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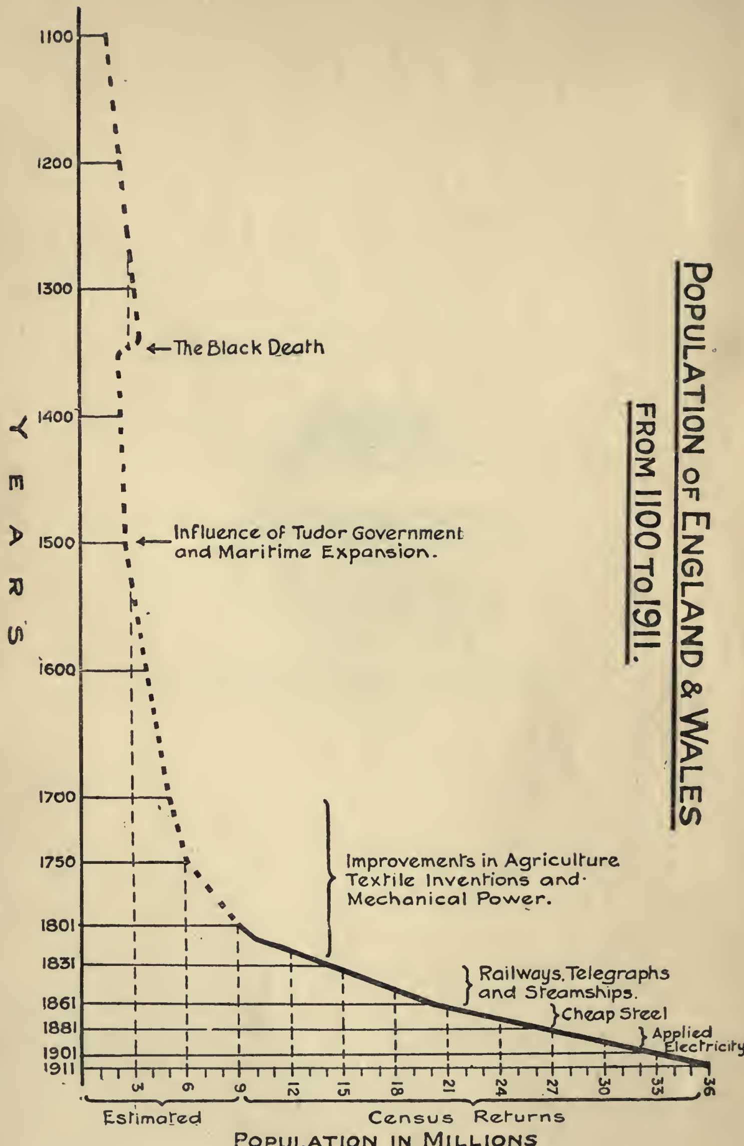
POPULATION OF ENGLAND & WALES
FROM 1100 TO 1911.
YEARS
1100
1200
1300
1400
1500
1600
1700
1750
1801
1831
1861
1881
1901
1911
←The Black Death
Influence of Tudor Government and Maritime Expansion.
Improvements in Agriculture Textile Inventions and Mechanical Power.
Railways, Telegraphs and Steamships.
Cheap Steel
Applied Electricity
3
6
9
12
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36
Estimated
Census Returns
POPULATION IN MILLIONS

AN OUTLINE

OF

INDUSTRIAL HISTORY

WITH SPECIAL REFERENCE TO PROBLEMS
OF THE PRESENT DAY

BY

EDWARD CRESSY

MACMILLAN AND CO., LIMITED
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PREFACE

THE object of this little book is to sketch lightly some of the facts and phenomena which lie between school-boy history and the politics of the man. Modern life is so complicated, and the development of the last two hundred years has proceeded so rapidly, that those who have not specialised in history find it difficult to connect what they have learnt in their youth with the problems upon which they are called to express an opinion in manhood's days. The historian, confining himself to documentary evidence and, in general, limiting his view to times so far remote that his interpretations may be free from suspicion of prejudice or party feeling, endeavours to draw a picture of things as they were, without reference to things as they are or may be. It is an inevitable result of his method that he should, as a rule, stop short of the problems which belong to his own age. And it is equally inevitable in periods of rapid social, economic, and political change, that the predominant features of one epoch should fade speedily and be replaced by others, quite different, in the next. Successive movements rise to maturity, and die away, to be followed by events which could hardly have been foreseen a quarter of a century before.

In no case is this so true as in the industrial history of the last two centuries, and it would be wrong to charge historians with failing to observe and to record either the character or the importance of the changes which have occurred. But while ample details have been given of the earlier portion, even in elementary books, the striking developments of the later years have only been described in large monographs or in blue-books which the layman has no leisure or no inclination to read. And yet, for the practical purposes of life, this knowledge is clearly a condition precedent to the formation of a sound political judgment. In a word, there seemed to be a need for a book connecting more closely the dead past with the living present; so this little volume is offered as a supplement to the smaller, and as an introduction to the larger histories which trace the growth of our national industry and commerce.

The supplementary character of the book will be apparent from its contents. Emphasis is laid upon the scientific basis of industry, not because it was a conscious feature in the earlier stages of human effort, but because it is a dominant fact to-day. The same principle of selection justifies a mere outline, in the first three chapters, of the economic and social fabric before 1700. From that date the development of certain important groups of industry and certain lines of political activity are traced in a series of parallel chapters. Thus, a brief historical account is given of Agriculture, Textile Industries, Fuel and its Applications, and the Union of Science and Practice, for the purpose of illustrating how scientific discovery and mechanical invention have increased the productive capacity of the individual workman, and have altered and are altering the technical character of industrial control. These are followed by chapters on Transport and Communication, and Banking and the Credit System, which have facilitated so considerably the growth of trade. From a consideration of technical achievement the book passes to a short account of Combinations of Capital, The Conflicts of Capital and Labour, Co-operation, and Municipal Ownership, as illustrations of modern business management and its problems. The Extension of the Franchise, The Change in the Function of Government, The State and the Factory, The Growth of Economic Thought, and the provision of Education complete the survey.

It is obvious that a book covering so wide a field can be no more than a framework, and the author has endeavoured to keep this fact in view throughout. It purports to give the chief historical landmarks in the evolution of modern problems of industry and politics, rather than a picture corresponding in its entirety to any other period; and the author hopes that this historical continuity will compensate for lack of historical unity which other writers have endeavoured, rightly and not unsuccessfully, to attain. He is under considerable obligations to the works mentioned in the appendix; he has been at some pains to check his facts; he has endeavoured to be fair and moderate in such inferences as it has seemed necessary to draw; and he presents the book as a small contribution to the efforts which are now being made to create a well-informed electorate, competent to maintain the great traditions committed to its care.

E. C.

November 1915.

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PART I

PRIMITIVE MAN AND ANCIENT CIVILISATION

CHAPTER I

THE CRADLE OF INDUSTRY

THE fundamental occupations of the human race arise out of the primary instincts, and their origin lies far away in the distant and shadowy past. Before history begins, in the vast dimness where the anthropologist gropes, primitive man acquired experience and developed that power of storing it up for future use, which distinguishes sharply the *genus homo* from all other branches of the animal kingdom. At first he fought for fruits and roots, and waged war upon those who would take them from him; the lust of conflict probably made him a meat-eater; and he stalked his enemy for food. The erect posture enabled a weapon to be used, and left his hands free to do what his brain suggested. Out of the weapon grew the tool, and ignition of the dust from the sharpened stick or sparks from the chipped flint added the production of fire to his accomplishments, forming the one bridge across which no animal has ever passed. Tools of a sort they may use, and some skill in architecture is not unknown; but fire is the unique possession of man, and in its genial warmth the seeds of civilisation grew and flourished.

From the need for food sprang the first attempts at organised labour. The results of hunting and fishing were irregular and uncertain, while bodily comfort, no less than bodily effort, demanded regular and adequate nourishment. Flocks and herds were collected, fed, watered, and protected against the beasts who desired to share the owner's food. At a later stage food-bearing plants were encouraged by uprooting too vigorous neighbours, and still later cultivated in cleared ground. Under man's protection and fostering care flocks and herds and corn increased and multiplied, so that the labour of preparing food no longer took up the whole of his time, nor monopolised his thoughts. And it was in these hours of leisure that new tools were devised, new enterprises were planned, social systems shaped themselves, and the seeds of political theory and political practice were sown.

The gregarious instinct which draws men into groups must have been in operation at a very early period, but the nature and rate of progress was largely determined by geographical conditions. In the tropical forest the hunter remained a hunter, approximating to the beasts amid which he lived. In the park-lands which fringed the temperate forest a pastoral life predominated. But, where men settled in the fertile river-valleys, there seems to have been more incentive to effort and more stimulus to progress. The practical arts which contributed to comfort and reduced toil varied with available minerals, and with the fauna and flora of the district. Save that the Stone Age preceded the Age of Metals there was apparently no universal order of development, and as copper and tin ores were only present in some places, and iron ores only were present in others, the use of bronze was probably contemporaneous with that of iron.

The beginning of land transport most likely arose among pastoral people who lived near enough to the forest to become familiar with the fallen tree, and in country sufficiently open to render a rough platform on rollers useful for carrying heavy burdens. Even this may have been preceded by a sledge formed of the skin of an animal. From the roller to the wheel, however, there must have been a long stretch of time. In the neighbourhood of a river or lake the floating log would suggest a boat, and the speed of a leafy floating branch on a windy day the advantage of a sail. A fallen tree on the side of a stream or gully would indicate the construction and use of a bridge. The first weapons and tools were sticks, sharpened by rubbing or pointed and hardened in the fire, heavy wooden clubs, and flints bound to a wooden handle with animal thongs or vegetable fibres. Lastly, from the springy branch would arise the idea of the lever and the bow.

Beyond these simple tools and methods the most important early arts were pottery, weaving, and spinning. Earthenware vessels were at first sun-dried, not burnt, and the bricks were made with straw to give them the necessary coherence. The existence of circular or cylindrical shapes indicates the use of the potter's wheel—a rotating disc upon which the lump of clay is placed, and moulded with the hands as it spins round. It marks a stage of progress. Weaving probably preceded spinning, reeds being used and plaited as in mats and baskets. The first vegetable fibres to be spun were silk and flax because the former is a continuous thread, and the latter is of long staple. The first device for spinning was the distaff and spindle. The former was a stout stick, one end of which had the mass of fibre attached. It was held under the arm, a bit of the fibre was drawn out, twisted, and wound round the spindle. Later, the lower end of the spindle was furnished with a heavy disc or lump of clay, the fibre was fixed in a cleft at the end, the spindle was allowed to fall, spun round to give a twist, and then wound up, the process being repeated until the spindle was full. The fabric woven from this was dyed with such vegetable colouring matter as was available.

The earliest industries, therefore, centred round food and clothing, and they represent a victory, more or less complete, over the forces of Nature. Until this had been won no progress, material or intellectual, was possible: men had to earn leisure before they could enjoy it or use it to their further advantage. We live to-day in a world so rich and varied, and under conditions so artificial, that the fundamental conditions of existence are hidden from view, and it is profitable to glance briefly at some of the earlier civilisations in order to see how large a part knowledge of the material world played in human development.

The first civilisations of which we have any connected record were those of Babylonia and Egypt. The former flourished in the hot, moist delta of the Tigris and the Euphrates, while the founders of the Egyptian nation settled in that deep, narrow depression along which the Nile conveys the surplus waters of the great African Lakes to the Mediterranean Sea. Fed by the melting snows of the mountains of Armenia and Abyssinia respectively these rivers were liable to floods, but with this difference: in Babylonia the floods were rare, irregular, and disastrous, while in Egypt they were annual and beneficial. To protect themselves and their property the Babylonians built embankments, raised their houses, and especially their temples, upon mounds, and cut canals by which their crops could be irrigated or their fields drained. The fertility of the Nile Valley depended entirely upon the mud brought down by the river, and when the flood was lower than usual there was famine in the land. So the Egyptians, too, had to dig canals and devise appliances for raising water when the river was low.

The main interest in these peoples is that, living in naturally fertile regions and increasing this fertility by artificial means, they obtained what food they required easily, increased in numbers, accumulated a surplus, and acquired leisure to exercise their ingenuity in other ways. Of these the first was pottery. The earliest earthenware vessels found in Egypt were made by hand with the aid of a piece of wood, and the shapes show that the potter's wheel was not in use. The discovery does not appear to have been made by the Egyptians, but by an earlier civilisation—probably Elam, to the east of Babylonia—whence it was brought by Semitic traders or settlers. In later times—we have been speaking of more than 7000 years ago—the Egyptians learned to weave linen from the flax which grows freely near water; and they made paper from the papyrus plant, until the land came under the dominion of the Hyksos or shepherd kings, when the parchment of shepherd peoples came into use.

The influence of pottery in human development is exercised in various ways. It is so easily broken that practice is obtained in its manufacture. The frequent necessity of replacing broken vessels causes the operation to be repeated, not once or twice, but many times in every generation. And as the primitive potter acquired more skill, he ventured on new forms and attempted fresh applications of the plastic material with which he was becoming more and more familiar. It is interesting also to note that, useless as broken earthenware was to the Egyptians, it has been of immense value in helping men of our own day to unravel the tangled skein of ancient history; the fragments cast on one side after they had served their period of practical utility remained, untouched and unaltered, to tell their story to those who, 7000 years later, desired to know something of the remote past.

In Babylonia and Syria clay served another purpose; for upon its plastic surface was engraved a record of the doings of men; and the great body of tradition handed down by word of mouth—upon which progress demands that posterity should improve—was emphasised and reinforced by the pictures and inscriptions which could be preserved on this well-nigh imperishable material. In Egypt the prevalence of the papyrus plant led to the introduction of paper at a very early stage, so that clay was rarely used for writing. But when intercourse with other communities arose, contracts were necessary, and these were impressed with a clay seal.

The earliest inhabitants of the Nile Valley probably constructed rough shelters of the large slabs of stone that lay ready to hand. These were succeeded by huts made from the reeds that grew freely along the river banks. Timber was not plentiful, but they built houses of it and made boats propelled by 50 or 60 oars a side. At a later date they utilised their knowledge of clay to make bricks, and they also constructed houses of the stone that formed the rocky sides of the valley. The practice of working in hard material encouraged accuracy of workmanship, and was not unconnected with the development of geometry. The pyramids are not more remarkable for their size than for the extraordinary exactness with which the blocks of stone were cut and laid.

The domestic animals were the goat, the ox, the ass, and the dog. The horse came to them about 2000 B.C. through Syria, from the grass lands that stretched between the Northern forests and the Caspian Sea. Until this animal arrived the great river from which they derived nearly all other benefits, served also as a means of communication, and enabled the kingdom to extend up to the shores of the Mediterranean.

The amalgamation of the long chain of tribes into a nation was only rendered possible by a system of writing; for there can be no cohesion unless orders can be transmitted with the accuracy and reliability that the written word does, and the spoken word does not, ensure. Something more, too, is needed than a merely pictorial form of expression, and the records show that signs, formerly limited to the description of things and operations, came to represent sounds. The invention of a suitable set of symbols was therefore a necessary condition of that co-operation which enables man to assume a wider control over nature.

The early civilisation of Egypt was due, then, to the fact that the ease with which food could be produced not only gave leisure, but also a surplus, which could be exchanged for the products of other lands. Stone implements and tools were replaced by those of bronze obtained in the course of trade with Nubia on the South, or with Cyprus on the North; ivory, again, came from the former district, coral from the Red Sea, and turquoise from Mount Sinai.

The fact that there was "Corn in Egypt" led many tribes, in less favourably situated areas, to visit the land for barter, and, occasionally for settlement or conquest. The great migrations of peoples throughout history seem to have been determined mainly by the *temporary* control of man over the natural conditions of his well-being. A disastrous flood, or a sustained drought, must be added to a wild and senseless war of extermination to account for the vast surgings of humanity which were so prevalent in early times. It was only as man acquired a fuller and more exact knowledge of the materials and forces around him, that he could brave an unkind climate, control a torrent, or wrest a sustenance from a reluctant soil.

On occasions when the forces of nature were too powerful for him, and he had to seek a more sheltered home, or when his peaceful life was invaded by others who coveted his wealth and easy existence, the result depended in great measure upon his skill in fashioning weapons of war. Thus, the early Semitic raids upon Babylonia owed something of their success to the fact that bow and arrow was opposed to sword and spear. Again, when the raiders from central Asia made their appearance they brought with them the horse, which was the most powerful agent in warfare until the invention of gunpowder. For, apart from the weight and terror of a cavalry charge, the horse enabled offensive and defensive movements to be undertaken with enormously increased rapidity.

In these early civilisations, therefore, we have glimpses of the way in which, at first, man bent his inventive powers upon means of existence. As conditions of life became easier he employed his leisure upon Art and Literature, and as intercourse with other groups of men grew, so also the human relations increased in complexity and necessitated codes both of local or national and international Law to regulate them. But local progress in the occupations of leisure depended in the first instance upon the inventive faculty which, arising out of primitive instincts, softened the asperities of his material surroundings, economised time, and saved labour. Whether, having secured these advantages he could retain them, depended to a large extent upon the direction of the same faculty upon the means of protection from marauding man. The struggle of man with nature for food and the necessaries of life is an unending warfare; and though men gain ground in the long run they quarrel among themselves for the tribute they have gathered from earth, and sea, and air.

The early history of man is very largely a history of conflict between two main groups of people, each of which had obtained a partial mastery of nature in different aspects. On the one hand, there were pastoral tribes inhabiting the grassy uplands and marginal park-lands of Central Europe and Asia, or the desert oases, who had learnt to keep flocks and herds, to hunt wild beasts, and to grow a little corn. Their weapons were the bow and arrow, and in Central Asia they had found and domesticated the horse. The chief dangers to which they were exposed were drought and wild beasts—for a country which was suitable for domestic animals was suitable also for these. The latter they overcame with their weapons; the former caused them to move their flocks and herds with the seasons, and when it fell upon them with exceptional severity, to migrate wholesale into well-watered lands where life of man and beast could be more easily sustained.

The activities of a pastoral people are almost wholly expended upon the care and protection of their flocks. Time is afforded for the contemplation of Nature, but there is little or no spur to active interference in the course of events. Such inventive genius as is called into play finds expression in means of offence and defence in regard to man and beast, and in means of transport. The nomad tribes became, therefore, the marauders or the carriers of the ancient world as occasion arose.

Agricultural peoples, on the other hand, were able to utilise the period of relative inactivity between sowing the seed and reaping the harvest for contemplation of natural forces, and were led to devise means of regulating the flow of water. As this achieved its purpose attention was directed to other aspects of surroundings: the art of metal-working progressed, clay and paper came into use, pictorial signs and then writing were invented, co-operation between different settlements arose, and hence the centralisation of control that binds scattered tribes into a nation.

The settled existence promoted by Agriculture encouraged the accumulation and storage of property other than food, and the experiments on various materials taught the value of substances obtained in the course of trade from other lands. Early conflicts had shown even the men of peace the use of better and more effective weapons of war, and they occasionally employed the knowledge thus gained to embark upon conquest, by which they opened the avenue for new material and goods, and added in this way to the results of their own toil. No doubt some of these wars were conducted for political power and personal aggrandisement, but they had the effect of increasing the wealth of a country, and they often provided slaves for public works.

Apart from the works of irrigation and drainage, ancient peoples erected enormous temples and tombs, much of this work being carried out by the aid of captives from other lands. At a time when natural laws were so little understood, superstition was rife, and good or ill effects were attributed to powers of light or darkness who were to be thanked or appeased from time to time. This accounts for the concentration of such time as could be spared from food-raising to the establishment of religious monuments, which in their magnitude outshadow those of our own day. On the other hand, the nomad people, not having obtained a sufficient mastery of food and water supply, lived from hand to mouth, relying more on their strong right arms, deadly weapons, and fleet horses, than upon permanent temples and a professional priesthood.

It has been well said that the nomads have no history, because they have left no permanent records. Their rules of life and conduct were and still are, opportunity and tradition. They devised means of protecting themselves against enemies, and means of transport suited to the country in which they lived. But in all ages they have done little towards material progress; they are fatalists, moving on when Nature orders them; settling occasionally and giving renewed physical vigour to a sedentary population; but on the whole remaining aloof from the world, treading the daily round in patience, ignorance, and animal submission.

As the nations of the Persian Gulf, the Syrian highlands, and the Nile Valley declined, the sceptre of authority in the Mediterranean passed successively to the Greeks and Romans—two peoples who differed as widely from one another as they did from those they superseded. The fame of the former rests rather upon their philosophy, literature, and art than upon any substantial additions to practical craftsmanship or industrial as distinguished from decorative arts. Much of our knowledge of the ancient world is derived from Greek writers. They collected and handed down to posterity information of incalculable value, and if, sometimes, they omitted to state how much was due to their own efforts and how much to the efforts of men who had preceded them, the reader can choose for himself between the charitable and uncharitable conclusion. Thus Hero of Alexandria wrote a book on Pneumatics in which he described the seventy-eight devices known in his day; and though he remarks that he has included his own as well as other men's inventions during and before his time there is nothing to show where the one ended and the other began.

There were two important centres of scientific learning. One was the famous Library at Alexandria—the city founded by Alexander the Great—which attracted scholars from all parts of the world. The extraordinary power of the Greeks for absorbing and improving upon the culture of a conquered race, and the value of their literary gifts, is nowhere more strongly emphasised than here. Egyptian geometry was acquired, extended, and systematised by Euclid in twelve books, four of which were destroyed subsequently in a great fire. Egyptian mechanical devices, the existence of which could otherwise only be inferred from the magnitude and accuracy of their works, were improved and recorded. Hero, apparently, invented the water-level, an instrument indispensable to a community pursuing agriculture in an organised way, and used for land-surveying in England down to Tudor times; while Ktesibius is credited with the invention of the suction-pump. The water-clock, which was first constructed by the Babylonians, was also modified by the Greeks.

The other centre was Syracuse, a Greek Colony on the eastern coast of Sicily, where Archimedes employed his genius largely in the interests of his Royal friend and master Hiero. He discovered the law of floating bodies—which implies a knowledge of the balance and the lever; he stated, perhaps not for the first time, the law of mechanical advantage; and he constructed ingenious engines of war which were used to defend the city against the Romans. The scientific discoveries and inventions of the Greeks were almost invariably applied to some practical purpose, but, except in an artistic sense, their practical achievements indicate no striking advance, and in craftsmanship the palm lay with the natives of India and Persia.

The Romans were essentially a nation of organisers, and they surpassed their rivals as law-makers and civil engineers. Wherever their armies penetrated they built roads of exceptional straightness and durability. The remains of their aqueducts show that they understood the construction of the arch, and Roman cement has stood the test of two thousand years. They drove a tunnel through the base of a mountain to convey water to the Imperial City, and they wrung from a somewhat unwilling soil a generous yield. Inventive in the strict sense of the term they were not, nor philosophical as were the Greeks. They were a military nation, winning wealth by conquest, and overcoming natural obstacles rather by efficient and systematic applications of known methods than by originality of thought and action.

The political systems of ancient civilisations, though of great intrinsic interest, are of small consequence to the purpose of this volume. They were slave-states, and relied upon military captives for the execution of their greatest works. Even in Greece, the home of ancient democracy and the cradle of political theory, probably one-third of the population were in a state of bondage. The most resilient product of the smith's hearth, the finest fabric from the weaver's loom, came from beyond the Indus, and when dissension broke out between the Eastern and Western sections of the Roman Empire, it was another race which carried philosophy, science, and craftsmanship to the Western world.

PART II

THE TRANSITION FROM ANCIENT TO MODERN CIVILISATION

CHAPTER II

THE MIDDLE AGES

When the barbarians under Alaric the Goth sacked Rome in the fifth century, they extinguished the light which had flung its rays across Western Europe. The period which, owing to the choice of school history, is one of the most familiar to English readers, is in some respects the darkest the world has seen since Egypt and Chaldæa were at the zenith of their fame. To the great practical achievements of these two nations Greece and Rome had added a little, but for seventeen hundred years the whole of Europe was to add less. True, the Greek and Roman historians and philosophers had collected a vast amount of information, and had recorded it in a form which would one day be useful to posterity; but for a time even this was not available. The barriers were the mediæval church, which sought to retain learning in its own control, and the Great Schism which for four centuries separated the Eastern and Western sections of the Roman Empire.

So far as scientific studies and certain practical arts were concerned, the break in continuity was more apparent than real. For the fall of Rome almost coincided with the rise of the Arabs to the pinnacle of their fame—a rise which is one of the marvels of history. Originally the nomadic inhabitants of the desert land east of the Red Sea, they invaded Babylon and came into contact with India and Persia, from whence they acquired skill in those handicrafts—textiles, leather-work, and steel-making—for which the East has from time immemorial been famous. From Persia, too, they acquired a knowledge of Geometry, Mechanics, Medicine, and Philosophy, which had been conveyed thither by refugees from Alexandria when the great Library there was destroyed by fire.

Striking westward, they spread along the northern shores of Africa, and entered Spain, where they founded many cities, including Cordova, which rivalled Bagdad in splendour. In Bagdad there is said to have been a palace with 38,500 pieces of carpet, of which 12,500 were of gold brocade. Cordova contained 200,000 houses and 1,000,000 inhabitants. A man could walk for ten miles through its paved streets, many of which were lighted throughout the night with hanging lamps. This was in the thirteenth century. Yet the streets of Paris were unpaved in 1460, and in 1550 London had not one public lamp. The Alhambra of Granada and the Cathedral of Cordova stand to-day as European examples of their stupendous architecture, though the beauty and luxury have passed from the buildings and the glory has departed from the race.

The Arabs did not hand on Indian, Greek, and Egyptian Science as they found it: they enriched it by contributions of their own. One of the greatest of their wise men—Alhazen—made many discoveries in Optics, and Geber has some right to be called the founder of Chemistry; for his discovery of the strong acids—nitric and sulphuric—opened up a field of experiment which had been closed to the Egyptians and the Greeks. Many devoted themselves to Medicine, and in Cordova alone there were nearly a hundred hospitals. Some of their astronomical observations were sufficiently numerous and accurate to be used in the eighteenth century to demonstrate the existence of certain changes in the Solar System which can be detected only by measurements spread over a long interval of time. But perhaps the most signal service from our point of view, that they are said to have rendered to posterity, was the addition of a 0 to the nine Hindu numerals, thus founding the decimal system of notation. Until that time the only mathematical process that had made any real progress was that of geometry. By the improvement of arithmetic the power of the ordinary man to give precision and definiteness to his ideas of material things was enormously increased, and the operations of trade must have been benefited in no inconsiderable degree. The Hindus had also made a beginning in the use of symbols instead of figures, and this was transmitted under the Arabic name Algebra. Several hundred years later a combination of Greek geometry and Hindu algebra was effected by Descartes, and proved to be one of the most powerful mathematical weapons ever discovered.

The Arabs appear to have been a practical race, and to have applied their knowledge effectively to the immediate problems of existence. The number of public baths and hospitals in their cities indicates that they appreciated the conditions of cleanliness and health. They settled in what are now known to be some of the most fertile regions of the globe, and they excelled in the construction of works for irrigating their land. By careful selection the varieties of cultivated plants were improved, and rice, cotton, silk, sugar, with many vegetables, were introduced into Europe. Attention was given to the breeding of sheep, cattle, camels, and horses. By some writers they are credited with the invention of gunpowder; they handed on the secrets of paper manufacture; and they are supposed to have introduced the compass in navigation. Methods of transport were developed, and a trade carried on in Spain alone, the revenue from which exceeded that of all the sovereigns in contemporary Europe. The most astonishing feature is the fact that they rose to eminence within a hundred years and six centuries later had ceased to exist as a European nation. This rapidity of growth is equalled only by the celerity with which the Japanese have adopted western methods during the last fifty years.

The importance of Arabian civilisation for us, however, lies in the fact that the Englishmen who devoted their lives to science in the Middle Ages derived the bulk of their knowledge and inspiration from Arabian sources. The first distinguished English student of nature was Roger Bacon. He lived from 1214 to 1292, and was, for those days, exceptionally well-equipped for ascertaining what had been done before his time. He knew Arabic, Greek, Hebrew, and Latin. The whole range of scientific knowledge claimed his attention. He was, after the fashion of his time, a chemist, a physicist, a mathematician, and an astronomer. He applied his knowledge to the correction of the calendar; he showed a rare grip of the essential interdependence of the physical sciences and the relation of calculation to experiment; and he was the first to introduce the experimental method into England.

The fact that Roger Bacon was the outstanding scientific figure of the age which witnessed the application of gunpowder in war, has led to him being credited with the discovery. But there seems to be no doubt that it was used before his time. The Chinese are said to have employed it in A.D. 84, and the Arabs in 1118 at the siege of Saragossa.

British records indicate that it was used by Edward II. at Bannockburn, and three pieces of cannon were in action at the Battle of Crecy in 1346. These were tree-trunks, bored out and strengthened with iron bands. The projectiles were of stone, about the size of a cricket ball, and if they missed the mark the noise and smoke were probably equally effective in striking fear into the hearts of the enemy.

Gunpowder consists of saltpetre, sulphur, and charcoal in the proportion 75, 15, and 10. Mixtures in other proportions either flare up or explode with less violence. It seems probable that incendiary mixtures were used for many years before the composition necessary for explosion was discovered. Even then success did not follow every attempt, because pure materials were difficult to obtain. The charcoal was prepared easily enough by partially burning wood in heaps, coated over with turves, so that the air supply was insufficient for complete combustion; sulphur was found native in volcanic districts; and saltpetre occurred as an efflorescence on the surface of the soil, from which it was scraped with care. Perhaps the charcoal varied least in composition, the saltpetre most; and the chemical science of the day was unequal to the task of separating undesirable constituents.

The unreliability of gunpowder owing to its varying composition, and its sensitiveness to damp, together with the imperfections of early ordnance, prevented fire-arms from exerting the immediate effect noticeable in the case of the bow-and-arrow and the horse. The success of the British arms under the Plantagenets was due to the skill and power of the English and Welsh bowmen rather than to any new device; and this skill alone led to the replacement of chain mail, famous during the Crusades, by plate armour. But the increasing use of gunpowder in the fourteenth and fifteenth centuries rendered any kind of armour useless, and it gave to infantry an ascendancy over cavalry which has never been lost. No body of horsemen can attack with safety an equal body of foot soldiers unless the latter are disorganised or taken in flank.

Let us now examine the conditions of life in England during this period. When the Roman legions were withdrawn the country fell back into a state of barbarism which was intensified by the raids of the Northmen and the Danes. The appreciation of comfort and the love of beauty which is so marked a feature even of the early civilisations was absent altogether from Western Europe, and life went on much in the same way after the Norman Conquest as it had done for hundreds of years before. The nobles who took part in the Crusades doubtless saw something of the amenities of existence, and perhaps endeavoured to introduce a higher standard of living into their own homes. But, if so, it took 300 years to have any appreciable effect. Meantime the personal uncleanliness and the insanitary condition of the houses had their natural result in the Black Death, which swept across Europe in 1347–48, and at intervals for twenty years afterwards. The scarcity of scientific knowledge, and, more particularly, the dissociation of scientific knowledge from the practical affairs of life, rendered the people an easy prey to the scourge. In England alone it has been estimated that from one-third to one-half of the population perished, and whole villages were wiped out. The result was a scarcity of agricultural labour and dear food—evils which Parliament endeavoured to remedy by imposing, in 1351, restrictions upon the migration and wages of those who worked upon the land.

The Statute of Labourers, however, was ineffective, for the organisation of Agriculture was far too thoroughly shattered to be repaired in this way. Personal service had gradually given place to money payments or wages. Food was terribly scarce, and the rate of wages obtaining before the disaster was insufficient to purchase the means of subsistence. So wages had to rise, and the landowner had to cast about for ways and means of increasing the yield of the soil. To understand how this was done we shall have to go back nearly a hundred years.

In the days of the early Plantagenets trade was very largely local, and money payments were not normal outside a few towns. The bulk of the men were engaged in Agriculture or in interminable wars, and the smith or carpenter often gave his services to the community in return for food and goods or the use of land assigned to him. The cultivation of the soil, and the care of flocks, herds, and droves of pigs was normally carried on for sustenance and not for profit. Clothing was mostly of rough cloth or untanned skins, except in the rare instances when opportunity offered for exchange with the merchants for cloth woven in other lands. The goods which a man could store were perishable, and there was no incentive to the accumulation of wealth. The French possessions, however, encouraged some exchange with the continent, and English wool was bartered for Gascon wines and the product of the Flemish looms.

The French wars of the later Plantagenets had two important effects. The use of money was largely increased and was recognised as the normal and best means of recompensing the soldiery. Moreover, the need for money directed the attention of Edward I. to the foreign trade as a source of income. He encouraged, therefore, the product of wool, placed an export duty on wool and hides, and an import duty on foreign wines, thus founding the Customs. The collection of these duties demanded that the trade should be supervised, so that it became necessary to indicate the towns in which it could be carried on, and, in accordance with mediæval ideas, the bodies of merchants to whom this foreign trade must be confined.

Before the Black Death wool-growing was limited by the methods of Agriculture which had been in operation since the Conquest. Generally speaking, the inhabitants of a village would consist of the lord of the manor and his immediate retainers, freemen, and serfs. The land was divided into three fields, and common land used by all for grazing. There were also usually common meadows identical with the common pasture. Each field was divided into narrow strips, which were distributed among the freemen and the lord of the manor. No man's strips were close together, so there was no monopoly of advantage as regards soil or position.

In this system there were certain drawbacks from the point of view of both tillage and pasturage. Cultivation in strips discouraged individual initiative and compelled, in effect, every one to follow the same routine. The methods which were causing exhaustion of the soil were continued, and for nearly four centuries very little improvement was made. Again, the most profitable rearing of sheep and cattle could only be carried out if the best breeds were isolated from the common herd. This obviously demanded that the fields should be enclosed; and when the landowners found themselves faced with the results of the Black Death they decided to go in for wool-growing and set about the consolidation of their holdings. The enclosures were of two kinds. In the first place the landowner collected the strips together and converted them from tillage to pasture; and in the second he enclosed a large amount—sometimes the whole—of the common land.

The concentration of the strips of the lord of the manor involved also the concentration of the strips of the freeman, and of customary tenants, and to this extent it was an advantage rather than otherwise to tillage, for it enabled each man to improve his methods of cultivation if he chose. But there were freemen who could not produce their title, and the enclosure of the common land robbed others who could of grazing for their stock, without which they were unable to make both ends meet. Consequently many had to give up their holdings and seek work at a weekly wage. But even here they met with difficulty, for though the lord now possessed a larger area of land, he required less labour for sheep-farming than for cultivation; so the dispossessed were driven into the towns.

Though the enclosures only affected about half the land in the country—and were far from universal in that half—they produced untold misery among the rural population. The movement was a perfectly sound one in that it led to a better use of the soil where arable culture was continued; but it was carried out in many instances by methods which cannot be defended. Before the Black Death the position of the agricultural workers was improving on evolutionary lines. The ultimate result of the visitation was a revolution which, while it brought good in its train, was accompanied by very much human suffering. The change marks the beginning of the period when industry in England was normally conducted not merely for sustenance, but for gain, and henceforth the Crown kept a jealous eye upon trade as a means of increasing its own revenue. But this led in turn to an increase in the political power of the tradesman and the merchant, for they could be of considerable use to the King and his ministers, and were people who could ask for privileges for themselves or the town in which they lived.

The towns in existence after the Norman Conquest were, except for about a dozen fairly important boroughs, merely large villages. The congregation of the population at certain centres was due to a variety of causes. Cross-roads, or a ford or bridge which was important for military reasons, or because it lay in the track of the travelling merchant, were commonly chosen. The mouth of a river to and from which ships sailed to foreign lands, and a shrine to which pious men came to worship were other selections. In more troublous times the stronghold of a great baron, whose retainers could police the surrounding district, formed the nucleus around which the houses clustered. The tendency to collect in groups was enforced by a certain division of labour which had arisen, and which rendered each man of some importance to his neighbours. Thus the use of windmills for grinding corn enabled one man to satisfy the requirements of a large number, and one carpenter or smith was capable of supplying the needs of a considerable village. But the towns or villages were the property of the king, or the lord of the manor, or the monastery, and sometimes a town was divided between two owners.

The mediæval view that it was immoral to strive for wealth by taking undue advantage in buying and selling, led to exchange being carried on in markets, which not only formed convenient meeting-places, but permitted of adequate supervision. The unfair control often exercised by the lord of the manor led some towns to seek the privilege of managing their own affairs, and with more or less difficulty they secured charters in return for annual payments. This movement arose about 1150.

For the purpose of regulating the trades of a chartered town there was organised in many cases a *gild-merchant*. This was open to membership on payment of a fee, but admission could be refused. Prices and qualities of the goods sold in the markets were fixed and, except for essential foodstuffs, only members of the *gild* could sell freely without payment of a toll. So long as the town and its trade remained small, the *gild-merchant* represented the whole of the traders;[1] but as the traders and the number of separate trades increased, each became organised into a separate *craft-gild* which began to be common about 1250. These bodies grew more powerful as money payment became usual, and it was soon found that by limiting membership of a *gild* to a few, these few could accumulate wealth more rapidly. The apprentice could no longer be sure of becoming a master, and thus a class of journeymen, who had to hire themselves out for a weekly wage, came into existence. There also ensued a separation in the gilds of *freemen* and *yeomen* of the gild, and there were sometimes separate "yeoman companies." At the same time the labour working for hire was increased by the exodus from the country consequent on the change in the methods of agriculture.

At first no distinction was made in the gilds between those who were workmen and those who were merely traders. But the latter were the men to whom fell the duty—and privilege—of opening new markets, and to whom the Crown granted monopolies and protection in order to increase its own revenue. The wealth which arose from trading for profit led to a demand for finer qualities of cloth, and successive monarchs from the early Plantagenets up to the

[1] There was no *gild-merchant* in London, only *craft-gilds*. The *gild-merchant* still survives, but merely as a ceremonial memorial, in Preston.

Tudors encouraged the immigration of Flemish weavers, while many skilled workmen were driven to seek refuge in England by religious persecution on the continent. In this way the weaving industry prospered greatly, and the country began to export cloth as well as raw wool. The gilds tended to become rich corporations who managed, or attempted to manage, the trade with scant consideration for the workman; and the latter, where they were sufficiently numerous, banded themselves into *fraternities* to protect their interests. Differences were settled, as a rule, without fighting in England, but on the continent they often led to scenes of violence. It was already obvious, however, that "to buy in the cheapest market and sell in the dearest" could not always be practised without regard for the welfare of those who did not belong to the favoured few.

Apart from the farmer and the weaver the most important craftsman in the Middle Ages was the smith. The preservation of this word as a surname both alone and in such combinations as Goldsmith, Arrowsmith, etc., in Great Britain, together with the similar preservation of the surname Schmidt, in Germany, Fabri in Italy, Le Febre or Le Fevre in France, indicates the widespread existence of workers in metal. Every military campaign depended no less upon the skill of the armourers and farriers than upon the prowess and courage of the knights and men-at-arms. Moreover, in the more peaceful arts the smith was a sort of link which held the community together, for he was able to supply tools and implements far beyond his own needs. In the ordinary sense his trade was a more separate and highly specialised one than spinning and weaving, and though many houses might contain a spinning-wheel or weaving-frame, none but that of the smith possessed a forge. Originally he was, perhaps, attached to a great noble as one of his most important retainers, just as to-day a large landowner keeps an estate carpenter; but he soon became one of the central figures of the village or township, rendering general service in return for food, clothing, or other necessaries of life.

Not a few of the most skilled craftsmen in metals were foreigners, or at any rate men who had learnt their trade on the continent. The cunning of the Eastern workman which had been conveyed to Europe by the Arabs was long, however, in making its way across the channel; and where a craftsman of special skill appeared his services were often commandeered by the king or one of his nobles. The arts of war claimed first attention, and the implements used in peaceful pursuits were often crude in workmanship and inferior in quality. It is a little difficult at this period to separate the smith from the ironfounder, but the armourers depended as a rule upon imported material. There were many iron-smelters scattered about the country—more particularly in the Forest of Dean where, in 1282, 72 forges were leased from the Crown: there were also forges in the neighbourhood of Leeds. The price of home-made iron, however, was higher than foreign metal, and the quantity produced was quite insufficient to meet the demand. In order to prevent the price rising Parliament enacted in 1354 that no iron, wrought or unwrought, should be exported, under heavy penalties. And again when the importation of a number of articles was prohibited in the reign of Edward IV., iron was allowed to come freely from abroad. In the fourteenth and fifteenth centuries imported iron came chiefly from Spain and Germany, and the trade was conducted by foreign merchants in a market called the Steelyard in

London. The Steelyard was the headquarters of the Hanse League, and its site is now occupied by Cannon Street Station.

The first vigorous development of the iron industry in England occurred in Sussex where the old cinder-heaps gave some idea of Roman activity. A beginning was made near Lewes in the thirteenth and fourteenth centuries, but the real importance of the industry here belongs to the next period. It will be observed that the locality was determined by the presence of both iron ore and timber. As timber contains much moisture, and yields a quantity of gas and liquid products of combustion, it was invariably converted into charcoal before being used in smelting. The furnace was of clay or masonry, and the first charge of charcoal was overlaid with a mixture of charcoal and ore. The iron produced in this way was similar to modern pig-iron—it was brittle and unworkable at the forge. Refining was accomplished by heating on a charcoal hearth under a blast from a bellows driven by hand, or horse, or water-power. The excess of air in the blast removed most of the carbon from the metal, producing wrought-iron, which could be worked under the hammer.

The difficulty of transport led to the close association of the smith and iron-smelter, so that the latter manufactured not only iron but iron goods; thus at Lewes an important trade was in nails and horseshoes. But the emancipation of the smith from the service of a particular lord or monastery, and the development of inter-town trade, led to special skill being developed in certain districts, so that some smiths became manufacturers. In this way Sheffield became celebrated for knives and arrow-heads, and laid the foundation of its fame as a cutlery town; while Birmingham became a centre for swords, tools, bits, and nails. And in

London, where wealth and rank had concentrated, probably with few set-backs from Roman times, the goldsmiths and silversmiths became established.

But metal-working was still in a backward state, and the metal-workers were far less influential in affecting government and moulding English life than the land-owners and the cloth-workers. The country still lived on the land, and such examples of foreign skill as the people could purchase was generally in exchange for the surplus of wool and hides produced as a result of the agricultural revolution.

CHAPTER III

THE RENAISSANCE AND THE PERIOD OF EXPANSION

THE two hundred years from the fifteenth to the end of the seventeenth century are more interesting from an intellectual and political point of view than in their industrial aspects. The methods of agriculture and the processes of spinning and weaving varied but little from those of the previous period, and such economic changes as did occur were mainly due to the strong personal government of Tudor monarchs, and the growth of trade which followed the adventurous voyages of the Elizabethan seamen. The most important social fact was the growing wealth of merchants. Both they and lawyers were quick to realise the profitable character of sheep-farming, and ready to invest their money in land. Enclosures still went on, though to a diminishing extent after 1500. Some attempt was made to put a stop to the practice in the reign of Henry VII., and again in the reign of Henry VIII.; but the latter monarch, having confiscated the property of the monasteries, gave the land to courtiers, who continued to acquire wealth in the same way as the former owners. Enclosure and the consolidation of holdings continued, therefore, well into the seventeenth century.

The misery and distress in rural districts which have been noted in a previous chapter continued throughout the fifteenth century. Many houses were wretched, insanitary hovels; pestilence was rife; and it has been estimated that, during the Wars of the Roses, which began in 1455 and lasted for thirty-five years, one-tenth of the population died prematurely from wounds or disease. The land was badly tilled, and an average crop of wheat was only 8 bushels per acre. Labour was scarce, and wages rose to 4d. a day, twice what they had been a hundred years before. The only occupations that remained profitable besides sheep-farming were spinning and weaving, and these were passing into the control of men who were merely traders.

Debasement of the coinage in 1543 by Henry VIII. led to a rise in prices which, however, was soon accentuated and rendered permanent by an influx of gold from America. A real revival took place during the reign of Elizabeth, whose minister, Lord Burghley, encouraged industry in many ways. Her reign marks the definite establishment of "Mercantilism," which was a protective theory of foreign trade, and which held sway as a political policy until the close of the eighteenth century. The principal methods by which wealth was to be secured were four in number:—

1. Goods must be carried in English ships, so as to stimulate shipbuilding.

2. Agriculture must be encouraged so as to render the country self-supporting.

3. Home manufactures must be encouraged so as to provide work, and competitive foreign imports must be discouraged.

4. Gold must be accumulated, and therefore exports must be encouraged and imports discouraged.

In pursuance of this policy Acts were passed covering a wide field. Those requiring goods to be carried to or from

English ports in English ships are known as Navigation Acts. The first of these had been passed in 1381, and the policy was pursued more vigorously during the Protectorate of Cromwell. The Commonwealth Navigation Act of 1653 was probably intended, however, quite as much to encourage British shipbuilding, and so to increase naval security, as to keep the foreigner out of the carrying trade. The acts which encouraged manufactures were also often closely connected with the naval expansion. For example, every man who had sixty acres of land under tillage was required to devote one-quarter of an acre to flax or hemp, in order to provide rope. Again, the manufacture of copper for brass cannon, and of sulphur for gunpowder was encouraged by granting monopolies. These monopolies were unpopular, and in the reign of James II. were abolished with one exception—that of an invention which could be protected by letters-patent. To this day the Patent Law remains the sole instance of a monopoly of this kind which can be secured from the State.

Manufactures were also encouraged by laws requiring people to wear garments of home-made cloth, and in this way the woollen trade benefited, but its growth was accompanied by a change in organisation. The old *gild* system had gradually broken down. In some cases the wealth of the *gilds* had been seized by Henry VIII., and in others their greed and exclusiveness had led to spinning and weaving becoming established in towns where there were no restrictions. Spinning, more especially, was becoming a *commission* industry in the country as well as in incorporated towns and in the latter case was carried on by women and children as a supplementary means of earning a living on the land. The yarn was taken into the market town to sell, and it was bought by weavers or by merchants, who handed it out to weavers in their employment. At a later date the merchant himself fetched the yarn when he required it, and in some cases he or the weaver bought the wool and gave it out to be spun. And they not infrequently drove a hard bargain with poor people, who depended upon them.

There were many cases in which this commission system was a great boon to those who made a poor living on the land. But the work was not done under healthy conditions; it involved long hours, and it was often the cause of great suffering and hardship. When a man found that he could sell more yarn than his family could spin or weave, he took in apprentices, and the wages and other conditions of employment of these were minutely regulated by an Act in 1563—an Act which remained in force until 1802, and was then only repealed so far as pauper children were concerned. Meantime no real change was made in the process. The spinning-wheel and the clanking wooden loom remained in vogue until the latter half of the eighteenth century. In fact, the only mechanical invention of industrial importance during this period was John Lee's Stocking-Frame. Invented in 1589, it marks the beginning of the hosiery trade in Derby, Nottingham, and Leicester.

In one direction, at least, the Mercantile policy was instrumental in retarding an industry. The iron trade, which was gradually moving to the Midlands as the forests of Kent and Sussex were destroyed, was making great inroads on the timber which was required for shipbuilding, and in 1558, 1562, 1580, and 1584 Acts were passed restricting the number and position of iron-works. This led Dudley in 1619 to try whether coal could be used in place of charcoal, and, though he was successful, opposition from other iron-workers forced him to abandon the method. Nearly a hundred years elapsed before another successful attempt was made.

The increasing wealth and the freedom of the country from civil strife can be traced in the changes in Architecture. The country houses, more especially, began to be built in a style indicating a desire for comfort rather than a necessity of defence. The loop-holes of mediæval dwellings gave way to glazed windows, and the high-pitched roof gives to dwellings of the Tudor period an individuality which marks them off sharply from earlier and later attempts. The moated castle—useful enough before the days of gunpowder—was now no refuge against an angry monarch, and the wealthy merchants and lawyers who became country squires were not of warlike disposition.

The maritime expansion which is characteristic of this period had its beginning in the merchant companies, which were established in connection with the trade in wool and cloth. It will be remembered that the imposition of an export duty on wool by Edward I. rendered it necessary for the trade to be carried on only at certain centres and by certain authorised persons. These Merchants of the Staple, who were sellers and exporters of wool to foreign merchants, were regulated by an Ordinance in 1353 when Edward III. was king, and they were a really important and powerful body in the reign of Henry III. Bodies with a wider range of operations were the Merchant Adventurers, who dealt generally in English products and manufactures, of which wool and cloth were the most important. They began to be important in the reign of Edward III., but only received a charter in 1407 during the reign of Henry IV. Overcoming their first rivals, the Merchants of the Staple, they entered into competition with the foreign merchants of the Hanseatic League, whose privileges were finally withdrawn towards the end of the sixteenth century.

Meantime other events were occurring which were favourable to their growth. During the fifteenth century the Portuguese, inspired by Prince Henry the Navigator, were creeping down the west coast of Africa, and acquiring that confidence and skill which was soon to find expression in voyages of greater daring. In 1487 a Portuguese navigator, Vasco de Gama, rounded the Cape of Good Hope; in 1492 the Genoese, Christopher Columbus, sailing under the patronage of Ferdinand and Isabella of Spain, discovered the West Indies; and in 1498 another Portuguese reached India by sailing round the African continent. These voyages were undertaken not only in a spirit of adventure and for commercial gain, but also because the capture of Constantinople by the Ottoman Turks in 1453 had closed the ordinary route to the East. The nations of Western Europe were constrained, therefore, to seek other paths to that little-known world, which, from time immemorial, had been a source of wealth and wonder.

Henry VII. had dallied with an offer from Columbus to sail on his behalf, but in 1496 John Cabot, another Genoese, who had settled in Bristol, obtained a patent authorising him to proceed on a voyage of discovery. Sailing in a small ship, the *Matthew* of Bristol, he sighted the coast of North America, and repeated his voyage in 1498. This marks the first step taken by England to expand into a world-wide empire, and it brought the English into conflict successively with Portugal, Spain, the Netherlands, and France. In 1494 the Pope had divided the New World between Spain and Portugal by a line of longitude, and while this did not prevent English seamen from taking what they could by force of arms, it stimulated attempts to find a North-West or North-East Passage to India and Cathay.

Henry VIII. continued his father's policy of building big ships—the *Henry Grace à Dieu* was of 1500 tons—and purchased others from abroad. The most famous of these, and the last built in foreign yards, was the *Jesus* of Lubeck, of 700 tons, which at a later date was lent by Queen Elizabeth to Sir John Hawkins for privateering in Spanish seas. The race of Devon seamen was now at the height of its fame, and in the years 1577–80 Drake sailed round the world.

About this time a new kind of company arose. The Merchant Adventurers had traded singly, and were only united for the purpose of securing concessions and crushing competition. But the Muscovy Company, which was formed under the governorship of Sebastian Cabot to discover a North-East Passage, and accidentally resulted in opening up trade with Russia, was a joint-stock company, in which each member contributed to the common capital and shared in the profits. Before this time the adventurers had received no tangible assistance from the Crown, though a portion of the profits went into the Royal Chest. But Queen Elizabeth contributed to the capital of the Muscovy Company, and was as well a participator in its success. The Levant Company, established in 1581 to trade with the Mediterranean, was also a joint-stock concern, and the East India Company, founded in 1600, adopted the same plan in 1612.

While the fifteenth century was one of pioneer exploration, pure and simple, the sixteenth was one of exploration and privateering. The great outburst of maritime enterprise was followed by a century of trade and settlement—less exciting but of more permanent value. With Spain and Portugal, Exploration and Empire went together; the English, coming later upon the scene, developed more slowly. For one thing, trade was mainly with the rich, thickly-peopled tropical East, and settlement was in the sparsely-populated temperate West, and the healthy tropical islands which lie off Central America. Sir Walter Raleigh and his half-brother, Humphrey Gilbert, had made strenuous efforts from 1578 to establish colonies, but the motive for emigration arose only when internal disturbance created a desire among people to leave their native land. In the seventeenth century there was religious persecution and civil war, but no foreign war of long duration. It was distinguished, therefore, by a lack of continuity of foreign and home policy, and by the continuous emigration of those who desired liberty of thought and action.

While the foundation of the Empire did much to mould national character, its importance to us lies in the wide range of raw materials which the new lands revealed, and the vast markets which it opened for British manufactures in the eighteenth and nineteenth centuries. Moreover, the stimulus which the struggle for the possession of the colonies and dependencies gave to British shipping not only enabled this country to become eventually the great carrying power of the world, but to become also the centre of the greatest shipbuilding industry which the world had ever seen. The impetus given to arts and manufactures, however, was not at first attended by any great improvements in method. The demand was met rather by proceeding upon old and well-established lines, than by venturing upon novel methods of organisation or process. It was left for the men of the two succeeding centuries to break away from tradition and to create that industrial revolution which stands as a landmark of material progress.

Returning for a moment to internal affairs, it may be noted that the improvement in the condition of those who worked upon the land during the reign of Elizabeth was maintained generally throughout the seventeenth century. The agricultural population, originally concentrated in the south and midlands, began to spread northwards, and by 1688 there was no great difference in density between the southern and northern counties. Clover was introduced, and the growth of turnips, which were already well cultivated in Holland, was encouraged. The practice of liming and marling, which had been discontinued since the fourteenth century, was revived. The improved hay crops which followed, together with clover and turnips, enabled a larger number of cattle to be kept throughout the winter. The supply of manure was thereby increased, impoverishment of the land could to some extent be prevented, and the corn crop rose to 20 bushels an acre. Except for the check experienced during the Civil War, agriculturists had little of which to complain. The domestic industries helped the small man, the landowner reaped a rich return, and the men who emigrated did so for conscience' sake rather than under the pressure of economic cause.

The influence of the central government upon the provision of local necessities is well illustrated by a series of events which were not without intrinsic interest, and subsequently not without considerable practical importance. The subject was the control of water, on the one hand for the supply of towns, and on the other for the reclamation of unproductive marsh land. At all times and in all places the growth of a large, and the maintenance of a healthy, population has been dependent upon an adequate supply of pure fresh water. One of the earliest examples in Great

Britain of a town supply from a distant source is that of Tiverton in Devon where, since 1240, water has been conveyed by an artificial channel from a spring on White Down, five miles away. A much more important undertaking was that by which Sir Francis Drake in 1591 brought water to Plymouth from the source of the Meavy on Sheep's Tor. For 24 miles the stream winds round the hillsides and finally flows through the main streets of the town. Both these works were carried out in the face of natural difficulties only.

In the middle of the fourteenth century the citizens of Hull were sometimes in straits for want of water, which occasionally had to be conveyed from Lincolnshire across the Humber in boats. An attempt to lead water into the town from springs in the neighbourhood of Hessle, Anlaby, and Cottingham met with vigorous opposition from the villagers, and in 1376 an appeal was made to the Crown. An enquiry was ordered, and as a result powers were given to construct an aqueduct from Anlaby springs to Hull. But the project was not accomplished in peace until some of those who objected to the scheme had been hanged at York. There are occasions of more recent date when the disappearance of ancient customs is to be regretted. The method of dealing with turbulent minorities was, at least, effective!

But no city can compare with London in the halo of romance which surrounds its water-supply. The early inhabitants who built their houses along the river, satisfied their needs from its placid stream, while those who lived farther from the banks relied upon springs or wells, the situation of which can still be traced in the names of streets and districts. When the springs gave out and the wells became polluted, water was conveyed in conduits (of which at one time there were sixteen) from Tyburn, Highbury, Hampstead, Paddington, and other places, then well outside the metropolis. An unusual quantity of water was needed, because the houses were made of wood, and the Corporation required every household to keep a barrel of water at hand in case of fire.

In the sixteenth century the springs which supplied the conduits began to yield less, the population was growing, and something like a water famine arose. The conduits were the scene of fierce struggles, and when an attempt was made to obtain water from the Thames the inhabitants of the streets leading down to the river claimed a monopoly and endeavoured to levy tolls. A number of persons then began to hawk water about the town, much in the same way as milk is hawked to-day. Water-carrying, in fact, seems to have been a fairly lucrative occupation.

At this stage the Corporation sought the aid of a Dutch engineer, and Peter Morice in 1582 constructed a water wheel under one of the arches of London Bridge, which worked a pump and thus conveyed the water to the inhabitants who lived remote from the river-side. The plan was successful, and a few years later instructions were given for another arch to be used in the same way. But while the needs of the people were met for a time as regards quantity, the increasing density of the population along the banks of the river rendered it necessary to seek a supply from a purer source. Accordingly, about 1600 the Corporation obtained an Act empowering them to obtain water from springs in any part of Middlesex or Hertfordshire, and in 1605 a further Act was passed which specified the springs of Chadwell and Amwell in Hertfordshire.

An Act of Parliament, however, was only the beginning of the difficulty. The next problems were, "How is the money to be found?" and "Who is to undertake the work?" The Corporation were willing to contribute to the expense, but private individuals with the necessary courage, capital, and experience were not easy to find. Matters hung fire until 1609, when Hugh Myddelton, goldsmith and merchant, stepped forward and essayed the task. His agreement, signed on the 21st April 1609, bound him to commence the work within two months of the acceptance of his offer, and to complete it within four years.

