I.

Economic literature is replete with controversies. So far as the central problems of economics are concerned, it may almost be said, quot homines, tot opiniones; and many of the minor problems are treated with a most appalling diversity in method and in point of view. Yet there is one small field that is practically unravaged by controversial warfare. With but few exceptions¹ economists are agreed that the ultimate effect of labor saving is invariably to increase the real income of the working classes. Whatever differences of view-point exist concern themselves chiefly with the relative emphasis laid upon the immediate loss to the laborers whose functions this form of progress renders obsolete.

Moreover, an examination of the arguments advanced in support of the prevailing view reveals a surprising uniformity. Attention is called to the fact that the cheapening of products, which normally attends the introduction of an improvement in the technique of production, represents a virtual increase in the incomes of all classes, in-

1 Among these may be mentioned Mill, Principles of Political Economy (Book I. chap., vi); Ross, Proceedings of the American Economic Association, Fifteenth Annual Meeting (pp. 151, 152); and, perhaps, Carver (Ibid, pp. 149, 150). Mill's argument rests upon a juggling of the concepts "fixed" and "circulating" capital, and their respective relations to the wage-fund, and is in so far quite out of harmony with modern thought. In Ross's view the effect of the introduction of machinery is analogous with that of the introduction of an exceptionally efficient body of alaves. From the published reports of the Proceedings of the Economic Association it would be difficult to discover the grounds on which Professor Carver based his view that it is not certain that labor-saving inventions invariably benefit the laborer; but, from his method of reasoning in an earlier address (Proceedings of the American Economic Association, Fourteenth Annual Meeting, pp. 183-198) it would appear that his position is not essentially different from that defended in this paper.

cluding the laborers; and emphasis is laid upon the development of the demand for the cheapened product. which may, in the end, result in a great increase in the employment offered by the industry affected by the change. The printing trade is often cited as an example of an industry in which labor saving has actually increased employment, and the business of transportation illustrates the same principle very well. The theoretical argument is often bolstered up by an appeal to economic history or to its allied branch, comparative inductive economics. The nineteenth century, pre-eminently the age of mechanical progress, witnessed an unparalleled improvement in the position of the working classes, and this in spite of an extraordinary increase in the population of the Western world. Again, those nations in which labor-saving machinery has been most extensively employed, as the United States and England, are the nations in which wages are highest and conditions of labor most satisfactory.

These are strong arguments, apparently. They are as conclusive as the arguments advanced in defence of some of the most unquestioned political and economic tenets. And yet, if we subject them to rigid analysis, we shall find that they are far from adequate. In the theoretical argument no attempt is made to discover the relative importance of opposing forces which enter into the problem. The cheapening of commodities does, indeed, have a tendency to increase all "real" incomes; but, if labor is displaced from one industry, it enters into competition with labor in other industries, and in so far tends to lower wages. The net effect upon the welfare of the working class can be ascertained only after a weighing of the opposing tendencies. This holds true, of course, only of those cases in which labor is actually displaced. But, if the industry in question develops to such a degree as to employ more laborers than formerly, such development may, nevertheless, be at the cost of some other industry which supplies a similar want. A reduction in the labor cost of artificial stone might greatly increase the demand for that material, and increase the number of workmen employed in its manufacture; but it would be unsafe to argue that a net increase in employment has taken place without first ascertaining how many quarrymen and brickmakers had been displaced.

Nor is the historical argument more conclusive. Economic history reveals numerous forces operating contemporaneously, but it has not succeeded in isolating any one and in imputing to it its just share in the joint result. The condition of labor has, no doubt, improved; but the causes of the improvement are still in dispute. One share in the result, however, must be ascribed to the vast increase in the available area of cultivable land.¹ Another important share is due to the unprecedented increase in capital. Popular education, by increasing the efficiency of labor and by strengthening its bargaining power, doubtless contributed some part of the total result. Trade unionism, many would maintain, has not been wholly without effect. When these and other factors are considered, it appears that history does not tell us how much labor owes to the labor-saving device. And, granting that a definite share in the sum could be traced to labor saving, we are still far from proof that all labor saving, under all conditions, tends to increase wages. We may even admit that most of those forces which dispute with labor saving the honor of having made tolerable the lot of the workingman would themselves have been inconceivable without the advance in labor-saving methods. The extension of cultivation, for example, was doubtless conditioned largely by labor-saving inventions in the iron industry. The progress of popular education may be ascribed in part, at least, to the vast increase in social wealth which resulted

