations. Such stations were located so as best to meet the requirements for cooling water and fuel delivery, and the comparatively small district heating plants had either to close down or to change over to live steam distribution. But even under favourable conditions, combined heat and power generation is not so efficient as on the Continent. This is due partly to steam distribution, but mainly to the poor load factor of the back-pressure electricity generating sets, and high operating costs.

In contrast, the development of district heating on the Continent has been based predominantly on combined heat and power generation. It started at a time when the superiority of large condensing sets was a well-established fact. It had often to be started from the older power stations which were conveniently located in regard to the heat supply area, but had comparatively poor boiler plants and high working costs. Combined heat and power generation has not only the advantage of saving coal, but also of reducing considerably the cost of boiler plant, its attendance and maintenance, as compared with straight heat supply. Old power stations with high working costs which, from the standpoint of power generation would have to be scrapped, could again be run economically when used in addition for heat supply. However, the greatest efficiency of combined heat and power generation can only be attained in modern stations. Great effort has therefore to be made, firstly, to extend

* Power District Heating at Brno, by W. Kulka. Proceedings of Mechanical Engineers, September, 1944.

district heating to the magnitude of electric power generation, and secondly, as we shall see later, to balance the variations of the heat and power loads and to adapt the supply of heat to the requirements of electric power generation.

3. DEVELOPMENT OF DISTRICT HEATING IN HAMBURG

In Hamburg I started district heating from the oldest power station in October, 1921. In 1924, a second power station was given over to the District Heating Company. In 1929, all rights for district heating were acquired by the Electricity Company, and a third power station was put into service for heat supply. Finally, in 1933, the heat-distribution system was connected to a comparatively modern power station located in Tiefstack outside the built-up area of Hamburg, with a generating capacity of 85,000 kW but with a working pressure of only 200 lb. per sq. in. Two new high-pressure boilers of 220,000 lb. per hour each, with a working pressure of 1,700 lb. per sq. in., and two back-pressure sets of 11,000 kW each, exhausting at the pressure of the old boiler plant, were installed. The exhaust steam was transmitted over a distance of 2.2 miles to the third power station where it was used again for power generation, and the exhaust steam of about 40 lb. per sq. in. was supplied to the network of the district heating plant. The existing back-pressure set was of 4,000 kW only, but the generating capacity of the station could be increased to a total of 20,000 kW.

The steam main of 28-in. bore was designed for a transmission of 550,000 lb. of steam per hour at 200 lb. per sq. in. and 660° F. When transmitting 220,000 lb. per hour, a test showed that the drop in temperature was 54°, corresponding to only 22° F. at full load, and the loss of heat to less than 1 per cent. over a distance of 2.2 miles. It demonstrates the fact that heat can be supplied from stations outside a city, if the demand is sufficiently large.

It is noticeable how closely the development of district heating has been following that of electric power supply. After the erection of the Tiefstack power station, the older power stations were taken out of commission and converted into transformer stations. Similarly, after the erection of the steam main from the Tiefstack power station, the boiler plants of the two oldest power stations were taken out of commission and the power stations converted into sub-stations. The higher rate of growth of district heating is demonstrated by the fact that, from the commencement of electricity generation in Hamburg, it took 35 years before a plant of the type to be seen at Tiefstack could be realised; whereas a comparable development in district heating has been accomplished in 12 years. During this period the annual heat supply rose from 36×10^9 B.Th.U. to 960×10^9 B.Th.U. It rose to 1210×10^9 B.Th.U. in the year 1937-38 and, according to the latest information, to 1600×10^9 B.Th.U. in the year 1941-42.

In Charlottenburg, district heating was started in 1926 from a modern power station with a boiler plant working at 500 lb. per sq. in. In Leipzig, Dresden, Barmen and Brno the new main power stations were erected for electricity and heat supply. In the Soviet Union this development took place on a much larger scale.

4. HEAT DISTRIBUTION

Most of the plants in Western Europe were built for steam distribution. This was due to the large number of steam central-heating installations which could be easily connected to a steam-distribution system. Hot water heating plants had to be connected by means of calorifiers. The heat supplied could be

easily metered by means of condensate meters. In contrast with American practice, the condensate was always returned to the boiler plants to be used as feed water. With due precaution steel pipes can be used for the condensate and the danger of corrosion eliminated.

The disadvantage of steam distribution is the reduction in electric power output of the back-pressure sets and the high, almost prohibitive cost, of steam storage. A further disadvantage is the high cost of connections for small heating installations.

From the standpoint of power generation, the low-pressure hot water distribution system is the most efficient. The heating water replaces the cooling water of a condensing station, and the total latent heat of the steam is regained in the simplest way and at a very low back pressure. The cost of a heat-electric station for low-temperature heat distribution, when properly designed, does not exceed the cost of a condensing station. Low-pressure hot water distribution is very suitable when all existing central-heating systems are carried out by means of hot water. It has been successfully applied for the heating of 4,000 flats in Steglitz, a suburb of Berlin, with a three-main system for heating and hot tap water supply.

The connection of steam-heating installations to a hot water distribution system is possible if the temperature of the circulating water is raised. This affects, however, the electric power output, and the increase in temperature of the water should for this reason be as low as possible. Moreover, this increases the quantity of circulating water, the size of mains and the cost of calorifiers.*

In Dresden a three-main hot water distribution system was installed in 1927-29. It consisted of two flow mains, one with a hot water temperature of 285° F., the other one with hot water at 260° F., and a common return main. All heating installations were connected by means of calorifiers, the steam-heating systems using flow water of 285° F. and the water heating system flow water at 260° F. In later years a system of injecting high-temperature flow water to the water of the heating systems was tried out and proved to be successful.

Hot water distribution with a flow water temperature of 275° F. and higher, and injection of flow water to the heating systems, was applied on a very large scale in the Soviet Union. Hot water distribution has been chosen for reasons of the increased electric power output, without giving sufficient consideration to the shortage of experienced engineers and skilled labour. According to the Russian literature it resulted in many unpleasant breakdowns. Under such labour conditions steam-distribution systems have the great advantage that repairs can be carried out in a very short time, whereas, for the repair of hot water mains, much time is lost for drainage and refilling.

When heat-distribution systems are placed in conduits and due regard is given to the welding and expansion of mains, temperature stress, venting and so on, the reliability of a district heating service is greater than that of any other service. The provision of conduits and of expansion protects the mains against any movement of the soil, and breakdowns as in the case of cold water or gas mains are actually excluded. All simplified methods, by burying the pipes direct in the ground, are done at the sacrifice of the reliability of service

* Superheated Hot Water from the standpoint of District Heating, by A. E. Margolis. The Journal of the Institution of Heating and Ventilating Engineers, April, 1938.

and should be applied with the utmost care. Most careful consideration should also be given to the method of heat insulation, which cannot be dealt with here.

5. BALANCING OF HEAT AND POWER LOADS

The co-ordination of heat and power generation depends upon balancing the variations of the heat and power loads, and a short review of the methods adopted should be of some interest.

Method (a). By back-pressure and condensing sets working in parallel.—This is the most expensive method, because the capacity of the back-pressure sets is not available on mild days at the time of the electric peak, and the load factor of the back-pressure sets is comparatively poor. The cost of the back-pressure sets must therefore be allocated to district heating. This was the case in Hamburg when 2,000 and 4,000 kW back-pressure sets were installed before heat storage was available.

Method (b). By back-pressure and low-pressure condensing sets in series.—The exhaust steam of the back-pressure sets, when not required for heating, is supplied to a low-pressure condensing set. This method was at first applied in Kiel in 1922–23, and later in Leipzig and Brno. It improves considerably the value and load factor of the back-pressure sets, and the additional cost of the low-pressure condensing set is much lower than that of a parallel high-pressure independent condensing set or sets.

Method (c). By the use of pass-out steam.—Pass-out turbines were extensively used in the Soviet Union. The cost of turbo-alternators is lower than that of separate condensing and back-pressure sets. The over-all steam consumption, owing to the great variation of the heating load, is, however, much higher than with back-pressure sets. According to a report to the Academy of Science in the U.S.S.R. in 1943, the over-all heat consumption was in many cases as high as for normal condensing sets without pass-out.*

Method (d). By hot water storage combined with any form of heat-electric station.—In the case of hot water distribution, heat storage in large-capacity hot water accumulators is the most efficient method of balancing the variation of heat and power loads. Both services can be run independently of each other, and the back-pressure generating sets can be designed either for peak load or base load.

In Hamburg a hot water accumulator with a storage capacity of 400×10^6 B.Th.U. was installed in 1929–30, for the hot water distribution system. After that I could always run the back-pressure sets of 2,000 kW and 4,000 kW installed in two stations, situated at a distance of four miles from each other, in accordance with the requirements of the electric load. Any surplus exhaust steam or deficiency in heat was made good by the accumulator. The average heat losses of the Hamburg accumulator amounted to only 0.04 per cent. per hour.

The application of the large-capacity hot water accumulator for heat-electric stations makes possible the use of electric heating on a very large scale† but, owing to the limitation of time, it cannot be dealt with here. Similarly, the treatment of the very promising co-ordination of heat-electric stations with heat pump plants must be excluded from this paper.

* The Principles of Operation and Design of Heatification, by L. A. Melentiev (in Russian). Proceedings of the Academy of Science in U.S.S.R., No. 3, 1943.

† An Outline District Heating Scheme for London, by A. E. Margolis, Engineering, May 26, 1944.

6. CONCLUSION

District heating is the final stage in the development of central heating. Central heating is now generally adopted for Government and communal buildings, for factories, offices and the better class of dwellings. There cannot be any doubt that, with the steady improvement of living conditions, central heating will become as general as electric lighting because it so greatly improves the comfort of living. Therefore, the general introduction of district heating is bound to come, because it gives an ideal and cheap service, and it has the additional advantage of eliminating most of the smoke nuisance and of saving very great quantities of coal. The development of district heating on the Continent shows that its adoption depends upon co-ordination of heat and power generation because it gives the greatest saving in coal and it widens the economic basis of both heat and power supply. The increasing difficulties in mining and the steady rise in the cost of coal makes this development a problem of paramount importance.

4. Prospects of District Heating in the United Kingdom

By S. B. DONKIN, M.I.C.E., M.I.MECH.E., M.I.E.E.

I. GENERAL

I am assuming in this statement that the principle of district heating is accepted by reason of the arguments described at this conference by Mr. Stubbs, Professor Holford, Mr. Pallot and Mr. Margolis.

I have, in the past few years, prepared reports on several schemes of district heating with special reference to its proposed adoption in communities that have been badly bombed during the war, leaving large areas available for reconstruction.

The application of district heating to reconstructed areas is obviously more favourable than to existing buildings in congested built-up towns, not only from the point of view of the buildings themselves, but also because special provision for distribution can be made in the roadways. In existing towns the roadways and footways are already congested with other services, such as water, gas, electricity, telephones, and little space is left for conduits for heat distribution pipes.

The opportunity now exists for the application of district heating to newly built areas because the conditions referred to above do exist and the opportunity to take advantage of them ought not to be lost.

It is essential that the fuel saved by district heating and the lower cost of heating in dwellings and business premises should be made available, and that some schemes should be put in hand as soon as possible, in order to convince all other interested authorities concerned that the system is sound, practical and economic.

2. HEAT DISTRIBUTION

There is no doubt that the transmission and distribution of heat is the most variable factor in preparing estimates of all schemes so far examined. The cost of any distribution scheme depends on the density of dwellings per unit area.

The system of distribution may be a grid, i.e. a set of multiple ring mains giving for each service an alternative path for the flow and return. It may, alternatively, be a radial system fed from one or more central points or substations, with or without some interconnection between the radial feeders. Thirdly, it may be a combination of both ring mains and radial distributors.

In any of the above systems the feed and return have to be run to and from the heat supply station, and the length of such transmission will vary with every scheme, depending on the selection of a suitable site for a heat supply station or the position of an existing electricity generating station.

In order to show some examples of the varying cost of heat distribution I have prepared a Table comparing the estimated cost of transmission and distribution expressed in £ sterling per therm of maximum demand for the following schemes :—the District Heating Sub-Committee's basic scheme already referred to by Mr. Stubbs, the Ministry of Fuel and Power and the Ministry of Works joint memorandum on District Heating as applied to Small Housing Estates to be referred to by Mr. Pallot, and two schemes for which I have made detailed estimates for the District Heating Sub-Committee.

In Schemes SBD(i) and SBD(ii) the cost of pumps and of heat storage vessels is included.

TABLE I

Price	Basic Scheme	SBD (i)	SBD (ii)	Small Housing Estates
	Grid system, short transmission, 2 pipes	Radial system, 3 miles transmission, 2 pipes	Radial system, 1½ miles transmission, 2 pipes	Short transmission, 4 pipes
£ sterling per therm of maximum demand.	£300	£179	£118	£215*

* Estimated.

The above rates are based on 1937 prices.

Table I shows the very variable prices for the several district heating schemes, which indicates how necessary it is for each scheme to be investigated separately and in considerable detail.

Transmission and distribution of heat in the four schemes referred to above is carried out by hot water. The use of hot water as a heat carrier is more economic and convenient, because the hot water can be supplied direct to the radiator systems in the buildings without the use of calorifiers, as they would be in the case of steam distribution. All radiator systems can be calculated for forced circulation, thus reducing the pipe sizes and the cost of the installations in the houses.

The water is heated at the power station, either in condensers or in calorifiers which are large and comparatively cheap units. When hot water is used as the circulating medium a lower back pressure can be used in the turbine giving a greater output of electricity, and this additional electrical energy, as compared with that obtained by the use of exhaust steam, is greater than the electricity required to operate the hot water circulating pumps.

Another advantage of hot water distribution is the opportunity it gives to provide temperature control at the power station, or at each substation on the distribution system.

Hot water distribution makes heat storage possible in large-capacity hot water accumulators, the advantages of which are referred to later in this note.

The foregoing reasons have led British engineers to recommend the use of water as the heat carrier in practically all district heating projects, provided variations in ground levels permit.

In most systems the transmission and distribution is carried out by two pipes (flow and return), but in some cases, especially in smaller schemes, four pipes are used, two for space heating and two for hot tap water. The latter system reduces the heat losses in summer when space heating is not required, and allows the use of a higher water temperature, thus reducing the cost of the calorifiers for hot tap water in each dwelling.

3. HEAT GENERATION

The efficiency of the generation of heat varies according to the system adopted, and the three systems at present available may be summarised as follows :—(1) Heat electric, (2) Direct heat, and (3) Heat pump. Table II shows the capital cost and over-all efficiency at the power station of the three systems referred to above, applied to the four schemes compared previously in connection with distribution. The prices are those available in 1937, and again for comparative purposes are expressed in £ per therm of maximum demand sent out. The prices also include the necessary spare or standby plant. The efficiencies are expressed as the ratio of heat sent out from the station to the heat content of the fuel consumed. The efficiency of the heat pump is based on a coefficient of performance of 3 and on a thermal efficiency of electric power generation of 20 per cent. In the case of the heat pump the figures indicate the application of this system to systems already reported on, although the systems did not include this alternative originally.

