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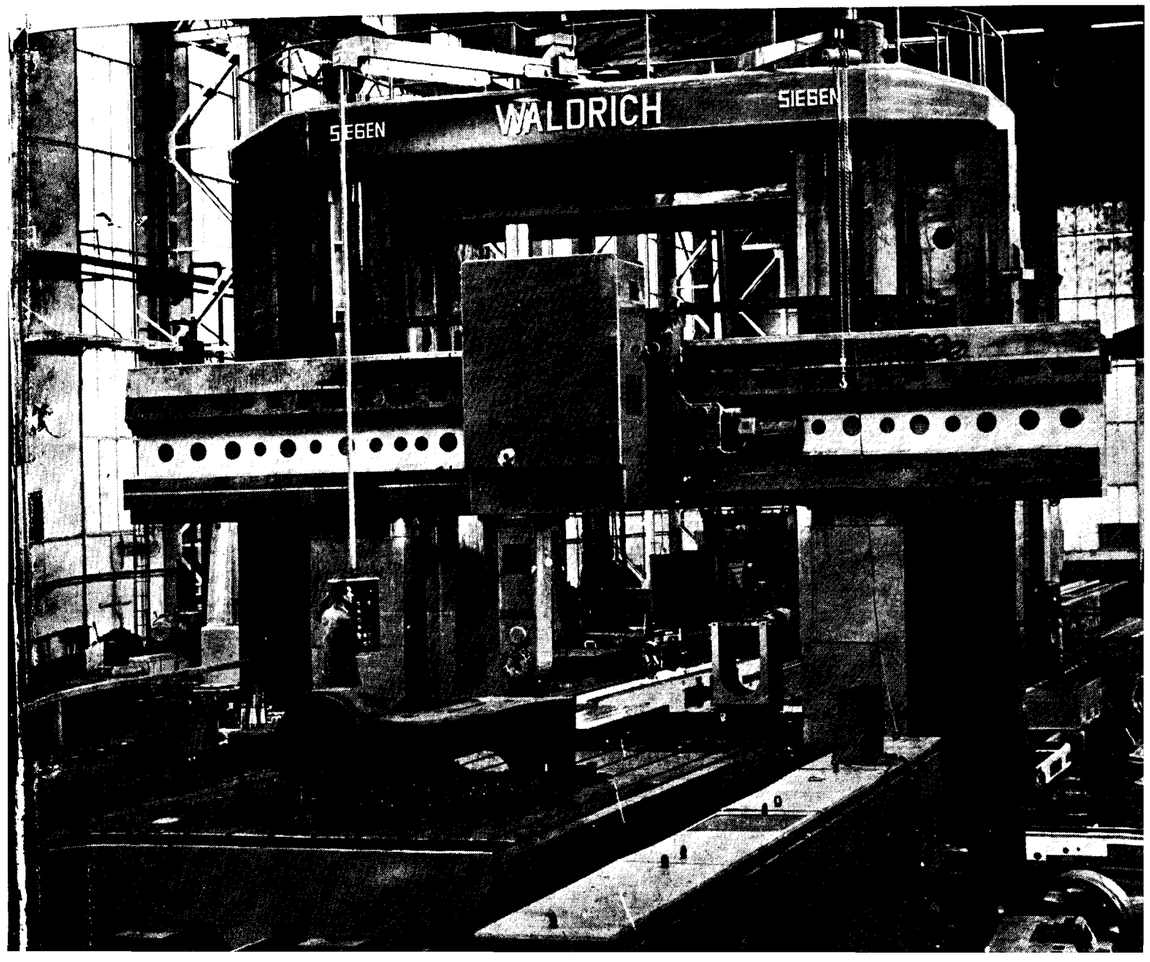

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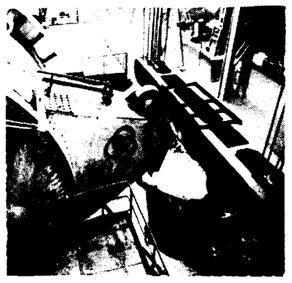

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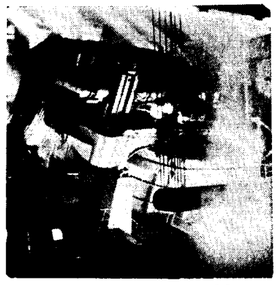

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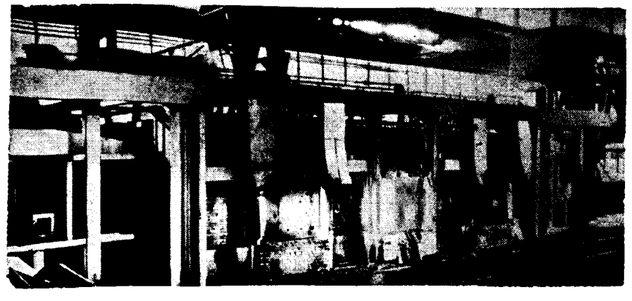

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CONTENTS

G. E. C. BLENDING MACHINES FOR BELGIAN STEELWORKS

The General Electric Company Limited of England has recently received an order, worth nearly £ 70,000, for blending machines to be installed in the Athus steelworks, Belgium, of S.A.Cockerill-Ougree. The equipment is to be incorporated in an ore-blending plant and comprises a reclaiming machine; transfer car; and a double-hinged boom stacker. The reclaiming machine will have a capacity of 400 to 500 tons/hr. (387 to 510 tonnes/hr.) depending on the density of the ores concerned, which varies between 93 to 118 lb/cu. ft. (1.5 to 1.9 tonnes/cu. m.) The stacker will be fitted with 43-in. wide (1.1 m) belt conveyors capable of stocking out at a rate of 800 tons/hr. (815 tonnes/hr.) All the structural steelwork is to be fabricated in Holland but all other parts will be manufactured in this country and sent by G. E. C. direct to site. Consulting engineers for the entire project are John Miles and Partners (London) Ltd.

The Setting up of the Fourth Steel Plant in Bokaro

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SINCE writing last, certain significant developments have taken place in the field of Iron and Steel Industry in India which open up bright prospects for the future of the industry in the next few years. I mean particularly, the very good chances for the participation of U. S. capital in the establishment of the steel plant in Bokaro and the certainty of the steel plant in Madras State.

The setting up of the fourth steel plant in Bokaro seemed to have figured prominent among other subjects in the discussion which the team of top U. S. businessmen had with the representatives of our Government last month during their visit to our country. Though the plant will be in the public sector in keeping with the policy of the Indian Government, it is stated that there is every possibility of participation of the U. S. private capital in the venture. The U. S. businessmen were reported to have been "most favourably impressed by the Indian industrial environment and the stability and continuity of India's public policy". A spokesman of the U. S. businessmen was quoted as saying that the Government of India put forward a new concept of evolving a third sector to be known as the Co-operative Sector in which there would be participation by the Government, Indian private enterprise and foreign private capital. Prof. J. K. Galbraith, U. S. Ambassador in India, who, at the time of writing this, is in the States, told a press conference at the Indian capital before leaving for the U. S. that he would take up this question with Washington, along with other subjects.

According to the preliminary project report submitted by the Indian consultants even two years ago, the total estimated capital cost of the plant will be Rs. 220 crores, based on the assumption that the initial production would be two million ingot tons. The foreign exchange required would be approximately 40 per cent of the total cost. The problem of rising cost of equipment and also construction of a steel plant, which is more or less a world-wide phenomenon, must influence our Government to move expeditiously in the matter. It is stated that roughly the cost of machinery and construction is rising up at the rate of 2% annually and hence any delay in commencing construction work will result in the total cost of the scheme going up far above the estimated cost.

It is now a certainty that Madras State will have a steel plant in the very near future, utilising the iron ore of Salem and the lignite of Neyveli. A report has been received from Norway speaking to the very successful experiments in producing steel out of Salem iron ore, making use of the lignite as coking coal. It is stated that Norway has evolved a process of electrical reduction of iron and the report mentions that Salem iron ore, "after-magnetic concentration is quickly pre-reduced using Neyveli lignite". It has been disclosed that raw lignite as well as lignite briquettes are very reactive and are suitable reducing agents. Further tests are being continued in Norway on a larger scale and similar tests are going on in East Germany also. There has been a feeling shared by many that the South India is being neglected in respect of industrialisation and the proposed steel plant will give a quietus to this feeling, justified or not, by opening up prospects of a number of new industries.

The need of the hour in the Iron and Steel Industry is the attainment of a higher standard of efficiency in the field of production and distribution. India has lost its position as the cheapest producer of steel caused by the higher capital cost of coal and the difficulties in the supply of coal of the right quality. Government must lose no time in tackling this problem on a permanent basis. In the Third Five-Year plan of the Government, the pride of place has gone again to the Iron and Steel Industry. Out of a total public sector investment of about Rs. 1300 crores in industry, more than Rs. 500 crores has been allotted for the Iron and Steel Industry. The ambitious target of production of 9.2 million tons of ingots and 1.5 million tons of pig iron for sale besides production of alloy and special steels has been fixed. It can be seen how essential it is that the problem of ensuring adequate supply of coal of the right quality should be successfully solved for realising the targets fixed.

PIG IRON EXPORTS FROM BHILAI

The Bhilai Steel Works had exported about 1,47,500 tons of pig iron upto the end of October 1961. This means earnings of over Rs. 3,20,00,000 of foreign exchange.

In addition, the Bhilai Steel Works have despatched 3,18,863 tons of pig iron to foundries all over India upto end of Oct. 61.

Yugoslav is the new buyer of pig iron from Bhilai. The other countries buying pig iron from Bhilai are Japan, United Kingdom and Pakistan.

The Cleaning of Carbon Steel Wire as affected by the Metallurgical Nature of the Scale*

By A. B. DOVE
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ABSTRACT

THE paper reviews the theory of scale formation, effect of furnace gases and the mechanism of scale layer growth during cooling. It is shown that scale layer thicknesses, analysis and properties may be adjusted by controlled cooling to increase the speed of pickling and to reduce scale losses by as much as 65 per cent with attendant savings. The operation of a batch rod pickling process has been reviewed in the light of $FeSO_4$ saturation values and operating temperatures to provide data which will be of value for the control of acid regenerative pickling systems. The mechanism of scale growth during patenting operations is explained, and shows, contrary to usual expectation, that the most valuable aid to rapid cleaning of patented rod is the scale-breaking operation at the takeup block due to tension rolls.

INTRODUCTION

Anyone who has been concerned with the pickling of steel wire rods has, at times, reached the point of complete exasperation when one type of rod has given difficulty in pickling, either by the extension of the normal period of cleaning or by the appearance of smut or black patches within the time limit when cleaning should have been accomplished. Cleaning difficulties have shown up more markedly, in the experience of pickling house operators, in heavy rods in low carbon types, while the greatest ease of cleaning is generally evident on material which has been patented, and on which the scale has been "broken" during the re-reeling operation after patenting. The problem has been further complicated by the advent of mechanical descaling, in which some of the conditions which give rise to good pickling relationships appear to have quite an adverse effect on a mechanical descaling operation. Very little has been published on the theory of descaling wire rods or on the metallurgical factors which will contribute to efficient pickling and mechanical descaling operations.

THE THEORY OF SCALE FORMATION

The resistance of metal to surface attack depends largely upon the type of scale formed and its physical properties, particularly those of adherence to the base metal, porosity and the tendency to crack. The type of scale depends upon its chemical properties, such as composition, density, melting and boiling points. Furthermore, the conditions during scale formation may tend to increase the thickness of oxide layers, and those formed on metallic surfaces may volatilize rapidly, may be porous, may crack intermittently, or may increase in thickness by the diffusion of the base metal outwards through the layer, or of oxygen atoms inwards through the layers.

When the specific volume of the scale is equal to, or greater than, the specific volume of the metal, a tough adherent scale is formed on a metal surface.[1] If the molecular weight of the oxide formed on a metal can be designated by M and its density by D, the volume occupied by a gram-molecular weight is $\frac{M}{D}$. Again, if m represents the metal destroyed by the formation of a specific weight of oxide and d represents its density, the volume of a gram-atomic weight is $\frac{m}{d}$. The relationship $\frac{M}{D}$ divided by $\frac{m}{d}$ determines whether the film may be considered to cover the surface. If this ratio equals 1 because the volume of the oxide has not changed in relation to the volume of the metal from which it was formed, the film may be considered

to cover the surface. On the other hand, when the relationship is less than 1, the oxide film may be stretched across the metal surface with a tension which results in cracking or crumbling of the film. If the relationship is greater than 1, the oxide layer is in compression on the metal surface and this condition may cause cracking. It should be noted that these arguments are not valid for the formation of the first microscopic layers which may have a thickness of up to about 0.0002 mm. For iron the value of the relationship Md divided by mD lies between 1.77 and 2.16. Therefore, the last condition in which the oxide layer is in compression applies to the formation of hot oxide scales on iron.

If impervious films were formed, they should protect the surface from further oxidation. But scales continue to form because, according to the theory of diffusion through films, when the radius of the metal cation is smaller than that of the oxygen ion, diffusion of the metal cation takes place through the lattice. It is characteristic of FeO that, like Cu_2O, it has slightly less metal than the oxide formulæ require and this suggests that vacant spaces on the oxide lattice exist through which the metal cation moves, and electrons are free to move outward through the film, tending to prevent accumulation of electrical charge. At the surface, the electrons can react with oxygen to provide the negatively charged bivalent oxygen and allow further oxide formation. When metals have more than one valency, the higher oxides are likely to be free of metal deficiencies and thus Fe_2O_3 has more iron than the formula requires.

Fe_2O_3 is one oxide which will fail to protect the metal beneath it due to mechanical weakness. But any film of sufficient thickness may crack simply due to its different rate of expansion from that of the base, and thereby, oxygen is permitted to penetrate to the metal and carry on the oxidation of the base.

THE MECHANISM OF IRON OXIDE FILM FORMATION

Temper colors are formed on iron at relatively low temperatures, and these are produced by interference films of Fe_2O_3 which lie directly on the metallic base. As the temperature rises up to about 575 C (1067 F), Fe_3O_4 forms as an inner layer and above this temperature an inner film of FeO forms which is stable above 575 C (1067 F). At 550 C (1022 F), the relative thickness of the layers appears to be:

FeO	85—90 per cent
Fe_3O_4	10—15 per cent
Fe_2O_3	0.5— 2 per cent

At 1000 C (1832 F), the composition of these three oxides does not correspond exactly to that required by the chemical formulae, and all three oxides have a deficiency in oxygen content which is higher at the inner layer,[1] as shown in Table I.

TABLE I

Percentage of Iron in Scale at Various Positions

	Outer Interface	Inner Interface	Theoretical	
Outer layer	—	70.3%	Fe_2O_3	69. 9%
Middle layer	72.35%	72.6%	Fe_3O_4	72.35%
Inner layer	75. 6%	76.9%	FeO	77.75%

After a short period, the innermost portion of the scale on the iron becomes porous, and this would appear to suggest that the iron ion moves outward at a faster rate than oxidation takes place at the iron base, and therefore porosity of the inner side of the film occurs.

There are two other features which affect scale formation on iron, and these are the effect of time and the effect of temperature. It would appear that increase of time causes an increase in film thickness according to a parabolic relationship expressed by $x^2 = kt$, where x is the weight or thickness of metal consumed in scale formation, t is the time and k is a rate constant.

The second relationship of the effect of temperature appears to be that the increase in the rate of film formation can be expressed by an exponential function. In actual fact, however, this latter phase can be summarized by the simple statement that the higher temperatures tend to produce the more stable scales, while scale thickness may be considerably reduced by accelerated cooling of the rod during the hot rolling operation. As bundle weights have tended to increase, there has grown a tendency for the rod mass to cool more slowly. Again, higher temperatures have frequently been employed in the billet heating furnace as the final coil weight of rods has increased, and these factors have tended toward the production of a slow cooling, adherent scale which has increased the problems in the wire mill pickling house.

THE EFFECT OF BILLET FURNACE ATMOSPHERES

Preece and Riley[2] show that the composition of the billet furnace atmosphere, especially in relation to its content of sulphur dioxide and oxygen, is an important factor in controlling the scaling properties of exposed steels. Sulphur dioxide increases the rate of scaling; it increases the tendency for breakdown of the protective film in chromium, aluminum and silicon steels, and even permits intercrystalline penetration of the scale in some degree in steels of some analyses. Oxygen in the furnace atmosphere, on the other hand, very largely counteracts the effect of sulphur dioxide and produces a less adherent type of scale. Griffiths[3] further states that the addition of steam to the atmosphere in which the steel is exposed to heat provides, under certain conditions, a readily detachable scale which leaves the underlying surface of the iron entirely free from oxide. But he brings out quite pointedly that the rate of heating to an oxidizing temperature does not have as great an effect on the type of scale formed as does the rate of cooling.

In cases of steels containing phosphorus, the oxide may penetrate around the grain boundaries, preventing detachment by bending and in a considerable degree strengthening the scale so that ultimate acid action will not readily remove it. Increasing carbon content is shown by Scheurer[4] to reduce the amount of scale formed on plain carbon nonalloy steels, while the presence of sulphur dioxide in the furnace gases can neutralize this effect. He further shows that nickel promotes the attack on grain boundaries tending to form an adhering scale, and this effect is further increased by the presence of sulphur dioxide in the furnace gases. Chromium, on the other hand, counteracts a possible attack along the grain boundaries, while silicon promotes the formation of a heavy dense scale. Aluminum decreases the amount of scale formed, creating a protective layer against further attack. Scheurer also shows that, in general, fine-grained steels are more likely to form heavy scales than are coarse-grained steels.

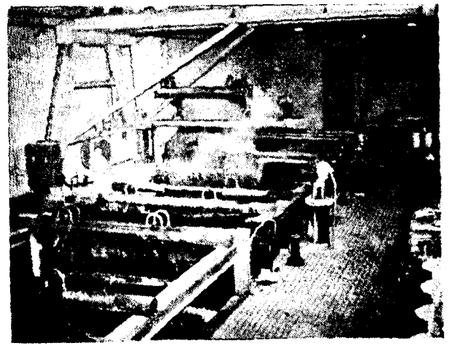


Fig. 1—Straight line batch rod cleaning operation. 4000-pound lots of rods are cleaned in tubs in the background, and are moved through washing, liming and backing by gantry crane.

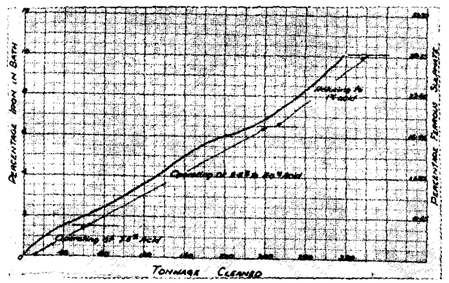


Fig. 2—Rise of iron value in pickling bath *vs.* tonnage cleaned. Values shown for average plot in 7300-gallon (Imperial) pickling bath with average scale 1.96 per cent by weight.

ACID ATTACK ON SCALE

Normally, the only portion of the scale which is readily attacked, according to the oxidation-reduction theory of chemical reaction, is the FeO layer which constitutes the major body of the formation. In order to arrive at the FeO layer, however, we must penetrate the Fe_2O_3 and Fe_3O_4 layers. The Fe_2O_3 is normally porous, but the Fe_3O_4 constitutes a major problem of attack. Some entrapped metallic Fe can be expected within the FeO and Fe_3O_4 layers, reducing at the periphery, higher within the areas adjacent to the steel base.

WIRE MILL PICKLING PRACTICE

In most cases, in wire mills, rod pickling (Fig. 1) is carried out on varied types of steels which may be placed in the bath consecutively. Fig. 2 shows the increase in iron value in a 7200 Imperial gallon sulphuric acid tank maintained at an average temperature

of 158 F over the greater part of the life of the tank. It will be seen that the iron value rises with a fairly straight-line characteristic until the percentage of ferrous iron reaches a value of 7, equivalent to about 20 per cent ferrous sulphate in the pickling bath, after which the iron value rises more rapidly until the bath is worked out.

It is normal in most cleaning houses to allow the acid value to reduce in this period of rapid ferrous sulphate rise, and the reason for this will be obvious if we examine Fig. 3 in which the solubility of ferrous sulphate in sulphuric acid solutions has been plotted showing the saturation content of ferrous sulphate against volume percentages of 66 Be. sulphuric acid. If the bath were to continue to be operated at 5 per cent sulphuric acid by volume at 158 F, it would become saturated with ferrous sulphate at about 23.5 per cent $FeSO_4$ by weight. By reducing the acid percentage, however, we are able to remain just below the saturation point, and the reaction for the formation of ferrous sulphate moves to the right.

If we examine Fig. 4, we see that we finally come to a point where there is insufficient acid to continue the action and the iron value rises more rapidly until the bath is worked out at about 1 to 2 per cent acid. It is interesting to note that, 2 per cent sulphuric acid by volume, the saturation point of ferrous sulphate in the pickling bath would occur at 27 per cent ferrous sulphate (9 per cent iron), but the bath has passed the saturation point, giving a value of 28.5 per cent ferrous sulphate (10 per cent iron) due to a short period of rise in temperature to allow the final loads to be removed in clean condition.

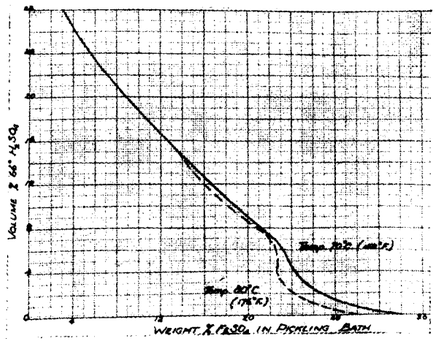


Fig. 3—Solubility chart for ferrous sulphate in sulphuric acid. It will be noted that the solubility of the salt decreases with rising temperature and rising acid content.

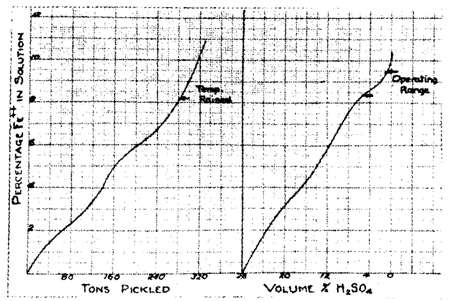


Fig. 4—Composite of Figs. 2 and 3. This graph indicates that the bath attains saturation at 70 C at 8.4 per cent ferrous iron at 5 per cent sulphuric acid by volume. If acid values are maintained, the bath will "die". Merely increasing temperature does not prevent this situation. Acid values must be decreased to permit the bath to continue in operation.

These graphs, then, illustrate the theoretical reason for the practical feature of lowering the acid content and raising temperature as the iron values approach saturation, and show that for iron values below 7 per cent the operation of a pickling bath may be considered to be a fairly straight-line operation with the exception of the "plateaus" which have occurred at just over 2 per cent iron and between 5 and 7 per cent iron. These "plateaus," we suggest, are probably due to an oxidation from ferrous to ferric iron which causes the action to proceed more quickly to the right and provides an apparent lowering of the rate of increase of ferrous iron in the bath.

Two further points are worthy of note. Firstly, the attack upon the steel base is reduced in acid containing ferrous sulphate. This is shown in Figs. 2 and 4, by the initial rapid rise of the iron value when less than 2 per cent $FeSO_4$ is present in the bath. Secondly, raising the temperature lowers the solubility of $FeSO_4$ in the bath, contrary to general opinion. This effect is, fortunately, overcome by increasing the rate of the acid reaction when the sulphuric acid content exceeds 1 per cent by volume.

If we are to consider acid regenerative processes, the above data provide the effective working ranges within which such processes may be successfully employed.

SCALE LOSS Vs. COOLING RATE

To return, for a moment, to the rod cooling operation, Knapp[6] has shown, as indicated in Fig. 5,

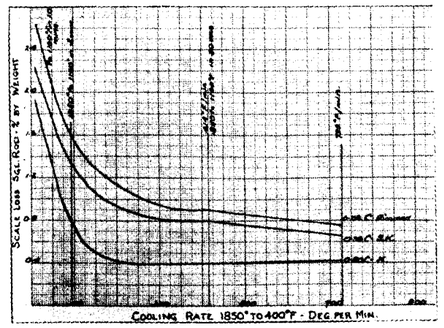


Fig. 5—Variation of scale weight with rod cooling weight. These results for 0.08, 0.38 and 0.80 per cent carbon, 5 gage rods are from a paper by E. L. Knapp.[5] Vertical markings indicate expected scale percentages resulting from cooling from 1850 to 1100 F in 10 minutes, 3 minutes and 30 seconds.

that the percentage of scale loss on 5 gage rod is a function of the average cooling rate of the rod and of the carbon content of the steel, and this is in accordance with the theory outlined above. At rates of cooling less than 48 F per minute, equivalent to cooling from 1850 to 1100 F in 10 minutes, the expected scale loss on various types of steel in 5 gage rod size would be as follows:

Low carbon, rimmed .08C	2.6 per cent
.38C silicon killed	2.2 per cent
.60C killed	1.8 per cent

It has been further shown that if the average cooling rate is increased to 414 F per minute, equivalent to cooling from 1850 to 1100 F in 30 seconds, these values become respectively 0.9 per cent, 0.8 per cent and 0.4 per cent. Our own studies in accelerated cooling have indicated similar values, and have shown that the weight of scale on rod is reduced by reeling at low temperatures according to Fig. 6. From these studies, we have determined that not only is the amount of scale formed a function of reeling temperature, but the cleaning time required is a direct function of the scale constitution and thickness, and therefore a direct function of reeling temperature.

If scale weight at the rod mill is kept at minimum value by accelerated cooling, most cleaning lines may increase their output by more rapid handling and baking, rather than by more tub capacity.

PHOTOMICROGRAPHIC STUDIES OF SCALE CONDITIONS

It would appear reasonable to assume that the more porous nature of the Fe_2O_3 layer and the amorphous nature of the FeO layer would, of themselves, assist chemical reaction in acidic solutions. Fe_3O_4, it has been pointed out, dissolves with difficulty and forms difficult-to-remove sludges. We have already have indicated that because the relationship $\frac{M}{D}$ divided by $\frac{M}{d}$ is greater than 1 for iron, the oxide layer is in compression on the metal surface, and this condition may cause cracking if the compression strength of the film is low. It has been shown during our experiments that difficult-to-remove scale has a complete coverage in the Fe_3O_4 layer and that those scales which may be easily removed are either cracked by their high compression values or have been broken away by bending in mechanical operation. In some plants it has been found desirable to normalize scaled steels in order to further increase the rate of growth of the FeO phase and cause cracking of the Fe_3O_4 layer.

Fe_3O_4, it will be recalled, is magnetic and—being difficult to dissolve—it may re-attach itself as a smut film to the iron after cleaning. Organic inhibitors tend to prevent this in large measure, but some commercial inhibitors which do not have a high film deposit may still permit the formation of smut on the cleaned rod, and such a contaminant will cause great difficulty in drawing operations, as well as contribute to poor finish quality. The elimination or reduction of the

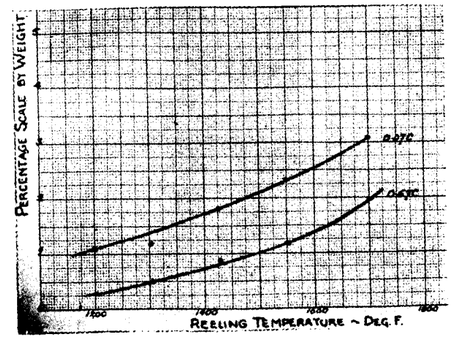


Fig. 6—Variation of scale loss on 5 gage rod with reeling temperature. Curves are shown for 0.07 and 0.57 carbon steels. These values do not include accelerated air cooling to 1100 F.

tendency to form Fe_3O_4 smutting can be accomplished in direct ratio to the reduction of the amount of Fe_3O_4 present, and this further, in turn, may be controlled by rapid rod cooling, by re-annealing in a reducing atmosphere or by high inhibition in the pickling operation itself.

If the smut once forms and presents a serious deterrent to drawing operations, the obvious way to remove it is to change the state of the oxide from magnetic Fe_3O_4 to nonmagnetic amorphous Fe_2O_3. This can be done by wetting the batch of rods and leaving it in the air to rust to the red oxide, or by other oxidation methods. While such conditioning will remove the smut, it does not decrease the tendency for surface roughness which can occur during the re-cleaning operation, and care is necessary when such material is handled through poorly inhibited baths. Again, some inhibitors tend to smut the surface of themselves because of the fact that they deposit a protective film, and for this reason many plants use cold uninhibited muriatic acid as a bright cleaning dip for process wire cleaning.

Two examples of difficulty in cleaning from actual case histories may well illustrate the above points.

CASE 1

A type of rod imported from the United Kingdom for special purposes continually exhibited poor cleaning characteristics. When solution of the scale was finally brought about, it was accompanied by a foaming of the bath which, in some cases, was likely to cause deterioration of plant equipment, apart from loss of solution. An investigation of this scale by photomicrograph showed that the Fe_3O_4 layer was almost completely unbroken around the circumference and that this impervious layer was thicker than normal, as shown in Fig. 7. Throughout the FeO mass were particles of unresolved iron which had been captured in transit, due to the fact that oxygen was cut off by the impervious Fe_3O_4 layer. It would appear probable that these iron particles were responsible for the formation of hydrogen which caused the bubbling in the bath and the foaming of the surface protective liquid.

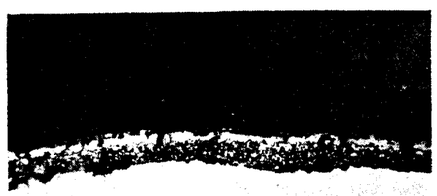


Fig. 7—Imported rod which gave long cleaning period and foaming. The Fe_3O_4 layer is unbroken, and metallic iron is dispersed throughout the FeO area. 500X. Etched in HCl and alcohol.

CASE 2

Two lots of .359-inch rod of the same heat of C-1006 analysis were prepared for drawing by chemical cleaning. One lot of these rods had been reeled at 1650 F at the rod mill and the other lot at 1585 F. The former lot could not be cleaned under normal conditions and required as long as 90 minutes in the cleaning tubs before scale attack could be accomplished. The second lot, reeled at 1585 F, cleaned in 40 minutes. Photomicrographs of the two structures are shown in Figs. 8 and 9. It will be seen at once that the FeO layer is thicker in the case of the 1650 F material, but that the Fe_3O_4 layer is almost completely unbroken. When reeled at 1585 F, the FeO layer is thinner than before and repeated breaks are visible in the Fe_3O_4 layer.

Fig. 8—C-1006, 0.359-inch rod, cooled to 1650 F at the reels. Note impervious Fe_3O_4 layer.

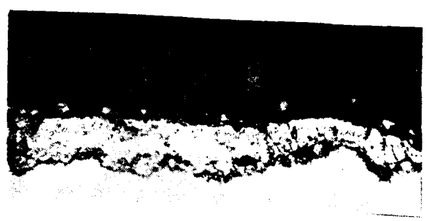
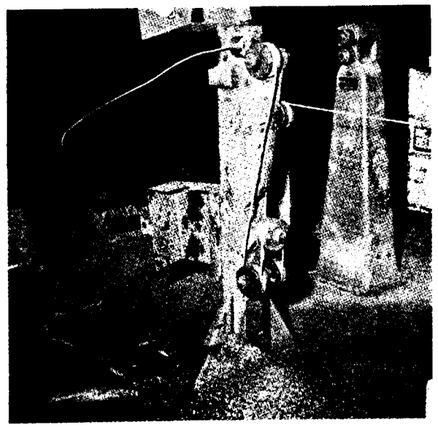


Fig. 9—C-1006 rod, same heat as shown in Fig. 8, but cooled to 1585 F at reels. Fe_3O_4 layer is now broken to permit acid attack. FeO layer is thinner than that of Fig. 8 due to faster cooling.

MECHANICAL DESCALING

Mechanical descaling may be accomplished by multiplane bending to crack off the scale, or by mechanical blast cleaning as performed by the Wheelabrator type operation. One simple multiplane mechanical descaler, as shown at Fig. 10(A) and (B), is employed as a scale remover ahead of wire drawing for wire intended for welded fabric. Typical loads of 5 gage rods were prepared by normal rod cooling, by accelerated cooling by water to 1400 F and by accelerated water cooling to 1400 F followed by air cooling. The material was then mechanically descaled and the scale was collected and weighed, with results as shown in Table 2.



A↑ B↓

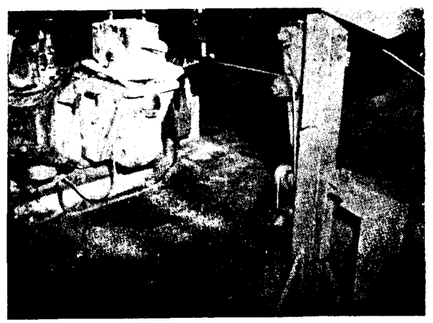


Fig. 10A and B—Simple, mechanical descaler. "A" shows the rolls over which the rod bends. "B" shows the rod passing directly from the descaler to the die stand on the wire drawing machine.

It is obvious from the finish produced by such mechanical descaling that complete cleaning—of the type resulting from chemical cleaning—is not obtained. The variations between mechanical and chemical scale removal for 5 gage rod in various carbon ranges are of interest as shown in Table 3.

These values indicate that chemical descaling removes more of the scale, as would be expected, but

TABLE 2

Comparison of Scale Removed Mechanically from Rods Cooled by Various Means

Treatment	Scale Loss per ton	Scale Loss per-centage	Steel Gain per ton by Cooling
5 gage Rod C-1012 normal cooling coiled at 1530 F	25.91 lb.	1.29	—
5 gage Rod C-1012 water cooled to 1400 F and air cooled for 35 seconds	12.22 lb.	0.61	13.69 lb.
5 gage Rod C-1012 water cooled to 1400 F	21.47 lb.	1.07	4.54 lb.

TABLE 3

Comparison of Scale Removal by Chemical and Mechanical Means on C-1012

Treatment	Scale Loss Mechani-cal	Scale Loss Chemi-cal	Differ-ence
A. C-1012 normal cooling to 1530 F	1.29%	1.92%	0.63%
B. C-1012 water cooling to 1400 F	1.07%	—	—
C. C-1012 water cooling to I400 F and air cooling	0.61%	0.66%	0.05%

further that cleaning by the multiplane bending process is more efficient when the rod is water and air cooled as in condition C.

The form of the scale cracked from the rod by mechanical descaling under various conditions of cooling is clearly different in each case, as shown in Fig. 11. The scale cracks from the rod reeled at the higher temperature in plates. As the reeling temperature falls, and as the rod is more quickly cooled thereafter, the scale cracks off in increasing fineness and in greater percentage of the total scale present.

The microstructure of the various scales points to the development of breaks throughout the Fe_3O_4 layer at right angles to the length of the rod as the reeling temperature is reduced, and reaches its limit when the rod is rapidly cooled below the red heat. This again is in agreement with the theory of scale density and coverage stated above.

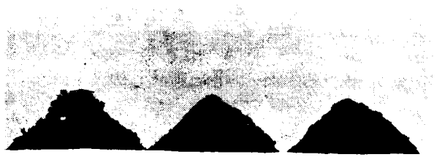


Fig. 11—Roll descaling of normal and accelerated cooled scales (actual size). The pile on the left results from normal cooling, coiling at 1530 F. The center pile was from rod reeled at 1400 F. The pile on the right was water cooled to 1400 F, reeled and air cooled for 35 seconds to 1100 F.

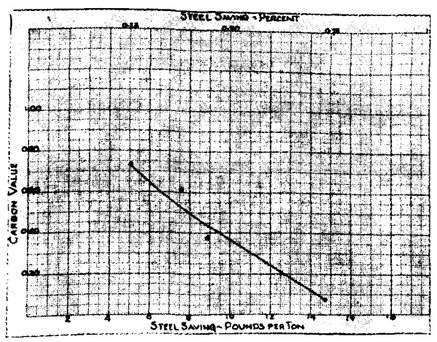


Fig. 12—Expected direct steel saving of various carbon steels by controlled reeling temperatures and accelerated air cooling. Values are shown in pounds per ton and percentage by weight. The curved line follows actual values.

CHEMICAL DESCALING

The removal of rod mill scale by chemical means still applies, in most mills, as the principal method of cleaning. Experimental evidence based upon actual rolling and cleaning was obtained on four types of rod mill scale by repeated actual cleaning of 4000-pound lots under normal working conditions in which loads were weighed carefully before and after pickling. A typical straight-line batch cleaning system is shown in Fig. 1.

TABLE 4

Comparison of Scale Weight vs. Carbon Value and Treatment

Scale Type	Scale Loss by Chemical Removal	Steel Weight Gain per ton
A. 5 gage Rope .71—.75 C unpatented normal cooling	0.918%	—
A1. 5 gage Rope .71—.75 C unpatented accelerated cooling	0.489%	5.06 lb.
B. 5 gage Rod Spring 134/178000 psi. unpatented normal cooling	0.975%	—
B1. 5 gage Rod Spring 134/178000 psi. unpatented accelerated cooling	0.332%	7.59 lb.
C. 5 gage Rod C-1035 unpatented normal cooling	1.091%	—
C1. 5 gage Rod C-1035 unpatented accelerated cooling	0.340%	8.86 lb.
D. 5 gage Rod C-1008 normal cooling	1.916%	—
D1. 5 gage Rod C-1008 accelerated cooling	0.662%	14.79 lb.

The above figures are in general agreement with the data provided in the section on Scale Loss vs. Cooling Rate, as demonstrated by Fig. 5.

It will be obvious from the foregoing Table 4 that, on a mill output of 15,000 net tons of low carbon rod there would accrue a reduction of over 200 tons of scale per month. This represents almost 121 tons of steel which can be saved at an average value of $12,100 per month. The economic advantage of reduced scale thickness will be obvious. The steel saving in pounds per ton for steel of various carbon groups is shown in Fig. 12.

THE EFFECT OF PATENTING ON PICKLING

Wire mill operators will at once select "green," as-rolled high carbon rods as one of the most difficult pickling problems facing the cleaning department, in spite of the fact that the scale is generally lower in weight percentage than that of low carbon steels when reeled at similar temperatures. We should expect that the higher carbon value induces increased reduction of the higher scales to FeO, but the fact remains that the thinner Fe_3O_4 scale is tight and generally free of breakage and such steels are difficult to clean.

Patented rods which have been heat treated at 1800 to 1900 F and quenched in air or lead are generally more readily cleaned. The effect is not actually due to the heat treating operation itself, but rather to the scale cracking operation performed as the rod or wire passes over the tension rolls at the takeup. The scale

Fig. 13—C-1035 steel. "Green" rod, as-reeled. 500X.

Fig. 14—C-1035 steel. Rod of Fig. 13, after passing through furnace, before passing over tension rolls at takeup. 500X.

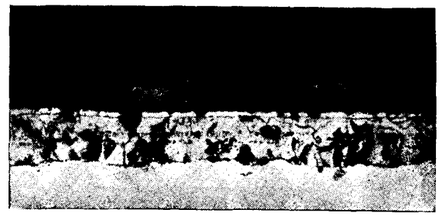


Fig. 15—C-1035 steel. Follows Fig. 14, showing structure of neutral zone after scale-breaking. 500X.

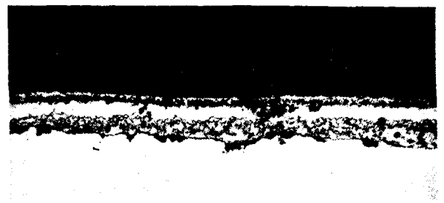


Fig. 16—C.1052 steel green rod, as-rolled, normal cooling. Note dispersed free iron, and fairly continuous Fe_3O_4 layer, 500X.

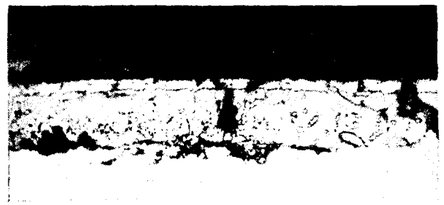


Fig. 17—Same as Fig. 16 after passing through patenting furnace. Note growth and continuity of Fe_3O_4 layer. 500X.

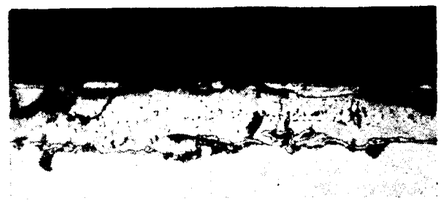


Fig. 18—Same as Fig. 17 after patenting and scale-breaking at tension rolls. Note broken Fe_3O_4 layer in peripheral areas where scale remains at neutral zone. 500X.

breakage which occurs here consists of removal, by cracking, of the tension and compression areas as the rod is bent over the tension rolls. A thick scale still exists, however, along each side of the rod. The scale conditions at each stage are shown in the photomicrographs. Figs. 13 to 18 inclusive for C-1035 and C-1052 steels.

The patenting operation is shown, in part, in Figs. 19 to 21 inclusive, commencing with the rods at the furnace exit. On leaving the patenting furnace and travelling in air, the scale grows. Fig. 20 shows the water quench arrangement. Very little scale is removed in this area, since the rod has already cooled to below 1000 F before entering the water bath. The cracked scale is seen at the reel position where it has fallen from the tension rolls as the rod passes to the block.

Two examples of the effect of patenting upon scale are shown in Figs. 7 to 12 inclusive. In Figs. 13, 14

Fig. 19—Rods leaving patenting furnace. Strands cool to black heat rapidly usually within 10 feet of furnace for 5 gage rod.

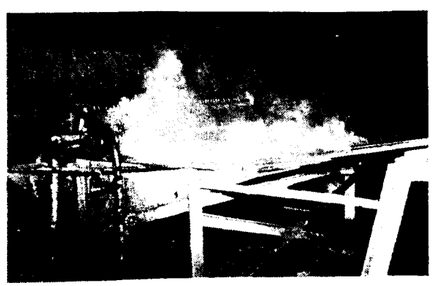


Fig. 20—Rods after patenting at water quench. The quench cools the rod so that it will not "shrink" onto the takeup reel. This cooling also assists ease of handling. Very little scale is removed in this area.

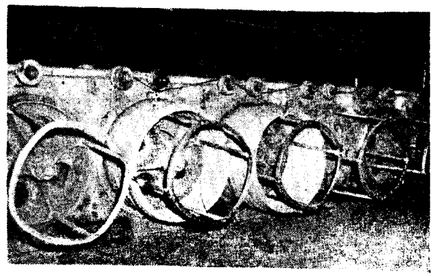


Fig. 21—Takeup reels at patenting operation. The scale is cracked as the rod passes over the tension rolls, and falls to the floor. Note piles of scales below the blocks.

and 15 we have shown photomicrographs of a C-1035 steel before patenting, after patenting and after scale-breaking. Before patenting, the oxide layer has a thickness of only 0.00025 in. and is composed of approximately 40 per cent Fe_3O_4 and 60 per cent FeO. Immediately after leaving the patenting furnace (Fig. 14) the scale is 0.001 in. thick and is now composed of 80 per cent FeO and about 20 per cent Fe_3O_4, and the new Fe_3O_4 layer, due to the more rapid cooling by strand operation, has only one-third the thickness of the previous layer of similar analysis. In the third photomicrograph (Fig. 15), we see that the scale, where still attached, is of the same relative thickness, repeatedly broken through the Fe_3O_4 layer and through the FeO layer where scale still exists on the periphery.

Figs. 16, 17 and 18 show a similar condition for a C-1052 rod. In this case the initial scale has a thickness of 0.001 in, as produced at the rolling mill. It consists of about 80 per cent FeO and about 20 per cent Fe_3O_4, with very little Fe_2O_3 present. The Fe_3O_4 layer is continuous, and areas of free iron are noted throughout the massive scale structure. In the second photomicrograph (Fig. 17) we see that the scale has grown 50 per cent in thickness by patenting, and that the structure is now about 90 per cent FeO. There is less unresolved iron, but the Fe_3O_4 is still fairly continuous. In the last photomicrograph (Fig. 18), after reeling over the tensioning rolls, we have the same thickness of scale in the few areas where it still exists, but the Fe_3O_4 layer has been broken up and there are many entries through which the FeO layer may be attacked by acid solution.

Photomicrographs of the green, as-rolled rod, reeled

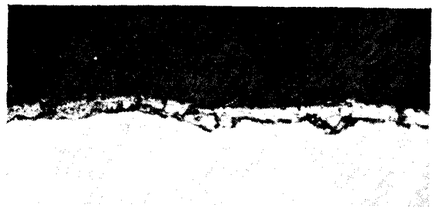


Fig. 22—Tire wire rod, 0.77 C, water cooled to 1300 F, reeled and air cooled. Fe_3O_4 layer is cracked, permitting entry to lower oxides. Thickness less than half that of normal cooling. 500X.

Fig. 23—Tire wire rod, 0.77 C, normal reeling at 1530 F. Fe_3O_4 layer thicker and more continuous than in Fig. 22. 500X.

at 1530 and 1300 F, are shown in Figs. 22 and 23 respectively. These indicate that if accelerated cooling is employed by reeling at 1300 F and air cooling according to the S-curve for the steel concerned, a new condition is brought about in which the surface scale is cracked, and the entire scale weight and thickness are reduced as shown in Table 5. Such scale will grow once more during patenting and the greater part will be removed by tension rolls as before.

The points which have been observed from this portion of the study are:

(a) High carbon rods, as rolled, when reeled at 1530 F, are difficult to clean due to an impervious scale surface of Fe_3O_4 which is tight and free of surface cracks.

(b) Similar rods, when patented after rolling and reeling at 1530 F, grow further scale body during patenting. The greater part of the scale is removed by cracking during re-reeling at the patenting furnace takeup. While the scale weight is low, it is thick where not removed by tension and compression forces induced by tension rolls.

(c) If such rods are cooled by water and air, and reeled in the rod mill at 1300 F. the scale weight is similar to that of patented rods, but uniformly distributed and cracked throughout. Scale removal is readily accomplished in about half the time required for patented rods.

(d) It would be desirable to lower reeling temperatures even on rods which are to be patented. This would reduce the scale thickness on the "uncracked" areas and still provide a saving in reducing steel loss by conversion to original scale.

TABLE 5

Comparison of Scale Loss on Green, Patented and Controlled Cooled Rod

	Quality:	Tire Rod				
	Analysis:	C. 0.77	P. 0.017	S. 0.034	Mn. 0.90	Type KHS
Condition	Rod Reeling Temperature	Forced Air cooled		Scale Loss	Average Time to Clean	Condition of Pickling
Green—as rolled	1530 F	No		1.25%	50.4 mins.	12.8% acid 2.4% Fe
Patented—air cooled	1530 F	No		0.22%	30.1 mins.	10.0% acid 2.3% Fe
Controlled cooling	1300 F	Yes		0.20%	15.3 mins.	11.0% acid 4.3% Fe

SUMMARY

1. By a review of the theory of scale formation, insofar as it concerns wire rods, we have shown that under normal conditions the surface scale produced by heating at the billet furnace, rolling, reeling and cooling is normally in compression.

2. We have indicated, by reference to the literature, the mechanism by which scale forms and the relationships between changes of time and temperature, showing that time increases the film thickness according to a parabolic relationship, while the effect of temperature is exponential.

3. References have been given from literature which show the effects of atmospheres and analysis upon scale formation.

4. A consideration has been made of the rates of solubility of the various scales and we have shown that difficult-to-clean material frequently possesses these characteristics because the Fe_3O_4 layer is relatively insoluble in sulphuric acid, and it is not possible for the acid to reach the soluble FeO layer readily.

5. We have considered the characteristics of the rise of iron value in an actual pickling bath and have verified the conclusion that $FeSO_4$ has an inhibitory effect upon the attack of the steel base and that the conditions under which a bath must be emptied are a function of saturation of the solution with $FeSO_4$; the lowering of acid concentration at workout is necessary in order to achieve maximum solubility. We have also indicated that this data will provide an operating procedure for regenerative control of batch pickling systems and could be extended to the control of continuous systems.

6. The results of experiments on accelerated cooled rods have indicated a feasible method of reducing scale thickness and increasing yield at the rod mill with attendant savings.

7. The scale constitution principle has been used to explain the formation of smut or "carbon" on cleaned rods.

8. The effect of low reeling temperatures on simple mechanical descalers has been indicated, and typical cases of rod cleaning difficulties have been reviewed and explained.

9. We have indicated that mechanical descaling is less efficient than chemical, but that the efficiency of mechanical descaling may be improved by lowering the reeling temperature at the rod mill and by subsequent accelerated cooling to black heat by air or water.

10. We have studied the effect of patenting upon the pickling operation and have shown that contrary to general expectation, the thickness of the patented scale is greater than that of the "as rolled" scale, even under normal reeling conditions without accelerated cooling. We have reviewed the scale formation which results from patenting and have shown that the improved cleaning conditions on patented rod over green rod are actually brought about by scale breakage over the tension rolls and not necessarily by the patenting operation itself. A comparison of cleaning times indicates that a green rod, reeled under controlled accelerated cooling conditions, can possess a complete coverage of the periphery by a reduced thickness of mill scale and still clean faster than a patented and reeled rod having almost identical scale weight.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the valued assistance provided by F. L. Jamieson, L. Eaton, F. Kurth and V. R. Jefferess of the metallographic staff of the metallurgical and chemical laboratories of The Steel Company of Canada, Limited, Hamilton Works, who prepared the photomicrographs and photographic studies used in this paper. The writer also wishes to acknowledge the contributions of E. G. Baker, chief wire metallurgist, and his staff at Canada Works and Parkdale Works in gathering data on the full scale pickling and descaling tests so necessary to this report.

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[*Presented at Buffalo Regional Technical Meeting of American Iron and Steel Institute, September 28, 1960.]

INDIAN MINING ENGINEER STUDIES BRITISH METHODS

When Mr. Narendra Nath Ganguly returns to his home at Kusundah, Dhanbad (Bihar), after two months in the United Kingdom, he will have spent almost as much time below ground as he has seeing the British countryside.

A colliery engineer, Mr. Ganguly is making a special study of British mining methods. He is also studying some of the new British-made equipment now being used by his company. This includes an underground locomotive, powered by a flameproof Diesel engine made by the Perkins group, of Peterborough (Northamptonshire).

At the Perkins service school, he told a correspondent: "It is very important I should learn all about this engine, for when I get home I shall have to arrange servicing facilities for it below ground."

Bethlehem Yard—Biggest and Modern on West Coast

THE Los Angeles Harbour Shipyard of the Bethlehem Steel Company now offers world shipping lines the biggest and most modern repair and conversion facility on the entire Pacific Coast, William Harrington, Manager of the yard, announced recently.

Harrington's announcement marked the completion of a $ 7,000,000 expansion programme at the 38-acre Bethlehem yard situated on Main Channel, and his acceptance for the firm's shipbuilding division of a laudatory resolution adopted by the Los Angels Board of Harbour Commissioners.

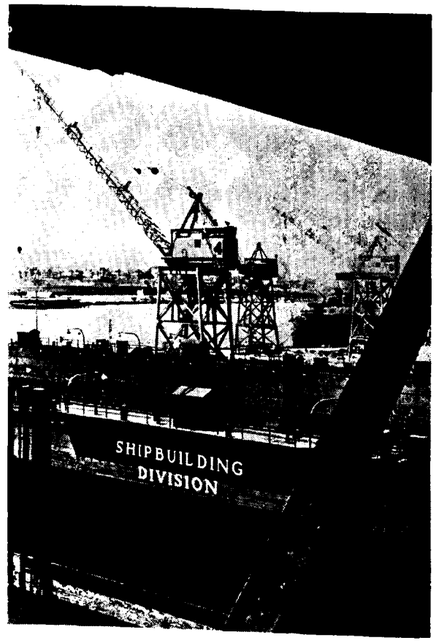
Improvements, started in 1959, have more than doubled Bethlehem's repair and conversion potential. When fully utilized, total employment will increase by more than 3,500 workers.

Four shipbuilding ways, used during World War II to build 26 destroyers, were dredged and the area expanded to provide facilities for repair and conversion of four large ships simultaneously.

Eight huge new gantry cranes, two with 140-foot booms and six with 90-foot booms, operate on four new pier platforms of concrete and steel. The docks are fireproof and the most modern ever designed. They are equipped with the latest time and labour-saving facilities, including lines for power, water, steam and sand blasting, plus other " built-in " equipment required in ship repair work.

The yard's 15,000-ton sectional drydock, formerly located on the north section of the yard, was moved to the new section. Old outfitting docks and piers of wood were removed and new modern concrete and steel facilities were built.

Bethlehem's decision to make its Los Angeles Harbour Shipyard a highly specialized and modern repair and conversion facility stemmed from two developments. These were: (1) the increased channeling of Navy ship repair work to private yards; and (2) the needs of the rapidly growing world merchant fleet serving this and other Pacific Coast ports.



Partial view of the recently enlarged and modernized Los Angeles Harbour Shipyard of Bethlehem Steel Company. In foreground is 15,000-ton sectional drydock; beyond are four of eight huge gantry cranes used in yard's repair and conversion work.

World's Largest Electric Furnace Designed

Soviet engineers have designed the world's largest three-phase, three-electrode electric furnace.

The furnace will produce about 250,000 tons of top-quality steel a year. Its capacity will exceed that of a 400-ton open-hearth furnace. This giant is to be put into operation in 1965.