1Cf. Ross, loc. cit., p. 151.

from technical progress. But most of these indirect effects of labor saving are dependent upon conditions which may disappear with the progress of society. Unoccupied lands are even now ceasing to be a significant factor in economic life. There is a natural limit to the advantages to labor as a whole which may be secured through trade unionism. From the purely economic point of view, popular education is probably subject to a law of diminishing returns. One who wishes to discover a universal defence for labor saving will hardly be content with an argument which rests upon the effects of secondary influences of a transitory nature. It is perhaps worth while to prove that the labor saving of the past has been beneficent; but we are chiefly concerned with the labor saving of the future.

Nor can a clear light upon this problem be gained from a study of the relative position of labor in countries which differ in respect to technical development. In the first place, the disparity in other conditions is usually so great that it would be extremely difficult to isolate the influence of technical progress. And, secondly, it is a familiar fact that the development of industry in one country may bring about the decay of similar industries in other countries. It is frequently asserted that one of the effects of the growth of the cotton industry in England was the decline of the ancient and prosperous cotton industry of some of the towns and villages of British India. Accordingly, if it be granted that the lot of the British workman was improved by the epoch-making inventions in the textile industries, it still remains necessary to set against that improvement the deterioration of the condition of the Hindu craftsman, if we are to attain any valid conclusion as to the net effect upon the world's working classes.

A complete study of labor-saving devices would certainly not ignore important effects merely because they depend upon conditions which do not possess even the

proximate universality posited of the main characteristics of the existing system. Nor would it ignore influences that affect the international balance of economic power. But the more fundamental problem in the theory of labor-saving inventions concerns the direct effects of such inventions upon world labor, since such effects may be said to be as universal as the competitive order. This problem alone will be considered in the present paper. Moreover, since the problem at best is a complicated one, it will be necessary to narrow the inquiry wherever possible, by excluding the elements of friction which everywhere modify the operation of competitive laws.¹ It. will be assumed that labor-saving devices are promptly adopted throughout the industries affected, and hence that no appreciable element of pure profit arises in consequence of them. A high degree of mobility of labor and of capital will be assumed; and, for convenience, it will be assumed that labor and capital displaced make their way immediately to the economic margin.

II.

It is obvious that no study of this nature can be fruitful unless it is based upon a consistent theory of distribution in its static aspects. For the purposes of the present discussion the essential soundness of the marginal productivity theory of distribution, as it is developed by Professor Clark in his *Distribution of Wealth*, will be assumed. It will be assumed that determinate parts of the current product of society, whether viewed as physical product or as value product, are imputable to the various factors in production, and that those parts form the normal incomes of the respective factors. It will

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¹A alight degree of friction will be assumed, since otherwise no motive for the readjustment of labor and capital would exist.

also be assumed that a universal law of diminishing returns is in operation,—that, with no independent change in the organization of the factors of production, an increase, actual or virtual, in one, unaccompanied by a parallel increase in the complementary factors, has a tendency to lower the productivity of the variable factor, and to increase the productivity of the factors that remain constant in quantity.

The term "labor-saving device" will be used to designate any technical improvement which lessens the absolute expenditure of labor per unit of physical product. As it is often the case that a labor-saving invention changes not only the quantity, but also the quality of the labor used in the production of a commodity, it is necessary for us to conceive of labor as measured in units of like potential efficiency. If the new process requires labor of a lower order than was formerly required, we must, in theory, reduce the new labor to terms of the labor formerly employed. We need also a unit of value with which to measure changes in productivity. Here we meet with a serious difficulty; for, if by value we mean general purchasing power, it is obvious that an improvement in technique will change in some degree the value of any commodity or group of commodities which we may select as a measure. Accordingly, the best that can be done is to be on our guard against any variation in the value unit, and to employ such devices as may keep it from vitiating our results.