TABLE II

Scheme	Heat Electric		Heat Direct		Heat Pump	
	Cost with spare boiler and H.E. set	Efficiency Per cent.	Boilerhouse cost with spares	Efficiency Per cent.	Cost with spare set	Efficiency Per cent.
Basic Scheme	£88 per therm sent out.	69·8	—	—	—	—
Small Housing Estates	—	—	£72 per therm sent out.	60	£500 per therm sent out.	60
SBD (i)	£60 per therm sent out.	83·7	—	—	—	—
SBD (ii)	£59 per therm sent out.	83·9	£153 per therm sent out.	80	£300 per therm sent out.	154*

* Comparative factor only.

The comparative economics of the capital cost and efficiency figures given above for the three systems can be illustrated by consideration of the percentage value of the coal saved by each system referred to later in this note.

The results of these comparisons based on the average figures for each scheme (except the heat pump schemes which are not averaged) show the influence of capital cost on efficiency or vice-versa. They are as follows :—

The Heat Electric System.—*1d.* per therm per hour in coal saved as compared with present-day heating methods, cost in capital £13 per therm per hour for generating plant.

The Heat Direct System.—*1d.* per therm per hour in coal saved as compared with present-day heating methods, costs in capital £22 per therm per hour for generating plant.

The Heat Pump System using electricity at 20 per cent. efficiency.—*1d.* per therm per hour in coal saved as compared with present-day heating methods, costs in capital £112 per therm per hour for heat pump plant.

The Heat Pump System using electricity by heat-electric method at 78 per cent.—*1d.* per therm per hour in coal saved as compared with present-day heating methods, costs in capital £42 per therm per hour for generating plant.

In the above figures, which do not include working costs, household coal is taken as costing 60s. per ton with a calorific value of 12,000 B.Th.U. per lb.

There is, therefore, no doubt from the above figures that the heat-electric system saves fuel with the lowest capital expenditure within the range of the projects referred to in this note.

With regard to the heat pump the capital cost at present is very high, but the cost of such pumps, when they are developed on a large scale, should in due course be much reduced and the performance coefficient increased. At present-day prices of heat pumps there may be still some cases where their use is economic. If it be assumed that a large town has its own electricity generating station and is equipped with the heat-electric system for the supply of heat to the town, the output of electricity from back-pressure sets and with low-pressure hot water distribution will be roughly three times that required for the town when producing sufficient heat to meet the demand. There would, therefore, be surplus electricity generated at a high efficiency and this surplus electricity could be used to give a supply to heat pumps, as well as to meet the demand for electricity in the surrounding suburbs of the town, if there were a source of heat in these suburbs. Other applications of the heat pump are referred to later under Hydro-Electric Generation.

4. DIFFICULTIES IN REGARD TO HEAT-ELECTRIC SYSTEM

The natural tendency in the electricity supply industry is to build new large economic base-load stations and to use the older stations for peak load purposes. It is probably only the older stations that can more easily be adapted for heat supply purposes as well as for electricity by the installation of back-pressure or special pass-out turbines and the provision of additional boiler plant. The Central Electricity Board controls the design, capacity and output of all selected generating stations. Their programme of extensions has to be drawn up at least three years in advance of the growing demand, so that any consideration of alternative plant to suit district heating supplies is difficult to organise.

If an existing or a new electricity generating station were to be converted to act or to work as a heat-electric station, there would be additional work connected with the regulation of the two supplies to maintain the demands for the two services—heat and electricity—and most generating station superintendents have enough trouble now to meet the demand for electricity alone without the complication of meeting the demand for heat, which differs in its daily and seasonal load characteristics.

There is also the very vexed question as to the allocation of capital and working costs between the two services, i.e. heat and electricity in a combined heat and electric station. Several suggestions have been made in the various reports on district heating which have been under consideration by the District Heating Sub-Committee. The method adopted in the District Heating Committee's basic scheme already referred to by Mr. Stubbs is based on the difference in the annual capital and working costs between an actual heat electric station for a given output of electricity and heat, and a hypothetical straight electricity-generating station to give the same output of electricity. Another suggestion for meeting these difficulties is to let the district heating authority purchase heat from the electricity undertaking at a price consistent with the principle mentioned above, leaving the district heating authority to be responsible for transmission, distribution, metering and house services, etc. In this case the question is, will the electricity supply undertaking be willing to do this on reasonable terms, that is on a limited profit-earning basis?

It will in any case be necessary for heat supply authorities to obtain Parliamentary powers to sell heat and to lay pipes in conduits or direct in the roadways or pavements. Such powers could quite well contain a clause to cover the charges made by the electricity authority for heat according to ascertained station costs.

Perhaps the simplest method of all, for a system of sufficient size, will be for the authorities supplying heat and hot water to erect their own heat-electric generating station and to sell all their surplus electricity to the existing electricity undertaking in the neighbourhood,* which electricity should, and can be at such a price which would make it a welcome addition to the electricity undertaking's system. There is no doubt that such electrical energy could be considered as firm units and could, therefore, be given at such times as the electricity authority in the area demanded.

5. COAL SAVED

The coal saved by district heating has already been referred to in other papers, but another way of expressing this saving is worthy of consideration. The saving in coal by the introduction of the heat-electric system as compared to the present methods of space heating for any given community is, at the present time, greater than the consumption of coal required to generate electricity alone in condensing stations for the same community. The coal consumed by the three systems which I have compared in this note, that is, heat-electric, direct heat and heat pump, is roughly proportional to the efficiency of the system, so that if the sub-committee's basic scheme having an efficiency of generation of 69·8 per cent. saves, as already stated by Mr. Stubbs,

* Shortly to be the Area Board.

48 per cent. of the fuel which would otherwise have been consumed by present-day methods of space heating and of hot water supply, the several schemes referred to by me would *save* the percentages shown below.

TABLE III

System	Basic Scheme Per cent.	Small Housing Estates Per cent.	SBD (i) Per cent.	SBD (ii) Per cent.
Heat-electric	48	—	57	57
Heat direct	—	4 ¹	—	55
Heat pump	—	4 ¹	—	48

6. HEAT ACCUMULATORS

I cannot conclude my very general survey of the prospects of district heating without reference to the advantages in the heat-electric system, of installing a large hot water accumulator or accumulators at the power station and/or at centres of distribution. There are, however, limitations within which these advantages are effective. We must remember that the ratio of the output of electricity to heat in a heat-electric station is more or less constant, whilst the demand for either product at any time of the day is variable. These variations can to a limited extent be dealt with by charging or discharging the accumulators, as required, to keep the ratio constant when the output of electricity and of heat varies according to the demand for each.

Another advantage is that the maximum demand for heat on the generating station may, under suitable conditions of electricity demand, be reduced, and the capacity and cost of the generating plant for heat thereby reduced. The cost of such accumulators is reasonable.

Hot water storage enables heat to be generated at a rate corresponding to the demand for electricity and distributed at a rate corresponding to the demand for heat. The load factor of the heat-electric station will, therefore, be that of the electricity sent out and this load factor is generally higher than that of the heat sent out.

7. HYDRO-ELECTRIC POWER

Hydro-electric power generated at an efficiency of the order of 80 per cent. does make the use of the energy from such schemes most suitable for hot tap water supply, the annual load factor of which is relatively high. The use of such energy in the form of non-firm units, as for instance from the Severn Barrage, has been considered for hot tap water with transmission by electricity, and by the use of electrode boilers in urban centres and heat storage vessels capable of dealing with the fortnightly variations between spring and neap tides and the diurnal variations between high and low tides.

The high efficiency of generation by hydro-electric power should also provide justification for the use of heat pumps seeing that the efficiency of generation by hydro-electric power is of the order of 80 per cent., whereas the average efficiency of generation by steam stations throughout the country in 1938 was only 20·6 per cent. and the maximum about 30 per cent.

5. The Wythenshawe Scheme

By R. NICHOLAS, B.SC., M.I.C.E.
CITY SURVEYOR, MANCHESTER

INTRODUCTION

Wythenshawe comprises some 5,567 acres of land added to the City of Manchester in 1930. It has been planned to accommodate 80,000 people, its present population being 40,000.

The district heating scheme can therefore be applied to about one half of the total development together with two of the three industrial areas—one being already partially developed on the traditional method of individual space heating—and the Civic Centre.

The total area to be served is :—

	<i>Acres.</i>
Residential	967
Industrial	290
Civil Centre	53
	<hr/>
Total	1,310
	<hr/>

THE DISTRICT HEATING SCHEME

The scheme is thermal-electric comprising two power stations located in the western and south-eastern industrial zones, servicing, by inter-connected mains, the intervening residential areas and civic centre as well as all the adjoining industrial undertakings. This dual power arrangement provides a standby or alternative source of supply to all parts of the scheme, as well as a more effective distribution in the two industrial areas.

Each boiler plant is designed for the generation of high-pressure steam, being of water-tube type and equipped with economisers, superheaters and air preheaters.

By use of mechanical stokers and an electrostatic precipitator, up to 98 per cent. of any grits or fines carried over in the flue gases will be removed, resulting in as clean a chimney emission as anywhere in the country at the present day. Coal will be serviced from railway sidings and elevated to high-level bunkers, gravitating to the stokers as required.

THE HEAT DISTRIBUTION SYSTEM

Heat distribution to the dwellings and other buildings will be by hot water circulated by pumps located in the plant houses and in a number of sub-stations.

Twin trunk mains connect the two boilerhouses, and branches from these connect to the sub-stations, from each of which a three-pipe system conveys water to the buildings to be heated. This system provides separate flow pipes for heating and domestic hot water, with a common return pipe.

The temperature of the water which supplies both the heating and the domestic hot water systems will be varied by means of mixing valves in the various sub-stations. Thus the temperature of the water in the heating system could be varied to suit the day to day heating requirements without interfering with the temperature of the domestic hot water.

It should be pointed out that the heating system has been designed as a closed circuit, that is to say, once it has been filled, the water remains in the pipes, and is circulated round and round the system. This will enable steel pipes to be used, as corrosion or deposition on the pipe surface will be avoided.

TYPE OF HEATING INSTALLATIONS IN HOUSES AND FLATS

The heating installations in the houses and flats will be of the conventional type in which the heat is emitted to the rooms by means of radiators and any exposed pipes. The greater part of the heat is to be provided by radiators and each will be fitted with a valve so that it may be turned "on" or "off" by the householder as desired. In general, installations in the houses and flats will, on the score of neatness, be designed on the single-pipe system.

DOMESTIC HOT WATER SYSTEM IN HOUSES AND FLATS

Each house will be equipped with its own separate domestic hot water system. This system will be of the conventional type except that the usual back boiler is dispensed with and, in lieu, a calorifier fitted inside the normal cylinder. The calorifier will be in the form of a copper coil through which the hot water from the district heating mains circulates and imparts its heat content to the surrounding water in the cylinder. The water passing through the coil is then returned to the district heating system for reheating and re-use.

The scheme provides for the cylinder in each dwelling to be large enough to store forty gallons of hot water so that, after overnight heating up, this amount of hot water will be available first thing in the morning. It is proposed that the water should normally be heated to 130° F.

The scheme has been prepared on the basis of an average consumption of 45 gallons of hot water per day in each dwelling. This is in excess of the average quantity used at present by the Wythenshawe householder.

COMPARISON OF SERVICE AND COST OF DISTRICT HEATING AND TRADITIONAL HEATING

It is estimated, from surveys carried out amongst the tenants on the estate, that the average cost of heating and hot water supply per dwelling by traditional methods is 6s. 11d. per week, based on pre-war fuel consumptions, and prices ruling in 1945. The average fuel consumptions were found to be five tons of coal, 2,000 cubic feet of gas and 130 units of electricity per annum, producing approximately 278 useful therms of heat.

The district heating scheme has been designed to meet the following space-heating conditions, over an average period of 35 weeks per annum, in addition to the domestic hot water service previously described :—

60° F. with 1½ air changes per hour in the living room, parlour and dining room.

55° F. with 1½ air changes per hour in the hall, staircase and landing.

50° F. with one air change per hour in bedrooms.

55° F. with one air change per hour in the kitchen.

The bathroom is warmed from the hot water system.

This service would provide the equivalent of 761 useful therms per annum compared with the 278 obtained by the older methods of heating.

Furthermore, in view of the income available from the sale of by-product electricity, it is considered that the district heating service could be provided at a charge of 5s. 1d. per week to the average dwelling, based on 1945 construction and operating costs. This charge would vary from approximately 1s. 9½d. per week for a single-person flat, to 7s. 1d. per week for a four-bedroomed parlour-type house.

This average charge of 5s. 1d. per week for a district heating service compares with the estimated cost of 6s. 11d. per week for heating and hot water supply by traditional methods ; it is considered that the difference of 1s. 10d. per week is ample to cover the cost of any supplementary heating in the form of gas or electric fires which may be desired.

THE INITIAL INSTALLATION

In a large-scale district heating and generating scheme it is not strictly economical to instal the heating and generating plant until a substantial number of houses have been erected and occupied. In such cases there must be an initial loss of from about £45,000 to £55,000 which can be reduced to the lower figure in a development programme of about 2,000 houses per year, when the commencement of plant operation is timed to coincide with the completion of the first 2,000 houses.

In the meantime it is more economical to provide these houses with immersion heaters, and a supply of electricity sufficient to heat 17 gallons of water per day during the seven colder months, than to accelerate the earlier capital charges on a plant working to small capacity.

To recover the initial loss of £45,000 over the subsequent ten years would mean an additional weekly charge per house of about 2d. per week, and a proportionate charge on public buildings.

GENERATION OF BY-PRODUCT ELECTRICITY

The greater part of the electricity used in this country is produced in power stations in which steam is the motive power and the electricity generation is effected in turbo-alternator sets. The steam is fed at high pressure to the turbo-alternators which extract energy from it and convert this energy into electricity. As a result of this conversion the steam, when it reaches the turbine exhaust, has been lowered in pressure and temperature. It still, however, contains its latent heat, which is dissipated by means of cooling towers or in warming the water of a nearby river. This wasted heat often amounts to upwards of two-thirds of the total heat in the steam and, consequently, even the largest generating stations in the country have an over-all thermal efficiency of only about 30 per cent.

It is this latent heat in the exhaust steam which it is proposed to use in the Wythenshawe scheme, to heat the water for circulation in the district heating service.

With this arrangement the only fuel which is required for generating the electricity is the additional amount necessary to put into the steam the work-producing energy absorbed in the turbines and converted into electricity. After allowing for boiler and all other losses, the over-all efficiency of converting this heat into electricity is in the region of 75 per cent., that is about two and a half times the over-all efficiency of a modern electricity generating station of the usual type in which the exhaust heat is wasted.

The great advantage of by-product electricity production from a combined thermal-electric generating station serving a district such as Wythenshawe is, that the maximum output of electricity would be available at the time of year when it is most required. The amount of electricity produced would vary according to the outside temperature and the resulting load on the district heating system ; this means that most electricity would be available during the months of December, January and February, and it is during these cold months that the peak annual demand for electricity occurs.

In the case of the Wythenshawe scheme, where water is the heating medium, the very large heat storage capacity of the water can be used to enable the turbines to be run up to maximum load for short periods.

The installation of by-product electricity generating plant in addition to that required for a straight heating station, involves only the expenditure of a fraction of the capital which would otherwise be necessary to instal plant of similar capacity in the usual type of condensing station.