The Great Victory in Steel

By CHU CHI-LIN

BY turning out 18.45 million tons of steel in 1960, China outstripped France* and assumed sixth place in world steel production. Only three years ago in 1957, the year prior to the big leap forward, China held ninth place with an output of 5.35 million tons. Going further back to 1949, the year the People's Republic was founded, China, with an output of 158,000 tons, ranked 26th among the 35 countries then producing more than 10,000 tons of steel a year. Within the short span of 11 years, China had caught up with and surpassed no less than a score of countries in the production of this all-important metal.

SPEED MARKS BIG LEAP

What is especially noteworthy is that China's steel production has maintained its big-leap rate of advance for three consecutive years. In 1958, steel output jumped from 5.35 million tons to 8 million tons, showing a net gain of 2.65 million tons. The further increase to 13.35 million tons in 1959 represented a net gain of 5.35 million tons, exactly equal to the total amount produced in 1957. Last year, the net increase also exceeded 5 million tons.

These three consecutive years of big leap forward meant that a new high speed had been introduced into the growth of China's steel industry. During the First Five-Year Plan, China's steel production increased from 1.35 million tons in 1952 to 5.35 million tons in 1957, giving an average annual rate of growth of 31.7 per cent and an average annual net increase of 800,000 tons. Whereas during the three big-leap years 1958—60, the average annual rate of growth was 50 per cent and the average annual net increase was an astounding 4.37 million tons, or 5.4 times the annual average during the First Five-Year Plan. The reader may be interested to know that China's first modern steel mill was established in 1890. In the 59 years between that time and the founding of the People's Republic in 1949, total of 7.6 million tons of steel were produced, or less than half of last year's output.

The fact that China's steel output zoomed from 5.35 million tons to 18.45 million tons within three short years is nothing short of phenomenal. To achieve a comparable increase took the United States nine years; postwar West Germany, six years; postwar Japan, nine years; and the oldest capitalist country, Britain, fully half a century!

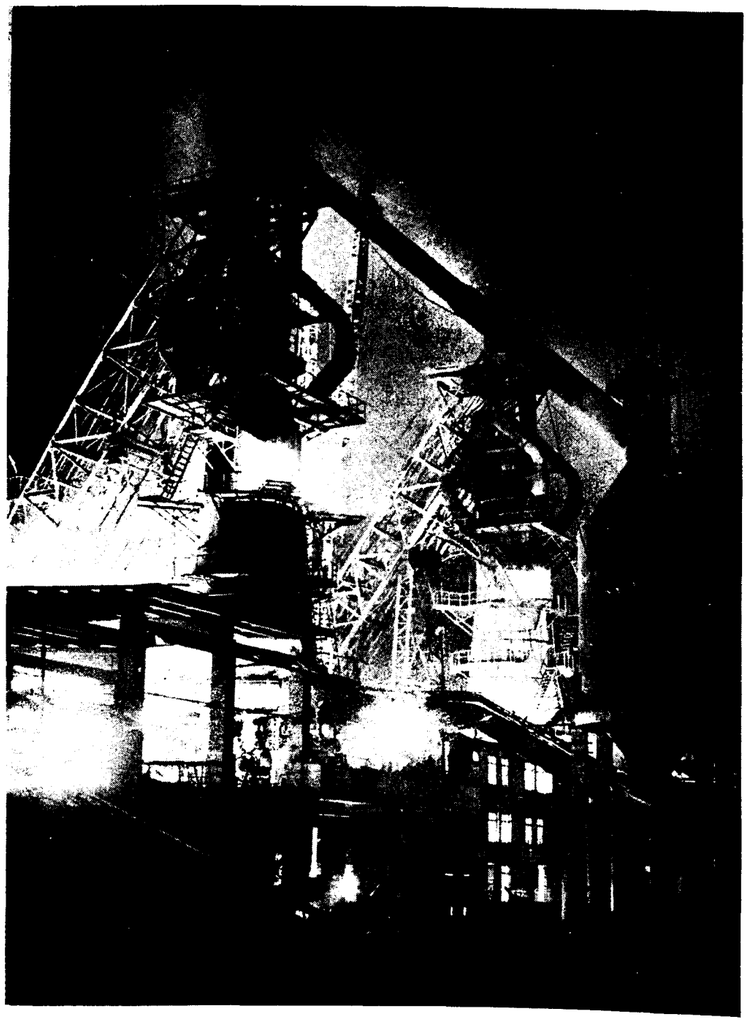
This swift advance enabled China in 1960 to top by more than 50 per cent the target originally set for 1962, the last year of the Second Five-Year Plan—10.5-12 million tons. Thus time has been gained to devote greater energy, in the last two years of the Second Five-Year Plan, to improving the quality of iron and steel and increasing the variety of steel and steel products while at the same time continuing to raise output.

NATIONWIDE IRON & STEEL NETWORK

The continued big leap forward of the iron and steel industry resulted in a fundamental change from the semicolonial state of affairs in old China in which iron and steel enterprises were concentrated in a few coastal areas away from its sources of raw materials and domestic markets. The beginnings of an iron and steel industrial network geographically rationally distributed and embracing large, medium-sized and small enterprises has taken shape over China's vast expanse.

The reconstruction of Anshan Iron and Steel Company, China's biggest steel base in the northeast, was completed in 1960. It has become one of the world's largest modern ferrous metallurgical enterprises. The building of two new giant integrated iron and steel works at Paotow in Inner Mongolia and Wuhan on the Yangtse in central China was accelerated last year during which time many projects were completed and commissioned. These three mammoth integrated enterprises constitute the backbone of China's growing iron and steel industry.

*According to figures released by the European Coal and Steel Community on January 11, 1961, France's steel output in 1960 was 17.2 million tons.



Night view of a blast furnace at the iron smelting works of the Anyang Iron and Steel Company.

Meanwhile, the construction of medium-sized iron and steel works is now under way in all provinces and autonomous regions. Some have already been completed and the overwhelming majority have started partial operation. The galaxy of small iron and steel plants that stud all parts of the country have all become complete, modern enterprises after having been overhauled, consolidated and improved. In Tibet where no iron and steel industry existed before, the first blast furnace of the new Lhasa Iron and Steel Plant turned out its first heat of pig iron in early October, 1960. Thus all 27 provinces and autonomous regions of the country now have their own iron and steel enterprises. Some 80 per cent of the

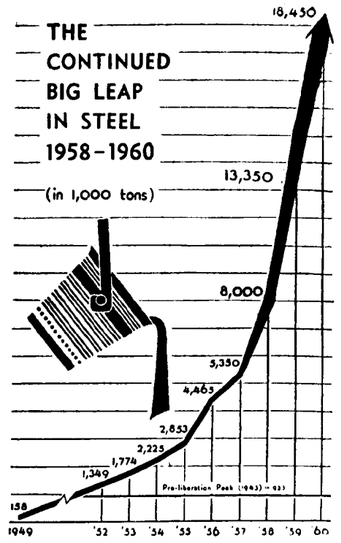
First small blast furnace went into production in August, 1958 in the small iron and steel plant run by the Anhwei Provincial Committee of the Communist Party.

country's special administrative regions and 30 per cent of the countries as well as many people's communes now boast their own iron and steel mills.

For an immense country such as China a nationwide iron and steel industrial network distributed in a way that is relevant to the dispersion of resources and the requirements of economic growth is of tremendous significance in the overall development of socialist construction and especially in the provinces and autonomous regions.

TOWARDS HIGHER QUALITY AND GREATER VARIETY

Concurrent with the rapid increase in output went a considerable advance in the technical level of China's iron and steel industry. After a year of actual operation the workers completely mastered the newly built giant modern 1,513-cubic-metre blast furnaces and the 500-ton open-hearth furnaces. In 1960, the best monthly average coefficient of utilization of the big blast furnaces (output of pig iron per cubic metre of



available volume of the furnace per 24 hours, an important index of the technical level) was 24.2 per cent higher than the previous year; the best monthly average coefficient of utilization of the large open hearths (output of steel per square metre of hearth floor per 24 hours) was 8.4 per cent higher than the preceding year. The best monthly average coefficient of the open hearths in Shanghai topped the 16-ton mark and set a new world record.

The continual increase in variety and improvement in quality of products are further indications of the rising technical level of the iron and steel industry. Old China had to import the steel windows and nails needed for construction, to say nothing of steel rails or high-grade steels. But to-day, after the First Five-Year Plan and especially after the three consecutive years of the big leap, many plants in China have successfully trial manufactured and are producing a wide range of new products technically highly exacting. These are essential for the manufacture of the many types of large and precision equipment that are of extreme importance to economic progress. The industry is now concentrating on the further increase in output of high-grade and alloy steels and the most important types of steel products so that these will constitute an increasing portion of its total output.

SMALL ENTERPRISES PLAY BIG ROLE

The small modern iron and steel enterprises played a big role in the fulfilment of the 1960 plan. The medium-sized and small mines and mills accounted for more than half the national output of both iron ore and pig iron and produced about two-thirds of the country's coke. Shanghai, one of the nation's important steel-making centres, produced no pig iron in the past. It started to turn out pig iron during the big leap forward, but output was small. Last year, the city made 40 per cent more steel than in the preceding year with by far the greater part of the necessary pig iron being supplied by the newly developed small blast furnaces of the east China provinces. This testifies to the vitality of the policies known as "walking on two legs." It would have been impossible for China's iron and steel industry to forge ahead at such a big-leap pace had efforts been limited to building giant modern enterprises alone and the development of large numbers of small ones been neglected.

The present small modern enterprises grew out of the great number of small indigenous ones built in 1958 when the whole country was swept by a drive for iron and steel. They were further improved technically in 1960 and both their productivity and the quality of their products have risen considerably while costs and raw material consumption have been drastically reduced. Thus weaknesses quite unavoidable in their initial period have been largely overcome. In 1959, only some 80 of the country's small blast furnaces attained the level of the more advanced big blast furnaces in coefficient of utilisation; by the first half of 1960, as still incomplete figures for only seven provinces show, the number shot up to more than 300. As far as quality is concerned, more than 90 per cent of the pig iron produced by small blast furnaces in Anhwei, Heilungkiang and other provinces are up to standard. Some of the small converters have also devised new techniques. Those in Tsingtao, Shantung Province, succeeded in making more than 50 types of high-grade and alloy steels. All this points to a very promising future for the small modern enterprises.

IMPETUS TO AGRICULTURE AND OTHER INDUSTRIES

The sustained big leap forward in the iron and steel industry gave great impetus to the development of all other branches of the national economy. Guided by the policy to taking agriculture as the foundation for

the development of the national economy, the iron and steel industry gave agriculture energetic support in every way. As a result of the rapid advance in steel, the state was able to allocate more than one million tons of steel products for direct use in agriculture in 1960. This was about double the amount allocated in the previous year or during the entire First Five-Year Plan. The results are tangible. By the end of 1960, the number of tractors on China's farms was about 3 times what it was in 1957; drainage and irrigation machines and hydro-electric stations for agricultural use were respectively 9 and 17 times the 1957 figures. From 1958-60, the area newly brought under irrigation exceeded the total added in the previous eight years following liberation.

Increasing amounts of steel are being supplied to agriculture. In the first month of this year, 100,000 tons of rolled steel had already been rushed to the farms for the manufacture of small farm tools for spring ploughing and summer harvesting alone, not to mention the steel that went into the manufacture of tractors and other modern farm machines.

The small modern iron and steel enterprises spread out all over the country gave effective direct support to the rural people's communes in their efforts to boost production. Wenhsien County, Honan Province, is an example. This was a rural county virtually devoid of industry in the past. But an industrial network serving agriculture has taken shape in the wake of the small modern iron and steel plants. In the two years and more since the establishment of the county-run iron and steel plant, more than 2,000 tons of pig iron and 600 tons of steel both made by indigenous methods have been supplied to agriculture. These contributed to the manufacture of the following items: 44 coal gas engines, 160 steam engines, 40 animal-drawn sowers and harvesters, 1,100 paddy thrashers, 100 fodder crushers and more than half a million hoes for middle-ploughing and other small farm implements—all made by local tool plants. There were no chemical fertilizer or machine-building plants in the county in the old days. Today, all six communes there have set up machine-building or repair and assembly plants with 55 machine tools among them. The communes' own indigenous-style chemical fertilizer plants turned out a total of 3,700 tons of chemical fertilizers. To fight the drought that hit the county in the spring of 1960, the county-run iron foundry and engineering plant using locally produced pig iron and steel rushed out in very short order more than 100 irrigation machines and over 300 sets of tools for sinking wells. This enabled the communes in the county to sink more than 1,000 mechanized wells for irrigation, thereby greatly alleviating the situation.

The site of this thriving Hsuanwu Steel Plant was a reed ground more than two years ago.

The sustained big leap in the iron and steel industry was also a powerful spur to other industries. In spite of serious natural calamities, industry as a whole maintained the leap forward in 1960. The planned targets for such important heavy industrial products as coal, electricity, petrolium, machine tools and tractors were all fulfilled or overfulfilled. Compared with 1957, gross industrial output value in 1960 registered a nearly threefold increase. The average annual rate of industrial growth during the three big-leap years was over 40 per cent, more than double that during the First Five-Year Plan. As a result, China's level of industrial production has been considerably heightened and its material and technical basis greatly strengthened. This has played and will continue to play a significant role in the technical transformation of the national economy, first and

foremost, of agriculture, and in the progress of science and culture.

VICTORY OF THE GENERAL LINE

The uninterrupted big leap forward of the iron and steel industry was a great victory for the Party's general line for building socialism and the complete set of policies known as "walking on two legs." It was at the same time the result of the heroic labour of the iron and steel workers whose subjective initiative reached a high pitch and who overcame many difficulties.

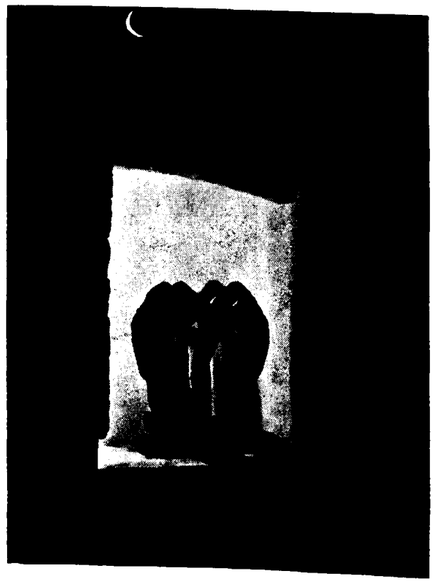
A gigantic movement for technical innovations and technical revolution centring on full and partial mechanization and automation got into full swing at the beginning of last year. It embraced all departments and enterprises of the iron and steel industry and yielded remarkable results. Since many metallurgical enterprises were able to substantially raise the degree of their mechanization and automation by devising all sorts of mechanized and automatic production lines, very favourable conditions have been created for the fulfilment and overfulfilment of production plans.

The great victory in steel was won only after battling against serious natural disasters. Early last August, the northeast's Liaotung Peninsula was ravaged by unprecedentedly heavy downpours. Several huge iron and steel enterprises were surrounded by flood at a time. The workers organized shock brigades that kept day-and-night vigils, did emergency repairs and moved in needed raw materials. The blast and open-hearth furnaces that were forced to suspend operations soon resumed production.

After mid-August, the iron and steel workers pushed their vigorous movement to increase production and practise economy to a new high and steel output has been on the rise ever since. Taking August's average daily output as 100, it was 120 in September, 144.6 in October and November and 154 in December.

As they enter the year 1961, workers on the iron and steel front continue to go all out, rolling the industry rapidly forward along the charted path of higher quality and greater variety while raising output.

Ancient Process adapted by British Company for Precision Casting



This is not a cunningly lit piece of contemporary sculpture, but one of the stages in the lost-wax process of precision casting. Taken at a British company's precision foundry at Patchway, Bristol, England, this picture shows a refractory shell which has been fired to some 1,000 degrees Centigrade to burn out residual wax and make the mould completely inert. The lost-wax process has, in fact, been known for something like 4,000 years, but remained for centuries the special province of Jewellers and sculptors. It was used, to particularly good effect, by the great 16th century Florentine master, Benvenuto Cellini.

The British company has adapted this ancient process for component manufacture for its range of aero-engines, as it allows for the production of units having complicated shapes.

BENZOL RECTIFICATION PLANT

By

P. R. GHOSH and B. C. MATHUR

CRUDE benzol, produced in the Benzol Recovery Plant is treated in the Rectification Plant for its final separation into pure benzene, pure tolume, pure xylene solvent, naphtha and still residues.

The Rectification Plant at Bhilai employs the conventional method of processing the crude benzol by first removing the carbon disulphide and other lower boiling components of crude benzol by fractional distillation and then washing the resulting product with sulphuric acid for the removal of other impurities. The washed material is again subjected to fractional distillation for the production of pure products.

CHARACTERISTICS OF CRUDE BENZOL

The Crude Benzol is received from the Benzol Recovery Section in two grades viz. (a) light crude benzol-boiling upto 150°C and (b) heavy crude benzol boiling over 150°C. The light crude benzol as being obtained at Bhilai is characterized by high benzol content and has the following boiling range.

Drop point		77°C
Distillate upto	100°C	86%
,, ,,	120°C	92%
,, ,,	130°C	94.5%
,, ,,	140°C	96.5%
,, ,,	145°C	97%

The yield of light crude benzol is about 9–10 times that of heavy crude benzol, whose boiling range upto 180°C, is only 6–9%. This heavy benzol is separately fractionated in batch type still and the fraction upto 180°C is collected and treated together with light benzol for further purification.

PROCESSING OF CRUDE BENZOL

The processing of crude benzol proceeds in the following order :—

1. Removal of head fraction (lower boiling components) in continuous CS_2 distilling column.
2. Washing the resulting benzol with sulphuric acid in batch type mechanical agitator for the removal of other impurities.
3. Rectification of washed crude benzol in continuous benzol column for the production of pure benzene and removal of higher boiling homologous of benzene.
4. Fractional distillation of higher boiling homologous of benzene in batch type still for the production of pure toluene, pure xylene and solvent.

REMOVAL OF HEAD FRACTION

The removal of head fraction is carried out continuously in carbon disulphide column. The column has been designed for the removal of head fraction in amount not exceeding 5% of the crude benzol. But depending on the content of sulphur compounds in crude benzol, removal may be somewhat less and may be taken as 2.5 to 3%.

Light crude benzol is pumped from the storage tank through a filter by centrifugal pump and is fed to the 19th plate of the column. Liquid from the base of the column passes through a steam reboiler where after being heated, the vapours are fed to the 5th plate of the column. Steam heating in the reboiler is regulated automatically according to the desired temperature at the 5th plate.

The head fraction leaves the column from the top and enters the condenser. The distillate then flows to the separator for the removal of water and then directed to a cylindrical vessel known as reflux tank. Reflux is fed to the column from this tank by a centrifugal pump. Liquid level in the reflux tank is maintained constant automatically by a pneumatic

valve installed in the delivery line of the reflux pump to ensure constancy in operation. Excess of head fraction corresponding to its content in crude benzol is removed from the delivery line through Rotameter and is collected in its respective tanks.

STORAGE

The crude benzol free from head fraction leaves the column from the bottom and is collected in storage tank after being cooled in tubular heat exchange. This benzol must have the drop point not below 79·5°C and its CS_2 content must not exceed 0.07%.

In order to get a product of such quality, the operating condition of the column is maintained as below :—

1.	Temperature at the base of column	80°C
2.	Temperature after the reboiler	94°C
3.	Pressure at base of the column	0.2–0.4 atm.
4.	Feed	2–2.5 M^3/hr.
5.	Reflux ..	..1.6–2.0 M^3/hr.
6.	Velocity of vapour.	..0.5–0.6 M/Sec.

The head fraction content of crude benzol at Bhilai is negligible and the CS_2 content of the crude benzol obtained from the bottom does not exceed 0.25%.

WASHING OF CRUDE BENZOL

After the removal of head fraction, the crude benzol is washed with 92% sulphuric acid to remove the other impurities viz. sulphur compounds, unsaturated compounds etc. This washing is done in batch type mechanical agitator.

Consumption of sulphuric acid is about 5% on the weight of crude benzol and the spent acid is regenerated and sent to sulphate plant for use. The sludge can either be disposed of as it is or neutralized and stripped of benzol before it goes as waste.

After the removal of regenerated acid and sludge, the washed benzol is given an alkali wash with 10% caustic soda solution to remove all the entrained acids and make the washed benzol slightly alkaline in reaction. The consumption of caustic soda per ton of crude benzol is about 5–6 kg.

RECTIFICATION OF WASHED BENZOL

The washed benzol is then subjected to rectification in continuous benzol column where pure benzene is removed as vapour from the top and other higher boiling homologous as liquid from the bottom. The bottom product is cooled in tubular heat exchanger and is then collected in storage tanks.

The washed crude benzol is pumped from the storage tank by centrifugal pump and is fed to the 13th plate of the column. Liquid from the bottom is similarly heated up steam reboilers and fed back to the 5th plate of the column. Steam rate to the reboilers is automatically regulated in the same way as that of CS_2 column.

The pure benzene vapour leaves the column from the top and is directed to the condenser. The liquid product then flows to the separator for the removal of water and then enters into a reflux weir box. In this box, the flow is divided in two streams one going to reflux tank and another going to pure product receiver. The rate of the flow can be manually regulated according to reflux ratio.

From the reflux tank, the material is fed to the top of the column by a centrifugal pump. Liquid level in this reflux is maintained constant similar to that of CS_2 column.

The pure benzene as being received at Bhilai from the continuous column conforms to the specification of Nitration Grade Benzene, of Indian Standard Specification.

TX contains the higher boiling homologous of benzene. This material is fractionally distilled in batch tube still for the production of pure toluene, pure xylene and solvents.

The batch still is a horizontal vessel of about 50 cu. m. working capacity and is provided with heating arrangement by means of open as well as closed steam.

The product leaves the column from the top and passes through a vapour neutralizer for the removal of acidic vapours. The vapour neutralizer is a cylindrical vessel of about 1,400 mm. in diameter and 3,200 mm. in height containing two numbers of bubbling plates. A 15% caustic soda solution is recirculated through this neutralizer by means of centrifugal pump after proper cooling and separating it from any condensed

product. The recirculating caustic soda solution is changed when the strength drops below 5%.

The vapour after leaving the neutralizer enters into the condenser and the distillate flows through the same system as described in the production of pure benzene.

The reflux ratio varied according to the products received and is usually maintained as below :—

For Toluene	.. 2.0
For Xylene	.. 1.5
For Solvent	.. 1.0

The intermediate fraction namely benzene-toluene is mixed with the washed crude benzol and toluene-xylene is mixed with the bottom of benzol column for reprocessing. The steel residue left after the distillate of pure products is disposed of by mixing with crude tar.

CONCLUSION

As per schedule, the plant is designed to handle about 10,700 tons of crude benzol per annum producing the following materials :

Motor fuel	50 tons
Pure Benzene	6250 ,,
Pure Toluene	1490 ,,
Pure Xylene	500 ,,
Solvent	400 ,,
Still Residues	1100 ,,

The Plant has been commissioned about 4 months back and so far 1200 tons of Nitration Grade Benzene have been produced and despatched. The quality as well as the quantity of crude benzol now being received are somewhat different from the earlier estimate and as a result of this, the production figures may vary a little from the original estimate ; the full picture will be available after the plant has been run for a few months more.

SECOND BLAST FURNACE AT KARAGANDA STEEL WORKS COMMISSIONED

The second gigantic blast furnace at the Karaganda Steel Works, which will be the biggest in the USSR after the famous Urals Steel Works, was commissioned. The commissioning of the second blast furnace concludes the construction of the first section of this enterprise, which is the firstling and integral part of the third steel industry centre of the Soviet Union.

* * *

TO 50 COUNTRIES

A large consignment of wire was shipped to Kathmandu by the steel-rolling mill of Odessa, Ukraine. Nepal is the twenty-eighth country where this plant is exporting its goods. In April it shipped consignments of metal to Ghana, Guinea, Ethiopia and Ceylon.

Factories of the Odessa Economic Area are increasing exports considerably. Companies in Austria, Finland, France, Argentina, Turkey, Japan, Canada and Pakistan are displaying growing interest in the produce of Odessa plants. Goods manufactured in Odessa are delivered to 50 countries.

* * *

ALUMINIUM HIGHWAY BRIDGE

The first aluminium highway bridge in the United States is under construction at Petersburgh, Virginia. The 97-foot-long, 28-foot-wide structure will weigh 48 000 pounds—less than one-third the weight of a comparable steel bridge, a Reynolds Metal Company spokesman says. The aluminium alloy being used is especially designed for strength and anti-corrosiveness. The bridge, scheduled for completion in August, will span the Appomattox River.

* * *

A NEW ELECTRONIC STRIP CHART RECORDER

A new electronic strip chart recorder, with alternative logarithmic or linear response, has been introduced by a U. K. firm. The recorder has two slidewires fitted in the standard position. One slidewire is included in the measuring circuit and, to obey a logarithmic law, it is wound in 12 linear sections, each section having wire of different gauge or material. The law accuracy of the logarithmic slide-wire is claimed to be better than 0.4 per cent.

Progress of Metallurgy in the Soviet Union

By Mr. N. I. GONCHARENKO
Chief Representative, Soviet Organisation (Tiazpronexport)
BHILAI

METALLURGY was, it is now and for a long time to come it will remain the foundation of social and economic system of any country. The vital impact of Metallurgy on human life and endeavours was understood by man even in ancient times. There is a popular legend.

When Jerusalem Temple was built, the Czar desired that the most important builder should be singled out and seated on the Tribune of Honour. As nobody could determine the person the Czar gathered all the builders and declared that the arm-chair of honour may be occupied by the most important builder. While the discussion went on, a very stout man approached the armchair and occupied it. The Czar asked the man by what right he had occupied the seat. "I have occupied the seat because I am the most important builder", was the answer. "Why" asked the Czar again. "Because I am an "iron-smith. You please ask any builder any carpenter or any mason what tools they have used".

The replies of the builders convinced the Czar that the iron-smith was right as all the tools used by builders were made of steel.

Thus, even in ancient times, steel was of great importance.

Now at the time of rapid development of technique one can hardly underestimate the importance of metal. Some 20 years ago we had neither space ships nor atomic stations. Man could only guess about the future shape of things and other unknown metals.

The things have changed. Science and life have already asked for new metals. Some 1000 years ago, iron stepped into the life of our forefathers. However radical the changes our old little planet might have undergone we are still living in the age of iron, and we have all the grounds to think that in spite of considerable importance of new metals, steel will retain its importance for at least one century more.

The economic potential of the Soviet Union has increased 45 times because the Soviets had realized the importance of steel. In a comparatively short span of less than 50 years, the Soviet Union, a backward country in the past, has emerged as a powerful industrial state with highly developed technique. And great has been the services done by the Soviet Metallurgists in these achievements. Today the Soviet Union occupies second place in the world as regards the steel production but the hour is not very far when the Soviet Union will take the first place. Quite recently in the American press there appeared an official statement of the United States Minister of Labour who admitted that the Soviet Union had reached the U. S. A. level in the steel production, if not outrun it, in the third quarter of 1960.

Metallurgical advance has been rapid in Soviet Russia since 1913. Very soon we shall discuss our plans for development of our economy in the following 20 years. How magnificent will our achievement be as regards our economic rise which will help us to outrun the main capitalist countries. We, the Soviet people, have no doubts that our programme of the seven year-plan (1959—1965), as well as other plans to follow, will be carried out successfully. The fact that the Soviet Union was far ahead of the planned schedule in the first two years of the seven years plan, is a striking demonstration of the actual possibilities of our plans.

SECRETS OF SUCCESS

What are the secrets of our success?

How did we manage to go up so high?

What are the bases on which we achieved these results?

Two major steps were taken.

The first step was to build more powerful industrial units and to replace the old ones. Some ten years ago, we had Blast Furnaces of 600 cubic meters capacity. The Blast Furnaces of today are of 1386-1513-1719 cubic meter capacity and more. Last year, at the Krivorozhaki Steel Plant, a blast furnace of 2,000 cubic meter capacity was commissioned. Our planners have been designing blast furnaces of 2,500 cubic meter capacity and more. Our steel production capacities have increased from 60-ton Open Hearth Furnaces to 500-ton furnaces (Alchevski plant, Cherepovetski plant and some other plants). Such is the way to the growth of the open hearth furnaces and their capacities. During this year open hearth furnaces of 600 ton capacity will be commissioned in Krivorozhski steel works. Our planners are working on designs of new open hearth furnaces of 800 ton capacity, and from 10-ton converters to 45-ton oxygen converters of today and to a 200 ton converter of tomorrow.

In the Rolling Mills field, all the old and unmechanised mills have been reconstructed during last few years. Powerful mechanised continuous mills, both merchant and sheet mills, have been commissioned and are now in operation, running with high speed and rational pass designs. Reheating furnaces have been considerably improved.

Furthermore, new refractory and ferro-alloys industries have been built, all anew.

Not less important is and will always be the 2nd step towards growth of metal production and that is better utilisation of the existing capacities.

Previously, the Blast Furnaces of 1,000 c. m. capacity gave the output of approximately 700 tons of pig iron per day. The production of the same furnace is now 1,300: almost two times. It is a system in the Soviet Union to estimate the work of the Blast Furnace by the coefficient of the useful volume utilization of the blast furnace capacity. The previous coefficient of blast furnace's useful volume was 1.5 whereas now we have 0.75 as the average throughout the Soviet Union in 1960. That means the previous utilization of blast furnaces volume was 1.5 c. m. of Blast Furnaces volume per one ton production now it is 0.75 only and even 0.5 to 0.6 cu. m. per one ton with such leading plants as Magnitogorski, Cherepotetski Plants and some other plants. Previously, the output from 1 cubic metre of open hearth bottom area was 4 tons. It was 8.09 tons as the average tonnage in the USSR in 1960. Some plants have the output of 10 tons per 1 cu. m. of the bottom and sometimes even more. So steel production of today with the same furnaces is two times more than that of the past years. Production per working hour in the rolling mill has also been increased twofolds.

The Soviet Metallurgists are rightly proud of the fact that from the same capacities of blast furnaces, open hearth furnaces and rolling mills, they produce 25 to 30 per cent more of metal than any other country, including the USA.

How was it done ?

The desire to increase production is there, it is not a secret. The Russians have it, but desire only is not enough. More important is the introduction of new technique and advanced technology which determined the better utilization of the existing capacities in the long run. Leading workers and engineers and technicians along with the innovators and inventors played a decisive role there. The importance of our scientific and research institutes and central plant laboratories has greatly increased during last few years.

We, the Soviet Metallurgists, are proud of assistance in the economical growth of our country to such an extent, which will give us the possibility of creation of material, cultural and spiritual well-being of the Sovietman—the master of his own country and reactor of plenty.

India of today and its people are doing their very best to build their own powerful industry as quickly as possible. During a rather short period, India has increased production of metal more than two times. A greater programme has been planned out for the future development.

On December 16, 1957, the Prime Minister Mr. Nehru in his impressions mentioned the importance of Bhilai and that of metal. He said Bhilai was a dream coming true. He said Bhilai was one of these places embedded in the national consciousness as a significant symbol of a new age in India. He said that as the result of his visit and personal acquaintance with its manifold activities he came to the conclusion that the old dream was taking its shape and coming true as a symbol and a portent of the India of the future. From the bottom of our hearts, we, the Soviet people, wish the Indian people a quicker and better turning of the dream into reality. An unusually honourable task is set before the Bhilai

(Continued on page 32)

The Revolutionary EIMCO 136-RO Type Slag Loader for Steel Mills

By An Engineering Correspondent

IN its never-ending drive to build better equipment for the industries it serves, The Eimco Corporation of Salt Lake City, Utah, has developed a specialized new Front End Loader for open hearth cleanout and loading slag and other material in steel mills.

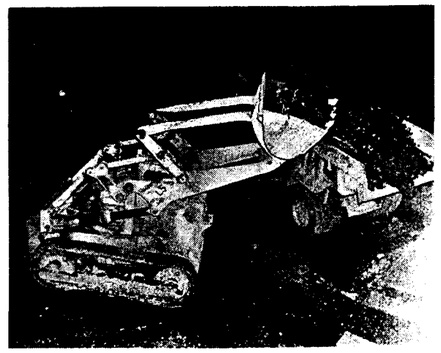
Designated as the Eimco 136-RO, Special Steel Mill Front End Loader, the new loader is offered either as a standard front dumping machine or with a side dump bucket, which can discharge to either side.

The primary purpose of the 136-RO is to provide the operator more protection from the heat and dust associated with slag handling and yet provide him with greater visibility. This has been achieved by repositioning the operator's seat and control cab high towards the rear of the machine.

In cleanout work, it is not necessary for the operator to go as far into the slag pit itself. Instead, the long arms of the RO reach out, break up the slag and scoop it up in the bucket for transport to the dumping vehicle.

The Eimco 136-RO has extraordinary power. It has a tremendous breakout force of 45,000 pounds and can lift nine tons of hot slag to 11 feet, high enough to discharge into railroad gondola cars or the largest of trucks and dumpers.

Operators who have used the machine, praise its



Eimco 135 special Steel Mill Front End Loader.

(Continued from page 31)

Steelworks. During the present five-year plan, they have to achieve the given project capacity in a short spell of time and not only this they will also have to expand the plant to two and a half times. The staff of high officers, supervisory and non-supervisory workers of Bhilai Steel Plant with such an experienced, intelligent and ripe man as Mr. Suku sen at the head, have already displayed their skill and capacity and ripeness in mastering the task set before them.

As the result of steps and measures taken, the Indian specialists, with the help of the Soviet experts, have considerably improved on production.

The plant has been running smoothly and making better technical and economic showings.

This achievement should be consolidated in spite of unfavourable climatic condition, I mean monsoons.

Far away from their homes, the Soviet specialists in Bhilai along with their Indian friends did their level best and worked hand in hand for better results. They shall not spare their efforts, labour and knowledge to assist their Indian friends in obtaining an effective grasp on metallurgy. May the work of Indian and Soviet Metallurgists be crowned with greater success and glory to render more useful service to their countries and mankind.

ease of control. Like all Eimco Crawler-Tractors, the 136-RO has finger tip control of the crawlers and power shifting. True spin turns are possible as a result of independent drive to each track.

Because of its ease of control, the Eimco 136-RO has a built in safety factor. The operator can concentrate on control of the bucket, which is something a man really appreciates when he is responsible for handling up to nine tons of red hot slag at a time.

There also is less danger of spillage out of the bucket when travelling. The track oscillation feature of the Eimco makes it possible for the machine to traverse over uneven floor or obstructions without tipping the bucket.

The 136-RO is powered by a 218 horsepower naturally aspirated General Motors V6-71 Diesel. As a result, there are no maintenance problems inherent in souped-up, turbo-charged engines. Another important maintenance-cutting feature is the self-cleaning air cleaner. This unit utilizes the venturi action of the exhaust to keep dust out of the engine air intake, eliminates daily servicing of the air cleaner, and in fact, can operate up to 1,500 hours without any servicing at all. And an indicator warns when such servicing is required.

From the RO cab, the operator has an unobstructed view to the front or back and can load with a minimum of spillage. The lift cycle of the machine is fast, with an average of 18.5 seconds. The Eimco is equipped with a 3 cubic yard bucket, specially reinforced to withstand the punishment of slag loading.

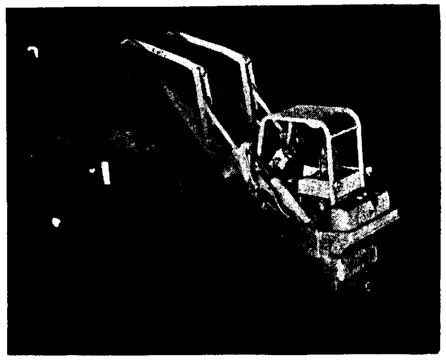
The side dump 136-RO is designed so the bucket can be dumped to either side just by changing the clamping arrangement on the pivot pin. The side dump provides a full 5 feet, 8 inch reach on either side.

The 136-RO is a heavy duty machine, with heavy duty construction features throughout. Heat-treated Utaloy alloy steel track shoes are precision keyed to the links, assuring long wear even in steel mill service. Additional protection is provided to the track rollers by track guards.

Eimco also manufactures other specialized steel mill loaders with standard buckets: the 115 Excavator, with overhead bucket action; the 136 Steel Mill Front End Loader and the 133 Steel Mill Front End Loader, a smaller 107 or 122 HP machine, as well as all types of Bull-dozers in each power series from 107 to 218 HP Diesel.

Virtually every major steel mill throughout the world, including those in India, use specialized Eimco Steel Mill Loaders and Excavators for more efficient, economical slag loaders.

Eimco 115 special Steel Mill Excavator



Eimco 136-RO special Steel Mill Front End Loader

The exclusive Eimco dealer in India is William Jacks & Co., Ltd., with sales and service offices throughout the country.

Eimco's head offices are in Salt Lake City, Utah, U.S.A., where the principal manufacturing centers are located. In addition to the manufacture of crawler-tractors, the corporation also is the world's largest manufacturer of underground rock loading equipment, designs and builds industrial filtration equipment, industrial thickeners, water and wastes treatment equipment and operates a large Research and Development Center. Eimco has branches, warehouses and dealers throughout the world and manufacturing affiliates in principal European and African countries.

Coke Oven Batteries of Bhilai and their characteristics

By SEN and RAMKRISHAN

Coke Oven Department, Bhilai

THE primary function of the Coke Oven department in an integrated steel plant as Bhilai Steel Works is the production of metallurgical coke for chemical reduction of iron ore at elevated temperatures in the blast furnaces. The properties of metallurgical coke are influenced by the following major factors :—

1. Types and analyses of the coking coals available ;
2. Coal preparation and blending methods ;
3. Oven battery heating operation methods and schedules ;
4. Oven battery design ; and
5. Coke preparation methods.

The objectives to be attained in a coke oven battery for efficient and economical working of the unit are :—

1. Production of coke of good uniform quality ;
2. Minimum consumption of fuel gas ;
3. Minimum loss of volatile products by leakage ;
4. A stable and strong oven structure ; and
5. A battery, simple and flexible in operation.

With the above objectives, a 3 battery unit of 65 ovens in each battery was envisaged and built. The operating batteries have a rated capacity to carbonize 1506 tons of dry coal per day per battery, with the carbonization period of 17 hours. The yield of coke as per project report will then be 1,145,000 tons of blast furnace coke per year with 40% moisture. Coking time can be reduced to 16 hours thereby increasing the output to 1,220,000 tons year.

OVEN DIMENSIONS

The cold dimensions of the oven are as shown below :—

Overall length	14,080 mm
Length inside oven door lining	13,350 mm
Height from oven floor to oven roof	4,300 mm
Height of coal charge	4,000 mm
Average width of oven	407 mm
Width of oven taper	50 mm
Chamber volume	21.7 cu. m.

Excluding checker bricks, the entire oven brickwork is of silica bricks. Total bricks in a battery weigh about 14,000 tons.

HEATING SYSTEM

It is of the twin flue compound firing type with waste gas recirculation. Rich gas is fired through gas guns on each side. Batteries are designed to use blast furnace gas in order to release richer coke oven gas for steel plant requirements. While blast furnace gas and coke oven gas can be fired separately, there is provision to mix the two also.

OVEN MACHINERY

The batteries are provided with self-sealing doors, and up-to-date oven door handling and coal charging equipments have eliminated a good bit of hot arduous labour on the ovens. Duet collecting mains provide extra advantages for easy operation. Charging ovens with steam injections aid smokeless charging with increased economy and improved top operating conditions. Modern equipment with automatic controls and electrical limits, protects oven equipment, aids in the maintenance of operating schedules and facilitates keeping operating areas clean.

There are 3 sets of pusher machines, charging cars and quenching cars and 4 sets of door extractors for the 3 battery unit. While the machines are of the conventional type, some special features in these machines which enhance the degree of automation and modernization in the plant are :—

1. A levelling window lifting device which opens and closes mechanically, the levelling window of an oven for purposes of levelling.
2. A compressed air blowing arrangement with air reservoir, compressors etc. on pusher machine to blow off roof carbon in the ovens. This is provided in addition to the normal graphite cutter.
3. Special pneumatic gate opening mechanisms in charging cars to open and close service bunker gates to receive charge from service bunkers.
4. Ascension pipe cleaning mechanisms to prevent building up of carbon in ascension pipes provided in charging cars.
5. Lid lifters provided in charging cars which remove and replace charging hole lids mechanically.
6. A weighing mechanism on charging car which records automatically, the weight of coal charge in the hoppers.
7. Special pneumatic interlocking between pusher ram and door extractor and electrical interlocking between pusher ram and quenching car doubly ensures proper pushing of ovens and proper receiving of coke.

SERVICE BUNKERS

The 3 battery unit is served by 2 service bunkers each capable of holding 3,000 tons of coal blend. These bunkers are provided with compressed air blowing arrangements in each and every section to dislodge coal when it hangs.

COKE QUENCHING

There are two quenching towers one on either end of the unit. Each tower has its own water circulating system consisting of pumps, setting tanks, breeze recovery and loading facilities. Instead of using fresh water for quenching purposes, the disposal water from bye-product plant in used effectively, saving fresh water consumption and at the same time providing a means to dispose contaminated water. About 0.5 cubic metre of fresh water is saved for every ton of coke that is quenched.

COKE SCREENING

The three battery unit is served by two wharfs. Coke wharf gates are operated automatically by a mechanism which takes 18 minutes, to empty a wharf. From wharf, coke is conveyed to a 100 minutes grizzly which discharges coke above 100 mm. size through a coke cutter. The crushed coke is further conveyed to a 25 mm. grizzly which screens the coke above 25 mm. size and feeds it to blast furnace conveyor. The under-pass of the 25 mm. grizzly is passed over a 25 mm. control vibrating screen which recovers +25 mm. coke and feeds it back to the blast furnace conveyor. The 25 mm. size coke is further conveyed to a 10 mm. vibrating screen which screens it to two sizes of 10 to 25 mm. nut coke and 10 mm. breeze coke which are stored in separate bunkers. The nut and breeze coke are loaded in wagons for utility purposes. Major consumer of breeze will be sintering plant which will be commissioned shortly while nut coke is mostly sold to outside customers.

The +25 mm. coke carried over the blast furnace conveyor, is fed by two tipper cars to the coke bunkers of the 3 blast furnaces.

The whole coke screening plant is worked from a panel board in a centralized control room. Full sequence and interlocking in starting and stopping of conveyors are maintained.

It is worthwhile to mention that all the three batteries have been successfully commissioned in only two years' time, considering the enormous difficulties of the initial stages of this huge venture. Besides commissioning various equipments and machinery, the training of men for different skilled and semi-skilled posts was an uphill task.

Aluminium Suspension Clamp for Overhead Transmission Lines

A new design of aluminium suspension clamp for overhead transmission lines has been introduced by a U.K. firm. It consists of two matching halves that when brought together enclose the conductor and grip it with the correct degree of tightness. Thus the clamp cannot be overtightened, as is possible with the old style, and damage to the conductor strands from this cause is eliminated. The axis of the side trunnions is level with the conductor centre-line, which ensures that any pivoting motion will have the least possible effect upon the conductor.

Material and Design Defects in Forged Steel Rolls

By A. A. BRADD

Coordinator of Rolls, Midvale-Heppenstall Co., Philadelphia, Pa.

(A wholly-owned subsidiary of HEPPENSTALL CO. Pittsburgh 1, Pa.)

Care in design and manufacture can reduce defects in rolls....roll life is extended and better product is produced.

ROLLS bear the responsibility for a large part of the success of any rolling operation. Both the quality of the product rolled and the rolling costs are directly related to roll performance. The increasing trend toward more stringent surface requirements in rolled products, the rolling of harder and more difficult alloys, and the effort to obtain more economical production by increasing rolling speeds and more efficient grinding practices have required parallel efforts by the roll makers to produce a product that will satisfy the user's needs.

There are few if any engineering parts that have as varied and severe requirements as rolling mill rolls. They are undoubtedly among the most highly loaded in service of all products. Many rolls are subjected to service loads that are well above their endurance limit. Surface finish requirements frequently approach optical levels. Wear and abrasion resistance and high hardness are often combined with the conflicting need to have the ability to withstand severe shock loading and at the same time to respond to shotblasting to produce a uniform and reproducible pattern that does not wear smooth too fast.

This paper outlines the production steps in the manufacture of a roll and describes how some defects get into roll material. It will also give a few examples of how these defects can affect roll life and performance. New melting processes are being used to make roll steel and the improvement that can be expected in material made by these new melting methods are mentioned. Design features can also an important bearing on roll performance and some examples of how simple design changes can sometimes result in marked improvement will be described.

Many of the defects to be discussed are very much the exception rather than the rule. The great majority of rolls are free from harmful defects and give entirely satisfactory service.

MELTING

The basic and probably most difficult to contr process in the manufacture of any steel product is tl melting operation. An otherwise perfect roll wou be useless if it contained non-metallic inclusions th produced unacceptable surface blemishes on the rolle product. Clean steel is essential for good rolls ar all melting efforts should be aimed at producing ste with maximum cleanliness.

The subject of non-metallic inclusions in steel is very complicated one. Non-metallics in steel con from two general sources. Molten steel is in conta with refractories in the furnace and in the ladle ar chemical or mechanical reaction with the refracto can result in the steel becoming contaminated. Tl molten stream of metal from the furnace to the lac and from the ladle to the mold is in contact with a and oxidation of the surface by the air can introdu oxides into the steel. These oxides and the refracto material constitute one type of inclusion source. T second source of inclusion is the result of reactio from within the steel itself or from additions to it a from changes in solubility while the molten steel cooling and solidifying. Sims([1])* has shown th non-metallic particles present in molten steel will ri very rapidly because of the difference in densi between the non-metallic and the steel. For instanc a particle 0.004 in. in diameter will rise at the ra of 2 fps. The larger the particle the faster it will ri There is fairly general agreement that most inclusio which result from refractory contamination cor from around the spout of the ladle and from t spout itself, as the steel is poured from the ladle the mold.([4]) Any refractory contamination th occurred previously and did not dissolve will ha had sufficient time to float out of the steel. T

*Numbers in parentheses refer to Bibliography at the end this article.

stream from the bottom of the spout becomes oxidized as it passes through the air. A layer of oxide material is also likely to be present on the rising surface of the steel in the mold. The falling stream carries refractory and oxide inclusions deep into the mold and also drives some of the surface material underneath.

The second source of inclusions result from the oxidation products of Al, Mn and Si added as deoxidizers at the end of the heat. These elements have a strong affinity for oxygen and they can become oxidized while the stream is passing through the air from the ladle to the mold. Sulphides have high solubility in liquid steel and low solubility in solid steel. They, therefore, precipitate as the steel solidifies. Deoxidation practice has an important effect on the size and shape of the precipitating type of inclusion. The cooling rate of the steel also affects their size. Larger inclusions normally are associated with large ingots that cool slowly. There are, therefore, two types of inclusion material in the mold as the steel starts to solidify. One type is present as distinct particles that rise very rapidly. The second type is in solution in the molten steel and is precipitated as the steel solidifies.

The steel in the mold freezes most repidly at the surface. The inclusion material that exists as distinct particles and is rising very rapidly would most likely be trapped at the surface of the ingot. The steel cools at a progressively slower rate away from the mold wall. Large inclusions would be expected to have enough time to float out of the usable portion of the ingot as a result of the slower freezing rate away from the surface. It could be anticipated that this type of inclusion would tend to be largest near the surface and at the bottom of the ingot and become progressively smaller toward the center of the ingot.

The type of inclusion that precipitates out of solution in the steel as it solidifies tends to become progressively larger with slower cooling rates. This type of inclusion would be expected to be smallest at the surface where the cooling rate is the fastest and largest at the center of the ingot where the cooling rate is the slowest and maximum time is required for solidification to take place.

Of course, this is an idealized description. Actually there is turbulence in the mold because of the stream of steel falling from the ladle, and occasionally large inclusions that were present in the liquid steel are carried to inner parts of the ingot and are trapped there by the freezing metal. Back pouring after a considerable quantity of inclusion material has floated to the top of the ingot would be an effective way of driving the inclusions back into the ingot and should be avoided where clean steel is required.

The surface of roll ingots will, therefore, be the most likely place for one type of large inclusions to be found and sufficient cut must be made when machining the forgings to remove this surface zone to avoid the presence of gross inclusion bearing material in the finished roll.

By similar reasoning, the second type of large inclusions are likely to be formed at and near the center of the ingot. This is particularly true of medium and large ingots where the cooling rate becomes quite slow and there is ample time for inclusions to grow to a large size. This is one of the reasons why we bore our larger rolls. The bore removes the material that is likely to contain large inclusions. It also removes center segregation, looseness and other possible defects. Table I shows the bore diameters that we have been using for several years where the roll design permits the relationship shown to be used. If the journals are too small to permit a bore as large as that shown on the table, or if the roll is to be remade later into a smaller design where a smaller bore is required, smaller bores than are shown on the table are used.

TABLE I

Recommended Roll Diameter-Bore Diameter Relationship for Forged Steel Rolls

Roll Diam, in.	Bore Size, in.	Roll diam, in.	Bore size, in.
10–11	$1\frac{3}{4}$	23	$4\frac{3}{8}$
12	2	24	5
13	$2\frac{1}{4}$	25	$5\frac{1}{4}$
14	$2\frac{1}{2}$	26	$5\frac{1}{2}$
15	$2\frac{3}{4}$	27	$5\frac{3}{4}$
16	3	28	$6\frac{1}{2}$
17	$3\frac{1}{4}$	29	$6\frac{3}{4}$
18	$3\frac{1}{2}$	30	7
19	$3\frac{3}{4}$	31	$7\frac{1}{4}$
20	4	32	$7\frac{1}{2}$
21	$4\frac{1}{4}$	33	$7\frac{3}{4}$
22	$4\frac{1}{2}$	34	8

The previous discussion covers the source and location of inclusions. What effect do they have on roll service? There appears to be general agreement among those who have studied this problem that it is the oxide type inclusions that are most likely to nucleate fatigue failures([1]), ([3]). Sulphide inclusions do not appear to be considered as a cause of fatigue failures in steel. However, sulphides lower impact strength and ductility and are undesirable from a surface cleanliness standpoint. Sulphides are most objectionable when they occur in the form of stringers.

Figure 1 shows the fractured surface of a backup roll sleeve that split in service after very short life. The failure originated in large non-metallic inclusions that were located about $\frac{1}{8}$ in. under the rolling surface. The inclusions nucleated a fatigue crack that progressed about one-fourth through the thickness of the sleeve and when the remaining section was too weak to withstand the working loads, the rest of the fracture was sudden. This is the type of inclusion that normally would be expected to float out of the steel before it solidified.

Figure 2 shows a section through a $15\frac{1}{2}$ in. diam. roll that was taken out of service because the user heard it making noises in the mill. The roll was found to be cracked from the bore to within about 1 in. from the surface. The fracture was progressive having started at a defect on the bore. This roll was made in 1951, before sonic inspection of all rolls was made a standard practice. A similar defect would undoubtedly be located by sonic inspection today.

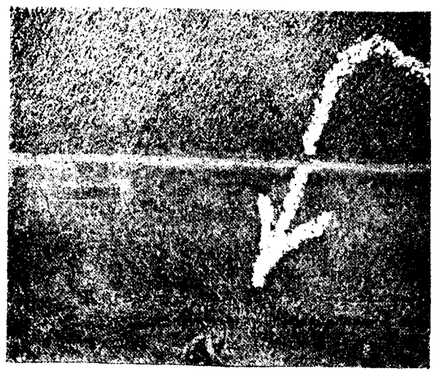


Fig. 1. Fractured surface of backup roll sleeve split in service. The failure originated at large non-metallic inclusions located under the rolling surface.

Figure 3 shows the as polished micro-structure of a section taken from near the surface of a foil mill roll that was scrapped because it contained large surface defects that made it unfit for foil service. The inclusions are probably ladle or spout material that was trapped near the surface of the ingot before it had time to float out.

For those without actual foil rolling experienee, it is sometimes difficult to appreciate how harmful a

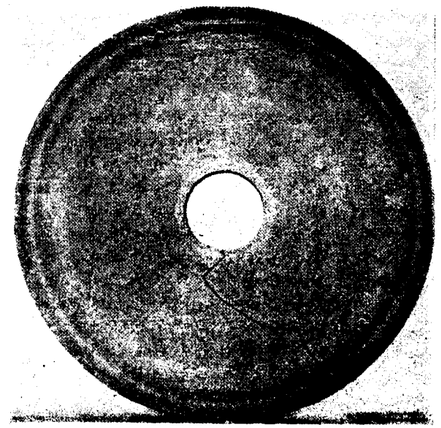


Fig. 2. This $15\frac{1}{2}$-in. diam. roll failed from fatigue fracture originating in defect on bore.

Fig. 3. Non-metallic inclusions on surface of foil mill roll. Roll was scrapped because of surface defects (100x unetched).

