# CONSETT DEVELOPMENTS

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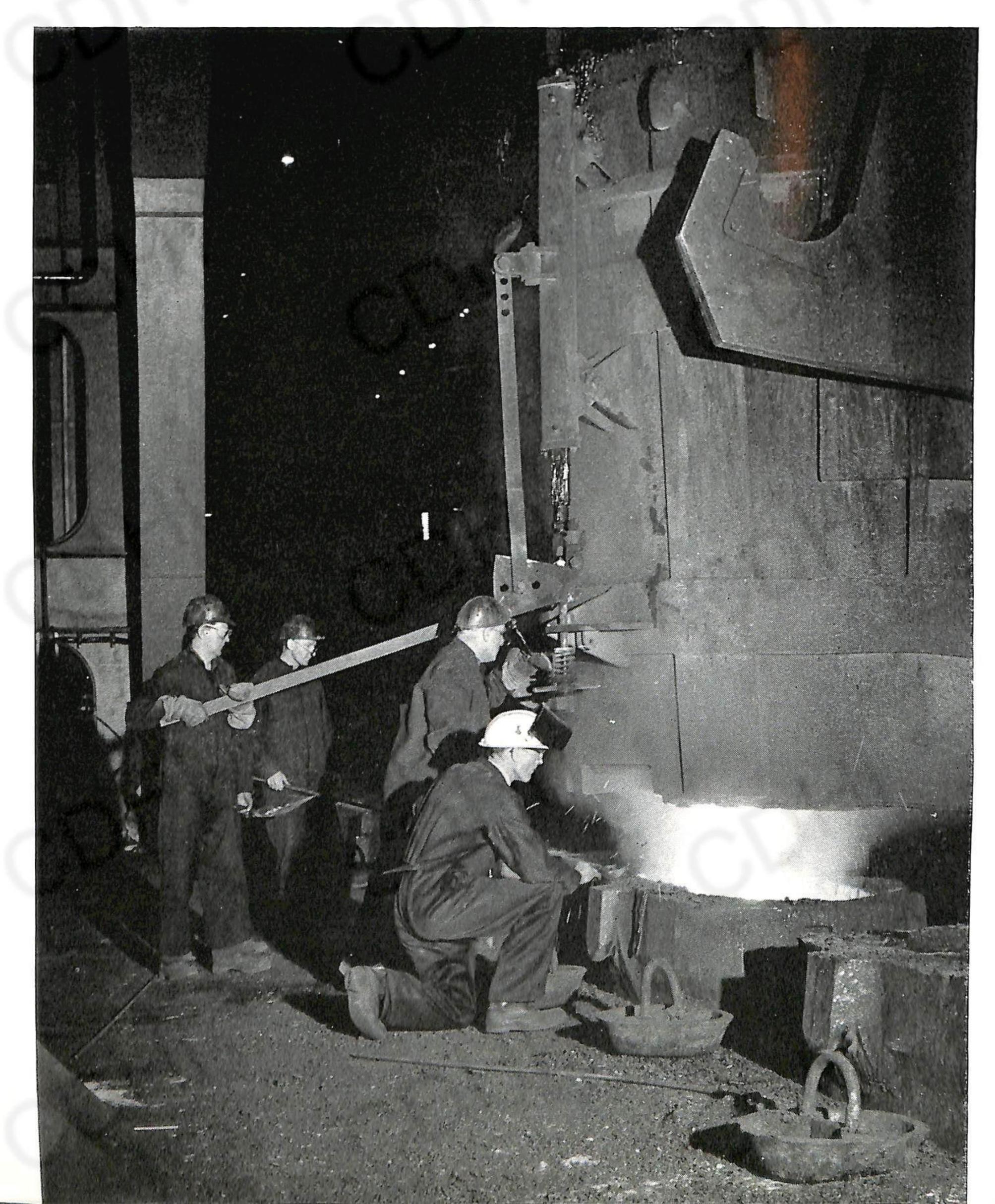


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# Consett Developments



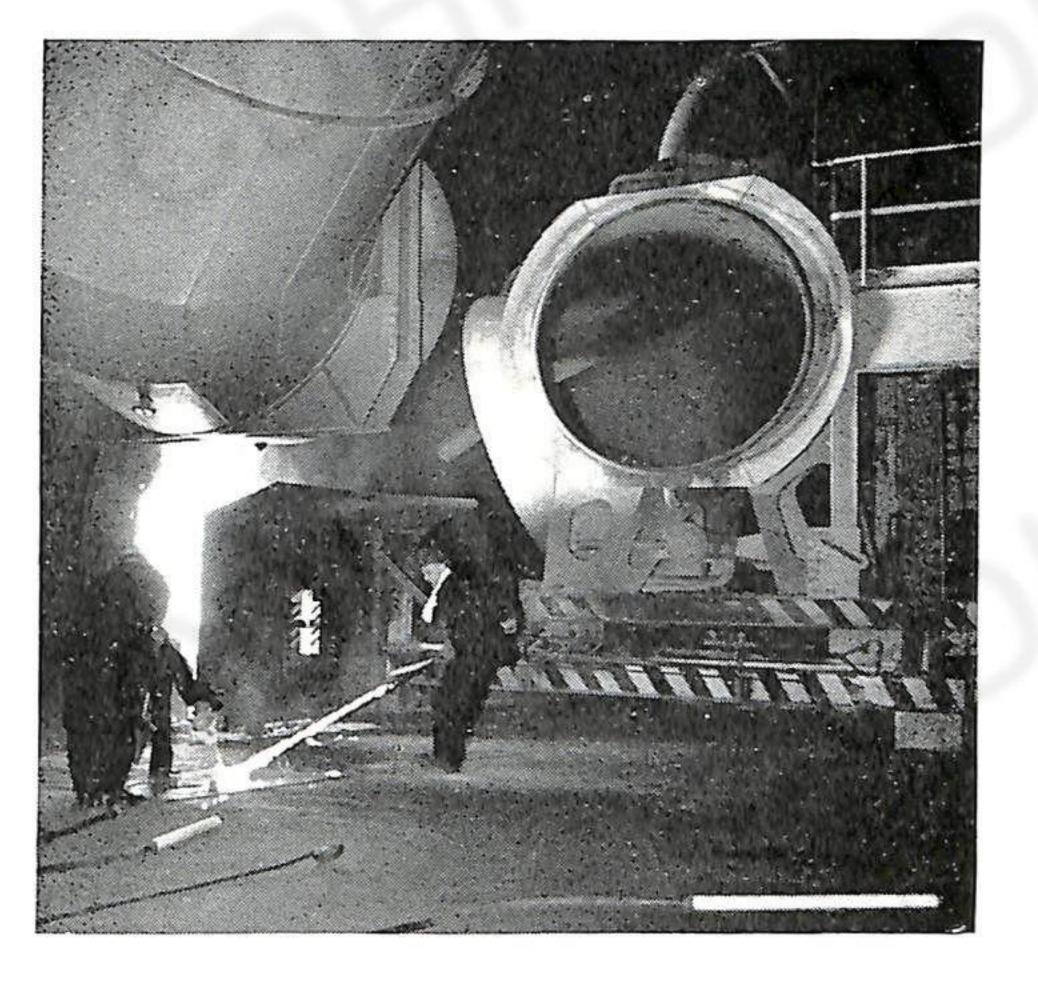
The successful commissioning of Consett's oxygen steel plant last year marked the end of a major period of reconstruction in the company. Immediately after the war and by 1953, a new ore-handling plant, blast furnaces, coke ovens, power station and a slabbing, blooming and continuous billet mill were installed. Four years later a further reconstruction scheme, of which the oxygen steel plant was an important part, commenced. On this occasion the first major section of plant to be installed was the four-high plate mill which cost £14m and was commissioned in September, 1960. This plate mill† is extremely modern in design and has a very high capacity for the production of steel plates. It embodies many of the latest innovations to ensure that a good quality product is turned out. The plate mill embodies finishing equipment which includes shot blasting and coating, cold levelling, normalizing equipment, and it has also pressure quenching and tempering equipment suitable for the treatment of special quality steels.

