CHAPTER I — NATURE

The term "nature" does not signify a definite, specific factor of production, but a vague entity, the sum total of those pre-existing elements which are provided for us by the world in which we live. If man is to produce, nature must supply him with a favourable *climatic environment*, sufficiently fertile *land*, and later on with *motive power* to assist his labour. We might add *time* to this list, for our existence is conditioned by time as well as space.

I. LAND

Land supplies man with three things: (1) a place to stand on, to build his house on, and to cultivate his fields; (2) those kinds of vegetables and animals which alone can satisfy his two primary wants — food and clothing; (3) the underground minerals and fuels which feed his industries.

§ 1

In his primitive state man is content with the products that the earth spontaneously gives him. But this does not mean that he has not to work terribly hard to procure them; it only means that he cannot modify them. This is the first stage in industry — the *hunting* or *fishing* stage. It lasted, so far as we can tell, infinitely longer than the industrial periods that succeeded it — some 200,000 years, according to certain palæontologists. At the same time it is by no means true to say that hunting was the earliest form of human industry, for it presupposes the existence of weapons — bow, spear, sling, or snare. It must therefore have been preceded by a period that is now lost in the darkness of the past, when human industry was in no way different from animal industry, when man was obliged to stalk and capture his wretched prey as best he could. That was the régime of the *quest*, as it has been expressively termed, to distinguish it from the hunting stage.

However many thousand years the hunting stage lasted, it never succeeded in raising any race of people to what we should call a civilized condition. This is because it was too little productive, or rather, perhaps, too destructive, to allow a population to reach

the minimum density required by social life and industrial development. If the population of the British Isles had to live by hunting, even supposing we could restore the game that has now disappeared, it would become reduced to some hundreds of thousands of men. The number of the Red Indians was no higher than that at a time when they ruled over a territory several times as large as the British Isles.

With the fishing industry it is quite different. Fishing, at least sea fishing, has been far more effectual in keeping men alive, and even in raising them to a relatively high level of civilization. This superiority of fishing over hunting is easily explained by the differences between these two modes of exploiting natural wealth:

(*a*) The food provided by fishing is generally more abundant and less dependent on chance than that yielded by hunting. Nor does it depopulate the sea as hunting depopulates the forests, especially when it is practised only with primitive tackle. The result is that it permits men to congregate in sufficient density and to settle down, whereas the hunting tribes must be for ever wandering in search of new hunting grounds. In other words, fishing permits the building of towns. None the less, as every fisherman is necessarily a sailor, this settled life does not exclude long ocean voyages, and it is thus that international relations were first established; witness the Scandinavian lands and their adventurous Northmen.

(*b*) Fishing can scarcely be usefully pursued by men in isolation; it is better practised by groups of men, whereas the hunter hunts alone and strives jealously to conceal his tracks. The boat and the fishing-net are the outcome of collective labour and can only be used by a group or association which can already be described as co-operative. The social influence of these instruments is quite different, therefore, from that of the bow or sling of the hunter; every boat's crew learns of necessity to obey its leader, and to choose him carefully. In this way, also, fishing has social and political consequences that differ largely from those of hunting.

§ 2

The second stage is the *pastoral* stage. This is a natural development of the hunting stage, with this vast difference, that man now breeds animals instead of killing them, and thus substitutes productive for destructive exploitation. But the greatest service rendered to man by pastoral industry is that besides providing him with his daily food (milk, butter, and meat) and clothing (wool and leather), it also procured him leisure, in his tent or in the field,

while idly watching his flocks. This enabled him to lay the earliest foundations of industry, in the weaving of wool; of science, in the observation of plants and stars; and of literature, in songs and heroic tales.

The pastoral industry also created the patriarchal family and, along with it, a social régime and forms of government of which traces yet survive in the laws and constitutions of modern nations. But we are not here concerned with these.

Thus the origins of civilization are bound up with the domestication of animals. This domestication, according to M. de Mortillet, dates back to some 16,000 or 18,000 years ago.

Pastoral industry, however, could draw nothing from the earth but what the earth spontaneously offered. Consequently it could only support a very limited population on a given area — a larger population than could be maintained by hunting, but a smaller one than fishing permitted; and the tribe could only exist by constantly changing its pasturage to maintain its flocks. Hence it was condemned to a nomadic life, and in this respect the pastoral régime was inferior to that of the fishing stage.

§ 3

So far we have spoken only of the exploitation of the earth for the purpose of procuring animal food. But the provision of vegetable food followed a parallel line of development.

