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THE SOCIAL EFFECTS OF MASS PRODUCTION[1]

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IN the center of the theater district on Broadway, New York City, behind large plate glass windows there stood a short time since a modern cigarette-making plant. One machine, fed constantly with pulverized tobacco leaf and wrapping paper, ejects continuously a cigarette bar which is cut into standard lengths as it issues from the machine at the rate of 500 cigarettes a minute. A neighboring machine takes the cigarettes and automatically places them in packages, closes them and delivers the finished marketable product. The degree of skill required to operate the machine is small, though, of course, some one must fully understand the mechanism and be competent to make adjustments. At the other extreme of size, consider the automatic factory of the A. O. Smith Company of Milwaukee. This great machine literally takes in steel plates at one end and ejects finished automobile frames at the other at the rate of 8,000 daily. The machine, for such it virtually is, cost $10,000,000 and requires only 200 men to operate it. Probably 5,000 men would be required to produce the same result with ordinary processes. Here again, of course, there must be a certain number of skilled engineers who can adjust the machine, but the labor cost of actual operation is comparatively insignificant.

A survey of any progressive industry will reveal similar developments and constant progress toward the mechanization of its processes. Everywhere one finds the handicraftsman displaced by the machine and the semi-skilled operators, backed by the most lavish use of power the world has ever witnessed. In many instances the product is equal to or better than the

[1] Address of the vice-president and chairman of Section M—Engineering, American Association for the Advancement of Science, Atlantic City, December, 1932.

work of the artisan and in all cases the volume of product per worker is vastly greater than can be achieved by handicraft. Of course, there is nothing new *in principle* in these developments, which began with the first stone axe and culminated in the industrial revolution. Until that event the tool had always been an adjunct to the skill of the worker; but the developments of the industrial revolution made the worker an adjunct to the machine.

Since 1900 the mechanization of industry has proceeded at a rapid and apparently at an accelerated pace. As long as industry was prosperous and displaced workers, in some measure, could find work elsewhere, little attention was given to this tendency, though thoughtful writers have from time to time called attention to the problem. But the present depression has aroused more interest in the basic reasons for unemployment than any other in modern times, and for the first time technological unemployment, as this displacement of labor is called, appears as a vital issue and as a possible factor, in a large way, in the general problem of unemployment.

The most natural reaction on first observing productive processes such as have been described is one of concern for the skilled workers who may have been displaced by the new invention and a consequent belief that such advanced methods can not be conducive to the welfare of the workers. If, however, the observer should voice such fears probably he would be reminded of the great economic gains made by this country since modern manufacturing methods came into use and his attention would be directed to the high scale of living that the workers in this country enjoy, the inference being that modern methods of production can not in the long run be anything but helpful for all. While much can be said in support of both of these somewhat antipodal assertions, neither of them reveal the trials and tribulations through which many men have passed in building up our present level of existence, they throw no light upon the complex forces operating in the industrial field, nor do they even in a remote manner advise us as to whether the net trend is for good or evil.

Whenever an advanced process, such as those referred to in the foregoing, is set in motion, several economic changes at once become operative. The first is an increase in the capital investment and a further separation of the worker from the ownership of the tools of industry. This tendency is not connected directly with this present discussion, except that it has progressively closed certain avenues of escape open formerly to the worker under simpler industrial conditions. As industrial equipment has grown more complex and more expensive, the worker's industrial independence has decreased until to-day he is no longer an economic self-sufficient unit, but dependent largely upon capitalistic management for an opportunity to earn his daily bread. Consequently, the need of protective measures in his behalf increases daily.

The greatest and most immediate menace to the worker because of industrial progress is this displacement in favor of more highly developed machines in the hands of less skilled workers or "degradation of labor," as it has been called. In the early days of the industrial revolution in England the ruthless application of improved methods in the textile industries and the displacement of handicraft workers by machinery operated by children of tender years forms one of the darkest pictures in modern industrial history. Such direful conditions never prevailed in this country, even from the earliest days. Industry itself was in the making, the frontier was always accessible and a change from one calling to another not so difficult as at present. Even during the rapid expansion and development of industry in the latter half of the last century, technological unemployment was never a serious issue, though it had begun to raise its head. This is not to deny, of course, that at times and places much distress has occurred because of such displacement. Industrial progress is necessarily accompanied by change and apparently such change is necessarily accompanied by suffering on the part of some one. Progress, change and distress for some persons appear to be concomitant. The U. S. Census Report of 1900 mentions this tendency specifically as a menace to the wage-earner and predicts a doleful future for the wage-earning class in the following words:

