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MECHANIZATION, EMPLOYMENT,  
AND OUTPUT PER MAN IN

# BITUMINOUS-COAL MINING

VOLUME I

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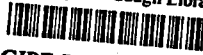
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**MECHANIZATION, EMPLOYMENT, AND OUTPUT PER MAN  
IN BITUMINOUS-COAL MINING**

by

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F. G. Tryon, Charlotte K. Warner, L. N. Plein, Walter M. Dake,  
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**VOLUME I**

**WORK PROJECTS ADMINISTRATION, NATIONAL RESEARCH PROJECT**

In cooperation with

**DEPARTMENT OF THE INTERIOR, BUREAU OF MINES**

Report No. E-9

*Philadelphia, Pennsylvania*

*August 1939*

**THE WPA NATIONAL RESEARCH PROJECT  
ON REEMPLOYMENT OPPORTUNITIES AND RECENT CHANGES  
IN INDUSTRIAL TECHNIQUES**

Under the authority granted by the President in the Executive Order which created the Works Progress Administration, Administrator *Harry L. Hopkins* authorized the establishment of a research program for the purpose of collecting and analyzing data bearing on problems of employment, unemployment, and relief. Accordingly, the National Research Program was established in October 1935 under the supervision of *Corrington Gill*, Assistant Administrator of the WPA, who appointed the directors of the individual studies or projects.

The Project on Reemployment Opportunities and Recent Changes in Industrial Techniques was organized in December 1935 to inquire, with the cooperation of industry, labor, and governmental and private agencies, into the extent of recent changes in industrial techniques and to evaluate the effects of these changes on the volume of employment and unemployment. *David Weintraub* and *Irving Kaplan*, members of the research staff of the Division of Research, Statistics, and Finance, were appointed, respectively, Director and Associate Director of the Project. The task set for them was to assemble and organize the existing data which bear on the problem and to augment these data by field surveys and analyses.

To this end, many governmental agencies which are the collectors and repositories of pertinent information were invited to cooperate. The cooperating agencies of the United States Government include the Department of Agriculture, the Bureau of Mines of the Department of the Interior, the Bureau of Labor Statistics of the Department of Labor, the Railroad Retirement Board, the Social Security Board, the Bureau of Internal Revenue of the Department of the Treasury, the Department of Commerce, the Federal Trade Commission, and the Tariff Commission.

The following private agencies joined with the National Research Project in conducting special studies: the Industrial Research Department of the University of Pennsylvania, the National Bureau of Economic Research, Inc., the Employment Stabilization Research Institute of the University of Minnesota, and the Agricultural Economics Departments in the Agricultural Experiment Stations of California, Illinois, Iowa, and New York.

**FEDERAL WORKS AGENCY**  
**WORK PROJECTS ADMINISTRATION**  
1734 NEW YORK AVENUE NW.  
WASHINGTON, D. C.

**F. C. HARRINGTON**  
COMMISSIONER OF WORK PROJECTS

August 25, 1939

Colonel F. C. Harrington  
Commissioner of Work Projects

Sir:

Although bituminous coal has been declining in importance as a source of fuel and energy, it is still this country's principal energy producer and it still employs as many workers as all of the other mineral industries combined. The average number of men employed reached an all-time peak of 705,000 in 1923. From that point on employment declined almost steadily until 1932 when it was down to 406,000 men; since then it has increased to 492,000 in 1937.

The fact that coal mining was one of our sick industries even during the prosperous twenties is attributable partly to the wartime inflation of capacity and partly to changes in demand. The high prices of the war led to the opening of new mines and further expansion of the capacity of an already overdeveloped industry. At the same time oil, gas, and hydroelectric power made inroads in the markets for coal and consumers turned to economies in the use of fuel. The former upward trend in coal demand flattened out. The combination of arrested demand and surplus capacity produced an inevitable readjustment and as early as 1924 the bituminous-coal industry experienced acute depression.

