try and the Captains of Salvation, what are they, in the last analysis but highly educated labourers, found most frequently in communities where culture and labour are working in alliance, least frequently in communities where they have drifted apart as, alas! they are drifting in these days? The great task of our times, once more, is to re-unite these separated elements."

With this global view of political and economic problems a new synthesis in the education of wage earners is needed which will match this world view. The key to this new synthesis will be found not in single discipline of the single subject such as economics, history, government or science, but in a combination of many disciplines. Mastery of subject matter is not enough; what is needed is Mastery of situations. To achieve that Worker's Education must relate all the sources of information that throw light on the situations with which workers are confronted. This new synthesis must, in a word, be an interpretation of the whole environment in which the worker finds himself in our modern industrial society which has now become world-wide. The emphasis must be an interpretation of the whole environment as the condition of the education of the whole man. If the proper study of mankind is man, the only way to study the whole man is against the background of all mankind.

In the past the education of workers has tended to be exclusive and separatist, to focus on the rights and duties of workers as workers or as members of the labor movement. It is important that these rights and duties be inderstood but they cannot possibly contain the whole interest or responsibilities of the worker. He is a political citizen as well as an industrial citizen; he cannot escape the duties of the one any more than he can the other. The education of the citizen-worker, then, for tomorrow's world must be the starting point for a new type of education which befits these new times.

The sum of the matter is this then, the education of the worker which is appropriate to the post-war era is education of the whole man for the whole environment which is the world. Nothing less will suffice. That must be our starting point; that must be our goal.

Technology and Full Employment

By Mary L. Fledderus

THAT full employment of all workers should prevail after the war, seems to be almost unanimously accepted as a goal in North America. As the end of the war draws near, post-war employment is no longer a distant aspiration, but an immediate, individual problem for returning veterans, a national concern, and the obligation of every community to which men and women are coming home from military service. Moreover, it has become an international problem, since the last post-war period demonstrated that policies in one nation may result in depression and unemployment in other countries.

Much of the discussion of this question in the U. S. A. and Canada has centred upon federal action inthe area of e conomic and financial arrangements. The problem is stated in terms of achieving a national income of some specified billions of dollars, assuming a given ratio between total employment and total income as achieved at some past date. In contrast, we propose an approach focused upon the nature of the new technology as the basis for new productivity profoundly

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affecting employment and living standards. The characteristics of this new system of technology seem to us to indicate both the potentialities and the immediate difficulties confronting any community which hopes to establish security of livelihood after the war, whether it be an agricultural village, a mining community, Nova Scotia, the United States, Canada, or the Balkans. For modern technology transcends national boundaries. All national policies, as well as the practices of management and labor, depend for their effectiveness upon an understanding, not of one branch of production alone, but of the totality of the new productivity inherent in modern technology.

The century in which we live to-day opened as an age of potential abundance, an age of new resources and new productivity, made possible through science and invention. Invention may be viewed as the result, or by-product, of a process of experience; while science, according to the biologist, Herbert Spencer Jennings, is "the organization of experience." *Applied science and the organization of experience into processes of production have been called technology.*

Each period in history has its own technology. In earlier days it was simple. To-day technology is complicated. But whatever the stage of its advance, four basic factors are ever present and always closely interact. These are (1) motive power, (2) raw materials, (3) equipment, (4) human manipulation or skill.

New Motive Power and New Substances

In early civilization, motive power was either human or animal. Before the wheel was invented, over four thousand years ago, there existed only the action of the animal and human body, especially the hand. The use of rollers in moving heavy objects is believed to have led to the invention of the wheel. With the hitching to the wheel of animal power and the powers of wind and water, a further stage in productivity was reached.

The wheel, crude at first, became increasingly perfected. Friction was reduced through invention and application of ball- and roller-bearing apparatus. This equipment greatly augmented the velocity of the wheel and its ability to transmit power, until, *as recently as thirty years ago*, the perfection of roller bearings overcame all friction and achieved the practically unlimited ability of the wheel to meet requirements of speed as well as of power transmission.

Without a certain degree of perfection of the wheel for transmission of power, the steam engine, and later the steam locomotive, could not, in all probability, have been invented. Their inauguration introduced the next, highly accelerated, stage of industrial productivity. Their availability and growing perfection underlay the factory and transportation systems of the nineteenth century.

