

THE STEEL INDUSTRY OF SOUTH YORKSHIRE: A Regional Study: by PROFESSOR CECIL H. DESCH: being a paper read to the SOCIOLOGICAL SOCIETY on 24th January, 1922.

THE SEQUENCE of events by which Sheffield has become the most important centre in the world for the manufacture of steels of the highest class provides an interesting study for the sociologist and the regional geographer. The factors which have led to its remarkable progress, in competition with other districts in situations apparently more favourable to expansion, are not obvious at a first glance, and a more detailed examination shows that a purely material explanation is insufficient, and that certain human and social elements have to be taken into account in the discussion. It will be convenient to begin with a simple survey of the regional conditions, and then to proceed to an outline of the historical development of the highly specialized industry that is characteristic of the area.

IT IS not difficult to trace the influence of the typical valley section already so familiar to members of the Sociological Society. Starting from the fishing villages at the mouth of the Humber, one passes through large tracts of fertile agricultural lands forming the south-eastern corner of Yorkshire and the north of Lincolnshire. Ascending the Don, the land remains flat until the site of Sheffield is reached, where the hilly country is entered, and the fertile low land begins to give place to heathery pastures and then to barren moors. At this point five small rivers converge, any one of which may be followed upwards into the moorland. Formerly, the steep sides of the valleys along which they flow were thickly wooded, and remains of the old forests are still to be seen. Passing across the Millstone Grit of the moors, the limestone hills of Derbyshire are reached, usually after crossing transverse valleys, and in these hills the veins of lead and zinc ore, of fluorspar and barytes, have been mined for centuries. The customs of metalliferous mining have a long life, and it is possible to-day, in wandering through some of the limestone valleys of this district, to meet with lead mines worked by two or three men, whose methods and appliances are almost precisely those described and figured by Agricola in his "De Re Metallica" in 1556. These mines are still governed by laws dating from that time, and administered by special mining courts. The moorlands, still the preserve of game, the agricultural flats, and the fishing villages, have undergone comparatively little change in the same time, but at a few points, and notably at the convergence of the streams at Sheffield, great industrial

towns have arisen, some of them within the last century, whilst a sparsely populated region has become densely peopled, most of the inhabitants being engaged in a single industry or dependent on it. Much of the country to the north and east has been greatly altered by coal-mining, but the steel industry was established before coal replaced charcoal as a fuel for smelting, and it cannot be accounted for by the position of the coalfields, important as that factor has proved in its later development.

PRIMITIVE iron smelting, from prehistoric to Roman times, was conducted in small open furnaces fired by wood charcoal, and usually placed on the tops of hills, in order to catch and make use of the prevailing wind. Remains of such furnaces have been found in the neighbourhood of Sheffield, as they are on many of the hills of England and Scotland having an exposure towards the south-west. They have been without appreciable influence on the later history of the industry, and it was only when artificial draught had been adopted in place of the natural force of the wind that a further step could be taken. Bellows worked by hand, still used by African tribes, gave way to bellows driven by a water wheel, and the sites of the furnaces were removed from the tops of exposed hills to the river valleys. The date of this change is very uncertain, but in the Sheffield area it is known that in 1160 the lord of the manor issued a licence to the monks of Kirkstead, in Lincolnshire, to erect two furnaces and two forge hammers to the north of the present town. These must have been driven by water power. From this time onwards the district was an important site of the smelting industry. Its natural advantages were great. Iron ore, although not of the highest quality, was easily obtained by shallow mining by the so-called "bell pits"; wood for making charcoal was abundant, and above all, water power was to be had with little trouble. The converging tributaries, which are like the five fingers of a hand, the Don below Sheffield corresponding with the wrist, have a rapid fall along their steep-sided valleys, the level falling as much as 700 feet in a distance of 3 miles. By erecting small dams at intervals, therefore, the streams could be broken up into a series of ponds, each with a fall to the next level, capable of driving a water wheel. These are the "hammer ponds," still a conspicuous feature of the valleys in and around Sheffield. At one time or another, there have been as many as 200 wheels driven by water power from ponds along the course of the five rivers and their tributary brooks. It is easy to see that a region with such natural advantages would become a centre of iron smelting, and that workmen would settle in groups in the neighbourhood. By the 14th century, the manufacture of cutlery had been established, as is proved by several documents, and by a well-known reference in Chaucer. For the finer qualities of steel, the local ores were insufficiently pure, and iron and steel were