Technical advances underground and on the surface reduced the number of men required to mine a given volume of coal, though doubtless aiding coal to meet the competition of other sources of power. At underground mines the average output per mine worker per hour increased by 24 percent between 1920 and 1935. The continued spread of the mechanical devices that were available before the war, such as the undercutting machine; the electrification of underground



transportation; and improvements in mine lay-out and management methods contributed toward the rising output per worker. Shortly after the war a new machine, the mechanical coal loader, was introduced. It is mainly with the progress of mechanical loading and its relationship to the other factors that influence production and employment in the industry that this report is concerned.

In a mine in which coal is loaded by hand, from one-half to two-thirds of the entire working force consists of miners who, in addition to undercutting the seam and preparing shot holes for blasting down coal, shovel the coal into mine cars. Most of their time is spent in loading coal and the mechanization of this process can obviously have an important effect on the amount of labor required by the mines.

Machine loading was adopted slowly in the early years of its introduction. Only 0.3 percent of all underground bituminous-coal tonnage was loaded by machine in 1923. By 1929 the percentage was 7.3 and in 1935 it was 13.5. Between 1935 and 1937 the machine-loaded tonnage increased from 47 to 83 million tons, or to 20.3 percent of all underground production, and it is estimated that in 1938 one-quarter of the output was loaded mechanically.

The installation of mechanical loaders has not taken place at an even rate in all producing areas. During the twenties and the years between 1930 and 1935 it had its principal acceptance in the great Illinois-Indiana producing district and in some of the less important producing States of the far West. In West Virginia, the country's leading coal producer, 21 percent of the output was mechanically loaded in 1938 as compared with 2 percent in 1935. While it was being adopted to an increased extent in other areas the coal loader also continued to be more extensively used in Illinois and Indiana.

It is estimated that within another decade as much as half of the total underground output may be mechanically loaded. How this will affect employment in the industry depends upon a multitude of factors. Between 1929 and 1935 output per man-hour in underground mines increased by 5 percent and production declined by 32 percent, but the average number of men employed declined by only 9 percent. The men have worked fewer hours per day and fewer days per year.

Technical progress has been a factor in aiding coal to meet its competitors in the market and offers one means of maintaining adequate wage rates and working conditions. No student of the coal industry, however, foresees a revival of demand such as to enable the industry to absorb any of the unemployed from other fields of labor. In fact, the most that can well be hoped for is to maintain the working force now employed at the mines.

If the cost of coal is reduced, new uses found, and former markets recovered, mechanical loading will result in the elimination of much of the backbreaking work of coal mining without exacting too great a price in terms of unemployment and reduced income. However, such a price has already been and is now being paid in some localities. Some mines and mining communities which by virtue of natural conditions or other factors have been unable to adopt mechanical loaders are being placed in unfavorable competitive positions and are finding their employment opportunities restricted. Some of the older miners, accustomed to the tempo of hand-loading mines, are finding themselves displaced and unable to gain a foothold in the mechanized mines. To many of these communities and for many of these older miners emergency relief measures of one type or another are the only alternative to destitution as long, at least, as mass unemployment remains a problem in the United States.

Respectfully yours,

A handwritten signature in cursive script that reads "Corrington Gill". The signature is written in dark ink and is positioned above the typed name.

Corrington Gill  
Assistant Commissioner

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## PREFACE

This study deals with the introduction of a new phase of machine technology into bituminous-coal mining, the largest employer of labor among the extractive industries. It illustrates the interaction between resource factors and changing economic conditions on the one hand and the process of technological advance on the other. The record is unusually complete. The spread of the technical change may be traced through large and small mines, strong and weak companies, union and nonunion working conditions, and through periods of declining and advancing wage scales.

The particular technological change under observation is the mechanization of the heavy labor of shoveling coal into the pit car underground. Machines adapted to this work emerged upon the commercial market about the year 1923, their appearance in practicable form following a long period of experimentation.

The mechanization of the loading process is but the latest in a long series of substitutions of more efficient forms of mechanical power for animal or manpower. Previous advances had centered around improvement of explosives, of the undercutting of the seam, and of hauling, hoisting, ventilation, screening, and washing. The mechanization of loading utilized these prior advances and in turn stimulated improvements in hauling, cutting, drilling, shooting, and mechanical cleaning of coal.