It is not in human nature that such a scheme could be carried out without opposition from the landowners through whose territory the river flowed; and in these cases it is never very difficult to create a great popular destructive movement among people who are not directly concerned. Myddelton, therefore, had to face enemies who made their presence felt, not only on the line of the river, but also in Parliament. Moreover, he found that he had under-estimated the time required, but here the Corporation met him by granting an extension of five years. And he finally triumphed over his other opponents by the aid of the King, who placed the Royal influence and the resources of the State purse at his disposal.

The water was allowed to flow into the terminal reservoir at Islington in 1613, and this event was the occasion of a great pageant. It is hardly necessary to dilate on the immense benefits which several million gallons of pure water daily conferred upon a city full of timbered houses, subject to disastrous fires, and visited from time to time by fever and plague; for these were recognised before the work began. But the certainty of the New River becoming a source of wealth to the promoters or their legatees was not so apparent. The capital was divided into seventy-two shares of approximately £250 each. Half of these belonged to

Myddelton and half to James I. Myddelton conveyed twenty-eight of his holding to other persons, and subsequently retained only two shares. Charles I., who had inherited thirty-six shares from his father, transferred them to the Company in return for a fee farm rent of £500 a year. The first dividend was in 1633, and amounted to £15 : 3 : 3 a share, but in 1636 it was only £3 : 4 : 2. At this stage King Charles unloaded his shares. He could not see far enough ahead. By the end of the seventeenth century the dividend was £200 a share, or 80 per cent; at the end of eighteenth century it was £500 a share; and in the latter half of the nineteenth century, £850.

The interest of the London water-supply lies in the fact that it was the earliest example on a large scale of what is to-day a great and growing problem, and that its solution was attended by all the human influences which have continued to face the efforts of a growing community to provide itself with the means of cleanliness and health. The records of nearly every modern industrial town are eloquent of unreasoning opposition, vexatious delay, heavy law-costs, and extortionate compensation. But as an engineering feat it was eclipsed by the great reclamation works which were undertaken in the seventeenth century. The most famous was the drainage of the Fens, carried out by Cornelius Vermuyden, the Dutch engineer who had the good fortune to enlist the aid of successive Stuart sovereigns in his schemes. Before his time the district was a vast marsh, 2000 square miles in area, and open to the sea, and which, from the days of the Roman occupation, had been an object of interest to men who realised what riches lay beneath the shallow waters. There is, indeed, reason to believe that the Romans did raise the embankment which formed naturally where fresh and salt waters met, and constructed a drain, known as Carr's Dyke, through which the surplus water could escape.

The old churchmen, who held the monasteries on the islands of the Fens, made numerous efforts to reclaim the land in their districts; but work of this character had been so seldom carried out in England that no man had the experience which would have ensured success. The Government took action. Dyke-reeves were appointed to maintain the old sea-wall in repair, and Commissioners, called Commissioners of Sewers, to see that the drains were kept open. Willows were planted along the banks, and swine were prohibited in the vicinity unless they were ringed, so that "rooting" was too painful to be pursued. In spite of all these precautions the Fens were for the most part unreclaimed down to the end of the seventeenth century; and the fenmen eked out an unhealthy and precarious existence by grazing, fishing, and fowling.

The great authorities on the control of water in those days were, of course, the Dutch, whose country had been wrested from the shallows of the sea. It was only natural, therefore, that when, in 1621, a serious breach occurred in the Thames wall at Dagenham Reach, James I. should invite one of their engineers to effect the necessary repairs. Having accomplished this work to the satisfaction of his Royal employer, Cornelius Vermuyden drained the Royal Park at Windsor, and reclaimed 70,000 acres of land at Hatfield Chase in the district of Axholme, where the island of that name rose above a waste of inland waters. Meantime, the kingly patron was no longer James I., but Charles I.

The task was carried out mainly by the aid of Dutch and Flemish workmen, and met with great opposition from the fenmen. Over and over again the embankments were broken down and drains filled up, while the conflict led to loss of life and the invocation of the law. But Vermuyden was undeterred by the difficulties which beset his path. He rose superior to every untoward circumstance, and having carried his project to a successful issue, he turned his attention to the West Country, where he reclaimed small areas on Malvern Chase and Sedgemoor.

In 1631 the problem of the Fens of the Eastern Counties was attacked by Francis, Earl of Bedford. The services of Vermuyden were obtained, and an energetic commencement was made. Again the fenmen banded themselves together, and hindered the work in every possible way. Much was made of the fact that it was being undertaken by foreigners, in whom no desire to benefit Englishmen was to be expected. The situation was rendered worse by the fact that the district was not so easily drained as Holland, so that mistakes were made; and by the shortage of funds from which the promoters suffered. The King then intervened, and the scheme was revised and extended. But a political crisis was at hand. The attempts of Charles I. to levy taxes illegally led to the trial of John Hampden for refusing to pay ship-money, and shortly afterwards Civil War broke out and interrupted the work for many years. The Earl of Bedford, who had undertaken the work, died, and when the final and successful attempt was made it was his son who was concerned, and the Commonwealth which celebrated the achievement.

But the price of tenure of the newly-won land was unremitting vigilance. The retaining-walls had to be maintained in a sound condition, the drains kept clear, and the water pumped from the lower levels by the force of wind. So long as these matters received attention the aqueous tyrant was subdued and turned to useful purpose.

It drove mills and served as a means of communication. Six hundred and eighty thousand acres of the richest land in England, which had lain hidden beneath its surface, were brought into cultivation, and a dismal, unhealthy swamp converted into a healthy and fruitful plain.

While the connection between industry and politics was growing closer, intellectual and industrial progress still pursued parallel paths too far apart to have any influence upon one another. Nevertheless there are some aspects of the progress of learning which should be noticed at this stage. It has already been remarked that the Eastern and Western halves of the Roman Empire were separated in the fourth century by the Great Schism. Constantinople was the centre in which the heritage of Greek learning was jealously guarded, and Western Europe was mainly dependent for its scientific knowledge upon the teaching and writing of Arabian scholars. Towards the end of the fourteenth century the Eastern capital was threatened by the Ottoman Turks, and in ones and twos scholars began to seek refuge in Rome and other Italian cities. When the storm finally burst in 1453 there was a wholesale transfer of scholars and manuscripts from East to West.

The result of this was twofold. Firstly, there was a renewed interest in problems about which the Greeks had observed a little and speculated much; and secondly, an exaggerated respect grew up for the opinions of the old writers. When Galileo Galilei put some of the accepted theories to the test of experiment and found that they were wrong, he was met with ridicule and abuse; and when, having constructed a telescope from meagre details of the invention which filtered to him from Holland, he turned this instrument upon the heavens, the enunciation of his discoveries brought down upon his person the heavy hand of ecclesiastical authority. But no trick of argument, and no appeal to ancient writings could explain away the facts which Galileo's labours revealed, and the invention of letter-printing by Gutenberg in 1445 provided a vehicle by which truth could outrun error.

The system of block-printing used by the Chinese two thousand years ago was of no value to Europeans, and until the middle of the fifteenth century books were multiplied by the laborious process of copying. Henceforth the printed book was a new force in the world, casting bridges across space and time, and bringing minds physically remote from one another into close and intimate relation. Hardly any other invention—not even the common knowledge of fire or the common faculty of speech—has done so much towards the intellectual progress of mankind as this one. It welded isolated workers and thinkers into serried ranks; it conserved for posterity the finest fruits of human genius, and, in time, scattered them so widely that few are unable to enter into the heritage.

To the great outburst of creative literature and political writing that characterised the next 150 years no attention can be given here. But, in accordance with the scheme laid down, it is necessary to indicate briefly the progress in scientific knowledge during this period. For Galileo laid the foundation of Mechanics upon which Newton built with rare skill and unexampled solidity. The Greeks had decided that falling bodies descended with speeds which depended upon their weights. Galileo, who in his student days had discovered the law of the pendulum and in his old age applied it to the construction of the first pendulum clock, took advantage of the leaning tower of Pisa to test the statement. He found that all bodies fell to the ground with the same velocity, whatever their weight or the material of which they were composed.

While Galileo was laying the foundation of mechanics in Italy Dr. Gilbert of Colchester was making discoveries in magnetism. For many centuries it had been known that a certain kind of iron ore had the property of attracting small pieces of iron. When an elongated lump of this substance was suspended by a thread, it turned to a north and south direction. The Chinese are said to have used this fact to guide their caravans; the Greek writers had told wondrous tales of a magnetic mountain in Asia Minor, which drew the nails out of a ship as they approached the shore, so that the ships fell to pieces; and the Arabs had constructed a compass and applied it to navigation. But it remained for Dr. Gilbert to discover and to state the laws of attraction and repulsion, and to give an intelligible explanation of the magnetic influence of the earth.

After Galileo died, his pupil Torricelli invented the barometer and gave a scientific explanation of the ancient observation that "Nature abhorred a vacuum." Pascal, the French *savant*, applied the barometer to the determination of the height above sea-level; Guericke the Burgomaster of Magdeburg found time, amid the stormy scenes of the Thirty Years' War, to construct a powerful air-pump; Robert Boyle discovered the law of elasticity of air and other gases that bears his name; John Mayow made fruitful experiments in Chemistry; and Descartes, in addition to his discoveries in optics, and the development of a system of philosophy, invented the process known as co-ordinate geometry, which is one of the most powerful mathematical weapons ever given to the world. It consists in the application of algebra to the solution of problems in geometry, and therefore of problems in mechanics and physics in which the quantities can be represented by lines of definite length, direction, and sense. The results of geometry are necessarily expressed in words, and the application of algebra enables them to be expressed in symbols, which are more convenient for calculation.

The achievements of these men were eclipsed by those of Sir Isaac Newton, who was not only the greatest scientific man of the seventeenth century, but has some claim to be regarded as the greatest in all time. He and his immediate predecessors, however, had the advantage of living after the invention of printing, and their results were recorded and circulated for the benefit of one another and of posterity. There is evidence that, before this time, discoveries were made and forgotten, inventions were achieved and lost, so that one generation of men gained little on their forbears. Moreover, early scientific writings were often fanciful, and obscurity of language often concealed the truth that lay within. To separate the grain from the chaff required two centuries of patient effort, and then men began to build with material upon which they could rely.

Isaac Newton was born at Woolsthorpe near Grantham in 1642, and, showing no aptitude for farming, was entered as a student at Trinity College, Cambridge. The year after he had graduated plague broke out in the town, he retired to his farm, and, in the quiet seclusion of his country home, he bent his mind upon that great enquiry which made the seventeenth century for ever a landmark in the history of science. The problem was—Why do bodies fall to the ground? And he was led to the conclusion that some force must act between them. He had Galileo's results to work upon, but they were not enough. For, if the force acted between the earth and bodies in its neighbourhood, did it not act between the sun and planets?—was it not the force which determined the configuration of the Solar System?

Galileo's experiments told him that the force—if it existed—varied inversely as the square of the distance. To test his theory in regard to the earth and the moon he required to know (1) the time of the moon's rotation, and (2) the exact radius of the earth. The first quantity he secured without difficulty, but for the second he had to wait sixteen years, until Jean Picard had made a measurement accurate enough for the purpose.

The result proved the correctness of his view. It enabled him to state the Universal Law of Gravitation—Every particle of matter in the Universe attracts every other particle, with a force which is proportional to the product of their masses, and inversely proportional to the square of the distance between their centres—and to apply it to explain the movements of the planets. Not only did it represent the greatest step ever made in systematising Astronomy, but it rendered possible a science of dynamics, and it gave real meaning to the terms weight and force, work and energy. To this day the achievement stands as "a feat unparalleled in the annals of science, sublime alike for its magnitude and for the labour it involved."

In order to solve the problem Newton invented a new mathematical process, called the Method of Fluxions. This enormously extended the power of calculation, not merely by enabling the solution of problems which could not be solved by other means, but also in shortening those which could be attacked only by long and cumbrous elementary methods. A few years later Leibnitz invented the Differential Calculus, a method equal in power, but more elegant and involving less labour in use. The Differential Calculus is to the Mathematician what the Microscope is to the Biologist, for it enables us to isolate and determine the value of a varying quantity for an infinitely small variation of another dependent quantity. Together with the reverse process—the summation of a number of infinitely small quantities—devised by Euler under the name Integral Calculus in 1768, it furnished the mathematician with a complete set of new weapons capable of dealing with quantities ranging from the smallest to the greatest, far beyond power of direct measurement and barely within the field of human comprehension.

Looking backwards it will be seen that the progress of physical science demanded three essentials—an experimental method, instruments for measuring physical magnitudes, and mathematical processes for recording and interpreting the results. The experimental method had been brought to Europe by the Arabs, was practised in England by Roger Bacon, and preached as a new doctrine by Francis Bacon 300 years later. But it was only in the sixteenth century, from the days of Galileo onward, that science in the sense of organised knowledge really began. The deductive method of Plato, handed down through Euclidian geometry, was supplemented by the inductive method of Aristotle; and wide generalisations, based on the patient and conscientious accumulation of facts, supplanted the vague guesses and ingenious deductions of the older philosophers.

These brilliant intellectual achievements had no influence, however, upon industrial methods or progress. Agriculture was fairly prosperous, spinning and weaving have never made much demand upon physical science, and had not then called forth a great deal of mechanical ingenuity. The political world, when not disturbed by civil strife, was absorbed in promoting industry and trade by granting monopolies, by protective legislation, or by war and colonial conquest; and almost the sole industrial change of real importance was the gradual development of the domestic or commission system on the ruins of the craft-gilds.

PART III

THE MODERN PERIOD

A. SCIENTIFIC & TECHNICAL PROGRESS SINCE 1700

B. FACILITIES FOR COMMERCIAL DEVELOPMENT

C. THE EVOLUTION OF INDUSTRIAL MANAGEMENT

D. INDUSTRY AND POLITICS

A. SCIENTIFIC AND TECHNICAL PROGRESS SINCE 1700

CHAPTER IV

FOOD AND FARMING

1. *The Eighteenth Century Revival*

WHEN the wave of enthusiasm for the profitable occupation of sheep-breeding and cattle-rearing created by the Black Death spread over the land, England acquired a reputation as a grazing country, while the art of cultivating the soil remained very much at the same stage as it was soon after the Norman Conquest. New methods had been employed and new food plants had been introduced, but only by isolated individuals who had not influenced very largely the general practice of their time. Conditions favourable to improved methods of husbandry, however, were arising in the increasing wealth of the landowners, and a small group of agricultural writers were soon to exercise an influence greater than any which had affected English farming for more than 300 years.

The earliest of these reformers was Jethro Tull, who was born about 1680 and died in 1741. He applied himself mainly to the prevention of waste and to giving the plant "a free field," if no other special favour. The old practice of sowing broadcast was uneconomical, and in 1701 he invented a drill and a machine for sowing clover which reduced the amount of seed required from 10 lbs. to 2 lbs. an acre. Further, he emphasised the importance of producing a fine tilth and a good root-run for the plant, together with the vigorous removal of weeds which impeded its growth. Many of his ideas were obtained as the result of a journey in the south of France, where he observed the care with which the vine was cultivated. Curiously enough he objected to manure, and grew wheat for nine years in the same soil without it.

Tull had a worthy successor in Lord Townshend, who, having quarrelled with his brother-in-law, Robert Walpole, forsook Politics for Agriculture. He re-introduced the practice of marling on light lands, adopted Tull's method of drilling and hoeing, and made extremely important experiments on the rotation of crops. Through his efforts the Heath near Norwich was enclosed by 1760, a good turnpike road constructed across it, and the land cultivated according to his plan. It yielded ample profit at a rent of 15s. per acre, an amount ten times greater than its value before the change.

In addition to these two men, an outstanding figure was Coke of Holkham in Norfolk. When he began to farm in 1776 the rents on his estate were from 1s. 6d. to 3s. 6d. an acre, though the prevailing rate was 10s. But he was a great traveller, and he modelled his own practice upon what he saw elsewhere in England and on the Continent. The rotation of crops was modified, a flock of 800 miserable-looking sheep was converted into a flock of 2500 excellent Southdowns, and the custom of using from three to five horses for a plough was altered to using two. Every year he planted 50 acres of trees on the hillsides until he had 3000 acres of woodland, and in 1832 he embarked in a ship built of oak from the acorns he had planted. Annual sheepshearings attracted large numbers of visitors from 1778 to 1821, and in the last year no less than 7000 were present. Nearly half-a-million was spent on improvements between 1776 and 1842, and the rent-roll rose from £2200 to £20,000 a year within the first forty years of this period. Yet the tenants were well treated. They held their farms on long leases at moderate rents with few restrictions, and once a family had obtained possession they rarely left. There was no ale-house on the estate, and the workhouse was pulled down because there was no need for it. The results are eloquent, both of the value of intelligent methods and of the importance of capital.

The rotation of crops was an especially valuable contribution to agricultural practice, because it not only prevented the impoverishment of the soil, but it also rendered unnecessary a year of fallow, and therefore of no return. By arranging the crops in a certain order the land would yield continuously without appreciable loss of fertility. This order varied in different districts—one, known as the Norfolk rotation, was turnips, barley, clover and rye grass, wheat. The clover not only revived the soil after the exhaustion produced by the turnips and barley, but seemed actually to improve it for wheat; though why this should be so found no explanation until 150 years later, when the microscope was used to peer into the mysteries of vegetable economy.

These methods, however, could only be carried on in closed fields, which enabled the more enlightened farmer to make experiments and shape his practice without consulting his neighbours; and, as we saw in Chapter II., only about half the land in the country was affected by the earlier process of enclosure. After having been comparatively rare for 150 years enclosure and the consolidation of holdings showed a revival during the first half of the eighteenth century, so that when the innovations of Tull and Townshend became more fully appreciated the movement gathered strength. The land already devoted to crops was consolidated, and as the population grew while exports of corn were hampered by the French wars, much waste land was brought into cultivation. In this way the remaining open fields, with few exceptions, were divided into closed fields by walls and hedges, and by 1850 the English landscape took on the appearance it bears to-day.

The rate of enclosure was, however, not uniform. There were two periods—from 1770 to 1780, and from 1800 to 1820—when the change proceeded at abnormal rate. The first of these coincided with a period of rapid development of the textile factories before the employment of steam. The Water-Frame of Arkwright was taking the spinning process out of the hands of those who could not provide power, and was thus making it increasingly difficult for them to get a living. Moreover, the examples of Tull and Townshend necessitated larger farms and a greater amount of capital, so that, however the small farmer might desire to adopt their methods, they were beyond his means. It was still more impossible for him to compete with the newer methods when his domestic industry migrated to the factories, and as the enclosure of common land often deprived him of the means of feeding his stock, he was driven to seek a living in other ways.

It has been estimated that in 1688 there were 160,000 small freeholders in England—more than in any other country in Europe; and before the enclosures of the seventeenth and eighteenth centuries the landless labourer was rare. Most of them possessed a share of the common field or the right to use the common pasture. The effect of the change in agricultural methods was foreseen by many people, and Arthur Young recommended that where extensive enclosures were made sufficient land to support a cow should be reserved for each cottage and secured by vesting it in the parish; while Lord Winchilsea pleaded that each cottage should possess a garden. The more enlightened landlords adopted one or both of these suggestions, but such landlords were not numerous. Gradually the yeoman was starved out or bought out, and he has only in recent years been partially replaced by men of a similar class who, having acquired a little capital, are endeavouring to make a living on the soil.

The second extraordinary period of enclosure occurred between 1800 and 1820, and is nearly contemporaneous with the Napoleonic wars. The textile inventions, the steam engine, and the new process for manufacturing iron led to such an increase in the rate of production in Great Britain as compared with other countries, that she was able to finance her Allies, to maintain naval and mercantile supremacy at sea, and even to assist in the campaign on land. But these changes were accompanied by an increase of population in which the towns grew relatively at the expense of the country, and a greater burden was thrown upon those who were concerned more directly in the production of food. Farming became more and more profitable, but only if it was carried out according to methods involving enclosure and the use of capital.

The necessity for improved methods of tillage, as well as the ultimate futility of the efforts to render Great Britain self-sufficing are well illustrated by the diagram on the frontispiece, which shows the rate of growth of the population for the last 800 years. It will be observed that the rate increased very gradually until 1800, and then went up at a speed which has been maintained practically to the present day. Before the introduction of the new methods England had been able to export food except in years of scarcity, but during the eighteenth century the imports gradually approached the exports, until between 1770 and 1790 they balanced one another; and from 1800 it was recognised that the home production was unequal to the demand.

The growing inability to meet the nation's needs gave rise to various remedial measures of a political character to which we shall refer directly, and also stimulated improvements in practice. Thus in 1793 a Board of Agriculture was established to collect statistics and to devise means for increasing production. It was not, in the ordinary sense of the term, a Government Department, but a Society created to distribute advice. Lecturers were appointed—one of them being Humphry Davy; experiments were undertaken in wheat substitutes for bread-making; influence was exerted in favour of improved roads, the wretched state of which tended to isolate markets and to render prices unequal; inventors received rewards; and prizes were offered for essays on agricultural operations. Under its advice Parliament removed the tax on draining-tiles, and enclosures were facilitated by the Act of 1801. Ultimately it got into financial difficulties by carrying out costly surveys; the Secretary, Arthur Young, who had a European reputation as a writer on Agriculture, was afflicted with blindness, and the Society ended a useful, if occasionally erratic, career in 1822.

The agricultural activity of the period is shown also by the amount of waste land which was brought into cultivation when the price of wheat was high; but a more permanent result was the growing use of machinery. A drill plough was patented in 1781, a sowing machine in 1784, a harrow in 1787, a reaper in 1799, a winnowing machine in 1800, and a haymaker in 1816. A threshing machine worked by a water-wheel, which enabled one man to do the work of six, had been invented in Scotland by Menzies in 1743, and in 1798 Meikle invented another one which is comparable with those used to-day. Though steam power was employed for threshing in 1803 it did not come into general use until fifty years later. These machines were beyond the means of the small man, but they were available for those with more capital who were attracted by the high price of corn and farm produce generally that ruled during this period.

With the close of the war agriculture entered on a period of depression, which lasted until the accession of Queen Victoria. The disbanded soldiers who had fought under Wellington flooded the labour market and lowered wages; a succession of wet seasons damaged the crops; an increasing quantity of grain was imported; rates and taxes were high, and rents were difficult to collect. The distress was aggravated, especially in the south of England, by the adoption of luxurious habits in the preceding years of prosperity. In the north this was less apparent, and the Scottish farmers, who had been the first to avail themselves of the reformers' methods, were still more successful in weathering the storm.

2. *The Corn Laws and Scientific Agriculture*

It will be recalled that until the wheat imports balanced the exports after 1770 the aim of the Government had been to maintain the price of home-grown wheat. The Act of 1463 prohibited import when the price fell below 6s. 8d. a quarter, and the Act of 1689 had provided for a bounty on export when the price fell below 48s. In 1773, however, importation was encouraged so as automatically to maintain the supply. Again in 1791 it was enacted that when the price of the home product was more than 50s. a quarter, there should be merely a nominal import duty, that when it was less than 50s. imports should be prohibited, and that when it fell below 44s. a bounty of 5s. per quarter should be given on exports.

Then the great war cut off supplies from the Continent, much waste land was brought into cultivation, and though high prices were the rule, there were violent fluctuations of price according to the harvest. The normal price rose to more than 80s. a quarter, and only when it fell below this was importation stopped. During the depression following the war, prices again fell, and the Act of 1828 imposed an Import Duty of 23s. when the price fell below 64s., 16s. when the price was under 69s., and 1s. when it was under 73s.—this is the well-known Sliding Scale.

So far the maintenance of an adequate supply had been secured with due regard to the farmer's profits. He had been protected from foreign competition; he had in some cases acquired habits which, compared with those of his forerunners, were those of luxury, indolence, and ease; and he had not been impelled by sheer necessity to adopt those methods which the pioneers of agricultural progress had shown to be so effective in securing a higher return from the soil. But the Reform Act of 1832 put the manufacturing interest in power. They were strongly impressed with the necessity for drastic measures to relieve the trade depression, and no doubt realised the impossibility of reducing wages while the price of corn remained so high. From this, as well as from worthier motives, they began to press for the abolition of the Corn Laws, and a powerful organisation called the Anti-Corn Law League was established in 1838. In 1842 Peel adopted a sliding scale to maintain the price between 54s. and 58s. a quarter, and in 1846 the duties were abolished altogether. The agitation against Agricultural Protection was only an example of the larger movement towards Free Trade which came into prominence at this time. At the same time it marks very clearly the separation between agricultural and manufacturing interests which had been created by the Industrial Revolution.

Thrown thus upon his own resources, the farmer endeavoured to get more out of the land. The methods of drainage introduced by Elkington in 1764 were replaced by the more effective plan of Smith of Deanston from 1835, and some of the more enlightened and enterprising landowners spent enormous sums in this form of improvement. Cylindrical earthenware pipes, which had been proposed by Switzer in 1727, came into use about 1843, and in 1848 Peel introduced Government Drainage Loans, repayable in twenty-two instalments at 6½ per cent. The Royal Agricultural Society of England was founded in 1838 on the model of the Highland Society, and in 1840 it was incorporated by Royal Charter. In its first year prizes were offered for essays upon twenty-four subjects relating to improvements in agricultural methods. On all sides the conditions for advance were favourable. The cultivators themselves were impressed with the necessity of improvement: the new railways were greatly facilitating the transport of goods; the telegraph was creating the modern newspaper; and the Royal Agricultural Society was an organisation for collecting and distributing technical information. But what was of perhaps greater importance was the fact that chemistry and botany were just becoming true sciences, capable of furnishing explanations of natural phenomena, and of guiding investigations which had for their object the improvement of everyday practice.

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Justus von Liebig's Report on the Relation of Organic Chemistry to Agriculture and Physiology at the meeting of the British Association for the Advancement of Science in 1840, is not only a landmark in the history of science, but an important link in the chain of human development. Hitherto man had imitated Nature in the cultivation of plants, and improved upon her methods by the laborious process of trial and error. His experiments had been made in the dark, and were successful rather by happy chance than by any concerted plan of attack. Long years of experience had taught him that continuous cropping of the soil by the same plant led to loss of fertility. Recognition of the fact that the original fertility could be restored, so far as he could judge, by a year of idleness or by the use of farmyard manure was implied in the three-field system of the Middle Ages. The methods of treating light lands with marl, and heavy lands with lime, were practised effectively in the fourteenth (dropped for 300 years) and revived in the seventeenth centuries; but the relations of the plant to the soil, from which it derived the material of its growth, were surrounded with the darkest mystery.

By analysing plants De Saussure, Boussingault, and Liebig showed that, in addition to complex organic bodies which defied their skill, they invariably contained lime, potash, iron, and phosphates. The carbon of the organic constituents was known to be absorbed from the atmosphere as carbon dioxide by means of small openings called *stomata* on the under side of the leaves, and they supposed, wrongly, that nitrogen was absorbed in the same way. Apart from this error Liebig had grasped the essential conditions of the food-supply of plants, though there were details which could only be revealed by experiments in the field, conducted with the greatest care and extending over a long period of time. These were undertaken by John Bennett Lawes, whose investigations entitle him to rank as one of the founders of modern agricultural science.

Losing his father at eight years of age, he took charge of the farm of 250 acres at Rothampstead in 1835 when only twenty years of age. A liking for chemistry and pharmacy led him to grow a number of medicinal plants, and two years later he turned his attention to growing plants in pots, in order to try the effect of various substances added to the soil. By 1840 he had accumulated a considerable amount of information, and in 1842 he patented a process for rendering mineral phosphates more soluble by treatment with sulphuric acid. A chemical factory was erected at Deptford, and a chemist, J. H. Gilbert, engaged to carry out the field experiments at Rothampstead. In the same year experiments were started with turnips and wheat, in 1847 with beans, in 1848 with clover, in 1851 with wheat and fallow and wheat and beans, in 1852 with barley, and in 1856 with grass, the plots covering forty acres. Investigations were commenced on the feeding of sheep in 1848, and of pigs in 1851. The care and accuracy with which the work was carried out rendered the results of great scientific value, while the scale upon which it was conducted gave many of them immediate practical importance. Lawes and Gilbert soon established a world-wide reputation: the manure factory was sold for £300,000 in 1872, and the farm established as a permanent Agricultural Experiment Station with an endowment of £100,000 in the same year.

The work of Liebig and Lawes resulted in the widespread use of artificial fertilisers, and the activity which was displayed in the search for suitable materials exercised an influence which was felt outside the sphere of farming. Phosphates were originally applied to the land in the form of bones, and came into regular use about 1840. The old method of breaking them with a hammer was replaced by grinding in a mill, but however finely they were crushed, the action was slow. Lawes and Gilbert discovered in 1842 that if they or mineral phosphates were treated with sulphuric acid, a superphosphate was produced, and this, being more soluble, was much more rapid in its action. The peculiar merit of the discovery lay in the suitability of mineral phosphates for the purpose. The annual production of superphosphate is now 6,000,000 tons, of which 1,000,000 tons is made in this country. The bones came chiefly from South America, but it is perhaps unwise to enquire too closely into other sources in view of Liebig's complaint that in their anxiety to secure phosphates the British robbed even the battlefields of Europe! But bones have long ceased to provide for the world's needs, and both natural phosphates and basic slag from steel furnaces are used in increasing quantities.

Although potassium compounds are widely distributed in the earth's crust, and especially in the felspathic constituents of granite and other igneous rocks, they are difficult to separate, and until 1760 almost the only source was from the plants themselves. When timber, seaweed, or other vegetable matter is burnt, the mineral matter is left behind in the ashes—hence the word potash from potashes. But the quantity obtainable in this way is small, and to burn down a forest in order to fertilise a garden is a wasteful process. Relatively to the other artificial manures there might have been a potash famine but for the discovery in 1857 of extensive deposits of potassium compounds at Stassfurt in Germany. Potassium chloride or *Carnallite* was introduced in 1861, and *Kainite* or potassium sulphate in 1865. The output of crude potash salts from the Stassfurt beds in 1881 was 2000 tons, and in 1912 it was 11,000,000 tons, the greater part of which was employed as a fertiliser.

The experiments at the Lawes Agricultural Experiment Station have shown that nitrogen is the most important of all plant foods. Wheat has been grown continuously on a certain plot of land at Rothampstead for more than seventy years, and, without manuring, still yields 13 bushels per acre. When a manure containing all the necessary mineral ingredients *except nitrogen* is used, the yield is only increased to 15 bushels per acre, while a nitrogenous manure alone increases the yield to 21 bushels. When both are used the yield rises to 35 bushels per acre. Moreover, without nitrogen the plant does not progress beyond the seedling stage, and there is only one class of plants—the *leguminosæ*—the members of which are capable of obtaining their nitrogen directly from the atmosphere by a process that was not explained until the year 1886. Of nitrogenous materials suitable for use as fertilisers, the earliest was farmyard manure, though the precise nature of the changes which take place when it is added to the soil was not understood until 1887. To explain the exact nature of these changes would be outside the scope of this book, but it may be mentioned that they are due to the action of bacteria, which have been shown to play a very impotant part in the economy of plant life. Another substance is guano, which was first analysed by Humphrey Davy in 1807, came into use about the same time as phosphatic manures, and is now becoming scarce. A third nitrogenous manure is sodium nitrate or Chile saltpetre, which is found in large quantities in the South

American Republic of that name. The present production is about 2,000,000 tons per annum, of which 80 per cent is used in agriculture; but the supply is rapidly nearing exhaustion. A fourth substance of value is ammonium sulphate, which is obtained by neutralising the ammoniacal liquor of the gasworks with sulphuric acid. In 1890 the total production of sulphate of ammonia was 210,000 tons, in 1900 it was 500,000 tons, and in 1912, 1,300,000 tons.

The use of the various fertilising agents which have been enumerated, together with effective drainage, assisted British farmers to escape the worst fate which had been predicted for them under Free Trade. The years between 1837 and 1875 were on the whole prosperous, and in spite of the increasing quantity of wheat imported, the area devoted to this crop did not decline until after 1880. It was, and still is, a profitable crop, provided it is not grown too frequently, and the season is not unfavourable. The most disastrous event of the period was the outbreak of potato disease, which made its first appearance both in England and on the Continent in 1844–45. Since its introduction in the reign of Elizabeth the potato had entered largely into the food of the poor, especially in Ireland, where the failure of the crop produced widespread distress, led to emigration on a large scale, and was incidentally the proximate cause of the repeal of the Corn Laws.

3. *The Meat Problem*

At this stage it will be convenient to consider how far the farmer was able to keep pace with the growing demand for meat and dairy produce. When Coke was beginning to provide an object-lesson in estate management and methods of tillage, Robert Bakewell was devoting himself to the improvement of stock. Born in 1725 at Dishley in Leicestershire, he succeeded to his father's farm at the age of 35, and began to make experiments in breeding sheep. His principal object was to obtain animals of small bone which would fatten well, and he produced first the Leicesters, and then the New Leicesters. Within fifty years these had spread over the country and gave Englishmen 2 lbs. of mutton where they had formerly been content with one. His breed of cattle was less successful and is now extinct, but several of his pupils were more fortunate.

These improvements were continued. The use of manure on grass-lands enabled a larger number of cattle to be fattened on a given area, and the improved yield of clover and turnips provided food for winter. Great as this progress had undoubtedly been, however, it was in no sense comparable with the increase of population, which had risen from 9,000,000 in 1800 to 21,000,000 in 1821. Moreover, the town workers demanded a greater quantity of meat than that to which their grandparents had become accustomed. No alarm appears to have been expressed, however, until the 'fifties, when an enquiry revealed the fact that the annual production of the country only amounted to 72 lbs. per head of the population, and that this quantity showed a tendency to diminish.

As there appeared to be no possible chance of so increasing the home production that it would meet the needs of the population, it was necessary to seek for new sources of supply. Obviously men turned to America and the Colonies. The former country possessed enormous herds of cattle, and Australia and New Zealand had proved especially suitable for sheep-farming. Two solutions presented themselves; one was to import live animals, and the other to preserve the meat in some way. A committee appointed by the Royal Society of Arts to consider the question met at intervals for fifteen years, and enquired into all sorts of weird proposals for keeping meat fresh; but the only one which could survive a test was to cook the meat and to seal it in air-tight tins. Hence arose the canning industry. At the same time live cattle began to be imported from America. In rough weather they suffered a good deal on the way, but the plan relieved the immediate anxiety.

The need, however, increased. In 1865 the rinderpest invaded England from Russia. Within a month 2000 animals had fallen victims to the disease, and within six months the infection had spread to thirty-six counties. By March in the following year 177,664 head of cattle had been killed by the plague, and 26,135 had been slaughtered, while by November the total loss was 209,332 valued at £3,000,000. Thirteen years later there was a terrible outbreak of foot-rot among sheep, and 3,000,000 died from the disease or were destroyed. In the face of these disasters it was hopeless to rely on the home product, and larger demands were made upon the United States.

Meantime the Australian colonists were anxious to enter the market. They were producing immense quantities of wool, and were gradually taking a similar place in the supply of this material to that which England had occupied in the Middle Ages. But they wanted to sell mutton also, and England was willing to buy. The distance was too great to permit of the animals being brought over alive, and the problem had to wait until 1880 for a solution. It had been known from very early times that putrefaction is prevented or goes on very slowly at a temperature below that at which water freezes. Many old English mansions have attached to them an ice-room built in the ground, usually in the shade of a wood, and thickly roofed to keep out the heat of summer days. In this room winter ice was stored and used as occasion required to preserve the freshness of food in hot weather. To furnish a ship with sufficient ice to bring many tons of food even from America was obviously impossible, but a long series of experiments on gases, dating from the beginning of the century, had established the fact that when any gas is compressed heat is produced, and when it is allowed to expand freely cooling occurs. By means of air-pumps, therefore, it was possible to reduce the temperature of air, and to circulate it through chambers in which meat was stored.

The first experiment on these lines was made in 1873. A cargo of mutton left Melbourne on July 23 and arrived in London on October 18 in a condition which rendered it unfit for human consumption. Two years later a cargo of frozen beef was brought from the United States with greater success, but it was evident that a more effective freezing machine for producing a low temperature was required, and the pioneers turned to one which had been invented by Edmund Carrè about 1860. This employed ammonia instead of air. It was installed on the steamship *Strathleven* in 1880 and enabled 400 carcases of mutton to be brought from Australia. The meat had cost 2d. a pound and was sold in Smithfield Market for 6d. The problem was solved, and since the year in which the *Strathleven* steamed up the Thames there has been an ever-growing influx of meat from the American prairies and the uplands of the southern continents. Though lamb and mutton can be frozen without any deterioration, beef becomes flabby in appearance owing to the bursting of the small blood-vessels, and is less saleable on that account. In the late 'nineties it was found that if care were taken thoroughly to disinfect the carcases, putrefaction could be prevented by a temperature of 30° to 32° Fahr. Under these conditions no freezing occurs and the meat retains its normal appearance. Since 1899 the whole of the beef imported into this country has been "chilled" in this way, and is hardly distinguishable from that which is home-grown. But to secure this result great improvements have been made in the refrigerating machinery, which must be sufficiently elastic, and yet sufficiently under control to maintain the hold of a vessel at constant temperature within a degree or two while crossing the Equator from the Southern to the Northern Temperate Zone.

During the last twenty-five years the population of the United States has increased so rapidly that the export trade has declined, and so far as beef is concerned the chief source of supply has been the Argentine Republic. The rapidity with which this change has taken place in recent years is illustrated by the fact that, while importations from the Argentine were only 22 per cent of the total in 1901, they reached more than 95 per cent in 1911. Lamb and mutton still come from Australia and New Zealand, though, owing to drought between 1905 and 1907, supplies fell off. The 60,000,000 sheep possessed by the farmers of New South Wales were reduced to 26,000,000, but the number has again risen to nearly 50,000,000.

During the year 1913 the United Kingdom imported more than 9,000,000 cwts. of beef, by far the greater proportion of which was chilled, and nearly 5,500,000 cwts. of mutton, practically the whole of which was frozen. To this must be added hundreds of thousands of rabbits from Australia, fresh fruit from Canada, South America, and South Africa, milk from France and Holland, cream from France, and fish from our own trawlers which had spent a month or six weeks at sea. Such food-supplies are rendered possible, not only by refrigerating machinery on ships, but also by cold stores on land, which enable perishable commodities to be kept until they are required. They avoid waste by rendering it unnecessary to destroy food or to sell it at a loss; they prevent shortage; they maintain prices at a more uniform level, and, by preventing fluctuations, they contribute towards the stability of trade.

4. *Agriculture since* 1875

In order to understand clearly the recent history of food and farming, it is necessary to consider the problem of tillage as we left it in 1875. At that time the increasing importation of wheat from abroad, and the definite adoption of Free Trade principles, had forced the farmer to employ more of that assistance which science alone could give him. The accumulation of scientific knowledge in regard to the analysis of soils, the use of manures, the nature and treatment of plant diseases, and the methods of waging war upon injurious insects has been brought to his notice in various ways. The Board of Agriculture, established as a separate Government Department in 1889, has exercised a missionary influence by a series of leaflets which embody the results of the most recent research and indicate the best practice. The Agricultural Societies, and especially the Royal Agricultural Society of England, provide the means through their annual shows for agriculturists to meet together to see the results of one another's work, and to examine the newest labour-saving machines which mechanical ingenuity has devised.

The growth of the towns with their large and prosperous populations has created a market for a variety of food materials and other products of the soil which has materially altered the nature of the crops grown in many districts. Thousands of acres of land which used to be sown with wheat are now given up to potatoes, and enormous market-gardens have sprung up near large centres of population. In the Fen District round the Wash large quantities of tulips and narcissi are grown in active and successful competition with Holland, and many men are living on five or six acres by growing celery and early potatoes. Finding that neither the British climate, the British soil, nor the small fields of the British farm will enable him to compete in wheat-growing with the prairie lands of Canada, Argentine, the black soil of southern Russia, or the Hungarian plain, the British farmer has grown that on which he could make the greatest profit. Instead of depending upon him absolutely for the necessaries of life, the people rely on him for only 50 per cent of their food, and a good deal of this is composed of luxuries rather than necessaries. Moreover, the price which he receives for some classes of agricultural produce is determined not by the relation between the home demand and the home supply, but by the world's demand and the world's supply.

Out of this situation two questions of interest arise. One is the condition of British agriculture since it ceased to have a controlling voice in politics, and the other is the feeding of an industrial nation from foreign or colonial sources.

The effect of competition was not felt immediately after the repeal of the Corn Laws for three reasons. The discovery of gold in California and Australia increased the purchasing power of the sovereign and led to an expansion of trade;

the Crimean War kept up the price of grain by closing the Baltic ports; and the American Civil War prevented the export of wheat from the United States. But bad times were to come. From 1874 to 1882 there were only two favourable seasons, and the development of American railways enabled the wheat crop of the United States to be trebled between 1860 and 1880. The price fell from 56s. 9d. in 1877 to 22s. 10d. in 1894, and though this might be welcomed by the town worker, it was bad for the owners of agricultural land.

Parliament sought to mitigate the distress by a series of Acts giving the tenant a greater interest in his farm. The Agricultural Holdings Act of 1875 established the principle that compensation should be paid to the tenant for improvements during his tenancy. This principle was extended by a similar Act in 1883 and again in 1900, while the Act of 1906 gave the tenant liberty to choose what crops he would grow—a privilege which had formerly been retained by the landlord and secured by a clause in the lease. Again, the Ground Game Act of 1880 gave the tenant the right to kill the rabbits and hares on his holding, and the Agricultural Rates Act of 1896, which was renewed in 1901, relieved the occupier of half the rates on land apart from buildings.

The condition of the labourer during this period was at first worse than that of the farmers. Their wages were low, and the houses for the most part wretched hovels. Some enlightened landlords had erected cottages and provided gardens, but these were the exception rather than the rule. The labourers themselves had no voice in the government of the country, for the Reform Acts of 1832 and 1867, while they had enfranchised the workmen of the towns, had not enfranchised the labourer. Combination had been tried as early as 1836, but to no purpose. It was not until Joseph Arch succeeded in founding the Agricultural Labourers' Union in 1872 that their voices could be heard.

Joseph Arch was born in 1826, and, until middle age, worked for farmers in various parts of the country. In 1872 his own wages were 12s. a week, the 4 lb. loaf was 7½d., sugar was 8d. a pound, and tea 6s. or 7s. On such a wage and in the face of such prices it was hardly possible for one man to live, and yet there were many who had to bring up families upon no more. These families were apparently expected to become strong, healthy, intelligent young men and women who were to maintain the traditions of a nation already distinguished for its wealth, and claiming to be recognised as the most enlightened in the world. The Union demanded a minimum wage of 16s. a week and a 9½-hour day. It was instrumental in raising wages until 1879, after which they gradually declined with the strength of the Union, which collapsed in 1894. Meantime the Franchise Act of 1885 had given the agricultural labourer a vote.

The low-water mark of depression was reached in the early 'nineties when wheat fell below 23s. a quarter. Since then it has gradually risen to more than 30s., for reasons which will be discussed at the end of this Chapter.

The scarcity of labour in recent years has become a serious problem. It is put down by some people to the compulsory education, which renders a boy discontented with the prospects of country life; but it is attributable with far more certainty to the attractions of town life and wages on the one hand, and on the other to the poor houses and lack of amenities in the village. Nevertheless the cry of "Back to the land" is insistent, and the Small Holdings Act passed in 1907 was an attempt to repeople the country-side. Under this Act, Local Authorities are empowered to buy land and to let it out on the hire-purchase system in lots of from five to fifty acres to men who can produce evidence of their ability to make use of it. It is not intended to invite the town-bred artisan, shop-assistant, or clerk to undertake work for which their training and experience offer no guarantee of success, so much as the man who, after being reared in the country, has migrated to the city.

The object is evidently to increase the rural population, not by importing labour, but by offering the attractions of ownership; and by creating a greater interest in the land to improve the methods of cultivation. It is pointed out that while the average return on the whole of the agricultural land in the country is less than £5 an acre, there are market-gardens in the neighbourhood of 7 large towns which yield £100 and even £1000 an acre. Incidentally, it is alleged, a healthier race of children would be reared in the country air, and by sanitary methods copied from the town.

Within certain limits the claim made on behalf of small holdings is demonstrably true, but the extent to which they can contribute to the provision of fundamental necessities is controlled within very narrow limits. On the larger farms dairying is successful, especially if it is associated with a system of co-operation for the purchase of materials and the sale of produce. But butter- and cheese-making are becoming to a greater extent factory processes, in competition with which the individual who works on a small scale is at a serious disadvantage. The smaller farms, on the other hand, will support pigs and poultry, and may succeed as market-gardens. In either case the occupier must put his own hand to the plough.

It is not contemplated that the land will yield such a return as will relieve him from personal labour, and it has even been suggested that the small-holder may occasionally help the farmers in his neighbourhood at busy seasons.

The experience in all forms of industry during the last 150 years has been to show the economy of production on a large scale. Experts in each branch are available, the various duties are delegated, and less responsibility falls upon the shoulders of a single man. A large concern is many-sided in its activities, with greater stability in regard to vagaries of climate, and more power of resistance during periods of trade depression. It is also more favourably constituted for utilising the results of scientific discovery and mechanical invention. If the small-holder concentrates upon what pays best in normal times—early vegetables and other delicacies for which people will pay abnormal prices—he will be the first to suffer when circumstances arise which necessitate economy. It is almost unthinkable that a law of economic progress which is so universal in its applications should have no meaning in reference to agriculture; and, however attractive the proposal may appear to be when viewed in a partial aspect, there can be no real or permanent gain from uneconomical methods of production.

Analogy with Holland and Denmark is not very valuable. These are predominantly agricultural, and Great Britain is, above everything else, a manufacturing country. In Holland and Denmark co-operation is so complete and effective that each is far more like one large Agricultural Co-operative Society than our isolated colonies of small-holders. Their experience indicates that ownership is a necessary condition of strong co-operation, but they are countries with an unbroken tradition of peasant proprietorship, the last traces of which in England were swept away with the advent of the Industrial Revolution. Moreover, they are essentially dairying countries, and dairying is quite possible in England on the larger holdings.

The necessity of a higher standard of technical training in agriculture has been emphasised by the establishment of the Development Commissioners in 1911. This is a statutory body with power to make grants towards agricultural education and research, and grants or loans towards the construction and maintenance of main roads. The Board of Education, and subsequently, owing to a transference of powers, the Board of Agriculture and Fisheries, adopted the policy of encouraging local authorities to establish Farm Institutes, offering a training of lower standard but of a more immediately practical value than that provided in the Agricultural Colleges. Systematic provision is to be made for the whole of the country, and a large proportion of the capital cost is to be met by the Development Commission. In addition to this, the Board make special grants to the Agricultural Colleges for research on the diseases of plants and animals, insect pests, the chemistry of the soil, and other matters of primary importance to the nation's food-supply.

Since 1907 there has been a distinct revival in agricultural prosperity. The seasons have been better; the "breed" of food-plants has been improved; the methods of cultivation and stock-rearing have benefited from the vast scientific progress of the last twenty-five years; and the facilities for transport have been very considerably extended. Continued expansion of trade—rendered possible in no small measure by scientific discovery and mechanical invention—has added to the wealth of the country, and increased the purchasing power of the people.

Improvements in British agriculture, however, derive greater significance from a study of the relation between the world's supply and the world's demand. In his Presidental Address to the British Association for the Advancement of Science in 1898, Sir William Crookes pointed out that, in view of the increasing population and the limit of available wheat-growing land, the maximum production would be reached in 1931. In the virgin lands in which the major portion of the world's wheat is now being grown, no manure is being used, and the soil must in time become exhausted. The centre of the wheat-growing belt in the United States has moved 700 miles westward in fifty years, and the eastern states are dotted with derelict farms. The average yield per acre in Great Britain was 28 bushels, but for the whole wheat-producing area of the world was only 12·7 bushels per acre; and the British figure had been reached by a scientific rotation of crops and by the use of artificial fertilisers. Of these, the importance of nitrogen and the sources of nitrogenous manures have been indicated on page 69. Unfortunately the Chile nitre-beds cannot at the present rate of output last another half-century, and the amount of available ammonium sulphate was at that time dependent upon the supply of coal. The area of cultivation being limited, the main question became how to increase the supply of artifical plant-foods, which was also shown to be in danger, and how to secure improved breeds of wheat with a heavier yield, greater resistance to disease, and less fastidious in regard to soil and climate.

In their scientific aspects one of these problems has been solved, and the solution of the other seems to be within measurable distance. Since 1902 two processes have been devised for obtaining nitrogen compounds from the atmosphere by the aid of electricity. The quantity of this element available is about 33,000 tons per acre over the whole of the earth's surface, and it is replenished by natural processes which liberate it from the soil. Large works have been established in Norway, Germany, Italy, Canada, and the United States, where water-power is plentiful and electricity can be cheaply produced.

The other problem is being investigated by Agricultural Colleges in various parts of the world. The first step is to produce a wheat which will resist disease, for *rust* destroys annually one-third of the world's crop. Experiments by Mr. Biffen, of Cambridge, have been distinctly encouraging, for they have resulted in varieties which bear heavily, yield a good quality of flour, and show no disposition to *rust* even in the damp climate of the British Isles.

Mr. G. F. Unstead has examined the statistics of wheat production of the world for the three decades 1881–90, 1891–1900, and 1901–10, and has shown that (*a*) the rate of increase is diminishing; (*b*) the increase is mainly due to an increased acreage; (*c*) the yield per acre has risen by 8 per cent. His results fully bear out Sir William Crookes' warning, and indicate that, unless the unforeseen occurs, a crisis will be reached within a hundred years. The growing demand can only be met by rotation of crops and manuring; and as this involves more labour on the land, there may be a vast redistribution of population with corresponding alterations in the habits and customs of the people.

Moreover, an equally serious problem arises in connection with the supply of meat. The population of the world is growing, and the consumption of meat per head has risen with increase of wealth. Originally capable of shipping cattle to the United Kingdom, the United States is now barely able to meet the needs of its own population, and is beginning to import frozen mutton and chilled beef. There appears to be no reason to doubt that meat will cost more, and unless the wealth of the British people increases in proportion, they will be obliged to eat it more sparingly. After a long period, taken on the whole, of unexampled prosperity, a national and even a world stocktaking has revealed the prodigality with which man has dealt with natural resources, and has shown the more thoughtful among them the nature of the conditions against which they and their children will have to struggle in the coming years.

CHAPTER V

THE TEXTILE INDUSTRIES

1. *Cotton*

THE coming of the Industrial Revolution was heralded by certain improvements in the ancient processes of spinning and weaving. These improvements did not, however, affect the whole industry at first, nor did they exercise much influence outside a particular narrow area. For nearly a hundred years they were restricted almost entirely to cotton manufacture, and were to be found only on the moist seaward slopes of the Pennine Chain. The nucleus around which the new movement gathered volume and strength was Manchester, then a market-town, free more or less from the trade restrictions that had grown up in the older boroughs, and with a traditional hospitality towards foreign workmen. The climate was so suitable in its mean annual temperature and humidity, that the cloth woven in the neighbourhood acquired a wide reputation, and in spite of the legislative protection of the rival woollen industry, cotton goods took first place in Manchester trade early in the eighteenth century, and became predominant after 1770.

The industry was very similar, technically and economically, to woollen manufacture—in fact the cotton trade was superimposed upon an earlier trade in woollen and linen goods. Women and children, working in their own homes, carded the raw cotton by means of wire brushes, and then drew it out either on the hand or treadle spinning-wheel. Weaving was a man's job, and was carried out as a domestic industry or, to an increasing extent, in weaving sheds by the aid of journeyman labour. This tendency to concentration was due in part to the fact that one weaver could keep five or six spinners at work, and the yarn had to be collected from a wide area. The cloth produced was linen-cotton, the linen fibre being used for the warp, and the weaker, cotton fibre for the weft.

The first revolutionary impulse was the invention of the fly-shuttle by John Kay in 1738. Hammers were fixed on each side of the loom and, when operated by springs, served to propel the shuttle backwards and forwards between the warp threads. The weaver could now make cloth of double width as well as a greater length in a given time. But the device was not largely used until after 1760, in which year John Kay's son Robert invented the drop-box. This was a contrivance for lifting a number of warps at once, so that coloured fabrics could be woven. The demand for yarn now increased, and invention in connection with spinning machinery was stimulated.

Up to this time, it will be recollected, two forms of wheel were in use. One had a large wheel turned by hand upon which the thread was twisted at the same time that it was drawn out; and the other, worked by a treadle, had a small spindle upon which the thread was wound *after* it had been drawn out. The first process was continuous, the second intermittent. In 1764 it occurred to James Hargreaves of Blackburn that the treadle-driven wheel might drive by means of a belt a number of spindles; and that instead of using the hands two pieces of wood might be employed to grip the thread and draw it out. Such a machine he called a *jenny*, and the first one had eight spindles, so that it would spin eight threads at once. As very little power was required to work the spindles, and the pair of boards which clipped the thread called for no great strength to move them backwards and forwards, the eight could be considerably increased, and it was not long before jennies were in use which spun twenty or thirty threads at one time. Thus the balance of speed now rested with the spinners; and as these received their raw material from the merchant or weaver, who only handed it out as he needed yarn, many people were often short of work. The new machinery became highly unpopular; it was frequently smashed up, and its inventor had to move from the district.

But this was only a beginning. In 1769 Richard Arkwright, a barber and wig-maker of Bolton, seizing upon a suggestion of Lewis Paul some years before, invented a machine which both involved a new principle and was intended to be worked by power. The carded cotton was passed between successive pairs of rollers, each pair revolving with increasing velocity, so that the thread could be drawn as fine as was necessary. It was then spun in a contrivance very similar to the old large wheel. The machine was at first driven by horses, but in 1771 a mill driven by water-power was erected at Cromford in Derbyshire, and in 1778 six small mills were put up at Oldham, three worked by horses, and three by water-wheels. Watt's engine was applied at Popplewick in 1785, Manchester 1789, Bolton and Glasgow 1792, and Oldham 1798. But by this time a further advance had been made by Samuel Crompton, who in 1779 improved on Hargreaves' jenny by a machine which came to be called the *mule.* The mule was a carriage carrying the bobbins, and mounted on rails so that it could be pulled back for drawing the thread out and pushed up for winding. The thread spun in Arkwright's and Crompton's machines was strong enough to be used as warp, and linen thread for this purpose could be dispensed with. The effect of these changes is indicated by the growth in the imports of raw cotton, which increased by over 319 per cent in the ten years from 1781 to 1791. A contributory cause was a new source of raw material in the southern states of America, where the cotton plant had been cultivated during the revolutionary war.

The next improvement took place in weaving. In 1787 the Rev. Edmund Cartwright invented the power-loom, and drove it by a steam-engine in 1789. Cloth of almost any width could be woven on it, and two machines could be controlled by one girl. In addition to reducing the labour of weaving, it enormously increased the speed; it also yielded a more uniform quality of cloth, but was not adapted for producing the finer grades. Moreover, it only came into use slowly, partly because steam-engines were not being made in large numbers, and partly because the start which spinning had obtained had drawn into hand-loom weaving a large number of men who were being displaced from the soil by the new methods of agriculture. Thus in 1813—twenty-six years after the date of invention—there were only 2400 at work in the United Kingdom. By 1820 the number had increased to 14,000, employing probably 7000 girls, whereas the number of hand-loom weavers in that year was about 240,000.

Meanwhile cotton-spinning was growing rapidly. The invention of the cotton-gin for removing the seeds by Eli Whitney, in 1792, rendered unnecessary much slow and inefficient work at home; and though the increase in the importation of raw cotton from 1781 to 1791 was not maintained, the following figures are significant:—

RATE OF INCREASE IN IMPORTS OF RAW COTTON

1791–1801	67½ per cent	1811–1821	93 per cent
1801–1811	39½ per cent	1821–1831	85 per cent

The steam-engine was rapidly replacing the water-wheel. At Stalybridge in 1825 there were twenty-nine steam-engines and six water-wheels; but in 1831 the number of steam-engines had risen to thirty-eight. The essential fact, however, is that the introduction of machinery had destroyed hand-labour, and the introduction of power which arose after 1769 led to a concentration of labour in factories. The spinners were the first to suffer, and then the hand-loom weavers, and in both cases the movement first destroyed domestic industries which had supplemented a living obtained partly on the land, and then to some extent absorbed into the factories the labour displaced in this way. It is also important to notice that the earlier factories were dependent upon water-power, and were therefore established in mountain valleys, remote from the towns, and somewhat off the main roads which had enabled town and country to supply one another's needs.

In the circumstances which obtained during the early period, therefore, the scarcity of labour in the mills was a serious difficulty. The keen commercial spirit of the times —traceable in part to the high prices which prevailed during the American and continental wars — was not influenced by humanitarian considerations. When the supply of women and children in the immediate neighbourhood of the factories was exhausted, the practice arose of apprenticing children of seven years of age from the poor-houses; these were lodged and fed in hostels provided by the mill-owners. The mills were hot, moist, and unhealthy; the work was carried out for the most part under an iron rule which permitted no lagging. The hours of labour were from twelve to fourteen a day, or often two shifts of twelve hours each, and the food was coarse and unwholesome. The effect upon the children was stunted growth, misery, and not infrequently disease.

