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# COMMERCIAL MOTOR ROAD TRANSPORT

BY

L. M. MEYRICK-JONES

ONE TIME EDITOR OF "MOTOR TRANSPORT"  
AUTHOR OF "STEAM ROAD VEHICLES"

WITH A FOREWORD BY

LT.-COL. J. T. C. MOORE-BRABAZON

M.C., M.P.

SOMETIME PARLIAMENTARY SECRETARY TO THE  
MINISTRY OF TRANSPORT



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## FOREWORD

WHAT is the purpose of that comparatively modern invention, the Foreword? If, as I assume, it be a species of recommendation to the public, then I can only say that a volume on motor transport of the type that follows is something that is long overdue.

In recent years mechanical road transport has undergone very great changes. The values, absolute and relative, change from day to day, and not only the values but the bases on which they are founded have changed, especially in the heavier class of road haulage. Loads carried in single units are larger than ever before. New sources of power are being mooted and methods of employing old ones, long attempted with but little success, are now being evolved with startling results. Over and above all this, mileage capacity—the very foundation of transport working—has been vastly increased by the device and development of the giant pneumatic tyre.

The economic possibilities of this are still further fostered by legislation; for the road transport of to-day is governed by a new law radically different in many respects from that of a year or two ago. Motor transport propositions are very changed to what they were only a few years ago, both from the mechanical, economic, and legal aspects.

Such being the position, it must be admitted that some sort of up-to-date guide is badly needed, and the publishers of this book are to be congratulated on having chosen the psychological moment to fill that need, and on having obtained a book by so eminent an authority as Mr. Meyrick-Jones. He gives us what is so much required at the present time, that is a straightforward

and accurate view of the possibilities, in simple language, of motor transport in all its branches.

This should enable the business man to assess the value of the commercial motor vehicle for his own purpose, besides doing a great deal to help him if he has already adopted motor transport.

To such people in particular, and to those of the public who wish to know more about a subject which concerns the whole country vitally, I can recommend this volume with confidence.

J. T. C. MOORE-BRABAZON.

## PREFACE

THE enormous increase in road motor transport which followed the War led to a number of excellent books on the subject; but it also brought with it such vast and far reaching developments that the need for a guide based on the altered conditions thus produced can hardly be questioned. Since those days new laws govern road transport and throughout the whole economic aspect vast changes have taken place, to which great activity in mechanical development has added. Goods and passenger chassis have been evolved into two separate and distinct types, the pneumatic has practically displaced the solid rubber tyre, new types of vehicle have been developed (among which the six-wheeler is perhaps the most prominent for road work) and now the heavy oil engine promises to revolutionize the £ s. d. outlook, at any rate for motor transport in its larger units.

Under these circumstances the question confronting the author has been how to fill the undoubted need in some small measure to the best advantage. It has been said that no man can please everyone and he who tries to do so is a fool. However that may be in general, the writer assuredly does not presume to attempt it in the present case. This volume therefore has been compiled primarily for that most numerous class which contemplates or has adopted motor transport in a small way and may have need of a general guide for reference. Consequently it makes no pretension to deal with the necessarily elaborate systems of large organizations entailing the services of departmental specialists. It merely attempts to give information on such points as may be useful to the average man engaged in motor

transport and to outline common-sense methods of applying his knowledge. After all, transport working, like most other things, resolves itself into little more than applied common sense based on knowledge, and it is hoped that within that modest scope this book may be found, if not "of the greatest good," at least of some service to "the greatest number."

For the last twenty-five years or more the writer has had the privilege of learning from those in motor transport who are in a position to teach and lead, and to them he wishes here to make the fullest acknowledgment. Also his most grateful thanks are due to all the leading firms in the industry for their kind co-operation in the matter of illustration and for much valuable information. In connection with the latter particular acknowledgments are due to the Goodyear Tyre & Rubber Co., Ltd., and to the Avon India Rubber Co., Ltd., to Mr. F. G. Bristow, C.B.E., Secretary of the Commercial Motor Users Association, to Mr. A. W. Rosamond, Secretary of the Guildhall Insurance Co., Ltd. and to the author's old colleagues Mr. Horace Wyatt, Major P. M. Sanders, and Mr. C. F. Haywood. Lastly, but very far from least, the writer must express his very real sense of obligation to Lt.-Col. J. T. C. Moore-Brabazon, M.C., M.P., late Parliamentary Secretary to the Ministry of Transport, for the Foreword which he has been good enough to contribute to this volume.

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# COMMERCIAL MOTOR ROAD TRANSPORT

## CHAPTER I

### ON CERTAIN GENERAL CONSIDERATIONS

MECHANICAL work may be defined as the effect of force exercised over a distance. That is exactly what transport is, and, though it results in nothing tangible, as does the production of goods, it is just as marketable a commodity as the merchandise with which it deals and just as essential as the most vitally necessary of those goods. For production to serve its purpose, or indeed for life itself to be maintained, obviously either the consumer must go to the goods or the goods come to the consumer, and under the complex conditions of modern life the former course is becoming ever less feasible and the consumer is becoming ever more and more dependent on means for bringing his concrete needs to his door. Such a stage has this state of affairs now reached that transport is by far the most universally indispensable of all human requirements, and, as such, may claim firmer foundations than any other calling. Civilized humanity may endure for a while without supplies of those conveniences that have come to be regarded almost as necessities; but without means for the distribution-supply of immediate real essentials, such as foodstuffs, it would perish within a few days. To an extent transport may fluctuate with trade; but only to an extent: beyond that, however bad trade may be, transport is inevitable; and in this lies the reason why any organized complete stoppage of

transport would, sooner rather than later, kill itself. It has been called "the life blood of trade," but it is more than that; it might well be called the life blood of communal existence.

At the present time the means for supplying the demand for inland transport are immensely complicated. Ignoring for the moment the considerable development of a form of cross-country conveyance independent of roads, there are on land the two main systems of road and rail. As yet, however, the scope and limitations of neither are very clearly defined. For years there has been much talk of co-ordination between the two, but little, or nothing, constructive has been done. Inland transport has in fact reached a stage of transition, and for the time being its two main components are having to find their own levels in the evolution of things.

### **What Commercial Transport Amounts To.**

Yet, though the conditions are complex, the business of transport can be resolved into a relatively simple formula. Commercial transport, whether by road or rail, is basically a matter merely of converting money into the work of carrying, and for those who make a trade of the conveyance of goods or passengers it means, further, the resolution of that work back into terms of money at a profit.

Nevertheless, simple as the problem may appear fundamentally, it must not be inferred that successful achievement is equally simple. Most big propositions, when thus broadly analysed, can be resolved into few and simple factors. "Is it difficult to paint like this?" inquired a lady admiring a fine picture. "Oh no, Madam," replied the artist, "you have only to apply the right colours in their proper places and in the correct manner, and there you are!" So it is in motor

transport. You have only to arrange expenditure to give maximum results, and "you are there"; but to do that calls for clear, logical thinking, judgment, foresight, unremitting attention, and a knowledge of the work sufficient to know whether it is being rightly performed. Moreover the field is wide. There is transport of goods and transport of passengers, the work in either case involving numerous phases each of which in a large organization must constitute the business of a separate department. In both these branches, too, an infinite variety of conditions and requirements is presented, though both are governed by the same fundamental principles, which latter call for first consideration.

#### **Importance of Adequate Mileage.**

In the first place mileage *must* be adequate. If a business vehicle cannot be given sufficient mileage, it cannot be worked economically and in such a case, unless other considerations than those of £. s. d. supervene, it is better not to sink capital in the proposition. To avoid misunderstanding and disappointment it is best to be quite frank at the outset and state the limitations as well as the potentialities of the prospect. No one uses a steam hammer to crack nuts, nor does any business man purchase a motor vehicle when there is insufficient work for it, the reasons for which will be more fully explained when dealing with expenditure and working costs.

#### **Economic Loads.**

The primary purpose of the business motor being to carry loads over distances, the same applies to loads; but with a difference. If mileage is uneconomic, there is an end of the matter. Loading, however, presents a more elastic problem. At the outset the size of the

vehicle can be selected with reference to the load, down to a certain point, and, if loads increase, the difficulty in some cases may be solved by running additional trips. In any case, however, the great point is to avoid overloading, which is the most prevalent fault and the source of more avoidable loss than anything else in motor transport, and this to an extent not generally realized, particularly as it affects the tyre bill, of which more anon.

### **The Influence of Working Conditions.**

As already stated, transport, regarded physically, is the conveyance of loads over distance; but always with due regard to the financial considerations that underlie the whole proposition. Indeed, it may be said that the observance of efficient economy in doing the work is more important than the work itself, since it is better not to run at all than to run at a loss. That must be borne in mind when choosing one's means of conveyance. It is unwise to saddle a business on the one hand with vehicles that entail higher capital costs than can be profitably carried, or on the other hand with those that involve high depreciation and repair charges.

The same considerations will also determine the nature of the power—whether petrol, heavy oil, steam, or electricity. Where coal is cheap, and loads large, steam may have the advantage, while in cities where low rates for electric current reign that source of power may be worth while, though possibly the electric vehicle is likely to have a better chance when cheap current becomes more general throughout the country under the electricity grid scheme. From this aspect also the suitability of the instrument for its purpose must be considered in other respects, and the size of engine must be suited to the work in hand, for fuel must not be wasted, yet time must not be lost.

**Road Conditions and Working Requirements.**

Physical conditions and working requirements also have a bearing in determining engine size. In hilly districts, for a given average speed, manifestly more power will be required than in level country, for speed lost uphill may be more than proportionate to that recovered downhill. For example, a car averaging 30 miles an hour (m.p.h. "for short") would cover 20 miles in 40 minutes. Yet, supposing that for the first 10 miles hills reduced the speed to 20 m.p.h., the first half of the journey would occupy 30 min., leaving only 10 min. in which to cover the last 10 miles, if the average were to be maintained. In other words, if the speed for the first half of the journey were 33 per cent below, for the last half it would have to be 100 per cent above the mean speed. A steady average is thus preferable to a fluctuating speed, and the desirability of maintaining speed uphill is evident. That can, of course, be ensured by high power, and assuredly a larger engine is advisable in hilly regions than in level country; but economy requirements demand an engine no larger than absolutely necessary, and such cases can generally be met by the compromise of a moderately powerful engine in combination with lower gear, rendering the vehicle able to climb hills faster but thereby less capable of extreme speed on the level. Still, most modern vehicles can afford to sacrifice some of their speed on the level to obtain the steady average which is the ideal to be achieved. It is a matter of exercising judgment in co-adjusting engine power and gear ratios, and any would-be owner of transport vehicles, before making a choice, would be well advised to inquire as to the powers and gears for his class of traffic in his neighbourhood. A too powerful engine is wasteful; but every engine is designed to give maximum economy at some given speed and, if too small, might



have to be geared so low that it would have to do too much work at an uneconomically high revolution speed. Too little power may be as bad as too much.

This relation of engine and gear ratios must also be considered in connection with other working conditions, for, speaking broadly, the higher the gear the slower the acceleration, and, if much traffic congestion is to be encountered or very frequent delivery stops have to be made, the relatively low geared chassis is much the more handy.

The need for handiness may also influence the choice of the chassis, a compact, short wheel-base possessing real advantages when backing up to loading bays in confined spaces or manoeuvring in narrow streets with sharp turnings, or in heavy traffic, though on long distance work or over average roads the long wheel-base machine certainly gives the easier riding.

**PART I**  
**MECHANICAL**

## CHAPTER II

### SOME LEADING MECHANICAL PRINCIPLES

To be able to form an intelligent and reliable opinion on motor transport a certain degree of knowledge in things mechanical is very necessary, and, though the average man of to-day is conversant with the working of the petrol car, at any rate sufficiently to drive it after a fashion, in managing a transport business he must understand to some extent the why and wherefore of things. The writer, therefore, makes no apology in here explaining certain fundamental mechanical principles.

#### **Some Key Definitions.**

To begin with it is very needful to have a clear-cut idea as to the meaning of certain mechanical terms such as force, work, and power.

Force is that which tends to produce motion in a body and is measured in pounds.

Work in the mechanical sense is the exercising of force through a distance, and its unit of measurement is the foot-pound, which represents the amount of work necessary to move through one foot against a resistance of one pound.

Power is the capacity for doing work and, as its measurement must indicate the rate at which work can be done, time enters as a factor. When James Watt began to sell his engines he found himself confronted with the need for giving some idea of their relative capacity and, as they were very generally employed on work formerly done by horses, he devised the horse power as a means of measurement, on the assumption that a horse could perform 33,000 ft.-lb. of work each minute. Undoubtedly, to be on the safe side, Watt's

estimate of the horse's capacity was very generous, for, though an animal can work at this rate and more for short periods, the average power which it can maintain for any extended period is only about 17,000 to 22,000 ft.-lb. per minute. Nevertheless, to this day the engineer's horse-power (h.p.) represents the capacity to do work at the rate of 33,000 ft.-lb. a minute.

### Heat and Work Inter-convertible.

The next point is that this work can be converted into heat and—which is more important to us—*per contra* heat can be converted into work. Heat and work are interchangeable currencies. To illustrate the fact, consider the working of a steam lorry. In its firebox heat is being generated by the burning of coal and that heat is being converted into the work of propelling the vehicle through the medium of steam, while downhill the work of braking is converted back into the heat which is evident at the brakes. Again, if a bearing runs short of oil, the work due to the additional friction thus caused is converted into heat which may be great enough to do serious damage to the bearing.

Not only do we know of this interchangeability between work and heat, but we know the rate of exchange. We know that  $772\frac{1}{2}$  ft.-lb. of work are equivalent to 1 British thermal unit (B.Th.U. for brevity) which represents the amount of heat requisite for raising the temperature of 1 lb. of water by 1 degree Fahrenheit.

### How Efficiency is Determined.

Further, as we know the number of B.Th.U.'s in a given quantity of any of the leading sorts of fuel available, it is easy to calculate the actual work that could be given out, supposing all its heat were converted without any losses. Thus, if we compare the actual

work done by an engine on test with the work-value of the fuel it consumes, we can discover the engine efficiency. Supposing, for example, an engine was consuming exactly  $\frac{1}{4}$  lb. of good quality petrol per minute. The heat value of that fuel would be somewhere about 4,500 B.Th.U., which represents 3,476,250 ( $4,500 \times 772.5$ ) ft.-lb. of potential work. If all that work were obtained at the rate at which the fuel was being consumed, it would represent between 105 and 106 h.p., and, if the engine were giving out, say, 21 horse, its efficiency, measured by its actual power as compared with the total available in the fuel, would be as 21 to 105, or 20 per cent.

That, rightly, is what is meant by engine thermal efficiency, and as the figure in the assumed example is fairly representative of the petrol engine, which averages 20–25 per cent efficiency, it will be realized that as yet we are able to convert into useful work only a mere fraction of the heat available in the fuel. Some is lost by contact with the colder walls of the cylinders, much escapes by the exhaust, and there are numerous other sources of loss, including the friction of the engine mechanism, if the horse power is taken at the shaft (brake horse power, or b.h.p.) and is not indicated horse power (i.h.p.) taken from inside the cylinders.

In heavy oil engines the losses, apart from those occasioned by the mechanism, are rather less, and on an average a thermal efficiency of some 30–35 per cent is claimed for them, but in steam engines efficiency is considerably lower, especially for such small units as are used on road vehicles. That is because opportunities for loss are more numerous, for not only does considerable heat escape up the boiler chimney and by condensation of the steam on striking against the cooler surfaces of pipes and engine, but a lot is absorbed by the conversion of the water into steam.

The following figures, giving roughly the number of B.Th.U. per lb., will afford some idea as to the relative heating values of the various fuels that have been used for road transport. Petrol, 18,000-20,000; paraffin or kerosene, 19,000; benzol, 17,000-20,000; alcohol, 9,000-11,000; heavy fuel oil, 16,000-20,000; suction producer gas, 1,000-1,100; coal, 11,000-15,000; coke, 10,000-14,000.

In transport, however, it is not so much thermal values that matter as the commercial aspect. The concern of the practical man is rather to know how much work he can get out of a shilling rather than trouble about heat units. Nevertheless it is important to grasp this idea of the conversion of heat into work, as it explains so many things, and is the foundation of the accepted basis for judging performance.

### **The Principle of Transmission Gear.**

Many a man, when driving, changes gear without in the least knowing the real underlying reason. He only knows that, if he changes up, he can travel faster, and that to change down gives him more power but less speed up hills.

Now we have seen that work is made up of force acting over distance, the one multiplied by the other; but these two factors can be varied and adjusted to each other without altering the total amount of work. It matters not whether in a minute an engine exerts a force of 3,300 lb. through a distance of 10 ft., 330 lb. for 100 ft., or 33 lb. for 1,000 ft.; the result in all cases is the same, namely 33,000 ft.-lb. of work a minute, or 1 h.p. A machine exerting relatively small force, but at high speed, may thus give just as much power as a far bigger slow-speed machine. A great 12 ft. water wheel, for instance, may yield only about 1 or 2 h.p., while a tiny motor-cycle engine may be able to develop

twice that power because of its capacity for putting in much work in little time.

It can thus be realized that to apply the power direct to the road wheels of a vehicle without the intervention of gearing would entail a very big engine, capable of exerting great force but running at much lower speed

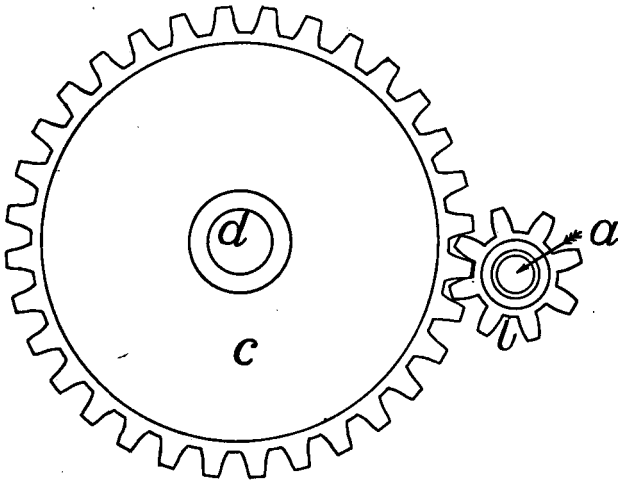


FIG. 1

A small spur pinion will rotate a gear four times as large with fourfold force, but at only one-fourth of its revolution speed

than is customary in automobile practice. Such an engine, even if practicable from other aspects, would be very heavy, apart from other disadvantages. Therefore the chassis designer drives the wheels by means of a smaller high speed engine through gearing which has the effect of multiplying the force at the expense of the speed or distance-in-time factor.

The principle of this gearing is best explained by a simple diagram (Fig. 1) in which *a* is the shaft driven direct from, and therefore at the same speed as, the

engine, say, 1,000 revolutions a minute (r.p.m.). Secured on this shaft is a spur pinion, *b*, its teeth in mesh with a spur wheel *c*, four times as large, mounted on the shaft *d* which is to be driven. Now in considering transmission problems like this gear wheels may be regarded merely as levers with endless handles for turning the shafts. In this case the rotation of the driving shaft *a* is resisted by the driven gear *c* at the rim of pinion *b*. This resistance, therefore, acts with a leverage equivalent to the distance from centre to rim of pinion; in other words, equal to the radius of the pinion. On the other hand, the driving pinion *b* acts on driven gear *c* with a leverage equal to the radius of the latter, and, as *c* is four times the size of *b*, the driving leverage is four times that of the driven resistance, and so the driven shaft *d* is rotated with four times the force of *a*. However, one cannot gain something for nothing, and it is obvious that to give a single full turn to the driven gear will entail four revolutions of the driving pinion, for there are thirty-two teeth on the former and only eight on the pinion. Thus, while the force is multiplied fourfold the rotational speed is reduced to a fourth at the driven shaft.

#### **Engine Turning Effort.**

In actual fact, as the driven axle generally lies at right angles to the driving shaft, a worm or toothed bevel gear is usually employed to effect the speed reduction when the engine is driving on direct gear; but, while such a reduction is quite suitable for good speeds on the level, it would not give sufficient force-multiplication up hills unless an engine with an uneconomically large reserve of power were employed. Even then the engine would have to run dead slow at times, while in traffic the same would apply. An engine is, however, designed to give its best results at



a certain given speed, and those of the internal combustion variety in particular fall off in power at low revolution speed. Accordingly, the designer generally adopts a moderate size of engine quite capable of driving direct through a single gear reduction on the level; but he provides a transmission giving further gear reductions, which can be brought into action at will for slower speed or greater power requirements.

From what has gone before it is clear that turning effort, positive or negative—driving or resistance—is made up of the force and the leverage or the distance from the centre at which that force acts. Force, however great, exactly at the centre of a shaft would exert no turning effort whatever. Consequently this turning effort, or torque as it is called, is calculated in "moments" made up of the force in lb. multiplied by the leverage at which it acts from the centre. For instance, a rope wound round a pulley of 1 ft. radius and with a pull of 100 lb. on it, would rotate the wheel with 100 lb.-ft. turning moments (not to be confused with the ft.-lb. unit of work.)

Now in an engine the leverage on the crank is constantly varying. At the beginning of a stroke piston and connecting rod are merely pushing on the crank radially towards its centre; there is no leverage and the turning effort is *nil*; it is all useless effort. The crank in fact is on its dead centre. As the crank turns, however, the useless radial thrust becomes less and effective leverage increases, until, just when connecting rod and crank are at right angles, in position *a*, Fig. 2, radial thrust has dwindled to nothingness and turning leverage is at its maximum, the radial thrust increasing and effective leverage diminishing thereafter until the opposite dead centre is reached, when all the force is again radial and leverage has fallen to nothing. Supposing a force of 100 lb. acting on a piston throughout

its stroke, and that the crank is 1 ft. long, then the way in which the useful turning fluctuates around the half revolution circle of a piston stroke may be graphically represented by the shaded portion in Fig. 2, assuming the distance from *a* to *b* to represent the full torque of 100 ft.-lb. moments. From this the loss in transforming the lineal motion of the piston into circular movement at the crank can be appreciated.

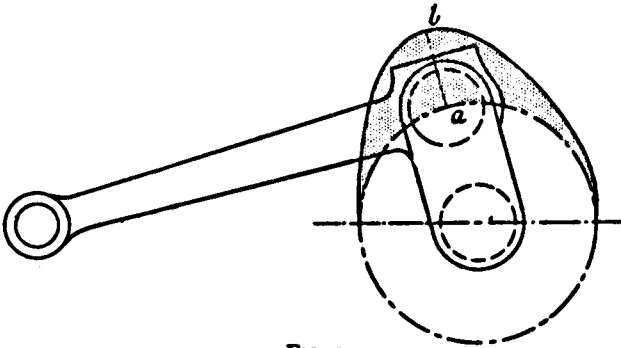


FIG. 2

The shaded area represents the *useful* crank turning effort of an engine during one cylinder stroke or half a revolution, the circle showing the path of the crank-pin centre and its diameter being equal to the piston stroke

But in an engine cylinder the pressure is not uniform throughout the stroke. In an internal combustion engine, for example, it rises suddenly at the moment of explosion, thereafter falling rapidly as the piston moves outwards and gives the gases more space to fill, until, by the time the exhaust opens and the pressure is released, it has fallen to comparatively little, and by the end of the stroke becomes practically non-existent. How the pressure thus varies is illustrated by the diagram in Fig. 3, wherein the base line *ab* represents the length of stroke, the vertical height *ac* the pressure in lb. per sq. in., as marked. The height of the line *adeb* then represents the varying pressure along the

stroke and a line carried vertically up to it from any point on the base or stroke line (line  $fd$  or  $ge$ ) will give the measure of pressure at that point of the stroke. This diagram shows at  $d$  how the pressure rises to its maximum of some 400 lb. per sq. in. on explosion, how

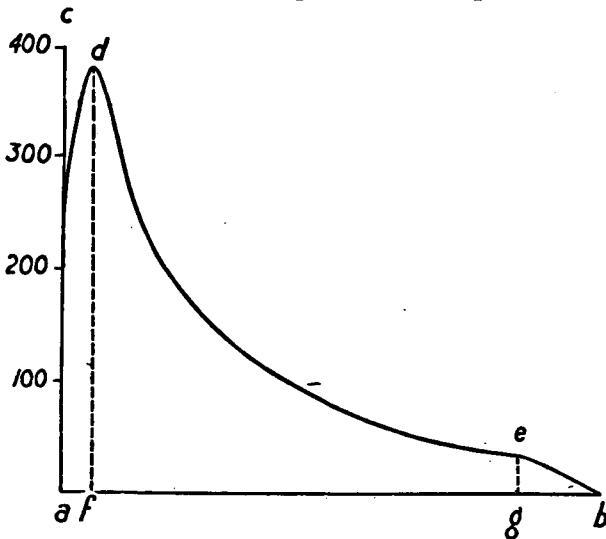


FIG. 3

How the pressure varies in the cylinder during the piston working stroke is shown by the curve  $adeb$

by the time the exhaust valve opens at  $e$  it has fallen to about 25 lb. and thereafter falls still more rapidly towards the end of the stroke.

It can thus be appreciated that the engine works with a constantly varying fluctuation of turning effort due to two combined causes, but it must be realized that these fluctuations, which are very rapid and continuous, are, so to speak, absorbed by the inertia (some people call it momentum) of the flywheel and moving vehicle, and thus cannot be felt.

**Road Propulsion.**

Again, how do the road wheels propel a car? If there was no weight on the wheels or if road and driving tyres were so slippery that there was no friction between them, the wheels would simply spin round without the vehicle moving. The friction must be sufficient to overcome the rolling resistance, which, with an average motor vehicle on a level road, may be anything from 30 to 70 lb. per ton of weight, according to the nature of the road surface, though on ultra-loose and heavy surfaces the figure may rise as high as 200 lb. per ton, or even more, while uphill the resistance will be additionally increased by the force necessary to raise the vehicle to the height involved by the gradient.

Whatever may be the resistance, however, if it is sufficient to overcome the friction between ground and tyres, the wheels will spin without driving, for it is this friction that gives them their grip. That friction depends on the nature of the ground and tyre surfaces: pneumatics give better adhesion than solid rubber tyres, solids better than metal tyres. Again, on greasy asphalt with solid tyres a force only 6 per cent of the weight on the wheels may be sufficient to cause slip, while on dry asphalt it may take ten times that force. If the coefficient of friction is very low, as on icy roads, it may have to be increased by fitting driving chains before the wheels will bite.

There is no need to go deeper into the matter. The point is that the driving wheels must carry sufficient weight to give them adhesion, and the weight on near and off side wheels should be approximately the same.

**The Principle of the Beam.**

One last point, which explains why a chassis frame, or front axle, is made of channel or girder section, besides many other things.

Suppose we have a beam supported at each end and carrying a weight at the middle (see *A*, Fig. 4). The weight will *tend* to bend the beam, even if it does not actually do so; and any bending will stretch the fibres along the lower side of the beam and compress those at the top. Imagine the beam bent into part of a circle (Fig. 4, *B*), and it is easy to realize that the fibres along the inner, and smaller, circumference must be shorter than those on the outer, while midway between the fibres are neither compressed nor elongated. Clearly, where the material is compressed or stretched there

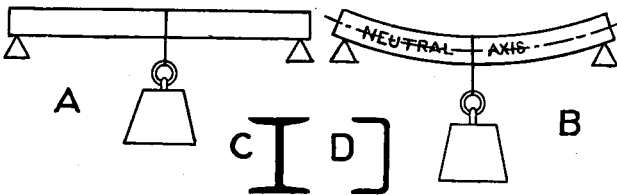


FIG. 4

Explaining the principle of the beam, and why beams are made of H and channel section

must be force or stress to cause such deformation, and so apparently the stress which causes the bending is greatest along the top and bottom of the beam, while along a plane midway (known as the neutral axis) there is no stress. Now it is of no use to put material where there is no stress for it to resist; it should be placed where there is the most stress to be met; and so the engineer puts as much material as possible into the top and bottom of his beam, merely leaving enough in between to tie top and bottom together; thus the beam assumes a section as in *C* or *D*, Fig. 4. From all of which it will be realized that in a chassis frame or any beam holes should as far as possible be drilled along the neutral axis and the fewer holes in top or bottom the better.

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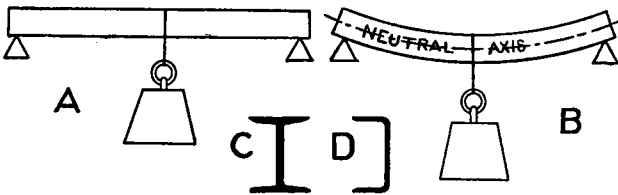


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Note also that in Fig. 4, *B*, the bending is greatest at the middle of the beam. Manifestly then the beam is most liable to bend where the weight comes and, if therefore it is made deeper at this point, it will be stiffened where most necessary and the material will be disposed to greatest advantage. That is why chassis frames are often made deeper between their supporting points at the back and front springs (Fig. 5, *A*).

The same principle can be effected by carrying a rod low down and well away from the neutral axis on the

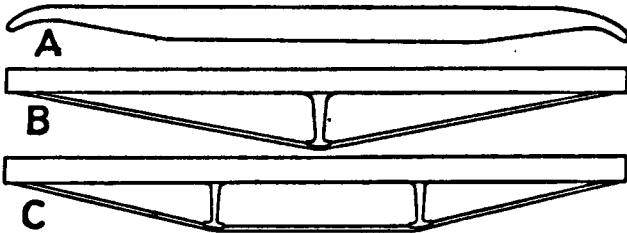


FIG. 5

The greatest stress commonly falls towards the middle of a beam, and that is why chassis frames are deepened between their points of support, as in *A*, while frames may be strengthened by trussing, as in *B* and *C*

lines of *B* and *C*, in Fig. 5, to take the tension or stretching stresses to the greatest advantage and so with the minimum weight of material. This form of construction is known as a truss (*B* being a king post and *C* a queen post truss) and is well exemplified on the long underframes of railway carriages, while it also affords a useful means of strengthening weak and sagging chassis frames.

If a beam is supported only at one end, like the jib of a crane, the principle is just the same except that the bending stress is greatest at the point of support, where the beam should therefore be deepest. A beam of this sort is known as a cantilever, and numerous examples of it are to be found in automobile construction.



## CHAPTER III

### ON THE CHOICE OF TYPES

THE vehicle should be suited to the load rather than the load to the vehicle. That appears a self-evident truth, but is often disregarded by men who, aspiring to enter the transport business, first acquire a car and only then look around for work. It is important to form a clear conception of the nature and size of the loads, as also the working conditions, before selecting the means for conveyance.

Apart from any exact idea of size, however, the intending transport owner has several broad types from which to choose. In the very smallest sizes there is the alternative between the three and the four wheeler, in the larger sizes he will have to decide between four and six wheels, and whether to have a chassis with the driver placed in the usual position behind the engine or with the driver beside the engine and all the space behind available for load—normal or forward control. Then for goods conveyance there are the alternatives of carrying on a single vehicle, of using such a conveyance in conjunction with a trailer, of a semi-trailer (sometimes termed a flexible six-wheeler, or a tractor trailer), or pure haulage by tractor and trailer. (In this country passenger trailers are banned by the law.) Lastly, for abnormally heavy loads eight wheelers, usually of the flexible variety, are available; but the weights of these with their loads usually put them outside the scope of the motor law, rendering them legally road locomotives.

Legal speed limits have a considerable bearing on such a choice, since transport is a question of speed as well as carrying capacity. It may be more profitable

to carry 5 tons in two or three trips at 30 m.p.h. than as a single load at 8 m.p.h.

### Trailers ?

The regulations which affect the point will be found in the speed limits set forth in Chapter XXV.

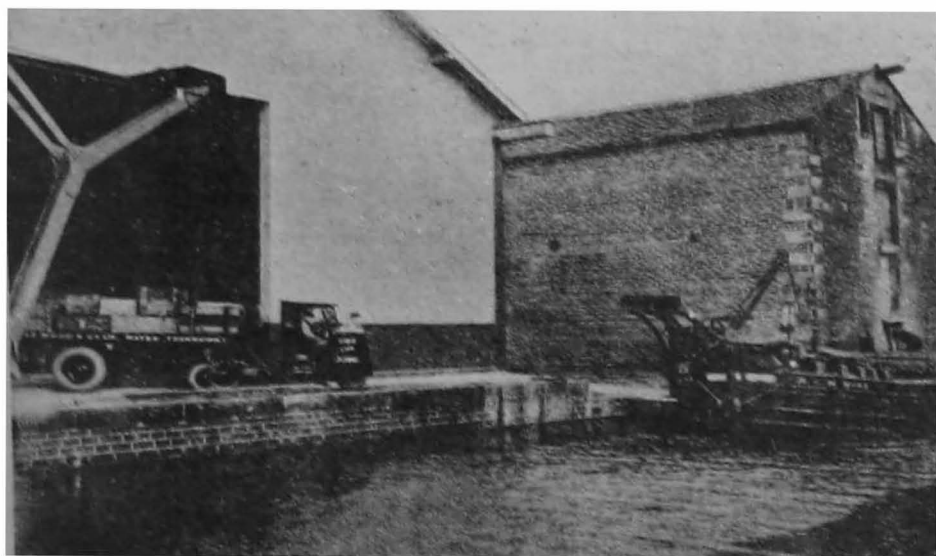
In employing a combination of solid tyred carrying wagon with trailer, as a trailer of more than two-thirds the load capacity of the tractive vehicle is seldom advisable, the useful load of the combination would be less than double, but its speed only half that of the single vehicle. The legal speeds are fairly proportionate to those in practice. Take the case of a 6 ton solid tyred wagon. Travelling fully loaded solo at 16 m.p.h. it could give  $6 \times 16 = 96$  ton-miles of useful load work: with a 4 ton trailer and a net load of 10 tons at 8 m.p.h. its useful work would be reduced to  $10 \times 8 = 80$  ton-miles in the hour; in other words, it could do 20 per cent more work without the trailer than with it. On pneumatics the same wagon without a trailer could do  $6 \times 20 = 120$  ton-miles in the hour and with a trailer  $10 \times 16 = 160$  ton-miles. Obviously then the pneumatic tyred trailer combination offers so much the better proposition under present conditions that for this class of work the solid tyred trailer can be regarded only as a survival from pre-pneumatic times.

In drawing this comparison it has been necessary to regard only the credit side of the account, for the debit side shows but little difference as between pneumatic and solid tyres. Between the working of vehicles singly or with trailers, however, there is some difference. Speaking broadly, a trailer two-thirds the weight of the tractive vehicle will take about 33 per cent additional power. Wear on the driving tyres will also be slightly heavier; and (except for a trailer weighing not more

than 1 ton with brakes applied when it tends to over-run the tractive vehicle) an additional attendant has to be carried unless the trailer can be braked by the driver from his cab.

### **Semi-trailers and the Motor Horse.**

Semi-trailers or flexible six wheelers are allowed 16 m.p.n. on pneumatics, 8 m.p.h. on solids—the same



**THE MOTOR HORSE AT WORK AMONG DOCKS AND WAREHOUSES,  
FOR WHICH IT IS PARTICULARLY SUITED**

*(By courtesy of Karrier Motors, Ltd.)*

speeds as for the wagon-with-trailer combination—and they offer the advantage of greater compactness and handiness in streets or yards where sharp corners demand manoeuvrability. Also some of the load is carried by the tractor driving wheels and so gives them greater adhesion on the road. On the other hand they have less flexibility in load carrying capacity. If there is not enough load for a 6 ton wagon and 4 ton trailer, the latter can be left behind; but a big six wheeler,

flexible or not, cannot be split up like that, however small its load.

And as a rule, this class of machine is restricted to large sizes, though recent months have seen the introduction of a smaller type of tractor, designed for low cost in construction and working, that can be run with its after end under the front axle of an ordinary horse wagon. Thus it constitutes what is constructionally and legally a semi-trailer, though in effect it virtually amounts to a motor horse. Almost inevitably, however, such a combination would be restricted to 5 m.p.h. by the iron tyres of the trailer wagon and for ordinary road transport its scope would be limited, though for special work about docks and railway yards it is finding its niche.

### **The Tractor.**

The next steps brings us to the tractor pure and simple, for haulage as apart from carrying. Recent legislation tends to restrict the field for this class of transport, for under present law the tractor drawing a trailer is limited to a speed of 8 m.p.h., whether on pneumatic or solid tyres. Nevertheless, as some petrol or oil tractors (the steam tractor is now of the past) can be relatively cheaply produced and worked at a low ton-mile cost, the disability in speed is to some extent counterbalanced, and where much standing about puts a premium on low capital and overhead charges, and considerable loads have to be shifted, then this form of transport finds a place. Consequently the tractor is not unfrequently adopted for municipal work like refuse collection; but where mileage is required it is handicapped by the law.

### **Three Wheels or Four ?**

Except for loads so small as to be uneconomic for the smallest four-wheelers, personally, the writer would

always prefer four to three wheels. The side-car arrangement, though against all theory it yields wonderful results as a domestic passenger carrier, is not suited to the severe everyday conditions of commercial service unless specially built for the work, which is seldom the case. True, instances are not uncommon of creditable service from side-car combinations adapted to business requirements; but they are the exception rather than the rule.

Against the other type of three-wheeler (with two steered wheels in front and a single central driving wheel at the back) the same objections may not hold, but there are difficulties in the way of giving it a direct quiet drive in top gear, while its three separate wheel tracks may be a disadvantage on primitive roads, and even on good surfaces present some slight additional risk of tyre trouble. Still, some are machines sturdily built for the job and can give good service. Nevertheless, on both types of three-wheeler the driving tyres are subjected to severe wear and tear with commercial loads, for even 3 cwt. is the equivalent of more than two average passengers, and the fact that it is a dead load makes a further difference.

#### **Four Wheels or Six ?**

The next step—four wheels or six—first demands an explanation of the main principle of the rigid six-wheeler. Its two hindmost axles are coupled together to constitute what is called the "bogie" and the frames or springs connecting the two axles support the chassis frame on a pivot or fulcrum lying across the frame at a point midway between the two pairs of wheels, and known as the "trunnion." Thus over ground inequalities each side of the bogie is able to rock up and down in a fore and aft direction, as in Fig. 6. Here the one wheel is seen surmounting an obstacle, and the end of

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the spring or bogie frame attached to its axle is also raised the same height. The other end, however, is not lifted at all and it is clear that the half-way point, where the fulcrum supports the chassis, is lifted only 3 in., or to half the height of the raised wheel. Thus, as each wheel in turn passes over any ground inequality, the vehicle itself is displaced to only half the extent of the wheel so that the effects of road inequalities are reduced

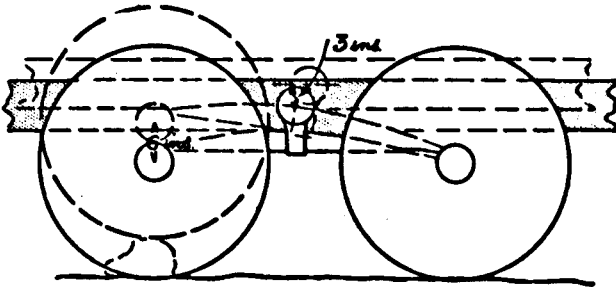


FIG. 6

Demonstrating why road inequalities at the tyre are halved at the chassis frame of rigid six-wheelers

and smoother riding is gained, though the obstacle has to be surmounted by two wheels instead of one.

In chassis of this class the springing and connections of the bogie are arranged to give great independent flexibility to the cross movement of each axle, on the lines of Fig. 7. In one of the big Scammell six-wheelers, designed mainly for overseas work, great flexibility is attained by the construction illustrated on page 28. In this the usual wheel axles have been eliminated, the engine power being transmitted to a single live axle shaft which acts as the trunnion and carries the chassis frame on springs. On each end of the trunnion casing strong cast-steel casings are free to pivot and at each end these carry short wheel axles driven through gearing also contained in the casing, the power being



transmitted from a spur gear on the trunnion axle shaft to an idler gear and thence to a gear on the axle of each wheel. Thus the gear casings also constitute the frames connecting the bogie wheels fore and aft.

This flexibility, coupled with the fact that in most six-wheelers both the bogie axles are engine driven, has rendered the type very successful over primitive roads

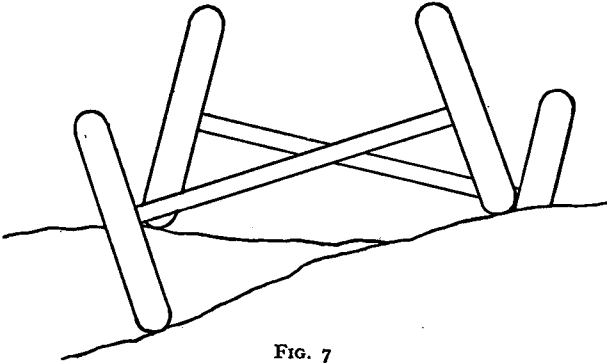
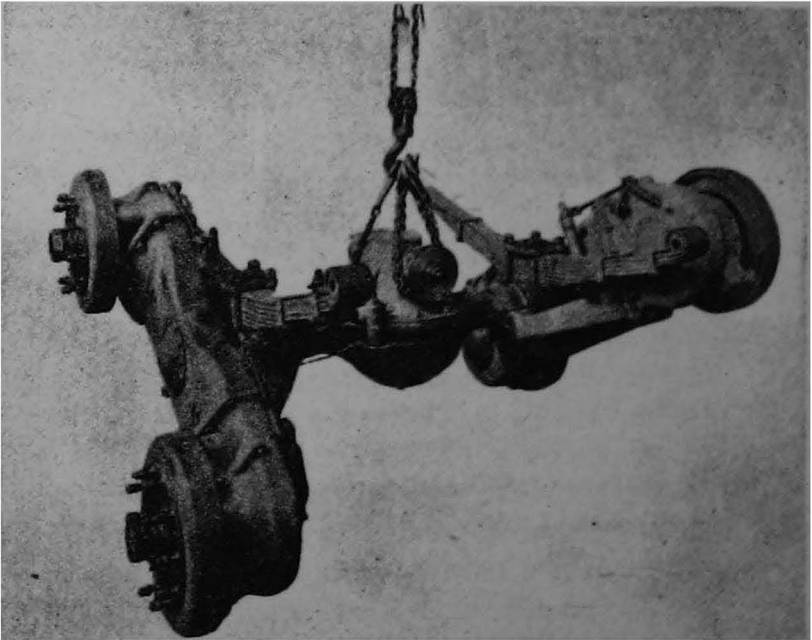
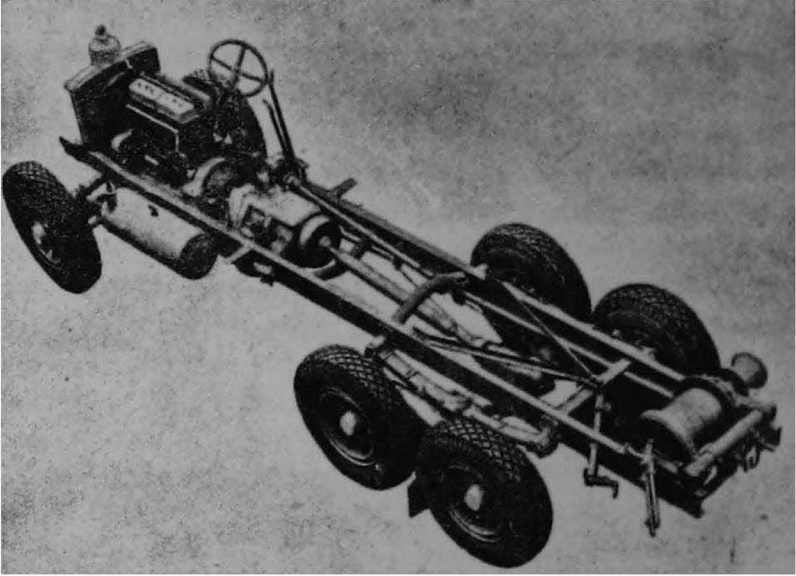


FIG. 7

The springing arrangements of six-wheeler bogies allow great flexibility and "cross-winding" of the axles over rough ground, on the lines here indicated

and roadless terrain, and they are consequently being extensively adopted for military work and transport in the less developed countries. Another quality, which gives the six-wheeler an immense advantage for work of this nature, lies in the fact that its weight is distributed over six instead of four wheels and accordingly, with the weight on the rear axle halved, it can travel over soft ground where the four-wheeler would sink. Even on good roads this more equal distribution of weight is a desideratum, particularly for the heavier classes of traffic.

It is not possible to ensure that back and front driving tyres shall wear equally and always be of absolutely similar diameter to the minutest fraction or



*Top.* A BIG SCAMMELL SIX-WHEELED CHASSIS

Designed to afford great flexibility over rough ground and without back axles as these are usually understood. How this is achieved can be seen from the lower illustration, showing the bogie arrangement and transmission to both pairs of wheels

*(By courtesy of Scammell Lorries, Ltd.)*

that they shall be inflated perfectly equally. Generally therefore a differential gear is introduced in the drive between the two axles to prevent any "drag" of the one wheel on the other, though tests with pneumatic tyred six-wheelers suggest that any such action is less than might be expected, the elasticity of the tyres apparently taking up much of the slip or lost motion. In some few chassis of this class, however, the rearmost axle is not driven, but merely carries its share of the weight, and with pneumatic tyres on good roads a single pair of driving wheels ought to afford all the adhesion necessary, except perhaps on such abnormal surfaces as ice-bound hills or very slippery mud.

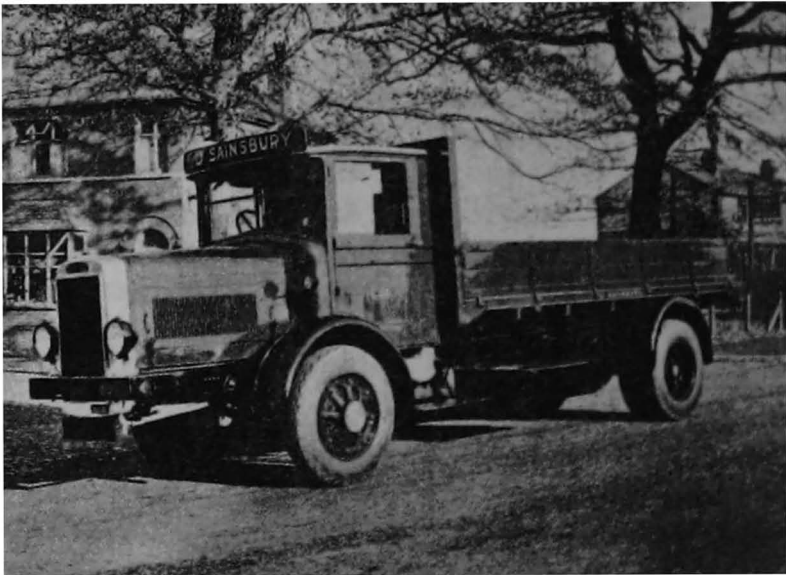
To sum up the relative advantages of six and four-wheelers we find that the former affords easier riding, holds the road better with less liability to side slip, gives better weight distribution on the ground and greater carrying capacity for a given power, while for those with two pairs of driven wheels greater propulsion effort and less liability to wheel slip may also be claimed. The four-wheeler on the other hand is simpler, lighter, cheaper in first cost and maintenance, and handier in confined spaces or heavy traffic.

### **Normal or Forward Control ?**

There yet remains the question of normal or forward control, affecting sizes from 30 cwt. carrying capacity upwards; below the 30 cwt. size, or its equivalent in the passenger-carrying class, width is seldom sufficient to allow room for the driver beside the engine.

For a given length of load space forward control offers a lighter vehicle with a shorter over-all length and shorter wheelbase, though among the larger examples of the normal control group a short wheelbase type has also appeared. There is little to distinguish chassis of this latter sort from others of normal

control arrangement; the only difference is that the front axle is set back to the extreme rear end of the engine, the primary object being to carry a greater proportion of the weight on the front axle, so that more load can be carried without exceeding the legal maximum laden weight on the back, though incidentally



A FORWARD ENGINE LEYLAND BUFFALO WAGON FOR  
7½ TON LOADS

*(By courtesy of Leyland Motors, Ltd.)*

a shorter wheelbase and more accessible engine are thereby afforded. The type is as yet restricted to the largest vehicles, but owing to its incidental advantages the idea conceivably may be extended to the smaller chassis and even to forward control machines, if that can be done without the additional weight on the front axle making the steering too heavy. Such a vehicle would combine maximum load length with the minimum of wheelbase, and over-all length, and would constitute the handiest type obtainable.

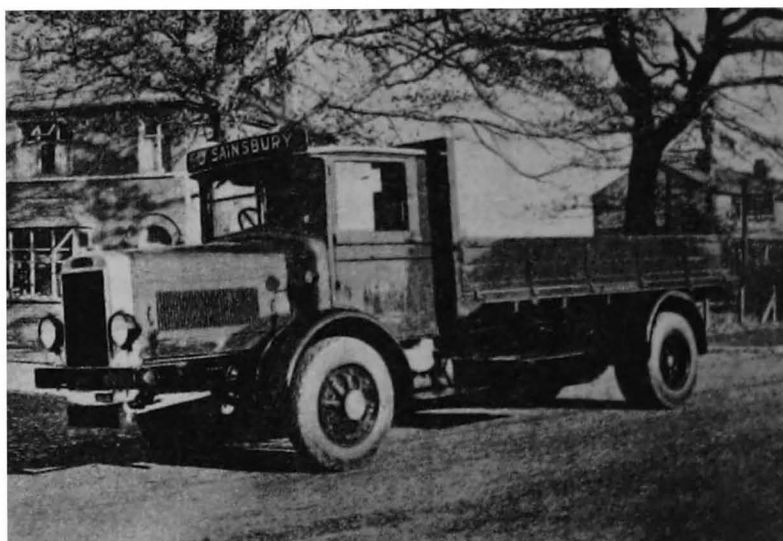
Nevertheless long wheelbase also has its advantage,

in tending to easier riding: also it holds the road better at speed, though this is less important to large vehicles at commercial speeds than to light fast cars; moreover the wheelbase in the average forward control chassis should be capable of giving all requisite steadiness at such speeds as are suitable to it.

The need for adhesion weight on driving wheels has already been explained; but, as normal control arrangement throws on the back axle, if anything, more than its share of weight, with forward control there should be no need to bring the back axle forward to take more of the load. Accordingly, there should be no necessity for any material increase of rear overhang, which, if excessive, tends to make a vehicle swerve from side to side at speed; although, be it said, a certain extent of rear overhang is desirable with big chassis, if steering is not to be unduly heavy.

Manifestly the forward control chassis offers advantages of handiness and minimum deadweight. Its chief objections appear to lie in the facts that the heat of the engine sometimes makes itself felt to an uncomfortable degree in the driver's cab, and that the driver is often cramped, more especially in the smaller vehicles. The remedy for the first of these complaints offers no insuperable difficulty however, while the removal of the engine and its transmission line from the centre to the left or near side of the chassis tends to give more room (see page 32). None the less, normal control must always offer the better cab accommodation. Yet, though a central transmission line is preferable to one at the side, it looks as if forward control will in time become universal on the larger chassis, except when very ample cab accommodation is specially required, while even in the smaller classes, down to 30 cwt. it will gain in favour.

control arrangement; the only difference is that the front axle is set back to the extreme rear end of the engine, the primary object being to carry a greater proportion of the weight on the front axle, so that more load can be carried without exceeding the legal maximum laden weight on the back, though incidentally



A FORWARD ENGINE LEYLAND BUFFALO WAGON FOR  
7½ TON LOADS

*(By courtesy of Leyland Motors, Ltd.)*

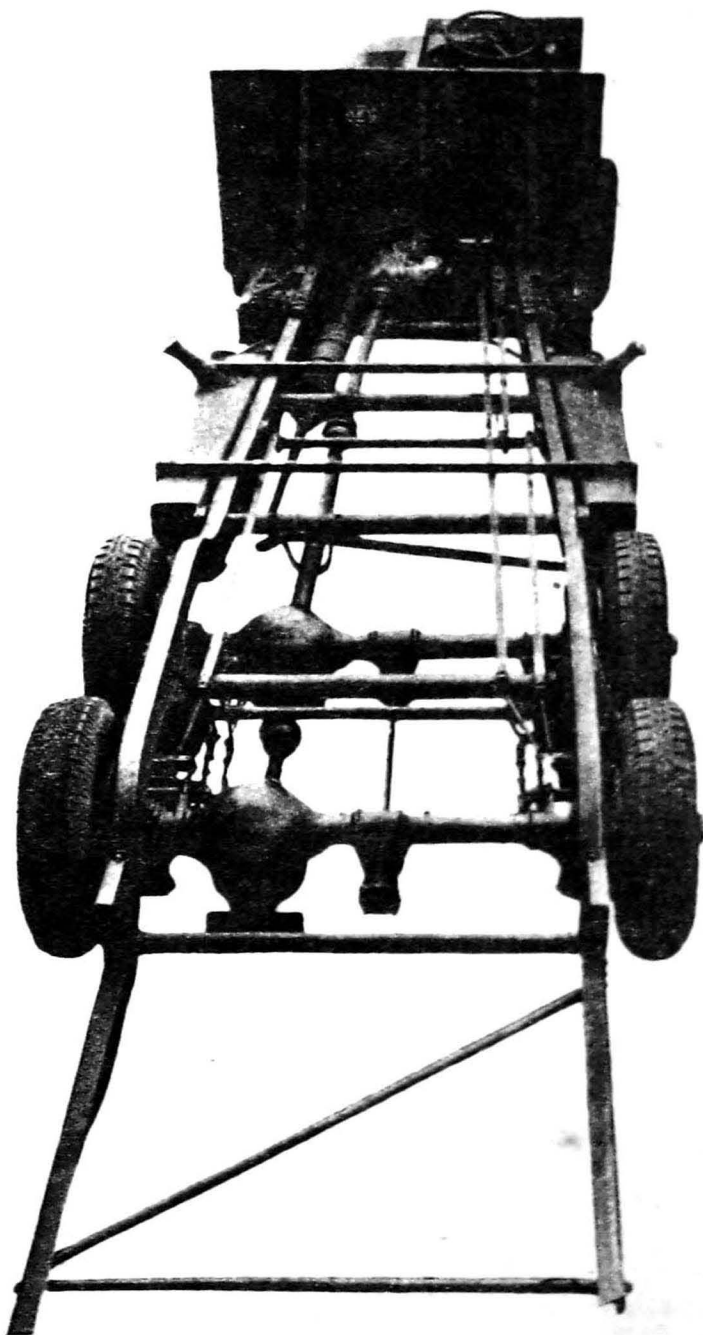
a shorter wheelbase and more accessible engine are thereby afforded. The type is as yet restricted to the largest vehicles, but owing to its incidental advantages the idea conceivably may be extended to the smaller chassis and even to forward control machines, if that can be done without the additional weight on the front axle making the steering too heavy. Such a vehicle would combine maximum load length with the minimum of wheelbase, and over-all length, and would constitute the handiest type obtainable.

Nevertheless long wheelbase also has its advantage,

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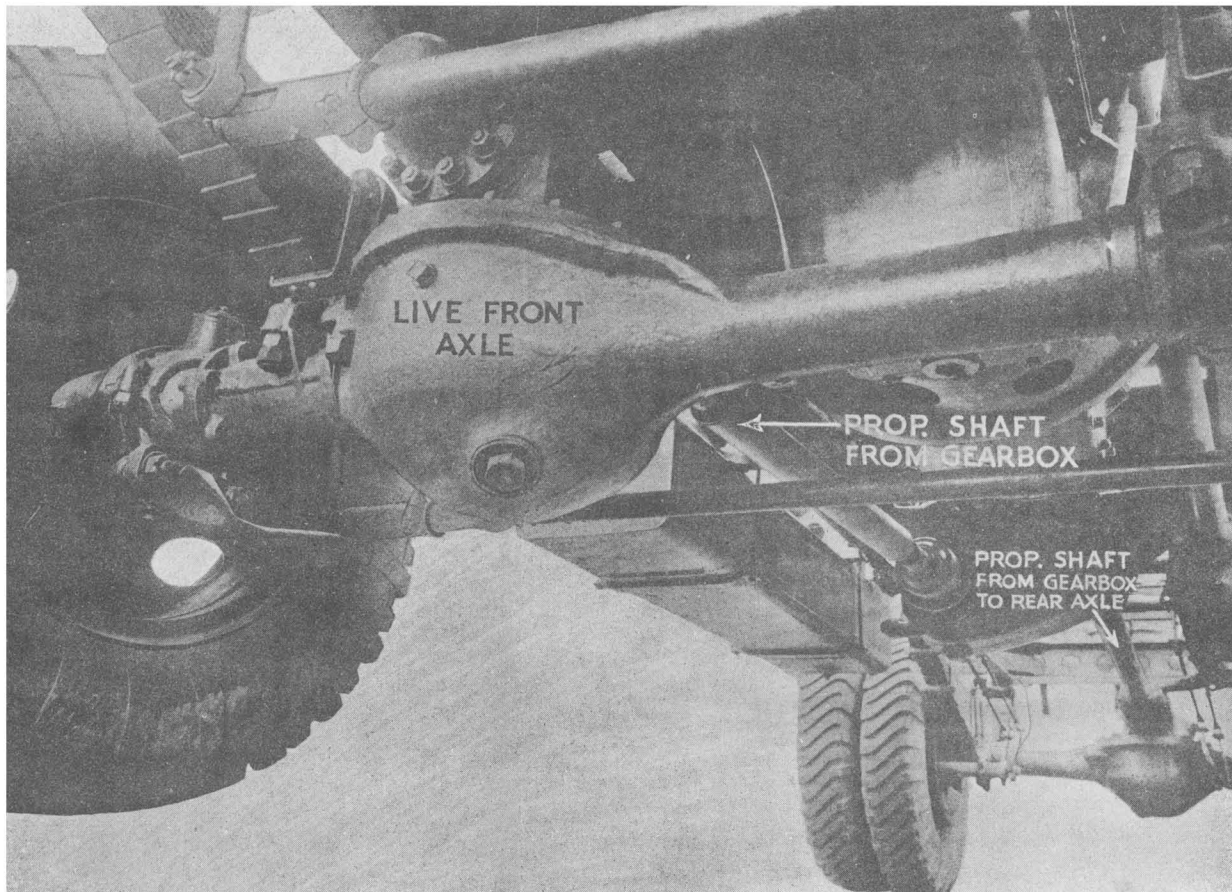


**DEMONSTRATING HOW THE ENGINE AND ITS TRANSMISSION  
LINE MAY BE OFFSET TO THE NEAR SIDE**

To give the driver more room on forward control chassis—this on a big  
A.E.C. six-wheeler

*(By courtesy of the Associated Equipment Co., Ltd.)*





**ON THE A.E.C. HARDY CHASSIS THE FRONT WHEELS CAN BE DRIVEN WHEN EXTRA POWER IS REQUIRED**

A subsidiary gearbox giving an additional range of low gears is also then brought into action

*(By courtesy of the Associated Equipment Co., Ltd.)*

**The Four-wheel Drive.**

Then there are chassis for special purposes. There is the four-wheel drive for work where great tractive force is required, as for example in carrying and hauling loads across country. In this the engine transmits to a central gear-box, whence a driving shaft is carried fore and aft to both front and back axle, the forward axle shafts being jointed to permit of their wheels being steered. In the shaft between back and front axle a differential gear is interposed, just as it is between near- and off-side wheels of an ordinary back axle or between the two driving axles of a six-wheeler—this automatically to regulate or equalize the distribution of power between the two axles. In the latest modification of this type the drive to the front axle is constructed so that it can be disconnected at will, leaving only the back axle driving, as in an ordinary four-wheeler (see inset opposite).

**Front-wheel Drive.**

Again, when a specially low loading level is required, as in the transport of horses or plate glass shop windows, a chassis with only its front wheels driven can be used, the dead back axle being cranked, or bent, downwards between its spring seatings to permit of a very low placed body.

Talking of low loading level, mention must also be made of the small wheeled type originated by Shelvoke & Drewry, and much used for special work like municipal refuse collection.

A new type of passenger vehicle, that has recently made its appearance, embodies some daring departures from the conventional. Not only are the front wheels driven but the low level chassis frame constitutes the foundation for the body construction. Further, it is carried at the wheels on a system of air springs so that

**The Four-wheel Drive.**

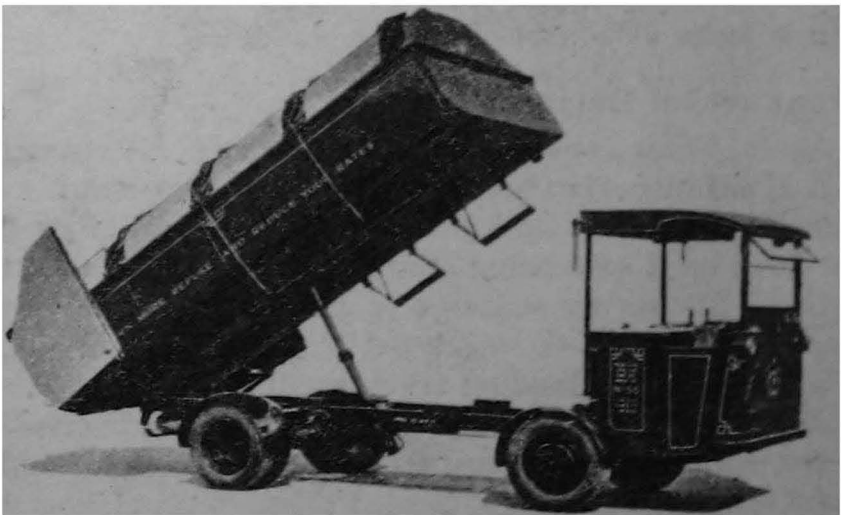
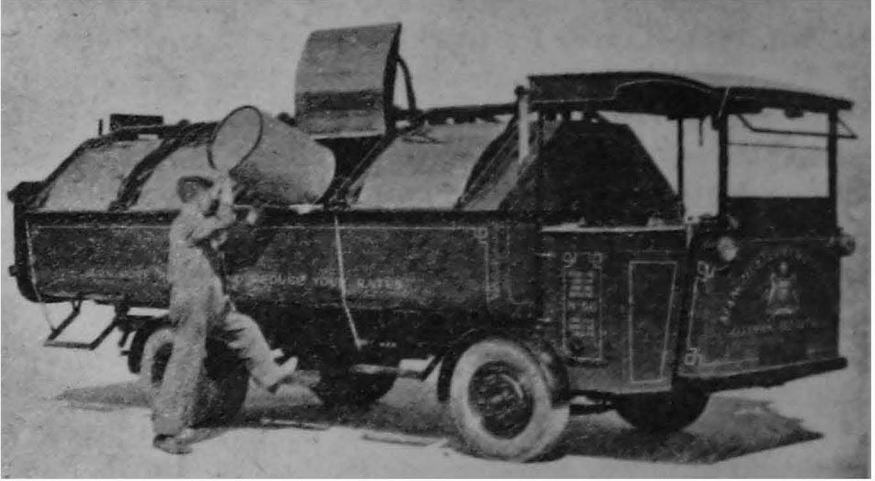
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**TWO VIEWS OF THE LOW LOADING, SMALL-WHEELED  
S.D. FREIGHTER**

**A type that has achieved much success in municipal work  
(By courtesy of Shallock & Drewry, Ltd.)**

at the back there is no straight through axle; which simplifies the arrangement for a low level frame.

### **Power from Water.**

The various power sources available are discussed in succeeding chapters, but mention must here be accorded to a development that has recently made its appearance. As is well known, water can be split up into its component gases of hydrogen and oxygen by electrolysis; that is by passing a current of electricity through it. These gases constitute an explosive mixture which gives a high thermal efficiency and many attempts have been made in the past to utilize water commercially as a power source on these lines, though hitherto without success. Now, however, Herr Rudolf Erren, a German engineer, claims to have solved the problem by a process entailing only about half the electric current previously necessary to separate out the gases.

For this purpose Herr Erren uses a cell materially different from accepted construction in that it is closed in and generates the gases from the water at a tremendous pressure—something like 15,000 lb. per sq. in.

It is not suggested that a road vehicle can carry a plant enabling its engine to run on water alone. For a self-contained transport unit an internal combustion engine could be employed to drive a dynamo supplying current to the electrolysing plant, and the gases so produced could be used; but only to supplement those of the fuel—petrol or heavy oil—so as to provide additional power and high efficiency; indeed, an efficiency of 50 per cent is claimed. To work solely on water it is said that the best method is to produce the gases in some large stationary plant and store the hydrogen in high pressure cylinders (at some 3,000 lb. per sq. in.) which are carried on the vehicle, relying for

oxygen on the air. On the same lines hydrogen and petrol can be used, or with both hydrogen and oxygen an engine can be run independent of any air supply. Further, the power is claimed to give very smooth running and great flexibility, while in conjunction with fuels like petrol or oil the complete combustion not only helps to account for the high efficiency but prevents any sooting up of the cylinders.

Another source of power that is being experimentally developed is coal gas, carried highly compressed in steel cylinders, but as yet the use of this fuel has not reached the stage of general adoption.

Machines of the creeper, or chain track, variety are essentially not intended for road work, and indeed are frequently designated under the term "roadless transport"; so, although involving the same principles as wheeled chassis short of the final transmission of the propulsive power to the ground surface, they hardly come within the scope of a volume on road transport.

## CHAPTER IV

### THE CHASSIS COMPONENTS—TYRES AND WHEELS, AXLES, SPRINGS, AND FRAMES

We may now proceed to build up our knowledge of the various parts of the chassis as a guide in selection.

Beginning with the parts common to all forms of power, we will first deal with tyres and wheels—the two must be considered in conjunction. Both have seen great changes in recent years. The wooden wheel has become of the past and the disc wheel has come into common use. In tyres pneumatics are rapidly superseding solids and cushion tyres for the heavier traffic, even for the largest classes; and to such an extent that under the present Road Traffic Act pneumatics, with certain exceptions, are compulsory on all vehicles registered after 1932. After 1939 they will not be allowed on the roads at all, the only exceptions being cars weighing not more than 4 tons unladen and working over rough ground or unmade roads, tower wagons, and certain vehicles worked by local authorities.

#### **Tyres.**

Great changes too have been seen in pneumatics. After the War the balloon tyre was introduced. This was of far larger section—much fatter—than the high pressure tyres previously in universal use, but was made with very thin walls to be run at much lower air pressures, the better to absorb road shock. The thin walls however were found too unstable, at the front especially setting up “shimmy” of the steered wheels, so the balloon tyre has now been replaced by a stronger

construction, but also run at low pressure. Since then the underlying idea has been extended by the development of medium pressure tyres and others capable of being run at pressures variable to the load, so that to-day the old high pressure tyre is being superseded by these low and medium pressure tyres. The latest extension of the principle is seen in the Airwheel, wherein tyre section is enlarged at the expense of the wheel, spokes being eliminated and a huge-section tyre mounted virtually on the hub.

If high pressures are adopted, for commercial working the straight sided type of tyre is generally preferred to the ordinary beaded edge construction; but whatever type is chosen, the tyres *must* be of a size adequate to their loads. Under-tying is the falsest of economies: far better to fit over-size than tyres too small. An overloaded tyre may give only half to a quarter of its proper mileage; indeed, in extreme cases it may be ruined in a few hundred yards. There can be no excuse now that tyre costs have been so reduced. Not many years ago 5,000 was reckoned as quite a creditable mileage; to-day the owner expects at least treble that, and quite usually obtains much more; indeed, in numbers of cases big pneumatics on "heavies" have run well over 50,000 miles though such results are only obtained by exceptional care in upkeep.