Economists have long recognized that there are certain salient characteristics that differentiate one invention from another, from a purely economic point of view. An improvement in technique may result in an increased capital cost¹ per unit of physical product at the same time

¹By "capital cost" I mean a gross sum covering the replacement of goods destroyed or depreciated in value, together with a normal return on the capital for the period in which it is used in producing a unit of commodity.

that it diminishes labor cost; that is, it may involve the substitution of capital for labor. On the other hand, capital cost may remain unchanged, or it may diminish *pari passu* with labor cost. Secondly, an improvement in technique, through the resultant cheapening of product, may so increase demand that the total value product of the industry will be increased; that is, labor-saving may be product-multiplying. The value product may, however, remain stationary, or it may even be decreased. In the third place, the improvement may affect some commodity which is primarily an object of consumption of the working class. It may affect, however, a commodity entering equally into the consumption of all classes, or into that of the well-to-do, say the capitalists, alone.¹

Without taking into account other possible differentiating characteristics,² it is evident that the above will serve as a basis for numerous types, each of which deserves special study. The economic quality of any concrete invention will be determined by a combination of three elements of greater or less purity, each one representing one of the three above series. Invention A, a labor-saving device, may so change the character of an industry as to increase the capital cost per unit of product; the resulting increase in demand may, nevertheless, be so

21	Wemay	rep	resent th	ue ab	ove fa	ta by th	e following table:
la	capital (oost	per unit	tof	physics	I produc	t increased.
Ib	**	••	** **	••	••	**	stationary.
Ic	••	"	** **	••	••	••	diminished.
Ila	total va	hae	product	of iz	dustry	increas	ed.
ΠЬ	**	••	**	"	••	station	ry.
IIc	••	**	**	44	••	diminie	hed.
Шa	product of industry consumed					wholly	by laborers.
пь	••	••	••	••		by labo	erers and capitalists alike.
lllc	44	**	**	••		wholly	by capitalists.

²One which will readily occur to the reader is exemplified by the introduction of agricultural machinery in a region which is already thoroughly cultivated. The gross product of the land may be diminished instead of increased. Hence the price of the product may well be increased rather than diminished, the ultimate effect being an increase in rent.

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great as to attract labor into the industry instead of expelling it. The product may be one which workingmen alone consume. Invention B may leave the capital cost per unit unchanged; it may result in a very slight increase in demand, and hence in the expulsion of labor; the product may be consumed almost exclusively by capitalists.¹

Since, then, labor-saving devices may vary so widely in their economic characteristics, it appears to be unscientific to group them together when it is our aim to discover their economic effects. Such a method of procedure may prove almost anything. Rather we should construct theoretical types possessing clearly defined characteristics which represent the various possible economic relations, and study the possible effects of each of these types. We may then arrive at practical conclusions by comparing our types with the labor-saving devices with which practical industry has made us familiar.

III.

For our first type we may be permitted to select the one which seems to present the least number of theoretical difficulties; that is, the one in which the smallest number of changes is involved. We shall assume that an improvement in industry A lowers labor cost per unit of physical product, but leaves capital cost unchanged.³

¹Employing the symbols of the table of the preceding page, an invention may represent a combination of I*a*, II*a*, III*a*; another I*b*, II*c*, II*c*, etc.

² In this and the following types all elements of cost other than labor and capital cost will be ignored. Since we are dealing here with a problem in dynamics, it is clear that by ignoring the distinction between land and reproducible capital goods, or by abstracting from the share imputable to land, all our conclusions are somewhat vitiated. But to consider the effect of a labor-saving davice upon two factors, labor and artificial capital, is a sufficiently complicated study. And, further, the introduction of the third factor would, in most cases, only emphasize the conclusions here reached. So far as the writer's study has gone in this direcclusion reached would be subverted. We shall assume, further, that the demand for the commodity produced is just elastic enough to maintain the total value product of the industry unchanged. Finally, we shall assume that the commodity is consumed by capitalists only.