It is estimated that the saving in fuel at Wythenshawe by the combination of thermal and electric generation would amount to 22,000 tons of coal per annum.

The amount of electricity which can be generated under the scheme is estimated at over 75,000,000 units per annum, and the generator output during the half-hour peaks of the period of annual maximum demand will be 31,300kW. The wholesale value of this electricity is in the region of £169,000 per annum.

ESTIMATED CAPITAL AND OPERATING COSTS

The capital cost of the whole Wythenshawe district heating scheme, based on prices ruling in 1945, is estimated at £2,427,000.

This is made up as follows :—

Land	£
Building work in boilerhouses, sub-stations, sidings, etc.	8,400
Plant	265,490
Mains in trunk and secondary distribution	1,255,402
Ducts for distribution mains	528,345
	369,220
Total	£2,426,857

The annual operating costs have been estimated as follows :—

Annual charges on capital cost	£
Maintenance and administration	151,905
Labour	40,422
Coal	16,550
Ash removal, water, etc.	136,310
Losses due to empty houses, etc.	1,786
Rates	641
	31,549
Total annual expenditure	£379,163

Income :—

7,945 dwellings at an average charge of 5s. 1d. per week	£
Public buildings (i.e. civic buildings, churches, cinemas, public-houses, etc.)	107,209
Industrial Buildings :—	43,550
Heating	43,166
Process steam	17,828
Sales of electricity	168,601
Total income	£380,354

SUMMARY OF ADVANTAGES TO WYTHENSHAWE

Advantages to Householders

(a) A district heating service will provide a constant supply of hot water day and night.

(b) It will provide a degree of warmth and comfort hitherto unknown, and within the range of the average householder's pocket.

(c) It will warm not only the rooms but the hall, staircase and landing, and so prevent cold draughts when the room doors are opened and shut.

(d) It will enable the occupiers of the larger houses to obtain, during the winter, the full benefits of the size of the houses, as they cease to be restricted to the use of only one or two rooms because of heating difficulties.

(e) The living rooms and kitchen will be warm when the family comes downstairs in the morning.

(f) The buildings will be kept dry and free from damp. This feature is specially advantageous in the Manchester area due to local climatic conditions.

(g) In case of sickness, an even warmth can be maintained in the bedroom without the emission of dirt or adding to the labours of nursing.

(h) Clothes and household linen can be kept fully aired.

(i) There will always be a hot pipe in the bathroom for drying towels.

(j) Water heating in the summer months will be effected without the discomfort of having a fire or sectional boiler in the kitchen or living room.

(k) It will obviate the worry to the householder of having to leave a fire alight and banked up when he goes out.

(l) It will be labour saving.

(m) It will be cleaner ; there will be less dust.

(n) It will be safe—particularly to young children.

(o) It will increase the available floor space due to the omission of a number of fireplaces and chimney breasts.

(p) It will minimise trouble from burst pipes in frosty weather.

(q) It will avoid carting through the estate thousands of tons of coal and ashes, the dust and grit from which would be scattered while handling into and out of consumers' premises.

ADVANTAGES TO THE CITIZENS IN GENERAL

The smoke nuisance is particularly serious in Manchester. Its effects are aggravated because the hills which surround the city on three sides encourage the condensation of moisture in the atmosphere.

The advantages which the citizen will obtain from the installation of a district heating system at Wythenshawe would accrue chiefly from the resultant reduction in smoke emission from domestic and industrial chimneys in the area. This aspect is particularly important in view of the proximity to the estate of the Corporation's Sanatorium at Baguley, and the Ringway Airport.

The ratepayers will obtain the monetary benefit resulting from a lesser expenditure on the upkeep of the property. Clean air in Wythenshawe will mean a considerable saving in respect of decoration and general structural maintenance. There will also be a considerable annual saving to the ratepayer in the cost of heating public buildings. This saving is estimated at £14,500 per annum.

As regards the adoption of a large-scale district heating scheme, Wythenshawe has a particular advantage in that approximately half the estate consists of houses already developed, but heated by traditional methods, and comparable

in size with those projected. This will afford a freedom of choice to the resident and enable a direct comparison to be made between the two methods of heating.

Acknowledgments.—The author wishes to acknowledge the assistance given by the Corporation's Consulting Engineers, Messrs. Ernest Griffiths and Son, from whose report on the scheme much of the information contained in this paper has been extracted. Thanks are also due to the Corporation's Technical Committee who have carried out much research into the practicability of the scheme, both in its technical and financial aspects, and to Mr. R. A. S. Thwaites, the Chief Engineer and Manager of the Corporation's electricity undertakings.

6. Proposed District Heating Scheme at Urmston

By E. L. LEEMING, M.SC. (TECH.), M.I.C.E.

ENGINEER AND SURVEYOR TO THE URMSTON URBAN DISTRICT COUNCIL

INTRODUCTION

Early in 1945 the Urmston Council proceeded to negotiate for the acquisition of a large estate at Flixton, the layout for which showed that within the neighbourhood unit some 1,300 new dwellings could be erected. At the same time the Council authorised the Surveyor to obtain a preliminary report from a Consulting Engineer on the prospects of district heating for the whole of the estate. Messrs. Donald Smith & Partners were invited to undertake this work.

The interest of the Council in district heating arose from several considerations: there was the need for fuel economy and the opportunity to put into practice smoke abatement—a subject in which the Council has always shown a deep interest; it was resolved, therefore, to explore all possibilities of smokeless heating and, if practicable, to improve or replace the inefficient old-fashioned open fires in connection with the new Flixton Estate.

The report indicated that it was a practical proposition, and the matter was further pursued and discussions took place at the Ministry of Health, together with the Ministry of Fuel and Power.

DESCRIPTION OF DEVELOPMENT

The whole estate has been designed in groups of dwellings around squares or open spaces of about $1\frac{1}{2}$ to 2 acres with various types of houses, bungalows and flats; the grouping of the dwellings has assisted to some extent the layout of an easy control of the proposed district heating system. The schedule below shows the total number of buildings proposed to be served by the district heating system.

763 Houses
224 Maisonettes
222 Flats
108 Bungalows for Aged People
<hr/>
1,317 Dwellings

It will also supply the Community Centre, Health Centre, Shopping Centre, Cinema, Hotel, Creche, Restaurant, Service Flats, Nursery School, two Infants' Schools, two Junior Schools, Secondary School, Pavilion, Laundry, Library, and miscellaneous premises, e.g. garages, greenhouses, etc.

GENERAL DESCRIPTION OF SERVICE

It is proposed to supply heat for all rooms, and hot water for domestic purposes from one central heating station. Mains will be laid in the different directions to give the required supply to the estate, including public buildings such as schools and others mentioned in the above schedule.

One open fireplace is being left in each house in the living room and it is anticipated that a small gas or electric unit placed there will be sufficient for topping-up heat in the coldest part of the winter. Hot water radiators will be fitted in each bedroom, kitchen and living room ; the bathroom towel rail is also heated. For this service there will be a separate closed circuit which will circulate water at a minimum temperature of about 160° F. The room temperatures will vary from 58° F. in the working kitchen to 62° F. in the living rooms and 52-54° F. in the bedrooms and hall. These temperatures will apply when the external atmospheric temperature is 32° F. The domestic hot water supply will be circulated in copper pipes at a temperature of about 130-140° F.

CONSUMPTION OF DOMESTIC HOT WATER

It is difficult to say what the average consumption of domestic hot water per day would be, but the following table is regarded as a fair estimate :—

Consumption per day per house	No. in family	No. of bedrooms
(a) 40 gall.	5-7	3-4
(b) 35 gall.	4-5	2-3
(c) 30 gall.	2-3	1-2

INDIVIDUAL UNIT CONTROL

Controls will be provided so that the supply to each house, as well as to the individual radiators, can be regulated or isolated. This will enable repairs to be made without affecting the working of the general system.

PUBLIC BUILDINGS

The inclusion of public buildings in the scheme makes possible a more economic price for the supply to the houses. This is on the principle that the greater the turn-over the less per head are the overhead charges. As already mentioned it is anticipated that there will be two new Primary Schools and one Secondary School within the scheme, and some of these will no doubt require heat at an early date. There will also be shop premises and flats on the estate for which a supply of heat will be advantageous. It is proposed to build a Community Centre and it is possible that this may have a small swimming pool which it is hoped might be run on an economic basis even during the winter months.

MISCELLANEOUS BUILDINGS

The layout provides for the erection of blocks of garages to be let in connection with the house tenancies, and it is anticipated that heat can be supplied during the winter months to these garages at a modest annual or weekly charge.

On the fringe of the developed area provision has been made for allotments and small holdings ; heat will therefore be available for heating greenhouses and other buildings concerned with this aspect of food production.

POSSIBILITY OF EXTENSION TO EXISTING HOUSES

On the easterly side of the Estate there is a considerable number of modern houses, built to a density of not more than 10 or 12 to the acre, where it is anticipated there will be a demand for the district heating service. The capacity of the scheme, therefore, should allow sufficient margin to meet such a demand and, no doubt, special rates would have to be arranged in the first instance according to the number of consumers in a particular area. Already enquiries have been received as to the prospects of connecting these existing houses to the service.

PROGRESSIVE DEVELOPMENT OF DISTRICT HEATING

It is clear that with a new estate it will be necessary to supply hot water to the first houses to be completed, and it may not be economic, or even practicable, to provide the final heating station and equipment until a later stage of the development. It is proposed, therefore, to put down a temporary boiler plant to serve the first 200 houses. It may be necessary, however, to give a supply even to a smaller number of houses which it is expected will be completed before the winter of 1946-7. It is proposed, therefore, to instal a small heating unit within one of the out-buildings; the building will serve later as a block of garages for the estate. It is of the highest importance that the occupants of the estate should be given this service from the outset.

COST OF THE SCHEME

The cost per house will vary according to size, i.e. the number of bedrooms, floor area, etc. When the scheme is finally completed the average cost per house for loan repayment and running costs will be approximately 4s. 6d. per week, excluding topping up heat in very cold weather. In all schemes of this kind one does not expect that, in the first six months, the first few houses will be running on an economic basis, and it may be found expedient to have a slightly higher charge in the initial period of the scheme. Much will depend upon the speed at which the estate is completed and the public buildings brought into use. At the present rate the whole of the estate should be fully developed within 3-4 years, by which time the charge would be stabilised to show a slight excess of revenue over expenditure.

ECONOMIC ADVANTAGES OF DISTRICT HEATING

We have all seen the advantages of the "Pay-as-you-earn" method of collecting income tax and the advantages of collecting rent and rates weekly. In the case of district heating the weekly charge will be collected along with the rent so that the cost of collection is negligible.

The social and economic importance of collecting the fuel costs as a flat weekly rate all the year round cannot be too strongly emphasised. In normal times people bought most of their coal in the winter: today they are compelled to acquire some stocks in the summer as well in order to carry through the winter.

The diagram, Fig. 4, shows how coal is distributed in Urmston throughout the year; from this it would appear that the average householder pays 9s. 6d. per week for solid fuel in the six winter months and 5s. 6d. per week for the six summer months—an average of 7s. 6d. per week all the year round.

Compare this with the estimated price for district heating at 4s. 6d. per week as a steady charge, winter and summer; the additional cost of topping-up heat with one gas or electric fire in the coldest part of the winter should not exceed an annual average cost of about 9d. per week. We must remember too that topping-up heat is needed in a house heated by the open coal fire.

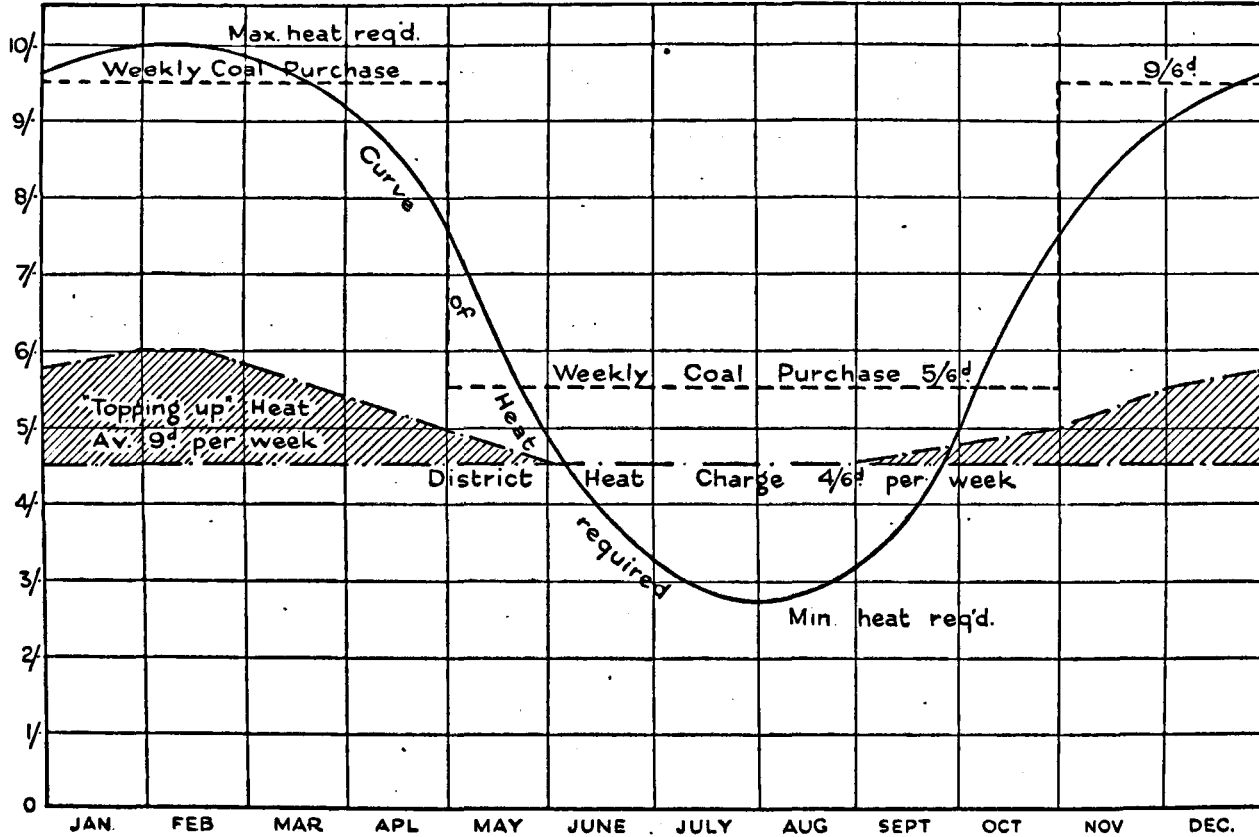
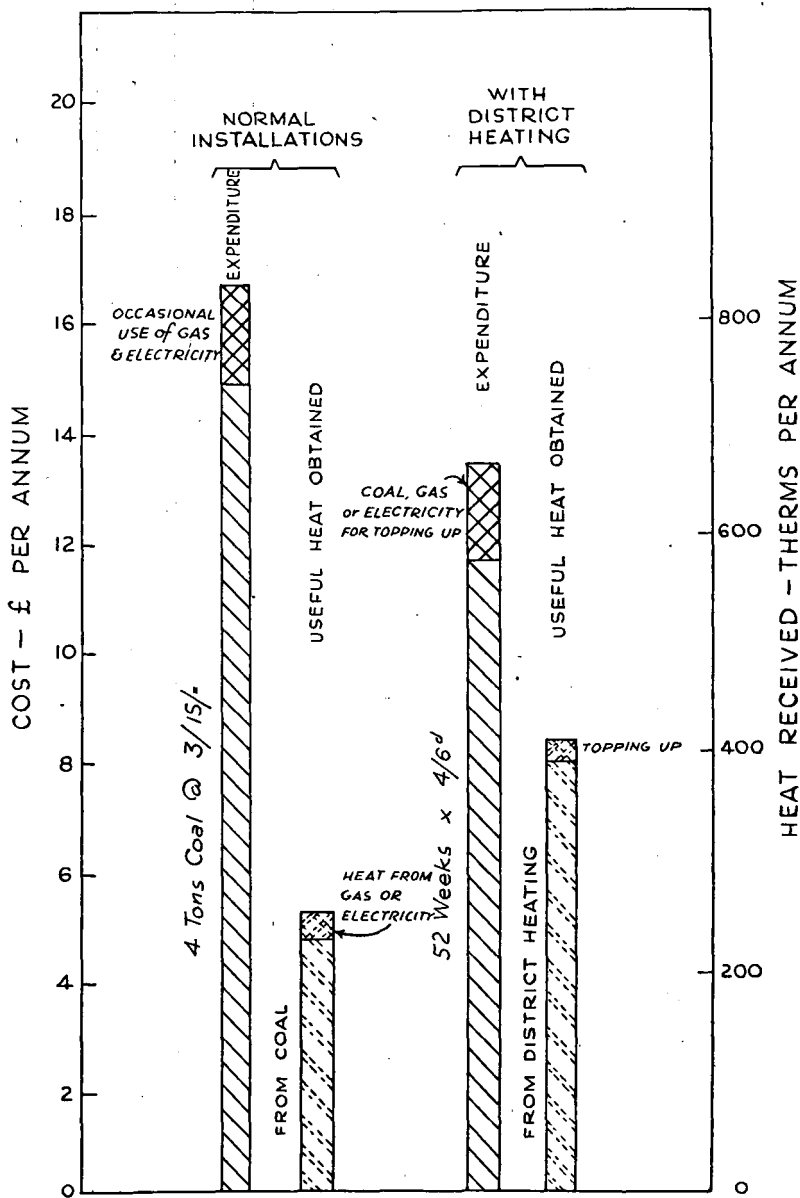