### **Wheels.**

In this country solid tyres are usually pressed on to their rims hydraulically, but pneumatics must for obvious reasons be easily demountable from their rims; or the tyres with their rims must be demountable from the wheels; or the complete wheel must be detachable. For the smaller chassis the detachable wheel is generally favoured, and it is also of real advantage in affording access to the brakes. On the larger chassis, wheel



and tyre combined would be too heavy for handling—in the largest special appliances are sometimes fitted for lifting the tyre alone—therefore very generally the rim is made with its outer flange detachable so that it can be drawn off, leaving the way clear for the withdrawal of the tyre.

In these days of steel construction there is little to choose between various wheel types. All are good. For the smaller chassis there is the choice between wire and disk wheels. The former are light, are easily repaired, and give greater accessibility; disc wheels are easier to clean, while for accessibility and cleaning, pressed steel wheels, shaped like the conventional wooden spoked wheels, offer a half-way compromise. On the heavier side the choice lies mainly between pressed disc and cast-steel wheels, sometimes made with their rims detachable.

Whatever the wheel the wider its bearings the firmer its support, and, to obtain ample bearing length, it may be worth sacrificing the lesser advantage of a flush wheel and allowing the hub to project beyond the wheel face; but any such projection should be as little as may be and should be rounded off as far as possible, since there is always the possibility of protruding axle caps striking an obstacle and bending the axle, besides other possible damage.

Wheel bearings may be of the floating bush, ball, or roller varieties. The first of these is just a sleeve of gun-metal, or bronze, interposed between stationary axle and revolving hub. Being subjected to rubbing, as distinct from rolling, contact, it requires careful lubrication, and, though its renewal is simple and cheap, it has given place to ball and roller bearings, both of which entail only rolling contact, and so the minimum of friction: further, as the latter are of hardened steel, they can stand up to any amount of

hard wear. Of the two, roller bearings are the better suited to very heavy loads, for they take the load all along their length while the balls do so only at the points where they touch their race surfaces; in other words, a roller gives line, a ball bearing only point contact. Accordingly, speaking broadly, ball bearings

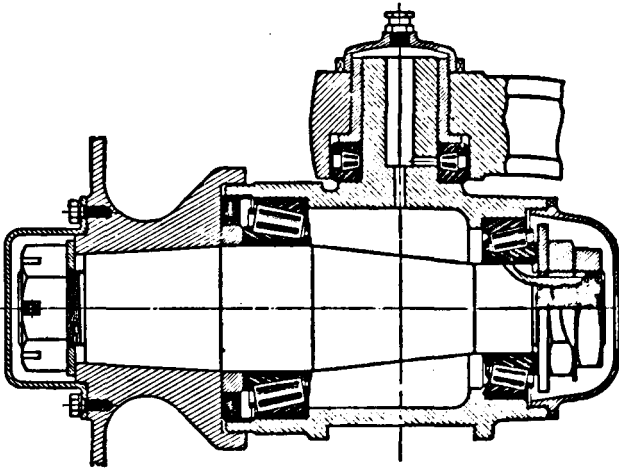


FIG. 8

Sectional drawing showing the use of tapered roller bearings on a front steering axle

*(Kindly lent by British Timken, Ltd.)*

are employed mainly for lighter chassis, though there is inevitably a good deal of overlapping, roller bearings being extensively used on quite light machines, while here and there one finds ball bearings on larger vehicles than might be expected.

For taking end thrust on a shaft, a form of ball bearing, often called a ball thrust washer, is very effective, and these ball thrusts were used in conjunction with plain bushed engine bearings. Nowadays, however, the roller bearings most generally employed

are tapered (see Fig. 8) which enables them to take considerable end thrust, sufficient for axle requirements.

### Axles.

On the axles spring seatings should be as wide apart and as near to the wheels as possible to give maximum lateral support, and flat surfaces on the under side, also as near to the wheels as possible, will facilitate jacking.

For a dead axle only carrying load a girder section is best, strength for weight; but, if the wheels are

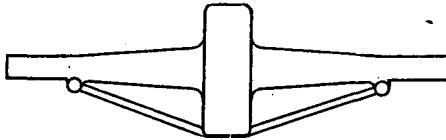


FIG. 9

Occasionally the back axle casing is strengthened with a truss rod, though this is seldom necessary in modern constructions

braked, the parts extending beyond the spring pads are subjected to torsional stress or twisting, to which a round section is best suited, a tubular construction being lightest for a given strength. That is why, with four-wheel braking, front axles are generally made of girder section between the spring seatings, and the parts projecting outside of the springs are round.

It matters little whether the jaws of the stub axle pivot joints are on the axle or the stubs, but at these joints the weight on the stubs is generally taken by ball thrusts or taper roller bearings (see Fig. 8).

By the very nature of their requirements live axles are made deeper towards the centre, and so stronger where strength is most required; but, even so, a truss rod is sometimes carried underneath the casing, as in Fig. 9. Very generally this truss can be tightened up,

if required, but that should be done only by a skilled man with means for very accurate alignment; otherwise the shafts may be adjusted "out of straight," to the damage of the axle. Therefore, to obviate temptation to unskilled tampering, many makers avoid the truss rod.

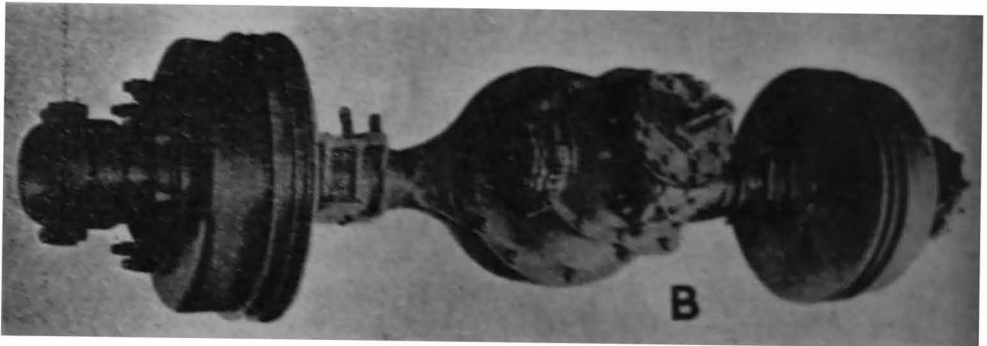
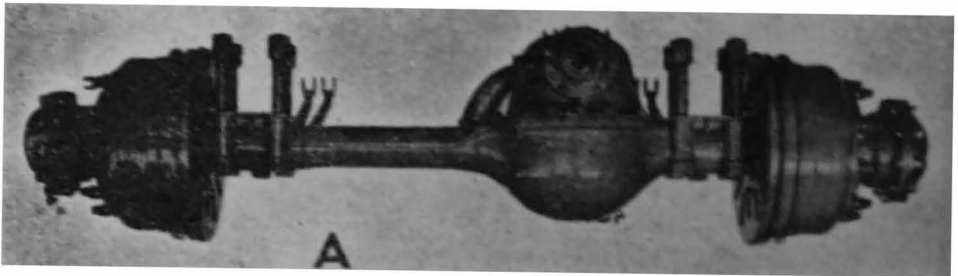


FIG 10 MODERN BACK AXLES OF FORGED STEEL

A, pot type; B, banjo type

(Kindly lent by the Kirkstall Forge, Ltd.)

Before live axles reached their present stage of perfection trussing was often necessary, but to-day most are amply strong enough without it. One of the reasons for this is that the modern live axle is usually constructed on the floating, or semi-floating, principle, whereby the weight is taken entirely by the axle casing, the shafts inside merely transmitting the turning effort of the drive. In such constructions the wheel bearings are mounted on the ends of the casing, and the shafts

are carried right through to connect with the outer faces of the wheel hubs; in other words, the wheels revolve on the ends of the axle casing. With an arrangement like this, if the differential gear wheels fit merely slidingly on keyed seatings at the inner ends of the axle shafts, when the axle is jacked both shafts and wheels can be withdrawn without any need of dismantling; and further, after removal of a cover plate at the centre of the casing, the crown wheel and differential assembly complete can be lifted out.

Axles on these lines may be either of the pot, or banjo, type. In the former, explained by Fig. 10, *A*, the casing is either a casting, or hydraulically pressed from forged steel. The banjo axle is built up on a steel forging shaped as at Fig. 10, *B*, the arms hollow to encase the axle shafts and the banjo "drum" fitted with covers enclosing crown wheel and differential.

In view of the fact that wheels and axles bear direct on the road and unsprung weight tends to wear and tear, the casings, if cast, are often made of light metal like aluminium, and certain parts, as for example, worm housings, may even be made of a still lighter metal—magnesium.

All things considered, the average transport back axle of to-day constitutes a superb example of strength combined with dismantling facility.

### **Springs.**

The plate springs, now practically universal in motor transport, are really beams of a material and form to give great flexion. Apart from the nature and temper of the steel from which they are made, their effectiveness is in great measure due to proportioning. The longer the spring the easier the riding, and springs should be as long as practicable. A wide shallow spring gives much more flexibility than a narrow deep one

embodying the same amount of material. It is the shorter plates that give the carrying strength and stiffness; the longer plates give the flexibility, and successful action depends on proportioning the relative length of each succeeding plate so as nicely to graduate the stiffness.

The modern tendency is toward a spring that lies almost straight when fully loaded, for around this position it affords maximum vertical movement under a given load variation. But road shock is made up of two factors, the load acting vertically and the speed of the vehicle in a horizontal direction; so to absorb the horizontal component of road shock springs are sometimes somewhat tilted at their front ends. At the back wheels there are often objections to tilting the springs, which however, in the case of elliptic springs, may be made with the part in front of the axle shorter than that behind, the shorter part absorbing the quicker, the longer part the slower, vibrations.

There is often another reason too for this arrangement, since in chassis without radius rods or torque tubes the propulsive effort of the driving wheels has to be transmitted to the frame entirely by the front ends of the springs. Incidentally, with live axles the drive from the engine tends to lift the wheel at one side of the chassis and press down the other, so, if no other arrangements are fitted for taking this stress, the spring on the one side must be rather stronger than on the other.

For commercial vehicles the difference between laden and unladen weight is often far greater than on private cars, and the springs have to work under much wider load variation. Accordingly, on some chassis the ordinary wheel springs, which give the main support, are made fairly flexible and are supplemented by additional auxiliary springs that come into action when the load deflects the main springing beyond a certain

point. The usual arrangement, long familiar on horsed wagons, is a cross spring mounted on the frame immediately above the axle, its ends an inch or two clear of the axle when unladen and taking their bearings as the load makes itself felt (*A*, Fig. 11). Another, and

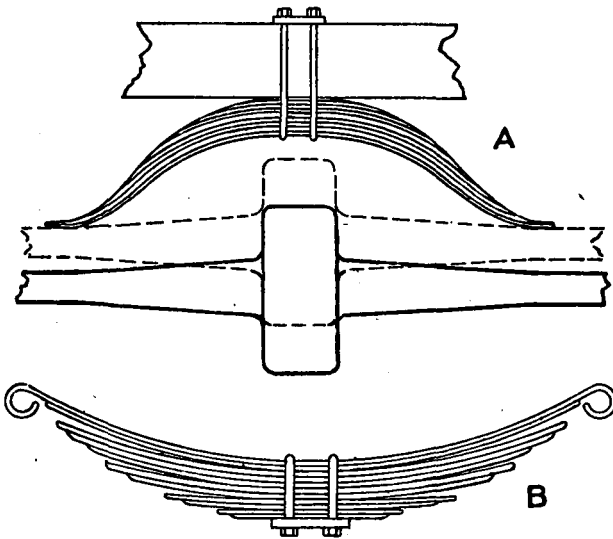


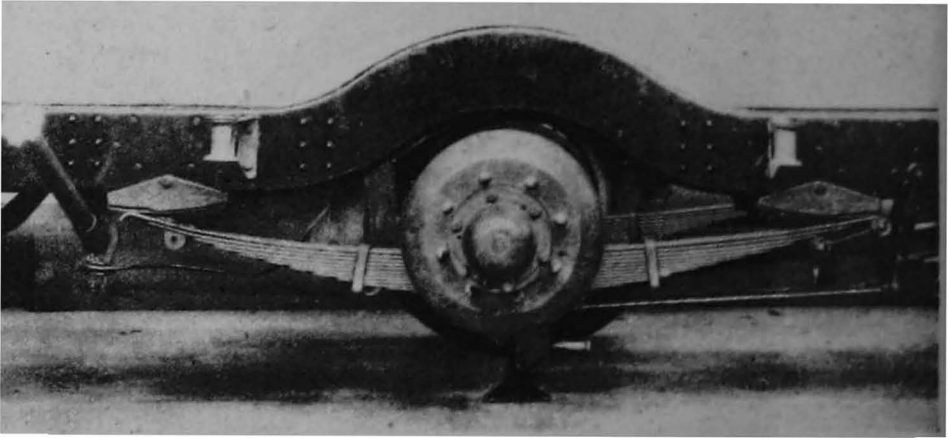
FIG. 11

Two simple methods for graduating the springing to the load

neat, way of achieving the same end is by grouping the plates of the main springs so that, as the spring deflects, these groups come into action progressively (*B*, Fig. 11).

These methods only take the additional load by fixed arbitrary stages, but in the Bristol chassis increase in spring stiffness is continuously graduated to addition of load by a simple device that in effect shortens, and so stiffens, the spring as the load deflects it. This is seen in the following illustration, which explains how

the chassis frame is carried by the springs on cam shaped supports in such a way that, as the springs deflect under load, they take their bearing farther and farther from their ends and thus the effective spring support is shortened. In the illustration the side flanges of the spring brackets have been removed in order clearly to show the contact between springs and cams.



HOW THE STIFFNESS OF THE SPRINGING IS GRADUATED TO  
LOAD ON THE BRISTOL CHASSIS

*(Kindly lent by the Bristol Tramways & Carriage Co., Ltd.)*

For commercial work these ancillary or progressive spring systems have much to recommend them, for, if the main springs are adequate to the laden weight, they are apt to be stiff unladen. Yet it is when returning empty, with the driver in a hurry to get home, that speed is often highest, riding roughest, and the consequent need for springing greatest. Light running in fact is more severe on a chassis than loaded mileage; but light running may be improved by fitting snubbers or shock absorbers to check the rebound, which otherwise is more accentuated when there is no load to steady things.



In transport the semi-elliptic spring is now almost universal, though in a few isolated examples cross springs are found, and very occasionally cantilever springing is adopted at the back axle. Cross springing can give very flexible carriage over rough ground, as witness the old Ford. Cantilever springing at the back also has much to recommend it, as it tends to draw or trail the wheels and gives them a slightly backward movement as with a tilted spring, which helps to absorb shock due to the vehicle's speed. It is, however, but little used in commercial work.

The eyes for the anchorage and shackle pins may be formed either by forging the ends of the master plate solid to take the bush for the pin, or the plate end may be rolled around the bush. The former is more expensive and, provided the bush is held secure from turning, the rolled eye is quite effective. For heavy work the top or master plate may preferably be made up of two leaves, both rolled round the shackle bush, or at any rate the second leaf should be carried right up to underneath the shackle eyes at each end, as the most likely point of fracture is close to the eye—particularly with vehicles working over rough ground. In the Thornycroft chassis the eye is formed on the second leaf, the top and third leaves both extending beyond the shackle pins.

Except perhaps for the lightest work rebound clips should be fitted, as they not only serve to hold the plates in alignment straight below each other, but, if a leaf breaks, they can be tightened up to hold things together until the defect can be remedied.

As the springs elongate under bending one end must be free to move, while the other is anchored to the chassis frame. Anchorage presents no complication, but there are two methods of allowing movement to the free end, either by a swinging shackle or a sliding

shoe (*A* and *B* respectively, Fig. 12), the latter, found in the largest chassis, affording the very desirable quality of greater lateral strength to resist side sway of the vehicle.

### Frames.

If the longitudinals of the frames are in-swept, to allow more room for steering movement of the wheels,

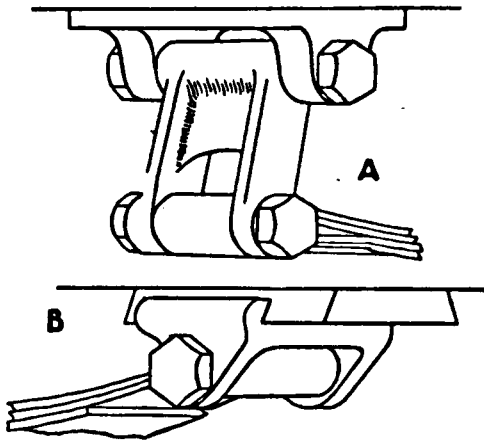


FIG. 12

For securing the free end of a spring to the chassis frame the swinging shackle, as at *A* is general, though a sliding shoe like that at *B* is sometimes adopted on the heavier chassis

they should not be curved in sharply, as they are apt to develop cracks at sharp bends. Nowadays, however, that contingency is minimized, for in the modern chassis in-sweep is generally slight or the longitudinals are perfectly straight looked at from above; which cheapens construction or repair. Absence of in-sweep is more common on large chassis, the frames of which tend to be narrower across than a few years back, doubtless in part owing to the big twin pneumatics

taking up more over-all width than solids and leaving less space between the back wheels.

But, while frame construction is thus simplified, the demand for low loading levels has necessitated more bending in an up and down direction than formerly, when most frames were straight horizontally. If a low load level is required, the frame is usually down-swept between front and back wheels, up-swept over back axle, then again down-swept behind. Such frames are pressed from thick sheet steel, but without up and down sweeps ordinary rolled channel section can be employed. Though heavier, a channel steel construction, with angle iron joints, makes a very strong and durable job for rough work with big loads.

The action of the clutch is rather severe on the frames, and therefore, if the longitudinals are deepened between front and back springs (for the reason explained in Chap. II, page 20) they should be of the full increased depth opposite or level with the clutch; or, if engine and gear-box are combined, just where the rear end of the engine gear-box unit is supported.

Cross members, tying the longitudinals together, can generally be limited to those at the ends and those necessary for carrying engine, gear-box, (and in long chassis with divided propeller shafts another for supporting the bearing at the division) with an additional one between the front supports of the rear springs on a four-wheeler: on a six-wheeler the trunnion for the bogie serves the same purpose. Except for end members, large tubes are much used, secured to the side frame in flanged sockets, and in such positions they are excellent and offer a simple inexpensive construction.

At the ends, however, especially at the back, channel section members are usually secured to the side frames by gussets (Fig. 13). These gussets are important, for they prevent the frame being pulled "out of square,"

though the same effect is often obtained by diagonal staying. The principle in either case is simple. Imagine

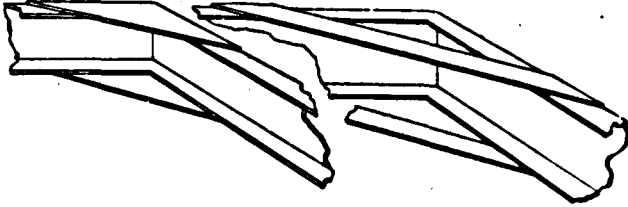


FIG. 13

Gussets and corner diagonals in frame construction

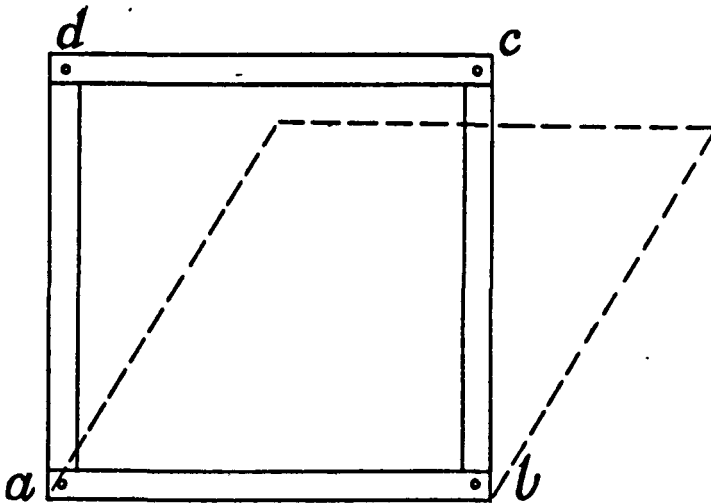


FIG. 14

Explaining why a rectangular frame without diagonal bracing can be pulled "out-of-square"

a square with diagonals, all made from flat bars with pin joints as shown by the full line in Fig. 14. If pulled out of square, as in the dotted lines, the distance from the corners *b* to *d* would be shortened, that from

$a$  to  $c$  lengthened; but this is rendered impossible by diagonals: if gusset strips were secured across the corners that between  $a$  and  $c$  would have to be lengthened, the one between  $b$  and  $d$  compressed, before any deformation of the square could occur. Particularly for trailer hauling vehicles is this bracing advisable at the back of the frame, as in taking sharp corners, for instance, the sideway pull of a heavy trailer exercises a strong tendency to drag the tractive frame out of square. An example of diagonal bracing is to be seen at the rear of the chassis frame illustrated on page 32.

## CHAPTER V

### THE CHASSIS COMPONENTS (CONTINUED)— BRAKES AND STEERING

UNDER the latest Ministry of Transport regulations motor vehicles must be fitted with two independent braking systems or a single system with two independent means of operation, provided that by one the brakes can be applied through direct action of the driver without the intervention of a pneumatic, hydraulic, or electric device.

The regulations differ for motor cars weighing not more than  $2\frac{1}{2}$  tons unladen and for heavy cars of over that weight.

In the former class, if two separate systems are adopted, one must act directly on the wheels, not through the transmission, and at least one must be applied direct without hydraulic, pneumatic, or electric power. The same applies to a single braking system with two means of operation, and it must be so devised that failure of one part shall not prevent at least two wheels being still effectively braked; consequently, the brakes applied by one of the controls must act on all four wheels.

In the heavier category when two independent braking systems are fitted much the same applies; but with a single two-control system, failure of one part must not prevent brakes effectively acting, in the case of a four-wheeler, on two back wheels and not through the transmission gear. That too implies four-wheel braking for one of the controls.

In vehicles of more than four wheels with two independent brake systems, at least half the number of wheels must be available for braking in the event of

one of the systems failing. Therefore each system must act on four wheels, either direct or through the transmission. With a single two-control braking system, at least four wheels must be brakeable by the driver directly and not through the transmission; and further, by one of the means of control brakes must be capable of being applied to all six wheels. Finally, in the event of part failure, it must be possible to apply the brakes on at least four wheels.

In steam wagons the engine, if reversible, may be regarded as an independent brake.

Trailers weighing over 2 cwt. unladen must have a brake acting on two wheels, or, if the trailer has more than four wheels, it must act on at least four of the wheels, and in all cases must be capable of holding at least two wheels locked with the vehicle stationary. Also, unless the brake can be applied from the driving seat of the tractive machine, an attendant must be carried in such a position that he can apply the brakes, except on a trailer weighing not more than 1 ton unladen, the brakes of which can be applied by its overrunning the tractor.

The farther the braking force is applied from the centre of a braked shaft the greater the leverage at which it acts and the greater the braking power, so the larger the brake drum diameter the greater this advantage. For that reason, as also because a large drum affords more braking surface, which permits lower braking pressures, the drums should be of ample size. On the smaller chassis this presents no difficulty, but on the larger the wheel diameters do not increase proportionately to the weight and the big pneumatics further restrict the available diameter. It is these tyres that make the difficulty, for, if the brake drums are large enough to come too near them, the heat from the brakes may seriously damage the tyres,

so as a rule the brake drum should be small enough to leave at least a space of some 3 in. between its outer circumference and the tyre. With a transmission brake there is not the same need for a large drum, as its power is multiplied by the gearing through which it is transmitted, but it should be remembered, that, running at a higher revolution speed, more heat is set up.

Drums may be of cast- or pressed-steel; with renewable cast-iron liners inside, and may be stiffened by ribs or flanges round their outer circumference, which also assist in cooling. The liner certainly facilitates repairs, and, when there is plenty of room between drum and tyre, ribs may be advocated; but they increase wheel drum diameter, and on large vehicles with low pressure tyres may bring the heat undesirably near the tyres.

Under good working conditions at 20 m.p.h. a man-applied foot brake should be able to stop a car in some 34 ft., a hand brake in about 54 ft., though in emergency these figures may be reduced.

All adjustments should be easy of access though proof against unauthorized tampering, so those outside the chassis frames had best be worked by spanner, although hand adjustments are very convenient for those between the frames. It is most important though that all adjustments be effectively locked against vibration. But brake adjustment is not only a matter of varying the lengths of the connections. Before wear has occurred the levers on the cross- and camshafts should stand about at right angles to the pull rods with the brakes applied (Fig. 15, *A*). In this position the pull of the rods exercises maximum effect for turning the levers. With the shortening of the rods for adjustment, however, the levers come to lie more in line with the pull rods, as shown with exaggeration in *B*, Fig. 15, and in that position the turning effort of the



pull rods is clearly much reduced, most of the force being devoted merely to pulling on the levers radially away from their centres. Accordingly, the levers are secured on their shafts by a number of serrations or castellations (explained by Fig. 16), so that the displacement caused by pull rod adjustment can be corrected

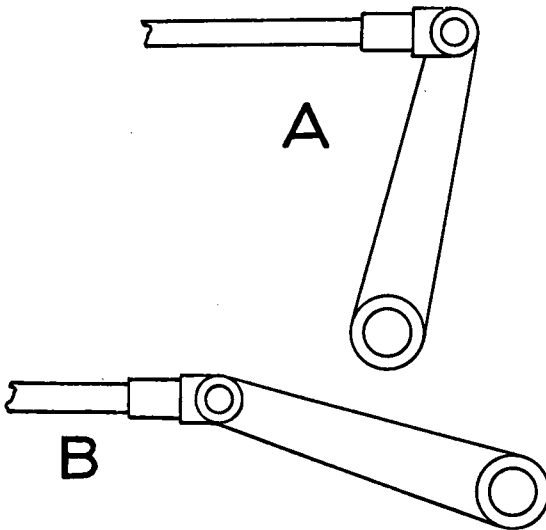


FIG. 15

Levers on brake cross-shafts should be kept positioned so that when brakes are applied they stand about at right angles with the pull-rod, as at A, not as in B

simply by putting the levers "a tooth or two back" on their shafts, the more numerous the serrations, of course, the finer the adjustment possible.

Front wheel braking constitutes one of the most important developments of recent years and has done much to lessen side slips and afford greater braking power. As a rule front brakes are unaffected by steering movement; but, if only very slight clearance

is allowed between shoes and drum, they may occasionally exercise drag on the steering when the wheels are locked over to extreme positions, and, as this is most undesirable, the point should be watched.

Another point is to see that the connections between frame and axles lie fairly horizontal, so that brake

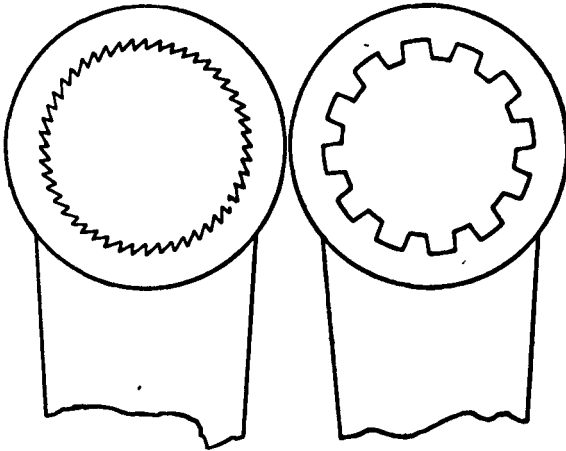


FIG. 16

Two methods of securing the drop arm to its shaft—on the right by serrations, on the left by a castellated shaft

action is not affected by the up and down movement of the chassis springs.

As a transmission brake acts through the differential, its effort on near- and off-side wheels is thereby equalized, and to obtain this effect on wheel brakes balancing or compensating mechanism is often introduced in the connections, the idea being explained by the compensating lever in Fig. 17. This illustrates the simplest expression of a principle that can also be applied as between back and front wheels. Opinion on the value of brake compensation differs, however. Some authorities

prefer unbalanced brakes, maintaining that the compensating mechanism is liable to become inoperative through rust, or repainting (which, however, implies poor maintenance), and that, even in action it may be undesirable, if one wheel is on slippery and the other on dry ground, if oil has got on to one brake and not on

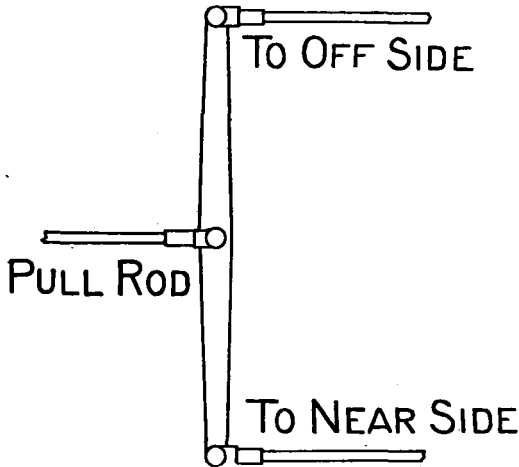


FIG. 17

The principle of compensating brakes is practically that of the balance beam in a pair of scales

the other, or if the connections on one side are stiffer than on the other, bringing the easier side into action first. Under such conditions they argue that compensation may even be a source of danger, and still more so if one connection fails; with all brakes of a four-wheel system compensated, failure of one connection might put all the brakes out of action. Still, with proper maintenance such possibilities should be fairly remote, and in the author's opinion the advantages and disadvantages of compensation between near- and off-side wheels are about equally balanced; but between front

and back axles personally he does not like it, though with fluid pressure methods such as hydraulic, or air systems, it is less open to objection. The latest Ministry of Transport regulations will tend against the adoption of brake compensation.

Expert opinion is also divided on the arrangement of brake controls. Usually the foot brake is used in service, the hand in emergency; but on the London buses, for instance, drivers are taught to use the hand

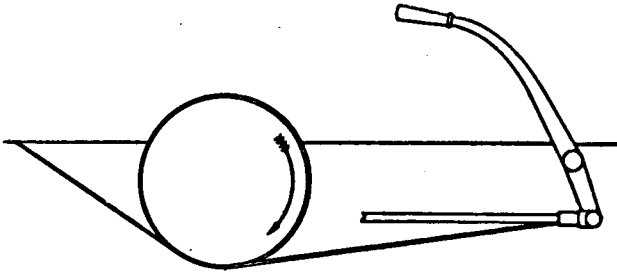


FIG. 18

Explaining the principle of the primitive servo. In the rope connection to the brake lever, of course, a coil spring would be interposed

brake for service. With a transmission and back wheel brakes the former practically always is worked by foot, the wheel brakes by hand, and with four-wheel braking the foot generally applies the brakes on all wheels, the hand on the brake wheels only. In a system acting on front and back wheels, in the writer's opinion, it is advisable for the front brakes to come into action slightly before the back, and with rather more power; which is impracticable with four-wheel compensation.

Another important since-the-War change lies in the introduction of mechanical power for applying the brakes. It began practically with the servo, a device borrowed from the carts used in some of the mountainous districts of France. Fig. 18 explains the broad-

principle. Imagine a rope or band wound round a drum on the axle or a shaft geared to it, one end connected with the operating lever applying the brake itself. When the rope is tightened by the operating lever it tends to wind itself round the drum, and this action produces a pull on the brake lever which assists in application of the brakes. Such, roughly, is the principle of the true servo, which, however, to-day is no longer made in its original form. Nevertheless the principle is still employed for the self-energizing brakes, wherein, in most cases, the initial friction of one shoe with the drum is utilized to apply the other with increased power; for since action and reaction are equal and opposite, the energizing shoe is also applied with equal force. At present this principle is employed more for private cars than for business transport, and there are difficulties in adapting it to the heavier classes of commercial vehicles, because, as the vehicle weight increases, the energizing power is more liable to "snatch" unless the angle at which the energizing shoe acts on the other is most carefully considered. Nevertheless in the future it is likely to be seen a good deal more in transport work.

Since the original introduction of the servo the term has come to be applied to any power braking system in which the force of the driver is supplemented from other sources, so that to-day we have hydraulic, air pressure, and vacuum servo systems.

The hydraulic system, though tried tentatively before ever the mechanical servo made its appearance, has only comparatively recently come into its own; but, as applied to road vehicles, it must be regarded as a means for distributing the power perfectly evenly to the brakes and with the minimum loss of effort rather than for increasing force of application. Briefly the system is made up of a master hydraulic cylinder or

ram immersed in a tank of the fluid medium employed (generally oil) and connected by pipes with double ended cylinders placed between each pair of shoes in each drum. In each of these cylinders are plungers, projecting from either end, their own outer ends rounded and bearing against the free ends of the brake shoes. The pivot of the operating pedal passes through the tank in which the master cylinder is immersed, and,

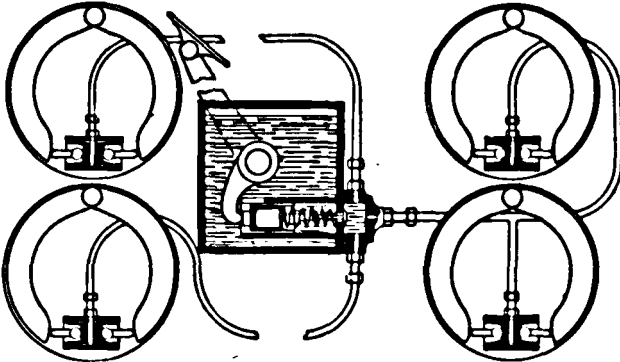


FIG. 19

Diagrammatic representation showing the application of hydraulic braking

when the pedal is pressed, the plunger of the cylinder is forced inwards with a leverage, thereby setting up pressure in the system. This pressure is communicated to the space between the pistons in the brake drum cylinders, forcing them apart and outwards so that they expand the shoe outwards and apply the braking force. Obviously, with the same pressure acting on both pistons, both shoes must be applied equally, and in the same way pressure as between each brake drum is absolutely equalized.

There are various modifications of the principle. In some cases the brake cylinders, instead of acting direct on the shoes, are mounted on the axle and act on levers

applying the brakes by cam in the usual way. On heavy vehicles two, or even three, master cylinders may be used, and a vacuum servo, instead of pedal direct, may be employed to multiply the power applied to the master cylinder.

The capacity for equalizing braking pressure is not confined to the hydraulic system; it is inherent, and available if required, in all systems using fluid as a means of transmitting the force of application, whether the fluid is air or oil.

In the vacuum system braking power is derived from a piston working in a cylinder. One end of the cylinder is open to the air, the other also in communication with the air or with the engine induction pipe, as required—this by means of a valve controlled by the driver. With brakes in the "off" position the working piston is open to the air at both ends of its cylinder, the closed end communicating with the air through the control valve. To apply brakes the valve first shuts off the closed end of the cylinder from the outer air and then connects it with the engine induction pipe, the suction in which draws the air from the cylinder, forming therein a partial vacuum and reducing the pressure on that side of the piston to less than that of the atmosphere on the other side. Thus, at a pressure ranging from about  $7\frac{1}{2}$  to 12 lb. per square inch, the piston is forced inwards along the cylinder and through its connections can apply the brakes with considerable power, as it is of some size. To release the brake, the connection with engine intake is closed and air admitted to the closed cylinder end, a coil spring then pushing back piston and its connections to the "off" position.

By a connection taken from between control valve and brake cylinder, and a flexible coupling like those on railway vehicles, the action can be transmitted to a

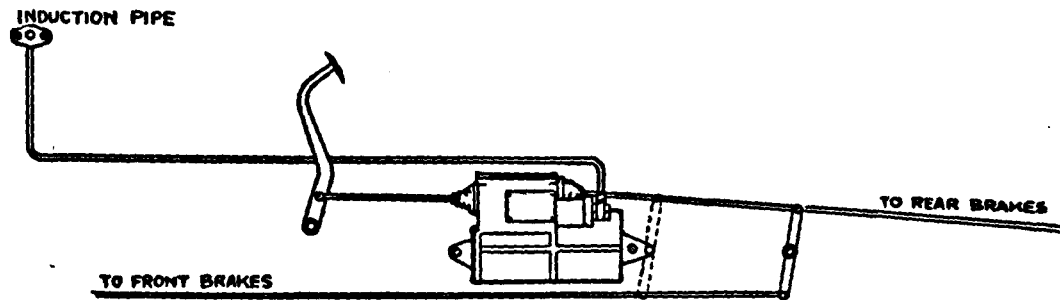


FIG. 20. DIAGRAM OF VACUUM BRAKING  
(Kindly lent by the Westinghouse Brake & Signal Co., Ltd.)



cylinder on a trailer, so that with a single lever the driver can apply brakes on both tractive and trailed units, a valve at the coupling ensuring that the vacuum in trailer pipe and cylinder shall be retained or created in the case of accidental breakage of the coupling.

As such brakes could be available only with the engine running, a vacuum reservoir is also provided, of a capacity to give at least two brake applications.

So much for the simple vacuum brake used independently; but it can also be arranged as a servo to add to the power of hand or foot operation. This is effected through a system of levers and linkage whereby brakes and vacuum valve are actuated by the same pedal lever, and vacuum and man power automatically regulate each other so that, if the pull of the driver exceeds or is less than that of the vacuum cylinder, the degree of vacuum is raised or lowered to adjust the difference.

On the larger British passenger chassis the vacuum servo is much the most extensively adopted of any power system. The force exercised by the driver is greatly multiplied, and to some extent proportionately, though not in direct proportion: tests have shown that, while a pedal pressure of 60 lb. produces a brake "twist" of 100 lb. acting at a radius or leverage of 1 ft. when applied direct, the brake effect was ten times as great when assisted by the servo; and with an 80 lb. pedal pressure it was 1,400 lb.-ft. against 180 by man power only. Moreover, with the servo the driver can "feel" the braking fairly sensitively.

While the vacuum system is generally employed on the servo principle, the compressed air brake is more often utilized as a means for directly increasing braking force, though it also can be employed as a servo. The mechanism comprises (1) an air compressor, driven from engine or gear-box, supplying (2) a reservoir

connected with (3) the driver's control valve, which regulates the supply of compressed air to (4) piston or diaphragm cylinders that actuate the brake cams in the usual manner. As soon as pressure in the reservoir reaches a fixed maximum it acts through a pipe on a check valve throwing the compressor out of action until the reservoir pressure falls to the minimum for working. The reservoir air pressure extends to a pressure gauge and to the driver's valve. When the latter is opened the brakes are applied with a force proportionate to, but much greater than, the pedal pressure by which the valve is operated; with the valve in the "release" position the air escapes from the brake cylinders and the brakes are released under the influence of springs. As to the effectiveness of compressed air for increasing the power of brake application there can be no question; indeed, so powerful is it that it calls for careful handling.

Only one other form of braking calls for mention, and that is the method of utilizing the engine, as originally adopted on the Saurer chassis. In this system by a simple movement of the engine camshaft the driving unit of the chassis is converted from an engine into a compressor. The resistance of the compression constantly being set up in each cylinder then acts as the braking force, so that the engine in effect functions as a transmission brake, but without the possibility of overheating at the high drum speeds at which ordinary friction transmission brakes have to work. At the same time the engine brake involves a minimum of complication and additional parts, virtually dispensing with one complete brake mechanism. True, the braking force has to be transmitted along the whole transmission line, including clutch; but shafts strong enough to take the engine turning effort should be strong enough to stand the braking

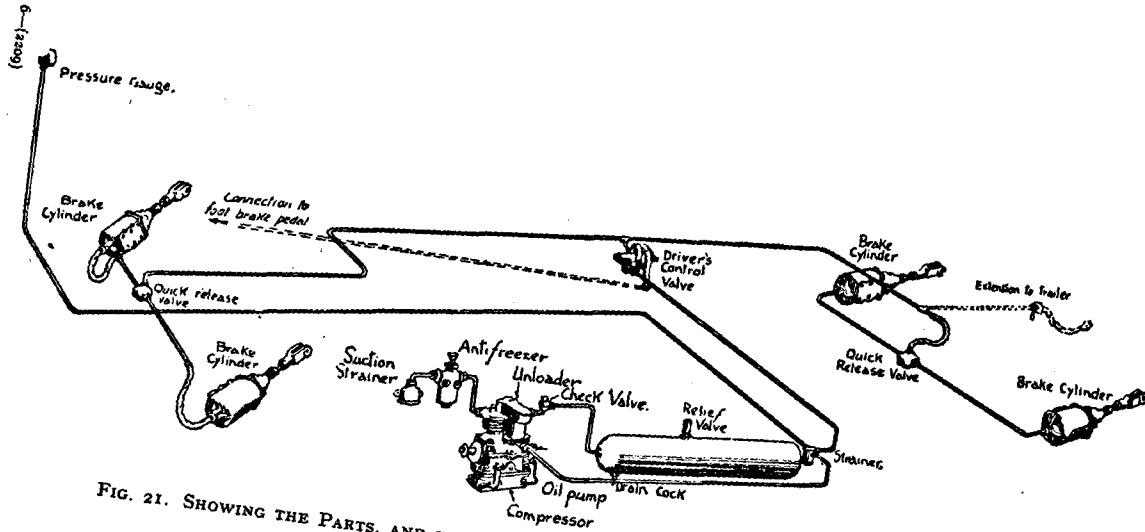


FIG. 21. SHOWING THE PARTS, AND THEIR ARRANGEMENT, OF A COMPRESSED AIR BRAKE SYSTEM  
 (Kindly lent by the Westinghouse Brake & Saxby Signal Co., Ltd.)

force in a reverse direction, and that it has for many years been successfully adopted by its makers, is sufficient guarantee of its effectiveness.

### Steering.

Vehicle direction is varied by moving the front wheels around their steering centres or stub axle pivots,

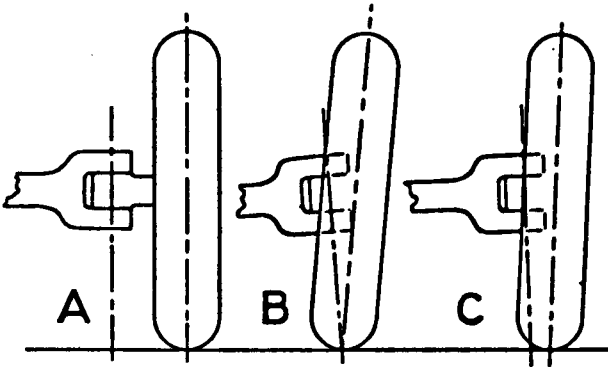


FIG. 22. THREE DIFFERENT SPECIFIC DESIGNS OF STEERING AXLE

The dotted lines show where the wheel tread centres and pivot axes prolonged strike the ground

and with those centres well to the side of the centres of the wheel treads, as indicated in *A*, Fig. 22, steering movement in effect amounts to rolling the wheels around their stub pivots on a small circular path, the radius of which is the distance between stub and wheel tread centres: thus the resistance of the road wheels to steering is exercised at a leverage equivalent to this radius. The gear through which the movement is imparted is irreversible, which means that the gear is supposed to maintain the front wheels in whatever position or direction it sets them, if the driver takes his hands off the steering wheel. With the steering centre immediately above the wheel tread, however, as

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in *B*, Fig. 22, theoretically no irreversible gear is required to hold them in position, while practically, with the road wheels not acting at a leverage, far less effort is required in steering them. When the vehicle is stationary and its road wheels not rolling, however, steering movement grinds the treads round, so to speak, on their centres, while with the off-set type *A* the wheels are rolled along a tiny circle around their steering centres. Thus, while centre-wheel steering, as it may be called, is more easily controlled when running, off-set steering has the advantage when standing; and so often a compromise is effected on the lines of *C*, Fig. 22 with the steering centres only slightly off-set—in large chassis between 1 in. and 2 in. to the side of the tread centre.

Steering may still further be improved by giving the steered road wheels castor action—on the principle which enables some bicycles to be ridden without hands on the handlebars. This effect is obtained merely by arranging the tread centre at a point rather behind the steering pivot centre, as in a furniture castor or railway luggage barrows. In motor chassis this is achieved merely by tilting the axle with wedges, so that the axis of its stub pivots, if produced, would strike the ground at a point somewhat in advance of the tread centre (as shown with some illustrative exaggeration by Fig. 23, the arrow indicating the direction of the vehicle's travel).

For steering light delivery vans little, if any, mechanical power advantage is needed, and a turn of the steering wheel through, say, a right angle will divert the front wheels through much the same angle; but for heavy chassis the steering gear must multiply the power applied by the driver at his steering wheel so that a full half turn of it may give, perhaps, only a quarter turn to the road direction. Consequently, requirements in the large and small sizes are not exactly the same,

the latter entailing heavier work and more need of adjustment.

Formerly in the usual form of motor-car steering the worm sector and the worm and nut gears were almost universally used, the latter being by far the most general. They are illustrated in Fig. 24, *A* and *B* respectively. In the worm and nut gear the screw thread at the foot of the steering column, when turned

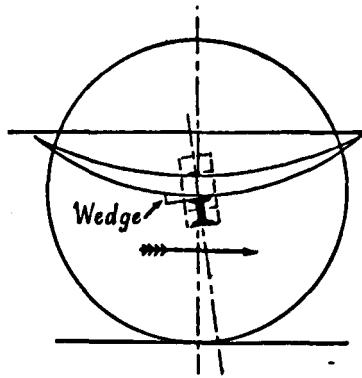


FIG. 23

How caster action is given to the steered wheels by tilting the axle with wedges

by the driver's wheel at the top, moves the nut up or down according to the direction of turning. The nut swings the end of the forked lever arm embracing it up or down, and the turning of this lever is imparted to the drop arm mounted on the same shaft, which actuates the connections to the steered road wheels. In both illustrations this drop arm is seen in dotted lines.

In the worm and sector gear the worm similarly part-rotates the sector which is mounted on the drop arm shaft, and so swings the drop arm.

Both these gears work through rubbing contact and so with more wear than if the parts rolled on each

other. To take up wear in the nut and worm type, therefore, the nuts are sometimes made in two halves which can be slightly expanded apart along the worm shaft. In worm and sector gears the sector frequently

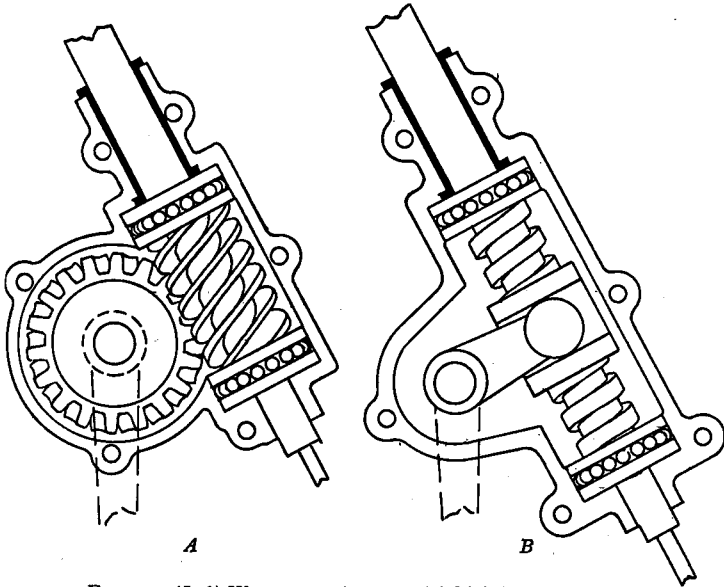


FIG. 24. (Left) WORM AND SECTOR, (right) WORM AND NUT, STEERING GEAR

takes the form of a complete wheel, so that, when it gets worn at one part, the wheel can be shifted on its shaft so as to bring another part into service. Adjustments may also be provided to bring the sector or worm wheel into closer engagement with the worm; but the trouble is that, as most of the work falls around the mid-steering position and comparatively little at extreme locks, the wear is not even, being more severe on the most central-position parts. Consequently,

adjustments made for this wear are likely to be too tight at the extreme end positions: some steering gears

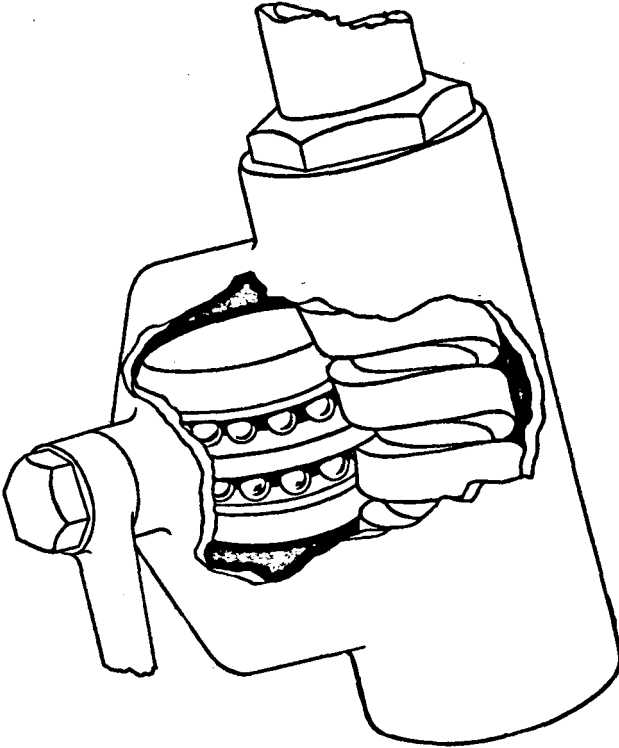


FIG. 25

In the Marles steering gear rolling contact is substituted in place of rubbing contact, which reduces wear

therefore are made with a slight margin of looseness towards the end locks, to allow for this.

For one reason and another, in steering gears of these types backlash therefore develops; even when new the steering wheel may be moved slightly without affecting



steering. Therefore, of late they are being supplanted to a considerable extent by what are called cam gears working nearly always with rolling contact and so with less wear to such parts as affect the steering. One of those most generally adopted is seen in Fig. 25, known as the Marles gear; from which it will be seen that the cam, so-called, is nothing more than a worm or screw thread of a certain shape. In this the drop arm is moved in the same way as the worm and sector; but the lever directly actuated by the worm cam is shaped to carry a double ball thrust, its central race in engagement with the cam thread, thus ensuring rolling contact. In another type rolling contact is obtained by the lever carrying a taper roller which engages with the cam worm.

As a worm entails considerable end pressures, thrust bearings—ball or taper roller—are commonly fitted on the steering column and sometimes on the drop arm shaft, where however the end thrust is less.

Outside of the steering gear casing the drop arm must be very securely fixed on its shaft. The seating may be castellated, serrated (Fig. 16), or squared as in Fig. 26, *A*, and either parallel or tapered; but, if parallel, the drop arm should be split at the top and clamped on the shaft by a well-locked pinch bolt (*A*, Fig. 26): if tapered, it is secured by a locked nut on the end of the shaft, as in *B*.

With steering gear having a complete worm wheel, requiring periodical re-positioning, the drop arm has correspondingly to be re-positioned and a serrated seating is best to give a finer degree of location. With tapered seatings, however, withdrawal of the drop arm is often rather a stiff job, the taper giving a very tight fit; in fact, so much so that the fine serrations may get damaged in the process; thus for this type of keying a parallel seating is preferable, and for castellated and

squared shaft ends too, parallel seatings should suffice for a taper somewhat complicates manufacture.

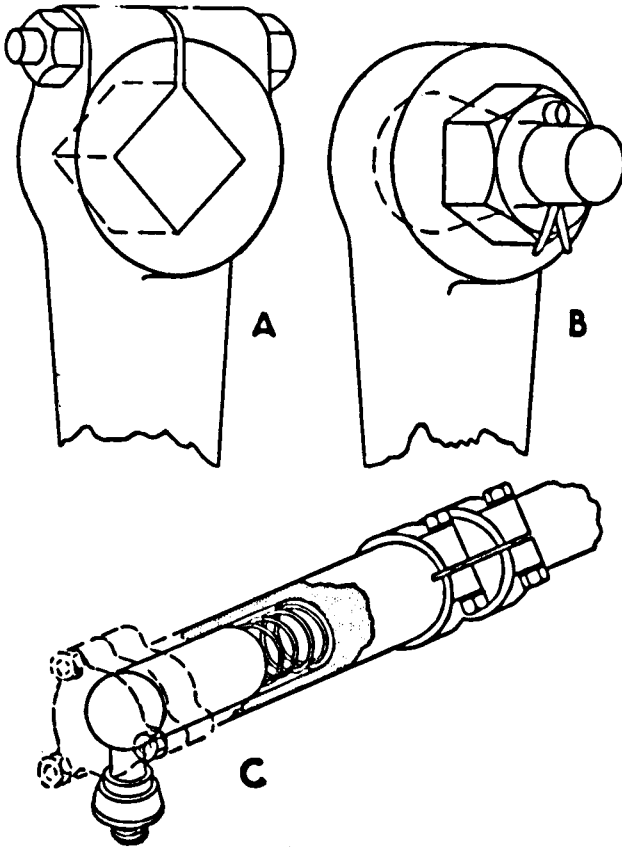


FIG. 26

Two methods of locking the drop arm on its shaft, and (C) a modern ball and socket steering connection

In the modern chassis the joints of the connections between drop arm and front wheels are of the ball and

socket type, the ball on the one connection generally firmly held between the socket halves of the other under the action of a strong coil spring pressing on one half socket which is slideable. The idea is best explained by Fig. 26, C. In these joints the bearing surfaces should be well encased, easily demountable, and adequately provided with lubricant. As most of the connections are tubular, their interiors are sometimes utilized as oil reservoirs, the joint being kept supplied through a worsted wick feed.

## CHAPTER VI

### THE CHASSIS COMPONENTS (CONTINUED)— THE TRANSMISSION

THE purpose of the transmission is not only to take the power from engine to road wheels, but to enable the relatively high speed and moderate turning effort of the engine or motor to be changed to the much slower and more forceful revolutions of the driving road wheels, and that in such a way as to give different degrees of speed reduction and force increase at will. There are many ways of achieving this and, setting aside for the moment the means for varying the reduction, the different systems for effecting the main reduction itself as a rule lie in the final transmission at the driving wheels, or axles.

#### Chain Drive.

For the heaviest work chain drive is often adopted, the wheels revolving separately on a dead or fixed axle, each driven separately by chain from a cross-shaft incorporating a differential gear, so that the drive may be duly proportioned between near- and off-side wheels when rounding curves, etc. Here we have a double speed reduction, for not only are the road wheels rotated by the chains at slower speed and correspondingly more powerfully than the cross-shaft, but the drive to the cross-shaft, usually by bevel gear, can be utilized to give still further speed reduction and increase of turning effort; also the arrangement involves a lighter axle and less unsprung weight. Consequently, for very heavy work at comparatively low road speeds chain transmission is well suited, especially over rough ground requiring good axle clearance,

though the lubrication of the chains requires additional attention. This form of final transmission, which is light on the repairs bill, is seen in the G.V. electric chassis illustrated on page 150.

### **Rack and Pinion.**

Still greater speed reduction, and increase of wheel turning force, may be obtained by what is known as the rack and pinion transmission, in which a counter-shaft, mounted on a dead axle and driven at less than engine speed, carries at each end a spur pinion engaging with the teeth of an internal gear on the road wheel. With this gear great torque can be imparted to the road wheels, but it is apt to be rather noisy.

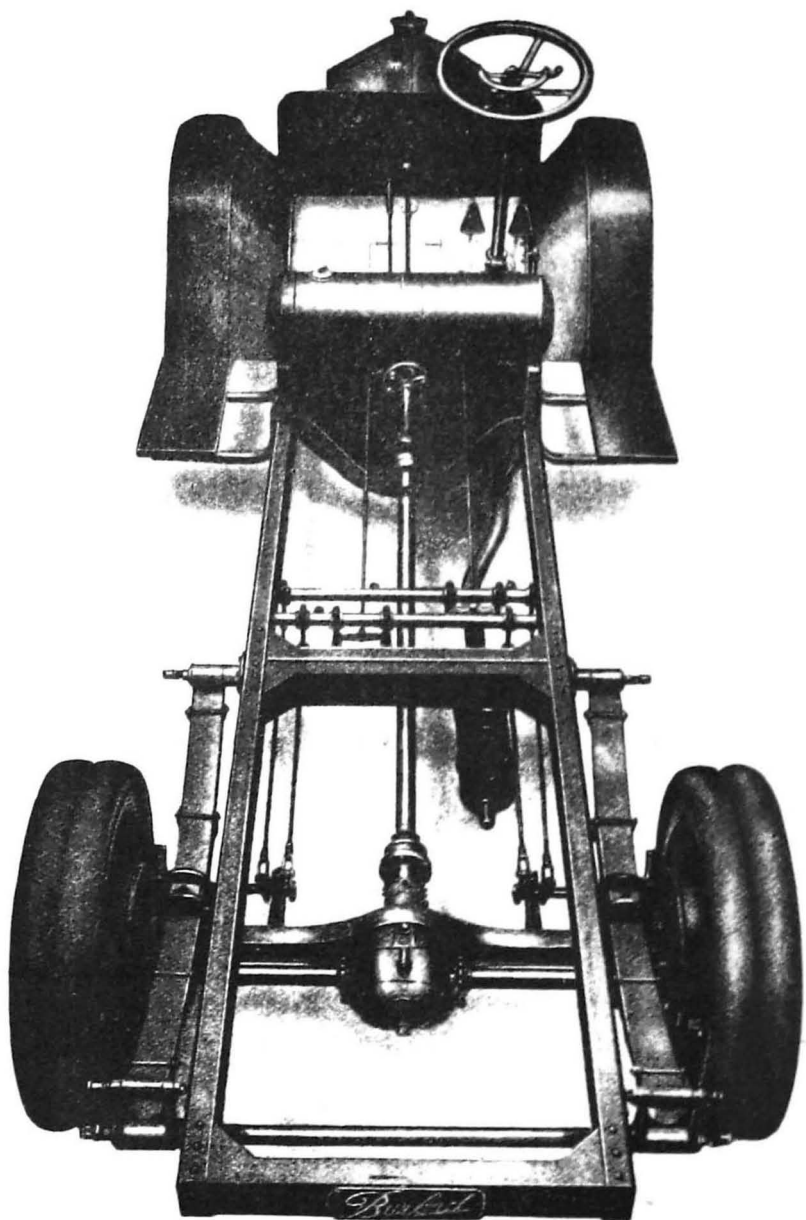
### **Double Reduction Live Axles.**

The same principle can be applied to a live axle by introducing in its casing a short intermediate shaft, bevel-driven from the engine at reduced speed and carrying a spur wheel in mesh with a larger spur crown wheel mounted on the differential of the axle.

Though they introduce extra friction and loss of an additional step in the transmission, all these final transmissions are well suited to heavy slow speed work. For the rest the ordinary propeller-shaft-live-axle drive is wellnigh universal. Yet even here we are confronted with variations: the propeller shaft may drive the axle either through worm or bevel gear, and in the latter case through straight tooth, or skew bevel.

### **Worm or Bevel ?**

With a worm final drive considerably greater gear reduction is possible; in fact, if necessary, it can give a gear ratio nearly as low as a double reduction bevel axle; hence it is much employed on heavy chassis, if direct drive is preferable to double reduction. This

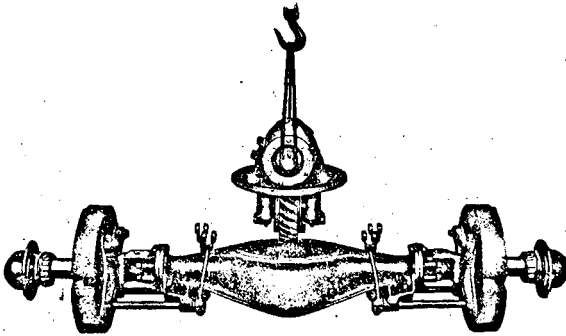


### THE BURFORD 30 CWT. CHASSIS

This has a rack and pinion final drive, which conduces to a lighter transmission behind the gear-box. The countershaft, with spur pinions on either end that drive the internally-toothed gears on each wheel, is seen behind the back axle

*(By courtesy of H. G. Burford & Co.)*

certainly simplifies matters; but a worm entails considerable end thrust, and the axle must be provided with fairly complete means for meeting this, in the shape of double thrust washers. Although the worm works with a rubbing contact, as compared with a rolling contact in bevel gear, there is little to choose



A TYPICAL WORM-DRIVEN BACK AXLE

By Dennis Bros., Ltd., who were among the first to use this form of transmission for motor vehicles

*(Kindly lent by Dennis Bros., Ltd.)*

between the two, for worm efficiency is remarkably high, though it falls off somewhat at the lower speeds and, up a hill, just surmountable by a bevel-gear car on top gear, a worm might require changing down.

As between straight and skew tooth bevels, with the former the teeth on engagement come into contact all at once along their entire length, whereas in skew bevel gear engagement is progressive, the meshing of one pair of teeth overlapping that of another; so for this reason skew gear is quieter, especially when any backlash begins to develop.

### Propeller Shaft Arrangements.

In propeller shafts also there are variations. If the propulsive effort of the back wheels is communicated to the chassis through the back springs and an unenclosed propeller shaft is used, there may be a universal

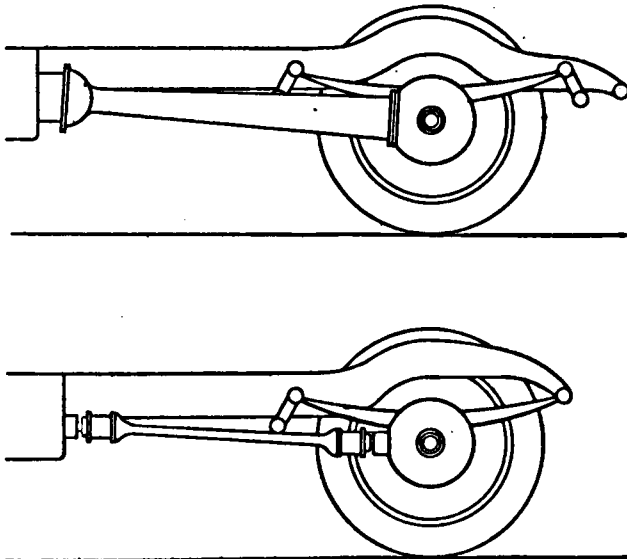


FIG. 27. PROPELLER SHAFTS WITH AND WITHOUT TORQUE TUBES

joint at each end of the shaft; but, if road wheel thrust is taken by a torque tube—often encasing the propeller shaft—only at the front end is a universal necessary. The reasons for this are explained by the diagrams of Fig. 27.

In long chassis with engine and gear-box far apart a single propeller shaft, if employed, might have to be so long that it would be "whippy" unless it was made unduly heavy, and in such cases a divided propeller



shaft is fitted; the shaft is made in two lengths in fact, the joint between them being supported in a self-aligning bearing mounted on a frame cross member, sometimes with a damper to reduce vibration.

### **The Unit System.**

The wider adoption of engine and gear-box construction in a single combined unit has no doubt contributed to an increase of divided shaft drives on the larger chassis; but unit construction is not confined to engine and gear-box. In some chassis, more particularly those made in big outputs, the components are sometimes grouped into three or four main units, any one of which can be quickly detached and replaced by a similar spare unit in the event of accidents or repairs. As a rule engine and gear-box constitute one unit; back wheels, axle, propeller shaft and torque tube another; chassis frame and its springs a third; and front wheels, axle, and steering a fourth. For owners to whom regularity of working is of importance and temporary loss of a vehicle's services serious, such an arrangement is of very real value.

### **Universal Joints.**

The mechanical universal or cardan joint is seen at *A*, Fig. 28 which explains by the double ended arrows how it can swing in any direction while the shaft is revolving. But a much simpler form is the disc joint, at *B*, composed merely of layers of special fibre, or thin metal plates, stiff enough to take the drive circumferentially but capable of bending across their flat. These have the advantage of extreme simplicity, and the discs can very easily be replaced when necessary. Between clutch and gear-box, just to take up any "whip" of the frame, they are admirable; but only advisable for the propeller shaft if the bending is

through a comparatively small angle. For long shafts on light chassis they are not infrequently used, though

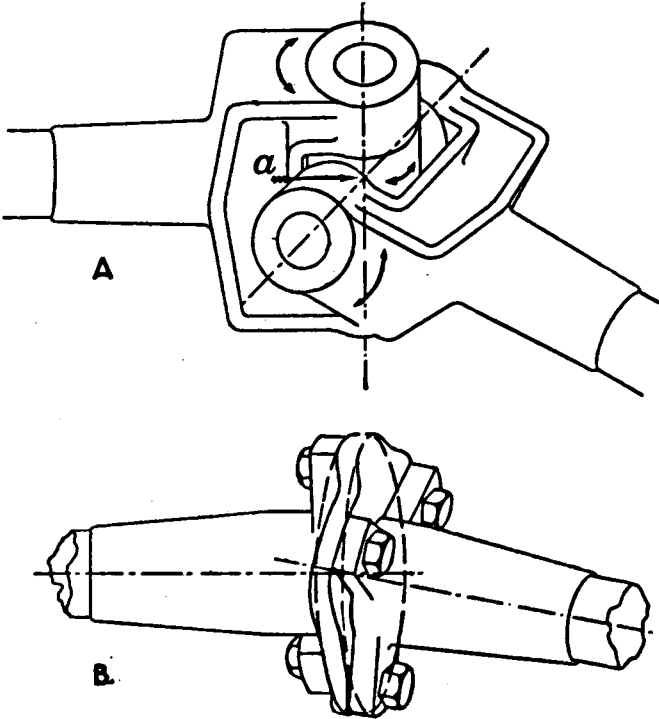


FIG. 28. THE TWO TYPES OF UNIVERSAL JOINT GENERALLY USED IN MOTOR VEHICLE TRANSMISSION

for short propeller shafts or for heavy work the mechanical joint is preferable; but the latter should have ample bearing surfaces and good lubrication arrangements such that the oil is not thrown away by centrifugal force. In some cases indeed centrifugal force is utilized to feed the oil to the bearing surfaces.

### **The Gear-box.**

From the broad aspect of progress the gear-box is perhaps the weakest point in the modern chassis. For the vast majority of vehicles the original sliding type of change gear is still employed; in face of all its drawbacks, but only owing to detail excellence in design, construction, and material it holds its own in spite of itself. Yet the principle, and its disabilities, still remain, and it is not surprising that at last the sliding gear change, as hitherto known, is being seriously challenged. This change is showing itself in two ways, the one in additional mechanism modifying the working principle and facilitating usage, the other in transmissions on radically different lines.

The reader is no doubt conversant with the ordinary gear-box, and there is no need to explain the detail mechanism of changing gear by momentarily disconnecting the transmission and sliding the gear wheels or dog clutches into engagement when driving and driven parts are judged to be running approximately at the same speed. The point is that, though the method works, it is mechanically crude, and, depending as it does on the judgment and skill of the driver, it is a source of wear and tear on the chassis.