The workers possessed no organisation and therefore no power of resistance. But the facts gradually leaked out, and in 1796 the Manchester Board of Health drew attention to the insanitary conditions and the consequent danger to the neighbourhood. The first Sir Robert Peel, himself a large employer, introduced into Parliament a Bill which, passing into law the same year, forms the first link of a chain of factory legislation reaching down to the present time. Looking at this early Act from our own day it does not appear to be a very ambitious measure. It was limited entirely to the case of pauper children. The age at which they could be bound was raised to nine, the hours of labour were limited to twelve, and night work was abolished. The factory was required to be properly ventilated, and the walls whitewashed. The children were to be provided with new clothes once a year, to receive some education, and to attend religious service.

Bad as were the conditions under which pauper children lived, they were not much worse than those suffered by the mill-hands themselves. The sturdy independence of the hand-loom weavers, and their resentment against the machinery which was gradually reducing the price of the product of their own looms, kept them out of the mills, which recruited their labourers from women and children and, on the whole, an inferior type of man. As more and more became known of the circumstances the public conscience was stirred. Robert Owen, a successful manufacturer who had introduced a number of reforms for the benefit of his own workpeople, collected a large amount of information and was indefatigable in his efforts to secure State interference. Sir Robert Peel the elder took up the matter in Parliament, and a long and bitter controversy ensued. The advocates of legislation appealed to sentiment against the hardships and misery imposed upon the little ones; emphasised the lack of educational opportunity for minds exhausted by the strain of a long day's toil; and painted a vivid picture of the moral and physical degeneration which must inevitably grow with the system. On the other hand, the opponents of Government control pleaded that manufacturers who benefited the nation so much by employing labour should be left to manage their own businesses in their own way. They argued that interference would spell ruin by putting this country at a disadvantage in foreign markets, and that experience had shown Government regulation to be a failure. Moreover, the facts were disputed, and the reformers were accused of exaggerating evils which either did not exist, or were far less serious than they were made to appear.

But in spite of notable examples to the contrary, the abuses of the factory system were too real to be explained away, and the sympathy with suffering was too strong to be denied. The second Factory Act was passed in 1819, and though it did little more than place all children, pauper or otherwise, on the same footing, it reaffirmed the principle of State regulation of industry under the new conditions.

At various times during the next dozen years measures were passed to deal with minor questions, and in 1833 an

Act of a more comprehensive character was placed upon the Statute-book. This applied to all textile factories. The minimum age was kept at nine, but children between nine and thirteen were only permitted to work for eight hours a day, and young people from thirteen to eighteen only twelve hours a day, night work being prohibited. Every child had to be certified by a surgeon as fit for employment, certain holidays were prescribed, and provision had to be made for education and cleanliness. But, above all, four inspectors were appointed to see that the requirements were fulfilled, and numerous prosecutions during the next few years showed how ineffective the Act would have been without them.

After the first Coal Mines Act in 1842 Parliament again turned its attention to the textile industries, and in 1844 passed an important measure which, besides requiring provision to be made for preventing accidents, limited the employment of children to half-time, and placed women in the same category as young persons between thirteen and eighteen in regard to a twelve-hour day and the abolition of night work. In 1847 the length of the day for these was reduced to ten hours, or ten and a half with a half-holiday on Saturday. By this means more than 360,000 work-people had their own hours and other conditions of labour regulated by the State. Every step had been bitterly contested. The ruin of the trade, and, through it, of the country, had been boldly prophesied. Every political expedient had been employed to prevent legislation. But the efforts of philanthropists like the Earl of Shaftesbury, and of enthusiasts like Robert Owen, aided by a growing sense of responsibility, carried the day. Great Britain had introduced the factory system to the world, but she had grappled courageously with the social and economic difficulties which followed in its train, and had shown that industrial efficiency was not incompatible with the practice of humanitarian principles.

The development of the cotton trade was aided very considerably by two inventions which were connected rather with the finish of cotton goods than with their manufacture. Until about 1780 the bleaching of fabrics had been effected by exposing them for long periods to air and sunshine. The introduction of chlorine (discovered by Scheele in 1774) for this purpose reduced the time required for the process from months to days. The fact that the gas rotted the cloth led about 1795 to its substitution by bleaching powder, which is prepared by passing chlorine over lime; the manufacture of this is now a very important chemical industry. Again, the pattern on the cotton and linen cloths was stamped with a block by hand in short lengths until Bell in 1783 fixed the dies on the rim of a wheel and rendered the process continuous. The cheapness of the material produced in this way did much to popularise the fabrics, stimulated trade, and led to competition in improved designs and faster colours.

Though progress in the adoption of the power-loom was slow, this had less effect on the development of spinning than might have been expected. At first the extra capacity of the mill was absorbed in making the cotton warp to replace the linen formerly used; and as the mills increased in numbers and size a considerable export trade in yarn kept them busy. The growth of these exports is indicated in the following table:—

1798	£30,271	1802	£428,605
1799	204,602	1803	639,404
1800	447,556	1804	902,208
1801	444,441	1805	914,475

But while unemployment and reduction of wages were prevented among the spinners, who were merely transferred from the home to the factory, the power-loom produced great distress among those who continued to weave the coarser kinds of cloth upon the more primitive machine. For example, the fall in price of a particular quality at Bolton is shown below :—

1797	29s.
1807	18s.
1817	9s.
1827	6s. 6d.
1834	5s. 6d.

Moreover, there were other influences at work. Richard Roberts had made the mule self-acting in 1825, and considerably improved it in 1830. Like the power-loom, it was particularly well adapted for the coarser material. The introduction of the self-acting mule coincided with a period of severe depression, and many hand-loom weavers emigrated to the United States and Canada. Again, the cotton famine which arose during the Civil War in America produced widespread distress in Lancashire, stimulated the use of machinery suited to East Indian and short staple cotton, and forced manufacturers to instal the self-acting mule for coarse spinning. To keep pace with the development of spinning, the power-loom was essential, and the rate at which this increase took place is indicated by the following figures :—

1813	2,400 looms	1835	116,801 looms
1820	14,150 ,,	1870	440,676 ,,
1829	55,500 ,,	1890	615,714 ,,
1833	100,000 ,,	1903	684,000 ,,

From about 1835, therefore, the power-loom was employed almost universally for coarser fabrics, and the hand-loom weavers of these goods were forced to come into the factories, to emigrate, or to enter other occupations.

Since the middle of the century there have been several improvements in mechanical processes of outstanding merit. The Heilmann comber, which was introduced into this country after 1856, has been of enormous value in the production of fine yarns, a branch of the industry for which the English climate and the skill of the English operative are peculiarly fitted, and which is annually becoming of greater importance to English trade. The finest yarns can only be spun from cotton of the longest staple, and the machine to which we have referred removes all the shorter fibres in the process of combing. During the last ten or twelve years an improvement has been introduced in the Nasmith comber, which performs the same function as the older machine but in a more effective way.

Another improvement relates to the continuous spinning process. In the first half of the eighteenth century the machines in use were known as throstle frames from the singing note they emitted when working. Between 1840 and 1870 these declined. In 1828 a ring spinning-machine was invented in the United States, and since 1880 it has been very largely adopted in this country. It is a continuous process, based on the original water-frame of Arkwright, but able, by the more perfect workmanship expended upon its construction, to work at enormously greater speeds. With spindles running at 6000 or 8000 revolutions per minute, and the thread being twisted and drawn at the same time, breakages may easily occur, and the finer counts are not attempted on these machines. The thinnest thread is still spun on the mule, which is the cheaper machine to instal, but requires male labour. The chief influence which thus determines not only the kind of machine but also the character of the manufactured product in any particular factory is the availability of male or female labour. At Wigan, for example, where the male labour is required for coal mining, the whole of the spinning is on ring-frames. As a matter of interest it may be remarked that, roughly speaking, one operative is required per thousand spindles on either machine for average counts.

In weaving, the principal modern invention which exerts an influence on the output is the Northrop loom. The Jacquard loom, invented about 1800 and used at first in silk weaving, was really an attachment for facilitating pattern weaving, and is still used for this purpose. But the Northrop loom, invented by a Yorkshireman in the United States in 1892, is an improved ordinary loom, superior in every way to the older machine, and fitted with a device by which the empty weft bobbins are replaced automatically. It is especially adapted for weaving plain cloths, and is as completely automatic as a machine can be—so much so that twenty or twenty-five can be controlled by one man. A comparison with the conditions in 1840, when one girl took charge of two looms, will give some idea of the reduction in the cost of manufacture which this invention secures.

There are other machines—such as the Barber Knotter—of great ingenuity, of which no description can be given here; but in spite of these the industry is not one which calls for a high degree of scientific knowledge—using the term in the ordinary sense—in its conduct and management. The machines are the product of invention rather than of investigation and discovery. This statement does not imply that all the problems, mechanical and physical, have been solved. The main interest of cotton spinning and weaving, however, is economic, not only because it is one of the most remarkable cases of a concentrated industry in the world, but because it is the most closely regulated by Statute, and because it is the most highly organised in regard to the relation between employer and employed. The nature of the Factory Acts up to and including that of 1847 have already been noted, and as subsequent legislation did not refer so exclusively to the cotton industry, it has been dealt with in Chapter XVI. Here, however, we may emphasise the fact that Factory Acts impose a joint responsibility, which brings employers and workpeople into close association. This accounts to some extent for the early recognition of the Unions and the right of collective bargaining in the cotton trade. The universal system of piece-work, as against day-wages, led to the establishment of price-lists, by which wages are calculated for every kind of work. The Bolton lists for spinners date from 1858, and the Oldham lists from 1876. The Blackburn list for weavers was first drawn up in 1853, extensively revised in 1892, and now controls the wages of over 200,000 workers. A list for cardroom operatives using flat cards was drawn up in 1903. This affects only 4000 men; but a list for men working on frames, drawn up in 1907, regulates the wages of 25,000.

From time to time items in these lists have to be revised, and the Trade Union official is the adviser of the operatives in regard to any change which is proposed, and every dispute which arises in the mill. After the great spinning strike of 1892–93 the Master Spinners and the Unions signed the famous Brooklands Agreement, which lays down rules of procedure and prevents premature strikes among 150,000 operatives. Though often in danger, it has stood the test for twenty years, and has completely justified the hopes of its promoters. The weaving branch adopted the same plan in 1909, and brought another 130,000 under the scheme. No other industry has reached such a high degree of organisation as is implied in this Agreement.

The dependence of the cotton-crop upon the weather, and the depredations of the boll-weevel, renders the raw material an attractive subject for commercial speculation, and these causes lead to violent fluctuations in the supply and market price. In order to prevent the rate of wages falling below a minimum the practice has arisen of restricting the output by working short-time; and as the employers are themselves well organised this can be done without an individual employer securing an advantage by running his mill full-time. In this way much periodical distress has been avoided, and the industry furnishes, again, an example of effective co-operation between capital and labour. The most important case of restriction of output, however, has been international in character. For a number of years the demand for goods had been rapidly overtaking the supply of raw material, and in 1904 an International Association of Master Spinners and Manufacturers was formed. The proposal that all mills should work short-time in order to avoid acute distress was favourably received, and the British hours of labour were reduced from 55½ to 40 per week. The Association holds an Annual Conference, publishes a valuable Annual Report, and has a standing Committee which meets twice a year. It works in close co-operation with the International Institute of Agriculture, which was established about the same time, with its headquarters in Italy. The extent of its influence may be gathered from the fact that statistics which it issued in 1912 were obtained from the owners of 126,714,982 spindles

—the total number of spindles in the world at that date being 142,186,308.

There is one feature of the cotton industry which gives rise to violent controversy. In common with woollen and worsted manufacture the cotton mills continue to employ child labour at a lower age than in any other occupation. From twelve years of age thousands of children are employed on work which, it is contended, it is advisable that children should do; and these little ones are deprived of the full enjoyment of those educational opportunities which the State provides. It has been shown over and over again that the effect is morally and physically bad, but the necessity is maintained by the employers, and supported by the operatives themselves. It is to be feared that both sections are too often influenced by sordid motives, in which the real interests of the child, and of the community, have no place. And it is incredible that an industry which can show so many triumphs of mechanical ingenuity and such effective organisation, should depend for its existence upon the fragile bodies, nimble fingers, and unformed minds of young children. The social and economic evil is aggravated by the fact that the preponderance of female labour renders it impossible to retain half the boys who enter the mills. They are cast off at an age when it is difficult to enter other skilled occupations, and without that educational advantage which a longer period at school would have conferred upon them.

2. *Other Textiles*

The manufacture of cotton goods has been considered in some detail, partly because it was so essential a feature of the Industrial Revolution in its early stages, and partly because it is such an admirable example of modern industrial organisation. Space will not permit of similar treatment being accorded to other textile industries, but it will be instructive to note a few of the salient features of their development, and it will be convenient to consider wool first.

(*a*) *Wool.*—Notwithstanding the fact that almost every kind of fibre which is obtained from animals is used in the manufacture of woollen goods, the basic material is still the wool of the sheep. The finest quality is merino, and all merino is Spanish in origin. The Spanish merino is supposed to be the descendant of the Tarentine breed, which was the special pride of the Romans, and it was introduced into Australia and New Zealand about 1821. Meantime a variety of long-woolled sheep of heavier build had been bred by Bakewell between 1760 and 1800. When the Colonies were called upon to supply meat as well as wool after 1880 the merino began to be replaced by cross-breeds in which the Leicester and Lincoln breeds gave weight both in carcase and fleece, at a slight expense of fineness of fibre.

In the eighteenth century the woollen and worsted mills were not concentrated in the West Riding. They were distributed in groups in the Eastern Counties, the west of England, Wales, Scotland, and Ireland. The most powerful reason for the migration was probably the necessity for proximity to dye-works; for wool may be dyed before or after spinning, or when it has been woven into cloth. Moreover, the first process carried out by mechanical aid was *fulling*, in which the loosely-woven material was soaked in soap and water. Under this treatment the material shortens and thickens, so that warp and weft become indistinguishable. The streams which ran down the eastern slopes of the Pennines provided the water for the soaking and the power which was needed to drive the machines. When spinning and weaving machinery came to be driven by the steam-engine the Yorkshire coal-fields encouraged concentration at the expense of East Anglia and other centres. The use of power-driven machines was later by thirty or forty years than in the cotton trade, and it is only within the last thirty years that many of the West Country mills have closed down.

The difference between woollen and worsted goods lies in the yarn. In the latter the fibres lie as nearly parallel as possible, while in the former they are more or less interlaced. Worsted, therefore, makes a finer, closer cloth. Wool is invariably spun on a mule; worsted occasionally on a mule, but far more frequently on a ring-frame. It is a peculiarity of the wool fibre that it can be used over again. About 1800 Benjamin Law discovered that old woollen rags or *shoddy* could be disintegrated and re-spun. The shoddy is mixed with more or less new wool according to the quality required, and the mills in Dewsbury and the immediate neighbourhood now use more than 200,000,000 lbs. per annum of this material. Woollen and worsted manufacture differs from the cotton industry in the use of old materials, in the fact that cotton, silk, and many kinds of animal fibre are employed, in the greater number of preliminary, and the wider variety of finishing, processes.

The trade is mainly a home trade, while cotton is largely manufactured for export. Fluctuations of price occur, but they are neither so frequent nor so large as in the case of cotton. The cause of a rise is due mainly to periodical droughts, or outbreaks of disease in the sheep-raising lands of the southern seas. Until recent years the whole of the Australian wool was sold in London, but many local sales are now held in Melbourne and other towns.

Another marked distinction is the absence of strong Trade Unions, and the prevalence, as a cause or an effect, of relatively low wages which show less uniformity. The wool-workers have from time to time initiated movements for better conditions of labour, but they have never exercised an influence comparable with that of the cotton operatives, the miners, the builders, or the engineers. Perhaps a reason is to be found in the high degree of specialisation that is entailed by the nature of the materials and processes. There is an absence, consequently, of that community of interests which excites and sustains concerted action. The factories are, in general, smaller than in the cotton trade, with more of the old personal relation between employer and workman which facilitates a settlement of differences. The later development of the Factory System probably enabled the industry to avoid some of the sharp issues which arose in cotton manufacture, and the Factory Act of 1847 was extended to this industry on general policy rather than as the result of a powerful movement from below.

(*b*) *The Silk Industry.*—Silk manufacture is at once one of the oldest, the most scientific, and the most artistic of the textile industries. Four thousand years ago the Chinese are said to have made beautiful fabrics of this material, and though their share in the world's markets has now dropped to less than one-third, this fact is due largely to the neglect of scientific methods in silk-worm culture. The prevalence of silk-worm disease in France in 1867 attracted the attention of Pasteur, who showed how to detect it, and proved that it could be eradicated if the eggs from unhealthy moths were destroyed. The general adoption of his methods in Italy renders the productivity of the Italian worm four times greater than that of the Chinese.

Silk throwing and weaving was introduced into this country in exactly the same way as the corresponding processes for wool and linen. There was a famous settlement of silk weavers at Spitalfields in the sixteenth century, and in Norwich a little later. Thereafter the industry became widely distributed, with more important centres at Macclesfield and Leek. As the silk fibre is continuous, the process of making it into yarn differs somewhat from that employed for wool and cotton, and is called *throwing*. Machinery was first used in England by John Lombe of Derby in 1717, but the ideas were brought from Italy. The Jacquard loom invented in 1801 facilitated fancy weaving, and the use of power followed a similar course to that in the manufacture of cotton goods.

The process of *throwing* only utilises the long continuous threads, and leaves a large quantity of silk "waste" which, from ancient times, has been *spun* into yarn. In the eighteenth century the waste was cut up and spun in the same way as cotton, but about 1830 it was subjected to the same methods as were employed for the long fibres of flax, and twenty years later this plan became universal. Spun silk is in no way inferior to thrown silk, and since it is prepared from a by-product, silk-spinning effects a real economy in what may be termed the parent industry.

No other textile material has been so much affected by vagaries of fashion and by scientific discovery. Originally an article of luxury, the increasing wealth of the nation enabled the middle and lower middle classes to indulge in it, so that it came to be avoided by leaders of fashion. Moreover, the incessant demand for variety and cheapness led to the replacement of all-silk fabrics by mixtures containing wool and cotton, and to a certain extent the silk industry became subsidiary to its more powerful rivals. In 1844

John Mercer discovered that when cotton was dipped in caustic soda considerable shrinkage occurred, the fibre took on a high lustre resembling silk, and acquired a greater affinity for dyes. A patent was taken out for "mercerising" cloth in 1888, but it was not until five or six years later that the material was made in large quantities. Meantime silk was prepared by a purely artificial process. The fibre is a hardened gum, composed almost entirely of cellulose, which the worm obtains from the leaves of the mulberry tree. In 1743 Réaumur suggested that if a jelly of this material could be obtained, it might be expressed through a fine orifice and the dried thread used instead of the natural product. Cellulose, however, which is the essential material of all vegetable fibres, was insoluble in any known liquid, but in 1863 a Swedish chemist patented a process by which nitro-cellulose was made into a solution like a quick-drying varnish and squirted through a fine hole. This had no commercial success. Twenty years later James Wilson Swan used a similar method for preparing the filaments of electric glow lamps, but proceeded no further.

Since that time three successful processes have been devised. Chardonnet about 1884 used a solution of nitro-cellulose in a mixture of alcohol and ether, which evaporated almost as rapidly as the thread was formed. In the earlier years the Companies made profits of from 40 per cent to 60 per cent, but development has been wholly prevented in England and hampered in some other countries by the high duties on the solvent liquids. The second process, invented shortly afterwards, depended upon the solubility of cellulose in a solution of cuprammonic chloride. A jelly is formed and the thread squirted into a bath, which causes it to solidify. It still contains copper, which is removed by subsequent treatment. The third process, patented by

Cross and Bevan in 1892, and again with considerable improvements in 1901, consists in converting the cellulose into zanthate of cellulose, which can be made into a jelly with water by the action of caustic soda and carbon disulphide, and then reconverting the thread into cellulose. The product goes by the name of viscose, and is made principally at Coventry. Its manufacture is increasing more rapidly than that of the other varieties.

The amount of artificial silk produced annually is probably more than 8000 tons, and the raw material may be any kind of vegetable fibre, though wood-pulp and cotton appear to be most widely used. Politically the industry is of small consequence; socially it increases the variety and attractiveness of clothing; but what strikes the imagination is, that by a process evolved in the laboratory 8000 tons of wood-pulp or waste cotton is converted every year into hundreds of thousands of miles of thread, and woven into fabrics the like of which have delighted the daughters of men for 4000 years. Nothing could exhibit more clearly than this achievement the new conditions of industrial progress which have been created since the dawn of the nineteenth century.

(*c*) *The Linen Industry.*—Linen is made from the fibre of the flax plant, and is in all probability the most ancient textile material except wool. At least 4000 years ago the Egyptians spun flax and wove linen equal in quality to the best that can be produced to-day. During the Middle Ages and the Renaissance it was manufactured on the Continent with a skill comparable with that displayed in the manipulation of wool, and many of the foreign artisans who at various periods found sanctuary in this country from religious persecution were accustomed to work in this material. But the protection afforded to wool and woollen goods before the eighteenth century, and the subsequent rise of the cotton industry, prevented the extensive growth of linen manufacture. A machine for spinning flax was invented about 1787, and came into general use soon after 1800; but the power-loom was not largely employed until after 1850. The number of spindles increased to a maximum in England about 1870, and in Scotland about 1875; while power-looms reached a maximum in England in 1875, and in Scotland in 1885. The decline in the northern part of the kingdom was accompanied by a concentration upon coarser goods, such as sail-cloth, etc.

On the other hand, progress in Ireland was continuous, and Irish linen has the reputation of being the finest in the world. There are now about 1,000,000 spindles and 40,000 looms. Originally distributed all over the country, the industry has gradually become settled in North-East Ulster, with Belfast as centre. The cause of the development is to be found, probably, in abundant labour and a suitable climate, while the geographical situation has been determined by the convenience for import of raw material and export of finished goods. In spite of the fact that flax can be grown in Ireland, most of it is obtained from Russia and Belgium: the coarser qualities coming from the former country, and the finer qualities from the latter. As the finer linen is somewhat of a luxury it is less subject to the vagaries of fashion than cotton, wool, or silk, and the trade is much less subject to fluctuations.

(*d*) *Jute.*—Jute is of interest partly because it is an example of an originally almost useless raw material being rendered available by an improved technical process, and partly by reason of the widespread use of jute fabrics. The fibre is closely akin to *sunn* hemp, which was spun and woven in India, and it was introduced into Great Britain at the close of the eighteenth century. Early attempts to spin the material were not very successful, and even after the introduction of machinery about 1822 great difficulties were encountered. The roughness rendered both yarn and cloth almost unsaleable until it was discovered that an emulsion of oil and water softened the fibre and immensely improved its appearance. Since the first ship-load from India reached Dundee in 1840 the industry has developed rapidly, and, as the demand increased, great benefits were reaped by Bengal and Assam, which have now about 3,000,000 acres entirely devoted to the cultivation of the plant. The chief use of jute is as a wrapping material and for sacks for grain and other foodstuffs. It is also used largely for awnings and mattress covers; twine, cord, and rope; the backing of linoleum; stair and other carpets, rugs, and mats. It replaces coarse linen by reason of its cheapness.

(*e*) *Hosiery.*—The manufacture of hosiery may be regarded as an offshoot of the cotton, linen, wool, and silk industries. Any of these materials are used, the yarn being knitted instead of woven. The process was carried out by hand until 1589, when William Lee, of Calverton in Nottinghamshire, invented the Stocking-frame. Like many of the early inventors, Lee found some difficulty in securing tangible recognition of his services. Queen Elizabeth accepted a pair of silk stockings from him, but would grant no privileges. Despairing of obtaining any reward in his own country, he went to France, where, having enjoyed the patronage of Henry of Navarre, he spent his remaining days. After William Lee's death, James Lee established the industry in London, and in 1660 Charles II. granted the London Company a monoply, which they held until 1753.

When Parliamentary protection was withdrawn, the trade had already become firmly established in Nottingham, Derby, and Leicester—particularly in the first-named town. In 1695, thirty-five years after the monoply had been granted, the number of frames in London was 1500; by 1714 Nottingham had 8000 frames, and by 1853 over 11,000 frames. The sole advantage of the original machine lay in the fact that a whole row of stitches could be made at once. The knitting was plain, the stocking could not be shaped, and it had to be sewn up by hand. An important improvement was made about 1760 by a Derbyshire farmer, named Jedediah Strutt, who invented an attachment for making ribbed hose, which were much more elastic than plain knitted stockings. In spite of the fact that ingenuity remained dormant at this stage for nearly a hundred years the trade developed rapidly in the Midlands, and the 20,000 looms in Nottingham in 1800 had risen to 50,000 in 1850. Within the next ten years important mechanical progress was made. Mellor invented the Loop Wheel Circular Frame, by means of which seaming was avoided, in 1850; the Latch Needle, with which various fancy stitches could be made on the circular frame, was invented by Townsend in 1856; and in 1857 Barton first operated machines by power. Until this date the industry had been mainly a domestic one carried on in the homes of the people by the aid of machines rented from the employers at from 1s. to 3s. a week. The system lent itself to abuse, and the greater economy of production in factories, combined with the increasing tendency of the State to regulate industry, led to its abolition in 1873.

(*f*) *Lace.*—Up to the end of the eighteenth century lace was made on a pillow, the net being formed by carrying the threads round pins stuck in the pillow at equal distances; and to this day pillow-lace making exists as a cottage industry in Devonshire and other parts of the country. The work of the nimble fingers of the country women is highly prized, but the process is slow, and the material would have remained an expensive luxury had not Morris improved Lee's stocking-frame in 1781. This was the first machine to make a round mesh, necessary for point-net lace, and the output of the new machines during the Napoleonic wars so brought down the price as to cause great distress among the workpeople. This continued for many years, so that even in 1844 fifteen per cent of the frames were idle, while the average wage for a week of sixty-six hours was only 7s.

Meantime the machines had been greatly improved. In 1813 John Levers made an important modification by which patterned lace could be made; and this was perfected by Draper in 1837. A later machine is the Plauen, which embroiders on plain net. The industry is almost wholly concentrated in Nottinghamshire and Derbyshire, but there is a large factory at Tiverton, which was established by a Nottingham man, named Heathcoat, who in 1809 had devised the mechanism upon which Levers' machine was based. The wreck of his factory at Loughborough by the Luddites caused him to leave the Midlands for the calmer atmosphere of the south-west. But wherever the factory is situated, machine-made lace is still called Nottingham lace—a striking tribute to the excellence of manufacture in the town in which all the pioneer work was done.

The industry was slow to develop on the factory system, for in 1840 there were about 4000 frames in the possession of 1300 artisans. But the wages have vastly improved since the first half of the nineteenth century. The Board of Trade enquiry into the lace trade in 1906 ascertained that 2100 workers in Nottinghamshire and Derbyshire received an average wage of 23s. The amount received by the majority of the employees is regulated by a piece-work price list, similar to those in use in the cotton trade, but several of the subsidiary processes are carried out by out-workers, and the Minimum Wage Act was applied to these in 1910.

CHAPTER VI

FUEL AND ITS APPLICATIONS

Great Britain is to-day the wealthiest country per head in the world. This position she owes to the variety and excellence of her manufactures, to her geographical situation, and to that command of the sea which enables her to carry the bulk of the world's merchandise. Striking, however, as had been the progress before the eighteenth century, there was little to distinguish her from other continental Powers. She was inferior in the practical arts; her coast-line was larger only in proportion to her area than that of other nations; and she was mistress of the seas only in succession to the Dutch, the Spaniards, and the Portuguese. She had no canals or navigable rivers like Holland, France, Russia, or the States of Central Europe, and her roads were such as to excite the contempt of the foreigner. Her strength lay in the narrow seas which formed a natural frontier, and in the sturdy independence of the people.

But beneath the surface of the land were coal and iron, hitherto regarded as having no value in relation to one another, and yet waiting only to be turned to account. The prime cause of the Industrial Revolution lies behind the textile inventions, behind the agricultural reformers, behind even Watt's steam-engine. It was coal and iron. The world was about to enter on a new epoch—the age of iron—which, starting from Great Britain, was soon to create a greater change in the material conditions of life than any yet recorded in history or handed down in the legends of prehistoric days. Backward as we had been in mechanical skill, and inferior as were our products, every important invention connected with mechanical power, until the middle of the nineteenth century, was made in this country. Great Britain became not only the workshop of the world, but the home of its scientific and technical advisers, and of the pioneers of modern industrial civilisation.

1. *The Iron Industry*

It has been shown how in Tudor times the inroads of the charcoal-burners upon the forests caused anxiety in regard to the supply of timber for ship-building; and how not only restrictive legislation but also the clearing of forest-lands in the neighbourhood of the iron-works had caused the industry to decline. It has been estimated that the total annual production of iron in Europe in 1700 was only 100,000 tons, of which probably 60,000 tons was obtained in the forests of Norway, Sweden, and Russia. The contribution of England was not more than 12,000 tons. By 1740 this had risen to 18,000 tons, produced in fifty-nine furnaces, of which ten were in the Forest of Dean and ten in Sussex. Increasing shortage reduced the southern furnaces to two before 1788, and the last of these, at Ashburnham, was finally blown out in 1827. The same fate would ultimately have overtaken the industry in South Wales, the Midlands, and the North, had not some means been discovered of smelting without charcoal. But iron was needed in increasing quantities, the growing scarcity of timber near the towns was leading to the use of pit-coal in dwelling-houses, and the more enlightened iron-masters were compelled to traverse again the ground covered by Dudley a hundred years before.

The first man to employ pit-coal or coke as a regular practice was Abraham Darby. Having served an apprenticeship to a maker of malt-kilns near Birmingham he moved to Bristol and set up a business of this kind for himself. At that time imported cast-iron pots were largely used by the poorer people as cooking utensils, and failure to make these in clay moulds induced him to visit the Continent in order to see the process in operation. Returning in 1708 he took out a patent for casting the vessels in sand, and with the assistance of skilled Dutch workmen he started a foundry near Bristol, moving a year later to Coalbrookdale in Shropshire. Here he made from five to ten tons of iron per week, and sometimes turned out as many as 150 pots in the same interval.

But supplies of timber in the neighbourhood becoming scarce he began, about 1713, to use pit-coal for calcining the ore. Some years later (about 1730) his son, Abraham Darby the second, began to make coke from coal by a similar method to that by which charcoal was prepared from timber. The coal was stacked in heaps, covered with turves and allowed only sufficient air to make the whole mass red hot. This coke was then used for smelting iron, a blast being provided by a large water-wheel 24 ft. in diameter, which worked a bellows. From that time forward coke came to be employed more and more in place of charcoal.

Useful as are cast- and wrought-iron, there is a metal of intermediate composition which has special properties of its own. When the percentage of carbon lies between 0·2 and 2·5 the metal is called steel, and steel can be either welded or cast. With a low percentage of carbon it behaves more like wrought-iron, and with a high percentage it approximates more closely in character to cast-iron; but in either case it is less easily broken. Moreover, if it is raised to a high temperature and then cooled suddenly by immersion in water it becomes extremely hard, the degree of hardness increasing with the percentage of carbon. A certain quality of brittleness is also produced, and this is removed to any desired extent by heating the metal to a definite temperature, lower than before, and then quenching. Thus the "temper" of any variety of steel can be varied considerably.

While Darby was establishing a method which was to effect nothing short of a revolution in the production of pig-iron, another epoch-making process was being worked out by John Huntsman. The son of a German, who had settled in Lincolnshire, he served an apprenticeship as a clock-mender, and started business for himself at Doncaster about 1725. Being dissatisfied with the German steel for springs he began experiments with the object of making a more suitable metal for the purpose. He removed to Sheffield in 1740, and after many years succeeded in preparing cast-steel by melting Swedish iron—which was far purer than English—in a crucible with charcoal. The iron took up from 0·25 per cent to 1·75 per cent of carbon, and was admirable, not only for springs, but also for cutlery. The Sheffield cutlers refused to purchase it, but made many attempts to discover the secret of its manufacture. A ready market was found in France and it acquired a great reputation, so that Huntsman's trade-rivals petitioned the Government to forbid its export. But as they refused to use it themselves this protection was denied them. The business grew so rapidly that a new factory was erected in 1770, but the process was ultimately found out and universally adopted, with the result that Sheffield leaped at once into its position as the most famous centre of steel manufacture in the world.

The great advantage of cast-steel was that it enabled metal-working tools to be developed. All softer metals could be cut and shaped with an ease which, if it had ever before existed, had long been lost to the world. The use of these tools inspired the workman with confidence, lightened his labour, and vastly increased his resource. By rendering iron more easily workable the tools increased the demand for that metal and stimulated its production. They exerted an incalculable influence in creating the conditions which were necessary for other inventions, such as those of Henry Cort, to bear fruit.

The crown of the series of inventions which have been described was forged by Henry Cort, who was born at Lancaster in 1740, and whose career is unrecorded until he is discovered in the capacity of a Naval Agent in London in 1765. In the course of his business he became impressed with the inferiority of British iron, which was rigorously avoided in favour of Russian or Swedish by Government Departments. So fully were the Russian Government convinced that the United Kingdom was dependent upon that country for the quality of metal they required, that in 1770 they raised the price from 70 and 80 to 200 and 220 kopecks per pood. Cort thereupon applied himself to the problem of improving the refining process, and opened a small foundry at Fareham in 1775.

Before his time some attempt had been made to replace charcoal for making wrought-iron. Two brothers named Cranege, who were employed by Richard Reynolds, the manager of the Coalbrookdale works, had succeeded in producing wrought-iron from pig-iron without using a blast, in 1766. They replaced the refining hearth by a reverberatory furnace, consisting of a shallow hearth, with a grate at one end and a flue leading to a chimney at the other. Between the grate and the hearth was a low brick wall, called a bridge, and as the flames from a coal-fire played over the bridge they were deflected upon the metal by an arched roof. The lining was of sand, leading to great waste of metal, and it was many years before this was improved by making it of hæmatite, resting on iron-plates kept cool by water. The method had been modified in South Wales by stirring the metal with an iron bar thrust through a hole in the side of the furnace, or "puddling" it; and Cort adopted this plan also. At the same time he employed grooved rollers for squeezing out the slag and making bars, and made a practice of beating the metal into tapered bars, "piling" them into a "faggot" and then beating or rolling them into a single bar. Though usually credited with the invention of the puddling furnace and rolling mill, he really collected details of practice, combined and improved them, and so devised a process which gave immensely superior results.

No sooner had the improved methods been worked out in 1783–84 than misfortune fell upon him. His partner had been a man whose father, an Admiralty official, had advanced considerable sums to the firm, and was subsequently found guilty of extensive embezzlement. The works were seized by Government officials and, strange to say, no attempt was made to collect the royalties. Cort was plunged into poverty, and died poor in 1800. The large iron-masters had all adopted his methods. Richard Crawshay, of Cyfarthfa, who in 1787 was making 10 tons of bar-iron a week, was making 10,000 tons a week in 1812. If he had paid a royalty, Cort would have received before his death £25,000 from this source alone. The 18,000 tons produced in England in 1740 had risen to 90,000 tons in 1784; but by 1820 it had reached a total of 400,000 tons per annum, and in 1860 there were no less than 8000 puddling furnaces in operation in the country.

The progress of the iron and steel industry since 1700 falls naturally into two periods, the first ending with the inventions of Henry Cort. The labours of Darby, Huntsman, and Cort, among hosts of others who contributed rather to its commercial than to its scientific development, had multiplied the production of pig-iron and wrought-iron more than thirty-fold in less than a hundred years. Moreover, the quality had been so much improved that it entered into competition with that from abroad for all purposes except the making of steel, for which the famous charcoal iron from Dannemora in Sweden was still unsurpassed. By its demand for coal it stimulated the mining industry, since at that time for every ton of pig-iron no less than 9½ tons of coke were required. Exactly how much coal was consumed in the iron industry it is not possible to say. While no exact record of coal raised in the United Kingdom was kept until 1854, it has been calculated that out of a total world-production of 11,600,000 tons in 1800 no less than 10,100,000 was won in this country.

By way of contrast it is interesting to note that coal was not used in American blast furnaces until 1838, and on the continent of Europe, where war did not interfere with peaceful progress, the people obtained domestic comfort or carried on their industries by the aid of wood or charcoal. When Napoleon called the British a nation of shopkeepers he missed the significance of the brawny men who wielded pick and shovel in the mine, or swung the hammer in the light of the glowing forge. But of that more anon.

Practically the whole of the iron industry was concentrated at first in South Wales, the Forest of Dean, and Staffordshire, and to a smaller extent in Yorkshire. But a beginning had been made in Scotland by Dr. Roebuck, Watt's first partner in the steam-engine, who established the Carron Ironworks in 1761. The fact is noteworthy, because raw coal was then first used in the blast furnace, and an extremely powerful blowing-engine driven by a water-wheel was constructed for the works by Smeaton, the famous engineer. Though iron had been worked in Ross in earlier times, the industry had died out, and the 1500 tons yielded by Roebuck's furnace was really the first contribution from the northern part of the Kingdom to the British iron trade.

The growth of the Scottish iron industry was slow. There were no mechanics in the country, and the men with native genius, like Telford, Watt, and Murdoch, had to come south to secure recognition of, and scope for, their abilities. But the seed of a great development was being sown. David Mushet, a book-keeper who learnt assaying in his spare time, discovered the blackband ironstone in 1801, and it was used to a slight extent for mixing with the better known and more easily smelted clayband ore. In 1825 the Monkland Company started using it entirely, but at first without much success. At this stage J. B. Neilson, who had been appointed the first manager of the Glasgow Gas Works in 1817, turned his attention to the matter, and after many experiments came to the conclusion that the blast should be heated. The invariable practice hitherto had been to keep it as cool as possible, and when he patented the method in 1828 he had to face a good deal of ridicule. Trial on a large scale turned the tables. The average amount of fuel per ton of metal required during the first six months of 1829 had been 8 tons 1¼ cwt. The average amount required during the first six months of 1830 with the blast heated to 300° Fahr. was 5 tons 3¼ cwt. In 1833, when coke was replaced by raw coal and the temperature of the blast raised to 600° Fahr., the amount required was 2 tons 5¼ cwt.

The effect of this on the Scottish iron industry was immediate. The production in 1830 was 37,500 tons, in 1840 it was 200,000 tons, by 1845 it was 475,000 tons. The joint use of blackband ironstone, which contains a good deal of combustible material but is not easily smelted by cold-blast, and Neilson's invention, developed an enormous industry out of a hitherto unusable raw material. The prosperity of this trade was primarily responsible for the growth of the Scottish railway system, it stimulated agriculture, and exerted a beneficial influence which penetrated everywhere except, perhaps, into the remote highland glens.

The advantage of hot-blast is smaller in England where the coal has good coking qualities, and the ore, native or imported, is more amenable to cold-blast; but it is used to a very considerable extent, and has been especially valuable with anthracite. A decided economy was effected by Budd, of Ystalyfera in the Swansea Valley, in 1845, who heated the blast with the hot gases that escape from the top of the furnace. It is a little curious that the plan was not adopted more rapidly. In 1882 there were still seventy furnaces with open tops, but increasing competition has reduced them gradually, so that to-day all are closed.

The period 1850–60 was one of extraordinary development in the iron industry. The Cleveland district was opened up by Messrs. Bolckow and Vaughan, who in 1851 erected three furnaces at Middlesborough, and they were followed two years later by Messrs. Bell Brothers. The Durham coal is said to make the best coke in the world, the Cleveland iron ore is easily smelted, and the district is close enough to the sea to reap the benefit of water transit. The association of suitable ore and fuel led about the same time to the development of the industry in Yorkshire and Derbyshire. The success of the iron industry in England, and especially in these three areas, must be attributed largely to the presence of raw material and fuel in close proximity, as well as to a favourable geographical position for world markets. The middle of the century, therefore, marks the birth of the great industrial towns of Durham and Derbyshire, and the development of the ports on the Tyne, the Tees, and the Wear, which had formerly exported only coal. The expansion of the iron trade was fostered by the rapid growth of the railway system, which, so far as the principal lines are concerned, was completed before 1860.

In 1825 Staffordshire was the chief centre of the iron manufacture, producing more than one-third of the British output, and it was here that experiments were first made in improving the shape and increasing the size of the furnace. The 30 or 40 tons per furnace was raised in 1832 to 115 tons, in 1838 to 236 tons, and in 1854 to 300 tons. When the Cleveland iron-masters started they kept up the rate of progress until, in 1870, 400–500 tons per week was a regular yield. The Americans constructed still larger furnaces, and in some cases as much as 700 tons of metal per day are now produced. The primary object, however, is not so much quantity of metal as economy of fuel. The amount of coke per ton of iron has been gradually reduced from $9\frac{1}{2}$ tons a hundred years ago to less than a ton to-day. Consequently, while the British production of 8,100,000 tons of pig-iron in 1882 required 18,011,000 tons of coal, the 8,500,000 tons in 1902 required only 16,500,000. A comparison, however, of the earlier and later rates of progress shows that beyond a certain point further economy is difficult of attainment.

The most far-reaching invention of the nineteenth century, however, was that of Sir Henry Bessemer, who, in a paper read before the British Association for the Advancement of Science in 1856, described a method of converting molten pig-iron into steel without the use of additional fuel. He relied on the fact that the carbon, silicon, and other bodies which are to be removed from pig-iron are combustible, and conceived the idea of burning them out by blowing air through the molten metal. The patent was not recognised as valid in Prussia or the United States, but a number of licences were granted in England. In Bessemer's hands the process had been a success, but others obtained variable results, and a long investigation had to be undertaken to ascertain the reason. By 1860 it had been discovered that phosphorus was not eliminated in the process, and pig-iron from a non-phosphatic ore must be used. Meantime steel manufacturers had grown shy, and Bessemer had to secure partners and to establish works of his own at Sheffield. The result was such an immediate and striking success that, on the dissolution of partnership in 1874, each had received eighty-one times his original capital.

Steel of any grade can be produced because the whole of the carbon is burnt out, and the requisite quantity then added in the form of ferro-manganese or spiegeleisen. Both these are alloys of manganese and iron with a high percentage of carbon. The value of manganese had been shown twenty years before by Heath, and was invariably used in steel-making. It had enabled British ores to be used, and had already reduced the cost of steel by 50 per cent. But Bessemer continued to use Swedish iron, and found a ready sale for his metal at £42 a ton. In fact, the real merit of his invention was cheapness. Before his time 3½ tons of fuel per ton of pig-iron were required, and afterwards 3 cwt. would suffice for the preliminary melting —a saving of 95 per cent. Moreover, the process lasts only from 20 to 40 minutes.

The new material was used for steam boilers in 1860, and allowed of an immediate increase of pressure. The first steel locomotive was built by Ramsbottom in 1863. In 1865 Bessemer showed steel rails that had outlived twenty similar rails of wrought-iron, and by 1880 two-thirds of the railway mileage of the kingdom were laid with them. The first steel ship was built in 1863, and since 1874 no iron ship has been launched. But for eighteen years the disadvantage existed that the pig-iron from which steel was made must be free from phosphorus, which renders it brittle when worked in the cold.

The removal of this defect by Thomas and Gilchrist in 1878 had a profound effect upon industrial development and international rivalry. They found that by lining the converter with dolomite instead of a siliceous material some of the lining combined with the phosphorus to form a slag. This at once rendered available enormous deposits of phosphatic ore, and influenced no country to a greater extent than Germany. Immense quantities of ore in Lorraine and Luxemburg, which had only sufficed for an inferior pig-iron, now became suitable for steel manufacture, and it is this process which enabled Germany so to develop her iron and steel industry that by 1906 her output exceeded that of the United Kingdom.

The cost of the Bessemer process is still further reduced by the fact that the "basic slag" which contains the phosphorus is valuable as a phosphatic manure on certain soils, and several million tons are used annually for this purpose. The application to agriculture is the result of investigations by Wrightson and others about 1885.

The Bessemer process was closely followed by a rival one which attained a high degree of economy by the use of a gaseous fuel, as well as a better control over the composition of the steel produced. The advantage of a gaseous fuel lies, of course, in the fact that it can be thoroughly mixed with the air required for combustion. The practice of using coal as a source of gas for lighting dates from 1792, when William Murdoch, one of Boulton and Watt's foremen, lighted up his house at Redruth. About 1859 Frederic and William Siemens devised a gas-heated furnace in which they employed what is known as the regenerative principle. The gas and air are passed through heated chambers filled with brick chequer-work, and are burnt right over a shallow hearth in which is placed the material to be heated. There are two chambers on each side of the furnace, and the waste gases are used to raise the temperature of each in turn. Such a furnace is known as an open-hearth furnace; it may have an acid or basic lining; and the steel is described as acid or basic open-hearth steel.

By 1869 the process had become firmly established. It requires about ten hours against about one-twentieth of that time for that devised by Bessemer, and is therefore slow enough to permit of samples being taken for analysis, so that the metal can be run out immediately the desired composition has been reached. For all structural work, in which the greatest reliability is essential, open-hearth steel is specified, and it is gradually gaining ground on the metal prepared in the quicker and cheaper way. The advantage of the basic process to this country in enabling non-phosphatic ores to be used is indicated by the fact that while the production of acid steel during the last ten years has remained stationary, the production of basic steel has increased from 1,000,000 to 3,000,000 tons per annum.

The greater strength which steel possesses over cast- or wrought-iron, its cheapness, and the wide range of quality from mild to hard which it can be made to assume, has led to its increasing use over the original forms of the metal. The year 1870 is the beginning of the age of steel. Wrought-iron is now only employed where great softness and malleability is required, and cast-iron where cheapness is essential and tensile strength immaterial. Used in the eighteenth century for springs, cutlery, tools, and weapons of war, steel has now become essential in all machines, engines for producing mechanical power, railways and rolling-stock, steamships, bridges, large buildings, bicycles, motor-cars, and aeroplanes. But some of these applications have been facilitated by, if they are not entirely due to, improvements which have not yet been described. Whereas in 1880 there was only a limited number of varieties, all containing only carbon and iron, there are now dozens of special steels which owe their peculiar properties partly to heat treatment and partly to the presence of one or more other metals in varying proportions. The simple scientific statement which, thirty years ago, would have sufficed to define steel has been swept away by a torrent of new discoveries, in which every addition to exact knowledge has served to reveal only more profoundly the complexity of the problems to be solved.

To attempt to describe with a due sense of proportion the new era in steel-making would involve an amount of technical detail out of keeping with the character of this book, and it must suffice to refer briefly to a few of the salient features. For example, the steel metallurgist has found that the properties of the metal are not determined by its composition alone, but also by its thermal history—the exact changes of temperature to which it has been subjected, and the order in which these have occurred. Consequently it has been found necessary in all works, except those producing ordinary castings or rolled bar and plate, to instal an elaborate equipment for measuring high temperatures, and in one works alone from 3000 to 5000 records are taken weekly. Incidentally this has given an impetus to the scientific study and manufacture of electrical pyrometers.

The influence of another metal on steel was first recognised by David Mushet, who in 1850 patented a self-hardening tool steel containing tungsten. This did not need quenching in water to harden it. For nearly fifty years it was supposed that if it was heated to a higher temperature than 845° C. it would be spoiled; but Messrs. Taylor and White, of the Carnegie Steel Co., discovered in 1900 that if it was raised to the point at which it began to crumble (about 1050° C.) and then allowed to cool steadily it became harder, would take heavier cuts at higher speed, and would cut quite well when the cutting edge was red-hot. This was the first of a series of new high-speed steels which have enabled machines to be speeded up from 90 to 250 revolutions per minute, and have considerably cheapened processes of manufacture.

The importance of nickel as a constituent of steel, especially for armour plate and armour-piercing shells, dates from 1889, and since Moissan's researches with the electric furnace in 1892, chromium has become nearly as important. Steels containing both nickel and chromium possess properties which render them more valuable than those in which only one of these elements is present. Another metal, molybdenum, rarely met with before 1900, is now a common constituent of high-speed tool steels, and still another one of more recent introduction is vanadium. An element, titanium, very similar in some of its properties to the last-named, improves the soundness of cast-iron. Manganese, which was formerly understood to be deleterious to steel if present in more than a small proportion, has been found by Sir Robert Hadfield to confer extraordinary hardness and durability upon the metal when it is present to the extent of 20 per cent. And so the tale goes on. Indirectly fuel is economised because additional strength and durability are secured. But it is clear that the control of steel-works, so far at any rate as the manufacture of special steels is concerned, has passed out of the hands of men of mere experience into the hands of men who combine experience with scientific knowledge and habits of mind.

2. *Mechanical Power*

While Huntsman was struggling with the mysteries of steel manufacture, James Watt was overcoming one by one the difficulties which surrounded the steam-engine. For more than two hundred years men had sought some means of utilising the energy of steam—even so far back as Hero of Alexandria it had been used to produce motion. Branca, in 1626, constructed a small model in which the steam, issuing from a pipe, impinged on the vanes fixed at the edge of a disc and caused it to spin round. Denis

Papin, a Huguenot refugee of considerable scientific attainments, who was for a time curator of the Royal Society, made many experiments which fell short of commercial success. A similar fate attended the efforts of Captain Savery, who endeavoured to construct a steam-pump for ridding the Cornish mines of the water which drained into them. Finally, in 1705, Thomas Newcomen, a blacksmith of Dartmouth, made a model which gave promise of satisfactory performance on a large scale.

Newcomen's engine consisted of a boiler and a vertical cylinder containing a close-fitting plug or piston. When steam was admitted below the piston, it was forced upwards, and the motion was communicated to a pump through a piston-rod and beam or lever. As steam occupies at 100° C. more than 1600 times the volume of the water from which it is formed, its rapid condensation in the cylinder after forcing the piston up caused a partial vacuum, so that the weight of the piston aided by the atmospheric pressure caused it to descend. This process was repeated at regular intervals by opening and closing the cock which admitted steam to the cylinder. When, eight years later, the first engine was erected for a mine near Wolverhampton, the inventor was a little disappointed with its action. But he observed that at times it went very well, and he traced this extra liveliness and vigour to the presence of a little condensed steam on the top of the piston, which occasionally trickled through between the badly-fitting piston and the cylinder walls, thus aiding the condensation. Seizing upon this fact he added a spray inside the cylinder, which was turned on at the end of each stroke, and obtained the permanent improvement of working which he sought.

Small improvements followed rapidly—one at any rate arising from a primary human instinct rather than scientific ingenuity. A boy named Humphrey Potter, being charged with the duty of turning the cock at the right moment, avoided a monotonous task by attaching it by cords to the moving beam, thus making the engine self-acting. Moreover, it had also the effect of improving the engine by increasing the number of strokes from 6 or 8 to 15 or 16 per minute. The success at Wolverhampton brought more orders. The collieries in the north were ceasing to be mere surface workings: they were getting deeper and deeper, and the problem of raising the water became more and more difficult. The second and third engines, therefore, were erected at mines near Newcastle; the fourth engine at Austhorpe, near Leeds, in 1714; and then the Cornish tin and copper mines claimed assistance. In 1720 an enormous engine with a cylinder 47 inches in diameter was erected at Wheal Fortune Mine, near Penzance; another at Wheal Rose, near Redruth. Gradually the engines spread all over the country, and just as gradually Newcomen himself seems to fade from view. It is not known how or where or when he died; whether he had friends or relations near him, or slipped out of the world a lonely and forsaken man. But his engines had for a time infused the mining industry with new life, and had rendered available the coal which was required for smelting iron. They were, however, costly to work, especially in Cornwall, where coal was dear. The huge pumps at Wheal Rose and Wheal Busy consumed nearly 13 tons per day, and by 1760 the cost of pumping was again rendering some of the mines in the south-west unworkable.

This was the state of affairs when James Watt, the hero of applied science of the eighteenth century, came upon the scene. The son of a carpenter and shipwright, and delicate from birth, he was first apprenticed to an optician in Glasgow in 1754. The small scope which this man's business offered for learning the trade, led to his journeying to London in 1755. Both here and on his return to Glasgow to set up in business a year later, he found great difficulty in the fact that he had not served an apprenticeship which would qualify him for the freedom of the borough. Ultimately by the kind offices of friends he was allowed to occupy a room in the University buildings—a privilege which carried with it a little custom in the repair of University apparatus. Apart from this there was little demand for workmen of his type, and he was compelled to eke out a precarious existence by making musical instruments. There was some compensation, however, in surroundings which stimulated scientific studies, and Watt made friends among the professors, who found a delight in the companionship of the young mechanic.

His attention was turned to the steam-engine in 1759 by a chance remark of his friend Robison—the founder and editor, at a later date, of the *Encyclopædia Britannica.* The model of Newcomen's engine belonging to the University was then in London undergoing repairs, but Watt succeeded in getting it returned. Meantime he read everything that was available on the subject, and made some preliminary experiments. In examining the Newcomen model in 1763, he found that it would only work for a few strokes and then ceased for want of steam. Persuaded by his experiments and calculations that there was some unnecessary waste, he set himself to find where this occurred.

By 1764 he was convinced that the cause of failure in the Newcomen engine lay in the cooling effect of the cold cylinder, by which a much larger quantity of steam was required at every stroke. It is pretty clear that Watt recognised the steam-engine as a heat-engine, in which the real source of energy was in the fuel. This fuel was used to convert water into steam, and the steam after doing its work was so much the cooler. What he desired to avoid was the cooling of the steam by the cylinder walls. They must be kept as hot as possible, not cooled every time. And for nearly a year this problem haunted him, filling his mind during the day, and robbing him of sleep when night should bring rest to those who toil.

When taking a walk in the spring of 1765 the idea of a separate condenser, and an air-pump to exhaust the cylinder after every stroke, flashed across his mind. The next morning he rose early and, gathering a few pieces of apparatus from friends, he constructed a model which fulfilled his expectations. But the experiment needed to be tried on a larger scale, and called for more capital than he possessed. He had recently moved from the University, was married, and was engaged in a ceaseless struggle to get a living and provide time for his experiments. The construction of a larger model required a degree of mechanical skill outside the range of his experience, and equally beyond the capacity of the mechanics who were to be found in Glasgow. To make an engine which would demonstrate the *commercial* value of his invention was still more beyond his powers.

At this stage he obtained an introduction to Dr. Roebuck, who had founded the iron industry in Scotland in 1760, and, after some time, assigned to Roebuck two-thirds of the interest in the invention on payment of his debts, amounting to about £1000. The patent was taken out in 1769, and an engine was erected; but the workmanship was bad—the cylinder had to be made of sheet metal—and the result was unsatisfactory. Meantime Dr. Roebuck got into financial difficulties, and Watt turned to canal surveying and other civil engineering work for a livelihood. When Roebuck finally failed in 1773, Watt succeeded in securing the assistance of Matthew Boulton, a Birmingham manufacturer of great ability and enterprise. A partnership was begun which, in spite of initial difficulties, was of profound importance to British industry. The inventor was a nervous, retiring man, wrapped up in his scientific studies, rendered peevish by misfortune and ill-health, and possessing none of the patience, tact, and urbanity which is necessary in dealing with men. Matthew Boulton had all of these qualities. He was a man of the world, upright in character, of inflexible will, with charming manners and ready address. If Watt had searched the country from end to end it is doubtful whether he could have found another man so admirably fitted to overcome the difficulties which, to him, were insurmountable.

In the hands of the skilled workmen in Boulton's Soho factory, the steam-engine was a success. Not only did orders pour in, but many claimants arose to dispute the validity of the patents. Though these failed, litigation swallowed up the early profits, and, as five years had been lost before the partnership had been effected, application had to be made for an extension of the period. This was obtained by Act of Parliament in 1775.

The first engine was made to blow the bellows of the iron-works of John Wilkinson of Broseley, and was erected early in 1776, and, later on in the same year, the second was set to work at Cooke and Co.'s distillery at Stratford-le-bow. The Cornish mines were the next to claim the services of the new engine, for not only was the coal consumption of the older ones ruinous, but they failed to keep down the water. The saving of fuel by Watt's engine in some of these cases was over 60 per cent. It was applied to a rolling-mill at Soho, then at Wilkinson's iron-works at Bradley, and shortly afterwards at Rotherham. The famous Albion Flour Mills were completed and driven by steam in 1786, and the first cotton mill a year earlier. These later applications involved the use of the "rotative" engine, as Boulton and Watt called it. The earlier ones merely gave a reciprocating motion, suitable only for pumping. The rotative engine was developed by 1782. Some difficulty occurring through a patent for the crank and connecting rod having been granted to a man named Pickard, Watt had recourse to a curious contrivance invented by William Murdoch, one of his foremen, and known as the "sun and planet" motion, which fortunately detracted very little from its value.

The patent for expansive working and double-action obtained in 1782 practically covered the whole field of the production of mechanical power from steam for more than a hundred years. Improvements were made in detail, and far more in accuracy of workmanship; steam-boilers became capable of using higher pressure and of evaporating larger quantities of water for a given amount of fuel; but the steam-engine as a heat-engine remained practically as Watt left it until 1884. Its invention was the first occasion upon which honest scientific enquiry had co-operated with mechanical ingenuity and keen business aptitude, and the intellectual achievement was equalled by the material consequences. By its aid the mines of the country were freed from water; and coal, copper, iron, and tin rendered freely available; with its assistance the forge and rolling-mill increased the output and quality of their products; the textile inventions owed to it an expansion ten or a hundred times greater than would have been possible with water-power alone.