Fruit-gathering supplied man with food long before hunting began. It corresponds to the *quest* period, but it held a far larger place among the means of existence of primitive peoples, and even continued into the earliest ages of civilization. If the oak was sacred to Jupiter, this was not only because it attracted the thunderbolt, but because it bore acorns, and the acorn was the staff of life for the peoples of Europe even in the historic period — for the Gauls, for instance. Acorn bread was eaten even in the time of Charlemagne.[1]

No doubt as soon as man had learned how to tame wild animals, he conceived the idea of taming, breeding, or cultivating wild plants. That was the birth of *agriculture*. However, it certainly did not begin with the operation of tilling the soil which is implied to-day in the word "agriculture." That operation presupposes a vast number of previous inventions — not only the plough, but the iron

[1] Those who have tried to eat raw acorns cannot believe that men could ever have tolerated such food. But they would hardly find wheat more appetizing if they had to eat it just as it comes from the husk! The men who lived on acorns did not eat them raw; there is no doubt that they found out how to cook them.

with which the plough is shod, and for which the bronze of the preceding age was no substitute. It presupposes also the training of the ox to submit to the yoke, for it is a curious fact that for thousands of years man knew how to make use of cattle to provide him with food and clothing, and how to employ the horse in hunting and in war, but he did not know how to make animals assist him in his work. Lastly, agriculture in its modern sense presupposes the discovery of cereal crops, beginning with barley, which seems to have been the first one to be grown. Imagination shrinks from measuring the full import of the action of the first man who was able to recognize that some of these humble grasses bore grains that were good to eat.

It seems probable, therefore, that the cultivation of cereals was preceded by a rudimentary form of horticulture or arboriculture that was already practised by the hunting or pastoral races, although their wandering life can scarcely have been convenient for gardening. Perhaps there is some historical significance in the story in Genesis that shows us Adam cultivating the Garden of Eden and gathering the fruits of the trees before Cain became a tiller of the soil.

Agriculture, in the sense of tillage, can scarcely date back earlier than the beginning of historic times. Its birth was celebrated by ancient writers as a comparatively recent event.[1] They greeted it as the dawn of the era of civilization, which was rather unjust to the pastoral age, though the latter had been less prominent in Europe than in Asia. Wheat-growing, however, laid upon the sons of Japhet a much heavier burden of labour than the previous methods of exploiting the land, for besides the toil of ploughing there was also the labour of the mill and the kneading-trough, groaned over by so many generations of women and slaves.

But wheat has well repaid man for his labour. It has done so, first, by teaching him the law of regular work which the pastoral life had been unable to teach: "In the sweat of thy brow shalt thou eat bread"; and then by teaching him thrift as well. Since wheat is easily preserved, man was able to store it in his granaries. The granary was the first savings-bank of the human race. Thus famine, hitherto a constant menace, became much less threatening, even if it was not altogether eliminated. The two other great cereals, rice, which has sufficed for the nourishment of enormous masses of the yellow race, and maize, the national food of the New World, require less labour to turn them into food, if not to grow them, for they do

[1] "Ceres taught men to turn up the earth when they could no longer find acorns or arbutus berries in the sacred forest." (Virgil, *Georgics*, I. 147–9.)

not need to be made into bread. But at the same time they have not engendered the same virtues in those who consume them: up to the present, at any rate, the leadership of the world has remained with the bread-eaters.

With the coming of agriculture, nomadic life gradually ceased, though not suddenly, for the first attempts must have quickly exhausted the soil. Then the city was born. The substitution of a partly vegetable diet for the flesh-eating of the preceding age seems even to have had a softening influence upon manners. Men no longer offered bleeding victims to their gods, but consecrated meal and unleavened bread. No doubt agricultural peoples made war like pastoral ones, but they fought with somewhat less ferocity, it would appear. Contrary to what might be expected, the sons of Cain were gentler than the sons of Abel.

With the coming of agriculture, labour took the first place in production, and nature, who till then had provided almost alone for the wants of man, retired into the second rank. We can leave her, then, for the time being.

It must be said, however, that not even to-day have primitive methods of exploiting the earth altogether disappeared. There are pastoral races still in existence in Asia and Africa, and if there are hardly any hunting or fishing peoples left, in the full sense of those words, yet fishing is still a very important industry, and a means of livelihood to millions of men. Moreover, hunting itself is still represented by such great undertakings as that of the Hudson Bay Company, which supplies the civilized world with furs. But the same process of development is apparent in these enterprises as that which transformed the hunting peoples, at the dawn of history, into pastoral ones.

In the case of living beings, whether animal or vegetable, industry is able to some extent to avert the fate which threatens them, by changing its methods of procedure. Instead of hunting, man can breed and rear animals; instead of fishing, he can practise pisciculture; instead of clearing the forest, he can replant it; in other words, he can leave the extractive industries for the agricultural. Thus, for example, in Canada, now that fox-skins have come to fetch exorbitant prices owing to the extermination of the foxes, fox-breeding has become a most profitable industry. More than ten companies have been formed to exploit it. Similarly in Florida there are actually farms for rearing crocodiles, whose skin is very valuable. As for the ostrich, it is well known that they are reared on a large scale in

South Africa; and some attempts have been made to rear them also in the French African colonies.[1]

II. THE LAW OF DIMINISHING RETURN

Since the area and the volume of the earth are alike limited in quantity, it is a necessary consequence that the quantity of produce that can be drawn from it is also limited. This fact has very important results.