### **Supplementary Gears.**

One development of recent times in no way alters the principle of the sliding gear, but extends the range of speed variation. This is a supplementary gear now sometimes introduced for heavy work, generally giving two additional speeds through either of which all the other gears can act, thus doubling the number of speed changes. In some cases the additional gears are included in the same gear-box as the rest; in others, they are in a separate auxiliary box nearer the back axle. Manifestly such a mechanism may influence the

question of final drive, rendering a double reduction unnecessary there.

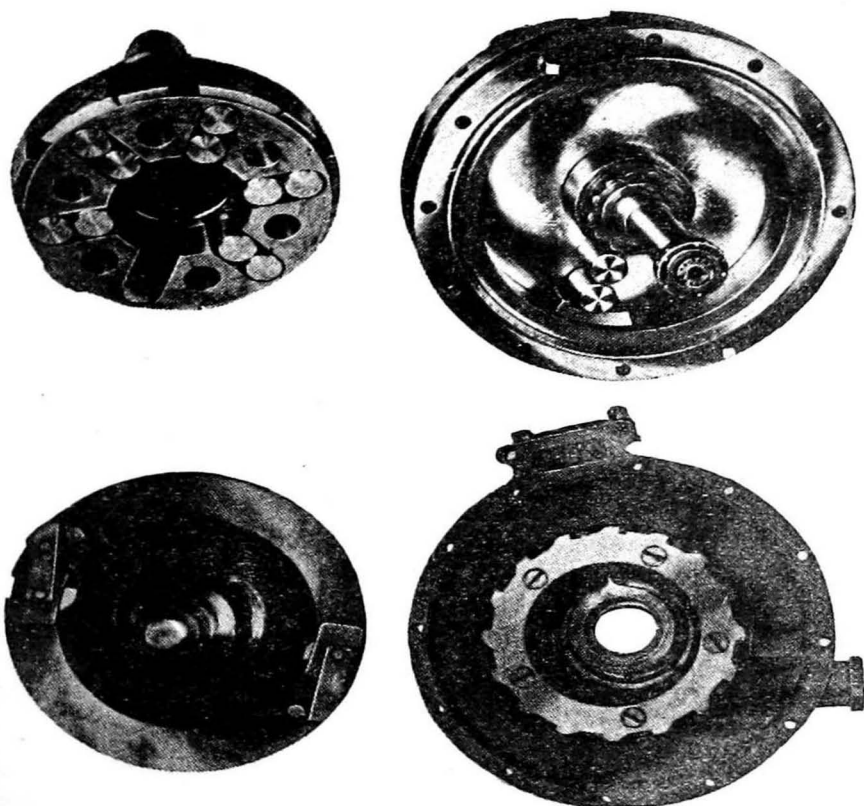
### **Free-wheel and Clutch Devices.**

To give easier and more fool-proof gear changing a free-wheel device is now sometimes fitted between gear-box and final drive, just as on a bicycle, so that in changing up or down the driven part of the transmission under the movement of the vehicle over-runs the driving transmission and gears can then be changed by regulating engine speed practically without taking out the clutch. Some mechanisms like this are proving definitely effective, and, as they permit of free-wheeling downhill, they reduce fuel consumption. Also by preventing oil being sucked up into the cylinders they lessen the carbon deposit which often forms when the engine is driven by the vehicle and used as a brake. Nevertheless, they necessarily put more work, wear, and reliance on the wheel brakes, and help to add to cost and weight. In some cases they include a sprag to prevent the vehicle running backwards and a "pick-up" clutch enabling the engine to be restarted, should it stop during free-wheeling.

To obtain ease in gear changing without extra reliance on the brakes therefore, instead of a free-wheel an ordinary large plate clutch has been tried behind, as well as in front of, the gear-box, the two clutches connected so that the one pedal operation breaks the transmission line at both sides of the gear-box. With this arrangement encouraging results in gear changing have been obtained on a light chassis; but to transmit the big torque given from the gear-box on its lower gears a very powerful clutch is necessary, and on heavy vehicles this presents a difficulty.

In a device brought out by the makers of the Crossley chassis that difficulty has been met by a

positive or locking form of clutch which is brought into or out of action respectively by the application or release of a brake band inter-connected with the



THE TWO MAIN DRIVING COMPONENTS OF THE MILLAM  
FREE-WHEEL CLUTCH

*Above.* These depend on sets of rollers and wedges acting between the centre and outer drum. *Below* is the sprag part of the mechanism, that comes into action only at speeds below 2 m.p.h., to guard against the vehicles running backwards

(Kindly lent by Sir W. G. Armstrong-Whitworth & Co. (Engineers), Ltd.)

engine clutch. So long as the brake is released the transmission behind the gear-box is locked practically solid; but as soon as the engine clutch is disengaged the brake is applied and the clutch thereby unlocked; thus the drive behind as well as in front of the gear-box is disconnected, the brake slowing down the driven

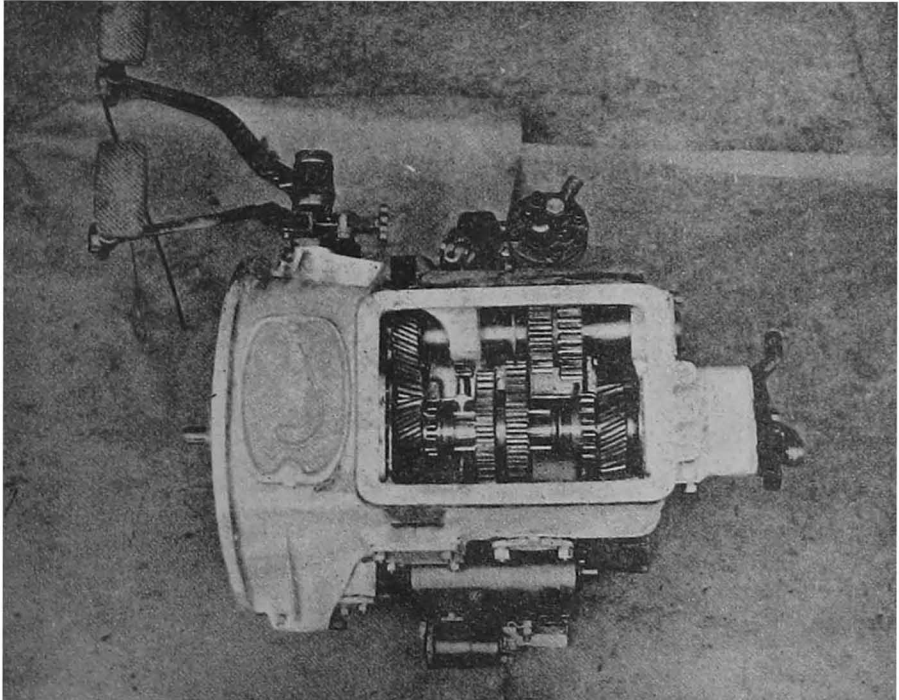
gear-box shaft, the clutch stop doing the same for the driving shaft, and under these conditions speed changing can be effected without using the accelerator and without need for special skill.

With the same object, of simplifying gear changing, synchro-mesh gears have been standardized on a number of American cars and a few in this country, and there is every possibility of their employment being extended to commercial work, for with them the driver can move his gear lever from one speed position to another without pausing, and the change is quite fool-proof.

#### **Constant Mesh Gears.**

In connection with bevel final transmission mention was made of skew cut gears as a factor in reducing noise, and in one or two British chassis, notably in certain A.E.C. and Commer models, the skew tooth has been used for the spur wheels in the gear-box, more especially for the third speed. These gears then are consequently always in mesh, since with skew teeth they cannot be slid sideways in and out of engagement and they are brought into action by sliding dog clutches. In some cases the idea is not restricted to a "silent third" and some of the other speeds are also thus obtained through skew gearing. In Germany, for instance, where this form of transmission has received more attention than in this country, one well-known firm (Maybach) has brought out a five-speed gear-box in which four speeds are transmitted through skew, or helical, gear as it is sometimes called. In this also, control has been simplified for all but top and bottom speeds, the intermediate gears being operated merely by two thumb-levers on the steering wheel in conjunction with the accelerator, a servo mechanism, worked off the engine exhaust, doing the rest. Incidentally, in

this gear-box needle roller bearings are fitted in which the rollers are of very small diameter (hence the name) and consequently the bearing is much more compact than the normal type.



GEAR BOX WITH SILENT THIRD SPEED AND SKEW CONSTANT  
MESH GEARS

As fitted to the 50 cwt. and 26 passenger Commer chassis  
(*Kindly lent by Commer Cars, Ltd.*)

### **The Epicyclic Gear.**

There is yet another form of change gear, and one differing radically from accepted sliding gear-box lines, namely the epicyclic gear; and as its control demands skill and it is far more fool-proof against damage, many attempts have been made to use it. Probably owing in many cases to defective design hitherto—with the

exception of the old Ford chassis—epicyclic transmission has not been notably successful; but in view

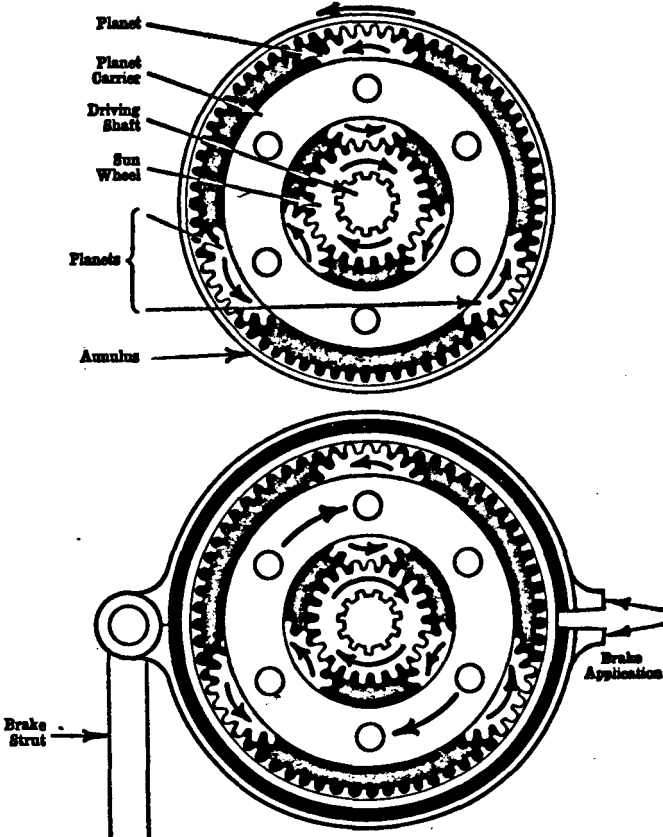


FIG. 29. EXPLAINING THE PRINCIPLE OF THE EPICYCLIC GEAR  
(Kindly lent by the Daimler Co., Ltd.)

of the fact that the Daimler Co. have now adopted it in conjunction with their "fluid" fly-wheel it certainly calls for serious consideration at the present, the



more so as it is also being successfully applied to private cars by other leading motor makers. Indeed, it appears quite probable that, with improved design and manufacture, the epicyclic gear may play an important part in the motor transport of the future.

Reference to Fig. 29 will help to make clear the underlying idea. The sun wheel is splined on to the driving shaft that rotates it; and is in mesh with planet wheels that revolve in bearings on the planet carrier. The planets in turn are in mesh with a toothed annulus to which a band brake can be applied. The planet carrier is the driven member, and with the gear out of action the sun wheel, running clockwise, rotates the planets contra-clockwise, and they rotate the annulus in the same direction but at slower speed, the planet carrier remaining stationary owing to the resistance of the vehicle transmission with which it is connected. If the brake is then applied to hold the annulus immovable, with the latter as a *point d'appui* the planet pinions roll clockwise along its toothed inner circumference taking their carrier with them and so driving the vehicle, though at reduced speed, for to travel the full circle of the annulus the planets in the illustration would have to make about three revolutions and the sun wheel, being about the same size, would have to do much the same. Assuming the gear in Fig. 29 to represent the lowest forward speed, for reverse the drive would be taken from a toothed sun wheel mounted on the hub of its annulus. When, therefore, the low gear brake is off, the annulus is rotated slowly and powerfully anti-clockwise, and this movement is imparted to the sun wheel on its hub which in turn drives another pinion carrier still more slowly and powerfully in the same direction around a braked annulus to give the reverse speed.

The change speed as a whole consists of a number of

these trains of gears grouped together, each in their own annulus drum. In the Daimler gear there are four such, arranged to give the various ratios by combinations.

Gear change is effected by pedal in conjunction with a hand lever. The latter controls a mechanism worked under spring action in such a way that, even while one gear is at work, the hand lever can be pushed into position for another speed; but only when the pedal is depressed can the pre-selected gear be sprung into operation just as the previous gear is released.

#### **The Fluid Flywheel.**

Epicyclic gears like this can be driven direct from the engine through their clutch or brakes; but to give best possible results at slow speed the Daimler Co. are applying it in conjunction with their fluid flywheel. This consists of two main parts, driving and driven, the one behind the other with a slight gap between and the driving member extended backwards to encase both. The inner faces of both these elements are made with a number of radial webs forming segmental cells filled with oil. When the driving member is rotated the oil flows outwards towards the circumference, and thus under the influence of centrifugal force it is circulated through the cells of the driven member, its velocity thereby being retarded. In this way it imparts some of its movement to the driven member, rotating it also. The action on the driven member is much like that on a water turbine. The result is not quite like that of a positive clutch: there is always a certain degree of lag or slip between driving and driven member. At low engine speeds of 600 r.p.m. and less the lag is 100 per cent and the centrifugal force is insufficient to move the driven member; but with increasing speed the drive is taken up smoothly and rapidly, until at

normal engine speed the lag amounts to only about 2 per cent.

### **The Hydraulic Torque Converter.**

Mention must also be made of the Leyland hydraulic torque converter, which entirely eliminates the gear-box, except for a reverse gear. Broadly, the device consists of a rotary pump driven by the engine and forcing light oil to drive a three-stage turbine connected with the propeller shaft, the oil having done its work, then returning to the pump. With a transmission like this there are of course no hard and fast gear ratios; just like the throttle of an engine, it is infinitely variable between its extreme limits which range from transmitting at anything from engine speed down to a 5 to 1 reduction; and, needless to say, its simplicity of control should render it as fool-proof as a transmission well can be.

### **Gear Ratios.**

For the same engine power and weight, gear ratios vary greatly on different chassis; which, perhaps, is as well, in view of the wide range of conditions to be met in a world market. Not very much can be said on the subject therefore; everyone must be guided by their own individual conditions and requirements, or by such experience as they can obtain from others in like circumstances. Two points only the writer would like to press. The first is to have a bottom gear really low enough for *all* emergencies; the second, that great difference between the top and the next speed may be undesirable; otherwise, hills may have to be climbed at slower speed than should be, involving waste of fuel as well as of time. Taking chassis fitted for four speeds, broadly speaking, a third gear giving about two thirds the road speed of the highest is low enough.

A case that came under the writer's notice illustrates the influence of correct gear ratios. A company had a number of 40 h.p. 3-ton chassis with a ratio of 1 to  $8\frac{1}{2}$  between propeller shaft and back axle when driving direct at top gear. Fuel consumption was high, so the gears were altered to give a ratio of 1 to 6 only, with the result that no less than 68 per cent more mileage was obtained from each gallon of petrol.

### Clutches.

There is no need to detail the construction or working of the ordinary types of clutch. The cone, though still widely used, is giving place to the single plate clutch which is now by far the most generally employed, although the double plate is occasionally adopted, chiefly on passenger chassis, to give smoother action.

Nevertheless, the cone clutch is still common and has the advantage of simplicity, though when lined with leather it is susceptible to wet and, if the water gets on to the lining when passing through a ford, the car may get stuck in mid-stream. Nowadays, however, fabric linings are very commonly fitted to cone clutches.

The plate clutch, as used to-day, is generally of the dry plate type; that is to say, the plates do not run in oil; indeed, they must scrupulously be kept free of oil—that and wet. Sometimes oil, leaking from the front gear-box bearing along the clutch shaft, gets thrown by centrifugal force on to the inner edges of the liners, where it collects; or, if the clutch is enclosed in a casing with engine and gear-box, oil collected in the clutch well may become more or less vaporized and deposited there. Still, these troubles are only very occasional, and, apart from them, the single plate clutch of the present day certainly gives the least trouble of any, partly because of the stronger engaging pressures possible in this form of construction.

In some clutches, particularly on American chassis, the friction drive is taken by flat circular pieces of cork inserted in driving or driven plates, and these as a rule give excellent service.

One of the latest developments, though not yet adopted on commercial chassis, is an automatic clutch control operated by the suction in the engine induction pipe. The suction of course increases as the throttle is closed. Therefore the induction pipe is connected with a cylinder wherein under this increase of vacuum a piston comes into action to release the clutch. Incidentally also a free-wheel at the other end of the gear-box is brought into action, thus virtually isolating it and reducing gear change merely to releasing the accelerator and moving the gear lever to the required speed position, leaving the rest to a synchronizing mechanism.

#### **Unit Construction Again.**

Reference has already been made to the unit system of construction, as applied to the chassis as a whole; but the engine-cum-gear-box unit, as it has a material bearing on the transmission lay-out, here calls for a few further words. On the smaller chassis nowadays it is general, and for the larger sizes is now extensively adopted. Yet, while it gives a very compact and desirable arrangement in itself, with gear-box close to the engine on a big chassis, it leaves a distance between gear-box and back axle too long to be spanned effectively by a single shaft. The choice then lies between a divided propeller shaft or a separate gear-box set far enough back to permit of a moderate propeller shaft length. In such circumstances some makers prefer the separate engine and gear-box arrangement. Much depends on the value of gear-box accessibility in each particular case, and, if it is undesirable to have the

gear-box below the floor boards of the loaded part of the body, the forward position may be preferable.

If, however, unit construction is adopted, there is much in favour of leaving the space between engine and gear-box open at the top. Admittedly, the clutch mechanism is thus exposed to dust and damp, but it is more accessible, and accessibility here is valuable. Moreover, in an enclosed clutch well, as we have seen, oil vapour is sometimes liable to get deposited at certain points between the plates and cause slip, though this is not very frequent.

### **Three Point Support.**

Practically invariably, when this system is adopted, the unit is supported at three points only on the chassis frame, to enable it to accommodate itself to any bending or twisting of the frame, on the same principle that a three-legged table can be stood firmly with all feet resting on any uneven ground while with four legs one foot is practically certain to be off the ground and the table will rock. It must be realized that a chassis frame is not a perfectly rigid structure, and, if one is lying on the assembly shop floor, it will be found that one corner can be lifted without the rest coming off the ground. Still further to take up any frame flexion, therefore, the supports themselves are often devised to give a certain degree of flexibility, often by interposing rubber pads (sometimes spherical) between the frame and the supporting points of the unit, the same method also being very advisably adopted for carrying the radiator.

### **Power Unit Removal.**

Where a large number of vehicles are employed easy removal and interchangeability of units is a most valuable feature, and in some few chassis engine, clutch,

gear-box, and radiator are combined so that, after removing a few bolts, the whole can be withdrawn forward from the chassis. Indeed, one maker has even gone so far as to provide the unit with let-down castored legs on which it can be run out on to the repair shop floor without any trolley, though even minus such refinements the arrangement may save a good deal of time when time is worth saving.

## CHAPTER VII

### THE CHASSIS COMPONENTS (CONTINUED)— THE ENGINE AND ITS FITTINGS

IN the modern commercial chassis electrical engine-starting and lighting equipment is now a commonplace. Even if it is not fitted, the modern engine should be designed with arrangements for mounting it, for it can no longer be regarded as a mere infrequent addition to be added anywhere there is room for it and to be driven or drive as best it can.

#### Engine Electric Equipment.

In car lighting the principle is much the same as in a country house installation. A dynamo supplies current to battery or accumulators, which supply the lamps, and the electrical pressure or voltage from dynamo to battery has to be regulated. In both the voltage must be kept as uniform as possible, but there is this important difference—in house lighting the engine driving the dynamo can be run at a steady, hardly varying, speed controlled by a sensitive governor; on a motor vehicle the engine has to be run at widely varying speeds to meet road conditions.

Accordingly, its system is so arranged that when the engine exceeds a pre-determined speed the dynamo output to the battery is checked. This can be effected either mechanically or electrically.

By the mechanical method a clutch, interposed in the drive between engine and dynamo, is controlled by a governor like those used on stationary engines, so that when the limit engine speed is reached the clutch, through which the dynamo is driven, slips and the output is checked.

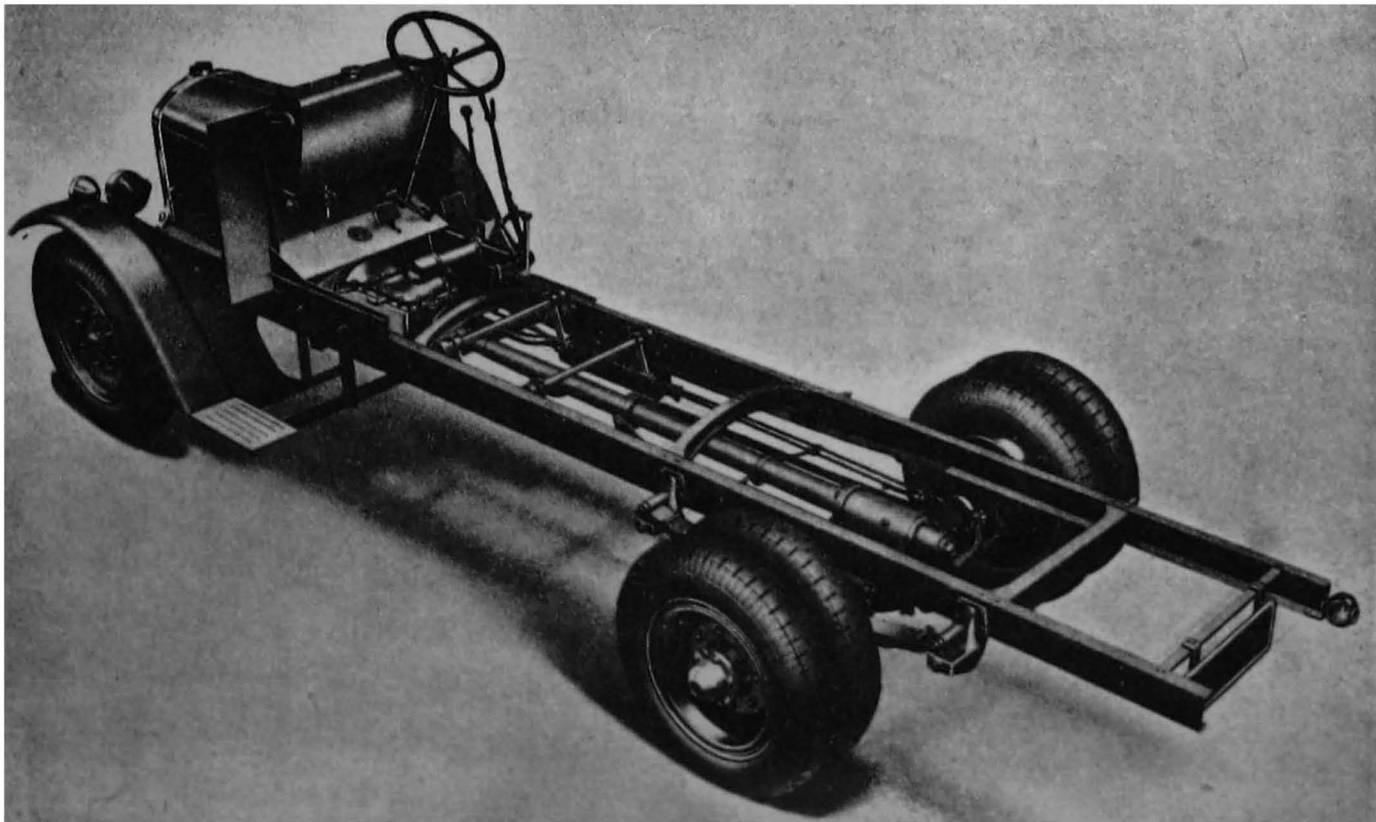


The electrical method depends on what is known as "armature reaction." Everyone knows that between the poles of a magnet there is a certain force, and how with an ordinary horse-shoe magnet an iron bar can be attracted and held to its two poles. The force between the two poles, constituting the magnetic field, is assumed to lie in "lines of force" and, if a bar of iron is passed between the poles without touching them, the work of thus cutting the lines of force is converted into electrical energy and the bar becomes electrified. If instead of a bar we use a loop of wire constituting a circuit and twiddle it round between the poles without touching them, an electric current is consequently set up in the circuit. That very roughly is the bare principle on which the dynamo works, the wire circuit representing the armature.

Further, if an electric current is passed along a coil wound round each pole, the strength of the magnetism is very greatly increased and we have an "electromagnet." For this purpose part of the current generated can be utilized. Naturally in the far stronger magnetic field thus produced proportionately more power is required to turn the armature and correspondingly more current is generated.

Now, in its rotation the armature itself also becomes magnetized and thus we have, so to speak, a subsidiary magnetic field at right angles to the main one. This subsidiary flow of magnetism tends to deflect the main field, just as when two currents of water meet, and, as the subsidiary field becomes stronger with increase of dynamo speed, the distortion increases with speed. But this distortion weakens the magnetic field and so above a certain speed-point it balances or counteracts increase of output. Alternatively separate magnets may be used to produce the distortion.

On the score of reliability there is little to choose



**THE DENNIS 2-TON CHASSIS WITH SINGLE DIRECT ENCASED PROPELLER SHAFT, WORM FINAL DRIVE, AND  
NORMAL CONTROL**

*(By courtesy of Dennis Bros., Ltd.)*

between this electrical method and mechanical means for regulating output, but the electrical method eliminates moving parts and gives a more graduated action, though it is not reparable by the average mechanic.

If also the dynamo runs too slowly it generates so little that current tends to flow from the battery and drive it, thereby running down the batteries. To prevent this, when dynamo speed falls below a certain point the current is broken, either mechanically or electrically, on much the same lines, the simplest device being a free wheel which enables the dynamo to be driven by very little current, and is noisy enough to call attention to the need for switching out the dynamo.

If, instead of being driven by an engine to convert mechanical into electrical energy, the dynamo is itself supplied with electric current, its working process is reversed: it can then convert electric into mechanical energy and it becomes an electric motor. For motor vehicles, therefore, the two duties of lighting and engine-starting can be combined in one machine; or they can be performed by a separate dynamo and motor respectively, each specializing, so to speak, on its own job. The dynamotor as the combined machine is sometimes called, certainly offers the advantages of compactness, weight-saving and simplicity of arrangement; but there is virtue in specialization in this case, for, while a dynamo is best run at about engine speed or half as fast again, for the engine-starter speeds ranging from ten to fifteen times that of the engine are most suitable. Consequently, a rather different method of construction is followed in the two, the starter motor being what is known as "series wound," the dynamo "shunt wound" (see Chapter X, pages 146-148).

Just as with the dynamo cut-out, the driving pinion of the engine starter can be slid either mechanically or electrically in and out of engagement with the gear ring on the fly-wheel, which it drives.

To do this mechanically the pinion is mounted on a screw thread on the starter shaft. As soon then as the starter begins to drive, the shaft screws the pinion along it, bringing it into mesh with the fly-wheel gear, and as soon as the engine gets going and over-runs its starting motor the reverse action draws the pinion out of engagement.

The electrical method depends on variation in the magnetism of the armature due to the fluctuation in the current passing. Under this magnetization the armature, and with it the driving pinion, are slid along to bring the pinion into working engagement, this against the action of a spring that normally holds the pinion clear of the fly-wheel gear. When current is switched on, the magnetization is strong enough to overcome the spring; but, as soon as the engine starts and begins to drive, the current falls and with it the magnetization of the armature; whereupon the spring forces the pinion out of engagement.

In some instances these two principles are combined, but the need for this may be questioned, as either by itself is very reliable, the electrical method being, perhaps, the more so of the two.

### **Petrol Engines.**

The principle on which the petrol engine works has already been explained so often that, nowadays, most people are broadly familiar with it, so, for elementary knowledge on the subject, the reader had best be referred to the numerous admirable textbooks that treat the matter in detail. For the time being, at any rate, we must confine ourselves to such recent changes

and tendencies as are influencing the development of the petrol engine at the present day.

Undoubtedly the modern petrol engine, though more cheaply produced than ever before, affords greater economy than ever before in both running and maintenance. Power output and fuel economy have been markedly increased by improvement in cam contours and cylinder heads without pockets, that promote turbulence of the inflowing mixture (or, with side valve engines the adoption of the masked inlet valve). Maintenance has been assisted by greater accessibility and better lubricating arrangements. Pressure oil feed to all crankshaft bearings is now practically universal, oil sumps on the whole are larger, more frequently one finds oil filters that can be withdrawn for cleaning without having to empty the sump, and in some cases, particularly on six-cylinder engines, arrangements for cooling the oil are being introduced with advantage. The detachable cylinder head has also materially assisted upkeep by affording ready access for decarbonization, which with the heavier motor spirits now employed is a more pressing need than formerly. Accessibility, though on the whole improved, has nevertheless in some cases been affected by forward control, the driver's accommodation rendering the off or right side difficult of access and involving adjuncts like the carburettor, ignition arrangements, dynamos, starter, tappet adjustments, and oil filter being grouped elsewhere within easier reach of hand and eye. These make a formidable list and it is scarcely surprising if accessibility has suffered in certain instances, though by careful arrangement and placing such auxiliaries as magneto at the front, the engines on some forward control chassis are nearly as accessible as on the normal type. It is not so much the number of fitments that matters, as their accessibility for adjustment or

removal, and that without having to disturb the others.

### Engine Speeds.

To-day engine speeds tend to wider variation: whereas 1,000–1,100 r.p.m. used to be fairly general, the modern transport engine, at normal speed, may run at anything broadly from 1,000 to 1,700 r.p.m., and many, even big engines, *can* run up to 2,500–2,700 r.p.m. On the whole, the present average may be put at about 1,300—in smaller engines perhaps rather more—though for heavy work there is a slight reaction towards somewhat slower speeds. A good deal may be said for a moderate engine speed. The old-fashioned engine running at 1,000 r.p.m. is a good “plugger,” well maintaining its power on hills. A high-speed engine, on the other hand, though more expensive in construction and maintenance, uses higher compressions and gives a greater efficiency, besides a wider range of speed without gear changing. Speaking very broadly, for general work the writer personally favours an engine running at about 1,300 r.p.m. normal speed.

### Cylinder Liners.

Much has been heard of late years concerning cylinder liners—dry and wet. The dry liner is simply a tube pressed firmly into the cylinder (*A*, Fig. 30) and is what its name implies—a lining for the inside of the cylinder barrel, which, when the bore is worn, can without much difficulty be withdrawn and replaced by another. Thereby the more troublesome and expensive job of cylinder re-boring is avoided and the cylinder bore kept to a diameter suitable for standard size pistons, whereas over-size pistons and rings would be required to fit the re-bored cylinder. Not only so, but, as the liners can be made of a special cast iron harder than the

main cylinder casting, they reduce the frequency of cylinder overhauls. Against these advantages the additional thickness of the dry liner somewhat retards the flow of superfluous heat from the interior of the cylinder walls to the water jacket, but the water

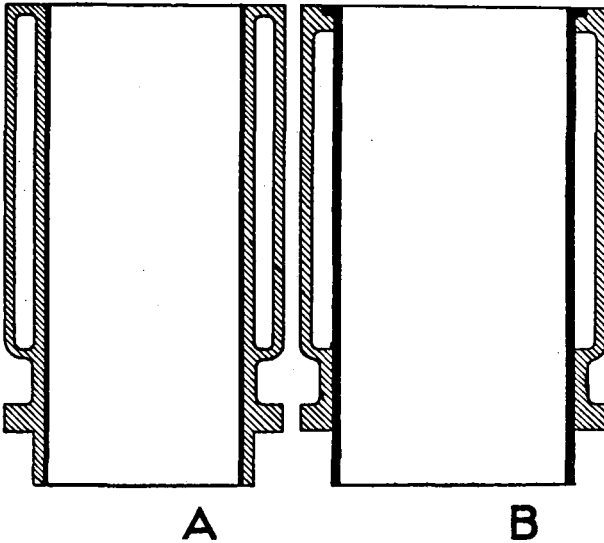


FIG. 30. CYLINDERS WITH LINERS SEEN IN SECTION  
The liners in black. *A*, dry; *B*, wet liner

circulation of the modern engine is practically always efficient enough to allow for this; at any rate, complaints of over-heating due to dry liners are practically non-existent.

The wet liner is in effect a separate cylinder barrel, its outer surface in direct contact with the water in the cooling jacket, and its ends making water-tight joints with the main cylinder casting, on the lines of the diagram *B*, Fig. 30. Thus it has the advantage of the

dry liner, in better conduction of superfluous heat from cylinder to circulating water, though the joints top and bottom may offer some very slight possibility of leakage. With proper construction, however, that should present no more insuperable difficulty than the detachable cylinder head now prevalent. Though expert opinion is divided on the relative merits of dry and wet liners, the latter will be more probably adopted as general practice in engine design of the future.

On the same principle, in some engines the valve seats are made separate and renewable, and, though opinions differ on the value of this feature, on the whole they are of advantage, but not to the same extent as cylinder liners.

Overhead valves, when first employed, caused some misgivings owing to valve breakages in certain cases causing serious damage to the cylinders; but those days are long since past, and very full reliance can be placed on the valves of to-day. It is not surprising, therefore, that overhead valves are being much more commonly adopted than of old, for by doing away with side pocket valve chambers they permit of a simply cast, symmetrical cylinder head which is markedly more efficient and fuel-economical.

A factor that has contributed materially to durability and decreased repair cost is to be found in the large diameters of crank shafts, for a "whippy" shaft is a fruitful source of wear at the bearings and at the journals (the parts of the shaft that run in the bearings) besides causing loss of power and excessive vibration at certain critical speeds. As a rough rule it may be said that the diameter of a modern crank shaft should be about half the bore of the cylinders driving it, but of course much depends on the nature of the steel from which it is made; this, however, is about the proportion given even with tough alloy steels.



**Fuel Feeds.**

In the smallest and most inexpensive chassis petrol may be fed direct from tank to carburettor simply by gravity, the tank being at a higher level than the carburettor, commonly in the cowl of the dash. This has the merit of cheapness and simplicity, but the tank position immediately above and behind the engine is not ideal for replenishing or in case of an accident; also without any intervening tank to act as a sump there appears a greater liability for the carburettor jets to become choked in spite of the intervening filter. With petrol tanks carried low down at the sides or back of the chassis frame, fuel has to be raised to carburettor level, and most readers will be acquainted with the Stewart vacuum system (better known as the "autovac") now commonly employed to meet these conditions. It is merely a device whereby the engine inlet suction is utilized to draw fuel from the main tank into a container, where it is maintained at a practically constant level for feeding to the carburettor by gravity. The system is still very widely used, but of late fuel pumps have found extensive adoption and many commercial chassis now depend on them. The pump draws fuel direct from the main tank, supplying it equally direct to the carburettor, and is so devised that, as soon as the carburettor float reaches its proper cut-off level, the action of the pump automatically ceases. Generally the pump effect is obtained by the movement of a diaphragm which is actuated by an eccentric on the engine cam-shaft against the pressure of a spring that causes the return stroke, but in at least one case the diaphragm movement is obtained electro-magnetically from battery current. The small glass bowls incorporated with the pumps not only collect any sediment but serve as sight feeds for the working of the pump.

In the air supply to the carburettor, too, there have been changes, and to-day air cleaners or filters are practically universal on transport chassis. In these any of three principles can be followed: (1) the air on being drawn into the cleaner can be whirled round so that dust particles are thrown off by centrifugal action to the outer walls, where they fall down and are trapped; (2) or the air can be drawn over oily, or greased, surfaces to which the dust adheres; (3) or it can be drawn through some filtering medium such as felt. Sometimes these principles are combined and a combination of the first two may certainly be recommended, but the third is apt to lead to engine choking, unless the filtering medium is cleaned fairly frequently from time to time.

#### **Four or Six Cylinders ?**

The last two or three years have seen also a marked increase in six-cylinder engines for commercial work, which, though it began with passenger chassis, has extended to the goods carrying class: at recent exhibitions quite a number of the latter have been in evidence.

The most obvious advantage of a "six" lies in its more even and sustained turning effort. With four cylinders there is one working stroke to each half revolution or to each stroke of the engine as a whole; but, as the exhaust valve opens before the end of the working stroke, there is something of a gap between the one explosion and the next; each impulse is to an extent distinct and separate. In the six-cylinder the explosion stroke of one piston begins before that of its predecessor has finished, and so the impulses overlap and impart a more continuous drive, particularly felt at low speeds when a more sustained effort is most needed. This enables the engine to pull more steadily

and frequently avoids changing down, while at the same time it tends to eliminate the "snatching" on the transmission that occasionally occurs at low speeds. All of which helps to reduce wear and tear on chassis as well as engine.

A distinction must be drawn between evenness of running and absence of vibration. The latter quality is mainly dependent on perfect balance of the moving parts which in a "six" presents a more difficult problem than with four cylinders. A normal decently balanced four in this respect may easily be preferable to a badly balanced six, which may evince excessive vibration at certain critical speeds. Nevertheless, all things being equal, a six runs more smoothly than a four cylinder engine, the smaller, lighter pistons, connecting-rods and crank-throws, and their more numerous and even distribution round the working circle of the crank, certainly producing less vibration. To achieve this, however, great care must be taken to ensure a perfectly equal distribution of the gas to all cylinders; it is not a matter only of balancing.

Finally, the smaller cylinders make for easier starting.

The main disadvantages of six-cylinders are their higher first cost, the greater chassis length they occupy, their greater complication, and it must be admitted that for a given power a "six" is rather heavier on fuel consumption than a "four."

For passenger working manifestly the six-cylinder offers real advantages, which are being very practically realized by adoption; but for goods carrying its scope is as yet not clearly defined. For very small powers the four-cylinder engine will probably hold its own, but for work in heavy traffic, demanding an engine capable of steady, powerful running at low speeds, the six promises to have a future.

## CHAPTER VIII

### THE HEAVY OIL ENGINE

ACCORDING to popular belief the type of engine known under the name of Diesel can use any grade of oil, even down to the residual left over after distillation. It *can* perhaps; but the small high-speed engines employed for road transport certainly *should not*; they can give no sustained or reliable service with any but a carefully prepared and filtered oil, which is not unlike kerosene in appearance.

#### **Lower Consumption the Main Claim.**

Again, most people think that the main claim of the heavy oil engine lies in its use of cheaper fuel. That, however, can be regarded only as an argument of the moment, and in any broad survey of future possibilities is likely to be misleading. At present oil fuel bears no tax, while on petrol a duty of 8d. a gallon is imposed, which, if removed, would leave not so great a difference in cost. True, with bigger demand and output of heavier fuel, price might be reduced; but the increased use of heavy oil vehicles which that would imply would inevitably bring taxation with it. The heavy oil engine by rendering a greater proportion of the world's fuel supplies available to transport may tend to check rise in price, and heavy oil may be cheaper than petrol. Still the difference in the future between the two fuels is not likely to remain as marked as at present, and the more far-seeing do not attach too much importance to the price factor, but rather to the undoubted reduction in fuel consumption that gives the heavy oil engine its real claim to attention.

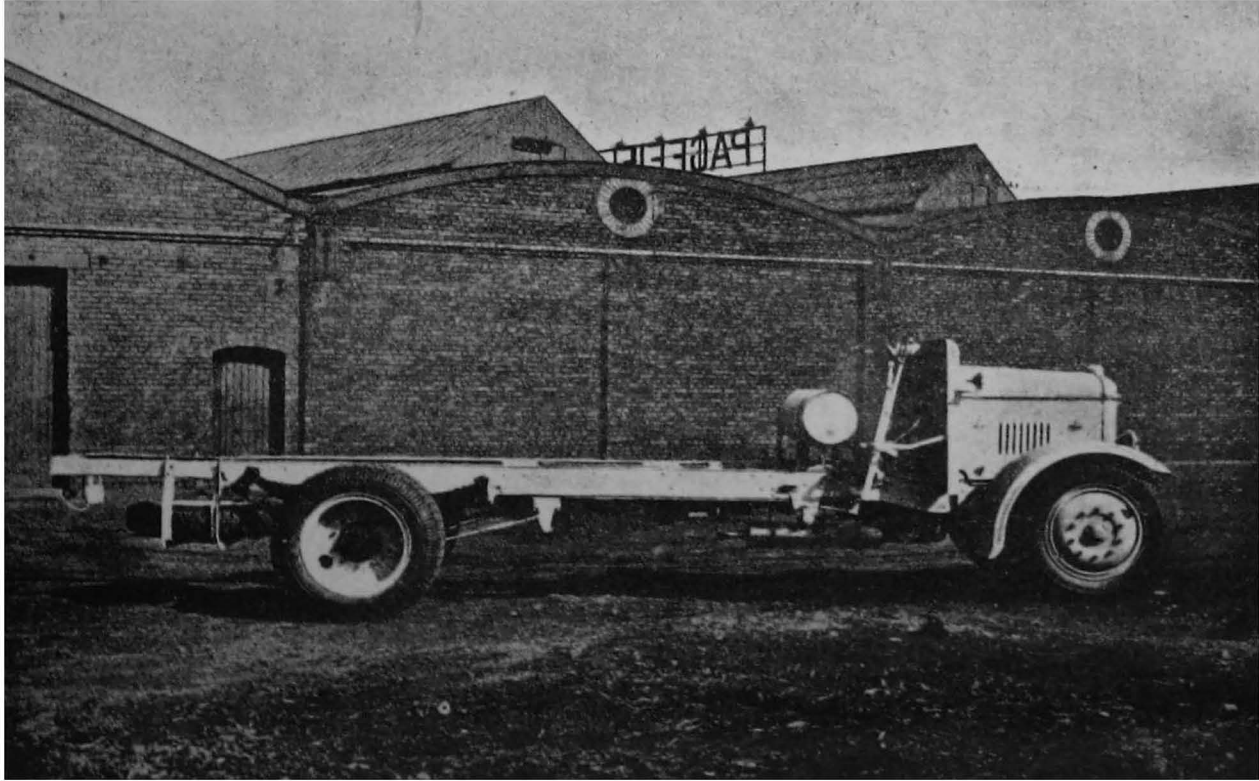
### Results in Working.

What these claims amount to may be gathered from some actual performances. As far back as 1928 in a Royal Automobile Club test a Mercedes-Benz heavy oil vehicle, weighing with load just over 11 tons 12 cwt., showed a consumption of practically  $13\frac{1}{2}$  miles to the gallon. This performance, which gives the extraordinarily high figure of  $156\frac{1}{2}$  gross ton-miles to the gallon, won the Dewar challenge trophy for that year. On petrol 6 m.p.g. would have been considered a creditable performance.

On the passenger side, in 1930, a six-wheeled omnibus was averaging 11 m.p.g. over a mileage of 21,000, according to Mr. Fearnley, general manager of the Sheffield Corporation Tramways, who had fitted it with a six-cylinder engine of nearly 4 in. and just over  $5\frac{1}{2}$  in. bore and stroke respectively. Previously the bus had given 5 m.p.g. on petrol.

Later a T.S. chassis, weighing with load just over  $9\frac{1}{2}$  tons, and fitted with a four-cylinder Gardner engine (having a bore of  $4\frac{1}{2}$  and a stroke of 6 in.) averaged 11.4 m.p.g. over a mileage of about 4,000, whereas the petrol engine with which it had previously been fitted had been using about  $6\frac{1}{2}$  gal. to the mile. It may be mentioned in passing that this vehicle was a petrol-electric—that is to say, the engine was driving a dynamo which supplied current for an electric motor that in turn drove the road wheels—and with this form of transmission the heavy oil engine proved to possess another advantage in that it afforded more uniform acceleration.

Again at Walsall a Dennis single-decked bus fitted with a four-cylinder Gardner heavy oil engine was giving 18 m.p.g. "It uses for a given horse power only about 50 per cent of the fuel required for a corresponding petrol engine," said Mr. Vane Morland, the general



**A PAGEFIELD FOUR-WHEELED BIG CAPACITY CHASSIS DRIVEN BY HEAVY OIL ENGINE**

*(By courtesy of Pagefield Commercial Vehicles, Ltd.)*

manager and engineer of the Walsall tramway and motor services.

### **The Working Principle.**

In the main construction and the sequence of their working processes the heavy oil and petrol engines are similar; in both classes there are engines working on the two- and on the four-stroke principle, and there is the same cycle of suction, compression, working, and exhaust on the four-stroke principle, which in both cases is by far the more prevalent, the two-stroke indeed being little used for transport engines. There is also the same arrangement of inlet and exhaust valves. But there is this very important difference: instead of a mixture of fuel and oil being sucked into the cylinder on the induction stroke, as in petrol engines, only pure air is drawn in. Then, instead of being compressed to the 75 lb. per sq. in. or so, general in petrol practice, the air taken into the cylinders of the heavy oil engine undergoes a compression of anything from 400 to 550 lb. per sq. in. or even more. Naturally, to effect such pressures entails heavy mechanical work which makes itself evident in the form of heat, so that, by the time the compression stroke is completed, the temperature of the air in the cylinder is raised to between  $1,000^{\circ}$  and  $1,100^{\circ}$  F., just as in pumping tyres it becomes heated. So hot in fact is the air under these high compressions that it is able to ignite the oil fuel which is then separately forced into the cylinder just at the top of the compression stroke; and that is why engines of this sort are often referred to as compression-ignition engines, or C.I. engines for short.

### **Starting.**

Inevitably with such compressions starting constitutes a problem, varying in difficulty according to the

design of engine ; but even in the worst cases it can be overcome by a powerful starter in conjunction with an electric resistance to heat the air in the cylinder, while in some cases starting by hand is possible with the help of a decompressor like those used on motor cycles. For the higher compressions an extra powerful starter is provided, working at 24 instead of the usual 12 volts and, with the decompressor holding open the inlet valves during the compression stroke, the crankshaft can be turned rapidly. If then the decompressor is brought out of action, the momentum of the fly-wheel suffices to start the engine. In some cases in one or two of the cylinders the compression is actually increased for thus starting, so as to generate all the more heat for ignition.

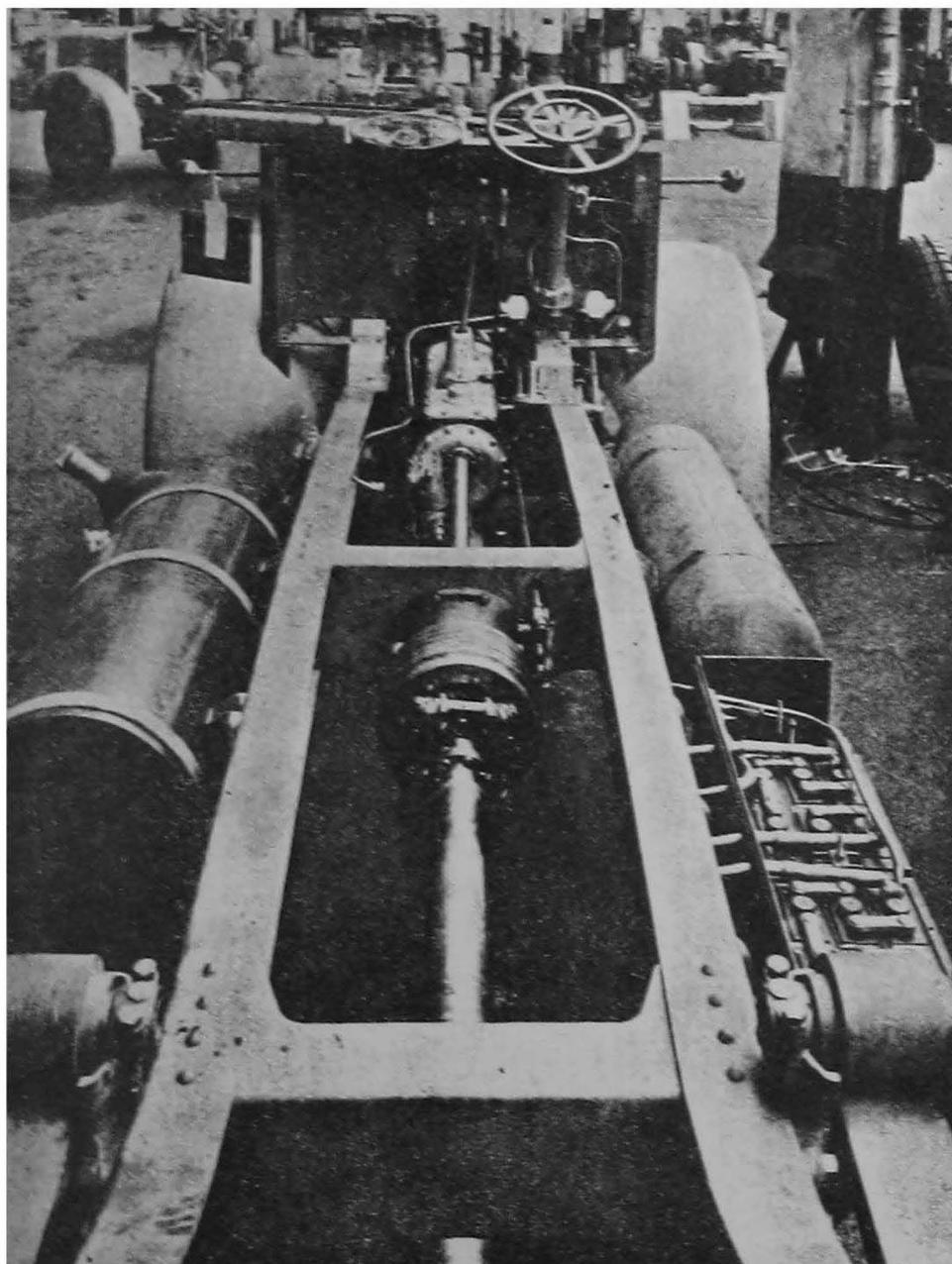
Compressed air has also been employed for engine starting, but it entails a compressor and reservoir, and so far has found little favour for vehicle working.

### **Some Essential Differences.**

It will be realized then that with heavy oil the ignition system of the petrol engine is dispensed with and the carburettor substituted by a fuel pump, while to obtain the necessary high compression the clearance, or combustion, space in the cylinder must be very much smaller than in petrol engines and the whole construction stronger and heavier. It is in the cylinder head and fuel pump, however, that the essential difference lies and these two items are the most vital features of the C.I. engine.

Explosion is only extremely rapid burning or chemical combination of the fuel with the oxygen of the air ; and, though there can be no definite line of demarcation between explosion and mere burning, there is a prevalent idea that in the oil engine this process is less rapid than with petrol, and partakes more of the nature of





A TYPICAL HEAVY OIL CHASSIS BY A LEADING FIRM

*(By courtesy of Armstrong-Saurer Commercial Vehicles, Ltd.)*

burning, less of explosion. That is only true in some circumstances: as a matter of fact free uncontrolled ignition in a C.I. cylinder is more rapid than in a petrol engine; but it can be controlled to some extent, and in this the position and direction of the fuel jet, the timing, rate and duration of the injection, and the shape of the cylinder head are all important factors.

### **Speeds and Power.**

Assuming these conditions favourable, the net result is that the fuel is consumed more completely than in the petrol engine, and under certain conditions more of it just when the crank affords a more advantageous position for the application of piston force. Thus at moderate speeds, between, say, 800 and 1,300 r.p.m., the C.I. engine can give the greater turning effort, and down to the lower limit there is less falling off of power with decrease of speed; in other words, the engine can keep plugging along and "hang on" better without getting "hung up." Indeed the C.I. engine has been described by one authority as "one gear better" than its rival. Nevertheless, at low speeds and idling, oil does not give as sweet running as petrol; and it is at such speeds that the disconcerting characteristic known as "Diesel knock" sometimes occurs. Still, with the recent improvements that have led to more complete combustion, that old-standing bogey about which so much has been heard is rapidly disappearing, and there is no doubt that already it has virtually been overcome.

As to acceleration views differ, but the general consensus of opinion seems to indicate little difference one way or the other. The C.I. speed range, however, is the more limited, extending only up to a practical working maximum of about 2,000 r.p.m. as against more than 3,000 r.p.m. for petrol.

**More Complete Combustion.**

Implying, as it does, less waste of fuel, the more complete combustion brings with it certain advantages other than economy and power. The engine runs cooler and, requiring less cooling, can do with a smaller radiator: there is certainly no more tendency to burnt valves than with petrol and markedly less cylinder fouling with its attendant need for decarbonization. Finally, the exhaust gases are practically free of carbon monoxide and are innocuous. And, though it must be admitted that in the earlier stages the smell of the exhaust was offensive, with modern improvements it is to-day certainly no more objectionable than that of the petrol engine running on commercial spirit; many people in fact prefer the bouquet of the oil.

**Lubrication Consumption.**

Further, there is perhaps less dilution of the lubricating oil in the crank chamber from unconsumed fuel from the cylinders, though, admittedly, once it finds its way into the crank case, the heavy oil does not evaporate like petrol, for in a petrol engine with fresh oil in the base chamber dilution takes place for only the first 100 miles or so, evaporation thereafter balancing further condensation. Experience seems somewhat at variance in the matter of oil consumption. In the Sheffield bus, already mentioned, a consumption of 700 miles to the gallon was at first attained; but it afterwards fell to only 100 m.p.g. At Walsall however, the lubrication consumption was all along superior to that of the petrol engine, ascribed mainly to its lower working temperature. It is, however, notoriously dangerous to argue from the particular to the general; but, bearing in mind the lower working temperature and improvement in the matter of crank-case dilution, a lower lubricant consumption may reasonably be

expected from the C.I. engine of the future, and already, in general, it at least compares creditably with petrol performance—within, say, 10 per cent.

Another point—since combustion is not dependent on vaporization, there is no need for warming up the engine; once started, it can take full load right away. Also the more stable fuel presents far less risk of fire—a fact which might well be reflected in the insurance premium.

### **Weight.**

The higher compressions involved by the C.I. principle, of course, call for stronger construction and greater weight, which constitutes one of the chief objections urged against this form of power. At its first introduction the C.I. engine weighed up to some 27 lb. per h.p. which was fully double that of the petrol engine, and extra deadweight is an important consideration in business transport. That this disability is being reduced, if not overcome, with amazing rapidity, may be inferred from the fact that, whereas in 1928 the engines produced by a certain firm weighed 26 lb. per h.p., in less than three years the firm had reduced the weight to 14½ lb. In some cases weights have been reduced even lower, rendering them quite comparable with those of petrol engines, and with the less weight of fuel to be carried, due to decreased consumption, the weight objection disappears.

### **Types of Cylinder Heads.**

For purposes of broad consideration heavy oil engines may be grouped into two main classes—those in which the fuel is injected direct into the cylinder above the piston, and those having an adjoining chamber connected with the main cylinder head into

which the ignition is, roughly speaking, propagated from the chamber.

The first type, which is most generally adopted by British makers, is exemplified by *A*, Fig. 31, and presents

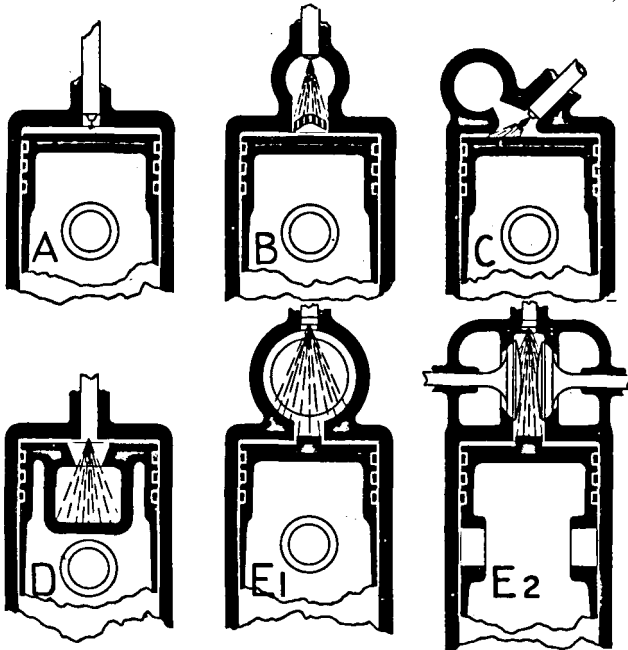


FIG. 31. TYPES OF COMPRESSION-IGNITION CYLINDER HEADS

perhaps the most efficient form in that it entails the minimum of external wall surface as a source of heat loss and because, thanks to its simple form and absence of pockets, the burnt gases can be completely exhausted and replaced by fresh undiluted air on the suction stroke. Moreover, it requires the most moderate compression of any C.I. engine and in a general way it

can be started cold. On the other hand, in its earlier forms it was inclined to harsh running; but by designing the interior so as to increase turbulence of the incoming air and so ensure a more homogeneous charge, and by a nice adjustment of the injection factors, this objection has in great measure been overcome.

The direct injection type represents what might be called open combustion in the cylinder head. At the other end of the scale is the engine with a pre-combustion or ante-chamber, separated from the cylinder by a partition, called the atomizer, through which a number of small holes connect the two, the object being to obtain a more sustained force on the piston. Such a cylinder head is seen at *B*, in Fig. 31. As the piston comes to the end of its compression stroke, it forces the air through the small passages of the atomizer into the ante-chamber, turbulence being imparted in the process by the form or direction of the holes. Neither fuel injection nor ignition can be absolutely instantaneous, so the beginning of the ignition sets up in the ante-chamber pressure which forces most of the unconsumed fuel in a fine spray through the atomizer holes into the cylinder where its combustion and expansion are completed. This gives a more graduated piston pressure than if the charge is ignited direct in the cylinder head. On the other hand, it demands a very high compression, so a powerful starter is necessary as well as a small electric resistance coil to heat the air in the chamber at starting. Also, after each working stroke some of the products of combustion tend to remain in the chamber where they dilute the air drawn in for the following charge.

The next development is known as the air cell type of engine, the air cell being in effect a modification of the pre-combustion chamber. Its arrangement is indicated by *C*, in Fig. 31. Here air is compressed into

a chamber connected with the cylinder head by a narrow-necked passage expanding into the cylinder. In this type oil is generally injected into the mouth of the passage, where ignition begins and, as the piston descends, the air is drawn from the cell, projecting the flame into the cylinder head to complete combustion. In some cases the air cell is situated in the piston head, as at *D*, Fig. 31. Yet, wherever the cell, the principle is the same and presents much the same advantages and disadvantages. In general, air cell engines can run at relatively high speeds, while the working pressure is graduated to some extent as with an ante-chamber; but, like the ante-chamber engine it calls for heavy compressions and means for heating the charge at starting.

Between the two extremes of direct injection and ante-chamber or cell types a compromise has been introduced in the form of what has been christened the "clerestory" head. It is seen at *E1* and *E2*, Fig. 31, the chamber between the valves being very generally circular to side view, and a boss on the piston entering the opening to the chamber at the end of the piston stroke. Engines on these lines have a good range of speed, and, though running at compressions considerably higher than for direct injection (but not as high as with an ante-chamber) give relatively smooth running and can be started cold. Taken all in all, they represent one of the types most likely to survive.

It must not be inferred from what has gone before that heavy oil road vehicle engines must definitely come within one or other of some arbitrary class. The types just enumerated stand for principles rather than constructions—and principles capable of modification or blending. For example, in air cell engines the fuel is not necessarily injected into the mouth of the connecting passage; in one instance the air cell with injection

from the top may become very like an ante-chamber without the atomizer, while in another case the cell is separated from the cylinder head by an atomizer and the fuel is injected across the air jets as they issue into the cylinder through the atomizer holes.

### **The Fuel Pump.**

The fuel pump is the most important and distinctive part of the heavy oil engine and it presents an extremely difficult problem. Not only has it to supply oil some 1,000 times a minute to each cylinder when the engine is speeded up, but it has to force in against enormous pressure a most accurately measured quantity, so minute that even at its maximum it amounts to only the merest fraction of a drop. Not only this, but it must begin injection at exactly the right moment, just before the piston reaches the end of its compression stroke. Further, it must maintain an even rate of delivery, and this in such a way as to break the injection jet up into as fine a spray as possible; also it must get to work and finish as instantaneously as possible without leaving any leakage. In addition the amount delivered at each stroke must be variable according to the needs of the engine and so, too, may the timing of the injection be, just as the ignition on a petrol engine can be advanced or retarded. All this has to be done exactly equally in each cylinder, the pump working at a pressure of anything from 1,000 to 6,000 or 7,000 lb. per sq. in. Small wonder then that the pump has to be made with the greatest precision, its plungers and the barrels in which they work hardened and ground to  $\frac{1}{1000}$  in. in accuracy.

A description of the most widely used fuel pump will best explain how these functions are performed. Of course there is a pump for each cylinder and, though in some engines a pump is mounted separately on each, in



the mechanism under consideration all pump barrels and their plungers are contained in a single casing and actuated by a camshaft driven off the engine camshaft, so as to give each plunger a stroke every other crankshaft revolution. The general arrangement is shown by Fig. 32

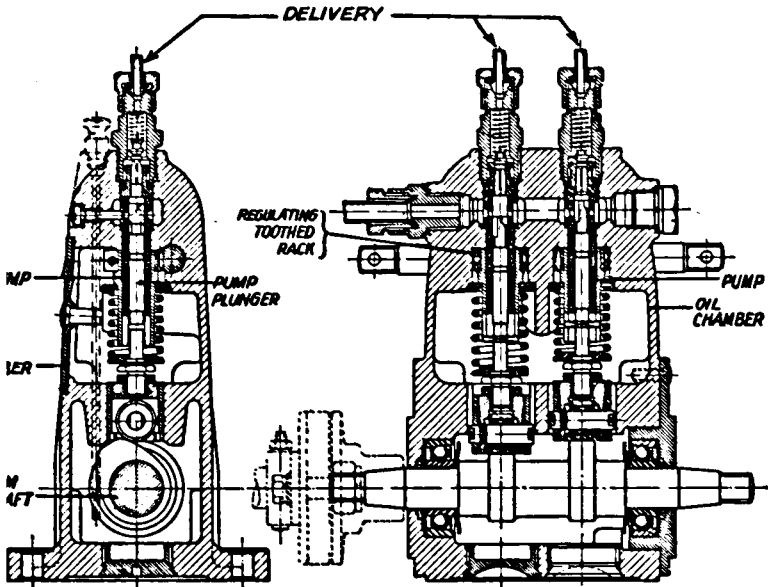


FIG. 32. A FUEL PUMP FOR TWO CYLINDERS IN SIDE AND END PART, SECTIONAL VIEW

(Kindly lent by C.A.V.-Bosch, Ltd.)

The oil fuel flows into a long chamber common to all the pump barrels, and at the bottom of its stroke each plunger uncovers holes or ports in the barrel so that the oil is free to flow above the plunger. As soon as it is lifted by its cam the plunger shuts off these ports and begins to exert tremendous pressure on the oil, forcing it up past a spring-controlled non-return valve

to the injection nozzle in the cylinder. But on the plunger an annular groove is cut, connecting with the top of the plunger by a widening groove one edge of which coils round the plunger as in Fig. 32A. Just as the plunger then reaches the top of its stroke, this groove uncovers the passage on the right side of its barrel that connects the space above the plunger with the main suction chamber, instantly relieving the pressure above the plunger and so cutting off the supply to the cylinder.

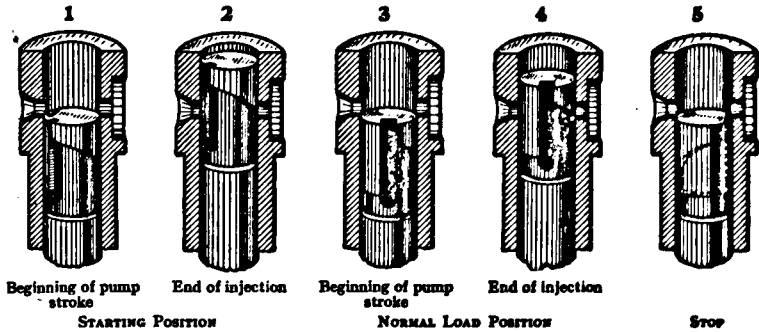


FIG. 32A. THE PUMP BARREL AND PLUNGER OF THE SAME PUMP IN VARIOUS POSITIONS OF REGULATION  
(Kindly lent by C.A.V.-Bosch, Ltd.)

Lower down on the plunger projecting teeth are found engaging with slots in a rack (see Fig. 32) that can be slid by the governor or hand control, whereby the plunger can be part-turned in its barrel and set so that the edge of the slot or groove already mentioned opens up the relief passage earlier or later on the plunger stroke as required. Further, by extreme movement of the control the plunger can be set far enough round for the vertical groove to open the relief port right at the beginning and hold it open for the whole of the plunger stroke, thus stopping the engine. That is how the duration of the stroke is regulated.

Timing can be varied through a setting which

enables the pump camshaft to be set round relative to the shaft that drives it, bringing the cams into action earlier or later relatively to the piston, as required.

To prevent residual leakage into the cylinder when injection is completed and oil pressure falls at the end of the plunger stroke, a valve closes the orifice of the spray nozzle and any left over is returned to tank or suction chamber.

This will serve to outline the idea underlying fuel injection; but it must be understood that fuel pumps vary much in construction; there is no uniformity of practice. On the Blackstone engines, for instance, the energy stored up in a compressed spring is very successfully utilized to actuate the plunger; in other pumps, for example, timing variation is achieved by working the plunger off a lifting lever the fulcrum centre of which can be varied; in yet others the duration as well as timing can be altered by cams of variable contour, and so on.

To assist in regulating the oil supply all C.I. engines are fitted with a governor in addition to the driver's control, and this automatically limits the delivery as soon as a pre-determined maximum speed is attained.

Inevitably with such a system filtering must be very thorough, and several filters are interspersed between tank and pump, while more perfect fluidity of fuel is often ensured by warming it from the cylinder jacket, though with standard brands of fuel that should not be necessary at the temperatures ruling in this country.

It will be realized that mechanism calling for such high degree of accuracy has its limitations, and for this cause so far the system has not been applied to small vehicle engines, a 4 in. cylinder bore being about the smallest found practicable. Consequently, heavy oil engines are seldom of less than about 25 h.p. in the four-cylinder class, or 36 h.p. with six cylinders, under



**THE FODEN-DIESEL SIX-CYLINDER 10-12 TON SIX-WHEELER WITH A GOOD LOAD**  
*(By courtesy of Fodens, Ltd.)*

Treasury rating, which probably means some 38 and 50 horse respectively in actual working at 1,000 r.p.m. At the present stage, therefore, the four-cylinder engine is not likely to be used on chassis of less than 2 ton capacity or the six for loads of less than 3 tons, or 30 passengers.

As the engine is controlled on the fuel, independently of the air supply, no vacuum is created in the inlet pipe by the closing of a throttle when the engine is shut off or closed down, and thus engine suction cannot usually be utilized for a power braking system dependent on vacuum. Accordingly, on most heavy oil engines a small rotary or reciprocating pump is mounted, driven from the timing gears, to exhaust the air from the brake cylinders.