From the assumptions that capital cost per physical unit of commodity remains unchanged, and that the total number of such units increases, it follows that capital must be drawn into the industry. Consequently, in all branches of production from which this capital is withdrawn,-and, if we assume perfect fluidity of capital, this would be in all industries whatsoever,-the physical productivity of capital will increase and that of labor will diminish. In industries B and C and D a greater share of the products b, c, and d will be imputable to each unit of capital, and a smaller share to each unit of labor. Again, from the assumption that the total value product of industry A remains unchanged, and that a greater share of that product is imputable to capital, it follows that some labor must be expelled from the industry. This labor, seeking employment in all other industries, must lower, in those industries, the productivity of labor and increase that of capital. Two forces, then, are operating to diminish the productivity of labor. Two forces tend to increase that of capital. A day's labor will produce less wheat or iron or cotton cloth after the change has taken place than it produced before. And, since there is no ground for assuming that the exchange ratios of commodities other than the product of A have changed, we may safely say that a day's labor in wheat production commands less of every product, except that of A, than before. Now the product of A, by our third assumption, enters into the consumption of capitalists alone. The laborer's increased command over that product is of no importance to him. He has lost in his power

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to command the necessaries and comforts of life; but he has gained, say, in his power to command racing auto-mobiles!¹

Passing now to a second type, we shall assume as before that capital cost per unit of physical product and total value product remain constant, but that the commodity produced enters exclusively into the consumption of laborers. As in the case just treated, a unit of labor produces less in all industries, except the one under consideration. than it did before the change in technique. As before, the laborer's power to command all other commodities diminishes. But this loss is offset by his increased power to command the products of the industry affected by the change,-industry B we shall call it. Now can we prove that the loss is counterbalanced, or more than counterbalanced, by the gain? The problem is difficult, at any rate for one who is unable to employ mathematical methods of analysis; but, as will appear later, it is fundamental to the study.

In discussing the productivity theory of distribution, it is usually most convenient to regard the original incomes of the factors as values. Thus a certain part of the value of the output of a cotton-mill is imputable to each laborer, another part to each unit of capital. But sometimes it is better to go a step farther back and treat, as the primary incomes, the commodities produced. The first form in which a cotton operative's wages appear is that of a certain number of yards of cot-

¹It is admitted that this type would be hard to discover in practical life. Professor Clark has pointed out to the writer that any such improvement, though at first affecting only those products which are consumed by the rich, will soon find application in the production of commodities consumed by rich and poor alike. The justice of the criticism is obvious. It remains true, however, that a labor-saving device, so far as its tendency is to cheapen goods consumed by the wealthier classes, may tend to degrade the position of labor.

If we single out a special class of laborers—e.g., the unskilled—it would not be difficult to conceive of types of labor-saving inventions which degrade the position of that class. ton cloth. From this point of view the primary wages of all labor consist in a heterogeneous mass of commodities, some adapted for the exclusive consumption of laborers, some for that of capitalists, some neutral, so to speak. A similar mass composes the primary income of capital. The transformation of primary commodity incomes into money incomes, and, finally, into "real" incomes, may be regarded as the result of a series of exchanges among laborers, among capitalists, and between the two classes. In the hypothetical industry B, which produces a commodity adapted for the consumption of laborers alone, the share imputable to capital is secured by labor through the surrender of an equal value of capitalist or neutral commodities primarily imputable to labor in other industries.

Now let us say that before the improvement took place the total value product of the industry was 4x, of which x was imputable to capital, 3x to labor. Labor, as a whole, then, had to surrender to capital a quantity of other goods, imputable to labor, of the value of x, in order to secure the product of capital in industry B. After the improvement, according to hypothesis, the value product of the industry remains 4x; but a greater part is imputable to capital, a less to labor. We shall assume that the proportions are reversed, x now being imputable to labor, 3x to capital. To secure the product of capital, labor, as a whole, will now have to surrender 3x in value of the products of other industries; that is, 2x more than formerly.

While the productivity of each unit of labor in other industries has declined, as we saw above, the number of such units has increased through the displacement of labor from B. There is, then, the product of some additional units of labor to set against the decline in the product of each unit of the whole working force, before we