FIG. 4.—Diagram showing Economic Advantages of District Heating on a Flat Rate.

AVERAGE ANNUAL EXPENDITURE PER DWELLING
& AVERAGE NETT AMOUNT OF HEAT RECEIVED.



Prepared by Messrs. Donald Smith & Partners (Consulting Engineers).

FIG. 5.

EFFECT OF LOW RATE OF INTEREST

Since the weekly charge of 4s. 6d. includes loan repayment on the capital cost at an interest rate of $3\frac{1}{2}$ per cent., the recent reduction of interest rates from $3\frac{1}{2}$ per cent. to $2\frac{1}{2}$ per cent., will mean a corresponding reduction in the weekly charge. This task of making the scheme self-supporting is made much easier than would appear to be the case with the higher rates of interest prevailing before the war. It should be mentioned here that the Consultant to the Council has insisted throughout that the scheme must pay its way and the service will be provided only on this basis. It is estimated that the installation of a district heating service will mean a saving of from one to two tons of coal per house per annum as compared with the conventional methods of burning raw fuel.

THE ADVANTAGES OF THE SCHEME

(1) *Smoke Abatement.*—Smoke will be eliminated, and as the site lies to the west of the town, from which quarter the prevailing winds blow, the advantage to the developed areas will be obvious.

(2) *Fuel Economy.*—Fuel will be burnt with a much greater efficiency in the Central Station than it could be in open fires ; low grades of fuel may be used.

(3) *Reduction of Local Traffic.*—Domestic deliveries and storage of fuel will be eliminated and refuse collection will be reduced to a minimum.

(4) *Domestic Labour Saving.*—Cleaner and easier conditions will be created in the home for the housewife, and a dry and warm atmosphere in all rooms will be available at all times of the day and night.

(5) *Economy in Housing Maintenance.*—Plumbing costs in the winter, due to frozen pipes, will be largely eliminated. The cost of interior decoration will also be reduced.

(6) *Financial Benefit to Tenants.*—The scheme will give greater heat at less cost and will assist tenants in their weekly budget by way of a flat charge which will be collected with the rent throughout the year.

7. The Application of District Heating to Small Housing Estates.

Mr. A. C. Pallot (Ministry of Works) introduced the memorandum on District Heating as Applied to Small Housing Estates prepared jointly by the Ministry of Fuel and Power and the Ministry of Works, written at the request of and with the approval of the Egerton Committee. The basis of the survey was a consumption of 575 useful therms a year for each household. Mr. Pallot said that before 1939, the average consumption of coal in the house amounted to about $4\frac{1}{2}$ tons ; the average cost of fuel for heating and hot water services was about 4s. per week, so the essence of the problem really was, could 575 therms per annum be supplied from a comparatively small, straight district-heating station at a cost of 4s. per week based on 1937 prices. The figure of 4s. would be approximately 6s. today, because of the increase in fuel prices. Three schemes were examined and the plans were reproduced in the memorandum. They comprised 122, 241 and 496 dwellings respectively, the houses being 12 to the acre and the flats 22 to the acre. This memorandum dealt only with houses and flats, no allowance being made for public buildings, or

commercial and communal buildings, although a considerable proportion of those buildings was included in housing and they materially assisted in the over-all economics.

The amount of heat supplied to buildings would be on the same lines as indicated by Mr. Stubbs and other speakers, and that amount of heat could be utilised as between space heating and water heating, very largely at the discretion of the householder, though the total could not be increased; a regulation was put on that by the district heating authority. The householder could not get more than he was allowed, and this enabled a flat-rate system of charging to be adopted and obviated the cost and complication of metering. The schemes were calculated on the basis of hot water distribution from the central station, the temperature of the hot water being controlled in accordance with outside weather, reaching a maximum of 270° F. when 25° F. was recorded outside, which did not happen very often. Such high figures were not suitable for direct use in housing, and a mixing cylinder was therefore proposed in the scheme to prevent excessive temperatures in the radiators. A full-scale trial of this arrangement had been made.

As an alternative the largest scheme was worked out on the basis of low-temperature distribution at 180° with a four-pipe system as compared with the one-pipe system envisaged under the other scheme; the capital cost of the low-temperature four-pipe arrangement was practically identical with that of the one-pipe high-temperature system. The total cost of complete district heating schemes per house, including all works, external mains, boilers, etc., would be about £100 in the larger schemes and about £112 in the smaller schemes. These were 1937 figures, which would be increased by about 60 per cent. These costs did not take into account credits which might be due to the omission of fireplaces, flues and hearths, or of independent hot water boilers in houses, and the cost of which might amount to anything between £30 and £50, and in any case they should not ultimately be charged because no house would be built today without a hot water installation.

In no case when 575 therms per annum were supplied did the weekly charge based on the 1937 figures as deduced in the memorandum fall to the pre-war figure of 4s. per week; it varied from 7s. 8d. in the small schemes, to 5s. 9d. in the large, and, as might be expected, costs tended to become excessive as the scheme became smaller; there were deficiencies of 16 per cent. in the larger schemes and as much as 27 per cent. in the smaller schemes.

The general conclusion was that district heating could be provided from a straight thermal station at an economic figure for 300 houses or more; if the number fell below 300 the costs began to rise very sharply. It seemed clear that the full 575 therms could not be reached from a large thermal electric plant, but the Egerton standard of 385 therms per annum could be given at an economic figure and at no more cost than would be incurred by householders using traditional methods and obtaining much less heat.

Memorandum on District Heating as Applied to Small Housing Estates

INTRODUCTION

We are familiar enough in Great Britain with central heating in our public buildings, offices, factories, and large business premises: indeed we should not contemplate any alternative for new construction. Yet domestic central heating has been confined to the larger houses, presumably because it has been felt that the capital cost of the installation ruled it out elsewhere. With the

present scarcity of coal, and its higher price, some extra capital outlay for heat services can be justified if it is accompanied by more efficient use of fuel.

Hence, today, there is widespread interest in "district heating", that is, the provision of heat and hot water from a central boiler plant to a whole housing estate. District heating from a central source, it is argued, will be less expensive to instal than a separate system in each house would be. It will bring within the reach of all greatly improved standards of heating and hot water supply at reasonable cost.

There would also be the following advantages :—

- (1) Elimination of much of the dirt and labour associated with the open fire ;
- (2) Reduction in the door-to-door delivery of fuel and collection of ashes ;
- (3) Reduction of atmospheric pollution.

[These advantages can also be secured by the use of gas or electric appliances and it should be noted that the costs of providing district heating should always be compared with those of heating the dwellings from the existing public utilities. Comparison should be made, too, with the costs of heating by means of the modern types of solid-fuel appliances, from which similar benefits can be derived to some extent.]

A number of district heating schemes have been in operation in Germany and Russia, but as the winters there are so much more severe and the population is more often concentrated in large residential blocks, experience in those countries is not directly applicable to British housing conditions. In the United States, district heating has also been applied throughout the country to groups of about 60 houses, in a density of about 8 per acre but generally arranged in terraces of 8 to 16 adjoining houses (of about 800 to 1,000 sq. ft. floor area), and is quite common in the north-west section of the country, where climatic conditions are not dissimilar to those in Great Britain. This experience should, therefore, encourage an investigation into the possibilities of district heating in this country, where, even if extreme cold is rare, our damp weather makes heating desirable, to a greater or lesser extent, for the greater part of the year.

Reference is made in the note above to the investigations of the District Heating Sub-Committee. The sub-committee is paying particular attention to the question of thermal-electric generation, with special reference to the supply of electricity and heat from a thermal-electric station serving a town of 250,000 inhabitants. Thermal-electric generation involves many complex problems, both physical and economic, which will be examined in detail in the report of the committee.

The scope of this memorandum is less ambitious. District heating need not be linked with the generation of electricity, nor need it be restricted to very large schemes such as those which the sub-committee is considering. The programme of housing now being undertaken may offer many opportunities for district heating. An investigation has therefore been made into the supply of heat and hot water from a central source to groups of between 100 and 500 dwellings, without regard to the possibility of generating electricity at the same time. A uniform layout has been assumed so that comparisons between schemes of different size should be fair, and the density of housing is that which is likely to be adopted by a local authority on a new estate. Moreover the

calculations of the costs of the various district heating schemes described herein have been arrived at by reference to an actual typical site.

It follows, therefore, that the conclusions reached cannot be automatically applied to other estates where housing density, heating load and geographical configuration may be quite different. Again the methods of construction that have been assumed, while representative of good practice, are not put forward as standards; there is as yet too little experience of district heating in this country for that to be possible.

To summarise, then, this report has been prepared, not to provide a blue print that is applicable to all conditions but to show what the costs of district heating may be expected to be when applied to housing estates by local authorities. Each individual scheme requires investigation on its merits, for what may be technically and economically suitable for one may require modification for another. Every scheme of district heating should, therefore, be prepared by experienced engineers collaborating closely with the architect and surveyor responsible for the planning of the estate.

STANDARDS OF HEATING

In 1937/38, the Ministry of Labour conducted an investigation into specimen weekly expenditure of industrial households in the United Kingdom, and found that the average consumption of coal was 1·7 cwts. per week, amounting to nearly $4\frac{1}{2}$ tons per household per annum. With the appliances then available the amount of useful heat obtained from the consumption of $4\frac{1}{2}$ tons of fuel might, at a generous estimate, vary between 250 and 350 therms per annum.

The pre-war standards of heating and hot water supply, however, are generally regarded today as having been far lower than is socially desirable. For example, the average usage of hot water, for a family of four, was less than 100 gallons a week, and space heating was generally confined to one or two rooms of the house. Post War Building Study No. 19 suggests that modern requirements might be 220 therms a year for space heating and 165 therms for hot water supply, a total of 385 therms a year for a family of four. The District Heating Sub-Committee has been working on a total supply of 575 therms a year, nearly double the estimate given above of pre-war consumption. This higher figure, ample to provide for warming the whole house sufficiently to keep it dry and for a hot water supply, has been adopted as the basis of this report. The higher heat standard is obtained by the consumption of about 4 tons of coal per household per annum, which compares with the pre-war consumption of $4\frac{1}{2}$ tons including some cooking.

SECTION I

CHOICE OF SITE

As stated in the introduction, the layout of a proposed housing estate has been adopted, the original scheme comprising 205 houses and 36 flats (in 3 blocks), in a density of 12 houses or 22 flats per acre. The housing generally was to be of semi-detached type, each house having a total floor area of 900 sq. ft. Each dwelling was assumed to house a family of two adults and two children.

In an attempt to determine the size of the area at which centralised heat supply might be regarded as economic, a sub-division and an extension of the proposed scheme were made, and particulars were worked out for the following :

	Scheme I	Scheme II	Schemes III, & IV
Houses	98	205	412*
Flats	24 in two blocks	36 in three blocks	84 in six blocks of 14 flats
Total dwellings	122	241	496

* Including 4 blocks each of 8 terrace houses.

Plans of the various sites are given in Fig. 6 and are there denoted as Schemes I, II, III and IV.

Level sites were assumed, and the heat requirements of flats were taken as equal to those of houses.

A similar scheme was also worked out for 30 houses, but this proved to be quite uneconomic and details are not given here.

CENTRAL STATION

The ideal site for the central station on economic grounds would, of course, be at the "centre of gravity" of the heating load, and the planning of any estate where district heating is proposed should aim at this. Full regard, however, must be paid to the important questions of access of fuel, removal of ash, and direction of prevailing wind.

SECTION 2

HEAT REQUIREMENTS

As stated in the introduction, the District Heating Sub-Committee's standard of an annual supply of 575 useful therms for each dwelling has been adopted in this document, and the calculations of costs are based on the supply of this amount of heat. The standard provides for space heating and hot water to the extent indicated below.

SPACE HEATING

The maximum demand per dwelling for space heating was estimated as 12,000 B.Th.U. per hour with an extreme outside temperature of 25° F. Assuming an average outside temperature during the heating season of 42.5° F., the mean heating load would be 6,300 B.Th.U. per hour. Allowing for this demand for 24 hours per day over a period of 37 weeks, the consumption would be 393 therms. This would be sufficient to maintain the living room continuously at 65° F. during average weather, with some heating in the hall and bedroom. During the greater part of the winter, both living room and hall could be continuously heated, and the dwelling would at all times be at a temperature sufficient to be dry and free from condensation. The importance to the householder of much greater freedom from damp and condensation will be readily appreciated.

HOT WATER SUPPLY

The estimated consumption of hot water per dwelling is 200 gallons per week. This would be heated through 100° F. and, allowing for losses from a 40-gallon calorifier and circulation pipes (part of which losses would be available for space heating), would require a consumption in the house of 182 therms per annum. It is estimated that the mean demand would be

3,000 B.Th.U. per hour over a period of 14 hours per day and 1,000 B.Th.U. per hour during the remainder of the 24-hour period.