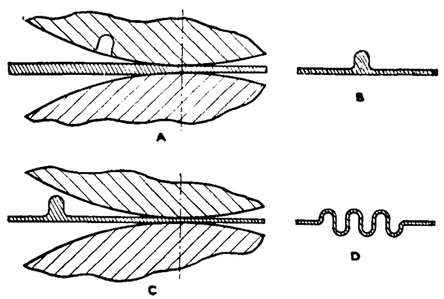


Fig. 4. Schematic representation shows how a defect in a roll affects foil rolling. The defect in the roll, "A", produces a bump on the foil, "B". When this is rolled out "C", the amount of reduction is greater than for the surrounding metal and a wrinkle is produced, "D". Very often the wrinkle is perforated.

small surface defect can be in a foil roll. Figure 4 shows schematically how a small inclusion can affect foil rolling. Normally, the inclusion would be pulled out of the roll surface by the grinding wheel when the roll is ground, leaving a small cavity. If the cavity has sharp edges, it can produce small tears in the foil. When the part of the roll containing the cavity passes over the foil, as at A, it leaves a small bump on the foil, B. On the next pass, C, this small bump is rolled flat and as the amount of reduction is greater than for the surrounding material, a wrinkle is produced, as at D, where the bump was located on the previous pass. Very often the wrinkle will be perforated. The size of a defect that can produce a wrinkle in foil being rolled to less than 0.0005 in. thick can be quite small. An insidious thing about this is that the defect in the roll and the bumps on the foil may not be noticed until after a lot of expensive scrap is rolled.

Another extreme example of the need for defect free rolls when processing foil was shown when a mill was pack rolling bright finished aluminum foil 0.00035 in thick. Two layers of foil were passed through the mill at one time. Mirror finished rolls were used and the outside surfaces of the pack were bright. The inside surfaces of the foil, which were pressed together as the foil went through the mill, came out with a matte finish. Where a defect in the roll was present, there would be no pressure under it and a bright spot would be left on the matte surface. In one batch of foil that was rolled in this way, a recurring pattern of 54 bright spots was found. These bright spots were traced to non-metallic defects in the rolls. Many of the spots were caused by defects 0.002/0.003 in. long. The largest one was 0.018 in. long. The amount of scrap produced ran into a four figure loss before this trouble was discovered. The purpose for which the foil was to be used permitted on bright spots on the matte side. Defects in the rolls are not the only source of bright spots on the matte side of pack rolled foil. Dirt on the foil, blow holes or other casting defects in the ingot from which the foil was rolled can also be responsible for this trouble.

Consumable electrode vacuum melting looks promising as a method for manufacturing foil rolls with a minimum of harmful defects.

In the consumable electrode vacuum melting process for making steel, an aircast ingot is forged, annealed, conditioned to remove all scale and oxide and this electrode is then remelted in a high vacuum averaging five microns, into a water-cooled copper mold. Oxygen, hydrogen and nitrogen gases are removed from the drops of steel as they fall from the bottom of the electrode through the vacuum. No refractory material is present to contaminate the steel and no additional oxides are formed since the steel does not fall through oxidizing air as air melted steel does when it falls into the mold. With oxides and contaminating refractory absent as sources of inclusions, steel made by this process can be expected to be exceptionally clean. This has been found to be true in rolls made by this process. The cleanliness of rolls made from consumable electrode vacuum melted steel has been found to be an order of magnitude better than we normally find in air-melted steel rolls. In the foil mill described above where defects as small as 0.002 in. long in air-melted rolls produced bright spots on the foil, no defects in the foil rolled on consumable electrode vacuum melted rolls have been traced to defects in the rolls. This is a very severe test for the presence of surface defects in the vacuum-melted rolls and they appear to have passed it very successfully.

With fewer and smaller oxide type inclusions and greater toughness because of the lower hydrogen content, one would expect fewer nuclei for fatigue fracture and greater resistance to spalling in the vacuum-melted rolls compared to air-cast steel. The consumable electrode vacuum-melted rolls that we have made have not been in service long enough to develop any comparable data against air-melted rolls. However, bearing manufacturers,(4) have run extensive life tests to compare air-melted bearing steel against vacuum-melted bearing steel. Bearings fail by spalling, very much like rolls. It is our understanding that vacuum-melted bearings consistently show about double the life compared to air-melted bearings.

Rolls made from consumable electrode vacuum-melted steel have shown advantages in grinding over air-melted rolls. This will be described later.

Vacuum pouring facilities have recently been installed in our works. In this process, steel is melted conventionally in basic electric furnaces and is then poured through a small pony ladle into a vacuum chamber where the ingot mold is placed. The vacuum in the chamber is maintained at about 600 microns. The stream from the pony ladle falls in droplets through the vacuum and hydrogen, oxygen and nitrogen gases are removed from the droplets as they fall into the mold. Oxygen is absent around the steel as it falls and few, if any, oxides are present on the surface of the metal as it rises in the mold. One would, therefore, expect the steel made by this process to be much cleaner than air cast steel. We have not yet made enough vacuum cast rolls to arrive at a definite evaluation of the benefits to be expected from the vacuum casting process. We do expect that it will produce cleaner rolls with fewer and smaller inclusions and greater resistance to spalling than air cast rolls.

FORGING

Forging operations must be carefully controlled to avoid introducing any harmful effects in this stage of roll manufacture.

Heating rates must not be excessive. If a forging is heated too rapidly, the outside will expand thermally before the inside is heated through. This can put a heavy tensile stress on the inside of the forging and has sometimes resulted in internal fracture known as "fire cracking." Heating rates must be carefully controlled to avoid this type of damage.

The forging temperature must not become too high. Roll steels tend to be stiff at forging temperature and the tendency to overheat them must be resisted. If a roll steel, like any other steel, becomes overheated, burning can result. A troublesome thing about the burning of roll steel is that it can occur near the center of the roll with no visible damage on the outside. A roll that has been internally burnt is readily detected by sonic inspection and would usually fail during the drastic quenching of the hardening operation. There is very little chance for a burnt roll to survive long enough to get into service.

The amount of forging reduction used to make rolls is sometimes arrived at by compromise. Sufficient reduction is required to consolidate the center of the ingot. At the same time, too much reduction could result in stringing out inclusions to objectionable lengths. Stringer type inclusions with sharp ends can be more harmful than shorter ones with rounded ends. When the shape and size of inclusions present a special problem in making a roll forging, the forging reduction used is designed to fit the special requirements.

Care must be taken during forging operations to avoid the formation of laps or folds that would leave decarburized and oxidized surface material under the finished surface of the roll.

Surface cracking during hot working is occasionally a problem when forging rolls. It is very likely that sub-surface non-metallic inclusions can be responsible for this type of defect.(5) When surface cracking occurs, the forging must be scarfed to remove the cracks or sufficient stock must be left on the forging to be sure that a roll of the specified size can be made from it after the crack is removed. If surface cracks do not clean up when a roll is finish ground, the roll cannot be used. Figure 5 shows a crack found on the surface of a finished roll that was scrapped because of the presence of the defect. This is the typical appearance of a defect resulting from leaving insufficient stock on a roll forging. Enough top and bottom scrap should also be cut from the ingot to avoid any defective material from the top and bottom of the ingot being made into part of a roll.

ANNEALING AND PRELIMINARY TREATMENT

After the forging operations are completed, rolls are taken while still hot and are charged into heated annealing furnaces for annealing and conditioning treatments.

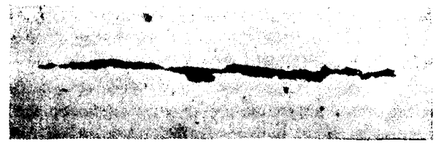


Fig. 5. Surface defect is typical of the type that results from leaving insufficient cut on roll forging (unetched 100X).

Flake prevention is a very important part of the annealing cycle and for large rolls very slow cooling rates and long holding times may require weeks before a roll forging is safely brought to room temperature. Flakes are readily discovered by sonic inspection. A flaked roll would rarely survive the high stresses produced by spray quenching during hardening. With vacuum pouring of large roll ingots, the possibility of producing a flaked roll will be reduced to an absolute minimum.

Another purpose of the preliminary treatment is to produce a micro-structure most suitable for subsequent hardening. A heavy continuous carbide network structure would be particularly poor at this stage.

The final journal hardness is determined at this stage of production for many rolls. On work rolls used in four-high mills the backup rolls take most of the load and the journal hardness and strength is not too critical, as long as sufficient strength and wear resistance to prevent excessive wear on the journals and to withstand the driving torque is present. The journals of backup rolls and work rolls in two-high mills are sometimes subject to very heavy shock loads and special care must be taken in the preliminary treatment to produce the required strength and impact resistance in the journals. Design has an important part in this problem. A few examples of how changes in design can help prevent neck failures will be given later.

Normally rolls are quenched and drawn to produce the required journal hardness. On smaller rolls this is done before they are machined. Larger rolls are rough machined and bored before treatment. A 40-50 scleroscope hardness range has been found to be suitable for most roll necks. Harder journals, usually in the 50-65 scleroscope range are specified when higher strength or increased resistance to wear is required. On some rolls where roller bearings operate directly against the necks with no inner race, journal hardnesses of 80-90 scleroscope and higher are required. The hardness of these journals is usually produced at the same time as the body of the roll is hardened, not in the preliminary treatment stage.

MACHINING FOR HARDENING

After preliminary treatment, rolls are machined for hardening. The benefits of good judgment and experience are very helpful at this stage to be sure that sufficient stock is left on the forging so that the roll can be finished with no decarburized metal present.

TABLE II

Minimum Bevel Requirements

(Normally 45-degree bevels are preferred when the roll design does not include a long taper from the end of the body)

Roll diam. in.	Bevel, in.	Roll diam. in.	Bevel, in.
Up to 4	$\frac{1}{4}$	9–20	$\frac{1}{2}$
4–6	$\frac{5}{16}$	20–28	$\frac{3}{4}$
6–8	$\frac{3}{8}$	Over 28	1
8–9	$\frac{7}{16}$		

At the same time too much excess stock on the body should be avoided. The outer surface of a hardened roll body contains the most effectively quenched part of the roll. If too much material is ground off to reduce the body to the desired diameter, less of the usable hardened outer layer will remain and less usable reduction will result. However, on all rolls we allow a minimum cut for grinding after hardening to be sure that all decarburization, scale and pits are removed before the roll is ready for use.

End spalling is a problem when hardening rolls. We have found that 45-degree bevels appear to be the best design to avoid end spalling with our hardening practice when the roll design does not include a long taper from the end of the body. Table II shows our standard minimum bevel requirements for hardening. Whenever possible, it is advisable to ship rolls with similar bevels to avoid the need for grinding off excess metal and the possibility of producing residual grinding stresses on the ends of the body.

HARDENING

The surface hardness requirements for rolls are usually given as a Shore scleroscope range, although Rockwell, Penetrascope, D. P. H. and Brinell are also used. It is general practice to allow a five point scleroscope range or equivalent when specifying roll hardness requirements. For many years roll makers and roll users were not always sure of the hardness that was actually specified because of a difference in the way that scleroscopes were calibrated. As a result of cooperative effort among the roll manufacturers, roll users and hardness testing instrument

makers, the American Society for Testing Materials has issued Specification A-427, which covers the hardness testing of forged steel rolls.

The scleroscopes used to test the hardness of rolls are calibrated in accordance with this standard and it is recommended that all roll users have their scleroscopes similarly calibrated to avoid possible confusion. The C and D type scleroscope do not usually give the same reading when used on the same roll. It is helpful to the roll manufacturer to be given the type of instrument to be used as well as the range when a hardness specification is made.

Forged steel rolls are made with a wide range of body hardness. Some rolls used in non-ferrous hot rolling are made as soft as 40 scleroscope. Many rolls used to roll foil, non-ferrous metals, and stainless steel are required to be harder than 100 scleroscope. Other rolls are made with hardness specifications inside these limits. Most work rolls are made in the 90–100 scleroscope range. The hardness range for backup rolls varies almost as much as for work rolls. Some backup rolls are as hard as the work rolls used in the same mill and some are 100 scleroscope hard. In other mills the backup rolls may range from 5 to 50 points softer than the work rolls. The usual average is for the backup rolls to be about 20–30 points softer than the work rolls. If a roll is too soft it will be more susceptible to surface damage, marking and denting and will require more frequent regrinding than a roll of the proper hardness. If it is too hard, it will be more susceptible to damage and more likely to spall if abused in service. The ability to respond to shotblasting is related to surface hardness and sometimes rolls are ordered below the best hardness range for service because the user's blasting equipment requires longer time to produce the desired pattern on harder rolls. We have seen examples of roll life between grinds being more than doubled with harder rolls when the additional time required to produce the blasted pattern was taken.

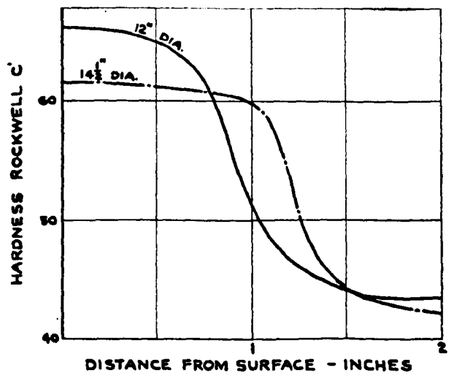


Fig. 6. Hardness penetration taken from 12 and 14½ in. diam. production rolls.

The depth of hardening in rolls is very important. The potential service that can be obtained from a roll is directly related to the depth of usable hardness. However, it is sometimes undesirable to increase the depth of hardening too much. We find, especially with small rolls, that too great a depth of hardening can result in increased roll breakage both during the hardening operation and in service. We are frequently asked how deep one can harden a roll. In a recently completed series of tests where we hardened roll blanks using different hardening practices, we found that the fully hardened outer layer varied from $\frac{3}{8}$ to as much as $1\frac{1}{2}$ in. thick. Figure 6 shows hardness penetration patterns taken from two production rolls.

We can heat our rolls for hardening both in conventional gas furnaces and by electric induction. Most work rolls are quenched in specially designed sprays using many thousands of gallons of water per minute. We normally aim for a fully quenched, fine grained microstructure in our hardening operation. Tempering is done in oil bath and air draw furnaces. Low temperatures and long holds are used for the tempering treatments. In addition to the depth of surface hardening, grain size and hardness requirements that must be met by the hardening operation, it is necessary to produce adequate strength under the fully hardened outer layer so that the roll can withstand the operating loads. The surface hardness must be uniform from one end of the roll to the other. And with it all, the roll must be strong enough and tough enough to withstand the high loads and not infrequent overloads associated with many rolling operations.

FINAL MACHINING AND GRINDING

After a roll is hardened and tempered, its hardness is checked carefully to be sure that it complies with the specified requirements. It is then machined and ground to the required dimensional surface finish and concentricity limits.

Care must be taken in the machining and grinding operations to avoid the presence of sharp tool marks

or other stress raisers in highly loaded areas. Where very high neck stresses are to be resisted, cold working of the necks by surface rolling is a useful practice to increase resistance to neck failure. Normally, concentricity limits of 0.0003 in. T. I. R. (total indicated runout) are held on the body and journals of work rolls, unless greater accuracy is specified by the roll user. On large backup rolls and assemblies a concentricity limit of 0.0005 T. I. R. is usually considered to be satisfactory. Grinding must be carefully done to avoid overheating the roll surface and softening it. The residual stresses produced by over severe grinding can be very high and have been reported as exceeding 100,000 psi at and near the surface. Shallow "onion skin" spalls are often the result of improper grinding. The heat generated by improper grinding can soften the surface of a roll and produce "heat checks" or cracks. If a roll is put into service with these cracks present on the surface, they can nucleate a fatigue fracture that can result in a spall.

It is our normal practice to recheck the hardness of rolls after they are finish ground. If a roll has been improperly ground, the heat produced will soften the roll surface and this can be readily detected by the hardness test. Grit blasting and etching with 7 per cent Nital are also effective methods of determining if a hardened steel part like a roll has been abused in grinding.

The rolling of foil, stainless steel, precious metals and high lustre brass mill products often requires the highest possible mirror finish on the work rolls. What is often desired is a "black lustre" finish, so called because the area outside the high lights where light is reflected have a black appearance that is almost three dimensional in quality. With a standard grinding practice some rolls can be ground to the "black lustre" finish very readily. Other rolls are much more difficult to grind to this finish, retaining a white cast in the areas outside the high lights in spite of repeated efforts on the part of the roll grinder.

The reasons for this difference in response to grinding are not clear. Probably the uniformity of micro-structure, grain size, hardness, severity of the dendritic pattern remaining from the ingot structure and size, type and quantity of non-metallic inclusions are factors involved in the response to grinding. Possibly, the smearing effect of non-metallic inclusion material pulled out by the grinding wheel and rubbed by it over the roll surface is a reason for trouble in getting the desired finish.

Rolls made from consumable electrode vacuum-melted steel generally respond very readily when they are ground to a "black lustre" finish. This probably results from the very high order of cleanliness of this steel and the very uniform fine grained cast structure resulting from the rapid cooling in a water cooled copper mold. The final polishing operation on mirror finished vacuum-melted rolls can generally be done in 30 to 50 per cent less time than with air-melted rolls and the "black lustre" finish is usually produced with very little trouble.

In one mill where a grinding practice finishing with a 600-grit wheel for final polishing produced a 1 to 1½ micro-in. finish on air melted rolls, the same grinding practice produced ½ to ¾ micro-in. finish on vacuum melted rolls.

DESIGN

Good design as well as good material is helpful in avoiding service failures in highly stressed parts like rolls.

Figure 7 shows the drive end of a two-high work roll with a blind bore. The roll was internally water cooled in service. The bore was drilled with a sharp-cornered drill and the stress-concentrating effect of the sharp corner started a fatigue crack that resulted in the failure of the roll when the drive extension broke off as shown. The location of the bottom of the bore was changed to strengthen the weak diagonal section and a round bottom drill was used to eliminate the sharp corner. The new design has been in service for several years with no failures.

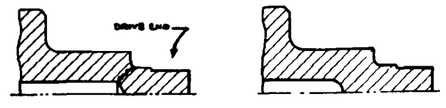


Fig. 7. The design on the left of the drive end of a two-high mill work roll resulted in neck failure when a fatigue crack started at the sharp corner at the bottom of the bore. The revised design shown on the right rounded the bottom of the bore and increased the distance across the weak diagonal section.

The splitting of backup roll sleeves is a serious and expensive problem. This type of failure sometimes occurs when the bearing housing rubs against the end of the sleeve or something falls between the housing and the sleeve. Figure 8 shows the end of a sleeve that split after the thrust bearing failed to hold the

backup assembly in position and the end of the sleeve was severely rubbed by the end of the bearing housing producing a series of radial heat checks as shown. One of the heat checks extended under the shrink and working loads and the sleeve split.

Figure 9 shows how the danger of this type of failure can be minimized. The left hand sketch shows how the sleeve length can be shortened so that additional clearance is allowed between the end of the sleeve and the housing. A greater amount of lateral motion can take place with the increased clearance before contact is made between the sleeve and the housing. Sleeves, that would become heat checked with the short clearance, remain undamaged with the increased space between the end of the sleeve and the housing.

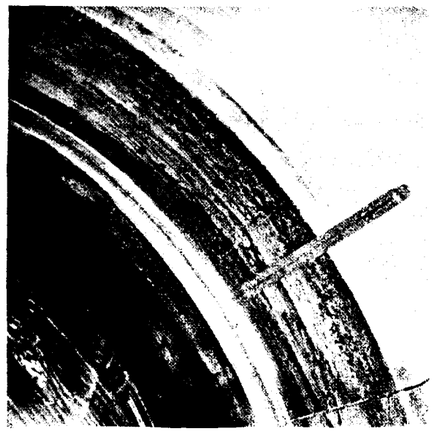


Fig. 8. End of backup sleeve that split in service shows heat checks that were produced when the bearing housing rubbed against the sleeve. Splitting occurred when one of the heat checks extended under the shrink and working loads.

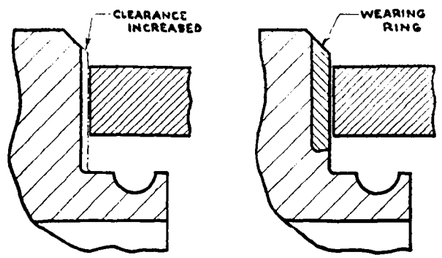


Fig. 9. Methods of minimizing danger of heat checking on ends of backup sleeve. Left, more clearance is provided between bearing housing and sleeve. Right, wear ring is assembled to absorb possible damage and protect the sleeve.

Another possible way to avoid heat checking on the end of the sleeve would be to assemble a wear ring as shown on the right hand sketch of Figure 9. If severe rubbing were to take place under these conditions, the wear ring would absorb all the damage and the ring could be replaced if necessary with no harm done to the sleeve.

The harmful stress-concentrating effect of sharp corners and small radii are well known and have contributed to many roll neck failures.

Figure 10 shows how a design can be improved by changing the radius. The effective strength of a roll neck can sometimes be more than doubled by increasing the radius.[6] Some rolls are designed with small journal radii because the bearings that are used do not provide sufficient clearance to permit larger radii that would substantially reduce stress concentration to be used.

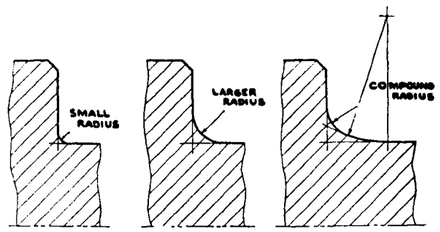


Fig. 10. Increasing the radius between body and journal can materially decrease stress concentration and increase effective strength.

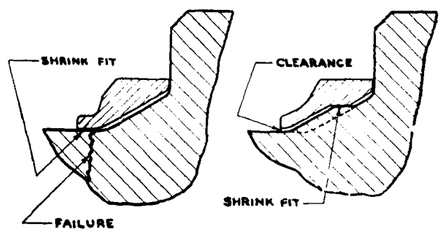


Fig. 11. Left is shown failure of two-high mill roll that occurred when fretting corrosion produced pitting which nucleated a fatigue crack. Right is revised design changing position of shrink fit of location away from most highly stressed part of journal.

Figure 11 illustrates how a change in thrust ring design was made to correct a condition that resulted in several neck failures in rolls used in a two-high mill rolling copper alloys. The original design for the thrust ring is shown on the left. It is fairly common. The ring is assembled with a shrink fit on the end of the bearing fit portion of the journal. Sometimes such rings rotate in service, scoring the roll necks. The score marks act as stress concentration points and progressive fractures start that result in the neck breaking off. In this case, the rings did not rotate. The mill was highly loaded and a slight flexing action of the necks in service caused fretting corrosion to start under the thrust ring. This corrosion eventually produced pits that became the nucleii of fatigue cracks and the necks failed.

To improve this condition, the ring was redesigned so that the shrink fit was on a shoulder closer to the body as shown in the right hand sketch. Clearance between the ring and the roll was provided at the base of the radius, so that no fretting would take place if the journal flexed. The diameter of the roll neck under the ring was increased so that the strength was increased by about 10 per cent. In addition, the surface of the taper and the radius was rolled to increase the resistance to fatigue failure. The new design eliminated the weakening effect of the shrink fit on the most highly stressed part of the journal and with the shrink being made on a larger diameter, the resistance to possible rotation was increased.

If roll designers were more fully aware of the effect of fretting corrosion and clamping pressure on strength, they probably would try to avoid the thrust ring design where the shrink fit is on or near the most highly stressed part of the journal. Figure 12 from Sachs[7] shows how fretting action can reduce the fatigue strength of steel. The endurance limit with fretting is 50 per cent lower. Figure 13 shows how the fatigue strength drops off very rapidly as the clamping pressure is increased.[7] Surface rolling is an effective procedure to increase the fretting-fatigue strength. This is shown in Figure 14.[7]

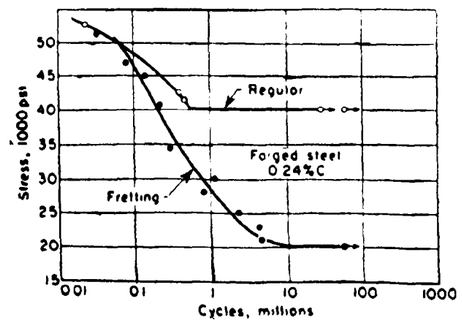


Fig. 12. Stress-cycle curves for tests on fretting fatigue and regular fatigue of a forged steel.

The effect of severe notches and corrosion on the endurance limit of steel is shown in Figure 15 from

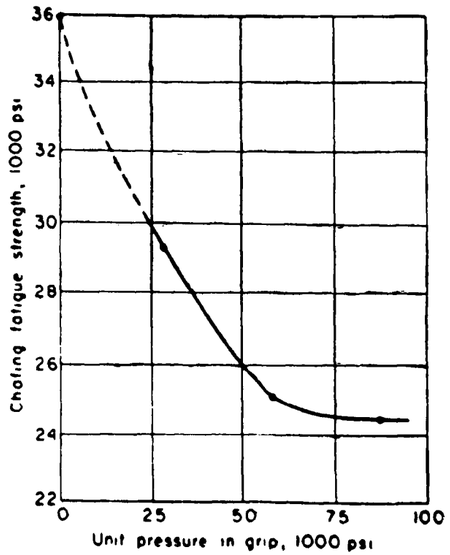


Fig. 13. Clamping pressure reduces fatigue strength of cantilever-type steel specimens.

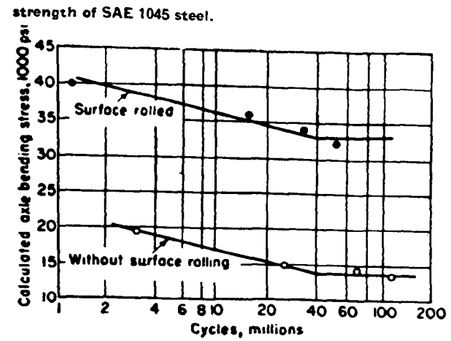


Fig 14. Surface rolling increases the fretting-fatigue strength of SAE 1045 steel.

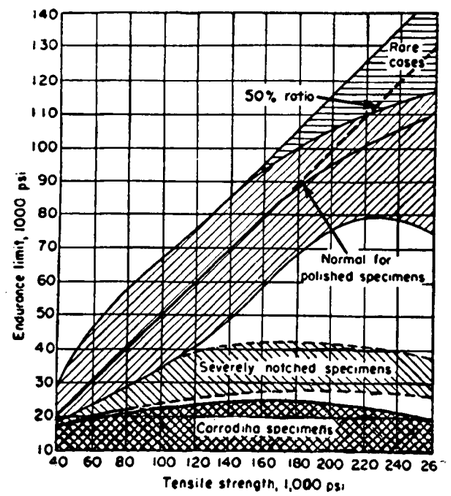


Fig. 15. General behaviour in fatigue of steel of polished, notched, or corroding specimens as related to tensile strength.

Dolan.(8) The decrease in the endurance limit is very pronounced. If a roll with highly loaded journals has heavy score marks or corroding conditions on the critically loaded areas of the necks, polishing out the score marks or corrosion pits as part of a preventive maintenance program could result in continued use of rolls that would otherwise be likely to fail with broken necks.

GRINDING PRACTICE

While the rollmaker can make every effort to produce a roll free of defects, an important factor controlling roll life and performance is how the user takes care of it. Grinding practice, especially in heavily loaded mills, can be directly related to roll life. Perhaps because the relationship is not immediately obvious, grinding practice is not given as much attention as it deserves in some mills.

The amount of stock removed per grind and frequency of grinding are directly related to spalling problems. As a roll is used, its surface becomes work hardened and residual compressive stresses are built up on the surface. Matching and opposite residual tensile stresses are developed under the surface. If a roll is left in the mill too long, or if insufficient grinding is done to remove the surface stressed material, so that the residual tensile stresses underneath are relieved, the residual tensile stresses under the surface can become so high that when combined with the working stresses they exceed the fatigue strength of the roll and a spall results.

An example of how this works in practice was shown in an aluminum foil mill. In this mill a practice of regrinding the backup rolls every 1500 hr. removing 0.050 in. from the body diameter had been followed for many years. No spalling of backup rolls had been experienced. During a period when there was need for more grinding capacity, it was decided to take only 0.020 in. off the roll diameter per grind. After this practice was adopted, three backup rolls were lost because of spalling in a period of less than a year. The original practice of removing 0.050 in. per grind was then resumed and no spalling of backup rolls has occurred in the last seven years.

Many other examples of how insufficient reduction per grind or excessive times between grinds have resulted in spalled rolls can be cited. Figure 16 is a typical S-N diagram for steel, showing the relationship between stress and cycles to failure.(3) The steel represented by this curve can be loaded indefinitely below 100,000 psi without failing. Above 100,000 psi the time for failure decreases rapidly with increasing stress. Many rolls are loaded in service to stress levels that will produce failure if continued indefinitely. If too much time is allowed between grinds the failure time will be reached and spalling will occur. The diagram is plotted logarithmically so that a small decrease is accompanied by marked increase in the number of cycles to failure. If the stress is reduced below the endurance limit, the roll could be used indefinitely without failing.

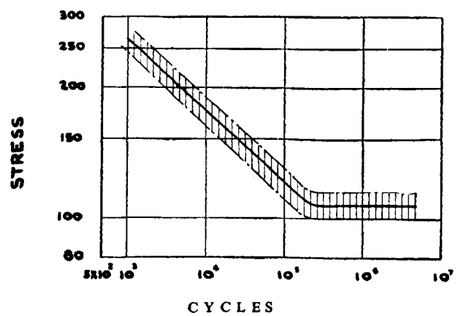


Fig. 16. Typical curve shows relationship between stress and cycle to failure for steel.

Fig. 17. Typical spall near edge of rolling surface of backup roll.

End spalling of backup rolls and sleeves is a serious problem in some mills. Figure 17 shows a typical spall of this type. From the S-N diagram it can be seen that the spalling can be prevented if the load on the spalled area is reduced or the time between grinds is shortened so that the combination of time and load do not reach the failure line. This can be done by relieving the ends of the backup roll or crowning its surface so that the load on the area where spalling takes place is reduced or by more frequent grinding so that less time elapses before the highly stressed surface material is removed, and lower residual tensile stresses are developed under the surface. The effect of decreasing the residual stress would be to increase the number of possible stress reversals before failure would occur.

When grinding out surface spalls, it is important to remove all cracked metal. Figure 18 shows the cross section through a backup roll that spalled. If any of the cracked material remained after the spalls were removed, they would act as sharp notches and could lower the fatigue strength to a very low level, as shown on Figure 15, and the crack would continue to grow very rapidly. Many rolls have been scrapped because insufficient stock was removed after a spall was ground out to completely remove all cracked or damaged metal.

SUMMARY

We have attempted to describe some of the defects found in forged steel rolls and how they may affect roll life and the product rolled. In addition, we have tried to point out some design considerations and the effect of grinding practice on roll strength and tendency towards excessive spalling.

It is hoped that an appreciation is left for the need for combined efforts by the roll designer, the rollmaker and the roll user to produce rolls that will be most suitable for their intended use and will not fail prematurely because of inadequate care after they go into service.

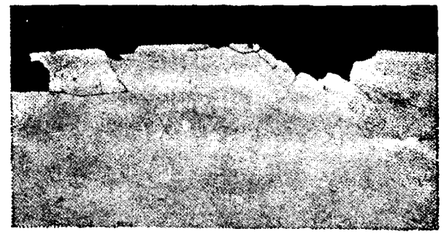


Fig. 18. Cross section through spall in backup roll.

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The Production of Metallurgical Coke From High Volatile Coals

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Assistant Director, Central Fuel Research Institute

INTRODUCTION

THE dearth of prime coking coals in most countries of the world has provided incentive for research on the utilisation of sub-standard coals for the production of hard, metallurgical coke.

Processes of beneficiation have enabled the use of high ash coking coals by reducing the percentage of ash thus raising them to the standard of coking coals and also, incidentally, improving the quality of their cokes to a certain extent. Special techniques of coal preparation have enabled the use of inferior coking coals in blends with standard coking coals.

Certain types of geologically younger, high volatile coals occurring in different parts of the world produce on their own friable, fingery, fissured and weak coke unsuitable for metallurgical use. This is largely due to the high rate of gas evolution from these coals in the plastic state. Various additives have been tried to improve the quality of the coke obtainable from this class of coals.

As a result of intensive experimentation, techniques have been developed in Japan, France, Poland and U. S. A. for blending high volatile weakly coking coals with low volatile coals and low temperature char or coke to obtain satisfactory coke.

In the Western part of the Raniganj coalfield there are substantial reserves of weakly to semi-coking coals which are unsuitable for use by themselves for the production of metallurgical coke. There are also fairly large reserves of certain low volatile type of coals in the lowest (zero) seam of the Jharia field which produce by themselves feebly agglomerated, pebbly coke with sub-normal physical properties. As a result of extensive researches on the blending and coking of coals carried out in the Central Fuel Research Institute, it has been found possible to obtain coke of standard quality from blends of these low and high volatile Raniganj coals referred to earlier. The use of suitable low temperature coke or char has also been found to serve the same purpose.

Some of the salient features of these investigations are presented here.

PROPERTIES OF COAL AND LOW TEMPERATURE COKE

In Table 1 are given some of the more important properties of two typical high and low volatile coals and also of a sample of semi-coke produced by low temperature carbonization (about 500°C) in a rotary oven.

Though the percentage of ash in the low volatile coal and low temperature coke is higher, this is not of much consequence in view of their much lower volatile matter which governs the percentage of ash in the coke.

Table 1—Properties of coals and Low Temperature Char/Coke

Sl. No.	Coal or L.T.C. Coke		Proximate Analysis (air dried) %				Coking Index (B.S.)	Max. fluidity from Gieseler Test
	Seam	Colliery	Moist	Ash	V.M.	F.C.		
1.	'0'	Bastacolla	1.0	17.8	18.2	62.0	12	1.8
2.	Dishergarh	Chinakuri	2.3	14.4	35.8	47.9	19	622
3.	Low Temp. Coke/Char		1.8	21.0	11.3	65.9	—	—

Excessively high ash in the low volatile coals may be reduced by washing to make the high ash coals more suitable from this point of view. The coking and fluid properties of the low volatile coal are lower than the desired values for normal coking coals. Though in this respect the high volatile coal is superior its excessive volatile matter content proves detrimental to the coke quality.

PROPERTIES OF COKE FROM COALS AND BLENDS

In Table 2 are given typical examples of the properties of the coke made in pilot ovens from the straight coals and their binary blends with low volatile coal and low temperature coke. The desired physical properties of coke to satisfy the Indian standard specification (I. S. 439–1953) are also shown in the last column (Sl. No. 5) in the same table. On comparison it may be seen that none of the cokes from the straight high and low volatile coals comes up to the standard in any respect (except Shatter Index on 1½ in. for the 'O' seam coal). In contrast, it is interesting to observe that the binary blends containing 30% of low volatile coal and 15% of l. t. c. char/coke with 70% and 85% respectively of the high volatile coal produce coke suitable for metallurgical use in all respects. Fig. 1 shows the fingery and fissured nature of the coke from the straight high volatile coal and Fig. 2 shows the compact nature of the coke obtained from the blends.

INFLUENCE OF VARIOUS FACTORS ON THE COKE QUALITY

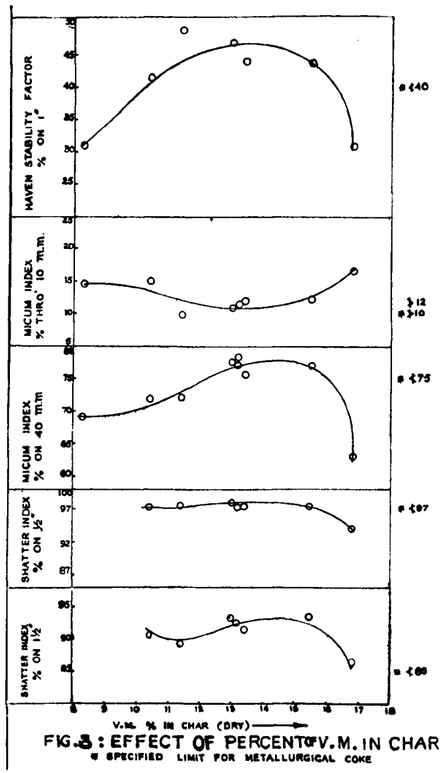
Some experiments were done to investigate how far

Fig. 1. Coke from straight high volatile coals.

Fig. 2. Coke from blend of high and low volatile coals.

Table 2—Properties of Coke from Coals & Blends

Sl. No.	Coals/Blend		Properties of Coke				Stability Factor % on 1 in.	Air-dried % ash
			% on 1½"	% on ½"	% on 40 mm.	% thr. 10 mm.		
1.	Bastacolla 'O' seam	100%	88.0	91.5	58.2	36.5	31.0	20.3
2.	Dishergarh Seam	100%	77.6	95.6	52.5	15.5	21.1	19.9
3.	Dishergarh Seam 'O' Seam	70% 30%	91.2	97.0	78.3	10.6	48.1	22.9
4.	Dishergarh Seam L.T. Coke	85% 15%	91.4	87.5	76.4	12.0	44.0	20.5
5.	I.S.I. 439–1953		85	97	75	10–12	40.0	20–24



Effect of volatile matter content of char on physical properties of coke.

weathering of coals affect the quality of the coke from binary blends.

For the l. t. c. coke-blends studies were made on the influence of the nature of coals, the manner of its carbonization for the production of semi-coke or char, the volatile content and amount of the latter etc.

EFFECT OF WEATHERING OF COALS

It has been found from a series of tests that it has to be ensured that the high and low volatile coals used in their binary blends should be in the fresh state. The use of either of them in the weathered condition would adversely affect the quality of the coke. It is of interest to state in this context that low fluid, low volatile coals (as the 'O' seam coals) are more liable to deterioration in their coking quality compared to the higher fluid, higher volatile coals.

EFFECT OF PROPERTIES AND AMOUNT OF CHAR ETC.

An overall study of the results has shown that best cokes are made from blends containing l. t. c. coke or char made from weakly or poorly coking coals. The use of natural coke or 'Jhama' (coal partially devolatilized by dykes, intrusion and the like) with similar volatile matter as l. t. coke was found to be unsatisfactory.

Generally better results were obtained when the volatile matter in the char ranged between 11 and 15 per cent. An optimum of 15 per cent of char was found to be usable for the production of best coke. Fig. 3 shows the influence of one of the factors on the quality of the coke.

The results of the pilot oven tests have since been confirmed by full oven tests. The results of this important investigation have established beyond doubt the possibility of producing standard metallurgical coke from blends of two coals both of which are by themselves incapable of producing hard and strong coke. Implementation of this finding in actual industrial practice is expected to go a long way by easing the grave situation created by the scarcity of normal coking coals in the country.

ACKNOWLEDGEMENT

The author is indebted to his colleague Mr. M.V.P. Menon for help in the preparation of the paper.

NEW ELECTRONIC SPECTROGRAPH

Detailed analysis of steel which at one time occupied four metallurgists for about an hour can now be carried out in four minutes by a new electronic spectrograph—the first of its kind in Britain. The machine was recently installed at Richard Thomas & Baldwins' Redbourn laboratory. In operation, a small piece of steel is placed in position at one end of the £ 12,000 machine. The steel is subjected to a spark in an atmosphere of argon gas and the light is transmitted to a prism which breaks it up into different colours, each representing various elements in the steel. The intensity of each colour is measured and transmitted electronically to a typewriter which records it automatically and types out a detailed analysis of the steel under examination.

Ventilating, Air Conditioning and Fume Removal for Steelworks

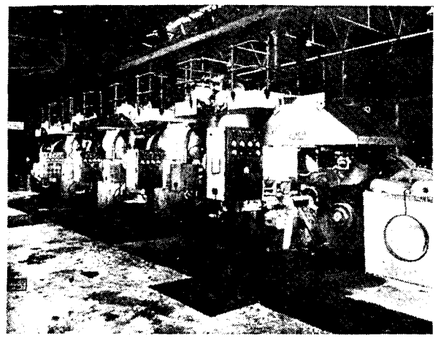
By An Engineering Correspondent

THE rapid expansion of the Steel Industry in recent years and the introduction of larger furnaces and heavier rolling mills have necessitated increased attention to the problems of fume removal and the maintenance of reasonable temperatures and conditions in the works. Modern methods of fume extraction and industrial ventilation have successfully dealt with these problems and by creating better working conditions, made a substantial contribution to increased efficiency.

The machinery and mechanical parts also benefit by the improved conditions owing to the bearings etc. being kept cool, in a clean atmosphere, thus prolonging the life of the plant and extending the working periods in between overhauls. There are many instances where the present high speed plants could not be run at the required output without these modern methods.

Visco Limited has played an important part in these developments and their plants are now found in most steelworks and in fact in all departments throughout the process of producing Steel.

A study of the Visco plants now in successful use show, that right from the start of mining the ore,



Davy-United 18" 4-stand Strip Mill equipped with "Visco" Fume Removal Plant at the Newport Works of The Whitehead Iron & Steel Co., Ltd.

Visco Filters are used in pressurizing the Control Cabin of the Excavator, to the benefit of the Machinery and the Operator.

Dust collection is applied at the crushing and ore handling and storage bunkers to alleviate the dust nuisance.

Rotary feed valves control regular feeding of dry free flowing material without personal handling from the hoppers to the process system.

Fume extraction on Furnaces when the Steel is being melted prevents shop atmosphere being contaminated and speeds up production owing to improved visibility. The fine particles can be collected in accordance with the latest regulations.

Crane Cab Air conditioning can eliminate sulphur fume etc. and maintain reasonable temperatures for the operators thus allowing longer "stints" between rest periods.

Lead Oxide Fumes generated when Lead Bearing Steel is produced can be highly dangerous, but this can be safely recovered and in fact becomes a saleable by-product.

The collection of Dust and Fume generated in the Deseaming of Ingots and the Grinding of Billets not only helps to keep the shop clean but improves the conditions all round and speeds up the output.

Vapour and Dust Extraction plants on Hot Rolling Mills not only improves visibility and conditions but prevents scale falling back on to the plate and thus improves the finish of the plate being rolled.

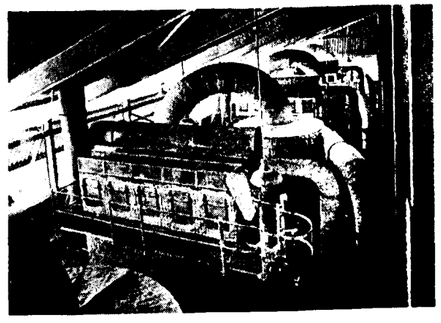
Fog elimination when cold rolling on a Strip Mill with Palm Oil allows speeds of 5,000 ft. per min. of the strip to be maintained. It also prevents the condensation on all the surrounding equipment which can make the conditions very dangerous. The collected Palm Oil can be treated and re-used.

A Plenum system with Visco Filters for Mill Motor Rooms and Ilgner Houses ensures longer life to all the electrical gear and is now a modern "must" in new steel works.

Water Cooling Towers for various processes, including Continuous Casting can effect a great saving in water and invariably save their own cost in a few months.

Dust collection from Temper Mills removes the dust as it is generated, thus diminishing the fire risk and keeping the product clean and improving the finished surface.

Fume extraction on profile gas cutting machines increases the visibility and improves the shop conditions generally.



Government Fertilizer Factory, Sindri, Bihar, India.

View of top portion of "Visco-Beth" collector, indicating guards over top plate shaking gear, and main and scavenging air headers. Two other collectors with associated equipment appear in the background. There are four plants in this line with a similar line on the opposite side of the building.

It will be noted that lagging of the two plants in the background is completed.

Dust Collection on Powder Metallurgical Processes has proved valuable in recovering dust which can be re-used without contamination.

Spray Blast Oil Coolers in Heat Treatment Departments not only reduces the amount of wastage of oil by keeping it in better condition but reduces the fire risk and increases output by controlling the temperature of the oil. The amount of oil vapour given off is also reduced.

Dust Collection in Fettling Departments of Steel Foundries removes dust as it is generated keeping the atmosphere clear and the shop floor clean.

Air Filters on the inlets of compressors ensures clean air being supplied to the air lines and lengthens the life of the compressors. On the outlets of compressors the Drum Filters look after any condensation developed and prevents chokage at the instruments etc.

Air Conditioning for Ball Bearing Stores controls the humidity and prevents rusting and maintains the Bearings in perfect condition for immediate use, thus reducing the change over time in the event of a breakdown.

Air Conditioning is a valuable asset also for Creep Laboratories, Standard Rooms, Offices, Stores and Computor Rooms.

All these applications have their own problems and the extensive experience of the Visco Engineers has provided them with the "know how" necessary in putting forward the correct proposal and a large staff is available for this purpose.

All these instances have been proved in practice in various Steelworks but there are many other industries where the same type of plant could be a definite saving in time and money.

It is impossible to illustrate here all the installations mentioned but a large number of them are shown in the literature which may be obtained on application to Visco Limited.

BHILAI SUB-CENTRE OF THE INSTITUTION OF ENGINEERS (India)

The Bhilai Sub-Centre of the Institution of Engineers (India), has started functioning. The Sub-Centre covers Bhilai as well as Durg and Raipur districts.

The following have been elected the office-bearers of the Managing Committee of the Sub-Centre :—

Chairman : Shri L. N. Misra.

Members : Shri P. C. Wadhwani, Shri M. Dinker, Shri Harbans Singh, Shri K. S. Inamdar, Shri Changulani and Shri Sanghvi.

Honorary Secretary : Shri K. M. Kukreja.

* * *

SUGGESTION BOX SCHEME

The Suggestion Box Scheme has been introduced in the Bhilai Steel Project with a view to enabling the employees to cash in on their Bright Ideas. Cash rewards upto Rs. 10,000/- are offered for suggestions which will enable the project : to reduce costs, waste and spoilage, maintenance expenses, hazards to health, possibilities of accidents, etc. ; to increase and improve the quality, yield, or output of products ; to conserve materials, energy, power or time of processes ; to improve the product or its design ; to rationalise works, materials or methods ; to simplify practices, procedures, etc. ; to promote sale of products ; to improve civic problems, traffic, hygiene and cleanliness in the plant and town ; and to economise in stationery, etc.

Every suggestion of the employees will receive careful scrutiny at the hands of a high power Committee consisting of General Superintendent, Chairman ; and Chief Mechanical Engineer, Chief Electrical Engineer, Chief Metallurgist, Members.

Suggestion Boxes have been placed at the various Shops and Departments.

It is hoped that this Scheme will serve as an incentive to the employees of the Project to put forward useful suggestions.

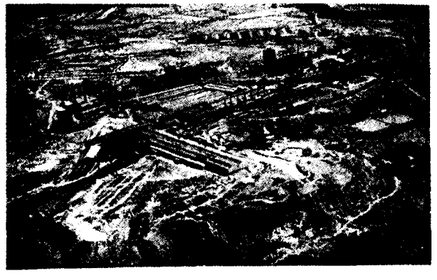
Consett's Contribution to Iron and Steelworks

A BRIEF HISTORY OF THE COMPANY

THE origin of the present Consett Iron Company was a Company known as The Derwent Iron Company, set up in 1840, to work the local ironstone deposits. This local ironstone was soon exhausted, but the abundance of good coking coal in this area made it possible to continue economic iron production at Consett, even when supplies of iron ore had to be obtained from farther afield. The original Company ran into financial diffieulties, however, following the failure of the Northumberland and Durham District Bank. The works were then operated for a few years by The Derwent and Consett Iron Company Limited, and in 1864 the present Consett Iron Company Limited was formed to take over.

Iron was at that time rapidly giving way to steel as one of the basic materials of the industrial age. Consett was not slow to introduce steelmaking processes and soon became a leader in this field, just as it had been in iron.

There followed a long era of steady development up to the time of the first world war—not without the setbacks and difficulties which affected industry generally during this period. But in the crippling after-math of the Great War, Consett was not content to wallow in the slough of despond which engulfed so many but pursued a bold policy of the building of new plate mills and the reconstruction of its entire plant—a policy which prepared it well for the recovery in business which eventually came in the late thirties.



Aerial view of Consett Iron Company's Works, 1960
(New Plate Mill in background)

After the Second World War great changes took place, many of them outside the control of the Company. First of all, the National Coal Board took control of the seven coal mines which the company then owned and operated; secondly, the Company was itself nationalised, only to revert to private ownership in 1955. Other changes also took place, changes, this time, brought about by the Company itself.

Two successive phases of development increased production from less than 400,000 ingot tons in 1947 to a million tons in 1957. This was achieved by introducing a new ore handling plant, new blast furnace and coke ovens, a new power station and what has until now been known as "the New Mill"—a Slabbing and Blooming Mill and Continuous Billet Mill. It is necessary to say "until now", because the third development plan, which will, by 1965, nearly double the works' present output, is well under way and a major part of that plan is another "New Mill"—this time a 4-high plate mill which has cost the Company £ 14m. and which will raise the output of steel plate to 10,000 tons a week—half a million tons a year.

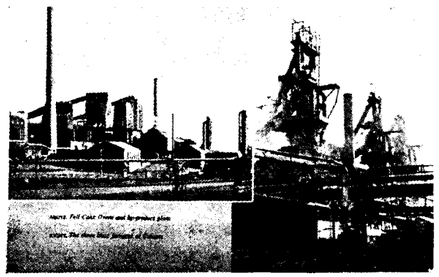
STEELMAKING AT CONSETT

A brief description of the processes necessary to produce the steel slabs which are the raw material of the new plate mill.

The first stage in the process is, of course, iron-making. In addition to the coke, produced in our own coking plant from Durham coal, vast quantities of iron ore are required. No longer does Consett get its ore from Great Britain or even from Spain, where at one time the Company had an interest in an ore field; it comes now from Sweden, from Africa, from the Americas. From all these sources, ore for Consett is shipped to Tyne Dock where special facilities for ore handling have been installed. It is there transferred into British Railways' specially designed 56-ton hopper wagons, which are drawn, nine at a time, to Consett by "decapods", the most powerful steam locomotives in the country. On arrival at Consett, the wagons are unloaded by more special equipment in a matter of seconds and the ore goes into the Company's stock yard which often contains as much as two million pounds worth of ore at a time.

Sometimes the ore is too fine to use in its original condition. Just as a shovelful of slack coal is as likely to put out a domestic fire as to keep it burning, so a quantity of ore in a fine, gritty form will at least impair the working of a blast furnace. This fine ore is therefore mixed with coke breeze and other materials and is roasted in the sinter plant to form a crusted, caked material which can then be used efficiently in the Blast Furnaces.

Naturally iron ore and sinter are not the only ingredients of the "burden" which fills a Blast Furnace; coke and limestone are also required. In the Blast



Above: Fell Coke Ovens and by-product plant
Right: The three blast furnaces at Consett

Furnaces these raw materials are subjected to a blast of heated air which accelerates the production of the molten iron and slag. An important additional product of the Blast Furnaces is the gas which is used as a fuel in various parts of the works.

After tapping from the Blast Furnaces, the molten iron is conveyed in ladles to the Melting Shop where it is charged either directly to the Open-Hearth Furnaces as "hot metal" or indirectly via the Bessemer converters as "blown metal" in the Duplex Process. Here the iron is heated to much greater temperatures than before, in order to reduce the impurities and turn it into steel.

On completion of the steelmaking process, the steel is tapped from the furnaces into ladles and from these ladles it is teemed into ingot moulds, an ingot being a rectangular block of steel. In these works ingots weigh anything from five to twenty tons, while the size is dependent on the quality and the ultimate use. When the steel has cooled sufficiently the moulds are removed; but the ingot is not yet ready for rolling because whilst it has cooled on the outside, it is still molten inside.

The ingot is, therefore, placed in a reheating furnace until a uniform temperature of about 1300°C. is obtained throughout. It is then ready for rolling.

On being taken from the reheating furnace the ingot is weighed on its way to the Slabbing and Blooming Mill. In this mill the ingots are rolled either into slabs—thick, flat lengths of steel from which plates are eventually produced—or blooms—long lengths of square section, which are suitable for further rolling in other mills down to such smaller sizes of blooms or billets as may be required.

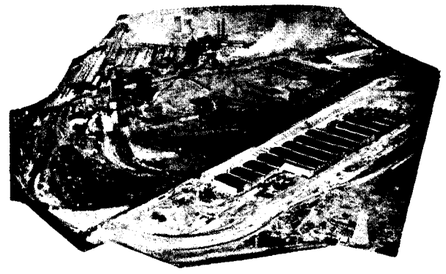
A large part of the billet production at Consett is conveyed by road to the Company's Jarrow Mill, where, after reheating, the billets are rolled into a variety of other products. These include the steel strip from which such items as motor car wheel rims are produced, as well as angles, flats, rounds, and channels.

Before describing the Plate Mill and the uses of plate, it is worth while to take a look at some of Consett Iron Company's other activities. The Company provides most of its own electric power, coke and gas (some gas is also supplied to the local Gas Board). In addition, the Company makes its own bricks for lining furnaces, ladles and anything else which needs insulation from heat. These heat-resisting products, or to give them their proper name "Refractories", are made in a large variety of qualities for differing purposes and are also sold to other steelmakers and to many other industries both at home and abroad.

THE NEW PLATE MILL

The old plate mills (for there were in fact two separate mills in the old plant) have been in continuous operation since 1926 and, although they have continued to produce plates of good quality, the new mill will produce larger and wider plates with a superior finish and to more accurate tolerances. It will also more than double the weekly output.

The work of clearing the site began in May, 1958, and included the difficult task of moving a large part of a colliery waste heap which was burning in places. In addition to the erection of the mill building itself, there were seven miles of new railway track to be constructed, two new bridges to be made and roads built. By the time the first main column of the building went up in May 1959, nearly two million cubic yards of earth had been moved, a quantity representing almost half-a-million truck loads. Once the steel construction had started, it was but a short time before changes could be seen almost daily and by July 1959 most of the framework was erected and some of the walls and roofing was in position. In all, 11500 tons of steel have gone into the building.