The law of limitation is most in evidence in the extractive industries. When the mine is exhausted the miner is bound to stop, and as a rule he is obliged to stop long before that point is reached, because his work ceases to be remunerative, though it may once more become profitable when the science of metallurgy makes fresh progress.

But this law of limitation embraces all human industry, and is not to be evaded by passing from extractive to agricultural production, for even in this higher form of industry there are obstacles to be met with.

(1) To begin with, agricultural production is limited by the quantity of *mineral substances* that are indispensable to plant life. Every plot of land, even the most fertile, contains only a fixed amount of nitrogen, potash, phosphoric acid, and so forth, and every crop takes away a portion of these substances. It is true that agricultural science succeeds not only in giving back to the land the elements thus withdrawn from it, but even in enriching it by the addition of new elements. But it must be borne in mind that the sources upon which the farmer draws to enrich the soil are themselves limited, for natural manure only restores to the soil a part of what the cattle have consumed, and chemical manures are minerals (phosphates, potash, nitrates, guano, etc.) the deposits of which are scanty and quickly exhausted.

(2) Moreover, agricultural production is limited by the conditions of *space* and *time* that are indispensable to vegetable and animal life; these conditions are much more rigid and less open to modification than those of industrial production. As has been suggested

[1] The finest example among plants is that of rubber. The destructive exploitation of the forests of the Amazon and the Congo has been gradually replaced by industrial cultivation in the Dutch and British colonies of the East Indies. It is owing to this that rubber is the only raw material whose price did not rise during the war, in spite of the enormous consumption that was caused by the war.

elsewhere, the right name for this industry is *viviculture* rather than agriculture. The farmer is reduced to an almost passive part; he must look on patiently while nature performs her work according to laws which he knows but imperfectly as yet, and whose slow operation he cannot change. It takes long months for the grain that sleeps in the furrow to become transformed into an ear of corn; and it takes long years for the acorn to become an oak. Again, every plant, whether wheat or oak, requires a certain irreducible minimum of room in which to spread its roots and to breathe. Of course we can hasten the flowering of the lilac or the ripening of peaches in hot-houses, at great expense; but this kind of cultivation, which has already become an industry, is merely a luxury of the rich. The industrial worker, on the other hand, is not tied down to the inexorable succession of the seasons: summer and winter, day and night, he can stoke up his fires or drive his loom. In his furnaces and his vats he can work up the inorganic materials at his pleasure. His concern is only with physical or chemical laws, which are far less mysterious than those of organic life. The proof of this lies in the fact that these laws have been tamed, and made to obey man's commands with mechanical precision.

The limitation of agricultural production, however, is elastic and not inflexible, as is that of extractive production. The amount of produce may even be increased to an almost indefinite extent, though only at the price of an effort which goes on increasing until it ends in being out of all proportion to the amount of produce obtained. There are two ways in which this increase can be secured.

(1) We may increase our produce by an *extension* of the area under cultivation. There is no country, even among the most highly civilized, where the whole of the soil is cultivated, even if we include pasture-land and forests under this heading. Nevertheless, the amount of land that remains available for cultivation is generally of little value, and we shall not find much help in this direction towards supplying the needs of future generations. Even in relatively new countries like the United States the limitation of the extent of land is beginning to make itself felt; the areas still available are generally lacking in water and can only be cultivated by the troublesome process of "dry farming." There is not much wheat-land in the world now remaining to be cultivated, since wheat can only be grown in the temperate zone; and it seems as if we cannot expect much more bread from this source than the amount necessary for the 600 millions of men who actually consume it.

Any surplus population above that number will perhaps have to find some other kind of food.[1]

(2) The second method of increasing the produce of the soil is more *intensive* cultivation. Perhaps there is not a single piece of land of which the farmer could not, if necessary, increase the yield. Only, after a certain stage of agricultural industry has been passed, he can only do so at a *constantly increasing cost in labour*. Consequently there will be a point at which the amount of labour expended to increase the yield is greater than the value of the crop.

Suppose an acre of land produces 30 bushels of wheat, which is about the average yield in the United Kingdom, and that these 30 bushels represent 70 days' labour, or £8 in money. Then the law of diminishing return (or of a return that is not proportional to the labour expended), declares that to make this land produce twice as much wheat (*i.e.* 60 bushels) we must expend more than 140 days' labour or more than £16 in money. To double the produce, we may have to treble, to quadruple, or perhaps even to multiply a hundredfold, the amount of labour and expense.

This law is certainly borne out by the experience of every day. Ask an intelligent farmer whether his land could not produce more than it does, and he will reply: "Certainly; the wheat crop would be larger if I chose to use more manure, to dig more deeply, to clear the soil of the smallest weeds, to have the soil dug by hand, to have each grain of seed transplanted by hand if necessary, and finally to protect the harvest from insects and birds and parasitic weeds." Then ask him why he does not do all this, and he will reply that he would not get back his expenses: the extra crop would cost more than it would be worth. There is therefore in the output of any piece of land a point of equilibrium which marks the limit beyond which no one will pass. It is not that we cannot pass it if we wish to, at any cost, but that we do not wish to, because there is no advantage in doing so.