The total requirements of each dwelling are thus 393 therms for space heating and 182 therms for hot water supply.

Apart from the adoption of an arbitrary figure for the total heat supply to each dwelling, it is necessary to make arbitrary assumptions about how this amount of heat is used. The combination of assumptions adopted in this investigation is only one of a number that is possible, and the following are some of the variable factors :—

(i) *Full central heating, or background heating.*—The whole or the major part of the heat supplied for space heating may be used to produce conditions of full heating in one room. In that event there will be comparatively little heat remaining for the other rooms. Alternatively, the heat may be distributed uniformly so as to provide conditions of “ background heating ” throughout the whole dwelling, an individual appliance, such as a coal, electric, or gas fire, being used to supplement the heating of the living or other rooms, when occupied.

(ii) *Duration of the heat service.*—The space heating and hot water service may be maintained continuously throughout the whole 24 hours of each day, as is here assumed, but alternatively the service might be reduced or cut off during the night. This would reduce the total annual heat demand.

(iii) *Division of the total heat supply between space and water heating.*—The allocation of the total heat received at each dwelling as between space and water heating may also be varied.

SECTION 3

CHOICE OF HEAT MEDIUM

Steam has some advantages over hot water in the transmission of heat over long distances, but presents difficulties in the return of the condensate to the boilerhouse. Steam is not considered to be so suitable as hot water for schemes of the type considered herein.

For the purpose of Schemes I, II and III in this investigation a maximum flow temperature of 275° F. was decided upon ; this figure would be reached when the outside temperature falls to 25° F. The flow temperature would be controlled in accordance with the outside temperature and the conditions of supply would be so arranged that the service water temperature (i.e. the temperature in the supply main) to the houses would at no time fall below 180° F. Scheme IV, however, was worked out on the basis of low-temperature distribution at 200° F. maximum, the temperature in the supply main at no time falling below 175° F. ; the heating and hot water service mains are separate, making a four-pipe system, and the internal installations of the dwellings are coupled direct to the main, thus avoiding the use of individual calorifiers.

The use of high-temperature water (Schemes I, II and III) necessitates the installation of a mixing cylinder, as mentioned in Section 4. The supply to each dwelling would be controlled by means of valves, regulated and locked by the heat service authority and not susceptible to interference by the individual tenant.

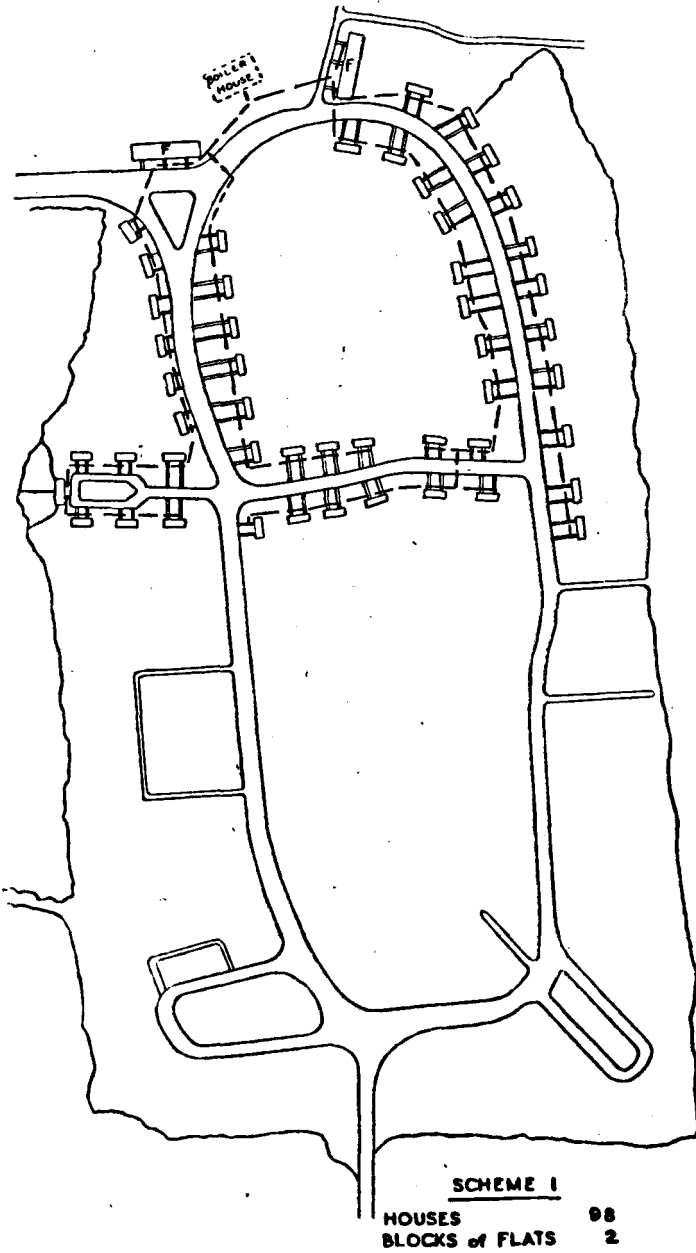


Fig. 6A

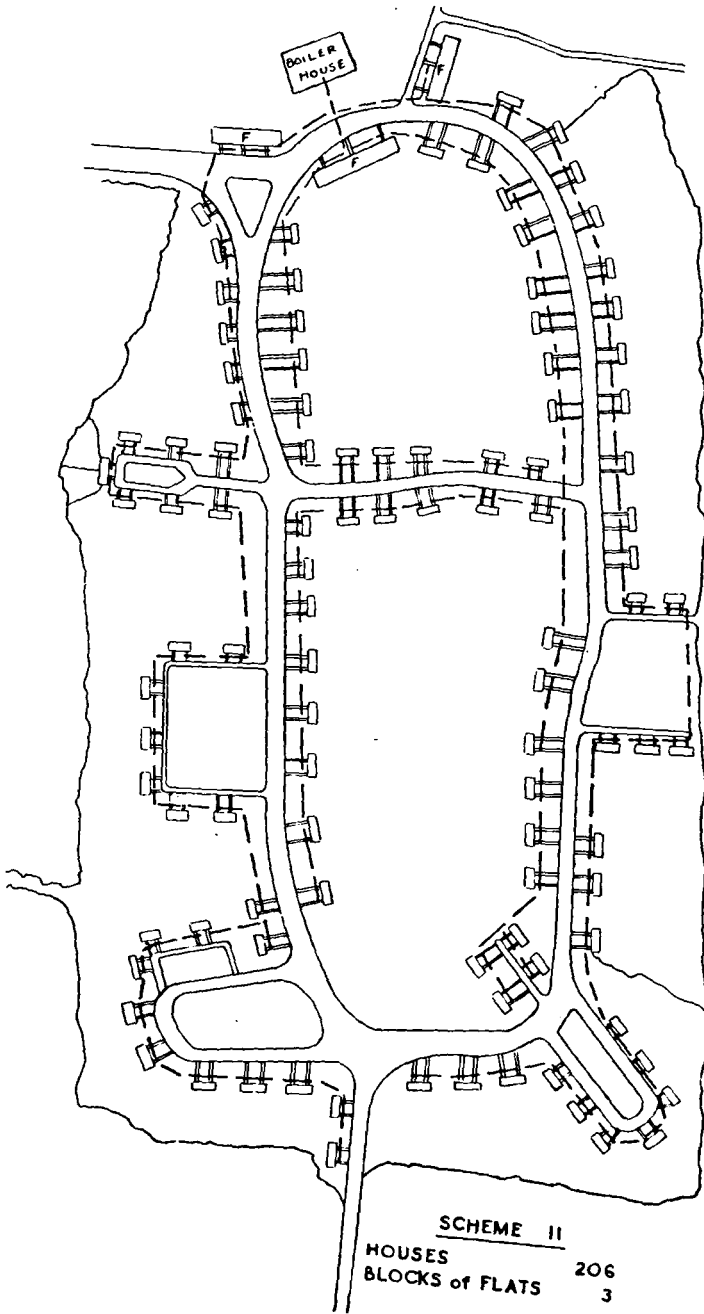


FIG. 6B

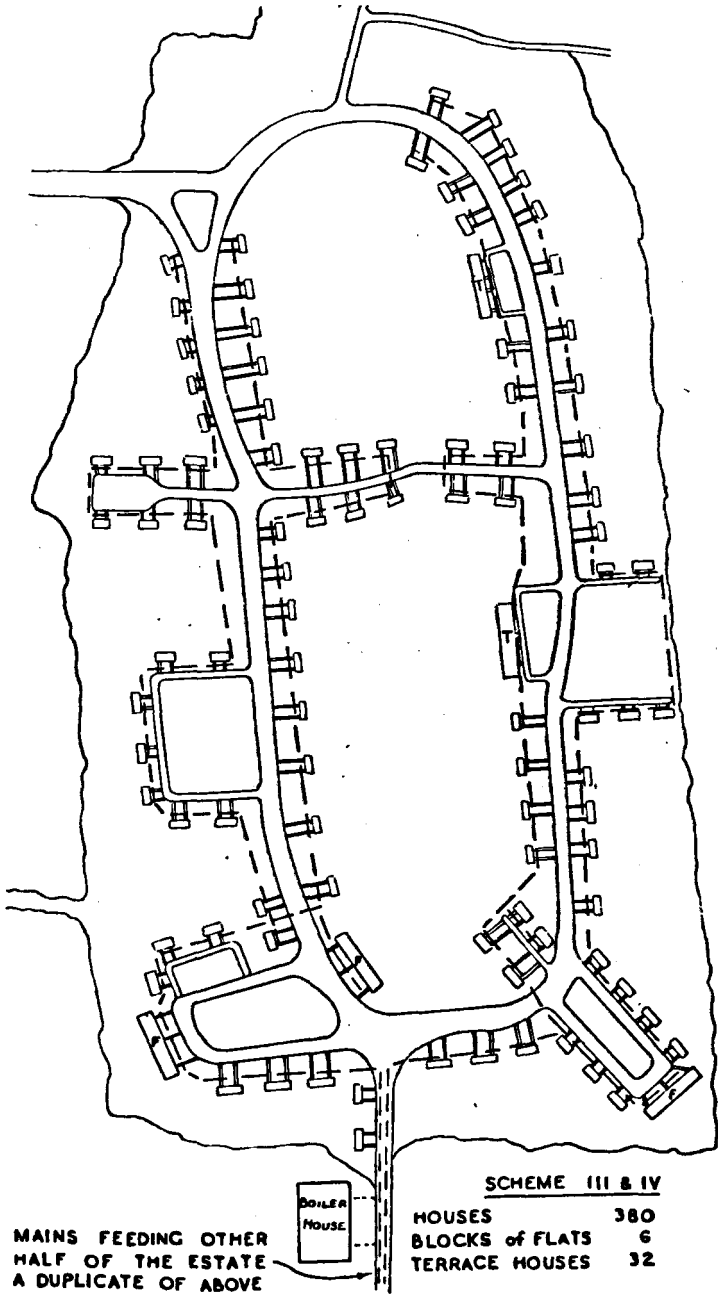


FIG. 6C

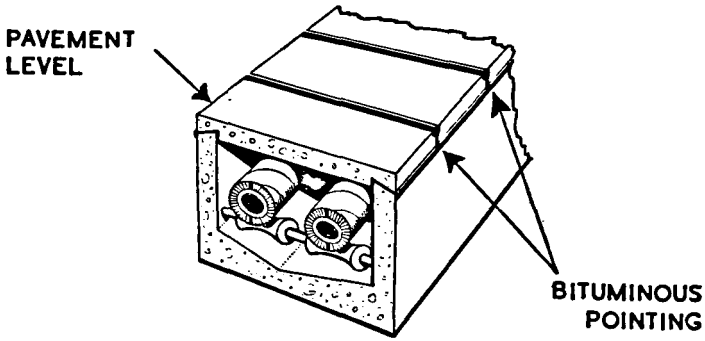


FIG. 7.—Section of Mains Duct

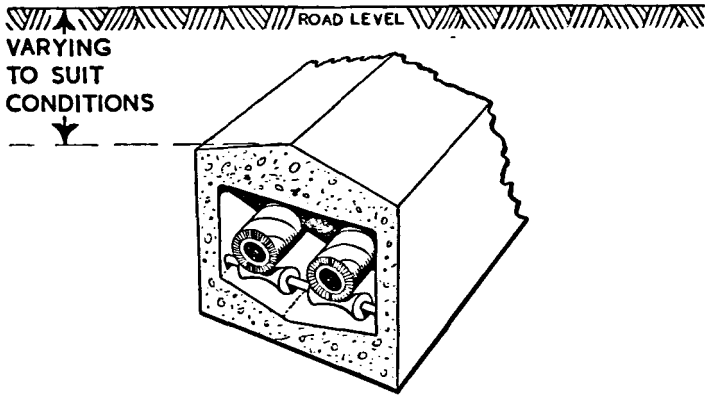


FIG. 8.—Section of Mains Duct under Road Crossings

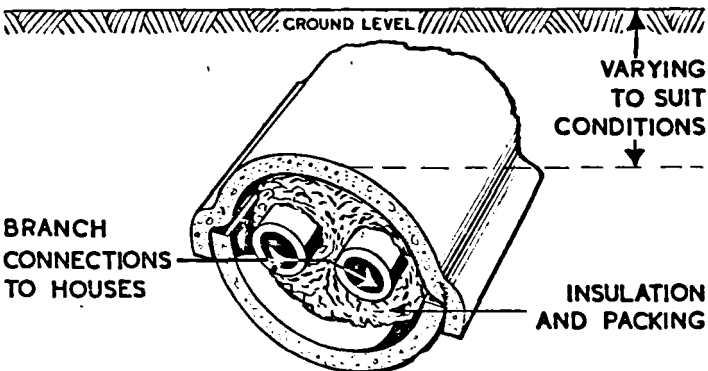


FIG. 9.—Section of Earthenware Conduit

Duct and conduit sizes depend upon pipe sizes and nature of the terrain

The runs of mains are shown in Fig. 6 (Schemes I to IV) and the types of concrete ducts and earthenware conduits are shown in Figs. 7, 8 and 9. The use of high-temperature water makes it necessary to consider carefully the insulation of mains and pipework generally. The annual loss is a difficult

factor to estimate, but a figure of 15 per cent. of the annual heat output of the station has been adopted here, and this seems to be a reasonable standard which should be aimed at in selecting types of duct construction and quality of insulation.

Automatic controls were also allowed for, boilers of economic or vertical type being selected, in accordance with the size of the scheme.

In order to reduce labour costs and ensure a high degree of boiler efficiency, full automatic stoking to the boilers has been allowed for in the estimate.

NOTE - OTHER NECESSARY ISOLATING VALVES NOT SHOWN. TEMPERATURES SHOWN ARE ONLY APPLICABLE WHEN THE OUTSIDE TEMPERATURE IS 25° F.