> A factor that has a real tendency to lower the actual earnings of the wage earner in many industries is the displacement of the skilled operator by machinery which permits the substitution of a comparatively unskilled machine hand. This tendency is noticeable in many lines of industry. Its effects are twofold; to reduce the number of employees producing the same or an increased quantity of product and hence to lower the total wages of the group; and to reduce the average rate of wages because of the lower degree of skill required. The effect of the introduction and improvement of machinery upon the condition of the skilled artisan is an economic question of the greatest importance.

Here is analysis and prophecy, the accuracy of which will be discussed subsequently, after an examination of some other phases of the problem.

If this displacement of labor, as described in the foregoing, were the only effect of modern productive methods we should have found ourselves long ago in great difficulties. But improved machinery, while frequently displacing labor of a certain degree of skill, provides employment for workers of a lesser degree

of skill, and thereby "extends" the field of industry to workers who otherwise could take no part in modern manufacturing. Hence in the older callings that have been mechanized, shoes are no longer made by shoemakers, watches by watchmakers, or knives, forks and spoons by skilled cutlers and silversmiths, but by semi-skilled workers operating highly developed machines. More important still, these new methods and processes have made possible the building up of new enterprises of vast proportions, such as the sewing machine, the automobile, telephone, radio, refrigeration and other new industries, and which, but for modern methods, must have remained small in size with their products classed as luxuries. And these new mechanized industries in turn have given rise to supporting industries of great importance. Thus it is estimated that the automotive industry when busy gives direct employment to 800,000 workers and indirectly to 4,000,000 workers who supply equipment, raw materials, accessory parts, gasoline, etc. The plants of the Western Electric Company, which is the manufacturing arm of the American Telephone and Telegraph Company, have a normal capacity of over 50,000 workmen and the supporting industries must employ many thousands of workers. One wonders what this army of men would be doing if these new developments had not appeared.

The history of the development of these new factors in our existence should be noted, for it gives a clue to the character of the inventions which may be needed to hold the pace that has been set. The story of one is the story of all. First, there appears the period of invention and incredulity on the part of the public. It is only a few years ago that the electric motor was looked upon as an interesting toy, and the same was true of the telephone. A very few years ago the drivers of "horseless carriages" were viewed with mild amusement. Then comes the period when it is a luxury to possess one of the new devices. In the year 1880, for instance, it cost as high as $280 to have a private telephone. Finally, when the new device has proven its usefulness, mass production reduces the cost, and it becomes an economic necessity, the number in use depending sometimes, as in the case of the watch, almost solely upon the population. The sewing machine, the telephone, the automobile and other modern products have all justified their existence economically. It should also be noted that the driving power back of these modern methods is increased production and decreased costs. And it is a peculiar characteristic of these methods that as the quantity to be manufactured is increased, the unit costs can be decreased, which stimulates consumption, and this in turn reacts upon production, thus creating an ever-widening cycle of increasing production and decreasing costs until some limiting factor checks the movement. The results of this cycle are too well known to merit discussion, but it may be noted that in all probability the greatest value ever offered the public for every hour of labor expended is to be found in some of the moderate priced automobiles. How cheaply they may be produced time, only, will tell. The net result of modern methods, therefore, has been a vast increase in the quantity of manufactured goods and a remarkable decrease in the cost of them. It should be remembered that these methods have also been reflected in the basic industry, agriculture, and it would appear that the problem of production is fairly well solved, since at this moment we are producing more goods and more food than we can conveniently use, or rather more than we can intelligently distribute.