The proof of this is as follows: If it were not so, if we could increase the production of a given piece of land indefinitely, on the sole condition of increasing the labour and expense in proportion, it is obvious that the owners of the land would certainly not hesitate to do this. Instead of extending their cultivation over a more or less wide expanse of land, they would prefer to concentrate it on

[1] The cultivation of the *bread-fruit* tree has been considered. This grows naturally in the tropical zone, and produces much more freely than wheat. Economic evolution would thus take us back to the time when men fed on the fruit of the oak-tree. (See above, p. 66.)

the smallest possible area: this would be far more convenient. But in this event the face of the earth would be quite different from what it is. The simple fact that things are not like this at all, and that cultivation is constantly being extended to less fertile or less favourably situated land, is a sufficient proof that we cannot in reality expect more than a limited crop from a given piece of land. (See Book III, Part II, Chapter I.)

Each kind of cultivation gives its own maximum return. So it is evident that if the farmer changes his cultivation he may move the limit a step farther. An acre of land under potatoes may produce eight or ten times as much in weight as wheat. But none the less the cultivation of potatoes is subject likewise to the law of diminishing return.

We must not confuse the actual return with the monetary return. The latter does not depend only on the fertility of the land, but also on the circumstances that determine prices, and these are not subject to the law of diminishing return. There are no limits imposed by nature on a rise of prices. If, for instance, we were to grow roses instead of corn, and produce otto of roses, we might make £80 an acre; but man does not live on otto of roses.

Again, the law of diminishing return is not confined to agricultural and extractive industries, as the classical economists taught. It is a general law of production, and can be formulated thus: every increase in yield requires a more than proportional increase of power. This can be proved from the transport industry: beyond a certain point, if we wish to increase the speed of a ship by only a tenth — say, from 20 knots to 22 — we must increase the motive power by more than a quarter. If we wanted to double its speed we should have to increase the power tenfold — and even then we should not succeed.

III. MOTIVE FORCES

The work of production consists simply in changing the form or the place of matter. The resistance that matter offers to these changes by reason of its inertia is often considerable, and man's muscular power is not very great. In all times, therefore, but especially since the abolition of slavery has forbidden him to employ the strength of his fellow-men for nothing, man has tried to make up for his weakness by using certain motive forces — more properly called "energies" — that are provided by nature.

Man makes use of these natural forces by means of machinery. A machine is merely a tool, with this difference: that instead of

being worked by hand it is set in motion by natural forces, such as the weight of falling water, the expansion of vapour, etc.[1]

It should be observed that the more powerful these natural forces are, the more time and trouble are required to tame them and make them serve the purposes of man. The harnessing of Niagara demands a different equipment from that needed to harness a small waterfall. And we shall see later on that it is the same even in agriculture: land that is naturally fertile costs more to clear than a sandy desert. Every employment of natural forces involves a struggle like that of Hercules against the monsters, and the energy that the victor must display is necessarily proportionate to the power of his adversary.

That is why there are still only four or five natural forces that man has been able to make use of in production: the muscular strength of *animals*, the pressure of *wind* and running *water*, the expansive power of *vapours* (especially of steam, though recently also of explosive gases), and lastly and quite recently, *electricity*, which, however, is generally only an altered form of water power or steam power. But there are numerous others, known and unknown. The waves raised by the wind on the surface of the sea, the tides that wash thousands of miles of coast twice a day, the store of heat enclosed in the centre of the earth[2] — these are truly inexhaustible reservoirs of power. And the forces that we can see are as nothing to those that we can guess at, even if it be only the energy latent in molecular combinations that radium has revealed

[1] This definition applies only to *power machines*, but in everyday speech the term "machine" is applied also to instruments worked by man whenever they serve to increase the rapidity of labour, as, for example, hand-looms, sewing-machines, typewriters, etc. We also call a bicycle a machine. But these would be better named *tool machines*.

Tools or implements enable man's strength to be better utilized, sometimes even by increasing it, just as power machines do, but with this defect: that *whatever is gained in power is lost in speed*. Thus with the help of a hydraulic press a child can exert a pressure that is theoretically unlimited, and Archimedes boasted, quite rightly, that with a lever and a place on which to rest it he could move the world. Yet the interesting calculation has been made that, even had he found this necessary point of support, he would only have succeeded in raising the world an infinitely small distance if he worked at it for several million years.

Now since time is a very precious factor, of which we ought to be extremely careful, the increased power obtained by the use of tools is in practice limited, whereas with power machines it is unlimited.

[2] There is a district in Tuscany where natural jets of steam (*soffioni*) issuing from the earth have been harnessed and intensified by the digging of holes; in this way several thousands of horse-power have been made available.

to us. If we may believe the physicist, the atomic energy contained in *a single gramme* of matter would amount to millions of horse-power, if it could be liberated.