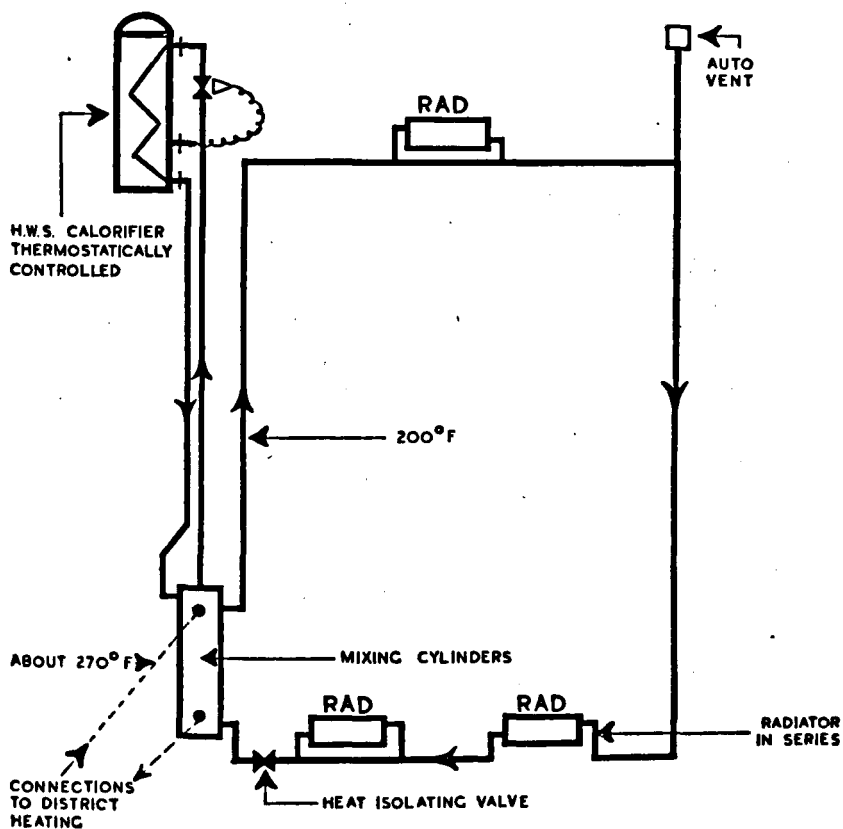


FIG. 10.—Diagrammatic Sketch of a Heating and Hot Water Supply System for a Small House

SECTION 4

INSTALLATIONS IN DWELLINGS

Installations in the dwellings may take a variety of forms. Fig. 10 shows diagrammatically one proposed system, which will limit the maximum demand of each dwelling to the amount intended. It will be observed that the high-temperature water from the district heating mains enters a "mixing cylinder"

from which connections are taken to a thermostatically-controlled hot water service calorifier, and to the radiator circuit. This arrangement ensures that the total heat consumption at any time in each house will not exceed the pre-determined figure for each house, i.e. at periods of peak hot water demand the heat supply to the radiators would be correspondingly reduced and vice versa. The effect of this arrangement is that the separate peak demands for heating and hot water supply will not be simultaneously imposed on the district heating mains. (Alternatively to the installations of a mixing cylinder in each house, schemes could be worked out on the basis of "substations", i.e. cylinders housed in separate buildings, supplying water at the required temperature to groups of houses).

An alternative system is offered by Scheme IV (*a* and *b*) which is a low-pressure hot water system with separate mains for space heating and hot water service. This arrangement does not require a mixing cylinder or calorifier to be used in the dwelling with a consequent saving in capital cost. This saving is, however, offset to some extent by the extra cost of the two sets of mains. This variation in costs is illustrated in the tables.

The heating installation in the examples considered in Schemes I, II and III includes a radiator in the hall, not provided with separate control valves, and thus providing a means of preventing the building-up of excessive temperatures in the mixing vessel. Other radiators are provided: one or more of these will normally be in the living room, but the disposition of the heating surface may be varied. For example, the installation would provide a temperature rise of about 30° F. in the occupied portions of the ground floor, and about 20° F. in one or two bedrooms. One possible layout of heating surface is shown in Fig. 11. For the greater part of the winter, therefore, little—if any—supplementary heating would be required in the living room, but under extremely cold conditions (which are comparatively rare) it would be necessary to use some auxiliary form of heating, such as a gas or electric fire, in order to raise the temperature of the dining room to the required level. As the total heat obtainable by the tenants is controlled, individual metering is unnecessary; its introduction would, of course, increase the cost of the schemes considerably.

SECTION 5

COSTS OF DISTRICT HEATING SCHEMES

Owing to the difficulty of estimating prices of equipment at the present time the estimates of costs have been based on 1937 prices. The year 1937 was chosen, because this was the recent pre-war year when prices were most stable. In the case of the Schemes II*b* and IV*b*, however, an attempt has been made to arrive at present-day costs. Although this is the best estimate it has been possible to make, based on present-day costs, the results should be regarded with reserve, in view of the instability of present prices of labour and materials.

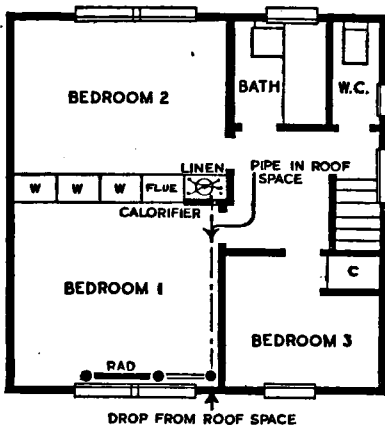
CAPITAL COSTS

The estimated capital costs are set out in detail in Appendix I (Table A), and are summarised below:—

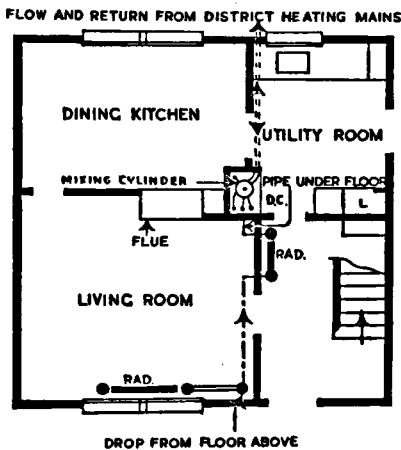
						£
Scheme I	(1937 prices)	.	.	.	.	13,628
„	II <i>a</i> (1937 „ )	.	.	.	.	26,282
„	II <i>b</i> (1946 „ )	.	.	.	.	43,200
„	III (1937 „ )	.	.	.	.	50,050
„	IV <i>a</i> (1937 „ )	.	.	.	.	50,446
„	IV <i>b</i> (1946 „ )	.	.	.	.	81,429

An analysis of the capital costs indicates the following typical subdivisions :—

	<i>Percentage</i>
Boilerhouse complete	15
Concrete ducts	20
Mains complete	25
House installations	35
Engineers' fees	5



FIRST FLOOR PLAN



GROUND FLOOR PLAN

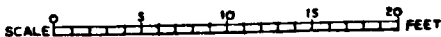


FIG. 11.—Detail of House Installation

CAPITAL CREDITS ARISING FROM DISTRICT HEATING

It will be observed from the schedules of costs in Appendix I (Table A) that the figures cover the complete installation, including builders' work and equipment within the houses. In considering the adoption of district heating for any housing scheme, therefore, certain credits should be taken into account. For example, some chimneys with their associated brickwork and hearths could be omitted and a piped hot water system would in any case be included in post-war housing. Again, it might be possible to utilise the concrete cover of the pipe duct to the house as an entrance path and, in this case, the cost of the normal path might be credited. The credit adjustment to be made in connection with any scheme can, however, only be determined when detailed plans have been worked out. As a guide for comparison with conventional methods of heating, the costs have been divided between internal installations in houses and all work up to the dwelling. Disregarding any possible allowance on the credit side, the cost of the scheme per dwelling varies from slightly over £100 in the larger schemes to £112 in the smaller.

ANNUAL CHARGE

The estimated annual charges, before allowing for any credits, are detailed in Table B and are summarised as follows :—

	(a) <i>All external work</i>	(b) <i>Internal installation</i>	(c) <i>Total Charge</i>
	£	£	£
Scheme I (1937 prices)	2,129	300	2,429
„ IIa (1937 „)	3,613	600	4,213
„ IIb (1946 „)	5,998	900	6,898
„ III (1937 „)	6,636	1,200	7,836
„ IVa (1937 „)	6,459	950	7,409
„ IVb (1946 „)	10,559	1,600	12,159

The corresponding costs per therm delivered to the consumer are :—

	(a) <i>Pence</i>	(b) <i>Pence</i>	(c) <i>Pence</i>
Scheme I (1937 prices)	7·3	1·0	8·3
„ IIa (1937 „)	6·3	1·0	7·3
„ IIb (1946 „)	10·34	1·56	11·9
„ III (1937 „)	5·6	1·0	6·6
„ IVa (1937 „)	5·45	0·8	6·25
„ IVb (1946 „)	8·88	1·35	10·23

and the weekly charges, to be made to the tenants throughout the year, work out at :—

	(a) <i>s. d.</i>	(b) <i>s. d.</i>	(c) <i>s. d.</i>
Scheme I (1937 prices)	6 8½	11½	7 8
„ IIa (1937 „)	5 9½	11½	6 9
„ IIb (1946 „)	9 7	1 5	11 0
„ III (1937 „)	5 2	11	6 1
„ IVa (1937 „)	5 0	9	5 9
„ IVb (1946 „)	8 2	1 3	9 5

VARIATION OF COSTS WITH THE SIZE OF THE ESTATE

Comparison of the running costs for Schemes I, II and III shows that the weekly charges that would have to be levied fall steeply as the number of houses on the estate is increased. In agreement with this conclusion, it is understood that the District Heating Sub-Committee's calculations for a city of 250,000 inhabitants tend to show that the costs of providing 575 therms to each house are no greater than those incurred by the tenants previously for a much lower standard of heating.

It is interesting to compare the make-up of the annual costs for Schemes I II and III :—

	<i>Scheme I</i> <i>Per cent.</i>	<i>Scheme II</i> <i>Per cent.</i>	<i>Scheme III</i> <i>Per cent.</i>
Fuel	30	33	36
Labour and supervision	27	20	16
Maintenance	10	10	10
Insurance	2	2	2
Electric power, etc.	1	1	1
Interest and depreciation	30	34	35

It is at once apparent that the item which increases most as the size of the estate is reduced is the cost of labour. Unfortunately this is the item which is most difficult to forecast accurately. Probably the allowances made in this report have been on a generous scale, particularly for the smaller schemes. With mechanical stoking of the boilers, it might be found possible to combine the work of the attendants with other duties. Indeed, it is understood that this is often the practice in the United States. Such possibilities, however, must depend entirely on local circumstances, and for the present the only safe conclusion is that the costs of district heating seem likely to rise sharply for estates smaller than about 300 houses.

COMPARISON OF COSTS WITH THOSE OF OTHER METHODS

It is difficult to make a fair comparison between these charges and the costs to tenants of heating by traditional methods. For one thing, the district heating scheme has been designed to give a far higher service than was available before the war, namely, 575 therms a year instead of between 250 and 350. District heating will provide more heat with higher efficiency, so that the comparison cannot be a direct one. On the other hand, the individual heating appliances that will shortly be available are also more efficient in design than the pre-war models, but their performance and their running costs in actual working conditions are not yet known with any certainty. Again, it will probably be thought advisable to provide the houses served with district heating with some means of securing high-temperature radiant heat, whether by an open coal fire or by gas or electricity. The extent to which the tenants would use such supplementary heating must remain a matter for speculation.

There is one further uncertainty which must be mentioned, that some of the tenants might not wish to avail themselves of district heating. If this occurred to any large extent, then the incidence of capital costs on the supply to the remainder would rise sharply. However, this has not apparently been the experience at Dundee, and another local authority, now putting forward

a district heating scheme, has pointed out that, as they are developing other estates heated by conventional methods, the tenants will, initially, be able to exercise a free choice.

However, some comparison must be attempted, and might be made on the basis of the Ministry of Labour Survey mentioned in the introduction. This showed that the average weekly expenditure, in 1937/8, on fuel and lighting was 6s. 5d. The proportion of this expended on cooking and lighting is not known, but a reasonable assumption is that about 4s. was spent on fuel for space heating and hot water.

This figure is substantially lower than the costs of district heating according to Schemes I to III. But the heavy increases in the price of coal during the war should alter the balance in favour of district heating, as the more efficient way of using fuel.

Some guide to the magnitude of this factor can be obtained from the costs of Scheme IV. The Board of Trade index-figures for the costs of fuel and light are :—July 1914, 100 : December 1937, 183 : and November 1945, 276. Thus the amount of fuel which cost 4s. a week in 1937 would cost about 6s. a week in 1945. It can be calculated that district heating could provide at least the standard recommended in Post War Building Studies No. 19 (*viz.*, 385 therms per annum) at the same cost as would be incurred in providing a much lower standard with individual appliances.

Since costs at the present moment are so uncertain, it is unwise to press the comparison too far. The general conclusion that one seems entitled to draw is that district heating of small housing estates can scarcely be economic as long as the tenants are satisfied with the pre-war standards. But as the standards are raised, as there are many signs they will be, the economic advantages of district heating become more marked.

There is a further consideration, however, which may weigh heavily in favour of district heating. It seems unlikely that, in future, local authorities' estates will consist solely of houses at a density of about 12 to the acre. The houses will be grouped round public and other larger buildings, such as schools, shops, community centres, etc. The inclusion of these buildings in the district heating will materially reduce the costs to the householders, since both capital charges and labour costs will be spread over a considerably greater heating load. In one scheme recently prepared for a local authority, the result of including the public buildings was to reduce the charges to the householders to 4s. 6d. a week.

Again, it may prove possible to provide the heating from surplus steam available from industrial works in the vicinity of the housing estate. Examples of this are already to be found in this country in several mining villages, where the householders' hot water is supplied from the exhaust steam of the colliery winding engine or a separate boiler plant burning low-grade fuel rejected from the coal cleaning plants.

Such possibilities as these serve to emphasise what has already been said, that the potentialities of district heating must, in every case, be judged on the individual circumstances of the estate. The need now, indeed, is to proceed with a number of district heating schemes in different parts of the country, so that the costs may be ascertained by experience.