The development from steam to electricity accompanied the turn from the nineteenth to the twentieth century. This new power of electricity did not merely bring about further acceleration of existing industrial productivity, *but fundamentally changed its nature.* Thus far all motive power, whether by hand, wheel, or steam, had been locomotive, that is, moving on the spot and hence tied to the location of its source. In contrast, electricity is an unlimited fluid force. It is a natural condition or attribute of the earth itself. Electricity can be generated at all times by the installation, in central stations, of electric dynamos driven by such prime movers as steam turbines, water turbines, or internal-combustion engines. Electricity can be distributed over long distances and wide areas. It can also be stored. Wherever transmission lines go, electricity can be tapped at will. This makes possible the installation, wherever desired of secondary movers, such as motors and other electrical tools for the purpose of production and transportation.

The immediate availability of motive power transferred the whole process of production to an entirely new level. The motor is the foremost conveyor of electric power. Its growing perfection and adaptability to almost any process of work, gigantic as well as minute, simple as well as complicated, has constantly increased the tempo of an already greatly expanding productivity.

Besides the motor, other electrical tools and instruments have become available. They consist of measuring and controlling devices. These devices are great auxiliaries to the productive process, increasing quantitative production as well as introducing many refinements into the final product. Electrical instruments, moreover, give rise to many forms of automatization. This automatization reduces, on the one hand, the need for human labor; on the other hand, it results in accelerated and regular operation and uniformity of product.

> Unaided by instruments, human observation is not sufficiently rapid or accurate to measure the large number of variables which enter into production, particularly in the many recently developed processes—such as those employed in the manufacture of synthetics or alloy steels—for which operating conditions must be maintained with a high degree of precision. Just as the development of the machine made possible the extensive application of mechanical power by removing the restrictions imposed upon production by the limitations of human or animal energy, so instruments have played an analogous role in regard to human perception and judgment. They have, in short, removed the restrictions imposed upon many production processes by man's limited ability to observe and control physical phenomena.[2]

And here we approach the domain of another great power of modern production, namely, that of chemistry. Chemistry may be defined as the science of the elements and their combinations and interactions. While physics, with electricity as its central phenomenon, has to do with the movement and force of energy, chemistry is concerned with substances and their changes. At the rame time, however, probably few people realize that the growth of the science of chemistry itself has been dependent on electric power, for the reason that no earlier source of heat could produce the enormously high temperatures which are needed to create the new materials and objects which we use and need to-day. Electric furnaces, for instance, produce much of the alloy steel of which electrical instruments themselves are made.

The field in which electricity and chemistry together have probably been most creative is that of electrometallurgy. In earlier days the metals at our disposal, other than gold and silver, were iron, steel, copper, brass, zinc, bronze, lead, and tin. To-day over 5,000 alloys are used in industry. The role played by alloys is that they improve upon the basic metal and make possible many things that were formerly unheard of. The most familiar example is the automobile. Fairly recently, an average automobile was found to contain 83 different alloys. Without these it would not have been possible to fabricate a machine able to withstand the vibration and friction due to the speeds to which an automobile to-day is subjected. Certain alloys, such as aluminum and magnesium alloys, moreover, have made available metal for lightweight construction. Such alloys appear in aircraft construction, especially in high-speed planes.

Thus it is the united action of these two great forces, electric power and chemistry, which gives us the profusion of raw materials and finished goods of which our present century can boast. Neither the one nor the other could, by itself, have brought about this abundance. It is due not only to their close alliance, but likewise to their complete reciprocity. Electrical instruments have given to chemistry new devices of registration and control, of automatic processing and continuous operation. These, in turn, have made possible the fabrication of many new materials and products. Materials have been endowed with entirely new qualities, and articles can

2. Quoted in *Technology and Livelihood*, pp. 26-27, from Works Progress Administration, report on Industrial Instruments and Changing Technology, 1938.

be made available in mass production whose cost would otherwise have been prohibitive. Even much of the laboratory equipment itself could only recently have been fabricated. The same holds true for electrical instruments and the materials of which they are composed.