When the decision was made to embark upon this £30m development scheme, the steelmaking capacity at Consett was in the region of 20,000 ingot tons per week. The open-hearth melting shop, which commenced operations in 1924, was originally designed to produce 7,000 tons of ingots per week. This original production was obtained from 70 ton furnaces but these were later converted to 160 ton units. These modified furnaces were fired by a mixture of coke-oven gas and creosote pitch with oxygen for flame enrichment as an additional aid to melting. Consett were the pioneers in this country in the use of oxygen for flame enrichment.

In 1954 the company installed an acid Bessemer shop for the pre-refining of hot metal in two 25 ton converters. This plant was built as an integral part of the open-hearth shop but solely for the purpose of pre-refining blast furnace hot metal in order to reduce metallurgical load on the open-hearth furnaces and also to increase shop output

#### TEEMING IN PROGRESS

Casting a heat of steel in the new oxygen steelmaking plant at Consett



Taking a sample of steel from one of the 120 ton Kaldo oxygen steelmaking converters at Consett

In spite of these additions to the existing open-hearth shop it was considered that a new steelmaking unit was fast becoming a necessity at Consett. Not only was there an increased demand for steel at that time but the openhearth shop had reached its maximum output.

After various alternatives had been considered it was decided that any new developments should include one of the oxygen steelmaking processes, and in order to assess the suitability of the various processes, a team of Consett technicians visited LD plants, a Rotor plant, and the only Kaldo plant at that time in operation, in Sweden. Following lengthy deliberations we arrived at the conclusion that the Kaldo process and the LD process could both be adapted to our practice at Consett, and to enable a positive decision to be taken extensive field trials using Consett pig iron were carried out on LD practice at Donawitz in Austria, and on Kaldo practice at Domnarvet in Sweden.

On the results of these trials it was decided that a combined LD and Kaldo plant would be most suitable for Consett's future operation and the decision was taken to instal two 120 ton LD units and two 120 ton Kaldo units. In any consideration of new steelmaking facility the thought which always prevails is the question of future expansion and it was considered that in installing such a steelmaking unit we should have the immediate ability to make up to 28,000 tons of ingots per week with a further increase in steelmaking output entailing the minimum of alteration and only a small amount of capital expenditure.

The oxygen steel plant as installed at Consett is unique in the industry since it has both the LD and Kaldo processes in the same shop; in this respect Consett are in the position of being able to compare the open-hearth, LD and Kaldo operations using the same iron quality to make different qualities of steels. We are sure that the future of Consett will be further secured by the addition of this extremely modern and flexible steelmaking unit and we look forward to the future with confidence.

<sup>\*</sup> Director, Consett Iron Co. Ltd.

<sup>†</sup> The mill and its ancillaries were described in the Iron & Steel Journal in a series of articles commencing December, 1960.

# INTRODUCTORY SURVEY OF PLANT

By D. M. POTTER\*, B.A.(Oxon.)

At the works of Consett Iron Co., Ltd., at Consett, Co. Durham, there has recently been completed and commissioned what must be considered one of the most important oxygen steelmaking plants in the world.

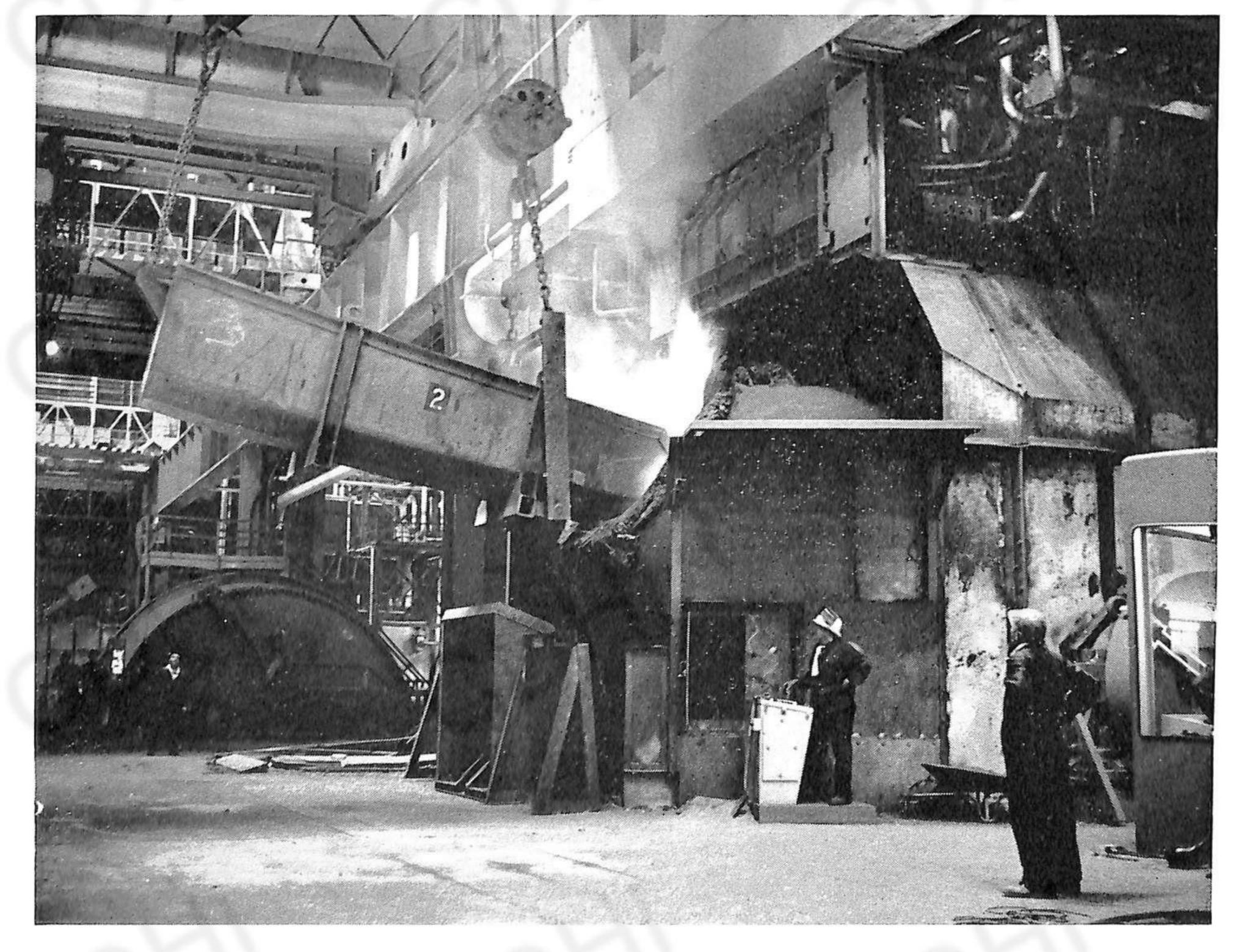
The principal items of equipment only are described in this article in terms of general arrangement since further contributions refer to each part in detail. These items include: two 1,000 ton inactive mixers; stockyard and material handling plant for charging additions; two oxygen