The fact that this group of inventions was born and bore fruit in Great Britain is one of the most salient facts in our history. In 1750 the National Debt was only £78,000,000; the American War of Independence raised it to £200,000,000 in 1784; and this enormous sum was swollen by the Napoleonic Wars to £900,000,000. Was it possible that any nation in Europe could face such a burden? Yet Britain did so. While other countries were swept by fire and sword, she remained inviolate behind her narrow seas. Armies had been despatched to America and again to the Continent, but at home factories and workshops were alive with machinery and busy men. The increased output maintained British credit, so that the money could be borrowed for carrying on the war. If this credit had been lower, it is doubtful whether Trafalgar would have been reached, and still more doubtful whether a victory would have been secured on the fields of Flanders. The Battle of Waterloo was won, not only on the playing-fields of Eton, but also in the workshops, factories, and mines which grew up under the Industrial Revolution.

This Revolution is still in progress, though it has become a custom in historical text-books to bring it to a hypothetical end in 1830 or 1840. That period covers only the phase of textile development, the entry of steam-power, and the improvement of roads and canals. The movement gathered fresh strength from 1830 or 1840 through the advent of railways, steamships, and the electric telegraph, and the progress until 1880 was almost a revolution in itself. From 1880 again a fresh outburst of activity occurred, partly by reason of new forms of mechanical power, and partly because of the rapidly widening applications of electricity. It is well to keep in mind that the Revolution really started by small beginnings soon after 1700, that it received an impetus about 1770, a second about 1830, and a third about 1880; but each of these was in the nature of a sharp rise in a continuous line of development.

Improvements in the manufacture of iron in the first half of the nineteenth century enabled boilers to withstand higher pressures, and in order to utilise a larger proportion of the energy in the steam compound-engines were devised about 1850. These consisted of two cylinders of different diameters operating on the same crank-shaft. Steam from the boiler entered the smaller or high-pressure cylinder and then passed through the larger or low-pressure cylinder. The advantage of high-pressure steam is that it is at a higher temperature when it enters the cylinder and a smaller proportion is condensed by the cylinder walls, and the compound-engine enables the expansive force of the steam to be utilised over a wider range. Watt's original engine required about 9 lbs. of coal for each horse-power developed, but the improvement in boilers and the plan of compounding brought this down to less than 2½ lbs. for a large engine. In 1880 the use of steel permitted a further increase of pressure, and the wider range of expansion was obtained in triple-expansion engines with three cylinders in series. By this means the coal consumption was brought down to 1·75 lbs. per horse-power.

These engines reached their highest perfection on steamships, where every unnecessary ton of coal not only adds to the cost of the voyage but also reduces the earning capacity of the vessel. A reference to Chapters IV., V., and VIII. will show how important economy in this direction was to the nation. Many British manufactures, and especially the textiles, depended upon raw material from abroad; the growing population was in need of an increasing supply of food from America and the colonies; and in more recent years the maintenance of trade has only been possible by a low cost of water carriage. High freights may be unavoidable, but they increase the cost of vital necessities, and are a loss to the State. Apart, however, from the question of supply of and demand for tonnage, the problem is, or ought to be, one for the engineer.

A little more than twenty years ago it was announced that the Hon. C. A. Parsons, a senior wrangler who had adopted the profession of engineering, had succeeded in solving the problem which had baffled inventors for a century. How to arrange for the steam to exert a direct rotary motion on the shaft without crank and connecting rod exerted a fascination which was not to be denied. The Patent Office Records are studded with attempts to overcome the difficulties by mechanical ingenuity alone; the ultimate machine depended far more upon sound theory and accurate workmanship than upon intricacy of design, and the principle involved had been utilised by Hero of Alexandria 200 years before the Christian era.

A number of thin blades are fixed round a drum, forming rings of successively increasing diameter, in appearance not unlike the laths of a venetian blind. Steam passing along the surface of the drum from end to end encounter these blades at an angle and tend to rotate the drum. The latter is enclosed in a casing, on the inside of which is fitted a similar series of blade rings which lie between successive rings of the drum. In its action upon each set of blades on the drum the steam is deflected out of its path, and is redirected by the fixed blades upon the next set of moving blades. It thus elbows its way through in a slightly zig-zag course from end to end.

The year after Parsons filed his patent specification, Dr.

Gustav de Laval, a Swedish engineer, invented a turbine similar to the model constructed by Branca in 1627. The Parsons drum was replaced by a disc, the blades were fixed radially upon the edge, and steam from specially designed nozzles playing upon them caused the disc to spin round. Each blade as it passed the nozzle receives an impulse, and the engine is called an impulse turbine to distinguish it from the reaction turbine of Parsons. Later turbines often employ the two principles of impulse and reaction in the same machine.

The turbine is essentially a high-speed engine. Anything less than 700 revolutions per minute is difficult to obtain, and the smallest size of De Laval makes 30,000. It is cheaper to construct than the older form of reciprocating engine, occupies less space, requires a smaller amount of lubricating oil, and for sizes above 200 horse-power it is more economical of steam, and therefore of fuel. It was at first applied to drive dynamos, for which it is peculiarly well adapted, and it offered certain advantages for ship propulsion which led to its trial in a small boat called the *Turbinia* in 1901. From 1905 onwards it began to be used in large vessels (the Allan liners *Victorian* and *Virginian*) and for ships of war. At least one-third of the power used to propel ships built during the last five years is produced by turbines. The recent discovery that the Parsons type is highly efficient with low-pressure steam has considerably widened its field of usefulness. But the most important historical fact is that, combined with the best type of modern boiler, it enables 1 horse-power to be obtained from a pound of coal. The cost of power in large installations has therefore been reduced to one-ninth of that which was possible 150 years ago.

While the turbine has become a serious rival to the older type of steam-engine in sizes ranging from 200 to 10,000 horse-power, the internal combustion engine has become an even more dangerous opponent in sizes from 1 to 1000 horse-power or more. The first practicable gas-engine was invented by Lenoir in 1860, but it was rapidly replaced by Dr. Otto's engine, which came on the market in 1876. The energy in this case is obtained by the explosion of a mixture of gas and air inside a cylinder, the pressure being communicated to the shaft by a piston and connecting rod. Wherever a supply of gas is obtainable, as in every town and many villages for the last forty years, the gas-engine performs useful service; but the fuel, prepared specially for the purpose of illumination, is expensive. In small workshops, where power is not a principal factor of production, this may not matter, but in factories where the cost of power is a considerable factor and has to be reduced to the lowest possible sum, there are obvious objections.

Illuminating gas is made by heating coal in closed retorts, whereby a quantity of gas and liquid matter is driven off and coke left behind. Now if air be passed through a deep coke fire, carbon dioxide is first formed by union of the oxygen in the air with the carbon, and is then converted by contact with the upper layers of red-hot coke into carbon monoxide. The last-named gas will burn in air to re-form carbon dioxide. It is possible, therefore, by burning coke in a supply of air insufficient for complete combustion, to produce an inflammable gas, and this gas, called *producer-gas*, can be used either for heating or in gas-engines. The process was invented for steel-making by Siemens in 1857, and as a source of power by J. Emerson Dowson in 1878, and could only be employed upon coke or anthracite.

Another inflammable mixture of gases, called *water-gas*, is produced when steam is passed through red-hot coke, but the temperature soon falls, and has to be raised again by blowing in air. The intermittent character of the process has limited its adoption. A most important modification was made in 1889 by Dr. Ludwig Mond, who caused both air and steam to act upon raw coal, and devised means of recovering the ammonia which is formed. This enables the cheapest kind of fuel to be used, and reduces the cost of power by recovery of the by-products.

An immediate result of Dr. Mond's invention was an enormous increase in the power of gas-engines, which had hitherto been of small size, and this in turn led to another means of economising fuel. In 1892 Mr. B. H. Thwaite suggested utilising the waste gases of the blast furnaces and coke ovens. The experiment was tried at the works of the Glasgow Iron Co. in 1895, and was sufficiently successful to be followed in many works in Great Britain, on the Continent, and in America. In the same year the Staffordshire Gas Power Co. was established to supply Mond-gas over an area of 123 square miles. This example of large scale production was followed some eight or ten years later by the formation of a company which purchases all the waste gas from the coke ovens and blast furnaces in the neighbourhood of Newcastle, uses this in gas-engines to drive dynamos, and supplies electrical power to the iron-works and ship-yards of the North-East Coast. There can be no doubt whatever that the production of power on a large scale in this way is very much more economical than a number of separate installations. The plant itself is not only more efficient, but more elastic, and the concentration upon a single narrow object leads to a higher degree of skill in management and a consequent reduction in working expenses.

The fact that gas can be produced from almost any material that contains carbon has led to a great extension of power in districts where the price of coal would render a steam-engine impossible. In various parts of the world producers are being fed with sawdust, wood refuse, tannery refuse, rice husks, olive oil refuse, cotton seed, and mealie cobs, the mere names of which will suggest the place in, and purpose for, which the power is required. And since the provision of mechanical power increases the output at a greater rate than it increases the cost of production, it follows that the goods or commodities from these places are being cheapened. The result is that what was at first enjoyed by the privileged few is rendered available for the many. In that sense all forms of prime movers are powerful agents in the growth of modern democracy, for they bring within the reach of all but the poorest, not only the newspaper and the cheap book, the means of cheap travel and rapid communication, but also that variety of diet which contributes so much to health, and the cheap clothing and home comforts which engender a feeling of self-respect.

3. *Coal Mining*

Though in the more commonly read books on Industrial History the winning and use of coal looms less largely than agriculture and textile industries, it was entirely responsible for the changes which are recorded; it was the subject of much of the industrial and social legislation that will be discussed in Chapters XIV., XV., XVI., and XVIII.; and it is fundamental to the economic problems of the present and coming years. The men who work with pick and shovel deep down in the bowels of the earth spend their days in grime and discomfort, face constant danger from falling roof and runaway tram, and are undeterred by the all too frequent calamities which result from an explosion of gas. The seams are in some cases barely 2 feet in thickness, and the height of the roadway less than 3 feet. The treacherous roof is supported by heavy timbers, and the roadways are often thick with dust. The coal in a few districts produces no gas, and can be worked with naked lights, but as soon as the miner penetrates beyond the surface in other districts he meets this enemy, which bids him stop at the peril of his life.

At the beginning of the eighteenth century coal was worked by *adits*, or galleries driven into the seams which cropped out on the hillsides, and raised through a ventilating shaft by a winch, or carried up ladders in baskets. The adit served to drain the mine only so long as the seam could be worked in a horizontal or upward direction. When it dipped, water began to accumulate and the miners were drowned out. The maximum depth of the shafts was 180 feet, the diameter 7 or 8 feet, and the area worked by one shaft not more than 200 square yards. Under these circumstances the industry languished, and many pits either closed down or were on the point of closing down when Newcomen's invention of the steam-engine saved for a time the situation. Thus, in 1760 the Walker Colliery, near Newcastle, was sunk to 300 feet, and equipped in 1763 with a powerful pumping-engine—at least if it was not powerful it was large enough to be so, for the cylinder was 7½ feet in diameter and 10½ feet long! Coal was first raised by a steam-engine at Willington Colliery, Northumberland, in 1780, and the first Boulton and Watt double-acting engine was installed at St. Anthony's, near Newcastle, ten years later.

So long as the shafts were not deep the gas evolved from the coal escaped easily, and though explosions occurred fairly frequently, injury or loss of life was rare. In fact it was a common plan to remove the gas periodically by thrusting a lighted brand near the roof where it was found in the greatest quantity, the fireman falling flat on his face at the same moment to avoid the flame. At the Netherton pits in Staffordshire, early in the eighteenth century, the gas was removed in this way three times a day—at 4 A.M., 12 noon, and 7 P.M.

The necessity for effective ventilation was recognised early, and a furnace near the bottom of a shaft was the method of drawing air through the workings. As the workings became more extensive the air had alternative paths, and as it was necessary that it should flow freely along the working face, Spedding, about 1760, devised doors to direct its course. This system was very much improved at a later date. But in spite of such precautions deeper shafts ushered in the era of big explosions, and as the pits became larger and employed more men, the loss of life grew more serious. As early as 1813 a "Society for the Prevention of Accidents in Mines" was formed at Sunderland, and it was this body that invoked the aid of Humphry Davy. The invention of his safety lamp, in 1815, marks an epoch in the getting of coal. It was based upon the cooling effect of metal. The flame was surrounded by a cylinder of wire gauze, and though the atmosphere in which it was immersed might burn freely inside, the gauze rarely became hot enough to ignite the explosive atmosphere outside. About the same time George Stephenson, who was engineman at the Killingworth Colliery, and who was working at the same problem independently of Davy, constructed a lamp in which the air was admitted through fine holes in a ring surrounding the oil reservoir. Though the danger was very largely reduced, neither lamp was absolutely safe, and many improvements have been made since their introduction. But they added a measure of safety to the mining of coal which had formerly been wanting, and saved many lives that would otherwise have been sacrificed on the altar of material progress.

The conditions of labour in coal mines during the eighteenth and the early part of the nineteenth centuries were almost indescribable; the townspeople who enjoyed the comfort of coal fires, and the people who grew more wealthy with each shovelful thrown into the furnace, knew or cared little of the toil, the hardships, and the injustice which lay behind every ton won from its subterranean hiding-place. One of the least of the evils was the "truck" system, under which the employer provided houses, and shops at which food, clothing, and other necessaries were supplied on credit, payment being secured by deductions from wages. Another grievance was the hire of colliery labour by the year—a practice which led to a serious strike in the north in 1836, and was still in vogue at Ashby-de-la-Zouch in 1841. But apart from these outward manifestations, what took place underground was concealed from view, and political action for the protection of the work-people was first taken in regard to textile factories. The Acts passed from 1802 to 1833 regulating the employment of women and children applied only to these, and it was not until 1840 that a Commission was appointed to ascertain the state of affairs in the mining industry.

The Report revealed the facts that children began their wage-earning at five, six, or seven years of age, and that neither age nor sex absolved them from the full working day of twelve or fourteen hours. Frequently they were engaged in drawing heavily loaded trucks along roadways not more than 2 feet in height, by a chain attached to a leathern belt round the waist. Not only children but women worked alongside men, both sexes clad only in a pair of trousers, and the males often in a state of nature. Save that they were paid wages, were free to seek work elsewhere, and to starve or go to the workhouse if they failed to secure it, they were little better off than the slaves of the tropical plantations.

The Collieries Act, which in 1842 followed these revelations, was a drastic measure for the times. It expressly forbade the employment underground of women and girls, and of boys under nine years of age; and the facts upon which it was based served as a powerful encouragement to those who believed that the State should take stronger action to protect the worker in industries other than mining. There was a growing feeling that even in regard to mining this legislation was only a beginning. The 10,100,000 tons of coal raised in 1800 had risen to 49,000,000 tons in 1850. Incidental dangers of falling roof, runaway tram, and defective winding gear were increasing yearly, and since the introduction of gunpowder for blasting the coal itself, sometime before 1820, the menace of disaster hung like a black cloud over the miner's life. From 1815 to 1825 Davy had made many investigations into the conditions under which explosions occurred, and in 1844 Faraday and Lyell had reported upon a terrible explosion at the Haswell Colliery. Scientific knowledge was being brought to bear upon the problem, and it was felt that the terrible disasters which occurred from time to time might be prevented by precautions which scientific experiments suggested. Accordingly, when the next Act was passed in 1850, on the petition of the miners themselves, inspectors were appointed to see that both masters and men obeyed the regulations. The further provision that all accidents must be reported enabled an immediate enquiry to be undertaken and facilitated precautions against their recurrence.

The effectiveness of such an Act depends upon the existence of an adequate number of inspectors, and at the time it was passed competent men with the necessary training and experience were difficult to obtain. It was not until the Government School of Mines, opened in 1851, had been established for some years that a sufficient number of men were available, and the staff of inspectors was increased. The administration of the Act was strengthened by another, passed in 1855, which included further regulations, and imposed severe penalties if these were not obeyed. Moreover, a prosecution of some mine managers for manslaughter, after a serious explosion in 1856, showed that the regulations were not to be regarded merely as the expression of pious opinion.

There seemed, however, to be no sure means of preventing explosions, and attention was directed to minimising their effects. By the Acts of 1860 and 1862 special precautions were required to be taken wherever there was a risk of abandoned workings, filled with gas, being penetrated, and two shafts were required to be provided, both of them equipped with winding gear, to enable men to escape by one if egress by the other was prevented.

In 1872 another Coal Mines Regulation Act was passed in which restrictions on child labour were extended. No boy under ten years of age was allowed to work underground except in the case of especially thin seams, and with the express permission of the Secretary of State. Boys of ten to twelve years of age were required to attend school for not less than twenty-two hours per fortnight, and for not more than three hours at a time, nor for more than five hours on one day, between 8 A.M. and 6 P.M. The hours of labour of boys from twelve to sixteen were limited to fifty-four per week, with a maximum of ten hours a day, and night duty was prohibited for boys of this age, above or below ground. The regulations for the management of mines were revised and extended, lamps had to be locked so that the miner could not open them himself, and every mine had to be under a Certificated Colliery Manager. Boards were established in each district to conduct the necessary examinations and award certificates. An increasing number of working miners took advantage of classes established under the Science and Art Department, which had commenced operations in 1853.

A source of grave danger which often led to great loss of life was fire in the mine. It is impossible to remove the whole of the coal in a seam, and at the end of the eighteenth century it was customary to leave 50 per cent. of it behind—mainly in the form of pillars for supporting the roof. As coal became more valuable—it doubled in price during the Napoleonic wars—the coal pillars were replaced by masonry or timbering, and between 1830 and 1840 a considerable economy was effected by improved methods of working. But gob-fires, as they are called, could not be prevented, nor, indeed, could the means by which the coal became ignited be explained. A Royal Commission on Spontaneous Combustion was appointed in 1875, but without much result.

A more fruitful step was the appointment of a Commission in 1879 to enquire into Explosions in Mines. A preliminary report was issued in 1881, and a final report five years later. Before that time there had been no systematic investigation on Safety Lamps other than those undertaken by a few individuals with limited resources—and sometimes with a vested interest in a particular lamp. The Report of the Commission provided Colliery Managers with definite data, but, in accordance with the British dislike of monopolies, the Act of 1887 which followed the Report did not prescribe any particular form of lamp, though the plan has been adopted in Belgium with success. In addition to amending the regulations, this Act raised the age of employment of boys underground to thirteen, and on the surface to twelve.

The year 1891 saw the appointment of a Royal Commission to enquire into the effect of coal-dust in causing or influencing explosions. Ever since 1803 it had been suspected to play some part in the more serious disasters, and the subject had been one of considerable controversy after the Haswell Pit explosion in 1835, explosions in France in 1867 and 1875, the Llan Colliery disaster in 1876, and the explosions at Risca and Seaham in 1880. There is no doubt that an explosion may be spread by dust even if it is not the initial cause, and it has been noticed in recent years that the driest mines are the most dangerous. This problem as well as others was attacked tentatively by legislation for some years, but the most important Acts are those of 1910 and 1911. The former gave power to the Secretary of State to issue orders requiring adequate provision for Rescue and Aid. It provides for the supply and maintenance of Rescue Appliances and of the formation and training of Rescue Brigades. The result is that in each district there is a Rescue Station where the men are taught to wear a helmet, like that of a diver, supplied with oxygen from two small steel bottles slung on the back. By means of a fire, the atmosphere of a large shed can be made as foul as that of a mine after an explosion or during a gobfire; and in it the men practise the operations of rescuing others who may be disabled, and effecting repairs. For the historian of the future these stations and their records will speak eloquently of the dangers of coal-mining at the beginning of the twentieth century, of the heroism of the men, and of the co-operation of science and practice which triumphs over natural obstacles.

The second Act was not only one of the most far-reaching measures which Parliament has ever adopted for the control of an industry, but it reflects in a remarkable way the tendency towards deliberate scientific, as well as what may be called legal, control by the State. The number of inspectors was increased, and the district boards of examiners, which were apt to differ considerably in standard, were replaced by a Central Board. In order to secure more efficient examination of the mine between the shifts, the fireman, examiner, or deputy upon whom this duty devolves, was required to pass an examination in testing for mine gases, and to this end classes have been established at a number of convenient centres. The provisions as to safety occupy forty-seven sections. No lamp may be used which has not passed the tests prescribed by the Home Office; the conditions which must be fulfilled in regard to the ventilation and to the machinery are set out minutely; the roadways must be watered to prevent the atmosphere becoming charged with dust; and it is recommended that fine stone-dust should be distributed in order to render the coal-dust less inflammable. The provision made in 1891, prohibiting explosives, the use of which had not been sanctioned by the Home Office, was retained.

But the most novel sections are those relating to the health of workmen. Not only accidents but diseases must be notified, and a mechanical drill used on hard rock must be fed with water to prevent dust. Baths were to be provided if two-thirds of the men desire them. The employer was to pay half the cost, provided it did not amount to more than threepence per week per man. Finally, the Act raised the age of employment to fourteen for work underground, and to thirteen for work on the surface. The attempt to prevent women working on the pit-brow, which has been made several times since 1887, was defeated.

Owing to the nature of coal-mining, there is no order of development, through domestic industry to employment in factory, such as occurred in the textile industries. The minerals which lie beneath the surface of the ground are by law the property of the landowner; they can only be won by the owner or his lessee; and no appreciable amount can be mined unless a number of men are engaged on the work. There was, from the beginning, an employer and a body of employès, and the dangerous and lucrative character of the occupation provided conditions which were favourable to disputes. When these disputes arose on questions which involved the safety of human life, the Government, as we have seen, intervened; but when they arose on questions of wages or hours of labour, the disputants were left, as a rule, to find their own solution.

Two grievances of the miners in the early days were the conditions under which they were employed and the Truck system. It was the custom to engage men for a year at a time, much in the same way as agricultural labour is engaged at the annual hirings down to the present day. The practice gave rise to several strikes, the most noteworthy of which occurred in 1836; but it was still followed at Ashby-de-la-Zouch until 1841. The Truck system, as already mentioned, consisted in the provision by the employer, not only of houses, but of shops at which all the necessaries of life had to be obtained. Credit was allowed and payment secured by a deduction of wages. The plan was open to obvious abuses, and payment by stoppage is not recognised, except under the National Insurance Act, in English Law. The Acts by which this system has been abolished are known as the Truck Acts.

Another source of trouble arose from the payment on tonnage, and the practice of the colliery-owner in making deductions for dirt. While no objection was taken to honest weighing and fair deduction, it was contended that these were occasionally dishonest and unfair. The Coal Mines Act of 1860 provided for the appointment of a checkweigher, selected from among, and paid by contributions from the colliers themselves. The first man elected to this position was discharged by the employers, and having ceased to be a workman at the colliery he became, so they contended, *ipso facto*, ineligible for the position. The result was a struggle in the courts, which decided after two years' delay that the employers had acted *ultra vires.* The office of checkweigher requires trustworthiness and force of character, and has been an excellent training for secretaryships and other offices of the Miners' Unions.

The miners are almost the only section of working-men to accept the employers' doctrine that prices should rule wages; and since 1873 it has been a very general practice to adopt sliding-scales by which wages rise or fall with the price of coal. In 1893, Conciliation Boards, consisting of representatives of masters and men, were established on each coal-field, and local disputes have been referred to them for settlement. Consideration of cases by an experienced tribunal has undoubtedly done much to soften the asperities of the situation, but the plan is only possible where the organisation of masters and men is sufficiently effective to secure obedience to the decisions of the Board.

The dangerous character of the occupation, and the peculiar circumstances under which it is carried on, gave more than ordinary force to the agitation for shorter hours of labour. It was contended that men who worked under the unnatural conditions of semi-darkness should not be required to put in the same number of hours as those who laboured on the surface or in a factory, and that the shorter hours would be attended by such an increase of efficiency as almost to maintain the output. The Eight Hours Act was passed in 1909, and since 1910 no miner has been required to spend more than that period away from the light of day.

In spite of all these changes probably no industry is so disturbed by disputes. The men have realised the importance of their work, and they are strongly impressed with their rights, if not always fully conscious of their national duty. They were almost the first body to win recognition for their Unions, they have learnt the value of organisation and discipline, and they refuse to work with non-Unionists. But apart from isolated cases, people as a whole have recognised the importance and the danger of the calling, and have not been unsympathetic towards the efforts the miners have made to secure a greater share of the profits of their toil. The truth of this statement is emphasised by the Minimum Wage Act of 1913. A coal strike on a national scale had dislocated the industries of the country, and had caused no little distress by closing down factories and works which depended upon fuel. One of the main causes of the trouble was that, though miners working in favourable places could earn high wages at the rates in vogue, there were many less favourably situated who earned less than their efforts deserved. The Act was passed to enable a Statutory Tribunal to determine and fix a minimum wage wherever the miners' difficulties were abnormal. To some extent it may be recognised as special legislation to meet the demand of a highly organised section of the community whose cessation from work stops the whole industrial machine; or it may be regarded merely as an extension of State responsibility for the settlement of industrial disputes. But it is the first time that statutory machinery has been set up to regulate wages in a large and well-organised industry.

This leads to a consideration of the enormous national importance of fuel. For more than a hundred years after Darby had initiated the employment of coal in iron manufacture, the nation continued to draw at an increasing rate upon its store of fuel, without giving a thought as to how long this would last. The steam-engine had spread everywhere, in factories and workshops, on railways, in steamships; an increasing amount of coal was required for iron and steel, gas, and chemical works; and it has become the ordinary domestic fuel for a population many times larger than it was when the value of the mineral was first appreciated. Between 1850 and 1861 the horse-power of steam-engines used in textile factories rose from 115,113 to 375,311, and the tonnage of British steamships from 187,687 to 506,308, a figure which was more than doubled in the next ten years. The total quantity of coal raised in 1800 was 10,000,000 tons, and in 1861 it was 57,000,000 tons. Yet no insecurity was felt, and no real economy had been introduced, apart from the inventions of Watt, Cort, and Neilson.

The first attempt to estimate the amount of coal in

British coal-fields, known or unknown, was made by Edward Hull, whose results were published in 1857. The matter was taken up in its economic aspects by Jevons three years later. In his book on *The Coal Question* he emphasised the extent to which British industrial supremacy depended upon an adequate supply of fuel and raw material, and he argued that the increasing rate of consumption would lead the country into a very difficult predicament within a comparatively short time. The startling character of the figures, the cogency of the reasoning, and the reputation of the author commanded attention. Something like a panic arose, and, in 1866, the Government appointed a Royal Commission to enquire into the problem. The Report, which was issued in 1870, estimated the quantity in known coal-fields at 90,207 million tons, and in unproved areas at 56,273 million tons, making a grand total of 146,480 million tons. To some extent it was reassuring, for it expressed the opinion that the rate of consumption would gradually fall as the industries of the country became more fully developed. That this view was a sound one is proved by the actual production in subsequent years, as set out in the table below:

Quantity	raised in	1861,	57	million tons
,,	,,	1871,	110	,,
,,	,,	1898,	202	,,
,,	,,	1899,	220	,,

The facts and opinions presented in the Report satisfied the country for thirty years, but the desire to take stock of natural resources which arose towards the end of a century unparalleled in the history of the world for its industrial development, led to the appointment of another Royal Commission in 1901. This sat for four years, and recorded evidence which rested upon a far more substantial basis of experience than had been possible before 1870. The new estimate of the amount still to be won was 140,000 million tons, and considering that nearly 2000 million tons had been raised in the interval, the difference is only about 3 per cent. Assuming a constant rate of production equal to that in 1903, viz. 230 million tons per annum, the supply would last for about six hundred years. But it is obvious that long before the end of this period the best seams would be worked out, and the cost of mining would considerably increase the cost of mechanical power. Moreover, the rate of production has recently taken an upward direction, which is indicated in the figures given below:

Quantity raised in	1911, 243	million tons
,, ,,	1912, 260	,,
,, ,,	1913, 287	,,

The amount is now more than 50 million tons per annum greater than it was ten years ago.

The Royal Commission was sufficiently impressed in 1905 with the necessity for economy, and made a fairly exhaustive enquiry into the various purposes for which coal is used, and the extent to which it was being wasted. The annual consumption was estimated to be as follows:

Railways	13	million tons
Coasting Steamers	2	,,
Factories	53	,,
Mines	18	,,
Iron and Steel Works	28	,,
Other Metals and Minerals	1	,,
Brick, Pottery, Glass, and Chemical Works	5	,,
Gas Works	15	,,
Domestic Uses	32	,,

It was reported that there was a considerable amount of waste in the production of power by small, inefficient, and badly managed steam-engines; and it was asserted that the loss through a boiler coated with scale might easily be 20 per cent. The average amount of coal used per horse-power per hour was estimated to be 5 lbs., though it should in no case be higher than 2 lbs., and in the largest and most efficient installations 1 lb. will now suffice. In view of the economy possible in a large well-designed and well-managed plant, and especially if gas-engines were used, there should be no difficulty in saving 50 million tons per annum. The value of this at 10s. per ton would be £25,000,000, a sum which would be added to the profits of industry, besides giving the nation the prospect of a longer industrial existence.

But the Commission did not confine its attention to the large industrial operations, and even the domestic fire came in for severe criticism. The combustion of coal in an open grate is wasteful in any case, but, in a badly designed grate, wasteful is too mild a word to employ. It is estimated that under this head alone 16 million tons could be saved. At present part of this goes to warm the air over the chimney-top and part to fill the atmosphere with particles of carbon, not only rendering it unhealthy, but necessitating a large amount of unproductive labour. The black pall which hangs over every industrial town is an avoidable nuisance, and a danger to health that need not exist. It represents an annual financial loss which falls to the largest extent upon poor people, in whose houses the cheapest and least satisfactory grates are installed.

The economy of coal is therefore a matter of national concern, for it is the basis of economic power, and is intimately connected with the health of the people. It is one of the larger problems of the century which lie behind the petty controversies of the hour. The engineer or the chemist may be able to render further assistance or they may not; and in the latter alternative the great political democracy which has been called into being within the last hundred years will have to take action, and will find its sincerity and its power tested in a more strenuous conflict than any upon which it has yet entered.

CHAPTER VII

THE UNION OF SCIENCE AND PRACTICE

1. *The Period of Mechanical Invention*

It has been noted incidentally that the Industrial Revolution, which began with a few mechanical inventions in the first half of the eighteenth century, not only involved striking changes in industrial practice and organisation, but also created equally marked alterations in social conditions and political outlook. The Revolution or Evolution, as it would more properly be called, is still in progress, but the statement so frequently met with, that the prime cause is still mechanical power, is a little too narrow in its ordinary meaning to describe the development of the last forty years. Speaking broadly, and in a technical sense, there have been three phases, each exhibiting certain characteristics which differentiate it from the others. The first, extending until 1820 or 1830, includes the textile inventions, the invention of the steam-engine and its application to factory machinery, and the economic stage of the agricultural revolution. The second, lasting until 1870 or 1880, is the era of the railway and the steamship, the telegraph, Bessemer steel, and the beginning of that vast number of chemical manufacturing processes which transform raw material and waste products into things of use and beauty. The third, covering the last forty years, is characterised by the penetration of scientific method into nearly every department of industrial activity. Ingenious but unmethodical inventors have been largely replaced by highly trained scientific investigators; new achievements are now to a less extent the result of blind groping than of conscious progress.

The nature and importance of the industrial changes during the first and second periods are described in Chapters IV., V., and VI. An equally detailed account of the third phase, with its extraordinary, rapid progress and manifold activities, is clearly impossible, and will not be attempted. But its essential feature is still so imperfectly understood that an outline of its growth and an indication of its significance will not be without interest and value.

In olden days, and, indeed, until the nineteenth century, scientific studies and practical arts ran in parallel grooves. The student of nature pursued his enquiries remote from the workshops and often held himself aloof from the events of his time. Except in Astronomy and Navigation he had no community of interest with the craftsman, who practised his art according to rules which were handed down from father to son, or from master to apprentice. The scientific investigators often lived remote, lonely lives, appreciating and being appreciated by only a few choice spirits, with whom they were by temperament akin. If they were poor, their material wants were few; if they were wealthy they sought information by travel and through the rare books that were available. The craftsman, on the other hand, lived the life of the people. The great ambition of the apprentice was to perform his task with skill equal to that of his contemporaries, content with that end rather than fired with enthusiasm to strike out a bold and original line for himself.

The first invention of industrial importance which displays anything more than mechanical ingenuity was the steam-engine. In order to improve Newcomen's model Watt felt that he must know why it failed; and to do this he must understand the principles which governed the transference of heat from the furnace to the cylinder. He was fortunate in his association with the University of Glasgow, where a band of eminent men were engaged in the study of physics and chemistry, and it can hardly be doubted that his success was largely due to this cause. The specifications of his patents of 1769 and 1782 show clearly that he was nearly fifty years in advance of his time in grasping the fundamental principles of energy, and this accounts for the fact that subsequent improvements of the reciprocating engine have been almost entirely modifications of detail.

The latter half of the eighteenth and the first quarter of the nineteenth century was a period of great scientific activity, when scattered fragments of knowledge were rapidly being welded into coherent groups. Mathematics and Astronomy were already well advanced, but Chemistry and Physics were just being born. Priestley, by his brilliant but erratic experiments on air and other gases; Black, by his painstaking investigation of alkaline earths, paved the way for Lavoisier to give a new meaning to the term chemical change. Scheele in Sweden, and Davy in London, were isolating new substances and widening the range of chemical knowledge. Benjamin Thompson, Count Rumford, proved what Watt had suspected, that heat is a form of energy; and Oersted, Ampère, Davy, and Faraday built up a solid body of organised facts upon Volta's electrical discoveries of 1800.

While the foundations of science were thus being well and truly laid by these men, machinery, mechanical power, and transport were being developed by Hargreaves, Arkwright, Watt, Cort, Cartwright, Smeaton, Rennie, Murdoch, and others of lesser fame. In some cases there was mutual interest and friendly co-operation, but not much more. The engineer was apt to regard the work of the others as of academic interest only; the scientific man, still struggling to evolve order out of chaos, was too fully occupied with his own problems to be drawn aside from his main purpose. But there were exceptions, as, for example, when Davy's assistance was sought in 1813 to prevent explosions in mines; and Michael Faraday was frequently consulted by manufacturers. Tyndal describes how at one time Faraday had seriously to consider whether he should devote himself to the pursuit of science for a pittance, or to industry for a fortune; and from an examination of his accounts he concludes that this decision took place about 1827, just before Faraday entered upon his investigation in electro-magnetic induction, upon which practically all modern applications of electricity depend.

2. *The Birth of Applied Science*

The years 1837–40 are marked by the first important examples of scientific utilitarianism since the invention of the safety lamp. These were the electric telegraph, the beginning of the agricultural experiments at Rothampstead, and Liebig's Report to the British Association on the relations between the plant and the soil. The chemists were at work making new discoveries, the physicists were pursuing the relations between different branches of their subject, and engineers were making railways, building ships, and devising new and more accurate machines for working in metals. But with the exceptions noted, each group neither poached upon its neighbours nor invited them across the fence. Even Bessemer's invention in 1856 was a failure for the first four years, because he had not ascertained how many of the possible impurities in pig-iron were removed by the blow; and the modification of the process to enable phosphatic ores to be dealt with was not made until 1878.

The most remarkable illustration of the value of science to industry during this period came from France. In 1856 Louis Pasteur, Professor of Chemistry at the University of Lille, was led to study the manufacture of vinegar from beet sugar, which was largely carried on in the district. Having shown that the process of fermentation was due to a lowly form of vegetable life, and having indicated the necessity for a pure "culture," he devised in 1861 the method of preventing the souring of wine by "Pasteurising" it. Six years later he saved the French silk trade by proving that the silk-worm disease could be stamped out if the eggs from healthy moths only were used. But the discovery of greatest importance to mankind was that which pointed to bacteria as the origin of gangrene in wounds; for it enabled Lister to develop the methods of antiseptic surgery, which not only diminished the death-rate, but enormously increased the scope of operative surgery. It hardly increases the debt which posterity owes to this famous Frenchman to add that Pasteur's investigation of anthrax led him to the discovery of a cure for hydrophobia, and supplied a foundation for the bacterial theory of disease. Modern sanitation was born in his laboratory, and by its aid twentieth-century civilisation keeps at bay the plagues which scourged the mediæval world.

The fusion, as distinct from the casual co-operation, of Science and Practice in Great Britain dates from 1851, when an International Exhibition was held in London. The necessity of scientific knowledge in order to explain the increasingly complex and exact methods of the workshops, so impressed the Prince Consort that he exerted himself to establish the Science and Art Department, to which fuller reference is made in Chapter XVIII. The subsequent development of scientific instruction both in Evening Schools and in Universities enabled thousands of men to acquire a knowledge of the facts and principles of physical science which they turned to good account in the workshop and the factory. The older type of inventor, who blundered blindly into success or stuck fast in the mud of failure, began to give place to men who picked their way by the light of knowledge. In no department was this more pronounced than in the production and transmission of mechanical power. For in 1848 the labours of J. Mayer in Germany and Joule and Thompson in England had established the law of the conservation of energy—that law which, in the words of Tyndal, "enables the eye of Science to follow the flying shuttle of the Universal Power as it weaves what the Earth-Spirit in *Faust* calls the living garment of God." Surmised by Watt, and on the verge of discovery by Rumford, it was now clear that energy could neither be created nor destroyed; that it might appear in one form or another, but that the total quantity in the universe was constant. Together with the Law of Universal Gravitation enunciated by Newton, and the Law of Conservation of Mass established by Lavoisier, it forms one of the three foundation-stones upon which the modern edifice of physical science rests. In its practical application this law gave exactness and precision to conceptions of and calculations on the production, transformation, and transmission of energy. Without its aid the reign of economy could not have been inaugurated. Man must have continued to grope in darkness, and to waste what in our time is the most precious of nature's gifts. Every step in the use of mechanical power, every advance in the applications of electricity, since that time have been based upon the relations between heat and work discovered and measured by the late Lord Kelvin and the late James Prescot Joule.

More important, perhaps, in its effect upon social and political philosophy was the publication in 1859 of Charles Darwin's work on *The Origin of Species.* Recognising in the world of plants and animals the struggle for existence, he applied his inferences to the *genus homo* in 1871, and traced man's ancestry back to a primitive type parallel with the monkey. Apart from the conflict of this view with the simple and direct interpretation of the Old Testament, the idea of the survival of the fittest initiated a fresh discussion of social aims and gave a new colour to political theories. The inherent brutality of "Nature, red in tooth and claw," smote the social conscience, and stimulated the instinct to help those who could not help themselves. Much subsequent social legislation and social effort has been inspired by the feeling that the social order ought not to aggravate but to mitigate the struggle for existence.

3. *Applied Chemistry and Applied Electricity*

The period is notable for the first preparation by Perkin of colouring matter from coal-tar. In the course of an investigation which aimed at the production of quinine, he tried the effect of oxidising agents upon aniline, which is prepared from coal-tar, and obtained a violet colouring matter called *mauve.* The process was patented in 1858, and the dye was the forerunner of hundreds of others which are now prepared from the same source. The influence of these discoveries was exerted in various directions. In the first place they stimulated research by showing what a wealth of material was hidden in the black refuse liquid of the gas-works. For fifty years this material had tended to accumulate until it became a nuisance. But when scientific investigation had revealed the possibilities, and the technical difficulties of manufacture had been overcome, it acquired a market value which encouraged the distillation of coal; such manufactures as required heat or light from town gas were cheapened, and the domestic use of this form of fuel was brought within the range of a greater number of people. The organic chemists of the 'fifties and their successors were the unconscious pioneers of democracy.

From coal-tar to-day are obtained not only hundreds of colours used for dyeing textile fabrics, paper, and leather, but nearly all the germicides used in modern sanitation; many substances of medicinal value; cheap perfumes, flavouring essences, and saccharine, a substance several hundred times sweeter than cane sugar, which may be taken by diabetic patients with impunity. The process of manufacture has created or increased the demand for a large number of other materials which are concerned in the transformation, and some of these were waste products from other processes which threatened to overwhelm the industries from which they were derived. Industries of great antiquity, again, were swept completely away. The preparation of alizarine from anthracene by Graebe and

Liebermann in 1868, drove out of cultivation the madder-root, from which one of the most ancient of natural dye-stuffs had been obtained. Thousands of acres of land were devoted to its cultivation in various countries of Europe and Asia. The production fell from about 70,000 tons in 1870 to nothing before 1890. British imports fell in ten years from 16,000 tons to 1600 tons, and the price dropped from £50 to £18 a ton. The British cotton and woollen industries benefited by a reduction from £1,000,000 to £38,000 for this kind of dye alone, and coloured fabrics became cheaper, and therefore more available, to those whose financial resources permitted of few luxuries.

History has been repeated within the last ten years by the preparation of artificial indigo, one (the better) variety of which was obtained from plants largely cultivated in the East, and the other (which had been grown in Britain before the Roman invasion) producing the dye called *woad*. In 1896 the export of indigo from the British East Indies was valued at more than £3,500,000; in 1914 the value was less than £70,000, and the price had fallen to one-half.

In their historical and economic as distinct from their scientific aspect, the industries which centre round the utilisation of coal-tar have had a smaller share than might have been expected in national progress. The first discoveries were made in this country, and they developed in Germany. So far as raw material was concerned we were, until the last dozen years or so, more favourably situated than any other nation. Fuel and mechanical power were as cheap to us as to them, and our production of tar was greater than our needs. The flourishing textile industries afforded a ready market, and now absorb ten times as much colouring matter as is manufactured in British works.

But it was the first industry to demand for its progressive development the employment of skilled chemists in sufficient numbers to enable them to make new discoveries as well as to control the original process. The Universities were slow, however, in the creation of technological departments, and the manufacturers appreciated insufficiently the necessity of progressive scientific improvement in addition to scientific control. This apathy and indifference have had the effect of allowing purely political considerations to strangle at birth other fruitful industries which would have contributed to national strength and prosperity. For the excise duties on alcohol, levied in the interests of temperance and of revenue, have rendered many other processes of manufacturing chemistry difficult, if not impossible, to conduct. And until the last dozen years even the small amount of spirit required for teaching and research could only be obtained at a price which is ridiculous compared with cost of manufacture.

In comparison with those of Chemistry, the applications of Electricity are of recent birth. Before the nineteenth century hardly anything was known of the mysterious power by which such wonders are worked in our own day. A few fragments of information were in possession of the Chinese and the Greeks, and the chaos of fact, legend, and speculation which the latter nation left to the world was disentangled by Dr. Gilbert of Colchester in the reign of Queen Elizabeth. In 1752 Benjamin Franklin put to the test his theory that lightning and electricity are identical, and thus showed how buildings could be protected by lightning conductors. That a current of electricity was produced by contact of two dissimilar substances was discovered by Galvani of Bologna in 1786, and investigated more thoroughly by Volta of Pavia a few years later. In

1819 Oersted of Copenhagen discovered the action of a current upon a magnetic needle, the phenomena upon which Cooke and Wheatstone's telegraph instrument was based; and between 1830 and 1832 Michael Faraday discovered electromagnetic induction.

The fruitfulness of the years 1786 to 1832 is sharply contrasted with the sterility of the next half-century. The only applications of importance were the telegraph and electroplating. On the purely scientific side Clerk Maxwell developed a theory of electricity and magnetism; and Sir William Thompson, afterwards Lord Kelvin, and James Prescot Joule measured the amount of heat into which a given quantity of electricity could be converted. But these results were not of much practical significance at the time. The problem which awaited solution was to produce large quantities of electricity at a moderate cost. The conditions under which electricity could be generated in a machine had been discovered by Faraday in 1832, but the laboratory and workshop were not in sufficiently close co-operation to render the achievement possible on a commercial scale for nearly fifty years. Dynamos or electric generators were, indeed, designed by Gramme, and improved by Pacinotti. The early machines, however, were mechanically defective, and when engineers tried their hands, their machines were electrically imperfect.

The first really satisfactory machines in this country were the Edison-Hopkinson, an improvement on the Edison, designed by Dr. John Hopkinson, and those produced by Siemens Bros. In mechanical stability and electrical output they were an improvement on all others, and they appeared at a time when new possibilities arose in the application of electricity to lighting and traction. Both of these are of extreme interest to students of industrial history, because they became very important subjects of municipal activity, and also because they illustrate certain economic and social problems which will grow in importance in the coming years.

In the eighteenth century most towns in Great Britain were in darkness after the sun had sunk below the western horizon. Even in London there were few street lamps, and people whose business took them abroad at night were lighted on their way by linkmen. About 1792 William Murdoch, one of the ablest of James Watt's assistants, was experimenting with various kinds of coal, and conceived the idea of using the gas which could be obtained from them to furnish light. Early in 1800 he illuminated the works at Soho, and inaugurated a new era in artificial lighting. Meantime some experiments had been made in Paris, and in 1814 an attempt was made to light certain streets in London. The method spread slowly at first, but rapidly after 1860. Its advantages were obvious, for a good cheap form of artificial light added to the hours which man could give to labour, and helped in the preservation of law and order by discouraging those practices which did not court discovery.

Until 1880 gas and oil held undisputed sway, and even for ten years longer they were not seriously threatened by the electric light. As long ago as 1809, however, Davy had shown, in the laboratory of the Royal Institution, that a light could be produced by allowing a current to flow across a gap between two copper rods; and Faraday, his successor, had, as we have seen, shown how to produce electricity mechanically in 1832. But it was not until after 1879 that dynamos sufficiently economical for general use were available. The first electric lamps introduced were known as Jablochoff candles. Two parallel carbon rods were separated by a strip of non-conducting material, across one end of which the electricity formed an arc. The carbon gradually burned away in the air, forming carbon dioxide, and, until the enclosed arc was invented about twenty years ago, the cost of the carbons and of the labour in replacing them was a serious item. Nevertheless their high efficiency rendered them capable of competing with gas, and they were almost invariably used in preference for railway- and shipyards, workshops and other large buildings. Great improvements have been made during the last ten years, and, where no special circumstances intervene, the tendency has been for arc-lighting to become almost universal for outdoor work.

About the time that Jablochoff invented his "candle" attempts were made to produce a lamp in which a metal wire in a small globe was raised to a white heat by the passage of a current of electricity. But platinum, then of all metals the most difficult to fuse, had to be raised to a temperature so near its melting-point that it was liable to give way. Edison in America and Swan in England were both working at the problem, and succeeded simultaneously in constructing a lamp which consisted of a thin filament of carbon in an exhausted glass bulb. The patents were amalgamated, and for nearly twenty-five years the Ediswan lamp held the field for indoor electric lighting. The bamboo filament used at first gave way to a squirted thread of dissolved cellulose, which could be produced of a more uniform thickness; but that was, practically, the only change made.

It is not a little curious that one of the earliest attempts to improve the carbon filament lamp resulted in an almost overwhelmimg advantage to its rival, namely the discovery of the incandescent gas mantle. In 1884 Dr. Auer von

Welsbach was endeavouring to increase the luminosity of the filament by impregnating it with the oxides of certain rare earths which glow brightly when heated to a suitable temperature. He discovered that the temperature of a bunsen flame was sufficient for the purpose, and that the oxides still held together after all the carbon was burnt away. Careful experiment showed that the best result was obtained with a mixture containing 98 per cent to 99 per cent of thorium oxide with 1 per cent to 2 per cent of cerium oxide. The influence of this small but limited proportion of cerium oxide remains one of the unexplained, if not inexplicable, facts of modern chemistry.

The form of the incandescent gas mantle is fixed by the shape of a bunsen flame. It is woven of ramie fibre, a raw material which is obtained from China grass, a member of the nettle family. After dipping in an emulsion of the mixed hydrates, it is dried, and was formerly sent out in this form, because when once the fabric is burnt away the skeleton of mixed oxides is extremely fragile. Domestic burners, however, do not destroy the fabric as completely as is desirable, so the mantles are finished off at the works and then dipped in collodion. This liquid is a solution of nitrocellulose or guncotton in a mixture of alcohol and ether. When exposed to the air the alcohol and ether evaporate, leaving a thin film which holds the skeleton together and burns off with a lurid flame when it is used for the first time.

Incandescent gas lighting has been a serious competitor to electricity from the beginning, and is even now not at such a disadvantage as to be rapidly displaced by its rival. By increasing the light per cubic foot of gas it reduced the cost of gas lighting below that of electricity. In spite of the obvious convenience of electric lighting, it was expensive because carbon lamps consumed too much current, and electrical engineers were placed on their mettle. They began to look for a substitute for carbon, and turned their attention to metals like tantalum, tungsten, and osmium, which the labours of Moissan with the electric furnace in 1892 had shown how to produce in quantity. Investigations carried out in Germany and in America led in 1906 to the tantalum, osram, and Mazda lamps, which for the first time brought the cost of electric lighting below that of gas. Still more recently (in 1914) a new form of tungsten lamp has been placed on the market, which is the most efficient which has yet been devised. It is known as the *half-watt* lamp, and consumes only one-seventh or one-eight of the current required by a carbon lamp of equal power.

The story of the conflict between gas and electricity conveys one or two useful lessons. The stimulus which the success of the one gave to the other is very similar in its effects to the reaction caused by invention between spinning and weaving 170 years ago. Whether, in the absence of such rivalry as was created by the incandescent mantle, the same improvements would have been made is perhaps open to question, but if that were really so, progress in discovery and invention would hardly be so rapid as it is. For the motives which lie behind human effort are not merely sordid ones. The honour and profit of finding or devising something new is not more stimulating than the joy of a first glance at a new fact or principle. The divine curiosity which has raised man from among the beasts of the field is not dead yet, and it is reinforced and strengthened by the sense of social service which is the inevitable accompaniment of honest enquiry.

That social service is the result of such examples as we have just discussed is obvious from the effect upon the consumption of electrical energy. If no increase in the number of consumers had accompanied the introduction of the metal filament lamp the electrical generating stations would have been hard hit, because for a given amount of light the current required is only 40 per cent of its former value. But as a matter of fact the output of these stations has gone on increasing year by year, thus proving that the number of those who enjoy the benefits of the electric light has increased in a still greater ratio. Moreover, any one who has compared the houses which are now being built with those erected ten years ago will not need to be told that the extension has been both vertical and horizontal, though, as usual, the poorer people are the last to reap the benefit of a public utility which makes for economy. The benefits are, however, filtering downwards from those more richly endowed with this world's goods to people whose lives have to be ordered under the limits of a weekly wage.

Incidentally the growth of electric lighting has given an impetus to subsidiary manufactures, for, whenever there is a large demand for a particular kind of material or a particular form of object, the process of making that material or that object is invariably improved. Thus the globes have become more reliable and cheaper; certain rare metals, formerly costly because they were only prepared in small quantities, are now produced in large quantities at a relatively low price; the process of wire-drawing has been improved; vacuum pumps, which forty years ago were only employed for scientific research, have been vastly increased in size and efficiency, and are the necessary equipment of every lamp factory. The knowledge and skill which was once the special possession of the scientific investigator is now an essential qualification for those in charge of industrial processes. Not only the atmosphere but also the instruments and methods of the laboratory have spread slowly outwards until they now permeate every corner of the workshop.

We shall refer in the chapter on "Transport and Communication" to the application of electricity to traction, and we may merely remark here that its introduction was nearly contemporaneous with that of electric lighting. While progress in these two fields of activity was obvious, electricity also came to be used to a greater extent inside the workshop and the factory, where its influence was unknown to, or but dimly appreciated by, those not actually engaged in production. In addition to the use of electricity as a means of transmitting power there is a whole range of electro-chemical processes which date from 1800 when Wollaston, and subsequently others, discovered that when an electric current is passed through many liquids—either solutions or solid substances which have been melted—decomposition ensues. In the case of certain salts dissolved in water the metal may be separated at the pole or electrode by which the electricity leaves the solution, and this fact forms the basis of electro-plating. Faraday in 1833 demonstrated that the amount of metal deposited in a second was proportional to the quantity of electricity which passed in the same interval, and thus gave a quantitative foundation to the process. It is used not only for the production of knick-knacks and fancy metal goods, but also for many articles of utility. A base metal is coated with one of greater value, durability, or resistance to atmospheric influences. Moreover, it is employed in the duplication of printing blocks for book illustrations, and by replacing lithography for this purpose it has enormously cheapened the manufacture of illustrated books.

An example of an electro-chemical industry on a large scale is the decomposition by electricity of common salt, whereby caustic soda, washing soda, and chlorine for bleaching can be obtained. And as caustic soda prepared by this or an alternative method is necessary for the production of soap, electrical discovery has had an important bearing on cleanliness and health.

As long ago as 1809 Davy prepared the metals potassium and sodium by passing an electric current through fused caustic potash or caustic soda respectively, but it is only within the last twenty-five years that this process has been used on a commercial scale. Meantime an electric furnace was patented by William Siemens in 1879, and in 1885 Cowles used a similar arrangement to obtain aluminium. This process was improved a year later by Hall, with the result that a metal which thirty-five years ago was rare and costly is now only a shilling a pound—not very different from the normal price of copper.

For nearly ten years this remained the sole example, until Moissan's researches, published in 1892, revealed the extraordinary power and utility of the electric furnace. Gradually increasing the power, he showed that the most refractory substances could be melted, or even vaporised, under the influence of the electric arc, and materials which had formerly been scientific curiosities could be prepared in quantities at a cost which depended mainly on the cost of electrical energy. One of the first results was the manufacture on an extensive scale of calcium carbide, the value of which is due to the fact that it is decomposed by water, forming acetylene. This is a gas which burns with a luminous flame and a high temperature. It has been adopted for lighting country-houses which are remote from a town supply, but its most important application is in the shipyard and the engineering workshop, where in the form of the oxyacetylene flame it cuts steel as though it were paper. During the last dozen years a new use has been found for the carbide in the production of nitrogenous manure; for when nitrogen, obtained from liquid air, is passed over the carbide heated to about 1000° C. to 1100° C. in an electric furnace calcium cyanamide is formed, and this substance, in contact with moist soil, yields ammonia. The bearing of this discovery upon the future wheat supply of the world will be apparent from the perusal of Chapter IV.

Another development of Moissan's work is the preparation of carborundum or silicide of carbon, which has practically replaced emery as a grinding material. The furnace is charged with anthracite coal and sand, together with sawdust and salt, which play a subsidiary part in the process; and out of that mixture comes a material which has largely modified practice in engineering workshops.

An even simpler process is the conversion of anthracite into graphite, the soft black substance which is used for pencils, and which is also largely employed as a lubricant. From the electric furnace, therefore, comes an ideal friction-producing agent, and a substance which is extraordinarily effective in preventing friction. In one sense these two substances, having properties so diametrically opposed, are significant of the range of modern factory methods; and in another sense they are eloquent of man's independence of raw materials. For a time he may have to rely upon substances which are scarce or difficult to obtain, but sooner or later he finds it possible to convert a commoner or more plentiful substance into the form he desires.

These processes are dependent entirely upon electricity. They cannot be carried on with ordinary fuel. But in other industries, hitherto employing coal directly, similar processes are coming into use. Most of the phosphorus, a good deal of the glass, and some of the most expensive varieties of steel are now prepared by the aid of electricity. The district round Niagara, and Norway, Sweden, and Switzerland, owe much of their present-day prosperity to the new development, in which France, Germany, and, to a very small extent, Great Britain are taking a relatively insignificant share. The reason is not far to seek. Cheap electricity is essential, and the cheapest electricity is obtainable in those countries which possess water-power. The ultimate result will be severe economic pressure in Great Britain unless the most efficient fuel plant is established on the largest scale. As a growing influence on British Industrial History it could not pass unnoticed here. But it is of interest in a wider sense, for the utilisation of water-power in the countries named is giving rise to a new Industrial Revolution, employing new processes, yielding new and important materials of manufacture, and effecting a redistribution of the population of the world.

4. *Scientific Features of Modern Industry*

The new industrial epoch which it is especially desired to emphasise in this chapter began somewhere about 1880. It was occasioned partly by competition from Germany and the United States, partly by the scientific discoveries of the previous fifty years, and largely reinforced by discoveries since that date. The necessity for economy in fuel has led to an increasing use of gas in place of coal, and the ever-widening sphere of construction, carrying with it economy of manufacture, has encouraged the immediate utilisation of new metals and alloys. This means that in every branch of industry there must be men capable of understanding and of applying the results of scientific research; and in those works under enlightened management, men also capable of undertaking the investigation of problems which constantly arise in practice. At the beginning of this period there was in reality only one applied science—that of mechanics. To-day there are scores of branches in which there is a sufficient body of organised knowledge to justify the title. If each of these groups is to contribute its quota to the national welfare, it must be afforded the proper conditions of development and growth. And here again is a point of contrast between this and previous periods.