New Labour Productivity

With such powers at his disposal, it goes without saying that the effectiveness of man's work has increased to an extent that is well-nigh fabulous. Blast furnaces, for instance, used to turn out five to ten tons of pig iron per day. Present furnaces can produce 1,000 tons per day, *while not using more men.* This picture has two sides. While it shows, on the one hand, profusion of basic materials for effective use in our living standards, it portrays, on the other hand, greatly decreasing need of human labor. Again, in the making of steel, many hand operations have been eliminated through use of electrically operated continuous mills, which roll the steel ingot into the finished sheet. Similar mills have been developed for brass and copper. Synchronization of various production processes has made possible the continuous pouring of iron castings, which, once more, results in a large saving of human labor.

At the same time high-speed tool steels, electrochemically produced, have immensely accelerated the cutting speeds of metal, thus considerably raising output throughout the metal industry, while making many former operations unnecessary, and the workers who performed them superfluous. In fact, in the metallurgical industries, which provide us with an abundance and variety of metals, technological processes based on electric power and chemical action, *not men*, are rapidly becoming the principal producers. In varying degrees the same development is true for the coal-mining industry and for the newer industries of petroleum and natural gas. A different situation still prevails in agriculture, our oldest industry, directly concerned with our great natural resource, the land.

At the time of the industrial revolution agricultural implements were still those of quite ancient times, namely, the wooden plow, the hoe, and the digging stick. Farm machinery began to develop between 1830 and 1860. It was driven by hand, wind, water, or steam. It was only with the invention of the internal-combustion engine, which in turn resulted from increased chemical knowledge of the properties of petroleum and natural gas, that our modern agricultural machinery could be developed, such as the many-purpose tractor, the harvester-thresher, and other combines, all of which are great savers of human labor.

But agriculture, in contrast to practically all other industries, continues to be made up of many small units. Hence application of modern technology in agriculture is conditioned by the scale of its many and varying single units. Tractors and other more specialized agricultural machines and equipment can seldom be purchased or operated by small farms alone.[3]

Motor-truck transportation greatly stimulated commercialization of agriculture, as did application of refrigeration to farm products. While these two highly important developments stem from electrification and motorization, it is nevertheless true that the possible application of electric power to farm operations far exceeds its actual use. Further use of electricity could immeasurably increase farm productivity, create abundance, and facilitate work. Even under present conditions, however, farm productivity has been greatly augmented, with constantly decreasing need of human labor. Of all persons gainfully employed in the United States between 1840 and 1930, the percentage of agricultural workers dropped from 77.5 to 21.5, and for every 1,000 persons in the population, the number engaged in agriculture dropped from 172 in 1870 to 85 in 1930.

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3. A logical development in agriculture, therefore, has been co-operative action, such as co-operative ownership of farm equipment, co-operative buying of fertilizer, feed, and other materials, and co-operative marketing.

Modern technology has also developed equipment which makes possible new large-scale methods of drainage as well as irrigation, thus greatly extending the areas of land available for cultivation. In addition, there is the growing scence of fertilization.

Living Standards and Modes of Life

All of these industries provide the basic productive forces and the materials needed for further fabrication of all those goods and articles which we need for our sustenance and protection, or which appertain in one way or another to our aims and activities.

As far as sustenance and protection are concerned, basic necessaries logically fall into four groupings. These are food, shelter, clothing, and fuel. If any one of these is lacking, the balance of our physical existence is disturbed. *The availability and accessibility of these necessaries in quantity, quality, and variety may be considered to represent our actual or potential standard of living.* Not entirely, however. For man does not live by bread alone. His innate powers constantly find life and expression in his aims and his activities. These include others than himself. In our present-day society, man lives in ever closer association with many other human beings.

Obvious as it sounds, it may nevertheless not always be fully realized that the *nature* of this association is conditioned by our means of communication and transportation. Hence these are two additional basic elements in our existence which greatly influence our mode of life.