In résumé, therefore, as industry advances, some classes of workers are displaced, while at the same time other workers of lower degree of skill are given employment in callings hitherto closed to them. The displaced workers may find employment at the same economic level elsewhere, or they may be compelled to drop to the level of the new semi-skilled group. If the displaced workers are skilled in the machine building trades, they are usually absorbed by these callings, and the movement in general has been of advantage to the so-called "mechanic arts" group through the great development of the machine-construction industries. Other classes of workers have not been so fortunate, for it should be remembered that it is very difficult for a mature man of limited education to change his calling, to say nothing of the restrictions now imposed by trade unionism upon such changes. The statement so often made that displaced workers "find work elsewhere" is not always true, and if they do so it may be at an economic sacrifice. In time, of course, the displaced workers pass out of the picture so far as their old vocation is concerned, and the calling appears in a greatly modified form.

For the new groups that have been recruited, the conditions are usually the reverse. Given a small amount of training, they can be made more highly productive than formerly, they can render a greater service to society, and their remuneration in general is increased. That is, they may be, and generally are, elevated economically and as a natural result socially. The absorption of immigrant people and their descendants by the industries of New England and their economic and social elevation is too well known to need discussion, and the process still continues, not only there, but in every manufacturing center of this country.

Until quite recently, our industrial progress was viewed with considerable satisfaction. Our per capita

wealth has risen from $383 in 1850 to about $3,500 at the present time. Our national wealth has reached the unprecedented total of about $400,000,000,000 and our national income approximated $90,000,000,000, a most remarkable amount. Our scale of living exceeded anything in history, and despite the present depression, other nations, notably Germany and Russia, are eagerly studying our methods and adopting those that may help them to emulate our success. It appeared to many of us that we had really entered a new era and that we had in some measure solved the problem of living through high wages and a constant increase in the manufacturing cycle that has been described. The depression, therefore, came as a very painful reaction to many.

Economists in times past have usually looked for the causes of depression in the law of supply and demand, a change in the supply of gold or in some disturbance in international trade, all of which would be adjusted with time. But now for the first time a new and sharp question is raised concerning our manufacturing methods and equipment, and the fear is expressed that our industrial equipment is so efficient that permanent overproduction, for the markets available, has occurred and that consequently technological unemployment has become a permanent factor unless remedial efforts are put in force. Other critics contend that our methods of distributing the products and profits of industry are hopelessly antiquated, and that overproduction can not occur as long as there is poverty, want and ignorance. It is indeed a paradox to see storerooms filled with raw material, shoe factories equipped with the most efficient machinery man had ever produced, and workmen, anxious and willing to work, walking the streets almost without shoes for themselves or their families. It is not the province of this article to discuss this last contention, but it must be admitted that our present methods of distribution are hopelessly behind our powers of production in scientific background and direction. And without doubt we shall not achieve any marked relief from some of our industrial troubles until the same methods of analysis are applied to distribution, including tariff-making, that have produced our magnificent machinery of production.

Many economists believe that permanent technological unemployment is unlikely or even impossible. Briefly, they argue that, as has been stated, technological progress increases the quantity and reduces the cost of production. This in turn creates a greater demand and hence enlarges the opportunities for labor. Or, if the demand is inelastic, even at reduced costs, the savings, either to the consumer or the producer, are eventually invested through banks in the production of other products, and thus the field of industry is indirectly expanded. Unfortunately, we have little quantitative knowledge concerning these complex relations. There are some facts concerning some individual industries, however, that are illuminating.

The census of 1900 lists the number of workers in the shoemaking industry, both handicraft and factory, as 153,600 and gives their earnings as $63,304,344, or about $415 per person. This industry has been very fully mechanized, yet in 1914 the number employed was 191,555, with average earnings of about $522 per person. In 1925 there were 206,992 workers in the industry, with total earnings of $225,787,981, or about $1,090 per person. The purchasing power of the dollar of 1925 was about 66 per cent. of that of 1914 and 53 per cent. of that of 1900, but even with these allowances there has been a gain in real wages since 1900. Furthermore, in 1900 there were 4,849 children under 16 years of age employed in the industry, with yearly earnings of about $177 per year per child. No such conditions are tolerated to-day in progressive states.