In the manufacturing and extractive industries the mechanization of conveying operations and of the handling of bulk materials seems in general to occur characteristically only after other production operations have been mechanized. It is probably for that reason that the mechanization of conveying and handling, in the form of loading devices and assembly belts, have occupied an important position among the types of technological changes that took place in American industry during the last two or three decades. The effects of these technological developments on labor requirements tended to be passed over lightly or dramatized depending on whether or not production and employment in the affected industries were expanding.

In the bituminous-coal industry the loading machine appeared at a time when the industry was undergoing a major economic readjustment, and the effects of this technological change are obscured by great changes in demand for the product, by the liquidation of mine capacity, and by declines in volume of employment due to external factors unrelated to the process of technical changes. The World War had intensified a chronic overdevelopment of mine capacity which had characterized the industry as far back as 1880. The war had likewise stimulated more efficient combustion, and technical advances in the arts of utilization of the product reacted sharply upon the conditions of its production. Meantime the competitive fuels made serious inroads upon the coal market.

This combination of factors brought on acute depression in the bituminous-coal industry as early as 1924. Between 1923 and 1929 more than 3,000 commercial mines were forced to close, 200 million tons of annual mine capacity was shut down or permanently abandoned, and over 200,000 men lost their jobs. In this readjustment, as indeed in many of the subsequent changes in employment, the effects of technical change tended to be overshadowed.

After the depression of the early 1930's had set in, still other external factors obscured the effects of technical change within the mines. Consumption declined, particularly in the heavy industries consuming the metallurgical and coking coals. The demand which had been comparatively stationary in the late 1920's fell from 535,000,000 tons in 1929 to 310,000,000 tons in 1932. Employment fell from 503,000 men to 406,000, the drop again reflecting chiefly factors of the market. From this depression low, production recovered to 442,000,000 tons in 1937 and employment to 492,000 men in the same year.

These sweeping changes make it difficult to ascribe to the single factor of technology either the debits of unemployment resulting from increased output per man-hour or the credits of employment resulting from retention of markets that, at higher levels of cost, might have gone to competing fuels. It is possible, however, to point out some of the effects which the new loading technique has tended to have and the points at which its impacts have been felt most keenly.

Mechanical loading of coal in underground mines cannot be introduced independently, without regard for the technological

level of other operations. Loading is in fact closely related to all preceding and subsequent production steps and can be effectively mechanized only when properly geared to those other steps, providing seam conditions are favorable. Given proper physical conditions, mechanical loading proves most easily adoptable, from the engineering viewpoint, in mines which have gone furthest in mechanization before. Where the methods used on related operations are not suitable to mechanical loading, the installation of loading devices requires also appropriate changes in these other operations and the equipment used in them before the mechanization of loading can be carried through without causing costly breakdowns and bottlenecks. Individual mines and even districts do exist in which physical conditions prevent, at present, the mechanization of loading despite the fact that other operations are carried on along the most modern lines. To such mines the introduction of loading machines elsewhere may have meant some impairment of their competitive positions. In general, however, the availability of machines for the loading of coal provides a technical base for increasing the economic advantages of those mines which, by reason of financial ability, good management, or other factors, have been able to make use of the most modern techniques available before. Such advantages were in the past enjoyed primarily by the larger mines. This is partly reflected in the fact that for decades past mines with an annual production of 200,000 tons or more had an average output per man per day which was about 50 percent greater than that of mines producing less than 50,000 tons. In part, however, this difference also reflects the fact that the larger mines are, on the whole, working the thicker and therefore the less labor-consuming seams.

The mechanization of loading is, as already stated, the present phase of a long history of technological changes. Once the general technology of machine construction and power utilization had developed sufficiently to make mechanical loading possible, commercially feasible machines were bound to appear on the market. Moreover, there was considerable economic pressure to mechanize. Under the system of underground coal production using the hand-loading method, wages constitute about two-thirds of total production costs and the process of loading coal by hand consumes about half of the labor employed in a mine. Depending on the type of mechanical loading device

installed, the resource conditions of the mine, and the efficiency with which a mine is managed, mechanical loading can displace from about 10 to 40 percent of the total mine labor used under hand loading.

