CHAPTER XIII.

ECONOMIC CONSIDERATIONS.

Object of the Metallurgist.—Viewed in its commercial aspect, the object of the metallurgist is to render science subservient to manufacturing art, or what is equivalent, to make science remunerative. If, as has been well observed, we hope to urge on practical metallurgists the importance of combining scientific with practical knowledge, it must be demonstrated that the combination will be of pecuniary advantage to themselves, as they can have no inducement for investing capital to carry into practice an invention, however beautiful and attractive in a scientific point of view, apart from the consideration of gain. This being the case, it will be well for the student to bear in mind a few of the principles by which the relations of capital and labour are guided, and the economic conditions under which metallurgical works are carried on.

Capital and Labour.—In the early stages of the metallurgical art, when the metals were extracted from their ores either by the direct action of heat, or by the aid of simple reactions, man was, as Gruner shows, in a measure the sole mechanical agent in this industrial art; but when machines and appliances were devised, the agency of man became less apparent. In order to obtain these machines, capital is necessary, and capital has been defined as "accumulated work," stored, that is, from some period anterior to that in which it has been brought into play. This accumulated work also demands payment when it is utilised, and this payment is the interest received by the capitalist who furnishes the equivalent of work. Manual labour is still necessary, and its influence is always considerable, even though it bears a less direct relation than formerly to the cost price of the product. It must be remembered, however, that there has always existed between capital and labour, between the employer and the employed, antagonism which it is very difficult to entirely banish. The utmost care should nevertheless be devoted to reducing it to the smallest possible limits, and, as the condition of operatives has materi-

ally improved during the last half-century, it is certain that the efforts that have been made on their behalf have not proved fruitless.

There is a widespread feeling that the interests of capital and labour must be antagonistic, and, as it is impossible to ignore the fact that the conflict between them is giving rise to grave apprehension, it becomes the duty of all who possess influence to strive not merely for peace, but to range themselves on the side of justice and humanity. The great labour question cannot be solved except by assuming as a principle that private ownership must be held inviolable, but it must be admitted that there was a time when capital had become arbitrary and some kind of united action on the part of workmen was needed in self-defence. If, however, we turn to the action of the leaders of trades unions in various lamentable strikes in the past, we are presented with a picture which many of us can only view as that of tyranny of the most close and oppressive kind, in which individual freedom cannot even be recognised. There are hundreds of owners of works who long to devote themselves to the true welfare of those they employ, but who can do little against the influence of the professional agitator, and are merely saddened by contact with prejudice and ignorance. The view is probably correct that some system by which the workman participates in the profits of enterprise will afford the most hope of putting an end to labour disputes, and we are told that profit-sharing tends to destroy the workman's sense of social exclusion from the capitalistic board, and contents him by elevating him from the precarious position of a hired labourer. No pains should therefore be spared in perfecting a system of profit-sharing.

Pensions are great aids to patience and fidelity. Watchful care over the health, interests, and instruction of the employed is exercised by many owners of works. Workmen must not forget that the choice of their own leaders is in their own hands, and on this the future mainly depends. "We may lay it down as a perpetual law that workmen's associations should be so organised and governed as to furnish the best and most suitable means for attaining what is aimed at, that is to say, for helping each individual member to better his condition to the utmost in body, mind, and property." The words will be found in an Encyclical letter which Pope Leo XIII. issued on the "Condition of Labour," and it is specially interesting that the Bishop of Rome, in his forcible appeal, again and again cites the opinion of St. Thomas Aquinas, who was a learned chemist as well as a theologian.

Those of us who realise that "the higher mysteries of being, if penetrable at all by human intellect, require other weapons than those of calculation and experiment," should be fully sensible of our individual responsibility. Seeing that the study of the

relations between capital and labour involves the consideration of the complex problems of existence, the solution of which is at present hidden from us, we shall feel with Andrew Lang that "where, as matter of science, we know nothing, we can only utter the message of our temperament." It is to be hoped that the patriotism of the masters and workmen will prevent them from driving our national industries from these shores, and those to whom the direction of the metallurgical works of this country is confided, may be asked to remember that we have to deal both with metals and with men, and have reason to be grateful to all who shall extend the boundaries, not only of our knowledge, but also of our sympathy.