Aerial view of Consett Works with the new Plate Mill in the foreground.

Whilst all this was going on, others of the labour force of 600 were excavating the foundations for the mill equipment. This was itself a very large undertaking. For example, the foundations for the mill stand itself consist of 5 columns, each of which is sunk 50 feet deep.

Early this year the mill equipment was arriving in a steady stream and the first pieces to be installed were the overhead cranes, for it was their duty to lift into place the rest of the mill's machinery. The focal point of the whole vast building, 2,000 feet long 435 feet wide and 75 feet high, is the mill stand which arrived in May and was installed soon after. The elements of this mill stand are two of the largest steel castings ever made in this country, and each one weighs more than 160 tons. Even after these were installed, however, there was a tremendous amount of work still to be done in fitting all the other associated equipment, as a look around the mill will readily show.

Having, though so briefly, described the building of the mill it is possible to take up the story of the rolling of plates from the point at which we left it. It will be recalled that mention was made in the earlier chapter on Steelmaking of the rolling of slabs in the Slabbing and Blooming Mill. After rolling in this latter mill the slab is loaded on to a specially designed rail wagon and taken to the west end of the plate mill where it is lifted into a reheating furnace. When it is required for rolling, the slab is taken from the furnace and goes through the descaling station and then on to a transfer bogie which takes it up to the approach tables of the 4-high mill. Now, it may be asked: "Why 4-high"?

The explanation is that a mill of this type has four rolls; two large rolls called back-up rolls with two smaller rolls, the work rolls, between them. It is between these two smaller work rolls that the slab is rolled into a plate. The advantage of this arrangement is that the mass of the back-up rolls (each of them 60 inches in diameter and weighing 61 tons) supports the work rolls and enables them to function more efficiently, thus producing rolled plates more speedily and to greater accuracy.

It is not possible here to dwell on the technique of rolling plates. It must suffice to explain that steel possesses the characteristic of elongating in the direction in which it is rolled. Thus, to produce a plate of say, 4 ft. in width, a slab is first rolled to a little over this length (the extra being allowed for trimming), it is then turned through 90° and rolling continues until the slab is reduced to a plate of the required thickness. During the rolling process no account is taken of the length of the plate which is being rolled, because this has been pre-determined by the size of the slab which has been provided for the particular job. It will thus be readily realised that the planning of plate production is by no means a simple task; especially when it is appreciated that almost every order is for a different size of plate and that orders may be received in any one of a large variety of steel qualities. Many people have the impression that steel plates are produced on a sort of mass production basis but, in fact, as has been explained, every plate is "tailor-made" to each customer's particular specification.

After rolling and for floor plates—rolled in either the Admiralty Diamond or the Supergrip patterns—the plates are passed through levellers to be flattened and are then left on the cooling banks. When they are coolenough, they are inspected on both sides; the size of the finished plate is marked out on them and they are stamped with identification marks. After this they are cut to the required size by shears or, in the case of plates more than $1\frac{1}{2}$ in. thick, by flame cutters.

Many plates are, at the stage, ready for despatch but on others further processes are required. Some of these processes provided by Consett's new Plate Mill are common to all Plate Mills but some are more unusual. Among the latter, there is to be equipment

for pressure quenching and tempering of special steels and shot-blasting of plates followed by protection of the shot-blasted surfaces. There are also many elaborate testing procedures to be carried out on some plates, including ultra-sonic examination.

Although the mill stand is the heart of the mill there is a vast range of equipment associated with it which in turn requires a variety of services to support it. Electricity comes from the grid system by way of a new power cable line and sub-station. No less than 60 miles of cable have been laid inside the mill in connection with all the necessary electrical equipment. Oil is used to heat the various furnaces and soaking pits and is stored near the mill in tanks made by the Company's own Fabrication Department. Water is also needed in large quantities for cooling and this has necessitated the construction of a pump house and a cooling tower as well as settling ponds for the purification of the water after use. Apart from these services the mill requires spare parts. Most of these are housed in a very large store which has been specially erected for the purpose, but many of them are stored in the mill. For instance, by the main cooling banks can be seen spare rolls and next to them, very intricate special machinery for re-surfacing the mill rolls.

Also associated with the mill are electrical and mechanical engineering shops where repairs and maintenance are carried out. There are also numerous offices provided and, of course, the motor room and electrical transformer bay which house the electrical equipment to drive the mill rolls—two enormous electric motors developing 10,000 H. P.

Outside the main building is the amenities block with its distinctive tower and British Railways' new marshalling yard from which the Company's products will go all over the country and the world, to be used for a multitude of purposes.

STEELS FOR THE JOB

Originally, steel plate was used in shipbuilding, for the manufacture of boilers and tanks and for not a great deal else and there were very few qualities to choose from. In these days, the variety of uses for steel plates has been greatly extended and there are a host of different qualities, each designed for particular purposes, the number of which is constantly increasing.

To take an example, one of Britain's newest industries—Nuclear Engineering—requires, for use in the reactor shells of Nuclear Power Stations, steel which has to be easily weldable at low temperatures and yet must stand up to the intense heat generated when the reactor is activated. It was thought that these two requirements were incompatible, yet Consett brought them together in "Bearcomo", a steel which won a gold medal at the Brussels Exhibition in 1959. This steel has been used in nuclear reactor shells at Latina in Italy and in the British Power Stations at Bradwell, Chapel Cross and Calder Hall. Other properties such as strength, resistance to corrosion and resistance to abrasion can be induced by the inclusion of alloying elements.

In these and in many other ways, Consett is meeting the growing and changing needs of its customers, both at home and abroad.

Indian Engineers Discuss Mining Problems in Britain

Four Indian mining engineers have just visited the Waterside works at Ipswich, Suffolk, of Ransomes & Rapier Ltd., manufacturers of giant walking draglines, and discussed with representatives of the firm problems of open-cast mining.

They were Mr. S. P. Ahuja, a colliery manager whose home is in New Delhi; Mr. M. Vasudevan, administrator and technical head of a group of mines in Andhra Pradesh; Mr. B. G. Pradhan, administrator and technical head of a group of mines in Nasik; and Mr. M. K. V. Subbiah, an official from Secunderabad. At the firm's works they saw the construction of draglines and a film showing the vast machinery in operation at various open-cast sites.

Before touring the factory, the Indian visitors saw a working scale model of a 1,650-ton dragline inspected by the Queen recently.

The Indian officials, who are in Britain under the Colombo Plan, left later for Newcastle, where they will see open-cast mining in operation.

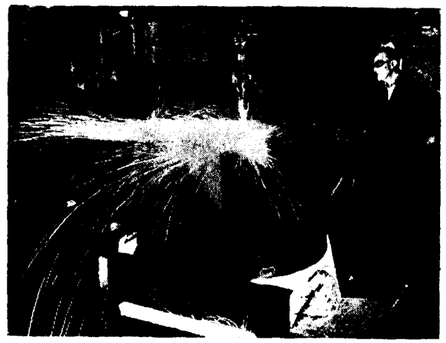
OXYGEN AIDS INDUSTRIAL GROWTH

By An Engineering Correspondent

INDIA'S vast industrial expansion in recent years has resulted in a remarkable upsurge in the nation's consumption of oxygen and other gases.

How is industry using this growing quantity of oxygen? Principally in doing things with steel—making it, cutting it, welding it and even cleaning it. Oxygen used in cutting of ship's plates reduces production time and handling. A structure "flame cleaned" with the oxygen/acetylene flame before painting resists rust more efficiently and lasts years longer without repainting. In heavy engineering, oxygen enables cutting of steel of varying thicknesses and shapes faster and more accurately than otherwise possible.

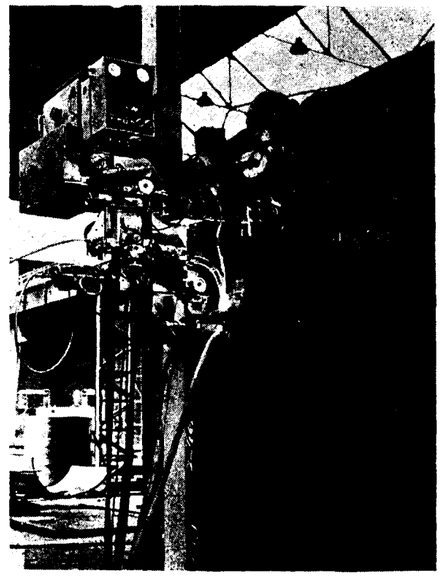
The development of methods for producing cheap oxygen on bulk scale is transforming steelmaking methods throughout the world. The gas is used to improve traditional processes and has made possible the development of several new, more efficient steelmaking techniques.



Oxy-propane is being used on an increasing scale in Britain for cutting large thicknesses of steel, in some cases over 60 in.
Picture shows two gear blanks—among the largest ever fabricated in single pieces—being cut at the Huddersfield engineering works of David Brown Industries Ltd. The cut, which involved 8 ft. of travel around the bore circumference, at a depth of 3 ft., was completed in 40 minutes with less than 3/16th inch taper over the full depth.

Oxygen requirements of a steelmaking plant are so great that they can only be efficiently met by "tonnage" oxygen plants, so called because their huge output is more easily measured in tons than cubic feet (one ton equals about 26,500 cu. ft.).

India's first tonnage oxygen plants were opened during the past year at Rourkela in the State of Orissa and at Durgapur in West Bengal. The Rourkela and Durgapur tonnage plants, built for Hindustan Steel Ltd. at a cost of £ 2 million, were installed by the



The first two British machines to automatically weld plates vertically are now in service in British shipyards.
The machines, which use the SUBARC process—British Oxygen's version of electro-slag welding—were developed and manufactured by B.O.C.
The vertical electro-slag method gives a high quality weld which is remarkably free from defects such as slag inclusions, cracking and porosity.
Picture shows one of the new machines, employing the SUBARC process, nearing the top of a seam.

Oxy-acetylene flame cleaning is a highly efficient method of removing mill scale, rust or old paint from the surface of steel. The process leaves the metal surface absolutely clean and dry, making possible a better bond between paint and metal.
Picture shows flame cleaning in progress on the Runcorn-Widnes Bridge, in England. It was the biggest flame cleaning project ever carried out on a British bridge, almost all of the 5,000 tons of steel, involving an area of over 60,000 sq. yd , being treated.

British Oxygen Group, of which Indian Oxygen Ltd., is a member. Similar plants are now being installed in all parts of the world to handle the requirements of the steel, chemical and gasification industries.

Meanwhile use of oxygen in other sections of Indian industry is expanding at an impressive rate.

Indian Oxygen Ltd., the country's biggest industrial gas producer, has, since 1953, increased its output of liquid oxygen fifteenfold while its gaseous oxygen production has gone up by 200 per cent.

The company now has more than 40 factories and service depots, producing oxygen, acetylene and other gases at strategic points across the country. It also operates factories, making electrodes for use in welding, gas-using equipment and cartridges for liquid oxygen explosives.

Oxygen plays a vital part in modern steelmaking. In the open hearth furnace (which produces some 80 per cent. of British steel) oxygen increases production. In Bessemer converters the use of oxygen permits the production of low nitrogen content high quality steels. New steelmaking techniques—the Linz-Donawitz, the Kaldo and the Rotor processes, developed on the Continent and now being introduced into the U.K.—are wholly dependent on the supply of tonnage oxygen.
Picture shows the transfer of hot metal to an open hearth furnace at the Port Talbot works of the Steel Company of Wales Ltd. The furnace is fed with high purity oxygen piped from the adjacent Margam Works of The British Oxygen Company Limited.

One of the nation's industrial pioneers, Indian Oxygen was incorporated in 1935. At that time it had factories in only five centres—Calcutta, Bombay, Jamshedpur, Colombo and Lahore. Except for Calcutta, most of the original works had only small oxygen plants and few were equipped to produce acetylene.

By the end of the second World War, the number of oxygen plants in India had doubled from six to twelve, sales had multiplied sixfold and the price of the gas was halved. The company's progressive policy has continued since 1945.

Apart from the supply of oxygen and other gases to all types of industrial users, Indian Oxygen has also pioneered the development of gas-using equipment and new processes in the welding and cutting field.

Pakistan Oxygen, Ltd., also a member of the British Oxygen Group, operates oxygen and acetylene works in Chittagong, Karachi and Lahore, an oxygen-compressing station at Lyallpur and sales depots at other important centres.

Besides India and Pakistan, the British Oxygen

One of the many applications for which nitrogen is used is the "shrinking" of metal. This process involves immersing a metal component in an insulated tank of liquid nitrogen (boiling point–195.8 deg. C.) for a period varying according to the metal concerned and the amount of contraction required.
Picture shows a pinion spigot being shrunk to fit the bore of a gear wheel on a 300-ton billet shear.
Contracting the 7.999-in. diameter spigot to fit the 7.993-in. wheel bore took only 30 minutes and consumed 56 gallons of liquid nitrogen (equivalent to 8,000 cu. ft. of gas).

Group also has member companies in Australia, New Zealand, South Africa, Canada, Ceylon, Malaya, Hong Kong, Rhodesia and East Africa. All of these companies are staffed largely by nationals of the countries concerned, all have their own boards and manage their own day-to-day affairs. A valuable interchange of information, constantly flowing between the companies is co-ordinated by the London Head Office, which also provides specialist advice on finance and administrative problems.

The British Oxygen Group, which this year celebrated its 75th anniversary, had its origin in a small oxygen production factory in Westminster, London. In those early days, oxygen was obtained from the air chemically, by absorbing it with barium oxide and then releasing it by raising the temperature or reducing the pressure.

Argonarc welding is a process widely used in welding of stainless steel, aluminium, magnesium and their alloys, and also precious metals.
Picture shows argonarc welding of aluminium ventilation ducting at a Scottish shipyard.

Among the diverse range of products of The British Oxygen Group are soda syphons, manufactured at the company's Sparklets Works in London.
Picture shows the latest Sparklets syphon, the Globemaster, which breaks away entirely from the conventional soda syphon shape, is only 10 in. high and weighs 1¾ lb. empty. Although shorter than the standard-size syphon, the new model hold 3¼ pints.

Electric welding equipment is widely used throughout the U.K. motor industry.
Picture shows British Oxygen's new S.T.2 electric welding torch and "Lynx" equipment in use on van bodies at a British Motor Corporation plant in Birmingham, England.

The chemical method of producing oxygen was later abandoned with the development of the cheaper and more efficient air separation process. By this method the air is compressed, converted to a liquid by expansion and then distilled to allow the various constituent gases to be drawn off.

The growing use of oxygen led to the development of a wide range of other gases and gas-using equipment. This, in turn, resulted in the establishment of a great new industry and the expansion of British Oxygen from a small back-street factory to a world-wide group employing 26,000 people. The Group's range of products and services today includes industrial and medical gases, gas separation plant, welding and cutting equipment, anæsthetic and analgesic apparatus, soda syphons, raw materials for plastics and paint resins, and aircraft breathing equipment.

The British Oxygen Group is now firmly established as one of the Commonwealth's great industrial assets.

GIANT EARTH-DIGGING MACHINE

A giant earth-digging machine which will move up to 3,000 cubic metres of earth per hour is on the drawing boards at the Institute of Hydro-Engineering Design.

This will be a dredge which will be capable of digging long canals up to 300 metres wide (surface width) and up to 18 metres deep. At the same time it will sluice up the embankments.

As different from similar units, the new giant earth mover will operate under its own power, for which purpose it will carry a 6,000 h. p. power plant. It will also have a 110-metre-long slurry pipe line which will do away with the need for pipe communications with the shore. Mounted on hydraulic stilts the earth digger will be able to move independently in any direction during operation.

The self-contained giant unit which will be automated to the utmost is well adapted for use in sparsely populated areas remote from sources of power.

* * *

INDIAN ENGINEERS STUDY OPENCAST MINING IN BRITAIN

Opencast mining by Britain's nationalized coal industry is being studied by four Indian mining engineers now in the north-east of England. For much of their first week of a three-month stay in Britain they have been visiting opencast sites near the industrial centre of Newcastle-upon-Tyne.

"These visits have given us a much clearer picture of highly mechanized opencast mining," Mr. B. G. Pradhan, administrator and technical head of a group of mines at Singareni, Andhra Pradesh, said in an interview. "Opencast mining in Britain is a much more difficult job than in India, in that more rock and waste material has to be cleared for every ton of coal produced. We have been specially interested to see the machinery developed to tackle this problem." "Another striking feature of opencast mining in Britain," said Mr. Pradhan, " is the way in which the land is restored after the mining is finished."

The four Indian engineers are on a general observation tour of Britain's coal industry under the Colombo Plan. With Mr. Pradhan are Mr. M. Vasudevan, administrator and technical head of a mining group, and two colliery managers, Mr. S. P. Ahuja and Mr. M. K. V. Subbiah.

The party will now spend several weeks visiting deep mines. The members will split up towards the end of November, Mr. Pradhan and Mr. Subbiah staying in the north-east area, and Mr. Vasudevan and Mr. Ahuja visiting some Scottish mines. Later they will all visit Manchester, Sheffield, and Worcester.

Russ Electric Furnaces for Ferrous and Non-Ferrous Industries

By A Special Engineering Correspondent

For 40 years "RUSS" has been engaged in the manufacture and development of electric industrial furnaces. Based on their long years' experience they are always prepared to discuss and advise on heating and melting problems. We are sure this write-up dealing with Russ Electric Furnaces would be of great interest to our readers in ferrous and non-ferrous industries.

AUTOMATIC Casting Equipment in combination with Russ mains frequency coreless induction furnace for melting aluminium alloys, with automatic charging and casting device. This device casts automatically given amounts of metal at regular intervals. The dies arranged on a rotating table are opening and closing automatically. Production of turntable : 300 castings per hour. Total weight of castings : about 330 lbs, Al/h.

Low frequency induction furnace with a capacity of 2200 lbs. for the melting of gun metal and bronze. Melting rate : 1750 lbs./h. Current consumption for melting : about 215 kWh per long ton of gun metal.

Low frequency induction furnaces for melting pure copper and Cu-alloys. Technical data of each furnace : Usable tapping capacity : 3300 lbs. Melting rate : 3750 lbs. of Brass per hour, 2200 lbs. of pure copper per hour, in combination with 2 Low frequency induction holding furnaces with a capacity of 4 tons each, combined with a continuous casting machine.

Low frequency Channel Type induction furnace with a capacity of 5 tons for melting, superheating and refining of grey iron and also for melting malleable iron and for the carburising and decarburising of iron. Connected load : 550 kVA. Melting rate : about 1750 lbs. grey iron/h at a tapping temperature of 1450°C. Current consumption for melting : about 450 kWh/long ton at a tapping temperature of 1450°C. Current consumption in holding : about 40 kWh/h.

Low frequency induction Furnaces for melting Aluminum and Al-alloys in combination with a 5 ton capacity Hearth-type holding and casting furnace. Usable tapping weight of induction furnace : 3 long tons. Melting rate : 3300 lbs. Al/h. Current consumption for melting : about 400 kWh/long ton.

2 Double-Chamber-Type low frequency induction furnaces for melting Aluminium. Usable holding capacity: 4400 and 2200 lbs. respectively.

Low Frequency Channel-Type Induction Furnace for melting pure copper. Usable tapping weight : 2 long tons. Connected load : 400 kVA. Melting rate : 2200 lbs. copper/h. Current consumption for melting : abt. 260 kWh/long ton copper. Life of refractory lining : abt. 1 year.

Low Frequency Channel-Type Induction Furnace for melting cast iron. Usable tapping weight : 2.5 long tons. Connected load : 400 kVA, Melting rate : 1550 lbs. cast iron/h at a tapping temperature of 1400°C. Current consumption for melting : 450 kWh/long ton. Life of refractory lining : 1 year and longer.

Small Stationary-Type Channel Induction Furnaces for melting, ladling and holding copper alloys. Technical data of each furnace : Usable holding capacity : 880 lbs. Brass. Connected load : 50 kVA. Melting rate : 400 lbs. Brass/h. Current consumption for melting : abt. 20 kWh/220 lbs. of Brass.

Stationary-Type *Double Hearth Low Frequency Channel Induction Furnaces* for melting, ladling and holding of Aluminium and Al-alloys in a die-casting foundry. Technical data of each furnace : Usable holding capacity : 440 lbs. Aluminium. Melting rate : 155 lbs. Al-alloys/h. Current consumption for melting : abt. 48 kWh/220 lbs. of Aluminium.

Double and Three Chamber-Type Low Frequency Induction Furnaces for Al-alloys, having usable capacities of 550, 800 and 1000 lbs. respectively. Melting rate : 220, 300 and 550 lbs./h respectively.

Double Hearth Low Frequency Induction Furnace for melting Aluminium and Al-alloys, stationary design. Usable holding capacity : 4400 lbs. Melting rate : 900 lbs. 1h. Current consumption for melting : abt. 420 kWh/long ton.

Double Chamber Low Frequency Channel-Type Induction Furnace for the die-casting of brass.

Small-Type Stationary *Induction Furnace* for melting, ladling and holding copper alloys, zinc and zinc alloys, for fitting and die-casting foundries, and for operations in combination with high pressure die-casting machines. Usable holding capacity : abt. 650–900 lbs. Melting rate : 220–650 lbs. Cu-alloys/h. Space required : abt. 16 sq. ft. no foundations necessary. Designed as single or double Hearth Furnace. Also Hydraulic titling device. Furnace tilting device, pump and air cooling system are combined in one unit. Therefore low installation and erection cost.

Mains Frequency Coreless Induction Furnace for melting cast iron and steel. Usable holding capacity; abt. 1300 lbs. Connected load : 150 kVA. Melting rate : 440 lbs. cast iron/h, 350 lbs. steel/h.

Double Hearth Mains Frequency Coreless Induction Furnace, stationary design, for melting, ladling and holding Al-alloys, in combination with a high pressure die-casting machine. Usable holding capacity : 440 lbs. of Aluminium. Connected load : 70 kVa. Melting rate : abt. 220 lbs. Al/h.

Crucible-Type Furnace with motor-operated titling device for melting white metal. Capacity : 1100 lbs. Melting rate : 1100 lbs./h.

Hearth Car-Type Furnace for annealing and stress-relieving of castings and for annealing Nodular iron. Connected load : 250 kW. Maximum temperature : 1000°C. Usable inside dimensions of the furnace : 1200 mm. wide 1200 mm high, 4000 mm deep.

Lead Melting Furnaces in combination with cable presses. Capacity : 4 long tons. Melting rate : 3 long tons/h. Special construction with stirring and tapping device.

7 Box-Type Furnaces with forced air circulation, for tempering steel. Maximum operating temperature : 750°C.

Box-Type Furnace for preheating and for the recovery of white metal out of bearings. Connected load : 70 kW. Max. operating temperature : 500°C.

Box-Type Furnace for annealing and case-hardening. Connected load : 85 kW. Max. operating temperature : 1000°C.

Box-Type Furnace with forced air circulation for the heat treatment of Al-alloys. Connected load : 150 kW. Inside furnace dimensions : 1200 mm. wide, 1200 mm. high, 3000 mm. deep. Precision of temperature : ± 5°C.

Large Drying Furnace for ceramics. Inside dimensions : 3500 mm. wide, 3000 mm. high, 7000 mm. deep. By vertical and horizontal partitions the furnace can be divided into chambers of various dimensions.

Glass Kiln for the heat treatment of glass. Kiln shown has a volume of 18 cubic feet. Connected load : 18 kW. Maximum operating temperature : 600°C.

Box-Type Furnace, type KBM, for the firing of pottery and other ceramics. Maximum temperature : 1200°C. Standard furnaces ranging from 4 to 35 cubic feet.

Car-Type Ceramic Firing Furnace, type KBH. A furnace having a usable capacity of 35 cubic feet. Connected load : 60 kW. Further standard types having usable capacities from 53 to 70 cubic feet.

" *RUSS* "—*Mains Frequency Induction Billet Heater*. Output : 2650 lbs. Aluminium billets/h. Billet dimensions : 150 mm. ○ and 150—600 in length. With fully automatic starting and discharging of all billets with a range of between 150–600 mm. i. e. all billets also the first and last billet of a cycle, are discharged with their exact temperature. Always ready for operation—Very short heating time, no formation of scale —Automatic temperature control, each billet is separately controlled.

SPHEROIDAL GRAPHITE CAST IRON

By A. C. Bhattacharya, A.M.I.P.E., A.M.I.Loco.E., A.M.A.I.I.E.

SPHEROIDAL graphite cast iron represents one of the most significant metallurgical developments in well over a century. It has the processing advantages of cast iron—low melting point, good fluidity and castability, excellent machinability and good wear resistance—with many of the engineering advantages of steel including high strength, toughness, ductibility, and hardenability.

" S. G. iron ", as the spheroidal graphite cast iron is termed for convenience, often replaces steel, malleable cast iron and other materials for a wide range of uses. It permits the production of castings in complicated as well as simple forms which are not subject to size or weight limitations. It is particularly responsive to all types of heat treatment and can be alloyed to develop special matrix structures and properties. It may be regarded as having its own " bank ", from which carbon may be drawn or into which carbon may be deposited as desired.

WHAT IS S. G. IRON?

In order to explain what is implied by spheroidal graphite cast iron, a brief reference to the metallurgical nature of cast iron is imperative. Essentially ordinary grey cast iron is made up of flakes of graphite embedded in a matrix having a combination of constituents such as ferrite, phosphide, cementite, pearlite and the like. The larger the flakes are, weaker will be the iron in terms of physical tests as they break up the continuity of the metal matrix and set up, in effect, a whole series of notches, which act as stress concentrations, thus causing relative brittleness and low strength.

Attempts in the past to make stronger cast irons of the high duty type were aimed at firstly producing smaller and finer graphite flakes and secondly a stronger matrix usually by means of alloying elements. It was subsequently thought that if in place of flakes, the graphite in the cast iron could be caused to assume a spheroidal shape, it would be possible to obtain best physical properties.

In S. G. iron, developed on these lines of thought, the graphite present, takes the form of spheroids and they are isolated from one another to present the minimum surface for a given volume and in consequence a minimum number of discontinuities in the surrounding metal.

The process in making S. G. iron depends on the treatment, in the foundry, of a suitable grade of molten iron with magnesium or cerium, or both, as a result of which the graphite, which separates in the casting during cooling, as umes the spheroidal form in place of the normal flake type.

HOW S. G. IRON CASTINGS ARE MADE

S. G. Iron castings are made as stated in the foregoing para by two processes, viz., cerium process and magnesium process. In both the processes, a choice of raw materials has to be made very carefully. The pig iron to be used is to have low phosphorus and sulphur contents.

The details of the cerium process were first published by Morrough & Williams of the British Cast Iron Research Association. In this case the prospects for the production of S. G. iron lie in the use of the base iron having a total carbon content of at least 3.6 per cent (that is a hypereutectic iron) together with low phosphorus (preferably 0.1 per cent maximum) and sulphur (0.04 per cent maximum). Production of a metal with such limitations in the use of the base iron is not a practical proposition for a normal acid lined cupola even if a desulphurisation process is resorted to, and either a crucible type or a high frequency induction furnace selects itself as the suitable means for production.

After the choice of base iron is made, cerium is added in the form of " misch-metal ", which is a compound of 45—55 per cent cerium and rare earths. The size of the casting dictates the amount of the compound to be added. It generally lies between 100 and 200 grams per 100 lbs. of molten metal. The addition is followed by inoculation in the same

way as is done with high duty cast irons. Ferro-silicon, calcium silicide or some such material are used as inoculant and the amount varies, but on an average is about 10 oz. per 100 lbs. of molten metal.

Because of the critical base iron composition required and a tendency for the irons to cast white when sulphur is above 0.04 per cent, the cerium process has not yet been able to establish itself in the ordinary grey iron foundry.

The magnesium process although fundamentally the same as the previous one, has several marked differences. The composition of the base iron required is not so critical and even if sulphur should be low it is only to conserve magnesium which first desulphurises before it has alloying effects. Phosphorus, which has the effect of decreasing impact strength and lowering elongation values, should be kept low and the carbon content should preferably be between 3.4 to 4.2 per cent although wider limits have been successfully treated. The addition of Mg in the melting process is done in its alloy form.

After experiments of various kinds to get spheroidizing agents, it has been found that a Ni-Mg alloy with 15 per cent Mg is the best. It has the added advantage of being absorbed completely. Cupola units can be, and are being used for the melting of the base metal, usually with a percentage of steel in the charge. The build up of nickel stabilises the pearlite, besides affecting elongation and impact values.

Inoculation as in the cerium process should add about 0.5 to 1.0 per cent of a graphitising material such as ferro-silicon in suitable particle size.

In both the processes, the graphite is spheroidised and the matrix may be ferritic, austentic, martenistic or acicular according to well-known alloying principles—the main alloying elements being nickel, molybdenum, copper and chromium.

As regards founding, the contraction in patterns for S. G. iron is the same but the shrinkage in the castings is greater than in other castings. This difficulty can be overcome by properly placed runners and risers. Because of its fluidity being the same as in any cast iron, moulding presents no difficulty. Fettling is similar to that required by steel castings.

ENGINEERING PROPERTIES

With regard to its properties, there is already an extensive literature on the general subject of S. G. iron. Properties are generally quoted for the two main types—the pearlitic matrix type and the ferritic matrix type. The latter type of S. G. iron is obtained by heating the S. G. iron to 900°C for a few hours followed by slow cooling to produce the maximum toughness and ductility in the metal.

The accompanying table taken from a paper read by A. B. Everest of the Mont Nickel Co. in June 1952 before the 4th International Mechanical Engineering Congress at Stockholm, summarizes the mechnical properties in the two types of S. G. iron as compared with a high duty flake graphite cast iron. It must be appreciated that advances in technique have produced even higher test figures since then.

Properties of S. G. iron—Pearlitic and Ferritic compared with these of graphite cast iron.

Property	High Duty Flake Graphite Cast Iron	Pearlitic S. G. Iron	Ferritic S. G. Iron
Tensile strength, tons per sq. inch.	18– 22	35– 45	27– 35
Yield point, tons per sq. inch.	—	25– 35	20– 25
Elongation per cent.	NIL	1– 5	10– 25
Transverse rupture stress, tons per sq. inch.	38– 42	55– 65	55– 60
Compressive strength, tons per sq. inch.	60– 65	65– 80	45– 58
Elastic modulus, lbs. per sq. inch.	18 Million	25 Million	25 Million
Brinell hardness.	210–240	230–280	140–180
Impact, Izod 10 mm sq., notched ft. lb.	1	4	12
Endurance limit, unnotched, tons per sq. in.	8.5	13– 18	11– 13

The tensile strength of S. G. iron is approximately double that of the corresponding flake graphite type of iron. It has a stress-strain curve similar to steel indicating that it can withstand higher loads without suffering permanent deformation. Its yield strength is high, exceeding that of malleable cast iron and equalling the values for some types of cast steel. These qualities coupled with high modulus of elasticity and good elongation permit of deformation by twisting and bending. Although it can be twisted and bent, it is a rigid material and resists deformation except under heavy load.

The toughness of S. G. iron as measured by the conventional Izod and Charpy tests, is intermediate between that of cast iron and steel. It can therefore be used with advantage in fabricating parts subject to shock.

The S. G. iron has a low melting point and good fluidity in the molten state. It, therefore, lends itself well to the production of intricate shapes and thin-sectioned parts. It shares the good castability characteristics of the other cast irons.

The wear resistance of S. G. iron is also equally good and the pearlitic type is stated to have equal or slightly better abrasion resistance than normal cast iron. The spheroidal graphite particles serve as reservoirs to store lubricant for starting-up periods and to prevent galling and scuffing during periods of positive lubrication failure.

The S. G. iron has good machinability, which is roughly the same as for flake graphite iron for a given matrix structure. When a comparison is made at equivalent hardness levels or at similar strength levels, the machinability of S. G. iron is superior to that of steel. Although power consumption is somewhat higher because of S. G. iron's much higher strength and toughness, but tool life is greater. S. G. iron can be machined wet or dry to an excellent finish. Ferritic S. G. iron yields long continuous turnings similar to those obtained from steel.

S. G. iron can be welded to itself and to other materials such as carbon steel, stainless steel and nickel by the metal arc process, using techniques applicable to good grades of gray iron. There is a danger of brittleness associated with the area around the weld, but this can generally be overcome by modifications of techniques The material can also be brazed with silver or copper brazing alloys.

Like other cast irons and steels, S. G. iron responds to heat treatment to obtain a wide range of hardness. It can be softened by annealing or hardened by normalizing or oil quenching and tempering. In fact, for parts requiring extra strength and wear resistance, heat treatment is recommended.

The combination of castability with the inherent ability to fill completely an intricate mould and mechanical properties which permit subjecting the casting to higher operating pressures, together with its metallographic structure which resists leakage or seepage by liquids and gases has led to the wide acceptance of S. G. iron for intricate pressure castings which are highly stressed in service.

Amongst its other properties are included high temperature strength roughly comparable to that of ordinary cast steel at 427 deg. C., corrosion resistance thermal conductivity, magnetic permeability, expansivity, density, damping capacity, etc.

DESIGN ADAPTABILITY

Of the ferrous casting metals, S. G. iron rates high in design adaptability. It lends itself well to the production of intricate shapes and thin-sectioned parts.

In general S. G. iron castings can be produced with dimensional accuracy better than malleable castings. Because of their relatively smooth as—cast finish, S. G. iron castings are frequently cast to finished dimensions, eliminating further machining.

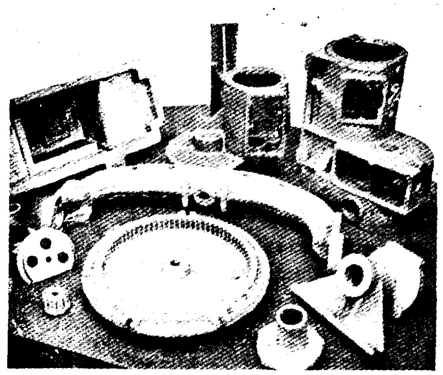
S. G. iron castings are not subject to size limitations. They are produced commercially in weights varying from fractions of ounces to 50 tons with section thickness from less than 1/8" to 48".

Because they have excellent machinability, S. G. iron castings can be finished at relatively low cost to final dimensions by machining. The finish allowances for machining are as follows :

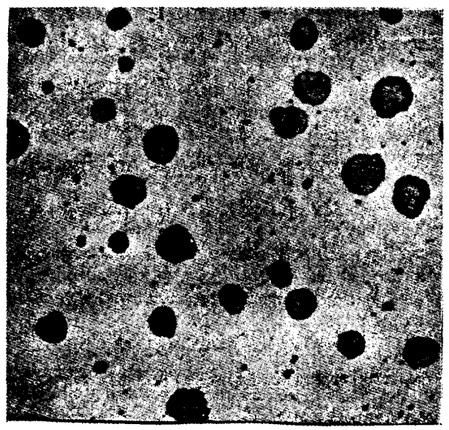
For milling : 1/16 to 3/32 in. for small castings ; 1/8 to 3/16 in. for medium castings ; and more for larger castings ;

For reaming : 3/32 in. on the diameter for cored holes under 1 in.; 1/8 to 3/16 in. on the diameter of the medium castings ; and more for larger holes.

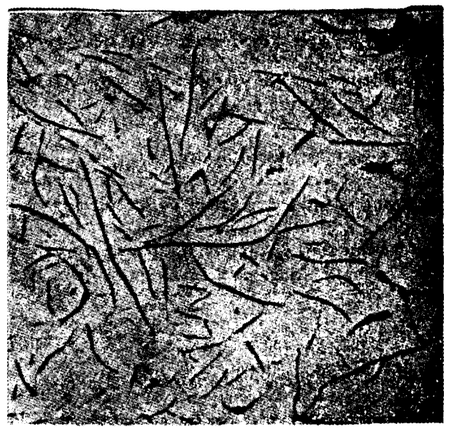
It is necessary with S. G. iron castings, as with all castings, to allow for pattern draft. The standard



Typical S. G. Iron Castings



Microstructure of S. G. iron showing random graphite spheroids, unetched, magnification 100 x



Microstructure of ordinary grey cast iron showing random graphite flakes, unetched, magnification 100 x

been widely adopted in almost every branch of engineering. It has found numerous applications in agricultural machinery, engines of all types, textile machinery, motor vehicles, railway and marine engineering, and in general plant and equipment.

Safety, accessibility and compactness are obvious "musts" in machine tool building industry and these are easily obtainable by using S. G. iron. For highly stressed structural components of machine tools, for which steel is presently employed for reasons of strength, S. G. iron may offer advantages in providing strength approaching that of steel with better damping capacity.

One of the earliest applications of S. G. iron in U. S. A. was for hammer blocks and anvils on drop forging machines, as well as for side frames. In Switzerland, S. G. iron has been successfully employed for small rolling-mill housings.

S. G. iron rolls have been applied successfully in increasing numbers in the metal working industry. The material provides superior wear resistance and high strength resulting in the elimination of breakage problems often encountered with cast iron rolls. Galling and scuffing are virtually eliminated due to the self lubrication provided by the graphite spheroids in the matrix.

practice in production castings is 1/64 in. per in. This is less than 1 deg, as compared to 7 deg. required for forgings. For loose patterns with a deep draw, a draft of approximately $\frac{1}{4}$ in. per ft. is required.

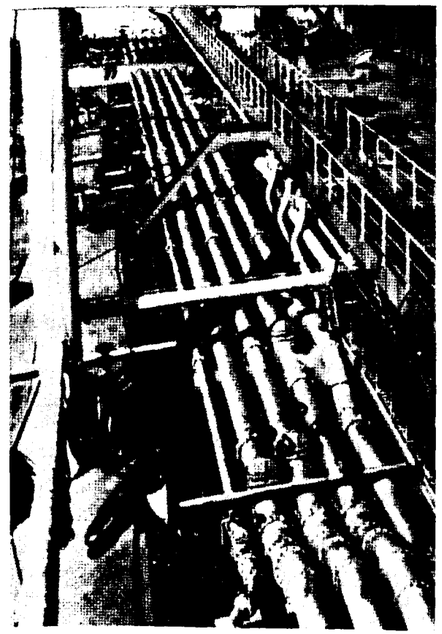
Its weldability facilitates repair and the preparation of assemblies in S. G. iron or composites with other materials.

APPLICATIONS

On account of its properties, S. G. iron has now been used with advantage and in one case they have shown no measurable wear after 2 years of service and no flat spots.

A particular application of S. G. iron which, it is considered, emphasizes the outstanding properties of the new material, is to gears. S. G. iron lends admirably to gear cutting. In gear applications impact loads or heavy loads that cause pitting of the gray iron, are involved and this failure is resisted by S. G. iron, which, it has been observed from several of the examples, can, in general practice, safely be used at loadings up to 90 per cent of those for steel at 180 Brinell hardness, and up to 78 per cent at 300 Brinell hardness.

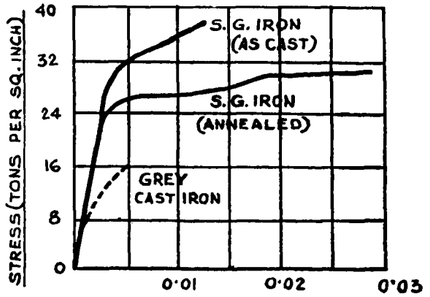
S. G. iron die for press jobs is its another application which has found favour because of its built in lubrication, toughness and wear resistance. It has also replaced steel for heavy duty face plates, tail stocks, carriages, etc., for lathes. S. G. iron crane



S. G. iron piping aboard a French tanker. The pipe has replaced steel pipe aboard 56 tankers. After six years of service in some of the tankers, none of the S. G. iron pipe has needed replacements and shows negligible pitting. S. G. iron pipe is used for both cargo piping and heating coils.

The facility with which it can be plated and enamelled makes it suitable for many items of decorative trim and chemical plant. It is readily "tinned" and this property, in combination with its high strength and its inherent good bearing properties, makes it ideal for bearing shells thus successfully replacing in many instances bronze or steel.

This fascinating material offers a very wide scope of application not because of its individual properties but for the unique combination of properties that it has and which are not achieved by other common engineering materials. In spite of difficulties associated with its production, S. G. iron is already being produced in this country by a few foundries and a few more foundries are also expected to take up production in the near future.



STRESS-STRAIN CURVES FOR S.G. IRON AND GREY CAST IRON.

Spheroidal graphite cast iron is thus a new engineering material in its own rights. As the designers introduce this material on a wider scale into their drawings, making the best use of its unusual combination of properties, it will make rapid strides towards its further development and play an increasingly important part in many fields of industry.

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FRIEDRICH UHDE'S CONTRIBUTION TO STEEL MILLS

By A Special Correspondent

[We have great pleasure in publishing below a short write-up on "Friedrich Uhde GMBH – Dortmund" a well-established and highly reputed firm with many years standing in the field of designing and construction of Industrial Plants and technical equipment for Petroleum and synthetic oil industries, Production of coal and petrochemicals, Nitrogen and fertilizer industries, Production and purification of synthesis gas, Organic and inorganic chemical industries, Plastic and synthetic fibre industries.—EDITOR]

AN opportunity for the production of nitrogen fertilizers is given in view of the presence of the steel mill and the coking plant.

The coke oven gas actually consists for more than 55% of hydrogen which can be freed from the other components by means of proven processes.

The hydrogen with the nitrogen which can be economically obtained in connection with the production of oxygen for the steel mill forms the synthesis gas mixture required for the production of ammonia from which in turn nitro limestone, a proven nitrogen fertilizer, can be produced.

The fertilizer plant is operated as follows:

The coke oven gas which has already been given a pre-treatment in the by-product plant is brought to a pressure of about 13 atm. g. and is thereafter freed from carbon-dioxide by scrubbing with ammoniacal water.

The gas then enters the LINDE gas fractionating plant in which the hydrogen is separated from the other components of the coke oven gas by means of physical methods under application of very low temperatures, namely down to about -190°C. Simultaneously so much nitrogen is added that a synthesis gas mixture consisting of 75% hydrogen and 25% nitrogen is obtained.

This mixture is compressed to about 450 atm. g. and led to the ammonia synthesis plant where hydrogen and nitrogen combine to ammonia.

About half of the ammonia is burnt with air and the nitrous gas mixture formed thereby is then processed with water to nitric acid.

This nitric acid forms together with the remaining ammonia an ammonium nitrate solution which is then concentrated and by adding of ground limestone nitro limestone is obtained.

With regard to the above mentioned plants the Friedrich UHDE GmbH., Dortmund (Western Germany), design and build all plants with the exception of those for the further processing of the ammonia to nitro limestone.

(The main sub-contractors are:

Hugo Ibing, Recklinghausen, gas scrubbing plant;

Linde, Hollriegelskreuth near Munich, gas fractionating plant;

August Klonne, Dortmund, gasholders and ammonia storage tanks;

Demag, Duisburg, synthesis gas compressors;

Siemens-Schuckertwerke, electric motors and equipment).

(The plant for the further processing of ammonia to nitro limestone is designed and built by Sindri Fertilizers so that it would be best that the details concerning this plant part are given by the relevant company).

Machining of High Alloy Steels on a Chrome, Chrome-Nickel and Chrome-Nickel-Manganese Base

By Dr.-Ing. Georg Menges
*and Dr.-Ing. Helmut Treppschuh, Geisweid**

[Knowledge of the basic properties influencing cutting action enables steels alloyed with chromium, nickel and manganese, which are very expensive and difficult to machine, to be processed economically. The machining properties of these alloys are largely determined by their structural constitution. These properties can be improved by suitable pre-treatment of the material. An extensive series of tests covering the various types of machining operation has led to the formulation of reference data for the cutting conditions involved, and of recommendations for tool cutting edge form which, if adopted, are capable of markedly increasing cutting performance. The corrosion resistance of stainless steels depends largely on the quality of surface finish imparted. To obtain the maximum of corrosion resistance, finished items in these materials should be thoroughly cleaned and passivated after machining.]

HIGH alloy steels on a Cr, CrNi and CrNiMn base are becoming more and more widely used in engineering. This applies particularly to the corrosion-resisting and heat-resisting steels which all have a high chromium content. As an alloying constituent, chromium gives steel non-scaling properties and when present to the extent of more than 12% also confers rust-resistance. Steel having a high chromium content of this order and less than 0.1% carbon forms a purely ferritic structure and is not hardenable by heat treatment. With a higher carbon content, on the other hand, the steel is amenable to hardening or heat treatment; in this case also the formation of pearlite, sorbite, troostite and martensite is possible.

Alloys having, for example, 8% nickel or 18% manganese in addition to 13 to 15% Cr possess an austenitic structure. In this condition the steel is very tough (when cold also). The mechanical properties, and, consequently, the machining properties also, depend largely on the structure (1 to 7). In addition, austenitic steels are non-magnetizable; they are therefore widely used for special applications in electrical engineering and in shipbuilding and aircraft construction.

How the Structure and Pre-treatment of the Material Influence its Machinability

The heat-treatable and hardenable chrome steels have machining properties similar to those of carbon steels of the same tensile strength or hardness; they are therefore machinable like the latter.

The purely ferritic chrome steels and the austenitic CrNi, CrNiMn and Mn steels possess certain qualities which are highly detrimental to the machining action. Both types of structure are comparatively soft and ductile at the start of machining, and therefore these alloys tend to "smear" and to form built-up edges owing to their very poor thermal conductivity. In the case of the austenitic steels, the tendency to work hardening (particularly evident in the Mn steels) increases cutting resistance. The large amount of thermal expansion also makes for further difficulty.

When machining stainless steels a smooth surface finish is important, since corrosion-resistance depends on surface quality. The low alloy stainless steels having 13% Cr, for example, are only immune to atmospheric influences when provided with a fine-ground or polished surface.

In the black rolled condition, heat-resistant steels carry a layer of scale enriched with silicon dioxide and aluminium oxide. This layer is extremely hard so that cutting tools dull rapidly. It is therefore preferable to start with material that has been peeled or pickled so that it will not be necessary to re-sharpen the tool after it has done no more than remove the layer of scale.

Pre-treatment of the steel (e.g. work hardening and heat treatment) affects the cutting conditions to a considerable degree. The type of structure, the grain size involved, the distribution of carbides in harden-

*Report from the Research Department of Stahlwerke Südwestfalen AG., Geisweid.

able steels and the arrangement of ferrite in ferritic-pearlitic and ferritic-austenitic steels are factors which become of critical significance. Krekeler's findings regarding the influence of structure apply analogously to the steels discussed here.

FERRITIC CHROME STEELS

The ferritic steels, soft and ductile by nature and with a tendency to smear, give rise to substantially better cutting conditions if machined in the work-hardened state (yield point 32 to 44 tons per square inch). Fine-grained ferrite machines better than coarse-grained.

HEAT-TREATABLE CHROME STEELS

According to analysis and heat treatment, so these alloys form pearlitic, sorbitic and troostitic structures just like pure carbon steels. Under conditions of heavy cutting, these steels give optimum tool life with a pearlitic annealed structure when the carbides are globular and uniformly distributed. For finish-machining a sorbitic tempered structure is preferable; it promises a smoother surface. Rough-machining is therefore best carried out in the annealed condition; finish-machining is performed following heat treatment. In this way it is possible to reduce the hardening distortion which usually occurs at the same time.

Heat treatment should on no account be omitted, since it is only in the structural condition thereby imparted that optimum corrosion resistance is obtained.

HARDENABLE MARTENSITIC CHROME STEELS

In the natural-hard condition, these steels are not machinable. On the other hand, in the soft-annealed condition (with coarse uniform carbides present) they can be machined quite readily. When hardening, however, soft-annealed structures of this kind require a fairly long holding time (at hardening temperature) so that the carbides go over into solid solution again. These steels also offer maximum corrosion resistance in the hardened condition.

AUSTENITIC STEELS

With all steels having a purely austenitic structure, as obtained, for example, after solution heating at 1000 to 1100°C with subsequent quenching, the tendency to work hardening is an impediment to machinability. The machining difficulties encountered can be slightly lessened by annealing between 600 and 850°C for 1 to 2 hours. The effect of this is to precipitate carbides which bring about an increase in strength so that the smear effect of the metal while cutting is lessened. In the same way, machinability is improved by mechanically increasing the strength of the material, e. g. by cold drawing. Machining is easier in the rolled condition also. Full corrosion resistance is only obtained (particularly in the case of carbide precipitation) following solution heating (1000 to 1100°C) and subsequent quenching in water. In the case of rust-resistant steels which have been stabilized (alloyed with titanium or columbium-tantalum) solution heating can generally be dispensed with.

FERRITIC-AUSTENITIC STEELS

Owing to their smaller work-hardening tendency, these steels usually exhibit better machinability than purely ferritic or purely austenitic steels. In normal cases, e. g. with banded ferrite present, the low cutting speeds available on conventional machines give poor results on drilling, reaming, threading and broaching; in addition, the surfaces produced in these operations are often rough.

RUST-RESISTANT FREE-CUTTING STEELS

The corrosion-resistant free-cutting steels widely used in the USA machine with a short chip formation and have less tendency to smear owing to the large sulphur addition or the presence of other alloying constituents (8) having a similar action. This means that substantially higher cutting speeds are possible than with ordinary corrosion-resistant steels. Furthermore, heat treatment to improve machinability is rendered unnecessary. It should be noted, however, that these alloys do not exhibit corrosion resistance to the degree typical of steels of the like kind without sulphur addition.

Basic Conditions to be met by Machines and Tools

All the alloys mentioned are very tough. For this reason only very rigidly built machines are suitable for machining them. Tools must be clamped with the minimum amount of overhang so that there will be no vibration to set up chatter marks and cause localized work hardening of the material. It is important to maintain a constant feed so that the cutting edge is in action all the time. If it starts to slide, work-hardened areas will result which will often be found difficult to remove later, and are frequently the reason behind

unjustified complaints made by the processor to the steelmaker alleging "hard spots."

All Cr CrNi and CrNiMn steels have poor thermal conductivity (about half the figure for carbon steels). This in turn leads to accumulation of heat and adversely affects the cutting edge of the tool. The contact or rubbing faces of the tool should therefore be fine-ground or, better still, lapped to obviate welding. Large tool cross sections are good because they conduct heat away more effectively. Lubricants and coolants should be used without fail whenever difficult cutting conditions are experienced.

Most machine shops are equipped only with light and medium-heavy machine tools, and the tools used are therefore generally of high speed steel. Owing to their extreme strength at elevated temperatures combined with toughness, these tool materials allow comparatively large true rake angles to be used, and this factor greatly facilitates chip clearance at low cutting speeds. When efficient heavy-duty machines are available there is scope for using carbide tools economically. Owing to the fact that carbides are not so shock-resistant, they should be used primarily for work involving uninterrupted cutting. The lip angle of carbide tools should be made larger than for high speed steel tools to prevent edge from breaking out. In the case of carbide tools, therefore, the true rake angles used are small or even negative so that high cutting speeds are essential to economic utilization. Since all stainless steels (with the exception of the free-cutting grades) tend to form stiff, flow type chips, it should be made the rule wherever possible to grind chip-breaking and chip-curling grooves into the tools. This precaution prevents the stiff flow chips from building up in the tool or scratching the machined surface of the work.

The very tough Mn steels, and especially the type known as austenitic manganese steel having 1.2% C and 12% Mn, as well as other austenitic steels usually machine better when hot. Satisfactory machining temperatures are found to lie within the range 200 to 400°C. Every steel has its own particular optimum machining temperature at which it can be cut by carbide tools. Since brazing fillers do not have satisfactory strength at elevated temperatures, however, the carbide tips must be clamped in position.

The Influence of Lubrication and Cooling

All steels in this group are poor conductors of heat and should not be machined without suitable lubrication and cooling. Since in nearly all cases the occurrence of the effect known as the built-up edge is likely, preference is given to the blended "extreme pressure" type of cutting oil on a mineral oil basis containing additions of sulphur, chlorine and phosphorus compounds. Oils with a sulphur additive are corrosion-inhibiting and therefore preferable. These oils are usually mixed half and half with paraffinic oils; when machining tough austenitic steels, however, the proportion of extreme pressure oil should be increased.

The oil temperature should be between 20 and 50°C and should not exceed the upper limit. Care must therefore be taken to ensure that a sufficiently large volume of oil is circulating, or that special steps are taken to cool the oil. Soluble oils emulsified with water are only used under light cutting conditions, during finishing operations for example, when the principal requirement is to provide a cooling action. For this, however, they contain a larger percentage of oil so that they show more tenacity and lubricate better. Russian investigations carried out by Jefremow and Schneider (9) have also yielded good results with the use of other lubricants. The lubricating medium had little effect on surface finish. The cutting oil supply must be consistent and liberal enough to ensure that the cutting point is properly cooled and that the chips are flushed away.

The oil in circulation must be carefully filtered otherwise fine particles may lodge between tool and work with resulting damage to the surface of the work and promotion of tooler wear.

The Cutting Conditions involved in the Different Methods of Machining

Cutting conditions vary enormously with the different types of machining process employed, so that every processor must use his own experience to work out satisfactory values to suit his own conditions. In view of the great diversity in workshop conditions, the remarks which follow can do no more than indicate general principles.

LONGITUDINAL TURNING

In the course of detailed machining investigations on an electronically controlled high performance lathe, *Fig. 1*, a range of satisfactory starting values was determined, and these are reproduced in Tables 1 and 2. The tool material used was high speed steel

EW 9 Co 10 and E 18 Co 5. Surface texture was checked with a " Perthometer ", *Fig. 2.* When turning austenitic steels between centres, the large amount of thermal expansion set up must be borne in mind, since, failing this, parts clamped too tightly will readily deflect.