#### **Comparative Summary.**

Setting off the fuel pump against the absence of carburettor and ignition apparatus, at present the case for or against the heavy oil engines may be summed up on the following lines—

##### *Against*

- Less speed range.
- Greater power required for starting.
- Slightly greater weight.
- Rougher running at low speeds (especially with direct injection).
- Diesel knock. (Nearly overcome in latest designs.)
- Difficulty in using engine suction for braking, etc.

##### *For*

- Higher efficiency and lower consumption.
- Cheaper and untaxed fuel.
- Smaller and lighter fuel tanks, or increased radius of action for same weight.

**I 24      COMMERCIAL MOTOR ROAD TRANSPORT**

**Greater turning effort at moderate speeds.**

**Reduced fire risks.**

**No need for preliminary warming-up of engine.**

**Cooler running.**

**Innocuous exhaust.**

**It may be noted, however, that all the disadvantages, with the exception of that relating to starting, are being rapidly lessened, if not improved out of existence.**

## CHAPTER IX

### STEAM VEHICLES

IN any study of the steam vehicle we must get right away from internal combustion ideas and think in other terms. We need not concern ourselves with the differences between the two types. The main thing here is to grasp the broad underlying principles on which the steam engine depends, and we can then the better understand why and how it differs from its rival in practical working behaviour.

#### **Expansive Working of Steam.**

Of these principles the most important for a prospective user is that underlying the expansive working of steam, which is really what renders steam commercially possible. It must be realized that steam is an elastic medium. Suppose a piston in a cylinder of 50 sq. in. area is forced along a stroke of 12 in. by steam at a pressure of 100 lb. per sq. in. The volume of steam thus used in the cylinder is shown by shading in *A*, Fig. 33 and amounts to 600 cub. in. Its total force on the piston will be 5,000 lb. and in travelling the 1 ft. of its stroke the piston will do 5,000 ft.-lb. of work, represented by the area *abcd* below, in which the height, *ab* represents the pressure and *bc* the stroke in feet or inches. For every inch of the piston stroke a corresponding amount of steam will be used.

Now if, instead of supplying steam for the full stroke, we cut off the supply when the piston has travelled only a quarter of its stroke, the piston will move with the same force and the same amount of steam-for-movement will be used as before—for the first quarter of the stroke. Beyond that point, however,

the steam will still continue to force the piston along; but having to fill more space its pressure will fall proportionately, and at half stroke it will have to fill double its original space and so will be at half its original pressure, while at the end of the stroke it will be filling four times the space at one-fourth the original pressure. As before, in the upper diagram of *B*, Fig. 33 the volume of steam used is shown by the shaded part and the work by the area *efghi* in the figure below.

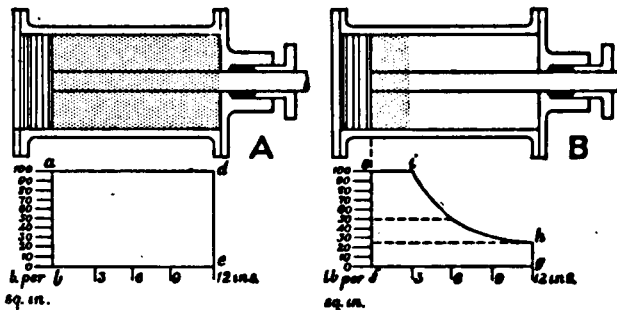


FIG. 33

Explaining how and why more work can be obtained from a given volume of steam by using it expansively

Manifestly then by cutting off the steam early and working it expansively, as in the second pair of diagrams, more work is got out of each unit of steam used: as a matter of fact by an early cut off we have obtained some three-fifths of the work with only one-quarter of the steam.

This, of course, gives only a very rough idea of expansive working, but it serves to explain the principle without subsidiary complications. In actual fact the diminution of pressure during expansion is considerably more rapid and greater than that shown in rough theory, because the pressure of steam varies with its temperature. Part of its heat is converted into work,



part is lost by contact with the cooler cylinder surfaces and part passes through the cylinder walls by conduction; from which causes the pressure falls on the steam entering the cylinder and still more so during expansion.

It will also be understood that expansion gives a lower *average* or mean effective pressure on the piston than if full pressure were maintained throughout the stroke, and the earlier the steam cut-off the lower the mean effective pressure. With a cut-off at three-quarter stroke the average pressure in the cylinder will not be so very much below boiler pressure; but with a cut-off at a quarter stroke it will be much less and the engine power will be correspondingly reduced. In the variation of expansion then the driver has an economical method of control that can be used in conjunction with, or up to a point instead of, the throttle.

### **Valve Motion.**

The mechanism that varies the expansion implies a valve that admits steam at a fixed point (generally just before the end of the previous stroke) and can shut off at a variable point. On engines with lifting poppet valves, like those on internal combustion engines, the inlet valve is operated by a cam with two or three different contours, all opening the valve at the same point but holding it open for different lengths of stroke period; and by sliding the cam shaft longitudinally any one of these cam contours can be brought into action under the inlet tappet as required.

In many engines, however, the steam supply to the cylinder is regulated by sliding valves which present a more complex problem. On the old oertype wagons these slide valves were commonly worked by the Stephenson or Howe eccentric link motion, which will serve to explain how expansion is graduated.

Fig. 34 shows a cylinder and valve chest in section with its passages and steam ports together with a valve in position when the piston is beginning its stroke. It will be noticed the valve has just opened the left hand end of the cylinder to steam, to cushion the piston before it has reached the end of its stroke, and the amount of this opening is known as "lead." If the

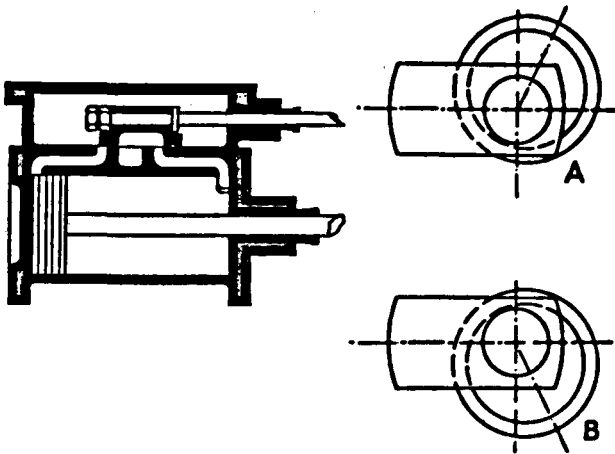


FIG. 34. STEAM CYLINDER IN SECTION

With slide valve just opening at the beginning of the piston stroke

engine runs clockwise, crank and eccentric will be in the relative positions indicated at *A*. This will give full steam opening when crank and connecting rod are about at right angles with each other and will cut off at some three-quarters of the stroke.

To run anti-clockwise with a three-quarter stroke cut-off the eccentric would have to be in the position shown at *B*.

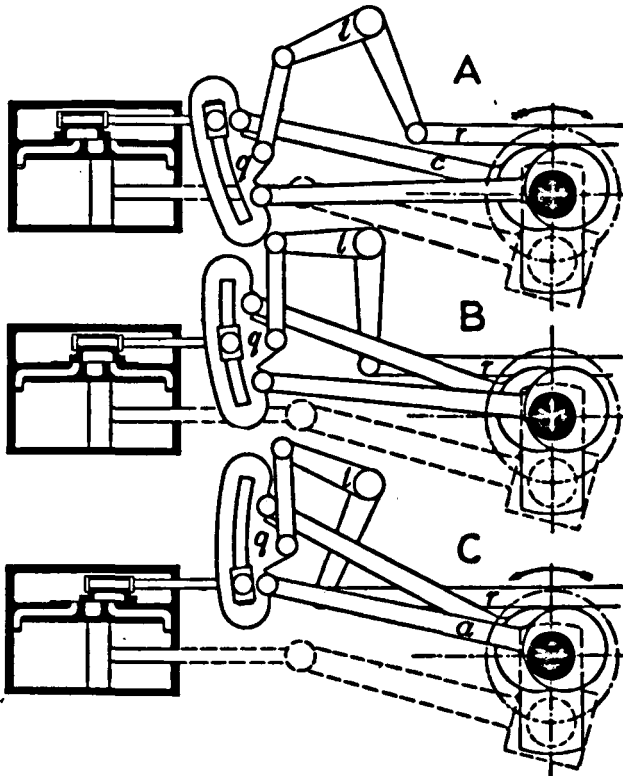
But supposing that with this anti-clockwise eccentric in action the crank were rotated clockwise. The valve would obviously begin to cut off steam at once right at

the beginning of the stroke. Now the three-quarter cut-off given by eccentric *A* is the maximum likely to be required for clockwise running; if, therefore, its action is combined with that of the anti-clockwise eccentric the result will be a cut-off somewhere between the two extremes, and the more the anti-clockwise eccentric is brought into action the earlier will be the cut-off. Thus we can obtain a cut-off anywhere between practically the beginning and three-quarter stroke.

Fig. 35 which shows the link motion looks very complicated but its explanation is quite simple. The slide valve is worked through a slotted quadrant link, *q*, which can be raised or lowered to bring either clockwise eccentric rod *c* or anti-clockwise rod *a* into action. This is effected by a rocking lever *l* fulcrumed at a fixed point and swung over into position by the rod *r* worked from the reversing lever. In diagram *A* the clockwise eccentric is driving to give the full three-quarter cut-off, the anti-clockwise eccentric merely swinging idle. In diagram *C* the anti-clockwise eccentric is fully driving, the clockwise eccentric swinging idle, while at *B* the valve motion is in mid-gear and it will be seen how the ends of the cylinder have been cut-off from the steam supply—as a matter of fact both practically at the beginning of the stroke, the valve only opening the lead, and no more, at either end.

In one or two makes of steam wagon, notably the Yorkshire and the Garrett, the slide valves are worked by Joy's gear which is seen in Fig. 36. In this case the longitudinal and up and down motion of the connecting rod are combined to give the valve movement. Link 1 swings from the connecting rod and is coupled at its other end to the radius link 2 which swings from a fixed pivot point *f*. Consequently, the joint between links 2 and 3 describes an oval path. Link 3 is pivoted on a

slipper block sliding in curved guides, so that, as it slides in the guides, its top end above this pivot swings



**FIG. 35**

Showing how link valve motion can vary the degree of steam expansion in working

to and fro. Now the guides are curved to the radius of the valve connecting rod, so that in mid-gear, as in diagram *A*, the up and down movement of the slipper block does not move the valve; the valve connecting rod end merely swings up and down; the only movement

of the valve is caused by the link 3 wagging to and fro on its slipper block pivot, and this is merely enough to open the valve to lead at the beginning of the piston stroke and close it again—ultra-early cut-off.

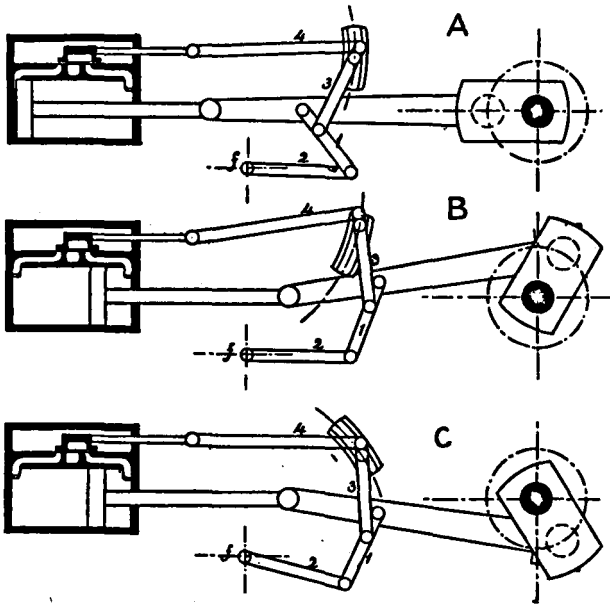


FIG. 36

In explanation of the Joy valve motion

(A, Fig. 36). If, however, the guides are tilted over one way or the other, the slipper block pivot moves also, and this movement combined with the oscillation of link 3 at its upper end gives a longer valve stroke and so a later valve cut-off, according to the degree of guide tilting. Thus, with guides tilted, at B the cylinder is being just cut off to steam at three-quarter stroke running clockwise and at C contra-clockwise.

### **The Double Acting Engine.**

With a medium like steam, relatively cool as compared with the burning gases in an internal combustion engine, power can be applied to both sides of the piston, and at every stroke, since there is no cycle of induction and compression: the steam merely exhausts from one side of the piston while working on the other. This, coupled with the almost perfect controllability of steam, gives a far more even turning effort; indeed, the torque of a single steam cylinder is more even than that of four internal combustion cylinders and the engine can be regulated to turn as evenly as ever required. Nor with its four times more frequent working strokes and more sustained effort during each is there the same need for high speeds as with explosion engines, and so on steam vehicles engine speeds range from only about 240 to 600-700 r.p.m.

### **Compound Engines.**

In some vehicles the principle of expansion is carried still further by compounding. To the lay mind compounding generally means using the steam twice over, first in a small high pressure and then in a large low pressure cylinder. But it is nothing of the sort; it is a double expansion of the steam, first in the high pressure, and then in the larger low at increased volume and correspondingly lower pressure. Speaking broadly, compounding may pay, if the cylinders can be maintained at a temperature to keep down condensation; consequently it is employed on overtypes or for wagons with the cylinders close enough to the boiler to be surrounded by a steam jacket; but on undertypes (with engine below the frame) non-compound engines are the rule.

In the figures illustrative of slide valve working the valves shown were flat or of what is known as the D

type, held tight against their working faces by the pressure in the steam-chest. With superheated steam, however, their faces are liable to get cut and their steam-tightness is thus affected. Mainly for this

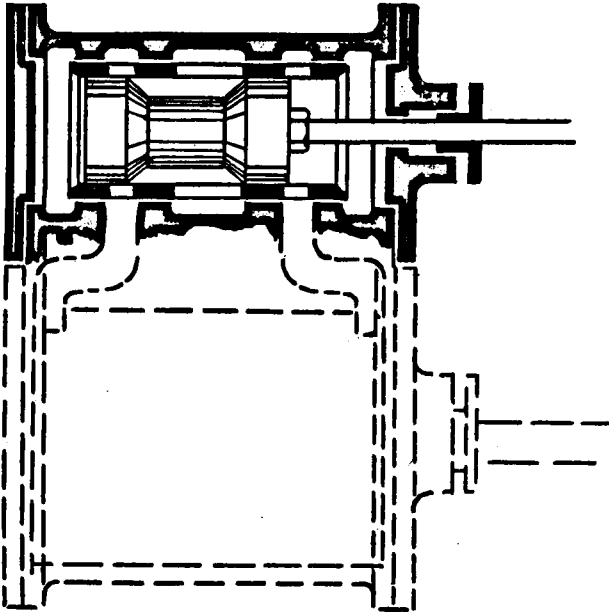


FIG. 37. A PISTON SLIDE-VALVE IN SECTION  
On the lines adopted in the Garrett wagons

reason piston slide valves are in some cases adopted (as in the Garrett and Yorkshire engines). These have the additional merit of working with less friction, not having to be held up against their faces by the enormous pressure of the steam. One of them is shown in section by Fig. 37.

Poppet or mushroom valves also work more satisfactorily with superheated steam, and in some instances

are made partly balanced so that they do not have to be lifted against the pressure of the steam on the full area of their heads.

### **Superheated Steam.**

It has been stated that the pressure of steam varies with its temperature. That applies only to ordinary boiler or saturated steam as it is called. With such steam, pressures and temperatures are inter-dependent; each pressure has its temperature; at 150 lb. per sq. in. it is 366° Fahrenheit, at 200 lb. 388° and at 225 lb. it is between 395° and 396°. But the moment the temperature falls so does the pressure, producing a tendency to condense back to water. This, of course, produces a loss of power. Fortunately, it is possible to impart to saturated steam an additional quantity of heat, raising it to a higher temperature than that normal to its pressure, and, if this additional heat is sufficient, although the steam may fall in temperature, no condensation occurs; the steam only parts with some of its margin of additional heat. Even during expansion in the cylinder this superheat may prevent the steam falling below its temperature of saturation, preventing condensation, and at the same time maintaining power.

In wagons known as overtypes, with engines mounted on the boiler, the cylinders are usually kept warm and free from condensation by being surrounded by a jacket of steam direct from the boiler; but on most modern vehicles steam is superheated, generally by passing it through pipe coils in the hot smoke box. Especially is superheating desirable when the engine is at a distance from the boiler, necessitating some length of steam piping, for, even though the steam pipe may be lagged with non-conducting covering, it is difficult otherwise to prevent condensation therein.

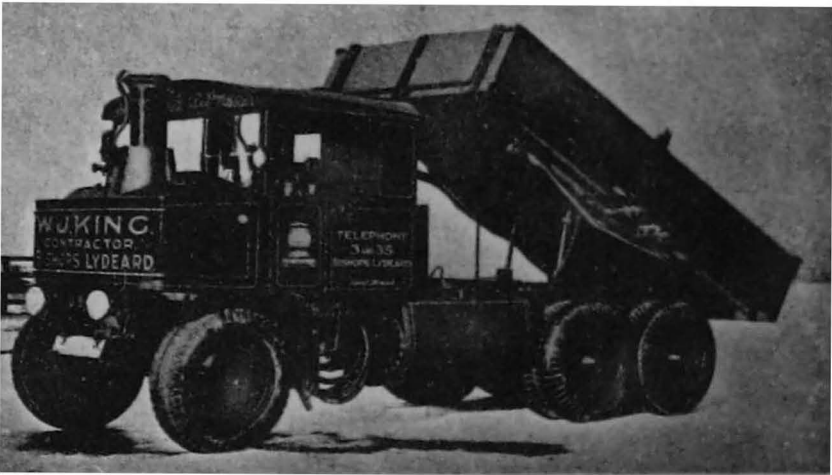


**Under- and Over-types.**

In the past the steam wagon owner has had the choice between the over- and under-type, the former with a locomotive style boiler at the front carrying the engine on top, the undertype with engine under the frame. Under modern conditions the overtyping is giving place to its rival; but at one time it was, if anything, the predominant type and considerable numbers are still in use. With a steam-jacketed engine on top of boiler and the shortest of steam connections condensation trouble is reduced, while as a whole the arrangement is economical, durable, and light on the repair bill. Also the engine is very accessible to the eye and hand of the driver, and it can work with waters that might cause trouble in other types, so is less inclined to priming (getting water in the cylinders, which may conceivably cause damage) when pulling hard up hill. Downhill, however, it is liable to be more troublesome in priming. Its main disadvantages, however, lie in the considerable chassis length occupied by engine and boiler, the consequent unsatisfactory proportions of the laden weight thrown on front and back axles respectively. It is chiefly due to these factors, and, perhaps, to undertype construction lending itself the better to the pneumatic tyres and higher speeds of to-day, that the overtyping is less in evidence than of old. The undertype arrangement leaves more space available for load, or is shorter for a given loading length, and so lighter. It gives better laden axle weight distribution, lends itself to one-man working, and affords the driver more comfortable accommodation and a better view of the road, while the water level in the boiler is less affected by tilt on hills and the boiler itself, being better suited to a wider range of fuels, can use coke and cheap fuel more effectively.

There is one make of wagon, however—the Yorkshire

—which, strictly speaking, comes within neither of these two classes, for its compound engine is vertically mounted above the frame near the boiler. The boiler itself also is distinctive, being of the double-ended locomotive type, placed across the chassis frame, with very short barrels and smoke boxes projecting from either side of a central firebox. This arrangement



VERY DISTINCTIVE IS THE DESIGN OF THE YORKSHIRE, WITH ITS DOUBLE-ENDED "LOCO." TYPE BOILER, EXEMPLIFIED BY THIS POWER-TIPPED WAGON

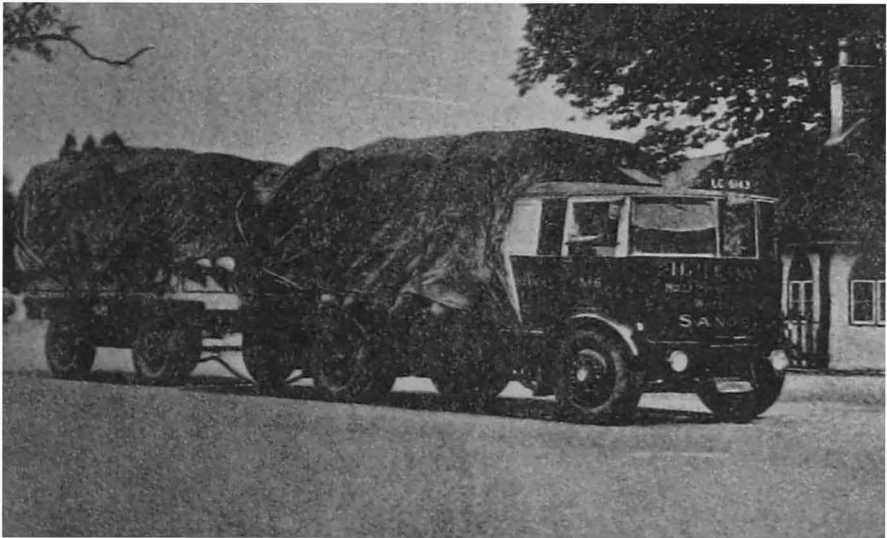
(By courtesy of Yorkshire Patent Steam Wagon Co., Ltd.)

combines some of the advantages of over- and under-types, and offers a construction that for many years has given excellent service.

### **Boilers and Their Feed.**

As to boilers—in road transport all are good and for such small units give excellent evaporative efficiencies. A test made by a representative of *Motor Transport* with a 6 ton Foden Speed Wagon at a boiler pressure of 275 lb. per sq. in. showed an evaporation of 8.2 lb. of steam to 1 lb. of coal. Even if the very best Welsh coal

were used, such a result would be highly creditable to much larger boilers. Particularly if the water is hard, arrangements for easy washing out and scaling are of importance, but apart from this there is really little to choose between the different types or makes, and choice is dictated rather by the type and make of the vehicle as a whole.



**A FODEN "SPEED SIX" 6 TON STEAM WAGON, HAULING A  
4-5 TON TRAILER ON PNEUMATICS**

*(By courtesy of Fodens, Ltd.)*

Feed water appliances, however, are more a matter of choice, which lies between the pump, the injector, or a combination of the two. In any case a boiler should have two means of feed, the one as a stand-by. Of the two alternatives the pump is more exactly regulated and can be set to deliver a steady continuous feed just sufficient to requirements—a particularly valuable feature when the driver's attention is much taken up, as in heavy traffic. Usually the waste heat from the exhaust steam is utilized to warm the feed water, so

saving heat and fuel, and a pump can work with hotter as well as dirtier water than the injector; and this last, too, is a consideration in road work, which often entails picking up such water as one can get. Finally, a pump is more certain in its action and does not reduce boiler pressure to the same extent as an injector; indeed, downhill it can be worked without any steam at all.

Yet in some circumstances disabilities may have their uses. In spite of the advantages of the pump in heavy traffic, the bigger steam consumption of the injector may also be of advantage under some conditions, for, if the boiler is just on the point of blowing-off, the injector is the more effective in rapidly reducing steam pressure; and no driver wants to court trouble with safety valves blowing in a crowded thoroughfare. But the chief claims for the injector are its ability to work with the vehicle standing, and the absence of moving parts and of glands requiring periodical re-packing, the only wearing parts of an injector being the cones (due to the cutting action of the steam at tremendously high velocity) and the check valves.

All things considered, probably the best arrangement lies in a combination of pump with a self-acting, re-starting injector, and, of course, the water lifter which is always provided.

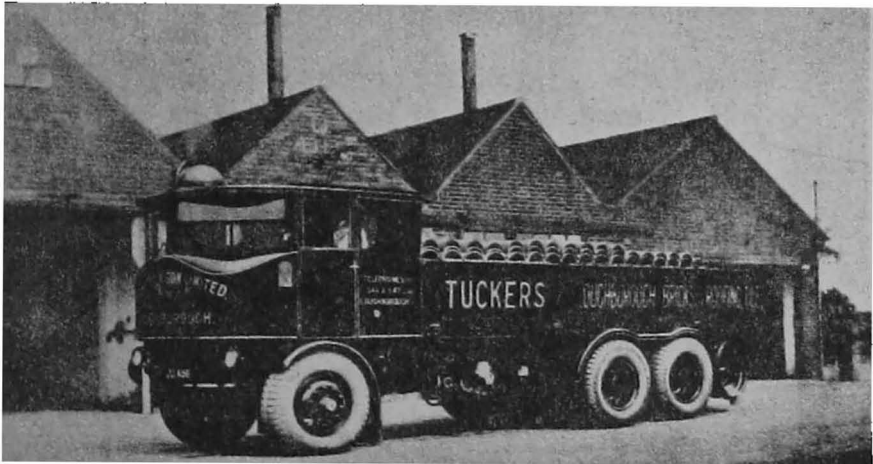
At first sight the injector appears to be something of a paradox in its capacity to use boiler steam to force water into the boiler against its own pressure. Yet the explanation is simple, for the steam, travelling through the cones of the injector, at about the speed of a bullet, drags along the water in its train and imparts to it such velocity that by the time the inlet to the boiler is reached the water has sufficient inertia or momentum to force itself past the check valve into the boiler.

Incidentally, an injector is used on some Sentinel

wagons for tipping the body, and the feed pump, too, when it is not driven off the transmission and can be used with the vehicle standing, is sometimes utilized to supply pressure to the hydraulic tipping ram.

### Transmissions.

Owing to its smooth working and easy control, in general, no clutch is necessary in the steam vehicle. On



THE SENTINEL SIX-WHEELED STEAMER HERE SHOWN IS CARRYING A BIG LOAD OF ROOFING TILES

It can carry easily up to 12 tons of useful load

(By courtesy of Sentinel Waggon Works, Ltd.)

the old overtypes the power is transmitted from the engine to a two or three speed shaft, and thence by a single chain to a live back axle. On undertypes back wheels were generally rotated separately on a dead, or unmoving, axle by two side chains from a live countershaft itself driven from the engine through a two or three speed transmission. Of late, however, there has been a marked trend towards a propeller shaft and live axle drive on petrol chassis lines, and in one six-wheeler—the Yorkshire—two separate

propeller shafts are employed to drive the two back axles.

**Summary.**

To sum up, the merits and demerits of steam for road transport may be set forth as follows—

*Disadvantages*

1. Time and labour of raising steam every day.
2. Need for firing and feed water control on the road.
3. Need for washing out the boiler weekly.
4. Greater tare weight, or non-paying load.
5. Risk of fire from sparks or ashes.
6. Difficulty of men in keeping clean while working.

*Advantages*

1. Smooth and quiet working.
2. Flexibility of power and ease of exact control.
3. Large reserve of power, and so fewer gear changes.
4. Good acceleration.
5. Use of cheap home-produced fuel.

## CHAPTER X

### ELECTRIC VEHICLES

FOR the purposes of this chapter an acquaintance with certain electrical definitions is necessary, and to enable the ideas underlying them to be grasped it is customary to imagine electricity flowing in its circuit and to liken its flow to that of water in a pipe.

#### Some Necessary Definitions.

On these lines—

A *coulomb*, the unit of quantity, is comparable with gallons of water; but it is rather an academic term used more in the laboratory than by practical engineers. Its absolute, scientific definition would convey nothing to the reader and it is introduced here only to explain.

The *ampere*, which is the unit of current strength and may be likened to flow in gallons per minute or per second passing a given point in a pipe line. It represents the rate of flow that allows 1 coulomb to pass in 1 second, so a coulomb is really 1 ampere-second, which is the quantity unit usually employed by engineers, or for larger quantities the ampere-hour which, of course, is 3,600 coulombs.

The *volt* is the unit of electromotive force or pressure (E.M.F. abbreviated) and corresponds with the pressure producing a flow of water in a pipe.

The *ohm* is the unit of resistance to that flow, and

The *watt* is the unit of work done by a current of 1 ampere at a pressure of 1 volt and represents  $\frac{1}{746}$  h.p.

#### Magnetism.

An electric vehicle is moved by magnets. That is what it really amounts to, so we must first get to know

a little more about magnetism. Of course, everyone is familiar with the ordinary natural or permanent magnet as it is called, usually of the well known horse-shoe shape, though it may be a straight or bar magnet.

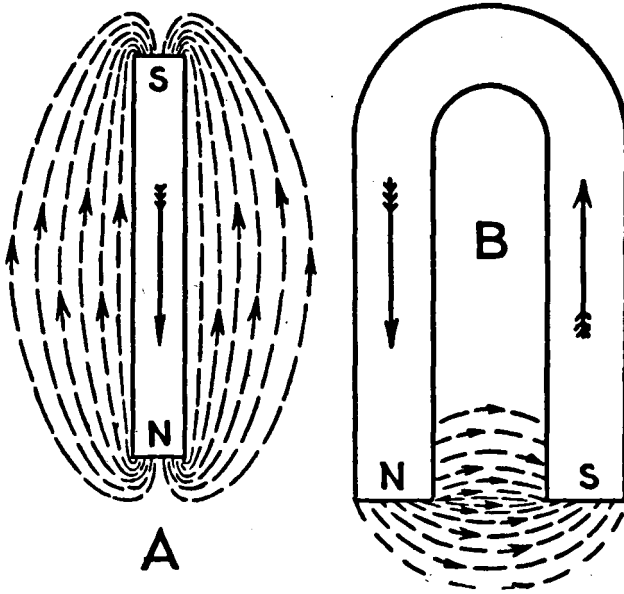


FIG. 38. LINES OF FORCE BETWEEN THE POLES OF A BAR AND HORSESHOE MAGNET

These lines also pass along the magnet itself, thus constituting a complete magnetic circuit flowing in the direction indicated by the arrows

Everyone knows too that, like a compass needle (which is only a bar magnet), the one end of a magnet constitutes a north the other end a south pole, and that between these poles a magnetic force is exerted. This force follows definite lines, indicated by dots in Fig. 38, A and B, and these are known as "magnetic lines of force," or the "magnetic flux," the space where they act between the poles being called the "magnetic field."



In these diagrams dealing with magnetism north and south polarities are marked *N* and *S* respectively, and it should be observed that the lines of force are not confined to the space between the poles, but pass along the magnet itself, thus forming a magnetic circuit.

Now between magnetism and electricity there is close inter-relation. If a loop of iron wire is passed between the poles of a horseshoe magnet without touching them, it will cut the lines of magnetic force

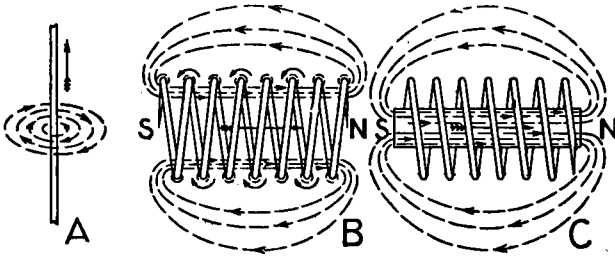


FIG. 39

The directions taken by the magnetic lines of force in a straight wire, coiled wire, and a coil with a soft iron bar passed through its centre

and an electric current will be generated in the wire loop, the mechanical work of cutting the lines of force having been converted into electrical energy. Conversely, if a current of electricity passes in the wire circuit, it sets up a magnetic field around itself, the lines of force surrounding the wire all along its length like ripples from a stone thrown into water, as in the dotted lines of *A*, Fig. 39 wherein the centre of the circle represents the wire.

Further, if the wire is made into a coil and a current then passed through it, the coil becomes a magnet (see *B*, Fig. 39), and, if a bar of iron is placed within the coil (*C*, Fig. 39), the magnetic effect is much increased, as the iron conducts the magnetism far better than does the

air. Similarly, if wire is coiled round the poles of a horseshoe magnet on the lines seen in Fig. 40 and a current of electricity passed through it, an electro-magnet again results, giving a far stronger field than the ordinary permanent magnet—how strong may be inferred from the fact that for electric cranes a magnet can be used instead of a hook for lifting loads of tons' weight.

The strength of an electro-magnet depends on the current and the number of turns of wire around its poles, and as a means of measuring it the "ampere-turn" is used, this indicating the degree of magnetism induced by a current of 1 ampere passing through one single coil or turn of wire wound round the core. Like other compound units its factors may be distributed in any proportions; it matters not in theory whether 12 turns are carrying 1 amp., 3 turns carrying 4 amps., or 1 turn carrying 12 amps.; the result in all cases is 12 ampere-turns.

#### **How the Motor Works.**

With this knowledge then let us suppose that a loop of wire *a* is wound longitudinally round a circular bar of iron so placed that it can be rotated between the poles of a magnet (which will represent the field magnet of the motor) without touching, and that the ends of the loop are connected with metal segments each nearly semi-circular but separated, as in Fig. 40. These segments, *b1* and *b2*, which represent the commutator of the motor, will rotate with the bar and wire loop, which stand for the armature. Each commutator segment is connected by a conducting brush *c1* and *c2* with one end of an electric circuit and a battery, and, when the current is switched on from the battery it flows round the field magnet poles and through commutator and wire loop, converting the armature also

into an electro-magnet the polarity of which is determined by the direction of the current.

Let us imagine for the moment that the poles are as shown in the figure. Since like poles repel and unlike attract each other, the south polarized part of the armature at *s* will be drawn to the north pole (N) of the field magnet, *n* to the south pole (S). Similarly *s* will be repelled from the south and *n* from the north magnet

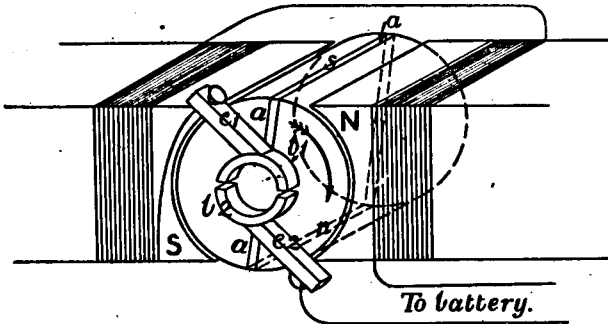


FIG. 40

Diagram to explain how the current and magnetization in the armature is reversed by the commutator to keep the armature revolving

pole, and the armature will thus be rotated in the direction of the curved arrow. Just as the wire loop reaches the position where magnetism can take it no farther and would begin to resist further rotation, each commutator segment leaves contact with the brush that was bearing on it and establishes contact with the other brush: the commutator segments change over their brushes in fact, and the direction of the current is thus reversed through the armature and so is the armature polarity. The part marked *n* up against the S magnet pole now becomes south polarized and is repelled by the field magnet pole to which it is close, and it is attracted towards the north pole of the field

magnet. Correspondingly  $s$  becomes north polarized and is repelled from  $N$  and drawn round towards  $S$ , until another half revolution is made, when current and polarity are again reversed to bring about another half revolution, and so on. With changes like this occurring hundreds of times a minute the armature is rapidly rotated; in other words, the motor is driven.

It must, of course, be realized that the armature is surrounded with many coils like the one indicated diagrammatically at  $a$  in Fig. 40, and instead of being composed of merely two segments the commutator is made up of many, which incidentally are of copper, and each insulated. Thus the effects just explained are overlapping and continuous. Naturally this gives the electric motor a very even turning effort in comparison with the explosion engine, or even steam. Moreover, as the field magnet poles are not necessarily limited to two, as in the diagram—there may be four or yet more—that evenness of torque may be still further enhanced.

### Field Magnet Windings.

To obtain the necessary magnetic force, of course, the field magnets are electrically energized or excited by current passing through coils wound round them, and by reversing this current *or* that in the armature—but not both—the motor can be reversed.

There are various ways of exciting the field magnets, the simplest being to include its windings in the main circuit supplying the motor. This gives what is known as a series wound machine that is very suitable for road vehicles, as it can exert a powerful turning effort at low speeds—just when turning effort is most needed—and it is almost universal in road transport. It is shown by diagram  $A$  in Fig. 41.

For constant speeds under variable load, however, it

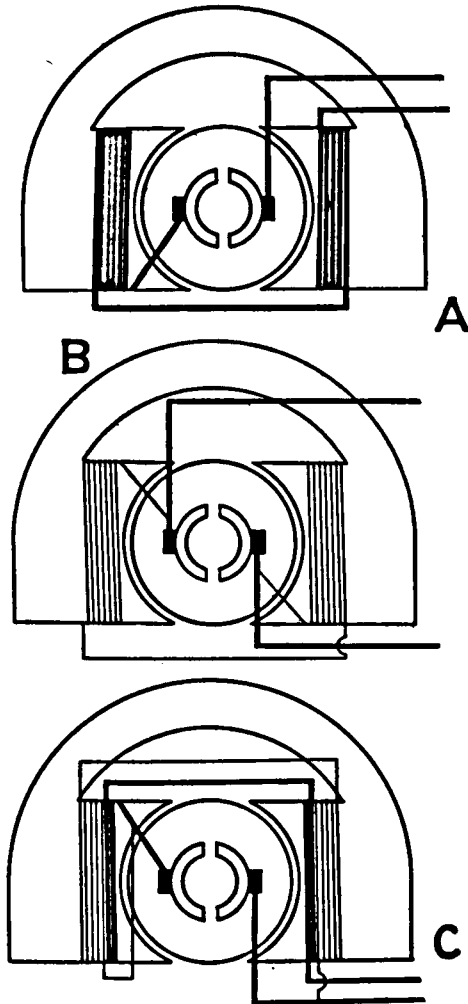


FIG. 41

The three broad types of field magnet winding diagrammatically explained

is not suited; and by "load" is meant the resistance that the motor has to overcome rather than what the vehicle has to carry. To meet these conditions a shunt winding is more suitable. On the shunt wound motor (*B*, Fig. 41) the field magnet windings are on a loop circuit or a "shunt" of the main circuit. In the diagrams the main circuit is shown in thicker, the shunt in thinner, lines.

Lastly, there is the compound wound motor in which a combination of the two first methods is adopted and to some extent the advantages of each are secured, though as a compromise. It is seen at *C*, Fig. 41.

Such is a very brief outline of the salient principles of the electric motor. We need not go deeper into the subject.

One of the chief claims of the electric vehicle is that it can be handled by relatively unskilled labour, and that the motor does not require the same detailed knowledge and work in maintenance as for petrol and steam; which is perhaps as well, for not only are the principles of the electric motor not so generally understood as those of engines, but they are more intricate; in fact, electric motors are not for the unskilled to repair with impunity. Besides, they do not call for running repairs and adjustments to the same extent as engines. Apart from lubrication maintenance may practically be restricted to the batteries and chassis, with an eye kept on electrical connections, for which a simplified diagram should suffice the driver.

#### **The Accumulator—What it is.**

The subject of motor control being deferred till later, the means of obtaining the electric supply for driving calls for attention. As all the intricacies of a power station supply are beyond the scope of such a volume as this, we may disregard the trolley bus (though the

principles governing the motor are the same whatever the source of supply) and confine ourselves to the purely independent road vehicle, which in all cases is driven by storage batteries or accumulators, sometimes alternatively termed secondary batteries.

Owing to its name there is a popular idea that the storage battery is a sort of reservoir into which electricity can, so to speak, be pumped and kept for use, as required. Such an idea is misleading and should be relinquished. In so far as it can be regarded at all as a means of storage the accumulator under the influence of electric current only stores up certain chemical actions which can be given out as reactions that produce electricity.

At present two distinct kinds of storage cells are employed for electric road transport, the one designated the lead-acid, the other the nickel-iron-alkaline, which is associated with the name of Edison.

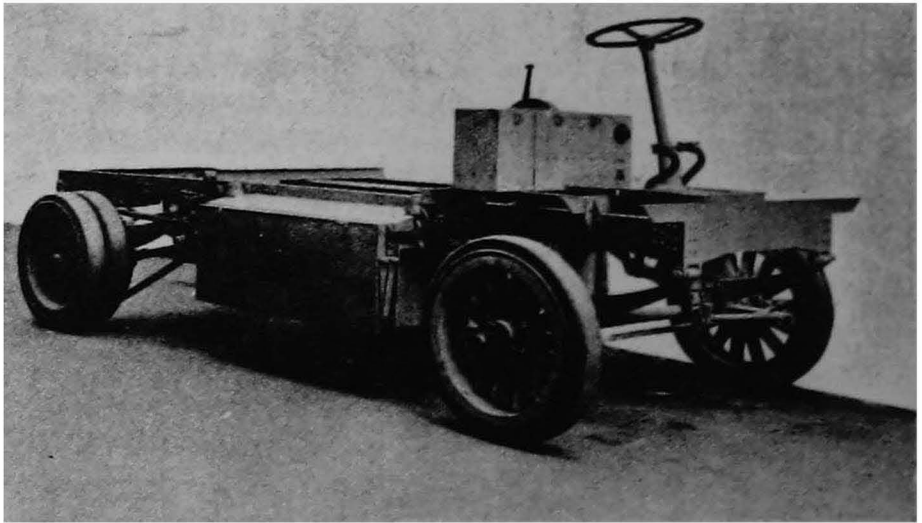
### **The Lead-acid Cell.**

Of the two the lead-acid accumulator has the longer experience behind it and is the more general. Its container or casing is made of a non-conducting material like ebonite or celluloid and holds a number of lead plates alloyed with antimony,—this to stiffen them and prevent any slight action from the solution of sulphuric acid in which the plates are immersed.

The plates are of two kinds—positive and negative—arranged alternately with negatives at each end; thus there is one more negative plate than positive. Both sorts of plate are usually in the form of grids, and in the interstices of the positive a paste of red lead is introduced as the "active material," the negative being pasted with lead monoxide, which on charging becomes spongy metallic lead. In the Ironclad-Exide cell, however, each negative plate is made up of a row of

pencils of active material with an antimonial lead core, each encased in an ebonite tube slotted to allow of access of the electrolyte.

Between each positive and negative plate is a separator, not only to keep the plates insulated, but also equidistant from each other, a point of some importance in working. All the positive plates of a cell are grouped



THE CHASSIS OF A 5 TON G.V. ELECTRIC  
(By courtesy of General Vehicle Co., Ltd.)

by being connected with a common bar; likewise all the negative.

The solution in which the plates are immersed is termed the electrolyte and constitutes the path whereby current is conducted from one plate to another. It is a mixture of pure sulphuric acid and distilled water in proportions to give a specific gravity of 1.28, or about  $4\frac{1}{2}$  parts of water to 1 of acid.

From the outset, when the electrolyte is put into the cell, it begins to combine with the lead of the plates to form lead sulphate (chemical symbol  $PbSO_4$ ) leaving water ( $H_2O$ ). If then an electric current is passed



through the cell a more extensive chemical action occurs. The sulphur and oxygen in the lead sulphate is separated from the plates and combines with the water in the electrolyte to form sulphuric acid ( $H_2SO_4$ ), thereby strengthening the solution and changing the active material of the positive plates from lead sulphate to lead peroxide ( $PbO_2$ ) and in the negative plates from lead sulphate to metallic lead. Chemically the state of affairs may then be stated thus—



On discharge the current passes through the cell in a reverse direction, and sulphur and oxygen from the electrolyte acid is again separated and restored to the plates forming lead sulphate; all of which may be chemically stated as—



The electromotive force produced after charging will at first be 2.20 volts, falling rapidly to 2.05, and, when discharge is started, it will drop to 2 volts, or slightly less, the reduction of voltage thereafter being gradual, until, when it reaches 1.83 volts, it is in a discharged condition. In any case the cell should not be discharged below 1.80 volts. The capacity of the cell, which is measured in ampere-hours, depends on the number of plates it contains and the area they expose to the action of the electrolyte.

### The Nickel-Iron Accumulator.

In the nickel-iron accumulator as a general rule the active material of the positive plates is nickel hydroxide with flaked metallic nickel for conductivity; for the negative, oxide of iron with just a trace of mercury (also to improve conductivity) is used, and the electrolyte is a

21 per cent solution of caustic potash in distilled water. There is some variation, however, in the mechanical details and even in the materials; in the Alklum accumulator, for instance, graphite replaces flaked nickel in the positive plate while for the negative powdered iron and chromium is used.

The chemical action in nickel-iron cells is very complex and really is not fully known, but roughly what happens may be expressed chemically as—

	+ or negative plate	Electrolyte	- or negative plate
Discharged	NiO	2KOH	FeO
Charged	NiO <sub>2</sub>	2KOH	Fe

It will be noticed that no change takes place in the electrolyte; it is the same on charge or discharge and acts only as a conductor between the plates.

Voltage is relatively low with this type of cell, being only 1·2, and, when discharged, ·90 to ·95 volts. Moreover, internal resistance is greater than in the lead-acid accumulator and its ampere-hour efficiency is considerably lower, ranging between 75 and 80 per cent on normal charge and discharge, as compared with 85–90 per cent for lead-acid cells. In service, however, the charging and discharging warms the cells enough to keep the internal resistance reasonably low. High cost is another drawback to the nickel-iron accumulator. Nevertheless, it is in road transport that its possibilities mainly lie, chiefly owing to its capacity to withstand rough treatment; the cells can be exposed to heat or charged and discharged at rates that would ruin a lead accumulator in no time; and here the high internal resistance is a positive advantage in that, even if the cell is short-circuited, damage is prevented. The absence of corrosive liquid and fumes is another real advantage in favour of the nickel-iron accumulator, but its greater lightness is offset by the fact that its lower voltage entails larger batteries which, broadly

speaking, total fully as heavy as the lead-acid. As a general rule for road vehicles 60 nickel-iron, or 40 lead-acid cells constitute the battery.

### **Efficiency and Internal Resistance.**

The allusions to internal resistance and ampere-hour efficiency in the preceding paragraph may here be explained.

With regard to the first—the electrolyte offers a certain resistance to the passage of the current, as also do the plates to a slight extent (for everything offers resistance more or less) and the total is the internal resistance of the cell. In connection with the efficiency of a battery, it should be understood that more current has to be put into it on charge than is got out of it on discharge, and the proportion of that got out to that put in, expressed as a percentage, is the ampere-hour efficiency.

### **Volts, Amperes, and Watts.**

As already explained, if the two terminals of a charged accumulator are connected, the circuit is completed and the current flows along the connection from the positive to the negative terminal and through the electrolyte from negative to positive plates; and it flows at a certain pressure depending on the type of cell and the degree to which it is charged. Also, in the definitions at the beginning of this chapter it was stated that the watt represented the work done by a current of 1 ampere at a pressure of 1 volt. The work then can be measured by multiplying amperes by volts. Supposing, for example, that a battery is giving a current of 25 amperes at 60 volts, the work would be  $25 \times 60 = 1,500$  watts, and since it takes 746 watts to equal a horse power, that would be equivalent to just over 2 horse power.

**Battery Connections—In Series and Parallel.**

The relative proportions of the voltage and amperage from a battery depend on the manner in which the cells are connected. If we take four lead-acid cells and connect them up with the negative of one cell coupled with the positive of the next, as at *A*, Fig. 42, the cells

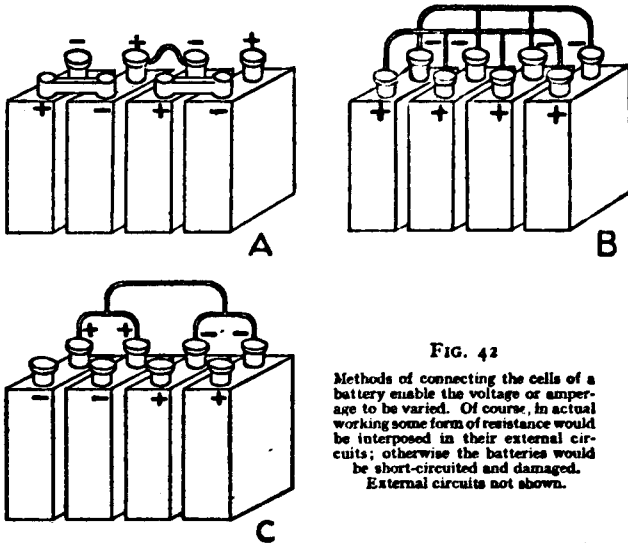


FIG. 42

Methods of connecting the cells of a battery enable the voltage or amperage to be varied. Of course, in actual working some form of resistance would be interposed in their external circuits; otherwise the batteries would be short-circuited and damaged. External circuits not shown.

are said to be connected "in series." Assuming each cell gives 2 volts, the pressure of one behind the other, like men hauling on a rope, will be the total voltage of all the cells—namely  $2 \times 4 = 8$  volts; but the amperage will be only the same as for a single cell. Suppose we say 25 amps. With cells connected in parallel, as at *B* in Fig. 42, the amperage will be passing through each cell; there will then be four paths for the current which accordingly will be four times that of a single cell or  $25 \times 4 = 100$  amperes; but to balance that the

voltage will only be the same as for a single cell—only 2 volts. Finally, there is the series-parallel connection, which is a combination of the other two. With four cells we can couple each two in parallel, and then connect these two pairs in series (see *C*, Fig. 42). Obviously the result will be a compromise between those of the other two methods. The two pairs of cells in series would have a voltage of  $2 \times 2 = 4$  and the parallel connection as shown gives an amperage of  $25 \times 2 = 50$ , the voltage remaining at 4.

Motors for lead-acid and nickel-iron batteries are commonly wound for 85 and 60 volts respectively, on which bases a lead-acid battery of 40 cells, or 50 nickel-iron cells in series would yield the full necessary voltages.

### Motor Control.

We can now deal with the question of motor control, but first one more explanation.

While the armature is being driven round and its coils are cutting the lines of force between the poles of the field magnets a certain amount of electromotive force is thereby being generated in the armature, and this in a reverse direction to that from the battery. This is what is termed "back E.M.F.," and, as it increases with the speed and strength of the magnetic field, the higher the speed the greater its effect in decreasing the useful E.M.F. from the battery for driving the motor.

With the motor stationary, if full current were switched on before any back E.M.F. could be generated, the flow through the windings would start the motor so violently as probably to damage it, and would burn out the insulation. Therefore a starting resistance is introduced into the circuit to reduce the voltage and, as the magnetic field is built up and back E.M.F.

takes effect, the resistance can be cut out section by section giving a graduated series of "steps up" so to speak.

Of course, an obvious method of control is to group the cells so as to produce the steps in voltage. For instance, a battery may be divided into two groups, each with cells connected in series, and the groups may then be coupled up in parallel. This arrangement, termed the "double voltage" system, is efficient in that less power is lost in heating up resistances; but the parallel connection is apt to produce inequalities in discharge, which may damage lead accumulators, though the nickel-iron cell can stand them. Moreover, there is always the possibility of one half of the battery being reduced to a lower state of charge than the other. There are also other technical disadvantages; but the arrangement which is suitable enough to fast, or slow, running (though not to intermediate speed variations) is sometimes used in conjunction with a system whereby the windings of the field magnets are in two sections that can be connected either in series or parallel to give two ranges of speed without loss of efficiency.

The more general arrangement, however, is to control through rheostats, or resistances, which, at different positions of the control lever can be included in various combinations from all to none.

As a rule a drum type of controller is used preferably with a single lever and a safety gate to prevent the reverse being inadvertently switched in when the motor is running on forward speeds. Also, as sparking is liable to occur in switching from one speed to another, tending to burn away the contacts, a system known as the "continuous torque" is adopted, whereby the drive of the motor is uninterrupted when changing from one speed to another and thus smooth acceleration is also achieved.

**About Transmissions.**

Methods of driving road wheels vary widely. A single motor may drive a live back axle through a propeller shaft on petrol chassis lines, or the motor may drive a differential countershaft which transmits by chain to each back wheel on a dead axle. In one system both armature and field rotate, each driving one of the road wheels.

Sometimes each wheel is driven by a separate motor incorporated with the axle, thus dispensing with a differential, and with this arrangement the motors may be connected up so that the two can be either in series or parallel at will. At starting they are in series and, each motor then receiving only half the available voltage, they can only run up to barely half speed; but, when connected in parallel, each gets full voltage and can run at full normal speed. This system can be applied to either front or back wheels and, though it complicates matters to drive the steered wheels, there is something to be said for front wheel drive in that it lessens tendency to side slip and makes possible a very low loading level. In some cases each of the four road wheels is driven by a separate motor, and here again the series-parallel system can be applied as between front and rear axle.

As road vehicle electric motors range in speed from about 800 to 1,700 r.p.m. some form of reducing gear is necessary, the more so as the road speed of the electric is nothing like as high as for petrol vehicles; though of course no change speed gears are required. With that exception, for a single motor transmission generally follows petrol chassis lines. The propeller shaft is also sometimes employed when the back wheels are driven by separate motors, which are accordingly mounted on the outsides of the chassis frame and drive their wheels through a bevel or worm

reduction gear. In most cases, however, when wheels are separately driven, the motor is mounted on the axle and drives through spur gearing—straight tooth, or skew—generally on to an internally toothed drum on the road wheel, though in at least one case the motor is mounted practically within the wheel itself.

#### **For and Against the Electric.**

From what has gone before it will be realized that the need for charging the batteries and the consequent dependence on charging facilities are the chief drawbacks to the electric. As a rule a vehicle will run from 30 to 40 miles on a charge. Much longer distances of course have been covered on a single charge; but under practical working conditions the weight of the batteries restricts the range as stated. When the size of a fleet, however, justifies highly organized arrangements, and a sufficient number of spare batteries, charging may be greatly facilitated and expedited. The battery case, for example, may be easily detachable from underneath the chassis frame, and removed on a truck run underneath the chassis, when a ready charged battery can be run underneath on a similar truck, and the freshly charged battery be quickly secured in position.

Nevertheless batteries are heavy, and so are the vehicles as a whole ready for the road. Also, compared with other power sources, they are slow and their first cost is high.

Nevertheless, the last objection is in large measure counterbalanced by the lower depreciation due to their smooth working, and this factor also keeps down the repair bill. Against that, however, the cost of battery maintenance must be set off. Still, on the whole maintenance and running costs are low, a saving which is accentuated by the fact that, thanks to its perfect



controllability and simple attention needs, the electric can be handled by comparatively unskilled labour. To this no doubt its short over-all length and general-handiness in manoeuvring contribute, which are accompanied by excellent weight distribution. Further, reliability constitutes a major claim, while its quick and smooth acceleration, its silence, the absence of exhaust gases, and the fact that no power is consumed while standing, all help to render the electric vehicle pre-eminently suitable for delivery work in crowded towns where electric current is cheap.

As the "grid"-system of electricity supply is developed throughout the country, doubtless facilities for re-charging batteries in the less urban districts will become more common, and, given proper organization, this should tend to increase the number of electrics on the road.

**PART II**  
**THE BUSINESS AND**  
**COMMERCIAL ASPECT**

## CHAPTER XI

### RECORDING THE WORK

THE object of recording the working results is to obtain an exact indication of what each car and, if possible, each man is doing week by week, as well as to know the situation at the end of the financial year; and this in such a way as to involve the minimum of work and attendant expense: multiplicity of recording forms can be, and often is, overdone: they should be as few and simple as possible.

#### **Mileage the Basis.**

Costs would be of little use, if the work that they stood for was not accurately recorded in the first place and, unless a vehicle is working invariably on the same round of a known distance, a mileage recorder is very desirable.

Incidentally, if it is combined with a speedometer there should be the less excuse for any loss of time and the expense of speed prosecutions. When vans are absent at work for days on end, a recording instrument charting each day's work may even be advisable; but, whatever course is adopted, precautions should be taken to minimize any risk of tampering with the instruments. For this reason, although a mileometer drive from the back wheels is mechanically preferable, it may be as well to drive the instrument off the front wheels, for with a back wheel drive it is an easy matter to jack up the back axle and run it so as to show a false additional mileage: the practice, though not common, is not unknown to a certain type of driver. Front wheel drive, however, is less accurate.

**The Driver's Daily Return.**

In any case, however, the mileage is the whole foundation of running cost, if one is to know what is being obtained in return for one's expenditure, and running cost records must be taken as directly as possible from the vehicle. The driver's return is therefore the basis on which the running costs and wages are made up, and this should be made out and sent in daily.

The form here suggested is of course modifiable to varying circumstances. In many cases no entries for assistants or trailers will be needed: power would be entered up in gallons, in tons, hundredweights, and quarters, or in units according as it applied to internal combustion, steam, or electric vehicles, and under the heading "Issued from Stores," prices could be inserted by the storekeeper or they could be subsequently run out and charged up in the weekly return, of which more anon.

**The Weekly Vehicle Record.**

Unless tyres are purchased on a mileage contract their cost keeping presents a difficulty, since their per-mile charge cannot be ascertained until they have run their full career. In such cases a certain sum per mile may be based on the maker's guarantee, if any, and carried to a Tyre Account, just as in the case of repairs, and any subsequent discrepancy with actual results can be adjusted when the results are known. For the small transport user probably the best course may be to enter up in pencil the tyre, running, and total costs as provisional figures, which will serve as a guide, and, when the tyres are worn out, these figures can be amended in ink. When only two or three vans are employed this will obviate the need for separate accounts, which in any case had best be as few as possible. In the case of tyres, however, a record of

### DRIVER'S DAILY STATEMENT

Vehicle No.....7..... Date.....23rd September, 1932..... Driver.....Ivor Kerr.....  
 Make.....Albion..... Load Capacity.....40 cwt..... Assistant.....Owen Money.....

From	To	Depart		Arrive		Load		Mileometer Reading			Remarks
		Hr.	Min.	Hr.	Min.	Ton	Cwt.	Start	Finish	Mileage	
Cheltenham	Tewkesbury	9	35	10	5	1	10	1006.7	1014.8	8.1	
Gloucester	Cheltenham	11	15	12	0	1	5	1022.3	1030.1	7.8	

#### ISSUED FROM STORES

Power			Lubrication						Stores												
			Oil			Grease															
Quantity		Value	Quantity		Value	Quantity		Value	Details	Quantity	Value										
Gal.	Qt.	Pt.	£	s.	d.	Gal.	Qt.	Pt.	£	s.	d.	Lb.	£	s.	d.	Value Spring	1	£	s.	d.	
5	0	0		6	3	1	1	1			7½										

#### PURCHASED ON JOURNEY

Expenses									

Time booked On Duty.....9.30 a.m.....  
 Time booked Off Duty.....1.15 p.m.....  
 Total time On Duty.....3 hr. 45 min.....  
 Overtime.....

Driver's Signature.....Ivor Kerr.....  
 Foreman's Signature.....Thomas Barr.....

their mileage must be kept ; but this can be done in the weekly returns (facing this page) by means of footnotes stating that a new set, or a near side front tyre, for instance (the tyre in question should always be clearly identified), was fitted on such or such date, as asterisked in the "Tyres" column. Then from these notes the mileage can be entered up in a record giving the mileage and history of each tyre—if and when it was changed from off-front to near-side back wheel and so forth. A tyre mileage record should certainly be kept, whether there is any mileage contract with the makers or not. Abbreviations, such as n.f. for near side front wheel, can be used with advantage.

Wages can be posted up each day, and standing costs like insurance, licences, depreciation and interest can be allocated at so much per day or week, as can the other overhead charges, which may be kept in an Overheads Account under headings showing expenditure on both labour and material in certain items, such as garage expenses, or management.

With these figures at our command the weekly returns can then be made up ; but here a slight difficulty is encountered in fuel and oil consumptions. At the end of each day, or week, a certain amount of petrol will be left in the tank and oil in the casings, and it would not pay to measure this off each time. Obviously then daily consumption figures over a few days would be worth nothing and weekly consumptions only approximations, the amounts left over at the beginning off-setting those left in at the end of each week. But the longer the period over which the consumption figures are spread the less the influence of any difference between these surpluses, until by the end of a month it may be slight, and negligible at the end of a quarter or half year. Accordingly, in the weekly return form here suggested additional columns have been introduced



for spreading the consumption figures over the whole period to which the entries apply and so showing a more accurate average. Their use is explained by the figures, and it need only be remarked that the "consumptions to date" should be the total consumptions divided into the total mileage, not merely an average of the weekly consumptions.

To save clerkage a weekly entry will suffice for the standing charges. At the end of the month a space may be left for the entry of the month totals, preferably in red ink; and here again consumptions should be calculated by dividing the total of the amounts issued into the month's mileage, not by averaging weekly consumptions. At the end of the financial year or half year the monthly figures can then be totalled to present the totals for the period. Under the same headings the totals for all the vehicles added together will give a summary of results from the entire fleet, cars of similar capacity being grouped together, for the average costs of a fleet of mixed sizes gives little useful information.

If each driver has his own vehicle, these returns will enable the management to follow the working of the men as well as that of the cars. There is everything in favour of the one-man-one-car system, unless the vehicles can be worked double shift, in which case the standing costs can be distributed over the two shifts and twice the mileage with highly profitable results. Such conditions, however, are seldom possible.

These returns are really the pulse by which the management can "feel" the working. From the weekly figures any undue rise in consumption can soon be detected, while the tyre, repair, and relief service accounts will periodically give indications of how a vehicle is being used.

If a clerk is available or time permits, the weekly, monthly, and yearly figures under each heading may be



worked out in cost per mile and kept charted to show cost fluctuations at a glance, on the lines here indicated. Charts are particularly useful in regard to fuel and oil consumptions, wages, and total costs—running, standing and all-in—both for individual vehicles and for fleets of uniform sized units. Moreover, if the drivers

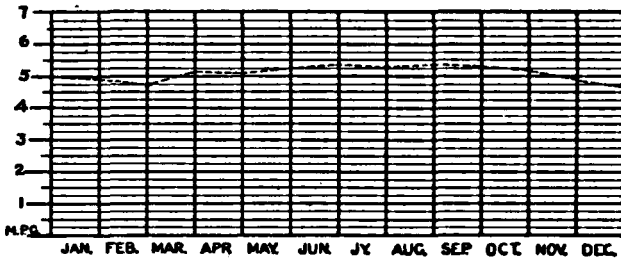


FIG. 43. A YEAR'S PETROL CONSUMPTION CHART OF A 7 TON WAGON

have access to the consumption charts, it affords a valuable stimulus in working.

Every large undertaking has its own system of costing, built up by specialists, and a complete volume would be required to detail all the intricacies of costing in a large business; but the foregoing outline, which can be modified to individual circumstances, will afford a framework upon which the small transport owner can build up his own system of working records, and in such a way as to allow for expansion of business.

## CHAPTER XII

### WORKING EXPENSE ITEMS—MILEAGE AND RUNNING COSTS

THE recording of working expenses should not be regarded as a mere routine, just to enable the transport owner to know where he stands at the end of the financial year. Working cost records should in fact be regarded as the most valuable of all tools for those who have to supervise the running of vehicles; but to serve this end they should be kept in such a way as to be able to show the position of any car (and, if circumstances permit, of any driver) in regard to any item at any time.

#### **Running and Standing Costs.**

For recording purposes the items of expenditure should be divided into two groups, under the respective headings of "running" and "standing" charges. The running costs are those which vary exactly with the mileage, as, for example, for fuel or tyre wear; the standing charges, which are overhead costs, are those which have to be met and are more or less invariable whatever the mileage. Though the fact is not generally realized, these latter are commonly the more important of the two; only when the mileage approaches 12,000 to 20,000 in the year (according to the size of vehicle) do the standing charges begin to get less than the running cost per mile. Assuming adequate and similar loading in both cases then, it is a better business proposition to spend, say, £500 a year in running a 1 tonner for 20,000 miles at a total inclusive cost of 6d. a mile, than to spend £375 on a mileage of only 10,000 at 9d. a mile.

Obviously, then, the greater the annual mileage over which to distribute the standing costs the lower the cost per mile. To exaggerate the argument to an extreme, for the sake of demonstration, if only 1 mile in the course of the year was run by the 1 tonner above mentioned, its all-in cost would work out at about £250 per mile; but on a mileage of 20,000 per annum the figure would be reduced to some 5d.-6d. a mile.

The importance of adequate mileage, therefore, can hardly be over-estimated. After all a vehicle is bought for use and unless used represents a sheer dead loss. If it is worth buying, it is worth using to the full and should be worked for all it is worth, consistent with proper usage and maintenance.

Opinions differ as to whether certain items should be included under the running or standing cost headings. Wages, for instance, are regarded by some as a running and by others as a standing charge. Again, if a vehicle is laid up for overhaul and the owner has to hire another temporarily to replace it, it may be argued that part of the hire represents running, part standing cost. There is no need, however, to split academic hairs, and the best rule from the aspect of practical record-keeping is to allocate as running items those charges that vary proportionately with the mileage and to include all others with the standing costs. On that system drivers' wages would be treated as a standing item. It would probably be more correct to consider van hire as a running charge, especially if the contract were by the mile, but it will probably be more convenient to treat it as a standing cost. Very usually, however, the items are so much per day or per week up to a given mileage, with an additional charge at so much per mile for anything over that limit, and in such a case it really would not matter much how the item was charged up: neither would be strictly accurate and

either would be near enough for practical purposes, unless a very accurate cost analysis were required. In that case no doubt the item could be split up into its component parts and each allocated strictly correctly. In this volume, however, the writer proposes to treat it as a standing item, though, since it should not amount to much, this is really a matter of no great moment.

#### **Average Figures for Comparison.**

Much value is sometimes set on figures obtained in actual working; but in a broad survey such as this they could serve but little, for no two owners keep their costs alike, and in many, important items are omitted: the published working costs of at least one well-known firm, for instance, altogether disregard tyre costs, ideas on depreciation vary greatly, and any charge for hire or a spare vehicle is the exception rather than the rule. Besides, each set of costs presents only a single case which may or may not involve the normal of conditions—working and trade—with the odds strongly against it doing so. There would thus be no common basis for comparison between vehicles or between classes, and in these circumstances the best course seems to lie in an average of the figures afforded by experience throughout the country in many trades, presenting all on the same lines—in effect an average of figures under an average of conditions.

Before going further we must now consider the items that go to make up the working cost. Taking the running costs first, they may be put down as fuel, lubrication, tyres, maintenance, and repairs.

#### **Fuel or Power.**

The fuel bill of course simply depends on the cost of the fuel and its consumption; but the latter is influenced

by a number of factors. Chief of these are the driver, the condition of the vehicle, the contour of the roads traversed, the surface and state of the roads (consumption is usually materially higher in winter than in summer, for instance), and the amount of stopping and starting involved by traffic and working conditions.

In late years the consumption of both petrol and steam vehicles has improved quite markedly; but it is open to question whether ideas in general on this point are not a trifle too optimistic, for the simple reason that as a rule only the more satisfactory results come into the light of day. Naturally, owners and makers of trade vehicles do not encourage the publication of any but reasonably creditable performances, and when the machines are nearing the end of their life, or beginning to show need for overhaul, little enough is heard of them. Yet a fair average has to include all periods of life and all sorts of drivers, so, bearing this in mind, the consumption on which the fuel figures are based in the working costs which follow are, if anything, on the high side, on the principle that it is better for performance to exceed promise than the other way about. They assume only reasonably good handling and maintenance. Nevertheless, the increasing use of pneumatic tyres, coupled with improvements by the makers, is markedly tending to lower consumption among the heavier classes formerly running on solids.

Prices, of course, vary with market fluctuations and according to quality and locality. Coal in the south of England, for instance, costs considerably more than in the coal measures. Even for petrol the price is higher in Ireland and the north of Scotland than for the rest of the country.

Commercial transport owners were formerly able to buy at 1½d. a gallon below standard retail price, but nowadays, unless the transport man has his own tank

storage, his right to a lower price is no longer recognized, and the installation of tanks and pumps would hardly be justified with less than about 20 vehicles.