The hope that workmen would not drive national industries from our shores was expressed in the author's address as President of the Chemical Section of the British Association in 1891, but it is to be feared that a warning is still greatly needed. In 1893, so trustworthy an authority as Sir Joseph Pease has addressed such a warning to *The Times*.[1] He says, "With peace between capital and labour we shall hold our own; with war, our trade will leave us. . . . A leading firm tell me," he adds, "that they are at this moment carrying out two lines of railways in British colonies and with British capital, but all the bridge work, steel sleepers, and rails come from Germany. At Aachen, some hours distant from the coast, thousands of tons of steel sleepers are being made for English companies; 30,000 tons of rolled joists were made at Halle, in Belgium, and used in London alone last year. The roof for the Athenæum in Liverpool, and that for the new United Service Institution at Whitehall, were manufactured abroad. And this is the case whilst there are multitudes at home who cannot get work at any price, and others are refusing it even on terms to be settled by arbitration."

It will be evident that some knowledge of political economy is absolutely necessary as an "Introduction to the Study of Metallurgy," and the author has written this in the earnest hope that the lesson that capital and labour must work together may not be learned too late.

Modes of Payment.—In metallurgical works piecework is the system generally adopted. This simply consists in paying the workmen, in proportion to the amount of work executed, at a settled rate. It is the only system that conduces both to the interest of the employer and the employed. The first and most considerable difficulty consists in fixing the price of the piece, or the unit of work, and the adjustment of the contract affords abundant opportunity for the exercise of forbearance and equity on the part of the employer. The arrangement is more complicated where, instead of agreeing with a single workman, it is

[1] *The Times*, October 6, 1893.

necessary to entrust work to several workmen associated as partners. It is then impossible to divide the work equally, for some of the workmen are more experienced than others. In this system it is also difficult to ensure that the work executed is of good quality, and careful supervision is necessary.

Remarkable results have been attained with this system at the Creusot, Terre Noire, and other French steelworks, where the wages have increased 50 to 60 per cent., and the production has been doubled in the space of a few years, and that without increasing the number of hours of work. A special stimulus, too, is given by progressive payments—that is to say, by increased payment for the supplementary tons in excess of the normal outturn of iron or steel.

The adoption of this system of giving premiums has been attended with marked success. At the great Belgian zinc-works of La Vieille Montagne, the smelters and mill men receive, in addition to a fixed wage, a premium calculated on the output, and a special premium is also given for unwonted energy. In some cases, the firemen receive a similar premium, based on the time their furnace lasts without repair. In other cases the workmen receive a premium when they obtain from the ores a greater amount of metal than that which they are calculated to yield. Two-thirds of this premium is paid periodically with the regular wage. The remaining third is retained until the end of the year, and it is not paid then unless the workmen have worked regularly throughout the year.

The majority of men in iron and steel works are paid per unit of work—that is to say, by the ton or quantity of work they turn out.

At the Royal Mint, London, a somewhat peculiar system is adopted. Prior to 1870, the workmen were paid on an average 2s. 8d. per 1000 accurately struck coins, and when the Mint was not at work they received a small payment amounting to from 6s. to 10s. per week. The objections to this system are obvious. When the department was in full work, the men received an average of £2, 15s. per week, and during the remainder of the year they received allowances insufficient to maintain them, or to prevent their forming other engagements. The result was, on the one hand, that the more improvident among them contracted liabilities and returned to work in debt, and, on the other hand, that the more skilful workmen were induced to accept employment elsewhere, and the Mint lost their services. The rate paid for piecework was therefore slightly reduced, and a uniform payment of £1 per week for the men, and 10s. to 15s. per week for the boys, as "subsistence money"—as it is termed—was set on foot.

There can be no doubt that the system of premiums renders it possible to retain the services of good workmen, as well as to

stimulate and encourage their intelligence. It is the best method of enabling them to share in the profits, and at the same time it indirectly augments those of the employer.