· Northern Editor, Iron & Steel.

blown LD converters, each of 120 tons capacity; two Kaldo converters, each of 120 tons capacity; waste heat boilers for the LD plant; precipitators for both the LD and Kaldo plants; oxygen production and supply plant; charging, teeming, stripping and mould preparation facilities, and laboratory, power, water, dolomite lining and similar services.

The overall layout of the plant has been developed by the Consett engineering staff in association with the International Construction Co., Ltd.

Charging scrap into one of the two LD converters at Consett



Iron from the blast furnace comes in 60/70 ton lots for charging to the LD converter

# AND LAYOUT

Of special significance in the plant are the following features:

The modern design and comprehensive layout of the installation in a new single-purpose shop with all the principal and auxiliary units specially designed to that

The size of the plant—it is the largest in Great Britain devoted to the oxygen process for the production of basic steel and special steels.

The inclusion of both LD and Kaldo converters in the same department.

The waste heat boilers heated directly from the flames of the LD converters.

The location of the plant close to the slabbing and blooming mill soaking pits consequently reducing inter-departmental transport and minimizing heat loss of ingots during transit.

#### Building and Plant

The principal building consists of a structural steel framework clad with steel sheeting and covering an area measuring 810 ft long by 345 ft wide. This is divided into four parallel bays of varying heights and the following

Charging bay (735 ft long x 72 ft crane span).

Converter bay (735 ft long x 75 ft).

Casting bay (810 ft long x 87 ft crane span).

Stripper bay (810 ft long x 87 ft crane span).

The column width when added to the crane spans mentioned above make up the overall width of the building.

The building includes many floors and platforms at various levels providing access for plant personnel to all equipment. Roof steelwork is also at various levels, to accomadditional in each particular bay and to support additional items, notably precipitators, which are located

For the purpose of this article the charging bay is considered as being the front of the plant and, therefore, the descriptions that follow are related to the plant when c' viewed from this direction. The remaining bays, viz: the converter bay, the casting bay, and the stripper bay, are to the rear of the charging bay and in that order. Reference to the drawing accompanying this article will reveal that incoming materials to be used in the plant, notably converter additions and hot metal, enter from the left by conveyor and ladle respectively and are transferred after their conversion by the steelmaking process, through the hot metal mixers and converters rearwards into the stripper bay where the finished ingots are despatched to the soaking pits.



#### CHARGING AND CONVERTER BAYS

Located in the charging and converter bays and mounted on independent foundations are the following major items of plant arranged in this order from left to right; two 1,000 ton inactive mixers; two 120 ton LD converters; two spaces for future converters; and two 120 ton Kaldo

The charging bay is equipped with two 160 ton overhead cranes for handling the 68 ton ladles from the blast furnaces to the mixers, and the 120 ton ladles from the hot metal mixers to the converters. Also contained within the charging bay and extending through to the full width of the converter bay is an operating platform situated 28 ft 9 in above ground level. This platform extends almost the complete length of the building, and inset into this are the hot metal mixers and the LD and Kaldo converters.

The operating platform provides easy access to the converters, for instance, when they are tilted for charging, de-slagging, tapping, sampling, or fettling of the lining. The controls for each converter are located on this platform and are arranged to provide the operator with a clear view of the various operations which he is controlling.

External rail tracks are arranged at ground level into the charging bay in a longitudinal direction and provide access for carrying the blast furnace hot metal to the hot metal mixers. Below each of the LD converters are two further rail tracks at ground level, of different gauge and running in a transverse direction, the narrower within the wider. The wider track accommodates the special ladle transfer car which is capable of travelling between the charging bay, through the converter bay and into the casting bay; the narrower track is designed to accept a slag ladle and carriage. This latter track connects directly to the main longitudinal rail lines which serve the steelplant and is used for removal of the slag from the steelplant building.

#### CONVERTER BAY

#### Raw Materials Supply

Incorporated in the building structure at high level in the converter bay is a series of storage bunkers for additions consisting of ore, coke, lime, etc. These are fed into the bunkers by means of a belt conveyor originating in an underground stockyard situated external to the building. Travelling trippers located above the storage bunkers ensure discharge of the materials into the appropriate bunker.

There are five bunkers in all; two for ore; each holding 193 tons, two for lime each holding 120 tons and one for crushed slag holding 116 tons. From the storage bunkers the additions are fed by vibrating feeders on to a reversible belt conveyor and thence to batch weigh hoppers for subsequent discharge into the converter.

In addition each converter has three individual bunkers which cannot be used to feed other converters; one of 140 tons for limestone chips, one of 73 tons for fine ore, and one of 14 tons for coke.

In the case of the LD converter, a fixed chute is arranged integral with the hood for the delivery of these materials blowing position, use is made of a special additions lance

which is incorporated within the fume discharge hood fitted to a specially designed hood carriage. This carriage is mounted on rail tracks on the operating platform at the 28 ft 9 in level, and is briefly described in the subsequent section.