The great advances before 1880 were made almost entirely by men of inventive genius who found a clear field and ploughed it with the energy of personal ambition. As a general rule their initial experiments cost little, and the reward was great. If they were hindered by a difficulty which only scientific knowledge could overcome, that knowledge did not take long to acquire. But the crude scientific weapons they wielded only sufficed for a certain degree of progress, and when this limit had been reached the subject became more difficult. Further steps were effected gradually, with infinite labour, and after long preparation. Some of the necessary investigation was undertaken by men actually engaged in industry, and some by men whose opportunity came with the establishment of technological faculties in Universities. The cost was often far beyond the means of those who were well equipped intellectually to carry out the work, and the professional institutions, like those of the Civil, Mechanical, and Electrical Engineers, gave grants in aid. The Chemical

Society established a Research Fund, the British Association for the Advancement of Science defrays the expenses of investigations carried out by its committees, and a Government grant of £4000 is administered by the Royal Society; but these are usually devoted to enquiries in pure science, and the results are not, as a rule, of immediate commercial importance.

When the solution of a technical problem demands expensive apparatus and equipment, it is obviously wasteful to establish it in a private or localised institution where it may never be used again; and an important step towards the provision of the means of research on an extensive scale was taken a dozen years ago by the establishment of the National Physical Laboratory. This is an institution situated at Teddington, and maintained partly by a Government grant and partly by fees received from manufacturers who apply to the Laboratory for assistance. Much of the time of the staff is taken up by testing thermometers and other scientific instruments, but the annual reports indicate that the amount of original investigation is large and is increasing. A good deal of the progress made in aviation is based upon experimental results obtained in the Laboratory, and a striking example of its usefulness is to be found in the work done in the experimental tank for testing models of ships. Such tests had for long been applied to the design of warships in the Admiralty tank at Haslar, and to the design of the large liners in one of the three private tanks in the country. But until this national tank was provided it was not possible to test the designs of cargo boats and the less important passenger vessels. The result has been to suggest alterations of design in these cases which effect a saving of from 3 per cent to 25 per cent of the power required for propulsion.

The work of the National Physical Laboratory exhibits the "research with a purpose" which characterises the modern period as contrasted with the undirected enquiry which was more prevalent a hundred years ago. The newer object has not, and cannot, displace the older one, for they belong to rather different fields. The one is concerned solely with widening the bounds of knowledge, and the other with improving the processes of industry and practice. The one aims at revealing the laws of nature, and the other at controlling the forces of nature. The ultimate result of both is to relieve from toil, to alleviate suffering, and to make the world a better place to live in. But, as we have emphasised repeatedly, by continually altering the material conditions of life, they create new social and political problems with which the statesman and the administrator have to deal.

Examples of the paramount necessity of scientific advice and assistance in the conduct of industry will be found in other chapters. They are met with most frequently, perhaps, in chemical and metallurgical operations, and especially in those which are concerned with the most recent developments. Medicinal drugs, new varieties of steel, the preparation of the metals required for incandescent electric lamps, and a hundred other illustrations at once suggest themselves. At the same time there are few firms which buy raw and manufactured materials on a large scale which do not find it necessary to test the quality of each consignment as it is delivered. Even firms which do not keep a permanent staff often employ a consulting chemist, engineer, or electrician, to whom they pay a retaining fee, and upon whom they call for advice whenever the necessity arises. The research which is thus frequently involved is not published, but it forms a very large proportion of the additions to technical knowledge every year.

These investigations are mainly directed towards small economies which can be effected by correspondingly small alterations in machinery or practice. A firm which ten years ago paid £1000 a year for the recovery of a valuable material now carries out the operation for £100; a machine shop saves £600 a year by a particular method of driving; a difference in the hours of labour in summer and winter adopted by some firms reduces their lighting bill by an amount that would not be suspected; an investigation of the rate at which a commodity is being produced shows that in what was thought to be a well-appointed factory the methods of measuring and checking the output are practically useless. These are actual examples, but for obvious reasons the names of the firms cannot be given here. It is, however, a significant fact that in every case the firm is one which has a reputation for fair treatment of its work-people, and in every case there is also organisation for promoting their general welfare outside, as well as inside, the works.

In addition to the establishment of works laboratories in which raw material and finished products are examined, and where fresh investigations are undertaken, there are other aspects of the modern period which deserve notice. The first is the use of automatic machinery, in which operations formerly conducted by hand are now done by the machine itself. The output is increased, the labour bill is reduced, and a less intelligent type of workman will suffice. The old system of apprenticeship has largely broken down, being no longer necessary when a boy or man can learn in a few months what formerly required several years. So far the reduction of labour has not led to unemployment—at any rate, not on a large scale—because the increased output and reduction of cost have created new markets, and there has been some reduction in the hours of labour. But there is not much reason to doubt that the gradually increasing proportion of men who are not called upon to think and to exercise initiative when at work is a social disadvantage which, combined with low wages, forms a serious political menace. The destruction of individual responsibility in an age when political power is extending over a wider and wider field is an evil for which some compensation will have to be sought in the near future.

A necessary accompaniment of automatic machinery is a high degree of specialisation. Such machines can only be economical when they are fully employed. They are to be found therefore mainly in factories which produce things that are required in large quantities. To this extent they tend to cheapen luxuries and to bring the triumphs of manufacture within the reach of many who could not otherwise afford them. In this way bicycles, sewing machines, newspapers, books, and scores of other articles which add to enjoyment or reduce labour, are produced so cheaply that they have long ceased to be luxuries. In any estimate of the social effect of machinery upon the man who controls it, regard must be had to the widespread benefit which the use of such machinery entails.

Though this aspect of modern industry tends to degrade the worker, it compels those who control it to rise in the intellectual scale. The design of the new machines rarely takes place *de novo*; rather are they the results of small improvements, by which first one and then another of the operations is rendered automatic. But just as competition is the cause of their birth, so also is competition the cause of their most effective use. They require the presence on the factory staff of men who have risen intellectually as far above the old-time skilled workman as the machine-minder has fallen below him. The records of cost in each stage of manufacture, and the alterations of process or procedure which an analysis of these records suggests, involve a degree of scientific knowledge and training which only a limited number of men possess. The scientific manager forms a new industrial type which has grown up almost entirely during the last twenty-five years. In some cases his function is to deal mainly with machines, in other cases mainly with men; on the one hand originality of mind, on the other hand sympathy, human insight, and personal address are essential qualities.

Scientific management is truly a product of the present age. It consists in so arranging the procedure within and between the different departments of a factory that there is the least expenditure of time and effort in its operations. It necessitates methods which have for their object encouragement to the workman to put forth the best that is in him; the regular supply of raw material and the smooth transfer of this material from one department to another; a record and a scientific study of cost at each stage, so that sources of waste may be discovered and leakage stopped. Its value to a business house is the same as good government to a nation, and, just as a nation benefits by good government, so does the industrial community benefit by the scientific control and economical expenditure of its resources.

There are no doubt many cases where human labour is inefficient, and, in so far as that arises from sheer perversion of spirit, it cannot be dealt with here. But there is also another aspect which may properly be discussed. The performance of hand-work does not depend wholly upon muscular development. A strongly-built, well-proportioned man is not necessarily an athlete. Proficiency in using the muscles is not merely a matter of use, but of right use; and unless a man has been trained to perform an operation in such a way as to involve the least expenditure of time or of physical effort, he is unlikely to be capable of doing what might reasonably be expected of him.

In many shops where the work is largely a repetition of the same series of operations on each machine, experiments are carried out to determine the best order of performance. Exact measurements are made of the time required from each stage, and a schedule is made out for the workman's guidance. If he can improve on the standard laid down he reaps a share of the benefit in the form of a bonus. Under the piece-work system, from which the writer suffered twenty years ago, an improvement was followed by a penalty—the price of the job was reduced and the employer took the profit.

Mr. F. W. Taylor, an American engineer, has recently shown that many of the everyday forms of manual labour are highly inefficient, simply because the workman has not learnt how to proceed. He is like a strong but clumsy man essaying an athletic feat requiring for its efficient performance a high degree of skill. The man himself is not to be blamed, because the problem of ascertaining how to secure the maximum effect with the minimum effort is far too difficult for him to solve. If the employer undertakes the investigation there is a very considerable profit to be divided between them. In a particular case certain men were offered a 60 per cent increase of wages for loading pig-iron if they would put themselves wholly under control. They were then trained by a man who regulated their rate of working by a stop-watch. Under these conditions the amount of pig-iron loaded per man per day was raised from $14\frac{1}{2}$ to $47\frac{1}{2}$ tons without any evidence of greater fatigue. Another example is afforded by shovelling ore, when the amount per man per day was raised from 16 to 59 tons. In both cases the men were specially selected as having small initiative and therefore being the more amenable to training.

Methods of this character inspire a certain amount of distrust at first, because they appear to aim at the conversion of a man into a machine. On the other hand, it may be argued that the man is already a machine, and, quite unintentionally, an unsatisfactory one at that. Left to himself, he will adopt inefficient methods which, after a time, are performed subconsciously. To replace the man's own system by one which enables him to do more work with less effort is rather a cause for gratitude than a reason for resentment. The man is directly or indirectly a consumer, and if the cost of manufacture is reduced he shares in the benefit. There are always men who cannot think for themselves, and to whom aid of this kind is the only hope of a higher standard of life—of a greater reward for toil. Hitherto they have looked to the Trade Union, and though the Unions are doubtless justified in resisting the cutting of prices, they are sometimes accused of lowering their standard to the level of the laziest or least intelligent of their members. When they realise that wages may be raised by a scientific reduction in the cost of manufacture they will be able to co-operate with the employer, and yet protect the interests of the men. To overwork men is criminal brutality; but to prevent them doing the greatest amount of work with the least effort is to prostitute human life.

Enough will have been said to show that the conduct of industry has changed radically during the last thirty or forty years. The tendency is not only to perform an increasing number of operations by machines, but even to organise many of the muscular movements which are concerned in hand-labour. Every operation of the workshop and the factory is being improved as a result of scientific investigation. While the man with small intelligence and initiative is being gradually relieved of what little responsibility rested upon him, greater demands are being made upon those who control the factory, the workshop, and the mine. Men are required in industry who are capable of understanding and utilising the results of scientific research, and also of carrying out themselves such inquiries as arise in daily practice. Moreover, to meet the competition which has arisen, and which will become keener with the passing years, the organisation of research on a national scale is a paramount necessity to an industrial nation dependent upon external sources for the greater part of its food and for much of the raw material of manufacture.

B. FACILITIES FOR COMMERCIAL DEVELOPMENT

CHAPTER VIII

TRANSPORT AND COMMUNICATION

1. *Roads and Canals*

FACILITY of movement of men and goods and the rapid transmission of orders and messages has at all times been an essential factor of civilised progress. Not only the development of internal trade, but also the ready and frequent opportunity for consultation depend upon easy communication by land or water; and road, canal, and railway have had an incalculable influence in promoting settled government and cementing national unity. External, as distinct from internal, communications, again, enlarge the boundaries of mental as well as of geographical outlook. For they enable men in every land to draw upon the material resources of the world, and to share in the intellectual progress of mankind. The ancient civilisations of Babylonia and Egypt grew to maturity along the banks of great rivers; and on the face of the waters was borne their commerce and the officers who formed the link between the Government and the people. The Phœnicians, Greeks, and Romans utilised the sea as a means of increasing their material prosperity and extending their political influence. When Rome extended her power away from the coastline her engineers built roads which are famous in history, and without which military occupation and political control would have been alike impossible. The first real step in the development of our own colonial possessions has been the establishment of roads and canals and railways. The explorer, blazing his way through the tangled forest, or striking a track across the unmapped plain, is marking out paths of human progress, and graving on the face of nature the picture of human power.

In England the roads constructed by the Romans served a military purpose only: they cut straight across country from camp to camp, enabling troops to be moved rapidly from one point to another. As the population grew under Norman and Plantagenet rule, each village—for the towns of those days were little more than villages—became centres from which three or more tracks radiated to other towns. But neither at this period nor yet under Tudor and Stuart kings were there roads in the proper sense of the term. At the beginning of the eighteenth century they often had ruts four feet deep, filled with mud, and those crossing low-lying areas were flooded in winter for weeks together. Where the ground was soft and sloping, the roads were cut deeply by the traffic until they were enclosed by high banks on either side. Such, in fact, is the origin of the Devonshire lanes.

Meantime the development of shipping was bringing new raw materials to our shores and creating a trade in manufactured goods, so that there arose a demand for improved highways. The first Act of Parliament authorising the construction of turnpike roads was passed in 1663, and the cost was to be met by tolls. To this form of payment people strongly objected, and they seized every opportunity to pull down the gates wherever they were set up. The opposition did not die out easily, and nearly a hundred years after the first Act, in 1753, a general raid was made upon all the toll-gates in Yorkshire. Military assistance had to be sought to protect property, and the rioters were only dispersed after a number had been killed and wounded.

Few of the roads were suitable for coaches, which travelled at an extraordinarily slow pace. Probably the earliest ran from London to Dover about 1650; there was one from London to Coventry in 1659, and another running as far north as Preston in 1663. A journey from York to Leeds in 1703 occupied eight hours; but this was under favourable circumstances, for in some cases the coaches were laid up altogether in winter, like ships caught in Arctic ice, and it was no uncommon thing for passengers to be delayed at one spot for several days. Apart from the risks of break-down and the vagaries of the weather, the traveller could not choose his own company, and was occasionally forced to suffer the inconveniences thus described by a contemporary writer:

> On both sides squeezed, how highly was I blest,
> Between two plump old women to be pressed!
> A corp'ral fierce, a nurse, a child that cry'd,
> And a fat landlord filled the other side.
> Scarce dawns the morning ere the cumbrous load
> Rolls roughly rumbling o'er the rugged road:
> One old wife coughs, and wheezes in my ears,
> Loud scolds the other, and the soldier swears;
> Sour unconcocted breath escapes "mine host,"
> The sick'ning child returns his milk and toast![1]

The terrors of a journey such as that from London to Newcastle, which in 1734 was performed in nine days, may appropriately be left as an exercise of the imagination.

So much for the transport of men in England in the

[1] Quoted by Smiles: *Lives of the Engineers.*

early years of the eighteenth century. A very little reflection will show that the conveyance of goods must have been small in amount and costly in character. Corn, wool, and similar merchandise that could be packed into sacks was sent to market on horses' backs, and coal and other forms of fuel were carried in panniers. Every merchant kept his own pack-horses, and long lines of them, travelling in single file, were frequently to be met on the narrow tracks that joined the chief towns, or led to some port to which ships came from foreign lands. There were few shops, and articles of everyday use were hawked round the country by pedlars; while owing to the state of the country in winter most housewives had to lay in a store of food, after the manner of hibernating animals. A good deal of the retail trade of the country was carried on at Fairs, much as it is in Russia and Eastern Europe to-day. Among the more important were those held at Winchester, Boston, and St. Ives, and at Stourbridge, near Cambridge. The first-named attracted merchants from all over Europe, and all four were attended by a vast concourse of people who came not only to buy and sell, but to peep at what the world could show outside "the common round, the daily task." For under such conditions knowledge was naturally slow in travelling, and in out-of-the-way places news had the flavour of ancient history. Macaulay has placed it on record that the death of Queen Elizabeth was unknown to some of her subjects in Devon until the courtiers had ceased to wear mourning, and Oliver Cromwell had been Protector for nineteen days before the fact was known at Bridgewater.

But a great change was at hand. The mechanical inventions which speeded up the textile industries forced the Government to develop better means of communication, and the problems were attacked with energy and success. Between 1760 and 1780 no fewer than six hundred Turnpike Acts were passed authorising the construction of new roads and bridges, and by the end of the century the main highways were immensely improved. That progress was not even more rapid is to be attributed partly to the fact that there were few men in the country capable of carrying out the work. And so, perhaps, it came to pass that John Metcalf was employed to so large an extent in a capacity for which he appeared to be singularly unfitted. Be that as it may, he stands out as one of those heroic figures who assisted so greatly in the establishment of England's industrial greatness.

John Metcalf, of Knaresborough, was a man who had lost his sight through an attack of smallpox when six years of age. After an adventurous career he turned his attention to road-making. Probably as a result of his infirmity, he developed an extraordinary sense of direction, seeming to know by instinct not only the best path to follow, but also where the materials were to be found. His first attempt was between Harrogate and Boroughbridge in 1765, and it was followed by a large number of others in Lancashire, Yorkshire, Cheshire, and Derbyshire, making in all about 180 miles, the cost of which was £65,000. Many bridges were included in the contracts. On the Huddersfield to Manchester road he employed nearly four hundred men at six different points, and by laying his track on the Pule and Standish commons, he proved the value of the method by which George Stephenson subsequently laid the Liverpool and Manchester railway across Chat Moss.

When the needs of the industrial north had been satisfied, progress went on quietly in other districts. From several points of view the most important developments were made in Scotland. Means of transport in this broken and rugged country were obviously far more difficult to provide. There was, however, a political necessity. England and Scotland were finally united in 1707, but attempts continued to be made by the Jacobites to regain possession. Between 1715 and 1745 some eight hundred miles of military roads were constructed; in 1761 the Scottish iron trade was inaugurated by Dr. Roebuck, and efforts were being made in various directions to develop the country. In 1802 Thomas Telford was commissioned by the Government to draw up a comprehensive scheme.

Telford was another man who started life without any advantages of education or influence. Born in a remote Scottish village in 1757, he was apprenticed to a stonemason, and coming up to London in 1782 he was employed in the building of Somerset House. From thence he went to Portsmouth, where he undertook the erection of buildings for the Admiralty. In 1797 he constructed the Ellesmere Canal, which connects the Dee, the Mersey, and the Severn. The completion of this work in the early years of the nineteenth century established his fame as one of the most competent engineers of the day. His proposals for the provision of roads in Scotland being favourably received, he was instructed in 1803 to proceed with the work. During the next eighteen years he constructed 920 miles of highway and more than 1200 bridges, an achievement which is of first-rate importance in British history. Before this work Scotland was "a country almost without agriculture, without mines, without fisheries, without shipping, without money, without roads. The people were ill-fed, half-barbarous, and habitually indolent. The colliers and salters were veritable slaves, to be sold together with the estates to which they belonged. To-day the face of the country has been entirely changed; its agriculture acknowledged to be the first in the world; its mines and fisheries productive to the highest degree; its banking a model of efficiency and public usefulness; its roads equal to the best roads in England or in Europe. The people are active and energetic alike in education, in trade, in manufacture, in construction, in inventions." And for this they, and we, owe much to Telford, who "by his roads bound England and Scotland . . . into one, and rendered the union a source of wealth and strength to both."[1]

The name most intimately associated with English roads is that of John Loudon M'Adam, who was a contemporary of Telford. Like that engineer, he recognised the need for thorough drainage, but he attached less importance to foundations, believing that the subsoil was sufficient to support the weight. Several of his views are now held to be erroneous, but he was so largely engaged in repairing existing roads, and was so persistent in his efforts to secure improvement, that a road surfaced with small stones is still said to be "macadamised." In time such a surface becomes cemented by the weight of the traffic and rain, but the process is a slow one. Rollers drawn by horses appear to have been in use about 1850, and in 1866 a traction-engine was employed to draw a 10-ton roller. The first combined traction-engine and roller was constructed in the following year. The early roadmakers experimented with various materials, and granite setts were introduced where the traffic was heavy. Wood was tried in Manchester in 1839, and in recent years the Australian woods *jarra* and *kauri*, together with American *red-gum*, have been used successfully in most great towns,

[1] Smiles's *Lives of the Engineers*, 1857.

but especially in London. They were at first laid on flat boards, but now invariably rest on a concrete foundation, and are cemented by bitumen. The use of Trinidad bitumen or asphalt alone for paving dates from 1854, when experiments were made in Paris. In 1867 it was adopted for Threadneedle Street in London. The elasticity of the material reduces the noise, but it is extremely slippery in wet weather.

As the traffic became heavier and more frequent, the face of the ordinary macadamised road became ground to powder, producing clouds of irritating dust in windy weather. This was avoided by the use of tar-macadam or "tarmac," which consists usually of limestone dipped in coal-tar. The same substance is also sprayed upon the surface from time to time. It is worth noting that the use of asphalt on a large scale would have been almost impossible but for the development of shipping, and that tar was a bye-product of the process of gas manufacture discovered by William Murdoch. Even such an everyday matter as road-making in the twentieth century is intimately connected therefore with the great movements which distinguish our own epoch from these which have gone before. The improvements are, moreover, the outcome of an extension of local government. Badly-made roads are not only hindrances to trade but sources of danger to travellers, and of ill-health or disease to those who live near them. The Public Health Act of 1875 more particularly increased the responsibilities of the boroughs, and the Local Government Act of 1888 contained provisions for the maintenance of the roads in rural districts. But the development of motor traffic since 1900 has converted road maintenance from a local to a national question, and in 1910 the Road Board was established. This is a Statutory Committee with an Advisory Board of Engineers, and having power to make grants and loans to local authorities for the construction and repair of main roads. The funds available are the proceeds of the duty on motor spirit and motor licences. There are now 230,000 miles of road in Great Britain, and at the International Road Congress held in London in 1913 they were stated to be the finest in the world. This result, achieved within 120 years, is due jointly to the example of the early pioneers and the wise local administration of Parliamentary Acts.

Until after 1880 the public highway was used almost entirely by pedestrians and by privately owned horse-drawn vehicles. Numerous attempts had been made to construct carriages propelled by steam, but the only form which survived was the traction-engine, and this was subject to strict regulation. The speed was limited to five miles an hour, and a man, carrying a red flag, was required to walk twenty-five yards in front. The invention of the petrol motor by Gottlieb Daimler in 1884 provided for the first time a really light engine of sufficient power; but owing to the "Red Flag" Act, which was not repealed until 1896, all pioneer work was done in France, Germany, Italy, and the United States. From that date, however, the wealth of the people and the admirable roads have enabled Great Britain to take a foremost position in Europe. According to an estimate made in 1913 there were 220,000 mechanically propelled vehicles—more than twice as many as in any other country in Europe, but only one-third as many as in the United States.

The great demand for oil created by new forms of internal combustion engine during the last twenty-five years has materially enhanced the price of that commodity. The smaller cars have been driven to use benzol, a product of the distillation of coal, and the larger ones the heavier, cruder, and cheaper forms of petroleum. Improved materials and machines have also enabled engineers to construct steam drays and wagons capable of carrying heavier loads than were usual with horse-haulage, and these use coal, which is, as a rule, a cheaper fuel than oil.

The striking extension of motor traffic is illustrated by the establishment of regular bus-services in rural districts. In a particular case a round journey which five years ago occupied a traveller two days and cost 10s. in railway fares is now accomplished in one day for a shilling. With increase of speed the distances covered in a day's journey are now so much greater that many roads have ceased to be merely of local or parochial importance, and contributions to their maintenance are made, as we have already indicated, by the Development Commissioners acting under the advice of the Road Board.

Before the mechanically propelled vehicle was brought to perfection, the needs of intercommunication had been met by tramways. The reader will find in Chapter XIII. some account of the growth of municipal enterprise in tramway construction, but we may refer here to the technical aspects. The first electric railway or tramway was exhibited at the Berlin Exhibition of 1879, where it carried passengers round the grounds for a small fee. The current was conveyed through the rails—an obvious disadvantage in a public street. At the Paris Exhibition of 1880 the first overhead wire was shown. The trolley pole was tipped with a sliding shoe, since replaced by a wheel. Fairly rapid progress was made on the Continent and in the United States, but in England the Tramways Act of 1870 was unfavourable to private enterprise, and local authorities were slow to move. The Act was passed at a time when growing towns were feeling the effects of monopolies, and just after the second extension of the franchise. It provided that the consent of the Local Authority should be obtained; that the concession should be granted for twenty-one years in the first instance, and that at the end of this period, or at seven-year intervals afterwards, the Authority should have the right to purchase the undertaking at its "then value"—sometimes not without reason, nor even unjustly, called "scrap-iron" terms. The result was that private companies hesitated to spend money unnecessarily on maintenance or improved services, the public suffered an inferior service, and the cars acquired an air of increasingly shabby gentility as they approached their majority.

In 1880 horse-tramways had become fairly well established, and electric tramways made very little progress in this country for ten years. Then a violent controversy arose between the advocates of underground conduits and overhead wires. Much was made of the unsightliness of the latter system, but the only town to decide upon conduits was London. At a later date a surface-contact system was adopted at Torquay, Wolverhampton, and Lincoln. But it came too late to be a serious competitor. The overhead system is universal, and objectors have become silenced. The electric tramway movement spread most rapidly after 1898, when there was just over 1000 miles of tramway, most of it worked by horses in the United Kingdom. A dozen years later this had increased to more than 2500 miles, wholly dependent upon electric traction.

The advantages of the electric tram over the horse-tram are an increase in speed, greater carrying capacity, a lower cost of maintenance, and a higher degree of elasticity, which enables it to deal with varying traffic. The electric tram has created a demand altogether beyond the capacity of the older form of locomotion. The maximum service of four trams an hour has been increased to twelve or even twenty on busy routes, and with the growth of the traffic the fares have been frequently reduced. To these facts the towns owe their rapid increase in size during the last twenty years. It is perhaps to be regretted that the residential ring which has grown round the old nucleus has made this less habitable than it was before; but the tramway has rendered it *possible* to replace slum dwellings by houses built within reach of the green fields and fresh invigorating air of the country. Unless, therefore, a man be very poor or very improvident, he can live farther away from his work, and is still able to go to and from the office or factory without loss of time or prohibitive expense—at least, that is the ideal towards which municipal effort is steadily being directed.

Incidentally electric traction has encouraged the large retail store to the detriment of the small shop, and many tradesmen complain that they stand idly at their doors while the tram carries customers from the outskirts to the centre of the city. Large scale distribution, however, like large scale production, is more economical than operations conducted on a small scale; and people who can afford the time and the cost of a journey will not deal with their next-door neighbours if they can find a wider selection of goods at a lower price within reasonable distance. Doubtless there are many who would sooner eke out a precarious living as their own masters than serve as subordinates in a modern emporium, and so long as they understand the price which must be paid for independence there is no more to be said. But too often they fail to see that waste of money or effort in distribution is as culpable as waste in production; they resent the magnitude of the rates, and are inclined to oppose improvements which aim at the benefit of the community as a whole.

Roads, however, are only one means of conveying goods; and the advantage of water-transport had long been known. Holland was built on the mud of central Europe, brought down by the rivers flowing north and west. Much of the land was kept from the sea by embankments, and the flatness of the country had stimulated the construction of artificial waterways. Like the great canals of ancient times these were merely sea-level cuts, though locks were used to prevent the canals being emptied at the fall of the tide. Canals rising above sea-level by flights of locks, however, were not unknown; the Grand Canal of Languedoc, which connects the Bay of Biscay with the Mediterranean, had been completed in 1684 at a cost—stupendous for those days—of £1,320,000. In England, though the question had been considered, very little had been accomplished before 1760. A locked canal about three miles in length had been constructed near Exeter under an Act obtained in 1539. James Watt had been engaged at various times in surveying for proposed canals in Scotland, and some improvements had been made in the navigation of the Aire and Calder, tributaries of the Yorkshire Ouse. The growth of manufacture in and around Manchester was increasing the importance of Liverpool as a port, and it was in this part of the country that the first great movement arose. The prime mover was the Duke of Bridgewater, who, having travelled much, and having been crossed in love, settled down to develop the mineral resources of his estate. The agent to whom he entrusted the execution of his plans was James Brindley, an uneducated wheelwright, with a positive genius for engineering.

The Duke possessed collieries at Worsley, and the coal was taken to Manchester in panniers, slung across the backs of horses. This laborious method of conveyance satisfied neither the ambitions of his Lordship nor the needs of his customers, so he decided to construct a canal and send the coal to town in boats. The project was attended with difficulties that might well have daunted engineers of greater experience than Brindley, and it had to run the fire of adverse criticism freely expressed. The chief objection arose against the proposal to carry the canal across the valley of the Irwell, but Brindley was confident that it could be done, and Parliament sanctioned the scheme in 1759. The canal was completed, and the result was a reduction in the price of carriage from 3s. 4d. to less than 2s. 6d. a ton.

No sooner was this completed than the Duke conceived the idea of extending his canal to Runcorn, and so obtaining access to the Port of Liverpool. The communication between the two towns was difficult and costly, the carriage per ton being 40s. by road and 12s. by water. To this scheme the most powerful opposition was raised. The Mersey Navigation Company perceived a serious competitor, and the landowners and farmers feared that the banks might give way, with resulting damage to their crops. Vigorous opposition was offered in the House of Commons, but the Bill was passed and a start was made with the construction. The difficulties were very great. The original Bridgwater Canal was 24 miles in length. The expense nearly ruined the Duke, but his own sacrifice in cutting down personal expenses and pledging the receipts of the first section, combined with the genius and indefatigable industry of his engineer, brought the venture to a successful conclusion in 1772. The cost of the whole canal was no less than £220,000; but in spite of the fact that the cost of water-carriage between Liverpool and Manchester was halved, it produced an income of £80,000 a year.

The importance of canals to our growing industries was now fully realised. Josiah Wedgwood, who had secured for Staffordshire pottery a European reputation, joined with others in promoting the Grand Trunk Canal from Runcorn to Birmingham. Extensions were also made which connected up the Trent and the Severn with the Mersey. All these were planned by the same masterly mind, and executed for the most part under its direction. When, a little later, the London and Birmingham Canal was constructed, the four principal ports—London, Liverpool, Bristol, and Hull—were united by navigable waterways. The immediate effect was to reduce the cost of carriage in the area to one-fourth. The charge per ton from Liverpool to Etruria, in the centre of the Potteries, was reduced from 50s. to 13s. 4d.; from Liverpool to Birmingham, from £5 to 30s.; from Liverpool to Wolverhampton, from £5 to 25s. The carriage of wheat for a hundred miles from the fruitful agricultural land to the hungry manufacturing towns fell from 20s. to 5s. a quarter. And the towns grew. The population of Manchester rose from 41,000 in 1774 to 84,000 in 1801, and 187,000 in 1821. In 1760 the Potteries contained 7000 people; in 1785 this had risen to 20,000; while a marked improvement had taken place in the standard of comfort, the habits, and the behaviour of the inhabitants.

Between 1760 and his death in 1772 Brindley was responsible for more than 350 miles of navigable waterway, and provided the means of transport which enabled the steam-engine to create a revolution in industrial methods. To some the change was and still is regarded with regret. They contrast the grime and the sordid streets of our manufacturing towns with the peaceful beauty of the country-side. They point the finger of scorn at the material triumphs of the age and speak slightingly of a "progress" which is merely "process," and which fails to remove the evils of which they complain.

But it is easy to idealise the conditions of life that prevailed before the industrial revolution. The coarser elements in the picture fade with lapse of time, and only the peace and contentment of a less strenuous existence remain. And these changes saved us in all probability from a fate still less to be desired even by those who lament most the materialism and hustle of their own time. For the growth in our manufactures enabled us to meet the cost of such a political error as the American War of Independence and of the Napoleonic Wars. When nearly every country in Europe was laid waste with fire and sword, our inventors, owing to our insular position, were busy, and our workmen were actively employed in establishing that commercial supremacy upon which the National Credit was based.

With the advent of the railway the importance of the canal declined, and during the height of the railway boom in 1845, 1846, and 1847, many were purchased by the new companies. The effect of the competition is shown by the fact that though between 1838 and 1848 the tonnage increased the receipts fell off enormously. A number of them fell into disuse, and upon many others the sum spent upon maintenance and repair was reduced to a minimum. Meantime, in other countries, the process of canal-building has gone on, and great benefits have been reaped by the facilities for cheap transport thus provided. A strong feeling that the British Canal system ought to be resuscitated and placed on a firm financial basis arose about the close of the nineteenth century, and in 1905 a Royal Commission on Canals and Waterways was appointed. The final Report, issued in 1910, though containing certain specific recommendations, was inconclusive.

2. *Railways*

From what has been said of the character of the roadways in the eighteenth century, it will readily be understood that, in the absence of canals, the difficulty of conveying coal and iron ore from the pit mouth was considerable. Though panniers slung across the backs of horses formed the easiest mode of transport, the amount of material which could be conveyed in this way was so small that in the iron-working districts wagons were more frequently used. To facilitate motion, wooden rails are said to have been let into the ground as early as 1630, and this method appears to have been extensively practised in 1676. One hundred years later Arthur Young noticed, during his "Six Months' Tour," that the tram-roads had also been rendered easier by levelling the ground upon which they were laid. From 1767 onward, however, they were gradually replaced by rails of cast-iron.

The success of Watt's engine naturally turned men's minds to the idea of applying it to the propulsion of carriages, and between 1770 and 1812 many experiments were made with that object. With the exception of Murdoch's model, which ran away from its inventor one dark night and nearly frightened the vicar of Redruth to death, none of those intended for use on ordinary roads were really successful. In the case of those intended for use on tramways the unevenness of the lines and mechanical defects in the engines prevented their adoption.

The first really successful step was taken, as every one knows, by George Stephenson, the self-educated engineman at Killingworth Colliery. He had already invented a safety-lamp for miners, and had introduced great improvements in conveying the coal from the face of the seam to the pit bottom; and he had studied with interest and insight such examples of the use of steam as had come to his notice. The conviction grew upon him that success was possible, and in 1812 he obtained the consent of the owners of the colliery to make the attempt. The engine did not give satisfaction at first, but on directing the exhaust steam into the chimney to improve the draught it hauled eight wagons containing thirty tons of coal at a speed of eight miles an hour up an incline of 1 in 450. Careful calculations, however, showed that the cost of a year's working was practically equal to that of horse haulage. In 1815 and 1816 further improvements of such a satisfactory character were made that some of the engines built in the latter year were still at work in 1857. The mining districts were not at that time the resort of men of influence, and the Killingworth experiment enjoyed but a small measure of fame. It resulted, however, in Stephenson being appointed engineer of the Helton Colliery tramway, on which he used locomotives along the levels, the inclines being overcome by rope haulage.

When the Act to construct a tramway between Stockton and Darlington was passed in 1821, Stephenson applied for the position of engineer, and ultimately converted the directors so far as to permit of steam traction being given a trial. The opening ceremony on 27th September 1825 was a great success. An engine constructed by Stephenson, and called "The Locomotion," hauled a train consisting of six wagons loaded with coal and flour, a coach containing the directors and their friends, twenty-one wagons with seats for passengers, and six more wagon-loads of coal, at a speed of twelve miles an hour.

The importance of this result is somewhat overshadowed by the construction of the Manchester and Liverpool Railway immediately afterwards. Since the opening of the Bridgwater Canal in 1772, the trade of these towns had grown so enormously that the available forms of transport by land and water were utterly inadequate. The quays were piled high with merchandise, the canal was full of traffic, and transport by road was so slow and expensive that the proposal to construct a railway received a large measure of support. But the opposition was no less active and vigorous. The Canal Company was up in arms in defence of its monopoly, and the proposal to use steam called up all the reactionary elements in the country-side. The landowners and the clergy denounced the scheme from platform and pulpit, the farmers threatened personal violence, and writers in the magazines assailed the promoters with ridicule. Compared with this storm the difficulties of the earlier canal-builders were as nothing. It was practically the first of a long series of conflicts in which ignorance and prejudice have combined with personal greed in attempts to rob the people of the fruits of material progress. For, in many cases, the most violent opponents had their price. The result of the struggles has been to retard progress, to make it more costly, but not to prevent it.

The first Bill for the construction of the Manchester and Liverpool Railway was rejected, a new survey was made, the new Bill passed the House of Commons by 88 to 41, and was opposed in the House of Lords only by Lord Derby and his relative, the Earl of Wilton. The difficulties which remained were those which Stephenson could face. Nature had no terrors for him. She could oppose his progress, but not by legal quibble; and he boldly proceeded to carry out his intention of constructing the railway across Chat Moss, the formidable bog which, it had been predicted, would swallow up his rails as fast as he laid them down. How he overcame the obstacles in his path cannot be described here, nor can his struggle to secure the final adoption of steam as the motive power. Suffice it to say that when the line was opened in 1830 the critics were silenced, though the ceremony was marred by an accident to Mr. Huskisson, M.P., who was knocked down, and died the same day.

The Railway, with its steam locomotive, had come to stay. The whole of the English lines, except the Great Central, were started between 1833 and 1862, the Midland (1844), the North-Eastern (1854), and the Great Eastern (1862) being formed by the amalgamation of small competing lines. The Scottish lines were later, being constructed between 1844 and 1863, while Ireland made little progress until after 1850. Stephenson or his son Robert was engineer for most of the early ones, but the Great Western was constructed by Brunel, who with characteristic originality employed a 7-foot gauge. Few, besides Stephenson, seem to have realised the probability of interpenetration of railway traffic, and at a later date the whole of Brunel's line had, unfortunately, to be converted to the original gauge of 4 feet 8½ inches. The new method of transport, by which the time occupied in the conveyance of goods was reduced from days to hours, created for itself an enormous business, far greater than anything within the capacity of the canal system. In 1836 the dividends were 10 per cent to 15 per cent, and a vast number of wild-cat schemes was proposed. For some years the railway boom increased, and reached a maximum in 1845, by which time nearly 2500 miles of track had been constructed. Curiously, the commercial success was largely due to passenger traffic, to the astonishment of those who had believed that the carriage of goods would be the chief business. In 1842 an Act was passed requiring the companies to run an adequate number of trains at a reasonable speed, and to provide covered accommodation for passengers at a penny a mile. This is the origin of the term "parliamentary train," which is only preserved now by the word "Parly" which is printed on third-class tickets.

Before 1840 the traffic was controlled by a cumbrous method of semaphore signalling, varied by the use of coloured lamps at night. In 1839 the Great Western installed the newly invented electric telegraph between Paddington and West Drayton, extending it to Slough in 1843. Public attention was directed to its value in 1845, when a man who had committed a murder at Slough, and escaped by train, found the police waiting for him when he reached Paddington. From that year telegraphy was universally adopted on railways, and enormously increased the speed and safety of travelling. A system of signals was invented by Charles Gregory in 1846, and much improved ten years later by John Shaxby. Since then the main improvements in signalling have been the use of compressed air or electricity to relieve the man in the box of the heavy labour in pulling over the levers, and the telephone for communication from box to box or station.

Parliamentary control of railways has been exercised in two directions—on the one hand to secure the safety of the travelling public and of those engaged in working the traffic, and on the other hand to prevent extortionate freight charges. The provision of adequate passenger facilities at a reasonable price was secured by the Act of 1842, to which reference has already been made. This Act also required a line to be inspected by a Government official before it was opened; but once it has been passed, the responsibility rests upon the company. The provisions as to safety were extended to additional lines, extensions, or deviations by the Regulation of Railways Act of 1871, which also required all accidents to be notified, and empowered the Board of Trade to hold inquiries into their cause. The Act of 1883 made it obligatory upon all railways to adopt the "block" system of working, by which two trains are not allowed to be on the same section of line at the same time; to arrange for the "interlocking" of signals and points, whereby the points must correspond with the signal; and to provide automatic continuous brakes.

The first step towards regulation of the hours of labour was taken in the Act of 1893. It empowered the Board of Trade to hold inquiries into the hours of duty of railway servants, and to make proposals for such alterations as seemed to the Board to be desirable. The penalty was a maximum fine of £100 for each day the company were in default. An Act strengthening the law with regard to notification of accidents had been passed in 1884, and in 1899 a Royal Commission was appointed to secure further evidence. The following year the Railway Employment (Prevention of Accidents) Act was passed. It gave the Board of Trade power to make rules, and the companies the right of appeal to the Railway Commissioners, who will be referred to again shortly. Conviction for a breach of the rules carried a maximum penalty of £10 a day or £50 in all. Railway companies also fall under the Accidents Compensation Act of 1846, the Employer's Liability Act of 1880, and the Workmen's Compensation Act of 1897. These form additional incentives to take precautions against accidents which involve both passengers and railway servants.

State regulation of railway charges has always been a difficult problem. Railways are peculiar in that they do not depend upon free competition. A line cannot carry goods from any origin to any destination, because they run between fixed points. The frequent necessity for goods to pass over two or more lines has led to many agreements or pools, and to the establishment of railway clearing-houses, where adjustments between the companies are made. The actual cost of carriage to a railway company is composed of two items—movement expense and terminal expense. The former is relatively small, and, indeed, half the expenditure of a railway is on maintenance. So that, while a mileage rate was adopted for passenger traffic, goods rates are exceedingly complicated. Short-distance rates were relatively higher than long-distance ones, because the terminal expenses are the same in each case, and small parcels are relatively more expensive than large ones, because the cost of handling is proportionately greater. These facts led to scales of charges for different classes of goods, according to the quantities usually despatched by rail, and, in some cases, to the danger involved in their carriage.

The problem of fixing fair and reasonable rates became important as soon as railways were well established, and a certain amount of competition ensued. Parliament intervened in 1854 by passing a Railway and Canal Act, which prohibited preferences either in the nature of facilities or in special rates. Disputes which arose involved a considerable amount of technical detail, and were hardly suitable for argument in a court of law; so in 1873 a Regulation of

Railways Act provided for a Commission to deal with such matters. A permanent Railway Commission was established by the Railway and Canal Traffic Act of 1883, with legal power to adjudicate upon questions arising between company and company or customer and company. It represents a very important principle in the assertion of State authority over railway charges, but has not had a very important effect upon them. Nevertheless it is a tribunal before which appeals against railway rates are heard, and to that extent is a safeguard against the evils of monopoly.

The United Kingdom had in 1910 more than 24,000 miles of railway, with 23,000 locomotives, 52,000 passenger carriages, 754,000 wagons belonging to the companies, and 650,000 belonging to private owners. The trains run 423,000,000 miles annually, carry 1,278,000,000 passengers holding day tickets, and have an income from passenger fares of £42,000,000. The 492,000,000 tons of goods produce a revenue of £58,000,000, and a further £10,000,000 is derived from docks, canals, steamboats, and hotels ![1] All that vast network of lines originated in the efforts of a poor man who learnt to write his own name only at nineteen years of age. His opponents were invariably those who ranked in their own time as educated men. Landowners, clergymen, barristers, politicians, who were or ought to have been intelligently concerned with the good government of the country, looked within the circle of their own knowledge, and finding there no confirmation of his views, called him ignorant and insane.

It is amusing now to read of the pious horror with which certain towns in England petitioned Parliament to keep the railway outside their boundaries, and how they afterwards regretted the mistake they had made. For wherever

[1] Prothero, *Railways of the World.*

the railway went prosperity followed, and with prosperity came relief from the strain of impending want. By facilitating travel it widened the mental horizon of the people, gave a great impetus to the movement for political freedom, and cemented yet more firmly the bonds of national unity. It rendered possible the penny post, and aided the distribution of newspapers. It was democratic force of the first magnitude.

But it is also in the wider sense a great political force. The total length of line in the world to-day is nearly 620,000 miles. Europe alone claims more than 200,000 miles, North America 62,000 miles, Asia 60,000 miles, South America 32,000 miles, Africa 20,000 miles, and Australia 18,000 miles. The steel road in America supplied this country for many years with cattle and corn, and it has enabled Canada, South Africa, Australia, and New Zealand to develop those natural resources which render them such valuable components of the Empire to-day. In India it has facilitated the distribution of food in time of famine, and has been no small factor in creating that patriotic devotion which is so important and striking an element in the War now raging throughout the world. The Dark Continent, known before the railway merely as a coastline, is being opened up and robbed of some of its terrors. To-day a line runs through a country where the native name of the capital meant "Kill-them-all," the name of the chief street "Never-dry-of-blood," and where human sacrifices were always in progress.[1]

In the Federated Malay States the railway again has been a powerful influence in the replacement of piracy and murder by industry and peace. There is, in fact, no more effective method of establishing order and good government

[1] Prothero, *Railways of the World.*

among warlike and primitive peoples than by the development among them of productive occupations. The construction of railways was the first step taken by Lord Kitchener in the subjection of the Soudan, and now that the primary military necessity has disappeared, they are serving their purpose in encouraging the arts of peace.

Railways spread first and most rapidly in those countries which possessed an ample supply of coal. In Russia and the United States—especially on the Southern Pacific Railway—the locomotives burn liquid fuel. In places where neither coal nor oil are to be found, and where the cost of carriage would materially raise the price of either, as in some of the Central American States, wood-burning locomotives are employed. But in all these cases the railway is assisting in the exhaustion of those precious stores of fuel, about which we have spoken in a previous chapter.

Manufactures depend not only on the cheapness of power to drive the machinery, but also on the cheapness of the motive power of transport. The coal bill of our railways is enormous, and was estimated to amount in 1903 to £6,000,000. That the necessity of economy is recognised by British engineers is indicated by the extraordinarily rapid spread of superheating during the last fifteen years. The steam passes through flues on its way to the cylinder, the higher temperature causes it to expand, so that more work is done per pound of steam than would be done were it taken directly from the boiler. Another economy consists in the employment of compound engines, which are widely used on the Continent and in the United States; but, as Mr. George Hughes of the Lancashire and Yorkshire Railway has shown, the extra cost of construction and maintenance is only worth while when the price of coal reaches 12s. a ton. There is, however, another method of saving coal. In suburban traffic steam is being rapidly replaced by electric traction, for which the power is produced in engines much more economical than locomotives. At present electric traction is confined to relatively short lines with a quick service and frequent stoppages; but there are signs of its extension to main-line traffic. It is used in all the Alpine tunnels, it is spreading rapidly in Northern Italy and on the Swedish State Railways, and it is making headway in the United States. The scientific problems are being solved, and the solutions tested. The time is coming when it will be necessary to consider the relative cost of conveying coal in trucks, or electricity along wires. The fact that railways in this country run over or near to coal-fields has prevented hitherto the alternative method from receiving the attention it deserves. But to economise coal in manufactures and to waste it on transport is absurd.

3. *Ships and Shipping*

The growth of manufacture and of oceanic trade at an early date revealed the inadequacy of means for guiding and protecting shipping. Lighthouses had been a necessity to navigation since the Phœnicians skirted the coasts of the Mediterranean Sea, and one of the most ancient was on the Island of Pharos, the site of the modern town of Alexandria. In this fact lies the origin of the term Pharos, which was given by the Romans to the lighthouses which they built on the Italian headlands, on the heights above Boulogne, and on the cliffs of Dover. At odd times during the next six hundred years, and by various people, beacons were erected and maintained with more or less regularity. Timber was the fuel generally used, but this gave way to pitch, and soon afterwards to coal.

The first systematic attempt to organise the lighting of the coast was probably made by Henry VIII., who established for this purpose the institution known as Trinity House in 1515. This body did not, however, interpret its functions in a very practical spirit. "The brethren prayed for the mariners at sea, but they did not erect lighthouses." As time went on their duties were more clearly defined. They had to appoint pilots for the Thames, collect dues for ballast, and erect lights and signals. But they confined their attention mainly to the navigation of the river, and gave concessions for lighting the coast to private individuals, who had to be bought out subsequently at an enormous cost to the nation. From the middle of the eighteenth century much attention was paid to the safety of the ships and men upon whom the national industries were beginning so largely to depend; and the leading engineers of the period were engaged at one time or another in erecting lighthouses at dangerous points of the coast, or at the entrance to the principal harbours. One of the most important was on the Eddystone Rock, fourteen miles south-west of Plymouth, and in a direct line from the Lizard to Start Point. There a ridge of rock rises up from the sea bottom, right in the track of coasting steamers. At high tide it is submerged, but at low tide a small portion rises above the level of the waters. A wooden structure had been raised by Winstanley between 1696 and 1700, but it was washed away in 1703. Between 1706 and 1709 Rudyard put up another wooden tower, which for nearly fifty years withstood the fury of the south-westerly gales. But it was destroyed by fire in 1755, and in the following year John Smeaton put up the stone pillar which brought joy to the anxious hearts of mariners for more than one hundred years.

Another famous lighthouse was on the Bell Rock, erected by John Rennie in 1809. It was said to have been protected by a bell buoy, and is known in song and story as the place where

> Sir Ralph the Rover tore his hair,
> And cursed himself in his despair,

at finding his ship driven upon the rock from which he had removed the warning bell. Throughout the next sixty or seventy years new lighthouses were erected and old ones repaired, so that an observer at any point on our coasts can see at least one light twinkling with hope across the sea. The writer was able, some years ago, to pick up seven lights from the high ground lying between Penzance and Cape Cornwall, where some of the most dangerous coastline round the British Isles is to be found.

A far more extensive work was the construction of docks and harbours. The latter are, of course, sheltered stretches of water in which vessels may ride out a storm or remain in safety at the beginning or end of a voyage. The former are enclosed areas of water bounded by quays, usually provided with the means of storing or of transferring goods to or from the vessels in port. During the last hundred years all the old harbours have been enlarged or improved and many new ones constructed. One of the earliest works was the Breakwater at Plymouth, a huge wall two-thirds of a mile long, stretching across the bay. It was commenced by John Rennie in 1811 and completed in 1848, after he had been dead for several years. No less than 3,670,444 tons of rubble and 29,149 cubic yards of masonry enter into its construction. Behind its massive proportions the largest ships can anchor in safety, without having to negotiate the narrow entrance to the Hamoaze or the Catwater.

To this period belong the Harbours of Refuge at Peterhead, and other places on the exposed coast of the northern portion of the Kingdom; and the Docks at London, Liverpool, Hull, Bristol, Cardiff, Sunderland, Newcastle, Glasgow, and Manchester—of which more anon. A little over a hundred years ago the Clyde would only permit of the entry of small fishing vessels, while to-day some of the largest vessels in the world have been constructed in the busy shipyards along its banks. In some places the bed of this river has been blasted out of the solid rock. Along the eastern bank of the Mersey there are ten miles of the finest and most perfectly-equipped docks in the world, and smaller, but still excellent accommodation on the opposite side. Bristol, after struggling for many years against its distance from the sea, has established enormous docks at Avonmouth. Southampton has also within recent years increased its dock accommodation, so that it can deal with the huge vessels employed in the Atlantic trade.

In 1701 England's merchant shipping consisted of fewer than 3300 vessels, amounting to about 260,000 tons; many of these ships were armed, and carried among them more than 5500 guns. The largest port was London, with about 560 ships and a tonnage of more than 84,000; Bristol was second, with about 160, of less than 20,000 tons; and Liverpool was then seventh, with about 100 ships. Before the end of the century British shipowners had in their possession nearly 13,000 vessels, totalling nearly 1,400,000 tons. During the American and French wars shipbuilding became a greater necessity, as the country depended upon outside sources for an increasing proportion of its corn. Great losses were incurred through foreign privateers, and 1000 vessels were commandeered by the Government for the transport of men and materials. But the French sea-power was broken by Nelson's victories off Cape St. Vincent and Trafalgar, so that when Napoleon closed continental ports to British shipping he only succeeded in isolating Western Europe, and in conferring upon Britain a monopoly where she had hitherto enjoyed no more than a considerable share.

Before this time the art of Navigation had been revolutionised by the achievement of one of those inventive geniuses who flourished in the eighteenth century. The only means at the disposal of the mariner for determining his position were the compass, the log, and the sextant. The compass indicated the direction in which the ship was travelling, the log gave an idea of the speed, and the sextant enabled the latitude to be measured approximately. The great problem which faced the navigator was to find the longitude. When Spain had command of the seas, Philip III. offered 100,000 crowns for a satisfactory method; and when the Dutch succeeded the Spaniards, Holland offered 30,000 florins with the same object. Again, when Charles II. founded Greenwich Observatory, Flamsteed, the Astronomer-Royal, was directed to search for an astronomical method, and where he failed Halley and Newton failed also. In 1714 a petition was presented to Parliament by a number of naval captains, merchants, and master-mariners, who laid stress upon the importance of the problem, and prayed that the Government would encourage attempts to find a solution. An inquiry was held, and in his report Newton stated that the whole difficulty lay in constructing a clock which would keep time under the conditions that obtained at sea. By an Act passed in the same year a sum of £10,000 was offered for an instrument which would enable the position to be determined within sixty miles, £15,000 for one which would give the result correct to within forty miles, and £20,000 for one which was correct within thirty miles; and a Board of Longitude was established to examine any instrument submitted.

The problem attracted the attention of John Harrison, a carpenter who had made clocks his hobby. He was born in 1693, and by the time he was twenty had constructed several instruments which were improvements upon those of his day. It was apparent to him that as the time of swing of the pendulum, by which the rate of the clock is regulated, depends upon the length, this must be kept constant whatever the variations of temperature; and he invented the "gridiron" pendulum, constructed of iron and brass rods of such a length and so arranged that the expansion or contraction of one compensated the expansion or contraction of the other. Of two instruments made on this plan before 1726, one varied less than a minute in ten years. This was the greatest step towards an accurate time-keeper since Galileo's application of the pendulum two hundred and fifty years before.

For the purpose of a marine chronometer the ordinary or gridiron pendulum was unsuitable, but Harrison applied the same principle of compensation to a balance-wheel. The first instrument was completed in 1735, and tested on the *Centurion* and the *Oxford* in the following year. The captain of the latter ship was ninety miles out of his reckoning from the log, while the chronometer gave an accurate reading. The Board of Longitude granted the inventor £500 in two equal sums for further experiments, a similar amount on the completion of a second and improved instrument in 1739, and a similar amount for the third instrument in 1758. In 1761 a fourth chronometer little larger than a watch was made, and tested on the

Deptford in a voyage to the West Indies. The log reckoning was found to be 3° or 180 nautical miles out, and the chronometer only 18 miles. The problem had been solved with far more accuracy than had ever been hoped for, but delay in awarding the prize ensued. The £20,000 had been earned, but only £2500 had been awarded. Petitions were presented in vain; scientific authorities acknowledged freely the value of the invention; but the Board of Longitude would not sign the certificate. Not until 1776, when the inventor was eighty years of age, was the balance of the money paid—forty years after the original conditions had been fulfilled.

In view of the importance of shipping in the development of the British Empire, it is a little curious that the nature and influence of the marine chronometer should be so little known. How essential it is to navigation will be apparent from the figures which have been quoted, and it is obvious that the regularity of modern steamship services is dependent upon the instrument which was invented only 180 years ago. It was conceived in poverty, and developed to a high degree of perfection at great personal sacrifice. At no time did John Harrison earn more than a bare living at his trade. On no occasion did he miss an opportunity of learning what had been done by others. He had to make many of his tools, and both his studies and his experiments were carried on in such time as he could spare from the work by which he maintained himself and his family.

The ships of the eighteenth century were sailing vessels, dependent upon wind and weather, and taking months to accomplish a voyage which is now performed in days. When the steam-engine had proved its value on land, attempts were made to adapt it to the propulsion of ships.

In 1802 the *Comet*, a small passenger steamer, made its appearance on the Clyde; a few years later Robert Fulton launched the *Clermont* on the waters of the Hudson; in 1819 a sailing vessel, aided by steam, made the voyage from America to England; and in 1825 a vessel similarly equipped made the voyage from England to India. But the first real steamer to cross the Atlantic was the Canadian vessel *Royal William*, which in 1833 reached London from Quebec in seventeen days. Five years later the *Great Western* did the journey to New York in eighteen, and the *Sirius* in fifteen days. The former ship inaugurated regular sailings, starting from Bristol.

The Atlantic steamship services really date, however, from the founding of the Cunard Company in 1840. Their first four vessels were the *Britannia*, *Arcadia*, *Columbia*, and *Caledonia*, each of about 1150 tons, with engines of 740 horse-power and an average speed of 8½ knots. Two more vessels of similar size but higher speed were launched in 1843; four of 1825 tons, 2000 horse-power, and 10¼ knots in 1848; two of 2226 tons, 2400 horse-power, and 12½ knots in 1850; and one—the *Arabia*—of 2400 tons, 3250 horse-power, and 13 knots in 1852. All these were wooden vessels propelled by paddles.

A new era in steam navigation was marked in 1845 by the *Great Britain*, which was constructed of iron and driven by a screw propeller. She had a gross tonnage of about 3000, and made the voyage to New York in fourteen days. The substitution of iron for wood increased the carrying capacity. A wooden ship will take approximately its own weight of cargo, and an iron ship twice its weight. Moreover, iron ships can be made longer. The strength of a wooden ship is in the ribs; of an iron ship, in the backbone. And as a ship can be increased considerably in length without increasing in the same proportion the power required for its propulsion, the use of iron enabled longer ships to be built, and reduced the cost of ocean carriage.

The most famous vessel of the nineteenth century was the *Great Eastern*, built by Brunel in 1858. She was of iron, 692 feet long, 83 feet beam, 60 feet deep, and had a tonnage of 24,000. The paddles used for propulsion were 24 feet in diameter, and were supplemented by a screw propeller also 24 feet in diameter. The horse-power of the engines was 8000, and accommodation was provided for 4000 passengers. After incurring a series of misfortunes the owners found themselves in financial difficulties, and though she had cost half a million, they sold her for £25,000. She was subsequently employed for many years in cable-laying; in January 1865 she set out with 2600 miles of cable coiled in tanks and weighing nearly 5000 tons, and laid the first cable between England and America.

This huge vessel indicates the extraordinary progress which had been made in heavy iron-work—a progress due in no small measure to the demand for this material in bridges. The iron plates used in forming the "skin" were 10 ft. long and 2 ft. 9 in. wide—no mean size, though the steel plates of the *Olympic*, built in 1910, were 30 ft. long and 6 ft. wide. It is nearly 130 years since Cort devised the process by which these plates of the *Great Eastern* were fashioned, and the standard reached sixty years ago was no mean development beyond the trivial work that was possible before his time.