can say whether the aggregate of commodities in the hands of laborers, exclusive of the product of B, has diminished or increased. All depends, obviously, on the shape of the curve of diminishing productivity of labor. If that curve is very elastic (and experience would indicate that it is), the aggregate product of labor may be increased considerably. The labor displaced from industry B had produced in that industry a value equal to 2x. It cannot continue to produce that amount at the margin of industry, for this would be the negation of the law of diminishing productivity. But it may produce enough to increase the aggregate product of labor by x or x+. Assuming an increase of x, that quantity of value may be regarded as a partial offset to the 2x of commodities which, we saw, labor is now required to surrender to capital, over and above what it formerly surrendered, to secure the product of capital in B. There would then remain a quantity of the products of other industries equal in value to x, to be surrendered by labor, which constitutes a net loss in value incurred by labor as a consequence of the change. But the product of B, although still representing 4x in value, represents a great increase in units of commodity; in the present case, a threefold increase.¹ Now it is not at all improbable that, although labor has lost outright a quantity of other commodifies equal in value to x, the threefold increase in the physical content of another part of its income, representing 4x in value, gives more than ample compensation. Labor has lost, say, \$10,000 worth of wheat, etc., receiving no compensation in the form of value income. But the \$40,000 it spends on working jackets now buys three times as many as before. True, the sat-

¹ It was assumed that capital cost remained constant per unit of physical product, and that the proportions of labor cost to capital cost changed from 3:1 to 1:3. That is, before the change the cost of a unit of product was a + 3a; after the change it becomes $a + \frac{1}{2}a$.

isfaction derived from each is lessened, but probably not in such degree that the additional number of them does not more than compensate the loss in wheat.

The objection will arise: Why assume that the product of industries other than B has been increased to the extent x through the labor displaced in B? Why not assume that the net increase in product is 0, or -x? For the assumption I have made there is no defence in pure reason. If there is any defence at all, it must lie in our knowledge of the actual shape of the curve of diminishing productivity; and that, it must be admitted, is hazy. Yet the assumption that an additional unit of labor increases the aggregate product of labor by only one-half the product of the unit which was formerly marginal would seem to be sufficiently conservative. But even if the total product of labor in industry, exclusive of B, remains unchanged, it would still be not improbable that labor had gained through the multiplication of the products of B.

Again, it may be asked, why assume so great a reduction in labor cost? If it be assumed that the reduction is less, it follows that the displacement of labor is less, and hence that the loss in productivity in outside industry is less. Any gain that labor may receive through the reduction in labor cost will be diminished as the real saving of labor is diminished; but there is no reason why it should disappear. Conversely, the more pronounced the saving of labor, the more important the gain to labor.

We may now construct a third type to illustrate the effect of a labor-saving device in an industry which produces a commodity entering equally into the consumption of laborers and of capitalists. As before, we shall assume that the value product of the industry—industry C, we shall call it—is 4x before as well as after the change in technique. Of this, as in the preceding type, we shall assume that 3x is imputable to labor before the change,

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x after it. Before the change took place, since capitalists consumed one-half the product, or 2x, they must have surrendered to labor commodities equal in value to x, to secure part of the product of C primarily belonging to labor. After the change, conditions are reversed. Labor is compelled to surrender x in value of other commodities to capital, if it is to continue consuming 2x of the product of C. Assuming, as before, that a net increase of x takes place in labor's product of other commodities, the value loss to all labor is measured by the withdrawal of the xof other commodities formerly surrendered by capital. As an offset, the 2x of the product of C consumed by labor has increased in its number of physical units of commodity. And this commodity gain is obviously just half the gain which appeared in the preceding type, although the value loss to labor is exactly the same. Not improbably the gain exceeds the loss, as measured in total well-being. But there is far less reason to affirm this than in the case of industry B above.

Putting together the results of our study of these three types, we may say that, when the value product and the capital cost per unit of product remain constant through the change, labor-saving means a net loss to labor when the product is one which enters entirely into the consumption of non-laborers, and most probably a decided gain when the product is exclusively adapted to the consumption of labor. There will be a point somewhere between these extremes where the loss and the gain neutralize each other. Where this will be, it is impossible to say. Our third type indicates that, when the consumption is equally distributed, labor may very probably gain. The two controlling factors are the curves of diminishing productivity of labor and of diminishing utility. If these are very gradual in their descent, the possibilities of gain to labor are great.

In comparing these types with real conditions, it is obvious that a practical invention is most likely to occur in an industry lying somewhere between B and C. The demand for vast masses of commodities—the great stimulus to invention—is possible only in the case of those industries which supply the needs of the laborer and the small capitalist. So far as this part of our study is concerned, it seems safe to regard the practical labor-saving device as beneficial to labor.