The domestication of various animals — the horse, ox, camel, elephant, reindeer, Eskimo dog, etc. — supplied man with the first natural force for carriage, draught, and tillage. This was itself a valuable achievement, for animals are relatively stronger than men. A horse's strength is estimated at seven times that of a man, whereas its food costs less than man's. But the number of these animals is limited, and the more so as a country becomes more populous, for they require much space to feed in; so the motive power that they represent is comparatively small.

The motive force of the wind and of rivers has always been used for transport purposes, but its industrial application has until recently been almost entirely confined to turning windmill sails and water-wheels. The water mill, which dates from the first centuries of the Christian era, was the first machine, properly so called, in the sense that it was the first application of natural forces to the work of production.

Of these two natural forces, however, the wind is generally too weak and in any case too intermittent, while the other force, water, though more powerful and amenable, suffers from the grave inconvenience of being localized in certain places. It was not until Newcomen (1705) and James Watt (1769) had made use of heat to expand water vapour in a closed vessel, that that marvellous instrument of modern industry, the steam-engine, was created. And the superiority of steam from that day to this is due to the fact that it is *artificial:* it is not created by nature, but by man. For that very reason it possesses this inestimable advantage, that man can use it *where* he pleases, *when* he pleases, and *as* he pleases. It is mobile, portable, and continuous, and its pressure can be raised to many times that of the atmosphere without any other limit in practice than that imposed by the resistance of the vessel that contains it.

But water is now beginning to take a highly important place as a motive force, since means have been found to convey its power for hundreds of miles. Moreover, it is infinitely *divisible* as well as *portable*, so that water power can be made to radiate at will around the point where nature seemed to have fixed it. Thus the Rhône, which used to waste its energy in grinding down pebbles, is carried nowadays into the lofty workrooms of Lyons to drive the looms of the silk-weavers. Motive power is already being distributed into

the homes of the people, like water and gas, so that it can be procured by merely turning a tap or pressing a button.

The action of water is due, however, to its flow, and not to its quantity or extent. (What use could be made for motive purposes of the thousands of millions of cubic feet of water that lie at rest in such a lake as Geneva, or even in a gently-flowing stream like the Seine?) Consequently, water has been utilized mainly at its maximum gradient, that is to say, at a waterfall; and this means going up as near as possible to the sources of rivers and to the glaciers which are the reservoirs that supply them. That is the origin of the famous name "white coal," which was given to this new force more than fifty years ago (1868) by M. Bergès, an engineer of Grenoble. What he meant by it was not running water in general, as is usually thought, but simply the glacier, as a reservoir of force — the force of gravity — which is stored up in it as heat is stored up in coal: the one force is liberated by the downward flow of the water, as the other is by combustion.

By a lucky chance, which would have been regarded in olden times as the work of Providence, but which can be explained geologically, the very lands that are poorest in black coal are those that are most richly endowed by nature with white coal, and conversely. Thus in Europe, Switzerland, Northern Italy, and Scandinavia, which have not an atom of black coal, have splendid supplies of white coal, whereas England, Belgium, and Germany, so rich in mines, have but few falls and water-courses that can be utilized for motive power.[1] It is the same in America: Canada and Brazil have tremendous quantities of power in their waterfalls, but they seem to have scarcely any supplies of coal. France is pretty equally divided, for without being destitute of coal (she produces two-thirds of what she consumes) she possesses a regular army of hydraulic horses, the equivalent of eight or ten millions of horse-power, half of it in the Alps, a quarter in the Pyrenees, and the rest in the Central Plateau, the Jura, and the Vosges. Less than a million and a half of this horse-power is actually utilized, however. In this respect France is surpassed in Europe by Norway and Sweden alone. If she could utilize the whole of her water power, it would suffice to

[1] [Water power is already being used, however, in the Snowdon region for the production of aluminium by means of the electric furnace. "As there is much water power in North and Central Wales it is most likely that in the future this power, now running to waste, will be made of service and provide work for more people than can get a living in these regions at present." (J. F. Unstead, *The British Isles of To-day*, pp. 117-8.)]

free her from the annual tribute she pays to the foreigner by her purchase of twenty million tons of coal a year.

The economic superiority of white coal over black coal lies in the fact that it is not consumed by being utilized. Black coal is like a treasure that has lain buried since primeval days; we are drawing on it lavishly, and the treasure chest will soon sound hollow. White coal, on the other hand, renews itself like the rainfall; it is the sun's task to keep on drawing up the water that has finished its work, and placing it once more on the heights. The supply of power will only come to an end in the event of a general drying-up of the earth and the disappearance of the glaciers — a contingency that we are threatened with, it is true, by some learned men, but which, fortunately, is not yet proved.

The cost of installation of hydro-electric plant, such as barrages, forced conduits, turbines, dynamos, reservoirs, or artificial lakes for regulating the flow of water, is very great, but once the installation is made the running cost per horse-power is practically *nil*. In using coal, on the other hand, this cost is comparatively high, the average consumption being about 2½ pounds of coal per horse-power per hour. That is why, in mountain villages lighted by white coal, they do not take the trouble to put out the lamps during the daytime.