We now come to a question that has been discussed with much interest in recent years. Certain economists and philanthropists urge that it would entirely remove antagonism between capital and labour, if the operatives directly participated in the profits of an undertaking. Others contend that this sharing of profits, far from effecting a better understanding between capital and labour, would only give rise to further troubles. In one shape or another participation of profits has found a good deal of favour on the Continent, where many works have adopted it with generally very beneficial results to all parties concerned. This has notably been the case at the ironworks of Godin, at Guise, France.[1]

M. P. Leroy-Beaulieu, editor of *L'Économiste française*, states that the system of participation in profits, viewed as a general method of organising labour, is both deceptive and dangerous. It may be possible to admit superior workmen and foremen to participation in profits; but in this country, at least, workmen are not ready for the change. Everything goes well as long as the works are carried on at a profit; but in bad times discontent soon breaks out. The system is not viewed with favour by the workmen themselves. They are perfectly willing to share in the profits, but they object to be answerable for their share of loss, and are even reluctant to contribute to a reserve fund to cover the losses of future bad years. A workman cannot either wait for better times, or turn out products at a loss in order to retain his employment. Moreover, the final participation appears too remote; the workman cannot appreciate the relation that exists between his work and the annual profit.

Among the methods that have been adopted for giving the men a permanent interest in the works, the following may be enumerated:—

1. The method of paying over to the workmen a share in an annual cash bonus.

2. Retention of the share for an assigned period, in order ultimately to apply it, together with its accumulated interest, for the workmen's benefit.

3. An annual distribution of a portion of the workmen's share and an investment of the remainder. This third method is adopted at the La Vieille Montagne zinc-works, where the results have been found to be most beneficial, and have entirely prevented strikes.

Whatever method be adopted, no effort should be spared to induce the men to exercise the utmost care in the conduct of their ordinary occupations. To illustrate this, Mr Kenward, the

[1] *Journ. Iron and Steel Inst.*, 1888, i. p. 102.

manager of Messrs Chance's works, near Birmingham, stated that in such an apparently routine occupation as superintending a machine punching holes in a metal plate, a thoroughly active workman could realise a surplus wage three times as great as that obtained, under identical conditions, by a less strenuous but not less skilful fellow-workman. With due care, a large amount of the waste that occurs in every trade could be avoided. In metallurgical industries, this waste is often apparent, and in some cases the dimensions of the scrap-heaps are a source of wonderment to foreigners who visit this country.

Those who are not engaged in active constructive work can form no adequate conception of the enormous waste caused by inaccurate or bad workmanship, and this is well shown by the fact to which attention has been directed by Mr R. Caird, of the well-known firm of engineers and shipbuilders at Greenock. He estimates that iron and steel to the value of £5,000,000 are annually wasted as "scantlings," or are employed in excess of actual requirements in shipbuilding, and he states that over £200,000 are spent per annum in propelling excessive and unnecessary material.

Quite apart from the methods of remunerating labour, much will depend upon the personal relations between employer and employed, and more especially upon the moral example set by the heads of the firm, and upon the amount of care and interest they display in providing for the wants of their people in the way of schools, gardens, savings banks, libraries, and hospitals. In this country the provision made in this respect at such works as Crewe, Elswick, and Dowlais deserves especial commendation. At Crewe there is a well-organised institute, in which competent teachers prepare the younger operatives for the various technological examinations. Similar institutes have been founded at many other works.

No doubt where, as in the Royal Mint and other Government establishments, pensions can be given, they afford the most powerful inducements to industry and fidelity.

It is not necessary here to dwell upon the importance of technical education. The advantages that craftsmanship constantly reaps from scientific knowledge are standing proofs of the necessity for special training. All may be summed up in a few words borrowed from the writings of a former French Minister of Finance, Jules Simon:—

"The practised eye and the sure hand are much, but they do not replace Science. The smith who knows the drawbacks of too rapid oxidation, who knows why throwing water on the surface of fuel increases the heat at the centre of the mass, the puddler who takes into account the effect of an oxidising or reducing flame, and who exposes metals to one or the other at the right moment —such are evidently the best workmen, more skilful for current

needs, less disconcerted by an accident, less embarrassed by having to describe an observation, less slaves to routine, and quicker to adopt new processes." He points to the fact that so many of the modern inventions are due to workmen, and justly urges that the more intelligent the workman becomes, the better he will understand the skill possessed by those who direct him, and the more he will appreciate work that differs from his own.

