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INTRODUCTION

THE machine has been the foremost factor making for economic and social change in the western world during the past hundred and fifty years. It has impinged upon man's modes of living in diverse ways. The means by which his productive energies have been utilized, and the directions in which those energies have been expended, have been substantially altered. The productivity of his labor has been increased; his standard of living has been advanced. The physical features of the world in which he works and lives have been changed, and a transformation has occurred in the character of the commodities entering into daily consumption and use. After generations of slow change, the skills essential to economic survival have been profoundly modified. Under the pressure of mechanization men have had to learn to do new things in new ways.

All this is commonplace enough. That the machine has worked great changes in human life is no discovery of the past few years. For more than a century social observers have commented on the progress of machine industry. All men alert to the currents of social change have known that major shifts in the modes and manners of living were in process. But the prevailing conceptions of what, precisely, was taking place have been vague and inadequate. In spite of the universality of the process of change, it was a move-

ment difficult to see and appraise as a whole. Here a new invention brought a striking change in productive procedure, and threatened the displacement of thousands of men. There a new application of power promised a ten-fold increase in output. A movement marked by wide diversity of attributes and by almost infinite ramifications was known to man, individually, only through isolated instances of technical change. It is not strange, therefore, that wild fears paralleled wild hopes in contemporary appraisals of the growth of machine technology. One man saw it as a Frankenstein monster, threatening the very life of its creator. Another saw a dawning millennium of ease and plenty in a world of push-buttons and buzzers through which man controlled his millions of yoked and mechanized horsepower.

In the face of these vague conceptions we have had sore need of an account in realistic detail, but presenting these details in a broad economic setting, and interpreting them with reference to the mechanization process as a whole, and to related processes of economic life. For in dealing with the characteristics and consequences of mechanization, as in many other economic fields, a part, to be truly appraised, must be seen in its place in the whole working of the economic system.

It is a great virtue of Dr. Jerome's study that he has tried to do this difficult job and has, indeed, done it better than it has ever been done before. We find here a wealth of detail as to the actual changes which mechanization has involved, over a wide area of industrial activity. Conveyors, electric hoists, mechanical stokers, concrete mixers, steam ditchers, steam-jet weed destroyers, rotary ballast sweepers, power tie tampers, portable escalators, trench excavators—these are the stuff of modern industry. Here is realism about the industrial process. But Dr. Jerome sees beyond his details. He has emphasized, as has no one before him, the wide range of

consequences which must be traced if one is accurately to measure the effects of a mechanical change. In doing so he provides an effective corrective alike for the visions of doom and for the prophecies of a mechanical millennium.

The mechanization process in its countless manifestations reacts upon the volume of employment, the skills and the working methods of the human factor in production. Dr. Jerome's treatment of one point, the effect of technical change upon the saving of labor time, furnishes an excellent example of careful technique and, by contrast with procedures confined to obvious consequences, illustrates the necessity of trying to see these movements in their broad relations to the working of the entire economic system.

To begin with, we must note the distinction drawn by Dr. Jerome between 'productivity-increasing' changes (those which increase the units of output per hour of labor) and 'labor-displacing' changes (those which reduce the number of workers required). The two concepts are closely related, of course, but the distinction refines our tools of analysis in the study of technological improvement. We do not stop here, however. A given change in technique may affect the productivity of *operating labor* (that required directly in a particular process), of *auxiliary labor* (plant labor necessitated by the use of a machine, but not engaged directly in its operation), of *embodied labor* (labor applied to the production of the machine itself, or to the production of power, oil, or some other commodity used in its operation), or of *indirectly required labor* (that is, all additional labor required, as for transportation, advertising or merchandising, in putting the given commodity in the hands of the final consumer ready for use). Furthermore, with reference to labor displacement, Dr. Jerome insists that we take account of labor requirements in the specific operations directly

affected, in the occupation in question, in the plant, in the industry, and in the economic system as a whole.

The mere citing of these diverse channels along which the effects of a given change may be felt is sufficient to indicate how fatuous it is to confine ourselves to the direct and immediately observable results of technical improvement. Technical change has brought striking advances in the efficiency of human labor, and has given rise to real problems of adjustment and adaptation, but we secure only a grotesquely distorted picture of the consequences of technical improvements if we take a microscopic view of that small industrial area in which the direct mechanical change happens first to appear. Dr. Jerome's study should improve our perspective.