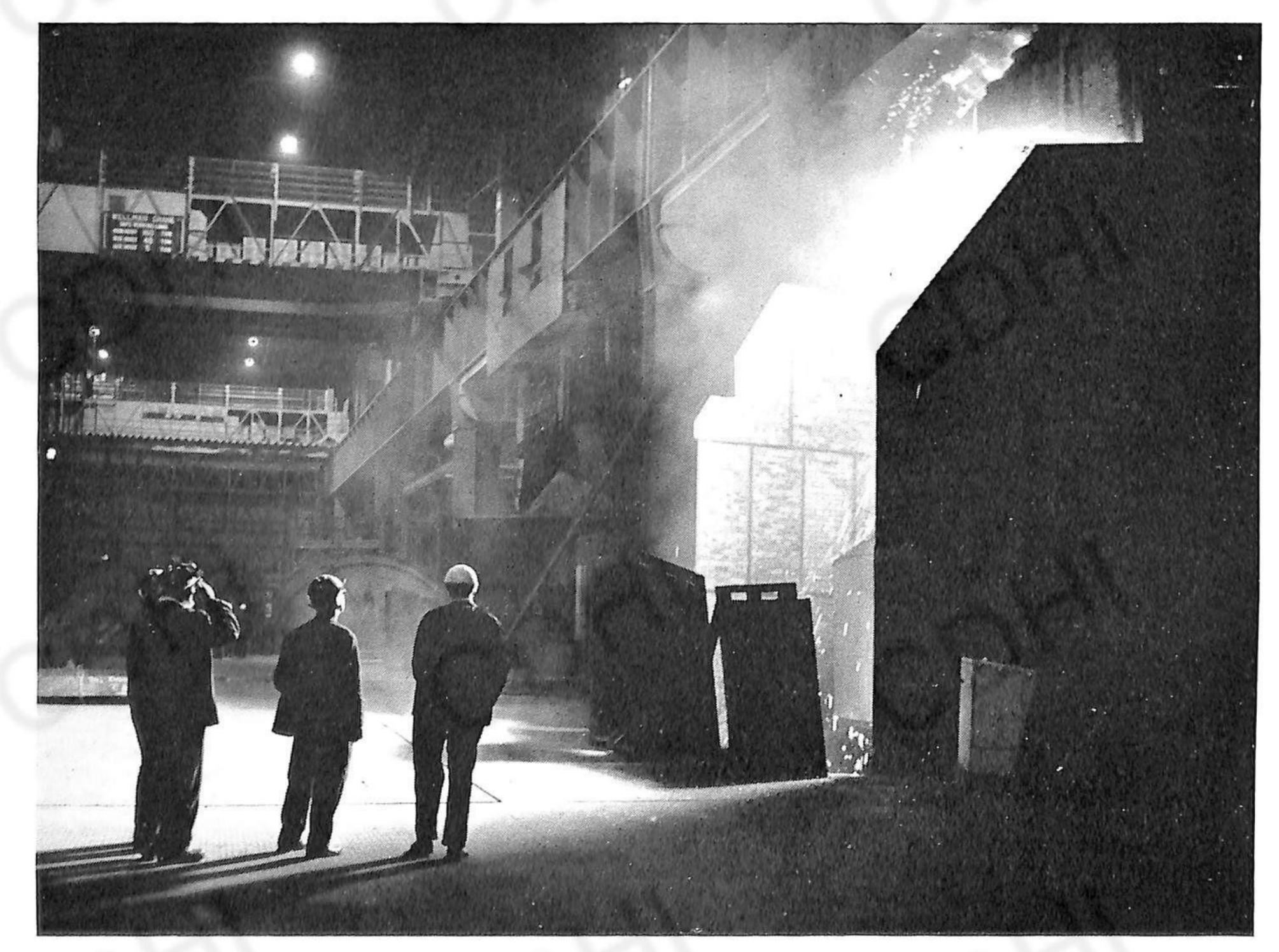
Oxygen is supplied from three 100 ton/day plants, operated by British Oxygen Co., Ltd., on a site nearby. The gas is piped through a high pressure line at 600 lb/in<sup>2</sup> and reduced to 200 lb/in2 for feeding to the steelplant.

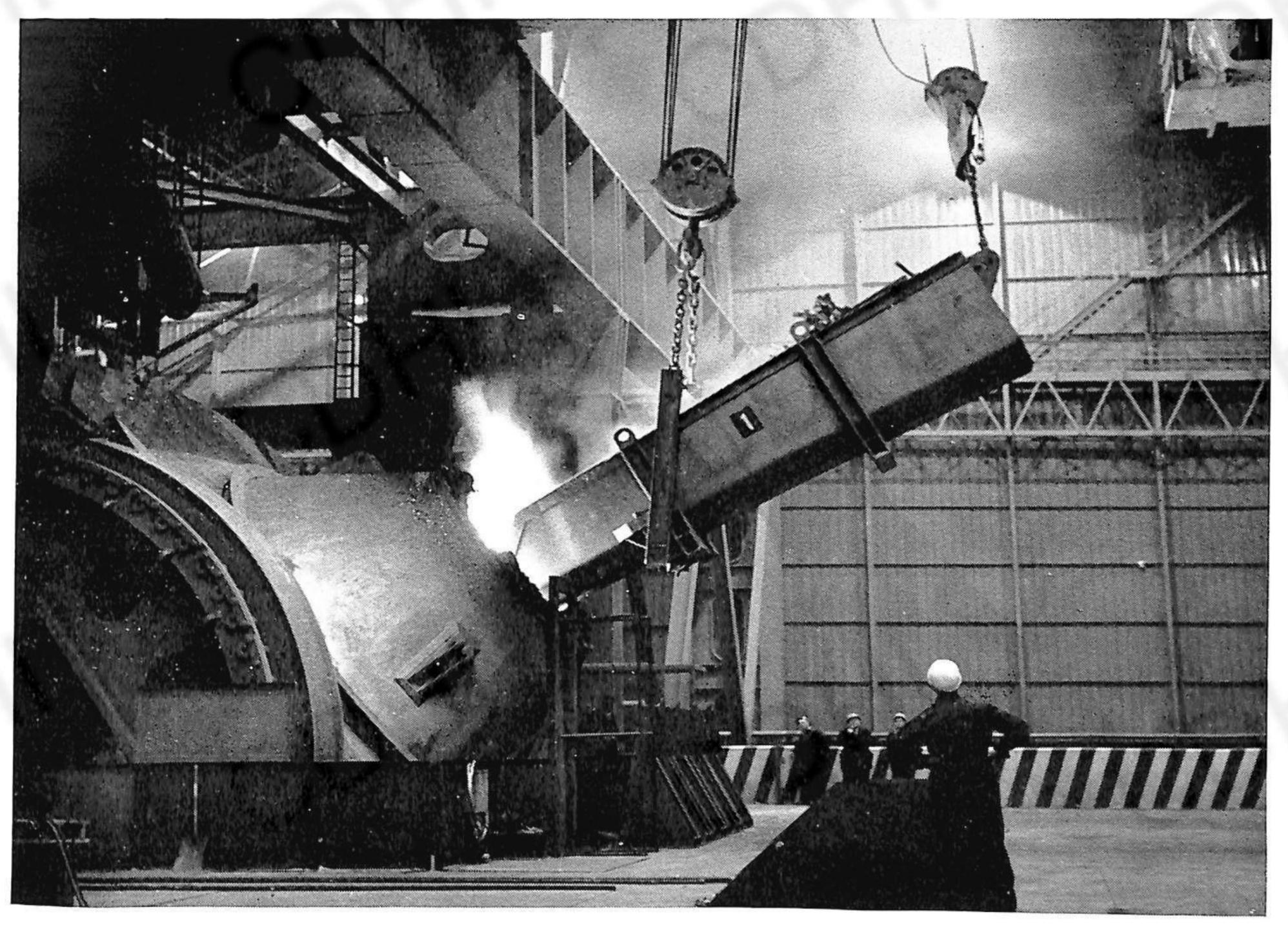
#### Oxygen Lances

The oxygen lances for the LD converter are handled by a monorail hoist block situated at high level within the converter bay and are transferred to a stationary winch situated above each of the LD converters. These winches are capable of lowering the lance at varying speeds, a fast speed to give rapid approach to the converter and a slower speed to give accurate final positioning prior to commencement of the blow.