IV.

We may now extend our study by discarding the assumption that capital cost per unit of physical product remains constant. The assumption is retained, however, that the total value product remains unchanged. Assume, first, that capital cost per unit of physical product diminishes. If capital cost and labor cost diminish in the same proportion, neither will be expelled. The same proportions of the total value product of the industry will be imputable to each. If labor produced 3x before, capital x, the same condition persists through the change. If, then, the product enters exclusively into the consumption of capitalists, labor gains not a whit, but loses no more. If the product is exclusively a laborer's ware, labor gains all. capital nothing. For, as before, the only use to which capitalists can put the x value imputable to capital is to secure other products through exchange. x remains the product of capital, and commands no greater quantity of other products than before.

If the saving of capital is more pronounced than the saving of labor, capital is expelled, labor drawn into the industry. The whole argument of our first type may then be employed, *mutatis mutandis*, to show that labor gains in every case, capital in every case losing in total value product and only in some cases securing compensation through increased commodity income. If, on the other hand, the saving of capital is less pronounced than that of labor, while labor stands to lose in case the product is consumed by capitalists alone, it loses less than in type A, since less labor is expelled from the industry affected by the change, less capital attracted to it, than in the case of type A. Capital saving, attending labor saving, manifestly tends to extend the range within which labor saving is beneficial to labor; and the greater the degree of capital saving, the wider that range.¹

But, if we assume that the diminution in labor cost is attended by an increase in capital cost, it is obvious that the result will be quite different. Labor was expelled, capital attracted, when capital cost per unit of physical product remained constant. If we assume that capital cost increases, it follows that both expulsion and attraction are accentuated. Where labor lost little before, it now loses much. Where it gained considerably before, it now may gain nothing: its greatest gains may be reduced to little, if the increase in capital cost be great. Increase in capital cost, attended by decrease in labor cost, narrows the range within which labor may gain through labor saving. The greater the increase in capital cost, the less the possibilities of gain to labor; and it is not difficult to conceive a labor-saving device which may wreak injury upon labor, though cheapening the products which laborers consume.

And here it is pertinent to compare reality with our fictitious constructions. Which type of invention are we

¹Capital-saving devices, though comparatively neglected in economic literature, are probably not less frequent or important than laborsaving devices. Simplification of machinery, cheapening of machinery through improvements in the technique of their manufacture, are processes taking place everywhere. In a complete discussion of the effect of technical progress upon wages this influence should receive detailed consideration; but it enters only incidentally into the present Problem.

more likely to find,—the one which lessens the capital cost per unit of physical product, at the same time reducing labor cost, or the one which increases capital cost? The writer, at any rate, would find it far easier to cite instances of the latter kind.

V.

The reader, no doubt, has found difficulty in suppressing his impatience while perusing the foregoing pages. It has been assumed consistently that value product has remained constant; but is it not an almost universal law that labor saving is product multiplying? I fancy that most defenders of labor saving are ready to rest their case with a study of the results of product multiplication; and by this, it will be generally agreed, is meant the increase in value product as well as in physical product. Accordingly, we may proceed to an examination of the results of product multiplication.

In order to simplify the problem as much as possible, I shall assume that industry A of the preceding discussion, after a period of time in which the value product remained the same as before the improvement in technique took place, undergoes a sudden development, the value product increasing many-fold. We may then consider how far this development of the industry repairs the injury to labor wrought by the original change. It is assumed as before that the capital cost per unit of physical product remains unchanged, the labor cost alone decreasing.

Under these conditions some of the labor at first expelled is drawn back into the industry. Quite conceivably the amount attracted into the industry exceeds that originally displaced; and this withdrawal of labor from other industries tends to increase the productivity of labor in those industries. But the expansion of the industry we are studying requires the withdrawal of capital also from other

industries,—a force which tends to reduce the productivity of labor. Quite manifestly our problem requires a weighing of the two tendencies. Otherwise we have no right to affirm anything at all as to the beneficence of multiplication of product.