But a new material was soon to be placed at the disposal of the shipbuilder. The inventions of Bessemer and Siemens were flooding the world with cheap steel, and since 1874 this has completely replaced iron in marine construction. Its greater strength reduces the weight of the hull, and effects a reduction in the cost of carriage beyond that resulting from the replacement of wood by iron. Moreover, increased trade and improved docks and harbours have enabled the size to be increased to an extent that, but for the *Great Eastern*, would hardly have been thought possible. In 1860, 4000 tons was the maximum; in 1915 we have the *Aquitania* of 47,000 tons, and the *Britannic* of 50,000 tons. These are, however, mainly passenger boats, engaged in the Atlantic trade; vessels sailing to the colonies and foreign lands rarely exceed 20,000 tons, and the average cargo boat stops short of 6000 tons, mainly owing to the difficulty of breaking cargo.

There is a similar difference in speed. The average cargo boat is content with 10-12 knots; the vessels engaged in carrying meat and other perishable materials make 15 knots; good passenger ships make from 18 to 21 knots; and the *Mauritania* with its 26 knots stands at the head of the world's mercantile marine. The greatest economy of fuel is secured at rather slow speeds—say 10 to 15 knots. Beyond this, an increase of speed requires more than a corresponding increase of power. Thus the fast liner which has just been mentioned has engines of 70,000 horse-power and consumes 1000 tons of coal every twenty-four hours. There is a point at which it is cheaper to feed the passengers and crew than to feed the fiery furnaces upon which the ship depends for its speed.

It will be remembered that shipping was protected in the eighteenth century by Navigation Acts, which required goods entering or leaving British ports to be carried in ships of the same nationality. But the practical monopoly of oceanic trade which was secured during the French war, rendered protection unnecessary. The first legislative changes inspired by Free Trade doctrines were modifications of the Navigation Acts, and as tentative experiments proved the wisdom of removing restrictions, these were gradually reduced until the final repeal of the Acts in 1849. In 1854 even the coasting trade was thrown open. Privateering, which had hitherto necessitated the carrying of guns on merchant vessels, was abolished by the Treaty of Paris in 1856, and from that time the difference between ships of war and peaceful traders became more and more marked. The chief reasons for the progress of British shipping during the middle of the nineteenth century were freedom from restrictions and the use which we made of coal and iron. Continental countries and America were still far in arrears, and their wooden ships were out-distanced and out-classed. Again, when the Suez Canal was opened in 1869 the eastern trade was revolutionised, and, in spite of the advantage to Mediterranean ports, Britain became still more the centre of the world's markets. This great engineering work introduced also a new factor in foreign policy by creating an interest in the Near East which had to be protected by a Mediterranean Squadron. And it is important to note that oceanic trade is the key to a foreign policy which would bewilder one not in the secret. For it was Napoleon who first taught the Government of this country the importance of sea-power, and the lesson has never been forgotten. The maintenance of adequate protection for the mercantile marine has been a guiding principle of British statesmen for a hundred years.

Just as the State intervened to protect factory workers and railway servants from unnecessary danger, so also it has exercised control over the conditions of life and labour at sea. The first step was taken when Samuel Plimsoll, member for Derby, secured the appointment of a Royal

Commission to enquire into allegations as to the unseaworthiness of ships. Shipowners are neither better nor worse than other men, and there was grave suspicion that some of them, in reckless pursuit of gain, were endangering the lives of the men who manned their vessels. In 1876 a Merchant Shipping Act required every vessel to be marked with a load-line indicating the maximum depth to which it might be loaded, and making it a penal offence to send an unseaworthy ship to sea. The next important Act was that of 1894 which contained, in addition to regulations as to loading, the requirement that masters, mates, and engineers were to hold certificates awarded by the Board of Trade. Moreover, in the case of all boats of more than eighty tons, the crews were to be engaged under an agreement in a form approved by the same Government Department, and a lower limit was placed on the number of the crew to prevent undermanning. It is worthy of note that shipping and mining are the only industrial occupations in which men in positions of responsibility are required to hold certificates of competency. The third stage in protection of life at sea was reached in 1906 by an Act which applied the British regulations to foreign ships within any British port. On those points there is now practically international agreement. An International Convention for the Safety of Life at Sea was signed in London in January 1912, and came into force on July 1st, 1915. The Act of 1906 also dealt with the provision of life-saving appliances, and required every ship to carry a certificated cook, thus contributing greatly to the health and comfort of men who must inevitably face no little danger, and endure hardships from which the landsman is free.

State regulation for securing safety is reinforced strongly by the system of marine insurance and classification. The insurance rates are invariably heavy, but are lowest for a vessel of the best construction. The rules of Lloyd's Register are especially severe, and the financial saving on a vessel which is classed A1 by this body encourages a high degree of excellence in design, construction, and equipment.

Before leaving protective legislation it is desirable to note that the Factory and Workshops Act of 1901 was applied to docks, wharves, and quays in 1904 by special regulations issued by the Board of Trade, and to repairs in shipyards in 1914. A ship in dry dock is now a factory within the meaning of the Act, but a ship in wet dock is not, and advantage is sometimes taken of this fact to elude the restrictions as to the hours of labour of young people on land. If a youth under eighteen years of age is sent on to a floating ship to effect repairs he passes out of jurisdiction of the Factory Inspector. The Workmen's Compensation Act of 1906 and the National Insurance Act of 1911 apply to the shipping as to all other industries.

For a hundred years British shipping has brought corn to feed the men engaged in British workshops, factories, and mines. From 1850 until 1890 our vessels brought live cattle to supplement the home supply of nourishing meat. Since 1880 steamers fitted with refrigerating apparatus have crossed the ocean laden with carcases of beef and lamb without which the workers must have lived more simply or emigrated. The dairy produce of Holland, Denmark, and the western provinces of Canada has added to the variety of food which is necessary for robust health and efficiency. The colonists, the farmers of the United States, the Argentine, and Southern Russia have found a market for their surplus foodstuffs, and obtained in exchange those manufactured goods which add to comfort or serve as weapons in their eternal conflict with nature.

When oil was found in large quantities in America in 1860 it was transported in barrels from the wells to the coast and across the ocean. A quarrel over the charges for haulage and carriage led the well-owners to make themselves independent of the Railway Companies by laying pipe-lines from the oil-yielding states to the Atlantic seaboard. Here it is pumped into tank-steamers specially constructed for the trade, and at the end of their journey it is pumped from them into tanks on wheels or railway trucks for distribution to the consumer. Until the last dozen years oil was the poor man's light, and the saving in cost effected by its transmission and distribution in bulk is a boon which, like many other boons of applied science, is hardly realised by the small consumer.

The importance of oil as a source of light has gradually been replaced by its importance as a source of power, but the growth of the internal combustion-engine during the last twenty years has created a demand far outweighing that of previous years, and some 300 oil-tank steamers are now engaged in conveying oil from America alone. The oil-carrying trade of the world is almost entirely in British bottoms. Freights have been forced up sevenfold, and yet the precious liquid has found a sale. The demand is for oil, and it can only be satisfied by the construction of ships and yet more ships.

Three or four hundred years ago we were unable to build ships, and were dependent upon foreign workmen. One hundred and fifty years ago we had no monopoly of shipbuilding experience or engineering skill. To-day we make ships for the world; and this fact has enabled us to develop trade and communications which keep alive the ties of kinship with those who have settled in the new lands beyond the seas. How much we are indebted to the Navy and Mercantile Marine for the unity of the Empire and the safety of the Motherland has been made apparent by the War. But the obligation goes deeper, and spreads more widely than appears at first sight. There is a tendency to regard the results of scientific discovery and mechanical skill as heaven-sent gifts, and to extol the merits of the men who use them to the neglect of the men who made them. In reality maker and user are linked by indissoluble ties of brotherhood, complementary in the fullest sense of the word, because neither can achieve his full purpose without the co-operation of the other.

It is well to remember that food and much of the new material of manufacture is brought to our shores by sea. The magnets that draw raw material from the places where they are won are the factories and workshops, the chemists and engineers, the experienced workmen, and the stores of fuel. In the last analysis, manufactures which are the subject of trade, shipbuilding which is the means of trade, and the ability to maintain a navy and a mercantile marine, depend upon fuel; for if this also had to be imported the cost of manufacture would be so largely increased that trade would dwindle to insignificant proportions. It behoves us, therefore, to husband our resources, and to exercise an intelligent economy in the utilisation of those gifts of nature upon which so much of our greatness depends. A great tradition implies responsibilities of corresponding magnitude; there is no triumph of literature or art which will compensate an industrial nation for a vigorous youth and healthy manhood, followed by a profligate old age. The reasonable conservation of our natural resources is the least we owe to the millions yet unborn into whose hands will fall the legacy of our works.

4. *The Transmission of Writing and Speech*

Some indication was given in Chapter I. of the commercial and political importance of means of communication. Except that they are more easily carried, letter post on any extensive scale is subject to the same conditions that determine the transport of goods, and the history of the one is also the history of the other—at any rate, so far as regular service is concerned. But the growth of trade, the spread of the railway, and the development of steamship services would have been far slower but for the invention of the electric telegraph in 1837. Moreover, in so far as the evolution of a political democracy depends upon newspapers, it is wholly indebted to the means by which thoughts, opinions, and events are flashed almost instantaneously across land and sea.

We have already referred to the foundations of electrical science which were laid between 1800 and 1832. A few years later it occurred simultaneously to Cooke and Wheatstone in England, and to Morse in America, that this agent might be used for sending messages along a wire according to a prearranged code of signals. Cooke and Wheatstone adopted a suggestion of Ampère, and used magnetic needles which were deflected to right or left by altering the direction of the current at the other end of the line. They used originally a number of needles, but patented a single-needle instrument in 1845. Morse used an electro-magnet and a bar which was attracted or repelled, according to the direction of the current in the coils. As the bar fell it made a sharp tap, and the combination of long or short intervals between the taps represented letters. The needle instrument has gradually passed out of use except on some of the railways, and has been replaced by the Morse "tapper," "sounder," or "key." At first two wires were required between sending and receiving stations, but in 1838 Steinheil discovered accidentally that the earth could be used as a return wire, thus materially reducing the cost of installation.

The telegraph was employed on the Great Western Railway between London and West Drayton in 1839, and in 1843 attracted public attention by facilitating the arrest of a man who had committed a murder at Slough and escaped to London. From this date it spread rapidly for the working of railways, and companies were formed to establish public services. Success on land led to attempts to lay a cable under the sea, and, after one failure, Dover and Calais were connected in 1851, at a cost of £15,000. In 1857, twenty years after the original invention, the first attempt to lay an Atlantic cable was made, but a breakage occurred 380 miles from the Irish coast in two thousand fathoms of water, and only about fifty miles of the cable was recovered. A second attempt in 1858 was also unsuccessful; two ships, the *Agamemnon* and *Maegero*, were employed, starting from the middle of the Atlantic and paying out as they steamed in opposite directions; but three times the cable broke, and when it was finally joined up and laid, it failed after a month's use. In 1865 the *Great Eastern* was employed on the project, and though the cable broke, another one was laid successfully in 1866, while at a later date the cable of 1865 was recovered and used as a second line.

It is impossible to describe the many improvements which have been made in the methods and rapidity of sending and receiving messages. Wheatstone, Morse, and

Hughes invented recording and printing telegraph instruments, and Sir William Thompson invented the mirror galvanometer and the syphon recorder to detect and register the feeble currents which flowed from the Atlantic cable. Without these instruments, and the discovery, about 1844, of the peculiar properties of gutta-percha, submarine telegraphy would have been much later in rendering commercial and political service. Greater capacity was secured by duplex and diplex systems of working, in which two messages can be sent along the same wire in opposite directions, and in the same direction, respectively; and by the multiplex system, which combines the two.

By 1850 the Electric Telegraph Company had some fifteen hundred miles of wire, and the more important towns in the country were in telegraphic communication. The charges were high, five shillings being asked for a short message over a moderate distance, while the minimum charge between London and Edinburgh was twelve shillings. As the magnitude of the system increased, its national importance became obvious. By 1870 the Government bought up all the companies and instituted shilling telegrams, twelve words being allowed for the message, and the address being transmitted free. Sixpenny telegrams were introduced in 1885, and the twelve words allowed included the address. The service has continued to grow in spite of competition from the telephone, which spread rapidly after 1890, and about one hundred million messages are transmitted annually in the United Kingdom.

The electric telegraph created almost as great a change in the methods of business and in political evolution as did the steam-engine. It is the nervous system by which the business man keeps in touch with the world's markets, and the statesman feels the pulse of the people in this and other lands. News is no longer old, but of fresh and compelling interest. Men act to-day because they can act in time. And, if it seems to them that they should co-operate rather than act singly, they can do so because they are within an hour's reach of one another. Every combination for good or evil is facilitated, and defence no less than attack is rendered easier by the rapidity with which it can be organised. Such a powerful weapon in the hands of authority is the greatest guarantee of the safety of the State and the good government of the people. The words of great men in Parliament and the cry of the humble and distressed are flashed across the wires without discrimination. As the printing-press in the fifteenth, and the steam-engine in the eighteenth, so the telegraph in the nineteenth century was a powerful agent in that extension of right and responsibility which goes under the name of Democracy.

An extension of the facility of communication occurred after 1877, in which year Edison and Bell invented the telephone. Progress was slow at first in England, but much quicker in the United States, where the people are readier to avail themselves of novelties. The national importance of telegraphs was so obvious that the Government took control from 1870; but as telephony was limited to relatively short distances, and had at first no special advantage over the earlier method, its development was left to private enterprise. The result was a conflict between competing companies which resulted in the National Telephone Company absorbing the others and establishing the monopoly which had been so much feared. Ultimately the ramifications of the telephone service began to be almost as great as those of the telegraphs, and in 1913 the Government purchased the business of the Company.

Meantime electrical discovery had proceeded apace. In

1888 Hertz had discovered that electric discharges produced wave motion in the surrounding ether, and Branly had devised a more convenient means of detecting them than was employed by the original discoverer. In 1895 Marconi hit upon a means of projecting electric waves to great distances, and came over to this country to push his invention. He was fortunate in securing the good offices of Sir William Preece, the chief engineer to the Post Office, who provided him with facilities for further experiment, and assisted him in obtaining recognition. For five years signals were transmitted under varying conditions over gradually increasing distances, and in the first year of the new century communication with America was established. During that period and throughout the last fifteen years many modifications and improvements have been made in the original apparatus. The present achievements are the result of many arduous investigations carried out by men of high scientific attainments. Hardly any invention, or rather group of inventions, in the history of the world is so truly a product of the research laboratory as in the now familiar "Wireless."

The celerity with which it has been adapted to the needs of oceanic traffic is a tribute to its value. No really important vessel is out of touch with land or with another ship throughout the whole of its voyage. The shipowner can keep in contact with the captain and direct him to any port at which it may be desirable for him to call. And in the annual series of disasters which are the inevitable toll of the sea, wireless telegraphy has been instrumental in bringing aid in cases where the older methods would not have availed. The fact that no connecting wires are required not only enables it to be established with less delay, but renders it of value in districts where the cost of maintenance of an ordinary telegraph line has hitherto been prohibitive. The trackless forests of the Amazon valley, the mountainous and elephant-infested country of Central Africa, offer no impediment to the transmission of wireless signals. Not only is trade encouraged, but the first necessity of civilisation is now a hundred times less difficult than it was twenty years ago. Before the war broke out the Government had made provision for a chain of wireless stations that would encircle the earth and connect up every colony and dependency with the Motherland.

The Marconi system is not the only one by which results of commercial importance have been achieved. The Telefunken, De Forest, Goldschmidt, and others have passed the experimental stage, but have hitherto been unable to show any superiority. Competition between them is leading to no little improvement of detail, and it is probable that in the near future even wireless telephony will come into general use. It has already been found possible to transmit speech over three hundred miles of space, and this is not regarded by any means as the limit. The absence of secrecy in wireless transmission will, however, confine its usefulness within a narrower field than is enjoyed by the invention of Edison and Bell.

CHAPTER IX

BANKING AND THE CREDIT SYSTEM

INDUSTRY and commerce could never have grown as they have done during the last two hundred years without a correspondingly extensive development of Banking and Credit. It matters little whether one is regarded as the cause or the effect of the other, for although Banking was practised before the textile inventions and the steam-engine came into being, the evolution of the Banking business was necessary to, and facilitated the expansion of, industrial operations. In his delightful book, *The Meaning of Money*, Mr. Hartley Withers classifies financial transactions into money here and now, money some day, and money somewhere. The first implies a simple purchase or sale in which cash passes directly from one man to another. The second represents the process of borrowing, in which for an immediate cash advance a promise is made to repay at some future time. The third transaction represents the transference of credit rather than of money. The first requires no special machinery, but the provision of facilities for the second and third, and especially the second, are the functions of a Bank.

In early days payment for services was rendered in kind, and goods were exchanged directly for goods. So long as each man wanted what the other had to spare, mere barter sufficed; but, to quote the oft-repeated story, the hatter who desired meat found a difficulty in coming to terms with a butcher who desired boots, and the practice arose of using coins as a common medium of exchange. It was only after many centuries that gold came to be the standard of value, by reason of convenience and its general acceptability; and at all times it has had to struggle with silver for pride of place. The single-metal standard was finally adopted because of the tendency under a bimetallic system to hoard the more favoured metal, and the difficulty of maintaining a uniform relative value. But even to-day there are distinguished advocates of "bimetallism," which was a subject of keen controversy in the 'eighties.

In the Middle Ages usury and even interest was held in abhorrence, and the chief function of a modern bank could not have been fulfilled. Very considerable variation in the currency of different countries, however, rendered the business of money-changer necessary and profitable in all trading centres; and there is evidence to show that as early as the thirteenth century the money-changers of Venice were becoming bankers in the proper sense of the term. Two banking institutions were established by Acts of the Venetian Senate—one, the Banco di Rialto in 1584, and another, the Banco del Giro in 1619. The practice of these Venetians spread to their brethren of Amsterdam, and later to the Goldsmiths of London, who began to receive deposits during the Civil War. The latter issued notes which were originally receipts, but ultimately became promissory notes, taking the place of cash. The Goldsmiths were not, however, the originators of bank notes, for "paper money" is said to have been in circulation in China in A.D. 800, and the first notes adapted to European requirements were issued by the Bank of Sweden in 1656. Cheque-books did not come into use until 1781.

The first bank to be established in England appears to have been Smith's Bank at Nottingham in 1688, but the pivot of the English financial system is the Bank of England, founded in 1694. Like many of the Continental Banks it originated in a loan to the Crown. The sum of £1,200,000 was subscribed in ten days; a Governor, Deputy-Governor, and Committee were shortly afterwards appointed, and the Bank took over the management of the National Debt, the business of which it manages to this day. It was a Joint-Stock Bank in which the liability of subscribers was limited to the amount of their shares, and it held a monopoly under Acts of 1697 and 1708, which was confirmed by another Act in 1800. No other Joint-Stock Bank was sanctioned in England and Wales until 1826, and the Bank of England was the only English Bank in which the liability was limited until 1862. In 1833 it was granted the privilege of issuing notes which were legal tender everywhere except at the Bank of issue, and by the Bank Act of 1844 it is the *only* source from which legal-tender notes can be obtained.[1] The private banks gradually relinquished the privilege of issuing their own notes.

Until 1826 no partnership of more than six persons could set up the business of Banking within sixty-five miles from London. The sixty-five-mile limit was removed in 1833, but no bank within this radius was permitted to issue notes. The Act of 1862 enlarged the permissible number of partners to ten, but if the bank issued notes the liability was unlimited. Great hardship was liable to result in case of failures, such as those of the Western Bank of Scotland

[1] In the special circumstances created by the War the Government, in 1914, issued Treasury Notes, of the value of £1 and 10s., which were legal tender for any amount.

in 1858 and the City of Glasgow Bank in 1878. The latter disaster was the immediate cause of the Companies Act of 1879, which extended the privilege of limited liability.

At first banks were purely local, but improved means of communication developed internal trade, and many private firms amalgamated, while Joint-Stock Banks began to establish branches. The unique position of the Bank of England, which is the Bankers' bank, led to most provincial banks having agents in London. The City Banks had established a Clearing House, at which settlements as between bank and bank could be made, in 1776, or possibly earlier, and country Clearing Houses were established, mainly by the efforts of Sir John Lubbock, in 1858.

The use of paper money, which is a promise to pay gold on demand to the amount stated, implies a high degree of confidence in the issuing bank. But once this confidence is secured it aids enormously in the manufacture of credit. For suppose a banker to have received a certain amount of gold and to have given notes for it, he can rely upon some time elapsing before the notes are presented, and, in the meantime, he can lend more money in the form of notes to those who can offer security. The notes, being regarded as legal tender, may remain in circulation for a long time, and even when paid in may not be accompanied by a demand for cash. The whole danger lies in the possibility of an unexpected demand for coin which the bank is unable to meet, for the inability would at once cast suspicion upon its solvency and cause its failure. Securities can rarely be realised without loss, especially if the amount be large. Thus disasters were common enough in the early days, before the safe proportion between gold and notes was understood, or where ordinary caution had not been observed. The result was a reduction of the number of banks issuing notes and, ultimately, the Bank Act of 1844. By this Act the maximum value of notes issued by the Bank of England was fixed at £14,000,000, and beyond this sum the Bank must possess gold and silver to the full value of the notes issued. As the country banks gradually gave up the practice of issuing notes, the privileges of the Bank of England were extended, so that the value of the notes now issued against securities is nearly £18,500,000. The minimum amount of gold and silver respectively to be held in reserve was to be in proportion of not less than 4 to 1, but the Bank now relies entirely on a gold backing.

The precautions imposed by the Act of 1844 were very necessary, but had the spirit as well as the letter been strictly observed the enormous development of trade since that date could not have occurred. The increase in the amount of the notes necessary for the expansion of business would have required an enormous deposit of gold. The bank-note, which had become equivalent to cash by faith in the banker's willingness and ability to convert it into gold on demand, now came to be used only for cash transactions, and commercial men adopted the plan of meeting their accounts by drafts on their bankers, payable on demand, generally called cheques. The acceptability of a cheque depended not only on the credit of the banker, but also on the credit of the man who drew it; and though, as we have stated, it came into use about 1781, a long time ensued before it commanded wide recognition as a valid and dependable instrument of exchange. But apart from this element of doubt, the cheque had certain advantages in that it is not so easily converted into gold by a wrongful possessor as the bank-note; it can be made out for the exact amount required, and when it has passed through the bank it constitutes both a record of, and a receipt for, payment.

The Bank Act of 1844 had imposed no restrictions on the then comparatively little used cheque, and the expansion of business was due to the fact that, as payment by cheques became more common, they were less usually converted into gold. Even when a large employer drew out a considerable sum weekly for wages, most of this passed into the hands of local tradesmen during the following week, and was returned by them to the banks from which it came. It was only necessary, therefore, for the banks to keep in hand so much cash as would meet the normal weekly withdrawals, *plus* a balance to meet exceptional circumstances. And as these exceptional circumstances do not, except in a time of crisis, fall on all banks at once, they were able to help one another in all cases where the ultimate financial position of the one in distress was sound.

The cheque is one form of a class of documents known as bills of exchange—the form which is payable to "order" or "bearer" *on dèmand.* But a man may instruct his banker to pay a sum of money to himself or a third party *at some future date*, and this kind of draft is more usually known as a bill. The use of such an instrument appears to be of considerable antiquity, but it has been closely associated with the expansion of commercial operations during the last sixty years. Its principal purpose is to enable a buyer to defer payment until he has received and sold the goods, or for a seller to receive payment before the goods have been actually delivered. What occurs in a very simple case is illustrated by the following example which is abstracted from one given by Mr. Withers.[1] "Silas P. Watt, farmer, of Dakota, sells his wheat crop for £2000 to John Smith of London, corn dealer; . . . Watt in Dakota draws a bill on Smith of London for £2000 at

[1] *The Meaning of Money*, pp. 43-45.

sixty days' sight . . . and is able to give this bill to his bank or trust company to be realised in payment for the loan on his crop. The bank endorses the bill by signing its name on the back of it, and sends it to its agent in London, together with documents showing that the wheat has been actually shipped and insured against risk on the way, and on its arrival it is accepted by Smith, who writes his signature across the front of it to show that he acknowledges the indebtedness at the due date, and is given possession of the documents." Smith is thus able to secure the wheat when it arrives, and probably sell it and have received payment before the bill falls due. Complication arises from the fact that such a bill is a "negotiable instrument"—that is, bankers and other people who deal in bills will cash it for a charge varying with the sum and the time the bill has to run, or "discount" it. That is, they buy the bill.

The advantage of bills of exchange of this character is that they create credit for financing industry and commerce, and they form an admirable investment for bankers as compared with houses and land, which are far more difficult to convert into cash. Moreover, they obviate the necessity of sending gold backwards from one country to another every time a purchase is made. For when, as Mr. Withers points out, Watt of Dakota desires to purchase agricultural machinery in England, payment is made by a bill passing in the opposite direction. The disadvantage of bills of exchange is that they are not always drawn against moving merchandise, but against houses, land, or even the "name" of the acceptor; they represent in some cases mere speculation, and in others, means of "raising the wind" on doubtful security.

The main results of the changes during the last sixty years are three in number. Firstly, the majority of commercial transactions are now effected not by cash as represented by the sovereign and the bank-note, but by credit as represented by the cheque and the bill. Secondly, credit implies confidence in the ability to pay, and in times of trade depression diminished confidence increases the demand for cash and enhances the difficulty of obtaining it. Thirdly, credit has become international, so that an unfavourable influence in one part of the world is felt at every point of the system. Labour troubles, a shortage of rain in the cotton or wheat-growing areas, or a rumour of war, send a tremor through every banking centre in the world, and the bankers tighten their hold on cash by raising the rate for loans to a greater or less extent as the disturbance affects them. The money market is at once the most gigantic and sensitive of all human organisations, and it owes its magnitude and its delicacy to the electric telegraph, by which time has been annihilated and the wide spaces of the earth have been bridged over.

C. THE EVOLUTION OF INDUSTRIAL MANAGEMENT

CHAPTER X

COMBINATIONS OF CAPITAL

In the Middle Ages practically the only means of acquiring wealth was by force of arms, but with the growth of trade in commodities not absolutely necessary for existence it became profitable to buy and store up things for which there was no immediate sale. Merchants endeavoured, therefore, to obtain a surplus either in money or goods, in order to be able to strike a bargain whenever the opportunity arose, and the tendency to accumulate capital increased during the period of oceanic expansion. Apart from mere trading, however, all industrial operations involve the use of capital in raw material or means of producing it, and in the tools employed in manufacturing processes. But, generally speaking, it was only in the late seventeenth and early eighteenth centuries that capital was employed in large aggregations in industries other than agriculture. And it is obvious that when the introduction of power-driven machinery rendered it more difficult for a man to establish himself in business, the necessary instruments of production tended to pass more and more into the hands of a few, leaving the rest with nothing but their labour to exchange for food and clothing.

The change in industrial methods brought about by the steam-engine led, on the one hand, to alterations of business organisation designed to facilitate the establishment and extension of manufacture and trade, and on the other to a series of conflicts between capitalists and workmen in regard to wages, hours, and other conditions of employment. In this chapter we shall be concerned with the first only of these results.

In the eighteenth century, apart from the Trading Companies to which reference was made in Chapter III., there were only two kinds of business organisation—that owned by a single employer, and that under a partnership. These forms were not only limited in regard to their resources but subject to heavy liabilities in case of failure. Many of the partnerships were what are known as common-law companies—they were not incorporated, but merely large partnerships with transferable shares, and as these changed hands the *personnel* of the company altered without people who dealt with them necessarily knowing anything about it. The tendency for such companies to be formed in pursuit of all sorts of wild-cat objects, born to failure like the famous South Sea Bubble of 1711, led to Parliamentary interference. By the Bubble Act of 1719 they were described as common nuisances, but in spite of the prohibition they continued to flourish.

Finding that the tendency towards the aggregation of capital was too strong to be suppressed, the Legislature began to encourage the formation of Joint-Stock Companies under proper safeguards. The earlier steps were tentative. In 1834 the Crown was empowered to grant by letters-patent the privilege of suing and being sued as a corporate body without becoming incorporated, and ten years later the necessity of securing a charter or obtaining a special

Act of incorporation was abolished except in certain cases. The Companies Act of 1862 prohibited all associations of more than twenty persons from carrying on any business without incorporation, and in the case of banks the number was limited to ten. But the chief difficulties hitherto had been the lack of publicity, and unlimited liability. The interests of the general body of shareholders were in the hands of the few who controlled the business. This Act, therefore, conferred the privilege of limited liability upon incorporated companies in return for a measure of publicity as to their affairs—a privilege which was extended in 1879. Under these conditions the unlimited company has practically ceased to exist, while by 1909 there were no fewer than 40,000 limited companies, with a capital of £1,850,000,000, and the number of shareholders had increased more rapidly than the capital. It is important to distinguish between ordinary Joint-Stock Companies and Public Companies, which are formed for the purpose of supplying public utilities, such as gas, water, railways, docks, etc., and cannot be broken up by creditors. In case of failure the business is administered by a receiver, who shares out the proceeds to the creditors in proportion to their claims.

Incidentally it may be noted that the Joint-Stock Company has created, during the last hundred years, a new class of people, who invest their money in some one else's business, and only meet once a year to receive a report of the year's trading. Often without any special knowledge of the business or its organisation, the shareholder regards it merely as a source of income, and those who are most intimately concerned in the management are expected to keep the working expenses at the lowest and the profits at the highest level. Not only has this been the chief cause of the destruction of the old personal relations between master and man, but it has created a new form of business in the purchase and sale of stocks and shares. The surplus which this invested capital represents is the result of the enormously increased productive capacity conferred upon man by scientific discovery and mechanical invention.

When a number of firms are engaged in producing the same raw material or manufactured article, there is a keen struggle to capture a fair share—or more—of the market. The effect of this struggle is aggravated by periods of trade depression and irregularity of demand and supply. The existence of world-markets with an extraordinarily sensitive system of international credit seems to render fluctuations of trade inevitable, and though over-production may sometimes be the cause of a period of bad trade, failure to anticipate accurately the demand is not always culpable. The employers themselves suffer equally with the men, and have adopted two methods of securing economy of production and greater elasticity of their resources. These are the Trust and the Cartel—both existing in this country, but not usually advertised by name.

The movement towards the formation of Trusts began in the United States thirty or forty years ago, but has only reached a high degree of development since 1893. A Trust consists of an amalgamation of different firms under the management of a small committee, which controls the rate of production, divides the orders, and endeavours to establish a monopoly in a world-market. While an attempt is thus made to destroy external competition, internal rivalry is maintained in order to secure efficiency. Regular statements of output and cost are submitted from each works, and the managers are encouraged by the award of premiums, or stimulated into greater activity by reprimand. On the other hand, the expenses are largely reduced. The firms no longer advertise against one another, raw material is purchased in greater quantities at a cheaper rate, and orders are distributed more evenly than they were before. So great is the saving that even an increased trade can be carried on in fewer works. Mr. Macgregor notes[1] that "out of twenty-four firms which came into the Sugar Trust it was found possible to supply the whole market with only six; while out of eighty firms which came into the Distillers' Trust it was found that sixty-eight were superfluous. The capacity of the Steel Trust for finished products in 1902 was nearly 60 per cent greater than the greatest actual annual output of finished steel ever reached previously in the United States."

External competition is by no means easy to abolish in this way, for even though the world-market may be captured in respect of the finished product, the Trust can rarely count on being the sole consumer of the raw materials which it requires. Such a powerful body creates powerful enemies, and competition arises in unexpected quarters. In order to shake off these, it extends its influence to ore and coal mines, to forests, to limestone quarries, etc., and gradually acquires, or endeavours to acquire, all that is necessary for its operations. And since there are all the elements necessary for internal friction, the larger it becomes the more is it dependent upon the outstanding capacity and strength of the men who build it up. It is never popular; not only because it grows at the expense of its rivals, but because the creation of a monopoly puts too many people at the mercy of a few. The workmen who produce and the customers who buy are liable to be sacrificed, not so much to greed, as to the idol of power and

[1] *The Evolution of Industry*, pp. 218-19.

dominion which exercises such a fascination for those who have drunk deeply of success.

The European counterpart of the Trust—the Cartel—which is most strongly represented in Germany, is more like an employers' co-operative society. It consists of an agreement between a number of firms in regard to regulation of output and price. The decision rests, not with an autocratic committee, but with a body consisting of representatives of each firm, and having no control over the internal organisation or management of particular firms. Adherence to the decision of the Committee is secured by requiring all sales to be made through a central bureau. The Cartel is intermediate in character between the Trust and the industrial co-operative societies, which will be described later. The British reader will find in the various bank amalgamations, shipping rings, the sewing cotton, tobacco, and steel industries, ample evidence that the tendency for capital to be combined in order to reduce external competition is a living force in his own country and in his own day.

CHAPTER XI

THE CONFLICT BETWEEN CAPITAL AND LABOUR

The first signs of a clash of interests between capital and labour are to be discovered early in the eighteenth century, and the first example of a strike in the modern sense appears to have been undertaken by the journeymen tailors in London at a time when ready-made clothing began to appear in the retail shops. Under the domestic or commission system of the seventeenth century the capitalist merchant often supplied raw material to the spinners and yarn to the weavers, and the weavers themselves frequently handed out raw cotton to be spun; but the spinning-wheels and looms were usually the property of the work-people, and they could, if necessary, seek elsewhere for wool or yarn if the ordinary supply failed. With the advent of the factory system the whole means of production, including the tools used in the process, passed into the hands of the masters. As capital became relatively more important in industry an increasing number of men found that they had only their labour to sell, and when the masters tried to purchase this, as they purchased raw material, in the cheapest market, the workmen were compelled to fight for a standard of comfort. Moreover, to make their demands effective, they were impelled to act in a body against their common employer.

That the situation was strained before the coming of the steam-engine is evident from the complaints which were made in the House of Commons during the first half of the eighteenth century. But in the second half they became far more numerous and bitter, with the result that in 1799 an Act was passed rendering combinations illegal. Under the Combination Laws, Associations of Employers for reducing wages, controlling prices, and similar objects were also illegal, but owing to the difficulty of detection they were generally immune from prosecution. The workmen were numerous and secrecy was not easily maintained; the employers, on the other hand, were few, and could meet under circumstances which, even if they were known, surrounded them with a veil of innocence. So secure, indeed, from attack did the Master Cutlers of Sheffield feel themselves to be, that in 1814 they formed openly the Sheffield Mercantile and Manufacturers' Union with the avowed object of maintaining the previous year's prices, and they bound themselves to act in concert under a penalty of £100. While this passed unnoticed, if any employer cared to initiate proceedings against a workmen's society, the offenders were punished with the utmost rigour of the law.

The workmen felt themselves to have been unfairly treated, and found able champions in Francis Place, a London master tailor, and Joseph Hume, a member of Parliament. Place was a man of extraordinary political ability, and, while remaining himself more or less in the background, he collected a vast amount of information relating to abuses under the Combination Law. In 1824 Hume moved in the House for a Committee, and cleverly hid his real purpose by associating it with emigration and other matters. Appointed chairman, he questioned the witnesses according to the brief supplied by Place, and contrived to bring out the real strength of the men's case. The employers on the other hand were badly served; the Committee reported in favour of the repeal of the obnoxious law, and an Act securing this was passed in the same year.

Intoxicated by success, the workmen cast restraint to the winds. Unions sprang up in great numbers, and, in spite of the counsel of moderation preached by Place and Hume, they pursued a militant policy for which they had not prepared by organisation, and they alienated a good deal of the public sympathy which would have strengthened their cause. The employers became alarmed, and the shipowners and master-shipbuilders secured a new committee within a year. On this occasion Hume's influence was smaller, but the men's evidence was admirably organised by Place, and though the Combination Laws were re-enacted, combination for the purpose of regulating hours and wages was exempted, or remained exempt, from prosecution.

It is somewhat remarkable that Place's view of the ultimate result should have been so different from what actually occurred. He imagined that when combination was legalised the need for it would disappear. The whole of the labour evils of the time were due, in his opinion, to the prohibition; and acknowledgment of the rights of the men to combine would give them a potential power which the masters would not dare to arouse. As a matter of fact a financial panic towards the close of 1825 was followed by four years of severe depression. A reduction of wages was inevitable, and no amount of violence could relieve the situation. Then for a time the movement fell under the spell of Robert Owen, who preached the doctrine that an adequate standard of life would only be possible when the workmen owned the means of production. His schemes were as admirable in theory as they were impossible in practice. They exercised a strong influence while the resentment at the limitations of the Franchise Act of 1832 lasted, but a series of abortive strikes led to a weakening of faith, and when the banner of Chartism was raised a few years later, it found many of the men disheartened and somewhat sceptical of political methods.

The period from 1829 to 1848 was characterised by numerous attempts to expand *Trade* Unionism into *Trades* Unionism. It was hoped to form a great national federation of labour which would be strong enough to enforce its demands. The textile operatives and the builders were the first to take action. The Builders' Union devoted themselves to organisation for a few years, but when they began to force matters they adopted such a peremptory tone as to create alarm among the employers. The latter entered on a deliberate attempt to destroy the union by declining to employ any man who refused to relinquish his membership. This method, known as the "presentation of the document," was a powerful instrument in the hands of the employers for many years. The aggressive policy of the Unions, and more particularly the truculence of the builders' leaders, excited alarm outside the ranks of the employers. At the request of the Government, Nassau Senior, Professor of Political Economy at Oxford, conducted an enquiry and presented a report. His recommendation that, as a last resort, the funds of the Unions should be confiscated was not acted upon, but the fact that meetings were conducted with an elaborate ritual and that an oath was administered rendered it possible to apply repressive laws which had been established for a totally different purpose. A climax was reached in 1834, when six Dorsetshire labourers were arrested and sentenced to seven years' transportation merely for taking the oath. In the face of this interpretation of the law the Unions were powerless. Their organisation was faulty. They had been accustomed, when mild methods failed, to use violence against employers and against traitors among themselves, and their efforts to obtain better conditions were beaten time after time; but to a large extent they were victims of unfortunate circumstances. The introduction of machinery had created new conditions; the masters were often ill-suited to control men, and were obsessed by the commercial keenness of the time; finally, there were financial crises in 1826, 1829, 1837, and 1842, in which distress was widespread and severe. The men foolishly thought that by smashing machinery, by abolishing overtime, and by reducing the number of apprentices they could improve their lot. The masters, soaked in *laissez faire* notions, demanded not only freedom in the management of their businesses, but freedom also to buy human effort and human skill as they bought coal, or iron, or cotton. The steam-engine had upset the economic equilibrium and created both an industrial and a social revolution. Neither masters nor men realised the new conditions, and political action was governed alternately by sentiment and fear.

From this period of struggle and adversity, of ostracism and persecution, the Trade Union movement passes into one of reconstruction and consolidation. The twenty-five years from 1850 were on the whole years of plenty. The influx of gold from California and Australia raised prices; the factory system had passed the stage of transition; Free Trade was definitely accepted and largely established; and, above all, educational opportunity was increased and widened. The telegraph and the railway were powerful agents in broadening men's minds; the writings of economists were beginning to be available at least to the employers and the men's leaders; and the men themselves were taking advantage of the Mechanics Institutes which grew up in the middle of the century. Moreover, the conduct of the Unions passed out of the hands of men who continued to work at their trade into the control of permanent officials with broader views, calmer spirit, and keener political instinct. These leaders, who formed what Mr. Sidney Webb calls the Junta, were the secretaries of Unions which had solved the problem of national administration with adequate local control. The central offices were in London. The men formed personal friendships, and they established informally a central committee which practically created a new general policy for the movement. Counselling moderation and carrying out their own administrative duties with efficiency, they exercised a restraining influence in local branches, and yet enabled them to take action successfully when the need arose.

The oath had been largely abandoned after the prosecution of the Dorchester labourers in 1834, and in 1843 the Northumberland and Durham Miners' Union adopted the plan of taking counsel's opinion in all cases in which they came into conflict with the law. Having secured the services of Mr. G. H. Roberts, a solicitor of democratic sympathies and marked ability, they fought every case which came into the Courts, and by this means warned off ill-advised attempts to set the law in motion against them. The larger societies established newspapers which were generally moderate in tone and discouraged strikes and violence. Gradually they attracted to their banner educated men like E. S. Beesly, Professor of History at University College, London; Frederic Harrison, the Positivist; F. D. Maurice, and the Christian Socialists, who not only aided with advice, but lent their powerful advocacy on the platform and in the press.

These remarks apply to the larger Societies. There were still many smaller Unions, the members of which were probably more fully at the mercy of the unscrupulous employer, and were accustomed to use methods of a ruder and more primitive order. On this account Sheffield had an unenviable reputation not unlike that which had once belonged to Glasgow, and in 1866 an outrage was committed which threatened to destroy the constructive work of the previous twenty years. A man who was suspected of being a traitor was killed by an explosion of a can of gunpowder, and the police failed to trace the criminal. In 1867 the Government appointed a Royal Commission of Enquiry, and it was soon seen that, notwithstanding the repudiation of the crime by all the responsible Unions, the whole movement was on trial. With the exception of one member nominated by the Employers and another by the Unions, the Committee was composed chiefly of high officials, with four representatives of the two Houses of Parliament. The witnesses for the men confined their evidences mainly to the refutation of the charge of complicity in terrorism, while the employers committed the tactical error of tarring all working-men's organisations with the same brush. They did not discriminate between the Unions which were in the main insurance societies, and the small trade clubs controlled by men of limited outlook and violent temperament. The final report was a document not unfavourable to the men, but containing few constructive recommendations beyond the registration of the Unions under certain conditions.

The problem which now agitated the minds of the men was their legal position. A judicial decision in 1867 had deprived the Boilermakers' Society of the right to sue a branch treasurer for embezzlement, and had thus placed in jeopardy the financial resources of all the Unions. At the same time registration under the Friendly Societies Act would have rendered them liable to be sued as corporate bodies for the acts of their members, and to this they objected strongly. Against the charge of thus seeking to evade responsibility they would reply that the law was opposed to workmen's combinations, and that the lawyers were prejudiced against them. They contended that the new economic circumstances had rendered Unions necessary in the interests of a standard of life, whereas the law was defined with reference to obsolete conditions and incapable of dealing equitably with their appeals. And as the Reform Act of 1867 had largely increased the political power of the town artisans, they began to force upon Parliament the need for an alteration of the law. After a private Bill had been withdrawn in 1867 on a promise that the Government would introduce one of their own, an official measure was proposed in 1871. The new Bill satisfied neither masters nor men. In effect it legalised a strike, but prohibited by severe penalties the ordinary method by which it would be conducted. Ultimately the Bill was split into two, and the clause to which the men took exception was passed separately as "The Criminal Law Amendment Act." The Unions felt that having regard to the way in which the law was interpreted against them, it was still a criminal offence for one man to speak to another in the street, while it was lawful for employers to deprive a man of employment by means of black lists and character notes. The position was intolerable, but the

Government were obdurate, and the fact that they suffered a heavy defeat at the General Election of 1874 may probably be regarded as an illustration of their failure to measure the political strength of the movement.

The Parliament of 1875 contained for the first time two direct representatives of labour in Alexander Macdonald and Thomas Burt. Viscount Cross introduced an Employers and Workmen Bill which placed employers and workmen on an equality before the law. The Criminal Law Amendment Act of 1871, and the Master and Servant Act of 1867, were repealed. The contract between employer and workmen was now a civil contract, and collective bargaining received legal sanction. At the same time, it must be noted that almost the whole body of educated opinion in the country was adverse to trade combinations; the political machinery was still in the hands of the middle classes; and the battle had been won not so much by the mass of Trade Unionists as by the efforts of a few able leaders and their friends. Moreover, they won it by adopting a policy which landed them on the horns of a dilemma from which they have only recently obtained release.

The employer based his arguments entirely on the principle of *laissez faire*—on the perfect freedom of every man to do as he liked. The men seized upon this principle and applied it to the question of bargaining collectively with their common employer. This was fully in harmony with the Free Trade principles of the times. But the willingness of unionists to work with non-unionists was often in doubt, and has in recent years been the cause of the most violent disputes, especially in the mining industry. Moreover, as a temporary measure of expediency they dropped from their programme such items as the use of machinery, the employment of apprentices, restriction on piece-work, and the abolition of overtime, which had formerly been the cause of much of their unpopularity.

The Unions were, from their point of view, unfortunate in securing a legal status just as the world-wide wave of trade depression began to be felt. For the next few years attempts to raise wages, or even to prevent their reduction on a falling market, were doomed in the majority of cases to dismal failure. The claim to enjoy a higher standard of comfort, sympathetically received in times of prosperity, was heard with impatience when trade was poor. Moreover, bad trade meant commercial failure, unemployment, and an overstocked labour market which gave strikes a smaller chance of success. And to these external difficulties were added differences of policy between the Unions themselves. One of these grounds of contention was a result of the new methods in industry which rendered the old classification of trades useless, so that disputes arose, for example, between shipwrights, ship joiners, and house carpenters, as to the exact sphere of each trade. The old craft-gild principle that in order to maintain a standard of workmanship only qualified men should be employed in each trade was here at work; but its operation was complicated by new and rapidly changing conditions which were hardly understood and certainly could not have been foreseen. To men outside the Trade Unions, ignorant of or indifferent to their traditions, these disputes seemed to be puerile and vexatious. But some allowance must be made for the professional zeal which lies behind them; and still more perhaps for the fact that the workman has to keep a jealous eye upon any movement which threatens his employment.

These differences, however, are petty compared with the deep cleavage which grew up between the miners on the one hand, and almost all the rest of the trade-union world on the other. The question at issue was, "Should prices rule wages, or should wages rule prices?" and the miners accepted the coalowners' contention that wages should rise and fall with the market price of coal. From 1873 onward there has been a tendency for wages in the mining industry to be regulated by a sliding-scale, so that they rose or fell with the price of coal. There is some justification perhaps for this plan in the case of a commodity in which the wages bill is nearly 75 per cent of the cost of production, and the market price of which is not appreciably influenced by speculation. But as a general principle it is wrong, because neither profits nor wages necessarily depend upon prices. The price of a commodity may remain constant, and yet profits may be increased enormously by improvements in machinery or processes. At the same time wages may fall by the employment of a cheaper form of labour.

The men engaged in trades in which the wages bill forms a small proportion of the cost, or in which the price of the raw material or manufactured products is affected by speculation, have invariably insisted upon the "living wage." They contend that wages should be a fixed charge, and when the price of the finished product falls it is due to over-production. The remedy then is to reduce the output by short time until prices rise to their normal level. This principle is adopted very largely in the Cotton Trade, and its application on an extensive scale has been noted in Chapter V.

Exhausted by the struggle for a recognised legal status, and rendered helpless by the instability of trade between 1874 and 1885, the Trade Union movement became more and more closely identified, in its general policy, with middle-class Liberalism. Individual trades struck when the need arose or when opportunity offered, with varying success; but stoppages received very little encouragement from the leaders who had achieved the victory of 1874. The doctrine of individualism—of the Survival of the Fittest—held the field. The fact that the strong became stronger and the weak weaker was almost accepted as inevitable until Henry George's *Progress and Poverty* emphasised the land as a source of wealth. This book, which did not touch the problems of industrial organisation, had a wide circulation in England in the early 'eighties, and exercised an enormous influence in directing attention to the way in which it was alleged that increases in the value of land were wholly appropriated by the landlords.

"But if Mr. Henry George gave the starting push, it was the propaganda of the Socialists that got the new movement under way. The Socialist party, which became reorganised in London between 1881 and 1883, after practically a generation of quiescience, merged the project of Land Nationalisation in the wider conception of an organised Democratic community in which the collective power and the collective income should be consciously directed to the common benefit of all. While Mr. George was, almost in his own despite, driving Peasant Proprietorship and Leasehold Enfranchisement out of the political field, the impressive description which Karl Marx had given of the effects of the Industrial Revolution was interpreting to the thoughtful workman the everyday incidents of industrial life. It needed no Socialist to convince the artisan in any of the great industries that his chance of rising to be a successful employer was becoming daily more remote. It required no agitator to point out that amid an enormous increase in wealth-production the wages of the average mechanic remained scarcely sufficient to bring up his family in decency and comfort, while whole sections of his unskilled fellow-workers received less than the barest family maintenance. Even the skilled mechanic saw himself exposed to panics, commercial crises, and violent industrial dislocations over which neither he nor his Trade Union had any control, and by which he and his children were often reduced to destitution. But it was the Socialist who supplied the workman with a plausible explanation of these untoward facts. Through the incessant lecturing of Mr. Hyndman and other disciples of Karl Marx, working men were taught that the impossibility of any large section of the working class becoming their own employers was due, not to lack of self-control, capacity, or thrift, but to the Industrial Revolution with its improvements of mechanical processes, its massing of capital, and the consequent extinction of the small *entrepreneur* by great industrial establishments. In this light the divorce of the workers from the ownership of the means of production was seen to be no passing phase, but an economic development which must, under any system of private control of industry, become steadily more complete. And it was argued that the terrible alternations of over-production and commercial stagnation, the anomaly that a glut of commodities should be a cause of destitution, were the direct result of the management of industry with a view to personal profit, instead of to the satisfaction of public wants."[1]

The seed of this teaching fell on fertile soil. Every industry in those troubled times abounded with illustrations. Gradually the rank and file as well as the leaders became permeated with collectivist principles. A new and more vigorous policy arose which found expression

[1] *History of Trade Unions*, Mr. and Mrs. Webb.

at first in the organisation of workers in unskilled trades. In 1888 the women and girls in a London Match Factory struck work, and, receiving unexpected aid from the public outside the ranks of Trade Unionism, won their case in a fortnight. In 1889 occurred the great London Dock Strike, during which an unorganised body of casual labour was welded into a coherent group by John Burns, Ben Tillett, and Tom Mann. No previous strike had ever gained such general and widespread support as this one. Subscriptions poured in from all sorts and conditions of people, and a large sum was contributed in Australia. Of the £48,000 raised £30,000 was transmitted by telegraph. The men were orderly but determined; the employers arrogant and stubborn. But the general public were with the men; Cardinal Manning and Mr. Sidney Buxton, M.P., were able to intervene on their own initiative; and the men went back on their own terms.

The effect of these and other successes led to an enormous increase in the number and strength of Trade Unions, and at the same time to a general policy differing somewhat from the idealism with which many of the leaders had originally been embued. The primary object was a minimum wage. As early as 1888 the Government had been persuaded to act as a model employer of labour in so far as to insist on the standard rate of wages being paid for all work done under their departments. The London School Board next conceded the principle. They were followed by the new London County Council, and during the next dozen years by practically all Local Authorities in the country. In 1888 the three London Gas Companies yielded to the demand for an eight hours' day, though the next year the South London Company succeeded in returning to twelve hours by introducing a system of profit-sharing. But the main difference between the new and the old Unionism was that, instead of aiming at a complete and immediate transfer of ownership of the means of production, the municipalities and the Government were pressed to undertake to a greater and greater extent the provision of public services, and to exercise increasing control of industrial conditions through Factory Acts and Sanitary Laws. The activity in municipal enterprise during the last twenty-five years is partly the result of the Labour movement, and partly a tacit acknowledgment that services which are essential to the people's welfare should be managed by the people and in the people's interest.

The truth of this statement is not affected by the fact that Trade Unions are not yet institutions universally admired. It is one of the characteristics of Democracy that there should be variety of opinion, and the *laissez faire* principles so widely held are apt to be interpreted in a light more favourable to one side than the other. Conflicts have frequently arisen over the refusal of the employer to permit any interference with the work of the factory. Yet so long as the Unions insist on the employment only of men who have served a proper apprenticeship and on the sharp differentiation between trades, such conflicts are almost unavoidable. In two of the most important industries it is part of the accepted practice. The Cotton Industry is carried on by the aid of elaborate piece-work price lists, and upon the Trade Union official is thrown the responsibility of accepting or rejecting on behalf of the work-people any proposed alteration or addition. The peculiar qualities necessary for this task compel the Trade Union secretaries in this industry to be, in the words of Mr. Sidney Webb, combinations of lawyer and accountant. In Coal Mining again, where men are paid on tonnage, and where there are elaborate regulations for safety, the Union official is in close touch with the daily work in the pit. Both these industries are more completely controlled by factory legislation than any others. The nearest to them perhaps is Railway work, though it is to be noted that the disastrous strike of 1912 was due largely to the refusal of the directors to meet the men's leaders. The most important question at issue was whether the large financial and public responsibilities of the directors, and the expert advice which is at their disposal, entitle them to act both as prosecutor and judge towards an undefended workman; or whether the workman himself is not entitled to employ the best legal and technical assistance he can secure for his defence. In view of their public obligations the Railway Companies consider that they are compelled to adopt a more autocratic attitude than the manufacturer, who has admitted the principle.

In contrast with Associations like those of the Miners and Cotton Operatives, which are essentially Trade Societies, many of the older Unions, like the Amalgamated Society of Engineers and the London Society of Compositors, are primarily insurance societies, with an enormous business in sick and unemployment benefit. While perhaps not less militant than the former type they are less prone to enter upon national movements, and proceed rather by means of local action. Still, the general tendency in recent years has been towards an increasing solidarity in the ranks of labour, the evidence for which is to be found not only in political effort, but also in sympathetic strikes, by which the employers—and the public—are attacked in front and on the flank. Without casting any doubt upon the effectiveness of this plan, it must be admitted that the inconvenience caused to the general public tends to alienate some of that sympathy which might otherwise be felt and expressed for the workmen's cause.

It is desirable to direct attention at this stage to the fact that combination has not been confined to the workmen. When the organising ability of Newton, Selsby, and Allan created the Amalgamated Society of Engineers in 1851, the employers recognised the strength of the men's Union and formed a Central Association of Employers of Operative Engineers. Since 1833 the chief weapon employed against strikes had been the "presentation of the document," which required men to resign their membership before re-engagement. But this ceased to be effective. It failed against the Amalgamated Society of Engineers in 1852, and against the Builders in 1859. By that time a new weapon had been forged, known as the lock-out. A local dispute was now fought by closing every shop of a federated employer over a large area, and the heavy burden thus thrown on the funds of a Union considerably reduced the men's power of resistance. The lock-out was frequently employed in the 'sixties by the South Yorkshire Coalowners, the Ironmasters of Staffordshire, and the Shipbuilders on the Clyde.

The rapid growth of the men's Unions again in the early 'seventies led to the formation in 1893 of the National Federation of the Associated Employers of Labour, which included engineers, shipbuilders, ironmasters, coalowners, builders, and textile manufacturers. But though the strike and the lock-out have still persisted, there has been since that time a greater tendency for disputes to be solved by means of Conciliation Boards and Arbitration. Twenty years before, such proposals would have been laughed to scorn, but tentative experiments had shown that the opposing factions were not wholly irreconcilable. In 1860, mainly by the efforts of Mr. Mundella, a Board of Arbitration and Conciliation was established in connection with the Hosiery and Glove Trade at Nottingham, and four years later Sir Rupert Kettle assisted in the formation of the Wolverhampton Board of Arbitration and Conciliation in the Building Trade. Encouraged by the success which attended these efforts, the Government passed Acts in 1867 and 1872 to facilitate the creation of similar Boards for other industries and in other places. The time was not yet ripe, however, for such legislation, and it was only after the Report of the Labour Commission in 1894 that an Act was passed which laid a solid foundation for the existing practice.

The Act of 1896 advised the formation of Conciliation Boards, and empowered the Board of Trade to approach the parties to the dispute. On the application of one of the parties they could appoint one or more persons to act as Conciliator or Conciliation Board, and at the request of both parties they could appoint an Arbitrator. The result of fifteen years' experience under this Act was a further measure in 1911 which established a joint panel of employers and representatives of labour, with a permanent official as chairman. There is now therefore a permanent committee with wide experience and a reputation for moderation and fairness which commands respect.

Emphasis has been laid upon these matters because they imply State recognition of combinations among both employers and workmen. The same scientific and mechanical developments which enabled the workmen to act in co-operation over a wide area enabled the employers to do likewise. When the Unions ceased to be merely local, then federation amongst the employers was obvious and inevitable. The workmen's Unions first acquired national importance, but the employers' Federations quickly followed. With improved organisation, discipline was strengthened in each group, and ultimately the State sought to utilise this discipline by bringing together the leaders in whose tact and ability lay the greatest safeguard against the extremities of the strike and the lock-out. The existence of the Industrial Commissioners set up by the Act of 1911 is a direct encouragement to both parties to appeal to an impartial tribunal, and to delay definite action until the arts of diplomacy have entirely failed.

CHAPTER XII

CO-OPERATION, CO-PARTNERSHIP, AND PROFIT-SHARING

We have seen how the growth of the factory system led to a concentration of capital into fewer and fewer hands and placed an increasing proportion of the population in the position of wage-earners, with an income often so little above that necessary to maintain existence that recurring periods of bad trade produced a terrible amount of misery and privation. We have also seen how the workmen entered into combinations in order to maintain a standard of life, and how Robert Owen had taught that the only security for their aims was to become themselves owners of the means of production. A practical form of this collective ownership is co-operation, whereby the men themselves provide the capital needed to carry on their trade. The amount of capital required, however, for production or distribution is usually so large in relation to the number of men actually engaged that great difficulty was, and still is, experienced in making a start. But if the capital is subscribed by consumers as well as producers the problem becomes easier of solution.