The results of this investigation are made available at the end of a decade of intense interest in the processes of mechanization, and in their economic consequences. Before the beginning of the present depression 'technological unemployment' was a subject of wide discussion, and the machine has been given a prominent place in many explanations of the current industrial crisis. Dr. Jerome does not undertake a precise definition of the part played by the mechanization process in the economic developments of the post-War era, but there is rich material here for the student of this period. That mechanization always involves some disturbance of an existing situation, in the markets for goods or in the markets for labor, or in both, is clear enough. Was the degree of disturbance intensified during the post-War years? Were the consequences of mechanization during this period materially different, in kind or degree, from the consequences of earlier mechanical changes in industry? These questions arise, inevitably, in any survey of recent industrial movements.

As to the relative speed of the mechanization process during the post-War period, in comparison with earlier periods,

it is difficult to give any precise figures. Dr. Jerome's general results accord with other evidence in indicating that mechanical improvements were being applied more generally throughout the industrial system, and probably more rapidly, during the years following the War than during the years preceding the War. The speed with which, in post-War years, a perfected technical innovation was introduced throughout an industry was not approached during the earlier phases of the Industrial Revolution. Taking account of the area, industries and occupations affected, it is a safe conclusion that the rate of technological change was high in post-War years, in relation to previous experience.

But the economic and social consequences of technical innovations do not depend on the speed of mechanization alone. It is probable that in post-War years certain other conditions contributed to accentuate the problems arising out of the widening scope of machine technology. In appraising these conditions we shall do well to recognize the distinction Dr. Jerome has drawn between changes that increase output and changes that displace labor. This distinction is highly useful in tracing the incidence of mechanization and in distinguishing different stages of industrial development.

One of the major factors determining the economic effects of a given technical change is the degree of elasticity of demand for the products of the process affected. With highly elastic demand lower prices stimulate new buying. Under these conditions mechanical improvements leading to lower per-unit costs and lower selling prices will make possible the marketing of a much larger volume. Output will be increased, and the net effect of the innovation may well be a substantial rise in the amount of labor employed. The growth of the automobile industry is a concrete manifestation of a series of such improvements in the making of a commodity for which the demand is elastic. Improvements in industries pro-

ducing commodities of inelastic demand, on the other hand, may be expected to lead to actual displacement of labor or, under certain conditions, to an uneconomic expansion of output. For such commodities may not be disposed of in much larger quantities, in a given market, even though costs and prices are reduced materially by technical changes. Given a labor supply without fixed job tenure, and therefore subject to ready reduction, real labor displacement may be expected to result from technical improvement. If the labor supply be tied to the productive processes in question (as it is in agriculture, to a large extent) an expanding output, produced under conditions of lower cost and without much regard to the ability of the market to absorb the increased supply, may be expected. Marketing troubles, price weakness, social distress and reduced living standards may result from this combination of circumstances.

With the widening, in recent decades, of the area within which mechanical improvements were being applied, it is probable that the proportion of technical changes affecting commodities of inelastic demand was greater than in earlier periods of mechanization. Retail coal handling, street cleaning, train operation, stevedoring provide examples of occupations the products or services of which are not marked by high elasticity of demand. But the outstanding example of such a shift is furnished by agriculture. The mechanization process in this important field lagged for years, and still lags, in comparison with the changes machine technique has brought in manufacturing industries. But recent years have seen a substantial advance in the use of mechanical methods and new sources of power in farming. Tractors, combine harvesters, potato-digging machines, milking machines, the application of gas engines and electric motors to agricultural operations—these are but examples of a process which has been going forward at accelerated speed in the last decade

and a half. Dr. Jerome cites figures compiled by the United States Bureau of Labor Statistics indicating that technical improvements in agricultural production were sufficient to have displaced 2,530,000 workers between 1919 and 1927, had volume of output been unchanged. Actually, only some 800,000 workers were displaced, because these improvements, in the main, were used to increase output rather than to reduce the number of workers employed.

Normally, increased efficiency in the production of goods of inelastic demand would tend to displace labor, rather than to increase output. The great technical advance in agricultural production during the decade in question did not have this result. One reason for this is that agricultural producers are, traditionally, tied to the soil. They do not react to innovation as would a market-conscious manufacturer, with a relatively mobile labor supply at his disposal. The effects of mechanization in this field, therefore, have been quite different from the effects experienced in other industrial areas, at earlier periods. A glutted market, with prices abnormally low even when account is taken of lowered costs of production, has resulted.[1]

In part, however, mechanization in agricultural industries displaced labor during this period, and probably contributed to the volume of unemployment which characterized the post-War years. Mechanization in other economic areas marked by inelastic demand for commodities produced tended also to displace labor, rather than to increase production, and so to widen the margin of unemployment which

[1] Other factors, of course, contributed to the agricultural situation that has prevailed in the United States since 1920. Reduced demand in foreign markets, after the War-time stimulus, and declining demand for animal feeds, resulting from the increased use of motor power on farms, have reenforced certain of the tendencies due to mechanization. The industrial depression was a major factor in the agricultural distress following 1929.

has always been a feature of an industrial economy. It is true that the purchasing power released when consumers are able to buy certain commodities at lower prices may be expected, ultimately, to find an outlet in increased demand for other commodities, and so to lead to the absorption elsewhere of the displaced labor. But this may be a very slow process, mitigating but slightly the immediate evils of labor displacement. Some portion of the increased unemployment which characterized the post-War years in the United States may be attributed to the mechanization of industries producing commodities of inelastic demand.