imported from Germany and elsewhere to be forged and worked by the local smiths and cutlers. Even armour was made, but only of the commoner sorts, fine armour being always imported from abroad. In time, the mining of the local ores was practically abandoned, and the forges were kept busy with foreign metal, iron from Sweden, Russia and Spain, and steel from Germany and Austria. The origin of the cutlery trade, which requires steel of fine quality, is doubtful. It was regulated in London as early as 1328, but the first regulations of the Sheffield cutlers dated from 1565 only, although records of the trade exist of much earlier date. The Cutlers' Company of Sheffield was incorporated in 1624, and still retains many of its ancient privileges. It was a typical Guild organisation, but as in so many other similar institutions, the leading members tended in course of time to become middlemen rather than craftsmen.* It still remains the only authority outside of London for the registration of trade marks.

THE manufacture of cutlery requires a supply of the finer qualities of steel, and a high degree of skill on the part of the workers. It has long been carried on as a domestic industry, the workshops being small and attached to the living-place. Associated with it is the manufacture of small tools, files, &c., the processes of forging and hardening being similar for both, with minor but essential differences leading to a sharp distinction of occupations. File-cutting by hand still remains a characteristic domestic occupation, conducted in small workshops of special type. The grinding of cutlery is carried on by means of sandstone wheels, formerly driven by water power, which thus served both stages of the manufacture, the forging of the raw material and the shaping and finishing of the product. Even at the present day, very little of this work is done in factories. Steam power has almost completely replaced water, although a few water-driven grinding wheels are still to be seen in use within the limits of the city of Sheffield, but the home workers and "little masters" still conduct most of the operations of the trade. The final product is often assembled and finished in a factory, although the earlier stages have been performed under domestic conditions. This survival of economic conditions dating from a time before the industrial revolution is highly characteristic of the cutlery trade. Grinding is commonly performed in buildings owned by a landlord, from whom the individual workers rent their wheels and power, but who does not stand to them in the relation of an employer.

How far the peculiar development of the cutlery industry has been determined by regional conditions may be clearly seen by a comparison with the most important of the Continental centres of the industry.

*A most interesting study of this industry is to be found in "The Cutlery Trades: an historical study in the economics of small-scale production," by G. T. H. Lloyd. (Longmans, 1913.)

Solingen, in Rhenish Prussia, is situated close to the confluence of a group of small rivers, descending from the hills in steep valleys, and bearing a striking resemblance to the neighbourhood of Sheffield in their general arrangement. The industry was established here before the 14th century, and still, like its analogue in this country, retains many of its primitive characteristics. Almost the same may be said of Thiers, in France, where, however, the water power is derived from a single river. The close connection between geographical and economic conditions is very striking. In Solingen, although small-scale working is still the rule, modern machinery, and such conveniences as electric furnaces, have been more widely adopted than in Sheffield. IT HAS been said that iron made from the local ores was insufficiently pure for the needs of the cutlery industry, and that Sheffield had to import raw material from abroad. There was therefore a conflict of interests between the iron-producing districts of this country and those which required material of foreign origin. In the 17th century, Sussex, at that time the great iron-smelting district of England, wished to exclude foreign iron, and in the contest which ensued Sheffield appears as the champion of free trade, so establishing a tradition which has influenced the city to the present day.