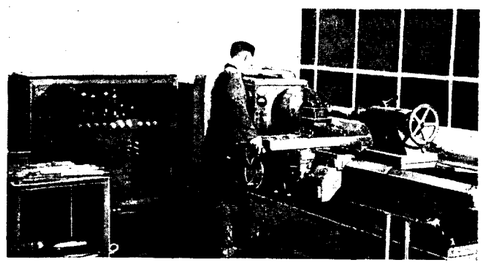


Fig. 1. Electronically controlled experimental lathe for machining tests.

A robust cutting edge is obtained by adopting a clearance angle of 6 to 10° ; for turning austenitic steels, the angle should be made 10° to avoid work-hardening the material through tool slip.

For all steels in this group of alloys, the true rake angle is made steeper than usual to improve chip flow and to minimize heat accumulation at the cutting edge. Suitable values are 5 to 8° for the true rake angle, and likewise 5 to 8° for the negative front clearance. The side angle should preferably be between 75 and 80°. Again, when turning austenitic steels, the upper limit—that is 8° and 80° respectively—is to be preferred. Chip-breaker or chip-curling grooves are to be recommended in all cases, *Figs. 3 to 5.* These have the effect of relieving the cutting edge so that less frictional heat is developed. The form and size of the grooves will depend on the depth of cut. Chip formers and chip flow behaviour in the context of lathe tools have been investigated in detail by Lang (10) who has pointed out that groove depth should increase with chip thickness if satisfactory chip formation is to be obtained. Like the cutting portions of the tool, the groove itself should also have the smoothest possible finish.

The depth of cut is of secondary importance. Since all the high alloy steels lend themselves readily to finishing operations, the amount of oversize left for the final cut need be no more than 0.004 to 0.01 in. The austenitic manganese steels having 12% manganese are economically machinable only with carbide-tipped tools (3).

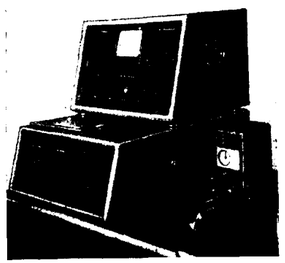


Fig. 2. Electronic instrument for measuring surface texture.

Fig. 3 Chip-breaker groove in a carbide tip

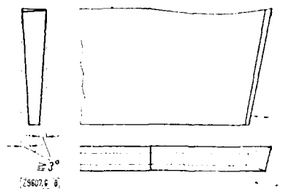
Fig. 4 Chip-curling groove in a high speed steel tool

Fig. 5 Chip-curling groove in a carbide tip

Figs. 3 to 5. Chip-breaker grooves and chip-curling grooves in lathe tools.

CUTTING OFF

All of these high alloy steels can be parted off without any difficulty worth mentioning. Owing to the greater strength of the material, however, the cutting off tools must be made wider and stiffer and given substantially larger clearance angles than similar tools for structural steel, *Figs. 6 to 8.*



Figs. 6 to 8. Cutting off tool with large clearance angle.

SCREW THREAD PRODUCTION

When screwcutting in a lathe, cuts of comparatively small cross section should be taken in view of the torsional effect of the high-strength material being cut. The tools must be kept in a properly sharpened condition, and the cutting edge honed at frequent intervals with a diamond stone. For screwcutting purposes the same cutting edge angles are used as for longitudinal turning, but the cutting speed must be reduced to from one-half to two-thirds of the figure normally used. Greater dimensional accuracy is obtained by cutting dry. It is advisable, however, after the tool has been honed to grease the work with tallow.

PROFILE TURNING

Profiles are usually cut into the work with flat or rounded profiling tools. Turned profiles should preferably not exhibit any sharp edges. If this cannot be avoided, the best course is to turn in two operations, and to delay forming the sharp-edged features until the finishing operation.

Wide form tools tend to " chatter ", particularly if not clamped up close enough. If the width of the profile exceeds the diameter turned by a factor of more than one and a half, it is essential to use two tools in succession. Profiles having surfaces disposed perpendicular to the lathe axis are difficult to produce. A convenient method is to use a roughing tool with a side angle of 3 to 5°, and to finish the faces square with a recessing tool.

Suitable true rake angles for profile turning tools lie between 7 and 10°. For carbide tools the angle is reduced to 3 to 7°. The clearance angle of the cutting edge should be 7 to 9°, and that of the side rake 2 to 3°.

Feed rates will depend on the width of the profiling tool and lie within the range 0.001 to 0.004 in./rev., whilst optimum cutting speeds are somewhat smaller than the values proposed in Table 1.

It is quite essential to remove all machining marks from the tool by honing carefully, since these may be transferred to the work. The flanks of the tool

Table 1. Tool Angles for High Speed Steel Tools in EW 9 Co 10 and E 18 Co 5 when turning Cr, CrNi and CrNiMn Steels

Material			Ferritic Cr steels		Troostitic sorbitic Cr steels (heat-treatable)		Martensitic Cr steels (hardenable)	Austenitic CrNi and CrNiMn steels: Stable austenitic structure		Austenitic CrNi and CrNiMn steels: Unstable austenitic structure		Austenitic Mn steels	Ferritic-austenitic steels
Material Code No (From Stahl-u. Eisen List)			4000 4001 4002 4016	4510 4511 4713 4724 4742 4762	4006 4021 4024 4057	4104 4119 4120 4122 4935	4034 4112 4126 4140 4535	4300 4301 4306 4307 4371 4373	4451 4505 4506 4577 4828 4841 4864	4310 4401 4404 4436 4449 4541	4550 4571 4573 4580 4878	3813 3817 3401	4460 4821 4873
Roughing tool	True rake angle	in°	8 to 12		8 to 12		8 to 12	10 to 15		10 to 15		12 to 15	10 to 15
	Front clearance	in°	8 to 12		8 to 12		8 to 12	8 to 12		8 to 12		8 to 12	8 to 12
	Clearance angle	in°	6 to 8		6 to 8		6 to 8	7 to 10		7 to 10		7 to 10	6 to 8
Finishing tool	True rake angle	in°	12 to 20		10 to 15		10 to 15	12 to 20		12 to 20		12 to 20	10 to 15
	Front clearance	in°	6 to 8		6 to 8		5 to 6	8 to 10		7 to 9		8 to 10	6 to 8
	Clearance angle	in°	5 to 7		— 5		— 5	7 to 9		6 to 8		7 to 9	5 to 7

Table 2. Reference Values for Cutting Speed and Feed Rate when turning Cr, CrNi and CrNiMn Steels

Material		Ferritic Cr steels		Troostitic and sorbitic Cr steels (heat-treatable)		Martensitic Cr steels (hardenable)		Austenitic CrNi Stable austenitic structure		CrNiMn steels Unstable austenitic structure		Austenitic Mn steels*)		Ferritic-austenitic steels	
Depth of cut in	Roughing	0.06 to 0.08		0.06 to 0.08		0.06 to 0.08		0.06 to 0.08		0.06 to 0.08		0.04 to 0.06		0.06 to 0.08	
	Finishing	0.004 to 0.02		0.004 to 0.02		0.004 to 0.02		0.004 to 0.02		0.004 to 0.02		0.004 to 0.02		0.004 to 0.02	
		Cutting speed ft./min.	Feed in./rev.	Cutting speed ft./min.	Feed in./rev.	Cutting speed ft./min.	Feed in./rev.	Cutting speed ft./min.	Feed in./rev.	Cutting speed ft./min.	Feed in./rev.	Cutting speed ft./min.	Feed in./rev.	Cutting speed ft./min.	Feed in./rev.
High speed steel E 18 Co 5	Roughing	59 to 75	0.012 to 0.024	66 to 82	0.012 to 0.024	66 to 82	0.012 to 0.02	49 to 66	0.004 to 0.012	59 to 75	0.004 to 0.012	26 to 33	0.008 to 0.016	59 to 75	0.012 to 0.024
	Finishing	82 to 98	0.003 to 0.004	82 to 98	0.003 to 0.004	82 to 98	0.003 to 0.00	72 to 82	0.002 to 0.003	75 to 92	0.002 to 0.003	39 to 59	0.002 to 0.006	82 to 98	0.003 to 0.004
High speed steel EW 9 Co 10	Roughing	66 to 82	0.012 to 0.024	82 to 115	0.012 to 0.024	66 to 92	0.012 to 0.02	66 to 72	0.004 to 0.012	72 to 82	0.004 to 0.012	33 to 39	0.004 to 0.012	66 to 82	0.012 to 0.024
	Finishing	98 to 131	0.003 to 0.004	98 to 164	0.003 to 0.004	98 to 115	0.003 to 0.00	82 to 98	0.002 to 0.003	89 to 108	0.002 to 0.003	66 to 82	0.002 to 0.004	98 to 131	0.003 to 0.004
Stellite tools	Roughing	115 to 131	0.012 to 0.024	82 to 98	0.012 to 0.024	82 to 98	0.012 to 0.02	89 to 108	0.004 to 0.020	89 to 115	0.004 to 0.020	39 to 49	0.004 to 0.020	115 to 131	0.012 to 0.024
	Finishing	131 to 164	0.003 to 0.004	108 to 141	0.003 to 0.004	115 to 131	0.003 to 0.00	98 to 131	0.002 to 0.003	98 to 131	0.002 to 0.003	66 to 82	0.002 to 0.004	131 to 164	0.003 to 0.004
Carbide tools	Roughing	—	—	—	—	—	—	131 to 164	0.008 to 0.040	—	—	49 to 66	0.008 to 0.020	—	—
	Finishing	197 to 328	0.003 to 0.004	197 to 262	0.003 to 0.004	197 to 230	0.003 to 0.00	197 to 230	0.003 to 0.004	164 to 230	0.003 to 0.004	66 to 98	0.002 to 0.006	197 to 328	0.003 to 0.004

*) The type known as austenitic manganese steel should be machined with a 30 to 50% reduction in cutting speed.

cutting edges must not be ground hollow, otherwise they may break out.

MILLING

For milling purposes, the basic considerations are the same as those for turning. For milling, however, even more importance attaches to rigidity in the machine and to proper mounting of spindles and absence of slackness in table movements. Cutters must be clamped as firmly as possible and as closely as possible to the spindle bearings; this applies particularly to milling with end mills and with other cutters supported on one side only. Down-cut milling gives better results (assuming scale-free work surfaces) particularly when machining austenitic steels.

With regard to selection of cutting speeds, the values recommended in *Table 3* should be used as a basis. The nomogram reproduced in *Fig. 9* is a quick method of finding the relationship between the cutting conditions. For instance, if a cutter of 3 in. diameter and 10 teeth is required to mill to a depth of 3/16 in., then cutter speed, chip thickness per cutter tooth and the right table feed to use are found as follows: Using the scale in the bottom left hand corner, run a line vertically upwards from the point corresponding to 3/16 in. depth of cut. Where this line intersects the curve for a 3 in. diameter cutter run a line off horizontally. At the point where this line intersects the datum

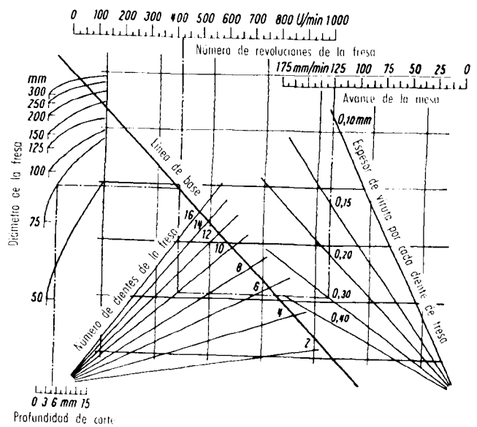


Fig. 9. Nomogram for determining cutting speeds, feed rates, etc. when milling Cr, CrNi and CrNiMn steels.

line, draw another vertical line. This vertical indicates a cutter speed of 420 r.p.m. where it meets the top scale, and it also intersects (produced downward) the line corresponding to the number of teeth in the cutter. A horizontal from this intersection also cuts the line giving the chip thickness per cutter tooth. A vertical drawn from this point indicates a value of 5 in./min. on the scale giving the table feed rate. When machining chrome steels, cutting speeds 10 to 15% lower than those for carbon steels of the same tensile strength and hardness should be used.

Feed rates (largely dependent on machine rigidity) are likewise given in Table 3. *If tool life is found to* be unduly short, the feed rate should be reduced. The minimum feed per cutter tooth should not go below 0.005 in. when roughing, or 0.003 in. when finishing (owing to work hardening effects). If feed is applied by hand, special attention must be given to this point. For the same reason, finishing is carried out with cutters having minimum "give".

Best results on steels of the category considered here are given by helical-tooth cutters with a lead angle of 30° which act with a draw cut and thereby lighten the load on the machine and minimize the tendency to chatter. Tooth pitch should be as large as possible to facilitate chip clearance.

Side milling cutters up to a width of $\frac{3}{4}$ in. give adequately good cutting with straight or staggered teeth. A satisfactory rake angle is 5 to 10° with 3 to 5° for the clearance angle. When the width of plain milling cutters is a whole-number multiple of the tooth pitch vibration is most likely to be avoided.

For shank type cutters and keyway cutters the same conditions apply as to plain milling cutters. The only difference is that the lead of the helices is somewhat *smaller and lies within* the range 20 to 30°. Plain milling cutters, shell end mills and shank type cutters are usually made of high speed steel. Experiments carried out by the author have shown the V 400 steel to be satisfactory for roughing purposes, and both the V 400 and V 450 grades for finishing.

Holes in austenitic steels are best milled from the solid, since pilot holes frequently exhibit a work-hardened rim.

With regard to cooling and lubrication, the same rules apply as for turning.

Table 3. Cutting Conditions for Milling with EV 4 or EV 4 Co High Speed Steel Cutters

Type of cutter	Material	Cutting speed ft./min.	Width of cut in.	Depth of cut in.	Feed in./min.
Plain milling cutter with 30° lead	Ferritic and heat-treatable Cr steels	72	4	5/32 to 3/16	3
	Austenitic and ferritic-austenitic steels	66	4	1/8	2
	Austenitic Mn steels	33 to 49	3 to 4	1/16 to 5/64	1 3/8 to 1 1/2
Face milling, radial, stepped and gear type cutters	Ferritic and heat-treatable Cr steels	66	3/8 to 9/16	15/32	2 to 2 1/4
	Austenitic and ferritic-austenitic steels	56	3/8 to 9/16	15/32	2
	Austenitic Mn steels	43 to 49	3/8	3/8	1 1/2
Shank type cutters	Ferritic and heat-treatable Cr steels	66	3/8 to 9/16	15/32	Manual feed
	Austenitic and ferritic-austenitic steels	56	3/8 to 9/16	15/32	Manual feed
	Austenitic Mn steels	43 to 49	3/8	3/8	Manual feed
Face milling cutters	Ferritic and heat-treatable Cr steels	82	4	7/32	2 1/2
	Austenitic and ferritic-austenitic steels	72	4	7/32	1 3/4
	Austenitic Mn steels	49	3 to 4	3/16	1

Table 4. Cutting Conditions when planing with EV 4 or EV 4 Co. High Speed Steel Tools

Material	Cutting speed ft./min.	Depth of cut in.	Feed in.	True rake angle degrees	Clearance angle degrees
Ferritic, heat-treatable and martensitic steels	56 to 75	7/32	0.08	10 to 15	3/16
Austenitic CrNi steels	33 to 56	7/32	0.05	10 to 15	3/16
Austenitic Mn steels*)	16 to 30	3/16	0.03—0.04	10 to 15	3/16

*) The very tough austenitic Mn steel should be planed with a cutting speed about 30% lower.

PLANING

The planing of Cr, CrNi and CrNiMn steels presents no difficulties; grooves and slots, however, are better milled. On its return stroke the planer tool should on no account slide over the work (work hardening). Rules for determining the shape, grinding angles and material for planer tools follow the same lines as those for lathe tools. Recommendations on cutting speeds, feed rates and tool angles are given in *Table 4*.

When large flat surfaces are being planed, particularly on rolled sections and castings, the likelihood of internal stresses being released must be reckoned with. After roughing, therefore, the work should be unclamped and (after annealing, where applicable) reclamped free of distortion. Only then should finish-planing be started.

(To be continued)

STEEL NOTES & NEWS

U. S. AID TO NEYVELI LIGNITE CORPORATION

U. S. Ambassador John Kenneth Galbraith announced at a press conference the signing of an agreement with the Government of India by which the United States would provide the services of eight American engineers to help increase coal production in this country.

By another agreement, also announced by the Ambassador, the United States would make available the services of four training advisers to Hindustan Steel Limited, to set up a comprehensive training programme within India for steel engineers.

Five of the American coal experts will work with the National Coal Development Corporation on its plans to develop new mines in the Ramgarh Coal Field, Bihar State, to obtain an annual production of 1.5 million tons of washed coal. The project includes the construction and operation of a coal washery.

Three other American experts will be associated with the Neyveli Lignite Corporation, Madras State. The corporation plans to extract 3.5 million tons of lignite yearly by 1964 and later to step up production to 6 million tons.

Assistance to the two projects involves an expenditure of nearly Rs. 20 lakhs of which $ 300,000 will be in dollars and the rest in rupees.

The agreement in respect of Hindustan Steel Limited, continues an existing training programme under which 295 Indian engineers have been trained in the United States under the auspices of the U. S. Technical Co-operation Mission. Three hundred other engineers have also been trained in America under a Ford Foundation programme. With the Government of India's decision to double the present capacity of steel plants from 3.3 million tons to 6.6 million tons, and to add another steel plant, it is now estimated that an additional 1,400 personnel will have to be trained. Hindustan Steel is setting up a training programme within the country. The United States Technical Co-operation Mission will make available a chief training adviser and also three training advisers. The latter will be assigned to the Rourkela steel plant. The project involves a total rupee and dollar expenditure of $ 176,000 (Rs. 8 lakhs).

* * *

ENAMELLING TOUGH GRADES OF STEEL : EFFECTIVE METHOD DEVELOPED

An effective method of enamelling tough grades of medium steel to prevent it from corrosion caused by acid, hydrogen sulphide and high temperatures has been developed by the Azerbaijanian scientist Magomedali Aliyev.

All previous attempts to this end failed because in the process of enamelling metal invariably releases gases when exposed to high temperatures. These gases prevented the formation of a durable and smooth coating and produced swellings on the surface.

Magomedali Aliyev proposed to subject the steel to a preliminary treatment with a special chemical solution which included nickel chlorite, sulphate and zinc chloride. The action of these chemical reagents on the metal's surface creates an impenetrable sub-layer which prevents swelling.

Experiments conducted at laboratories and industrial undertakings have shown that the enamel, whose composition has also been invented by Aliyev, gives a smooth and strong coating.

Installations with parts made of tough grades of medium steel, coated with enamel after Aliyev's method, are already operating at several oil refineries in Baku.

The scientist has also worked out a method of enamelling pipes with the use of automation and flow-line methods.

Enamelled pipes are needed for oil and gas pipelines.

They may be used as piles in the building of off-shore oil fields.

The enamel coating will guarantee life-long service to pipelines and piles, the durability of parts of oil machinery will increase four-five fold, Aliyev told a TASS correspondent.

Magomedali Aliyev is fifty years old. His speciality is metallurgy. He graduated from the Leningrad Polytechnical Institute in 1933. Academician Vladimir Kistyakovsky, a famous Soviet specialist in combating corrosion, was Aliyev's teacher. Aliyev has been working on the problem of enamelling strong grade steels for over ten years.

* * *

DURGAPUR STEELMEN GAIN EXPERIENCE IN U. K.

Now training at the Lackenby works of Dorman, Long & Co. Ltd., Middlesbrough, are two steelmen from the Durgapur steelworks in West Bengal. They are Mr. Kailash Choudhury and Mr. Dilip Kumar Roy Chowdhury.

Mr. Choudhury went to Britain last February for a tour of instruction under the Colombo Plan in blast and steel furnace and coke oven maintenance. He spent three months with Stewarts & Lloyds at Bellshill, Scotland, a week at the British Iron & Steel Federation's Staff College at Leamington Spa for a managerial course, and over two months with John Summers & Sons at Chester.

Mr. Roy Chowdhury has been gaining experience in the mechanical maintenance of coke ovens and a by-product plant. The plant is of the same type as is being installed at Durgapur.

He went to the United Kingdom last December, and has gained wide experience from a lecture course in industrial practice and labour relations, and from practical work at Middlesbrough and Swansea.

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IMPROVEMENTS IN BRITISH STEEL-MAKING -NEW FULLY AUTOMATED HOT STRIP MILL

A steelworks being built for Richard Thomas & Baldwins Ltd. at Newport, near the border between England and Wales, will be unique in that it will be the only plant in the world to use exclusively a method which refines iron by top-blowing pure oxygen into vessels containing the molten metal. Three such vessels, each of 100-ton capacity, are being installed.

The managing director of the firm, Mr. H. F. Spencer, made this claim when journalists visited the new works, where construction is going well. He said it was planned that the new plant would begin to produce next April.

The new hot strip mill would be one of the most powerful and speediest in the world and would be the first to be fully automated from slab heating to the final coiling of the product. "There will certainly be nothing like it elsewhere in Europe," Mr. Spencer added. At first, production would be 1,400,000 tons of steel ingots a year.

The most recent cost estimate given by the Government for the form of works that is being built was £ 119,000,000.

Richard Thomas & Baldwins are also expanding their other works. At Ebbw Vale, in Wales, a new electrolytic tinning line — one of the largest and fastest in the world — will begin producing in July, and at Redbourn, in the English Midlands, they are installing the first rotor process in Britain for pre-refining and steel-making.

* * *

PVC/STEEL LAMINATES AT LONDON EXHIBITION

One of the major British industrial triumphs of recent years — PVC/steel laminates — will be prominently featured by British Geon at Interplas, at Olympia, London.

Steel with its intrinsic toughness and durability can now be given a permanent protective coating of PVC, available in a wide range of colours and cuts out the need for painting or finishing. For the same reasons, products made with PVC coated sheet steel require little or no maintenance.

The PVC is also non-flammable, tough and long lasting. Thus PVC coated steel is ideal for a wide range of constructional and engineering purposes, as well as consumer durables such as occasional furniture.

Also on the stand will be exhibits illustrating the protection of metal by dip-coating in PVC paste. This technique cuts out costly coating by hand and at the same time gives a corrosion—and abrasion-resistant coating with outstanding adhesion to the metal.

* * *

COLD ROLLING MILL PRODUCES CUSTOM FINISH STEELS

Strip steel to suit any subsequent manufacturing process is now being produced by a Sheffield steel making group in a new £ 2 million cold rolling mill. The strip, in widths up to 18 ins., is available in a wide range of tempers — from mirror finish, "hard bright", for high quality plated articles, to "dead soft" for the more utilitarian articles.

A feature of the mill is its simplicity with push button and automatic controls operated by 50 men. Although the cold mill is only in the running-in stage, the output potential is 2,500 tons of strip a week.

Raw material for cold rolling is supplied from the adjoining hot strip mill, and after pickling, the strip is delivered to the cold mill in coil form via a tunnel which connects the pickling plant with the cold rolling department.

* * *

NEW STYLE SHARP FACED FOUNDRY PATTERN LETTERS

The successful introduction of Polythene pattern letters for the foundry trade by A. E. I. Plastics (Aldridge) Ltd. is now followed by a new range of sharp faced pattern letters for the small sizes (below $\frac{1}{2}$") which have the advantage of producing an improved impression in all types of castings. These letters are immediately available.

In common with the range of larger pattern letters, the new type are only half the price of equivalent metal characters yet maintain all the advantages.

Polythene characters are extremely resilient — direct hammer blows cause only momentary distortion and the most rigorous hand or machine ramming is withstood without burring. The irritating and often costly waste of time that occurs through damaged lettering on a moulding (only discovered when the moulding has been withdrawn) is thus eliminated.

In addition polythene has good "non-stick" properties and the useful characteristics associated with lead. It is pliable and can be easily moulded to any contour; it can be pinned or glued to a pattern without difficulty ('Evo-Stik' Impact Adhesive 528 is recommended for both wood and metal patterns); it is unaffected by water.

The characters are normally supplied in light grey to contrast with the conventional red, yellow and black used for pattern indentification.

Full descriptive and price leaflets are available on request to: Associated Electrical Industries (India) Private Ltd., Calcutta-1.

* * *

BRITISH AID FOR TUBE-MAKING FACTORY IN INDIA

The Commonwealth Development Finance Company is to provide a loan of £ 175,000 for the manufacture of non-ferrous tubes, pipes, rods, and sections in India, it is announced in London.

The loan will provide the foreign-exchange requirements for a factory being erected in Bombay by Kamani Tubes Private Ltd., in collaboration with Yorkshire Imperial Metals Ltd., an associate of Imperial Chemical Industries, which has arranged the procurement of plant in the United Kingdom, and will assist in the early period of running, under a 10-year technical-collaboration agreement.

A spokesman of Yorkshire Imperial Metals said in an interview in Leeds that his firm's part in the scheme was largely one of supplying know-how. They also hoped to provide assistance from time to time by means of short visits to India by technicians from Leeds.

* * *

RECORD HEAT MADE AT BHILAI

A new record in steel making was set up at the Bhilai Steel Works, on the 23rd May 1961, when steel was made in six hours and thirty-five minutes in the Open Hearth Furnace No. 6. This is indeed a big feat for a large size furnace of 250 ton capacity. The actual amount of the heat was 259 tons.

Another important feature of the performance was

that the heat was meant for making rails.

Engineers responsible for the record performance were Shri K. P. Pillay, Foreman, Shri B. C. Bandopadhyaya, Melter acting as Assistant Foreman, and Shri S. K. Shrivastava, Assistant Melter acting as Melter. They were warmly congratulated by Shri P. H. Kutar, Director of Production, Hindustan Steel Limited, Shri Suku Sen, General Manager, Bhilai Steel Project and others.

One of the main factors which enabled this feat to be performed was the liberal use of oxygen in the Open Hearth Furnace with Chrome-magnesite roof.

The tonnage Oxygen Plant of Bhilai was commissioned on the 5th of May, 1961 and Oxygen to Open Hearth Furnace is being supplied continuously since the 13th May 1961. The tonnage Plant at Bhilai is the biggest in India at present and has two air separation blocks, each with a capacity of 168 tons of oxygen a day.

The type of the plant at Bhilai is a complicated one and highly automatic. The plant is giving a trouble free target production from the day it started functioning.

* * *

MORE STEEL FROM CHEAPER PROCESS OF USING COAL

Britain's National Coal Board is helping the steel industry in a plan to introduce a more economical method of using coal in blast furnaces, Lord Robens, chairman of the Board, has disclosed.

The new process, never before tried in the United Kingdom could eventually replace at least 30 per cent of the coke used in furnaces, and would have the advantages both of being cheaper and of making possible an increased output of steel.

Lord Robens, speaking at the annual dinner of the Society of the Chemical Industry, said the new technique was to be tried out at the Stanton Ironworks, Nottingham, toward the end of this year. "This process will mean the steel industry will use not more coal but less, but we regard it as our public duty to get the best we possibly can from the indigenous material beneath our feet," he added.

Speaking of "dramatic changes" likely in the coal industry, he said that in a few years' time the industry would have reached the stage where coal could be mined without a single man being employed on the coalface. "It seems to me that this is a very sound development....When this comes about, science will have made not only a great economic contribution; it will have made a very great human and social contribution as well."

* * *

INAUGURATION OF THE ROURKELA STEEL WORKS BY PRIME MINISTER NEHRU

The Rourkela Steel Project in India, inaugurated on March 28, 1961, by Prime Minister Nehru, is, without exaggeration, one of the most modern steel works of the world. The AEG, a German electrical company, has cooperated with India for some decades. It has installed power stations with a total capacity of about 1 million kW. For energy generation in Rourkela it has supplied transformers for the power station and the power distribution of the iron foundry and the steelworks with more than 130 AEG-transformers with an overall capacity of about 600,000 kVA. Thus, it can be said that all generated or consumed electric energy in Rourkela is supplied by AEG-transformers.

Transformation of electrical energy is bound to losses which are accepted by the surrounding in the form of heat. The AEG has therefore equipped three power transformers of 32,000 kVA, twenty of 16,000 kVA, five of 8,000 kVA, and four of 4,500 kVA with water or oil-operated heat exchangers. Only the numerous smaller AEG-transformers of 1,600 and 400 kVA respectively are of conventional surface-cooled design.

Besides these transformers, the AEG supplied notably twindrive rolling mill motors for the blooming and slabbing mill and the plate-mill in Rourkela. These direct current motors belong to the largest ever built for Asia. The giant twin-drive motors have a maximum capacity of 30,800 HP. Its rotors have a weight of 73 tons each and the driving shaft end has a diameter of 600 mm, i e. more than 23½ inches. In spite of its huge mass the rotor is being reversed from forward to backward within 1.5 seconds only. In order to support the power system, the large motors are being powered by motor generator sets with flywheels. The flywheel is intended to overcome the load variations of the drive.

Editorial Notice

Articles in original are invited for publication in this Journal from Works Managers, Production Engineers, Foundrymen, Metallurgists, Plant Engineers, and Chemical Engineers on all subjects relating to Iron and Steel Industry.

Articles should be of a high quality, exhaustive and accompanied by illustrations, wherever possible. Only glossy photographs will be accepted. All contributions intended for publication in any particular issue should reach the Editor 30 days in advance. This Journal is issued twice in a year i. e. ***May*** and ***November***.

All copy should be brief and typed as far as possible. Used manuscripts and photographs will not be returned.

The Editor is not responsible for the views expressed in the articles. Contributions for publication should be addressed to the "Editor, Journal of Iron & Steel Engineering, 2258, Manojiappa Street, Post Box No. 57, Tanjore (South India)".

Furthermore all direct current auxiliary drive motors for the rolling mills are within the scope of the AEG supplies for Rourkela. They comprise, among others, 200 mill-type motors of heavy duty design and about 600 separate roller drive motors. Direct current is fed from the three-phase current system partly by means of mercury vapour rectifier controls, but mainly by means of AEG motor-generator sets. Beyond that, the electrical equipment of the tube welding plant, and the skip-hoist drives for the three blast-furnaces came from AEG. Thus, the total continuous rating capacity of all AEG motors in Rourkela amounts to more than 75,000 HP and the capacity of the direct current AEG generators is more than 40,000 kW.

All AEG supplies of electrical equipment, transformers, and apparatus have a weight of 5,000 tons which corresponds to the capacity of five fully loaded goods-trains.

The AEG is not only building in Rourkela. Giant AEG steam-turbines are being operated in Trombay and Madras, and electric generators of even larger size are running in Durgapur and Bokaro. AEG hydro-electric alternators are supplying electricity to large areas of the country, operating in the South from Periyar and in the East from Panchet Hill.

AEG transformers for India are now being manufactured in a plant erected by AEG together with the Government of Mysore in Bangalore. According to AEG design transformers, motors, and switchgear are manufactured there.

Hundreds of Indian engineers were and will be trained in AEG factories and research stations in Germany so that they may cooperate in the great Indian build-up, which has scheduled that by 1966 India's electric power generation is to be doubled.

* * *

UNFAILING PERFORMANCE

Reports about new technical developments spread around the world nearly every day. Machinery and equipment seem to be curiosities or look like models for museums after less than ten or twenty years of operation. So it is difficult to imagine that in the electro-technical field which is progressing very fast, there are still machines in operation, built more than 50 years ago. Nevertheless, it is possible, as a report of the Taiwan Power Company from Taipei proves.

Since August 1910, two 500-kVA AEG-generators are operating at the Ho-Li Power Station. During the last ten years they were in action for about 8,300 hours per year.

Three other AEG-generators of 800 kVA each are in operation since 1908 at the Hsiao-Tsu-Keng Power Station, owned by the same company.

All these generators are still operating excellently and to full satisfaction, as it is stressed in this report.

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NEW BRITISH BRIDGE HAS WORLD'S THIRD-LARGEST SPAN

A new high-level road bridge across the River Mersey in England, with the third-largest span of any bridge in the world, has just been opened. The main bridge has a span of 1,628 ft, as compared with the 1,650 ft of Australia's Sydney Harbour Bridge, and the 1,652 ft of New York state's Bayonne Bridge.

The £3,000,000 bridge, which links the two industrial towns of Runcorn and Widnes and the two counties of Cheshire and Lancashire, has taken just over five years to complete. It carries a 33 ft-wide carriageway and two footpaths, each six feet wide, across the Mersey and the busy Manchester Ship Canal. A graceful arch of steel network rises at a central point to 282 ft above the river.

The bridge has been built by Dorman, Long (Bridge & Engineering) Co. Ltd., which built the Sydney Harbour Bridge. Main subcontractor for civil-engineering work was Leonard Fairclough Ltd.

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SEALING FLUID FOR GREATER SAFETY IN MINES

A new safety aid for miners — a tough non-inflammable "skin" which can be sprayed on to underground stoppings to prevent air being fed to heatings or harmful fumes reaching other parts of a pit — was demonstrated recently at a mine in the north English midlands.

The scaling fluid — a synthetic rubber latex spray — is the result of three years' research and practical experiments by the West Midlands division of the U.K.'s National Coal Board and the Dunlop Chemical

Products Division. It has already been used successfully at various mines.

The idea of using some form of self-adhering outer coating as the final sealant, similar to the "cocooning" process for equipment preservation, originated in the Warwickshire area of the West Midlands division. The help of the Dunlop Chemical Products Division was sought in developing a suitable material. It had to be water-based to prevent toxic or fire hazards, yet capable of drying out in a reasonable time in humid conditions. It had to be fireproof and capable of adhering to any material for a long period, and the method of applying it had to be rapid and adaptable to coal face conditions. It also had to be tough.

A Chloroprene Latex spray was developed in the Dunlop Laboratories and for the past two years trials have been carried out successfully on heatings in several collieries in the West Midlands Division.

The sealant, contained in drums, can be applied by any mine with a splatter-spray of the type used for applying under-body seal to a car. The film applied has air retaining properties roughly equal to those of a natural rubber inner tube of a car.

* * *

GIANT ROLLING MILL OF 1,600,000 TONS CAPACITY

A rolling mill with an annual capacity of 1,600,000 tons of structural steel or almost twice as much as that of conventional mills of such a type, is being manufactured at the Izhorsk Works in Leningrad.

The designers achieved greater rolling speed by increasing the number of working stands up to 17 and arranging them consecutively in continuous groups. They also found it possible to make the stands movable which considerably reduces metal consumption.

The new mill is automated.

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NEW COMPANY TO MAKE METAL AND DIAMOND DIES IN BOMBAY

A new company, Gannon Norton Metal & Diamond Dies Ltd., Bombay—a joint venture of Gannon Dunkerley & Co. Ltd., Bombay, and Wire Drawing Dies (Manchester) Ltd.—has been formed to manufacture wire drawing dies of tungsten carbide and diamonds. Wire Drawing Dies is a subsidiary of the British firm Sir James Farmer Norton & Co. Ltd.

Gannon Norton has erected at Mahul, Bombay, a plant designed to manufacture 150 diamond dies and 400 to 450 tungsten carbide dies (for wire drawing purposes) a month. Experimental and trial production started some time ago, and the new company is now in a position to start commercial production on a small scale.

The plant is expected to manufacture dies to the value of about Rs. 7,20,000 a year, which—allowing for the essential import of certain parts—would help in the saving of foreign exchange to the extent of some Rs. 5,30,000 annually.

Wire Drawing Dies has many years of experience in the manufacture of tungsten carbide and diamond dies. It has provided the plant and machinery for the Bombay factory, and will also supply the technical know-how.

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A NEW METHOD OF CUTTING STEEL UP TO NEARLY 5 FT. THICK

Steel up to 55 ins. thick can now be cut in a fraction of the time previously taken by a new method adopted in the Huddersfield (Yorks) works of David Brown Industries.

The method was used as the first step in the manufacture of a very large fabricated wheel. The steel forging from which the wheel was made was circular in section, five feet in diameter and three feet thick. The cutting of the centre boss by propane/oxygen flame took only 40 minutes, in which time a central 31-inch, four-ton core had been removed. Molten metal from the one-inch wide cut was poured into a specially prepared kit.

The finished bore which the company said had an exceptionally smooth surface in a good condition for subsequent machining, tapered less than three-sixteenths of an inch over the full three feet depth.

In preparation for the job a $1\frac{1}{2}$-inch hole was drilled through the three-foot thick forging and the metal was preheated before actual cutting began.

* * *

UNDERGROUND "SKI LIFT" FOR MINERS

Miners at a colliery in Nottinghamshire in the English Midlands may soon be using a new form of mine transport—a "ski lift" which will carry them up steep slopes nearly a quarter of a mile below ground.

The "ski lift", already installed at one colliery (Clifton), is now undergoing extensive trials and has already carried scores of men on the 370-yard journey, negotiating gradients of 1 in 2, 1 in 5, and 1 in 15. Passengers are carried in special "chairs" attached to a wire rope by patent clips.

At present only five chairs are in use, but the system is designed to carry men at ten-yard intervals. The prototype runs at speeds of up to 4 m. p. h. carrying men far faster than they could walk along the same route. A signal wire is near to hand along the full length of the rope-way.

Engineers and officials who have ridden on the "ski lift" are enthusiastic about its possibilites, and a similar installation is now being tried out on a 500-yard stretch of easier roadway at another colliery.

From the safety aspect, the system has an advantage over train transport in that men are not concentrated in one place in the event of a mishap, and on the prototype ropeway passengers, feet are never more than 18 inches from the ground.

Indications are that the aerial ropeway system is also likely to prove cheaper to install and operate than other forms of underground transport.

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HOMES REAP MANY BENEFITS FROM STEEL

More steel is invading the home building field. In addition to the use of steel framing and siding, several new applications have been recently put on the market by steel companies.

One is a system of a faster dry wall installation which is said to cut cost and construction time. Strips of cold formed strip steel at all corner and ceiling joints are formed to receive dry wall sheets and hold them secure.

Another development is a nailable steel stud which takes wallboard, metal lath and gypsum lath.

Steel gang nailing is a process of nailing without actually handling individual nails. The working part of a gang nail is a steel plated formed so that part of its surface is die stamped into dozens of nail-like fingers which stick out from the plate ready to be pushed into the wood. When a builder wants to fasten, for example, two parts of a truss, approximately half of the gang nail plate is laid over each piece. Then the plate is driven home by means of an air press. In making a truss, gang nails are driven into place on both sides at the same time.

The banging of bicycles, baby carriages and bundles is resisted by the textured stainless steel sheets in the entrance area of a multiple dwelling unit in New York City. The beautifully patterned sheets are designed for long, maintenance-free service in the lower portions of the entrance walls and doors.

* * *

NEW DUTY PERFORMED BY WIRE FABRIC

Double duty as concrete reinforcement and a radiant heating installation offers wire fabric a new area of usefulness, reports of winter testing in a Midwest warehouse indicate.

The steel wire fabric reinforcement—modified and encased in a layer of concrete flooring—is made to act as the electric heating element of a gigantic toaster. The entire installation warms a floor area of about 6500 square feet and an enclosure of 105,000 cubic feet. Winter temperatures in the vicinity of the warehouse have been known to reach 40 degrees below zero, Fahrenheit, recent engineering reports say.

Although called "fabric," the product is a modification of the one usually called by that name. To make it serve its conventional reinforcing function and, at the same time, conduct electricity, it was necessary to insulate the steel wires at the points where they cross and would normally touch each other. After the strips of insulation were inserted, the wires were firmly tied together, rather than welded or woven.

The use of a well known steel industry product, rather than specially designed materials, is reported to be of interest to builders and designers for economic reasons. Experiments with steel reinforcing fabric as a heating element are reported to have started about 1957.

* * *

LARGEST ELECTRIC ARC MELTING FURNACE IN U. K.

The largest electric arc melting furnace in the United Kingdom has been commissioned at the Sheffield works of the English Steel Corporation, for the production of special alloy steels. The furnace has a shell diameter of 21 ft. and a rating of 29 MVA. It is capable of melting a 90-ton charge in less than three hours.

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ONE OPENCAST MINE TO PRODUCE 33 MILLION TONS OF ORE A YEAR

A huge opencast mine has been developed at the extremely rich Kachkanar iron ore deposit in the Central Urals. Upon commissioning it will produce 33 million tons of ore a year.

All work in the mine will be fully mechanized.

Geologists have estimated that the Kachkanar deposit contains enough ore to last for no less than 130 years. Despite the low iron content in the ore (16—18 per cent on average), the Kachkanar ore concentrate and agglomerate will be the cheapest in the country. This will be achieved by the use of the cheap opencast method of mining and a high degree of mechanization during enrichment.

The Kachkanar ore dressing combine, which is being built on the basis of this deposit, will start deliveries to industry next year itself. By the end of the Seven-Year Plan (1965), when it will be fully in operation, it will become the principal raw material base for the rapidly developing metallurgical industry of the Urals.

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DLF LOANS TO INDIA TOTAL Rs. 243.8 CRORES

During the last three years the United States Government allotted to India loans from the Development Loan Fund (DLF) totalling 513.4 million dollars or 243.8 crores rupees, according to a recently released fact sheet.

The DLF loans are given for development projects in the country under the categories of transportation, capital equipment, metal imports, power, financial institutions, and fertilizer.

Heading the list is $ 143.1 million for power projects in India, which includes the provision of $ 29.9 million to help finance the Sharavathi hydro-electric plant in Mysore State.

The second largest category of loans is for transportation, ($ 134.3 million) the bulk of which is for modernisation and expansion of the Indian railway system. For metal imports, mostly steel, a total of $ 105 million was allocated by the DLF during this period.

* * *

ENGINEERING FEATS AT NEW U. K. RESEARCH LABORATORY

Tearing apart 2-inch-thick steel plates of bending 12-inch-wide steel girders are some of the unusual engineering feats carried out at research laboratories opened recently at Cambridge, England. The laboratories, owned by the British Welding Research Association, enable scientists to work in ideal conditions with the most modern equipment available.

Hundreds of British engineering companies take their problems to the laboratories. Gruelling trials are carried out on experimental welds to test the reliability of the process employed. The machines that tear apart the 2-inch-thick steel plates under a tension of 2000 tons enable the scientists to examine numerous metallurgical processes and find the best welding technique for the job.

To enable tests to be made on even thicker steel plates, a machine will shortly be made that rips apart plates under a tension of 4,000 tons.

* * *

U. K. STEEL INDUSTRY PLANS FOR MID-SIXTIES—PRODUCTIVE CAPACITY LIKELY TO REACH 34,000,000 TONS

The British steel industry is engaged upon a programme of unprecedented technical innovation and expansion. Its plans for meeting the demand of the mid-sixties are given in a booklet just issued by the British Iron & Steel Federation in London.

In 15 years, production roughly doubled to reach 24,300,000 ingot tons in 1960. Productive capacity by the mid-sixties will be about 34,000,000 tons Capital expenditure in 1960 was at the record annua

level of £ 145,000,000, and may be about £ 200,000,000 this year.

The best estimate the industry has been able to make of future prospects is that demand in the mid-sixties may be about 30,000,000 ingot tons—25,000,000 ingot tons for the home market and 5,000,000 tons for direct export. Home consumption last year was 20,300,000 ingot tons, and 4,200,000 tons was exported.

* * *

" URAL-2 " CONTROLS BLAST FURNACE

The special designing bureau of the " Uralmontazhavtomatica " Trust (Russian Federation) has completed the design assignment for all-round automation of a blast furnace at the Nizhni-Tagil Iron and Steel Works. All Blast-furnace technological progresses—feed of materials, charging of burden, maintenance of heat schedule, as well as outlet of metal—will be performed without the interference of man. All these operations will be controlled by the " Ural-2 " electronic computer.

* * *

MILD STEEL WIRE FOR MANUFACTURE OF WOOD SCREWS

With a view to assisting the manufacturers to supply mild steel wire of suitable quality for the manufacture of wood screws, the Indian Standards Institution has just published Indian Standards Specification for Mild Steel Wire for Manufacture of Wood Screws (IS : 1812-1961).

This standard covers the requirements for cold drawn mild steel wire up to 12.5 mm. diameter suitable for the manufacture of wood screws by the cold heading process.

* * *

COAL CUTTER-LOADER OF HIGH-SPEED DESIGNED IN UKRAINE

An experimental specimen of a narrow-range coal cutter—loader is now being manufactured at the mining machinery works at Gorlovka (Donbas, Ukraine). It has a high speed of moving along the coal face (up to 4.5 metres a second).

New machines designed in the USSR are 50 per cent faster than conventional narrow-range coal cutter-loaders manufactured by the British " Underton " firm. Their capacity is up to four tons of coal in a minute.

The cutter—loader has been designed in two versions : one removes a metre broad strip of coal, the other half a metre. They operate from the frame-work of a conveyor which is moved simultaneously throughout the entire length of the coal face by means of a hydraulic system. Instead of a loader coal is carried to the conveyor by a ploughshare. The new system of loading and the high speed of the machine make for sorting of coal and increase the number of large lumps.

* * *

BLAST FURNACE REFRACTORIES FOR STEEL PLANTS

Refractories required by steel plants constitute the bulk of production of the refractory industry, the quality of refractory to be used in different units of the steel industry varies depending upon the performance requirements. The requirements of refractories for steel plants are greatly increasing with the establishment of three new steel plants and with possible further expansion of steel production during the Third-Five-Year-Plan period.

In order to meet efficiently the requirements of the industry, the Indian Standards Institution is formulating a number of Indian Standards for refractories for use in steel industry. The first Indian Standard published in the series is the Indian Standard Specification for Blast Furnace Refractories for Steel Plants (IS : 1529-1961).

This standard covers the requirements for blast furnace refractories for steel plants, and gives necessary details with respect to chemical composition, physical test requirements, etc.

* * *

STEEL INDUSTRY'S CONTRIBUTION TO BRITISH BALANCE OF TRADE

Net export earnings of the British steel industry this year are expected to be greater than in 1959, when they reached £ 85,000,000, and substantially higher than the £ 14,000,000 earned in 1960.

These figures from part of the outline of the role played by steel in Britain's balance of payments published in the latest issue of *Steel Review*, the quarterly journal of the British Iron & Steel Federation.

Direct exports of steel, says the review, have so far been higher this year than the average for 1960.

Discussing the contribution the steel industry makes to the British balance of trade, the review points out that direct exports of steel alone more than pay for all the imports of steelmaking materials and steel. If account is taken of the steel content of indirect steel exports and imports, steel normally contributes a surplus of over £ 200,000,000 a year to Britain's balance of trade. Even this sum, the review adds, considerably underestimates steel's contribution to Britain's balance of payments, since much of the freight and insurance element in imports is paid for in sterling.

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FAVOURABLE TREND

The relative trend in direct steel imports and exports has been favourable during the post-war period, the review continues. Net exports of steel averaged 1,150,000 product tons a year in 1948-55 and 1,800,000 tons in 1959-60.

In the current year, net exports have been running at the record annual rate of 2,700,000 tons. The surplus on direct steel trade should, therefore, improve considerably this year, the review concludes.

* * *

DURGAPUR STEELWORKS MODELS FOR INDUSTRIES FAIR

A scale model of part of the Durgapur steelworks has just been completed in the north-east of England. Measuring 32 ft. by 13 ft. 6 in. it will be one of the main exhibits at the Indian Industries Fair which opens in New Delhi next November.

The model represents the four main areas of the steel plant for which the Davy & United Engineering Co. Ltd., of Sheffield, England, have been responsible. It has been made by the model-making department of the Power-Gas Corp. Ltd., another member of the Davy-Ashmore group.

The model, which took over three months to make, is scaled to 1/16 inch to a foot. Already its workmanship has won high praise from the Davy-United engineers who were responsible for building the full-scale plant.

At the Fair, the model will be displayed on the stand of Hindustan Steel Ltd. The four sections illustrated are the rolling-mill plant, including a plant for making railway sleepers; the wheel and axle plant; the iron and steel foundry; and the central engineering maintenance department, which is a complete engineering works within the steelworks, responsible for executing the regular maintenance work essential to maintain full operational efficiency.

Also on show on the Hindustan Steel stand will be a working model—made by H. Clarkson & Son, of York, England—of a section of the Davy-United rolling-mills at Durgapur.

The two models will complement a complete model of the entire steelworks which will be displayed on a separate stand at the Fair which is being taken by the Indian Steelworks Construction Co. (ISCON).

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ROLL-FORMING MACHINES FOR METAL PRODUCTS

Giant roll-forming machines, used in the manufacture of motor car parts, building supplies and tubes, and made by All Purpose Engineers Pty. Ltd., of Sydney, are new products of Australian industry recently displayed at the Company's plant.

Although the machines are used in the United States and Great Britain, the limited size of the Australian market has made them a rarity locally. They are cheaper than the conventional metal press and the Company envisages wide export markets for them.

They carry out six important operations—uncoiling of metal strip, levelling, roll-forming the shape required, cutting to required length, ejecting on to a table, and automatic stacking.

They will roll any required length of material, such as aluminium and brass, and only two men are needed to operate them. Production of each machine averages 30,000 feet a day. This compares with about 1,000 feet a day from the conventional machine.

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AEI CONTRACT FOR MINE WINDER

The West Midlands Division of the National Coal Board has placed an order with Associated Electrical Industries Ltd., Heavy Plant Division, for an 1840-h.p. single drum a.c. winder for Victoria Colliery, near Stock-on Trent.

Dynamic braking will be employed and winder control will be obtained by the use of rotor contractor-gear and metallic resistances instead of the conventional liquid controller. Two of the main advantages of the control system to be used are, firstly, that since no mechanical linkages are involved, the control equipment can conveniently be installed wherever space is available, and secondly, that very little maintenance is required.

Another interesting feature of this installation is that the winder motor will be wound for a 2,500-volt supply but can be re-wound for 3,300 volts when the supply is altered. The switchgear and reversing contractors are suitable for both voltages.

The winder motor and metallic motor resistance will be made at AEI's Rugby Works and the mechanical parts of the winder are to be manufactured by Fullerton, Hodgart & Barclay Ltd.

A similar winder was supplied by AEI in 1955 to the N.C.B. for Barony Colliery in Scotland.

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NEW BIRLEC FURNACE FOR STAINLESS STEEL STRIP

True bright annealing—i. e. annealing without any detriment to a bright, cold-rolled or drawn surface — has always been difficult for producers of stainless steels and other chromium — containing alloys. Acceptable results have been obtainable in certain cases—e. g. wire and narrow, thin strip — by heating in a muffle purged with a very pure hydrogen or nitrogen-hydrogen mixtures. This practice has the severe limitation of recurrent muffle repair or replacement costs and satisfactory muffles have not been available for any but narrow furnaces.

Several successful Birlec furnaces have been installed over the past 20 years within these limitations for bright annealing stainless strip and tube. Meanwhile development of improved designs has been actively pursued, taking into account overseas practices as well as the work of the Research Department of AEI-Birlec Limited. This has now borne fruit in the form of a new furnace, needing no muffle, a prototype of which has been in operation for some months with highly satisfactory results.

Based on the use of a special type of refractory for the lining, this new furnace breaks through the limitations of the muffle type in several respects. The electric heating elements radiate directly onto the work without the intervening obstacle of the muffle wall, and therefore permit higher heat inputs and higher work temperatures than could be safely used in the old design. Means for conveying the material through the furnace are no longer limited to those which could be contained within a muffle. Furnace chamber size and shape is similarly freed from restrictions imposed by muffle design.

Furnaces of the new Birlec design therefore can be built in a wide variety of sizes and shapes to suit a range of products and processes. In all cases they are based on the continuous passage of the material since batch operation is impracticable by reason of the time required to establish in the work chamber a protective gas atmosphere of sufficient purity to give truly non-oxidising conditions. In any case, the producers of sheet, strip, tube, etc., generally base their work on continuous operations, this being dictated by the metallurgical requirements of many of the materials concerned.

In its prototype form, the furnace is designed for the continuous bright annealing of strip which passes horizontally through the consecutive heating and cooling chambers. Special gas seals at the ends reduce the loss of atmosphere gas (cracked ammonia or hydrogen) to a minimum and rollers support the moving strip. A vertical version of the furnace is available for dealing with highly finished strip which must not come into contact with rollers or other supports while heated but the horizontal type is adaptable to handle tubes or other forms of material on a moving belt or roller conveyor.

This new Birlec furnace offers important advantages to producers of stainless alloys in the elimination of pickling and mechanical cleaning plant. Bright annealed material can have the mirror finish which is essential to many of the common uses in which their decorative aspect is important. The possibility of achieving this result on material of almost any type and section may contribute significantly to the wider use of stainless materials in all fields.

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ENGINEERING NOTES & NEWS

BRISK NEW BUSINESS FOR BRITISH ENGINEERING FIRMS

New business for British engineering firms was very brisk, according to a statement issued by the Board of Trade in London.

Orders, deliveries, production, and exports in the engineering industries were all buoyant. Output in these industries continued to rise in March. It is provisionally estimated as 2 per cent. more than a year ago. In the first quarter of this year it was 3 per cent. higher than a year earlier.

Exports of products in the engineering and electrical industries were rising strongly in the fourth quarter of 1960 and in the early months of this year after a lull in the preceding quarters. In the fourth quarter of last year, the volume of exports was 6 per cent. more than a year earlier; in the first quarter of this year, it was 15 per cent more.

It is pointed out in London that although these figures relate to March, they are the most up-to-date on the engineering and electrical industries, inevitably delayed by the need to get returns from a wide range of industries. They bring out, in particular, the strong rise in exports by the industries concerned. Even if this is, to some extent, exaggerated by shipments delayed by the dock strike, there is clearly a genuine rising trend in engineering and electrical exports.