But if it is true that the motive force of water is everlasting, or continually being renewed, unlike coal which is dead and fossilized, it is no less true that the quantity of water in existence is limited as that of coal is. We shall never be able to increase the number and power of water-courses, but only to make better use of them.

In default of more water power, some people have had visions of obtaining from the sun itself the power that is needed. But, even if we could succeed in doing so, the force borrowed from the sun would be limited to an even greater degree than are the other natural forces, for the sun does not shine always or everywhere. If some day the sun is used to work our factories, what a blow that will be to England — far worse than the competition of white coal! The fogs of the North Sea will be her funeral shroud, and men will have to carry on their industries and build their cities in the heart of the Sahara.

IV. THE PROBLEM OF MACHINERY

The natural forces harnessed by machinery work wonders to which we have become hardened by familiarity. Not only do they enable us to perform the same tasks as before under conditions

of amazing superiority, but, more than that, they allow us to do things hitherto undreamed of. To name only two examples out of a hundred, the newspaper press and the railways, those two great factors of civilization that have so profoundly modified all the conditions of modern life — public, intellectual, and moral, as well as economic — were both of them created by the steam-engine.

The everyday use of the motor-car — and to-morrow probably it will be the aeroplane — has already had important social consequences whose full significance cannot yet be estimated. These are indeed the instruments that set men free from the bondage that the physical world imposes upon them — the bondage of distance, of time, and of gravity. And while they increase man's independence in relation to nature, they knit more closely the ties of solidarity that bind him to his fellows.

Suburban railways in large towns will be the most effectual agent in remedying the evils of overcrowding and in solving the distressing problem of working class housing.

The superiority of machinery over human labour is due both to technical and to economic causes.

The *technical* causes are these: (1) The *power* that enables matter to be raised, moved, or worked up. The Pharaohs were able, by collecting a sufficient number of workmen, to build the pyramids; and the Panama Canal might possibly have been constructed in the same fashion if a hundred years had been devoted to the task. But the combined blows of the hammers of a thousand smiths could not do what is done by the steam hammer, the hydraulic press, or the rolling mill; nor could a hundred thousand rowers propel gigantic steamers or ironclads at thirty miles an hour. — (2) *Speed.* — Man cannot follow with his hand or even with his eye the rotation of a turbine or a spindle, or the tick-tack of a boring machine or an electric riveter. — (3) The *precision* and especially the *uniformity* of the work, that makes it possible to produce interchangeable parts. The hand of the most highly skilled workman can reach a degree of precision of $\frac{1}{250}$ of an inch, but it will not succeed in making two identical parts. Machinery does this, and cannot even do otherwise; and thus all the parts of thousands of guns or bicycles are interchangeable.

The *economic* causes of the superiority of machinery over human labour may be summed up in the one word *cheapness* — the lowering of the cost of production. If we consider that one horse-power involves an average hourly consumption of only $2\frac{1}{2}$ pounds of coal (rather more in the case of small machines, and rather less in bigger

ones), and that the normal cost of this amount of coal — not the present day cost! — is not more than a halfpenny, we shall realize the difference between the cost of machine labour and the workman's wages. It is true that coal is not the only expense in using machinery: there is also the cost of oil, expenses of maintenance, interest and depreciation fund on the capital represented by the machine (whose life is a fairly short one), and finally the wages of the man who works it, for machinery will not quite run by itself, though it very nearly does. Nevertheless the saving is enormous, even when everything is counted in; and it goes without saying that the more expensive hand labour becomes, the greater is the saving. So the rise of wages has been one of the most effective agents in stimulating mechanical progress; a single strike has sometimes been enough to cause the introduction of machinery into a factory. If the slave system had continued, machines would never have been invented.

Books on political economy are full of examples of the cheapness produced by machinery. The most striking instances are drawn from the transport and the printing industries: a ton of goods carried at the rate of a penny a mile, or a newspaper of four or six pages, containing as much matter as a book and sold (until recently) for a halfpenny — these are the miracles wrought by machinery.

In France at the present day, although she is far from being one of the most advanced manufacturing countries, there are fifteen millions of horse-power, each representing the strength of a score of men. As the number of men employed in industry and agriculture in France is not more than ten million, we may say that the productive power of each man is thus multiplied by 30, or, to put it more picturesquely, that each French workman has thirty slaves at his service.[1] He ought therefore to be in very much the same position as the Roman patricians, and able, like them, to accumulate all the refinements of wealth and idleness. How is it, then, that with these new servants in place of the slaves of old, the men of to-morrow will yet be unable to live the noble life of the ancients, devoting the hours saved from material labour, like the Greeks in their Agora and the Romans in their Forum, to politics, to artistic recreations, to gymnastic exercises, or to lofty philosophical speculation — with

[1] [Similarly, Professor Marshall says, speaking of the English textile industries which employed nearly half a million men and more than half a million women: "The strain that is taken off human muscles in dealing even with those soft materials is shown by the fact that for every one of these million operatives there is used about one horse-power of steam, that is, about ten times as much as they would themselves exert if they were all strong men." (*Principles of Economics*, p. 342 n.)]

this difference only, that what was then the privilege of a small class will now be the rule for every one? This is, indeed, an alluring prospect. But our exultation disappears if we consider how slight is the assistance rendered by machinery in satisfying the two fundamental needs of every human society — the need of food and the need of shelter.