Communication and transportation have their origin in the same basic forces which underlie our production system as a whole. This is true as regards both the effectiveness of available equipment and its velocity. Modes of life have changed to a degree that would make the present scene in Canada or the United States unrecognizable to the Indians who once inhabited these areas. Motive power for the Indian was the hand on a simple wooden tool; for the man of the twentieth century, it is electricity with all its manifold uses. Raw materials consisted for the Indian of wood and stone and vegetable fibres. For modern man, chemistry, including metallurgy, has created new and hitherto undreamed-of materials, which transform the products used in daily living. As regards tools and equipment, it is sufficient to envisage the wooden fork of the Indian and the mammoth blast furnace which creates products of steel to be assembled into means of transportation unimaginable in earlier days.

While transportation and communication closely interact, both, in turn, depend upon the construction industries. Modern construction of highways, bridges, airports, tunnels, dams, and other structures of public service has become wholly feasible, on the one hand, through the availability of new power equipment, and, on the other hand, through chemical knowledge of the properties of entirely new building materials.

From the foregoing description it may well have become clear that the whole structure of our basic productive forces may be viewed as a closed circle. Any point of this circle partakes of the whole. Neither is there at any point a break in the circle. In fact, we may liken it to a mighty wheel at man's disposal and for his control. But no longer can such all-powerful apparatus be individually steered and used. Unification in production requires men's concerted action. It demands unity of purpose in human association.

During the past four years there has been such unity of purpose. Unfortunately, it has been the purpose of war. This very same war, however, has demonstrated our enormous, well-nigh fabulous industrial productivity.

What, then, when this war will have ended, can and should be the common purpose which will stimulate united action and which human beings may readily support? In the United States and Canada, as well as in Europe, it is constantly being emphasized, by all peoples and all groups in the population, that such common aim should be prevention of unemployment. Encouraging as is the general realization of this need, in relation to our great new potentialities it remains a negative statement of aim. Whether we shall have full employment or unemployment after this war, cannot be merely a question of developing some new industry to absorb workers displaced elsewhere through technological invention. To-day the same immensely accelerated productivity is inherent in all manufacturing as well as in the basic industries. At the same time it must be pointed out that, during the last two decades, the relative positions of man and equipment in the productive process have been greatly altered. In fact, the primary question has become one of labor requirements rather than employment opportunities.

Labor Requirements and Employment Opportunities

This difference between labor requirements and employment opportunities has, in itself, become highly significant. In earlier days, except during periods of ever-recurring business depression, employment opportunity was equal to man's will to work. An ever-expanding industrial production needed available man power. This was true until shortly after the first World War. Statistically speaking, 1923 was the year when a definite change in this hitherto normal trend became apparent. It is not difficult to find the cause of this changing situation. It is due to increasing use of electric power, and hence to motorization and automatization of hitherto manual work processes. This development, already described in connection with our basic industries, is equally, and perhaps even more, true for the manufacturing industries.

The process of electrification and automatization, as earlier mentioned, constantly raises the level of industrial productivity. In fact, in many instances automatic processes do the actual work of producing, while man is needed merely o watch and guide. Thus often the situation is reversed. It is no longer man who uses tools, but electric and automatic machinery which requires man's supervision. *Hence man's employment to-day is increasingly conditioned by the labor requirements of modern equipment.*

This situation implies that full employment has acquired *a new relationship* to such workshop policies as hours of work, or the length of the working day and the allied problem of remuneration. Hence upon those responsible for industrial relations—upon management and labor—rests the necessity to plan the terms of employment so as to use increasing production for living standards: to shorten hours, with increase in output; to raise wages in planned proportion to total productivity; and to lower prices in relation to general purchasing power, in order to distribute goods to the ultimate consumer. For the great majority of ultimate consumers, family income depends upon wages or salaries, while purchasing power is affected also by price.

Dependent on these conditions and relationships remain all other elements in the standard of living, including such basic considerations as health and creative leisure, education and training, social participation, and cultural development. For the basic unit of all production and supply is at all times the workplace, be it mine, farm or factory.

What our immense new resources and enormously enhanced productivity have made incumbent upon us may well be to aim at their full utilization in the interest of livelihood and living standards. Livelihood is the living won by work. The conditions of man's work are basic in his standard of living, affecting his wellbeing and his opportunity for creative living. Only full utilization can create full employment. For such utilization, all contributions of the technical and human sciences will be fully needed. Duly integrated, they could create a truly social science of administration of the new technology for human security and social advance.