THE old process of converting iron into steel by the aid of charcoal was performed on a very small scale, an account of the methods and appliances being given in Swedenborg's work, "De Ferro," published in 1734. The first important change came in the latter part of the 17th century, when the process of cementation in comparatively large furnaces was introduced into this country. The works of Abraham Crowley, established near Newcastle in 1682, are remarkable as the first example of a large metallurgical works, several hundred men having been employed. Here shear steel was first made by hammering the cemented bar iron. This industry soon reached Sheffield, and henceforward steel was made locally from imported Swedish bar iron, which was converted into steel in cementation furnaces and forged into a fine material suitable for cutlery and tools. In 1740 Benjamin Huntsman made the first homogeneous steel by melting cemented bars in crucibles, and so established in Sheffield the crucible steel industry, of which the town has ever since remained the most important centre in the world.

By this time the iron industry was undergoing great changes. Coke was replacing charcoal as a metallurgical fuel, and the nearness to coalfields became important. Here it may be noted how fortunate South Yorkshire has proved to be in its possession of necessary raw materials. When the cementation furnaces were introduced, the "firestone" required for the construction of their chests, which have to withstand a high temperature without risk of cracking, came from local sources. The clay for making Huntsman's crucibles could be

obtained at no great distance, and when coal came to be employed, in the form of coke, in place of charcoal, the district proved to be situated on the most important of our coal-fields. Later, when the Bessemer process revolutionised the whole steel industry, the ideal material for lining the converters was found in Sheffield ganister, a local siliceous rock.

THE new fuel made a larger scale of operations possible, and the establishment of large works in Sheffield began early in the 19th century. It will be noticed that both the factors that had led to the settlement of the steel industry in the neighbourhood of Sheffield had ceased to be of importance. Water power had given place to steam, the first steam-driven wheel in the district having been set up in 1786, whilst charcoal had almost disappeared from use in the industry. Nevertheless, the fact that a special, highly-skilled occupation had become localized in the district led to new inventions being brought there as a matter of course, for nowhere else could the same reserve of skilled labour and supervision be found. This factor has repeatedly outweighed the more purely economic factors in deciding the situation of an industry.

FRÉDÉRIC LE PLAY, who was a metallurgist by profession, published a detailed survey of the iron and steel industry of South Yorkshire in 1843, and from this memoir we can learn better than from any other source how the manufacture of steel was carried on before the introduction of the Bessemer and Siemens processes. Sheffield steel was made at that time almost exclusively from Swedish iron, Sweden being unable to manufacture steel owing to the scarcity of fuel, whilst England controlled nearly the whole of the foreign markets. Le Play's review, which included economic as well as technical conditions, was one of the first of those studies of an industry which led him to become a sociologist, and to undertake that series of monographs which served as the foundation of his sociological teaching. It is to be hoped that the regional survey of the Sheffield area, now under discussion and so auspiciously begun by Prof. Abercrombie's survey of the city of to-day, will in time be adequate to present a complete picture of the industry as it now exists, after the transformation that it has undergone during the 80 years since the publication of this important memoir.

THE Siemens process, which enabled still larger quantities of metal to be dealt with at one time, and also allowed of a more perfect control over the operations, followed close upon the heels of the Bessemer process, and the manufacture of steel then passed definitely into the region of large-scale industry. Nevertheless, the steel manufacturers of Sheffield have retained a distinctive character throughout all the changes of the last century. Whilst Middlesbrough and Glasgow are also great centres of steel-making, the manufacture of the highest

classes of steel, for tools, cutlery, automobiles and aeroplanes, is centred in Sheffield, and is of greater importance than that of common steels for ship plates, rails, girders, and similar purposes. The change of scale has, however, brought with it great changes in the region. A huge population has grown up, crowded into a comparatively small area, and a beautiful countryside has become disfigured by smoke and slag heaps. The growing use of electric power for mechanical operations and for furnaces points to one way out of this, one of the worst concomitants of industrial progress, and the restoration of the valleys of South Yorkshire to something like their early beauty is not an impossible dream.