Cheap fuel is a doubtful economy. Recently the Commercial Vehicle Committee of the Society of Motor Manufacturers and Traders, in conjunction with the Petroleum Distributors' Committee, pointed out that since paraffin was not subject to duty certain vendors had taken to blending it with petrol. In buying motor spirit, therefore, it may be advisable to insist on a guarantee that it contains no adulterant, for the paraffin condensing on the cylinder walls ultimately finds its way down into the engine base chamber, where it dilutes the lubricant, sometimes to the severe detriment of the engine bearings.

#### **Lubrication.**

Lubrication is only a small item, but important. Here again cheapness may prove an expensive economy. Not that high price necessarily means satisfactory oil, but it is of great importance that the oil should be suitable to the engine, whatever the price: an unsuitable oil may cause pounds worth of damage, and it is best to follow the advice of the chassis makers on this point.

Prices vary greatly; on a contract heavy oil might be obtainable at 2s. 9d., medium at 2s. 6d. a gallon, and grease at 2d. a lb., and lower; but for the small user buying in relatively modest quantity the cost will more probably work out at anything from 4s. to 5s. 4d. a gallon for engine oil, and from 3s. 9d. to 5s. for gear oil; or even more for worm driven axles. Broadly speaking, 4s. 3d. to 4s. 6d. per gal. should certainly procure a satisfactory oil in single drums or barrels, unless anything very special is required. Grease is an inconsiderable item, and in small quantities its price

should range from 3s. 9d. for a 7 lb. tin to 56s.-67s. 6d. per cwt.

The disparity between bulk and retail prices here appears very large, but it must be remembered that lubricant is awkward to handle and entails expensive storage.

### Tyres.

Since the inception of motor transport, no part of the vehicle has made more extraordinary progress in the direction of cutting down costs than the tyre. At one time tyre expenses threatened to end the career of the motor omnibus in its early stages, and the author can recall instances of buses costing from 2½d. to 3d. a mile for tyres. To-day, for vehicles of considerably larger carrying capacity, the corresponding figure ranges around ½d. a mile. The years since the War have seen enormous improvements in tyre construction, with the result that the mileages of to-day would have been deemed unbelievable a few years ago. Only quite recently the representative of a well-known tyre firm gave the writer the following as *average* mileages, as the result of investigation: giant pneumatics 40,000, smaller pneumatics 20,000 to 25,000, solids 25,000 to 30,000. Not so many years ago a pneumatic tyre that gave 5,000 miles of life was regarded as quite satisfactory, while solid tyres were not guaranteed for more than 12,000 miles.

All this has been accomplished not only without increase of price; to-day, tyres are cheaper as well as far better than ever they were before.

Tyres may be bought outright or in some cases on a contract basis, the vehicle owner paying so much a mile. In either case he will have to keep a record of each tyre, but for the man in a small way of business nothing elaborate is really necessary: all essential

particulars can be noted in the "Remarks" column of the weekly vehicle return. Each tyre, identified by its make and maker's number, can be located by such abbreviations as F, I, and B for front, intermediate and back, or N and O for near and off sides. Thus, whatever happens to any tyre—fitting, refitting or scrapping—can be noted at the date it occurs, while performance can be ascertained from the mileage column.

### **Maintenance.**

This item is mainly made up of the costs for material and labour in running repairs, adjustments, and cleaning. When the drivers themselves attend to these jobs (and they usually do at least the two former in any but really considerable garages), their time booked in their returns as spent in the garage should be charged up to this item; but, if men are specially employed for the work, separate allocation of time in garage and on road may become superfluous in the driver's return.

Various methods are adopted for cleaning. In large concerns sometimes engines and vehicles are cleaned by separate sets of men, and for passenger working the outsides of the cars may be washed by one set, the interiors attended to by another, women occasionally being employed for the inside work. One man on an average should be able to wash about five big cars in a night.

### **Repairs.**

For the first year or two of its existence a car will cost little, if anything, for repair, the item becoming heavier with increasing age. Consequently, if repairs were charged up as they occur, a fair comparison of one year with another, or between two vehicles of different ages, might be misleading. It is, therefore, a fairly common practice week by week to carry into a Repairs



Reserve Account a fixed sum for each vehicle and to charge up the repairs against that account.

It is also maintained by some that experience has shown that, if £1 a week is allowed for vans up to 2 ton capacity and 30s. above that size, the repair costs will be adequately averaged over the life of the vehicle. Such a system may be correct enough up to a point, for the repair charges do not increase proportionately to vehicle size, but, unfortunately, repairs are largely a function of mileage, and mileages vary enormously. While therefore we may accept the principle of charging a fixed estimated periodical amount, the author holds that it should be on a per-mile rather than a time basis.

Considerable plant is necessary for a thorough overhaul after 25,000 or 30,000 miles, especially when a vehicle is getting old. If the work is to be up to modern standards, grinding machinery will be required for cylinders and journals, and this holds just as good for a single car as a large fleet. Moreover, certain repairs, such as the welding of broken castings, can be properly carried out only in specialized shops, and in any case would have to be done outside. The average owner will, therefore, be wise to have his repairs done by some firm with adequate equipment for the work, or to arrange with them for maintaining the cars on contract, unless the fleet is large enough to justify the locking up of capital in a repair shop, equipment, and staff. This, however, does not imply that the employment of a fitter may not be worth while, if the vehicles are numerous enough to keep such a man occupied but not to justify a complete repair equipment.

## CHAPTER XIII

### STANDING COST ITEMS

WAGES naturally fluctuate from time to time and vary with locality. Broadly speaking, it may be said that wages are highest in London, where the cost of living is greatest, and the farther away from the great centres the lower become the rates. Throughout the country, however, organization exists for adjusting wages by the arbitration of industrial courts which fix the ruling rates in their area after hearing the cases of both collective employers and employed.

#### **Wages and Bonuses.**

In the London area the approximate recognized wages (subject of course to fluctuation) for adult drivers range from 54s. to 72s. a week according to the size of vehicles, drivers of those over 5 ton load capacity and all steamers drawing the higher figure. For mates the wage may be put some 12s. a week lower than for drivers on petrol vehicles, 11s. on steam wagons. Youths in their first year of driving may get from 35s. to 40s. weekly, and thereafter 40s. to 45s. For night work between 10 p.m. and 4 a.m. an additional 2d. an hour is paid, and for Sunday work men are paid at time and a half rate. For boys employed as vanguards the wage varies with age, ranging from 16s. a week for lads under 16 years old up to 25s. for those between 18 and 19 years of age.

In addition to wages, employers frequently pay their men bonuses, and probably the majority of readers will agree with the principle of some tangible encouragement to save working expenses—this as a matter of business. Yet there is wide diversity among employers as to

method. Some offer a bonus on fuel consumption, others on tyre wear, repair cost, or freedom from accident. Obviously, a bonus calculated proportionately on each separate item of cost would be impracticably complicated, for any scheme must essentially be simple and understandable by every man; otherwise those who fail to grasp it may be liable to harbour imaginary grievances. Another point—a bonus should not be paid at too long intervals or its stimulus will flag; every three months, at the outside, is quite long enough to keep a man waiting for his money.

Personally, the author favours a system based on per-mile *running* cost and freedom from accidents as all round the fairest and most satisfactory method. For quarterly payments repairs, and generally tyres, could only be estimated, though it might be possible to pay a provisional quarterly bonus on fuel and oil plus freedom from accidents, with an additional bonus on tyres and repairs when their costs are known.

Whatever system is adopted, however, it must be very carefully considered with regard to the conditions of working, and above all it must be easily workable and fair to all the men alike.

### **Relief Service.**

Costs of vehicle hire will be calculable from the costs of working, with a fair profit added, and if the chassis is built on the unit construction principle and overhaul carried out unit by unit, the hire of the units, or, if bought, the standing charges on them, need only be debited under this item, the cost of changing them over being, of course, charged to the repairs account.

If a relief van is kept, its total working costs, entered up like those of any other vehicle, should be divided among each other unit of the fleet in proportion to the mileage run as a substitute. Thus, clearly an additional

vehicle as a relief can be justified only for a considerable fleet, or if there is also enough extra work to keep it employed in its off time, and that duty can be worked in with its service as a spare.

**Garage and Management.**

Garage expenses will comprise salaries and wages of garage staff, rent, rates, insurance, and repairs of premises, besides any capital and repair charges on the plant for keeping the vehicles in condition, and they may also include insurance of the men under the National Health scheme, against unemployment, and against employers' liability under the Workmen's Compensation Acts.

Management expenses will include salaries for supervision and clerkage, stationery, and any other incidental expenses.

**Licence Duties.**

For every motor vehicle on the road a licence duty is payable annually or quarterly, the fee varying with the size of the vehicles as below—

**GOODS VEHICLES.**

<i>Petrol or Steam.</i>	<i>Annual.</i>		<i>Quarterly.</i>	
	<i>£</i>	<i>s. d.</i>	<i>£</i>	<i>s. d.</i>
Of a weight up to 12 cwt. unladen . . . . .	10	- -	2	15 -
Of a weight over—				
12 cwt. up to 1 ton . . . . .	15	- -	4	2 6
1 ton „ 1½ tons . . . . .	20	- -	5	10 -
1½ tons „ 2 „ . . . . .	25	- -	6	17 6
2 „ „ 2½ tons, with pneumatic tyres . . . . .	28	- -	7	14 -
„ „ „ „ other vehicles . . . . .	35	- -	9	12 6
2½ „ „ 3 „ with pneumatic tyres . . . . .	32	- -	8	16 6
„ „ „ „ other vehicles . . . . .	40	- -	11	- -
3 „ „ 4 „ with pneumatic tyres . . . . .	38	8 -	10	11 3
„ „ „ „ other vehicles . . . . .	48	- -	13	4 -
4 „ „ 5 „ with pneumatic tyres . . . . .	43	4 -	11	17 8
„ „ „ „ other vehicles . . . . .	54	- -	14	17 -
5 „ „ „ with pneumatic tyres . . . . .	48	- -	13	4 -
„ „ „ „ other vehicles . . . . .	60	- -	16	10 -
If used with trailer (additional duty) . . . . .	6	- -	1	13 -

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<i>Electric.</i>	<i>Annual.</i>		<i>Quarterly.</i>	
	<i>£</i>	<i>s. d.</i>	<i>£</i>	<i>s. d.</i>
Of a weight up to 25 cwt. unladen . . . . .	6	- -	1	13 -
.. .. over 25 cwt. up to 2 tons . . . . .	13	- -	3	11 6
.. .. " 2 tons .. 3 .. . . . .	20	- -	5	10 -
.. .. " 3 .. .. 4 .. . . . .	24	- -	6	12 -
.. .. " 4 .. .. 5 .. . . . .	27	- -	7	8 6
.. .. " 5 .. . . . .	30	- -	8	5 -
If used with trailer (additional duty) . . . . .	6	- -	1	13 -

**PASSENGER VEHICLES.**

For up to 4 persons . . . . .	10	- -	2	15 -
For over—				
4 up to 8 persons, . . . . .	12	- -	3	6 -
8 .. 14 .. with pneumatic tyres	24	- -	6	12 -
.. .. " .. other vehicles	30	- -	8	5 -
14 .. 20 .. with pneumatic tyres	36	- -	9	18 -
.. .. " .. other vehicles	45	- -	12	7 6
20 .. 26 .. with pneumatic tyres	48	- -	13	4 -
.. .. " .. other vehicles	60	- -	16	10 -
26 .. 32 .. with pneumatic tyres	57	12 -	15	16 10
.. .. " .. other vehicles	72	- -	19	16 -
32 .. 40 .. with pneumatic tyres	67	4 -	18	9 8
.. .. " .. other vehicles	84	- -	23	2 -
40 .. 48 .. with pneumatic tyres	76	16 -	21	2 5
.. .. " .. other vehicles	96	- -	26	8 -
48 .. 56 .. with pneumatic tyres	86	8 -	23	15 3
.. .. " .. other vehicles	108	- -	29	14 -
56 .. 64 .. with pneumatic tyres	96	- -	26	8 -
.. .. " .. other vehicles	120	- -	33	- -
Additional for each person in excess of 64, pneumatic tyres . . . . .	1	4 -	6	8
Additional for each person in excess of 64, other vehicles . . . . .	1	10 -	8	3

**Insurance.**

All motor vehicles on the road by law have to be insured against third party risks; but, apart from that, policies may vary considerably, and the terms of a policy are of more importance than the amount of

**LIGHT GOODS VEHICLES.**

(Carrying capacity not exceeding 30 cwt.)

Not Exceeding	Country	Large	London and
	Districts.	Towns.	Glasgow.
	<i>£</i>	<i>£</i>	<i>£</i>
	<i>s. d.</i>	<i>s. d.</i>	<i>s. d.</i>
10 h.p. and £300 . . . . .	10	12	15
15 h.p. and £400 . . . . .	13	15	19
£500 . . . . .	14	16	21
Excess value, 14s. per cent.	3	6	6

## NEW LICENCE DUTIES

UNDER the Finance Act, 1933, which came into force at the beginning of 1934, vehicle licence duties have been materially altered as follows—

### GOODS VEHICLES.

<i>Petrol.</i>	<i>Annual</i>
	<i>£ s. d.</i>
Of a weight up to 12 cwt. unladen, pneumatic tyres . . . . .	10 - -
Of a weight over—	
12 cwt. up to 1 ton . . . . .	15 - -
1 ton „ 1½ tons . . . . .	20 - -
1½ tons „ 2 „ . . . . .	25 - -
2 „ „ 2½ tons, with pneumatic tyres . . . . .	30 - -
„ „ „ „ with solid tyres . . . . .	40 - -
2½ „ „ 3 „ with pneumatic tyres . . . . .	35 - -
„ „ „ „ with solid tyres . . . . .	46 13 4
3 „ „ 4 „ with pneumatic tyres . . . . .	50 - -
„ „ „ „ with solid tyres . . . . .	66 13 4
For each ton or part thereof exceeding 4 tons with pneumatic tyres . . . . .	20 - -
For each ton or part thereof exceeding 4 tons with solid tyres . . . . .	26 13 4

### *Heavy Oil.*

Of a weight up to—	
2½ tons unladen, with pneumatic tyres . . . . .	35 - -
„ „ „ with solid tyres . . . . .	46 13 4
Of a weight over—	
2½ tons up to 3 tons, with pneumatic tyres . . . . .	45 - -
„ „ „ with solid tyres . . . . .	60 - -
3 „ „ 4 „ with pneumatic tyres . . . . .	65 - -
„ „ „ with solid tyres . . . . .	86 13 4
4 „ „ 5 „ with pneumatic tyres . . . . .	90 - -
„ „ „ with solid tyres . . . . .	120 - -
5 „ „ 6 „ with pneumatic tyres . . . . .	120 - -
„ „ „ with solid tyres . . . . .	160 - -
6 „ „ 7 „ with pneumatic tyres . . . . .	150 - -
„ „ „ with solid tyres . . . . .	200 - -
For each ton or part thereof exceeding 7 tons, with pneumatic tyres . . . . .	25 - -
For each ton or part thereof exceeding 7 tons, with solid tyres . . . . .	33 6 8

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<i>Steam or Coal Gas.</i>		<i>Annual</i>	
		<i>£</i>	<i>s. d.</i>
Of a weight up to 2 tons unladen		25	- -
Of a weight over—			
2 tons up to 2½ tons, with pneumatic tyres		30	- -
" " " " with solid tyres		40	- -
2½ " " 3 " with pneumatic tyres		35	- -
" " " " with solid tyres		46	13 4
3 " " 4 " with pneumatic tyres		50	- -
" " " " with solid tyres		66	13 4
4 " " 5 " with pneumatic tyres		70	- -
" " " " with solid tyres		93	6 8
5 " " 6 " with pneumatic tyres		90	- -
" " " " with solid tyres		120	- -
For each ton or part thereof exceeding 6 tons, with pneumatic tyres		15	- -
For each ton or part thereof exceeding 6 tons, with solid tyres		20	- -

*Electric.*

Of a weight up to 12 cwt. unladen		10	- -
Of a weight over—			
12 cwt. up to 1 ton		15	- -
1 ton " 2 tons		20	- -
2 tons " 2½ tons, with pneumatic tyres		25	- -
" " " " with solid tyres		33	6 8
2½ " " 3 " with pneumatic tyres		30	- -
" " " " with solid tyres		40	- -
3 " " 4 " with pneumatic tyres		35	- -
" " " " with solid tyres		46	13 4
4 " " 5 " with pneumatic tyres		40	- -
" " " " with solid tyres		53	6 8
5 " " 6 " with pneumatic tyres		45	- -
" " " " with solid tyres		60	- -
For each ton or part thereof exceeding 6 tons, with pneumatic tyres		10	- -
For each ton or part thereof exceeding 6 tons, with solid tyres		13	6 8

*If used with trailer (additional duty)*

Showmen's special vehicles		10	- -
Other vehicles—			
Of a weight up to 2½ tons unladen		10	- -
" " over 2½ tons up to 4 tons		15	- -
" " over 4 tons		20	- -

Articulated vehicles not subject to trailer tax.

NEW LICENCE DUTIES

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<i>Tractors.</i>	<i>Annual</i>
	<i>£ s. d.</i>
Of a weight up to 2 tons . . . . .	25 — —
" " over 2 tons up to 4 tons . . . . .	40 — —
" " " 4 " " 6 " . . . . .	55 — —
" " " 6 " " 7½ " . . . . .	70 — —
" " " 7½ " " 8 " . . . . .	85 — —
For each ton or part thereof exceeding 8 tons . . . . .	15 — —

Special lower duties are allowed for motor vehicles used in agriculture or for showmen's purposes.

PASSENGER VEHICLES.

*Petrol, Coal Gas, Steam, or Electric.*

For up to 4 persons . . . . .	10 — —
For over—	
4 up to 8 persons,	
8 " 14 " with pneumatic tyres . . . . .	12 — —
" " " " with solid tyres . . . . .	24 — —
" " " " with pneumatic tyres . . . . .	30 — —
14 " 20 " with pneumatic tyres . . . . .	36 — —
" " " " with solid tyres . . . . .	45 — —
20 " 26 " with pneumatic tyres . . . . .	48 — —
" " " " with solid tyres . . . . .	60 — —
26 " 32 " with pneumatic tyres . . . . .	57 12 —
" " " " with solid tyres . . . . .	72 — —
32 " 40 " with pneumatic tyres . . . . .	67 4 —
" " " " with solid tyres . . . . .	84 — —
40 " 48 " with pneumatic tyres . . . . .	76 16 —
" " " " with solid tyres . . . . .	96 — —
48 " 56 " with pneumatic tyres . . . . .	86 8 —
" " " " with solid tyres . . . . .	108 — —
56 " 64 " with pneumatic tyres . . . . .	96 — —
" " " " with solid tyres . . . . .	120 — —
For each person exceeding 64, with pneumatic tyres . . . . .	1 4 —
" " " " with solid tyres . . . . .	1 10 —

*Heavy Oil.*

For up to 4 persons . . . . .	10 — —
For over—	
4 up to 8 persons,	
8 " 14 " with pneumatic tyres . . . . .	12 — —
" " " " with solid tyres . . . . .	32 — —
" " " " with pneumatic tyres . . . . .	40 — —
14 " 20 " with pneumatic tyres . . . . .	48 — —
" " " " with solid tyres . . . . .	60 — —
20 " 26 " with pneumatic tyres . . . . .	68 — —
" " " " with solid tyres . . . . .	85 — —
26 " 32 " with pneumatic tyres . . . . .	88 — —
" " " " with solid tyres . . . . .	110 — —
32 " 40 " with pneumatic tyres . . . . .	108 — —
" " " " with solid tyres . . . . .	135 — —



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*Heavy Oil (contd.).*

				<i>Annual</i>	
<i>For over (contd.)—</i>				<i>£</i>	<i>s. d.</i>
40 up to 48 persons, with pneumatic tyres				128	— —
" " " " with solid tyres				160	— —
48 " 56 " with pneumatic tyres				148	— —
" " " " with solid tyres				185	— —
56 " 64 " with pneumatic tyres				164	— —
" " " " with solid tyres				205	— —
For each person exceeding 64, with pneumatic tyres				2	— —
" " " " with solid tyres				2	10 —

premium. The latter too varies not only with the terms, but in different districts. The figures on pages 180-181 will give some idea as to the cost of insurance for goods vehicles—

## HEAVY GOODS VEHICLES.

	£	s.	d.	£	s.	d.	£	s.	d.
Ordinary risks . . . . .	17	5	3	19	12	9	23	4	3
Cartage contractors, etc.	22	13	6	25	16	-	30	10	6
Trailers £1 8s. additional up to £100 value.									
Total weight fully loaded not to exceed 12 tons. Excess charge, £1 per ton, or part thereof.									

The figures above cover damage to the vehicle, or its fitments, including fire or loss by theft and third party insurance covering death, or injury, unlimited as to amount; also legal defence of driver in connection with any accident covered by the policy.

Insurance of goods in transit is an additional cover, varying from 20s. to 50s. per cent on the value, according to the nature of the goods.

For passenger working the following premiums are a fair average—

(Seating more than 15. Value up to £1,000.)

	Country Districts.	Entering Large Towns.	Entering London and Glasgow.						
	£	s.	d.	£	s.	d.	£	s.	d.
Coaches for private hire and not running to time-table . . . . .	23	16	-	26	3	6	30	-	-
Plus 10s. 9d. per seat for injury to passengers.									
Buses . . . . .	45	-	-	49	10	-	55	-	-
Plus 12s. per seat for injury to passengers.									

**Depreciation.**

Depreciation is influenced by two, possibly three, considerations—wear and tear, obsolescence, and in some cases subsequent price reductions due to improved production methods, increased output and so forth.

In working costs, either a percentage of the full value of a vehicle may be written off yearly, or off the diminishing value as it is written down year by year. The

first of these methods does not show the true state of affairs in any given year, and the second, of course, is the more correct, the more so in that it entails the heaviest depreciation in the earlier years when depreciation is actually greatest. Also, it is the more desirable since it is the method recognized by the taxation authorities in calculating any income tax allowance on account of depreciation; and here it is as well to mention that some years ago the Commissioner of Taxes, in accepting the taxpayer's right to some relief on that score, suggested 15 per cent on the written down values of steamers, 20 per cent for petrol vehicles, as a fair guide for allowances in general, though, of course, as was pointed out, each case must be decided on its own merits by the local supervisor. On this basis each £100 value would year by year be reduced to the following amounts—

At End of	At 15 per cent		At 20 per cent	
	£	s. d.	£	s. d.
	100	- -	100	- -
1st year	85	- -	80	- -
2nd "	72	5 -	64	- -
3rd "	61	8 3	51	4 -
4th "	52	2 3	40	19 2
5th "	44	6 -	32	15 4
6th "	37	13 1	26	4 3
7th "	32	- 1	20	19 5
8th "	27	4 1	16	15 6
9th "	23	2 6	13	8 5
10th "	19	13 1	10	14 9
11th "	16	14 2		
12th "	14	4 -		
13th "	12	1 5		
14th "	10	5 2		

Depreciation, be it added, should only be written off the cost of the vehicle *less tyres*, which, as a more or less consumable commodity so to speak, are treated as a running item at so much a mile.

As wear and tear is such an important factor, it is best to base depreciation primarily on mileage rather than time. As a rule 140,000 to 160,000 miles may be

reckoned as a fair life's work, and, if the annual mileage is known, or can be estimated, the vehicle can then be depreciated year by year to a fairly correct amount. Usually some 10 per cent is allowed for scrap value at the end of a car's life, so that the depreciation only covers about 90 per cent of the full value. On that basis the following tables give the approximate yearly written down values for various lengths of life—

APPROXIMATE ANNUAL WRITTEN DOWN VALUES OF EACH £100 FOR DIFFERENT LENGTHS OF VEHICLE LIFE

Life in Years Depreciation at (per cent)	17			16			15			14			13		
	12·7			13·4			14·2			15·2			16·2		
At End of	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
100 — —	100	—	—	100	—	—	100	—	—	100	—	—	100	—	—
1st year	87	6	—	86	12	—	85	16	—	84	16	—	83	16	—
2nd "	76	4	3	74	19	11	73	12	4	71	18	2	70	4	6
3rd "	66	10	8	64	18	11	63	3	3	60	19	7	58	17	—
4th "	58	1	8	56	4	11	54	3	11	51	14	3	49	6	3
5th "	50	14	2	48	14	2	46	10	—	43	17	—	41	6	6
6th "	44	5	4	42	3	7	39	17	11	37	3	8	34	12	7
7th "	38	12	11	36	10	7	34	4	7	31	10	8	29	—	5
8th "	33	14	9	31	12	8	29	7	5	26	14	10	24	6	5
9th "	29	9	—	27	7	11	25	4	—	22	13	6	20	7	7
10th "	25	14	3	23	14	6	21	12	5	19	4	7	17	1	7
11th "	22	8	11	20	10	11	18	11	—	16	6	1	14	6	3
12th "	19	11	11	17	15	10	15	18	4	13	16	6	11	19	10
13th "	17	2	2	15	8	2	13	13	2	11	14	6	10	1	—
14th "	14	18	8	13	6	10	11	14	4	9	18	10			
15th "	13	—	9	11	11	1	10	1	1						
16th "	11	7	7	10	—	1									
17th "	9	18	8												
Average Annual Depreciation	5	5	10	5	12	6	6	—	—	6	8	7	6	18	6

In estimating second-hand values as exactly as possible, any price reduction in the model, subsequent to the purchase of a vehicle, is included in the depreciation; but against this may be set the appreciation due to any considerable replacement, such as a new

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**APPROXIMATE WRITTEN DOWN VALUES OF EACH £100 FOR DIFFERENT LENGTHS OF VEHICLE LIFE—(contd.)**

Life in Years Depreciation at (per cent)	12 17.4	11 18.9	10 20.5	9 22.5
At End of	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1st year	100 - -	100 - -	100 - -	100 - -
2nd ..	81 12 -	81 2 -	79 10 -	77 10 -
3rd ..	68 4 7	65 15 5	63 4 1	60 1 3
4th ..	56 7 1	53 6 10	50 4 11	46 11 -
5th ..	46 11 -	43 5 3	39 18 11	36 1 6
6th ..	38 9 -	35 1 8	31 15 2	27 19 2
7th ..	31 15 2	28 9 1	25 4 11	21 13 4
8th ..	26 4 8	23 1 6	20 1 5	16 15 10
9th ..	21 13 5	18 14 4	15 19 1	13 - 3
10th ..	17 18 -	15 3 7	12 13 8	10 1 9
11th ..	14 15 8	12 6 2	10 1 8	
12th ..	12 4 3	9 19 8		
13th ..	10 1 9			
Average Annual Depreciation	7 10 -	8 3 11	9 - -	10 - -

Life in Years Depreciation at (per cent)	8 25	7 28	6 31.9	5 36.9
At End of	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1st year	100 - -	100 - -	100 - -	100 - -
2nd ..	75 - -	72 - -	68 2 -	63 2 -
3rd ..	56 5 -	51 16 10	46 7 6	39 16 4
4th ..	42 3 9	37 6 6	31 11 8	25 2 6
5th ..	31 12 10	26 17 6	21 10 2	15 17 1
6th ..	23 14 7	19 7 -	14 12 11	10 - 1
7th ..	17 16 -	13 18 7	9 19 6	
8th ..	13 7 -	10 - 7		
9th ..	10 - 3			
Average Annual Depreciation	11 5 -	12 17 2	15 - -	18 - -

back axle (which should not however include the cost of labour for fitting it, as that in no way adds to the value).

**Interest.**

If the money for the purchase of cars is borrowed, interest of course will have to be paid; and, when a man invests his own money in the same way, he naturally argues that the capital, if put into investments, would have yielded a safe interest up to, say, 5 per cent, and that, therefore, the loss of this income should be debited against his transport. Accordingly it is common practice to charge up interest on capital cost of the vehicles in the standing expenses; and, when the work is being performed in the service of some business other than transport, such a course is perfectly justifiable, as the capital could otherwise have earned interest in the main business. When, however, the business lies in transport itself, as, for instance, in the case of a carrier or bus proprietor, the profits represent the interest on capital, coming back to the owner in the form of dividends, and in such cases no interest can justifiably be charged. No public company deducts interest on its capital before paying out dividends; the dividends *are* the interest.

**Contingencies.**

To be on the safe side and meet such possibilities as legal proceedings, parking, etc., a small sum has been allowed for contingencies, but this calls for no comment.

## CHAPTER XIV

### WHAT WORKING COSTS—GOODS VEHICLES, PETROL AND HEAVY OIL

Costs of working vary enormously, and in nearly every item; even in the same fleet a 2 or 3 tonner, for instance, may cost more on certain points than, say, many a 4 ton vehicle. Specific costs of individual cases may, therefore, be misleading and rarely, if ever, represent the normal in all respects. Accordingly, the figures which follow afford only a general guide as to costs based on averages over a wide field, but each item is calculated on a basis liberal enough to be attainable under ordinary circumstances throughout the life of a vehicle, given always competent handling and management. Founded on conservative estimates, the figures present a case of no extravagant expectations nor should they lead to subsequent disappointment. Yet they profess to be no more than a general guide, and it is for the transport worker, actual or potential, to modify them according to his own individual circumstances and to the times, for prices are continually fluctuating and conditions changing.

A few preliminary explanations are, however, advisable to detail the bases on which the various items are founded.

**Fuel.** Although a vehicle owner, if he has his own tank installation, can obtain petrol at lower prices, storage tanks imply a considerable fleet to justify their cost, and therefore the price of petrol has been put at 1s. 4½d. a gallon. That assumes a standard quality, for quality is of importance.

For the light delivery vans at any rate consumption is, if anything, assessed on the high side owing to the

frequent stopping and re-starting incidental to the retail deliveries for which they are generally used, and to the traffic conditions in the more populous areas where they usually work.

**Lubrication.** Figures are based on an average price of 4s. 4d. per gal. for oil, and 6½d. a lb. for grease.

Consumptions vary immensely. The writer has known cases of 3 tonners using a gallon of oil every 65 miles, and of a 4 tonner running something like 3,000 miles to the gallon, though only of course as a star turn, the desirability of which may well be questioned. Here are a few further consumptions taken at random : 15 cwt., 675 m.p.g. ; 1 ton, 500 m.p.g. ; 3 ton, 170 m.p.g. ; 4 ton, 325 m.p.g. ; 10 ton, six-wheeler, 350 m.p.g., and modern instances of 6 tonners running 1,000 miles to the gallon or even more are not altogether uncommon.

**Tyres.** Broadly speaking, tyre costs are calculated on a mileage-life of 12,000 for the smaller pneumatic tyres, about 20,000 for giant pneumatics and, say, 18,000 for solids. Commercial vehicle owners are generally accorded a discount varying with the number of vehicles employed.

**Maintenance.** Strictly speaking, perhaps running repairs should be entered under the "Repairs" heading, but for small businesses where the drivers have to do their own running repairs, and overhauls are undertaken by outside firms, it may be more convenient to treat them as maintenance along with cleaning, which constitutes a main component of this charge. That course has been here adopted.

**Repairs.** As a vehicle ages the repair bill grows, but the figures given strike an average throughout the life of the vehicle.

**Depreciation.** On the other hand, as the value is written down depreciation diminishes and off-sets the



heavier repair bills, but here, too, an average throughout has been taken, based on the mileage appropriate to size of vehicle and on the depreciation tables in the preceding chapter.

Opinions differ as to whether depreciation should be regarded as a running or standing charge. Here it is treated as a running item, but only to facilitate comparisons between different mileages and classes, for, personally, the writer considers it really a standing charge. At any rate for income tax allowance it should be regarded as a standing cost, and operators are advised to treat it as such in general.

**Wages.** For single vehicles no assistant has been assumed, but with a trailer one is carried, more often than not for load handling quite apart from any legal requirements.

For retail delivery work, too, a van boy will sometimes be required, especially with vans of 1 ton capacity and more, while with the larger vehicles an adult assistant is often employed—indeed, more often than not for the heaviest classes. For uniformity of comparison, however, assistants or loaders have only been entered in the trailer accounts and, if one is employed for a single vehicle, his wages must be added to the standing costs.

**Relief Service.** A week's overhaul every 25,000 miles has been assumed, and this entry covers the services of a spare vehicle for that period; but with a chassis constructed on the unit principle much of this expense may be avoided by good management.

**Garage Expenses.** These are made up of such items as rent, rates, lighting, heating, and repairs to premises; also insurance of premises, and unemployment, health, and employer's liability insurance of the staff, though, by some National insurance is included with the wages. Under the circumstances it is possible to assess only a

reasonable charge under this heading, leaving it to the reader to adjust the figure to his own circumstances.

**Management.** In a small concern, when the manager has to look after the business as well as the operative side, it is not always possible to separate administrative and operating charges. As, however, for firms effecting their own deliveries, the former generally do not exist and, in any case, they vary greatly according to the nature and size of the business, the figures in the costs cover only the management of the vehicle working inclusive of office—as distinct from garage—charges, clerkage, and stationery.

**Insurance.** The middle or “large town” figures given under this heading in the preceding chapter (pages 180 and 181) have been taken, but no insurance of load has been assumed.

**Interest** covers the cost of the vehicle less tyres. For those running transport as a business this item need not be included unless the capital is borrowed.

**Contingent Expenses.** In each case a small amount has been allowed under this heading, and in ordinary circumstances it should suffice to cover occasional lodging expenses or garaging away from headquarters. Any fuel, lubrication, or tyres purchased on the road must however be debited under their own headings.

#### WORKING COSTS

5 Cwt. (Price, less tyres, £135.)

<i>Running Costs.</i>	<i>d.</i>
Fuel at 22.5 m.p.g. . . . .	·73
Lubrication . . . . .	·06
Tyres . . . . .	·14
Maintenance . . . . .	·13
Repairs . . . . .	·36
Depreciation . . . . .	·17
	<hr/>
Per mile . . . . .	1.59
	<hr/>

## COMMERCIAL MOTOR ROAD TRANSPORT

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver (1st year lad)	.	91	-	-
Relief Service	.	9	-	-
Garage Expenses	.	11	10	-
Management	.	10	-	-
Licence	.	10	-	-
Insurance	.	12	12	-
Interest	.	6	15	-
Contingencies	.	5	-	-
		<hr/>		
		£155	17	-
		<hr/>		

## 10 Cwt. (Price, less tyres, £165.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 15.75 m.p.g.	.	1.05
Lubrication	.	.08
Tyres	.	.18
Maintenance	.	.14
Repairs	.	.46
Depreciation	.	.23
		<hr/>
Per mile	.	2.14
		<hr/>

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver	.	104	-	-
Relief Service	.	11	10	-
Garage Expenses	.	11	10	-
Management	.	10	-	-
Licence	.	15	-	-
Insurance	.	15	2	6
Interest	.	8	5	-
Contingencies	.	5	10	-
		<hr/>		
		£180	17	6
		<hr/>		

## 15 Cwt. (Price, less tyres, £200.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 14.5 m.p.g.	.	1.14
Lubrication	.	.10
Tyres	.	.25
Maintenance	.	.14
Repairs	.	.51
Depreciation	.	.28
		<hr/>
Per mile	.	2.42
		<hr/>

WHAT WORKING COSTS

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<i>Standing Costs.</i>	£	s.	d.
Wages, Driver (1st year lad)	104	—	—
Relief Service	12	—	—
Garage Expenses	11	10	—
Management	10	—	—
Licence	20	—	—
Insurance	15	2	6
Interest	10	—	—
Contingencies	5	15	—
	<u>£188</u>	<u>7</u>	<u>6</u>

20 Cwt. (Price, less tyres, £200.)

<i>Running Costs.</i>	d.
Fuel at 12.5 m.p.g.	1.32
Lubrication	.13
Tyres	.30
Maintenance	.16
Repairs	.58
Depreciation	.31
Per mile	<u>2.80</u>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver	117	—	—
Relief Service	12	15	—
Garage Expenses	12	6	—
Management	10	—	—
Licence	20	—	—
Insurance	16	4	6
Interest	10	—	—
Contingencies	6	—	—
	<u>£204</u>	<u>5</u>	<u>6</u>

30 Cwt. (Price, less tyres, £280.)

<i>Running Costs.</i>	d.
Fuel at 9.25 m.p.g.	1.78
Lubrication	.15
Tyres	.38
Maintenance	.19
Repairs	.64
Depreciation	.40
Per mile	<u>3.54</u>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	161	4	-
Relief Service . . . . .	14	10	-
Garage Expenses . . . . .	12	14	-
Management . . . . .	10	-	-
Licence . . . . .	20	-	-
Insurance . . . . .	16	4	6
Interest . . . . .	14	-	-
Contingencies . . . . .	6	10	-
	<hr/>		
	£255	2	6

## 40 Cwt. (Price, less tyres, £395.)

<i>Running Costs.</i>	d.
Fuel at 8.50 m.p.g. . . . .	1.94
Lubrication . . . . .	.13
Tyres . . . . .	.50
Maintenance . . . . .	.19
Repairs . . . . .	.67
Depreciation . . . . .	.56
	<hr/>
Per mile . . . . .	4.01

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	161	4	-
Relief Service . . . . .	14	15	-
Garage Expenses . . . . .	12	14	-
Management . . . . .	10	-	-
Licence . . . . .	25	-	-
Insurance . . . . .	19	12	9
Interest . . . . .	19	15	-
Contingencies . . . . .	7	-	-
	<hr/>		
	£270	-	9

## 8 Ton. (Price, less tyres, £580.)

<i>Running Costs.</i>	d.
Fuel at 6.25 m.p.g. . . . .	2.64
Lubrication . . . . .	.16
Tyres . . . . .	.59
Maintenance . . . . .	.21
Repairs . . . . .	.93
Depreciation . . . . .	.79
	<hr/>
Per mile . . . . .	5.32

WHAT WORKING COSTS

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<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	176	16	—
Relief Service . . . . .	17	5	—
Garage Expenses . . . . .	12	14	—
Management . . . . .	10	—	—
Licence . . . . .	32	—	—
Insurance . . . . .	19	12	9
Interest . . . . .	29	—	—
Contingencies . . . . .	7	10	—
	<hr/>		
	£304	17	9
	<hr/>		

4 Ton. (Price, less tyres, £730.)

<i>Running Costs.</i>	d.
Fuel at 6.00 m.p.g. . . . .	2.75
Lubrication . . . . .	.16
Tyres . . . . .	.79
Maintenance . . . . .	.21
Repairs . . . . .	.96
Depreciation . . . . .	1.01
	<hr/>
Per mile . . . . .	5.88
	<hr/>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	176	16	—
Relief Service . . . . .	18	5	—
Garage Expenses . . . . .	12	14	—
Management . . . . .	10	—	—
Licence . . . . .	38	8	—
Insurance . . . . .	19	12	9
Interest . . . . .	36	10	—
Contingencies . . . . .	8	—	—
	<hr/>		
	£320	5	9
	<hr/>		

5 Ton. (Price, less tyres, £810.)

<i>Running Costs.</i>	d.
Fuel at 5.50 m.p.g. . . . .	3.00
Lubrication . . . . .	.16
Tyres . . . . .	.99
Maintenance . . . . .	.23
Repairs . . . . .	1.01
Depreciation . . . . .	1.13
	<hr/>
Per mile . . . . .	6.52
	<hr/>

## COMMERCIAL MOTOR ROAD TRANSPORT

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .		176	16	-
Relief Service . . . . .		19	5	-
Garage Expenses . . . . .		12	14	-
Management . . . . .		10	-	-
Licence . . . . .		38	8	-
Insurance . . . . .		19	12	9
Interest . . . . .		40	10	-
Contingencies . . . . .		8	10	-
		<hr/>		
		£325	15	9

## 6 Ton. (Price, less tyres, £920.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 5·25 m.p.g. . . . .		3·14
Lubrication . . . . .		·16
Tyres . . . . .		1·19
Maintenance . . . . .		·23
Repairs . . . . .		1·01
Depreciation . . . . .		1·30
		<hr/>
Per mile . . . . .		7·03

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .		187	4	-
Relief Service . . . . .		20	10	-
Garage Expenses . . . . .		12	14	-
Management . . . . .		10	-	-
Licence . . . . .		43	4	-
Insurance . . . . .		19	12	9
Interest . . . . .		46	-	-
Contingencies . . . . .		9	-	-
		<hr/>		
		£348	4	9

## 7 Ton. (Price, less tyres, £990.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 5 m.p.g. . . . .		3·30
Lubrication . . . . .		·16
Tyres . . . . .		1·39
Maintenance . . . . .		·23
Repairs . . . . .		1·02
Depreciation . . . . .		1·42
		<hr/>
Per mile . . . . .		7·52

WHAT WORKING COSTS

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<i>Standing Costs.</i>		£	s.	d.
Wages, Driver . . . . .		187	4	—
Relief Service . . . . .		21	—	—
Garage Expenses . . . . .		12	14	—
Management . . . . .		10	—	—
Licence . . . . .		43	4	—
Insurance . . . . .		19	12	9
Interest . . . . .		49	10	—
Contingencies . . . . .		9	10	—
		<hr/>		
		£352	14	9
		<hr/>		

10 Ton. (Price, less tyres, £1,360.)

<i>Running Costs.</i>		d.
Fuel at 4.50 m.p.g. . . . .		3.66
Lubrication . . . . .		.17
Tyres . . . . .		1.79
Maintenance . . . . .		.26
Repairs . . . . .		1.09
Depreciation . . . . .		1.98
		<hr/>
Per mile . . . . .		8.95
		<hr/>

<i>Standing Costs.</i>		£	s.	d.
Wages, Driver . . . . .		187	4	—
Relief Service . . . . .		22	10	—
Garage Expenses . . . . .		13	2	—
Management . . . . .		10	—	—
Licence . . . . .		48	—	—
Insurance . . . . .		25	12	9
Interest . . . . .		68	—	—
Contingencies . . . . .		10	—	—
		<hr/>		
		£384	8	9
		<hr/>		

12 Ton. (Price, less tyres, £1,450.)

<i>Running Costs.</i>		d.
Fuel at 4.10 m.p.g. . . . .		4.02
Lubrication . . . . .		.17
Tyres . . . . .		2.00
Maintenance . . . . .		.26
Repairs . . . . .		1.12
Depreciation . . . . .		2.12
		<hr/>
Per mile . . . . .		9.69
		<hr/>



## COMMERCIAL MOTOR ROAD TRANSPORT

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .		176	16	-
Relief Service . . . . .		19	5	-
Garage Expenses . . . . .		12	14	-
Management . . . . .		10	-	-
Licence . . . . .		38	8	-
Insurance . . . . .		19	12	9
Interest . . . . .		40	10	-
Contingencies . . . . .		8	10	-
		<hr/>		
		£325	15	9
		<hr/>		

## 8 Ton. (Price, less tyres, £920.)

<i>Running Costs.</i>		<i>d.</i>		
Fuel at 5.25 m.p.g. . . . .		3	14	
Lubrication . . . . .			16	
Tyres . . . . .		1	19	
Maintenance . . . . .			23	
Repairs . . . . .		1	01	
Depreciation . . . . .		1	30	
		<hr/>		
	Per mile . . . . .	7	03	
		<hr/>		

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .		187	4	-
Relief Service . . . . .		20	10	-
Garage Expenses . . . . .		12	14	-
Management . . . . .		10	-	-
Licence . . . . .		43	4	-
Insurance . . . . .		19	12	9
Interest . . . . .		46	-	-
Contingencies . . . . .		9	-	-
		<hr/>		
		£348	4	9
		<hr/>		

## 7 Ton. (Price, less tyres, £990.)

<i>Running Costs.</i>		<i>d.</i>		
Fuel at 5 m.p.g. . . . .		3	30	
Lubrication . . . . .			16	
Tyres . . . . .		1	39	
Maintenance . . . . .			23	
Repairs . . . . .		1	02	
Depreciation . . . . .		1	42	
		<hr/>		
	Per mile . . . . .	7	52	
		<hr/>		

WHAT WORKING COSTS

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<i>Standing Costs.</i>		£	s.	d.
Wages, Driver	.	187	4	—
Relief Service	.	21	—	—
Garage Expenses	.	12	14	—
Management	.	10	—	—
Licence	.	43	4	—
Insurance	.	19	12	9
Interest	.	49	10	—
Contingencies	.	9	10	—
		<hr/>		
		£352	14	9
		<hr/>		

10 Ton. (Price, less tyres, £1,360.)

<i>Running Costs.</i>		d.
Fuel at 4·50 m.p.g.	.	3·66
Lubrication	.	·17
Tyres	.	1·79
Maintenance	.	·26
Repairs	.	1·09
Depreciation	.	1·98
		<hr/>
Per mile	.	8·95
		<hr/>

<i>Standing Costs.</i>		£	s.	d.
Wages, Driver	.	187	4	—
Relief Service	.	22	10	—
Garage Expenses	.	13	2	—
Management	.	10	—	—
Licence	.	48	—	—
Insurance	.	25	12	9
Interest	.	68	—	—
Contingencies	.	10	—	—
		<hr/>		
		£384	8	9
		<hr/>		

12 Ton. (Price, less tyres, £1,450.)

<i>Running Costs.</i>		d.
Fuel at 4·10 m.p.g.	.	4·02
Lubrication	.	·17
Tyres	.	2·00
Maintenance	.	·26
Repairs	.	1·12
Depreciation	.	2·12
		<hr/>
Per mile	.	9·69
		<hr/>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	24	15	-
Garage Expenses . . . . .	13	2	-
Management . . . . .	10	-	-
Licence . . . . .	48	-	-
Insurance . . . . .	26	12	9
Interest . . . . .	72	10	-
Contingencies . . . . .	10	10	-
	<hr/>		
	£392	13	9
	<hr/>		

### With Trailers.

The speeds permissible with trailers are detailed elsewhere (see Chapter XXV, page 339).

While then a trailer increases carrying capacity, it tends to a reduction in mileage and correspondingly higher overhead charges. Nevertheless, the rise in costs is not proportionate to the increase in loading capacity, and with big loads and trailers ton-mileage costs are very considerably lower than for single vehicles within the trailer hauling sizes, say from 3 to 7 tons. Moreover, the latitude it allows in carrying capacity may be a valuable asset, if loads vary much from day to day, as the trailer can be left at home when there is only enough load for the motor vehicle. Also, if a trailer can be dropped with one consignee on the way while the tractive vehicle goes on to dispose of its own load and pick up the trailer on its return, traffic can be carried at a minimum cost. On the other hand, trailer working has been considerably discounted by the coming of the big six-wheeler for 8 to 12 ton loads, since the latter can travel at anything from 25 to 50 per cent faster, legally and practically, according to the nature of its tyres, while its greater handiness also gives the big six-wheeler real advantages.

Taking these facts into consideration, the mileage capacity of a vehicle with a trailer, as compared with a single vehicle, may be put at about 80 per cent on

pneumatics and perhaps 66 per cent on solid tyres, the overheads correspondingly rising. For the rest—

**Fuel.** With a trailer carrying two-thirds the full load of the tractive vehicle consumption will generally increase about 33 per cent.

**Tyres.** For this item 30d. has been allowed.

**Maintenance.** Additional maintenance for the trailer will be incurred.

**Repairs.** The same applies to repairs, which, for the trailer, will probably average some £6 per annum.

**Wages.** With a trailer an assistant must generally be carried.

**Garage Expenses.** Larger accommodation will be required.

**Licence.** An additional duty of £6 is payable on a trailer.

**Insurance.** An additional premium of some 28s. up to £100 value is commonly charged on a trailer.

In these costs a trailer carrying about two-thirds the load of the tractive vehicle has been assumed.

**3 Ton.** (Price, less tyres, £680.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 5.00 m.p.g.	.	3.30
Lubrication	.	.18
Tyres	.	.89
Maintenance	.	.32
Repairs	.	1.00
Depreciation	.	.88
		<hr/>
Per mile	.	6.57

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver	.	176	16	—
„ Assistant	.	145	12	—
Relief Service	.	20	2	6
Garage Expenses	.	17	—	—
Management	.	10	—	—
Licence	.	38	—	—
Insurance	.	21	—	9
Interest	.	34	—	—
Contingencies	.	8	10	—
		<hr/>		
		£471	1	3

## COMMERCIAL MOTOR ROAD TRANSPORT

## 4 Ton. (Price, less tyres, £830.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 4.80 m.p.g.	. . . . .	3.44
Lubrication	. . . . .	.18
Tyres	. . . . .	1.09
Maintenance	. . . . .	.33
Repairs	. . . . .	1.03
Depreciation	. . . . .	1.09
		<hr/>
Per mile	. . . . .	7.16

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver	. . . . .	176	16	-
.. Assistant	. . . . .	145	12	-
Relief Service	. . . . .	21	15	-
Garage Expenses	. . . . .	17	-	-
Management	. . . . .	10	-	-
Licence	. . . . .	44	8	-
Insurance	. . . . .	21	-	9
Interest	. . . . .	41	10	-
Contingencies	. . . . .	9	10	-
		<hr/>		
		£487	11	9

## 5 Ton. (Price, less tyres, £910.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 4.40 m.p.g.	. . . . .	3.75
Lubrication	. . . . .	.18
Tyres	. . . . .	1.32
Maintenance	. . . . .	.35
Repairs	. . . . .	1.08
Depreciation	. . . . .	1.23
		<hr/>
Per mile	. . . . .	7.91

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver	. . . . .	176	16	-
.. Assistant	. . . . .	145	12	-
Relief Service	. . . . .	22	15	-
Garage Expenses	. . . . .	17	-	-
Management	. . . . .	10	-	-
Licence	. . . . .	44	8	-
Insurance	. . . . .	21	-	9
Interest	. . . . .	45	10	-
Contingencies	. . . . .	10	-	-
		<hr/>		
		£493	1	9

WHAT WORKING COSTS

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6 Ton. (Price, less tyres, £1,020.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 4.20 m.p.g.	. . . . .	3.93
Lubrication . . . . .	. . . . .	.18
Tyres . . . . .	. . . . .	1.49
Maintenance . . . . .	. . . . .	.35
Repairs . . . . .	. . . . .	1.08
Depreciation . . . . .	. . . . .	1.39
		<hr/>
Per mile . . . . .		8.42
		<hr/>

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	. . . . .	187	4	-
.. Assistant . . . . .	. . . . .	156	-	-
Relief Service . . . . .	. . . . .	24	-	-
Garage Expenses . . . . .	. . . . .	17	-	-
Management . . . . .	. . . . .	10	-	-
Licence . . . . .	. . . . .	49	4	-
Insurance . . . . .	. . . . .	21	-	9
Interest . . . . .	. . . . .	51	-	-
Contingencies . . . . .	. . . . .	10	10	-
		<hr/>		
		£525	18	9
		<hr/>		

7 Ton. (Price, less tyres, £1,090.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 4.00 m.p.g.	. . . . .	4.12
Lubrication . . . . .	. . . . .	.18
Tyres . . . . .	. . . . .	1.69
Maintenance . . . . .	. . . . .	.35
Repairs . . . . .	. . . . .	1.09
Depreciation . . . . .	. . . . .	1.51
		<hr/>
Per mile . . . . .		8.94
		<hr/>

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	. . . . .	187	4	-
.. Assistant . . . . .	. . . . .	156	-	-
Relief Service . . . . .	. . . . .	24	12	6
Garage Expenses . . . . .	. . . . .	17	-	-
Management . . . . .	. . . . .	10	-	-
Licence . . . . .	. . . . .	49	4	-
Insurance . . . . .	. . . . .	21	-	9
Interest . . . . .	. . . . .	54	10	-
Contingencies . . . . .	. . . . .	11	-	-
		<hr/>		
		£530	11	3
		<hr/>		

**Heavy Oil.**

As compared with petrol, the chief differences in working costs with heavy oil engines lie in the reduced fuel bill and rather higher capital charges due to their greater cost: apart from these points experience shows but little difference. The price for fuel has been put at 4½d. a gallon.

**6 Ton. (Price, less tyres, £1,340.)**

<i>Running Costs.</i>		<i>d.</i>
Fuel at 9·75 m.p.g.	. . . . .	·44
Lubrication . . . . .	. . . . .	·25
Tyres . . . . .	. . . . .	1·19
Maintenance . . . . .	. . . . .	·23
Repairs . . . . .	. . . . .	1·01
Depreciation . . . . .	. . . . .	1·89
		<hr/>
	Per mile . . . . .	5·01
		<hr/>

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	. . . . .	187	4	-
Relief Service . . . . .	. . . . .	20	10	-
Garage Expenses . . . . .	. . . . .	12	14	-
Management . . . . .	. . . . .	10	-	-
Licence . . . . .	. . . . .	48	-	-
Insurance . . . . .	. . . . .	19	12	9
Interest . . . . .	. . . . .	67	-	-
Contingencies . . . . .	. . . . .	9	-	-
		<hr/>		
		£374	-	9
		<hr/>		

**7 Ton. (Price, less tyres, £1,410.)**

<i>Running Costs.</i>		<i>d.</i>
Fuel at 9·30 m.p.g.	. . . . .	·46
Lubrication . . . . .	. . . . .	·25
Tyres . . . . .	. . . . .	1·39
Maintenance . . . . .	. . . . .	·23
Repairs . . . . .	. . . . .	1·02
Depreciation . . . . .	. . . . .	2·02
		<hr/>
	Per mile . . . . .	5·37
		<hr/>

WHAT WORKING COSTS

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<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	20	10	-
Garage Expenses . . . . .	12	14	-
Management . . . . .	10	-	-
Licence . . . . .	48	-	-
Insurance . . . . .	19	12	9
Interest . . . . .	70	10	-
Contingencies . . . . .	9	10	-
	<hr/>		
	£378	-	9
	<hr/>		

10 Ton. (Price, less tyres, £1,730.)

<i>Running Costs.</i>	d.
Fuel at 8.50 m.p.g. . . . .	.50
Lubrication . . . . .	.25
Tyres . . . . .	1.79
Maintenance . . . . .	.26
Repairs . . . . .	1.09
Depreciation . . . . .	2.52
	<hr/>
Per mile . . . . .	6.41
	<hr/>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	22	10	-
Garage Expenses . . . . .	13	2	-
Management . . . . .	10	-	-
Licence . . . . .	48	-	-
Insurance . . . . .	25	12	9
Interest . . . . .	86	10	-
Contingencies . . . . .	10	-	-
	<hr/>		
	£402	18	9
	<hr/>		

12 Ton. (Price, less tyres, £1,820.)

<i>Running Costs.</i>	d.
Fuel at 8.00 m.p.g. . . . .	.53
Lubrication . . . . .	.25
Tyres . . . . .	2.00
Maintenance . . . . .	.26
Repairs . . . . .	1.12
Depreciation . . . . .	2.66
	<hr/>
Per mile . . . . .	6.82
	<hr/>



202      **COMMERCIAL MOTOR ROAD TRANSPORT**

<i>Standing Costs.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	24	13	-
Garage Expenses . . . . .	13	2	-
Management . . . . .	10	-	-
Licence . . . . .	48	-	-
Insurance . . . . .	26	12	9
Interest . . . . .	91	-	-
Contingencies . . . . .	10	10	-
	<u>£411</u>	<u>3</u>	<u>9</u>

On the basis of these figures then the cost per mile over a wide range of annual mileages would work out as below, but it will of course be realized that some of the higher mileages given would be obtainable only under very exceptional conditions and with double manning, while some of the lowest are not such as to be profitable except to meet special circumstances.

**PER MILE WORKING COSTS FOR VARIOUS ANNUAL MILEAGES**  
(Pence per Mile)

Miles	6,000	7,500	10,000	12,500	15,000	20,000	25,000	30,000
<b>PETROL.</b>	<i>d.</i>	<i>d.</i>	<i>d.</i>	<i>d.</i>	<i>d.</i>	<i>d.</i>	<i>d.</i>	<i>d.</i>
<i>Single Vehicles.</i>								
<i>Pneumatic Tyred.</i>								
5 cwt.	7-82	6-38	5-33	4-58	4-08	3-46	3-09	2-84
10 "	9-34	7-93	6-48	5-61	5-03	4-31	3-84	3-50
15 "	10-06	8-45	6-94	6-04	5-43	4-68	4-23	3-93
20 "	10-97	9-34	7-70	6-73	6-07	5-23	4-76	4-43
30 "	13-74	11-70	9-66	8-44	7-60	6-60	5-99	5-58
40 "	14-81	12-65	10-49	9-19	8-33	7-23	6-60	6-17
3 tons	17-32	15-08	12-64	11-17	10-20	8-98	8-23	7-76
4 "	18-69	16-13	13-37	12-03	11-00	9-78	8-93	8-44
5 "	19-35	16-96	14-34	12-78	11-74	10-43	9-41	8-73
6 "	20-96	18-17	15-39	13-78	12-60	11-21	10-37	9-68
7 "	21-63	18-78	15-99	14-29	13-13	11-73	10-61	10-34
10 "	24-35	21-23	18-18	16-33	15-10	13-56	12-64	12-03
12 "	25-40	22-26	19-11	17-23	15-97	14-40	13-46	12-83
<i>With Trailer.</i>								
3 tons	25-41	21-64	17-88	15-61	14-11	12-22	11-09	10-34
4 "	26-31	22-76	18-86	16-38	14-96	13-01	11-84	11-06
5 "	27-63	23-69	19-74	17-38	15-80	13-83	12-64	11-85
6 "	29-46	25-25	21-04	18-31	16-84	14-73	13-47	12-63
7 "	30-16	25-91	21-67	19-12	17-43	15-31	14-03	13-18
<b>HEAVY OIL.</b>								
6 tons	19-97	16-98	13-99	12-19	10-99	9-50	8-60	8-00
7 "	20-49	17-47	14-44	12-63	11-42	9-91	9-00	8-39
10 "	22-33	19-30	16-08	14-13	12-86	11-23	10-28	9-63
12 "	23-17	19-98	16-69	14-71	13-40	11-73	10-77	10-11

With double manning of course the second driver's wages would have to be added to obtain the total per-mile cost.

Should the cost per ton-mile be required, it can be obtained merely by dividing the total vehicle per-mile cost by the number of tons carried.

## CHAPTER XV

### WHAT WORKING COSTS—GOODS VEHICLES, STEAM AND ELECTRIC

THE same remarks as for petrol apply to the items here with the following exceptions.

#### **Steam Vehicles.**

**Fuel.** Consumptions vary much according to the fuel used. Welsh steam coal gives the best results. For example, on a typical test within the writer's knowledge a wagon running on Welsh consumed 1.4 lb. of Nixon's Navigation per ton-mile, while on gas coke the figure was 1.8 lb., and this in spite of the fact that the boiler was well suited to burning coke. Consumption then broadly varies with quality, and quality and price more or less balance each other. Price of course varies with the locality as well as the grade, and it has been assumed that the fuel is bought by the truck load at 35s. per ton and an allowance of 20 per cent has been made for loss and wastage, as is not unusual.

**Water.** Not infrequently water supplies are required on the road and in urban areas at any rate these entail small payments, an allowance for which has consequently been included.

**Lubrication.** For the old overhead or loco type wagons with unenclosed engines a fair allowance is 1½ pt. of oil for valves and cylinders, 2 pt. for the motion and other parts, and ½ lb. of grease per 100 miles. For enclosed engines 1 gal. per 100 miles may be allowed.

**Tyres.** Owing to the elastic nature of the power steam is fairly easy on tyres, but for comparable sizes heavier weight has to be carried and so tyres are rather larger than for petrol wagons.

**Maintenance.** Boilers must periodically be washed

out to remove scale and dirt and a vehicle should be laid off for this process at least once a fortnight or, far preferably, once a week unless the mileage is very small. This weekly washing out adds considerably to maintenance cost; and so, too, does the need for lighting up and steam raising; for, if a man is not employed for the work, it shortens the driver's time on the road or may result in overtime, even though he can be "going over" his vehicle while steam is raising. In the figures it has been assumed that the driver or his mate do the work, which is paid at time and a half rate on Sundays.

**Repairs.** The boiler tends to send up costs under this heading; otherwise repair costs would probably be rather lower than for petrol vehicles of similar capacity.

**Insurance.** This again has been based on the conditions of work in large towns, with an addition of £2 10s. to cover boiler insurance, which is most advisable, especially for the small owner.

## PNEUMATIC TYRES

5 Ton. (Price, less tyres, £940.)

<i>Running Costs.</i>		<i>d.</i>
Fuel at 6·75 lb.p.m. . . . .		1·52
Water . . . . .		·07
Lubrication . . . . .		·25
Tyres . . . . .		·99
Maintenance . . . . .		·40
Repairs . . . . .		1·18
Depreciation . . . . .		1·35
		<u>5·76</u>
<i>Standing Costs.</i>		<i>£ s. d.</i>
Wages, Driver . . . . .	187 4 -	
Relief Service . . . . .	16 5 -	
Garage Expenses . . . . .	12 14 -	
Management . . . . .	10 - -	
Licence . . . . .	48 - -	
Insurance . . . . .	22 12 9	
Interest . . . . .	47 - -	
Contingencies . . . . .	8 10 -	
	<u>£352 5 9</u>	

**6 Ton. (Price, less tyres, £965.)**

<i>Running Costs.</i>		<i>d.</i>
Fuel at 7.25 lb.p.m.	.	1.63
Water	.	.07
Lubrication	.	.25
Tyres	.	1.19
Maintenance	.	.40
Repairs	.	1.18
Depreciation	.	1.39
		<hr/>
		6.11
		<hr/>

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver	.	187	4	-
Relief Service	.	16	12	6
Garage Expenses	.	12	14	-
Management	.	10	-	-
Licence	.	48	-	-
Insurance	.	22	12	9
Interest	.	48	5	-
Contingencies	.	9	-	-
		<hr/>		
		£354	8	3
		<hr/>		

**7 Ton. (Price, less tyres, £990.)**

<i>Running Costs.</i>		<i>d.</i>
Fuel at 7.75 lb.p.m.	.	1.74
Water	.	.07
Lubrication	.	.25
Tyres	.	1.39
Maintenance	.	.40
Repairs	.	1.19
Depreciation	.	1.43
		<hr/>
		6.47
		<hr/>

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver	.	187	4	-
Relief Service	.	17	-	-
Garage Expenses	.	12	14	-
Management	.	10	-	-
Licence	.	48	-	-
Insurance	.	22	12	9
Interest	.	49	10	-
Contingencies	.	9	10	-
		<hr/>		
		£356	10	9
		<hr/>		

## WHAT WORKING COSTS

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**10 Ton.** (Price, less tyres, £1,260.)

<i>Running Costs.</i>	<i>d.</i>
Fuel at 9.25 lb.p.m. . . . .	2.08
Water . . . . .	.07
Lubrication . . . . .	.26
Tyres . . . . .	1.79
Maintenance . . . . .	.43
Repairs . . . . .	1.27
Depreciation . . . . .	1.89
	<hr/>
	7.79

<i>Standing Costs.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	19	2	6
Garage Expenses . . . . .	13	2	-
Management . . . . .	10	-	-
Licence . . . . .	48	-	-
Insurance . . . . .	28	12	9
Interest . . . . .	63	-	-
Contingencies . . . . .	10	-	-
	<hr/>		
	£379	1	3

**12 Ton.** (Price, less tyres, £1,340.)

<i>Running Costs.</i>	<i>d.</i>
Fuel at 10.00 lb.p.m. . . . .	2.35
Water . . . . .	.07
Lubrication . . . . .	.26
Tyres . . . . .	2.00
Maintenance . . . . .	.43
Repairs . . . . .	1.30
Depreciation . . . . .	1.93
	<hr/>
	8.34

<i>Standing Costs.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	19	15	-
Garage Expenses . . . . .	13	2	-
Management . . . . .	10	-	-
Licence . . . . .	48	-	-
Insurance . . . . .	29	12	9
Interest . . . . .	67	10	-
Contingencies . . . . .	10	10	-
	<hr/>		
	£385	13	9

**With Solid Tyres.**

With the exception of certain vehicles for municipal work and those of not more than 4 tons unladen weight working mostly over rough ground, all vehicles registered after 1932 have to be mounted on pneumatic tyres, although those registered before that date limit are granted exemption till the beginning of 1940. After that, with the exceptions mentioned, all motor road traffic must be pneumatic tyred. The solid rubber tyre is therefore assuming ever less importance in the order of things; but, as many of the largest vehicles are still using it, the following costs are appended as means of comparison.

Solid tyres reduce mileage. For single heavy vehicles the legal speeds are 20 m.p.h. on pneumatics, 16 m.p.h. on solids, and with trailers 16 and 8 m.p.h. respectively; but, for single vehicle working at any rate, the practical difference is greater than the legal limits would imply: on an average pneumatic speeds are practically some 33 per cent higher than on solids. While, therefore, directly the solid tyre costs less than the pneumatic, both in consumption and maintenance, it decidedly increases the overheads. Further, it is heavier on fuel, usually by fully 10 per cent, and sends up the repair bill on an average by something like 15 to 20 per cent. Thus the costs on solids actually run higher in some cases than with pneumatics, which would have been thought a surprising result even a year or two ago.