APPENDIX I

TABLE A

Capital Costs of the Five Schemes

Items	Scheme I 122 houses and flats high temp. distribution 575 therms/ h'hold/ann. 2 pipe system (flow and return)		Scheme IIA 241 houses and flats high temp. distribution 575 therms/ h'hold/ann. 2 pipe system (flow and return)		Scheme IIB 241 houses and flats high temp. distribution 575 therms/ h'hold/ann. 2 pipe system (flow and return)		Scheme III 496 houses and flats high temp. distribution 575 therms/ h'hold/ann. 2 pipe system (flow and return)		Scheme IVA 496 houses and flats low temp. distribution 575 therms/ h'hold/ann. 4 pipe system (flow and return hot water service) (flow and return space heating service)		Scheme IVB 496 houses and flats low temp. distribution 575 therms/ h'hold/ann. 4 pipe system (flow and return hot water service) (flow and return space heating service)	
	1937 prices		1937 prices		1946 prices		1937 prices		1937 prices		1946 prices	
1. Concrete ducts	4,256 ft.	£ 2,128	9,346 ft.	£ 4,673	9,346 ft.	£ 6,900	18,000 ft.	£ 9,000	23,000 ft.	£ 10,000	23,000 ft.	£ 15,375
6-in. conduit	1,250 ft.	350	2,500 ft.	700	2,500 ft.	1,050	5,000 ft.	1,400		14,500		22,876
2. Insulated mains laid in ducts, welded, etc.		2,353		6,400		10,300		10,700		13,144		24,800
3. Installation in houses and flats.		4,400		8,700		16,400		17,870		13,144		24,800
4. Builders work in houses		250		500		602		1,000		750		1,250
5. Boiler house and chimney.		1,000		1,200		2,000		2,000		2,400		3,250
*6. Boilers complete with mountings, fuel tank, etc.		1,410		1,630		2,280		3,600		5,000		7,000
7. Circulating pumps and motors.		329		337		475		400		500		750
8. Automatic stokers and controls.		555		641		800		1,000		1,000		1,250
9. Insulated pipework and fittings in boiler house.		204		250		335		700		750		1,000
		<u>£12,979</u>		<u>£25,031</u>		<u>£41,142</u>		<u>£47,670</u>		<u>£48,044</u>		<u>£77,551</u>
10. Consulting Engineers' fees at 5 per cent.		649		1,251		2,058		2,380		2,402		3,878
TOTAL		<u>£13,628</u>		<u>£26,282</u>		<u>£43,200</u>		<u>£50,050</u>		<u>£50,446</u>		<u>£81,429</u>
*. Details of boiler plant.	2 Cochrane boilers, each rated at 1.73 million B.Th.U/hr., complete with feed tank, etc.		2 Cochrane vertical boilers, each rated at 2.3 million B.Th.U/hr.		2 Cochrane vertical boilers, each rated at 2.3 million B.Th.U/hr.		2 Economic boilers, each rated at 5 million B.Th.U/hr., complete with mountings, flue pipe and feed tank, etc.					

APPENDIX I—continued

TABLE B

Cost of Capital calculated at 3 per cent. plus Sinking Fund

Items	Scheme I		Scheme IIA		Scheme IIB		Scheme III		Scheme IVA		Scheme IVB	
	Capital Cost	Annual Charge	Capital Cost	Annual Charge	Capital Cost	Annual Charge	Capital Cost	Annual Charge	Capital Cost	Annual Charge	Capital Cost	Annual Charge
1. Boilerhouse and chimney (loan period 30 years).	£ 1,050	£ 53	£ 1,260	£ 64	£ 2,100	£ 107	£ 2,100	£ 107	£ 2,520	£ 128	£ 3,412	£ 173
2. Work inside boilerhouse (loan period 25 years).	2,623	219	3,001	250	4,080	342	5,985	498	7,612	633	10,500	874
3. All external work (loan period 30 years).	5,072	258	12,361	628	19,800	1,015	22,155	1,123	25,725	1,305	40,164	2,038
4. Installation in houses (loan period 30 years).	4,883	248	9,600	490	17,220	880	19,810	1,006	14,589	741	27,353	1,389
TOTALS	13,628	778	26,282	1,432	43,200	2,344	50,050	2,734	50,446	2,807	81,429	4,474

TABLE C

Heat Delivered and Fuel Consumed

Items	Scheme I	Scheme IIA	Scheme IIB	Scheme III	Scheme IVA	Scheme IVB
1. Heat delivered (therms per annum).	575 × 122	575 × 241	575 × 241	575 × 496	575 × 496	575 × 496
2. Annual fuel consumption (tons).	500	990	990	2,030	2,030	2,030
3. Cost of fuel per ton taken at .	28s.	28s.	52s.	28s.	28s.	52s.
4. Annual cost of fuel . . .	(1937 Price) £700	(1937 Price) £1,386	(1946 Price) £2,574	(1937 Price) £2,842	(1937 Price) £2,842	(1946 Price) £5,275

NOTE.—In the above calculations the calorific value of the fuel has been taken at 11,500 B.Th.U. per lb. boiler efficiency at 60 per cent. and mains losses at 15 per cent.

TABLE D
Annual Costs

Items	Scheme I (1937 prices)	Scheme IIA (1937 prices)	Scheme IIB (1946 prices)	Scheme III (1937 prices)	Scheme IVA (1937 prices)	Scheme IVB (1946 prices)
	£	£	£	£	£	£
1. Cost of Capital (<i>see</i> Table B) . . .	778	1,432	2,344	2,734	2,807	4,474
2. Cost of Fuel (<i>see</i> Table C) . . .	700	1,386	2,574	2,842	2,842	5,275
3. Labour and Supervision . . .	644	800	1,000	1,250	1,000	1,250
4. Maintenance . . .	242	500	875	750	500	875
5. Insurance . . .	45	65	75	200	200	225
6. Power for motors and lighting . . .	20	30	30	60	60	60
TOTAL	2,429	4,213	6,898	7,836	7,409	12,159
	Pence	Pence	Pence	Pence	Pence	Pence
Average cost per therm delivered to house	7·3	6·3	10·34	5·6	5·45	8·88
Cost of internal installation	1·0	1·0	1·56	1·0	·8	1·35
Average total cost per therm	8·3	7·3	11·9	6·6	6·25	10·23
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Weekly cost excluding internal works . . .	6 8½	5 9½	9 7	5 2	5 0	8 2
Weekly cost for internal installations . . .	11½	11½	1 5	11	9	1 3
TOTAL weekly cost	7 8	6 9	11 0	6 1	5 9	9 5

APPENDIX II

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Discussion

Mr. Donald Smith: This is neither the time nor the place to thrash out technical differences ; this can best be done in the drawing office or the accountant's department. In my opinion, it will be more useful if we can persuade Government Departments to adopt a policy which will ensure that technical issues will be fully explored and encouragement given to enough schemes to obtain speedy and decisive information.

Irrespective of differences in systems advocated or examined, all the experts who have spoken today agree that district heating is practicable in Great Britain, that it should result in a great economy in fuel consumption, and that it enables a higher standard of heating to be obtained in the average home with less fuel than by the traditional methods in use in Great Britain.

That comprehensive agreement is a striking fact, and so is the estimated saving—in certain cases nearly two tons per house per year.

Professor Holford stressed the need for co-operation. Too often the engineer has been brought in too late. Sewage, water, light, for example, were not dealt with on modern lines until conditions became so bad as to threaten the life of the community. Heat is a necessity ; to be healthier and to produce more, we need more energy, and heat is energy. We must produce the conditions, not of comfort merely but those which will promote mental and physical activity and well-being.

One point that Professor Holford does not stress deserves emphasis, and that is the provision of an ample supply of hot water on tap. How can children be kept clean or healthy without adequate cleansing facilities ? Cleanliness promotes health ; dirt and damp promote disease, and surely prevention is better than cure.

Mr. Donkin and Mr. Margolis dealt with thermal-electric stations, and both showed that there is practically no limit to the areas that can be successfully served.

In both Germany and Russia, I have seen a number of the installations of the type Mr. Margolis described, some of them very fine examples of engineering practice. There is nothing experimental about them ; they work satisfactorily

and have done so for years. One thing, however, I will not concede to any continental countries, and that is pride of place in pioneering these systems in Europe ; that belongs to Britain. The first European scheme was started in Manchester in 1911, thirty-five years ago. Only a year or so later the question was discussed with the then City Architect of Dundee, and it was decided to plan a large area served from a central source. Owing to the first world war this was not carried out until some years later ; but in 1918 two housing schemes, with densities of less than ten per acre, were planned, and have worked for the last twenty years. Including continental schemes, there are now well over 200 district heating schemes in operation in Europe.

Those three schemes in Britain have been in operation for periods of from a quarter to a third of a century. If any sceptics still exist, I ask them how much longer do you expect these schemes to work before you will admit they are practical propositions ?

At Urmston we are not dependent upon a large installation to get the scheme going. We have planned the work in several stages, and the first 20 houses have just been put into commission.

A point I would like to bring out is the effect on electricity. If thermal-electric schemes are pushed to their fullest extent, at least 40 schemes similar to that proposed at Wythenshawe are possible. This would involve the generation of between 3,000 and 5,000 million units of electricity a year at a fraction of the cost of the present generation, and sufficient in quantity to reduce the average cost of electricity supplied by the C.E.B. by 10 per cent.

I will close on a lighter note. The situation reminds me of a story of a rather desirable young lady (Miss District Heating) who toyed with many suitors. Glancing over a book of names while waiting for her latest swain, she exclaimed : " Mother, this book says David means brilliant and Gwilym means steadfast ; I must see what Emanuel means ". " I hope," said her mother severely, " that Emanuel means business." To my personal knowledge Minister after Minister for twenty years past has been informed and warned of this matter. They lay low and did nothing. I trust the Chairman will convey to the Minister this afternoon the hope that he means business.

Mr. Sumner : I believe that the engineering and the town planning professions have been suffering for many years from a very uneasy conscience. They have now done a wise thing in facing the two matters that were worrying them—district heating and heat pumps. It is reasonable to say that as a result of this session and previous meetings district heating is properly launched, and we have no longer an uneasy conscience there.

I am not quite sure that the second matter is not still causing concern, and that it is my duty to amplify and probably encourage engineers even a little more than Mr. Donkin has done with regard to heat pumps. The figures that Mr. Donkin has taken for the heat pump—that is a reciprocal efficiency of three and an over-all thermal efficiency of 20—are of the past. At Norwich we have been getting 3·2 and 3·3 on our very inefficient, improvised heat pump. I want to suggest that quite a reasonable figure would be 3·5 or 3·7.

The other point is this : It is true that the over-all thermal efficiency of electrical generation has been about 20 per cent., but if, shall we say, we get the first district heating scheme going about 1960, which seems to be about the earliest date, surely we can reasonably assume that the over-all thermal efficiency of a generating station will be nearer 27 per cent. ? If you can get 3·7 from your heat pump and 27 per cent. over-all thermal efficiency you

will get 100 per cent. of the heat that is in the coal at the station put into your houses. I have had recently to look into two schemes for district heating in Norwich ; in one case we shall get 90 per cent. and in the other case 110 per cent., in fact we shall put rather more heat into the buildings than was originally possible with the power station. That is only assuming good working. I think we can reasonably assume 100 per cent. efficiency for the majority of schemes. One cannot generalise, but I think if that note is kept in mind—Mr. Donkin has probably wisely been conservative—our conscience may be a little bit easier in the future with regard to the heat pump.

Major Markham: The question of costs has been repeatedly raised in these discussions, but material cost figures cannot in themselves be complete and it is necessary to take into account the happiness, energy and welfare of the people of this country. It has been my privilege during many years to inspect heating systems all over the world, and I want to give a very brief comparison of the sociological effects of the different heating systems in various countries. In countries such as Sweden and New Zealand, where there is no smoke pall over the cities, and where every house within the urban areas is well heated throughout, the infant mortality is about 25 per cent. below that of our cities, and the expectation of life is one year longer. The total illness during a year is at least 10 per cent. less than ours ; much less time is lost both in industry and private life.

Therefore, when considering newer methods, such as district heating, in comparison with the older methods still being installed in this country—methods which produce smoke at both ends of the chimney—I would suggest that the ultimate argument is this : Will the methods that it is proposed to adopt in any new housing estate improve or worsen the health of the people ? If that question is fairly faced there is no other answer but this, that methods of heating where smoke is abolished will help us to produce in this country that clear beautiful air such as we used to have in the olden times, but which we have lost during the last 200 years.

Given that clear air, one could promise a tremendous reduction in respiratory diseases in this country ; a great reduction in absenteeism through illness in all our industries ; and above all, one could promise most decisively that the result of clearing this country of its great smoke palls, and of introducing modern methods of heating and warmth and hot water into all our homes, would be a very great improvement not only in the physical but the mental well-being of this country.

Mr. Thwaites: I have been asked to say a few words about the pioneer work which has been done by a number of electricity supply undertakings.

Some 35 years ago, Manchester began to show the way, and heat is still supplied from a rather old and somewhat obsolete generating station in the centre of the city. Steam is supplied at 100 lb./sq. in. and at 300 lb./sq. in. to industrial premises and to places of amusement, including a large theatre. In Liverpool steam has been supplied for 15 years from the Clarence Dock to large industrial establishments. The quantity is of the order of 400 million lb. of steam a year, corresponding to 4 million therms. There are certain condensation problems here, but it is understood that heat exchangers are to be installed to overcome the difficulty. Leicester Electricity Department is supplying $1\frac{1}{2}$ million therms a year to nearby premises. The interesting feature of this scheme is that it is virtually a thermal-electric station within a large condensing station, the steam being normally derived from a 40,000 kW

condenser, and the whole of the condensate being returned to the generating station. The South Wales Power Company have for many years been supplying steam to many places, and here again, the condensate is returned to the station. The pipe lines are supported on stanchions about 12 ft. above the surface of the ground.

The technical problems have therefore been solved. Minor questions which have still to be answered are : Will the general public take kindly to this new form of heating ? [In Russia where there is district heating you have to have it or go without.] Will hot water be wasted ? Many people believe that where supplies are unmetered the residents will be extravagant. For this reason I support other speakers who have advocated that there should be put into operation a full-scale experimental installation. If there is to be such a scheme, why not at Wythenshawe ?

Mr. W. H. Duffett (Engineer and General Manager, Rotherham Corporation Electricity Department) wrote making the following points :—

1. In dealing with the Wythenshawe scheme, Mr. Nicholas refers to a generating station operating at 30 per cent. thermo-dynamic efficiency, this being improved to 75 per cent. if operating non-condensing and if credited with the heat rejected. This suggests high initial steam conditions with modern refinements and while this latter figure of 75 per cent. has no practical significance, I would expect a value between 65 per cent. and 70 per cent.

2. Mr. Nicholas refers to the electricity as a by-product, but I prefer to consider it as an integral part of the heating scheme since, given initial steam conditions, there is a definite relationship between the amounts of electricity generated and heat available.

Assume the ratio required to be 9,000 B.Th.U. per unit of electricity sent out, this could be achieved by large modern sets, non-condensing, using steam at the stop valve at 1,200 lb./sq. in. pressure (gauge) and 935° F., returning the feed water at 400° F.

On the basis of 450 million B.Th.U. and 50,000 units per hour, the coal required (11,000 B.Th.U. calorific value) would be 30·75 tons per hour. Similar sets exhausting into a vacuum of 28·7 in. (Bar. 30 in.) would send out 50,000 units for a coal consumption of 24 tons. Thus the expenditure in coal for 450 million B.Th.U. works out at 6·75 tons.

3. With a heat pump of advantage $3\frac{1}{2} : 1$ supplied with electricity from an independent source, the coal consumption would be 18·25 tons per hour and with an electrode boiler 70·5 tons. Direct production from a coal-fired boiler would require 23·4 tons.

If an increased ratio of heat to electricity is required, this can be achieved only by sacrificing fuel economy such as by producing the additional heat by less efficient methods. These include reducing the initial steam conditions to the non-condensing turbine, omitting some of the modern refinements, extracting steam at a higher back pressure and using heat pumps or separate boilers as boosters.