Again, in the printing industry, which also has been highly mechanized, the census of 1900 gives the number of workers as 162,992 with yearly earnings of $84,249,963, or about $517 per person. The census of 1925 lists 251,276 persons as employed in this calling with total annual earnings of $438,832,974, or about $1,746 per person. Here again, allowing for the difference in the value of the dollar, there has been a decided gain in earnings. Furthermore, such statistics do not take into account the increased employment due to the production of machinery for these industries. In 1925 the value of the printing machinery produced in the United States was $69,216,683, and the corresponding value of shoemaking machinery was $11,769,137, and each of these machine industries in turn has many ramifications, the money value of which would be difficult to compute. No doubt an analysis of other industries over this period of rapid mechanization would show similar results and it would appear that so far as some individual callings are concerned, the recorded experience does not bear out in any way the gloomy predictions of the editor of the Census of 1900 quoted in a preceding paragraph. And it is fair to assume that under present circumstances any calling that is transformed by mechanization will stabilize "in the long run," as economists say, on a higher level so far as those workers who survive the change are concerned. We need not be troubled apparently at the *final* results of such metamorphoses. It is the *immediate* results of such changes that are now engaging the attention of thoughtful men.

It is usually assumed by ardent advocates of indus-

trial progress that the workers who are displaced by reason of advanced technological methods, whether mechanical or administrative, will find work elsewhere. This is not so easy to do. In former days, when industry was simpler, less specialized and less highly organized, such a transfer was not so difficult without great loss of time or economic standing: but conditions are vastly changed. The displaced worker is, in general, debarred from engaging in his wonted calling on his own responsibility, both for lack of funds and administrative experience. It is this lack, indeed, that makes cooperative production so difficult, if not impossible, under modern conditions. Again, the displaced worker can not, in general, engage in some other calling, at the same economic level, since his knowledge, skill and experience are not transmutable. If he does find employment in some other calling it is usually at a lower salary, that is, he suffers degradation of labor, so called. The few statistical studies that have been made of this problem indicate clearly that many displaced workers find employment elsewhere only after a considerable period of idleness and often at a lower wage scale. These difficulties are, of course, greatly increased where the decline in employment is such as to require the worker and perhaps his family to migrate to some distant point, a procedure that he faces with greatest reluctance. The most startling index of these new and changed conditions is the growing group of men over forty years of age that are finding it very difficult to get a foothold in industry once they are displaced for any cause. In this sense it may be that permanent technological unemployment already exists to a certain extent. It is, therefore, the immediate and not the ultimate results of technological progress that are of greatest concern and it is an open question as to how far we should permit the good of the majority to be advanced at the cost of suffering and poverty on the part of the minority. We are sadly lacking in accurate data as to the quantitative results of modern methods as affecting permanent unemployment. Perhaps nothing but a careful study of these phenomena or a pragmatic return to normal production can reveal to us with surety just what the true trends are, but in the meantime there are indications enough to put us on our guard as industry becomes increasingly scientific in its background and practices.

If an understanding of past progress and present conditions be important, some estimate of what the future may hold is even more so. The last thirty years has witnessed an unprecedented improvement in the science and art of production. Not only has this reshaped many of the old callings, but in some cases new and unheard-of industries based upon scientific processes have placed products on the market that have threatened or even obliterated old industries. In addition, the entire philosophy of industrial management has been rebuilt and made much more efficient. In its effect modern management is analogous to improved mechanical methods in that it aims to produce more per worker and hence tends to technological unemployment. There has also been a vastly greater use of power, particularly in heavy construction. Dean W. B. Donham, of the Harvard Graduate School of Business Administration, in his excellent and thought-provoking book, "Business Adrift," voices the opinion that "technological progress in the direction of better processes and methods will continue and accelerate during the generation ahead of us." He makes a similar prediction concerning the progress of efficient management. This may or may not be a true prediction, but if it be true, there are certain features of our economic life that must be studied carefully if our present system is to endure and if we are to keep up the present level of existence and escape extreme technological unemployment.

First, our home markets must be developed extensively. Foreign trade must, of course, be cultivated as heretofore, for the United States is far from being self-sufficient in the materials needed in modern industry, and it would appear that progressive nations are increasingly interdependent. But the field of foreign trade promises to be a very crowded place in the near future, and one in which our high tariff will not be a welcome passport. This means also the full evaluation of such economic theories as high wages and consequent high purchasing power. Our own people now purchase 90 per cent. of our products, it is said. Can this ratio be maintained if new methods greatly increase production? New inventions of economic value must be found, which, like the automobile, the radio, etc., will absorb the surplus labor and the increase in population. No such inventions are at present on the horizon, but no one knows what the day may bring forth. Industry individually and collectively must plan a program years in advance and thus endeavor to reduce the periods of feverish activity and corresponding periods of depression. Much thought is even now being given to this problem by forward-looking industrialists and economists in the hope that the business cycle can be controlled. Manufacturing must be freed from the incubus of speculation. Its inherent troubles are great enough without being thrown out of balance periodically by spasms in the stock market. It is inevitable, I believe, that we shall come to a shorter working week. There is nothing new or startling in this idea. Not many years ago the working day in most fac-