It is calculated that in France less than 200,000 horse-power are employed in agriculture — not even 1½% of the total. Is this slow development of the use of machinery in the production of food entirely due, as is often thought, to the conservative attitude of agricultural folk, or is it not rather due to the very nature of agricultural production? This latter explanation seems to us to be the true one. Land is life's laboratory, and life has special laws of development which are peculiar to it (see above, p. 64). Moreover, most of the machines used in agriculture aim only at economizing hand labour or speeding it up, and not at increasing the quantity of produce. Threshing machines and sheep-shearing machines, like the machines that chop sugar, and those (in Chicago) that turn a pig instantaneously into sausages, add not a grain to the sum of human wealth, to the stock of corn, wool, sugar, or meat. Machines for ploughing or irrigation, however, may increase the depth and fertility of the available land.

In the matter of house-building, machinery is hardly used at all, except for cutting stones and in certain special kinds of construction.

The employment of natural forces is restricted, then, more completely than one would think, to the sphere of manufacture and transport, and it is here that it has procured all the abundance and cheapness that could be expected. It is true, however, that mechanical progress in transport reacts indirectly on food and housing, by facilitating the importation of agricultural produce, fertilizers, and building materials.

But here is another aspect of the question. If it is true that a single horse-power does the work of twenty men, each new horse-power created will enable the one man who controls it to dispense with the labour of twenty other workmen, who will be condemned to unemployment in consequence. And since each of these twenty men will strive to retain his place, it looks as if the result must be an underbidding of each other which will cause a lowering of wages.

A century ago the economist Sismondi obtained a reputation for heresy, which was better merited on other counts, by the eloquence with which he denounced machinery as the scourge of the working

classes and the whole nation. He said that the invention of machines "made population superfluous," (which is the title of one of the chapters in his book, *Nouveaux Principes d'Economie Politique*). If, said he, machinery should reach such a degree of perfection that the King of England could produce all that was needed to satisfy the wants of his people by merely turning a handle, what would become of the English nation?

It is well known that the workers also were violently opposed to the introduction of mechanical processes in industry, and showed their hostility on many occasions by breaking the machines and mobbing the inventors. We need only mention the Luddite Riots in the midland counties early in last century, the burning of the Jacquard loom at Lyons about the same time, and the destruction of Papin's steamboat in 1707. Even to-day we have seen the dock labourers of Marseilles and Boulogne objecting to the installation of cranes, and the fishermen of Brittany rebelling against the employment of steamboats and revolving nets in the sardine fishery, because they think that the more fish they catch the less they will be paid — and this at a time of general food shortage!

This attitude is natural, for the workers are necessarily the first to feel the effect of the mechanical inventions that come to cut the ground from under their feet. And as they live from day to day they cannot wait till things settle down.

But, on the other hand, those economists who were out to prove that in our economic organization there can be no conflict between social interest and individual interest, were bound to deny the existence of the evils attributed to machinery, and to declare that it always provides more work and more comfort for the worker. Thus arose a controversy which once held a prominent place in the classical treatises, but which has lost much of its importance to-day.

Here are the arguments by which the classical economists sought to set aside the grievances attributed to machinery. It must be recognized, however, that they are not unanswerable.

(1) *Reduction of the cost of living.* — Every mechanical invention, it is said, results in a lowering of the cost of production and therefore of prices. Numberless instances may be cited. We have just mentioned two of them — railways and newspapers; we can also mention all articles of clothing of the ready-made kind. Consequently, it is said, even supposing that the result of the introduction of machinery is a fall in wages, yet the workman gets compensated, as a consumer, for the misfortunes he suffers as a producer.

But the workman only gets this compensation if he is a consumer

of the products that he makes himself. Now such a coincidence as this is extremely rare. The mechanical manufacture of certain kinds of lace has lowered their price, but the poor woman who used to make them by hand is not in the habit of wearing them, so she gets no compensation whatever.

Even admitting that the product in question is consumed by the worker, it can only constitute a minute fraction of his consumption, and the compensation thus obtained would be ridiculously small. The woman who used to knit stockings, and who loses her wages through the invention of a knitting machine, will find little consolation in the prospect of buying her stockings more cheaply from the shop.

To make this compensation a real one, *mechanical progress would have to take place simultaneously in all branches of production*, so that the consequent fall in prices would be general and simultaneous. In this case it might be said to matter little to the workman if he receives only half his former wages, since all his expenses would also be halved. But unfortunately, as we have just pointed out, mechanical inventions are not applied in all branches of production, but only in a small number of them; and their effect is particularly slight upon those very expenses — food and housing — which occupy the chief place in the working-man's budget.