The earliest and still the most important example of co-operative effort was a combination of consumers. The "Rochdale Pioneers" were originally a group of twenty-eight men who in 1844 subscribed £1 each, set up a store in the house of one of their number, and re-purchased the articles as they required them at ordinary market rates. New members were admitted freely, so that by the end of the first year they numbered seventy-four. The capital then stood at £187, the year's turnover was £710, and a profit of £22 was the amount left after each subscriber had received interest at 5 per cent per annum on his capital and all the expenses of working and management had been paid. This profit was distributed among the purchasers, and the whole plan formed a model upon which subsequent societies were founded. All retail co-operative societies are conducted on the basis of 5 per cent interest on subscribed capital *plus* a discount paid in the form of a dividend on purchases. The Rochdale business grew with great rapidity. Within forty years there were over 11,000 members, the capital exceeded £324,000, the annual turnover was more than £250,000, and the profit was more than £45,000. Meantime two similar societies were established in Oldham before 1850, and shortly afterwards Manchester, Liverpool, Birmingham and many other towns followed suit. The Rochdale society had extended its operations to linen and woollen goods in 1847, meat in 1850, and bread in 1867. The great industrial centres of the North of England and the South of Scotland provided the most favourable conditions, but the plan spread into practically every industrial town in the country, and in practically every case the range was gradually widened until it covered the whole field of food and clothing.

There are now more than 1500 retail societies, and about one-fifth of the people subscribe to the movement. The total capital is about £35,000,000, the turnover more than £110,000,000, and the profits over £10,000,000—

figures which show that co-operation is well beyond the range of destructive competition. The financial stability of co-operation depends upon the facts that the goods are principally necessities with a steady sale; that the purchasers are interested in the success of the business; and that each addition to capital is necessarily accompanied by an increase of trade. The danger of over-capitalisation is therefore avoided.

Various attempts have been made during the last hundred years to establish co-operation in manufacture. In the middle of last century there were ten such societies in existence, but they all failed and were replaced by others. The most important is the Co-operative Wholesale Society, which is not only a large manufacturing concern, but also a wholesale distributing agency. It was founded in 1864 as an association of consumers, the capital being subscribed by the retail societies, and the first year's working showed a turnover of more than £50,000 on a capital of £2456. Twenty years later the capital exceeded £360,000 and the turnover £7,000,000.

In the examples which have been given so far the management has been wholly in the hands of the work-people, just as in the examples described in the chapter on Combinations of Capital it was wholly in the hands of the employers. There is another system, known as Profit-sharing, or Labour Co-Partnership, in which, while the employer retains control of the management, the workmen share in the firm's prosperity. The idea seems to have originated in France, and two of the most successful examples are the Maison Leclaire, painters and decorators, in Paris, and M. Godwin's iron foundry at Guise. In both these cases care was taken to offer special inducement to the older and more experienced employees, who were given a share in the control of the business. The essential feature, to which not a little of the success of both firms was due, appears to have been a gradual transfer of a going—and growing—concern from private to collective ownership, the change taking place so slowly that selected workmen were trained to the duties and responsibilities of management. By way of contrast it may be noted that the workshops founded in England by the Christian Socialists in the 'sixties, in which there was apparently no special selection, were generally unsuccessful.

The modern movement towards Labour Co-Partnership in England began with the establishment in 1884 of a body which is now known as the Labour Co-Partnership Association. As a result to a large extent of its missionary efforts there are now more than a hundred Co-Partnership Firms, of which fifteen are Textile, eighteen Boot and Shoe, twenty-six Agricultural, and fourteen Printing. Thirty years ago there were only fifteen firms with a total capital of £103,436; in 1911 there were 110 firms with a capital of £1,991,551. But while these schemes demonstrate that a body of workmen are competent to conduct modern industrial establishments with success, they are insignificant in comparison with true cases of profit-sharing, which have spread widely during the last twenty-five years. In some cases the plan adopted is to divide surplus profits after a reasonable interest on capital has been earned; in others the workman is encouraged to invest in the company; and in others a special form of share is distributed among those who have fulfilled certain conditions of service.

One of the earliest examples in England occurred in 1865, when a firm of colliery owners, after several disastrous strikes, offered their employees half-profits over 10 per cent. The scheme remained in force for ten years, during which time from £1000 to £6000 a year was distributed. With trade depression the men's claims received smaller consideration, and no other important step was taken until 1889, when trade had improved and the Unions had grown stronger. In that year the South Metropolitan Gas Company, having previously yielded to the demand for an eight-hour day, destroyed the influence of the Union and persuaded the men to return to the old conditions by means of a system of profit-sharing. The Company offered $\frac{3}{4}$ per cent bonus on wages for each penny by which the price of gas was reduced below 3s. 1d. per thousand cubic feet. The scheme has been extended (1) by encouraging the men to leave their dividend on deposit, whereby they became shareholders in the Company, and (2) by securing parliamentary sanction to representation of the men on the directorate.

It is a somewhat remarkable fact that some form of profit-sharing has been adopted in Gas Companies having a capital of over £50,000,000 out of the £92,000,000 invested in similar concerns, but in only two cases as yet are the men interested in the management.

There are a number of other cases, for an account of which other books must be consulted; but it is of interest to note that by the Limited Partnership Act of 1908 the employees can be formed into a company to hold shares in the employer's business with limited liability, while his liability remains unlimited. Advantage has been taken of this Act by a number of firms, but it is obvious that the unlimited partner retains full responsibility for management. We must proceed now to discuss another method by which a more equitable division of the profits of industry may be secured.

CHAPTER XIII

MUNICIPAL OWNERSHIP

There are certain things, such as water, public lighting, transport, which are most economically provided on a large scale, and cannot be purchased over the counter of a retail shop. They are services of which the need is so general that efforts to secure them receive the support of practically the whole of the townspeople; and though the original method was for the town to grant monopolies to public companies, there has been a rapidly growing movement towards municipal ownership during the last thirty years. It is proposed in this chapter to indicate briefly the chief stages of development.

The first necessity when men congregated in towns was an ample supply of pure water, and it was to the absence of this that the fires and plagues of the Middle Ages and the succeeding periods are to be attributed. The river, the spring, and the well were successively drawn upon, and in the eighteenth century the latter were often in the hands of private persons who sold water, with less regard to the hygienic and sanitary requirements of the population than as a commercial enterprise. For example, towards the end of the century some sixty carts delivered about 100,000 gallons a day in Liverpool, and a little later there were two companies, established under Acts of Parliament, which laid pipes side by side in the streets and competed with one another for custom like neighbouring shopkeepers.

The rapid growth of towns under the influence of the steam-engine rendered the problem of water-supply extremely serious, and many municipalities availed themselves of the larger powers and more effective machinery of the Municipal Corporations Act of 1835 to take the necessary steps. By this time nearly all available wells had been tapped, and the water had to be sought at a considerable distance. Thus Manchester secured a supply from the Longdendale Valley, and a little later Liverpool obtained one from Rivington, near Bolton. Between 1835 and 1847 the procedure by which Corporations could purchase or construct undertakings was fairly well established. The result is that at the present time two-thirds of the County Boroughs, and nearly all the non-County Boroughs, own their water-undertakings.

In one respect water differs from the other services which will be described in that it is paid for by rate, and only in the case of large users according to the quantity consumed. While this is a recognition of the universal necessity of water, it does not contribute to economy. In some towns in the United States a great saving has been effected by the use of meters, but in Great Britain the authorities rely upon the adequacy of inspection. Water has been used in this country with the same prodigality as coal, and the one appears likely to set a limit on the population as the other upon the duration of manufacturing ability. Local Authorities are finding an increasing difficulty in obtaining new sources of supply, and are competing against one another just as they compete in the market for coal. It is through fire and water that the nation will be put to the test.

The supply of gas for public and domestic purposes is governed by the Public Health Act of 1848. Local Authorities may enter into a contract with a Gas Company, or undertake the supply themselves by Provisional Order, under the Gas and Water Works Facilities Act of 1870, but when two or more districts are concerned an Act of Parliament is necessary. By the Gas Works Clauses Act of 1847 the profits of a Company are limited to 10 per cent. The capital invested in Gas Works under Local Authorities is now more than £27,000,000, and under Companies more than £92,000,000; the Local Authorities have nearly 3,000,000, and the Companies nearly 4,000,000 consumers. Since 1880 Electric Lighting has been a serious competitor, and the fact that gas-supply also shows continuous progress is an indication of the extent to which the newer and more convenient forms of illumination have spread into the homes of the people. The initial technical difficulties of lighting by Arc Lamps were not overcome until 1879, and the Ediswan Glow Lamp was not invented until 1880. In 1882 appeared the first Electric Lighting Act, and in 1888 the second. The Electric Lighting (Clauses) Act was passed in 1899, and in 1909 the procedure was simplified. The provision of Electric Power by Public Companies over wide areas was regulated by an Act in 1899, and now applies to thirty-four areas.

Tentative proposals for the establishment of Tramways were made soon after 1850. In 1861 the Corporation of Birmingham obtained powers but did not exercise them. The first general legislation was the Tramways Act of 1870, and two other Acts of importance are those dealing with Light Railways in 1896 and 1912. The Act of 1870 was unfavourable to private enterprise, because it gave the Local Authorities power to purchase the undertaking at the expiration of twenty-one years or later, on "scrap-iron" terms. The power of the authorities to float Municipal Stock after 1880 facilitated municipal ownership, but in many cases nothing could be done until the Companies' leases ran out from 1892 onwards. The growth of tramway systems during the last twenty-five years is shown by the following figures from the Municipal Year Book:

	1879 (Horse).	1898 (Steam).	1913 (Electric).
Mileage .	32,127	106,419	266,169
Passengers .	150,881,515	858,485,542	3,219,777,515

At the present time nearly £80,000,000 capital is sunk in 2661 miles of track and equipment, and of 286 undertakings 171 belong to Local Authorities.

Throughout the nineteenth century the problem of housing the growing population of the towns has been a serious one. In 1801 the single large town was London, and the total number of inhabited houses in the country was estimated to be about 1,468,000. By 1831 this had increased to more than 2,866,000, showing that more than a million had been erected in thirty years. The lack of sanitary precautions exposed the country to grave dangers when cholera spread over Europe in 1830–32, and Britain did not wholly escape. The result of the warning was a series of Public Health Acts from 1848 onwards, while in 1851, Lord Shaftesbury's Act contained the first building regulations. Model by-laws were issued by the Local Government Board under the Public Health Act of 1875, and power under this and later Acts was given to Local Authorities to demolish insanitary dwellings.

The actual municipal provision of houses dates from the Act of 1890. In 1884 a Royal Commission on the Housing of the Working Classes took evidence and presented a report. After the Local Government Act of 1888, the Local Authorities were empowered to clear slum areas, to buy land, and to raise loans for the erection of new dwellings. The Act of 1890 had been frequently amended, and in 1899 was supplemented by the Small Dwellings Acquisition Act, under which the authorities could lend four-fifths of the amount necessary to purchase houses of a limited size and rental.

From the "house healthy" the function of Local Authorities has been extended to the "town beautiful." The towns had grown, and as they grew they enclosed the slum. The land had not been used to the best advantage; individual choice had determined the site and character of the dwelling; and insanitary arrangements were accompanied by an ugliness which offended the sensitive eye. An attempt to avoid these defects was made by certain enlightened employers of labour who erected their factories outside the town and built model villages in the neighbourhood. Port Sunlight was founded by Mr. (now Sir) William Lever in 1887, Bournville by Mr. George Cadbury in 1889, the first Garden City was laid out at Letchworth about 1900; and the idea arose that at least the extensions of the great towns should be planned in such a way as to secure a proper amount of light, air, and general attractiveness at a reasonable cost. In 1909 the Housing and Town Planning Act enabled Local Authorities to control the laying out of, and the character of the buildings upon, large areas before they were developed piecemeal by the speculative builder. But consideration of this phase of the problem lies outside the range of this book.

As we shall have occasion to point out again, Municipal Trading owes much of its development to the practical form of Socialism which arose in the 'eighties. Instead of enunciating vague theories or spending their energies entirely in violent attacks on capitalism, men who believed that there should be greater equality of opportunity and a more uniform distribution of the advantages of wealth turned their attention to the Local Authorities, and through them endeavoured to attain some of the objects they desired. The fact that they were successful indicates the wide popularity of their views, for no such result could have been achieved by a few agitators backed by a minority of discontented workmen. Municipal activity is as much a middle-class as it is a working-class movement. The existing municipal liabilities of more than £600,000,000 is a measure of the feeling that necessities should be provided by public rather than by private enterprise. In many cases some enlightened and wealthy man has shown what could be done, and the public have subsequently decided to do it for themselves.

But Municipal Ownership is not beyond the reach of criticism. It is often held to be less economical than similar undertakings under private management, because it is not exposed to the same competition, and the influence of shareholders in regard to economy of production and management is more powerful than the influence of the ratepayers. On the other hand, the municipality can obtain officials as competent and as energetic as those employed by private firms, the accounts are closely scrutinised, and towns compared with one another. Those who disbelieve most in municipal trading are usually the keenest on each undertaking being conducted at a profit, and of applying this profit to the relief of the rates—a plan which has been criticised on the ground, for example, that relief of the rates from tramway profits aids the rich man with the motor-car at the expense of the poor man who uses the trams. It remains to be noted that the efforts of the Local Authorities have been exerted in a narrow field and in order to meet a purely local demand; they are social rather than economic in character; and they are only to a negligible extent in competition with manufacturing industry under private control. Municipal Ownership illustrates, perhaps, the limitations as well as the possibilities of practical Socialism.

D. INDUSTRY AND POLITICS

CHAPTER XIV

EXTENSION OF THE FRANCHISE

While inventors have been busy expressing their genius in machines and processes, and while capital and labour have been struggling, the one for the right to control wages, and the other to secure a higher standard of life as the reward of toil, political reformers have been engaged in expanding the constitution and functions of government to meet the social and economic needs of the nation. When the eighteenth century dawned the influence of the people upon the policy of Parliament was substantially what it had been during the preceding four hundred years. Broken only by a return to personal government under the Tudors, and affected but slightly by the creation at this period of a number of boroughs, the composition of the electorate and the character of their representatives showed little variation since the Model Parliament was wrung from an unwilling monarch by the efforts of Simon de Montfort in 1296.

An Act passed in 1710 limited membership for the counties to those who possessed land of the value of £600, and for the boroughs to those who had an income of £300 a year. In the counties the electors were forty-shilling freeholders, but in the boroughs there was considerable variation. Some members were elected only by the owners of particular houses, some were elected by the freemen, and others by the votes of the whole of the ratepayers. Corruption was rife, and while decayed towns in the south were fully represented, the rapidly growing towns of the industrial north were mostly without a spokesman. The interests of the members were predominantly agricultural in the sense that they were landowners with only a secondary interest in the towns.

The demand for reform is attributable partly to discontent with the political corruption of the time, and partly to the industrial changes which were altering the occupations and distribution of the population. The increase in wealth and influence of the manufacturing and mercantile community which arose from the textile inventions of 1739, 1764, 1765, and 1789 was accompanied by the agricultural revolution which has been described in Chapter V. The return from the soil was fluctuating; the changes in agricultural practice were driving labour into the towns; and the absorption of this labour by the new manufactures led to that enormous expansion of trade which was a feature of the latter half of the eighteenth century. By 1790 the home production of corn failed to meet the growing demand, and the nation learned to look to its merchants and seamen to make good the deficiency. The rise of a new, coherent, and powerful group of interests which claimed to have a voice in the government of the country was facilitated by the improvement of roads, and newspapers served to disseminate political theories. The able conduct of the *Times* by Mr. John Walter secured for it considerable influence, and, when it was printed by steam in 1806, the paper obtained a still wider circulation. But during the long years that the nation was at war, and in the succeeding years of depression, the Government and the aspirants to political power were too fully occupied in dealing with emergencies to embark on any large scheme of reform.

Meanwhile the movement had been growing in volume and strength, and the first Reform Bill became law in 1832. The result was the disenfranchisement of 55 boroughs, the reduction by one member of 30 more, and of one four-membered borough to two members. This rendered vacant 143 seats, which were distributed among large towns and counties hitherto without adequate representation. The Act, however, did not merely effect redistribution; it changed the character of the electorate. In the boroughs all £10 householders were now entitled to vote. In the counties the franchise was given to £10 copyholders, to long leaseholders, and to tenants-at-will whose rent was £50. The forty-shilling freeholder still retained his right.

The new members signalised their accession to power by two Acts which are of first-rate historical importance. The Poor Law Act of 1834 created machinery for the more effective administration of the Poor Law, and the Municipal Corporations Act of 1835 conferred a large measure of local government upon the boroughs. Both Acts illustrate very clearly the triumph of the manufacturing and commercial interests, and their nature and purpose will be more fully explained in the following chapter.

Some years before the middle classes achieved their political aspirations the workmen had become interested in politics. The new industrial system had largely destroyed the personal relations between employer and employee; the new factories were often managed by men who used their power unwisely; and the workers combined to enforce their demands for the removal of abuses, the limitation of hours, and the improvement in other ways of the conditions of labour. In so far as these combinations acted directly and locally, they will be discussed in Chapter XI.; but the improvement ultimately assumed a national character, and in that aspect must be briefly considered here. The men had taken an active part in the agitation which preceded the Reform Bill, and were disappointed by the Act of 1832, which left then without the right to record their own opinion at the polls. Moreover they were encouraged, by the success of their masters, to press for a similar privilege for themselves, and when Robert Owen held out the prospect of a new Heaven and a new Earth they were not unwilling to enrol themselves under his banner.

Owen was at once a benevolent and successful cotton manufacturer and a political visionary, and was one of the ablest advocates of the early Factory Acts. He preached the doctrine that an adequate standard of life could only be secured through collective ownership of the means and instruments of production, and he proposed to achieve this object by creating *trade* and *trades* unions, in which each group of workers would own and control the trade in which they were engaged. Exchange of goods would then take place between different groups of workers, according to the time and labour involved in production. The fallacy lay in this idea of a labour currency—in the assumption that the value of a commodity depends upon the time required to produce it, and that the time value of all men's labour is the same. He imagined that his plan would destroy personal competition and personal property; but even if his ideals had been practicable, the methods of transferring capital were too vague to stand the fire of criticism or to be put to the test of experiment.

The impracticability of Owen's scheme was emphasised by a series of strikes in which the workmen were beaten, and the alarm conjured up by recollection of the excesses of the French revolutionaries led to repressive measures. No new Act was passed, but the law of conspiracy was so administered as to apply to cases to which it was never intended to apply, and many who were drawn within its jurisdiction were punished with brutal severity. That the fears were groundless, however, was shown in the relative impotence of the Chartist movement which was active from 1832 to 1848. Beyond a few strikes, and one threatened rising on a large scale, there was nothing to suggest the Parisian barricades. The temper of the people was, in fact, so mild during 1848, when all Europe was in a state of ferment, that mistrust of the working-classes gradually subsided. It was clear that in Britain working-men were taking things more seriously; a good many availed themselves of the opportunities for study afforded by the Mechanics Institutes which flourished during the middle of the century; some were reading works on political economy; trade union policy was directed by the moderate councils of the junta; and several of the larger Unions were concentrating attention on sick and unemployment benefits.

While the conditions were obviously becoming ripe for a further extension of the franchise, this was delayed by the indifference of Lord Palmerston, who cared for little but foreign affairs, and, as a matter of fact, was not subjected to very great pressure. On his death in 1865 William Ewart Gladstone and John Bright created a new interest in parliamentary reform. Gladstone's Bill of 1866 was not favourably received by the House, and on the accession to power of the Conservatives in 1867 Disraeli executed his famous manœuvre of "dishing the Whigs" by introducing the Reform Bill of 1867.

The new Act again dealt with both a redistribution and an extension of the franchise. Thirty-five boroughs lost the right of separate representation, and eleven had the number of their members reduced. The vote was given to all householders, and to lodgers whose rooms were of the value of £10 a year. In the counties the new qualification was a tenancy of the value of £12 a year. The result was to give almost complete representation to working-men in the boroughs, but to leave the agricultural labourers outside the constitution.

With the Education Act of 1870, the growth of the newspaper, and the ever-widening political outlook of the people, many statesmen recognised that this arrangement could not be final, and that sooner or later the country districts must receive similar treatment to the boroughs. Ultimately the Act of 1884 placed town and country on the same basis; and in the following year another Act reduced each constituency, except a few of the larger boroughs, to a single member. These two measures did something towards equalising the value of a vote.

The Acts of 1832, 1867, and 1884–5 mark the successive stages by which the people have acquired a predominant voice in the government of the country. They mark quite clearly also definite stages in scientific and material progress, for had not the steam-engine been applied successfully as a source of power it is unlikely that the conditions for the first Reform Bill would have been ripe within the century. Again, the rapid growth of railways between 1830 and 1860 created the political force which rendered the second Reform Bill inevitable. And finally a dozen years of popular education, together with the growth of the newspaper, not only led to the extension of the franchise in the counties, but also to the striking development of local government which occurred between 1887 and 1890.

The first of the Reform Acts added half a million voters to the register, the second a million, and the third two millions. That they still fail to satisfy the most ardent advocates of electoral reform is evident by the insistent agitation for manhood suffrage and votes for women—questions which lie outside the scope of this volume. More important considerations arise from the fact that the parliamentary vote represents only one outlet for political activity. Ever since the Municipal Corporations Act of 1835 there has been a tendency for the legislature to delegate more and more to Local Authorities the administration of, and financial responsibility for, the various measures concerning the health and welfare of the population; and it is in this membership of, and influence upon, these bodies that many have found scope for political and social effort. The development and results in this field will, however, be discussed in Chapter XV.

An extended franchise, compulsory education, free libraries, and newspapers have enabled the voice of labour to exercise an increasingly powerful influence in the House of Commons. The first men to secure seats as labour candidates were Alexander Macdonald and Thomas Burt, who were unequivocally elected on a labour programme. The numbers have increased with slight fluctuations until they form a fourth group, ready, like the Irish, to cast their weight against either of the older parties which merits their displeasure. The old two-party system has to some extent broken down, and a clear issue is not so easy to raise as in the old days. On all except one or two questions which, for a time, dominate the situation, there is liable to be a cleavage which cuts right across the ordinary classification, and may cause any one group to become a house divided against itself. Members of the House of Commons are often only nominally representatives of a constituency, and are really representatives of a section of the community not limited to the area in which the votes are cast. In respect of all social legislation the controversy rages in the main between a solid labour group and a solid capitalist group, each with a fringe of varied political colour. And it is quite conceivable that, on some questions, a section of capital may find itself in agreement with a section of labour in defence of an interest which for the time being binds employers and workmen in one industry together. The labour group has hitherto shown a remarkable solidarity; but it has not been seriously tried by any attempt to control one industry for the welfare of the country as a whole. In fact the Labour Party is still so much concerned in the struggle for political power, that it can hardly be said to have such a clearly thought-out policy on broader national questions as it has in respect of those which arise from the conflicting interests of capitalists and workmen.

It is impossible to leave this subject without emphasising the extent to which the government of the country is in the hands of the people. No statesman to-day dare embark on a new venture unless he is sure that he has a very considerable body of public opinion behind him. However much he may feel the need for reform or the urgency of a new departure, he is only able to proceed so far as the electorate believe in the need and the efficacy of his proposals. The programme by means of which a party in opposition endeavours to secure a transfer of power from the party in office to themselves does not represent so much what they feel the needs of the country to be, as what they feel the country will welcome with the greatest unanimity. It follows, therefore, that a truly enlightened policy can only spring from an enlightened electorate; the nation more or less gets the government that it deserves; and the highest patriotic duty is to educate the people up to the measure of their great responsibility.

CHAPTER XV

THE FUNCTIONS OF GOVERNMENT

THE constitutional changes described in the last chapter were not the sole results of the industrial revolution. Alterations in the methods by which the people maintained their existence broke down the old modes of life and social relations, and created new problems which legislation alone could solve. This legislation brought in its train administrative machinery of corresponding magnitude and complexity. Matters which were formerly of individual and local importance such as the Postal Service, became national in character, and needed special Departments of State for their management and control. In the same way Education also came to be recognised as a service which could not be left wholly to local initiative and effort. The relief of distress had been regarded as a national responsibility from Tudor times, but the old Poor Law was found to be ineffectual in practice, so it had to be revised. The rapid growth of the factory system placed thousands of men, women, and children in unfavourable conditions not entirely of their own choosing, or at the mercy of unscrupulous employers, and the State intervened to safeguard the lives of its future citizens. And finally, as legislation increased in scope and volume, Parliament delegated more and more of administrative responsibility to Local Authorities, a method which had at least the advantage that the authorities were under the close observation and influence of those on whose behalf the laws had been made.

National Education and the State Control of Factories are of such profound importance to an industrial community that they will be discussed separately in Chapters XVI. and XVIII.; here we shall be content to describe briefly the stages by which Local Authorities obtained their powers, and the scope of their functions.

The first Act of the Reform Parliament of 1832 was to deal with the defects of the Elizabethan Poor Law. The Act of 1601 had not worked, on the whole, unsatisfactorily; its value had to some extent been destroyed by the Restoration Law of Settlement, but it was improved by the Workhouse Act of 1723. In the latter half of the eighteenth century, however, the industrial revolution and enclosures, together with the high prices which prevailed during the wars, created an abnormal amount of distress. An attempt was made to meet the situation by an Act in 1787—Gilbert's Act—which not only permitted parishes to be combined into Unions, but empowered the magistrates to give relief from the rates without requiring the recipients to perform their task in the workhouse. Five or six years later the Berkshire justices held their famous meeting at Speenhamland and, while exhorting farmers to raise wages, created the unwise precedent of supplementing these wages out of the rates. The result was that the farmer paid the lowest wages for which he could obtain labour, and the labourers lost the incentive both to industry and to independence. Further, it led to a decrease in the age at which pauper children could be apprenticed, without the safeguards which the Act of Elizabeth had secured.

The Poor Law Amendment Act of 1834 grouped the parishes into Unions, required the Guardians to be elected, abolished outdoor relief, and practically reimposed the workhouse test. It was, in effect, a return to the earlier system, but with much more efficient administrative machinery, and to this last fact it owes nearly all its importance. The employer had to offer a reasonable wage, and the labourer had to earn it; for wages could no longer be supplemented from the rates, and the workhouse came to be regarded as an institution to be avoided at all costs. But as the Act recognised no obligation on the part of the State or the Local Authority to provide employment, many undeserving people suffered the ignominy of pauperism through fluctuations of trade over which they had no control. The grouping of parishes was also such as to cause wide variations in the poor rate, so that the poor kept the poor. But the chief indictment against a system which has been in existence for eighty years is that, while it seeks to give a minimum of relief, it does not *prevent* destitution. It is a palliative, and not a cure.

The shortcomings and disadvantages of the Poor Law have always attracted the attention of social reformers, and during the last thirty years both the need for some alternative provision and its nature have been revealed by a more scientific study of economic and social problems. The result of the investigations led to a series of Acts between 1908 and 1911 which affords relief to industrious work-people without the civic disabilities and stigma which were inseparable from relief by the Guardians. By means of Labour Exchanges workmen are informed of employers who need labour, and can ascertain where vacancies exist, and employers can obtain the labour they need; by Old Age Pensions the aged and indigent obtain such assistance as will, in the majority of cases, enable them to keep out of the workhouse; and by the National Insurance Act people with incomes of less than £160 per annum are compelled to insure against sickness and unemployment.

Apart from one or two isolated efforts, attempts to establish Labour Bureaux date from 1892, when a number of municipalities endeavoured to deal with the prevailing distress; but without very much success. In 1905 an Unemployed Workman Act was passed, the main object of which was to relieve distress by the provision of employment on public works and in other ways, but it also included the power to set up Labour Exchanges. The only town to make any use of this power was London, where the Central (Unemployed) Body established a system of Metropolitan Labour Exchanges, co-ordinated by a Central Clearing House. In 1909 the Royal Commission on the Poor Laws and the Relief of Distress recommended the establishment of a National System of Labour Exchanges, and an Act was passed in the same year empowering the Board of Trade to adopt the suggestion.

There are now about 400 Exchanges in the country. At these centres workmen who are out of employment can register their names and obtain information as to vacancies in their own neighbourhood or in any other part of the country. The Exchange is neutral, and takes no responsibility either in regard to the competence of the workman or the wages or conditions of labour of the employment. By increasing the mobility of labour unemployment is diminished; and by removing the necessity for workmen to tramp from town to town in search of work, the Labour Exchange helps to separate the idle vagrant from the industrious "out-of-work." The Poor Law can then be administered with greater stringency in regard to the ne'er-do-well. It is also possible to reduce the disadvantage of seasonal trades by drafting men from one to another, and some effort has been made to reduce the amount of casual labour in such towns as Manchester, Liverpool, and other ports. Juvenile branches working under the same Act or in co-operation with Local Education Authorities under the Education (Choice of Employment) Act of 1910, render assistance in placing children under seventeen years of age in suitable occupations, and, by means of voluntary After-Care Committees, keep them under observation for the first few years. Finally, the Labour Exchange is the medium for the payment of unemployment benefit under the National Insurance Act.

The idea of old age pensions is not of recent growth, but has developed gradually as part of the social doctrine created by the Industrial Revolution. As long ago as 1879 a scheme was drawn up by Canon Blackley which formed the basis of proposals by Mr. Joseph Chamberlain and others. It involved a compulsory contribution of £10 at eighteen years of age, or of 1s. 3d. a week between eighteen and twenty-one, the amount being deducted from wages by the employer and paid to the State through the Post Office. The insured person was to be eligible for 8s. a week sick pay, with an old age pension of 4s. a week at seventy years of age. Various modifications were made from time to time on the recommendations of the Friendly Societies.

An alternative scheme for the Endowment of Old Age was advocated by the Hon. Charles Booth, as the result of his enquiries into the "Life and Labour of the People in London" between 1887 and 1892, and at a Conference of Friendly Societies in Manchester in 1902 a resolution was passed in favour of a pension "of not less than 5s. a week for all thrifty and deserving persons of sixty-five years of age and upwards who were unable to work and were in need of the assistance." They demanded, however, that there should be no interference with Friendly Societies' funds.

By this time the provision of old age pensions had become absorbed in the larger question of State Insurance against Sickness and Unemployment. The Friendly Societies appeared to have reached the limit of their influence, and it was obvious that one way to prevent destitution was to compel people to insure against misfortune. As a first instalment of the greater scheme the Pensions Act was passed in 1908. Within three years nearly a million persons were enjoying a free pension of 5s. a week at a cost of £11,000,000 a year. There was an immediate reduction in the amount distributed by the Guardians, and many poor families were relieved of a burden which they had willingly shouldered to spare their parents from the ignominy of the workhouse.

In 1909 the Chancellor of the Exchequer (Mr. Lloyd George) proceeded to deal with National Insurance. An agreement with the Friendly Societies was reached, but the Budget of 1909–10 was delayed by the House of Lords, and it was not until 1911 that any progress could be made. A dispute then arose with the medical profession, the members of which complained that the allowance of 4s. per person per annum for attendance and medicine was insufficient. They demanded 8s. 6d., and feeling ran so high for a time that there was some possibility of an attempt being made to establish a State Medical Service. Ultimately they accepted the offer of 6s. 6d. for attendance and treatment, with 6d. extra for the home treatment of tuberculosis, 1s. 6d. for medicines and drugs, and a reserve of 6d. between the doctor and chemist.

The administration of the Act was placed under the general control of Insurance Commissioners, there being separate bodies for England, Scotland, Ireland, and Wales, with a Joint Committee of Commissioners to deal with larger questions of policy or interpretation. Detailed administration was delegated to Insurance Committees of from eight to forty members in each County and County Borough, with District Sub-Committees in the Counties. The constitution and functions of these bodies are, however, too complex to be described here.

All persons in receipt of wages less than £160 a year fall within the scope of the Act. Subject to certain modifications depending upon age and amount of wages, the contribution to the State is 7d. for a man and 6d. for a woman, of which the employer contributes 4d. and 3d. respectively; but both men and women earning less than 15s. a week pay a reduced contribution, while that of the employer is increased. These payments are made through the Post Office by stamps affixed to the card which every insured person must possess. The benefits, again, are subject to appropriate variation, but it will be sufficient to state that men between twenty-one and fifty, if married, or having others dependent upon them, are eligible for 10s. a week sick pay and 5s. a week disablement pay after 104 weekly contributions, while women receive 7s. 6d. and 5s. under similar circumstances. There are, in addition, maternity benefits, and various provisions for the treatment of tuberculosis. Payment is made through the Friendly Societies, and in this way a mass of existing machinery is utilised. The scheme affects 10,000,000 people who were previously uninsured. The benefits amounted to over five millions in

1912–13, over fifteen millions in 1913–14, and will gradually increase to more than twenty-five millions in 1932–33.

The provisions of the National Insurance Act relating to unemployment apply compulsorily only to certain scheduled trades, but voluntary insurance is encouraged outside this field by State contributions to approved associations of workmen in all trades. Members of a Trade Union which provides out-of-work benefit may draw their benefit from this source, the Union recovering from the Labour Exchange the amount which would have been distributed in the ordinary way. The first week of unemployment is ineligible for benefit. After that the amount is 7s. a week for fifteen weeks in each year. No man can have more than one week of benefit for each five weeks' contribution, and men on strike, locked out, or dismissed through misconduct are not eligible. The money is provided by contributions of 2½d. per week from the workman, and 2½d. from the employer, with certain modifications where the duration of employment has been less than a week.

We may pass now to a brief consideration of functions of government which are of a more general character—functions which are more intimately concerned with the every-day life of the whole population than with the economic conditions of the work-people. The second matter which engaged the attention of the Reform Parliament of 1832 was the local government of the towns which, under the Industrial Revolution, had outgrown their old constitutions. The Municipal Corporations Act of 1835 set up Borough Councils elected on a similar basis to the members of the House of Commons. The Justices in Quarter Sessions remained the sole authorities in counties until the Local Government Act of 1888, when County Councils were established. Meantime the Act of 1870 had created School Boards, whose functions were transferred to County and Borough Councils by the Education Act of 1902.

The first important duty delegated to the municipalities was the administration of the Public Health Act of 1848. This provided for Local Boards in boroughs and other populous districts, called Local Government Districts, but in the former the existing Town Council generally undertook the work. The central control was vested in a Public Health Board, which grew out of the Poor Law Board, and was expanded, after an enquiry by a Royal Sanitary Commission, into the Local Government Board in 1871. This central body took over certain duties formerly discharged by the Poor Law Board, the Home Office, the Privy Council, and the Board of Trade. Outside the towns and urban districts there was no authority responsible for sanitary arrangements, but in 1872 a general system of urban and rural sanitary districts was created. Since that time the responsibilities of the Authorities in regard to Public Health have been enormously increased, partly as a result of the discoveries in the cause and prevention of disease, partly on account of the increasing density of the industrial population, and partly in view of a growing feeling that these matters are truly the function of enlightened local government. The Act which led to the largest increase of responsibility was that of 1875.

A series of Acts also defined the obligations of the various authorities in regard to main roads—a problem which acquired greater importance with the increase of heavy traffic. The growing cost and national character of this work has been recognised by the establishment, in 1910, of a Road Board with power to recommend grants and loans from funds at the disposal of the Development

Commissioners created in the same year. In 1870 the Tramways Act regulated the provision of Tramways and gave Local Authorities the right to purchase the undertakings on "scrap-iron terms" after twenty-one years, or later, at their discretion. The conditions were not very favourable to private enterprise, and when the Act of 1882 gave Authorities the right to purchase land and raise loans, they availed themselves of it to undertake tramways and several other services which are discussed in Chapter XIII.

In addition to Municipal Trading, Education, and certain powers under or akin to the Factory Acts, the chief functions of the Local Authorities may be classified roughly under four heads, viz. Public Health, Highways and Communications, Protection of Property and Regulation of Trade, and what have been called extra-Municipal Powers and Services. In the first section fall wide responsibilities in regard to sewerage, the collection and disposal of refuse, the abolition of nuisances, the regulation of offensive trades, the prevention of infectious disease, the provision of hospitals, burial of the dead, inspection of food, the employment of Medical Officers of Health, and health visitors.

Under the second head they must construct and maintain roads within their areas, they have power to construct tramways, they can maintain motor or horse omnibuses and steamboats, and they may undertake the transport of goods as well as passengers. Before the telephone system was taken over by the State municipalities could, and some did, obtain powers to establish their own systems.

The protection of property and the person is secured by the police, first established in London by Sir Robert Peel in 1828, and in the provinces some years later, and the administration of Acts and By-laws is enforced through the magistrates. The Authorities maintain fire brigades, have powers in relation to the diseases of animals, the accuracy of weights and measures, the quality of gas supplied by private companies, the storage and sale of petroleum and explosives; they issue licences to dealers in game, to theatres and music-halls, and certificates to pawnbrokers; they inspect slaughter-houses, emigration agencies, pleasure-boats, and race-courses; administer charities and the Wild Birds Protection Act, take care of lunatics, keep a register of midwives, and exercise a right of veto over the discordant notes of steam-whistles.

The last section comprises duties in relation to markets and fairs, baths and wash-houses, libraries, museums, gymnasiums, pleasure-grounds, commons, allotments and small-holdings, ancient monuments, unemployment, and the power to advertise in order to attract industries or seasonal visitors.

The extraordinary complication of local government is intensified by the fact that many powers are exercised under Local Acts, and even when these deal with what is commonly undertaken, there is considerable variation in detail. Moreover, under many Acts which are of general application the Authorities frame their own By-laws, and these vary in number and scope according to the special circumstances of the area. Again many Acts are permissive, so that some Authorities do, and some do not take advantage of the powers conferred. The tentative legislation is due partly to a recognition of differences in local conditions, and partly to the growing difficulty of raising a clear issue upon which a definite affirmative or negative can be obtained. The theory, such as it is, behind local government in England is that Local Authorities may do nothing without statutory powers, whereas in Germany they may do anything which is not expressly forbidden. But the use which has been made in England of the progress of Science and Invention has given Democracy such a generous measure of political freedom that an enlightened Authority has very little difficulty in securing additional powers for any desirable object.

CHAPTER XVI

THE STATE AND THE FACTORY

THE regulation by the Central Government of the hours and other conditions of employment dates nominally from the decline of the Gilds, but the Act of 1802 was the first of a series rendered necessary by new industrial conditions, and inspired by motives which had not hitherto been called into being. The older legislation was directed towards the prevention of idleness, the newer towards the prevention of overwork. In the older Acts questions of health and sanitation never appear; the newer ones are essentially measures for securing hygienic and sanitary minima. The commission system of industry which became prevalent in the seventeenth century was conducted in many cases under conditions as harsh and demoralising as those in the early factories; but it lacked that concentration which was necessary to attract the attention of the philanthropist, the sanitarian, or the social reformer. Not until large numbers were brought together, amid surroundings which threatened the health of the community, did the voice of protest make itself heard in high places.

The evolution of Government control in the cotton and coal-mining industries, and in transport, has already been discussed in the chapters dealing with these subjects; but as the principles upon which interference is based are now universally recognised, and as the practice has been extended to many trades which receive no separate treatment, it will be convenient to trace in outline the growth of this type of parliamentary activity. It is interesting to notice, in the first place, that the birth of the factory system was contemporaneous with a great outburst of scientific enquiry. Watt, Priestley, Black and many others had been lifting the veil from the face of Nature and obtaining glimpses of mysteries which they laboured to solve. Most of the preceding centuries were graced by one persistent investigator, but the eighteenth could boast a dozen. Nor was this curiosity and unrest confined to the world of inanimate nature. The seeds of the events which led up to the French Revolution were sown many years before, and though they did not germinate in violence in this country, there were many who gave anxious thought to the social fabric, and sought diligently for some means of mitigating the evils which met their view on every side. The teaching of the single celebrated English exponent of Economic Science at this period—Adam Smith—was opposed to interference.

Among the men who allowed their scientific habits to wander outside the limits of the laboratory was Dr. Percival of Manchester, who founded the Philosophical Society of that city. When, in 1784, an outbreak of fever occurred in a cotton mill at Radcliffe, the Lancashire justices requested a Committee of Manchester medical men to investigate the cause and circumstances, and one of the leading spirits of this Committee was Dr. Percival. The Report of the Committee, which was printed and circulated, failed to specify the exact cause, but attributed the extent and virulence of the outbreak to overcrowding and the long hours of labour, which combined to reduce the vitality of the employees.

The magistrates passed a resolution to the effect that pauper children should not be apprenticed to employers who required them to work at night or for more than ten hours a day. In 1793 an Act was passed which authorised justices to impose a fine of 40s. on masters convicted of ill-using an apprentice, but there appears to be no evidence that it was ever enforced.

In 1795 Dr. Percival and his colleague established a "Manchester Board of Health" and reinvestigated the conditions obtaining in mills. In a series of resolutions they emphasised the insanitary conditions, and pointed out the gravity of their results. They expressed the opinion that nothing short of an Act of Parliament would successfully combat the evil, and that this Act should secure cleanliness of the buildings both for working and sleeping, cleanliness of the body, adequate clothing, wholesome food, time for sleep and recreation, medical attendance, and the rudiments of education. These resolutions are to be taken as the most outspoken manifestation of a growing opinion against the exploitation of the most helpless members of the community; and when, in 1802, Sir Robert Peel brought in the "Health and Morals of Apprentices" Bill, it passed with hardly any opposition. But this was largely due to the fact that it was regarded rather in the light of Poor Law than of Factory Legislation.

The first test case on the expediency of State interference in the management of factories was fought when the pauper children had become a less important element in factory labour. Since 1785 the steam-engine had been more widely employed as a source of power; the factories were larger, and were no longer situated in remote valleys; and child labour was recruited from the populous towns which were springing up on or near the coal-fields. With increasing prosperity came a wider outlook; and employers like Robert Owen introduced on their own initiative a reduction of hours and improved conditions which showed that these changes were not incompatible with commercial success. In most mills, however, the conditions were disgraceful, and in 1815 the first Sir Robert Peel secured the appointment of a Committee to investigate the whole circumstances.

The evidence tendered to the Committee was perplexing in the extreme—not because it was consciously biassed, but because it consisted so largely of opinion and so little of fact. The prevailing tone of the opposition to restriction was that trade should be fostered by the State and that the proposed regulation would be injurious. Nevertheless the Act of 1819, the chief provisions of which are given on pp. 90-91, was passed, and the threatened national catastrophe did not occur. It was slightly amended in 1820, 1825, and 1831, but no very great changes were involved.

From 1830 began a new agitation for the extension of Government control, and in 1832 Michael Sadler brought in a Ten Hours Bill. The opposition of manufacturers led to its being referred to a Select Committee, but before a report was issued Sadler lost his seat at the General Election of 1832, and his work was taken up by Lord Ashley, afterwards Earl of Shaftesbury. When the conclusions of the Committee were found to be unfavourable to the employers, they pressed for Commissioners to investigate matters on the spot, and were again astonished to receive a decision in favour of legislation. It is important to notice that some of the dissatisfaction with previous Acts arose from the difficulty of enforcing the regulations, and from the practice by which children were engaged, not by the employer but by the workman. Even where the employer was desirous of improving the conditions he was not always able to do so.

The Act of 1833 which arose out of the above-mentioned enquiry was not merely a measure for reducing the hours of labour for children and young persons. It brought, for the first time, adult women into line with young persons so far as a twelve-hour limit and night work was concerned. It required machinery to be fenced; it applied to all textile factories; and it provided for the appointment of inspectors to see that the law was obeyed. Moreover, for the first time a special section of a Government department was established for the administration of a particular Act. The employers, by pressing for a Select Committee and for Commissioners, had inadvertently provided Parliament with information which showed a need far wider than had been contemplated at the beginning of the controversy. It was obvious that the Industrial Revolution had brought along with it new problems which only State intervention could solve; and that *laissez-faire* principles, however applicable they might be to fiscal policy or industrial combinations, could not be used as a cloak to protect industrial oppression arising from indifference and commercial greed.

The mere passing of the Bill through Parliament was not enough to secure the objects at which it aimed. The inspectors—four in number—were too few to exercise very effective supervision, and, wide as were their powers, they were unable to enforce the regulations. Unscrupulous manufacturers found ways of evading the Act, the most important of which was known as the relay system. The eight hours which a child could work might fall anywhere between 6 A.M. and 6 P.M., and it was extremely difficult to ascertain the exact time of starting and leaving off in each case. Then there were difficulties at first in obtaining evidence as to age, owing to the fact that births were not registered by law until 1837, and medical certificates of fitness were rather easily secured. Again, schools were few and often unsatisfactory, while the relay system, even when worked in strict accordance with the Act, entirely prevented attendance for instruction during the usual hours.

To the accumulated evidence of the inspectors was added an agitation, which had been insistent for a number of years, to secure a uniform ten hours' day. Arising first among the woollen workers of Yorkshire about 1830, it spread to Lancashire and London within a couple of years. But legislators had gone so far by the Act of 1833 that they were unwilling to proceed further. One difficulty was that it would have involved increasing the hours of children's work, and this alienated the sympathies of some who would, on general principles, have been in its favour. After 1841 the plea was advanced definitely on behalf of adult women, and in 1844 an Act was passed which fixed their hours at twelve per day, and incorporated several recommendations of the inspectors. Thus the half-time system was established to enable children to attend school at the ordinary hours, machinery was to be more securely fenced, and many details which experience had shown to be necessary for effective administration were included. Three years later, by the Act of 1847, the maximum number of hours to be worked by women was reduced to ten. In order to defeat this some employers had recourse to the relay system, and a further Act, fixing the hour at which work could be commenced, and the hour by which it must cease, as well as the maximum duration of employment, had to be passed in 1850. This is the first instance of a legal working day.

Up to this period Factory Legislation had been mainly the result of individual effort on the part of philanthropists, of whom the Earl of Shaftesbury was far and away the ablest and most influential. It was also supported at times by representatives of the landed interest, as a sort of revenge upon the manufacturers for their campaign against the Corn Laws. Joseph Hume, who had been such a tower of strength in securing the repeal of the Combination Laws in 1824, was opposed to it on the ground that it was incompatible with *laissez faire*; and for the same reason John Bright and Richard Cobden threw their weight into the scale on the side of the manufacturers. In the height of the controversy at the election of 1832, when Sadler, the strenuous advocate of the Ten Hours' Day, lost his seat, his opponent was the famous historian, Macaulay.

By 1860 practically all these men had been converted. It was recognised that the actual production in eleven hours might be, and in some cases was, greater than that in twelve. Moreover, it was becoming more and more apparent that periods of rush and hustle were often followed by periods that led both to moral and physical deterioration. The revelations of the Commission of 1840 on the conditions of labour in Coal Mines had done much to convince responsible people that events were happening in the rapidly growing industries which, if not stopped, would prove a canker in the life of the nation. The demand for legislation was also taken up by the workmen themselves. The Coal Mines Act of 1850 was drawn up on the petition of the miners, and provided for the appointment of inspectors; and the Act of 1860 secured the appointment of a check-weigher for each pit to prevent fraud by employer or employed. And though the law still took note only of Mining and Textile Trades, the expansion of, and rapidly increasing variety in, industry was beginning to force legislators to take a wider view of their responsibilities.

The principal extension of Government control took place in 1867, but it was preceded by tentative experiments in several trades outside those originally regulated. The practice of appointing a Children's Employment Commission to collect evidence, which had been established in 1833, had been followed again in 1843. An enquiry into calico-printing showed that out of nearly 20,000 employees more than 5600 were children under thirteen years of age; and that of 565 children taken at random, nearly two-thirds had begun to work before they were nine years old. The trade was not found to be unhealthy, but it was liable to irregularity; and the children were required to take their share of overtime and night work. The report is interesting, because it contains exact evidence to show that even in machine-minding an excessive number of hours of labour leads to an increase in the amount of spoilt work. A Bill brought in by Lord Ashley, similar to, but less drastic than, the Factory Acts, was passed in the face of some opposition in 1845.

In 1853 the Bleachers in Bolton and the west of Scotland commenced an agitation for shorter hours, and many of the employers in the north conceded the men's demands. But in this, as in other cases, a few of the masters stood out, and forced the others to return to the older practice. As a result of a Bill introduced by Lord Shaftesbury in 1854, the Government appointed Mr. Tremenheere to report on the conditions obtaining in the industry. The trade was similar to that of cotton-printing in that it depended largely upon material sent to be bleached or dyed in a hurry. Legislation was favoured by the Commissioner, but after several abortive attempts to frame a Bill which would be acceptable, a further enquiry was undertaken by a Select Committee. Incidentally, this revealed the fact that work was sometimes carried on in a temperature of from 90° to 130° Fah. for sixteen or eighteen hours a day, and an Act was finally passed in 1860. Bleach and dye works were placed under the same regulations as textile factories, except open-air bleaching, which was dealt with two years later. By permitting time lost in the course of trade fluctuation to be made up again it was, however, not so effective as its promoters desired.

The Factory Acts had originally applied to work in populous centres. On the other hand, the Print and Dye Works Acts of 1845 and 1860 regulated employment in industries scattered about the country, where water for the process was plentiful, and where there was ample space to dry the cloth. An enquiry into the Lace Trade in 1860 dealt with an industry that was still to some extent in the domestic or commission stage. There was also a special feature in the fact that women and children came into the factory to change the bobbins when the machinery was at rest. Owing to this fact and to the practice of working in shifts, the hours of labour, even when not excessive, were apt to fall very early in the morning or undesirably late at night. The workers had to be available, for example, at any time between 4 A.M. and 10 P.M. This was held to be sufficiently unsatisfactory to justify interference, and the Lace Works Act of 1861 placed this industry under practically the same conditions as the Textile Factories.

The third Children's Employment Commission was appointed in 1862 to enquire into the conditions of labour in industries "not already regulated by law." The first outcome of their investigations was the Act of 1864, which covered the manufacture of pottery, lucifer matches, percussion caps and cartridges, and the employments of paper-staining, hooking and finishing (connected with dyeing but still unregulated), and fustian cutting. In all these cases the employment of children at a very early age, the long hours of labour, and the unhealthy or even dangerous character of the employment were the main reasons for State interference. The Act was the first measure in which home employments were placed under regulation, and it was also the first occasion on which Special Regulations were sanctioned for dangerous trades.

The mass of information accumulated by the Commissioners led to two further Acts in 1867, one dealing with Factories, and one with Workshops. The distinction between them was the number of persons employed. Originally the intention was to fix this at 100, but 50 was the number finally adopted. The Factory Acts Extension Act made no change in the law with regard to Textile Factories or the industries covered by the Acts of 1845, 1860, and 1864, but it regulated work in a large number of metal, rubber, paper, glass, and tobacco trades. In addition to limiting the age of admission and hours of labour of children and young persons, it empowered the employer to draw up regulations for dangerous trades, and contained clauses prohibiting the employment of women and children upon certain processes. Nevertheless the list of exemptions occupied more space than the Act itself, and much of the benefit that might have been derived from it was lost.

The Workshops Act contained similar provisions in regard to hours of labour, but permitted earlier and later hours of starting and finishing. The same difficulty of supervision which had been experienced under the earlier Factory Acts arose again in this case. Moreover, the administration was placed in the hands of Local Authorities, who were mostly either unwilling to undertake it or were more amenable to local influence than an officer of a Government department. In many respects, therefore, this Act possessed little value other than as an illustration of the attitude of the State towards the industries conducted on a small scale.

Since the Ten Hours Act of 1847 there had been many attempts to secure a shorter legal day, and several industries had in fact secured a fifty-four hour week without aid from the legislature. In 1847 the textile operatives began an agitation for an eight-hour day, and in 1872 the Factory Acts Reform Association started a campaign for a fifty-four hour week, the forty-eight hour week not being considered as within the range of practical politics. The concession was desired by male rather than female workers, but as no one dared to suggest limitation of the hours of labour of adult males, the battle was waged "from behind the women's petticoats." Commissioners who were appointed by the Home Office in 1873 to enquire into the health of women, children, and young persons in textile factories, reported that the stress had increased since 1847. There were more machines to one operative, the machines were run at a higher speed, and pressure was exercised by overlookers and foremen, who received a premium on output. A Bill known as the Factories (Health of Women) Bill was killed by Liberal opposition in the same year, and when the Conservatives returned to power in 1874 they passed an Act which, while confirming the twelve-hour day, secured half an hour extra for meals and abolished overtime. The age of commencing work was raised to nine, and to ten in the following year.

It is rather curious to notice that the opposition to this measure for reducing the hours of women came from Liberals who were permeated with individualism, and from the women themselves. The former, finding *laissez faire* effective as a principle of fiscal policy, made the principle a shibboleth and applied it to the exclusion of common sense and common humanity. It is a remarkable general fact of political history that men whose sincerity, humanity, and intelligence were beyond question, appear to have been able to understand only one thing at a time. The women were impressed with the fear that limitation of hours for them would lead to their replacement by men—a fear that has died hard, though it has over and over again been proved to be groundless.

By this time the result of dealing with the industries of the country piecemeal was leading to confusion, and in 1876 a Consolidation Commission was appointed. The result was an Act in 1878 which brought factories and workshops into line, reaffirmed the sanitary requirements (which have since been placed under the jurisdiction of Local Authorities), but was lax in regard to women's hours, and exhibited the weakness of previous legislation in the number of exemptions. Thus, while it brought about some order into the heterogeneous law relating to factories, public opinion was still so little formed that there were many inconsistencies. A mistaken view of individual liberty was still strong enough to prevent interference with many industries, and tended to neutralise the efforts towards a satisfactory standard of public health over the whole field. The child was protected only where vested interests were unable to oppose State regulation, and where adult labour was available in plenty for the employer whose principal deity was Mammon. So far, and only so far, had a movement based on emotion, sentiment, or religious fervour succeeded. But a new influence was about to arise. A report of a House of Lords Committee on the Sweating System in 1889, the report of the Labour Commission in 1894, and the researches of Mr. Charles Booth on the Life and Labour of the People in London from 1886 to 1893, are examples of a more scientific study of industrial conditions and their social effects. Without such study no satisfactory solution could be found.

The results are to be seen in various directions. There has been a gradual strengthening of parliamentary opinion implied in the Acts by administrative regulations issued or approved by the Home Secretary. These have special references to health and safety. Beginning in a small way with the Act of 1864, the principle was extended in the Acts of 1867, 1878, 1883, 1891, and made applicable to workshops employing men only in 1895. It is clear from the discussions which took place, as well as from the nature of the regulations, that the Factory Acts were not now regarded as charitable arrangements for the protection of the poor and helpless, but as standards of life and labour which must be maintained by those who wished to exercise the privilege of employing others. By the Act of 1891 every occupier of a Factory or Workshop was required to keep a list of all those employed inside or outside his premises, and in the latter case of their places of residence. By the Act of 1895 a copy of this list had to be supplied to the Factory Inspector, and by the Act of 1901 the Local Authorities concerned were also to receive a copy. The number of inspectors has been increased, and the practice of employing women as well as men inspectors was adopted in 1893.

The extension of Factory Legislation to Laundries and to Retail Shops is rather outside the scope of this volume, but we may note that the same arguments have been used, and the battle has had to be fought as though there was no governing principle behind it. The same remarks apply to the regulation of street trading by the Employment of

Children Act of 1903, which in 1915 has still not been adopted in some towns. The establishment of Trade Boards, to regulate wages in chain-making, box-making, lace-mending and finishing, and the making of ready-made clothing is, however, of first-rate importance. The practice has been in operation in Victoria since 1896, and a similar result has been secured in New Zealand by an Arbitration Act passed in 1894. The British Act was passed in 1910, and is at present only an attempt to destroy the evil of sweating in those industries which are specially favourable to the practice. Nevertheless it furnished a precedent for the Minimum Wage in Coal Mines Act which came into operation in 1913.

The importance of taking adequate measures for the protection of work-people from injury in the course of their occupation is emphasised by certain Acts which secure for them monetary compensation when the accident is not due to contributory negligence. To a certain extent this is provided for in the Common Law, but there are three main Acts which, together with minor ones, constitute a special code, defining in detail the circumstances and extent of the employer's liability. Under Lord Campbell's Act of 1846 certain relatives of a person killed by accident can recover damages if the person himself would have been entitled to do so had he survived. When the person is a workman, and injury or death is due to wilful act, negligence, or omission on the part of the employer, the employer is liable either under Common Law or Lord Campbell's Act. The workman or his relatives are not entitled to recover if the accident arises from contributory negligence or common employment.

The Employers' Liability Act of 1880 provided for damages in the form of a single sum of money, limited to three years' earnings, in case of injury or death; and the only defence was that of contributory negligence. The scope of the principle was widely extended by the Workmen's Compensation Act of 1906, which included practically all occupations—manual, clerical, and domestic—and excluded only seven classes of people. In case of injury the compensation consists of weekly payments equal to half the average earnings during the previous twelve months, or such shorter period as the injured person may have been employed. In case of death the award is three years' earnings or £150, whichever is the greater, with a maximum of £300. Cases of dispute are settled by an arbitrator, who in England is usually a judge of the County Court, and in Scotland the Sheriff. The arbitrator has the right to call in a medical referee to act as assessor. The injury must arise out of and in the course of ordinary employment, and serious and wilful misconduct is a bar to compensation unless death or permanent injury ensues.