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QUEEN OPENS COLLEGE OF ADVANCED TECHNOLOGY

During a two-day visit to north-west England, the Queen officially opened the £ 1,250,000 Royal College of Advanced Technology at Salford, near Manchester, on May 24.

The Duke of Edinburgh accompanied the Queen, and after the ceremony they were escorted on separate tours of the eight-storey modern college building, which covers a two-acre site. The college, with over 4,000 students, many of whom are from oversea countries, has a teaching staff of 200. It will be further extended within the next 10 years to include a nuclear science block and three halls of residence which will have a total of about 500 bedrooms.

The college is recognized for the award of diplomas in technology in aeronautical engineering, civil engineering, electrical engineering, mathematics, and mechanical engineering Research work is done in all departments.

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INDIAN GRADUATE TRAINEE ATTENDS LONDON DINNER

Mr. K. Neelakantan, a graduate apprentice with the English Electric Co. at their Bradford (Yorkshire) works, attended the Industrial Welfare Society's national apprentices dinner in London (May 30) as part of the Commonwealth Technical Training Week.

Mr. Neelakantan is one of three Indians who were awarded English Electric oversea fellowships for 1961 to undergo graduate training in engineering at the company's works in the United Kingdom.

This is the fourth year that the English Electric fellowship scheme has been operating for Indian graduates. The fellowships cover two year's post-graduate training in the United Kingdom.

Mr. Neelakantan, who comes from Madras, is a specialist in foundry engineering. He began his two-year training in February this year.

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ELECTRICAL POWER MEASUREMENT STUDIED BY INDIAN IN U. K.

The great expansion of the electrical supply industry has led to an increased need for more accurate methods of measuring electrical power. Research now being undertaken by Mr. B. B. Saha at the Manchester College of Science & Technology could help the industry by providing greater accuracy in the measurement of power and energy.

Under Professor Eric Bradshaw and Mr. J. Rawcliffe, who is in charge of the electrical measurement laboratory. Mr. Saha is working on the development of a new wattmeter which would be used for testing existing wattmeters.

Mr. Saha is on a three-year course under the auspices of the Colombo Plan, and hopes to take his Ph. D. Before he went to Manchester last autumn, he was an assistant professor of electrical engineering at the Bihar Institute of Technology, Sindri.

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INDIAN FIRM TO MAKE WELDED ROLLING-STOCK

Under an agreement recently signed between the Metropolitan-Cammell Carriage & Wagon Co., of Birmingham, England, and Southern Structural, of Madras, the Indian firm will soon be producing welded rolling-stock instead of riveted carriages.

The agreement was signed in Birmingham by Mr. N. Ranganadhan, managing director of the Indian company, and, for the British firm, Mr. D. J. C. Robertson, managing director, and Mr. W. Scott, financial director of Metro-Cammell.

"This agreement will mean an extension of the Madras plant," said a spokesman for Metro-Cammell.

The British firm, under the agreement, is to acquire a substantial share-holding in Southern Structurals.

One effect of the agreement will be to make it possible for the Indian firm "to utilize the knowledge and experience of Metro-Cammell in the design and manufacture of railway rolling-stock," the spokesman said.

Metro-Cammell, the largest rolling-stock manufacturers in Britain, have been producing rolling-stock in Birmingham since 1845, and have supplied at one time or another nearly every country in the world. They have four plants in Birmingham—one making bus bodies and three railway rolling-stock. In all, the firm employs about 4,500 people. It is an associated company of two famous British industrial firms—Vickers and Cammell Laird. Each holds 50 per cent. of the shares of Metro-Cammell.

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£405,000 FURNACE ORDER FROM CZECHOSLOVAKIA

Furnace orders worth £405,000 have beeen received from Czechoslovakia by AEI-Birlec Limited.

The contract calls for the supply of Continuous Tray Pusher Furnaces, Gas Carburising Furnaces and Sealed Quench Furnaces. Also included in the order are Birlec Nitrogen Generators. These furnace installations are all for the motor vehicle and tractor industry.

The continuous tray pusher furnace installations will each comprise two linked gas-fired furnaces—one high and one low temperature—which will be served by a flow of atmosphere from two nitrogen generators. When installed, this plant will be used in the production of Annealed pearlitic blackheart malleable castings.

A continuous tray pusher gas carburising installation will comprise two gas-fired, single track, continuous furnaces one of which will incorporate a hot and the other a cool oil quench. This installation will also have atmosphere provided by Birlec generators. It is for the production of gears for the motor vehicle industry. A further gas carburising furnace and two Sealed Quench furnaces will be utilised in the production of small components.

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NEW DE-HUMIDIFIER WILL RAISE INDUSTRIAL EFFICIENCY

A British firm (O. N. Beck & Co.) has developed a compact de-humidifier for use in industry generally which it believes will be of tremendous value in tropical countries.

The Dryzair—as the unit is known—is designed around a ½ h.P. refrigeration unit and uses a chemical known as Refrigerant 12. In shipbuilding, the makers claim, the unit keeps the air dry and prevents corrosion. Perishable goods, whether stored in warehouses or in ships' holds, are kept fresh. In oil tankers the correct temperature can be maintained.

There are many more uses: the makers suggest the rapid drying of cement, paint, concrete and plaster, the seasoning of timber, photographic processing, and so on. Its uses in humid climates will be endless.

Very little attention is needed for the Dryzair, which, although robustly constructed, is light enough to be carried by two men.

The unit operates on the principle that moisture-laden air is drawn over an evaporator and cooled to a temperature below its new point. This condenses the moisture, which is allowed to run into a container. The air is then passed over the condenser and the dry bulb temperature raised. The air is further heated by mean of a thermostatically controlled electric heater, and as a result dry warm air is dispersed and re-circulated.

In operation, the Dryzair will extract approximately five gallons of water per 24 hours under ideal working conditions and, using the 3-kilowatt heat element fitted to the outlet grill, it will also automatically warm the air should the temperature fall below 55°F. The thermostat is locked to cut in should the temperature fall below that figure, but it can be adjusted up to its top range of 70°F.

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BIRLEC DRYER USED IN WIND TUNNEL TEST

Facilities for the wind tunnel testing of models of future aircraft and guided missiles at up to six times the speed of sound are used by British Aircraft Corporation. Built at Warton Aerodrome, Lancashire, the two tunnels have cost more than £700,000 and are the most modern anywhere in Europe.

The tunnels were designed by engineers of English Electric Aviation, which is one of the four subsidiaries of British Aviation Corporation.

It is of vital importance that the air used in these tunnels be dry to ensure safety and maximum efficiency. The dryer selected for the installation was manufactured by AEI-Birlec Ltd.

The dryer, type SA 1100, is a single cylinder unit, which contains 1100 lbs. of activated alumina as the absorption material. Passing the air through the cylinder at the rate of 2,500 s.c.f.m. and at a pressure of 600 p.s.i. results in moisture free air becoming available for use in the wind tunnels.

After a period of 8½ hours, the saturated alumina is automatically reactivated by an electric heater. This installation is one of the many that AEI-Birlec Ltd., have manufactured for high pressure applications, including control for guided weapons.

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TYRE MANUFACTURING MACHINERY FOR RUSSIA

One of the largest tyre factories in Europe, which has absorbed approximately £14,000,000 (Rs. 18.7 crores) worth of engineering service plant and rubber and tyre manufacturing machinery supplied from Great Britain, will shortly be going into production at Dneipropetrovsk, near the Dneiper River in the Ukraine. The plant has been supplied by a consortium of six British companies operating under the name of Rustyfa Ltd.

The factory, built on a 79-acre site, has been designed to produce 2,000,000 tyres per year ranging in size from the small car tyre to the tractor and giant earthmover types.

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HYDRAULIC CLAMP FOR PLANNING AND MILLING MACHINES

A hydraulic device for use on planning machines or heavy duty milling machines has been introduced by a U. K. firm. It is for spiking down flat plates when other means of clamping are impracticable.

Called a planner hydrajaw, it consists of a solid mild steel body having slot located at either end which are used for clamping the device to the bed of the planning machine.

The slots are of sufficient length to give 3 ins. of adjustment to the edge of the workpiece. Having clamped the hydrajaw to the bed of the planning machine the only operation necessary is the turning of the actuating handles. This exerts a pressure on protruding plungers, transferring energy through the medium of hydraulic oil to the three spiking down plungers.

Since the invention a self adjusting hydraulic vice-jaw three years ago this firm has made a whole range of multi-point compensated, closed-circuit, hydraulic clamping equipment for machine tools. The range includes indexing fixtures, centralising mandrels, special mandrels for large diameter rolled tubes and for general purpose turning and facing.

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ALL ELECTRIC LOCOMOTIVES FOR INTERCITY TRAFFIC

Delegates to the Tenth Pan American Railway

Congress have been told that electric locomotives may in future take over a bigger share of high-speed intercity rail service.

The prediction came from D. R. MacLeod of the General Electric (U. S. A.) Locomotive & Car Equipment Department and was contained in a technical paper delivered to the Congress by the engineer.

MacLeod's paper traced the progress of electrification of railroads in the United States, something that his company, General Electric, has been intimately associated with for 65 years.

MacLeod's prediction about the possible future expansion of electrification was based on the belief that higher and higher speed intercity traffic will be required in the future. Diesel-electric locomotives that can supply the horsepower to attain the required speeds may be prohibitively heavy, the engineer said.

Trains of over a mile in length pulled by several diesel-electric locomotive units and moving at 60 miles an hour are not uncommon in the U. S. In future, even more power may be necessary to meet speed and load requirements. Electric locomotives can supply this higher horsepower without the same kind of weight increases that would be necessary in more powerful diesel-electric locomotive designs.

Recent design favours the rectifier-type electric locomotive for alternating current electrification. This type of locomotive uses mercury arc rectifiers to convert the alternating current supplied from the trolley wire to direct current for the traction motors. Looking to the future, the rectifier-type locomotive using silicon rectifiers is a distinct possibility.

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INDUSTRY CHANGING SICILIAN LANDSCAPE

Southern Sicily, traditionally one of the least developed parts of Italy, is undergoing a major change. Areas formerly covered with lava from extinct and semi-active volcanos, sparse vegetation and groves of fruit trees are now being built up with mile after mile of industrial plants.

This economic development, which began in 1950, is not only changing the face of the land, but it is bringing prosperity as living standards rise.

An example of the kind of industrial complex growing up here is the Societa Industriale Catanese petrochemical plant. This is one of the largest petrochemical plants in all of Italy and covers more than a square mile. It gives employment to over 2,000 persons.

Equipment for this new plant has come from several countries. For instance, Worthington Corporation (U.S.A.) supplied three 1,000 horsepower compressors. Worthington's associated company in Milan, Italy, supplied a number of pumps and smaller compressors. The petrochemical industry is one of the fastest growing "new" industries in the world.

* * *

RESEARCH AT THE NATIONAL ENGINEERING LABORATORY

Research at the National Engineering Laboratory is helping the British engineering industries to keep ahead. During the last two years the Laboratory has produced valuable results of immediate industrial application in three important fields—hydrostatic power transmission; automatic error correction in machine tools using moire fringe techniques; and cold extrusion of steel.

Results of work on all three of these projects were among the items shown by the laboratory at the Engineering, Marine, Welding and Nuclear Energy Exhibition, held in London from April 20 to May 4.

The NEL moire fringe error-correcting system has been fitted to the table drive of a gear hobbing machine, in collaboration with David Brown Industries Limited. Gears cut by this machine have only one-quarter of the tooth-spacing errors normally encountered and the accuracy of the gears produced is unaffected by gradual wear in the driving mechanism.

The advantages of using hydrostatic power transmission for machine-tool drives were demonstrated with a vertical boring mill. The main advantages of hydrostatic transmission, as applied to machine tools, are constant cutting rate, no gear changing, better surface finish, and the elimination of expensive electric servomechanisms.

The Laboratory has also obtained data on the cold extrusion of steel to help in the design of tooling and in the selection of the best extrusion conditions. The Laboratory has first-class facilities which it can make available for sponsored research and has already undertaken a good deal of work at the request of industry.

* * *

PART-TIME ENGINEERING COURSE FOR TEEN-AGE BOYS

A new step toward overcoming Britain's shortage of skilled technicians has been announced by the Ministry of Education.

It is a part-time engineering course for boys of 15 and 16 who show promise of being able to fill skilled jobs in industry. The course will be introduced in technical colleges throughout the country in the autumn, and in it the boys will need to study technical subjects for about 240 hours a year.

The idea is that employers should give the boys time off from work to attend classes. The course will provide an introduction to both mechanical and electrical engineering.

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U. K. EXPERT TO ADVISE INDIA ON FUEL ECONOMY

Mr. C. A. J. Plummer, of Britain's National Industrial Fuel Efficiency Service (NIFES), has arrived in Delhi to carry out a six-month programme of investigation into fuel consumption at selected Indian factories.

The tour, arranged under the Colombo Plan by the Common-wealth Relations Office, has begun with a few days' discussion at the Ministry of Commerce & Industry in New Delhi. Mr. Plummer will move on to Calcutta for two months' work with the Indian coal control organization, where he will be joined later in the month by another NIFES engineer, Mr. B. R. Addicott.

The visit is a sequel to an application made last year by the Government of India for an expert in fuel economy to advise industries on problems of fuel and steam conservation. With India's growing industrial expansion, coal economy is specially necessary, despite a programme for stepping up coal output.

In Britain it has been established that fuel savings of from 15 to 20 per cent. can be obtained simply by improving operational efficiency and by more attention to plant maintenance.

In 1938, Mr. Plummer joined Carbo-Ice Industries Ltd., a company engaged in the recovery of carbon-dioxide from flue gas. From 1938 until 1942 he was a chemist with the company, and was then, until 1948, works manager. After six years with the Ministry of Fuel & Power, Mr. Plummer joined NIFES, and has recently been in charge of its Birmingham office and Midland area.

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AEI CABLE ACROSS THE THAMES

Associated Electrical Industries Ltd. has received a £ 100,000 contract from the South Eastern Electricity Board to reinforce the electricity distribution system between sub-stations at West Weybridge in Surrey and Laleham in middlesex.

The project will involve laying four miles of 33 kilovolt oil-filled cable and associated pilot cables. They will be taken across the River Thames in buried pipes. Two canal crossings are also involved.

The work will be carried out by AEI Construction (Cables and Lines) Division. The cable will be of AEI manufacture, from AEI Cables Division's Gravesend factory.

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MAGNETIC CRACK DETECTION

A Magnetic Crack Detector, which will be used to detect surface cracks and flaws in a main component of gas turbine aero engines has been ordered by a German company from the U. K. firm, Associated Electrical Industries Ltd.

It works on the basis that in magnetic materials a magnetic field will be distorted in the neighbourhood of a fault.

The unit is designed for testing, on a production basis, gas turbine aero engine discs up to 42 inches diameter with or without blading, and shafts of up to 6 ins. diameter and 84 ins. long. A combination of AC and DC methods of magnetisation and multiple adjustable pole pieces enables all types of surface cracks to be revealed, whatever their direction.

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AUTOMATIC SPREADING UNIT

An automatic spreading unit which can be built on to a tandem diesel road roller to lay tarred chippings has been developed by a U. K. firm. The new unit eliminates haphazard hand spreading and the mechanical discharge results in more uniform, skid-resistant surfaces.

The spreading unit consists of a two-ton capacity hopper, an hydraulic motor-driven eight-blade rotor to control discharge, an agitator to prevent solidification, and a pump to operate the hydraulic motor. The rate of discharge is adjustable between 80 and 150 sq. yds. a ton by means of a variable flow valve.

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AEI AGREEMENT WITH FACIT ELECTRONICS

Associated Electrical Industries Ltd., has made an agreement with Facit Electronics AB of Sweden as a result of which the Electronic Apparatus Division of AEI has been appointed sole Agents in U. K. and British Commonwealth (except Canada) for Facit Carousel memory, high speed tape punch and high speed reader.

Facit's Carousel is a completely new type of random access magnetic tape memory and differs radically from all other random access external memory machines previously introduced. When full it contains more than three million checked alpha numerical characters or more than five million checked decimal digits. The average access time for a block of information is about two seconds.

Facit high speed tape punch is transistorised and designed to accept 5-6-7-8 channel paper tapes. The moving parts have been kept to a minimum, a feature which ensures more reliable operation and easier servicing.

Facit high speed tape reader is fully transistorised and will read tapes of 5-6-7-8 channels by means of a dielectric reading unit which ensures there is no ageing of components and that the unit is not affected by dust or light.

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NEW AIR-CONDITIONING AND REFRIGERATION EQUIPMENT

The Blue Star Engineering group of Companies recently announced the introduction in India of several new products in Worthington Corporation's "Full Choice" line of air-conditioning and refrigeration equipment.

The new products were presented to the international market at a recent distributor conference in Hong Kong. Mr. Mohan T. Advani, Chairman of the Blue Star Engineering group, attended the week-long meeting as representative from India, which was one of 22 nations participating in the conference.

Included among the new products are a packaged multizoned unit, a "Roofair" air-conditioner for roof-mounted heating or cooling, and a new line of centrifugal fans.

The new packaged multizone unit combines the ultimate in packaged multizone design features with unmatched engineered application flexibility. The new series consists of three models having a cooling capacity range of 30 to 35 tons, full choice heating coils having adequate heating zone controls for heating, cooling, or a combination of both.

One of the outstanding engineering and application features of this unit is its ability to handle any load requirement from 0 to 100 per cent of the total system capacity. Filter boxes, mixing boxes, humidifiers, and other accessory equipment is also available.

The basic "Roofair" roof-mounted air-conditioner is designed for cooling and dehumidification. Combination units are also available with gas, oil or steam heat for year-round conditioning.

This series includes six models with a cooling capacity range of 5 to 35 tons with standard heating ratings matched to the unit cooling capacities. Larger heating components are optional.

Unique Feature

The unique feature of Roofair units is their self-contained packages shipped as single pieces completely factory wired, piped, and charged with refrigerant. A specially engineered single air distribution chamber is furnished for standard roof-top mounting application to provide controlled supply and return air distribution from the unit directly to the conditioned space. The unit is adaptable also for duct work.

The new centrifugal fans are called Centriflow Fans and feature a modern design which combines heavy duty construction with high efficiency and economy. The basic fan structure has been pre-engineered to utilize the latest production techniques. Its exclusive uniweld construction makes preferred all-welded housings standard on all fans regardless of class—an important feature normally available only as an extra.

A new advanced wheel design with backwardly inclined blades assures smooth and unrestricted air flow for high efficiency and quiet operation making the Series 600 fans especially desirable for operation were low noise level is a pre-requisite.

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PERKINS ENGINES TO BE MADE IN ARGENTINA

A large-scale scheme to manufacture Perkins engines in Argentina is announced by the British diesel engine group. Production is expected to reach an annual figure of about 12,000 units for vehicles, combines harvesters, tractors, industrial and marine applications in four years.

Although the bulk of the capital for the project is being provided from Argentine sources, Perkins are also making a financial contribution. The British company will provide technical know-how, including a residential technical adviser and technicians, with facilities for Argentine personnel to receive training in the U. K. At present nearly 25,000 Perkins engines are operating in Latin America, including 11,000 in Argentina.

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SHOULDER BALLAST CLEANING MACHINE

A Yorkshire locomotive manufacturer recently demonstrated a shoulder ballast cleaning machine which is claimed to be an important advance in this aspect of permanent way maintenance. It is a self-propelled machine which ensures efficient drainage through the ballast with a minimum of line occupation. It travels from stabling point to work site under its own power and when in operation is capable of speeds up to 600 yards an hour, during which time it can handle 300 tons of stone ballast.

The machine is powered by a Rolls Royce type C6TFL diesel engine developing 208 b.h.p. at 1,800 r.p.m., continuous rating, which drives four Deri-Sine duplex hydraulic pumps through a toothed belt and "Hunslet" gearbox.

Two digging heads are provided, one each side of the machine. Each one is individually controlled for speed of digging, depth of cut and so on, and by means of hydraulic rams is completely retractable within the body of the machine for travelling.

Double-deck dry type vibrating screens are provided, with a mesh suitable for 2 in. to $\frac{3}{4}$ in. ballast, and these are divided by a centre plate to provide independent screening for left and right hand digging heads. From the screens the cleaned ballast gravitates to chutes on either side of the machine and is returned to the track. The dirt is carried away by two dirt disposal conveyors.

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AEI UNDERGROUND ELECTRIC LOCOMOTIVES FOR SOUTH AFRICA

An order has been received by the Traction Division of Associated Electrical Industries Ltd., through AEI South Africa (Pty.) Ltd., for three 2 ft.—gauge 28-ton 500-volt underground locomotives for Goldfields of South Africa Ltd. Delivery will be in 1962.

The locomotives, of the double-bogie type and with both rheostatic and compressed-air braking, will be fitted with a pantograph and will be driven by force-ventilated traction motors. A triple combination of the motors will provide groupings of "all in series", "series/parallel in pairs" and "all in parallel".

On the control side, electro-pneumatic contractors will be used, and the automatic acceleration will be controlled by a current limit relay.

Both driving cabs will be fitted with a shatter-proof glass windscreen, a forward-facing driving seat and a small cooling fan. A hotplate will also be provided.

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PLANT AND FACTORY MAINTENANCE EXHIBITION

With the increasing movement of industry towards automation and continuous processes, the problem of maintenance has become more and more acute. In the old days if a batch machine broke down, it was simply a matter of a minor hold-up which hardly affected the output of the factory as a whole. But with modern production lines and automatic processes, any break-down such as bearing failure, pump leak, pipe corrosion, and so on, can cause a whole plant to shut down with consequent loss of thousands of pounds.

For that reason scheduled maintenance (which means that a machine is mended before it breaks down) is being adopted more and more by far-sighted companies. But the importance of modern maintenance techniques is not appreciated by all managements (even by some engineers) and the exchange of views on these techniques by maintenance engineers,

who keep industry's wheels turning, will be of great value to all concerned.

The four-day conference, to be held in London, will ensure adequate coverage of the many facets of the maintenance manager's work, which includes plant equipment, building and instrument maintenance, as well as the installation of new and the moving of established machinery, while discussion groups will give the opportunity for frank exchange of views on problems in various industries and their solution.

The chairmen and speakers at the various sessions, who are well known for their outspoken views on the importance of maintenance, have been carefully selected by a committee composed of practising engineers.

It is expected that many hundreds of works engineers, plant engineers, works managers and others responsible for maintenance work will attend. Throughout the period of the conference an exhibition will be conducted in the same building and at which many firms, prominent in the maintenance field, will be showing their latest products and processes.

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INTO SPACE WITH STAINLESS STEEL

The widespread use of stainless steel in the aircraft industry was highlighted at this year's Farnborough Air Show by the disclosure that the metal is being employed in a number of British rocket and guided missile projects.

Although detailed information is not available, guided missiles and rockets employing stainless steel include the De Havilland "Blue Streak", A. V. Roe "Blue Steel", the Armstrong Whitworth "Sea Slug", the English Electric "Thunderbird" and the Bristol "Bloodhound".

The entire outer skin of the "Blue Streak" satellite launcher is manufactured by cold rolled high tensile stainless steel sheet of the "Staybrite" 17/7 type. The sheet is supplied in the form of coils by Firth-Vickers Stainless Steels Ltd., in gauges as thin as .010 inches. This possesses considerable problems in maintaining a flat condition at high tensile strength of 80 tons per square inch to which some of this material is supplied.

The A. V. Roe "Blue Steel" is produced entirely from sheet and castings while some quantities of bar is used in the "Sea Slug". Stainless steel is also being used in the manufacture of rocket engines including the de Havilland "Spectre" and "Gyron Junior" as well as in Rolls Royce engines for "Blue Streak".

On the pure aircraft side, the increasing use of stainless steel in all types of civil and military aircraft is amply borne out by the Bristol T. 188 all-steel supersonic jet. Over 90 per cent. of all the material used in the construction of this machine was manufactured by Firth-Vickers.

The stainless steel for the T. 188 has been supplied in several forms. Sheet and plate for the skin of the aircraft had to be made available in reasonably large sizes to avoid to many joins and with a very high surface finish. Rolled bars were used for bolts, fasteners and other fittings.

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M & B AND STONE GROUP EXHIBITS FOR THE INDIAN INDUSTRIES FAIR

Fourteen member companies of the J. Stone (Holdings) Group will be participating in the Indian Industries Fair in a combined display, partly by the display of products and partly by photographs.

A member of the group, J. Stone & Co. (India) Private Ltd., will be exhibiting an electric railway pantograph and other electrical equipment for Railways.

Photographic displays will Cover: air-conditioning for rail and road vehicles, (J. Stone & Co. (Deptford) Ltd.); marine air-conditioning & Refrigeration Equipment (Winsor Engineering Co. Ltd.); non-ferrous castings (J. Stone & Co. (Charlton) Ltd.); ships' Propellers, watertight doors, Windows and Sterngear (J. Stone & Co. (Propellers) Ltd., Bull's Metal & Marine Ltd, Stone Marine Engineering Co. Ltd., and Bruntons Ltd.); foundry equipment, gears, metal bobbins and tubes (Stone-Wallwork Ltd.); lighthouse optical equipment, marine beacons and buoys (Stone-Chance Ltd.); automatic stand-by electric generating plant—by (Austinlite Ltd.); submersible electric pumps for water supplies and drainage (Sumo Pumps Ltd.); vitreous enamel signs (Mead McLean & Co.); and oil and water well drilling equipment, pumping units and foundry products (Le Grand, Sutcliff & Gell Ltd.)

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ENGINEERING SUPPLEMENT

How Engineers could help to develop Commonwealth

DUKE OF EDINBURGH'S LONDON LECTURE

Addressing the Institutions of Civil, Mechanical, and Electrical Engineers in London on April 13, the Duke of Edinburgh gave his views on how engineers could help to develop the Commonwealth. He was delivering the seventh Graham Clark Lecture.

The Duke said: "I wrote most of this lecture at odd moments during our recent tour of India and Pakistan: not, perhaps, an ideal way to set about it, but it did have the advantage that I was able to look at things from the point of view of relatively less developed countries.

"All large-scale projects and modernization plans are bound to have a profound and lasting influence upon the lives of great numbers of people. Unless their conception, execution and running are all based upon a practical humanity, they will contribute very little to man's progress.

"That is why technological training must be combined with broad general education. Each generation must learn that technical knowledge without a sense of mission and responsibility is wasted. Education which merely produces a sense of dis-satisfaction and frustration and the kind of topsy-turvy snobbery about what is suitable and unsuitable employment is a failure."

The Duke said the wealth of a nation depended on the efficient organization of its resources — both natural and industrial as well as human — and in this the engineer had the chief responsibility.

AGRICULTURAL PRODUCTIVITY

Turning to agricultural productivity in relation to population, the Duke compared production in Australia with that in India. He said: "Australia employs 12 per cent which produced 17 per cent., whereas in India 71 per cent of the population only produce 47 per cent of gross domestic product. This shows very clearly that great strides are possible in agricultural productivity."

Fortyfour per cent of the Commonwealth's land area, said the Duke, was either unused, built on, or wasteland, and qualified his statement by saying that one-fifth of the undeveloped land surface was too cold, one-fifth too arid, one-fifth was mountainous, and one-tenth had no soil. "This leaves about 30 per cent as potentially cultivable, and gives some idea of the scope for bringing deserts, equatorial forests and tropical grass lands into production, and the tremendous contribution which engineering can make to agriculture."

The Duke continued: "Four things are needed to stimulate and increase agricultural productivity:

"(1) Extend the area under cultivation, which generally means provision of water in dry areas, removal of water in swampy areas, and control of pests, disease and weeds.

"(2) Increase the productivity of the soil by applying more nutrients. This is the first impact of industry proper upon agriculture, because plants need nitrogen, phosphorus and potassium, which have to go through some sort of industrial process before they are usable.

"(3) Better equipment for use on the land so that, together with the increased use of fertilizers, output per acre can be substantially improved. In industrially developed countries, very sophisticated machinery is needed to increase output per man. In less-developed countries the emphasis should be on improved design of simple instruments.

"(4) A system of agricultural organization which will make it worthwhile for the rural population to grow food for sale. This includes organization of land tenure, proper transport and marketing facilities, and a comprehensive advisory service."

The Duke said the points might be self-evident to an outsider, but "you cannot, without much suffering, force human nature to accept a complete change—even for the better—of the basis of its existence overnight. The task in this case is to reconcile the interests of the individual with the interests of the State."

It was "rather sobering" to find that the Commonwealth's share of world food production was not very impressive, said the Duke. He added: "I need hardly emphasize what is expected of engineers for agriculture, especially in the less-developed countries. The next stage after food production is food preservation... This whole field of preservation and distribution of food is wide open to the engineer." The Duke said he thought it was generally recognized that "our harvest of food from the sea is still very underdeveloped".

ENERGY PROBLEM

Turning to energy, the Duke went on: "Hand-in-hand with agriculture to supply the world's basic needs is energy. Energy is the very basis of modern civilization." There was a close relationship between the amount of energy available per head of population and the state of material development of a country, and there was a very real urgency to increase energy production and distribution in the Commonwealth.

"In this field, the engineer has almost unlimited scope, and the solution of this energy problem demands more than skill and intelligence," the Duke declared. "It demands the services of far-sighted engineering administrators to exploit every indigenous source of energy and to plan the most economic form of energy production from other sources."

Referring to industry, the Duke said: "Industry exists for three reasons:

"(1) It produces those things which are needed by the community to live a reasonably comfortable existence.

"(2) It also produces those things which, though not essential to human existence, are very nice to have.

"(3) It produces things which can be sold to other countries, preferably at an overall profit." The Duke said industry must also produce all those things which were needed by industry at all stages of the industrial process.

The Duke continued: "It is very difficult, and probably misleading, to try to generalize about the overall position of industry in the Commonwealth... But the implication is that in agriculture, the basic industries and energy, Commonwealth output is not in proportion to its area or population."

The total resources of the Commonwealth were roughly in proportion to its size, but that did not mean that resources were evenly distributed. "Each country has certain limiting factors and many lack certain raw materials, but on the other hand most countries have probably got something which is needed or wanted by others. There is no absolute need for countries to be self-sufficient; the real need is for Commonwealth countries to co-operate in such a way that people can enjoy a reasonable standard of existence and a chance to develop their talents and their resources for the common good."

TRANSPORT AND COMMUNICATIONS

But, the Duke went on, "I must quickly add that none of their efforts would bear any fruit without an adequate system of transport and communications." We had not reached the end in the development of transport systems: aircraft capable of vertical take-off and landing, blind landing systems, monorails, flat electro-magnetic traction, and air-cushion craft were all waiting to be converted into economic possibilities by engineers.

"The Hovercraft type of vehicle, in particular, may easily revolutionize overland transport in the more remote regions of many Commonwealth countries," he said.

Speaking about engineering training in the Commonwealth, the Duke said the problem of higher education and technical training could not be solved once and for all. But, he added, "every country in the Commonwealth should look forward to progressive development, which means that plans for education must look ahead to the needs of the next generation". If the various aid programmes, such as the Colombo Plan, were to be of any lasting value, there must be strong emphasis on technical education.

Summing up, the Duke said: "Clearly, the contribution engineers can make to the development of the Commonwealth depends, to a large extent, upon the organization of the engineering profession both nationally and inter-Commonwealth." He added that if the Commonwealth were to make the most of its varied talents, it was essential that professional institutions should make determined and continuous efforts to keep in close contact with each other.

AEG IN THE FIELD OF ELECTRICITY

By An Engineering Correspondent

THE Allgemeine Elektricitats-Gesellschaft, generally known as the "AEG", is one of the most important Electrical Manufacturing Concerns that were founded during the period of industrialisation at the end of the 19th century, and which grew in a few decades from a small beginning to a concern of world-wide repute. This rapid development was mainly due to the foresight and organizing talent of its founder, Emil Rathenau.

The business started at the beginning of the 80's with the manufacture of electric generating installations for lighting purposes; but its fields of activity expanded rapidly and very soon included Power Engineering and Telecommunications. The first electric Power Stations in Germany were built by the AEG. In the field of power transmission an AEG Engineer, Dolivo Dobrowolsky, developed the three-phase system as early as 1889, thereby making modern Power Supply stems possible.

Three-phase current was tested for the first time on a High-tension Transmission Line from Lauffen/Neckar to the grounds of the Frankfurt Electricity Exhibition in 1891.

The speed with which electricity invaded commerce and transport considerably influenced the growth of the AEG concern; larger and larger factories and workshops appeared in various parts of the city of Berlin. From the very onset the AEG also took a leading part in the electrification of industry, mining and agriculture, mainly supplying Generators, Transformers, and all kinds of motor equipment for Rolling Mills and Handling and Conveying Machines — not forgetting to mention a few special items — namely Industrial Furnaces and Welding Machines.

Since then many Steam and Hydraulic Power Stations, as well as industrial installations of all kinds, both in Europe and Overseas, give proof of the AEG's versatility and efficiency.

The AEG, furthermore, undertook valuable pioneer work in the field of electric traction and as early as 1903, a three-phase Railcar built by the AEG attained a speed of 210 kilometres per hour on a Berlin Suburban Line. Since then, and up to the present day, the AEG has always remained in the lead in the development and construction of Electric Locomotives for Main Line-, Industrial- and Mining Railways.

Headquarters of the concern is still Berlin, where the main Administration Offices and Planning Departments are now in Hohenzollerndamm in Western Berlin. The West German Administration Offices and their affiliated departments are concentrated in Frankfurt/Main. Consequently two-thirds of the employees are working in the Federal Republic and one-third in West Berlin. The largest AEG Works in West Berlin are again the Brunnenstrasse Factory, where Motors of every size and type, also Traction-motors and Rectifiers, as well as Hydro-electric generators are manufactured, and the Turbine Factory in Berlin-Moabit, which has supplied the equipment for many Power Stations in all countries of the world, and again delivers Steam-turbines up to the highest ratings — one-third of its capacity being devoted to the Overseas Export Trade. Furthermore, Electricity-meters, Clocks and Measuring-instruments are also manufactured in Berlin, and added hereto a factory has been newly erected for the manufacture of Radio-valves, Electronic-tubes etc. The AEG already possessed many large and important factories in West German cities, such as Nuernberg, Stuttgart and Muelheim; but to compensate for losses in the Soviet Zone after the war these had to be extended and a number of new ones built, including a Turbine Factory at Essen, a Meter Factory at Essen, a Meter Factory at Hameln, a factory for Switchgear-plant at Neumuenster, as well as factories for High-tension switchgear, Refrigerators, Teleprinters and Insulating-material in Kassel; and a factory for Measuring-instruments in Heiligenhaus, for Mining equipment in Muelheim-Saarn, and a factory for Valves and Rectifiers in Belecke.

Today, the AEG's scope of production has practically attained its pre-war standard. Steam Power Station Equipment for the highest pressures, temperatures and ratings is again being designed and constructed; whereby full utilization is made of the experience gained over a period of seven decades. The first large installation to be erected many years ago by the AEG

was the Klingenberg Power Station, Berlin, with an output of 290,000 kW. But proof of the confidence placed in the AEG, especially from Overseas, is reflected in the number of large Hydro-electric generators up to 45,000 kVA output, totalling more than 1,000,000 kVA, which have been supplied and ordered since 1946.

The AEG also has excellent reputation in the field of Electric-drives and equipment for industry. Increased production and improved quality and efficiency are of decisive importance today. The high achievements in the field of Material Handling and Conveying, Rolling Mills, Machine Tools and in the Medium and High-frequency techniques, are based on many years of research and development work. Some 60 years ago the AEG delivered the first Crane—and Rolling Mill-equipment, and, about the same time individual drives for Machine-tools were introduced; since when, with due consideration to the ever increasing demands and in closest cooperation with Machine-tool Manufacturers and other branches of electrical engineering, they have been developed to their present high degree of efficiency. Increasing speeds then led to automatic controls; whereby the operator was relieved of carrying through manipulations that could be performed mechanically — the control, however, had to be absolutely foolproof. The AEG employs automatic controls in Rolling Mill, Machine-tool, Electric Furnace and other Equipment, thereby helping to eliminate waste in industry, at the same time ensuring uniform quality. New achievements in Electronics and Magnetics (Transductors), Amplifying Elements (Amplidyne) and their combinations have proved how accurate these installations can be, even under the most exacting conditions.

In the field of Electric Traction the AEG has been leading the way for more than 50 years. The first to establish itself, however, was the Electric Tram, and at the turn of the century there were 38 tramway systems in operation in Europe, all of which had been built by the AEG, and a further 27 were already under construction. At this time the idea was conceived that Railways, which up till then had been driven only by steam, could possibly be adapted to electric drive. In 1903 the AEG built the first single-phase alternating current Railway near Berlin, for a voltage of 6,000 V at 25 cycles. This successful experiment opened the way for electrification of Railways in Germany and the rest of the World. Since then the AEG has built and equipped all types of Railways, using direct current, single-phase-alternating current at 50 and 16 2/3 cycles, as well as Diesel-electric or Diesel-hydraulic Transmission. More than 7,000 Electric Locomotives have been built to date by the AEG for Main and Branch Line Railways, Industrial Railways and Mines, including the first Electric Locomotive for single-phase alternating current at 50 cycles for the Freiburg to Titisee-Seebrugg Line of the German State Railways.

In January 1936 operation with 20 kV, 50 cycle, single-phase alternating current was commenced, whereby the Tandem-commutator Motors developed by the AEG proved to be particularly suitable for mountain railways requiring frequent and extremely heavy starting.

Another important and specialized field in which the AEG has been very successful is the construction of Geared-turbine and Diesel-electric drives for Ships, including all types of equipment, particularly for winches and rudder-gear.

In the course of the last few years four 10,000 ton cargo vessels for the Hamburg-America Line and the North-German Lloyd have been equipped with AEG Ships-turbines and further installations of this type — also for customers abroad — are under construction.

A further notable advance is the Automatic Rudder-gear whereby, through the gyro-compass, the ship maintains its course on long sea journeys.

It should also be mentioned that the AEG devotes special attention to measuring techniques, and, apart from Measuring-instruments for switchboard mounting, also manufactures Precision-instruments of highest accuracy and sensivity, Astatic Watthour-meters, Microammeters, Mirror — and Light-spot Galvanometers, as well as Flash Stroboscopes.

A wide range of Electric Household-appliances serves to complete this comprehensive Production Programme.

CONTROLLING HIGH-VOLTAGE POWER SUPPLIES

A British firm has introduced a new design of switchgear equipment to control electrical power supplies at voltages approaching that of lightning. Voltages of this magnitude are becoming necessary for feeding power economically over great distances, such as exist in India, Australia, and North and South America.

The new equipment was introduced to engineers at a conference held by the firm, English Electric, at Stafford, in the Midlands. The delegates saw multi-million-pound test machinery which has been installed to prove the reliability of the switchgear before it goes into service. This machinery also ensures that the gear can deal swiftly with faulty conditions, such as short circuits caused by birds or falling trees, which could impose on the equipment voltage surges of up to 1,500,000, volts, comparable to the full power of a lightning flash. The capacity of the test equipment has recently been doubled to prove very-high-duty switchgear, worth £1,500,000, ordered for Britain's new 400,000-volt Grid system.

MAIN PROBLEM

In any electricity supply system, writes an industrial correspondent, means have to be provided for switching power into and out of supply lines and for dealing quickly with faults that could cause severe damage to generating machinery if left uncorrected for a few seconds.

The main problem in switching off electrical power, particularly at the high currents and voltages common today, is to put out the electric arc that forms and keeps the current flowing even when the switch is pulled out. In high-voltage, high-power switches, the arc is normally blown out by a powerful blast of air. This is done more quickly and reliably than before in the new design by pressurizing the whole switch assembly with dry air, which ensures that the arc is not only blown out immediately but prevented from re-forming.

The new equipment is compact, makes use of reliable and cheap new high-strength materials, and is built from standard components to lower costs.

* * *

Hunslet Patent Hydraulic Transmission

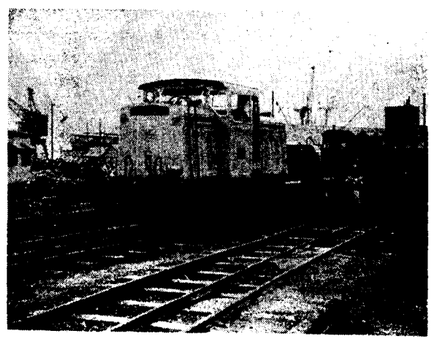
By An Engineering Correspondent

EVER since Hunslet started designing Diesel Locomotives in 1927, the closest watch has been kept upon hydraulic transmissions of all types and numerous units have been tested and tried out in service. It was not, however until 1946 that Hunslet found a torque converter which was considered to be suitable for locomotive work. Several were installed in trial locomotives, and excellent results were obtained. An agreement was then made to use this type of torque converter in future ' Hunslet ' Locomotives, and a patent was taken out covering this new application.

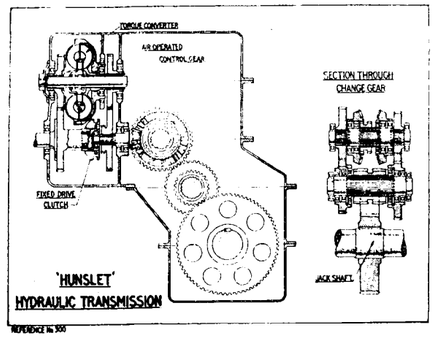
There are, of course, today a large number of torque converters of different designs available. None give better efficiency than about 85% and that only at the peak of the efficiency curve, which curve is very like that of electric transmissions. As a consequence, torque converters generally lend themselves to easy abuse and severe overheating which is especially the case in locomotive work. There is no doubt that for starting from rest, and also for periods of acceleration the torque converter gives a performance second to none, but for continuous operation its characteristics are most unsuitable and this is particularly the case for shunting or heavy freight service.

Ever since 1927, Hunslet have been building Straight Diesel Locomotives with mechanical transmission, the main clutch being either their own 'Hunslet' patent friction clutch, or in addition, an hydraulic coupling. All these locomotives have been, and still are, extremely successful, but as greater horsepowers have been developed, there has been a tendency to require a greater number of speeds in order to obtain the high tractive efforts necessary for starting from rest and also to give satisfactory acceleration between the gear steps. The one weakness of the straight mechanical transmission is not, as many people think, the fact that there is a momentary break in tractive effort between gear steps, but the big difference in tractive effort between one gear step and the next, which means that there is little tractive effort available for accelerating up to full speed in that particular gear. It can, therefore, be seen that the weakness of the straight mechanical transmissions is the strength of the torque converter, and by taking advantage of the torque converter for starting and accelerating period, an ideal transmission can be obtained provided that the torque converter can be discarded after it has performed these useful functions. This is exactly what the ' Hunslet ' patent hydraulic transmission achieves.

The latest ' Hunslet ' transmission consists essentially of the 'Hunslet' standard type of gearbox preceded by a special torque converter unit which can be engaged or disengaged at will. It is naturally engaged during those periods of starting and accelerating already discussed. The sequence of events, for instance, is that at starting from rest, low gear is engaged in the gearbox and the torque converter is in series. A very high tractive effort indeed is, therefore, available with a smooth curve up to within about 20% of the full gear speed. Immediately this speed is obtained the torque converter is cut out and the performance of a straight mechanical transmission is obtained. This not noly means increased efficiency and increased speed, but what is more important, no further heat generation in the torque converter and, therefore, it is possible to maintain this maximum tractive effort on low gear indefinitely without any question whatsoever of overheating, an achievement which cannot be equalled by any other form of either electric or hydraulic transmission. When greater speed is required a double operation takes place; second gear is engaged in the gearbox and at the same time the converter is placed in circuit. In this way



' Hunslet ' 274HP 0-6-0 Type Diesel Hydraulic Locomotive in Service at Madras Port.



the usual step associated with a straight mechanical transmission is avoided and a smooth rapid acceleration is obtained, until in the same way the torque converter is once more cut out and full performance at something like 95% efficiency is obtainable on second gear. In this way an extremely useful tractive curve is obtained.

In this way full advantage is taken of the converter during those periods when it is of most value, yet it is not called upon to do any work during those much longer periods of heavy continuous duty, when it is normally so much at a disadvantage and during these periods very much better powers and speeds are attained than could possibly be the case were the torque converter in operation.

One very important advantage of this new transmission is that while it gives a first-class tractive effort curve for normal operation up to full speed, it also has the tremendous advantage that on approaching any long severe gradient, the particular speed suited to the gradient and load can be engaged, the torque converter can be cut out and the climb can be negotiated quite regardless of its length without any over-heating whatsoever. In the same way for heavy shunting this new transmission is ideal, and in fact, has tremendous advantage over any other known form of locomotive transmission.

SPECIFICATION

(1) The gearbox unit contains the hydraulic converter with its step up gears and direct drive clutch followed by a set of reversing bevels and two trains of speed wheels giving the speeds in both forward and reverse directions, after which is the final gear reduction and jackshaft with flycranks, having side rods to transmit the drive to the road wheels.

(2) The torque converter used in the ' Hunslet ' hydraulic transmission was developed specially for locomotive use. It is a simple, single stage type having three main components, the impellor, the turbine and the reaction member.

The reaction member corrects the direction of oil flow between the impellor and the turbine and also takes the torque reaction. This reaction reaches a maximum when the output shaft is stalled and decreases as the output shaft speed increases. In any transmission the torques must balance. The increase in output torque obtained from the converter is due to the fact that the output torque is equal to the sum of the input torque from the engine plus the torque resisted by the reaction member.

One advantage of the ' Hunslet ' torque converter is that the reaction member is designed to transmit torque in one direction only. The reaction torque cannot, therefore, change direction and subtract from the output torque. The reaction member is carried on a roller clutch and is free to run with the input shaft but locks on reverse rotation. When the speed of the output shaft increases to the point where the output torque equals the input, the roller clutch frees itself and, with any increase in speed, runs with the normal rotation. Under these conditions conversion ceases and the drive is similar to that of an hydraulic coupling.

(3) When the fixed drive clutch is engaged, there is no further slip at all in the converter. Both impellor and turbine are driven at the same speed and rotate together with the reaction member, the fluid is relatively stationary and no heat is generated. The whole gearbox then behaves as a straight mechanical box with very high mechanical efficiency.

WHEELED TRACTORS FROM KHARKOV FOR INDIA

The Kharkov Tractor Works (Ukraine) started fulfilling a big order for wheeled tractors for India. The first consignment of tractors designed to operate in the tropics has already been manufactured. During May and June the plant will ship 330 wheeled tractors to India. The speedy and highly efficient wheeled " DT–20 " tractors of the Kharkov Works is in high demand abroad. This machine powered with a 20-h.p. engine, which was awarded a certificate of merit and a gold medal at the World Fair in Brussels, is the world's best among tractors of this class.

Industrial Post-Graduate Training in Britain

By Dr. WILLIAM ABBOTT

Director of Studies of the Federation of British Industries

THE system of works training for graduate engineers in Britain is more easily understood if the position of the professional engineering institutions, civil, mechanical and electrical, is appreciated. These institutions are the arbiters of professional engineering standards in education and training, and their requirements are made public. Only they confer the "Chartered" title, a pre-requisite for successful practice in Britain. They are not only learned societies, but they are examining bodies.

A young man wishing to secure Corporate Membership, and the right to the title Chartered Electrical Engineer, has to satisfy three requirements of the Institution: first, to present equivalent educational qualifications or take the Institution's examinations; secondly, to show a satisfactory record of practical training, and, thirdly, to hold a responsible position as an electrical engineer.

TRAINING RECOMMENDED

The British graduate, therefore, enters industry for the express purpose of securing training for a period of two years to satisfy the second part of the Institution's requirements. The training recommended by the Institution is set out in detail in its publications, and here is a brief summary.

The pattern for graduate training should extend over two years and comprise: basic workshop training for two to four months, general mechanical and electrical training for eight to 15 months and directed objective training for six to 12 months.

Basic workshop training is intended to give the graduate an opportunity to become familiar with the uses and limitations of machine and hand tools, learn the properties of engineering materials, and know something of the basic manufacturing processes.

General training is intended to provide the opportunity for experience in fitting and assembly, inspection and testing, installation, operation and maintenance of plant as well as drawing office practice, and experimental or development work.

Directed training requires of the graduate a choice of the type of work he wishes to make his career — research, development, design and application, manufacture, plant commissioning, operation and maintenance or commercial engineering.

3,500 GRADUATES A YEAR

The training schemes developed in Britain have naturally tended to satisfy these requirements. The training has a continuing popularity, as shown by the large numbers of graduates with British firms. It is estimated that while the number of United Kingdom graduates in the various branches of engineering is about 3,500 a year there are, in addition, at least 2000 graduates a year from countries overseas being trained in industry in Britain. Assuming that most are training for two years, the total number of graduates in industry at any one time is about 11,000.

The training picture in industry in Britain does not lend itself to generalisations. Some organisations have massive research departments, others rely upon research associations; some firms have their own colleges and give supplementary courses while others cannot do so: one firm may be active with development work, whereas another will have little. In a consultant's office, a graduate trainee will be in close contact with professional engineers, and in a productive works he will mostly be associated with operatives, foremen, inspectors and similar people.

It follows that there is no general pattern for industrial training. It also follows that while many oversea graduates are satisfied with their training in Britain, others are a little disappointed.

NEEDS MUST BE STATED

To avoid disappointment it is necessary for the oversea engineering graduate to put his requirements clearly before the education and training officers of British firms approached, and to be sure they can satisfy his particular needs. Perhaps industry alone cannot give him all the information he needs, and he should get operational experience with, for example, The Post Office, the British Broadcasting Corporation, or the Electricity Authority. The vital thing is for the graduate to state precisely the kind of training he requires. He will then find his needs can be satisfied in one firm or organisation or another, but these must be located by careful enquiry.

The supplementary education available in many technical colleges in Britain should be kept in mind. Every large industrial centre is served by a technical college which operates part-time courses and these are arranged to satisfy the needs of those already in industry. Excellent courses, many of post-graduate level, are available at trifling cost, and many graduates attend Management Courses, where the lecturers are drawn from industry.

PROBLEMS TO BE OVERCOME

Most oversea engineers are expected to assume responsibility in their own countries at an earlier age than their United Kingdom counterparts, and in most developing countries they often have to cover more than one branch of engineering. For example, an engineer may have to give advice on all aspects of hydro-electric power and not solely on the electrical, civil or mechanical side.

They are not usually interested in becoming members of British institutions, and while they appreciate the purpose of the institutions' training schemes, they may feel their own requirements are not met.

Many engineers from overseas might be satisfied with experience in the office of an electrical engineering consultant in Britain, coupled with experience in organisations concerned with the planning, equipping and services of factories. Unfortunately, there are not many such firms, and their capacity for receiving trainees is limited.

The young oversea graduate is always anxious to secure information, but he finds that his questions can often be directed only to those who cannot answer them. It is unusual for him to receive help from the professional engineers in many manufacturing organisations because they are too involved in their own work to help the young graduate, as they would wish.

(Continued on page E.10)

CHANGES AND DEVELOPMENTS

These considerations have been set out to tell the graduate some of the difficulties inherent in United Kingdom, and any other industrial training schemes. As far as Britain is concerned, a recognition of the reasonableness of many of the reactions of the young graduate may be taken for granted. The problem was debated at a joint meeting of the three major institutions at the Institution of Electrical Engineers on November 3, 1960 and it can be said that there is a new and vital interest in this matter throughout professional circles in Britain, and developments will come, and will be continuous.

The best service a young engineer going to Britain can render after experiencing some training, is to offer constructive comments. But before this, he should be able to put what he believes to be his own requirements clearly to a firm when he joins it. For this he needs a sufficient command of English for without it misunderstandings and difficulties can multiply.

TRAINING IN TELECOMMUNICATIONS

The following are the arrangements made in a well-known British firm for the training of electrical engineering graduates who opt for telecommunications.

FIRST PERIOD (about a year)

Basic production processes, including machining and finishing — two months.

Assembly and adjustment of relays, uniselectors and two motion selectors — up to three months.

Fundamental lectures on telephone exchange principles — one month.

Final inspection and functional test of automatic telephone exchange equipment — about one month.

Assembly of multi-channel line communication equipment — about one month.

Test of multi-channel line communication equipment — about two months.

Development of line communication equipment or electro-mechanical switching equipment — about three months.

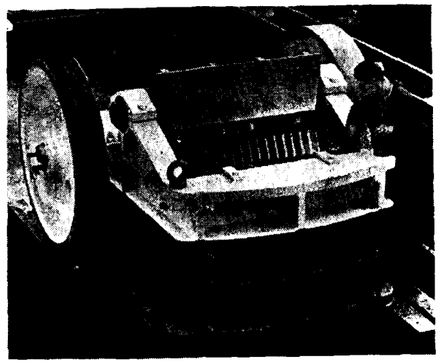
BLAKE CRUSHERS WITH EXTRA-WIDE JAWS—GEC EQUIPMENT FOR INDIAN COPPER MINE

THE Indian Copper Corporation Ltd. has recently increased the output of its Masaboni Mine in Bihar State to about 100 tons per hour, necessitating the replacement of the existing crushing equipment which was unable to cope with the increased rate. The Corporation has therefore installed a Blake crusher fitted with extra-wide jaws, (50 in. × 16 in.), the plant being manufactured at the Fraser and Chalmers Engineering Works of The General Electric Co. Ltd. of England.