By the time the first loading machines were put on the market these economic pressures toward mechanization, inherent in the character of the production process, had become augmented by others which flowed from the arrest of the growth of the demand for coal. Two factors in particular tended to determine the regions of mechanized loading activity. One was the suitability of natural-resource conditions to the available types of loaders; the other was the level of wage scales. The wage rates, never so high as to yield more than a meager annual income for the mass of the mine workers, had during and shortly after the war reached a point where, relative to the purchase price of the machines and the carrying charges, it would generally have been profitable to substitute mechanical loading for hand loading.

When, shortly after 1923, the wage scale collapsed in the Appalachian region, it was not profitable for the coal operators in that region to install the loading machines. This was especially true of the southern part of the region where wage rates eventually dropped to less than half of their former levels. The situation changed abruptly with the adoption of the NRA codes, the resumption of collective bargaining, and the elevation of wage rates to levels more nearly approximating those paid in the North. The fluctuations in wage rates and their incidence go far to explain the jerky and spotty way in which the mechanization of loading has thus far proceeded in the several producing areas of the coal industry: first the mechanization mainly in Illinois, Indiana, and the far West, then, since 1934, the extremely rapid mechanization in certain portions of West Virginia where seam conditions were most favorable to the new technique. For, in the face of over-expanded mine capacity, the mechanization of loading played an important economic role in the struggle for survival. The complicating factors that serve to obscure this role involve the simultaneous spreading of another technological change - strip mining, a method which is even more intensely mechanized and labor-saving than mechanical loading; wide variations in resource conditions and the degree of their adaptability to

different types of mechanical loading and to strip mining; differences in the degree to which individual mines are controlled by their markets; wide variations in the size of mining enterprises; their financial and managerial resources; and their consequent abilities to adopt mechanical loading successfully.

The statistics for Illinois and Indiana indicate that the mines that mechanized their loading were chiefly the larger mines and that, so far as stability of operations and of the level of employment are concerned, they fared far better than those which continued to load by hand. However, for many coal operators the alternative to mechanize or not did not exist. The data on underground mining presented in this report show that when the coal mines of a particular region are classified according to whether or not they had successfully adopted mechanical loading by 1935, the result is a grouping of mines into what might loosely be called "good" mines and "poor" mines. By and large, the group which includes the mines that successfully mechanized their loading processes consists of those whose physical resources were peculiarly adaptable to mechanical loading, whose financial resources were superior, whose management was alert, or who were otherwise in a position to make effective use of the new technology, perhaps because their mine lay-out followed modern principles and was therefore more easily adaptable to modern techniques, or because their size made possible a more economical utilization of the new equipment. Mines with widely different financial and physical resources may be able to continue competing in the same market so long as all are on a hand-loading basis, but the introduction of mechanical loading in some may force the others into submarginal positions and lead to their eventual shut-down. In most instances the mines which mechanized had enjoyed more stable operations than the other mines even before the mechanical loaders were installed, and the very factors which enabled them to mechanize were also the ones that enabled them before to maintain a relatively stable level of employment.

It is not possible to determine the extent to which the stability of the mechanized mines was attained at the expense of those that either could not or failed to mechanize. The severe competition which set in shortly after the World War

took its toll principally among the smaller mines of "commercial" size. While the total number of mines producing over 200,000 tons a year increased between 1923 and 1929, the number of mines producing from 10,000 to 50,000 tons a year declined about one-third between 1922 and 1924 and has continued to decline to date. The mushroom-like growth of truck mines in recent years has multiplied the number of mines producing less than 10,000 tons a year, but this growth is ascribable to technological developments outside the coal industry - the rise of hard roads and cheap trucks - rather than to improvements in the technology of mining. Much of the decline in the number of mines producing from 10,000 to 50,000 tons a year represented a liquidation of overcapacity, but some part of it was doubtless the result of inability or failure to mechanize and thus to compete effectively with the larger, mechanized mines.