(2) *Increase in the demand for manual labour.* — Far from suppressing or restricting the demand for manual labour, machinery results, it is said, in increasing this demand. In fact every mechanical invention, simply by causing a fall in prices, must bring about correspondingly larger sales, according to the "law of demand," and consequently it always ends by bringing back the workers who have been temporarily turned out. Instead of taking work from them, it makes work for them. And there are plenty of examples to support this view. Thanks to the multiplication of books since the invention of printing, there are many more printers to-day than there were copyists in the Middle Ages. Thanks to the railways, there are many more travellers, and therefore many more workmen employed in transport than there were postilions, ostlers, and postmasters. Thanks to mechanical looms, there are many more workers employed in textile industries than there were hand-loom weavers in former days.

To this we may answer, first of all, that although an increased sale is the normal consequence of a fall in prices, this is not always the case. It is notably not so in the following cases: (*a*) Whenever a commodity satisfies only a limited want. The example of coffins

has become classical, but there are many other products — such as salt, umbrellas, spectacles, and keys — the consumption of which would be only slightly increased by a fall in price. If the price of hats was halved it is not likely that we should use twice as many. As for articles of luxury, an increase in their number might even result in a diminution of consumption, by lowering their value. — (*b*) Whenever one industry is bound up with other industries. This is a very common case. The production of bottles and casks might become cheaper, but no more of them would be sold if there were no more wine to put into them. Similarly, the production of watch springs is limited by that of watches, the production of iron bolts by that of rails and boilers, while that of rails and boilers is limited in its turn by other causes independent of prices, such as the development of transport, mining production, and so forth.

Moreover, even admitting that a fall in prices produces a proportional or more than proportional increase in consumption, yet a certain time must elapse — perhaps several generations — before this is brought about. It takes time for the old prices to fall, especially since the manufacturers are interested in keeping them up, and old acquired habits also delay the fall. Competition wins in the end, but rival industries are not set up in a day. Still more time is needed for the fall in prices to extend the sale of these products into those new strata of society that do not quickly change their tastes and desires. If the weaver of last century, looking at his idle and superseded loom, could have known that his grandchildren would find work and higher wages to-day in splendid factories, he would no doubt have found some moral consolation in the knowledge, but it would not provide him with bread and butter.

In short, the classical argument comes to this: that though the invention of machinery may provoke crises and produce suffering, these are only temporary and right themselves spontaneously. This may certainly be admitted, but it is poor consolation, for the same could be said of all the evils in the world — they are all temporary, except death.

What we ought rather to say — though the optimist school does not like making such confessions — is that the evils complained of are not confined to machinery. *All economic progress*, whether it consists in mechanical inventions or in new methods of organizing labour, *can have no other effect than to render a certain amount of labour useless*. As the organization of our modern societies is founded on the division of labour, so that each man lives by one particular kind of work, this progress, whatever form it takes — not only

mechanical invention, but all improvements in organization, like large shops, co-operative societies, trusts, and so forth — must make some one's labour useless, and rob him of his livelihood at the same time. There lies the fatal obstacle.

It is from that point of view that socialists regard things. They attribute all the evils resulting from machinery not to the machines themselves but to their *appropriation by the capitalist.* The most enlightened of the workers, the trade union leaders, understand well enough that, notwithstanding all the disturbances it brings in its train, machinery is a necessary and beneficent form of industrial evolution, and that it would be contrary to the highest interests of the working classes, as well as useless, to try to stop it. They refuse to be hostile to machinery through conservatism and hatred of new things; they are inclined, on the contrary, to extol beyond measure the miracles of social transformation that they expect from it. If the machines belonged to the community, they think, then they would have no other effect than to reduce everybody's share of toil — they would no longer rob anyone of his livelihood. Their object, therefore, is no longer to destroy the machines, but to nationalize them.

Meanwhile the workers' organizations and the employers themselves have learned to take the necessary measures to soften the shock that results from the introduction of machinery into industry: they strive to make the workers benefit by the economies effected in the cost of production, either by an increase of wages or by a reduction of their hours of work.

Nevertheless it would be a decided exaggeration to claim that complete success will be attained in this matter. The existence in all industrial countries of a surplus of manual labour — what socialists call the reserve of the industrial army — which employers can draw on when they need, and whose very existence keeps down the rate of wages, can hardly be explained except by the continued action of mechanical inventions and other forms of industrial progress, tending constantly to reduce the number of human arms that are needed.

All we can reasonably hope for the future is that the grievous after-effects of mechanical inventions will tend to grow less. It is plain enough, indeed, that the introduction of a new machine into an industry that is already carried on by mechanical means does not now provoke a rebellion like that caused by the first mechanical loom among the hand-weavers, any more than the discovery of a new gold mine that pours its produce into a huge existing stock,

provokes a disturbance of prices like that which followed the discovery of the first mines in the New World. In the economic development of humanity, history shows us sudden and convulsive changes, followed by long periods when things are in a more or less stationary condition. So it is quite possible that the great economic transformation of our own time will be followed by a long period of rest, or at least of very slow progress, like the peaceful course — peaceful from an economic standpoint — of the periods that have gone before.