After the lance has been lowered through the boiler leg (the flame hood) above the converter, it is clamped in position in readiness for the commencement of the blow. At the intersection of the lance and boiler leg, fume and flame are diverted away from the lance passage by a flame to the converter. In the case of the Kaldo converter the arrester delivering steam. The lance itself is water-cooled, materials are added through a similar chute arrangement coolant water and oxygen being fed in at the top. A system when the vessel is vertical; but when it is inclined in the of standby lances, with one on a reverse winch, is ready for immediate transfer to the operating position.

Blowing in progress on one of the 120 ton LD converters at Consett





Scrap is charged from an overhead crane to one of the two 120 ton Kaldo vessels

In the case of the Kaldo converter the oxygen delivery arrangements are rather different due to the fact that when blowing, this converter is inclined at an angle of approximately 20 degrees to the horizontal. A fume hood is accordingly provided to cover the mouth of the converter when inclined and the oxygen lance is arranged integral with this. To permit movement of the hood in both transverse and longitudinal directions, to facilitate the operations of charging and tapping, etc., it is mounted on a carriage. The oxygen lance is secured within the hood in a pivoted power driven guide, thus providing means of oscillating the lance during the blowing period.

# The Converters

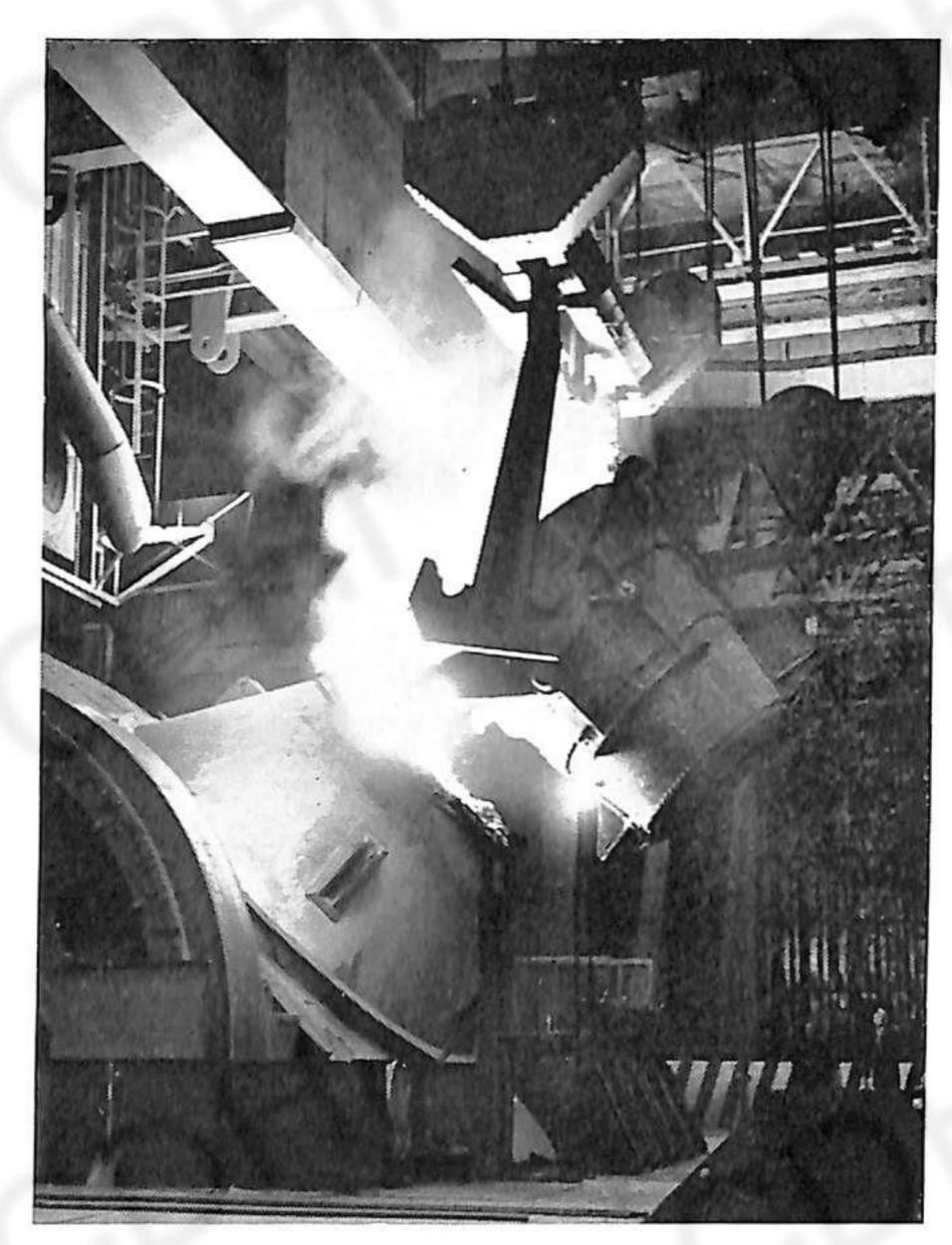
Each LD converter measures internally, within the brick-work, 14 ft 5 in dia at the centre and 6 ft dia at the nose, air and is 26 ft 2 in high; the volume is 3,180 ft<sup>3</sup>. Each Kaldo cor is 13 ft dia at the centre, 6 ft dia at the nose, and is 24 ft 6 in high, with a volume of 2,650 ft<sup>3</sup>. The LD converters are pivoted on heavy duty trunnions and are provided with tilting gear enabling them to be turned through an angle of 360 degrees. This facilitates the work of charging hot metal, slagging off, and tapping during production, and the wrecking and breaking out of a worn converter lining when servicing. The Kaldo converters are also provided with tilting facilities, and in addition, are capable of rotation about their longitudinal axes during the blowing period. Maximum rotation speed in the inclined

position is 35 rev/min and the tilting speed in either direction is 1 rev/min maximum.

#### Waste Heat Boiler

In the case of the LD, immediately behind the converter but still in the converter bay is a waste heat boiler, whose principal function is to cool the waste gases. The flame hood itself is a leg of the boiler, and its inner walls are lined with a series of boiler tubes. As well as acting as a water cooled guide for the flames and hot gases, it also serves as a housing for the oxygen lance and the chutes delivering additions to the converter. This combined flame-hood and boiler leg is then of considerable significance. It is designed to accommodate the variable flame from the converter which is surrounded by a mantle of air drawn in from the atmosphere at the side of the converter mouth. Air jets are provided at changes in direction in the duct.

Dampers separate the leg from a by-pass stack and an auxiliary firing chamber. In effect, therefore, the boiler consists of the entry chamber (including the leg or flamehood) heated only by the incoming flames, and a second compartment which is fitted with oil firing equipment and may be heated by one of three alternative methods: (a) by the converter waste hot gas during the blow, (b) by the oil firing modulated by the heat input from the converter, or (c) by the independent oil firing only. In this last case the plant would be operating as a conventional boiler.