When the coal industry ceased to expand its production, technological improvements had to result in a reduction of labor requirements, although failure to take advantage of the economies which could be effected by the mechanization of loading might itself have resulted in further loss of markets and jobs. Regardless of what the eventual or indirect results of mechanization may be, individual workers were bound to suffer unemployment as a result of technological displacement. Unless the rate of mechanization was geared to the number of job separations which normally occur as a result of voluntary quitting, retirement, death, and similar causes, some workers were displaced by machines even if they had been attached to the pay rolls of mines that were successfully mechanized. For those who remained on the rolls of these successfully mechanized mines, the change in technology meant an increased measure of immediate job security, but for those displaced and for many of those who were attached to mines that could not mechanize, the effect was just the reverse. As long as production did not expand, the total number of jobs available in the industry as a whole would have declined much more sharply than it did had not employment policies been adopted which involved both temporary and permanent reductions of standard working hours per day and per week.

This report was prepared under the administrative supervision of O. E. Kiessling as one in a series of studies conducted by the National Research Project in cooperation with the United

States Bureau of Mines. The factual information upon which the report is based is drawn largely from statistics collected by the Bureau over a period of many years. The statistical approach to the study and the handling of original data were directed at the start by Frederick G. Tryon, formerly Chief of the Coal Economics Division of the United States Bureau of Mines and now Director of the Division of Research of the National Bituminous Coal Commission, and by Fred E. Berquist, formerly Special Consultant to the National Research Project and now Special Assistant to the Attorney General, United States Department of Justice.

The outline followed, with some modification made in writing the report, was prepared largely by Mr. Tryon who also assembled the staff of authors and participants. Responsibility for writing the report was taken by Willard E. Hotchkiss, Consultant to the National Research Project, now Maurice Falk Professor of Social Relations at the Carnegie Institute of Technology. As author or joint author of individual chapters Mr. Hotchkiss contributed largely to the text of the final report.

Charlotte K. Warner, Assistant Economist of the National Research Project, was associated with the study from its beginning and was responsible for supervising the staff, assembling new materials, drafting much of the report, and editing copy. Responsibility for the accuracy of the statistical operations fell chiefly upon Mildred A. Keller, Research Assistant of the National Research Project.

Leo N. Plein, Senior Engineer-Economist, formerly of the Bureau of Mines and now of the National Bituminous Coal Commission, assembled materials and drafted the major portions of chapters III and VI. He reviewed all of the final copy. Joseph J. Gallagher, Assistant Statistical Analyst of the National Research Project, collaborated in the preparation of chapters V and VII and read critically many sections of the report, especially those dealing with labor conditions.

Walter M. Dake, Research Manager, Mining Publications, McGraw-Hill Publishing Company, New York City, as Consulting Engineer of the National Research Project, supplied information, gave generously of his time and advice, and reviewed the manuscript of the report. Mr. Dake is also joint author of chapters III and V. Robert L. Anderson, Engineer Economist of the National

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Bituminous Coal Commission; collaborated in the preparation of chapter IV.

Indispensable data were drawn from Margaret H. Schoenfeld's unpublished monograph, "Physical Conditions in Bituminous Coal Mines." This study, prepared originally for the Brookings Institution in 1926 under Mr. Tryon's supervision, contains valuable descriptive material on resource factors and has been largely used in chapter III.

Former and present National Research Project staff members J. Edward Ely, Nicholas Yaworski, and D. C. Ashmead furnished access to some of the materials used, especially in chapters I, II, and VII. Cooke Settle is largely responsible for the design and lay-out of the graphic charts. Wilhelmina F. Whiting aided in the editing of the final draft of the report.

Invaluable assistance in meeting many of the problems which arose as the study progressed was also given by the following: M. van Siclen, Chief Engineer of the Coal Economics Division of the United States Bureau of Mines; Lida Mann, Staff Member of the same division; and Mary W. McMillan of the Division of Research of the National Bituminous Coal Commission. The completed manuscript was edited and prepared for publication under the supervision of Edmund J. Stone.

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August 22, 1939