tories was twelve hours long for six days in the week, or 72 hours for the week. This working period has fallen steadily to approximately 44 hours a week of eight working hours a day. How much shorter the working week may be, time and technical developments alone will determine. And, lastly, management must provide a greater degree of security for the worker against unemployment and indigence in old age, the two calamities most dreaded by the worker. In such a program the effect of new technological processes in effecting unemployment must be studied in advance of their application. It may well be that we shall see legislation making it obligatory upon the part of ownership to provide some means of escape for displaced workers, though a happier solution would be a humanitarian interest in this problem on the part of the employing class that will minimize this difficulty by allowing longer period of readjustment and such provision for the transfer of displaced workers as may be possible. Unless some such program as this can be put into effect, an acceleration of our industrial machinery will make life unbearable for a large part of our population.

Personally, I am not convinced that the rate of progress during the next thirty years will be as rapid as during the last thirty. Scientific progress we shall surely see, and this is sure to be reflected in our industrial methods. But there are reasons, also, for believing that retarding factors are already at work. The most important of these is the old law of diminishing returns that so far has never failed to put in an appearance where economic progress has been active. Only a few of the more easily recognized indications of the working of this principle can be given here.

Consider first the transmission of intelligence by the telegraph and the telephone, which probably have accelerated the pace of modern industry as much as or more than any other factors. It is not conceivable that this quickening effect can be greatly increased. The solution of this problem is practically perfected. Since 1880 the time required to cross the continent by rail has been reduced from eight days to less than four. It is not conceivable that the next fifty years will witness anything like a proportionate reduction in rail time, and flying is still to be fully developed. Again in 1880 steamships were crossing the Atlantic in about eight days. The new giant liners now under construction are expected to make the passage in four days. Again it is not conceivable that this time will be reduced to two days in the next fifty years. The new methods of industrial management have accelerated industry and much more can be done in that field, but its limitations have already been evaluated by thoughtful observers. It is a well-known fact that in all engineering it is becoming progressively difficult to increase the efficiency of operation of power plants and machinery, in general.

Lastly, and most important of all, there are good reasons for believing that there are economic limitations to the growth in the size of manufacturing enterprises and consequently to the efficiency of mass production itself. Indeed, if the facts were known, it probably would be found that many modern industrial enterprises have already passed the point of greatest efficiency and greatest economic returns. The value of the industrial product per worker in this country in 1900 was about $1,600, while in 1919 (the last census in which such data are available) this ratio had risen to $7,500. Making due allowance for the changed value of the dollar, this is a great gain in production per worker. But *the ratio of the value of products to the capital invested has decreased* steadily for a number of years. In 1850 this ratio was close to 2, but it has fallen progressively until in 1919 it was only 1.39. This would appear to indicate that even if the number of workers were materially reduced in favor of more refined machinery the cost of production will eventually rise with increased complexity of mechanisms. This is already foreshadowed in some industries where the fully automatic machine as yet is not so economical as the semi-automatic operated by a skilled worker. Barring some new and eruptive change like the industrial revolution there is little likelihood of startling changes in the immediate future.

Finally, whether industrial progress be slow or rapid, these new methods are here to stay and their deeper significance should not be forgotten. Through them there is held out a hope that as we have achieved political and religious freedom, so we may also achieve economic freedom, freedom from physical drudgery and an opportunity for all men to live like men and not like beasts of the field, as the majority of our ancestors have done. But this will be no easy task, for it involves many changes in our ideas of economics and government. It involves the discarding of some economic ideas and taboos of Adam Smith and others who viewed industry as handicraft and the worker as a self-sufficient economic unit. And it also involves a realization on the part of ownership that it can no longer absolve itself from the responsibility of either controlling the business cycle or making the effort to provide continuous dividends to industry as it now does to insure continuous returns to capital. We can not continue with the present uncertain methods faced with even moderate technological progress.