Above: Tapping a heat of steel from one of the Kaldo converters

Above: Blast furnace iron being charged to one of the Kaldo

units

two heat sources (i.e. converter flame and oil firing) are then in use simultaneously for part of the time so that sufficient heat is supplied to be able to maintain a constant output of steam from the boiler. When the converter is off and oil firing is operating alone

When the oil firing is used in conjunction with the heat

from the converter the oil burner flames modulate. These

then a damper is shut to prevent ingress of large quantities of air into the combustion chamber.

As the heat input from the converter exceeds the amount required for the export steam rate from the boilers, this excess steam generated is stored in a steam accumulator. The stored heat is then discharged during the oil firing period by heating up the feed water through a suitable heat exchanger. Considerable significance is attached to the accumulator and boiler being mounted in parallel, rather than in series, in the steam circuit, as this arrangement avoids the undesirable feature of a large line pressure drop. By avoiding this pressure drop the boiler can be designed for a much lower pressure and can therefore operate under less stringent conditions; furthermore, an unnecessary thermodynamic loss is avoided.

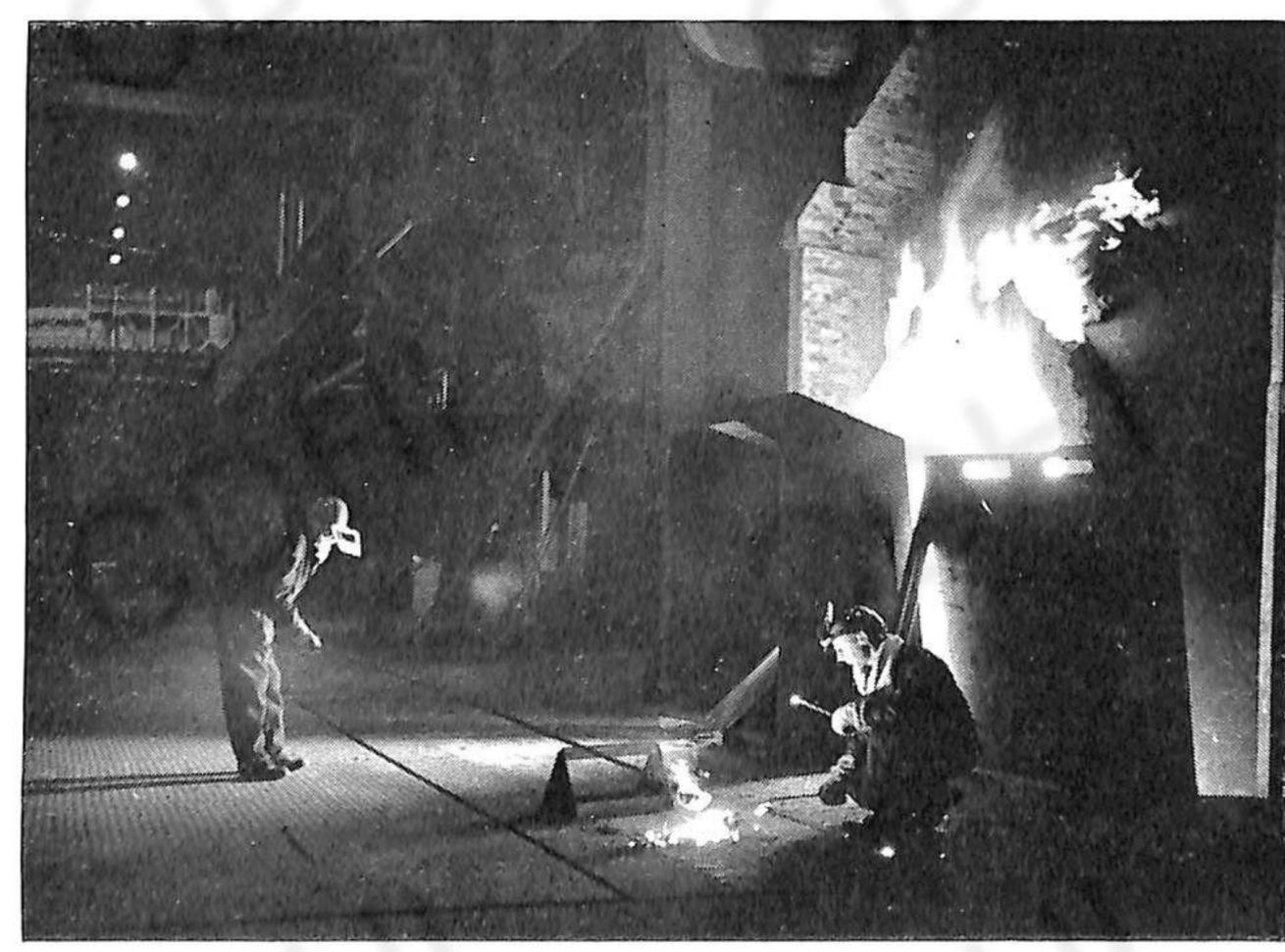
The boiler is designed to reduce the waste gas temperature to a sufficiently low value so that the humidity will be correct for its entry into the precipitator after the addition of moisture in the conditioning tower.

In the conditioning tower the velocity of the gases is reduced by the diameter of the tower being greater than the preceding ducting and this lengthens the treatment time. The treatment itself consists of high pressure water sprays projected at the incoming gases to condition them by reducing their temperature and providing them with the desired moisture content. These gases then travel to the electrostatic precipitator.

#### Precipitators

Each LD converter has an independent electrostatic precipitator, whereas for the Kaldos one precipitator will serve whichever of the two converters is being operated.

The electrostatic precipitators are erected in line on the top



Right. Sampling a heat of steel from one of the LD converters

## SOME DETAILS OF CONSETT'S OXYGEN STEEL MAKING PLANT

#### The Contract

Total new plant cost £10 million.

Steelplant contract awarded to Head Wrightson Iron & Steel Works Eng. Ltd., for the design and supply of: Two 100 ton Kaldo units. Two 100 ton LD units Two 1,000 ton mixers. Hot metal ladles, each 125 ton. Electrics and instrumentation for above.

#### Plant Design

Head Wrightson Iron & Steel Works Eng. Ltd. in collaboration with: Pintsch Barmag AG, Cologne. Research Cottrell, U.S.A. Svenska Maskinverken AB, Sweden.

#### Possible Future Developments

Space allowed for two more converters. Possible lime powder injection on LD.