According to our assumption that, after the improvement, capital cost per unit exceeds labor cost, it follows that the expansion of the industry attracts more units of capital than of labor. While, however, it may be affirmed that the withdrawal of a unit of labor from the margin tends to increase the productivity of labor, and that the withdrawal of a unit of capital tends to lower it, we have no right to assume that the withdrawal of one unit of each leaves the productivity of labor unchanged. If labor and capital are at present combined in the average proportions of one unit to ten, it would be very unlikely that the withdrawal of one unit of capital would diminish the productivity of labor in the same degree that the withdrawal of one unit of labor would augment it.

We may, however, assume that there is some quantity of capital the withdrawal of which will diminish the product of labor in the same degree that the withdrawal of a unit of labor will increase it. Call that quantity q. If labor and capital are combined in industry A in the proportions of one unit of labor to q units of capital (after the invention has taken place), the expansion of the industry will be of no positive advantage to labor, though of no disadvantage. For the gain to labor in other industries from attraction of labor into A will be exactly counterbalanced by the loss from attraction of capital into that industry. The social gain from an increased consumption of the products of A means nothing to the laborer, since, it is assumed, the product is designed for capitalist consumption. If, however, labor and capital are combined in the proportions of one unit of labor to one-half q units

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of capital, labor will gain more from the attraction of labor to A than it loses from the attraction of capital. Product multiplication, in this case, tends to undo the injury of the original change; and the greater the degree of multiplication, the greater the probability that the initial loss to labor will be transformed into a positive gain. Conversely, if labor is combined with capital in the proportions of one unit of labor to 2q units of capital, expansion of the industry only emphasizes the mischief originally wrought by the improvement in technique.

Next we may assume that industry B of the earlier discussion undergoes expansion. As we left that industry after the improvement in technique, one unit of labor was combined with three of capital. Expansion of the industry would attract, then, one unit of labor for every three of capital. Let this proportion represent one unit of labor to a units of capital. So far as labor in industries other than B is concerned, the expansion of industry B would have no effect on the productivity of each unit. A day's labor would command as much of every article other than the product of B as it did before. It would command, also, the same amount of B as before the expansion. But the expansion implies that labor parts with a greater quantity of the product of other industries, in which no improvement has taken place, for a correspondingly greater amount of the product of B in which such improvement has taken place. Quite probably, then, the material commodities consumed by labor and the real welfare of labor have increased.

If we assume, however, that the proportion of one unit of labor to three of capital represents one to 2q, conditions change. When capital and labor are drawn into the industry in these proportions, the withdrawal of capital from the remaining field reduces productivity more than the withdrawal of labor increases it. Under such conditions the expansion of the industry reduces the command of labor over all articles except the product of B. Nor is the command over B increased, although, as before, expansion means a larger consumption of that product, and may mean a gain in material welfare to the laborer. The net gain, however, is manifestly less than in the preceding case. And, if the expanding industry combines labor and capital in the proportions of, say, one unit of labor to 10qunits of capital, the effect on labor may well be disastrous.

Obviously, the study of the expansion of an industry under the influence of invention is merely one part of the general study of the expansion of special industries in its effect on the welfare of society and its classes; and this study must be treated under the dynamics of consump-tion. When an industry expands, it must be because of such a change in wants as will make the product of a unit of capital or of labor in the expanding industry represent a greater value than a like unit in some other industry. It is not difficult to conceive of cases in which the development of an industry may injure one of the factors, however, though such development must almost necessarily increase total human welfare. If the total quantity of labor and capital remain constant, a great increase in the demand for hand-made lace, for example, would draw labor away from other industries, while leaving capital practically unchanged in those industries. Accordingly, the physical productivity of labor would increase everywhere. That of capital would diminish in every industry except, perhaps, in that of lace-making. Capitalists would, of course, receive partial, or perhaps complete, compensa-tion through increased consumption of lace. If the commodity had been one not consumed by capitalists, there would have been no compensation for the capitalist. Sim-ilarly, we can conceive of an industry in which expansion lowers the product of labor in general industry without

offering any recompense in the form of increased production of commodities adapted for laborers' consumption.

Returning now to the main subject, and resuming the re ults of this part of the inquiry, it appears that the advantage to labor of product multiplying is by no means certain and universal. Whether advantages shall arise or not depends on the kind of product affected by the expansion, and still more upon the combining proportions of labor and capital in the expanding industry. The former consideration has already been sufficiently exploited. What we are here interested in is the question whether a practical invention will be most likely to cause an expansion resulting in the withdrawal of labor and capital from outside industry in the proportions of one to q, one to q—, or one to q—. And, to answer this, we must first consider whether q can be given definite significance.