In spite of all the advantages that technical education offers, it must be remembered that many metallurgical works in this country are successfully conducted by so-called practical men; not the kind of man so forcibly described by Sir Frederick Bramwell,[1] as one "whose wisdom consists in standing by, seeing, but not investigating, the new discoveries which are taking place around him, the aim and object of such a man being to ensure that he should never make a mistake by embarking his capital or his time in that which has not been proved by men of large hearts and large intelligence"; nor the man who accepts no rule but the rule of thumb, but practical men possessing technical knowledge of a high order, whose careful observations enable them to use the results of past experience in dealing with circumstances and conditions analogous to those they have met with before, and with which long practice has made them familiar. It would be difficult to overrate the value and importance of such knowledge as theirs, and, when we remember the scale on which smelting operations are carried on, it will be obvious that this kind of knowledge can only be gained in the works, and not in the laboratory or lecture-room, for, however careful metallurgical teaching in a school may be, it is only practical in a limited sense. At the same time, it must be borne in mind that a man trained to scientific methods starts with the enormous advantage of being able to deal with circumstances and conditions that are new to him, and with which, therefore, he cannot be said to be familiar. The technical skill that time and opportunity can alone give him will then rest on a solid basis. It is necessary, however, to guard against undervaluing the teaching of experience unaided by reasoning that we should recognise as scientific, for it is only necessary to witness such operations as the roasting of a large mass of ore on the bed of a furnace, or the forging of many tons of iron under a steam hammer, to appreciate the value of the subtle skill of sight and touch on which success depends.

The relation between scientific and technical men is thus traced, as hitherto there have been misunderstandings on both sides, or, as Dr Williamson[2] well observed, "Men of detail do not sufficiently appreciate the value or usefulness of ideas or of general principles; and men of science, who learn to understand and control things more and more by the aid of the laws of

[1] *Brit. Assoc. Rep.*, 1872, p. 238.
[2] Inaugural Lecture, University College, London, 1870.

Nature, are apt to expect that all improvements will result from the development and extension of their scientific methods of research, and not to do justice to the empirical considerations of practical expediency which are so essential to the realisation of industrial success in the imperfect state of our scientific knowledge."

While it is no longer necessary to justify the scientific teaching of metallurgy, it is as important as ever that the true relation of theory and practice should be clearly understood. It rarely happens that a process can be transferred from the laboratory to the works without important modifications; and it must be remembered that metallurgy is a manufacturing art, and that, when the truth of a theory has been demonstrated, a dividend has to be earned. This would, indeed, often be difficult without the aid of the practical man. Practical men have, however, ceased to undervalue science, and the most practical body of men in the world, in the best sense of the term, the ironmasters of this country, on whom its prosperity so largely depends, formed themselves, in 1870, into an Iron and Steel Institute, of which many of the members possess high scientific attainments, and are distinguished for scientific research.

Turn, then, to the advice given by those who were accustomed to deal with metals on a large scale. In 1873 Sir Lowthian Bell[1] stated: "If we would avoid the failure of what may be designated unscientific practice, or the failure of impracticable science, we must seek to combine commercial intelligence with a knowledge of those natural laws which form the only trustworthy groundwork of the complicated processes in which we are engaged."

Again, Sir W. Siemens,[2] in 1877, said, "It is not many years since practical knowledge was regarded as the one thing requisite in an iron smelter, whilst theoretical knowledge of the chemical and mechanical principles involved in the operations was viewed with considerable suspicion."