IT HAS been shown how the steel industry came to Sheffield, but the reasons given do not explain why it has remained there throughout the changes brought about by modern inventions. Water power and woodlands have lost their importance, and although Sheffield is fortunate in its position on the great coal-field it has other geographical disadvantages. Iron ore or pig has to be brought from a distance, pure iron for conversion into steel has still to be imported from abroad, and both for this purpose and for that of reaching foreign markets the distance from the sea coast is an unfavourable condition. Middlesbrough is far more conveniently situated, and yet Middlesbrough has no such specialised industry of high quality steels. The reason is to be sought in the human factors. The establishment of the cutlery industry, and of the processes of making steel suitable for it, led to the growth of a population possessing exceptional skill in the handling and working of steel. Social inheritance is at least as important a factor as heredity in the individual, and where workers grow up, familiar from childhood with the conduct of highly technical processes, an environment is created which is particularly favourable to the progress of the industry. Hence it is that advances in the industry have so frequently come from the Sheffield area. The improvement of tool steels by the introduction of the metal tungsten was due to Robert Mushet about the middle of the last century, and the credit of the further advance to high-speed tool steel, although shared by America, is again largely due to Sheffield manufacturers, who now hold the first position in that industry. Stainless steel and iron, the latest development of metallurgy, are also Sheffield inventions. The fact that a certain population has acquired a degree of skill and knowledge in dealing with a material is so important as to outweigh numerous unfavourable conditions, and this fact is a fundamental one for all students of regional sociology and economic history.

As AN interesting illustration, it may be mentioned that during the war it was necessary to send out to America particulars of the methods of manufacturing certain special steels of types almost peculiar to Sheffield, as a supply of these was required for military use. Details

were given, and men were sent out for purposes of instruction. Nevertheless, when export again became possible after the close of the war, it was found that American users preferred to import the steels from Sheffield, the lack of men trained by long practice in the processes of manufacture being a difficulty not to be overcome.

THE nature of the occupation has the profoundest influence on the character of the worker. The peculiar organisation of the small-scale industries has led to the development of a strong individualism amongst its members, and in consequence even the trade unionism of Sheffield presents unusual characteristics. The workers are divided among a large number of small unions, so that, according to Mr. Lloyd, the steel forgers of the town numbered 1,500 in 1910, and were distributed amongst no less than 14 trade unions, whilst the 30 unions in the cutlery and tool trades only numbered 4,000 members altogether. Moreover, some of the small unions retain many characteristics of the old trade guilds, and control workmanship as well as rates of payment. Any student of economic conditions will recognise in the Sheffield Labour Movement certain individualist tendencies marking it off from the general movement. Naturally, this is less true of the unions concerned with the manufacture of steel on the large scale by modern processes, the conditions of which have become similar all over the country.

LASTLY, reference may be made to the development of science in connection with the industry. Formerly, the great knowledge possessed by the steel workers was entirely empirical, but with the introduction of new processes, and especially with the invention of alloy steels containing tungsten, chromium, vanadium, and other metals, scientific study of steel became an imperative necessity, and in view of the localisation of this specialised industry, it is not surprising that Sheffield proved to be the scene of the greatest advance in scientific metallurgy. This was the work of Henry Clifton Sorby, a Sheffield amateur, who, having devised the method of studying the structure of rocks by cutting thin sections and examining them by means of the microscope, turned his attention to iron and steel, and introduced the methods of microscopical metallography, by which the chief advances in metallurgy in recent years have been so greatly assisted and even made possible. Sorby described correctly the principal constituents of iron and steel, and opened up a new field of investigation which has proved both interesting and profitable. It was natural that Sheffield should become the site of a great technical school of metallurgy, and the University of the city has occupied a foremost position in that science since its establishment.

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