THE CONVERTERS INSTALLED TO DATE							
	LD	KALDO					
Nominal capacity. Weekly production. Estimated annual production.	Two 120 ton.  26,000 ton/week has been attained.  In excess of 1½ million tons.						
Cycle time, tap/tap. Blowing time, min.	14 ft 5 in dia (centre), 6 ft dia (nose) 26 ft 2 in high, vol. 3,180 ft <sup>3</sup> . 60-65 min. 20 min.	13 ft dia (centre), 6 ft dia (nose) 24 ft 6 in high, vol. 2,650 ft <sup>3</sup> . Not available. Not available.					
*Foreign trials on processing Consett pig iron Materials charged/heat	at Donawitz  Liquid iron 90%, scrap 7%, iron oxide 3%, fluxing materials 12% of metallics charged	at Domnarvet  Varies depending on cooling  medium (scrap, sinter, or  oxide) Lime about 10% of  ingot tonnage					

#### OTHER OPERATING DETAILS

Water-cooled lance, 58 ft long, of concentric tubes—oxygen delivery tube (copper)  $4\frac{1}{2}$  in dia, nozzle throat  $2\frac{1}{2}$  in dia; o.d.  $8\frac{1}{2}$  in (stainless steel)  $O_2$  flow rate 14,000 ft<sup>3</sup>/min, inlet pressure 180 lb/in<sup>2</sup>, nozzle  $O_2$  speed supersonic to penetrate slag. Tilts  $0\cdot 1$  rev/min and  $1\cdot 0$  rev/min.

Vessel inclined at 20°, lances similar size to LD. Rotates 35 rev/min max, tilts 0·1 rev/min and 1·0 rev/min. O<sub>2</sub> rate 6,000-7,000 ft<sup>3</sup>/min, inlet pressure 90-100 lb/in<sup>2</sup>, velocity at nozzle (5½ in dia) 650 ft/sec. O<sub>2</sub> lance oscillated 17 times/min in arc 17°-23° from horizontal. Also designed for vertical top

KALDO

\*Consett medium phosphorus pig iron. Italic figures based on foreign trials and intended to give only a very rough guide to materials consumption.

#### Materials Handling

Five additions bunkers: two 193 ton ore, and Precipitators two 120 ton lime, one 116 ton crushed slag. Individual bunkers per converter: 140 ton limestone chips, 73 ton fine ore, 14 ton

Blast furnace iron transferred to two 1,000 ton mixers, fitted with coke oven gas burners, and then by 120 ton ladle to the converters.

Oxygen supply from three 100 ton/day plants.

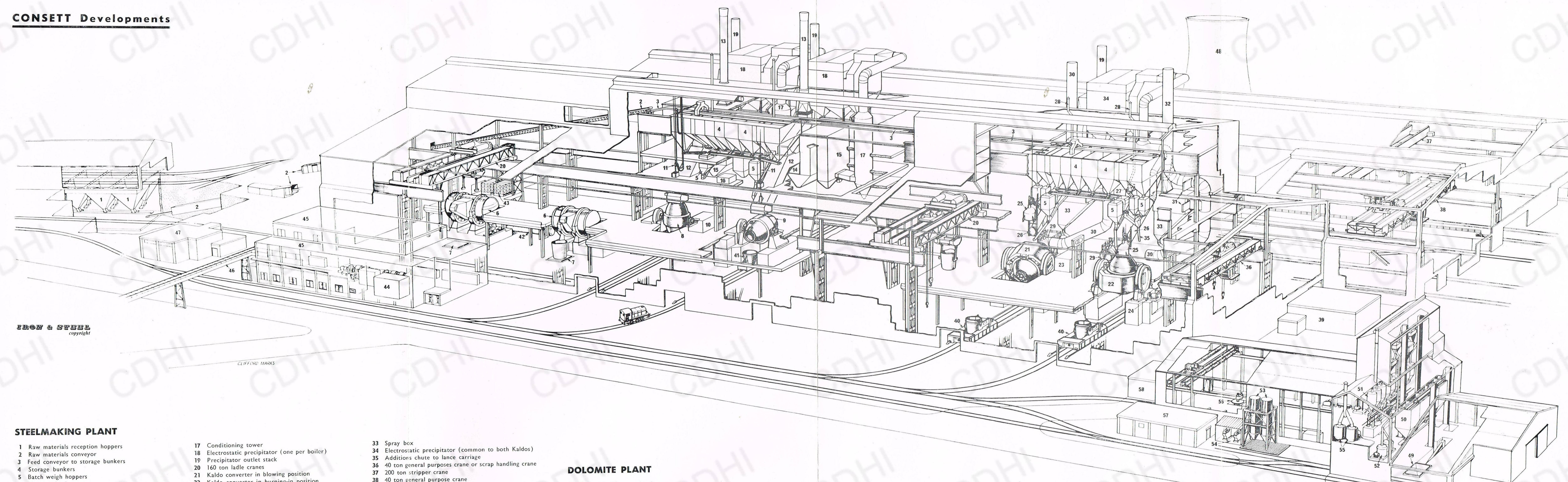
# Waste Heat Boilers

Waste heat boiler for LD plant only (Kaldo burns CO→CO₂ in furnace). Steam raising rate during blow 220,000 lb/hr, export rate 174,000 lb/hr at 420 lb/in2 and 775°F. Accumulator accepts 123,000 lb/hr for very short periods.

Precipitator plant dry plate electrostatic type. Gas cleaned to 0.04 grains/ft3 dust.

The teeming bay in the oxygen steelmaking plant of Consett Iron Co. Ltd., Consett, County Durham





- 6 Hot metal mixers
- 7 200 ton weigh bridges
- 8 LD converter in blowing position 9 LD converter in slagging position 10 LD converter control pulpit
- 11 LD converter oxygen lances12 Converter leg of waste heat boiler
- 13 Waste heat boiler by-pass stack
- 14 Main damper 15 Waste heat boiler
- 16 Control room for waste heat boilers

- 21 Kaldo converter in blowing position
- 23 Kaldo control pulpit
- 24 Kaldo tilt drive