**8 Ton. (Price, less tyres, £875.)**

<i>Running Costs.</i>	<i>d.</i>
Fuel at 7.50 lb.p.m. . . . .	1.69
Water . . . . .	.07
Lubrication . . . . .	.25
Tyres . . . . .	.79
Maintenance . . . . .	.35
Repairs . . . . .	1.41
Depreciation . . . . .	1.33
	<hr/>
	5.91
	<hr/>

WHAT WORKING COSTS

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<i>Standing Costs.</i>		£	s.	d.
Wages, Driver . . . . .		187	4	—
Relief Service . . . . .		14	10	—
Garage Expenses . . . . .		12	14	—
Management . . . . .		10	—	—
Licence . . . . .		60	—	—
Insurance . . . . .		22	12	9
Interest . . . . .		43	15	—
Contingencies . . . . .		8	10	—
		<hr/>		
		£359	5	9

6 Ton. (Price, less tyres, £900.)

<i>Running Costs.</i>		d.
Fuel at 8·00 lb.p.m. . . . .		1·80
Water . . . . .		·07
Lubrication . . . . .		·25
Tyres . . . . .		·96
Maintenance . . . . .		·35
Repairs . . . . .		1·41
Depreciation . . . . .		1·39
		<hr/>
		6·23

<i>Standing Costs.</i>		£	s.	d.
Wages, Driver . . . . .		187	4	—
Relief Service . . . . .		14	15	—
Garage Expenses . . . . .		12	14	—
Management . . . . .		10	—	—
Licence . . . . .		60	—	—
Insurance . . . . .		22	12	9
Interest . . . . .		45	—	—
Contingencies . . . . .		9	—	—
		<hr/>		
		£361	5	9

7 Ton. (Price, less tyres, £925.)

<i>Running Costs.</i>		d.
Fuel at 8·50 lb.p.m. . . . .		1·91
Water . . . . .		·07
Lubrication . . . . .		·25
Tyres . . . . .		1·12
Maintenance . . . . .		·35
Repairs . . . . .		1·43
Depreciation . . . . .		1·43
		<hr/>
		6·56



210      COMMERCIAL MOTOR ROAD TRANSPORT

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	15	-	-
Garage Expenses . . . . .	12	14	-
Management . . . . .	10	-	-
Licence . . . . .	60	-	-
Insurance . . . . .	22	12	9
Interest . . . . .	46	5	-
Contingencies . . . . .	9	10	-
	<hr/>		
	£363	5	9

10 Ton. (Price, less tyres, £1,125.)

<i>Running Costs.</i>	d.
Fuel at 10·00 lb.p.m. . . . .	2·25
Water . . . . .	·07
Lubrication . . . . .	·26
Tyres . . . . .	1·60
Maintenance . . . . .	·38
Repairs . . . . .	1·52
Depreciation . . . . .	1·74
	<hr/>
	7·82

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
Relief Service . . . . .	16	5	-
Garage Expenses . . . . .	13	2	-
Management . . . . .	10	-	-
Licence . . . . .	60	-	-
Insurance . . . . .	28	12	9
Interest . . . . .	56	5	-
Contingencies . . . . .	10	-	-
	<hr/>		
	£381	8	9

12 Ton. (Price, less tyres, £1,200.)

<i>Running Costs.</i>	d.
Fuel at 10·75 lb.p.m. . . . .	2·42
Water . . . . .	·07
Lubrication . . . . .	·26
Tyres . . . . .	1·92
Maintenance . . . . .	·38
Repairs . . . . .	1·52
Depreciation . . . . .	1·85
	<hr/>
	8·42

WHAT WORKING COSTS

211

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	—
Relief Service . . . . .	16	17	6
Garage Expenses . . . . .	13	2	—
Management . . . . .	10	—	—
Licence . . . . .	60	—	—
Insurance . . . . .	28	12	9
Interest . . . . .	60	—	—
Contingencies . . . . .	10	10	—
	<hr/>		
	£386	6	3

WITH TRAILER, PNEUMATIC TYRED

5 Ton. (Price, less tyres, £1,040.)

<i>Running Costs.</i>	d.
Fuel at 9·75 lb.p.m. . . . .	2·19
Water . . . . .	·07
Lubrication . . . . .	·25
Tyres . . . . .	1·32
Maintenance . . . . .	·52
Repairs . . . . .	1·25
Depreciation . . . . .	1·47
	<hr/>
	7·07

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	—
Assistant . . . . .	158	12	—
Relief Service . . . . .	21	10	—
Garage Expenses . . . . .	17	—	—
Management . . . . .	10	—	—
Licence . . . . .	54	—	—
Insurance . . . . .	24	—	9
Interest . . . . .	52	—	—
Contingencies . . . . .	10	—	—
	<hr/>		
	£534	6	9

6 Ton. (Price, less tyres, £1,065.)

<i>Running Costs.</i>	d.
Fuel at 10·25 lb.p.m. . . . .	2·31
Water . . . . .	·07
Lubrication . . . . .	·27
Tyres . . . . .	1·49
Maintenance . . . . .	·52
Repairs . . . . .	1·25
Depreciation . . . . .	1·50
	<hr/>
	7·41

212      **COMMERCIAL MOTOR ROAD TRANSPORT**

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
"   Assistant . . . . .	158	12	-
Relief Service . . . . .	21	17	6
Garage Expenses . . . . .	17	-	-
Management . . . . .	10	-	-
Licence . . . . .	54	-	-
Insurance . . . . .	24	-	9
Interest . . . . .	53	5	-
Contingencies . . . . .	10	10	-
	<hr/>		
	£336	9	3

**7 Ton. (Price, less tyres, £1,090.)**

<i>Running Costs.</i>	d.
Fuel at 11-00 lb.p.m. . . . .	2-47
Water . . . . .	0-07
Lubrication . . . . .	0-27
Tyres . . . . .	1-69
Maintenance . . . . .	0-52
Repairs . . . . .	1-26
Depreciation . . . . .	1-69
	<hr/>
	7-97

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
"   Assistant . . . . .	158	12	-
Relief Service . . . . .	22	7	6
Garage Expenses . . . . .	17	-	-
Management . . . . .	10	-	-
Licence . . . . .	54	-	-
Insurance . . . . .	24	-	9
Interest . . . . .	54	10	-
Contingencies . . . . .	11	-	-
	<hr/>		
	£538	14	3

**WITH TRAILER, SOLID TYRED**

**5 Ton. (Price, less tyres, £975.)**

<i>Running Costs.</i>	d.
Fuel at 10-50 lb.p.m. . . . .	2-36
Water . . . . .	0-07
Lubrication . . . . .	0-27
Tyres . . . . .	1-04
Maintenance . . . . .	0-47
Repairs . . . . .	1-50
Depreciation . . . . .	1-85
	<hr/>
	7-56

WHAT WORKING COSTS

213

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
" Assistant . . . . .	158	12	-
Relief Service . . . . .	20	5	-
Garage Expenses . . . . .	17	-	-
Management . . . . .	10	-	-
Licence . . . . .	66	-	-
Insurance . . . . .	24	-	9
Interest . . . . .	48	15	-
Contingencies . . . . .	10	-	-
	<hr/>		
	£541	16	9

**6 Ton.** (Price, less tyres, £1,000.)

<i>Running Costs.</i>	d.
Fuel at 11.00 lb.p.m. . . . .	2.47
Water . . . . .	.07
Lubrication . . . . .	.27
Tyres . . . . .	1.21
Maintenance . . . . .	.47
Repairs . . . . .	1.50
Depreciation . . . . .	2.09
	<hr/>
	8.08

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	-
" Assistant . . . . .	158	12	-
Relief Service . . . . .	20	15	-
Garage Expenses . . . . .	17	-	-
Management . . . . .	10	-	-
Licence . . . . .	66	-	-
Insurance . . . . .	24	-	9
Interest . . . . .	50	-	-
Contingent Fund . . . . .	10	10	-
	<hr/>		
	£544	1	9

**7 Ton.** (Price, less tyres, £1,025.)

<i>Running Costs.</i>	d.
Fuel at 11.50 lb.p.m. . . . .	2.59
Water . . . . .	.07
Lubrication . . . . .	.27
Tyres . . . . .	1.37
Maintenance . . . . .	.47
Repairs . . . . .	1.52
Depreciation . . . . .	2.13
	<hr/>
	8.42

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<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	187	4	—
„ Assistant . . . . .	158	12	—
Relief Service . . . . .	21	—	—
Garage Expenses . . . . .	17	—	—
Management . . . . .	10	—	—
Licence . . . . .	66	—	—
Insurance . . . . .	24	—	9
Interest . . . . .	51	5	—
Contingent Fund . . . . .	11	—	—
	<b>£546</b>	<b>1</b>	<b>9</b>

For various annual mileages then vehicle cost per mile would be—

PER MILE WORKING COSTS FOR VARIOUS ANNUAL MILEAGES  
(Pence per Mile)

Miles	6,000	7,500	10,000	12,500	15,000	20,000	25,000	30,000
<i>STEAM.</i>								
<i>Single Vehicles.</i>								
<i>Pneumatic Tyred.</i>								
5 tons	19·85	17·03	14·21	12·32	11·40	9·99	9·14	8·58
6 "	20·29	17·45	14·62	12·91	11·78	10·36	9·51	8·95
7 "	20·73	17·88	15·03	13·32	12·17	10·75	9·89	9·33
10 "	22·95	19·93	16·89	15·07	13·86	12·34	11·43	10·82
12 "	23·77	20·68	17·60	15·75	14·31	12·97	12·04	11·43
<i>Solid Tyred.</i>								
5 "	20·27	17·41	14·53	12·81	11·66	10·22	9·36	8·78
6 "	20·68	17·79	14·90	13·17	12·01	10·57	9·70	9·12
7 "	21·09	18·19	15·28	13·54	12·37	10·92	10·05	9·47
10 "	23·08	20·03	16·97	15·24	13·92	12·40	11·48	10·87
12 "	23·87	20·76	17·69	15·84	14·60	13·06	12·13	11·51
<i>With Trailer.</i>								
<i>Pneumatic Tyred.</i>								
5 "	28·44	24·17	19·89	17·33	15·62	13·48	12·20	11·34
6 "	28·87	24·58	20·29	17·71	15·99	13·83	12·56	11·70
7 "	29·31	25·21	20·90	18·31	16·59	14·43	13·14	12·28
<i>Solid Tyred.</i>								
5 "	29·23	24·90	20·56	17·96	16·23	14·06	12·76	11·89
6 "	29·84	25·49	21·14	18·53	16·79	14·61	13·30	12·43
7 "	30·26	25·89	21·53	18·90	17·16	14·97	13·66	12·79

**Electric Vehicles.**

Under practical working conditions the electric vehicle is restricted to a speed of about 17 m.p.h., and owing to this and its relatively limited range of action without recharging batteries its mileage capacity is comparatively low and overheads consequently high. Nevertheless, thanks to its handiness and rapid

acceleration, its average speed is not as low as might appear in congested areas where conditions permit only slow running; and under these conditions, when daily distances range only from, say, 20 to 35 miles, the electric has its sphere, though the increase of the legal speed limits under the Road Traffic Act may conceivably lessen its scope even here. Still, the point is that the electric covers a field in which other sources of power might not offer a commercial proposition, and, that being so, comparison between it and petrol or steam, particularly the former, are hardly fair or possible in ordinary conditions. Also electrics are not generally made in quite the same sizes as petrol vehicles, which renders comparison still more difficult.

**Electric Energy.** The price has been put at 1d. per unit, inclusive of all charging expenses, which is high.

**Battery Renewals.** This is the most considerable item in electric vehicle working. In time the batteries become worn out and have to be replaced; but the makers supply them under a guarantee, which is for three years in the case of the lead Ironclad-Exide batteries exemplified in the figures. Nickel-iron and alkaline batteries are guaranteed for considerably longer periods, but their cost is proportionately higher and their efficiency is lower. As the lead-acid cells, on which these costs are based, more often than not considerably outlast their guarantee, and nothing has been allowed for the value of the worn out batteries, the figures should be well on the safe side.

**Tyres.** Owing to its moderate speeds and easy controllability the electric is very easy on tyres, and costs are low under this item. For the two ton sizes, and above, solid tyres have generally been fitted, as full advantage can seldom be taken of pneumatic tyre speeds; moreover, in the larger capacities the use of the electric in this country is almost exclusively confined

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to municipal purposes in work for which solid tyres are specially permitted under the law.

**Wages** are on the generous side and, as one of the main claims of the electric is the possible employment of relatively unskilled men for driving (always provided they are possessed of road sense), quite possibly a reduction may be effected on this item.

**Insurance.** Up to 30 cwt. carrying capacity the same premiums are charged as for light goods vehicles not exceeding 10 h.p. and an extra 10s. 6d. is payable for a value in excess of £300.

**7 Cwt. (Price, less tyres, £170.)**

<i>Running Costs.</i>	<i>d.</i>
Electric Energy . . . . .	'40
Battery Renewals . . . . .	'37
Lubrication . . . . .	'02
Tyres . . . . .	'16
Maintenance . . . . .	'24
Repairs . . . . .	'34
Depreciation . . . . .	'33
	<hr/>
	1-86

<i>Standing Costs.</i>	<i>£ s. d.</i>
Wages, Driver . . . . .	91 - -
Relief Service . . . . .	5 - -
Garage Expenses . . . . .	11 10 -
Management . . . . .	10 - -
Licence . . . . .	6 - -
Insurance . . . . .	12 12 -
Interest . . . . .	8 10 -
Contingencies . . . . .	5 - -
	<hr/>
	£149 12 -

**10 Cwt. (Price, less tyres, £185.)**

<i>Running Costs.</i>	<i>d.</i>
Electric Energy . . . . .	'49
Battery Renewals . . . . .	'45
Lubrication . . . . .	'02
Tyres . . . . .	'17
Maintenance . . . . .	'24
Repairs . . . . .	'35
Depreciation . . . . .	'35
	<hr/>
	2-07

WHAT WORKING COSTS

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<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	104	-	-
Relief Service . . . . .	6	2	6
Garage Expenses . . . . .	11	10	-
Management . . . . .	10	-	-
Licence . . . . .	6	-	-
Insurance . . . . .	12	12	-
Interest . . . . .	9	5	-
Contingencies . . . . .	5	10	-
	<u>£164</u>	<u>19</u>	<u>6</u>

15 Cwt. (Price, less tyres, £210.)

<i>Running Costs.</i>	d.
Electric Energy . . . . .	·63
Battery Renewals . . . . .	·63
Lubrication . . . . .	·02
Tyres . . . . .	·24
Maintenance . . . . .	·24
Repairs . . . . .	·35
Depreciation . . . . .	·40
	<u>2·51</u>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	104	-	-
Relief Service . . . . .	6	10	-
Garage Expenses . . . . .	11	10	-
Management . . . . .	10	-	-
Licence . . . . .	6	-	-
Insurance . . . . .	12	12	-
Interest . . . . .	10	10	-
Contingencies . . . . .	5	15	-
	<u>£166</u>	<u>17</u>	<u>-</u>

20 Cwt. (Price, less tyres, £330.)

<i>Running Costs.</i>	d.
Electric Energy . . . . .	·75
Battery Renewals . . . . .	·99
Lubrication . . . . .	·02
Tyres . . . . .	·28
Maintenance . . . . .	·25
Repairs . . . . .	·36
Depreciation . . . . .	·62
	<u>3·27</u>



## COMMERCIAL MOTOR ROAD TRANSPORT

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	117	-	-
Relief Service . . . . .	7	17	6
Garage Expenses . . . . .	12	6	-
Management . . . . .	10	-	-
Licence . . . . .	6	-	-
Insurance . . . . .	13	2	6
Interest . . . . .	16	10	-
Contingencies . . . . .	6	-	-
	<hr/>		
	£188	16	-
	<hr/>		

## 40 Cwt. (Price, less tyres, £425.)

<i>Running Costs.</i>	d.
Electric Energy . . . . .	1·10
Battery Renewals . . . . .	1·41
Lubrication . . . . .	·03
Tyres . . . . .	·30
Maintenance . . . . .	·25
Repairs . . . . .	·45
Depreciation . . . . .	·82
	<hr/>
	4·36
	<hr/>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	117	4	-
Relief Service . . . . .	10	10	-
Garage Expenses . . . . .	12	14	-
Management . . . . .	10	-	-
Licence . . . . .	13	-	-
Insurance . . . . .	13	2	6
Interest . . . . .	21	5	-
Contingencies . . . . .	7	-	-
	<hr/>		
	£204	15	6
	<hr/>		

## 2½ Ton. (Price, less tyres, £510.)

<i>Running Costs.</i>	d.
Electric Energy . . . . .	1·19
Battery Renewals . . . . .	1·73
Lubrication . . . . .	·03
Tyres . . . . .	·35
Maintenance . . . . .	·26
Repairs . . . . .	·49
Depreciation . . . . .	·98
	<hr/>
	5·03
	<hr/>

WHAT WORKING COSTS

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<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	130	16	—
Relief Service . . . . .	11	10	—
Garage Expenses . . . . .	12	14	—
Management . . . . .	10	—	—
Licence . . . . .	20	—	—
Insurance . . . . .	13	2	6
Interest . . . . .	25	10	—
Contingencies . . . . .	7	5	—
	<hr/>		
	£230	17	6
	<hr/>		

**3½ Ton.** (Price, less tyres, £640.)

<i>Running Costs.</i>	d.
Electric Energy . . . . .	1·25
Battery Renewals . . . . .	2·46
Lubrication . . . . .	·03
Tyres . . . . .	·52
Maintenance . . . . .	·26
Repairs . . . . .	·56
Depreciation . . . . .	1·23
	<hr/>
	6·31
	<hr/>

<i>Standing Costs.</i>	£	s.	d.
Wages, Driver . . . . .	156	16	—
Relief Service . . . . .	13	—	—
Garage Expenses . . . . .	12	14	—
Management . . . . .	10	—	—
Licence . . . . .	24	—	—
Insurance . . . . .	13	2	6
Interest . . . . .	32	—	—
Contingencies . . . . .	7	15	—
	<hr/>		
	£269	7	6
	<hr/>		

**5 Ton.** (Price, less tyres, £705.)

<i>Running Costs.</i>	d.
Electric Energy . . . . .	1·50
Battery Renewals . . . . .	2·77
Lubrication . . . . .	·03
Tyres . . . . .	·75
Maintenance . . . . .	·26
Repairs . . . . .	·65
Depreciation . . . . .	1·35
	<hr/>
	7·31
	<hr/>

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<i>Standing Costs.</i>		£	s.	d.
Wages, Driver . . . . .		176	16	-
Relief Service . . . . .		14	-	-
Garage Expenses . . . . .		12	14	-
Management . . . . .		10	-	-
Licence . . . . .		27	-	-
Insurance . . . . .		13	2	6
Interest . . . . .		35	5	-
Contingencies . . . . .		8	10	-
		<hr/>		
		£297	7	6

PER MILE WORKING COSTS FOR VARIOUS ANNUAL MILEAGES  
(Pence per Mile)

Miles	3,000	6,000	7,500	10,000	12,500	15,000	17,500
<i>Electric.</i>	d.	d.	d.	d.	d.	d.	d.
<i>Single Vehicles.</i>							
<i>Pneumatic Tyred.</i>							
7 cwt.	9-08	7-83	6-63	5-44	4-72	4-23	3-91
10 ..	9-99	8-67	7-35	6-03	5-24	4-71	4-33
13 ..	10-34	9-18	7-83	6-31	5-71	5-18	4-80
20 ..	11-33	10-04	8-31	7-00	6-09	5-59	5-06
<i>Solid Tyred.</i>							
40 cwt.	14-19	12-55	10-91	9-27	8-29	7-64	7-17
50 ..	16-11	14-17	12-04	10-37	9-46	8-72	8-20
3½ tons	19-04	17-09	14-93	12-76	11-48	10-68	10-00
5 ..	21-38	19-21	16-63	14-43	13-08	12-07	11-39

## CHAPTER XVI

### WHAT WORKING COSTS—PASSENGER VEHICLES

It must be realized from the outset that the conditions and requirements of passenger working differ greatly in many important respects from those of goods conveyance. In the first place it is controlled by government regulations and supervision to a far greater extent, even to the charges for fares and to the routes taken in the case of bus services. Then also working must be keyed up to a higher standard than is customary in goods transport: schedule times have to be observed more rigidly, speed is of more importance and mileages are ordinarily far greater; quite commonly 30,000 to 45,000 are covered by a vehicle each year and yearly mileages approaching 70,000 are not unknown. Therefore, while the first cost of vehicles is necessarily higher and they cost more for maintenance, the overhead expense per mile is relatively low.

Since the conveyance of passengers is practically always undertaken for direct profit—primarily for the sale of transport and not as a mere means to an end in another business—the costs of administrative and traffic working can also be included; and this is the more advisable in that it facilitates making certain returns required by the Ministry of Transport.

Passenger working may be divided into three broad classes. There is the local bus service, the longer distance bus or coach service, and touring; but, though some of the conditions vary very considerably in these different classes of work, in the net result there is no great dissimilarity, and costs in one class of vehicle working, as apart from traffic costs, will not deviate

from those in another so greatly as to prevent one set of figures acting as a general guide for all, provided those figures are applied with intelligence to individual requirements. The chief difference lies in the annual mileages of regular services as contrasted with seasonal work; but that can be allowed for merely by modifying the depreciation figure to the length of life as estimated on annual mileage.

Now for a few notes on some of the items.

**Lighting** of vehicles is a small additional, though quite material, matter, chiefly for renewals of electric bulbs.

**Maintenance.** In passenger working the cost of running repairs should be entered under the "Repairs" heading, whoever performs them, because the annual repair cost has to be given in a yearly financial return to the Ministry of Transport. Maintenance therefore in the main represents cleaning, which, with highly finished bodies requiring daily attention inside and out, is a good deal higher than in goods service. Cleaning costs show much diversity. For fifty-two buses of sundry sizes at Leicester the cost worked out at .771d., in Birmingham 379 large buses cost only .336d. per mile; and neither the car-mileages nor the difference in the sizes of the fleets can altogether account for so great a disparity.

**Uniforms.** As these add relatively little to the cost and smart appearance is a distinct asset, they usually justify their expense.

**Wages.** Drivers' and conductors' wages have also to be entered in the M.O.T. financial return, so should be kept separate. In the two cases where the employment of conductors has been assumed the wages have been put at 32s. 6d. and 35s. per week respectively.

**Hire.** This also has to be included in the financial return.



**LONDON'S BUSES, SIX- AND FOUR-WHEELED, BUT BOTH WITH THE ENCLOSED UPPER DECK THAT HAS NOW BECOME THE STANDARD THING FOR CITY TRAFFIC**

*(By courtesy of the London General Omnibus Co., Ltd.)*

**Garage Expenses.** Repairs to "buildings and fixtures" and to "machinery and plant" are other items that have to be entered in the return, and should be kept distinct.

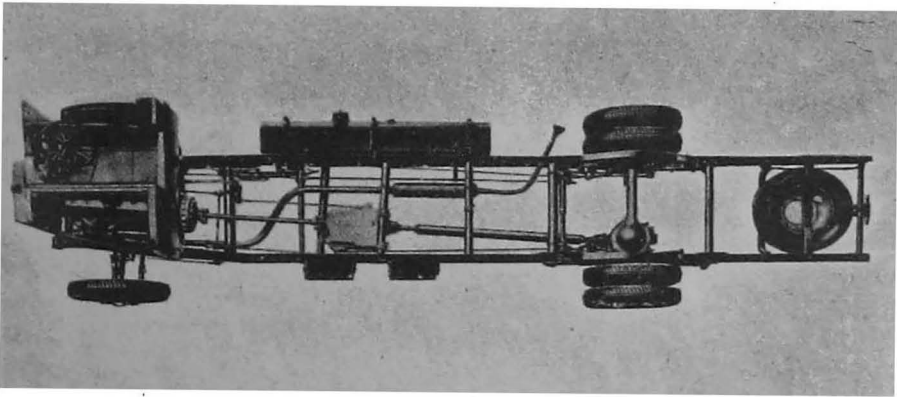
**Administration Expenses.** This heading represents both traffic and office expenses and, since in a small business it is generally difficult to separate out the management of the vehicles from that of the traffic, both may also be included, allocated as required. In the traffic figures, office expenses and salaries and wages of the traffic staff are included, ticket check, travelling, any garage fees or men's expenses incurred away from headquarters, and incidental items. In a small business ticket checking need involve no serious expenditure, but in a large bus organization it may amount to an appreciable figure; at Birmingham, for instance, it cost ·177d. a mile, while at Edinburgh it was ·238d., and at Cardiff ·25d. per mile. Office expenses will comprise office rent, rates, light, heating, cleaning, telephone, postage, financial charges like auditor's fees, stationery, publicity, etc.

**Licences.** It is to be noticed that this heading is in the plural, because, in addition to the ordinary vehicle duty, for passenger working a certificate of fitness, and a public service vehicle licence will be required in the case of a local service; and for longer distances a road service licence, besides backings for that licence if the service extends beyond the traffic area in which the licence is issued. For costs of these special licences see Chapter XXV, pages 349 and 350.

**Insurance.** The rates for buses "entering large towns," as given in Chapter XIII (page 181), have been assumed, plus insurance against liability for injury to passengers.

**Depreciation.** As it is not necessary for purposes of comparison to regard this as a running charge, it has

been entered as an overhead, for income tax purposes, 20 per cent on the written down values being allowed by the authorities. As shown by the table in Chapter XIII (page 182), this gives a life of 10 years before the value is written down to approximately 10 per cent of its original; but on the mileage commonly covered in passenger working this is quite inadequate, the average being more nearly five years. True, when a vehicle is



IN THIS FORWARD-CONTROL DAIMLER PASSENGER CHASSIS ENGINE AND TRANSMISSION LINE ARE OFF-SET AT AN ANGLE TO THE SIDE

*(By courtesy of Daimler Co., Ltd.)*

replaced allowance is also made for the difference between the actual and the 20 per cent written down value; but it is best to treat this difference as an obsolescence charge which should be covered by a reserve before any yearly profits are distributed. For simplicity in showing average values over a number of years in our costs the depreciation and obsolescence have been combined under the former heading at a rate allowing for approximately a five year life.

The figures on page 228 give the total per-mile cost for different annual mileages up to the maximum likely to be possible for a single driver, but even then probably



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**14-18 Seats. (Price, less tyres, £570.)**

<i>Running Costs.</i>		<i>d.</i>
Fuel at 12.50 m.p.g. . . . .		1.25
Lubrication . . . . .		.15
Tyres . . . . .		.44
Lighting . . . . .		.03
Maintenance . . . . .		.38
Repairs . . . . .		1.14
Uniforms . . . . .		.05
		<hr/>
		3.44

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .		176	16	-
Hire . . . . .		20	2	6
Garage Expenses . . . . .		10	-	-
Administration . . . . .		87	-	-
Licences . . . . .		30	-	-
Insurance . . . . .		58	2	-
Depreciation . . . . .		102	12	-
Contingencies . . . . .		16	-	-
		<hr/>		
		£506	12	6

**19-27 Seats. (Price, less tyres, £700.)**

<i>Running Costs.</i>		<i>d.</i>
Fuel at 10.00 m.p.g. . . . .		1.50
Lubrication . . . . .		.16
Tyres . . . . .		.54
Lighting . . . . .		.04
Maintenance . . . . .		.44
Repairs . . . . .		1.25
Uniforms . . . . .		.05
		<hr/>
		3.98

<i>Standing Costs.</i>		<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .		187	4	-
Hire . . . . .		23	2	6
Garage Expenses . . . . .		13	-	-
Administration Expenses . . . . .		87	-	-
Licences . . . . .		48	-	-
Insurance . . . . .		62	14	-
Depreciation . . . . .		126	-	-
Contingencies . . . . .		23	-	-
		<hr/>		
		£570	-	6

## WHAT WORKING COSTS

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**28-36 Seats.** (Price, less tyres, £1,300.)

<i>Running Costs.</i>	<i>d.</i>
Fuel at 8.00 m.p.g. . . . .	1.88
Lubrication . . . . .	.16
Tyres . . . . .	.59
Lighting . . . . .	.04
Maintenance . . . . .	.46
Repairs . . . . .	1.30
Uniforms . . . . .	.10

4.53

<i>Standing Costs.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	187	4	-
"   Conductor . . . . .	84	10	-
Hire . . . . .	30	10	-
Garage Expenses . . . . .	13	-	-
Administration . . . . .	87	-	-
Licences . . . . .	67	4	-
Insurance . . . . .	68	14	-
Depreciation . . . . .	234	-	-
Contingencies . . . . .	28	-	-

£800 2 -**48-56 Seats.** (Price, less tyres, £1,700.)

<i>Running Costs.</i>	<i>d.</i>
Fuel at 6.00 m.p.g. . . . .	2.50
Lubrication . . . . .	.17
Tyres . . . . .	.71
Lighting . . . . .	.06
Maintenance . . . . .	.77
Repairs . . . . .	2.00
Uniforms . . . . .	.10

6.31

<i>Standing Costs.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
Wages, Driver . . . . .	187	4	-
"   Conductor . . . . .	91	-	-
Hire . . . . .	38	2	6
Garage Expenses . . . . .	20	-	-
Administration Expenses . . . . .	137	-	-
Licences . . . . .	86	-	-
Insurance . . . . .	80	14	-
Depreciation . . . . .	306	-	-
Contingencies . . . . .	30	-	-

£976 - 6

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a good deal would have to be added for overtime in the case of the highest mileages: a mileage of 30,000 a year means about 96 miles a day per six-day week. Some of the figures appear high because the mileages are relatively low, a mileage of 6,000 a year, of course, being utterly uneconomic and only serving to show the impracticability of too restricted seasonal working. Even the higher mileages are comparatively low for these modern times and with double manned cars on bigger mileages the costs would be very considerably reduced.

It will be noticed the 48-56 seater is not included in the table below, as it is of a size that would be likely to be used only for local working with frequent stops, and its inclusion in comparison with the others might be misleading. From the costs given, however, readers need have no difficulty in estimating for any given annual mileage.

**PER MILE WORKING COSTS FOR VARIOUS ANNUAL MILEAGES**  
(Pence per Mile)

Miles	6,000	7,500	10,000	12,500	15,000	20,000	25,000	30,000
	d.	d.	d.	d.	d.	d.	d.	d.
<i>Passenger Vehicles.</i>								
14-18 passengers	23·71	19·65	15·60	13·17	11·53	9·52	8·30	7·49
19-27     "	26·78	22·22	17·66	14·92	13·10	10·82	9·45	8·54
28-36     "	36·53	30·13	23·73	19·89	17·33	14·13	12·21	10·91

## CHAPTER XVII

### ON FIXING GOODS RATES

IN selling transport correct charges are obviously of the first importance. Whatever else, they should be adequate: it is better not to take work than to work at a loss. In the past rate-cutting has been the curse of the goods haulage and carrying trades. Especially after the War, hundreds of men bought second-hand government wagons and set out to make their fortunes equipped with the scantiest knowledge of the business, and in the great majority of cases the sequence of events was unhappily the same. First came the difficulty of getting work at a profitable figure, in which, many not knowing what they should charge and with more still cutting rates, things moved in a vicious circle. Then followed work at a loss, always "with a view to future business" and to keep things going. Then collapse. It was a pitiable story; but it has its moral. The temptation to take work at an unprofitable figure, with an eye to building up a connection should be resisted at all costs. It seldom, if ever, leads to future profitable business; more often than not it has exactly the reverse effect, because work undertaken on such a basis cannot consistently be carried on in a satisfactory manner; and, even when it leads to further inquiry, the necessary increase of charge is apt to be resented, the customer naturally arguing that, if the transport owner could afford to do the work at the previous rate, the revised quotation is an overcharge. Cut rates are not only bad for those who quote them, but in the long run for the customer as well.

Once the costs of working are known (and no one in

his senses should start in business without knowing them) there can be no excuse for rate-cutting. But vehicle working costs do not necessarily represent all. To them must be added any expenditure in selling transport—office expenses, advertising, travelling, and the like, which of course will be recorded separately and when worked out or estimated may be allocated to each vehicle as a standing charge in proportion to its tonnage capacity. This will give the all-in figure which can be used as a foundation for the rates to be charged.

### **Hire Charges.**

With the all-in cost per mile known, vehicle hiring becomes a simple matter. The charge will be based on a figure somewhere between two extreme points, the minimum being the all-in cost plus the lowest profit at which the operator can afford to work, the maximum what the traffic will bear. The latter in turn will generally be governed by what competitors are charging, and it will probably be found that there is not so very much difference between maximum and minimum. In calculating profit, however, an additional margin may be necessary on casual work entailing a vehicle standing unemployed for a considerable proportion of its time between jobs, and in this class of work a car may be waiting for jobs as much as one third or more of its possible normal working hours. Also as short hires for only part of a day usually so break into the day's work that vehicle and crew may be of little service for the rest of the day, allowance will also have to be made for that and jobs of this nature are to be avoided as far as possible. Usually, however, a vehicle is hired for a considerable mileage or by the day, week, or longer period, and in such cases a maximum daily mileage is commonly stipulated with an additional per-mile charge above that limit, if necessary, on a scale to cover

overtime rates. It may be as well to draw up a scale of charges for each size of vehicle; but in adding the requisite profit a distinction must be made between gross and net. For example, if the all-in cost of a job is, say, £100, and 33½ per cent is added for profit, the total is £133 6s. 8d., but on this gross amount the profit works out at only 25 per cent.

To return to our scale of charges, however, let us take the case of a 2 ton van. The standing costs for the year, we will suppose, amounts to £283 17s. 6d., the administrative charges per vehicle to £18 12s. 3d. and, with 33½ per cent added for profit, the charge on the overheads works out at £403 6s. 4d. or, assuming 250 working days per year, £1 12s. 3d. a day. The running cost is 3·66d. per mile, or 4·88d. with 33½ per cent profit added. On these figures we can construct a scale for mileages within the practicable daily range of the vehicle, by steps of, say, 4 miles—certainly not more, as 4 miles a day may represent something like 1,000 to 1,200 miles a year. Moreover, intervals of 4 miles are suggested because intermediate mileages may be so easily calculated by splitting the differences.

SCALE OF CHARGES BY TIME AND MILEAGE  
(At 33½ per cent Profit)

Daily Mileage	Running Charges		Standing Charges per Day		Total Vehicle Charge per Day		Charge per Hour		Charge per Mile	
24	4·88 × 24	s. d. 9 9	£ s. d. 1 12 3	£ s. d. 2 2 —	s. d. 5 3	s. d. 1 9				
28	4·88 × 28	11 4½	1 12 3	2 3 7½	5 5½	1 6½				
32	4·88 × 32	13 —	1 12 3	2 5 3	5 8	1 5				

and so on up the maximum eight hour daily mileage, always remembering that under the law a driver must

not work continuously for more than five and a half hours and must then have at least half an hour's interval. In calculating above the ordinary working day limit wages at overtime rates must be added; but here again it must be remembered that a driver cannot legally be employed for more than eleven hours at a stretch, including any rest intervals. As these additional wages vary with the extra time worked, they had best be added, with their rate of profit, to the per-hour charge, and for the per-mile charge they can be added to the total charge per day before dividing it by the mileage.

#### **How Rates are Calculated.**

In the conveyance of goods, as distinct from vehicle hire, there are several classes of work, and anyone intending to undertake transport business should have a clear-cut idea as to the kind of work he intends to adopt. He may either carry the more considerable consignments, generally rated by the ton, or go in for the conveyance of miscellaneous parcels and "smalls."

The heavier work may either be that of the private transport contractor or it may be a regular service, but for both certain broad principles alike apply. The form in which rates are built up (as prescribed by the Railways Act of 1921 and here presented) is not suggested as a pattern for road working, but rather to show what goes to the making of a transport charge and to bring out the differences between road and rail requirements in the matter. It applies to the ordinary rates for minerals and goods.

#### **Classification of Goods.**

Taking each heading in turn, first it will be noticed that provision is made for dividing the goods into classes. Many road transport people do not adopt any classification, merely basing their charges on the cost

Class in respect of Merchandise to which Charges are Applicable	Standard Rates for Conveyance					Standard Terminals				
	For the first Miles or any Part of such Distance	For the next Miles or any Part of such Distance	For the next Miles or any Part of such Distance	For the next Miles or any Part of such Distance	For the Remainder of the Distance	Station Terminal at each End	Service Terminals			
							Loading	Unloading	Covering	Uncovering
	Per Ton per Mile <i>s. d.</i>	Per Ton per Mile <i>s. d.</i>	Per Ton per Mile <i>s. d.</i>	Per Ton per Mile <i>s. d.</i>	Per Ton per Mile <i>s. d.</i>	Per Ton <i>s. d.</i>	Per Ton <i>s. d.</i>	Per Ton <i>s. d.</i>	Per Ton <i>s. d.</i>	Per Ton <i>s. d.</i>
1										
2										
3 etc.										

Showing how a railway rate is built up



of the work. Yet it stands to reason that dangerous, fragile, or valuable goods involving heavier risks and more care in transit, should be charged at higher rates; that more should be paid on delicate, easily damaged, freight carried in a box van body than for what can be carried in open wagons without harm; and that half a ton of light bulky stuff capable of filling a five ton wagon should not be carried at the same rate as sheet lead.

Taking such points into consideration then the railways group the merchandise they carry into no less than twenty-one classes, and, though the same elaborate system may not be possible or even advisable in road transport, some of the road carrying firms base their charges on those of the railways, with a discount deducted.

The various classes are all set out in a book issued by the Railway Clearing House (Seymour Street, London, N.W.1) under the title of *General Classification of Merchandise*, at 2s. 6d., and by grouping the classes into perhaps half a dozen categories the system might quite feasibly be modified to the needs of the small road contractor who has not the time to devise an elaborate system. The rates under this classification are contained in Scale 1 of the Standard Charges, issued from the same source, price 1s. and other scales that may be useful are Scale 4 (Owner's Risk, price 1s.), Scale 5 (Small Parcels, price 9d.), Scale 6 (Returned Empties, price 3d.), and Scale 14 (Insurance Charges, price 3d.).

In the scale of charges for ordinary merchandise it should be noted that the first four classes apply to goods carried in owner's wagons, and for the maximum distance quoted (800 miles) they range from 37s. 6d. to 56s. per ton. These might form the basis of one group. Classes 5 to 10 are all within the 100s. limit, Class 5 starting at 56s. 2d. (the prices are quoted in shillings and afford easier comparison in this form). These

might constitute another group. Between 100s. and 150s. are Classes 11, 12 and 13; between 150s. and 200s. are classes 14 to 17; Classes 18 and 19 come within 200-300s. mark, while for Class 20 the figure for 800 miles is 311s. 3d. and for Class 21, 466s. 10d. It must be left to the reader, however, to decide on any arrangement to suit his own circumstances, should he decide on any system of classification.

### **The Mileage Factor.**

Returning to the form for fixing railway rates, in general practice there are not so many variations in the charge of distance as in the Railways Act: for the first 20 miles, the next 30, the next 50 and the remainder of the distance is the usual arrangement. But, though cost decreases with increase of distance even here, the influence of mileage is far greater on the road.

The ton-mile charge in this section brings us up against a very vital difference between road and rail, for, whereas the ton-mile cost by railway is practically a fixed figure, by road it not only decreases with increase of mileage, but varies enormously for different vehicle sizes, decreasing also with increase in the size of vehicle. Under similarly favourable conditions the ton-mile cost for a two tonner may be a good 50 per cent more than for a five ton vehicle, while in comparison with a twelve tonner its figure will generally be considerably more than double. This fact in the author's opinion is in itself sufficient to preclude the possibility of standardization of road rates, however desirable—and that they would be of great benefit to the public as well as the trade can hardly be denied.

### **Terminal Charges.**

For road working the same elaboration of technical charges is hardly possible, or indeed necessary, as for

the rail. Loading and unloading is usually done on the premises of the senders or consignees, and, whether the driver and his mate perform the work or merely wait during the work, they have to be paid just the same, and so have the standing charges on the vehicle. Therefore, generally speaking, perhaps the best way of calculating terminals is to estimate the waiting time of men and vehicles and charge for that. In some cases, particularly for dockside traffic, it may be considerable.

#### **Vehicle Rates.**

The work of what may be called the private haulage contractor resembles vehicle hiring in some respects. He is asked to take loads, greatly varying in size and nature to this, that, and the other destination, and this usually implies the sole use of a whole vehicle for each specific job. A good assortment of vehicle sizes is therefore necessary to any considerable work of this kind, for obviously two tonners are of little service commercially for twelve or twenty ton lots, nor is a six tonner much use for 10 cwt. loads.

Since ton-mileage costs vary so greatly for different vehicle sizes, in this class of work each size of vehicle should have its own scale of charges, and, in whatever form the charge is quoted to the customer, it should be based on the all-in cost per vehicle-mile or, if there is much standing about, per vehicle-hour, or a combination of the two. For this purpose the form on page 231 will serve; but, if classification of goods is adopted, after deciding on the proportionate charges for each class the operator will have to adjust his rate of profit in each case to give the requisite charges. That will mean working out five or six scales, which appears to promise considerable expenditure of time and labour; but the calculations are quite simple and quickly made.

**Return Loads.**

In quoting for a job on this class of business allowance may have to be made for casualness of the work, for mileage in going to pick up the load and for return empty mileage.

Every effort particularly should be made to reduce the latter, that is perhaps the greatest disability from which goods road conveyance suffers. If paying loads could be carried both ways, the business would be highly profitable; but unfortunately, thanks largely to the return load difficulty, the average lading of goods vehicles throughout the country is only about one-third to two-fifths full capacity over their total mileage. There appears no complete remedy for this waste of effort: it is inherent to conditions that can only in part be avoided under the present order of things.

Of course, the transport man will presumably keep in touch with possible customers requiring goods conveyance from surrounding places to the centre where he has his headquarters. Also, something may be done to reduce waste mileage by arrangements with transport firms in neighbouring towns. Further, the contractor can use the freight exchanges or clearing houses, which have been established in various large towns to meet the difficulty. They usually charge a commission of 10 per cent on business done, though at least one very reliable clearing house has had to increase the rate to 11 per cent. The great majority of these organizations are of course highly reputable, but there are some less scrupulous that farm out the traffic at considerably lower rates than they receive. This practice is more prevalent than is generally realized and has been indirectly responsible for the failure of numerous contractors. Some clearing houses will make cash settlement for a 5 per cent discount, after the

delivery of the goods against signed delivery notes, while yet others may attempt to squeeze  $2\frac{1}{2}$  per cent from contractors for monthly settlements. Other freight exchanges again deduct a further  $2\frac{1}{2}$  per cent for insurance cover and the premiums payable by them are usually based on this percentage; but this means in effect that contractors covered by their own insurances are being charged twice over, if they are foolish enough to accept the deduction. Such things like this, while legitimate enough, are points against which the contractor may have to contend.

Yet even a part load for part of the distance will help to render the return mileage less unprofitable. If the contractor cannot get a load back to his own locality, it may yet pay him to take a load to another town nearer to his headquarters, even though additional mileage may be entailed. Let us assume, for instance, that a haulage contractor at A has a 3 ton load for B, 30 miles distant, and that from B he can get 2 tons for C which is equidistant 20 miles from B and A. The total return mileage would then be 40 instead of 30 miles direct; but the receipts for the first 20 miles may more than cover the cost of the extra ten miles, even if the detour involves overtime.

### **Contract Work.**

So far no mention has been made of what is known as contract business, in which the transport man undertakes all the conveyance and load handling for a given job or a given time, some contracts running into many thousands of tons. Business like this is really the same as that which we have just been considering, but on a wholesale scale, and to quote for it is a comparatively simple matter once all the conditions of working are known. Nevertheless, as large issues are involved, it is very necessary first to ascertain all the

working conditions, and then exercise the greatest care in estimating the cost.

### Goods Services.

Regular services for heavy goods are usually run between two fairly extensive business centres. If others lie along the route, so much the better; but the main consideration as often as not is the end-to-end traffic. Such work will very usually demand offices at both ends, and on long distance services garage accommodation, so as a rule it requires fairly substantial capital, for good sized vehicles will have to be employed.

This class of work does not suffer from return empty mileage; but full loads even at the start cannot always be expected and, if deliveries are made along the route, the load probably diminishes towards the final destination, so allowance must be made for this.

Circumstances differ so much with local conditions that figures as a guide are not possible: the only way is to calculate the average load over the route and work on that. To take a simple example. A service runs 25 miles from A to B through C and D, C being 9 and D 17 miles from A. We will assume that over a period of working—not less than a week—a 4 ton wagon averages  $3\frac{1}{2}$  tons for the nine miles from A to C,  $2\frac{3}{4}$  tons for the next eight miles from C to D, and  $2\frac{1}{4}$  tons for the remaining eight miles to B. The work on each stage then is—

A-C	$9 \times 3\frac{1}{2}$	=	31.5	ton-miles
C-D	$8 \times 2\frac{3}{4}$	=	22.0	..
D-B	$8 \times 2\frac{1}{4}$	=	18.0	..
			71.5	..
Total			71.5	..

Divided by the total mileage of 25, this gives an average load of 2.86 tons per mile.

For calculating charges the same type of scale as

before can be used, but with the mileage stages only representing distances between places that are served, and with the "Charge per hour" substituted by a "Charge per ton" column. Also, as the average of lading will vary from period to period (and will have to be watched carefully) the charge per ton may have to be adjusted from time to time in accordance with actual experience. The charge per mile may be useful in quoting for a full load.

### **Parcels and "Smalls."**

In the conveyance of parcels there are broadly two distinct types of business—long and short distance—differing widely from each other in conditions and requirements. In both the charges are graduated according to the weight of the parcel in pounds and for the longer distances on a combination of weight and mileage.

Let us deal first with weight. Fewness of categories of course makes for simplicity and some carriers classify up to 14 lb., from 14 to 28 lb., 28 to 56 and 56 to 112 lb. or 1 cwt., beyond which point increases of charge progress by steps of 56 lb. up to 3 cwt. which is ordinarily the limit for parcels rates both by road and rail. Finer gradation, however, tends to "finer" prices and in some businesses the lowest charge covers parcels up to only 3 lb. weight, the succeeding steps being something like 3-5 lb., 5-7 lb., 7-10 lb. and 10-14 lb., the charges beyond this last point advancing by 7 lb. stages up to 56 lb. and thereafter by 14 lb. steps.

In variations of charge on account of mileage the lowest rate often covers the first 15 miles, the next from 15 to 25, and the next 25 to 30 miles, subsequent steps progressing by 10 mile stages. The operator will, however, have to decide on mileage stages to suit his individual case, and the position of collection and

delivery points along the route will probably influence matters in no small degree.

A scale on these lines as below gives fairly average figures for this class of work in an industrial district.

Weight		Up to 15 miles	15-25 miles	25-30 miles	35-40 miles
Lb.		<i>s. d.</i>	<i>s. d.</i>	<i>s. d.</i>	<i>s. d.</i>
Up to	3	2	2	2	3
	3-5	2	2	3	3
	5-7	2	3	3	3
	7-10	3	3	3	4
	10-14	4	5	5	5

and so on.

It is a comparatively simple matter to construct a scale of charges once the weight and mileage stages are settled, but in assessing the charges the transport man may have to allow for some unprofitable traffic in the shape of returned empties. These are the curse of the transport man, though generally unavoidable if business is to be retained. Ordinarily on this class of traffic the charges may range from 2d. to 1s. 4d. per cwt. for varying distances up to 150 miles and about half these figures for empties that will pack flat, like sacks or sheets, while for greater risks, such as carboys, crates containing shavings, or other inflammable packings the charges may be put roughly at 6d. to 2s. or 2s. 6d. per cwt.

The point, however, is to fix the rates for standard traffic and in doing so it is usual to use a year's working as a foundation. Take the case of a man contemplating a six-day week service between two points A and B, with towns or villages C, D, and E intervening. He decides that two mileage scales would be advisable and estimates that outwards and return there should be—



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*Above 15 miles.*

Between A and B . . . . .	6,100 parcels per annum		
.. C .. H . . . . .	1,400	..	..
.. F .. A . . . . .	900	..	..
	<hr/>		
Total . . . . .	8,400	..	..

*Below 15 miles.*

Between D and B . . . . .	3,400	..	..
.. E .. B . . . . .	1,700	..	..
.. D .. A . . . . .	1,600	..	..
.. C .. A . . . . .	600	..	..
	<hr/>		
Total . . . . .	7,300	..	..

Grand Total . . . . . 15,700 .. ..

That will give an average of just over 25½ parcels per single trip, and, allowing a generous margin for market days and rush periods as at Christmas and the like, he reckons a 10 cwt. van adequate, the more so as he can run two trips a day on emergency. Allowing for business expenditure, including receiving office arrangements and agent's commissions, he calculates the all-in cost with such a vehicle as £360 per annum and, as he himself drives and draws the driver's wages, he is content with a net profit of 25 per cent added. The traffic would thus have to bring in a gross income of £450 a year, and, to ensure this, an average of 6-9d. or, say, 7d., would have to be charged on each parcel. The differences in rate for distance will have to be decided by what the traffic can bear rather than difference in working cost. As a matter of fact the purely operating per-mile expenses for the van on a 15 and a 25 mile basis respectively would be as about as 7 to 5, excluding all handling charges. Suppose, as a general thing the total working cost for the longer distance over the same mileage is put at 15 per cent higher, then for the 7,300 parcels on the 15-20 mile scale the charge should be nearly the same per parcel as for the 8,400 parcels

over the longer distance: thus each distance scale can cover half of the required £450.

The prospective carrier will presumably have studied the possibilities of the route, and have some idea of the amount of traffic to be expected under the various weight categories, and on his estimates in this direction he can proceed to work out his charges on the following lines. For simplicity weights up to only 1 cwt. and few categories have been assumed.

Weight	No. of Parcels	Charge per Parcel	Total	
<i>Up to 15 miles.</i>				
lb		<i>s. d.</i>	<i>£ s. d.</i>	<i>£ s. d.</i>
Up to 7 . . .	1,900	2	15 16 8	
7-14 . . .	2,700	4	45 - -	
14-28 . . .	2,000	7	58 6 8	
28-56 . . .	1,800	9	67 10 -	
56-112 . . .	800	1 -	40 - -	226 13 4
<i>15-25 miles.</i>				
lb.				
Up to 7 . . .	1,800	3	22 10 -	
7-14 . . .	2,100	5	43 15 -	
14-28 . . .	1,600	8	53 6 8	
28-56 . . .	1,200	1 -	60 - -	
56-112 . . .	600	1 6	45 - -	224 11 8
			Total .	£451 5 -

To obtain the required total the rates have to be adjusted by trial and error, and this adjustment is easier in the heavier categories where a penny does not make such a big difference.

### Collection and Delivery Services.

It is impossible to draw any hard and fast line between long and short distance services, the more so with the present tendency towards the spread of urban

areas. Still, for short, as for long distance, the same broad principles apply in rate making.

In local working, however, conditions are generally far more complex. Services have to be more frequent, distances are shorter and collections or deliveries per mile more numerous. Customers' requirements are more exacting and they may vary in each town and for each class of customer. Wholesale business houses generally demand deliveries as early and collections as late as possible in the day. That is a difficulty severely felt in collecting traffic for the railways, and it long contributed to the retention of the horse for this work, seeing that a motor van cannot be in two places at once, as can two horsed vans costing in those days no more than a single motor van. For this reason several small vans may be preferable to a few large ones, although their aggregate working expenses will be greater. For shops or stores, though each trade has its own particular requirements, the work can be more evenly distributed throughout the day; yet even in their case the outlying districts call for collections towards 4 and 6 p.m.—just when pressure from the wholesale houses is at its peak. In the more central districts, however, though three collections a day are usually necessary, the first two at 10 to 11 a.m. and about 2 p.m. are at more convenient times, although the last at 5 to 6 p.m. is at the height of the rush hours. Then, too, goods collected in the morning must be delivered the same day, and even to some collections as late as 5.30 p.m. the same applies, involving special services. To reduce unladen mileage, vans delivering on their outwards journey should as far as possible collect on their return, and the goods then have to be sorted at the depot for delivery in their respective destination localities.

Since these are only a few of the main considerations

entering into the problem, it will be realized that a number of vans and considerable capital will be essential to effective working. Not only that, but this class of business requires very intimate local knowledge and such an extensive traffic experience, that it cannot be recommended to anyone not possessing those qualifications.

On the other hand, there is often an opening for the small man to undertake the parcels work of certain specific firms at a weekly charge, and in those cases if the van is not hired outright, his quotation will in nearly every instance have to be based on the number of parcels handled, to which the methods already outlined apply, bearing in mind that on this class of work an average light van should be capable of about 100 deliveries in the ordinary working day.

#### **Variety in Methods of Charging.**

The whole question of rates is much complicated by the lack of any uniformity in practice. The railway companies group their traffic into different classes, each with its own rate; some road transport firms have their own classifications; others adopt the railway classification and charges, less discounts; while others again merely frame their charges at a flat rate based on the cost of the work. The problem is big enough to fill volumes, and the most that can be done in this chapter is to give an idea of the underlying principles and their application.

## CHAPTER XVIII

### KEEPING TRACK OF TRAFFIC RECEIPTS

IN addition to the cost of actually working the vehicle those carrying on transport as a business in itself will have to include the expenses of what, for want of a better term, is often called the administrative side. Added to the total vehicle working cost, they give the all-in cost. Mention has already been made of administrative costs in a preceding chapter and here it will suffice to do little more than name them in detail, for no purpose could be served by giving figures, since they are so entirely dependent on the individual conditions of each case, and are a matter of ordinary business rather than of specialized motor transport.

#### **What Make up Administrative Expenses.**

For the conveyance of goods the administrative charges may include—

Management, which, if undertaken by the same person that supervises the vehicles, can be allocated between operation and administration in proportion.

Salaries and wages of traffic, as distinct from operative staff.

Office expenses, including rent, rates, repairs if necessary, light, heating, cleaning, etc.

Agents' commissions.

Travelling.

Telephone.

Postage.

Stationery. A larger item than might be expected.

Advertisement and publicity.

Insurance of goods.

Lost goods. This refers to claims too small to recover from the insurance companies, and should amount to only a mere fraction of 1 per cent of the all-in cost.

Cartage on emergency or in special circumstances.

Bad debts.

Bank charges.

Miscellaneous.

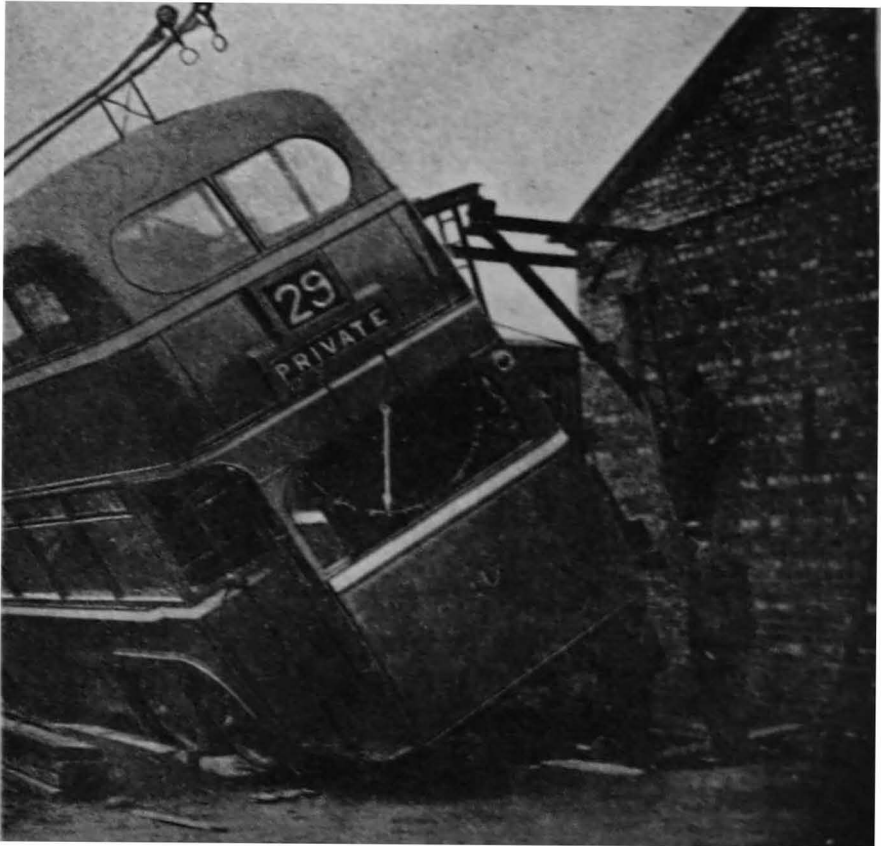
To record the costs of these items entails only the ordinary methods of book-keeping and the same applies to the receipts which can be entered up in the usual way once they are known: it is only in using them statistically as a guide to working that any special treatment is involved. The problem is merely to decide what information is required, and to obtain it with the minimum expenditure of time and money for all concerned. To that end there should be as few forms, as little writing, and as much simplicity as possible (too much time can easily be spent on non-productive labour) and in this chapter it is proposed to give the bare outline of such a system, which, however, can be modified or extended as required to meet more complex needs.

### **Using Receipts Statistically.**

We may again take the case of the hypothetical carrier in the previous chapter.

First then, what information does he require? For book-keeping purposes he will want to know the amounts paid or due on each consignment or parcel, and the total receipts per day. As a guide to working he may require number, total receipts, average receipts and average weight of parcels per year, in each weight category, and in each distance category. Between each two distributing centres he may want the number of parcels and receipts per van per day, and incidentally, for supervision, the time taken by each van on the

whole and each stage of each journey. It may be desirable also to know the nature of each parcel as



**THOUGH THE ENCLOSED DOUBLE-DECK BUS LOOKS TOP HEAVY,  
IT TAKES MUCH TO UPSET IT**

As may be inferred from this view of a Guy six-wheeler undergoing a  
Ministry of Transport test

*(By courtesy of Guy Motors, Ltd.)*

some means of identification and, of course, this is necessary if goods are carried by classification.

All this appears fairly complicated; but it can all be included in a comparatively simple form of way-bill and consignment note.

### **The Way-bill and Consignment Note.**

Just as the driver's daily return is the link between road and office for the vehicle working records, so for keeping track of parcels and receipts *en route* the way-bill serves the purpose, while at the same time it can also be used as a check on the working. A form for the purpose is given on pages 250.

As it is desirable to lessen to a minimum the filling in of forms by men on the vehicle, it has been reduced to its simplest elements so that, in conjunction with the consignment note, no particulars shall have to be filled in twice, for the time of the men and vehicle are of more importance than that of a clerk working more easily and quickly in the office. From the way-bill and suggested consignment note that follows all the particulars already specified can be extracted.

Certain transport firms undertake cash on delivery business (sometimes on a 5 per cent cash discount basis), and in such cases an entry for C.O.D. payments can be inserted below that for "Carriage forward."

### **The Consignment Note.**

Consignment notes should be of handy size, certainly not much larger than, say, a post card, and can be made up in books, perforated to tear off, the numbers printed large and clear; two copies to each number, so that with carbons copies can be made out for both sender and carrier. Occasionally transport firms also have gummed, perforated tear-off labels, one of which is affixed to each parcel as a cheap and effective form of publicity. It may be suggested that these labels might also be utilized as a means of identifying the parcel with its consignment note, if they were printed with consecutive numbers corresponding with the numbers of the consignment notes. An ideal arrangement would be for the labels to be incorporated with the books of



# WAY-BILL

TELEPHONE

O. VAN DER LIVERIES & CO.,  
TRANSPORT CONTRACTORS,  
CARHOLME ST., LINCOLN.

DATE.....

Vehicle No.....

Load Capacity.....

Driver .....

Make.....

Vanguard .....

Consignment Note No.	No. of Items	From	To	Time Dep.	Time Arr.
				Hr. Min.	Hr. Min.

Driver's Signature.....

FOLIO REF.

No.

**CONSIGNMENT NOTE**  
O. VAN DER LIVERIES & CO.,  
TRANSPORT CONTRACTORS,  
CARHOLME ST., LINCOLN.

NATURE OF GOODS.

WEIGHT  
Cwt. Qr. Lb.

CONIGNED FROM

DELIVERED TO

CARRIAGE { Paid  
          { Forward

£ s. d.

RECEIVED BY  
(in good order and condition)

NOTE. All goods carried subject to Company's conditions and liability limited to £10 per package.

*You are requested to obtain Receipt from carman.*

consignment notes; but there is the objection that, if the book got even damp, it might get gummed up. Also, some transport contractors furnish their regular customers with consignment books, and even with separate gummed labels there might be some difficulty in ensuring that each note should invariably be accompanied by its correspondingly numbered label. Nevertheless, a suggestion for such a label is given below and, if circumstances render numbering impracticable, it can be omitted.

<p><i>Delivered by</i> O. VAN DER LIVERIES &amp; Co.    <b>No. 1447</b>  CARHOLME ST., LINCOLN.                      <i>Telephone</i>.....</p>
--

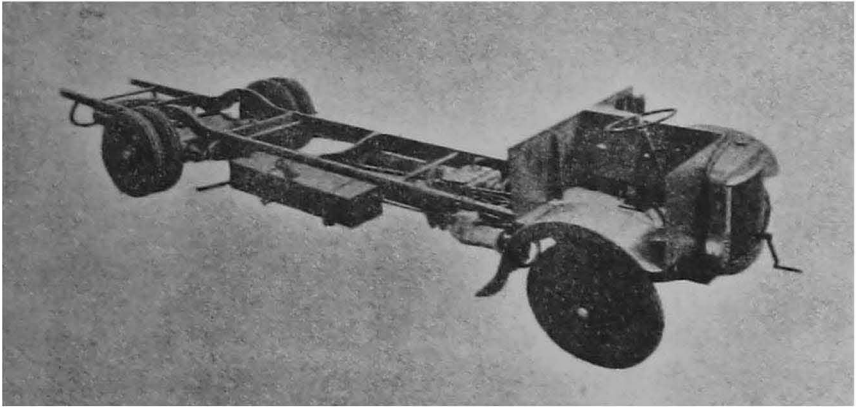
When a driver has to collect goods it is customary to make out a collection note for each call and hand them to him before starting. In small undertakings, however, it will probably suffice to make out in duplicate a list of calls for each van, giving as far as possible name, address, nature and weight of load expected. A copy can then be handed to the vanmen, the other being retained in the office.

### **In Passenger Transport.**

The principles on which the way-bill and consignment note details are embodied into records, for guidance in business working, are much the same in passenger transport methods, which may here also be broadly outlined.

In this form of traffic, however, it must be remembered that the Ministry of Transport also require certain statistics. Everyone working public service vehicles carrying eight or more passengers must send to the Ministry a quarterly return showing, among other things, the miles run, passengers carried, receipts

from passengers and receipts from parcels, dogs, and other traffic ; and when six or more vehicles are worked a yearly return will have to give passenger receipts, parcels traffic receipts, and receipts from advertising and other sources. Taking these into consideration, in



A VIEW OF THE T.S. FORWARD-CONTROL FOUR-WHEELED CHASSIS FOR UP TO 32 PASSENGERS

*(By courtesy of T.S. Motors, Ltd.)*

local, or bus, working, the following will probably be useful—

**AGGREGATE—**

- Miles.
- Passengers.
- Receipts (passengers).
- ,, (other traffic).

**FOR EACH ROUTE—**

- Miles.
- Passengers.
- Receipts.

**FOR EACH TICKET DENOMINATION—**

- Passengers.
- Receipts.

**FOR EACH VEHICLE AND CONDUCTOR—**

- Miles.
- Passengers.
- Receipts.

From these the operator can easily work out receipts per mile for the different classes of traffic and for the different routes, average number of passengers per mile, average fare, and average fare per mile or distance travelled for one penny. These will afford him his leading guides in traffic working.

### **Tickets.**

In passenger carrying the ticket constitutes the equivalent of the receipt and the customers part of the consignment note combined. Tickets are generally issued in series of 10,000 in consecutive numbers and with some distinguishing series letters, such as AD0000 to AD9999. They are made up in bundles of 50 or 100, which are placed in boxes that are issued to the conductors when going on duty and have to be returned on going off duty. With tickets thus numbered, if the series numbers at the start and finish of the journey are recorded under each denomination, subtraction of the commencing serial number from the finishing one will give the number issued. Then, when numbers issued in all denominations are added together to give the total ticket issue for the journey, the result can be checked from the punch register.

On these lines a simple form of way-bill might be devised as given on page 255.

For explanation the form has been filled in with actual figures.

To ascertain the numbers of passengers between places, the "next-ticket" numbers at sundry points along the route, or for each stage, can be noted on the back of the way-bill, the rulings on which may be arranged accordingly.

This form pre-supposes the very simple conditions of a service with perhaps more than one route, but with

**WAY-BILL**

**SERVICE & KNOTT, LTD.,**  
**BUSSING,**  
**SUSSEX.**

Date.....1 Jan.....

Telephone 181.

Time on duty: 7.25 a.m.

Time off duty: 3.25 p.m.

Turn No.: 2

Car No. 3                  Punch No. 127      Conductor: Owen Money

Route No. 1              Box No. 5              Driver: Ivor Kerr

Ticket Denom.	Series Letters	Quantity Issued	To	From	Finishing Nos.	Nos. Issued	Receipts
<i>d.</i>							<i>£ s. d.</i>
1	SL	500	3779	3300	3696	396	1 13 0
2	TV	400	7599	7200	7501	301	2 10 2
3	NR	360	8499	8140	8427	287	3 11 9
4	CF	300	1699	1400	1578	178	2 9 4
<b>Total</b>						<b>1162</b>	
<b>PUNCH REGISTER</b>							
Finish: 5560							
Start: 4398							
Total: 1162							
Total . . .							£10 4 3
Parcels . . .							1 6
Dogs . . .							—
Total . . .							£10 5 9
Notes . . .							—
Silver . . .							7 13 10
Copper . . .							2 11 11
Tokens . . .							—
Total . . .							£10 5 9

Conductor's Signature O. Money

no return or exchange tickets and single-shift working without changing over men or cars.

### **The Daily Receipts Book.**

From the way-bills the daily receipts may be entered up, the headings extended across both opposite pages somewhat on the lines given on page 257.

The fifth main heading, of course, refers to the total number of tickets of all categories, while "shorts" and "overs" stand for any discrepancies between value of tickets and what is paid in. The mileage, it may be added, can be extracted from the driver's daily return.

With every turn each day entered up, we shall be able to obtain from this statement the aggregate mileage, number of passengers, passenger receipts, and other traffic receipts; also total receipts and the total number of tickets sold of each denomination. From it we can easily work out the total value of receipts in each ticket category, and from it and the way-bills we can obtain the numbers in each category and their totals for each route, which can be worked out for an analysis showing the value of each route. Further, as the length of each route will be known, the mileage and receipts per mile can be obtained. Similarly the figures can be got out for each conductor and each car, if desirable.

### **Bookings.**

For long-distance services requirements are rather different in that all or some of the tickets (and seats) are booked beforehand and not on the journey. In addition to this the long distance man may have to submit to the Traffic Commissioners yet further details when applying for road service licences and bookings.





258      **COMMERCIAL MOTOR ROAD TRANSPORT**

Thus, with the other forms that he has to send in to the Ministry of Transport, he needs to keep his records in a manner that will show at any time the following particulars—

Vehicle miles in service.

“    “    light.  
“    “    total.

Number of passengers on ordinary services.

“                    “    on excursions, tours, and contract work.  
“                    “    at single fares.  
“                    “    at day return fares.  
“                    “    at period return, contract, or season fares.

Receipts from ordinary services.

“                    “    excursions, tours, or contract work.  
“                    “    hiring to other operators.  
“                    “    mails, parcels, dogs, etc.  
“                    “    other sources.  
“                    total.  
“                    per mile.

Number of days on which services are run.

“                    service journeys.  
“                    seats available.

Not only this, but particulars as to working on the different days of the week and on bank holidays have to be given, and most of these details have to be arranged so that they can be furnished quarterly. Then for his own purposes he will probably also require to know the distance covered and average number of passengers per vehicle on each service.

All this again appears very complicated; but for the most part the figures officially demanded are only what the operator himself would in any case require for his own information.

**Booking Slips.**

For long distance services many of the bookings may be received by telephone from agents and a booking

slip is customarily employed to note down the particulars, somewhat on the following lines—

AGENT..... DATE.....  
 Tickets..... S..... D.R..... P.R.  
 From..... to.....  
 Date..... Time.....  
 Pick up.....  
  
 RETURN.  
 Date..... Time.....  
 Pick up.....  
 Ticket No..... Fare £ s.

The entry "Tickets" applies to the numbers required which are marked against S (single) D.R. (day return) or P.R. (period return) as required. "Date" refers to the day on which the tickets are required and "Time" to the time of leaving.

**The Journey Booking Sheet.**

Whether the bookings come through agents, or direct, they can be entered on a journey booking sheet that gives a plan of the seating accommodation and allots the seats, somewhat on the lines given on page 260.

At the foot of the form entries can be added for parcels and other traffic, if advisable.

Little explanation is necessary. The letters D and U of course stand for "down" and "up" and, since according to official requirements return fares are reckoned as two passengers, provision is made for recording both up and down return journeys, the particulars relating to the down traffic being filled in to the left of the "Tickets" columns, those for up journeys to the right. Sufficient space should be left between the lines to permit both up and down fares to be entered against any seat.





From these forms particulars as to all the required mileage figures will be obtainable, also of passengers and receipts for ordinary services, besides the numbers of service days, service journeys and seats available. Nor does there appear any reason why they should not be used when some of the tickets are issued on the vehicle.