Make no mistake in this matter. If we shall achieve a semblance of economic freedom for all men, a high

standard of life, security and delight in work, and leisure, it will be through much trouble and opposition, such as men have always encountered in winning political and religious freedom. There is an opportunity to attain this economic freedom in the United States by peaceful means, and this problem offers a challenge to business men, economists and engineers such as no similar group has ever had. Will they have the vision, courage and intelligent statesmanship to accept this challenge?

PREVENTION OF POLIOMYELITIS[1]

By Dr. SIMON FLEXNER

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THE evidence presented on the mode of infection in poliomyelitis has established two important facts: First, that the disease is a particular form of infection of the upper respiratory tract; and second, that in harmony with other epidemic diseases of respiratory origin, the cases arising during an epidemic cover a wide latitude in degree of symptoms and pathological effects. There is consensus of opinion among clinicians that the number of children suffering some degree of infection, the slight cases expressing themselves as minor illnesses only, is very large, being in comparison with the number that are frankly paralyzed many times as great. The wide occurrence of the slighter forms of infection can be taken as a means, favorable in character, of delimiting the prevalence of the severer affection, since early experimental observations showed Lewis and myself[2] that any degree of actual infection, irrespective of whether muscular paralysis arose or not, protected the inoculated monkeys from the effects of a second administration of the virus.

Hence the investigation of the immunological phenomena in poliomyelitis became at once a rewarding field of experiment. The knowledge of the phenomena has become considerable during the twenty-year period of the experimental study of the disease, and the application of this knowledge to the prevention of epidemic poliomyelitis has met with encouraging results in the severe outbreaks occurring in New York State in 1931 and in Pennsylvania in 1932. I shall endeavor to guide you quickly through the main discoveries which have led to the practical achievements to be described. It is, however, necessary at the outset to explain that I have taken the lecturer's privilege of including in this statement certain later results bearing out the earlier ones presented, which were obviously not available when the lecture was delivered. It is sometimes advantageous to defer writing a lecture until the time of publication arrives, especially when, as in this instance, a new method has been under trial. During the intervening period, the method may have been given a wider test, with results sometimes favorable, and of course sometimes unfavorable to its employment. We appear in this instance to be in the happier situation, and while it is still too early to pass final judgment on available means of preventing poliomyelitis in the young during the prevalence of an epidemic, it is desirable that the nature of such means shall become widely known, since epidemic poliomyelitis continues to appear annually in some parts of America and Europe during the summer and autumn season.

The observation of Lewis and myself, already referred to, that monkeys which had recovered from an attack—irrespective of its severity—of experimentally induced poliomyelitis were not subject to reinfection, led quickly to the testing of the blood of recovered monkeys and human beings for immune substances to which the protection might be attributable.[3] Tests made almost simultaneously in France, Germany and the United States disclosed the existence in the blood, after recovery from the disease, of neutralizing, antiviral bodies. A mixture consisting of the virus of poliomyelitis and the serum of the blood was injected into monkeys. No symptoms of disease tended to arise from this injection; while mixtures of virus and normal monkey serum, or the serum of many, but not all persons not known to have had poliomyelitis, proved incapable of protecting the animals against the onset of the symptoms, including paralysis, characteristic of the experimental disease. I shall return a little later to a consideration of the circumstances under which the blood of supposedly normal individuals acts in a measure similar to that of persons known to have had paralytic poliomyelitis, since this action has come to have such pregnant meaning.

Let me repeat, the blood of normal monkeys invariably failed to act upon or neutralize the virus of

[1] Abstracted from the John M. Anders Lecture on Poliomyelitis delivered at the College of Physicians, Philadelphia, January 6, 1932.

[2] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 45, 1910; *Jour. Exp. Med.*, xii, 227, 1910.

[3] P. H. Römer and K. Joseph, *Münch. med. Woch.*, lvii, 568, 1910; C. Levaditi and K. Landsteiner, *Compt. rend. Soc. biol.*, lxviii, 311, 1910; S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 1780, 1910; A. Netter and C. Levaditi, *Presse méd.*, xviii, 268, 1910.