As regards the preliminary training in metallurgy, the utmost efforts of the student should be devoted to securing a thorough acquaintance with scientific methods and metallurgical principles, and at the same time, to gathering as many well-ascertained facts as possible, remembering that applied science is nothing but the application of pure science to particular classes of problems. It consists of deductions from the general principles, established by reasoning and observation, which constitute pure science. No one can safely make these deductions until he has a firm grasp of the principles, and he can obtain that grasp only by personal experience of the processes of observation and of reasoning on which they are founded.

[1] *Journ. Iron and Steel Inst.*, 1873, p. 12.
[2] *Ibid.*, 1877, p. 7.

Production of Metals.—According to a diagram prepared by order of the French Minister of Public Works, and shown at the Paris Exhibition of 1889, the world's production of metals in 1887 was as follows:—

	Quantity. Tons.	Value. Francs.
Pig-iron	22,721,000	1,155,297,000
Silver	3,383	700,500,000
Gold	158	629,600,000
Copper	291,000	324,908,000
Lead	474,000	180,785,000
Zinc	333,000	129,795,000
Tin	35,000	95,123,000
Mercury	3,794	19,780,000

The world's production of coal during the same year amounted to 435,024,000 tons, valued at 3,000,652,000 francs.

Since this table was compiled, an enormous increase in the production of metals has occurred, and the figures given for the year 1907 [1] are as follows:—

Pig-iron	60,680,014 metric tons.
Steel	51,183,340 ,,
Silver	193,542,381 troy ounces.
Gold	19,958,764 ,,
Copper	723,807 metric tons.

Price of Metals.—In an able paper,[2] published in 1887, Dr W. A. Wells contends that depression in trade is largely the result of depression in the prices of metals and other metallurgical products. It is interesting, therefore, to consider past experience in the production and price of metals.

In the case of iron Sir Lowthian Bell fixed the world's production of pig-iron in 1870 at 11,565,000 tons, which increased to 14,345,000 tons in 1872. From that date production remained stationary until 1879, when it was 14,048,000 tons. After 1879 the average make for the ensuing five years was 18,000,000 tons, and in 1883 it rose to 21,063,000 tons, or nearly 50 per cent. more than it was in 1879. In 1900 the world's production was considerably over 40 million tons, and in 1907 it was over 60 million tons. While the production of iron increased in the United Kingdom at the rate of 131 per cent. from 1870 to 1884, the increase in the production of the rest of the world during the same period had been 237 per cent.

Under such circumstances the price of pig-iron throughout the world has rapidly declined.

In America, pig-iron was 45 dollars per ton in 1870; in 1885 it was 16 dollars. Cleveland pig-iron was £4, 17s. per ton in 1872,

[1] *The Mineral Industry*, vol. xvi., 1908.
[2] *Contemporary Review*, 1887, p. 523.

£2, 10s. in 1880, 37s. 2d. in 1887, and 36s. in December 1893; while at the present time (May 1910) it is about 50s., Scotch pig-iron being 56s. In 1874 Bessemer steel rails were £12 per ton; in 1887 they were £4. Since 1870 there has been a marked increase in production on the same expenditure in capital and labour. In Great Britain, the yield of iron per workman per year was 173 tons in 1870, 194 tons in 1880, and 261 tons in 1884. During the period under consideration, there has been a large substitution of steel for iron. A ship of 1700 tons requires 17 per cent. less material if made of steel than if of wrought iron; at the same time its efficiency is 7 per cent. greater in the former case. Again, on account of the greater durability of steel, a rail of this material has a life probably three times as long as that of an iron one. The same period has witnessed a great diminution in the production of puddled iron. This, it has been computed, resulted, in the ten years from 1875 to 1885, in the loss of £4,667,000 of capital invested in puddling-furnaces in England alone.