But other factors, as well, contributed to this widening margin of unemployed men. Among these we must include the pricing policies followed in those industries in which rapid technical improvement occurred in the post-War years. For whether a given technical advance shall be 'labor-displacing' or 'productivity-increasing', in Dr. Jerome's terms, depends not alone upon the relative elasticity of demand for the commodities affected. With demand elastic the given innovation may still displace labor, rather than increase output, if the reduction of costs is not passed on in the form of correspondingly lowered prices to buyers. If the reduction of costs served exclusively to swell profit margins or, conceivably, to increase wage rates, the final effects of the innovation might be to yield higher profits or earnings to producers, to leave the volume of production substantially where it was before the change in productive methods was made, and to displace a quantity of labor corresponding to the enhanced efficiency of the manufacturing process. Here, again, the increased purchasing power represented by higher dividends or other disbursements might be expected to offset the reduction of purchasing power due to the displacement of labor and to lead, ultimately, to increased demand in other economic areas and to increased employment elsewhere. But

the time lag between displacement and ultimate re-employment might be a very long one indeed.

The actual effects of mechanization, at any time, are undoubtedly a blend of the various possible consequences. To some extent profits may be increased, to some extent wage rates may be advanced, to some extent prices may be lowered and the volume of output increased, and to some extent labor may be displaced. The state of competition, the bargaining position of labor, the character of the demand for the product and the pricing policies of management all combine to determine the relative importance of these possible consequences. During post-War years these different effects of mechanization were all present, in varying degree. Although the physical volume of production was substantially increased, it is probable that in certain manufacturing industries full advantage was not taken of opportunities for increased production at lower prices. This was partly due to relative inelasticity of demand for the products of some of the industries in which advances in mechanization occurred. It was probably also due, in part, to the observance of policies of price maintenance, even where lowered prices might have served materially to stimulate demand. The existence of relatively high prices for manufactured products was a characteristic feature of this post-War period. To some extent, then, mechanization during post-War years was manifest through labor displacement as well as through increased output. The margin of unemployment which has persisted since the industrial system came into being, and which tends to expand during a period of rapid technical change, was widened still further by the special conditions characteristic of the post-War years. The focusing of public interest on 'technological unemployment' was a consequence of this combination of circumstances.

In appraising some of the results of the mechanization process which Dr. Jerome illuminates in the following pages we should take account, also, of the relative ease, or difficulty, of the industrial readjustment which any innovation necessitates. The concept of general economic equilibrium remains a somewhat vague one, in so far as the actual processes of economic life are concerned, and the conditions of such equilibrium in an industrial society have not been defined. Yet, even without such definition, it is a fair assumption that technological changes disturb in greater or less degree the equilibrium, or the tendencies towards equilibrium, which prevailed prior to such innovations. The more rapid the rate of technical change, the more thoroughly mechanized and integrated the economic system, and the more rigid its parts, in relation to one another, the more difficult adaptation to such changes must be. On all these counts we should expect the problems arising out of the mechanization processes of the post-War years in the United States to be of exceptional difficulty. Dr. Jerome's studies indicate that the rate of technical change was relatively high during this period. Furthermore, our national economic system and the world economic system had become more thoroughly mechanized and more highly integrated than in earlier eras. The increasing importance of fixed costs in industrial operations, and other forces operating both within and without the industrial system proper, had probably tended to lessen the flexibility of the industrial structure. Post-War mechanization broke with exceptional force, then, upon this system, and involved greater difficulties of adaptation than had similar mechanical innovations in earlier stages of our industrial development.

The process of mechanization described in the following pages is thus not merely a technical affair, of interest only to production engineers and factory managers. It needs no

argument to establish its relevance to the major problems of the day, and its bearing on the central processes of contemporary economic life. When exaggeration and fantasy about the machine are duly discounted it remains, it is safe to say, the most compelling factor in the changing culture of modern man. It is the story of the machine, in its recent and mature development, which Dr. Jerome tells in the pages of this book.

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MECHANIZATION IN INDUSTRY