G. E. C. makes two sizes of Blake crushers with extra-wide jaws, namely 40 in. × 16 in. and 50 in × 16 in. The particular value of these crushers is that they bridge the gap between the smaller range of jaw crushers and the larger true primary breaker. The two wide-jaw 16 in. crushers are specifically designed for reducing hard or tough ore which is not more than 12 in. in size to 3—4 in. ring at the rate of 50–100 tons per hour.

This feed rate cannot be handled economically in any single primary machine in the normal range. A 30 in. × 16 in. jaw crusher has too small a capacity, and the next larger size in the normal range, a 36 in. × 24 in. machine, is too big, since it is designed to take pieces considerably coarser than 12 in. and is therefore unnecessarily heavy and expensive for the smaller size of ore. A gyratory crusher with a 16 in. feed opening is much too large, its capacity being nearer 150 tons per hour.

One method of handling the tonnage would be to install two 30 in. × 16 in. crushers, involving duplication of the feed and discharge arrangements, the motor and the switchgear, this being very costly.



A 50 in. x 16 in. Blake crusher assembled in the Fraser and Chalmers Engineering Works of The General Electric Co. Ltd. before shipment to The Indian Copper Corporation Ltd. (Photo: GEC)

It will be seen therefore that G. E. C. crushers with extra-wide jaws satisfactorily cover the intermediate range of 50—100 tons per hour, being cheaper both in first cost and in running expenses than any other crusher or combination of crushers suitable for hard ore or rock. They have all the features of the Company's improved design of Blake crushers, including all-welded construction throughout and roller bearings on the eccentric shaft for both the main frame and the pitman.

(Continued from page E.9)

SECOND PERIOD

(Selected from not more than four of the following)

Development of very high frequency and ultra high frequency radio communications equipment.

Installation and commissioning of telephone exchange and transmission equipment.

Design of electro-mechanical switching systems.

Attachment to The Post Office (for attendance at the Training School, Stone, Staffordshire). Maximum period of three months.

Attachment to B. B. C.

Attachment to the Company's Research Laboratories.

Design and manufacture of electro-medical equipment.

Sound reproduction and public address systems.

Design and development of digital computers.

Telecommunications Systems Planning.

Design and development of electronic switching systems.

Similar training schemes to the one outlined here exist for all other branches of the electrical industry.

The High Pressure Boiler Feed Pump— A Dynamic Evolution in Design

By I. J. KARASSIK

Manager of Planning and Consulting Engineer, Worthington Corporation Harrison, New Jersey, (U. S. A.)

THERE can be no question that the boiler feed pump shares the distinction of being one of the most important pieces of equipment in a steam power plant along with the turbo-generator, the boiler and the condenser. It acts as the heart of the power generating system as it pumps the feed water, which is the life blood of the system throughout the system. It is the feed pump that imparts the kinetic and pressure energy to the steam cycle, whose controlled operation permits the whole power generating system to perform its useful function.

No attempt will be made to present a detailed historical survey of every single development which took place in the last three decades. This discussion will be limited to the major changes which have had a profound influence on the design, application and operation of high pressure boiler feed pumps.

By 1926, it became necessary to design and build boiler feed pumps for pressures over 1500 psi. Fortunately, there had taken place major advances in the art of electric motor design and two-pole, 3600 rpm. motors were available to drive the pumps. While a certain reluctance first persisted on the part of some users to take the major step from 1800 rpm. to 3600, the choice was really not avoidable; either the higher speed was to be accepted or pressure could not be developed to match steam power plant requirements.

The first high pressure boiler feed pumps to be built with a radially split casing were ordered from Worthington by the Boston Edison Co. for the Edgar Station in 1926. The reason for this departure from the formerly accepted practice of splitting the casing along its axial plane was the inadequacy of that design for the higher pressures which were now necessary on boiler feed service.

This first design was a far cry from the modern double casing pump. The individual stage sections and separate suction and discharge heads were held together with large through bolts. Various modifications were introduced between 1926 and 1934 in an attempt to lengthen the periods between required overhauls. But in their essential features, the pumps remained an assembly of bolted-up sections.

The sectionalized design presented a serious problem in dismantling and reassembly, especially since it required that suction and discharge connections be broken each time a pump had to be taken apart. At that time this was unfortunately quite frequent.

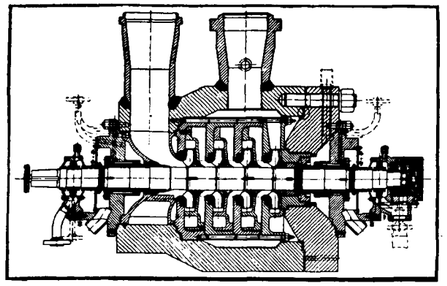
TRUE DOUBLE-CASING PUMP

The true double-casing pump did not emerge as a fully developed design directly to replace the sectionalized boiler feed pump. The process, instead, was evolutionary. By 1934, Worthington had built a pump with a solid forged steel barrel to which were

welded the suction and discharge nozzles. The individual stages were inserted into this barrel and each diffuser was packed against leakage along the casing barrel by rings of packing. This type of construction first made use of the principle which is still incorporated in double-casing boiler feed pumps with a radi-

ally split inner assembly, namely that of using the pressure generated by the pump to hold the interstage joints tight against internal leakage. But it still presented assembly and dismantling shortcomings, as each impeller and its diffuser had to be inserted separately into the solid barrel.

It was a short step from a pressure sealed and packed joint to an assembly bolted together and pressure sealed. This step was taken in 1936 and incorporated into the pumps built by Worthington for the Waterside Station of the Consolidated Edison Co. The inner element of this pump could be assembled externally to the pump itself and inserted into the barrel as a complete unit.



The growth in the number of high pressure boiler feed pumps required for the power industry brought in the appearance of new manufacturers of double-casing pumps. Naturally this led to a variety of new conceptions of design philosophy although the basic concept of a double-casing pump was common to all designs.

Some of the differences are much less significant than they appear at first glance. This is the case, for instance, with the means used in balancing the axial thrust developed by single suction impellers. Two apparently different methods have been selected by pump designers. One method arranges the impellers in sequence, all facing in the same direction. A hydraulic balancing device is located after the last stage impeller. The second method consists of using an even number of impellers, one half of these mounted in the opposite direction to the other half so that the axial thrusts on the two groups of impellers balance each other. But both methods depend on some kind of a balancing device subject to a differential pressure equal to the total pressure generated by the pump.

The total differential pressure has to be broken down in either case. Whether this is accomplished across a single running joint or whether the balancing device is split up into three separate portions distributed throughout the pump and given a different name, is really immaterial. The significant difference is that a true balancing device is so located within the pump that the flow through it is subject to measurement, whereas "three-part" balancing device does not permit this since leakage occurs internally.

CHOICE OF MATERIALS

Until the early 1940s, there had been very little interest in using materials other than cast steel, forged steel or cast iron for the inner casings of high pressure boiler feed pumps. That this practice did not immediately lead to serious difficulties may be ascribed to the fact that in the early days of high pressure power plant practice, feedwaters carried an appreciable amount of natural salts which acted as buffering elements. But as the trend towards evaporated and treated make-up became more and more general and as the purity of feedwaters grew in importance, the beffering elements disappeared and trouble jobs became more prevalent.

These trouble jobs manifested themselves as "corrosion-erosion" which attacked boiler feed pump casings as well as such pump parts as wearing rings or balancing devices when these were not made of corrosion resisting alloys.

By 1944 this effect had reached such proportions that an investigation was started by the boiler Auxiliary Sub-Committee of the Prime Movers Committee of the Edison Electric Institute acting in cooperation with a committee appointed by the Hydraulic Institute. The result of the wok of these committees was the universal use of chrome steel in high pressure boiler feed pumps. Chrome steel has proven satisfactory over the years and is now considered entirely adequate for the inner casing parts.

Once corrosion-erosion disappeared as a source of damage to boiler feed pump internal parts, the number of operating hours between complete overhauls lengthened measurably. And whereas operators had become accustomed to open feed pumps at regular intervals, the practice soon became established not to open them unless wear had made it justifiable to renew the internal clearance or, of course, unless evidence of accidental internal damage manifested itself.

The evidence at hand indicates that barring accidental interference with the normal life of a pump, today's high pressure boiler feed pump can reasonably be expected to have a life of 100,000 to 150,000 hours before wear makes it necessary to renew internal clearances.

DESIGN TRENDS

The stuffing box problem had always been an unwelcome thorn in the side of manufacturer and user alike. Many factors in the service for which these pumps are intended make it difficult to obtain long life for the packing and a life of 12 to 18 months is seldom exceeded. In the meantime, improvements in design and materials have made the modern boiler feed pump capable of operating as much as 100,000 hours or more without internal overhaul. These two time intervals are obviously incompatible and a search for a more adequate solution to the stuffing box problem had attracted a great deal of interest. Two solutions appear to have evolved out of this search: the mechanical seal and the condensate injection sealing.

The principle of the mechanical seal is to provide sealing by having face contact between a stationary face and a rotating face.

Greater experience exists at this moment with condensate injection sealing than with mechanical seals. The reason for this is that at the time it became desirable to eliminate packed stuffing boxes, field experience with mechanical seals was still inconclusive. In addition, no experience whatsoever was available with the application of mechanical seals on boiler feed pumps operating in the speed range of 6000 rpm. to 9000 rpm.

Since it was impossible to advance with the development of high speed pumps without first solving the stuffing box problem, the condensate injection construction received the major amount of attention and development.

PRINCIPLE OF OPERATION

The principle of operation of condensate injection sealing is essentially simple. The stuffing box is replaced by a stationary bushing which forms a close clearance running joint with a shaft sleeve mounted on the pump shaft. Cold condensate is introduced under pressure centrally within the stationary bushing. A small portion of this condensate flows into the pump proper and the remainder flows to a collection chamber and is returned to the condenser.

Field experience with pumps incorporating this construction has been very gratifying. One phase of installation that requires special attention with condensate injection sealing is the warm-up piping. Because a definite quantity of cold condensate is constantly flowing into a stationary pump held on standby duty, it is very important to provide an adequate warm-up arrangement, to avoid pump distortion through unequal temperature distribution over the pump casing.

The second of the two latest developments is by far the most important. It concerns the "coming of age" of high speed boiler feed pump. The major reasons which favoured the trend towards higher speeds are the following:

(1) The higher head-per-stage which can be developed at higher speeds reduces the number of stages and increases the rigidity of the pump. This contributes heavily to the reliability of the equipment.

(2) Coincidentally with the reduction in number of stages, higher speeds lead to smaller impeller diameters and therefore to smaller casings. This reduces the stresses which higher operating, pressures were threatening to send sky-high.

(3) The high speed pump is better matched to the optimum speed of the steam turbine which, as we have seen, is emerging as a formidable competitor to the electric motor.

(4) The trend to super-pressure plants and the operation of boiler feed pumps at pressure up to 5500 psi. makes it imperative to use higher operating speeds.

The first high-speed, high pressure boiler feed pump was built by Worthington for the Kearny Station of the Public Service Electric & Gas Co. of New Jersey. It went into service late in 1954 and has been in operation since then. It is a 4-stage pump driven by an electric motor through a hydraulic coupling and a step-up gear which brings the pump speed up to 9000 rpm. The pump handles 592,000 lb./hr. of 400 F. feedwater against a discharge pressure of 2720 psig.

Except for a reduction in the number of stages, in impeller diameter and in over-all dimensions, the high speed pump is but a reduced scale model of the line of double-casing pumps with radially split inner element.

But the high speed pump requires considerably more NPSH than would be practical to supply by locating the deaerating heater of an open cycle at even the highest possible elevation in the steam power plant. When an open cycle is used therefore, it becomes necessary to provide a low head booster pump, located just ahead of the main feed pump.

MAIN ADVANTAGES

Although at first glance this appears to be an added complication, the booster pump brings certain advantages which more than offset the complication. In the first place, it permits lowering the heater well below its required location for a 3500 rpm, installation, since the booster pump is generally driven by a 1750 rpm. motor. Besides the possible savings in structural steel, this re-location of the heater often permits to drain all closed heaters on the discharge side of the feed pump to the deaerator by gravity at all loads. Thus, the booster pump eliminates the high pressure heater drain pumps which have always been the most severe service in the power plant. If, on the other hand, no heater drain pumps were contemplated, and the drains were to be flashed back to the condenser at light loads, the booster pump eliminates the attendant losses. Finally, the use of a booster pump reduces the hazards from transient loads during a sudden load drop.

The high speed boiler feed pump is well on the way to replace the conventional 3600 rpm. designs. This evolution of the high pressure boiler feed pump covered about 33 years.

DISTINCTIVE FEATURES

Let us review briefly the features which distinguish the Worthington high pressure boiler feed pump.

1. A barrel type boiler feed pump should first be reliable. After reliability, it should have as many other attributes as possible without impairing that reliability which came first. This is the basic philosophy which dictates the shaft design of all Worthington barrel type boiler feed pumps. It is our intention to produce the shortest and stiffest shaft having the maximum diameter shaft and minimum shaft span possible for the hydraulic conditions desired. There is a direct relationship between shaft rigidity and reliability.

2. In addition to shaft stiffness, liberal clearances at rotating parts also contribute to pump reliability. Obviously, during periods of stress, if amplitude of vibration plus shaft deflection exceeds internal clearances disaster will result. On the other hand, if clearances in rotating parts exceed the sum of amplitude of vibration and shaft deflection disaster will be avoided.

3. In view of the fact that Worthington barrel type boiler feed pumps are built of materials and designed to last 100,000 to 150,000 hours between overhaul, it seems foolish to incorporate internal gaskets having much lesser life. As yet, we have no gasket material which has an expected life equivalent to the life of the basic pump. Therefore, there are no internal gaskets in a Worthington barrel type boiler feed pump and all internal joints are metal-to-metal joints ground and lapped. In addition, hydraulic pressure acts to seal the internal joints.

4. Worthington high pressure boiler feed pumps incorporate machined twin volutes. In this fashion exact dublication is available stage-to-stage, and optimum hydraulic characteristics and performance are insured.

5. Worthington manufactures a high pressure, boiler feed pump to last a long time between overhauls. It is built ruggedly for the service intended and consequently all impellers are shrunk on the shaft for a solid design in contrast to a loose rotor construction.

6. When the inner assembly is inserted into the barrel, it is centered and supported at both ends by circular fittings concentrically machined with the barrel bores. The inner assembly is cradled at the discharge end and is bolted only at the suction end. In this manner it is free to expand and contract due to temperature variations without destroying perfect centering of running joints and bearing supports. Thus the inner assembly is free to expand and contract without introducing thermal stress in any of the pump parts. This feature permits cold start-ups under emergency conditions.

7. High speed construction requires the use of a specifically designed bearing to prevent vibration caused by oil whip. During operation, a specially designed pocket in the upper half of the bearing builds up a pressure pad of oil. High pressure here creates a downward force on the journal holding it down in the bearing, eliminating vibration caused by oil whips. This type of bearing increases life and cuts bearing maintenance.

8. The Worthington high pressure boiler feed pump is designed for long trouble free service with low maintenance expense. Standardized parts provide maximum interchangeability, permitting substantial reductions in field parts inventory. Barrel type boiler feed pumps with the same barrel sizes use identical shafts, impellers, diffusers, bearing rings and balancing devices. Custom fitting is eliminated by machining these parts to close tolerance, interchangeability reduces downtime maintenance costs, parts inventories and other engineering problems.

FUTURE PROGRESS

We have come a long way from the sectionalized pump of 1926 which was so complicated to take apart and which had to undergo this process so very often by present day standards. We are now building boiler feed pumps which develop four times the pressures, take twenty times the horsepower and run at five times the speed of the pumps built a short thirty-three years ago. We have solved the problems which faced us then. But as we advance in our steam power technology we create new challenges.

As long as steam power plants continue to supply us with electric power, we will need to build high pressure pumps to feed the boilers. We will find new problems facing us each time that we make progress in the design of the steam power plant. And the success of the past holds the promise that we will find adequate solutions to solve future problems as they arise.

Tomorrow's high pressure boiler feed pump is certain to be quite different from those in common usage today. There is a definite possibility that the Super Speed pumps operating at speeds of 30,000 or 40,000 rpm. will in time find its place in the steam power plant. At this speed, a single stage unit could be applied with its simplicity of construction and operation.

The great strides made in aerodynamics in the area of turbulent and laminar flow, boundary layer, and secondary flows in the past few years are being used in hydraulic design. These modern concepts are used in the development of higher heads-per-stage, of inducers, and of energy transformation which will make possible the most efficient pumps at the lowest possible NPSH. Materials of construction will change radically and we will find super hard materials in common usage which will permit the almost infinite life of wearing parts. Lubrication and sealing arrangements will be simplified or eliminated with the use of water lubricated bearings and "canned" rotor construction.

Tomorrow's high pressure boiler feed pump, radical as we may think them to be, will progress in the direction of ever-increasing reliability. The day will come when a boiler feed pump can be built, tested and welded permanently into the feedwater circuit, without ever requiring to be dismantled for inspection or overhaul. Whether this happens before those of us who have had a hand in the progress achieved to date will have retired is not important. But that it will happen, I believe very firmly.

METHODS OF CHEMICAL ANALYSIS OF MANGANESE ORES

The Indian Standards Institution has just published IS: 1473-1960 Methods of Chemical Analysis of Manganese Ores, which lays down the methods for the determination of moisture, silica, barium oxide, manganese, manganese dioxide, iron, alumina, titania, calcium oxide, magnesium oxide, phosphorus, sulpur, lead, combined water, copper, arsenic and nickel in manganese ores. India has extensive deposits of manganese ore, a vital raw material in steel manufacture, and she is at present the second largest producer of this ore in the world. But the value of the ore depends, to a great extent, on the chemical composition for which correct analysis of the elements is essential therefore, the need for the formulation of this standard was felt.

U.S. TO FINANCE TWO BIG POWER PLANTS

AMERICAN Ambassador John Kenneth Galbraith announced approval of two U. S. Government loans which will together finance installations providing more than 300,000 kilowatts to India's electric power generating capacity.

"These two power plants," the Ambassador stated, "represent a very substantial step forward in India's power development programme."

The entire anticipated cost of the two projects located in Orissa and Madhya Pradesh will be met by U. S. Government credits. In recent months the United States has concluded similar agreements with India for the construction of five other projects. In all, the United States is financing the entire cost of constructing power facilities which would produce more than three-quarter million kilowatts.

The two new power stations will be built at Talcher in Orissa and at Amlai in the Birsinghpur District of Madhya Pradesh. The U. S. Development Loan Fund will give loans totalling $41.4 million (Rs. 19.7 crores) to meet the costs of acquiring equipment, materials, and service abroad. Rupee costs of the projects such as payments to workers and purchase of materials in India will be met from loans totalling Rs. 15.1 crores from the sale proceeds of U. S. agricultural commodities supplied to India.

The projected 250,000 kilowatts power station at Talcher in Orissa will rank among the biggest sources of energy in India. A smaller thermal plant producing more than 60,000 kilowatts will be built at Amlai, near Birsinghpur, in Madhya Pradesh. Amlai, a small town, is rapidly becoming a major industrial centre in east Central India.

Last January the U. S. Export-Import Bank announced authorisation of a $ 18.5 million (Rs. 9 crores) loan to a private Indian firm for purchasing machinery for a big paper mill to be built at Amlai.

Like other credits to India by the U. S. Development Loan Fund, the two loans announced are repayable in rupees.

During the last four years Orissa has taken in hand projects to increase generating capacity from 21,000 to 280,000 kilowatts. But further power is urgently needed to utilise the state's vast industrial potential. The new quarter-million kilowatt plant will be located in the coal-mining town of Talcher.

The U. S. loan will also pay for the construction of 142 miles of high-voltage double-circuit transmission lines. Conductors for these lines will be fabricated in India from aluminium ingots. Steel cores will be procured from the United States as will four turbo-generator sets, boilers, and other ancillary equipment.

The Amlai power plant in Birsinghpur District includes 352 miles of transmission lines and will make possible the exploitation of the abundant natural resources of the north-eastern region of Madhya Pradesh. The new power plant is expected to make possible the establishment of cement, pulp and paper, coal-mining, diamond-mining, and aluminium enterprises and serve existing ordnance and calcium carbide industries and electrify railways.

Since the application for this loan was submitted with completed engineering and design specifications before the U. S. Development Loan Fund announced its policy of placing primary emphasis on the procurement of material financed by its loans from the United States in October 1959, procurement with DLF funds will be world-wide.

SCIENTIFIC RESEARCH IN INDUSTRY

By R. THEDIECK

Manager of Research Operations
AEG, Frankfurt / Main, Germany

TWO pillars sustain the development of the modern technical industry: practical experience, and scientific research. Experience is the result of a civilization which has never ceased to progress within six millenniums. Science is only 300 years old, and has been a working partner of industry over a span of a hundred years at the most. Both exponents of modern industry thus tend at times to show distrust. Their frequent lack of full sense of partnership is due to the almost haphazard definition of the objectives and the limits of scientific research as sponsored by an industrial enterprise. If their interdependence can be brought into clearer focus, we can promote the collaboration between the scientist and the practical man which will largely increase the efficiency of both partners.

"Industrial Research" mainly comprises two functions: Research and Development. Research means search for new scientific knowledge and methods, an highly intellect-oriented creative work, relatively independent from economic aspects. Development means a rather product-oriented work, based upon the results of foregoing research, and ending with a functional model of a new, better or cheaper product, process or application. In the following stages of Design and Engineering, the functional models — the results of Research and Development — will be completed for production or application.

Apart from these functions, Industrial Research has some other important objectives:

— to provide methods, facilities, and services for production and product control;

— to provide personnel for technical and administrative positions;

— to provide technical informations for other company-divisions and to customers;

— to prevent or cure troubles of production or use;

— to assist in standardization.

The problems to be solved within the Research Department of an industrial enterprise are not self-contained, separated problems without relations to work and problems of the other departments of the company. Research-problems represent rather a link involved in a network, sub-problems in a complex system of problems, having multiple relations with, and causing a manifold of reactions on the other problems of that system. Within the scope of their functions, all divisions of a given company have to

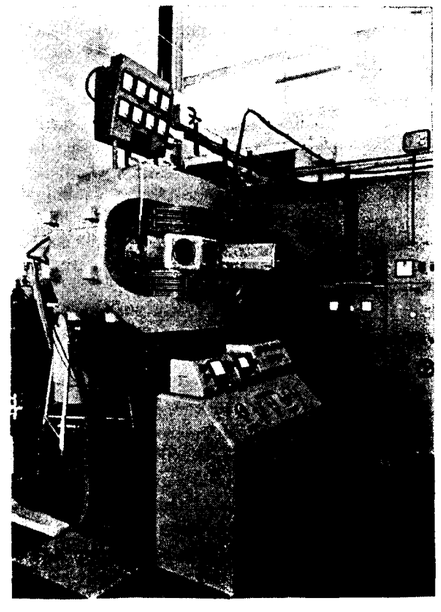


Fig. 1. Contact system of the AEG Vector-Meter at different times of the switching sequence. The element illustrated on the right, is the fixed contact, that on the left is the moving contact strip. The necessary damping effect was achieved by covering the spring with the plastic cheath.

(AEG Works Photo)

cooperate on the same set of systems or "projects". The final results of that cooperation must pay off. This leads to the postulate that Industrial Research must work for profit. Incompatible with this stays the almost pure scientific interest of the scientist; he wishes a science-minded atmosphere of work, enabling him free scientific decisions and creative solutions, without regard on commercial utility or profit.

The indicated conflict must be solved by Research Management.[1] The experience shows that there are three main problems:

(1) The growth of an appropriate Research-Organization;

(2) The selection of personnel for Industrial Research;

(3) The selection of suitable Research-Projects.

The smaller and medium companies need not to set up an own research organization. There may be a research group, but this would rank below the production department and be administered by it. Such a group will mainly deal with scientific tasks capable of a short-range solution which are immediately applicable to the daily problems of the production department. — Within larger enterprises with decentralized plants and with a diversified production programme, it is best to give each plant its own Research Laboratory for the work on short-range problems. In addition to this, a central Research Institute should be created which either works on long-range problems, or on problems which exceed the capacity or the interest of a single plant.

A sound organization scheme for a research institute, proven in many cases, takes the following form: Where a Research Institute limits its work to only one branch of sciences it is divided according to the fields of Application of that branch. Should the institute, however, be planned for one field of application only, the proper sub-division would be divided into scientific branches. Frequently an added horizontal organization is super-imposed upon the vertical one. This is certainly necessary when a large-scale project calls for the participation of workers from various scientific or engineering disciplines. Such horizontal collaboration may reach over many branches of the enterprise, e. g. in the form of a line-staff-organization.

[1] For detailed information, see the publications of the American *Institute of Radio Engineers (Professional Group on Engineering Management)* and the reports and series of the *American Management Association.*

The most important consideration in setting up a research organization, however, is to warrant optimum work-conditions for the individual scientists; the *organization* is as good as the part of working-time the scientist can spend for real research.

When faced with the selection of staff for Industrial Research, there are some facts to be considered: All major research projects call for team work. Team work calls for men with a wide-flung basic training in sciences to which has been added detailed knowledge and practical experience in (at least) one special field. Many a man may acquire such knowledge, but more important for team research are genuine human qualities which cannot be learned: Common sense, decency of character, and enthusiastic capacity for creative work.

A lack of qualified and experienced scientists may reduce the choice to men having only a basic scientific training. There remains then only the way to train such men in the firm's research laboratories. Almost good results have been gained with a special training method: The scientist to be trained gets a "task to grow with", i. e. he gets a clear defined and limited research problem for which solution he remains personally responsible from the first theoretical planning up to the translation of the results of his particular work into production. Thus, the budding scientist passes through all stages of research and development and learns to find his way along the many paths of scientific work.

The specific qualifications of the industrial research workers and the particular nature of the problem to be solved, give rise to special forms of organization and collaboration which we will name "object-related" and "subject-related" organization: If there is a research project of outstanding importance, difficulty or extent, then it is suitable to establish a special research-group solely for the work on that project and solely for the life time of that project (*object-related organization*). Wherever an out-standing qualified scientist (or a highly effective team) exists or can be hired, it seems to be useful to organize a group around this scientist (or this team) and make use of the best advantage of their particular aptitudes (subject-related organization); the problems to be solved by this group must be selected in correspondence to the qualifications of that scientist (or that team).

Considering the aims of an industrial enterprise, industrial research has either an aggressive or a

defensive character. *Defensive research* endeavours to retain company's position in the market, while *aggressive research* tends to expand and to improve this position. Tasks for defensive research (e. g. improvement of existing products or processes) proceed mostly from the production and sales departments. Tasks for aggressive research (e. g. development of new products, methods, and applications) are likely to grow out of the research institute's own work, by chance they proceed from the sales department or from the customers.

In an industrial research institute there will rarely be a lack of tasks to work on. There is rather the problem to select from a given manifold of research problems those tasks which are most important and most profitable. A thorough discussion on the various proposed research tasks is generally held by representatives of research, sales and production departments who endeavour to place them in order of priority. In a very close contact with the company's management, the director of research decides which are the worthwhile objectives, judging the likelihood with which a given research effort will bring the greatest gain in production and profit. To do so, the research director has to weigh the economic and technical conditions of the company itself (e. g. capacity of research, production, and sale) as well as external conditions (e. g. market, competitors, patents) which could have an influence on the research work and on the utilization of its results.

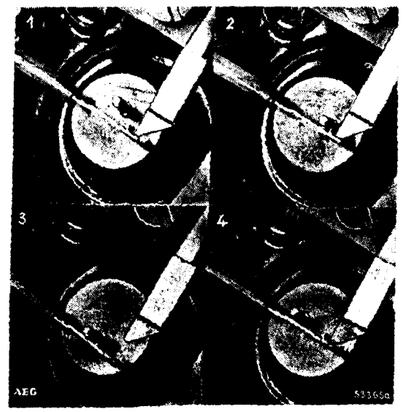


Fig. 2. Experimental model in the scale 1 to 5 of the relativistic isochron-cyclotron of the AEG.
(AEG Works Photo)

An important aspect of industrial research is the time needed to get results. In the field of pure basic research and in all cases where the target of a given research task is not very sharp defined or where a task calls for extensive work on complex problems, quick results cannot be anticipated and the probability of success is very low. The pursuit of such projects falls, therefore, with hardly any exception within the purview of major enterprises. The smaller the enterprise, the sharper defined, limited, and specialized must be the target set before its research workers, accordingly decreases the time needed to get results and increases the probability of success.

The realization of the described conception of industrial research can be shown by quoting some examples of organization and research of the AEG (Allgemeine Elektricitats-Gesellschaft): The AEG is a major enterprise of the electrotechnical industry in Western Germany. With its 28 factories in the Federal Republic and in Berlin, the AEG is a company with a decentralized production and with a wide diversified production programme. Each single factory of the AEG represents a fairly independent enterprise of medium size and with a closed production programme. Each factory runs its own research and development laboratories equipped for an immediate investigation into tasks of specific interest for this factory. These laboratories are mainly working on short-range problems growing out from the day-to-day problems of the factory. In addition thereto, the AEG maintains some central research institutes to deal with research on problems which are of interest for a group of factories or for the whole enterprise. These problems are likely to be long-range projects which call for great research capacity; the work on these problems is often involved with a high economic risk and a low probability of success. How the division of responsibility is handled between the factories' research and the central research institutes is best brought out by three examples taken from practice:

Example 1: Scope of work: Short-range research; improvement of an existing product, involving little effort in technique and time; results are confidently anticipated. A typical problem for the laboratory of a factory; this assignment may also be tackled by a smaller enterprise.

The AEG produces a precision-grade measuring instrument, called Vector Meter, to determine the phase relation

ships between alternating currents. A synchronous switch, comprising a fixed contact and a moving contact spring (fig. 1), constitutes an important part of the instrument. This switch is driven by a motor in synchronism with the electrical quantity being investigated. The system suffered from contact bounce. The transformers and chokes lately used in alternating current circuits are highly magnetized and thus give rise to harmonics. This calls for an expanded measurement range of the AEG Vector-Meter towards the high-frequency end. The expansion was limited because of the contact bounce. Hence the formulation of a research task with the aim to develop a bounce-free contact mechanism for the Vector-Meter.

A careful planned investigation conducted over a short period established the cause of contact bounce: contact pressure and damping of the contact spring were insufficient. A minor constructional change of the system eliminated the disturbing bounce and led to the desired increase in the measurement range of the AEG Vector-Meter.— Physicists and design engineers worked together on this assignment.

Example 2: Scope of work: Medium-range research; development of a new product and improvement of existing products, involving medium effort in technique and time, medium probability of success. A typical case of collaboration between the laboratories of a factory and the central research institute.

An important component, the core of transformers and chokes, of motors and generators is built up from thin sheet-steel stampings. The stacked iron-alloy laminations so far employed cause fairly high eddy-current losses impairing the efficiency of transformers and electrical machines. Magneto-strictive effects further cause the sheets to change shape and produce noise. The use of alloy steel with a high percentage of silicon helps to bring down these disturbances, but such alloys are difficult to roll down to the necessary small thickness. Hence the briefing of the research teams was to find either a new alloy possessing the required properties, or else to work out a method to modify the alloy of the ready-rolled orthodox steel strip afterwards. The laboratories of the transformer works as well as those concerned with the magnetic properties of material in one of the central research institutes are now busy in solving these problems. The assignment is broken down into its physical and metallurgical, chemical and technological aspects. There is no great probability of success because there is as yet no clarity whether there is an iron alloy possessing lower eddy-current losses and magneto-strictive effects without simultaneous loss in some desirable qualities such as the shape of the hysteresis curve.

Example 3: Scope of work: Long-range research; development of new products and processes. This programme is exacting in terms of both time and engineering effort. Results cannot be defined in advance. The typical research programme of a large business concern.

For the equipment of a German nuclear research institute a cyclotron is being developed. This machine is to accelerate deuterons on a terminal energy of 50 MeV. The particle beam is to have a high current density. Investment cost and running cost of the plant must be kept low. A vast amount of theoretical and experimental work led to the decision to adopt a novel physical principle in building this cyclotron. The main problems of this project were assigned to the central institutes of the Company to work on, but the laboratories of several AEG factories and of allied enterprises are working on sub-problems of this project. Even the latter call for special research: The magnet-yoke which weighs some 300 tons, and is illustrated in fig. 2, requires trials with several alloys and machining processes; a novel measuring and control system had to be worked out for stabilising the magnetic field; various materials had to be checked for their reliability against radioactive radiation etc. This vast project gives rise to research work, the duration of which is measured in terms of years. To solve the many individual tasks occupies scientists from all walks of the sciences and from all branches of the Company.

The conception reported upon and the practical examples quoted from actual working experience show that the scientific results and the economic success of industrial research do not necessarily fall to the most heavily endowed research budget. The desired economic success must, however, be won by the company employing both scientists and practical men who perform their work in close and active collaboration. To increase the efficiency of industrial research itself the primary requisite is a closely thought out organization covering both the staff and its methods of scientific operation. The conclusion drawn from these first principles is that small enterprises, too, are capable of performing research work of lasting scientific and economic value to themselves.

U. K. FIRM SELLS £ 4,000,000 NYLON PLANT TO RUSSIA

The British firm Vickers Ltd. announced in Moscow that it had sold to the Soviet Union a £ 4,000,000 plant to produce nylon.

The plant, which will turn out industrial yarn and tyre cord, will have a capacity of more than 6,000 tons a year.

It is the first large contract to be announced at the British Trade Fair in Moscow which opened on May 19, but negotiations for it have been under way for more than five months.

Deliveries to the Soviet Union will begin in more than a year's time, and the plant will be completed early in 1964.

The nylon plant will be assembled by the Russians, but Britain will send out technicians to supervise the work.

A Review of GEC in 1960

By A Special Correspondent

NEW CHAIRMAN

THE General Electric Co. Ltd, started off the New Year with a new Chairman, Mr. Arnold Lindley. He succeeds Sir Leslie Gamage who retired on December 31st, 1960.

Mr. Lindley, who started with the Company as an apprentice at the Erith Works in 1918, continues as Managing Director. During his career Mr. Lindley has advised the South African Government on heavy engineering industry and pioneered the manufacture in South Africa of heavy mining and other mechanical equipment. Mr. Lindley was also responsible initially for the G.E.C.'s atomic energy interests.

Sir Leslie Gamage joined G.E.C. in 1919 as Assistant Secretary, becoming Secretary in 1920 and a Director in 1925. Sir Leslie, who was responsible for the recent reorganisation of the Company, became Chairman and Managing Director in 1957. Before that he was Vice-Chairman and Joint Managing Director. Sir Leslie is currently on a tour of G.E.C. Companies and Branches overseas.

RESEARCH

Work at Wembley Research Laboratories supports most of the activities of the Company. Much of the fundamental work is concerned with new materials and components, but subjects as well established as lamps and lighting continue to yield significant new basic knowledge.

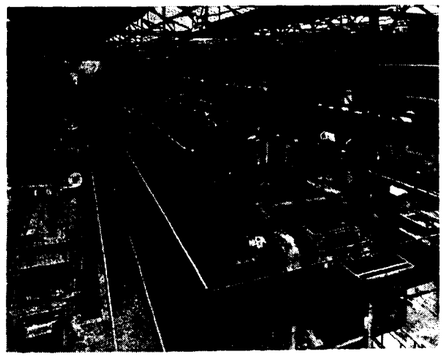
VALVES AND TELECOMMUNICATIONS

Microwave Systems

In addition to general work on microwave generators and amplifiers, studies are being made of various types of very low noise amplifiers with good bandwidth properties. These include electron beam versions, amplifiers using specially developed semiconductor diodes, and types using synthetic ruby or other paramagnetic crystal elements. The transmission properties of waveguides filled with ionised gas reveal new possibilities for amplification and power generation in the millimetre wave field.

Distortion in Frequency Modulation Systems

Numerous theoretical studies associated with broadband microwave communication systems (a field in which the Company is a major exporter), have been made during recent years. The results have provided means for calculating the effect of multiple echoes in long feeders of mutual interference in areas where large numbers of links are used. Design data for improving performance where these and similar difficult distortions apply is now available.



GEC 2000 kW continuous-strip inter-annealing furnace, viewed from the entry end. It is installed in the Cookley Works of Richard Thomas and Baldwins Ltd., and is over 350 ft. long. (Photo: GEC)

Network Topology

The solution of several outstanding problems in the theory of electric networks is being attempted using the ideas and concepts of a branch of mathematics known as linear graph theory. The types of networks to which these considerations are applicable include those used in communication systems and also the switching or logical circuits used in digital computers.

Colour Television

A 625 line colour monitor which uses novel techniques has been developed for closed circuit colour T. V. applications.

The latest developments of 405 line colour television receivers capable of working on the B.B.C. experimental colour transmissions emphasise the outstanding results of some years of research in this field. The receivers give excellent pictures in colour or black and white, are relatively simple, very highly stable, and no larger in size than the comparable black and white receiver apart from a somewhat greater back-to-front depth.

Clamp Switches

As a contribution to the Atomic Energy Authority's nuclear fusion projects, mercury vapour switches capable of controlling very large currents have been developed at the Research Laboratories. These switches, evolved from single-anode steel tank mercury vapour rectifiers and having some similarities of construction, conduct pulse currents of 130,000 amps. and withstand voltages of 40 kV.

FLUORESCENT TUBES

Extensive studies are being made of the basic factors affecting the luminous performance of fluorescent tubes. Optical studies of the fluorescent coatings are yielding a better understanding of the conversion of the ultra violet energy of the gaseous discharge into visible light and indicate that the limit for the theoretical efficiency of the process may be higher than the previously accepted value.

Parallel studies of the relationship between the composition of the gas-filling and the ultra violet output of the gaseous electrical discharge indicate the possibility of some further increase in the luminous efficiency of the tubes.

Phosphors

Further study has confirmed the improvement in the quality of fluorescent lamps resulting from the use of phosphors of special particle size distribution. Recent work has been concerned with chemical techniques for achieving this during phosphor manufacture to replace physical methods subsequent to manufacture.

New red and green emitting phosphors of improved stability and performance have been developed to replace Cadmium Borate and Willemite in de luxe colour lamps.

METALS

Fundamental research is in progress on new phenomena associated with the superconductivity of metals at the very low temperatures obtained by using liquid helium refrigerants.

Studies of the mechanical properties of very pure metals have shown that recovery and recrystallisation after deformation at low temperatures are sensitive to traces of impurities in amounts as small as 10—100 parts per million.

New methods have been developed for dispersing in pure metals refractory oxide particles of extremely small size. Significant improvements of the tensile properties of copper and nickel have been achieved with particles less than ½ micron in diameter without affecting electrical and thermal conductivity.

GRAPHITE

In association with the U.K.A.E.A., studies of the graphite : carbon dioxide system have been accelerated in a programme which has required the irradiation of well over 1000 specimens. Results have confirmed the Authority's findings that irradiation-promoted corrosion of graphite in carbon dioxide takes place throughout the bulk of the material and does not result in appreciable dimensional changes of the graphite components in a reactor. The value of impermeable graphites in highly rated reactors has thus been emphasised and development work on such materials has continued. Production plant is available to exploit these developments.

Earlier discoveries in irradiation creep of graphite have been consolidated and a preliminary lack of relationship between creep and irradiation temperature has been established.

Measurements of changes of inter-atomic spacings with temperature have been investigated over the range from—190°C, to 2,600°C, using a specially developed X-ray diffractometer.

THIN MAGNETIC FILMS

The potential importance of thin magnetic film as a basis of quick access stores in digital computers has been confirmed. Higher speeds than those of conventional storage systems can be obtained at lower costs. Experimental 200×25 matrices have been constructed for appraisal and manufacturing techniques are being developed. Basic studies include development of apparatus for the visual display of domain patterns which provide a useful means of studying the behaviour of the films.

THERMO-ELECTRIC COOLING

For some years the Laboratories have been studying semiconductor thermo-electric materials which combine the features of good Peltier cooling with minimum Joule heating and thermal conduction. Methods of preparation of thermo-electric materials of high uniformity and reproducibility have been developed and a new technique for the direct measurement, with speed and accuracy, of the thermo-electric figure of merit has been devised.

Increasing emphasis is being placed on the practical applications of these materials and a range of four cooling devices is now available in experimental quantities for assessment and use in industry. They incorporate junctions between p- and n- thermo-elements of bismuth-antimony-telluride materials and, under conditions of zero heat absorption at the cold face, are capable of developing a temperature difference of 80°C. between the hot and cold faces. This ideal condition of operation can be approached only in a suitable vacuum environment.

Smaller temperature differences are exhibited when the cold face is required to absorb heat. For a typical temperature difference of 40° the coefficient of performance is a maximum at a current of 10 amperes and the cooling powers of the units are then $\frac{1}{4}$, 1, 3 and 8 watts respectively. Maximum cooling is obtained at some 17 amperes.

ANALYTICAL TECHNIQUES

The new technique of gas chromatographic analysis has been developed and adapted to the examination of gases used in different fields of the Company's activities. For example, gas filling for lamps, gas reactions in nuclear systems, gas atmospheres for welding and furnace atmospheres used in the production of lampblack. Impurities in the rare gases have been determined at the level of a few parts per million.

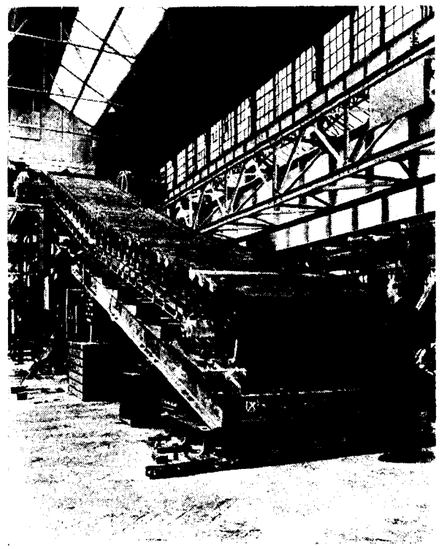
ERITH WORKS

During 1960 the largest hammermill ever built by the Company was successfully commissioned by Adelaide Cement Ltd., Australia. It is a 7260 D.N.C. Dixie Non-clog machine which can reduce limestone to 85% minus one inch square mesh in one pass at a rate exceeding 350 t.p.h. Feed pieces up to 48 in. can be accepted. The machine is directly driven by a G.E.C. 650 h.p. 600 r.p.m. slipring motor.

A range of Dyad double-rotor hammermills was introduced during the year. The main advantage of the Dyad is that it crushes large pieces of limestone and similar materials more slowly than its single-rotor counter part. This enables economies to be made in design, and in power consumption.

The Company also developed a jar-bar grizzley feeder, believed to be the first of its type in this country. Having a succession of revolving elliptical bars mounted with the major and minor axes successively at right angles, it is suitable for the screening of wet and clayey ores. On certain occasions it can also carry out the function of a feeder. Heavy duty machines are available for receiving yard cube lumps, as well as lighter models for more general use.

Development of Sherwen vibrators has been directed at the production of light, cheap-to-produce equipment. Research has resulted in G.E.C. marketing a new range of vibrating equipment using rubber in shear in place of the usual batteries of coil or leaf springs.



A pan feeder recently manufactured at the Fraser and Chalmers Engineering Works of the General Electric Co. Ltd. is believed to be the longest ever built in the United Kingdom. The feeder which is 72 in. wide and 45 ft. long forms part of a contract placed with GEC by the Associated Portland Cement Manufacturers Ltd. for a limestone crushing plant in Western Nigeria. (Photo: GEC)

Successful progress has also taken place in reducing the size of the control gear used for this equipment by using semi-conductor devices.

For a long time the Company has manufactured a wide range of mechanically operated screens and feeders. During the past year attention has been focussed on adding to this range by the addition of resonant mechanically operated vibratory equipment. An advantage of such machines is the reduction in power required.

New Range of Screens

Where medium and fine screening properties are required by the mining industry G.E.C. can now offer a new range of screens known as Vibrex, in single or double deck arrangements. Another new range of screens, the Eliptex, is also ready for full-scale production. The Eliptex screen finds its greatest application in the sizing, dewatering and draining of heavy media, and it is made with both single and double decks.

Three side-discharge wagon tipplers supplied to the South Durham Steel and Iron Co. Ltd., were commissioned during 1960. They are among the heaviest machines in use in this country and comprise a 50-ton coal tippler and two 60-ton ore tipplers. G.E.C. has continued pushing ahead in this field and is now in a position to supply heavy-duty rotary wagon tipplers up to 100-ton capacity. These tipplers have been developed because of the demand from overseas, and the latest designs include a hydraulic wagon clamping system.

An order was placed by Coppee Co. (Great Britain) Ltd., for a blending plant for Bhojudih, India, and it is being manufactured at the G.E.C. Erith Works. Comprising a reclaiming machine, double-wing stacker and a transfer car, it is designed to feed a coal preparation plant. It is of interest on two counts, one that the system blends for size as well as quality, and the other that the reclaiming machine, with a capacity of 500 tons per hour, is the largest ever to be ordered.

Earlier in the year Colvilles Ltd. placed a £2m. power plant contract for its Ravenscraig Works with G.E.C.

Furnace Developments

Two most important developments by the Furnace Department are a 1-ton semi-continuous induction heated furnace for the vacuum melting and casting of heat resisting alloys, and a furnace for heating and quenching under vacuum brazing assemblies made of heat-resisting materials. One of the features of the 1-ton furnace is the independently controlled stirring action of the molten metal which aids outgassing and ensures homogeneity of the alloy.

A pan feeder sent from Erith to a limestone crushing plant in Nigeria last summer, was one of the longest ever built in this country, if not the world. It formed part of a £75,000 contract placed with G.E.C. by the Associated Portland Cement Manufacturers Ltd.

WITTON WORKS

Serious limitations in conventional controlled chopping gaps used for generating high impulse voltages at voltages higher than 100 kV peak have resulted in the development of a new controlled chopping gap by the High Voltage Laboratories at Witton which overcomes many of the disadvantages of conventional rod gap or controlled spark equipments.

The new equipment, besides being compact, is not so sensitive to the proximity of surrounding earth apparatus as rod gap equipment and has the further advantage that it can be arranged to discharge precisely when required.

A new method of achieving either speed or torque control of a.c. winder motors has also been developed and incorporates bi-stable magnetic amplifiers. In conventional a.c. winder equipments, liquid controllers are used for introducing continuously variable resistance in the rotor circuit of the motor.

In the new scheme, the place of the liquid controller is taken by groups of grid resistors which are cut out successively by contactors controlled by bi-stable magnetic amplifiers. The magnetic amplifiers act as static switches which only permit current to flow to the contactor closing coils when they are magnetically saturated.

New ring-main units for circuits up to 11 kV and 250 MVA breaking capacity have been introduced for indoor and outdoor use. Providing a small and economical means for controlling a transformer rated up to 1500 kVA in urban and rural areas, the ring main units are designed so that the operation of one fuse automatically trips a tee-off oil switch to isolate the circuit completely.

For use where space is severely restricted, a new type of double-fronted motor control centre has been developed. With a total depth of only 2 ft. 6 in. the cubicles can accommodate starters in both sides. Motor control centres having starter trays fitted with plug-in contacts for both the incoming and outgoing supply were also introduced during the year.

BIG CONTRACTS

Big contracts placed with the heavy electrical engineering side of the Company include a £ 2.25m. order for rolling mill drives for the Llanwern Spencer works of Richard Thomas & Baldwins Ltd. The 63-in. hot strip mill, for which G. E. C. will supply the main drives, will be one of the most powerful of its kind in the world. Five 8000 h. p. motors and a 7000 h. p. motor will drive the 6-stand mill.

Two overseas orders received by the Company are worth together £ 2m. The first was for two 60 MW turbo-generators for Kelvin 'B' power station, Johannesburg, and it covered the third and fourth sets for the station, a contract for the first two machines having been received earlier.

The second large order was for two 15 MW pass-out turbo-generators for installation in the Ras Abu Aboud power station, Qatar, a rich oil state bordering the Persian Gulf. To this contract, which was valued at £ 700,000, should be added an earlier one of £ 207,000 for switchgear for the same area.

100 M. P. H. ELECTRIC LOCO

A G. E. C. 100 m. p. h. 25 kV a. c. electric locomotive was used to inaugurate the new electrified route between Manchester and Crewe. In all ten G. E. C. locomotives were ordered for this line.

G. E. C. electrical power equipment was also used in the new high speed inter-city diesel-electric Pullman trains.

Other important contracts included one for 2,800 traction motors for new London Underground trains. It was the largest single order for traction motors ever placed in this country and brings the total number of G. E. C. motors for London Transport to over 6,000.

A new G. E. C. development which has been used on rolling stock is the use of transistor inverters for operating fluorescent tubes on low-voltage d. c. supplies. For British Railways Eastern Region, the Company has developed a power-pack type inverter, input being from a 110V d. c. battery. The largest transistor unit made so far, it feeds four 4 ft. 40W tubes and is being used in multiple-unit coaches.

Transistor inverter operated fluorescent lighting is also being installed in a new batch of coaches being built for the Pullman Car Company.

In addition to lighting equipment, G. E. C. has developed a range of special electric heaters for use alongside existing steam heaters in coaches which will be hauled by steam, electric or diesel locos during the traction changeover period. The unit is designed to operate from either the 1,000V a. c. supply of electric locomotives, or the 800V d. c. supply on diesels. Also for these coaches, the G. E. C. has produced a 1-gallon toilet water heater which incorporates a steam pipe and which can operate from 1,000V a. c. or 800V d. c.

Signalling plays an important part in British Railways modernisation plans. S. G. E. — an associate Company — has extensive contracts in this country and abroad. For instance, S. G. E. is responsible for the conversion to $83\frac{1}{3}$ c/s of the signalling installations from Liverpool Street to Bethnal Green, Shenfield to Chelmsford and Southend, and Fenchurch Street to Bow.

MULTIPLE-UNITS

Last October, the British Transport Commission placed an order worth over £ 580,000 for electrical equipment for 23 high-speed a. c. multiple-unit electric trains. These will run on inter-city services on the Eastern Region between Liverpool Street and Clacton or Walton.

In November, 71 new multiple-unit electric train sets fitted with G. E. C. traction equipment went into service on the Liverpool Street line to Enfield Town, Chingford, Hertford East and Bishops Stortford.

These trains developed electrical faults and many of them had to be withdrawn from service. A team of top G. E. C. traction experts was sent to Ilford, where workshop facilities had been made available by B. R. Eastern Region, to investigate the breakdowns.

When the trouble was found, it turned out to be a high-voltage surge which was sometimes generated in the traction motor circuits. This fault had never before been experienced with the equipment used.

Work is now going on fitting the units with equipment to overcome the surge. The trains which had already been tested for 34,000 miles without any failures, are now undergoing further track testing.

SALFORD ELECTRICAL INSTRUMENTS LTD.

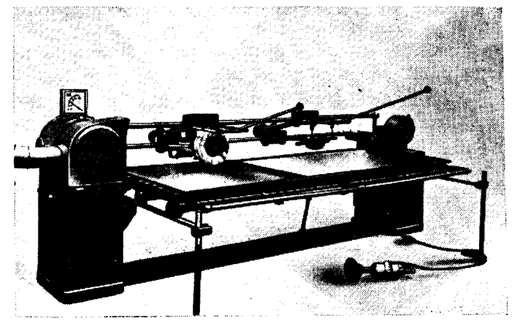
Nucleonic level indication for rough, heavy materials is fast establishing a reputation for reliability which is of paramount importance in industries such as coal mining. A complete installation by Salford Electrical Instruments of its multi-level transistorised equipment has been working continuously night and day since August, 1958, without maintenance of any sort, at the Gedling Colliery of the National Coal Board.

Particular attention has been paid in the design of this equipment to operator safety against gamma radiation and the stray radiation at 12" is below the level of that from a luminised wrist watch. The N. C. B. has now adopted this design, which has been developed in conjunction with its Central Engineering Establishment, as a standard for the industry.

The first commercially available thermo-electric cooling unit in the U. K. was marketed by S. E. I. during September last year. This is designated the B. T. 4 with a capacity of 1 watt and is the first of a line up to 10 watts which are now available. Years of research by the Research Laboratories of the G. E. C. have culminated in the marketing of the most compact cooling blocks available anywhere in the world. This range of coolers is aimed at the instrument market rather than domestic refrigeration and fills a gap below the capacity of conventional refrigeration systems. Typical of this instrument application is the thermo-electric hygrometer, also introduced in 1960 by S. E. I. By adaptation of this basic hygrometer, gas water contents as low as 50 parts per million can be measured and their variations continuously recorded.

JOHANNSEN Single-belt Sanding and Buffing Machine – Model BSME

THE single-belt machine is employed wherever the work volume is not sufficient to utilize the full capacity of a double-belt grinder. It is also much better suited for fine and wet grinding since it permits better observation of the progress of sensitive work, giving the operator at the same time a better "feel" for the grinding pressure. Otherwise, operation and design are similar to those of the double-belt grinder. The machine can be equipped with a wet grinding device, a brushing and buffing unit, and a hand grinding attachment. The wet grinding device consists of a simple band sprinkler with pump, drop feed bucket, and distributing brushes which do not touch the belt so that they are not subject to wear. Dropfeed supply is easy to regulate and a container is provided to collect excess grinding fluid.



Model BSME
Single-belt Sanding & Buffing Machine

By continuously wetting the grinding belt, the grain is kept open and fully effective the work piece is cooled and grinding quality improved. With soft material, too, and especially with aluminium, wet grinding is indicated to obtain a clean finish.