#### **The Daily Instruction Sheet.**

In special excursion work and touring, the driver will be given an instruction sheet filled in at the top with his name, car number, and seats available, while at the bottom, following his instructions, provision should be made for times of arrival and departure, mileage and number of passengers, with space for entry of expenses on the road.

#### **The Traffic and Receipts Book.**

Working from these forms, if various classes of traffic are undertaken by the same firm, a record can be arranged to give nearly every required detail, by entering each journey in a statement with headings as given in inset.

Of course, large transport organizations will have their own highly developed systems for recording receipts. This chapter can at the most attempt only the rough outline of a few methods whereby the man in a small way of business may keep track of them in such a manner as to use them for intelligent supervision, to meet official requirements and to marshal them for the book-keeper, with whom any further treatment must rest.

(The official forms referred to in this chapter will be found given in full on pages 353 to 358.)

## CHAPTER XIX

### SOME CONSIDERATIONS IN PASSENGER SERVICES AND FARES

As for goods so for passenger carrying, a careful survey should be made of any locality prospectively to be served. Nevertheless, there are certain important differences to be taken into account. A passenger service cannot run unless licensed, and time and money may be wasted on investigation if opposition is too strong, or if the Transport Commissioners cannot be persuaded as to the public need for the service. Therefore it is advisable to make sure first of a reasonable probability of getting the service licensed, as far as that is possible.

Another difference between goods and passenger transport is that in the former, more particularly in its heavier branches, industry and trade rather than population may be the main factor, and so work in a comparatively thinly populated area covered with docks, factories or warehouses, for instance, might be more profitable than in housing areas.

For a prospective passenger service the population is the main consideration, and not only its extent but its distribution, its type, occupations and habits. Are the houses scattered or close together? Are they at a distance from the shops and places of business? Are the inhabitants of the middle and working classes that require transport or are they themselves car owners? The number of private cars in use may be a valuable index even in these democratic days. What is roughly the average income in the neighbourhood and to what extent could the "bus habit" be developed? Do the

workers live at a distance from their places of business, are they given to get about socially, what are the amusement facilities in the neighbourhood and are the places of amusement at a distance from the homes? Is there much going on in the way of local entertainment—race meetings, cricket or football matches and the like? Then, too, are there schools, or training centres, situated where they would make for traffic? Again, is there any floating population in the shape of visitors and to what extent might their sightseeing requirements play a part in the proposition? And, finally, are these qualities likely to diminish, or develop with time? In such a matter a long view is necessary.

All these considerations and others must have an important influence on prospects and the question of fares.

#### **The Any Distance Fare.**

Of course the simplest way of charging passengers is by a flat fare—the same for any distance—but though that method was extensively adopted years ago, particularly for trams in certain American cities, its application at the present in this country is practically limited to long distance point to point traffic between considerable towns or very short journeys, such as trips along the front at a seaside resort.

#### **Stages and Their Arrangement.**

The next step is to split the journey up into a number of stages charging so much for each stage. On this system in the longer distance working the length of stages may vary according to where local circumstances and needs call for stopping places, or sometimes according to where vehicles are permitted to take up or set down passengers. In local working, however, the route is generally divided as far as possible into



**THE ALPHA LUXURY CROSSLEY COACH IS DESIGNED FOR 32 PASSENGERS**

*(By courtesy of Crossley Motors, Ltd.)*



stages of approximately equal length with the same fare for each.

In either case the division into stages offers the advantage of simplicity. Its chief drawback is that passengers who have to join the car at intermediate points between the stage terminals are at an undue disadvantage. With a service based on mile stages people living half-way along any stage would be faced with the alternative of paying at practically double rate for their first half mile or of walking that half mile to the next stage pick-up point, while anyone boarding the car, say, a furlong before the end of a stage would be paying for that distance at some 700

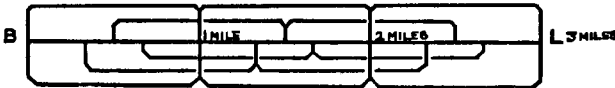


FIG. 44. DIAGRAM OF OVERLAPPING STAGES ON A 3 MILE ROUTE

per cent above fare rate. Naturally people resent being charged like this and traffic is thereby lost.

To lessen the disability overlapping stages can be adopted, the route being first divided into stages of the determined length. Then overlapping stages are introduced, starting and ending about midway of the primary stages, as in the upper part of the accompanying diagram (Fig. 44), which represents a three mile route divided into mile stages with half-mile overlaps.

That shows the overlapping stage system in its simplest form; but there is nothing to prevent the elaboration of the principle to give overlaps, say, every third of a mile, on the lines indicated by the lower part of the figure below the base line B.L.

The greater the number of stages the more continuous the drawing power of a service all along its length and, in general, traffic that might otherwise be lost is thereby

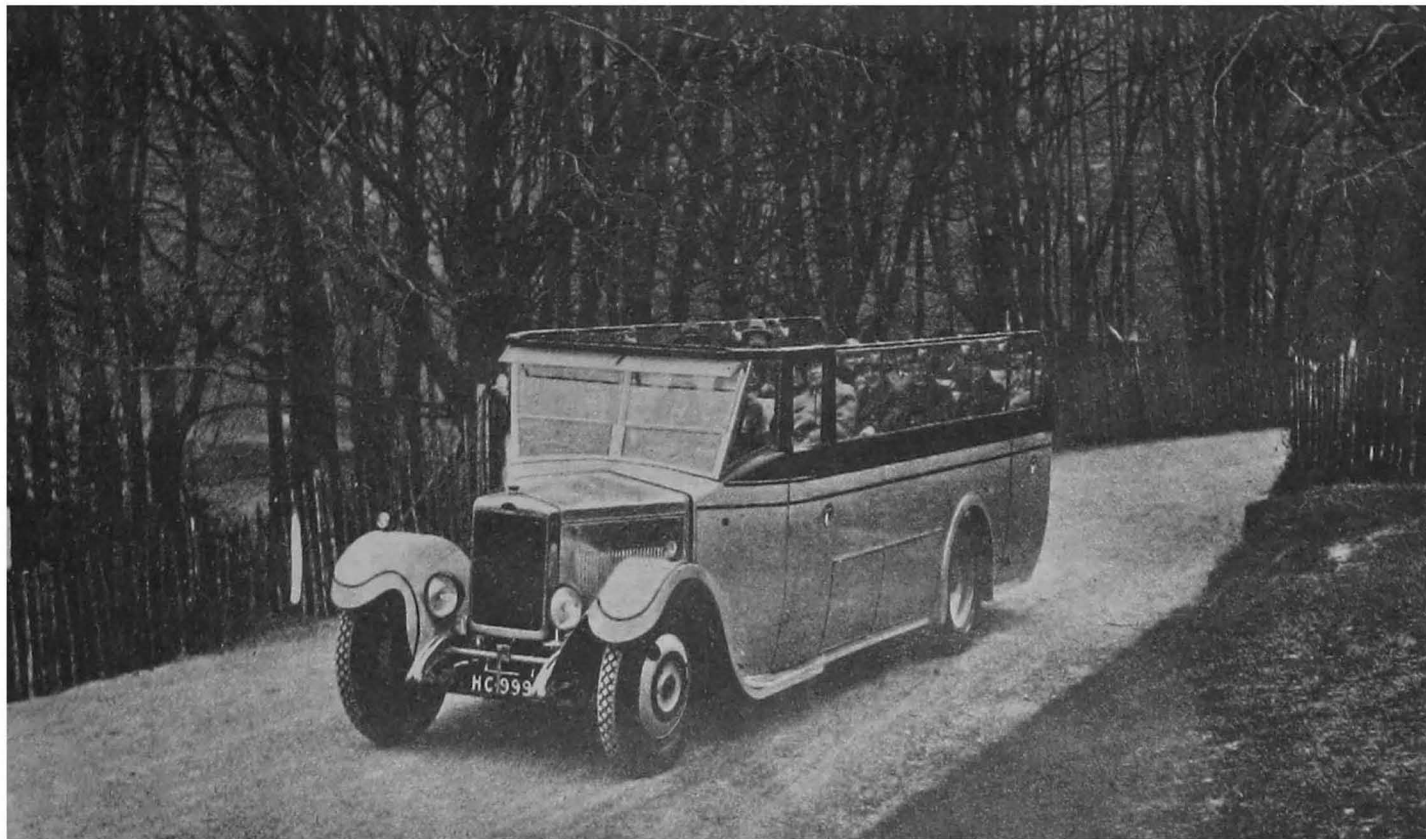
retained or obtained. On the other hand the system has its limitations. It not only implies more stopping and starting, but each additional pick-up point means an additional issue of tickets and sufficient time must be allowed between stages for this and for the conductor's other duties. Moreover, each fresh set of stages involves an additional complete scale of fares and for them the conductor will have to rely largely on his memory, for there will be little enough time to look up fare tables when a rush of passengers gets on at a stopping place, particularly on a double-decker.

Applied with due regard to such considerations, however, overlapping stages certainly in general tend to increase takings; in some instances known to the writer quite a lot of traffic is lost by adopting a hard and fast system of fixed stages without overlaps.

### **Return Tickets.**

The next point concerns return tickets, which very often are certainly a valuable means of retaining traffic, especially when competition exists. True, to be effective, the "return" means a slight reduction on two single fares; but, when one of those fares might otherwise be lost, that small reduction is usually well worth while to retain the traffic.

The difficulties lie in complication of the ticket system and the possibility of the return being used twice over. Since one of the purposes of the punch is to register the number of tickets issued on a vehicle, it might complicate matters to cancel by punching on one bus the return of a ticket issued on another. The ticket on the return might of course be cancelled with special clippers; but probably the best and simplest course is for the conductor to issue exchange tickets in place of the returns (which latter he will keep) on the understanding that no such exchange ticket may be



**A MAUDSLAY MONTROSE COACH ON TOUR IN BEAUTIFUL SURROUNDINGS**

*(By courtesy of the Maudslay Motor Co., Ltd.)*

issued unless a corresponding return ticket is produced and handed in.

It will probably be found inexpedient to issue returns on values much below 4d. to 6d. ; but, it may be added, that for bus working carried on under a public service vehicle licence the numbers of single and return tickets do not have to be separately entered in the M.O.T. forms mentioned in the previous chapter—only the total number of passengers. Singles and returns have to be separately recorded only in the case of express carriages (for definition see page 348) working over the longer distances.

The results of the preliminary survey will go far to decide the size of vehicle to be employed, and on its working cost plus profit and the estimated average number of passengers per car the basic fare can be decided.

#### **The Halfpenny Stage.**

Suppose we take the basic fare at 1d. a mile. In bus work a question may then arise as to the advisability of introducing halfpenny fares. Since no system of stages can graduate charges perfectly fairly according to distance but must advance by a series of arbitrary steps, the adoption of a halfpenny fare for half stages may do much in some cases to smooth over the inequalities of the stage system. Particularly in poor and working class districts it may be appreciated and useful, though it need not necessarily imply a minimum fare of a halfpenny: more often a minimum of 1d. may be found expedient, with advances by halfpenny half stages up to 4d. or 6d.

#### **Encouraging Traffic.**

This question of encouraging the more impecunious passenger brings us up against the problem of developing traffic by cheap fares—workmen's returns, cheap

tickets during slack hours, excursion and holiday tickets, and arrangements with local shopkeepers for the refund of fares on purchases over certain values. These in the main must be left to decision by local and individual conditions and it must suffice here merely to mention them as suggestive possibilities.

Then also season tickets must be considered. These are based on the ordinary fares; that is to say, a season covering any distance up to 3d. would be based on the 3d. fare, and so on. Tickets of this class may further be issued at reduced rates for school-children and students; but it is very doubtful whether as a general rule they are directly profitable, though indirectly they may be so by encouraging traffic and developing residential areas.

A season, of course, permits its holder to travel unlimitedly over any distance up to which it is available during its period of validity; and that recalls another type of ticket that allows unlimited distance, permitting the holder to travel for one day by any vehicle belonging to the issuing company to any place served by them. At present very little experience is available of these "rover" tickets, as they may be termed; but they might be worth further investigation in certain circumstances.

#### **Fare Tables.**

The Metropolitan Police, who are responsible for the issue of public service vehicle and road service licences in the London district, insist on a table of fares being displayed on the vehicle, and even in localities where fare tables are not compulsory it might be worth while to consider whether they would not be sound business policy.

In the past there were two ways of displaying the fares, one being to group them in order of values, the

first group showing the places between which penny fares, were in force, the next showing the twopenny fares, and so on. That method did not really meet requirements, as what the passenger wanted to know was not how far he could travel for a penny or twopenny, but how much he had to pay for travelling from one given point to another.

In the second type of fare board, known as the paragraph form, the fares from the starting point are



A BRISTOL DOUBLE-DECKER WITH FORWARD CONTROL

*(By courtesy of the Bristol Tramways & Carriage Co., Ltd.)*

grouped into the first paragraph or list, the fares from the next point on the route constituting the next paragraph and so forth, each list consequently showing one less fare than its predecessor until the paragraph for the last stage shows only a single fare.

To the uninitiated, however, these numerous lists were confusing, particularly for the reverse direction, and the paragraph method has now been superseded by the triangular, stepped or squared method, as it is indifferently termed. This is the form prescribed by the Metropolitan Police, and certainly enables the fare

between any two places to be ascertained at a glance, and more easily than by any other known system.

### Setting Out a Fare Table.

Mention has been made of these fare tables because they are indicative of the way in which the fares are compiled. We need not concern ourselves further with the older forms of table, but will devote our attention to the now almost universal stepped form. Let us take the case of a service between two provincial towns 16 miles apart, with villages, cross-roads, or other stopping places at varying distances giving seven stages. Suppose a minimum basic rate of 1d. a mile is adopted with a tendency to increase, if anything, as the journey mileage shortens.

In the example table below the places served are denominated by letters, beginning with A at the starting point, and for convenience in compiling the fares the distance of each from A has been inserted to the left, though this would not be required in the table as presented to the public. First then the column of fares from A can be filled in and, since the longest distance is to be at the rate of 1d. a mile, and from A to H is 16 miles, the fare to H can be inserted as 1s. 4d. A to G is 14 miles and at a fare of 1s. 3d. the rate would be 1 $\frac{1}{4}$ d. per mile. From A to F is 11 miles and a fare of 1s. would give a rate of 1 $\frac{1}{4}$ d. a mile. Similarly with a fare of 10d. for the 9 miles from A to E the rate would be 1 $\frac{1}{3}$ d. a mile, and at fares of 7d., 4d. and 3d., the per-mile rates from A to D, C, and B would work out at 1 $\frac{1}{4}$ d., 1 $\frac{1}{3}$ d. and 1 $\frac{1}{2}$ d. for the 6, 3, and 2 miles respectively.

The columns for B, C and the rest have been filled in on similar lines; but in doing so care is necessary to ensure that the longer distance fare is never greater, and preferably less, than any two or more shorter distance fares covering the same ground; in other words,

it must not be possible for a passenger to book say from A to E and then on from E to H more cheaply than he can book direct from A to H. Such anomalies are not unknown to tables of fares.

Miles from A

	A							
2	B	-/3	B					
3	C	-/4	-/2	C				
6	D	-/7	-/5	-/4	D			
9	E	-/10	-/8	-/7	-/4	E		
11	F	1/-	-/10	-/9	-/6	-/3	F	
14	G	1/3	1/1	1/-	-/9	-/6	-/4	G
16	H	1/4	1/3	1/2	-/11	-/8	-/7	-/2

To H from

A	1/4	1/6	1/6	1/6	1/6	1/7	1/5
B	1/3		1/4	1/4	1/4	1/5	1/3
C	1/2			1/3	1/3	1/4	1/2
D	-/11				1/-	1/1	-/11
E	-/8					-/10	-/8
F	-/7						-/6

Systematic checking is therefore advisable and such a system is indicated by the figures beneath the table. The first line deals with fares from A, whence a ticket over the whole route costs 1s. 4d., as marked in the first column. In this line the 1s. 6d. under column B represents the combined prices of tickets from A to B and from B to the end of the route at H. The 1s. 6d. under column C shows the combined prices of tickets



from A to C and C to H. Thus, in the first line combinations of two tickets for the whole route are shown between A and each stopping place, while the second line covers the rest of the route with combinations of tickets between B and the remaining stopping places. Similarly the other lines serve for the other places.

A study of these check figures indicates that by booking to G and thence on in most instances the cost is no more than a single through booking, while in the last case one can book from F to G and thence to H actually for a penny less than by booking direct from F to H. The discrepancy will be found in the fare from G to H, which is only 2d. for two miles, whereas the charge for the same distance between A and B is 3d.; so the fare GH must be adjusted to 3d. This will give the requisite gradation.

**PART III**  
**WORKING AND UPKEEP**

## CHAPTER XX

### VEHICLE WORKING—TYRE UPKEEP

IN dealing with vehicle working and upkeep it is proposed to attempt nothing more than an indication of some of the considerations that arise and of the work that has to be done in conjunction with them, merely detailing that work sufficiently to enable the reader to form some opinion as to whether it is being properly performed. If he is already a mechanic, this last will be unnecessary and he can skip it; if he is not, anything further would be useless.

To maintain maximum efficiency on the minimum of expenditure should be the first consideration in working vehicles that have to be run on a purely £ s. d. basis, for, even in transport business carried on for direct profit, the margin for that profit is achieved only by careful saving in expenditure. Accordingly, the subject may well be treated from this angle, item by item.

Of the details common to all vehicles, the item for tyres is the most important, and probably more money is lost by faulty working and maintenance in this direction than in any other.

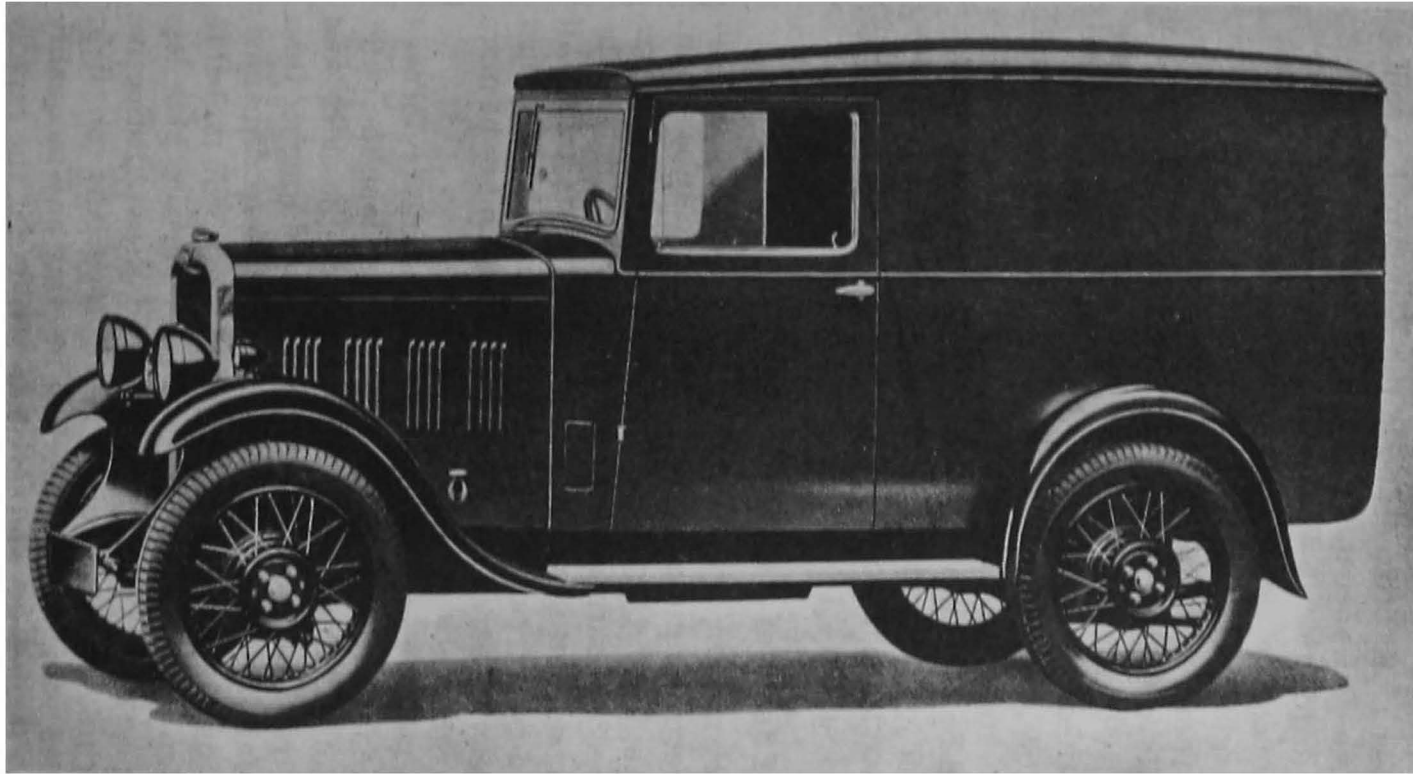
#### **Against Overloading.**

Of all the troubles to which solid and pneumatic tyres are alike liable the most serious is overloading. It is no exaggeration to say that a few hundred yards with a serious overload may shorten the tyre life more than hundreds, or even thousands, of miles of legitimate running and may cost the owner many pounds. Therefore, from the first it is best to make an inflexible

rule against overloading and to have one's vehicles over- rather than under-tyred. Of course the first of these recommendations is more easily made than achieved in many cases; but the second may then prove a valuable safeguard.

When a solid tyre is carrying load it is pressed between the wheel rim and the ground. Therefore, following lines of no resistance, the part under compression tends to bulge outwards to each side, for, contrary to popular belief, rubber is incompressible: it can only be displaced. If the load is excessive, the rubber is displaced to a greater extent than its nature can stand, its internal structure is crippled, and soon little circumferential cracks begin to appear at the sides near the base. At first these will be hardly noticeable. That is what makes overloading so insidious, for its effects are not realized until some time after. But those cracks will rapidly develop so that the rubber peels away in strips from off the sides. On tyres that have been long overloaded cracks sometimes develop from the centre of the treads outwards, and lumps of rubber break away from the sides. Sometimes the softer rubber of the tyre breaks away from its hard rubber base, or the hard rubber from its steel base ring. Overloading can always be diagnosed from these symptoms and when the representative of the tyre makers calls he can invariably tell with unflinching certainty whether or not a tyre has been overloaded.

On overloaded pneumatic tyres the sides are bulged out in much the same way, so that the cover tends to get pinched between rim and road and is thereby bruised, which results in circumferential tears just above the bead. Too much stress is also imposed on the walls of the cover, producing cracks, which develop, while the foundation of the cover is weakened and inside shows the beginnings of breakage. Once the layers of



**THE SINGER JUNIOR VAN IS DESIGNED FOR LOADS UP TO 5 CWT.**

**Essentially for retail deliveries.**

*(By courtesy of Singer & Co., Ltd.)*

the casing are broken above the clinch real repair is impossible. Under-inflation shows just the same symptoms, in addition to which the inner tube is more liable to damage by being nipped between road and rim. Overloading and under-inflation are, in fact, much the same thing only looked at from opposite aspects; in the one case the load is too great to be supported properly by the air pressure, in the other the air pressure is insufficient to support the load. Drivers should, therefore, be made responsible for inspecting their tyres before going off duty and before starting, and tyres should be periodically tested for pressure with a gauge, but not too frequently, as that may produce a tendency to valve leakage; once a week or every thousand miles should suffice.

#### **The Effects of Excessive Speed.**

Overspeeding is the twin evil of overloading, though its effects are not so serious. Still, they can be serious enough, for when running fast under a heavy load tyres can become surprisingly hot and are then not in the best condition to withstand wear and tear: indeed, if a solid tyre is cut open, right across, after a really fast run heavily loaded, its interior will be found to be more or less fluid.

On solid tyres excessive speed is usually evidenced by the formation of grooves or troughs along the outer edge of the tread, just where they join the sides, and both tread and sides will be more cut and rougher than with fair use. Also, if excessive speed is accompanied, as is usual, by excessive braking, flats will probably develop on the braked wheels. Pneumatics give less evidence; but commonly the tread shows distinctive scratches, since at high speed, especially on light unladen vehicles, the wheel on meeting any inequality leaves the ground and on again striking it the rapidly

revolving tyre gets scratched. More cuts also are sustained and, if these are not attended to promptly, road dirt gets in, forming blisters. These should be cleaned out, the interior washed with benzine, and smeared with solution. A binding should then be wrapped round the tyre which can be inflated and left for three or four hours. If severe, the cut may be "stopped" with mastic.

Should more wear be evident along one side of the tread than the other, whether on a solid or pneumatic, it indicates either loose wheel bearings or that the wheels are out of alignment. Looseness in the bearings can be detected by jacking up the wheels and shaking or pulling them backwards and forwards to show any end play, and by rocking them crossways to discover radial wear. It may be due merely to bad adjustment, in which case the cure is obvious, or on the other hand it may indicate the need for repairs. The looseness can, however, sometimes be reduced, as a temporary measure only, by inserting a washer between the shoulder of the axle and the wheel, but care must be taken to leave the wheel turning freely. If the trouble is due to misalignment, very possibly the other wheel on the same axle will show similar symptoms, though not necessarily so. Of alignment, however, more hereafter.

### **Flatting on Solid Tyres.**

Flats on solid tyres may also be caused by misalignment or by bad braking. Sometimes a whole series of them will appear at regular intervals along the tread. This was long a puzzle, but the explanation is fairly simple. If one flat forms or a stone becomes embedded in the tread, raising a lump, when that part of the tread strikes the road the wheel tends to jump. On descending, some other following part of the tread

strikes the ground and this action, continually repeated, produces a flat which in turn produces another flat behind it, and so on in series.

Once its cause is removed, a flat, if not too far developed, may work itself out and disappear. Otherwise the only course lies in sending the tyre to the makers to be skimmed up, though that is only justified by a very clear promise of a long subsequent life; for old worn tyres it would not be worth while, especially at present tyre prices.

### **Wheels Out of Alignment.**

Defective wheel alignment is perhaps the most fruitful source of avoidable tyre wear. It is more commonly in evidence at the front wheels. If a pair of wheels are out of alignment, the one tends to run inwards or outwards—towards or away—from the other; generally outwards. But only as far as its bearings or connections will permit: then it is suddenly checked and is dragged forwards at an angle until it reverts to its normal position, the tread meanwhile grinding against the road surface in the process. This action is repeated indefinitely. A pair of 34 in. wheels,  $\frac{1}{8}$  in. out of alignment, if thus free to run away from each other, at the end of only a ten-mile run would be 550 ft. farther apart than at the start, so the measure of this sideway drag on the wheels can be appreciated. Little wonder that misalignment causes tyre wear!

When wheels are out of alignment it is a case of one wheel on an axle pulling sideways against the other. Yet axles can also be out of alignment. The near side hindmost axle of a six-wheeler strikes the kerb or some other obstruction and is shifted backwards. This axle then is no longer parallel with the others and its wheels tend to run towards the near side and so pull against the straight-running tendency of the others.



Under such conditions the off sides of both its tyre treads will show undue wear.

### **Testing for Alignment.**

If symptoms suggest wheels or axles out of alignment, notice along which sides the treads are worn. If the axle is out of line, both tyres will be worn on the same side of the tread—both on near or both on off sides. If, however, the axle is in line and it is the wheels that are at fault, the tyre treads will be worn along opposite sides: if the wheels are turning inwards too much, both tyre treads will be worn along their outer edges, and if the wheels tend to run apart from each other, then both inner edges of the treads will be affected. It should of course be understood that though the alignment of an axle on its springs may be preserved correctly, wheel, as distinct from axle, misalignment may be due to the axle being bent outside of its spring seatings, in which event the wear symptoms would be those of wheels out of line.

Bearing in mind these points then, and having made sure that the trouble is not due to mere wheel looseness, one can generally form a fairly shrewd idea as to the cause. If no clue is forthcoming, stand the vehicle unladen and with its steering in exact central position on a perfectly level floor, making sure that the chassis frame is riding evenly on its springs. With a steel tape measure, held taut but not stretched, find the distance between back and front wheel centres on both sides. If axles are parallel, these measurements should be identical; otherwise it means that one axle is bent or shifted, almost certainly backwards, and, if it is the front axle that has suffered, the displacement will be on the side where the measurement is smallest; in the case of a back axle it will be on the side of the greater measurement.

With a rough test like this it would not be of much use looking for any bending in a live back axle; the possible distortion would probably be too small to be detected. Nevertheless, if such an axle is suspected, each of its wheels can subsequently be jacked up and turned by hand to see whether it is running freely for its full revolution.

Bending in a front or dead axle may sometimes be discovered by "sighting" along the axle, if the brake

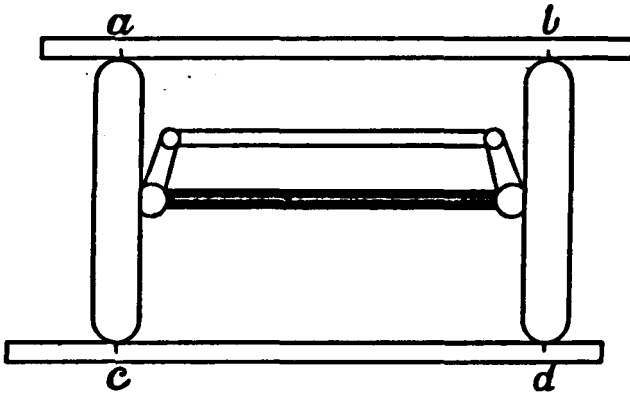


FIG. 45. DIAGRAM OF FRONT WHEELS SEEN FROM ABOVE  
If the wheels are in alignment, their centre line will be the same distance apart back and front—from *a* to *b* as from *c* to *d*

drums permit, or by a straight-edge. A bent axle will, of course, have to be taken out and straightened, and in the case of a displaced axle the springs will have to be re-positioned very carefully to measurement, so that on test, measurements between axle centres are again the same near and off side.

Having ensured the parallelism of axles, our next step is to ascertain whether the wheels are parallel. This is done by measuring the distance apart of each pair at the front and back of the wheels. If these measurements are equal, the wheels are parallel with each other.

A straight lath can be used to check the distances either between the inside edges of the wheel rims or between marks made at exactly the centre of each tyre tread. The measurements should be taken at the same height, back and front, for each pair of wheels, as nearly at the height of the wheel centres as circumstances permit, and the measuring lath must be kept parallel with the floor.

This test should show the back wheels perfectly

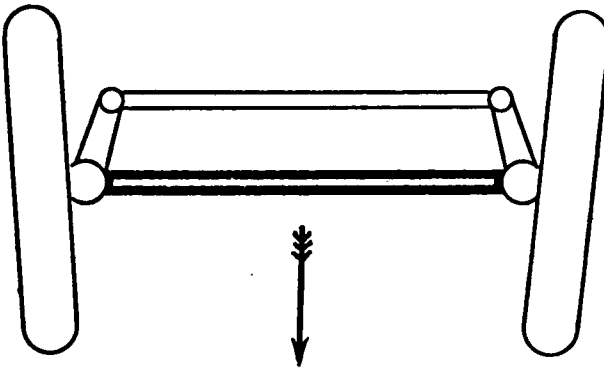


FIG. 46. FRONT WHEELS SET WITH "IN-TOE" (EXAGGERATED) ARE SHOWN IN THIS PLAN DIAGRAM

The arrow indicates the direction of forward movement of the vehicle

parallel, but it may be that the front wheels at their rearmost points will be  $\frac{1}{8}$  in. or so farther apart than at the foremost points on their circumference. That may be quite correct, however, because steered wheels, when perfectly parallel, tend to run outwards away from each other, and, if spring or wear at the tie rod joints permit the slightest action of this sort, undue tyre wear is the result. Therefore, to allow for it the wheels are generally turned slightly inwards at the front and this is termed "in-toeing." Fig. 46 explains it. For solid tyres in-toeing is the invariable rule,

ranging up to  $\frac{1}{4}$  in. or even more, but for pneumatics, owing to their greater flexibility, more than  $\frac{1}{4}$  in. of in-toe should not be given, and indeed many operators allow none.

As these are only rough tests, they must not be regarded as too conclusive; but they will generally suffice to discover and locate any appreciable defect in alignment.

## CHAPTER XXI

### VEHICLE WORKING—REPAIRS

As a general rule, a thorough repair overhaul will be needed every 20–30,000 miles—probably nearer the higher figure in the first year or two of a vehicle's life, the intervals decreasing with age. Much, however, depends upon the driver and the working conditions, especially in the matter of maintenance. If running repairs and adjustments are effected as soon as they become necessary, before defects have time to develop, the repair bill can be materially reduced. The "do-it-now" policy should be cultivated.

Repairs may be carried out on either of two systems; either the car may be laid up in the ordinary way or, if constructed on the unit principle, each unit in turn—engine-cum-gearbox, back axle and torque tube assembly, and so on—can be taken out during the night or week-end, and temporarily substituted by a spare one while it is under repair.

The latter method reduces the "spare" charges to a minimum and, as the cost of spare vehicles is a serious consideration, the time occupied in overhaul should be reduced to the minimum. Therefore when the work is done by an outside repairer a limit should be definitely specified in writing. Though in many instances a fortnight is allowed, a week should suffice; indeed, by some large highly organized transport concerns that do their own repairs the time is reduced to two or three days.

In any case, chassis not built on the unit plan will have to be laid off for overhaul and, unless a very considerable number are in use, the expense of a repair shop and plant will not be worth while. Then it will

be best to employ an outside repairer to maintain the vehicles on contract or at an estimated quotation for each repair; but the owner should make sure beforehand as to the repairer's competence and the adequacy of his plant.

The transport manager will arrange as far as possible for repairs when business is slackest; but, if the work is done outside, he may also have to work them in when the repairer is not too pressed.

Before deciding on repairs, however, not only will the manager have to be satisfied as to the need, but he must form a perfectly definite idea of the work required.

### **The Preliminary Survey.**

The vehicle will first have to be given a general survey and the manager may, with advantage, take a run on it, noting any knocking, rattling, or other signs of looseness or wear. If he has the car driven past him once or twice at varying speeds, he may get some useful impressions, for noise more or less implies wear and tear and most of it can be heard better from outside than inside the vehicle. Then, with the car standing on the level, any drippings of oil should be noticed, to see if they are due to leakages past worn bearings. Oil leaks are rather instructive in this way, and it is often worth while also to stand the machine on a steepish hill, facing both up and down, to discover which, if any bearings, are letting oil past; only the car must be well warmed up so that the oil is fairly fluid, and time given it to run. Absence of leakage from the engine under these conditions does not, however, necessarily imply unworn bearings, for in the casing precautions are taken to prevent oil flowing unduly to either end on a gradient—this to prevent front or rearmost cylinders getting over-oiled and sooted up.

The engine may next be tried at various speeds with vehicle stationary. In dealing with petrol engines, speaking very broadly, a rumbling roar at speed indicates worn main crankshaft bearings, the distinctive knock of connecting rod big ends can usually be detected at lower speed and a tapping sound is probably due to wear in the gudgeon pin small ends of the connecting rods. For this work a thin stick of hard well-seasoned wood is useful in locating the noises, the one end applied to the teeth, the other to the engine near suspected parts, on the stethoscope principle. Indeed, special stethoscopes are sold for the purpose. Still, there is no need for a fancy instrument; the stick will serve just as well, if not better.

#### **System in Inspection.**

A systematic inspection can now be started unit by unit and detail by detail, beginning with the engine. First the condition of cylinders, pistons, and valves can be tested by trying how they hold the compression. With ignition switched off, each cylinder can be tested in turn by opening the compression cocks (or failing them removing the sparking plugs) of all the others. The starting handle should then be pulled steadily round—not jerked—until the full resistance of compression is felt, and the pull should be sustained. If the resistance gradually lessens and the handle can be pulled further round bit by bit, the compression is not holding, as may perhaps be evidenced by a slight hiss in the crankcase. If the engine is cold, it may be best to put a drop or two of petrol or paraffin into each cylinder before this test, to loosen any gummed-up oil and free the piston rings.

By rocking the flywheel sharply backwards and forwards a few degrees any looseness in connecting rod bearings may be verified, and play in the main bearings

can be detected by engaging the starting handle and trying to "jump" it up and down. True, that will only indicate radial play towards the front end; but, if there is wear at the front, it is practically certain to exist at the rear bearing which has to take the weight of the flywheel.

All bearings throughout the chassis will, as far as possible, have to be tried for wear, which is evidenced in two ways. Radial play is due to wear on the diameters of shafts or bearings, end play to wear on the ends of bearings or the collars or fittings on the shaft that retain it longitudinally in position. Of these, as a general rule, radial slackness is much the more important, less than  $\frac{1}{8}$  in. on engine bearings, for instance, setting up a very serious knock, whereas  $\frac{1}{16}$  in. of end play may possibly entail no immediate consequences, though certainly requiring attention.

To discover radial play one should try to lift the shafts sharply up and down or from side to side and try and rock anything to which the shaft is attached, such as a wheel or coupling joint. For instance, in trying over the wheel bearings with the axle jacked up, the wheel should be grasped top and bottom and an attempt made to shake it by pulling on the top and pressing on the bottom, then rapidly reversing the action. To ascertain wear all round, this should be done top and bottom and from the sides. To try for end play one would simultaneously pull both top and bottom, as though trying to draw the shaft from its bearing, and then push, rapidly repeating the process, virtually trying to shake the wheel on and off its shaft.

All gears, too, will have to be tried for backlash to see to what extent they are worn; that is to say, how far one gear wheel can be turned round without moving the other with which it is in engagement.



If the owner has no specialized mechanical knowledge, he will, of course, have to rely on the opinion of his foreman or driver in these matters; only experience will enable a man to judge what amount of play is permissible and what is not. It is to a great extent instinctive. Nevertheless, the moral effect on one's men of appearing to know what should be done is worth something, and by discreetly sounding them, in conjunction with his own observations the owner with but little knowledge of mechanical matters should generally be able to form a fairly shrewd opinion. Indeed, with a little practice and experience he will find himself more and more in a position to form such opinions independently, until before long he will be capable of reporting on a chassis "on his own," if he keeps his eyes, ears, and mind open.

Even then, however, the driver will be able to provide much information that can save work in inspection. He should know, for example, without breaking any joints or connections, whether the water circulation system is beginning to get furred up and want scaling out, whether the engine will need decarbonizing, the clutch re-lining, and so forth.

### **The Vehicle Report Sheet.**

The need for system in inspection has been mentioned, and this is facilitated by a report sheet on which the condition of the various details can be noted. Some firms that do their own repairs make out reports on which every detail of the car is entered, short of individual nuts, bolts, and split pins—all arranged unit by unit. One such is appended here, the items more or less in order of their dismantling as a memo, so that none should be overlooked.

Clearly the condition of many of these items can be filled in only when the car is dismantled and the casings

## REPORT SHEET

**ENGINE.**

<i>Cylinder head</i> . . . . .							
<i>Cylinders.</i>	Nos.	1	2	3	4	5	6
Bores . . . . .							
Pistons . . . . .							
Piston rings . . . . .							
Gudgeon pins . . . . .							
Connecting rod small end bearings . . . . .							
" " big end bearings . . . . .							
<i>Crankcase</i> . . . . .							
Base chamber . . . . .							
<i>Crankshaft.</i>		1	2	3	4		
Journals . . . . .							
Bearings . . . . .							
<i>Distribution Gear.</i>							
Pinion . . . . .							
Camshaft gear . . . . .							
<i>Camshaft.</i>		1	2	3			
Journals . . . . .							
Bearings . . . . .							
Cams . . . . .		1	2	3	4	5	6
Tappets . . . . .							

ENGINE—(contd.)

	<i>Water Circulation.</i>			
	Pump	.	.	.
	Pump shaft	.	.	.
	" drive	.	.	.
	" bearings	.	.	.
	" gland	.	.	.
	Circulation pipes	.	.	.
	Water jackets	.	.	.
	Radiator	.	.	.
	<i>Lubrication System.</i>			
	Pump	.	.	.
	" drive	.	.	.
562	Filters	.	.	.
	<i>Fuel System.</i>			
	Carburettor	.	.	.
	Fuel pump	.	.	.
	" " drive	}	(if any)	.
	Auto-vac (if any)	.	.	.
	Filters	.	.	.
	Fuel tanks	.	.	.
	<i>Ignition System.</i>			
	Magneto	.	.	.
	" drive	.	.	.
	Distribution	.	.	.

	<i>Electrical Equipment.</i>			
	Batteries	.	.	.
	Dynamo	.	.	.
	" drive	.	.	.
	" cut out	.	.	.
	Starter	.	.	.
	" drive	.	.	.
	" cut-out	.	.	.
	Bendix pinion	.	.	.
	" gear	.	.	.
	<i>Clutch.</i>			
	Spigot bearing	.	.	.
	Linings	.	.	.
	Spring	.	.	.
	Thrust collar	.	.	.
	Fork	.	.	.
	Pedal	.	.	.
	Sleeve	.	.	.
	Shaft	.	.	.
	Bearing	.	.	.

	<b>TRANSMISSION.</b>			
	<b>GEAR BOX.</b>			
	Casing . . . . .	.	.	.
	Bearings, main . . . . .	.	.	.
	" layshaft . . . . .	.	.	.
	Gears . . . . .	.	.	.
	Selector . . . . .	.	.	.
	" rods . . . . .	.	.	.
	" striking forks . . . . .	.	.	.
	Propeller shaft . . . . .	.	.	.
	" " joints (front) . . . . .	.	.	.
	" " " (back) . . . . .	.	.	.
	Joint casings . . . . .	.	.	.
	Torque tube . . . . .	.	.	.
	Driving pinion . . . . .	.	.	.
	" " shaft . . . . .	.	.	.
	" " " bearings . . . . .	.	.	.
	Crown wheel . . . . .	.	.	.
	Differential . . . . .	.	.	.
	Axle shafts . . . . .	.	.	.
	" " bearings . . . . .	.	.	.

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	<b>WHEELS, AXLES, AND SPRINGS.</b>			
	Springs . . . . .	.	.	.
	Spring buckles . . . . .	.	.	.
	" shackles . . . . .	.	.	.

	<b>WHEELS, AXLES, AND SPRINGS—</b>					
	<i>(contd.)</i>					
	Journals . . . . .	.	.	.		
	Bearings . . . . .	.	.	.		
	Wheel centres . . . . .	.	.	.		
	Rims . . . . .	.	.	.		
	Tyres . . . . .	.	.	.		
	<b>BRAKES.</b>					
	Drums . . . . .	.	.	.		
	Shoes . . . . .	.	.	.		
	Camshafts . . . . .	.	.	.		
	Camshaft bearings . . . . .	.	.	.		
	Cams . . . . .	.	.	.		
	Connections . . . . .	.	.	.		
	Compensation . . . . .	.	.	.		
	Rocker shafts . . . . .	.	.	.		
	Pedals or levers . . . . .	.	.	.		
	<b>STEERING CONTROLS.</b>					
	Steering column . . . . .	.	.	.		
	" wheel . . . . .	.	.	.		
	" worm . . . . .	.	.	.		
	" sector . . . . .	.	.	.		
	" " shaft . . . . .	.	.	.		
	" " " bearings . . . . .	.	.	.		
	" gear casing . . . . .	.	.	.		
	" drag link . . . . .	.	.	.		

Back | Front

STEERING CONTROLS—(contd.)

Tie rod . . . . .  
 Stub pivots . . . . .  
 „ pivot bearings . . . . .

FRAME.

Longitudinals . . . . .  
 Cross members . . . . .  
 Running boards . . . . .  
 „ board hangers . . . . .

BODY.

Underframe . . . . .  
 Framing . . . . .  
 Floor . . . . .  
 Panels . . . . .  
 Roof. . . . .  
 Doors . . . . .  
 Lights . . . . .  
 Fittings . . . . .

505 REMARKS—

opened up; so, if repairs are done outside, much of the form could be filled in only by the repairer. Doubtless he could do so; but it would put extra work on him, all of which would have to be charged for, and it is politic to leave him free to adopt his own methods. The more he is interfered with the more his responsibility diminishes, and it is better to work with him than appear to work over him. All the owner requires is to ensure the work being done properly and not over-charged. For the former he must rely mainly on the repairer's reputation, and as a check against the latter a simple form of vehicle report is suggested opposite. Armed with that, the owner or his representative, in company with the repairer, can go over the vehicle when dismantled, and come to a definite understanding as to the repairs necessary, and based on that understanding the repairer can then submit in black and white a detailed estimate for the work. If any replacements are entailed, their prices can be checked against those in the maker's list of spare parts.

## VEHICLE REPORT

McKERREL & SALMON, LTD.,  
 FISHMONGERS,  
 THE QUAY, LOCH FVNE.  
 Driver

DATE

Vehicle No.

Make

Capacity

ENGINE.

General condition . . . . .  
 Cylinders, compression . . . . .  
 Valves . . . . .  
 Valve guides . . . . .  
 Journals and bearings: Con. rod,  
 small ends . . . . .  
 Journals and bearings: Con. rod,  
 big ends . . . . .  
 Journals and bearings: Crankshaft  
 camshaft . . . . .  
 " " water pump . . . . .  
 " " oil pump . . . . .  
 " " magneto . . . . .  
 " " dynamo . . . . .  
 " " starter . . . . .  
 Gears, distribution . . . . .  
 " oil pump . . . . .  
 " magneto . . . . .  
 " dynamo . . . . .  
 " starter . . . . .  
 Valve tappets . . . . .

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ENGINE—(contd.)

Tappet guides . . . . .  
 Clutch lining . . . . .  
 " thrust collar . . . . .  
 " fork . . . . .  
 " spigot bearing . . . . .  
 " shaft . . . . .

TRANSMISSION.

Gear box shafts . . . . .  
 " " bearings . . . . .  
 " " gears . . . . .  
 Selector . . . . .  
 " rods and strikers . . . . .  
 Propeller shaft . . . . .  
 " " joints . . . . .  
 Torque tube . . . . .  
 Final shaft bearings . . . . .  
 " " pinion . . . . .  
 Back axle crown wheel . . . . .  
 " " differential . . . . .  
 " " bearings . . . . .

**AXLES, SPRINGS, AND WHEELS.**

Back wheel bearings . . .  
 " " springs . . .  
 " " tyres . . .  
 Front wheel thrusts . . .  
 " " bearings . . .  
 " " springs . . .  
 " " tyres . . .

**STEERING.**

Stub pivot bearings . . .  
 " " arms . . .  
 Tie rod . . .  
 Drag link . . .  
 Drop arm . . .  
 Steering gear . . .  
 " " bearings . . .

**BRAKES.**

Front drums . . .  
 " shoes . . .  
 " camshafts . . .  
 " connections . . .  
 Back drums . . .  
 " shoes . . .  
 " camshafts . . .  
 " connections . . .  
 Control levers . . .  
 Frame . . .  
 Wings . . .  
 Body . . .

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**REMARKS—**

*Foreman's Signature* .....



## CHAPTER XXII

### VEHICLE WORKING—FUEL AND LUBRICANT CONSUMPTION

SINCE the practical introduction of the commercial motor, immense improvements have been effected in fuel consumption. Twenty-five years ago an omnibus required just about double as much petrol as a bus of to-day. But, though continual progress in both petrol and steam engine design is still being made, in the nature of things the advance is likely to become ever slower as the scope for economy is reduced, and it looks as if we may be nearing the point beyond which little improvement may be possible on present lines. Although even the last few years have seen a marked improvement in consumption, it, therefore, seems probable that any very material further progress is likely to be brought about by radical changes in principle rather than in detail. One such development is already promised by the compression-ignition heavy oil engine, with prospects of some 50 per cent reduction in fuel consumption, while, if the claims of a system for using water split up into its component gases can be substantiated, far-reaching effects on these lines may be expected.

Yet, although for any further sweeping fuel economies we must look to the vehicle maker rather than the user, the latter by continual vigilance and small savings here and there can do much to keep down what is generally the biggest item in purely running expenses.

#### **Causes of Excessive Carburettor Consumption.**

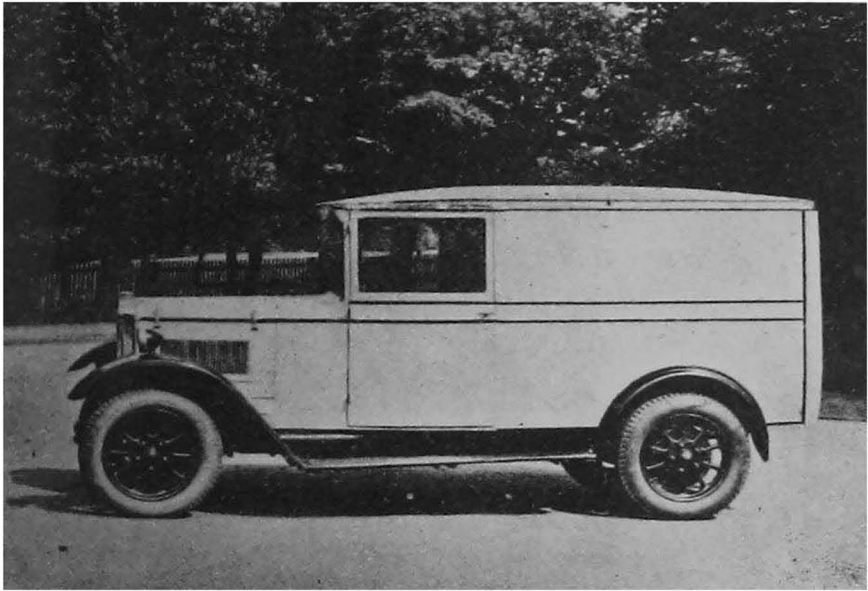
The consumption records will be the main guide; as soon as their figures show signs of going up, steps should

be taken to ascertain and remove the cause. Then, too, the man in charge will have to keep his eyes open for any symptoms of excessive consumption, as for instance an exhaust smelling strongly of motor spirit or giving off brown or blackish smoke; both of which indicate bad carburation and that either the engine is not using all its petrol efficiently or that it is getting more than it can completely use—in other words, the proportion of petrol to air in the charge is too large.

These relative proportions are generally dictated by the sizes of the petrol jet and of the choke tube which regulates the air supply and, since both of these can readily be replaced by others of different size, the usual remedy for excessive consumption is either a smaller jet or a larger choke tube. If the engine does not develop any too much power, yet shows signs of defective carburation, a larger jet is indicated, otherwise a larger choke tube; though to obtain the correct mixture will be a matter of trial and error, since choke tube and jet intimately act and react on each other. Again, in most modern carburettors there are two jets—one for slow running, since the petrol supply to the cylinders depends partly on the suction of the piston and partly on the induction of the rush of air up past the jet. Given proper inlet valve opening, ample air can always rush in and fill the cylinder, but at the slower engine speeds a less proportion of petrol is drawn in: hence the second jet which is automatically cut out of action by increase of engine speed. Consequently it may be that symptoms of too strong a mixture may be in evidence at low speeds only.

Another possible cause of waste may be flooding at the carburettor. Here the petrol level should be maintained just short of the top of the jet, so, as the spirit flows into the float chamber, a float rises and by its action moves a needle valve to cut off the supply as

soon as ever the required level at the top of the jet is reached. But, if the mechanism for doing this becomes worn or the needle valve becomes leaky, the level is exceeded, the fuel starts to overflow from the top of the jet and a steady drip sets up, even if the level is the very slightest bit above the jet top. When the



A 10-CWT. VAN BY A LEADING FIRM MAKING A WIDE RANGE OF TRANSPORT VEHICLES

This is the Morris Commercial light delivery van

*(By courtesy of Morris Commercial Cars, Ltd.)*

engine starts running at any speed, the dripping may cease for the time, but as soon as ever the engine stops it begins again till the petrol is shut off; and quite a lot may be lost in this way. Consequently, when excessive petrol consumption is in question about the first thing to do is to see if the carburettor is flooding. The remedy usually lies in grinding in the needle valve; but not with ordinary emery powder; only the finest crocus powder should be used, mixed with a little oil.

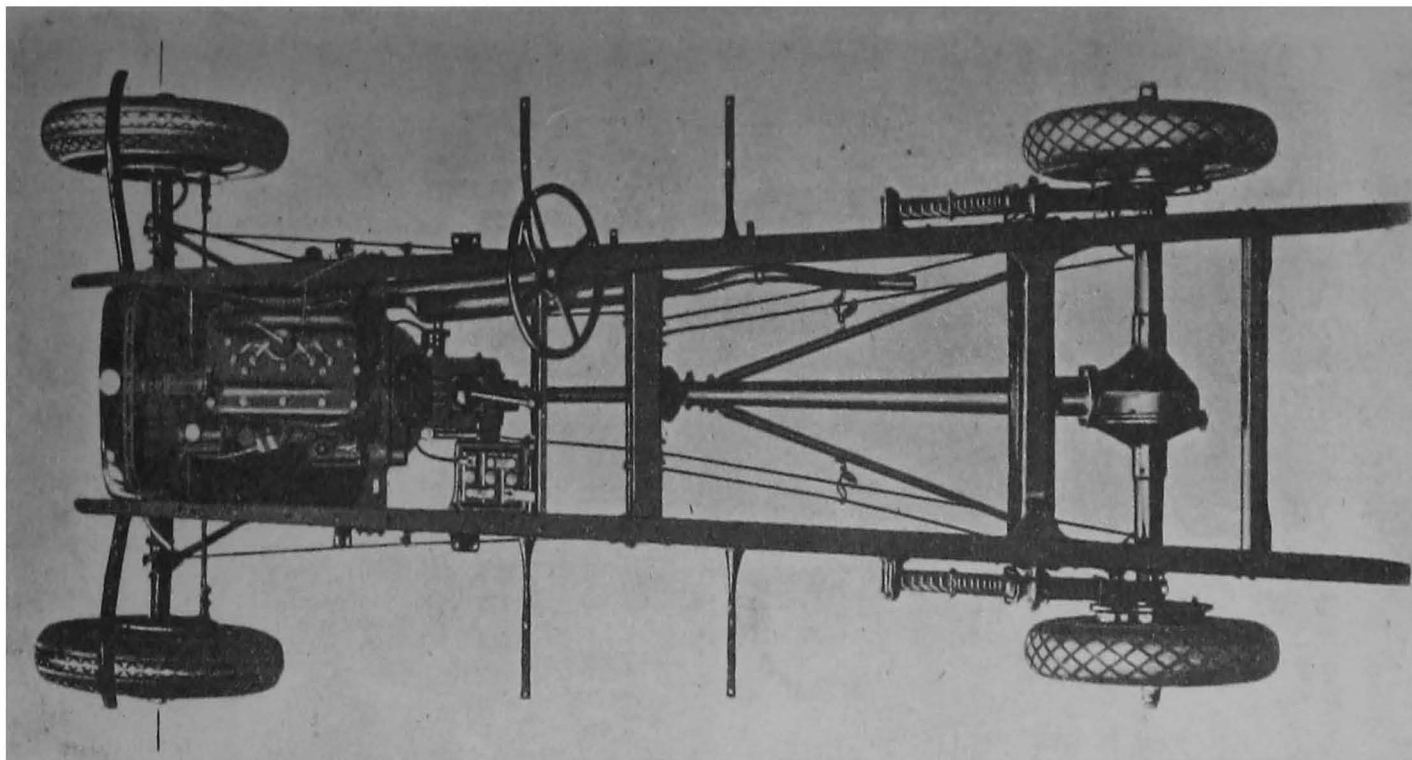
**Engine Condition as an Influence.**

But the carburettor is not the only influence affecting consumption. The reason for fuel waste may lie in the engine itself. Too weak a mixture may be caused by a worn inlet valve guide or spindle letting an undue proportion of air into the cylinder from below the inlet valve when it is open. Then, not only does the engine lose power, but such power as it gives is not proportionate to the fuel used.

Again, if its compression is bad, an engine is bound to use all the more fuel and often from this reason among others consumption increases as the time for repairing a vehicle approaches, or towards the closing years of its life.

**Other Possible Leakages.**

Over and above any question of mechanical efficiency, other possible sources of loss may have to be borne in mind. Cases have been known of drivers consistently drawing more fuel than their vehicles were using, and selling the surplus; or, when buying petrol on the road, of charging up more than the actual purchase. Of course, as all receipts for purchases on the journey would have to be produced, the latter type of fraud can be effected only by faking the receipt or in collusion with the man at the pump, but it is impossible to ensure that chance supplies along the road shall be obtained only from firms of reputable standing. Fortunately such cases are so rare that mention of them can make no reflection on drivers or garage men as a class; yet none the less on principle an owner should always recognize such possibilities and protect himself as far as may be by care in engaging his drivers and checking consumption and petrol in vehicle tanks against issues when anything of the sort is suspected.



**A MODERN FORD TRANSPORT CHASSIS WITH A WHEELBASE OF JUST SHORT OF 11 FT.**

Carried on cantilever springs at the back

*(By courtesy of Ford Motor Co.)*

**Steamer Fuel.**

The same applies to solid fuel for steamers which, unless kept under lock and key, is always open to pilferage. Another source of loss is the slack, or dust, which more or less accompanies all coal, sometimes constituting rather too large a part of it, and the more friable the coal, the more slack it forms. Thus from one cause or another it is not unusual to make an allowance for such losses, sometimes up to 20 per cent. The loss allowed on a railway truck of coal in transit, however, is only  $\frac{1}{4}$  cwt. to the truck.

Generally coal or coke will be bought by the truck load and, as coals especially vary enormously, loss may be avoided by careful buying. A good steam coal should give out plenty of heat, as evidenced in its capacity for steam raising; it should have plenty of "last"—that is, it must not burn away quickly; it should not be "mucky" and make a lot of ash and dirt, it should give as little smoke as may be, and it should not make a lot of clinker (which is only fused ash) to choke up the fire-bars. Moreover, such clinker as it does make should not be hard: some is almost as hard as metal.

**The Principles of Combustion.**

To be in a position to know whether steam fuel is being properly used some knowledge of the principles of its consumption is necessary.

Air, when heated, becomes less dense than the surrounding colder air and so tends to rise. Accordingly it passes from the firebox up the funnel and to fill the space thus left in the box fresh air flows in between the firebars from underneath. That accounts for the natural draught of a fire.

Now the process of burning is simply the chemical combination of the fuel with the oxygen of the air under the heat that is produced thereby, and, as the air flows

into the firebox that is what happens. If there is not enough air, some of the carbon from the disintegrating fuel is left uncombined and passes up the chimney as very finely divided particles, in the form of smoke: with too much air the fire is unduly chilled. In either case combustion is inefficient and the most is not being got out of the fuel. Smoke, however, may be consumed and complete combustion obtained by admitting additional air above the fire to combine with the unconsumed carbon, so drivers frequently leave their fire doors open for this reason, though it chills the firebox and is a practice that should be avoided except in really urgent cases. It is far better to open the damper which regulates the air supply from underneath, so that the air can first be warmed up by passing through the fire, for cold air striking against the hot plates of the firebox sets up contraction which may cause all sorts of trouble, leaky tubes the most prominent. Another way to reduce smoke is by turning on the blower which by sending a jet of steam up the chimney increases the draught and so the air supply; but this practice, too, cannot be recommended: far better rely on the natural draught past the damper. The chief function of the blower is to draw the fire up gently when raising steam, though even then it should be used gently and sparingly.

#### **Fire Management.**

Thus, the fire should be controlled mainly by the damper, and every facility given the air to flow in from underneath. Ash and clinker on the firebars will obstruct the flow (that is why a fire tends to die down) and so will an ashpan choked with ashes which, if allowed to pile up so as to surround the firebars, would result in the bars fusing or at any rate becoming badly deformed. The ashpan must therefore be kept clean, and the fire cleaned from time to time to keep the space

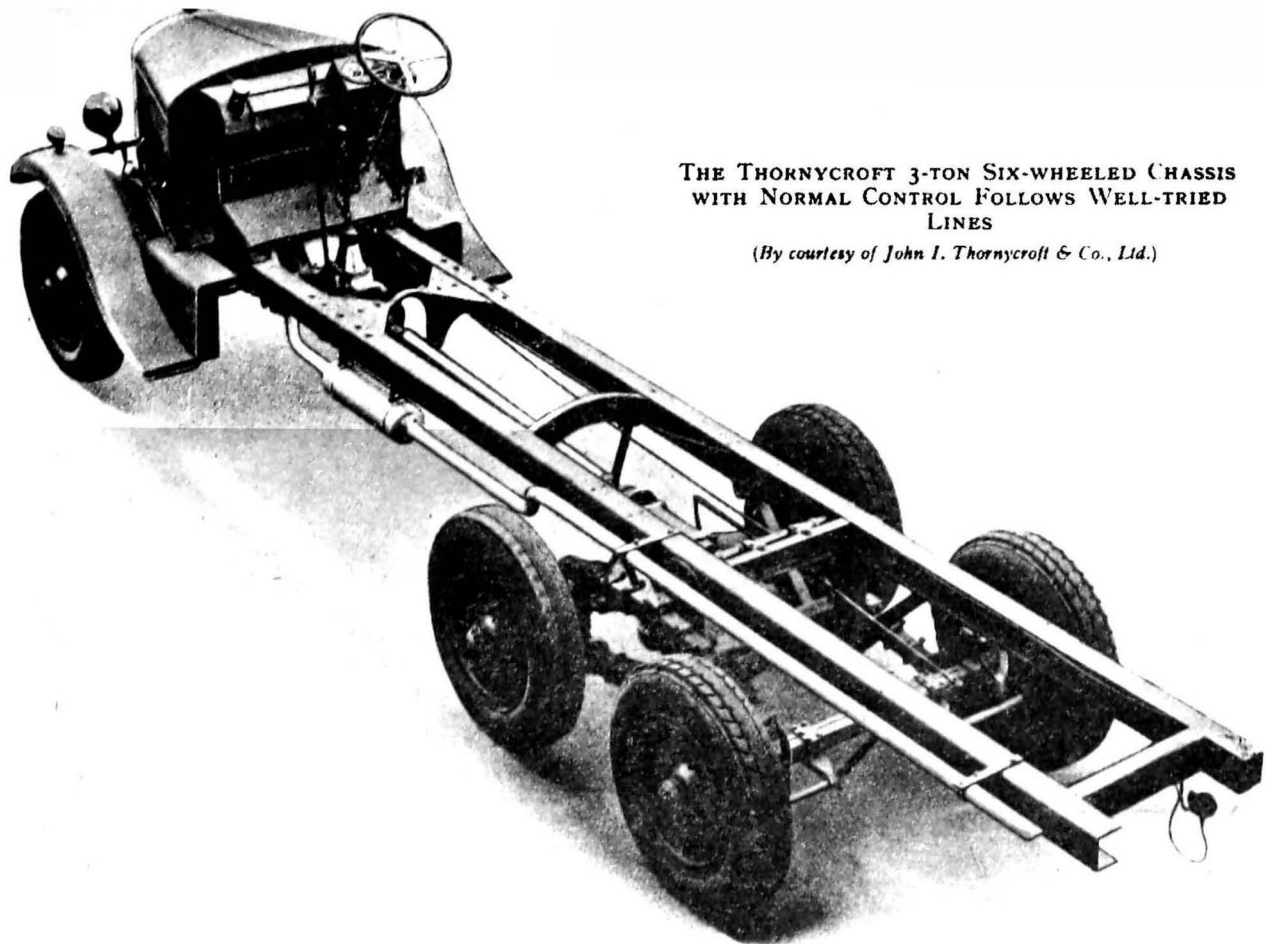
between firebars clear; but this should be done when the fire is low, as the firehole door must not be kept open with a hot fire, or the firebox might get chilled. Moreover, a hot fire with the wagon standing is waste of fuel, so the damper should be kept closed when standing about, as, of course, should the fire door. For a slow fire the air supply should be shut down as much as possible.

When running, with coal it is best in general to work with a thin fire, but not so thin that the firebars are left uncovered anywhere, as the air coming up through such holes in the fire would not get properly warmed and the firebox would then get chilled. The fire should, therefore, be kept at a constant level by frequent replenishment rather than by heavy firing at long intervals and the fuel should be put on just where it is wanted, where the fire is thinnest. With coke, however, which calls for considerably wider air spaces between the firebars, a much thicker or deeper fire is necessary. And, by the by, if gas coke of poor quality is used, it should be mixed with a proportion of hard coke.

### **Testing Steam Pistons.**

But fuel is not saved only in the firebox; the engine may have quite a lot to do with the matter and, even though it be in good repair, may be wasting steam, and consequently fuel, by leaky pistons. If therefore heavy consumption cannot be explained, the pistons should be tested for tightness by placing each close to the end of its stroke with the valve just opening to steam at that end. Then, with the cylinder cock at the other end open, transmission engaged and all brakes tight on, steam may be turned on very gently, just enough to see if any is getting past the piston and coming out through the cock at the other end of the cylinder. Each cylinder in turn should be subjected to this test.





THE THORNYCROFT 3-TON SIX-WHEELED CHASSIS  
WITH NORMAL CONTROL FOLLOWS WELL-TRIED  
LINES

*(By courtesy of John I. Thornycroft & Co., Ltd.)*

**Lubricant—Saving not Stinting.**

True economy never sacrifices efficiency and of no item is this more true than of lubrication. A distinction must be drawn between stinting and saving. The stint of six penn'orth of oil may cause damage costing hundreds of times more than the so-called saving, and there should be no cutting down of the lubricant supply—it is too dangerous. Economies must be sought in other directions by stopping up channels of waste.

Very little oil is actually consumed by a car. In engines a certain amount is consumed in the cylinders, but for the rest its expenditure is due to deterioration and the consequent need for replacement, though some may be lost at the bearings when they become worn. Friction means wear and it can never be eliminated; lubrication can only reduce it to within practicable working conditions. "Frictionless bearings" is only a relative term and in reality there are no such things. Consequently, under this wear that cannot be avoided tiny particles of metal, in time, get abraded from the bearing surfaces and these get carried into the oil. Thus, after a time, the oil becomes slightly charged with metal particles and has to be replaced, for, if thereafter the particles find their way between the bearing surfaces, they tend to cut into the metal and set up trouble.

**Oil Renewal.**

The frequency of the need for oil replacement varies much on different chassis. For internal combustion engines it depends partly on the extent to which the oil becomes diluted with condensed fuel; but in petrol engines after the first hundred miles or so dilution remains stationary as the fuel, being volatile, vaporizes more or less as fast as it collects. In heavy oil engines, however, it increases with use, and will of itself in time

necessitate a change of oil. Again, much depends on how an engine is run, a cool engine being more liable to dilution than a warm one; and, if it is throttled down to excessively slow speeds or run idle, dilution is the more likely.

Under these circumstances any hard and fast rule for changing the oil is impossible, and makers differ widely as to the period between each change, some advising it every 500 miles or so, others allowing 2,000 miles. As a general rule engine oil may with advantage be changed after the first 500 miles of running, and thereafter every 1,500 miles or so, and for the gearbox and back axle casings about every 2,000 miles. Should excessive dilution be suspected, a sample of the oil should be drawn from the sump, and, if it is thin and smells of the fuel, a change of oil is necessary.

After the old oil is drained off (it should be well warmed up before doing so) the casing should be washed, but not with petrol. In the writer's opinion paraffin is best, though some people prefer clean oil. If paraffin is used, however, it should not be allowed to collect in any pockets or hollows in the casing, but be wiped out with a perfectly clean cloth. Then, before charging with fresh oil, clean the filter.