If the ratio is increased to 10,000 B.Th.U. per unit so that for 50,000 units of electricity sent out, the heat available would be 500 million B.Th.U. To obtain the additional 50 million B.Th.U. the heat pump would require the least amount of fuel since this offers a two-fold advantage inasmuch as it provides heat itself, and by increasing the demand on the non-condensing turbo-set, additional heat is available thereby.

The heat pump advantage ratio depends on the temperature adopted for condensation and on the difference between this temperature and that of evaporation. Assuming an advantage of $3\frac{1}{2}$, the coal required for the additional 50 million B.Th.U. would be 1.47 tons.

4. An electrode boiler also increases the demand on the turbo-set to an even greater extent than the heat pump ; but notwithstanding this, the fuel required would be 2.55 tons. A coal-fired boiler would require 2.6 tons.

As regards the booster plant required for augmenting the heating requirements beyond the ratio of the turbo-set, the heat pump requires the least fuel, as already stated, viz., 1.47 tons against 2.6 tons by a coal-fired boiler. However, the coal-fired low-pressure boiler is a relatively inexpensive plant in first cost, operation and maintenance ; whereas the heat pump is expensive in itself and, in addition, must be debited with a proportion of the standing and running costs of a modern generating station operating non-condensing. In this example, the capacity required is 2,390 kW. Boosting by an electrode boiler would consume 2.55 tons but would require 4,150 kW of generating plant.

5. There should be little difference in the annual standing and running costs (excluding fuel) between condensing and non-condensing plant. Increased boiler capacity, including buildings, would be required for non-condensing sets but against this, the cost of providing, operating and maintaining screening and condensing plant with ancillary apparatus would be avoided. If cooling towers are required for condensing purposes, a material saving would be effected. Thus, heat by non-condensing turbo-sets is economical within the ratio limits from all points of view.

If the increased ratio be obtained by reducing the steam conditions, the generating station would be less costly in capital outlay, operation and maintenance, while the availability factor would be increased.

6. The relative fuel consumptions stated refer to a definite ratio of heat to electricity ; whereas, in practice, the ratio will vary both daily and seasonally, and the extent of the variations will be important in determining the economics of any scheme. During periods of lower ratio, heat accumulators might find a place in the scheme to assist higher ratios at other periods. Other alternatives for peak service are steam from the station boilers through a reducing valve and de-superheater ; steam normally used for feedwater heating ; increase in the back pressure of the exhaust ; operating the boilers at steam conditions inferior to normal or a combination of these alternatives and those previously discussed.

7. Mr. Nicholas points out that peak demands for electricity occur during cold months and are, therefore, likely to coincide with peak demands for district heating. It is scarcely safe to rely on such conditions of balance, since the intention of the district heating scheme is to supersede the electric fire excepting for topping-up purposes during extreme conditions, and even in such cases the gas fire might be used. Figure 5 in Mr. Leeming's paper supports this view.

8. In assessing the relative advantages of the different schemes, it is probable that the best site for the generating station is some distance from the centre of gravity of the load.

9. The stabilised cost of fuel must figure in the decision. It is safe to predict that the era of cheap boiler slacks has ended ; although this does not mean that prices and quality will remain at the present level. I have long

held the view that heavy capital expenditure should not be based on coal costing less than is economically possible at the pits and I stressed this point 19 years ago in discussing the paper on Power Plant Design at the I.M.E.A. Convention. (I.M.E.A. Proceedings, 1927.)

10. As regards the equitable charge for heat from a thermal-electric station, there should be no difficulty in determining this ; in fact, Selected Station Owners have had considerable experience in similar computations in agreeing their costs with the Central Electricity Board.

Mr. Nicholas proposes a charge of 5s. 1d. per week for 761 therms per annum, whereas Mr. Leeming proposes 396 therms per annum for 4s. 6d. per week. The Manchester figure is encouraging compared with present-day alternatives. Even at Rotherham, which is recognised as having an electricity undertaking with low production costs, the present-day charges for electricity to give equivalent service would be 11s. 10d. per week for 761 therms per annum or 6s. 4d. per week for 396 therms.

11. Unfortunately, the general adoption of the thermal-electric scheme of district heating would introduce a serious complication in the effect it would have on the national electricity grid. Under the Electricity (Supply) Act, 1926, Selected Stations are required to generate such quantity of electricity at such rates of output, and at such times as the Central Electricity Board directs. In practice, certain stations are now required to curtail their generation during certain periods and may be directed not to generate at all ; but if district heating is involved, it would be necessary and efficient to operate the stations concerned at all times. Possibly Mr. Nicholas had this complication in mind in referring to the electricity as a by-product, assuming that he will be generating at a non-selected station notwithstanding Section 10 (3) of the 1926 Act. No doubt this is a matter which will receive attention in framing the Bill for the nationalisation of the electricity supply industry.

12. The coal fire in the Urmston scheme provides a convenient means of destroying undesirable refuse not suitable for the dustbin.

13. The capital involved in either scheme would not be insignificant, but the economics of district heating are not confined to the expenditure of capital and fuel ; in fact, a true balance sheet should be drawn up on a national basis and should include on the credit side such important items as saving in labour, in decorations, in building renovations, the reduction in cost of health services and sickness benefit and the increase in output per head. The only additional item on the debit side appears to be increased costs of pensions due to longer life.

Mr. W. J. Dickie (Thomas Board Mills, Warrington) wrote advocating the adoption of thermal-electric rather than straight thermal schemes, to serve industrial as well as domestic users. He drew attention to the power district heating scheme proposed by the Warrington Chamber of Commerce.

QUESTIONS

Questions answered by Mr. Stubbs

(1) Do houses which are at a distance from the heat generating station receive heat at a lower temperature than other houses nearer to the station ?

Answer : No. The temperature available at all houses is higher than that required by the house. This question was dealt with by Mr. Pallot when discussing the trials carried out on the inclusion of a mixing chamber. (See page 181.)

(2) Though the average consumption may be estimated, is there a maximum beyond which the service would be cut off, since a house with basins in every bedroom tends to use more water and heat than one with a basin in only one upstairs bedroom ?

Answer : The heat available for each house is a pre-established maximum, and the user will pay for that maximum quantity whether he uses it or not. He may use it either as hot water or for space heating, and if he uses an additional amount for hot water he deprives himself of space heating. Since the hot water demand is over a short period only, it is unlikely that that would affect his space heating unless he continues to draw hot water off in very large volumes.

[This statement applies to the hypothetical case considered in the "Basic Scheme".]

(3) What form of individual house metering for district heating is to be adopted ?

Answer : None. The use of hot water as the medium for the distribution of heat permits centralised control so that the heat supplied to houses would be in reasonable relation to requirements dictated by external weather conditions. This renders house metering unnecessary.

(4) Over what period have capital charges to be calculated for boilers and installations ?

Answer : Thirty years has been suggested for the installation, with 15 years for pumps and boilers. (See Appendix I, Table B, page 198.)

(5) An architect has advised district heating for housing schemes for 130 plus, and suggests that the cheapest means of heating is by oil-fired boilers. Do you agree ?

Answer : It is very difficult to say whether I agree or disagree with that recommendation. It is very possible that the recommendation is a correct one, and in considering the advantages or otherwise of oil-fired boilers one would have to give due credit to the adaptability of oil firing.

Questions answered by Mr. Nicholas

(6) Why did the Manchester Corporation, after they had been supplying district heat for two years, suddenly abandon the scheme and instal new grids with ugly additions to each house ?

Answer : There is a misconception here of the sort which does much damage to district heating. This was the Blakeley scheme, but it was not a district heating scheme in the full sense of the term ; it was arranged for the supply of hot water through the hot water tap only. The transmission of hot water through the pipe caused severe corrosion and instead of getting hot water in which clothes could be washed people received very dirty water. Because the Blakeley scheme failed, district heating must not therefore be condemned.

(7) If you have a direct supply of electricity from the grid system, and you are thereby not able to take advantage of electricity or surplus heat from the district heating system, where do you suggest any excess demand should come from ?

Answer : There are two methods of district heating, the thermal-electric and the direct thermal station. If the thermal-electric station cannot be used a straight thermal station may be installed.

Written Answers to Questions

Considerations of space will allow of the printing of answers to only a certain proportion of the questions which were received. The answers to many questions will be found in the addresses and discussion contained in this report of the session.

(8) Can any information be given about heat-transmitting media other than steam and water, e.g. special chemical oils ?

Answer : Steam and water are considered to be the most economical media for district heating schemes. Special media may be used for industrial work where high temperatures, but not high pressures, are desired.

(9) What is the probable smallest size of housing estate to make district heating worth while ?

Answer : No general answer can be given to this question : it depends on the relative industrial and domestic loads. The Wythenshawe Scheme, for instance, proposes to serve some 8,000 houses and flats, and will have two central stations, while in Scotland a scheme for 183 cottages has been approved. In the U.S.A. schemes serving as few as 60 houses are known.

(10) It has been said that heat can be transmitted up to 6 miles with a loss of 2 per cent. and up to 2·2 miles with a loss of less than 1 per cent. Has it been found generally that transmission losses are low ?

Answer : With a sufficient thickness of insulation and a sufficiently rapid rate of flow the losses incurred in transmitting heat in the form of hot water or steam over fairly long distances (up to, say, 3 miles) would not be greatly dissimilar to the transmission losses of other services, such as gas or electricity.

(11) In many towns the heat from the refuse destructor is allowed to go to waste. Could not this be used for a supply of hot water to houses ?

Answer : Some local authorities are already considering the useful application, as part of district heating schemes, of the heat generated in refuse destructors, and it is open to others to follow their example.

(12) Is it possible to modify the plans of a district heating scheme for a new housing estate of less than 200 houses, with a view to serving another adjacent estate as well ?

Answer : Yes.

(13) Is it considered desirable that a standard of insulation should be insisted upon in all buildings served by a district heating system ?

Answer : Yes. It would, however, be difficult to introduce any form of legislation to effect this. Chapter 8 of the Code of Functional Requirements of Buildings deals with standards of heat insulation. A British Standard for thermal insulating materials is in preparation.

THE CHAIRMAN, **Sir Patrick Dollan**, bringing the session to a close, referred to Major Markham's argument that whether a good system of heating cost 6s. 6d. or 8s. 6d. a week was immaterial compared with the ultimate criterion of its effect on health. He could support that from his experience of New York. He had spent some time there studying the civic services and found infantile mortality to be only 33 per 1,000, whereas in London it was 60, in Glasgow 84, and in some smoke-laden towns between 90 and 110. That, he felt, was the final test.

At the Closing Session of the Conference, **Dr. E. S. Grumell** summed up the conclusions which he drew from the deliberations of this Joint Session. Dr. Grumell said :—

The Joint Session on District Heating was attended by over 2,000 people. I think it would be fair to say that the potential advantages of district heating are beginning to be more fully appreciated, especially when district heating includes public or other large buildings such as schools, shops, community centres, etc., to which may be added in some cases connection with industrial works. There would still be some doubt about the actual costs, and it would seem desirable, as more than one speaker put it, that a number of district heating schemes should be proceeded with in different parts of the country so that the cost may be ascertained by experience. That is sound advice but unfortunately such schemes take time to develop, and in many reconstruction schemes one could not afford to wait for the experience.

I think that the papers submitted have made out a strong case for the application of district heating to reconstructed or newly-built areas that is sufficiently strong for any element of risk to be justifiably ignored.

CLOSING SESSION

Chairman : The Rt. Hon. EMANUEL SHINWELL, M.P.
MINISTER OF FUEL AND POWER

The Closing Session was devoted to an address by the President of the Board of Trade, the Rt. Hon. Sir Stafford Cripps, K.C., M.P., which will be found in extenso in Volume I of the Proceedings of the Conference, and to summaries of the work of the conference by the Sectional Chairman, which will be found at the end of the proceedings of their respective sections. Summaries only are given here of matter which intimately concerned the sections whose proceedings are contained in this volume.

The Chairman

There is general agreement that this conference has proved its worth in spreading a wider knowledge of the facts, in the presentation of new ideas and in the recognition of the vital part that fuel efficiency methods can and will play in maintaining and improving the industrial prestige of the nation.

The search for additional labour in the mines in order to repair the weekly wastage, which is considerable, has been persistent. But here we suffer from years of disparaging and gloomy propaganda. Now the process must be reversed and we must demonstrate that coalmining can be made safer and more attractive and offers opportunities for engaging in an essential and honourable calling.

The other important factor, which has been fully appreciated by the Ministry of Fuel and Power for over twelve months, has been the steady rise in consumption. In gas and electricity it has exceeded the expectations of everybody. In gas and electricity, but particularly as regards electricity, the rise in consumption compared with 1938 has been phenomenal. It is because of this exceptional rise in consumption that we are compelled to ask for the exercise of economy and the elimination of waste. There has been a persistent campaign directed to this objective. But leaving exports aside, and no one is more anxious than I am to revive our export trade in coal, what stands between us and the provision of all the requirements of inland consumption is a little more than another 100,000 tons a week. Again I must repeat that the present labour force, provided we can repair wastage, is capable of producing sufficient for our purposes. Deep coalmining is hard work and must be met, and I say to this conference the newly-appointed members of the National Coal Board who will be in charge of the industry very shortly and who are entrusted with the task of reorganising on modern lines, must receive the utmost encouragement and goodwill. This fuel problem must be solved and, in spite of many difficulties—most of which are not of our making—but derive from a disordered and ugly past, we are determined that it shall be.

The Rt. Hon. Sir Stafford Cripps, K.C., M.P. (President of the Board of Trade) said that he wished to support strongly Mr. Shinwell's call for fuel efficiency and economical production. Although in many fields we had made a good beginning, this country was still producing for the home market only about three-quarters of our pre-war output of clothing and footwear ; our rate of furniture production in the second quarter of 1946 was only about 60 per cent. of pre-war ; in exports we had reached pre-war value, which meant that

to restore the pre-war volume of imports we must increase our present exports by 75 per cent. in volume. To these colossal tasks must be added our housing and building undertaking. In these circumstances the nation was trying to do almost more than was possible, and certainly more than was possible unless the highest productive efficiency was secured. Fuel and power were the foundation for modern industrial production and for the comfort of the people. There was only one way in which this ever-growing demand could be met and that was by increased efficiency in production.

Mechanisation was the basis for mass production and it was significant that whereas the horse-power used in this country between 1930 and 1939 was increased from 2·8 to 3·5 per industrial worker, in the U.S.A. it was 6·3.

Fuel economy was a very good investment, even looked at from the purely financial point of view. Often the total capital cost of fuel economy could be written off in two or three years by the economies achieved. The introduction of fuel efficiency and of saving in fuel did not mean that we must cut down the degree of mechanisation or the amount of fuel and power used ; that would be to defeat the main purpose of getting more efficient production. It was often quite possible to increase production with a reduction in the fuel used per unit of output.

Three things were necessary : watchfulness against waste of fuel ; research to discover new ways of using fuel more efficiently ; and application of the results of research and technical development as rapidly as possible.

Those who had attended this conference must not allow the knowledge they had gained to be pigeon-holed in their minds or in their desks. It must be used and put into practice.

The Chairman concluded the conference by thanking all the many people and organisations who had so generously collaborated and given of their time to make the conference the success it had been.

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