Against the liability thus thrust upon him the employer adopts the most effective safeguards in his factory, workshop, or yard, and takes out an insurance policy which covers any claim likely to be made upon him under the various Acts. The amount of the premiums adds slightly to the cost of production in manufacture, and, in so far as it is measurable, probably the consumer pays. In professional callings, or in case of private or domestic service, it adds a little to the cost of living. But it provides a means of preventing a great deal of hardship which might otherwise be suffered by people who have very little reserve, and who live from week to week only slightly removed from destitution.

So much for a brief outline of the steps by which the State has gradually asserted its right to regulate industry.

It remains to be said that the most satisfactory conditions of employment—the healthiest surroundings, the maximum safety, and the highest wages—are to be found in those factories and workshops which are most completely governed by rules prescribed by the legislature. While the proposals have been generally welcomed by both manufacturers and men, it cannot be said that either has played the most prominent rôle in securing the benefits which both enjoy. The men have always been active enough in securing shorter hours or higher wages, the employers in pleading for legislative protection against those who exploited the workpeople under their control. In the early stages philanthropists did much, and in later years the labours of serious students of economics and the annual reports of H.M. Inspectors of Factories have been the main contributory causes responsible for the present Factory Code.

CHAPTER XVII

THE EVOLUTION OF ECONOMIC THOUGHT

JUST as the increasing complexity of factory processes necessitated a study of the conditions which make for economy and efficiency, increase of output, and the avoidance of break-down, so the growing complexity of social and economic relations attracted the attention of scholars who devoted themselves to the human as distinct from the technical problems of industry. While British political history reveals little evidence of the policy being guided by any broad and comprehensive theory of government, the investigations and writings of economists have not been altogether without influence upon the march of events. The references in this book to *laissez faire*, and to wage disputes, will justify, even if they do not necessitate, a brief account of the more important views which have been held during the last two hundred years.

The word "economic" is derived from two Greek words, *oikos*, a house, and *nomos*, a law. The Greek writer Xenophon wrote a book entitled *Oeconomicus*, which is a treatise on the conduct of the estate from which the Greek household derived its livelihood. Thus economics, from the earliest times, was concerned with the "laws" or general propositions which are found to underlie the actions of a family (including slaves and dependants) engaged in getting a living. The family is not, and for long has not been, a sufficient unit for study of this kind. In England the term Political Economy, and in some other countries the term National Economy, have been used to denote the science which is an endeavour to state those "laws" which can be discovered to underlie the activities of a larger unit, the nation, whilst engaged in "getting a living." That the term "Economics" is now more generally used may be taken as an indication that students of this science are increasingly inclined to study mankind whilst engaged in the ordinary business of life without any national or political limitations.

When people are getting a living they are engaged in obtaining food, clothing, shelter, and, unless this occupies all their energies, they also obtain as much as they can of other good things by which people live: ornament and decoration, amusement, refinements, the use of beautiful dresses, pictures, books, comfortable arm-chairs, and cosy beds, in short, all the things we call the amenities of life. But one who can obtain all that he wants of necessities and a very large share of amenities is, we should say, a rich or a *wealthy* man. Without troubling to discuss in all its details what is or is not wealth, we can agree that wealth consists of all those things which people want in order that they may use or "consume" them. The livelihood of people, therefore, depends upon what wealth is produced, how that wealth is shared, and how, to what extent, and by whom it is consumed. Thus an economic theory is a theory (or general proposition) which has to do with the production, the sharing, or the using (consumption) of wealth.

It is obvious that in the history of the world people must at all times have thought, spoken, and written on these subjects. And if we search the literature of the world at any available period we shall find evidence of this. For instance, economic theories are to be found in the Bible; and *Piers Plowman* is, in motive, almost entirely an economic work. Nevertheless, it is true that Economics is one of the youngest of the sciences. It is only when the business of life becomes more specialised and less simple that we get notable attempts to set out in a systematic way any theories concerning the production, sharing, and consumption of wealth. We must pass over the many writers, including, for instance, Sir Thomas Gresham and Sir William Petty, and numerous French writers, who gave attention to these things before and during the eighteenth century, and come down to the great Scotsman, Adam Smith (1723–90), who, by the publication of *The Wealth of Nations* in 1776, may be said to have founded the modern science. It is perhaps notable that the first book which established the true meaning of trade, and laid down principles as to the nature of wealth which are to-day unchallenged, was not a business man, but a shrewd and capable philosopher. It is impossible here to deal adequately with his great book, which is concerned with the production of wealth, its distribution into rent, wages, and profit, and with the causes which govern these, with the nature of money and of capital (or "stock" as Smith called it), with international trade, and with taxation.

Briefly, we may say that Smith showed that the material progress of society was based upon the "division of labour," and in doing this he foreshadowed all those investigations into industrial organisation with which modern Economics is so considerably concerned. He led the way to theories of rent, wages, and profits elaborated later by Ricardo, Malthus, and the two Mills. But the most famous portion of his work is the fourth book, in which he demolished mercantilist theories and delivered an attack upon protection which was to change the whole fiscal system of this country, and affect permanently the ideas of the civilised world as to the nature of international trade. Incidentally, he was able to show that government regulation and "interference" had in history usually been stupid in its methods and unfortunate in its results, and to him must be attributed (though he did not use the term) the general doctrine of *laissez faire* as the best principle to be followed by a Government, particularly in its dealings with commerce, but also its relations with industry. As elaborated by theorists who followed Adam Smith, and misunderstood by practical men, this doctrine worked much mischief. But his attack on a policy of restraint and unwise regulation of trade was necessary, and justified in the circumstances of his time. Adam Smith had no immediate follower as a leader of economic thought, nor, owing to the period of war which marked the close of the eighteenth and the opening of the nineteenth centuries, did his book for some time have much practical influence, though the repeal of the Usury Laws, and the repeal of the Apprenticeship Laws, may be said to mark the way in which his belief in economic "non-interference" was put into practice.

After that of Adam Smith the two greatest names among those who are now generally termed the "old economists" are those of the clergyman Thomas Malthus, and the stockbroker David Ricardo. With them we may associate James Mill, father of the more famous economist John Stuart Mill. The most famous work of Malthus was his *Essay on the Principles of Population*, first published in 1798; but he was a very voluminous writer on economic topics, and published *Principles of Political Economy considered with a view to their Practical Application* in 1820. In the meantime Ricardo had published his *Principles of Political Economy and Taxation* in 1817, whilst James Mill published *The Principles of Political Economy* in 1821. It will be noticed that, except Malthus's Essay, all were published in the years of stress and distress which followed the termination of the Napoleonic wars, in a period of industrial transition following on nearly a generation of economic waste. Their general doctrine was, no doubt unconsciously, affected by the special circumstances of their time. We have no space to deal individually with each of these writers, though their ideas, often loosely expressed and very often misunderstood, gave to Political Economy the nickname of "the dismal science." Malthus had been concerned about the distress which, in England, marked the end of the eighteenth century, the scarcity, the high prices, the low wages, and the consequent suffering; and he thought he had found the cause of the distress in the increasing numbers of the people. In a very learned and still interesting essay he was easily able to show that, in the absence of certain checks, the tendency of the human race has always been to multiply its numbers very rapidly; that numbers tended to increase faster than the supply of food-stuffs could be increased; and he argued that, in the future as in the past, unless numbers were restricted by prudence they would be restricted, if not by war, by disease and finally starvation. How far his arguments are justified we will enquire in a moment.

Ricardo, though he dealt with the whole scope of economics, is chiefly famous for his Law of Rent. He pointed out (and he was not the first to do so) that the amount of produce to be got out of any given area of agricultural land is not unlimited. That if the amount of capital and labour applied to the land is increased, the increase in the produce obtained may at first be considerable or even more than in proportion to the means employed; but that this cannot continue; that the time comes, and in most cases comes soon, when the increased produce obtained from increased efforts begins to diminish, and that a point is reached eventually when no increase at all is obtained. This statement has been called "The Law of Diminishing Returns." Now since this is so, runs the argument, there will be land somewhere which, owing to its deficiencies in fertility or advantages, only just affords a normal living provided the occupier pays no rent. This we may call land "on the margin of cultivation." If people will work for this return upon the marginal land, they will work for the same return upon other land. If land is owned, therefore, and competition is free, the owner of the land will, indeed, have to leave the occupier as much of the produce as he could get in the "marginal land," but no more. The rent of land therefore is a surplus. It is the amount by which the produce of any given area exceeds that of an area which it only just pays to cultivate; and, under conditions of private ownership and free competition, this surplus will go to the owner of the land. Such is the famous Ricardian Theory of Rent.

The doctrine, as propounded by Ricardo, was criticised, for instance, upon historical grounds. He had argued that as fertile land became fully occupied and people, owing to the operation of the Law of Diminishing Returns, moved to less fertile land, the excess of the product of first quality land over the second quality land could be taken by the owner of the first as rent. People answered that relatively infertile lands were often occupied first and more fertile lands afterwards, and that Ricardian principles therefore did not apply. They also pointed out that fertility was not the sole merit of land; proximity to markets might be more advantageous than fertility, and so on. But a moment's thought will show that if care is taken to state Ricardo's Theory accurately, these criticisms do not touch the substance of his doctrine. The more modern criticism is something like this: that Ricardo's doctrine tells us just nothing; that it merely means that some land has so few advantages that it will fetch no periodical payment and the more advantageous land will; and the greater its advantages the greater the rent—in other words, that the value of the use of land, like the value of anything else, is what it will fetch; and that what it all means is that, given private property, the owners of useful things will always be able to sell the right to use those things at a price varying with the degree of their usefulness. This, however, is not destroying the Ricardian theory but applying it far more widely; and this is, indeed, the justifiable modern tendency.

Of perhaps greatest interest, however, are the deductions concerning wages and the material prospects of the mass of humanity which, either by economists or politicians or lay or clerical preachers and pamphleteers, were drawn from economic writings and were sought to be applied in practice. The doctrine of *laissez faire* became for any one class a maxim to be applied, if not to one's own class, at least to all others. Adam Smith had pointed out that regulative laws concerning foreign trade, apprenticeship, usury, and even merchant-shipping had been usually a failure and always of doubtful utility. A fair field and no favour therefore became a maxim of universal application. Men are the best judges of their own economic interests, ran the argument. Leave them alone and the force of competition will guide them into the most profitable avenues of business. This doctrine, which, owing to the inefficiency and impotence of governments was undoubtedly one which needed preaching at the time concerning the larger activities of business, was sought to be applied where obviously it was inapplicable. Since the government should not seek to regulate foreign trade by duties, *ergo*, individual labouring men should not be allowed to combine to raise wages, shorten hours, or make other conditions of employment. The merchant and the manufacturer should be free, and the conditions of employment should be a matter for individual contract. Thus combination by the workpeople and regulation by the State were equally and entirely inadmissible. Indeed, Malthusian doctrines showed to the educated man that even were such combination or regulation admissible, it would be futile. Population tended to press upon the means of subsistence. Increase wages, said they, and people are tempted to marry, children are born, or to put it more elegantly, "the supply of labour is increased," and wages must diminish. Wages, therefore, cannot permanently rise above the minimum necessary for subsistence. This was the "iron law of wages" with which Karl Marx was to make such terrible play. In fact, doctrinaire Socialism of the German type is a direct and logical deduction from the Malthusian and Ricardian doctrines that owners can and will take all surplus product above the ordinary remuneration, and that that remuneration cannot for long rise above the minimum means of subsistence. The wages of the labourer are governed by the cost of his production.

Fortunately, mankind, in so far as it determines its future, always, in the long run, chooses to test theories for itself. The very years in which the doctrines of individualism and free competition and economic hopelessness were being preached as the new economic and political evangel, saw practical men, forced by the spectacle of human misery for which they as employers were responsible, bringing Factory Bills before Parliament. It was a cotton lord who brought in the first Factory Act, and a philosophic Radical who destroyed the Combination Laws. Men are never entirely dominated by their own doctrines. Looking backward we may indeed regard the political doctrines of Malthus, Ricardo, and James Mill, especially as elaborated and preached by McCulloch and Nassau Senior, and even by John Stuart Mill, very much as we regard the Copernican astronomy. The Science of Economics had to have its beginnings, that is to say, its mistakes; and they were no greater, indeed they were less completely and ludicrously wrong than were the corresponding early generalisations of the physical and natural scientists. For much of what Smith, Malthus, and Ricardo wrote is, and apparently must remain, as true as time or sunlight. It may be useful, however, to summarise some of the major errors of the old political economy, and in doing so to state some of the accepted and fortunately more cheerful doctrines of the new.

1. A major error, still committed by many estimable people, is to regard "laws" of political economy as "imperative," and not as generalisations which may be followed or not just as we please. An imperative law is one which says, "if you do or neglect to do some act you will be fined forty shillings." It is not open to you to deny the validity of this law, or, if its provisions be not observed, to avoid its consequences. A scientific law is merely a statement of fact or rather of hypothesis. If I can show that Newton's laws of motion are not valid, not only may

I do so, but I ought to do so, and shall acquire merit thereby. Further, though the law of gravity seems to be a sound generalisation, a miner is not acting wickedly if he props up the roof to prevent it falling upon him. Civilisation largely consists in resisting the consequences of the unregulated action of "natural" forces. So if an economist tells me that wealth will be maximised under conditions of free competition, it is open to me (*a*) to prove that it will not, or (*b*) to say very well, but we do not want wealth to be maximised; we prefer to be honest, happy, and relatively poor. To sum up, the laws of political economy are no more imperative than other scientific laws, and though so far as they are valid, they must always be taken into account, we may always choose to modify their operation by altering one or more of the conditions upon which their validity depends.

2. Malthus's doctrines, or the fears based upon them, have been shown to be false by history. The operation of the Law of Diminishing Returns has been retarded by modern inventions which have opened up the world and made the Black Lands of Russia, the pampas of South America, and the "illimitable veldt," for economic purposes, the "land" of England. Moreover, the fact that diminishing returns only operate provided our knowledge of how to produce even from agricultural land remains stationary, seems not to have been realised by the early economists. Forty-five millions of people can live in the United Kingdom at twice as high a level of comfort as half that number did a century ago, because the effects of time and distance have been minimised by improvements in methods of locomotion. And it is still possible that, even if such improvements ceased, increase of scientific knowledge might bring it about that an area now needed to feed a hundred may, in the

future, feed a thousand more easily. There is no known limit to human ingenuity. A short-sighted and bald-headed chemist may yet double the whole productivity of mankind. From the strictly economic point of view the expenditure of 100 millions of money on the discovery of a single scientific genius might be a ridiculously cheap investment.

Further, time has shown that as the subsistence level of people increases their tendency to multiply diminishes. Every modern civilised state now dreads not the bogey of Malthus, an increasing population, but a diminishing one.

3. Though it has not specially been mentioned above, yet it is implied in what has been said that the older economists thought the value in exchange of any commodity (including the labourer himself) tended to be governed by the expense of producing it. The actual price of a commodity, it is true, is decided by the "higgling of the market"; but if this price is for any length of time less than the expenses of production, production will be slackened and prices will rise. If the market price remains above the expenses of production the supply will increase and the prices will fall. Prices, therefore, it was argued, cannot normally differ from the cost of production, including in that cost normal profit to the producer. This normal value must be sufficient to remunerate the producer whose circumstances are least fortunate—the "marginal producer." More fortunately situated producers will obtain a surplus which in the case of agricultural commodities will be rent. In the case of other commodities there will be a similar surplus, "a quasi rent" which, according to circumstances, may take the form of specially high profits, wages, or interest, or rent of urban land. The modern economists, in England Jevons, on the continent the Austrian School, were able to

show that, as a complete theory of value, this cost of production theory was untenable. Take the case of an old picture, of the Koh-i-noor or of fifty things, said they, how is the value of such things related to the cost of their production? They developed a new theory somewhat to this effect: that the value of any group of commodities depends upon the amount of that commodity in relation to the demand for it. If there be only one Koh-i-noor its value will be very high, for the demand for it will be great. If there are half a million Koh-i-noors, and they are all to be sold, the price must be such as will induce the least willing of half a million purchasers to buy. Value is determined not by the marginal cost of production, but by the estimation placed upon the article (*i.e.* its *utility*) by the marginal buyer, that is, by its marginal utility.

Volumes of refinements could be written about this. And both theories are to a certain extent true and reconcilable. The value of ordinary goods which are reproducible does tend to be governed by the cost of their production. But for a comprehensive theory of value the "marginal utility" theory is the truer. We have written of this because of its bearing upon the value of a particular and vital commodity, labour. The value of the labourer, the modern economist would say, is determined not by the cost of feeding and clothing the "marginal," *i.e.* the most needed and least efficient labourer, but the utility of the labour. Make the labourer physically stronger and more intelligent, put him to work with better appliances, he will be more productive, therefore more esteemed, the margin of his "utility" rises, and his price, *i.e.* his wages, will rise too. This is the theoretical justification of material hope for mankind. There is *no* Iron Law of Wages. The wages of the sweated worker may go below a decent subsistence level. The wages of strong, intelligent, and cheerful men may and do rise far above it. And the rise does not, as we have seen, bring about an overstocking of the labour market—often the reverse. Economic theory, therefore, is for the labourer no dismal science but a doctrine of hope, and a justification of material progress.

Further, we may add one word as to the methods of science. The old economist sat in his chair with books and blue books and the dome of his head as his only weapons. These weapons are, and must always be, of great service. But the modern economist is no arm-chair theorist. He follows, as far as is possible, inductive methods, investigating facts, studying particular problems, and generalising rather upward from his observations than deducing downwards from a set of postulates. The danger to-day, in fact, is not in over but in under generalisation, not in a tendency to theorise, but in a disinclination to do so. Pendulums, however, *swing*.

CHAPTER XVIII

NATIONAL EDUCATION

THE History of Education is the history of attempts which have been made from time immemorial to equip the youth to work out the destiny of the race. It begins in the dim past, when the parent instructed his son in those arts by which existence is maintained, and when the mother trained her daughter in those duties and responsibilities which fell to the lot of woman. Education was practised by the early priesthood, firstly, for training the members of their own order, and, secondly, for enabling their adherents to understand their teaching. When the written code superseded the unwritten custom the function of education spread from ecclesiastical to civil government and administration. Sometimes the training was casual and sporadic, sometimes conducted with a definite curriculum and time-table, but all the while signifying that unerring instinct by which man seeks to perpetuate his triumphs whether in the sphere of intellect or of practical achievement. But profoundly interesting and important as the History of Education is in its wider aspects, the size and purpose of this volume compel the author to confine his discussion mainly to its nature and purpose in a limited field over a limited interval of time.

The subject can be regarded from three points of view—as a phase of the function of government, as an expression of democratic ideals, and in relation to industrial progress; but none of these is independent of the others. Moreover, there are three motives behind all educational controversy. The desire of the parent—selfish but not unnatural—is to secure for his offspring the greatest measure of material prosperity and happiness, and he is willing, therefore, so far as his means allow, to pay for artificial equipment as an addition to natural ability, or as a compensation for its shortage. The idea of the philanthropist, who wants to educate everybody, has its theoretical basis in the instinct which preserves the traditions of the race. But the principles upon which a national system of education rests are in harmony with both views only in so far as the persons educated can thereby render more useful service to the community. Neither Factory, nor Trade Union, nor Educational Legislation were intended to confer privileges upon an individual or a class. They are not charitable in the ordinary sense of the word; they are protective in respect to the State and not to the individual; and they exist in order that the highest individual excellence shall be secured to the service of the nation.

The Grammar Schools and the Universities trace their origins to mediæval times, but it was only after the invention of printing that schools, as we understand the term, arose. The pamphlet and the book were such powerful political weapons that henceforth no government could afford to remain indifferent to the number of schools and the character of their teaching. Under the parental care of the Tudors education was encouraged but regulated, and under the Stuarts it suffered from the political unrest and the religious controversies of the time. In these circumstances higher education declined, and many Grammar Schools made no recovery until after the Endowed Schools Act of 1869. On the other hand, there were several distinct movements in the direction of elementary education, which would take us too far afield to describe in detail.

The chief landmarks in the history of elementary education in England are 1833, 1870, 1891, and 1902. In its first year of office the Reform Government made a grant of £20,000 for the erection of school buildings. Until that time the chief agencies for the supply of education were the National Society and the British and Foreign School Society—the former a Church and Tory, and the latter an Undenominational and a Whig organisation. Their efforts were the outward and visible sign of a widespread feeling that schools were necessary to counteract the evil influences of the factory system and town life on the child. The appalling conditions which led to the Factory Acts of 1802 and 1819 revealed the fact that the moral and intellectual life of the children was being sacrificed on the altar of material progress, and that some measure of education was necessary in order to prevent them sinking still lower in the moral scale. But the system of parochial schools was quite unable to cope with the problem, especially in the industrial north, and the aid of Parliament had to be invoked.

For six years the administration of the grant remained in the hands of the Treasury, and then passed to a Committee, consisting of the President and five members of the Privy Council. In 1856 this Committee was expanded into an Education Department, with a Vice-President as representative in the House of Commons. To the grant for school buildings one of £10,000 for normal schools was added in 1834. The Treasury had initiated the practice of financing the inspection of schools by the two societies in 1838, but the Committee of the Privy Council undertook this duty themselves. They intended also to establish a Normal College of a national character, but in view of the acute religious controversy they handed this over to the societies. In other respects the Committee adopted a bolder policy. In 1847 aid was extended to the provision of schoolmasters, pupil teachers, and monitors, so that in 1852 the total sum disbursed was £188,000. By 1863 the estimates reached £804,002, and more than a million children were under instruction, while an enormous sum had been expended on buildings.

But in spite of this expenditure, and the progress which had been made, no one was satisfied. Not more than half the children of school age were receiving instruction, and not more than 27 per cent of those were over ten years of age. Efforts were made time and again to establish a national system controlled by central and local bodies with power to provide the necessary accommodation, and to compel attendance for a reasonable period. But every attempt was wrecked on the religious question. The controversy reached its height in 1839, but lost little in bitterness as the years rolled by. The Liberal party, in its adherence to *laissez faire*, objected to rate-aid as tending to undermine voluntary effort, and a conscience clause was opposed by the religious bodies on the ground that it "would make England a nation of infidels." The proposal of a purely secular system united all denominations in determined opposition. But the voluntary system had failed, and Lord Brougham, who had spent half a century in unremitting toil on its behalf, acknowledged his conversion to a State system in 1864.

The outcome of fifty years of strenuous effort was the

Education Act of 1870. It divided the whole country into educational districts, and provided for the election of School Boards in all those with insufficient accommodation. In London there was one Board with special rating powers; in the Boroughs the rating authority was the Town Council; and in the country districts Boards were to be selected for single or grouped parishes, and the rate collected by the Overseers of the Poor. The provision of schools, where the existing provision was inadequate, was compulsory, and fees were to be approved by the Education Department; but attendance could only be enforced through local bye-laws, the strict administration of which was not obligatory. In 1876, however, an amending Act imposed penalties upon parents who did not educate their children, and upon employers who infringed the provisions as to school attendance in the Act or the local bye-laws.

While the Act did not replace the voluntary system, the increase in efficiency and cost in the towns subjected the voluntary schools and the rural Board Schools to severe competition. The threepenny rate, foreshadowed by Mr. Forster when introducing the Bill, was insufficient from the beginning, and in areas where the assessable value was low the Board Schools were starved. The voluntary schools had to depend upon fees and private subscriptions both for the upkeep of the fabric and for working expenses not covered by the grant. To some extent the difficulty had been recognised in the Act of 1876, which provided that the grant should in no case fall below 17s. 6d. a head; but stipulated also that it should not be increased beyond 17s. 6d. except by so much as the income from local sources, including endowment, rates, fees, and subscriptions, exceeded that sum. Moreover, very small rural schools were to receive an additional grant of £10 or £15 in view of their special circumstances. The 17s. 6d. limit was withdrawn in 1897, but in the meantime voluntary schools were on the average 10s. a head poorer than the schools which could claim the support of the rates, and the saving was effected largely on the staff.

It is difficult to enforce any compulsory system unless it is free, and though the Act of 1870 had given School Boards the power to exempt from payment of fees in cases of poverty, there is always a feeling that what is to the national advantage ought to be paid for out of the national purse. In 1891, therefore, an Act was passed which increased the grant by 10s. a head, the equivalent of a fee of 3d. a week, and required that schools which had formerly charged a fee of this amount or less were to be free. Where the fee had been more than 3d. a week the managers were entitled, with the approval of the Education Department, to charge the difference.

Since 1856 the Education Department had been linked in brotherhood with, and, in accordance with the traditions of the Civil Service, had maintained an attitude of armed neutrality towards, the Science and Art Department. In the country the School Boards, encouraged by the liberal Evening School Code of 1890, had embarked on higher education, and the Science and Art Department had begun to give aid both to Secondary and to Higher Grade Board Schools through the medium of Science and Art subjects in the curriculum. After some years the legality of the application of the School Board rates to secondary education was called in question by Mr. Cockerton, an auditor of the Local Government Board. When the courts decided that the sphere of elementary education was confined to children under fifteen years of age, and that the School Boards were not entitled to provide instruction usually given to older students, the necessity of further legislation became imperative.

By an Act passed in 1899 the two central authorities had been amalgamated into a Board of Education, with a President and Parliamentary Secretary, on the same plan as the Local Government Board and the Board of Trade. The unification of local administration was then achieved by the Act of 1902, which swept away the School Boards and made the council of a County or County Borough Council responsible for all forms of education within its area. There were two exceptions in that Boroughs with more than 10,000 inhabitants, and Urban Districts with more than 20,000, were the authorities for elementary education within their own boundaries. The elementary education rate was unlimited in all cases; the higher education rate was unlimited in the County Boroughs, and limited to 2d. in the Counties; while the autonomous Boroughs and Urban Districts were entitled to supplement the County rate of 2d. for higher education by an additional 1d. in their own area.

But administrative unity was not the only purpose of the Act. For the first time voluntary or non-provided schools were to be aided out of the rates, and for the first time a local authority had full legal sanction to provide secondary education. Voluntary school managers were required to maintain the school fabric, and could even, if they wished, build new schools; but the rates were to be devoted to the sole purpose of carrying on secular education.

The storm of religious controversy which the Act aroused, both before and after it came into operation, has hardly ever been exceeded. With the exception of a few British and Wesleyan Schools the Nonconformist bodies had no schools of a strictly denominational character, and they had come to regard the Board Schools as the only ones in which the Established Church exercised little or no influence. The historical antagonism between church and chapel had found its modern expression in the conflict between a voluntary and a rate-aided system of education, and each side was more willing to sacrifice the secular instruction of the children than to yield on the question as to what kind of religious teaching was to be given to them. Bitter, however, as was the controversy for the first few years, it has largely died down, and is now little more than an echo flung across the valley of time.

The curriculum of the people's schools has never been limited absolutely to the mere rudiments of Reading, Writing, and Arithmetic. In his evidence before the Select Committee of 1834 Lord Brougham pleaded for "The elements of historical and geographical knowledge, a little natural history and drawing, with grammar and singing," as an irreducible minimum. But while the years of school life were so few, practically the whole time had necessarily to be devoted to the attainment of proficiency in the mechanical processes. Educationalists could not fail to be impressed, however, with the scientific and mechanical triumphs which followed the application of the steam-engine, and the growth of democratic ideals fostered hopes and aspirations far exceeding those which were entertained by the pioneers.

One change which marked the effect of these ideas was the introduction of Manual Instruction. It originated in the Report of the Royal Commission on Technical Education which was issued in 1884, and which pleaded for a more practical training to be given in the schools. The first experiment was made by the London School Board, and it was quickly followed by Manchester and other industrial towns in the North and Midlands, but it did not spread to many counties until after 1900, and during the last few years has undergone an important alteration in principle. The early instruction was a modified course in carpentry, with formal teaching in the use of tools, and a complete independence of the rest of the curriculum. The tendency now is to utilise handwork to explain and reinforce the teaching in other subjects, and the attainment of skill is regarded as subsidiary to the general educational value of the exercises. It is probable that the pendulum has swung too far in some cases, but whatever the errors of the past or present, Manual Instruction has brought a new interest into school life, and it tends to develop accuracy and resource to a degree which was wanting in the old days.

Another noticeable development to be recorded was the introduction of Nature Study. This was, no doubt, a reaction from the formal and academic instruction in "specific subjects" of science which was prevalent in the 'eighties and early 'nineties. The study of plants and animals, with far too casual and occasional glances at other features in the neighbourhood of the school, soon became a fetish; and a really effective element in education, if judiciously employed, was occasionally rendered ludicrous by well-intentioned zeal. Conducted by a sympathetic teacher in a country school, and associated with practical achievement in the shape of a school garden, the subject does much to create observant, thoughtful, industrious, and intelligent children. It gives reality to lessons in geography, and a practical purpose to manual training and drawing.

There has always been a desire to train the child for the responsibilities of citizenship by definite instruction in civic rights and duties; but in spite of meritorious effort, two obstacles have always stood in the way. One is the difficulty which a child of fourteen or under has in comprehending the complex human relations—still more the ethical and political principles—which have grown up during the last hundred and fifty years. And without comprehension the effect of the teaching is negligible. The pupil may acquire some ideas about civics, but what he needs is civic ideas. This distinction leads to a second difficulty. The elementary school teacher has to deal with children whose school life is an existence apart from their own home life. In thousands of cases the home life fails to reinforce the lessons learnt in school. They are taught cleanliness and temperance; some of them see filth and drunkenness. They are taught industry; they see on every hand examples of idleness. They live for a few hours a day for five days a week, for ten months a year, in an atmosphere of order and discipline, and during the rest of the time they are exposed to disorder and anarchy. Finally, they leave school just before the age at which permanent habits begin to be formed. This is the darkest side of the picture, but it is the side upon which the elementary school is too often judged and condemned.

The direct teaching of civics, therefore, is attended on the whole with only moderate results; but it is strongly supplemented by the corporate life of the school. Not only in class, but in organised games, and in the school journey, the children learn the essential inter-dependence of human life and effort, and become imbued subconsciously with that sense of social service which is the highest expression of civic virtue.

Evening Schools

When elementary schools were as yet few and scattered, there were to be found in odd places men who eked out a scanty livelihood by giving lessons in the evening to those who desired to learn. It was in such a school that George Stephenson, the father of the World's Railways, learnt at nineteen years of age to write his name, and he was one of a hundred examples that lie hidden away in the biographies of the men whose labours are manifest in the material progress of the present age. Occasionally schools of this kind were established and conducted by persons whose benevolence at least was highly developed, though their scholarship might be open to suspicion, and in other cases classes had the honour of being taught secular subjects by a bishop of the Established Church. In the first half of the nineteenth century many of the evening schools were definitely associated with day schools, and by 1855 they received capitation grants from the Government. But until 1861 day-school teachers were forbidden to teach in night schools also. The subjects recognised were Reading, Writing, and Arithmetic, and the grant was determined by examination. From 1860 to 1876 the limits of age were twelve to eighteen, but in the latter year the upper limit was raised to twenty-one. In 1870 there were 73,375 in attendance, but this number steadily declined until, in 1886, it was only 26,009.

The cause of this fall may be traced to the fact that when a generation of children had enjoyed an elementary education under the Act of 1870 the need for instruction in the rudiments had almost entirely disappeared. But in the meantime a new need had arisen. Large numbers of young people were seeking knowledge in Science and Art Classes, for success in which their elementary education was an insufficient preparation; and the Report of the Royal Commission on Technical Education in 1884 emphasised the desirability of utilising the night schools for preliminary training. Unfortunately the two types of school were under different central authorities and different local authorities, which rarely displayed a spirit of co-operation and were often mutually antagonistic. So that, when the Education Department issued its Revised Code in 1890, the School Boards took advantage of their wider powers to embark on competitive schemes, without even providing adequate preliminary training for their own students.

The new Code was followed by ten years of anarchy. The teachers were instructed to make the work "interesting," and they often succeeded in making it ineffective. In London and other towns the schools were free. The numbers at the beginning of the session were exceptionally high, and at the end of the session abnormally low. Sometimes the organisation broke down altogether; fragments of classes were continually amalgamated, and the staffs reduced. If, to some people, this still appears to have been the golden age of evening schools, it is because they have in mind isolated cases in which the influence of a headmaster of personality and genius created in his own school an island of order in a vast ocean of aimless confusion.

When the Act of 1902 placed both types of school under one authority the industrial towns of Lancashire and Yorkshire led the way in establishing spheres of influence for each type of school—an example that has been followed slowly by the rest of the country. Tentative experiments in a few towns had shown what sort of preliminary curriculum was best suited for subsequent technical and commercial studies, and, largely under the influence of the Examinations of the Lancashire and Cheshire Union of Institutes and of the West Riding County Council, the schools began to provide only systematic courses of study, as distinguished from instruction in single and unrelated subjects, for students whose economic interests lay in industry, in commerce, or in domestic duties.

The system has been criticised on several grounds. The purely vocational aim of the instruction invites condemnation from those whose ideals are those of a cultured leisure, and who fail to realise that the highest service which some men can render to the community is expressed in professional zeal. The requirement that a student must attend three nights a week or not at all is said to impose an undesirable strain on the growing boy, and to deter many who would join if the conditions were less exacting. On the first point it may be said that the schools cannot pander to a system of slavery, and that if a boy is working for so many hours a day that he is physically and mentally exhausted, the conditions call for vigorous interference by the State. The second point is an argument in favour of the individual as against the community. It is a plea for a national system of education to be modified so as to be more favourable to the weakling and the slacker; it is often an attempt to convert the schools into factories for the production of cheap labour; it ignores altogether the educational experience which has led to the adoption of three nights as the normal for technical and commercial courses.

There is often complaint that the schools are narrow in the scope of their operations, and narrower still in the measure of their success, and that they fail to provide for the wide variety of mind and temperament which may be supposed to exist among the youth of the nation. But the curriculum is not altogether illiberal, and a teacher with knowledge, enterprise, and skill can give instruction within its limits which is not without educational value. Moreover, the system possesses greater stability than any which has yet been tried, and the very definite purpose which is set before the schools is responsible for not a little of their efficiency.

Technical Education

In the first half of the nineteenth century, when strenuous efforts were being made to supply every child with the rudiments of Education in day or evening schools, another movement arose which was of almost incalculable value to industrial development. The new inventions were creating a desire for scientific knowledge among intelligent workpeople. The steam-engine and the wonderful mechanical devices which its use called forth, the steamship, the railway, the electric telegraph, together with the multiplication of books and newspapers, were things which affected everyday life and spurred into activity the instinctive curiosity which is so intimately connected with human progress. Such needs were met to some extent by courses of lectures to working men, such as those delivered in Anderson's College, Glasgow, in 1823, and later, by the establishment of Mechanics Institutes in the industrial towns.

Meantime a Committee of the Privy Council in Trade had been created by an Order in Council of 1786, and this body acquired more and more responsibility until it became ultimately a separate Government Department with the title of the Board of Trade. In 1836, acting on the Report of a Select Committee, a Normal School of Design was established, and this was followed by provincial schools in 1841. The Great International Exhibition held in London ten years later drew attention to the wide scope for scientific and artistic training in the industries modified or created by the industrial revolution. In 1852 a Department of Practical Art was formed, in 1853 a Science Division was added, and in 1856 the Department of Science and Art was transferred to the new Education Department —as a partner, but with some differences in constitution, procedure, and responsibility.

The first Act of the Department was to establish a Science College in London. The nucleus out of which this was formed was a private institution known as the Royal College of Chemistry, which was subsequently amalgamated with the Royal School of Mines. The name of the Science College was altered to Normal School of Science in 1880, when the training of Science teachers became its main function. It was altered to the Royal College of Science in 1890, and both the science and mining divisions were merged in the Imperial College of Science and Technology in 1905. In 1859 payment on the results of examinations was instituted in Science, and in 1863 the same plan was adopted in Art. A partial alteration to payment on attendance took place in 1899, and the change was completed in 1902 when the Education Act of that year came into force. Building grants were made for Schools of Art in 1856 and for Schools of Science in 1868, the practice being continued in both cases until 1897, when the rating powers of the Local Authorities and the Exchequer Grant had rendered special aid from the Central Authority of less importance. The right to build schools out of the rates had also been conferred under the second Public Libraries Act of 1865, but the amount was limited to 1d., and not many were erected under this sanction.

The history of Evening Technical Education is divisible into three periods. Until 1890 the work was mainly unorganised pioneer effort. Students selected their own subjects of study, the classes were farmed out to the teachers, and the schools were supervised by non-statutory committees and unpaid local officers, whose main qualifications were their earnestness and respectability. But yeoman service was rendered in those days by teachers who were mostly enthusiasts, and many of whom were real sources of inspiration. In their hands was moulded the army of trained men who kept the flag of British Industry flying when continental nations entered the field, and it was upon the results of their labours and their experience that subsequent improvements were made.

The Government was in those days alive to the need of artistic and scientific training. In 1864 a Select Committee reported on Schools of Art, and in 1868 another one reported on Scientific Instruction for the Industrial Classes. From 1870 to 1875 a Royal Commission on Scientific Instruction took evidence and presented a Report in ten volumes; and in 1880 a Royal Commission on Technical Education was appointed, which issued its Report in 1884. The result of all these enquiries was a mass of information, which revealed the urgent need of reform in all branches of education, and especially in its bearing upon industry and trade. The spirit of the times is indicated by the formation in 1877 of a Committee of the London Livery Companies with the avowed intention of developing a national system of Technical Education. The Finsbury Technical College was established in 1879, and the committee was registered as a company under the title of the City and Guilds of London Institute in 1880. The Central Technical College at South Kensington was founded in 1884. The Institute took over the examinations in Technology formerly conducted by the Society of Arts, leaving that body to continue the examinations in Commercial subjects.

A number of legislative enactments and administrative changes which encouraged industrial education cluster round 1890. In 1887 a Technical Instruction Act for Scotland was passed; in 1888 the Local Government Act created County Councils; in 1889 the Technical Instruction Act applied to England, Wales, and Ireland, and permitted a rate to be levied; the Customs and Excise Act of 1890 allocated the "Whiskey Money" to County and County Borough Councils, and gave them power to apply it to Technical Education. This marks the beginning of the second period—the era of confusion in the counties and of Bricks and Mortar in the towns.

It was not without great unwillingness that the County Councils undertook the new duties. They were not, as a rule, interested in Education, and they had to do pioneer work in a new and difficult field. The Town Councils, on the other hand, had been in close touch both with industrial needs and educational efforts; the building of Mechanics Institutes had long since stopped, and there was a crying necessity for more and better accommodation. Technical Schools sprang up all over the country, though the expense on many of them was, perhaps, hardly justified by the magnitude and importance of the evening work alone. But the expansion of the ordinary night schools under the ambitions of the School Boards acted as a stimulus, and the new buildings served a useful purpose at a later stage as the homes of Pupil Teacher Centres and Municipal Secondary Schools.

The efficiency of the schools was largely increased by the influx of a body of teachers who had been trained at the Royal College of Science and in the provincial University Colleges, which had developed rapidly in the preceding twenty years. But the organisation still left much to be desired. The School Boards competed with the Technical Instruction Committees, except in commercial subjects, for which the latter could obtain no grant. There was no obligation upon either authority to provide preliminary instruction, so students continued to be admitted to classes for which they were unfitted, and but little control was exercised over the choice of subjects. The British attitude towards specialised education was not unfairly illustrated by the fact that a boy of fourteen was tacitly recognised as competent to decide upon his own course of study.

When the Act of 1902 placed the two types of school in each area under one local authority, overlapping was immediately stopped, and in the North of England, more especially, the new curriculum ensured a supply of suitably prepared students to the Technical Schools. These schools on their part arranged courses of instruction appropriate to the different industrial groups, and effected order where chaos formerly ruled. The period since 1902 has been a period of organisation. The changes have not been made without opposition, and, in some places, must be regarded as still in progress. But the stability of the classes and the efficiency of the schools have been enormously increased, so that there is no likelihood of a return of the confusion or anarchy which characterised the 'nineties.

Objections to recent changes have usually been based upon the hardship and possible danger to health involved in attendance on three evenings a week; but both the hardship and the danger are exaggerated. It is an especial merit of the evening-school system that the men who succeed possess power of sacrifice, and a quality of perseverance which increases their industrial value. But there is no doubt that hours of labour make the burden heavier than it need be, and we have the sorry spectacle of the State providing Technical Education, while taking no steps to secure the full national benefit which might accrue from the expenditure.

It remains to be noted that between the first and the third periods there has been a marked change in purpose. In the 'seventies the object was ostensibly to train workmen, but the introduction of labour-saving machinery in all but a few artistic crafts has reduced the importance of the workman, while it has called for greater scientific and technical knowledge on the part of those in responsible positions. For various reasons which cannot be given here the purpose of the instruction, except in commercial subjects, has tended to become most suitable for men aiming at higher posts, and the training of foremen and others of intermediate grade has, outside the largest towns, been comparatively neglected.

Non-Vocational Schools

The old Science and Art Classes attracted many serious students who, without any special industrial object, desired to learn anything and everything. The new Technical Schools are attended almost entirely by students with a strong economic motive—so strong in fact that only the rigidity of the course system secures that they shall not waste their efforts in narrowness and premature specialisation. Moreover, there has always been a feeling of regret that the schools did so much for the limited life of the workshop, and so little for the wider life of citizenship. Great hopes were held at one time that the University Extension Lectures, started in 1867, would provide the leaven that was needed, and in 1896–97 there were 332 courses with an average attendance of 40,909 students. But though they resulted in the establishment of certain University Colleges, they never really constituted a working-class movement, and greater success was obtained, though over a limited field, at the Working Men's College established in London by F. D. Maurice and his friends.

A movement fraught with greater possibilities arose out of a Conference on the Higher Education of Working Men held at Oxford in 1903. From this sprang the Workers' Educational Association, the object of which was to provide additional facilities for the higher education of artisans and others similarly situated, not by overlapping, but by utilising existing educational agencies. The Tutorial Classes established under their auspices have spread with considerable rapidity. The academic standard of the teaching is ensured by the fact that all tutors are supplied by the University Extension Boards, and by the requirement that students who join should undertake to attend a three-years' course. The success of the movement is due to the fact that in many cases the classes are grafted on to a local branch of the Independent Labour Party, the Adult School Union, or similar body. There is no limitation as to the subjects of study, but the fact that the students are mostly men who are interested in politics and social questions accounts for the popularity of History and Economics. Through these classes the results of historical and economic research are being brought within the reach of industrial democracy—a result, moreover, not so much of pressure from without as of a demand from within. And in that fact lies the whole strength of the movement.

Day Technical Classes

The Evening Schools which have so far been considered are truly national in origin and character, and have their counterpart in no other country in the world. But the obvious disadvantage of a part-time system confined wholly to winter evenings has led to numerous attempts to establish day schools with an industrial aim. In 1872 the Science and Art Department issued regulations for

Organised Science Schools, and a few were actually opened; but they were never very successful, and only three were in existence in 1885. The grants were increased in 1892, and in 1895 the regulations were so modified as to require the inclusion of literary subjects. As a result the number of schools rose to 112, and two years later to 169. These were mostly Higher Grade Board Schools, and it was their competition with the Endowed Grammar Schools which caused the latter to apply for recognition under the regulations in considerable numbers, and which led ultimately to the legality of the School Board's expenditure being called into question. In the case Regina *v.* Cockerton the judges decided that the School Boards had exceeded the authority conferred upon them by the Education Acts.

To meet the difficulty a new type of school, called a Higher Elementary School, was suggested in a Minute issued by the Board of Education in 1901. This differed from the Schools of Science in that the upper limit of age was fixed at fifteen, and the scheme was planned for younger students. Higher Elementary Schools have since been provided for in the Code, but for reasons which will be given later they have never become numerous. Another attempt to establish schools which would provide a post-elementary school-training for boys who would enter industrial life at sixteen years of age was made by the Technological Branch of the Board of Education in 1905. These were preparatory trade schools, with a larger proportion of workshop training than any other type. Out of the experiments which followed this proposal Junior Technical Schools were evolved in 1914, and this form shows signs of coming into closer touch with industrial requirements than any of its predecessors or rivals.

But schools for students under sixteen are only preparatory in character, and where Great Britain has always been considered inferior to Germany and America is in the number of older students in attendance. During the last twenty-five years the Technological Faculties of the Universities and University Colleges have shown steady growth, and some of the larger Technical Schools have also provided systematic instruction for full-time day students over sixteen years of age. This development has been encouraged by the Regulations for Technical Institutions issued by the Board of Education in 1905, which provided for grants on a fairly liberal scale. Some of the Universities also obtained grants under these regulations for a time on the ground that the work of the Technological Faculties was not properly covered by the grant which they received from the Treasury; but the Treasury grant has recently been considerably increased.

Secondary Schools

The paramount importance, even to an industrial community, of that broad outlook which only a liberal education can confer, renders it necessary to include a brief outline of the development of secondary education. It has already been remarked that after the seventeenth century the Endowed Grammar Schools fell upon evil days. Their condition attracted the attention of those who were struggling to establish a national system of elementary education, and in the middle of the nineteenth century there were numerous appeals in Parliament for improved facilities for the children of middle-class parents. The chief source of trouble was the absence of any control over endowments, and the difficulty of securing reform without long and expensive proceedings in the Court of Chancery. After many more or less futile attempts the Charity Commission was appointed in 1853. It was a permanent body with power to conduct enquiries, and to draft schemes. In 1860 it received legal power under certain conditions.

A Royal Commission to enquire into Public Schools in 1861 issued its report in 1864 and resulted in the Public Schools Act of 1868. A similar Commission appointed to enquire into the middle-class schools in 1864 reported in 1867 and led to the Endowed Schools Act of 1869. This abolished for a time the control by the Charity Commissioners, which was, however, restored by the Endowed Schools Act of 1874. In 1902 the jurisdiction of the Commissioners over the Educational Endowments was transferred to the Board of Education, and the first step was taken to establish a State System of Secondary Education. The Act included a number of recommendations in the Report of a Royal Commission on Secondary Education in 1894–5.

Reference has already been made to the attempt of the Science and Art Department to aid Secondary Education through Science and Art grants. Not only did the Regulations of 1895 require Literary Subjects to be taught, but the instruction was inspected and reported upon. The movement was bitterly resented by those who felt that too much time was being given to the scientific element in the curriculum, and the Higher Grade Board Schools, which had adopted the system with open arms, were the object of much hostile criticism. For they rapidly came to be looked upon as the people's secondary schools. To the artisan and lower middle-class parent they provided a curriculum indistinguishable from that of an ordinary Grammar School. They taught History and Geography, Mathematics and Languages; and some of the students passed into the Universities with distinction. Whatever their faults—and these were doubtless many and grievous—they at least succeeded in stimulating a degree of educational enthusiasm among the people which was, and still is, a consummation devoutly to be wished.

The measure of appreciation of Higher Grade Schools of Science was a measure of the mistrust with which Higher Elementary Schools were received. The former did, and the latter did not, prepare for matriculation; and the result of the appeal to the law was regarded as an attempt to side-track the working-man's child from the path to a liberal education. The Secondary School was not yet cheap enough to afford the same opportunity, but the grievance did not remain for long. Under the new Act the Local Authorities made a liberal provision of Junior Scholarships, and in 1905 the Regulations of the Board of Education required each school to maintain a number of free places, up to a maximum of 25 per cent. Moreover, the considerable increase in the number of schools which followed the Act, and the improvement of others which were languishing for want of funds, so extended the facilities that few children are now deprived of that further education for which they have shown themselves to be fitted during their elementary school career.

In this brief review of educational progress it will be observed that the foundation was laid by individual effort which struggled in vain to keep pace with the growth of population and its ever-widening requirements. Under the quickening influence of the industrial revolution the State was forced, slowly but surely, to intervene, and to meet a national demand on a national scale. Elementary Education, Science and Art and Technical Education, Secondary Education, and to a certain extent University

Education, have in turn become subject to State control. And yet Englishmen in general do not believe in Education—except selfishly, in so far as it affects their own sons. In many instances they resent public expenditure, and do not realise that the nation is compelled to aid and foster Education for its own safety, for its very existence. And those who urge that the education of the people need not extend beyond the three R's, forget that people have votes. We stand to-day on the shoulders of those who have lived before us; we profit by their errors and add success to their successes. If even an outline of human knowledge as it grows is to be withheld from those who possess the franchise, there must be stagnation in political thought, and shackles of steel on political action. And above all, if education be not itself progressive in thought and action, it loses all power of human service. It becomes a plaything of the intellect, a shuttle-cock tossed backwards and forwards on the battledores of pedantry.

CHAPTER XIX

CONCLUSION

In the preceding pages we have described briefly how some of the more characteristic features of modern industry and its relations to social and political problems have arisen. We have traced the decay of family and domestic industries and the rise of a system in which large numbers of people are employed as wage-earners in factories, where they are subject to the will of a few men who own, or represent the owners of, the capital engaged. We have seen how the State intervened to protect the workers from unfair or injurious conditions which might be imposed by employers who failed to recognise their social obligations. At first merely an expression of sympathy with the weak and helpless, the movement has expanded until the responsibility of the State to secure for its citizens a reasonable standard of life has become accepted as a guiding principle of politics. Unwilling at all times to restrict the freedom of the individual, the Legislature has done the minimum which appeared to be necessary to prevent oppression and moral and physical injury. But the workmen have striven on their own behalf, and have secured for their Unions a recognised status under the law.

Slowly, too, political freedom has grown, so that most men have the vote, and all the right to express their opinions. The admission of working men to the constitution involved the State in the obligation to provide education on such a scale and at such a cost that those who possessed the franchise should have as far as possible the knowledge and intelligence to use it rightly. Moreover, by wider diffusion of educational opportunity the nation has secured for the common service men of marked capacity who, in less fortunate circumstances, would have been unable to make use of their gifts. Whatever views may be held of social and political changes during the last two hundred years, the world is, from a material point of view, a better place to live in. The child has a greater chance of life and wider scope than ever before for his manifold activities. Just as the private soldier in the army of Napoleon was said to carry a marshal's *baton* in his knapsack, so the boy to-day, be he rich or poor, holds within his grasp the chance of that career for which nature has specially endowed him. For never in the history of the world has man's productive capacity been so large, and never, therefore, has his leisure and opportunity for intellectual development existed on so generous a scale.

Emphasis has been laid on the fact that the primary cause of the changes which have been recorded was the vast increase in scientific knowledge and its applications which began as a trickling stream in the eighteenth and became a roaring flood in the nineteenth century. For more than a hundred years the steam-engine was the driving force which carved out a new world, and created fresh conditions of life and labour. But it was only one of the agents which the engineer, the chemist, and the electrician placed at the disposal of mankind. And as each in turn, or several in co-operation, exerted an influence, it or they caused new kinks in the social system and created new problems for statesmen to solve.

It will be apparent that technical science has developed more rapidly than social and political science; and perhaps this was inevitable. But it is, nevertheless, responsible for the fact that technical difficulties are overcome with more ease than those which involve human relations. Machines are scrapped more readily than opinions, and adjustments are made with less opposition among the dead things of the factory and the workshop than in the world of living men. But if the same spirit of honest, scientific enquiry, the same judicious weighing of facts, and the same calm judgment as have been so successful in promoting scientific progress are used in approaching social and economic problems, it is to be hoped that many of the sharp issues will disappear, and the bitter antagonism of capital and labour be dissolved.

But the pressing nature of this problem in no way obviates the necessity of encouraging the scientific and technical developments of industry. Great Britain does not now stand alone. She has powerful competitors who have long since destroyed the monopoly she once possessed. Her proud position is due partly to geographical position, partly to the character of her people, and partly to the use which they made of coal and iron. The distribution of population in the world is altering; geographical position counts for less than it did; and the supplies of coal and iron are not inexhaustible. Markets are gained and held by relative cheapness, and cheapness is secured by those economies of manufacture which increase productive capacity. If wages are to be kept up and all those advantages which belong to a high standard of comfort are to be retained, then economy of fuel, improved processes of manufacture, and scientific organisation are primary necessities. These are, doubtless, technical problems which are supposed to be intelligible only to the specialist; but the solution can be encouraged or retarded by the State. And inasmuch as any political party can proceed only so far as the importance and value of its proposals are recognised by the general body of voters, it follows that an intelligent appreciation of the more fundamental technical problems of the age is an essential component of political education. Unless, therefore, the Industrial Democracy of the Twentieth Century recognises this fact its labours towards political freedom will be in vain, for social and political reforms must tread closely on the heels of material progress if they are to be of real and lasting benefit to mankind.

APPENDIX

LIST OF BOOKS FOR FURTHER READING

In view of the introductory character of the volume it has not been considered necessary to give references to original authorities in the text; but the following list of books will serve as a guide for further reading:—

CHAPTER I

Clodd. The Story of Primitive Man.
Myres. The Dawn of History.

These are cheap introductions, containing well-chosen lists of larger works.

CHAPTERS II and III

Cheney. Introduction to the Industrial and Social History of England.
Ashley. Introduction to Economic History, Parts 1 and 2.
Cunningham. Essay on Western Civilisation.
Part 1. Ancient Times.
Part 2. Modern Times.
Cunningham. History of English Industry and Commerce.
Unwin. Industrial Organisation in the Fifteenth Century.

CHAPTER IV

Curtler. Short History of English Agriculture.
Prothero. English Farming, Past and Present.
Russell. The Fertility of the Soil.
Wood. The Story of a Loaf of Bread.
Raymond and Critchley. History of the Frozen Meat Trade.
Hammond. The English Labourer.

CHAPTER V

BAINES. History of Cotton Manufacture in Great Britain.

SCHULZE-GAEVERNITZ. The Cotton Trade in England and on the Continent.

CHAPMAN. The Lancashire Cotton Industry.

CLAPHAM. The Woollen Industry.

FELKIN. History of Machine-wrought Hosiery and Lace.

"The Times" Textile Supplement, June 27th, 1913, contains a mass of miscellaneous information on the Textile Trades.

CHAPTER VI

SCRIVENOR. Comprehensive History of the Iron Trade.

SMILES. Lives of the Engineers—Boulton and Watt.

SMILES. Men of Invention and Industry.

SMILES. Industrial Biography.

JEANS. Steel, its History and Manufacture.

JEVONS, S. The Coal Question (Revised by Flux).

JEVONS, H. S. The British Coal Trade.

A popular account of progress is to be found in—

ROUTLEDGE. Discoveries and Inventions of the Nineteenth Century, 15th edition;

CRESSY. Discoveries and Inventions of the Twentieth Century.

CHAPTER VII

ROUTLEDGE. Discoveries and Inventions of the Nineteenth Century.

CRESSY. Discoveries and Inventions of the Twentieth Century.

WALLACE. The Wonderful Century.

WILLIAMS. The Story of Nineteenth Century Science.

CHAPTER VIII

SMILES. Lives of the Engineers—Brindley.

SMILES. Lives of the Engineers—Metcalfe and Telford.

SMILES. Lives of the Engineers—George and Robert Stephenson.

PRATT. History of Inland Transport and Communication in England.

JEANS. Waterways and Water Transport.

KIRKALDY. British Shipping.

PROTHEROE. Railways of the World.

Report of the Royal Commission on Canals and Waterways issued in 1910.

The *Encyclopaedia Britannica* for legal and economic aspect of Railways and Shipping.

CHAPTER IX

Jevons. Money.
Withers. The Meaning of Money.
Withers. Stocks and Shares.
Nicholson. Money and Monetary Problems.

CHAPTER X

Well-chosen lists of books on the subject-matter of this and the following chapters, except XVIII, will be found in—

Macgregor. The Evolution of Industry.
Shadwell (Ed.). An Encyclopaedia of Industrialism.

CHAPTER XI

Webb. History of Trade Unionism.
Webb. Industrial Democracy.

CHAPTER XII

Aves. Co-operative Industry.
Fay. Co-operation at Home and Abroad.
Potter. Industrial Co-operation.
Williams. Co-Partnership and Profit-Sharing.
Publications of the Labour Co-Partnership Association.

CHAPTER XIII

Meyer. Municipal Ownership in Great Britain.
The Municipal Manual.

CHAPTERS XIV AND XV

Medley. English Constitutional History.
Taswell-Langmead. English Constitutional History.
Lowes Dickenson. The Development of Parliament in the Nineteenth Century.
Ostrogorski. Democracy and the Organisation of Political Parties.
Anson. Law and Custom of the Constitution.
Courtney. The Working Constitution of the United Kingdom.
Odgers. Local Government.
The Municipal Manual.

CHAPTER XVI

Hutchins and Harrison. History of Factory Legislation.
Oliver. Dangerous Trades.

CHAPTER XVII

Price. Short History of Political Economy.
Spencer. Introduction to Political Economy.
Hobson. The Science of Wealth.
Hobson. The Industrial System.

CHAPTER XVIII

Balfour. History of Educational Administration in Great Britain and Ireland.
Montmorency. The Progress of Education in England.
Sadler. Continuation Schools in England and Elsewhere.
Creasey. Technical Education in Evening Schools.
Birchenough. A History of Elementary Education.

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