Like the grinding device, the brushing and buffing unit is arranged movably above the table. Contact pressure on the brush and buffing mops is effected by hand. The polechanging motor is layed out for 1500 and 3000 rpm.

A Hand grinding attachment is recommended for the correction of pronouncedly faulty work. The metal is briefly ground to make the faulty spots clearly visible. After all faults have been eliminated, by means of the hand grinder, the hand grinding marks are ground off uniformly with the belt. For all work on this machine, only the inexpensive paper grinding belts are used.

HEAVY-DUTY METAL CLEANING MACHINE

A U.K. firm, specialising in dish and bottle washing machines and metal cleaning and degreasing plant, have introduced a heavy-duty dunking machine.

Pneumatically operated throughout the dunking operation the machine is intended for applications where soaking and agitation are more suitable than other metal cleaning methods. Typical of the variety of uses to which it can be put are the washing of sand from castings and the rough cleaning of cylinder blocks,

The pieces to be cleaned are transferred from a feed roller conveyor to the dunking table which the operator lowers into the cleaning solution by means of a control valve. When the table reaches the bottom of the tank the dunking automatically begins immediately. A strong turbulence is started on the cleaning solution which scours all surfaces of the pieces and penetrates the recesses, loosening and removing sand, grease or other residues. At the end of the cleaning period, the operator reverses the control valve which stops the dunking action and elevates the table. The action of pushing the next batch of soiled pieces on to the table ejects the cleaned load on to a roller conveyor at the other side of the machine.

A filtration system can be fitted to provide continuous filtration of the cleaning solution.

The Modern Lathes of French Machine-Tool Manufacturers

IN recent years, considerable changes have taken place in the design of machine-tools in which French manufacturers are often in the lead. The tendency for simplification of operation together with a wider range of performances on the same machine has become generalized. Although the solutions to the same problems differ widely, they all endeavour to satisfy the demand for greater productivity and for greater flexibility of operation which aims at lower costs.

Although these characteristics from the economic point of view are essential preoccupations of the manufacturers, the latter have not lost sight either of esthetic questions and the label "Beaute France", awarded to machine-tools also, denotes the union of simple and pleasing forms with mechanical precision and operational protection that is difficult to achieve.

The user knows that it is not easy to tell in advance what the tooth of time and unfavorable climate will do to a machine but can rely on the fact that specialized machine builders and specialized research laboratories work hand in hand in France. In research for eliminating undue vibration, for constant precision under variable demands and temperature, for lasting accuracy of precision-measuring components such as lead-screws, the designers widely have reference to the Machine-Tool Testing Station which is an official organization equipped with the latest means of investigation and analysis.

The contributions of the welding Institute, the Metallurgical Research Institute and the Foundry Investigation Center have had a large share in the progress of machine-tool design which is a perfect example of the interplay of science, engineering and technics. A few French machine-tool builders have acquired a world-wide reputation, including such countries as Switzerland and the United States, and their designs are being built and sold under license in several countries.

Lathes are being produced by almost all manufacturers with many years of specialized experience and more than one of the latter has quietly celebrated the centenary of the company in years past. The engine lathe is, of course, the most widely utilized machine-tool because even the smallest machine-shop has at least one and large plants have them in long rows. Characteristics of the machines vary from one manufacturer to the other and from one model to the next which is an indication of the wide choice offered the buyer so that we can here give only the range of the dimensions between which the characteristics of individual models vary.

SLIDE LATHES AND SCREW MACHINES

Small-Size Lathes

This classification covers the following limits:

Center height	100—155 mm
Distance between centres (average)	315—800 mm 550 mm
Speed changes (quite often)	6—12 16
Spindle speeds	25—3,000 rpm
Motor rating	0.6—4.0 hp

Noticeable among them is the utilization of nitrided steel spindles; precision roller-bearings; turret tailstocks; and fast-return feeds for screw-cutting and tapping.

Some lathes have hardened and chromed beds with instant brake-stopping and clutch-release of headstocks. Some others allow 100—150 mm (3.937—5.905 in,) off-center turning without chattering. Still others are three-in-one combinations of production, finishing and tool-room lathes. Nearly all of them are designed to permit easy mounting of a copying attachment. Their general characteristics are very suitable for Technical Training Centers.

Medium-Size Lathes

There are many more models of these which have much wider limits:

Center height	170—315 mm
Distance between centres (in some cases)	500—1,500 mm 4,000—6,000 mm
Speed changes	16—18
Spindle speeds: (smaller sizes)	30—2,000 rpm
(larger sizes)	6—2,000 rpm
Motor ratings	7—20 hp

Two models have exceptional characteristics with 36 spindle speeds from 5—2,000 rpm for one and 58 spindle speeds from 12—1,000 rpm for the other. As a general rule, feed and thread gears make it possible to cut International Standard and Whitworth threads directly. A copying attachment can be mounted easily and quickly on almost all of these lathes.

Some of the lathes have characteristics not shared by all of them which are indicated here as part of individual designs, without general validity:

Headstock: permits changing spindle speed during cutting so that optimum cutting speed can be utilized for turning different diameters on the same piece; there is no need to stop the motor for changing speed either during working or idling;

Tailstock: has an automatic feed for drilling and boring simultaneously with exterior turning operations;

Foot controls: in order to reduce idling time, a system of foot controls has been designed for starting, braking and clutch-release of the spindle, together with a car-type gear shift for speed-changes and a tailstock, fitted with a fast-action approach and return of dead center which has a direct-reading vernier scale of longitudinal displacement on the bed.

Particular attention has been given to precision and protection by incorporating some or all of the following features:

hardened and ground slideways; oil-bath lubrication of gears; overload clutches for automatic disconnection of carriage drives; interlocking systems for carriages; pilot lights for components under tension or in movement; automatic switches.

Some lathes are built for full-electric operation with start, stop and reversing switches and have no clutches. Operations are simplified and speeded up by a variety of auxiliary devices such as synchronized stops for reducing manual displacement of tools; adjustable vernier-scale stops for turning diameters to within 0.005 mm. (0.0002 in.); pre-setting devices which make it possible to prepare outside of the machine all tool and synchronized-stop settings for machine-feed travel and diameters with an accuracy of 0.01 mm. (0.004 in.).

Large-Size Lathes:

These lathes are built only by the larger companies and their characteristics as shown in the table below vary widely between the different models whose capacity and range of speeds permit a great variety of operations.

Center Height	*Distance Between Centers*	*Spindle Speeds*	*Revolutions per Minute*	*Horsepower Rating*
600—700 mm.	2--15 m	22	3.2— 400	50
1,700 ,,	10 m	24	0.7— 56	90
360—500 ,,	1—22 m		6—1,600	20—40
650—800 ,,	2—22 m		1.5— 250	50-120

Slide Lathes

In answer to the demand of customers who do not want to utilize the engine lathe any longer, certain models with center heights between 100 and 800 mm (3.937—31.496 in.) are designed for operation exclusively as slide lathes and most of them are arranged to permit the use of a copying attachment.

Vertical Boring Mills

One model with the characteristics of an engine lathe (center height of 200 mm = 7.874 in. × distance between centers of 1,000 to 1,600 mm = $3\frac{3}{8}-5\frac{1}{4}$ ft.) ha a variable center height with a maximum of 400 mr (15.748 in.). The vertical movement of the head has a automatic drive, linked to the thread and feed gears s

that milling operations are possible. Various accessories such as a steady-rest for boring and a universal-milling head give it an all-around character of operation which has considerable advantages in machine-shops building prototypes or in an installation on board ship.

Copying Lathes

There are three distinctive models of these :

	Center Height	*Distance Between Centers*
(1) Stationary or revolving template	180—220 mm	700—1,000 mm
(2) Automatic cycle and revolving template (with automatic feed & delivery	190 mm	750 mm
(3) Automatic cycle permitting 4 successive operations under punch-card control	200 mm	500—1,000 mm

The last model meets the requirements for repetition of small and medium-run production. Set-up is very simple and very little time is required to convert from one production run to the next.

Turret Lathes

The makers of turret lathes offer machines which differ widely in their characteristics as shown below :

Swings	180— 500 mm
Spindle bores	16— 40 mm
Spindle speeds	25—1,800 rpm 40—3,000 rpm
Motor ratings	0.75—12 hp

One special model is designed for a spindle bore of 72 mm (2.834 in.), 24 spindle speeds from 40 to 1,600 rpm, and a 25-hp motor. All these lathes are arranged to change speed during operation and under load and are equipped with one or more of the following features :

pneumatic clamping of bar stock ;

automatic adjustment of cutting speed to cutting tools through rotation of turret ;

reverse spindle rotation for backing off thread taps and dies ;

direct starting and automatic stopping ;

electrohydraulic controls subservient to electronically controlled sequence of operational cycles ;

operational cycles determined by position of plugs on the ordinator panel ; placing of plugs requires only a few seconds and no special knowledge ;

punch-cards are provided for standard operational cycles.

Automatic Lathes

The greater part of these machines have single spindles and the following characteristics, depending on manufacturer's types and models :

Spindle bore	10— 65 mm
Spindle speeds	190— 930 rpm 1,200—6,000 rpm
Motor rating	3—8 hp

Stationary or mobile headstock ;

Double-taper chuck for face-plate work ;

Friction-clutch drive for thread cutting.

The standard model of one type has 12 working positions (6 on turret) which can be increased to 14 by mounting an 8-position turret.

There is also a special 6-spindle lathe with a capacity of 73 mm (2.874 in.) and a 44-hp motor which was designed specifically to cut setting-up time down to a minimum. The single cam shaft is located at the top to afford ease in adjusting the cams. The 6 cross-feeds have individual controls. For each spindle, a pre-set stop trips the stop-screw of the carriage.

A recent new design for a lathe is intended for automatic high-speed machining of foundry and die castings. It has a single spindle in a mobile headstock with an air-operated mandrel and a stationary tool column with two vertical slideways, on each of which two groups of tools can be mounted, and a longitudinal cam shaft. In addition, it is equipped with a hydraulic drillstock and a thread-cutting attachment with thread-pitch changer as well as a tapping device for r. h. or l. h. threads in small and medium dimensions. A camshaft accelerator reduces idling time when there are many unproductive intervals.

Vertical Lathes

With lathes which are able to machine even the largest pieces and reach a diameter of 8 m (26¼ ft.) with a height of 3 m (9¾ ft.), French manufacturers of such models are among the leading machine-tool builders in the world. They are built with 1 or 2 uprights and generally have a stationary seat. However, some of them have a mobile seat for machining very large dimensions. Motor ratings range from 25 hp for the smallest to 90 and 100 hp for the very large ones.

Beside the taper-turning attachment and direct cutting of International Standard and Whitworth threads, other recent features include :

face-plate drive through variable-speed DC motor ;

very wide range of spindle speeds ;

direct starting on motor without the use of the clutch ;

electromagnetic brake for face-plates ;

hydraulic feed-drives ;

automatic hydraulic clamping of the arm on the upright and of the seat on the bed ;

full-automatic lubrication ;

ventilation of the upright of the transmission casing and the motor.

These lathes can be equipped with automatic copying devices and can carry, instead of one of the carriages on the arm, either a milling/boring head or a grinding unit or a special device for boring diesel-engine cylinders.

Face Lathes

Center heights	1,000—1,200 mm
Face-plate diameters	2,000—2,500 mm
Spindle speeds	2—2,000 rpm
Motor ratings	48 hp

Wheel Lathes

Center heights	650— 800 mm
Maximum turning diameters	1,274—1,650 mm
Minimum turning diameters	750— 950 mm
Face-plate speeds	3.5— 30 rpm
Motor ratings	75 hp

By offering the large variety of lathe types and models discussed above, the French machine-tool manufacturers have been able to enter world markets successfully. Very recently, 200 single-column vertical lathes, some of them of very large capacities, were sold by the same manufacturer to Great Britain and 60 were exported to the United States. The same manufacturer has also delivered lathes of all capacities to nearly all countries of the world.

All of the same trademark, 450 semi-automatic turret lathes have been sold to large British companies in recent years. Spain has taken delivery of 70 lathes with a swing up to 1.75 (5⅝ in.) and distance between centers of up to 10 m (32¾ ft.).

In 1959, exports of engine lathes with a weight of less than 5 metric tons amounted to 1,000 units and one manufacturer in this field can point to the fact that more than 10,000 lathes of the same model from his shops are in service in France and abroad.

(Courtesy : French Economic and Technical Bulletin)

Heinrich Guideway Grinding Machines & Surface Grinders

By An Engineering Correspondent

We publish below a brief technical write-up on "Heinrich Guideway Grinding Machines and Surface Grinders" and their salient features. The products marketted by the firm of 'Heinrich Schneider O.H.G. Werkzeug-und Maschinenfabrik' throughout the world have more than two decades of research, leadership and manufacturing experience. We are sure, in view of our Country's pledge to industrialise during the third plan period, the following write-up will be of considerable interest to our Indian Industrialists—Editor-JOISE.

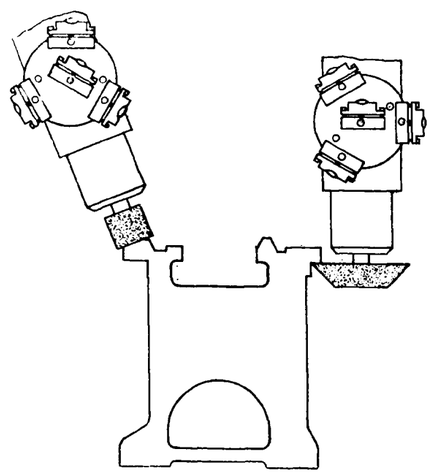
HISTORY

MR. JOSEF SCHNEIDER, the present chairman of the Company, has first started to develop surface grinders a few years before the second world war. During the war, more urgent production has prevented any further development. As soon as the war was over, newly designed machines were produced and continuous development was especially concentrated on improvement of Heinrich slide way grinders.

Upto now, the range of machines comprise all types of surface and slide way grinders, necessary to perform

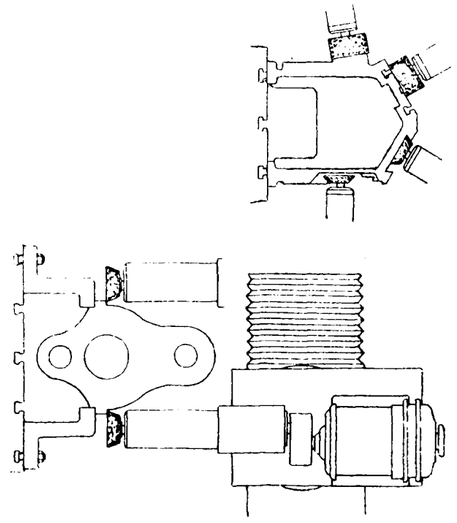
all grinding problems—the only firm throughout the world building all types of these machines.

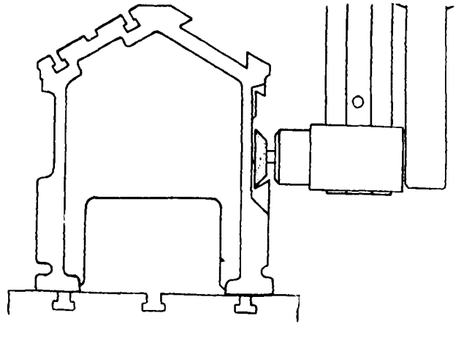
The range of machines being built starts with a small simple single column grinder with either a horizontal or vertical spindle. This machine is being built in different sizes. The same type of machine can also be delivered as a double column surface and slide



way grinder. More variations have been developed of which that slide way grinder is especially noteworthy which allows to grind workpieces with grinding lengths upto 10—20 meter. Also rotary table surface grinding machines have been developed allowing to grind workpieces upto 3 meter diameter.

As the field of application has been extended, automatics have been required to grind parts to closer limits of accuracy for long periods with the minimum of attention. The extensive range of program is mainly covered by a few fundamental units allowing to produce the machines most economically. It may be mentioned here again, that the company is mainly interested on the description of the slide way grinders. Slide way grinding on machine tools and similar machines has proved to be far superior to any other

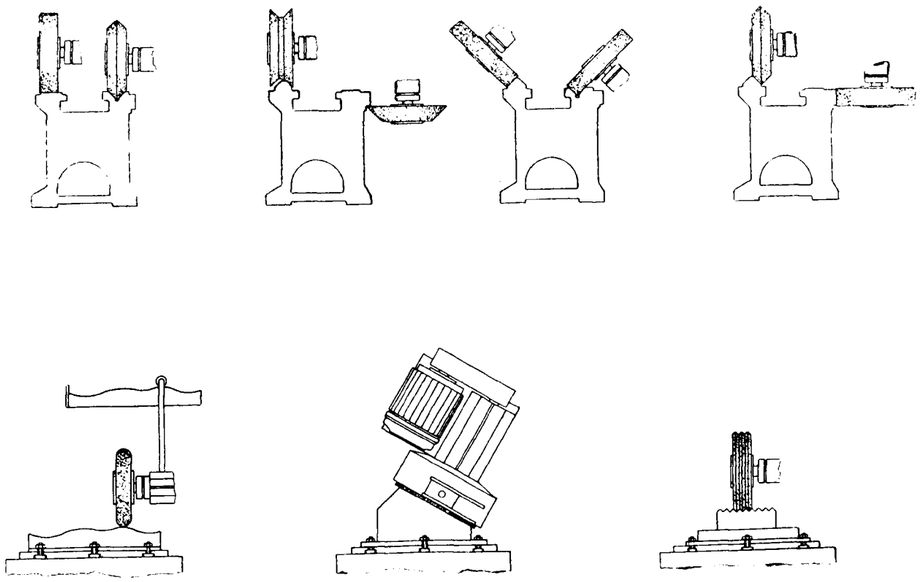




method of finishing. Therefore, all leading makers of machine tools prefer ground slide ways.

As the sizes of machine tools have constantly grown in recent years, the slide ways have grown with as far as length and width is concerned. This brought about that more attention has to be paid to the grinding problems. Another type of slide way grinder had to be introduced. It is Heinrich's Model JO WFS. Conventional grinding is termed when the workpiece is fastened on the table which slides towards the grinding wheel. This method of grinding is no more applied on the Model JO WFS. Instead the workpiece is placed on a base plate in front of the machine and all movements are concentrated on the grinding wheel. In this case the grinding machine will become more stable and the length of the machine will be shorter.

Slideways on machine tools are often placed in most intricate positions requiring angular setting of the spindle. The universal grinding head delivered with machines if ordered can be swivelled through any angle upto 90°. Using the appropriate grinding wheel all



grinding operations can be carried out to exact requirements. While the dimensions of slide ways on machine tools have been increased, the tolerances for geometrical accuracy and surface finish have become more closer. But the design of the grinding machine is dictated by the requirements of the job and had to stand up to it.

Heinrich machines have proved throughout the world their adaptability, efficiency and accuracy. Grinding lengths of 4 meter and more may be finished within tolerances of 0.005–0.01 mm. over the whole length while surface roughness may not exceed 0.8—2.

On special request, finer limits may be achieved. However it is to bear in mind that too high accuracy may be very costly and may even be a danger to the life time of the machine. The life time of the machine and accuracy depend very much upon the finish slide ways. If a constant oil film can be maintained between two surfaces sliding on each other a long service life is achieved. On reversing of the sliding parts the oil film will be interrupted, even more, if the surface finish is too high. If the finish is not at its best oil may remain in the fine grinding grooves and lubricate.

The continuous development of Heinrich machines based on the accumulated experience and the close co-operation between engineering service department and the industry at large will result that these machines comply with all requirements as far as shape, stability, efficiency, accuracy and life time is concerned.

All slide ways of Heinrich grinding machines are ground on their own makes. All the sliding parts are lined up with plastic materials creating ideal sliding conditions.

BRITISH OXYGEN FIRM'S DISPLAY AT INDUSTRIES FAIR

"British Oxygen aids the growth of modern India" is the theme of the exhibit organized by the British Oxygen Co. Ltd., of London, in the British pavilion at the forthcoming Indian Industries Fair in New Delhi. Products, photographs and diagrams will indicate the many ways in which British Oxygen is helping Indian development plans. On show will be a scale model of a tonnage oxygen plant, and there will be illustrations of the two tonnage oxgen plants which have been installed in the new steelworks at Durgapur and Rourkela. The firm will display a comprehensive range of products, including a selection of the company's specialized anaesthetic equipment, electric tube-welding machines, various items of aircrew breathing apparatus, and a new liquid-oxygen system which is used in many modern fighter aircraft.

BID TO ELIMINATE COAL-DUST EXPLOSIONS

A full-scale explosion gallery is to be set up on a site at Buxton, Derbyshire, as part of a drive to eliminate coal-dust explosions in Britain's mines.

The gallery will be 400 yds. long, have a cross-section of 60 sq. ft. and be completely instrumented, states a report issued by the Safety in Mines Research Establishment of the Ministry of Power.

According to the report, the establishment has extended its studies of layers and accumulations of gas and of the means of detecting them. The study of a flame lamp has confirmed that it performs well in detecting fire damp in the general body of mine air. But in thin layers the response of the lamp is less certain, and modifications to improve its performance are being considered.

The real solution to the problem of mine gas ignition due to shot firing is the development of explosive detonators and exploders with which chance ignition is negligible. Manufacturers have developed safe detonators and an adequate exploder, and are making progress with safer explosives. A method of assessing the safety of these special explosives has also been devised. Visitors from all over the world, including some from India, were shown round the laboratories at Buxton during 1960, says the report.

* * *

NEW PROCESS FOR THE MANUFACTURE OF REFRACTORY INSULATING BRICKS

A new process for the manufacture of refractory insulating bricks and special shapes, known as the "23 range", has been announced by a British firm. The process produces standard rectangular shapes with a density of 48 lb. per cubic ft. and special forms of 60 lb. per cubic ft., both with a service temperature of 2,300°F.

The new method breaks away from the traditional process in which a mixture of clay and combustible is kilned in order to produce an oversize block from which the finished brick has to be machined. The need for a combustible constituent is entirely eliminated, and the as-kilned product is true to shape and ready for dispatch. Production rate is twice that of the traditional system.

* * *

SAFE-LOAD INDICATOR FOR CRANES

Ekco weight trip amplifier, type N684, is a fully-transistorised, battery operated instrument designed to provide accurate indication to the crane driver when the maximum safe load is being approached or has been attained. Two main systems are in production, one of which provides an amber lamp signal at the pre-set safe load and two further lamp signals at a pre-determined per cent. deviation below and above the safe load respectively. The other system provides a red signal lamp indication when the safe load limit is reached in addition to continuous meter indication of per cent. actual safe load.

The instrument utilises the normal 12 volt supply fitted to the crane and draws very little current.

* * *

AUTOMATIC MACHINE DRILLS PRINTED CIRCUIT BOARDS

A new fully automatic printed circuit drill specifically designed for fast drilling of component fixing holes in printed circuit boards, has been produced at the Scottish plant of Ferranti Ltd.

The machine is already being used successfully for drilling the hundreds of printed circuit boards required for the company's Atlas high-speed computer, and Argus process control computer.

Basically, the machine consists of two drilling heads allowing either tandem or single spindle working; a hydraulically-operated co-ordinate table carrying the printed circuit boards which is automatically moved to bring the board hole centres in turn below the drills; and a control system for the drilling action and table movement which enables the machine to work unattended except for loading and unloading.

* * *

ELECTRON ACCELERATOR EXAMINES STEEL UP TO 12-INCH THICKNESS

The English Steel Corporation Ltd., of Sheffield, has become the first British steel producer to introduce a linear electron accelerator for the examination of steel castings and weldments made from forgings and castings.

The accelerator is incorporated in a six million volt X-radiographic unit. This new piece of non-destructive testing equipment (of the sealed off type) will be used by the corporation and its subsidiaries for the examination of steel up to 12 ins. thick. It will provide considerable reductions in the time previously taken for examination of steel products by means of radioactive isotopes and definition is expected to be greatly improved due to the much smaller size of the X-ray source.

WALDRICH HEAVY MACHINE-TOOLS

By A Correspondent

HIGH investment costs require special consideration and impose exacting demands upon the manufacturers of heavy-duty machine-tools. Machines are expected to incorporate universal production facilities, since the purchase of a special machine for any single operational process is not economical. Design, dimensions and operation have to be closely adapted to prevailing demands made by practice. In addition to these features, a maximum economical rate should be achieved, such as :

* max. metal removing capabilities and fullest possible automation, to obtain shortest production times

* high surface quality and machining of workpieces to close tolerances in order to avoid any manual retouching work

* long life machine performance and accuracy

The purchase of a heavy duty machine-tool is a matter of confidence.

The H. A. WALDRICH GmbH. SIEGEN with their approved staff of specialized workers and designing engineers supply *heavy duty machine-tools according to production requirements in approved quality.*

Decades of exacting experience in the design of heavy duty machine-tools, thorough investigations into their practical use, and latest findings in the metal removing and control techniques characterize the conception of their machines. Owing to the *sturdy construction* which has been consistently applied in all machine components — from the cutting tool to the foundation — WALDRICH-SIEGEN heavy duty machine-tools satisfy the highest demands for performance and accuracy.

In the world of roll foundries, steel and rolling mills, large motor- and turbine manufacturers, shipyards and machine-tool factories, WALDRICH-SIEGEN products are renowned for their high efficiency and reliability.

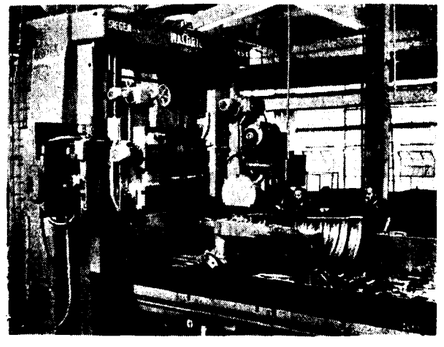
The Company, with Dr. Ing. e. h. Oskar Waldrich as sole proprietor and president, deems it its first duty to maintain its worldwide reputation and to fulfil always their customers' expectations.

PLANING MACHINES

By a correlation of such design features as sturdy construction and careful manufacture of all machine components, WALDRICH-SIEGEN planing machines are intended for both roughing and finishing operations with maximum surface quality and precision. In addition, the compact design favours service life of the tools and allows full advantage to be taken of current carbide techniques.

The *baseplate*, the cross beam, the particularly stout columns, and the bed center portion form a rigid framework construction, the rigidity being increased by the crossrail with a number of clamping elements. Even the heaviest cutting forces are absorbed without inadmissible deformation or vibrations. In addition to this, the base plate facilitates assembly and allows repair work to be done by withdrawal of the bed without dismantling the columns.

The gear in the center portion of the bed meshes immediately below the cutting location in the table



Machining of joints of a high-pressure steam-turbine housing on a WALDRICH-SIEGEN combined planer type grinding machine.

rack so that a short power flow is obtained and no moments occur. Precision helical gears, machined from the solid, guarantee smooth running.

The *table drive* by a D. C. motor in conjunction with a Ward Leonard set incorporates such features as:

Large, infinitely-variable speed range at constant pulling power

Cutting and return travel speed variable independently of each other

No distortion of the bed by heat influences

Table reversal without shock and uniform movement even with varying cutting force, which is of prime importance for the service life of carbide tools.

The *table* runs in two unsymmetrical prismatic ways which, with their acute angles, safely absorb all cutting forces in the transverse direction and eliminate any detrimental bearing upon the rectilinearity of the table guide. The sliding faces of the table are covered with synthetic plastic plates (wear plates) in order to eliminate any damage to the bed ways by seizing or scoring and to preserve guiding precision over years. Planers from 158" (4m) working width upward have two symmetrically arranged bed gears standing side by side as well as one prismatic way in the center and two flat ways at the outside.

Lubrication of the *bed ways* and *gears* is controlled by an oil pressure switch which is located in the lubrication line with fail-safe operation so that if the lubrication pump should fail, the main drive motor is immediately cut off from its power source.

The planing heads on the crossrail and at the columns can be swivelled over a wide range in order to enable machining of oblique surfaces. The vertical retraction of the tool slides allows a high amount of tool lift (as is necessary for instance in the planing of T-slots) even for short run-outs. To eliminate any backlash and vibrations, tool slides and head slides are automatically clamped during the cutting process.

On machines having a planing width of up to 100" (2.5 m), horizontal and vertical feeds and rapid traverse for the crossrail heads are arranged through a gearbox and traversing spindles, whilst machines with a planing width of over 100" (2.5 m) have individual drive of the heads over worm and worm rack. Due to the Ward Leonard regulation of the feed motor and two mechanical gear steps set over magnetic clutches, a feed ratio of 1 : 100 is available.

Resistant to torsion and deflections, the *crossrail* is suspended in its gravity points by two synchronized precision spindles. In order to ensure a continuous and uniform parallelism to the table plain, the crossrail is automatically relifted for some distance after every move.

Should deviations caused by ambient temperature influences occur, optical means are provided at the right-hand spindle of the rail to check and compensate these.

The *operational control* of the machine is possible either from the centralized operator's control station, where instruments showing cutting speed, feed and load are installed, or from pendant stations at the operator's discretion.

COMBINED PLANING AND MILLING MACHINES

In addition to satisfying the demands made upon heavy duty machine-tools as previously mentioned, the combination planer milling machine offers the essential feature of versatility.

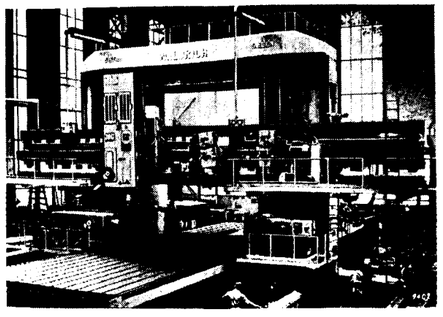
With milling cutter production at current high standards, milling (perhaps except for very long surfaces) is superior to planing as far as metal removing capability and economy are concerned. In addition to the typical operations which are possible on a planer, such as the machining of long, uninterrupted surfaces, these machines are also capable of typical milling work, such as the machining of transverse, oblique or vertical surfaces and slots, the machining of various internal bores and, of course, surface milling to any given dimensions. In spite of these features, planing cannot be overlooked in cases where accuracy and surface quality are the prime demands made.

In designing two features, namely milling and planing, into one machine and by adding a grinding head, an ideal solution has been found, since workpieces, such as gearboxes, turbine housings or Diesel engine frames with all their surfaces, bores and bearing locations (except the base which has been planed prior to this) can be finish machined in one set-up.

The success is derived, not only from a substantially shorter machining time, but above all from an increased measuring and angular accuracy, since each fault unavoidable in re-setting a workpiece can be eliminated. In addition, two further vital factors cannot be overlooked when considering the high chip removal and machining accuracy that is obtained on WALDRICH-SIEGEN combination planer milling machines, namely :

It is quite obvious that greater faults will be inherent in a movable guide (crossrail, bed) than in a firm frame construction (portal), since these faults increase as the square of their distance from the cutting point. The workpiece on a table planer and miller is, however, enclosed by a rigid portal so that distances of the cutting points from the corresponding guides are reduced to a minimum. Likewise, the resultants caused by cutting forces are minimized in the guides.

The horizontal set-up is particularly favourable, since it does not require any complicated auxiliary means (such as angular clamping plates) and consequently reduces any tendency to distortion by the clamping forces. A better support of the workpiece is the direct result of the above fact with subsequent possibilities of increasing the cutting forces. The horizontal position also facilitates measuring operations prior to and after machining.



The largest type WALDRICH-SIEGEN combined planing and milling machine with a capacity of 16' 5" x 13' x 72' 2" (5 m width x 4 m height x 22 m) planing length equipped with a combined planing and grinding head on the right-hand side of the crossrail.

The *frame work construction* in its known design with base plate offers even higher stability by providing an additional column guide to the crossrail and by increasing the number of clamping elements on the rail.

The *table milling feeds* are derived from an intermediate gearbox having two mechanical steps over magnetic clutches and Ward Leonard regulation of the drive motor. Change-over from planing to milling can be performed instantly.

The table ways are protected by the use of a special babbit-type metal which runs against the ways to ensure perfectly smooth operation at both low and high table speeds.

Milling heads are designed (optionally with swivelling possibility to both sides or with vertical slide) with special consideration being given to the high performance rate of modern milling tools, particularly milling cutters. From the enlarged surface by the third guideway on top of the crossrail over the stout gear up to the compact sleeve, no feature has been overlooked to eliminate any deformation and vibrations that may be caused by cutting forces. The *drive of the milling spindle* by D. C. motor with Ward Leonard regulation and magnetic amplifier which allows a continuous speed variation at even torque of 1 : 16 is an essential addition for the increase of the metal removing capability. By means of 3—4 additional gear steps and field weakening in the upper steps an extremely wide speed range is obtained which allows the utilization of the most advantageous cutting speeds for any given milling or boring operations. Easy operation by push button control helps tremendously in minimizing handling times.

Angular milling heads with uni- or bi-lateral tool reception serve for machining vertical surfaces. Such a head is mounted to the carriage housing and can be swivelled to either side by 90° with the aid of a special measuring instrument. This angular milling attachment may be prepared exactly in conformity with customer's requirements.

For an exact alignment of the table and the carriages, *positioning devices* with optical measuring possibilities (Komelup or Cm-device) can be provided, optionally with precision scales.

HIGH SPEED LATHES

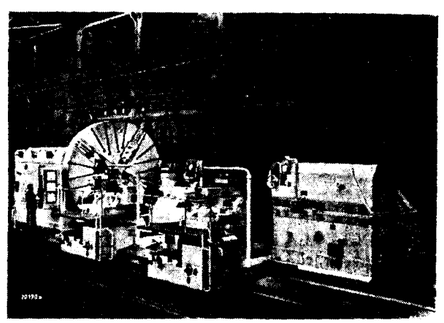
The requirements for higher efficiency, in the construction of motors and turbines and in many other branches of industry, call for ever-increasing dimensions and weights. Heavy crankshafts, engines of 65' (20 m) length and rotors of 13' (4 m) diameter are no longer unusual. However, a difficult problem to solve is the selection of machine-tools which allow high chip

removal and, at the same time, machining to close tolerances. Machining of high-speed turbine rotors demands special accuracies which, in former times, were unobtainable even on small high-speed lathes.

WALDRIGH-SIEGEN High Speed Lathes accomplish these requirements due to their rigid design and manufacturing and assembly precision. Their assets are high driving power, ease of operation, rapid chip removal, and correct support on the bed of carriage, tailstock, steadies in accordance with the flux of forces as well as play free guide on wear-resistant ways. They can be furnished from a center height of 20″ (500 mm) up to maximum possible dimensions.

The rear high drawn guideway makes the rigidly ribbed, three-track bed highly resistant to torsions and twisting, eliminates vibrations and provides a solid support to the tailstock. The prismatic guideways allow the carriage, and, on large type machines, also the tailstock and steadies to operate on the guides without play due to their own weight. Varying cutting forces and even slight wear have no effect or the accuracy of the guides. To reduce wear to a minimum, the guideways are well spaced and the sliding faces of of carriage and tailstock are equipped with plastic plates.

To avoid damage of the guideways by hot chips, these are removed through vertical outlets over chip slides on to a conveyor belt in the foundation or into containers on the rear side of the machine.



WALDRICH - SIEGEN high speed lathe with 7′ (2100 mm) center height and 65′ 8″ (20 m) center distance. The feed boxes are mounted on the bed slides, permitting the machine bed to be set below floor level thus facilitating operation of the machine.

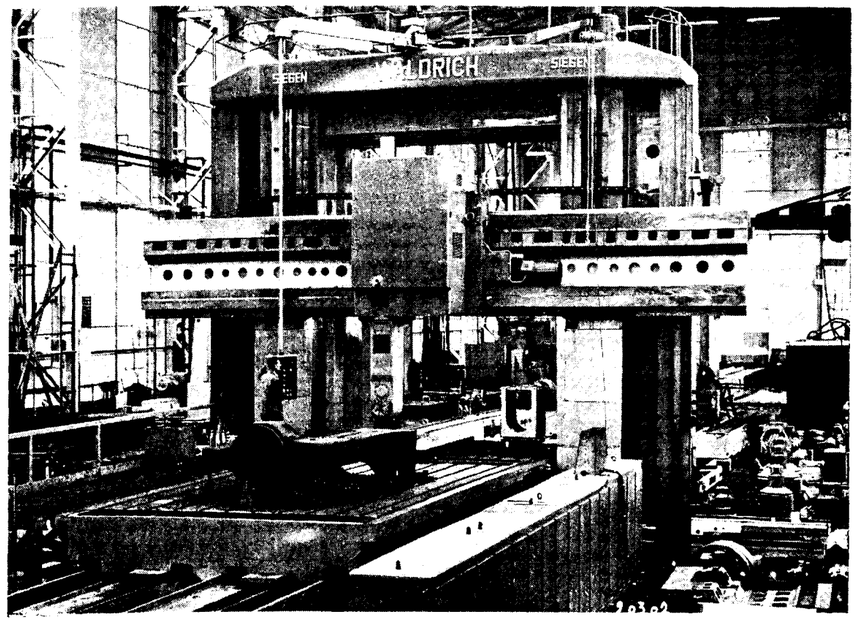
Vibrationless running in spite of high speeds and load and a practically unlimited life determine design and construction of the *headstock*. Adjustable, carefully-scraped plain bearings for the main shaft allow minimum play and high concentricity. All other shafts are carried in roller bearings which are inserted in hardened steel bushings to protect the bores of the gear housing and for facilitating assembly. All gears, with the exception of the highly-annealed face plate gear ring are hardened and ground. Precision machining of tooth gears and housing bores in accordance with special templates assure exact gearing in of the teeth over their entire width. Ample and reliable lubrication protects the gears against any damage from lack of oil.

ROLL TURNING LATHES

It is a well-known fact that the majority of roughing work has to be done in roll foundries and rolling mills. Turning of rolls with cast-on journal on the driving end and plunge cutting of large sections in the plain barrel require an enormous chip production. It is essential that the machine used for this purpose be capable of producing the work in the minimum of time, as the eventual stand still of a rolling mill train may depend on the machining time of a roll.

Design and equipment of the WALDRICH-SIEGEN roll lathes are such as to accomplish shortest possible machining times. High chip production is obtained due to the excellent stability of the entire machine which is partly even superior to that of our high speed lathes. Electric and automatic devices simplify the operation of the machine and thus reduce the non-productive time to a minimum. In addition to this the design of our lathes is such as to accommodate all kinds of machining jobs which are characteristic of roll foundries and rolling mills. Roll turning lathes are appropriate for roughing jobs under severe work shop conditions as well as for precision profile turning.

In view of the high cutting forces, the bed has three ways only, the tailstock guideway being of the elevated inverted V-type. Upon request, the bed ways may be equipped with hardened and ground steel inserts eliminating any wear. To avoid torsional vibrations even under the heaviest loads, the driving motor and headstock gearing are built to great rigidity. The face plate ring gear and all other gears with the exception of the straight toothed sliding gears for the gear step change, have external helical toothing to assure absolutely quiet running of the machine even at high speeds.



Special design: All gears including sliding gears have helical toothing (for one direction of rotation only).

The tailstock is characterized by its compact design which is partly due to the rear elevated guideway. For reasons of stability the tailstock is made from a single casting.

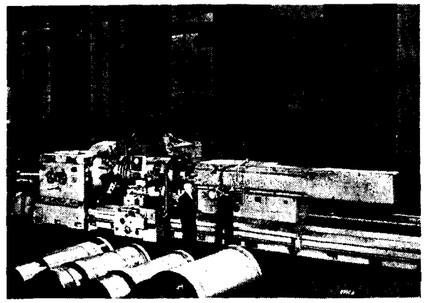
Regardless of the work to be done, whether difficult plunge cuts or complicated sections, whether roughing or finishing, the lamellated tool post will produce excellent results without wearisome tool post changes. The rugged lateral tool slide gives effective support even to far projecting tools. The lamellae are of several different widths to allow composition of combinations to suit the shape of the tool edge. By staggering the different lamellae to conform approximately to the tool contour, rigid support can be provided up to the tool edge. A vertical adjustment of the lamellae, by means of a wedge slide, allows the profile tools to be set in correct relation to the principal axis of rotation.

The advantage of the WALDRICH-SIEGEN lamellated tool post consists not only in assuring a higher output but also in increasing the life of the tools.

COMBINED COPY TURNING AND PLUNGE CUTTING LATHES

Experience has shown that the copy turning procedure is most economical for plain sections, while small and slender sections require plunge cutting with form tools. The advantage of copy turning lies in the use of plain tools and in the fact that no specialized operating personnel is required. For the particular requirements of rolling mills we have developed a copying and plunge-cut lathe which combines the advantages of the lamellated tool post with a reliable and accurately working copying device. This combination allows the most economical turning procedure for a particular job to be chosen.

The basic design of the machine complies in all details with the normal type WALDRICH-SIEGEN roll lathe except that the *feed gearbox* is separated from the carriage and installed at the extreme right-hand end of the bed. Drive to the carriage is transmitted over a spindle and shaft system which is safely protected between the carriage ways. This enables the operators to observe the tool as closely as possible during the cut.



WALDRICH-SIEGEN combined turning and boring lathe for machining large diesel engine cylinders.

The *top rest* has on its left-hand side a normal tool slide and on its right-hand side the bracket with the tracer. The template can be fixed to the bed with a little manipulation.

The copy turning and plunge cut lathe can be equipped with our newly-developed *numerical control* which allows machining of all existing sections, that can be duplicated. It has the following advantages against the electrical tracer controlled copying device.

1. No templates are required. Apart from savings in cost for the preparation of templates, this system eliminates errors caused by inaccurate manufacture, torsion or damage of the templates. The mathematically exact form of the sections are fed into the computer and the lathe motions are controlled over a punched tape so that the precision of copy turning no longer depends on the operating personnel but on the machine.

2. For redressing of rolls with unilaterally used sections, special equipment is supplied which allows the calculation of the most favourable position of the section in order to minimize chip removal. This procedure and the necessary correction of punched tape control is fully automatic.

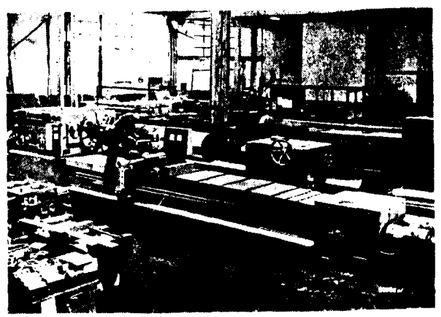
ROLL NECK MILLING MACHINES

WALDRICH-SIEGEN roll neck milling machine, type WZFU for machining necks of all kinds including oil bores. By setting up the roll in transverse direction to the milling spindle or by means of an angular milling head, multi-spline or flat necks may be milled. As on the type WF machine, the roll is rotated by means of a friction gear. In this instance the dividing head is placed on the free end of the roll. Column and gear box feeds are infinitely variable. The milling spindle is carried in a sliding quill.

WALDRICH-SIEGEN roll neck milling machine, type WF for machining wobblers. The 16-step head stock which, in design, corresponds to the lathe type headstock, is operating the longitudinal feed. In order to perform turning operations with the dividing device, the roll is slightly raised by back-up rollers to reduce friction. The rapid loosening and reclamping in the steadies is actuated through an eccentric mechanism. For increasing the performance, a second headstock may be arranged at the opposite side.

ROLL GRINDING MACHINES

The demand made upon planing machines and roll turning lathes as regards vibration free operation with special consideration being given to the tool life, is exceeded by quite a considerable margin for roll grinding machines. Although hardly perceptible vibrations can impair the exact roll contour and can produce chatter marks on the finished surface of the rolls with subsequent appearance on the roll material and complaints from customers.



The design of our roll grinding machines has not only been confined to an utmost sturdy construction in order to eliminate any vibration, but we have in addition successfully tried to avoid any tendency towards vibrations. WALDRICH-SIEGEN roll grinding machines are the complete answer to most complicated tasks occurring in practice, from rough grinding with high chip removal up to finish grinding with maximum surface quality and precision.

The design of the bed ensures extreme resistance to torsions and deflections. The rear high drawn outer guideway supplies a favourable support with regard to power flow to the wheel carriage, the tailstock and the steadies. All ways are made of highly resistant casting, scraped with maximum precision. The wheel carriage slides on one flat and one prismatic way, thus ensuring an automatic play-free adjustment and extreme guiding accuracies. Stout telescopic sheet metal covers protect the carriage ways from grinding dust. Water drains to the rear through openings in the bed are minimizing the risk of clogging by grinding dust. The headstock is rigidly bolted to the bed and contains only a V-belt reduction gear with adjustable belt tension which, even at high speeds, ensures absolutely smooth running of the face plate and also of the roll. The drive is performed by means of a D. C. variable speed motor (on larger type machines through intermediate gearbox). For starting the rotation of the heavy rolls, a special starting drive is fitted which meshes in the internal gear rim at the face plate. After the required momentum has been obtained, this drive is automatically released and stopped. For a continuous drive of the roll a pendant driver is installed in the face plate (upon request the driver can be provided with dual Cardan joint and 4-jaw chuck).

Cast body and sleeve of the tailstock are robustly designed so that heavy rolls can be ground between centers. A transverse movement of the top part allows realignment of the center. Traverse of the tailstock on the bed ways is performed by hand, on larger type machines by motor.

For an exact grinding of the roll barrel (centrically to the neck) we are supplying steadies with two, for larger diameters, with three sliding jaws which allow correction of roundness by regrinding of the necks. With the aid of a special measuring instrument, roll can be instantaneously and exactly aligned. Special steadies for grinding the rolls in their bearing chocks can be supplied as optional extra.

Since most versatile but none the less important functions are inherent in the *wheel carriage*, particular value has been attached to its sturdy construction and carefully designed components. With the exception of our smallest type WSF 400, all WALDRICH-SIEGEN roll grinding machines utilize the movable grinding carriage and the stationary workpiece.

The *feed drive* of the bed carriage is performed by a D. C. motor with Ward Leonard set and a 2-step gear with automatic reverse control to be connected over magnetic clutches. Babbit-lined carriage ways ensure uniform movements both with high and low feed speeds.

The stoutly dimensioned *grinding spindle*, made of high-quality nitrided steel, has hardened bearing locations and is ground with utmost precision. The spring-loaded multi-sliding face bearings of bronze are split into three segments, so that the grinding spindle is automatically centered and guarantees a high concentric accuracy. The bearing play is also adjusted automatically depending on the differing strength of oil films with changing circumferential speed, so that excellently smooth running, resulting in the complete absence of imperfections on the roll surface, is assured throughout the entire speed range. A screw-type pump supplies sufficient oil and ensures excellent hydro-dynamic lubrication. In case of a break-down of the oil current, the grinding wheel is automatically withdrawn and set out of operation.

For the *feed* of the grinding wheel the following different possibilities are given :

1. Rapid feed by electric motor.

2. Coarse adjustment, to be set with a hand-wheel, by transverse movement of the top head in the guides.

3. Precision adjustment by tilting the top rest around one turning point below the grinding spindle with the aid of a hand-wheel. This feed movement is also applicable for concave and convex grinding.

4. Automatic (coarse) adjustment at the reversing points.

5. Continuous feed during the grinding operation. The feed size may be set according to the wheel wear so that grinding performance is constant. The advantages of this new feature are obvious by the improved accuracy in shape during roughing operations and by the reduced production time.

The *drive motor* for the grinding spindle (normally D. C. variable speed motor) is mounted on a separate motor scale. By intercalation of a V-belt drive, transmission of vibrations to the grinding spindle is avoided.

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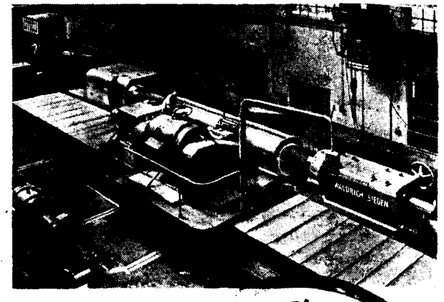
The tilting movement of the top rest for the *concave and convex grinding operation* is engaged by an eccentric. By a change gear and variable lever transmission, both size and shape of camber can be varied within their limits.

The central operator's station on the grinding head incorporates all operational elements for any movement and control of the machine as well as for the reading instruments. A cable drag chain is the ideal solution for a safe supply of current, oil and water.

For *grinding tapers* of a certain lead a special gear may be incorporated in the head which combines in-feed movement in a certain ratio with the longitudinal feed. To make the machine more versatile, special equipment such as radius, taper and center grinding devices, balancing scales etc. may be supplied as optional extra.

WALDRICH-SIEGEN roll grinding machine WST, specially designed for the paper industry and similar production lines. Since headstock, tailstock and steadies can be moved on traverses in transverse direction, a wide range of diameters to be ground can be obtained enabling the machine to grind both thin calender rolls and large dry cylinders.

In order to increase the service life of rolls, many lines in the rolling mill technique are using rolls with steadily increasing hardness which often do not allow metal removal by means of carbide or ceramic tools. The WALDRICH-SIEGEN rough roll grinding



machine with its extraordinary compact design and high driving power is the complete answer to the economical, accurate machining of the hardest rolls.

Main specifications:

Driving power of the grinding motor	136 HP
Max. dia. of rolls to be ground	40"–48" (1000–1200 mm)
Driving power of headstock motor	38 HP
Feeds of the head	5"–240" (130–6000 mm/min)
Max. weight of workpiece	35 tons

INGOT WORKING MACHINES

WALDRICH-SIEGEN ingot planing machine with automatic clamping and change-over device. The machine is equipped with two tables, one of which is used for the machining operation while the other is reloaded.

For the production of material free from rolling defects, casting imperfections must be removed from the rough ingots. WALDRICH-SIEGEN can supply suitable equipment for any machine operation and any ingot form.

WALDRICH-SIEGEN Square Ingot Turning Lathe WVD for completely scalping the ingots. According to the ingot form, the carriage performs an oscillating movement which is controlled by a template (also for hexagonal and octagonal ingots, or—without oscillation—for round ingots). The machine is also arranged for tapar turning.

WALDRICH-SIEGEN round ingot turning lathe of the type WBD. By a number of simultaneously cutting tools (6) and the rapid automatic clamping of the ingots in the face plate by means of eccentric clamping jaws, optimum production times can be obtained. The top bed, with three carriages, is adjusted according to the tapered form and diameter of the ingots, the space between the carriages depending upon the ingot length. The rear side of the machine carries a stout cutting-off saddle with manual longitudinal adjustment and continuous transverse feed.

WALDRICH-SIEGEN ingot slicing machine of the type WAB for dividing ingots into slice shaped forged pieces. The headstock drive motor is automatically set to constant cutting speed in dependence on the cutting depth and the movement of the front carriage respectively. Both carriages have automatic feed in transverse direction. At a predetermined plunge-cutting depth the feed automatically trips. Up to 9 tools on one carriage can be cutting simultaneously. Minimum space between the tools is 150 mm. The tool holders are connected to the coolant circuit.

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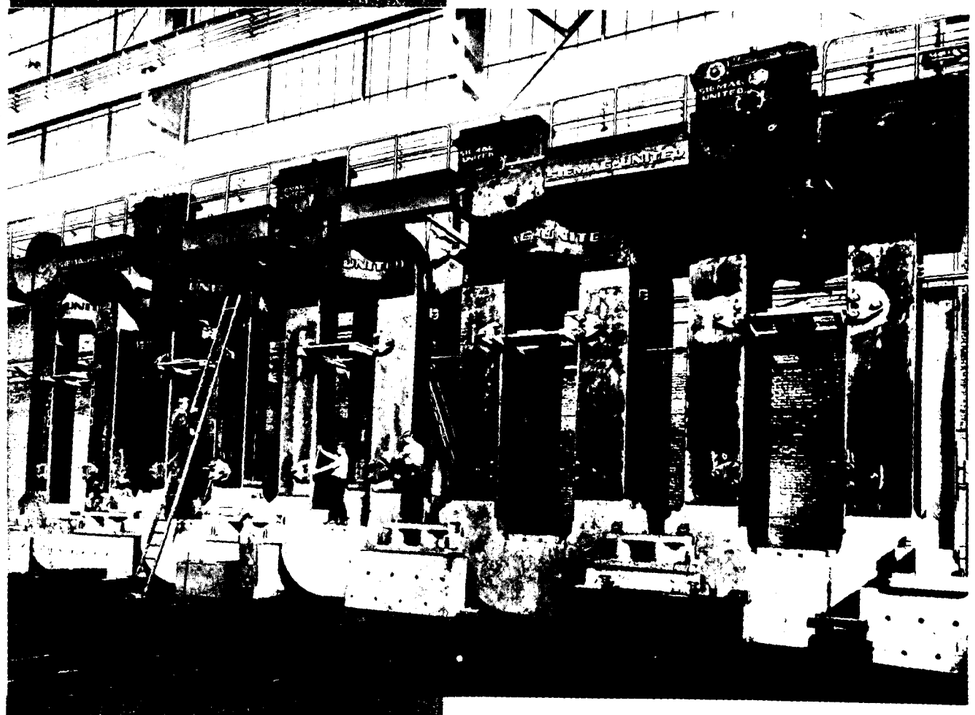
IN ROLLING MILL CONSTRUCTION



Workshop Assembly of a
SIEMAG-UNITED
5-stand Tandem Cold Strip Mill

Roll dia.	1420/585 mm
Barrel length	1420 mm
Speed	1800 m/min. maximum

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