A little reflection will show that the proportion one to q is something very near the average in which labor and capital are combined in all industries. To withdraw labor and capital from outside industries in such a way as to leave the relative values of the products of those industries unchanged, a certain amount will have to be withdrawn from each industry. If the amounts of labor and capital taken from each industry are taken in such proportions as accord with the general combining proportions in that industry, the productivity of the remaining units of each agent remains unchanged. From some industries one unit of labor will be withdrawn together with one of capital; from others one of labor, together with ten of capital; and the regrouping in the expanding industry will combine the factors in about the average proportions of all industries.

Then, to understand the effect of the expansion of an industry, we have first to consider whether the industry is one in which the proportion of labor to capital is superior or inferior to the average proportions throughout society. Practical labor-saving devices take place most frequently in the industries that are already highly capitalistic, and the expansion that follows the introduction of such devices is in effect the expansion of an industry more than ordinarily capitalistic. So far, then, the tendency of practical product multiplication would appear to be to lower the productivity of labor in outside industries. At the same time, however, since the products thus multiplied are most likely to be such as enter into the consumption of the laborer, a certain amount of compensation is afforded through the increased consumption of such products. The degree of adequacy or inadequacy of such compensation will vary with specific cases.

In all the preceding discussion the effect of substitution has been ignored. The cheapening of the product of one industry may lead to its substitution for the product of some other industry. If the value product of the industry affected by the change is not increased, and productive agency, consequently, is not drawn into that industry, the labor and capital that may be driven from some other industry by the substitution of the cheapened product must find employment on the economic margin. If the proportions in which the expelled units of labor and capital were originally combined were about the average proportions, the productivity of units of labor and capital in general industry will not be affected. If the proportions, on the other hand, were one to q— or one to q+, this secondary effect of an invention may have a decided influence in determining the net effect of the improvement in technique upon labor. The same principle will explain the effect of the substitution of the products of an expanding industry for other products.

The result of our study may now be summed up as

follows: There is no logical basis for the view that every labor-saving invention must necessarily benefit the laborer in the long run. Most practical inventions probably do, owing to the fact that most inventions cheapen products largely consumed by labor. Secondly, there is no logical basis for the view that product multiplication must necessarily repair damage that may be caused by the original displacement of labor. The beneficence or maleficence of product multiplication turns upon the combining proportions of capital and labor in the industry concerned.

VI.

But these conclusions are based upon the assumption that the total amounts of labor and capital remain unchanged,—an assumption similar to that on which the ancient argument for free trade, now so widely discredited, was based. I have assumed that, when more capital is needed in an industry, it is drawn from other industries. Would not the results of the study be changed if it had been assumed that the capital required is not so withdrawn, but comes from a new source?

All depends upon the origin of the new capital. If it has not been created specifically to meet the need of the industry in which the invention takes place, it makes not the slightest difference whether that industry attracts new capital or an equal amount of old capital. Without the change in technique the new capital would have gone into general industry, and would have increased the physical product of labor there. Its absorption by the industry in which the invention takes place is no less real a loss to labor than the loss labor would have incurred if that capital had distributed itself in other industries, to be later withdrawn.

But it may be that the capital has been specifically

created to meet this need. In practical life the possessor of an improvement in technique is often at his wits' end to secure capital with which to exploit it. All that he can save from his income is thus employed. His offer of a high rate of interest induces those who trust him to save what they can. Thus new capital is created ad hoc. Furthermore, when once developed, a practical invention creates a fund of profits which is naturally employed for further development. Thus the profits due to an invention are not only the lure that induces men to make inventions, as Professor Clark has said: they are also the inducement to the formation of capital to exploit an invention, and, to a certain extent, the source of such capital. The existence of profit, with the consequent growth of capital, very probably renders advantageous to labor every labor-saving device, if a sufficient period is given for adjustment. But eliminate profit through improved financial methods, render it easy to withdraw capital from established uses for employment in a new field, or to divert the natural increase of capital from the old fields to the new, and it becomes impossible to hold to the view that labor saving is invariably a force making for higher real wages.

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