Exhaust gases always contain a certain amount of water vapour and, if there is any exhaust leakage past the piston rings, water may form in the crankcase where it combines with any dirt present to form a sort of sludge. As water is heavier than oil, this collects at the bottom of the base chamber and for two or three consecutive days can be drawn off at the drain tap (with engine cold before starting in the morning) until none is left. The only real remedy, however, is to wash out the crankcase and change the oil; but the washing must be very thorough; and the piston leakage must be stopped; otherwise the evil will recur.

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It is often advisable to use a heavier oil in summer than in winter, but both oils should have the approval of the engine makers. When bearings become worn the oil passes them the more easily, and some drivers then also adopt a heavier oil; but this is not recommended. A heavier oil will not stop leaky bearings and, if it is unsuitable, may lead to fouled cylinders involving decarbonization and all the evils that lead to it. A better plan is to adjust the relief valve of the oil system to a rather lower pressure; but the driver who does this must know what he is about or interference with the oil pressure may result in damaged bearings.

The problem of oil economy is largely inter-dependent on other things. Loss of lubricant through worn bearings, for example, can be prevented only by maintaining the vehicle in thorough repair, and it constitutes a fairly strong hint that the chassis is due for an overhaul. On the other hand, care in regularly keeping the oil, from day to day, up to its maximum level (but never above) and all the steps necessary to counteract dilution and sludge, tend to lessen the need for decarbonization and so to reduce maintenance costs. And incidentally, if there is trouble from dilution, over-lubrication, or badly leaking piston rings, a bluish smoke is given off at the exhaust; which, if it occurs only just when the throttle is opened, may be put down to dilution; if more continuous, to over-lubrication or piston rings. Smoke due to oil can always be distinguished from that due to the fuel, the latter being brown or blackish.

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The possibility of reclaiming the waste oil from engine and transmission casings is bound to arise, and several appliances for the purpose are on the market. Where a large number of vehicles are in service a plant of this sort may pay, but, unless the oil can be rendered fit again for lubrication, it would not be worth while for a small fleet; there would not be sufficient use for oil suitable only for cleaning purposes. Some appliances, however, claim to transform the waste into sound, lubricating oil, and, if that claim could be substantiated, the plant would be well worth consideration; but the claim should be proved up to the hilt. It is not merely a matter of filtering, but of separating out any dilution, and, though that might be possible enough with waste oil from petrol engines, it might prove more difficult

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## CHAPTER XXIII

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### **The Importance of the Boiler.**

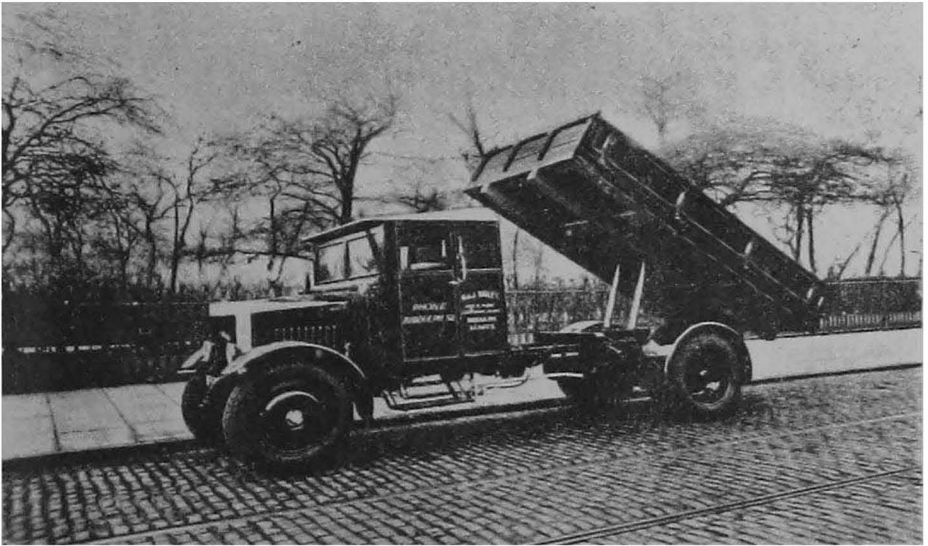
The chief difference between petrol and steam lies in the presence of a boiler, and a knowledge of its maintenance is essential in the supervision of steam vehicles, for boiler working entails considerable responsibility. The fact that steam is one of the safest sources of power is a remarkable testimonial to boiler construction considering the negligence and abuse to which many boilers are subjected: as far as the steam wagon is concerned an explosion is almost unknown. That, however, should be no excuse for neglecting the least precaution for safety, but rather it is proof that the modern boiler is really a superb example of material and workmanship which should be respected as such.

In the author's opinion every boiler should be insured, and examined annually by a competent inspector. In that event advice as to repairs will always be available; but let the need for keeping track of those repairs be emphasized. A record book should give the date and nature of every examination and of the repairs resulting therefrom, and this may in part be done by diagrams of the tube plates and firebox stays whereby the history of every tube and stay can be traced—whether and when it has been expanded, replaced, or riveted up, as the case may be.

### **The Prevention of Scale.**

It will then be in the everyday maintenance of the boiler that guidance will be most needed, and of this work the most important part lies in keeping the interior clean and free from deposit or scale. A steam wagon has to work with such water as is available, and, if the water is hard, salts of lime get separated out and deposited in the form of scale, especially on the flat surfaces of the firebox where it obstructs the passage of heat to the water: indeed, if the scale were allowed to

become thick enough, it would prevent the heat being conducted away to such an extent that the firebox crown would get badly overheated, resulting in serious damage or even an explosion. Plates that have been overheated in working cannot be restored to their former condition, remember! Grease is even worse than scale, the resistance to conductivity offered by a



THIS 3-TON HALLEY WAGON CAN TIP ITS LOAD BY HYDRAULIC POWER EITHER TO THE END OR EITHER SIDE

*(By courtesy of Halley Motors, Ltd.)*

$\frac{1}{16}$  in. thick coating being equivalent to a thickness of nearly 6 in. of steel plate.

It is, therefore, essential to prevent these deposits as far as possible. There is little danger from grease, the causes which lead to its deposit not existing in wagon boilers, and it will only be needful to see that no oily or greasy water gets into the tanks. As to scale, the tendency can be neutralized in some degree by reagents in the boiler; but the particular reagent employed would depend on the nature of the water, which could

only be determined by analysis. An indiscriminate use of reagents may do harm. Ordinary soda, however, is fairly harmless and, incidentally, may check corrosion by neutralizing any acids in the water; but it only renders the scale comparatively soft and easy of removal, rather than eliminating it. Boilerine also is good.

### **Washing Out.**

These deposits, then, must be constantly removed by washing out at intervals. On an average for a steam-wagon boiler this should be done at least every 100 hours that the boiler is in steam, though, unless the work is very irregular, it is much better to make a practice of washing out once a week.

Boilers should not be washed out until they have been out of steam for at least four hours. Then, when the boiler is cold, all mud covers and plugs can be removed and a hose nozzle inserted with a decent pressure of water available. The scale, as it is loosened, will fall to the bottom, so it is best to work from the top downwards, beginning with the firebox crown. To reach it and other parts two or three nozzles may be advisable—long or short, straight or bent, according to the boiler—and these can easily be contrived out of  $\frac{3}{4}$  in. gas piping. The hose will have to be used in conjunction with a scraper and, working from the top downwards, this will bring the scale down to the foundation ring where it can be drawn and swilled out through the mud holes.

When most of the deposit is removed, the hose should be inserted through these lower mud holes and the walls of both internal and external firebox shells well washed sideways and upwards, to bring down any further scale. The washing upwards, though frequently neglected, is of importance. Finally, any other parts



of the boiler must be similarly treated, and when the water coming away is clear and free from scale, a lamp may be inserted (if necessary on the end of a rod) to make sure that all is in order. That being so, mud covers and plugs can be replaced.

The cover joints are ordinarily made tight by washers or gaskets of woven asbestos soaked in boiled oil, and to prevent their sticking they should be well blacklead. The threads of the plugs may be greased (thick grease) but not too much towards their inner ends, or some of the grease may get into the boiler. In replacing plugs and covers great care should be exercised to ensure that the former are not screwed in with their threads on the cross, and that the cover gaskets lie flat and do not get nipped; therefore, the job had best be done by an experienced person; otherwise delay on the road may occur, to say nothing of any damage to the screw thread which will entail re-tapping and a larger plug. When the boiler is cold the plugs must be screwed up tight, but not too tight, or it may be difficult to remove them after subsequent expansion of the metal under heat: if necessary, they can be "taken up" a bit more when the boiler is warm.

### **The Weekly "Once-Over."**

Washing out should not be the sole duty on a shed day; the occasion should also be utilized for a general inspection. Tanks and strainers should be examined to see that they are perfectly free from dirt or grit; the exterior of the boiler should be inspected at all joints and fittings for traces of any deposit that might indicate leakage; pump and injector check valves should be taken out and carefully cleaned, as also the injector cones, any scale from which may be removed by a 10 per cent solution of hydrochloric acid in water, or, failing that, by the strongest possible solution of

common soda in boiling water. Then, too, the fusible plug may have to be cleaned of incrustation both on the water and fire sides, and every six months should be renewed.

And though the driver will, of course, go over his engine bearings every day (with an unenclosed engine) he will utilize shed day as an occasion for a systematic inspection and adjustment over the whole vehicle and for remaking any joints threatening trouble.

### **The Daily Round.**

This, however, must not absolve him from his daily duties, and every day the safety valve should be tested by lifting it from its seat to make sure that it is not sticking. Every day, also, the water gauge cocks should be blown through to see that the gauge is working, and the boiler should be blown off. In trying the water gauge the bottom cock should first be opened to test both steam and water passages; then the steam cock may be shut to test the water passage, and, finally, with water cock shut off, the steam cock can be opened to test the steam passage. If, for any reason, both cocks are shut off, the steam cock should always be opened - first to lessen the risk of the gauge glass breaking. Occasionally, once a month or so, the screw plugs of the gauge should be withdrawn to make sure that these passages are not choked, and, if they are, they must be cleared. After blowing through on the daily test the water should rise smartly in the gauge glass; if it rises sluggishly choking is suggested, and this might be dangerous.

A good deal of scale formation and deposit can be prevented by making a regular practice of blowing off the boiler every day, and so getting rid of some of the stuff that would form scale and dirt. The blow-off cock should be fully opened, but for a very brief period

only; if half open the plug of the tap and its seating are apt to get cut by the steam and grit rushing past at tremendous velocity.

The importance of these three points as a daily duty should be impressed on drivers, as they are all too commonly neglected, and they should be introduced into the daily routine which must be systematic.

### **Coming on Duty.**

When no shed hand is employed for lighting up and steam raising, the driver will first make sure of his water level in the gauge, which ought to stand at fully half-way up the glass and, if necessary, he will fill up with water, though this should be done only with the boiler practically cold; to run cold water on to the hot boiler plates sets up contraction that may do serious damage, and many a firebox has been ruined by this practice. Then he will sweep the tubes, clear the fire-bars, open the damper, clean out ashpan and smoke-box, and his next concern will be to get the fire going. The fire-lighting wood, which should have been ready chopped overnight, may be allowed to blaze by itself for a little, to dry the tubes and warm them up; then the coal can be put on.

While steam is raising, the driver, having drawn his oil, grease, and any needful stores, can systematically go over the machine with spanner and oil can, beginning with the engine and finishing up with the wheels. All this time the damper will be open until sufficient head of steam is attained and then, if steam has to be raised quickly, the blower can be put on moderately, though only if absolutely necessary, for reasons already explained. It is now that the safety valves can be tested, and they should be opened sufficiently to get rid of any air in the boiler.

Finally, with a good head of steam, bunker replenished,

and water tank filled; the wagon will be ready to start.

### **On the Road.**

A man responsible for steam vehicles should have some idea of their working on the road to know whether they are properly handled, and from this aspect the following few hints may help.

In the first place it must be recognized that with the engine running the natural draught of the fire is supplemented with that induced by the engine exhaust, and the maintenance of steam pressure depends in no small measure on the latter. As an example in point, the oil in the steam from the cylinders, combined with the action of the smoke box gases, tends to an incrustation on the inner walls of the exhaust orifice. This deposit, if allowed to develop, will partly choke the exhaust pipe restricting the free working of the exhaust, and the result will be reflected in poor steaming, as will be the case also if the exhaust opening is not dead concentric with the chimney, and the blast, instead of passing up the centre, strikes the chimney walls.

Methods of firing will depend on the nature of the fuel. With bituminous coal—that is to say, practically any in this country except Welsh—the fire is replenished when the steam pressure shows signs of falling, and the effects from the coal are rapidly evidenced by a rise in pressure. Welsh coal, on the other hand, takes longer to burn through, and its immediate effect is to damp down the fire and lower the steam pressure; only when the coal gets well alight does the pressure begin to rise, and for this reason with Welsh coal firing requirements have to be anticipated further ahead than with other fuels.

In any case, however, a certain degree of foresight will be needful, for firing should, as far as possible, be

avoided when the engine is pulling hard. Therefore, hills should be anticipated by firing before reaching them and on the gradient firing should be avoided if possible, as also should the use of the water feed, since the introduction of the water into the boiler lowers the steam pressure when most required. The feed, therefore, should not at any time be turned on when the pressure is low, unless such a course is unavoidable; it may necessitate forcing the fire with the blower. Downhill, too, foresight in firing may be useful, for, if the engine is fired at the top of a hill, a good head of steam may be available by the time the bottom is reached.

In passing ricks, thatched houses, or inflammable goods the driver should close his damper and ease the engine down to avoid the risk of flying sparks; also, through towns he will be wise to keep the boiler pressure some 15-20 lb. below blow-off point, unless any steep hills have to be surmounted; in open country, however, he had best keep his boiler just short of blowing off.

Though, of course, up hills the engine may have to be worked at full cut-off, if the wagon is handled with a view to steam and fuel economy throughout the journey, the steam will be worked as expansively as possible; in other words, the valve gear will be "notched up" to cut off the cylinder steam supply at as early a point in the stroke as the load on the engine permits (see pp. 125-127).

### **Cleaning the Fire.**

To clean the firebars when opportunity allows the fire should be worked fairly low or thin, and then all of it should be cleared over to one side of the grate, leaving the bars on the other half bare. When the clinker here has been removed and the spaces between the bars cleared, all the fire can be brought over to the

cleaned side and the other half of the grate similarly treated, after which the fire can be levelled and livened up with a little fresh fuel.

**For the Next Day.**

When nearing home on the return the wise driver will turn on his water feed to ensure a good level for the next morning, and, on arrival, will leave the fire in, close the damper, also close the fire-door, and cover the chimney top with a metal plate, to keep the heat in. Then, when the cylinder cocks are opened (a wagon should not stand for any length of time with them closed), and the firewood chopped, everything will be ready for the next day.

## CHAPTER XXIV

### ON THE UPKEEP OF STORAGE BATTERIES

THE requirements of an electrically driven chassis are essentially similar to those dependent on other sources of power, but simpler, and are covered in the preceding chapters: the only specialized requirements of the electric are attendant on the battery, and it will, therefore, suffice here to confine our attention to an outline of the working and maintenance of that item; and this, incidentally, may be of service also to users of petrol and steam vehicles, seeing that electrical equipment for lighting or engine-starting is now becoming well-nigh universal.

#### **The Initial Charge.**

Accumulators are usually sent out by their makers in an uncharged or semi-charged state, and their future performance and length of life depends to a far greater extent that is often realized on the way in which the initial charging is carried out; indeed, the object of this first charge should be not the mere charging of the battery but the conversion of the lead sulphate into active material and the softening of the plates. After seeing that all the plates hang vertically and equidistantly from each other, the electrolyte, made up to a specific gravity of 1.22, should be poured cold into the cells, to come well over the tops of the plates, and the battery should then carefully be given its first charge.

During the process of charging the lead sulphate on the plates is converted into spongy lead on the negative and lead peroxide on the positive plates, and when this

action is near completion gas liberated from the plates will form bubbles which rise to the surface, the size of the bubbles indicating the rate of charging. When gassing is fairly free, the current should be reduced. The fully charged condition will only be accurately ascertained by the voltmeter and hydrometer; but it will also be evidenced by the colour of the plates, which should be deep chocolate for the positives, light slaty bluish grey for the negatives. If after this charge the electrolyte is replaced by fresh, the life of the battery in the long run may be prolonged.

In charging the voltage will rise rapidly from 1.8 to 2.2, thereafter more slowly to 2.3, and beyond that again more quickly. The final voltage varies according to the age of the battery, the charging rate and the temperature, and when a cell is new it may be anything from 2.5 to 2.75 after an extended charge (of which more hereafter) at half normal rate, though with age it will fall to between 2.35 to 2.55 volts.

A battery after charging should not be left idle for days; it should be put to work promptly; otherwise the acid of the electrolyte will combine with the active material to form lead sulphate again, turning the positive plates to anything from a light brown to whitish and the negatives white either wholly or in parts.

The cells should be given plenty of work to keep them fit; too long intervals between charging should not be allowed—not more than about a week.

### **Charging Rate.**

In re-charging the normal rate will depend on the output capacity or the area of the plates in the cells, and for rough calculation the amperage of the charging current may be put at one tenth the capacity of the battery in ampere-hours. Thus a 200 ampere-hour



battery might be charged at 20 amps., though this should be regarded as a maximum figure and about two thirds, say 14 amps., would be better. Too large a current may do harm by generating too much heat; normally the temperature should never be allowed above 110° F. However, charging instructions are usually given by the accumulator makers, who will probably specify two rates—one for starting and one for finishing.

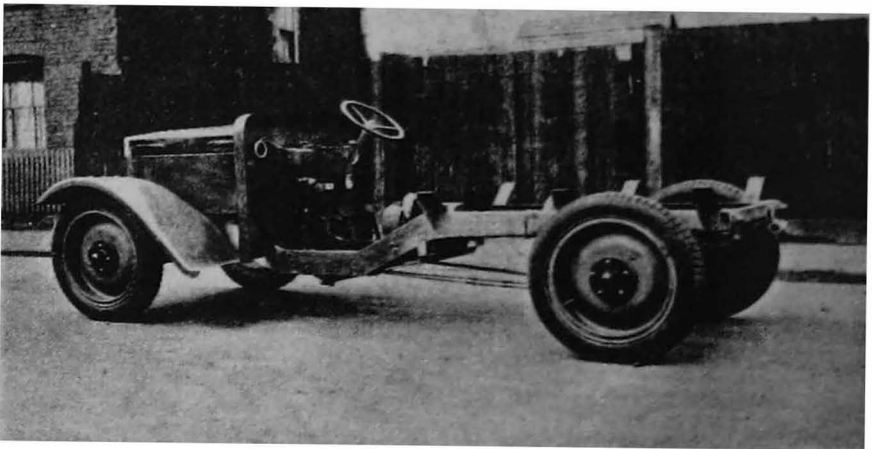
For the initial occasion an extended charge should be given; that is to say, after the battery has given all indications of being fully charged the current should be continued for 45 to 60 minutes. In every-day working, however, the life of a battery is prolonged if not quite a full charge is given unless the full output is likely to be required. That is where the larger battery scores with a margin of capacity in hand.

#### **A Boosting Charge.**

Sometimes in transport work an additional charge may be required to carry the vehicle over an extra long or severe day's work and to do this in the limited available time—probably the driver's dinner hour—the battery may be given what is termed a "boosting charge." In this either the voltage of the supply is gradually raised to meet the increase of voltage in the battery while the current (amps.) remains constant, or the voltage is kept constant while the current is by degrees decreased. In either case the charge should be kept short of causing gassing, and the temperature well below 115° F. for lead acid and 110° F. for nickel iron or alkaline cells. The charging rate is usually roughly calculated by dividing the number of ampere-hours already discharged by the number of hours available for charging, plus 1. As an example, if one hour was available for charging a battery that had

already given out 50 amp.-hrs., the charging rate would be  $\frac{50}{1 + 1} = 25$  amps.

We need not concern ourselves further with the charging, which can be left to the switch-board attendants, while for lighting or starting batteries on a car the state of charge can be shown by the voltmeter. Nevertheless, in connection with the latter it may here



A LIGHT 1-TON ELECTRIC CHASSIS WITH TRANSMISSION ON PETROL CAR LINES

(By courtesy of Electricars, Ltd.)

be suggested that an occasional long charge at a slow rate from some outside source may be desirable, for, although the battery, when on the vehicle, is being constantly charged at irregular intervals, the conditions of charging are by no means ideal.

### **Discharge.**

Of course excessive discharge, like that caused by short-circuiting the terminals, must be avoided at all costs with lead acid cells; but, within reason, there is no harm in a high rate of discharge; it is in discharging too long and running the voltage of the cells too

low that the danger lies. The minimum final voltage depends on the rate of discharge and the size of the cell. With less than 400 sq. in. of plate area and discharge in half an hour the final voltage may be as low as 1.7, but with a ten-hour discharge 1.85 volts. With a plate area of over 600 sq. in. the corresponding voltages would be 1.6 and 1.83 respectively. This is not to say that half hour discharge rates are to be recommended, but is merely given by way of illustration.

#### Concerning the Electrolyte.

The specific gravity of anything is practically its *relative* weight, that of water being taken as the standard unit and designated 1000° sp. gr. Thus, if some heavier or lighter fluid is added to water, the specific gravity of the mixture will be an indication of its constituent proportions. As too strong or too weak an electrolyte would offer excessive resistance to the current and damage the plates, its specific gravity is of great importance, and to test it from time to time a hydrometer will be needed. It is quite an inexpensive little instrument.

Only pure sulphuric acid and distilled or filtered rain water should be used for the electrolyte; ordinary commercial quality acid will not suffice. The acid is diluted with about four times its quantity of water, till the hydrometer shows a specific gravity of 1.220° at a temperature of 60° Fahrenheit. Temperature affects the specific gravity; for every 2½ degrees it rises the specific gravity will be lowered by 1°, and *per contra* for every 2½ degrees fall in temperature the specific gravity rises 1°. This is a point to remember when taking specific gravities during charging, as then the temperature may rise to 100° F. or more, in which event an exactly correct specific gravity of 1.215° at 60° F. would be reduced to 1.199° at 100° F.

### **Making up the Electrolyte.**

In mixing acid with water chemical action generates considerable heat, and so the electrolyte must be made up with the greatest care in an open earthenware or glass vessel, the acid being added slowly and cautiously to the water—drop by drop if need be. Water should never on any account be added to the acid, as heat is then generated so rapidly that the mixing bowl may quite probably be broken and even an explosion may result, which, if only a minor one, may be extremely dangerous with stuff like sulphuric acid.

As already stated, output depends on the area of the plates in a cell; but only the area acted on by the acid is effective, and any parts of the plates left exposed may be ruined. Therefore the electrolyte level should be kept well above the tops of the plates, say  $\frac{1}{2}$  in.; but not up to the top of the casing or it will overflow in working.

### **Specific Gravity and Charging.**

As discharge takes place, the specific gravity falls owing to chemical changes and, as the degree of discharge can be measured by the fall in specific gravity the hydrometer comes in useful also for testing the state of charge. For batteries fully charged the specific gravity varies among different makers, ranging from  $1250^{\circ}$  down to  $1215^{\circ}$  (American makers commonly adopting the higher); but, whatever the initial specific gravity, when the figure reaches  $1180^{\circ}$  it may be taken that a cell is exhausted and it should be re-charged without delay. On no account should the specific gravity be allowed to fall below  $1150^{\circ}$ .

Besides varying with the charge, the specific gravity is all the time tending to rise owing to evaporation of the water leaving an ever larger proportion of the heavier acid, which does not evaporate. Consequently

the cells should be topped up with water added from time to time to give the required specific gravity, and it is important to keep the strength the same in all the cells of a battery. All this should be done before beginning to re-charge.

On the prevention-better-than-cure principle all stoppers and vent plugs should be kept secure and in good order; but, if any electrolyte does get spilt, it should be made up with acid of the same specific gravity as that already in the cell. Any parts on which the acid gets spilt should be wiped, then washed with a strong solution of ordinary soda, and given a coat or two of acid-resisting paint, or in the case of terminals a thin coating of vaseline or paraffin wax.

#### **Battery Troubles and Their Remedies— Sulphating.**

Of all battery troubles the most general is abnormal sulphation. The word "abnormal" is used because sulphation occurs normally and legitimately in the working of the battery, and indeed it is that which produces the current from the battery. Sulphation, as an evil, is directly due to the electrolyte acid combining with the lead of the plates to form a sulphate of lead which deposits on the plates and destroys their porosity—on which the capacity of the cell largely depends—hardens the negative active material and strains the positive plates; in fact, in bad cases the paste falls out of the grids, sometimes internally short-circuiting the cell, the grids themselves become rotten the plates buckled and the cell ruined.

These conditions may be set up by various primary causes chief among which are over-charging, cells left idle while wholly or partly charged, too rapid a discharge, incorrect electrolyte mixture, or a negative plate distended by a reverse current.

Symptoms of sulphating appear chiefly in the colour of the plates which tends to whitish, or a red scale may form on the positives.

In ordinary cases the remedy lies in prolonged charges at low rates, beginning at not more than half the normal and, when gassing becomes pronounced, finishing at quarter rate, preferably with pauses of about an hour at intervals towards the end.

### **Buckling of Plates.**

Plates may get buckled by sulphating, shorting by the paste dropping out of the grids or from external causes, by too rapid discharge or over-discharge, and by charging at too high a rate, or too much or too little.

A positive plate, if buckled, is very brittle and should therefore first be softened by prolonged charging at low rate, and negatives, too, should be fully charged before attempting to straighten them; which can be done by pressing them between boards of correct thickness to fit between the plates: no hammer should ever be used, as it would loosen the active material. If the plates are too brittle for straightening, they can only be put back in their cells with separators placed where any paste seems likely to loosen and fall out.

### **Reversed Cells.**

Sometimes a cell may get reversed by being wrongly connected up either in charging or discharge. In such a case the other cells tend to charge it up when they are themselves discharging, and *per contra* it discharges when the other cells are on charge. Either event leads to damage if continued long enough, resulting in a grey deposit, the positives first turning white, then blue grey, and the negatives brown.

**Leaky Accumulator Cases.**

The simpler sort of leakages in a celluloid accumulator case can quite well be remedied by home-patching; all that is necessary is a little amyl acetate, some thinnish sheet celluloid and a medium sized camel-hair water-colour brush, preferably with metal ferrule. The leak, if very slight and undiscoverable, can be located with blotting paper after thoroughly wiping the casing dry; there is no need to empty the cell.

In the amyl acetate some celluloid shavings can be dissolved until the mixture is about the consistency of gum, and then the celluloid patch, cut out to the required size and shape, its edges bevelled with a sharp knife, can be applied with the amyl adhesive. If the celluloid has to be bent round two sides of the casing or over an edge, it must first be soaked in hot water to render it pliable; but it is not advisable, in the writer's opinion, to attempt patching at the corners without wooden angle clamps to hold the patch in position, and in such cases the simplest course will probably be to hand the job over to a repairer.

**PART IV**  
**LEGAL**



## CHAPTER XXV

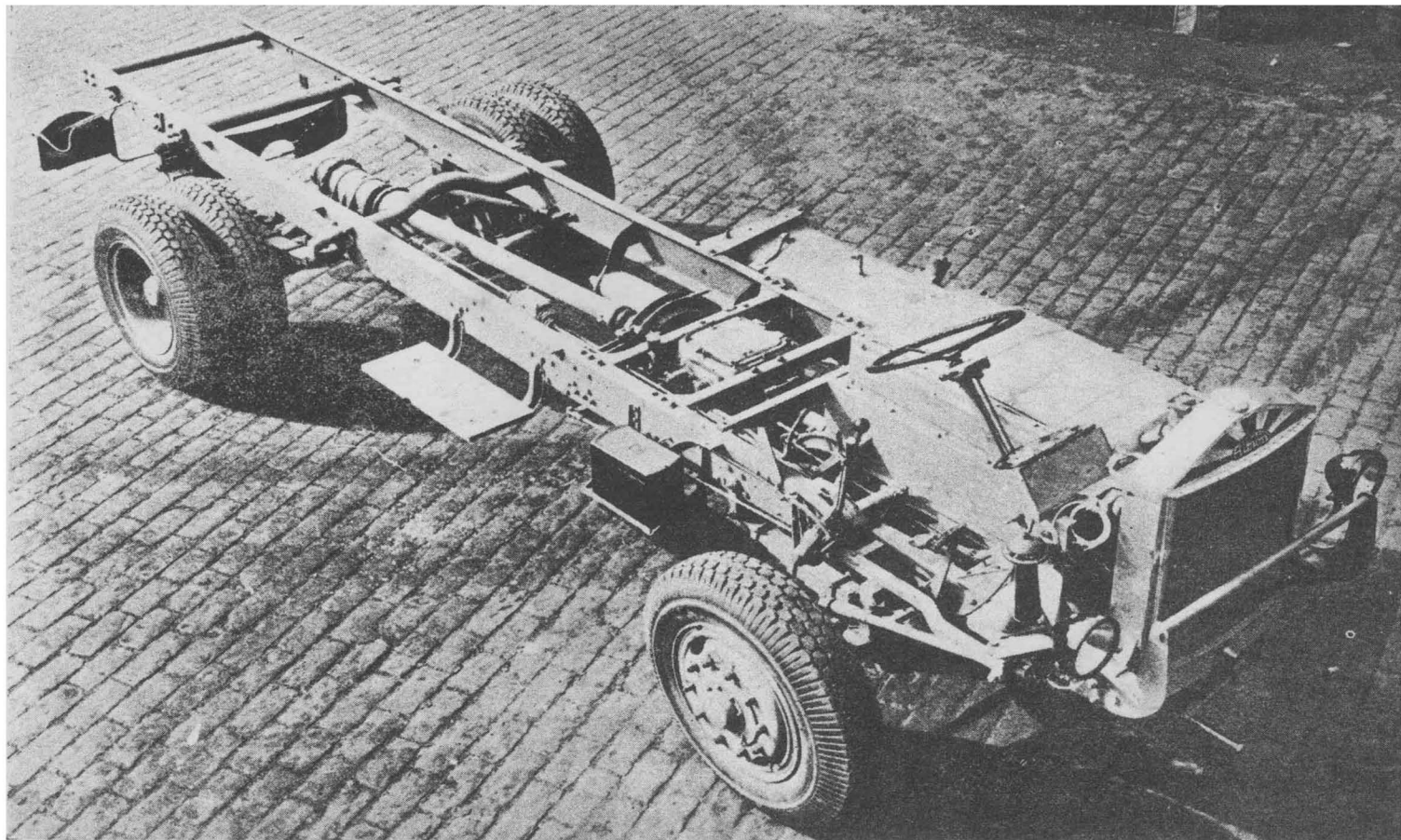
### LEGAL REQUIREMENTS

THE law governing motor vehicles in this country was a patchwork of Acts, drafted as need arose under changing conditions and superimposed on an old foundation built up for horse traffic conditions going back to 1832. Most of this old legislation, in so far as it concerns self-propelled transport, has been repealed by the Road Traffic Act, 1930; but under the existing law the Minister of Transport has wide powers to make on many matters such subsequent regulations as he may think fit, with the result that much of the present-day motor legislation is subject to modification. Such conditions, while they present the advantage of flexibility in dealing with ever-changing conditions, make it advisable to confine such a chapter as this to the main structure of the law that is not likely to be affected by subsidiary regulations, and, therefore, the writer proposes here only to outline the salient points that have to be observed in the ownership and working of commercial vehicles.

Taking the points as they are likely to present themselves to the consideration of the owner, we may first deal with those common to all forms of motor transport.

### ALL VEHICLES

To begin with, if any subsequent regulations, as mentioned in the first paragraph, vary constructional requirements, vehicles registered one year or more before the making of the regulations shall be exempted from them for not less than five years.



A FINE EXAMPLE OF SCOTTISH WORKMANSHIP IS THIS 6-TON ALBION CHASSIS WITH FORWARD CONTROL  
(By courtesy of Albion Motors, Ltd.)

**Definitions.**

At the outset certain clear definitions are necessary—

A *motor-car* is legally a self-propelled vehicle of not more than  $2\frac{1}{2}$  tons unladen weight.

A *heavy motor-car* is one of over  $2\frac{1}{2}$  and not more than  $7\frac{1}{2}$  tons unladen weight.

A *motor tractor* is a self-propelled machine, not itself constructed to carry load, of not more than  $7\frac{1}{2}$  tons unladen weight.

When a vehicle is constructed so that it can carry a substantial proportion of the weight of a trailer partly superimposed on itself the combination is regarded as a single flexible six-wheeler.

*Unladen weight* means the weight of the vehicle and all parts ordinarily used in its working inclusive of spare wheel or tyre, but does not include loose tools, loose equipment, water, fuel, or electric accumulators. In motor vehicles fitted with special appliances, like cranes, welding plant, etc., such apparatus is included in the unladen weight.

**Weights and Dimensions.**

**Weight Limits.** These definitions are reduced to a finer point by the limiting weights and dimensions imposed by the subsequent Use and Construction Regulations. These do not affect the weights of motor-cars, but merely lay down maximum detail weights for all motor vehicles as follows—

**FOUR-WHEELERS.**

Maximum laden vehicle weight, except as below	.	12 tons
"    "    axle	"	8 "
"    "    vehicle	"	steam wagons registered after 1931
"    "    axle	"	steam wagons registered after 1931
"    "    vehicle	"	steam wagons registered before 1932
"    "    axle	"	steam wagons registered before 1932
"    "    total	"	vehicle with trailer

private premises and only occasionally used on the road and motor-cars used by public authorities for street cleansing or refuse collection.

On any vehicle, tractive or trailer, registered after 1932, except those in the preceding paragraph, non-pneumatic tyres must have a rim diameter of not less than 670 millimetres or just over 26½ in. After 1939 this regulation will apply to all vehicles whenever registered.

All trailers constructed after 1932 must have pneumatic tyres, and all trailers, whenever constructed (except furniture vans, agricultural trailers, and one or two other exceptions) must have rubber tyres.

### Speed Limits.

The maximum legal speeds are in the main dependent on weight and tyres. They are—

Motor-cars, pneumatic tyred, single	. . .	30 m.p.h.
"    "    "    with trailer	. . .	16 "
"    solid    "    single	. . .	20 "
"    "    "    with trailer	. . .	8 "
Heavy motor-cars, pneumatic tyred, single	. . .	20 "
"    "    "    with trailer	. . .	16 "
"    "    solid tyred, single	. . .	16 "
"    "    "    with trailer	. . .	8 "
Tractors, pneumatic or solid tyred, single	. . .	16 "
"    "    "    with trailer	. . .	8 "

The higher speeds allowed to pneumatic tyred motor-cars or heavy motor-cars with trailers are permissible only if the trailers also are pneumatic tyred. Similarly, with solid tyres.

The term "solid tyre" applies to tyres of rubber or soft, elastic material. If metal tyres are used, speed is in all cases restricted to 5 m.p.h.

Numerous other dimensions and structural requirements are contained in the Use and Construction Regulations; but the foregoing are those likely more immediately to concern the transport owner, and the rest may safely be left to the makers of the vehicle.

**Trailers.**

A motor vehicle is restricted to a single trailer, a tractor to one trailer laden or two unladen.

Except for trailers owned by public authorities, every trailer weighing over  $\frac{1}{2}$  cwt. unladen must be fitted with brakes acting on two out of four or four out of all wheels, and these must be capable of holding the vehicle when at rest.

Unless the trailer brakes can be applied by the driver from his cab or footplate, an attendant must be carried in a position where he can apply the brakes, except in the case of trailers weighing not more than 1 ton unladen and fitted with brakes applied by any tendency of the trailer to over-run its tractive vehicle.

**Drivers' Licences.**

No one may drive a motor vehicle without a driver's licence, obtainable at 5s. from the council of the county or county borough in which the applicant for it lives. It must be renewed annually at a fee of 5s.

To drive a motor vehicle weighing over  $2\frac{1}{2}$  tons unladen or a motor tractor the applicant must be at least 21 years old; to drive a car weighing not more than  $2\frac{1}{2}$  tons unladen he must be 17 and to drive a motor-cycle not less than 16 years of age.

Further, he must make a declaration that he is not suffering from any disease or physical disability that might render his driving dangerous to others. If he is, a licence is refused; but the applicant, on payment of a fee, may undergo a test to decide his fitness or otherwise and, if that proves satisfactory, he can no longer be refused a licence, while on subsequent applications no further test is necessary unless from his declaration it appears that the disability has become more pronounced or some additional disability has arisen.

A driver must show his licence to a policeman on

request or within five days produce the licence in person at some police station specified at the time he was requested for it.

Although it is customary for drivers to procure their own licences, the employer is held liable for allowing any unlicensed person to drive his vehicles.

Drivers' licences issued in Northern Ireland are valid in Great Britain.

### **Vehicle Licences and Registration.**

**Licences.** On every motor vehicle using the roads an excise licence duty is annually payable to the council of the county or county borough wherein the vehicle is ordinarily kept, the fee varying according to the nature and size of the vehicle, as shown on pages 179 and 180, Chapter XIII.

These annual licences expire each 31st December; but quarterly licences are obtainable at 27½ per cent of the annual licence cost.

If the character or use of a vehicle is altered so as to entail a higher duty, the difference between this higher duty and that indicated on the original licence must be paid. This, however, does not apply to a vehicle used for the conveyance of employees of the person keeping the vehicle, in the course of their employment.

When a vehicle is broken up or sent out of the country the licence value outstanding will be allowed on the owner taking out a new licence for another vehicle of similar class; but no part of the licence will be refunded.

If a council is satisfied that a licence has not been used during its currency, the duty will be refunded upon surrender of the licence and registration book.

The licence must be carried on its vehicle in an approved form of holder secured either—

(a) facing outward sideways on the near side between

2 ft. 6 in. and 6 ft. 6 in. from the ground, somewhere between the back of the cab or footplate and a vertical line 6 in. in front of the windscreen, or

(b) facing forward or backward on the near lower corner of the windscreen or within 2 in. of the windscreen glass, if it is visible through the glass. If so carried as to be weather-proof, a holder is not obligatory.

Not more than fourteen days before the expiry of the licence of a vehicle that has not changed hands application for renewal, in the prescribed form, may be made either to the council with whom the vehicle is registered or to a post office; but no application should be made at a post office after the expiry of the fourteen days.

**Registration Books.** For every vehicle licensed, a registration book is issued except when over six vehicles of uniform type in the same ownership have been registered all under one declaration.

The registration book must be produced for inspection on request of a police, customs or local taxation officer.

If any alteration is made to a vehicle so as to affect the registration particulars in the declaration made by the owner, the registering council must be notified and the registration book sent to them.

The same must be done on the owner changing his address.

On a change of ownership the registered owner must enter in the proper place in the registration book the name and address of the transferee or new owner, and send the book to the council.

The new owner before using the vehicle on a public road must notify the council of the area where he will keep the vehicle that he has acquired it, and, unless the registered owner has transferred the licence to him, he must obtain a licence from his council.

If a licence or registration book gets lost or destroyed, the owner may obtain a duplicate from the council on payment of 5s.

**Number Plates.** Every vehicle must carry number plates, bearing the index mark and registration number assigned to it.

Number plates must be fixed one at the front, the other at the back of the vehicle, in a vertical position, and must be lighted up by a lamp half an hour after sunset and half an hour before sunrise.

With a trailer the number plate and, if necessary, means for illuminating it must be fixed to the back of the trailer.

Number plates must not be allowed to become obscured by dirt or other cause.

The number plates and their lettering must be of certain dimensions, which however may be left to those who supply the plates.

### **Third Party Insurance.**

With the exception of certain vehicles in the service of the state or some public bodies, every motor vehicle on the road must be insured against third party risks with an authorized insurer who, within the meaning of the Assurance Companies Act, 1909, has given security for ability to meet claims, unless the owner deposits £15,000 with the Accountant-General of the Supreme Court as security.

The policy need not cover employees of the policy holder; or "except in the case of a vehicle in which passengers are carried for hire and reward" persons carried, entering or alighting from the vehicle; or any contractual liability.

Conditions that no liability shall arise in the event of some specified thing being done or omitted will be of no effect.



A policy is not recognized until the insurer has delivered to the insured a certificate of insurance.

This certificate must be shown to a police constable on request or, failing that, be produced by the driver in person within five days at a police station specified by him at the time he was requested for his certificate.

(This has given rise to some trouble owing to certain owners objecting to such a document being carried on the vehicle or entrusted to the driver.)

### **Drivers' Hours.**

A driver must not be employed—

1. For a continuous period of more than five and a half hours, a "continuous period" being one without at least half an hour's interval for rest supervening;

2. For continuous periods aggregating more than eleven hours in any twenty-four commencing two hours after midnight; or

3. Without at least ten consecutive hours rest in any twenty-four, reckoned from commencement of driving, or nine hours, if in the following twenty-four he has not less than twelve hours' rest.

Employment includes any work in connection with vehicle, or load.

### **Contingent Limitations.**

Before embarking on road transport certain contingencies and limitations of working should be known.

**Restricted Roads.** If a council or the governing body of a university in receipt of a public money grant wish to restrict or prohibit any particular class of traffic on any road (e.g. omnibus services or heavy lorries) they may apply to the Minister of Transport, who, if he considers such traffic as endangering public safety, may—

1. Prohibit or restrict the use of any specified class of traffic on such roads;

2. Order one-direction traffic thereon; or
3. Specify routes to be followed by the traffic.

Such orders, however, cannot prevent access by traffic of any class to premises on the road in question.

Before making an order of this nature the Minister may hold a public inquiry, notice of which must be published beforehand, and all those interested in the matter may be represented either in person or by an agent or lawyer.

**Restricted Bridges.** If the controlling authority of any bridge is satisfied that the bridge is insufficient—

1. To carry a motor vehicle of over a certain laden weight; or

2. A vehicle of over a specified weight at more than a certain speed,

[provided that the specified weight limitation is not less than 5 tons, the authority can prohibit the use of that bridge to such traffic by notices to that effect at both ends of the bridge.

Anyone aggrieved by such a restriction may appeal to the Minister of Transport, who, if he considers the bridge suitable to a weight or speed greater than specified, may order the restriction to be amended or removed.

**Extraordinary Traffic.** Where exorbitant expenses, as compared with average cost, are incurred in the upkeep of any road by excessive weight or other extraordinary traffic, the highway authority may recover such expense from the person causing it, either by arbitration or by proceedings in the local county court for claims up to £500, in the High Court for claims above that amount. Proceedings must be commenced, however, within twelve months of the damage being done or, if the damage is consequent on contract work, not later than six months after completion of the work.

These provisions do not apply to the administrative county of London.

### **On the Road.**

**Weighing of Vehicles.** Any person authorized by a highway authority, or a police constable, may on production of his authorization require a vehicle to proceed to a weighbridge to check its weights laden or unladen; but he has no right to require the vehicle to be unloaded.

If the weighbridge is more than a mile away and the weight found legally correct, the county authority must pay for the loss occasioned, the amount, if necessary being determined by a single arbiter appointed by agreement or, failing that, by the Minister of Transport.

When a motor vehicle is weighed the driver should be given a certificate which will exempt him from further trouble during the journey.

**Accidents.** In cases of accident causing damage to any person, animal or vehicle the driver must stop and, if required, give his name and address, the vehicle owner's name and address and the identification marks of the vehicle, to any person having reasonable grounds for demanding them.

If for any reason he does not give these particulars, he must report the accident to a police station or constable as soon as reasonably possible; but at any rate within twenty-four hours.

The Minister of Transport may direct an inquiry into the cause of an accident—a public inquiry, if he thinks fit.

Any person authorized by him with that in view may enter any premises where the vehicle is and inspect it without let or hindrance.

Any report thus made on an accident shall not be used in any resulting legal proceedings.

**Drink or Drugs.** Any driver in charge of a motor vehicle on a road or other public place, if, through drink or drugs, incapable of proper control is liable—

1. On summary conviction, to a fine not exceeding £50 or up to four months' imprisonment; or, in the case of a second or subsequent conviction, to £100 fine, four months' imprisonment, or both, and to disqualification from driving for not less than twelve months unless there are special reasons to the contrary.

2. On conviction on indictment, to a fine, to six months' imprisonment, or to both, and disqualification as before.

**Dangerous Driving.** For driving on the road to the danger of the public "having regard to . . . the amount of traffic which is actually at the time, or which might reasonably be expected to be, on the road" is punishable by the same penalties as drunkenness.

**Careless Driving.** This is a punishable offence, but a first or second conviction will not entail disqualification for holding or obtaining a licence.

Such are the main points with which every transport owner should be conversant.

### PASSENGER VEHICLES

In addition to the foregoing, those engaged in passenger transport as a business have to observe considerable further legislation.

As before, certain definitions are necessary as a preliminary.

#### More Definitions.

*Public service vehicles*, as the larger passenger conveyances are termed in the Road Traffic Act, are divided into the following classes—

*Stage carriages*, which are motor vehicles carrying passengers at separate fares not exceeding 1s. for the

single journey, "or such greater sum as may be prescribed" stage by stage and stopping to pick up or set down passengers along the route; or any other vehicles, carrying at separate fares, which do not come within the definition of express carriages.

*Express carriages* convey passengers at separate fares not less than 1s. for a single journey "or such greater sum as may be prescribed"; but they carry from one or more points specified in advance to one or more specified common destinations, not stopping to pick up or set down passengers, save only those "paying the appropriate fares for the journey or journeys in question."

*Contract carriages* are motor vehicles carrying passengers for hire "under a contract expressed or implied, at a fixed or agreed rate or sum for the use of the vehicle as a whole." If separate fares are paid, even to some person other than the owner, the vehicle *ipso facto* becomes an express carriage, except for the conveyance of parties on special occasions. This proviso then does not prevent the use of contract carriages for *bona fide* outings, but rather is intended to prevent their use for what might be called syndicalized regular travel. A vehicle employed for carrying eight or more persons to business, even without payment, is deemed a contract carriage unless the persons so carried are "work people," in the wording of the Act.

#### Traffic Areas and Commissioners.

All these three classes have to be licensed as public service vehicles and are subject to inspection, while, if they run a regular service, a licence has to be obtained for the service itself.

Accordingly, for these purposes the country is divided into "traffic areas"—eleven for England and Wales, two for Scotland.

For each traffic area there are three commissioners with powers to grant licences and administer the Act.

Of these commissioners, one is nominated by the county councils of the area, one by the county borough and urban district councils, and one is selected by the Minister.

The chief duty of the commissioners is to hear and decide on applications for the licensing of passenger vehicles and their working.

#### **Passenger Working Licences.**

**Public Service Vehicle Licences.** All vehicles in the three categories mentioned must be licensed annually as public service vehicles of one class or the other.

A vehicle licensed as a stage or express carriage may be used as a contract carriage, and a stage carriage may be used as an express carriage subject to any condition in the road service licence (to be detailed hereafter). An express carriage *per contra* may be used as a stage carriage, if the commissioners in each traffic area wherein the vehicle works consent in writing.

A public service vehicle licence may be refused, suspended, or revoked by the commissioners, if they think that the conduct of the applicant or holder shows that he is not a proper person to hold a licence.

Applications for licences must be made on official Forms P.S.V.i. in duplicate, and forwarded to the commissioners of the traffic area, or, when the vehicle is to be used as a London omnibus, to the Commissioner of Police of the Metropolis, in which case a licence under the Metropolitan Public Carriage Act is required.

The cost of a public service vehicle licence is £3, but no money should be sent with the application.

**Certificates of Fitness.** Unless the vehicle so licensed has been granted a certificate of fitness, it cannot be

used. A certificate may last for five years or such shorter period, not less than a year, as may be specified.

The certificate may at any time be revoked by the Minister of Transport or the certifying officer, if it appears to him that the vehicle does not comply with requirements; and in that case the licence ceases to have effect until a new certificate is obtained.

Applications for certificates must be made in duplicate on official Form P.S.V.3 to the commissioners of the traffic area.

The cost of a certificate is £3; but when a number of the same type of vehicle are employed they may be covered by a type certificate costing £25 or, if the type is essentially similar to one already approved, the fee may be reduced to £10.

**Road Service Licences.** Every route of every service must be legalized by a road service licence, cost £1, and no vehicle may be run as a stage or express carriage except under such licence.

Application for these licences should be made on official Form P.S.V.8 & 9 in triplicate to the traffic commissioners of the area within which is the route or, if the route lies in more than one area, to the commissioners of that area for which the licence, as distinct from a backing, is desired. (The term "backing" to be explained hereafter.)

In applications for licences particulars must give—

1. Types of vehicle to be used;
2. Fare-tables and time-tables in the case of regular services;
3. In other cases service-frequency and times taken on journeys.

In deciding on the grant or otherwise of a licence the commissioners will more particularly take into consideration public interest, and the representations of those already working services that might be affected

by the grant, or of local authorities in whose area the route wholly or partly lies.

Conditions may be attached to the licence, especially with a view to securing—

1. Reasonable fares ;
2. Fares fixed to prevent wasteful competition ;
3. Copies of fare- and time-tables exhibited on the vehicles ;
4. The taking up and setting down of passengers at specified points and not between.

**Backings.** A road service licence is valid only in the area where it is granted and, if the service extends to other areas, the licence must be backed by the commissioners for those areas, the cost of a backing being 10s.

Applications for backings should be made in triplicate on official Forms P.S.V.10 and 11 to the traffic commissioners of the area concerned.

A road service licence may be revoked by the traffic commissioners for frequent or wilful breach of conditions or on the grounds of public safety.

**Public Service Driving Licences.** Drivers of public service vehicles must hold a special licence in addition to the ordinary motor driver's licence, the cost being 1s.

Application should be made on official Forms P.S.V. 15A and B to the traffic commissioners of the area in which the applicant resides, except applications to drive a London omnibus, which should be made to the Commissioner of Police of the Metropolis, under the Metropolitan Public Carriage Act, 1869.

On the issue of the licence a badge also will be issued on which a deposit of 2s. 6d. must be made.

No driving licence can be issued to anyone under twenty-one years of age.

**Conductors' Licences.** The same applies to licences and badges for conductors, but application must be



made on Forms P.S.V.16, A and B and the minimum age permissible is eighteen years.

**Drivers' Hours.** Time spent by the driver on a vehicle while on a journey in any other capacity than a passenger is reckoned as time spent in driving.

In London conditions are essentially similar, but licensing is carried out by the Chief Commissioner of Metropolitan Police, who has powers to prohibit or restrict the use of certain streets by omnibuses under the London Traffic Act.

Mention has been made in Chapter XVIII of certain information that has to be furnished by passenger transport operators to the Ministry of Transport, and the forms for this purpose are given herewith.

This Return to be addressed to—  
**The Assistant Secretary,  
 Finance and Statistics Department,  
 Ministry of Transport,  
 Whitehall Gardens, S.W.1**

**FINANCIAL RETURN TO BE MADE PURSUANT  
 TO SECTION 75 OF THE ROAD TRAFFIC ACT,  
 1930, BY PERSONS CARRYING ON THE BUSINESS  
 OF OPERATING PUBLIC SERVICE VEHICLES**

Name and Address of Person } \_\_\_\_\_  
 carrying on the Business } \_\_\_\_\_

Number of Public Service Vehicles owned at  
 end of period to which the Return relates \_\_\_\_\_

Return for Year ended \_\_\_\_\_ 19\_\_\_\_\_

(I) **CAPITAL EXPENDITURE.**

(a) On public service vehicles	£
(b) On garages, workshops, and stations	
(c) On plant and machinery	
(d) On any other Capital assets (including Goodwill, if any)	
Total	£ _____

Note. The depreciation provided for to the date of this Return in respect of the above Assets is—

(e) Written off Capital Account	£
(f) Renewal and Depreciation Funds	
(g) Provided by Local Authorities for redemption of Debt	
Total	£ _____

(II) **REVENUE ACCOUNT.**

Particulars	Public Service Vehicles				
	Services Operated under Road Service Licences		Contract Services	Sundry Receipts	Total
	Stage Carriages	Express Carriages			
(a) <b>RECEIPTS—</b>	(1) £	(2) £	(3) £	(4) £	(5) £
(i) From Traffic Passengers					
Parcels, Mails, Luggage, Dogs, etc.					
(ii) From Advertising on vehicles and Miscellaneous.					
(iii) From vehicles let on hire					
TOTAL RECEIPTS	£				
(b) <b>EXPENDITURE—</b>					
(i) Repairs—					
Vehicles, including Tyres					
Buildings and Fixtures					
Machinery and Plant					
(ii) Traffic Expenses—					
Wages of Drivers and Conductors					
Other Expenses					
(iii) Petrol or other Fuel or Power for vehicle propulsion					
(iv) Licences					
(v) Payments for Hire of Vehicles					
(vi) General Expenses					
(vii) Depreciation—					
Vehicles					
Other Assets					
TOTAL EXPENDITURE					£
(c) BALANCE OF RECEIPTS OVER EXPENDITURE					
(d) Add or Deduct BALANCE OF RECEIPTS OR PAYMENTS UNDER THROUGH AND/OR INTER-OPERATION AGREEMENTS					
NET RECEIPTS					£

I hereby certify that to the best of my knowledge and belief the information given above is true and correct.

Signed\* \_\_\_\_\_ Dated \_\_\_\_\_

\* The Return to be signed by the person carrying on the business, or by a person or persons authorized to sign documents on his behalf.

## REVERSE OF FINANCIAL RETURN

EXPLANATORY NOTES FOR THE COMPILATION OF THE FINANCIAL RETURN TO BE MADE PURSUANT TO SECTION 75 OF THE ROAD TRAFFIC ACT, 1930, BY PERSONS CARRYING ON THE BUSINESS OF OPERATING PUBLIC SERVICE VEHICLES.

The Return is to be compiled for the year ended 31st December, or, if the accounting year of the business ends on a date other than the 31st December, to the end of that year; and is to be furnished to the Minister of Transport within two months after the close of the accounting year.

### (I) CAPITAL EXPENDITURE

The total Capital expended, viz.—cumulative capital expenditure from year to year upon all physical assets in existence at the date of the Return is to be entered against the items (a) to (c).

In the case of (b) the figures are to include the cost of land acquired and used for the purpose of Garages, Workshops, or Stations. In the case of (d) they are not to include Investments.

If other businesses are carried on by the operator, the figures entered against items (b), (c), and (d) are to be those attributable to the public service vehicle business only. If actual costs are not ascertainable, an estimate of the amount so attributable is to be made.

Where depreciation has been deducted from capital expenditure on existing assets in the operator's accounts, the original cost of the existing assets is to be included as capital expenditure (items (a) to (d)) and the total amount of depreciation written off is to be shown in the note at the foot of the table (Item (e)).

### (II) REVENUE ACCOUNT

#### GENERAL NOTES

Figures relating to the operation of public service vehicles ONLY are to be entered in this return. Operators working other businesses in addition to Public Service Vehicles are to divide their Receipts and Expenditure on Revenue account between Public Service Vehicles and other Businesses as far as possible on an actual basis. In cases where this cannot be done the proportion applicable to Public Service Vehicles is to be estimated.

The Receipts from the running of vehicles that have been hired are to be included under the Receipts Heading II (a), but apportioned in the columns (1), (2), and (3), according to class of service on which the vehicles are used.

The Expenditure incurred on the running and maintenance of such hired vehicles is to be entered opposite the appropriate expenditure items under Section II (b).

The Amounts received as payments for vehicles let on hire to other persons are to be entered under II (a), sub-section (iii) under column (4), Sundry Receipts.

Payments made to other persons for the hire of vehicle are to be entered under Section II (b) (v). Income Tax (Sch. D.) is not to be included in this account.

#### NOTES RELATING TO SPECIFIC ITEMS

#### Item

#### II (a) RECEIPTS.

- (i) To be the actual gross receipts from the operation of Stage, Express, and Contract Services respectively.
- (ii) The receipts from advertising on vehicles and miscellaneous are to be entered under column (4), viz.—Sundry Receipts.

#### II (b) EXPENDITURE.

- (i) Repairs, Vehicles including Tyres: In cases where Tyres are hired, to include hire of tyres
- (ii) Traffic Expenses: Other Expenses to include all Traffic Department salaries, wages (other than wages of Drivers and Conductors, but including wages of Inspectors and Ticket Office Staff) and travelling expenses: the cost of clothing, cleaning vehicles, tickets punches, lubricating oils, and grease; tolls, garage fees and Agents' fees, garage expenses, including power, light, heat, water, and all other charges in connection therewith except repairs to structures and machinery.
- (iii) Petrol or Other Fuel or Power for Vehicle Propulsion: To include distribution expenses and bonuses for fuel economy.
- (vi) General Expenses: To include salaries and wages of general officers and staff; office etc., rents; rates and taxes (except Income Tax, Schedule D), printing (except tickets) stationery, advertising, general office expenses, compensation (accidents and workmen and fire and other insurances).
- (vii) Depreciation: To be the amounts set aside for renewals or depreciation in respect of the year covered by the Return. In cases where provision is made for renewal or depreciation of tyres, the amount set aside for this purpose is to be included under the head of Vehicles. To include also amounts provided by local authorities for the redemption of debt.

#### II (d) BALANCE OF RECEIPTS OR PAYMENTS UNDER THROUGH AND/OR INTER-OPERATION AGREEMENTS

This item applies only to operators who are parties to such agreements and is to be the balance (plus or minus) of the receipts from and payments to other parties under Through and/or Inter-operation Agreements.

*Note.* The actual gross receipts collected and the operating expenses incurred in running such services are to be dealt with in the return of the operator running the service as follows—

Receipts: To be included in the relative columns under the appropriate Receipts item—Section II (a).

Expenditure: To be included in the appropriate Expenditure items under Section II (b).



EXPLANATORY NOTES FOR THE COMPIIATION OF THE STATISTICAL RETURN TO BE MADE BY PERSONS CARRYING ON THE BUSINESS OF OPERATING PUBLIC SERVICE VEHICLES PURSUANT TO SECTION 75 OF THE ROAD TRAFFIC ACT, 1930

- (1) The Return is to be rendered for periods of three months, i.e. for the three months ended—(1) 31st March, (2) 30th June, (3) 30th September, (4) 31st December.
- (2) Seating capacity. Each seating capacity above 7 to be shown—see example under (4).
- (3) Number of vehicles of each seating capacity annual. I.e. the number of vehicles of each seating capacity belonging to the person making the return (including (1) vehicles in his possession under a hire purchase agreement, and (2) any vehicles let out on hire by him) at the 31st March in the case of the return for the first quarter of the year, and at the 30th June, the 30th September, or the 31st December respectively in the case of the return for the other three quarters of the year. (See example under (4).)
- (4) Number of vehicles of each seating capacity licensed—i.e. the number of vehicles of each seating capacity for which licences issued under the Road Act, 1930, are current at the 31st March in the case of the return for the first quarter of the year, and at the 30th June, the 30th September, or the 31st December respectively in the case of the return for the other three quarters of the year. (See example below.)

Number of vehicles of each seating capacity—

(1) Licensed under the Road Act, 1930.	(2) Overd.	(3) Seating capacity.
8	3	Total
9	16	24
10	16	26
11	30	41
12	4	16
etc.	43	59

- (5) Passenger receipts. Children are to be counted as adults. A passenger to whom a return ticket or a ticket for a round trip (out and home) has been issued is to be reckoned as two passengers. A passenger to whom a weekly ticket has been issued is to be reckoned as 12 passengers and a passenger who has issued a monthly ticket is to be included in respect of the period during which the ticket was issued.
- (6) Passenger receipts. I.e. the receipts in respect of the passengers above under (5). The full amount paid by the passenger for the journey by road is to be included. The receipts are to exclude amounts in respect of meals, hotel accommodation, etc., but commission paid to booking agents for the journey is not to be deducted.
- (7) Receipts from the conveyance of parcels, mail, baggage, dogs, etc. I.e. the receipts from the conveyance of all traffic, other than passengers.
- (8) Vehicle miles. I.e. the aggregate number of vehicle miles (both loaded and empty) run during the hours the vehicles are in service for the purpose of conveying passengers.
- (9) Receipts. In the case of bookings (1), (2), (3), (4), (5), (6), (7), and (8) separate figures are to be given in respect of each of the three years, viz. Stages, Express, and Contract, classified in accordance with the following Part IV (Regulation of Public Service Vehicles) Section 61 of the Road Traffic Act, 1930—

- (1) Public service vehicles shall, for the purposes of this Part of this Act and the regulations made thereunder, be divided into the following classes—
- (a) Stage carriages; that is to say, motor vehicles carrying passengers for hire or reward at separate fares (any or all of which are less than one shilling for a single journey or such greater sum as may be prescribed), stage by stage, and stopping to take up or set down passengers along the line of route, and any other motor vehicles carrying passengers for hire or reward at separate fares and not being express carriages as hereinafter defined;
- (b) Express carriages; that is to say, motor vehicles carrying passengers for hire or reward at separate fares (none of which is less than one shilling for a single journey or such greater sum as may be prescribed) and for a journey or journeys from one or more points specified in advance to one or more common destinations as prescribed, and not stopping to take up or set down passengers other than those paying the appropriate fare for the journey or journeys in question;
- (c) Contract carriages; that is to say, motor vehicles carrying passengers for hire or reward under a contract arranged or implied for the use of the vehicle as a whole or for a part or agreed rate or sum;
- (d) The fares for express carriages are, however, to be divided as between (1) Ordinary Express Services, and (2) Extraordinary and Town, as indicated on the other side of the Form.

Columns 2, 3, and 4 of the Form. To be completed by the person from whom the vehicles are hired, and not by the person hiring the vehicle.

Items 2, 3, and 4.

(a) Services operated with hired vehicles under road service licences: the information should be given only by the holder of the road service licence under which the vehicles are operated. The vehicles operated with hired vehicles are listed above the amount received for hire of (b) Contract services operated with hired vehicles: If vehicles are hired by another operator (i.e. a person holding either a public service licence, or a permit to hire public service vehicles), information relative to items 2, 3, 4, 7, and 8 of the Form should be given by the operator hiring the vehicles, while the operator from whom the vehicles are hired should show the amount received in respect of the hire of the vehicles operated by a person who is not an operator (i.e. who holds neither a public service licence nor a permit to hire public service vehicles), the operator from whom the vehicles are hired must show information relative to the transaction opposite items 2, 3, 4, 7, and 8 of the Form, and not opposite item 10. The Return is to be rendered to the Minister of Transport within two months after the end of each three-monthly period.

**ROAD TRAFFIC ACT, 1930**  
**ROAD SERVICE LICENCES**  
**TRAFFIC ANALYSIS—STAGE CARRIAGE SERVICES**

Traffic Commissioners reference number for present application—

Where so required by the Traffic Commissioners, this form, completed in triplicate, must be submitted in respect of applications for the grant or backing of a road service licence.  
 In the case of a service affecting two or more traffic areas the information to be given should relate to the service as a whole and not merely to that part of it which lies within the particular Traffic Area to which the application for grant or backing relates.  
 Before filing in this form reference should be made to the explanatory notes on the back.

Name of Applicant \_\_\_\_\_ Address \_\_\_\_\_  
 Service between \_\_\_\_\_ and \_\_\_\_\_ Route No. (if any) \_\_\_\_\_

Item Number and Description	Period				REMARKS
	1st Jan. to 31st Mar.	1st Apl. to 30th June	1st July to 30th Sept.	1st Oct. to 31st Dec.	
1. Year . . . . .					
2. (i) Number of tickets issued each quarter—					
(a) Single . . . . .					
(b) Return, contract, or season (reckoned as indicated overleaf)					
(c) TOTAL . . . . .					
(ii) Estimated number of passengers carried each quarter . . . . .					
3. Number of service vehicle journeys each quarter (journeys out and home reckoned as two)					
4. Total estimated seats available each quarter . . . . .					
5. Number of days on which service was operated during each quarter . . . . .					
6. Number of service vehicle miles run each quarter . . . . .					
7. Receipts from passengers carried each quarter . . . . .	£	£	£	£	
8. Average receipts per vehicle mile (in pence) . . . . .					
9. Maximum number of vehicle journeys operated on any one day in each quarter	{ Mondays to Fridays Saturdays Sundays Bank Holiday Periods				
10. Maximum number of vehicles leaving any terminal point at any one departure time in each quarter	{ Mondays to Fridays Saturdays Sundays Bank Holiday Periods				

I certify that to the best of my knowledge and belief the information given above is true and correct.  
 Date \_\_\_\_\_ (Signed) \_\_\_\_\_

## EXPLANATORY NOTES

**ITEM 1.—Year.**—Information must be given for the last four quarters prior to the application. Thus, an application made in March, 1932, should contain information for the periods January to March, 1931; April to June, 1931; July to September, 1931; and October to December, 1931; an application made in July, 1932, should contain information for the periods July to September, 1931; October to December, 1931; January to March, 1932; and April to June, 1932.

**ITEM 2 (i).**—*Number of tickets issued each quarter.*—Children's tickets should be reckoned in the same way as adults' tickets and not as half tickets. A return ticket or a ticket for a round trip (out and home) should be reckoned as two tickets. A weekly ticket should be reckoned as 12 tickets and a monthly ticket as 30 tickets; in these two cases the number 12 or 30, as the case may be, should be included in respect of the period during which the ticket was issued.

**ITEM 2 (ii).**—*Estimated number of passengers carried each quarter.*—To be the total number of passengers carried, estimated from the number of tickets issued and reckoned on the same basis in the case of a passenger who takes a ticket for a round trip, a return ticket, or a contract or season ticket. This number will be the same as the number of tickets issued (Item 2 (i)), except where the ticket system employed sometimes requires two or more tickets to be issued to one passenger.

**ITEM 3.**—*Number of service vehicle journeys each quarter.*—To be the aggregate number of journeys made by vehicles whilst in service for the purpose of conveying passengers. A journey out and home should be reckoned as two journeys.

**ITEM 4.**—*Total estimated seats available each quarter.*—This figure should be the sum of the seats provided for passengers each quarter. For example: 273 journeys out and home (i.e. 546 journeys) by 14 seaters and 182 journeys out and home (i.e. 364 journeys) by 20 seaters gives a total of  $(546 \times 14) + (364 \times 20) = 14,924$  seats available. If full details of this nature are not available the figure should be obtained by multiplying the number of service vehicle journeys by the average seating capacity of the vehicles used.

**ITEM 6.**—*Number of service vehicle miles run each quarter.*—To be the aggregate number of vehicle miles run whilst the vehicles are in service for the purpose of conveying passengers.

**ITEM 7.**—*Receipts from passengers carried each quarter.*—To be the receipts (to the nearest £) in respect of the passengers shown in Item 2. The full amount paid by the passenger for the journey by road should be included. The receipts should exclude amounts in respect of meals, hotel accommodation, etc., but commission paid to booking agents for the journey by road should not be deducted.

**ITEM 8.**—*Average receipts per vehicle mile.*—To be given in pence to two places of decimals.

**ITEM 9.**—*Maximum number of vehicle journeys operated on any one day in each quarter.*—To be the largest number of vehicle journeys actually operated and not the maximum number allowed under the road service licence. A journey out and home should be reckoned as two journeys.

**ITEM 10.**—*Maximum number of vehicles leaving any terminal point at any one departure time in each quarter.*—To be the largest number of vehicles actually operated and not the maximum number allowed under the road service licence.

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