Other metals have also undergone great fluctuations in price; in most cases there has been a decline. In the case of copper, the increased annual production for the year 1885, compared with 1873, was 97 per cent., the increase being chiefly in the United States, Spain, and Portugal. In 1886 copper reached its lowest price, it having been, at New York, 9½ cents. per lb., whilst in 1880 it was 25 cents per lb. In January 1887, Chili bars cost £40 per ton. Many mines had to stop working, for at such prices they could only work at a loss. The great mines alone kept on, but their dividends were considerably reduced. This state of things led to speculation in copper, and endeavours were made to buy up a certain quantity of this metal, to raise the price, and then to sell at a profit. A syndicate was formed in Paris, and large quantities of copper were bought. The first results exceeded all expectations. Copper rose in a short time from £40 to £80. It was then resolved to make the affair permanent, and the syndicate contracted with the leading copper mines to buy their output at a given price. It undertook, in fact, to take 150,000 tons a year, involving an outlay of at least £9,000,000. Besides this, in order to keep up the price and the monopoly, it was necessary for the syndicate to buy all the output of those mines which declined to contract. One of the chief factors in the affair, however, was overlooked. Consumers did not come forward as in previous years. Copper came into the market from all directions, and, owing to the high prices, old sheathing was melted down, meeting the consumption, and copper in many cases was superseded by iron or steel. In short, the stock of the syndicate swelled daily in alarming proportions, and in February 1889 the crash came, and copper fell to £39. Since this date it steadily rose, until August 1890, when it was £60 per ton. In August

1897 the price of copper was £51 per ton, while in April 1899 it reached the high figure of £78, after which it fell, and during December 1902 the average price was £51. After this a gradual rise again took place, and in February 1907 the price reached £107, 5s., from which figure it has gradually fallen again and is now (May 1910) £56 per ton.

From 1880 to 1885, the world's production of lead increased about 30 per cent., and the price fell in the same proportion. In the latter year, there was great commercial distress among British lead miners and smelters. The price in August 1897 was about £13 per ton, in July 1907 over £20, whilst at the present time (May 1910) it is £12, 10s. per ton.

From 1860 to 1864, the demand for tin exceeded the production, and consequently prices ruled high. In 1872 the price was as much as £159 per ton. The large yield of the Australian mines from 1872 to 1878 brought the price down to £52 in the latter year. Since then, however, the Australian output has diminished, but the supply from the Straits has augmented. The demand has also increased, and prices have been £110 in January 1887, and £167 in January 1888. In March 1897 it was £60, and slowly rose up to £146 in September 1899; from this date to September 1905 it fluctuated between £113 and £144. It then rose and reached £196 in December 1906, from which figure it has slowly receded until now (May 1910) it is £150 per ton.

Better plant and the revolution in the price of iron has caused the production of tin plates to be much increased for the same price during recent years. There are no absolutely reliable figures available as to the output of tin-plate in Wales, but it is estimated by the *Ironmonger* at 650,000 tons, requiring 11,600 tons of tin. The production of tin-plate in the United States was about 600,000 tons in 1907, requiring 10,800 tons of tin. Consequently the tin-plate trade of Wales and the United States consumed approximately 22,400 tons of tin out of a world's production of about 100,000 tons.

The price of mercury in 1874 was £26 per flask. In 1884 it fell to £5, 2s., and in 1888 it rose to £10, 7s. The decline in price of this metal was due to the increased production of California, which yielded 30,000 flasks in 1870, and 80,000 flasks in 1877. The demand for mercury in the treatment of silver ores is diminishing on account of the more general adoption of other methods for extracting silver. In 1897 it was about £7 per flask (of from 70–80 lbs.), and has since varied between this and £10.

The annual supply of silver increased from 1872 to 1885 from 50,275,000 oz. to 95,908,000 oz., and during the same period the price of the metal fell very considerably. It was in 1890 4s. 3d. per ounce; but the author pointed out in the first edition of this book (in 1890) that, as the cost of production of the metal does

not exceed 1s. 8d. per ounce, it was very probable that its market value would again fall considerably below that rate. He also stated that its market price might have been expected to fall below the lowest point actually reached had it not been for the artificial stimulus imparted by coinage legislation in the United States of America. This stimulus has since been removed, and in February 1894 silver fell to 2s. 5⅛d. an ounce, the lowest price it had ever touched. In August 1897 it fell to 23¾d. an ounce, but after that it steadily rose, and the average price in London during the year 1900 was 28·17d. per ounce; in 1902 it was again low, 24d., and has since varied between this figure and 30d.