- 31 Interconnected Javelle dampers

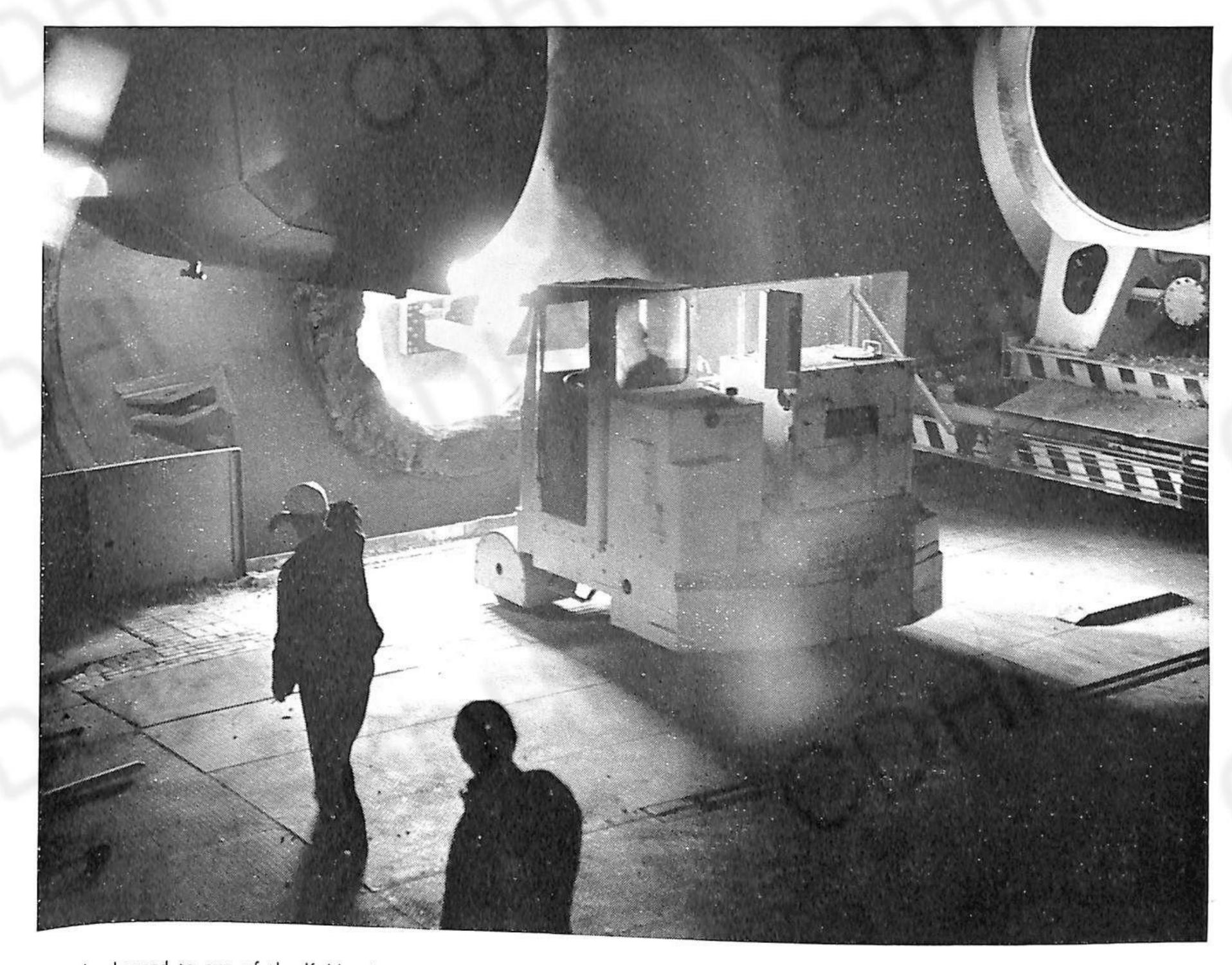
- 22 Kaldo converter in burning-in position
- 25 Burning-in hood and lance

- 26 Burning-in stack
  27 Coke igniters
  28 Coke igniter stacks
  29 Lance hood and carriage
  30 Water cooled mains for outlet gases
- 32 Spray box by-pass stack

- 41 Slag ladle and car
- 44 Sub-station

- 38 40 ton general purpose crane 39 Compressor house
- 40 Ladle cars
- 42 Steam accumulator for waste heat boiler
- 43 Feed water storage for waste heat boiler
- 45 Offices and administration
- 46 Bridge carrying service mains
  47 Spectograph house
  48 Cooling tower

- 49 Raw materials reception hopper
  50 Storage bunkers
- 51 Material bins
- 52 Cone crushers
- 53 Tar storage tanks54 Tar pumps55 Tar boilers
- 56 Dolomite block presses
- 57 Sub-station58 Water pump house



Lime is charged to one of the Kaldos by means of a mobile charging machine

of the roof of the casting bay and are thus one bay further to the rear than the waste heat boilers and gas conditioning units. The precipitators themselves are of the dry type with alternate collector plates and charged wires suspended inside a casing through which the gases pass. The dust (mainly iron oxide) falls into hoppers emptied by totally enclosed conveyors and passes through a chute to a holding hopper from which it is drawn off for disposal by lorry.

## CASTING EQUIPMENT

As already mentioned, a ladle transfer carriage is provided below each converter at ground level and after completion of a blow the ladle is filled and then self-propelled through the converter bay to the casting bay. Here overhead cranes lift the ladle from the car and carry it over the ingot moulds which stand on ingot bogie cars, located on parallel sidings between which is a working platform. There are three sets of these teeming tracks each of which can be served independently and from which the train of full ingot moulds may also be hauled independently into the stripper bay. A ladle preparation pit is located in the casting bay at the entry end behind the mixers.

#### STRIPPER BAY

When the ingot bogie cars arrive in the stripper bay (immediately to the rear of the casting bay) they may be

allotted to one of two tracks. The moulds are stripped from the ingots by two overhead strippers, the ingots being conveyed by ingot bogies to the existing slabbing mill soaking pits which are immediately adjacent to the left of the stripper bay. Mould preparation also takes place in this stripper bay.

#### PRODUCTION FROM LD

Production with the LD converter is based on a cycle time of approximately 60 to 65 min tap-to-tap, one converter being in use while the other is being relined. Hot metal is delivered into the steel plant from the blast furnace in special ladle cars and is transferred to either of the gas-fired inactive hot metal mixers by means of the overhead crane in the charging bay.

When a converter is to be charged, hot metal is poured from the mixer into a 120 ton capacity ladle mounted on a weighbridge; this allows accurate control of the quantity of metal charged into the converter. The filled ladle is then handled by the charging bay overhead crane, transferring the hot metal to the converter, which is tilted to the appropriate angle for this operation. The converter then returns to the vertical position, and the necessary additions are added through the chutes leading from the overhead storage bunkers.

The oxygen lance is next lowered into the converter,

passing through the converter leg of the waste heat boiler. The lance is clamped rigidly in position, with the lower end positioned above the charge, and blowing is commenced. Oxygen and cooling water are supplied to the lance by means of flexible hoses attached to the lance at the upper extremity. The blow will continue for approximately 20 mins with interruptions for slagging off (depending on the original metal analysis), sampling and temperature measurement. Further additions may also be required during the blow and these are supplied through the chutes as already briefly described. Slag is poured into a special ladle mounted on a carriage on the narrower gauge rail track at ground level on the converter centreline. It is then removed from the steelplant along the rail tracks in the charging bay.

After sampling, if the neighbouring laboratory confirms that the analysis is correct, the steel is poured through a taphole on the converter which is tilted towards the casting bay for this operation.

When the melt has been emptied into the ladle the

converter is reversed into the hot metal charging position, so that the cycle may be recommenced.

Production with the Kaldo is somewhat similar to that of the LD, but, of course, with changes in practice necessitated by the individual design characteristics of the Kaldo.

#### Services

There are, of course, a great many items of auxiliary equipment in such a large undertaking. These include the following: laboratory service; water service; oxygen service; compressed air service; and converter lining

#### Acknowledgment

The author would like to thank Consett Iron Co., Ltd., for permission to obtain and publish this information. In addition, he would like to express appreciation to the consulting engineers and the main contractors for principal plant for assistance with the necessary technical

#### LIST OF CONTRACTORS

The main contractors and consulting engineers for the whole of the new steelmaking plant at Consett were the International Construction Co. Ltd. Other contractors and items of plant for which they were responsible are as follows:

LD and Kaldo converters and hot metal mixers-Head Wrightson Iron & Steel Works Engineering Ltd., in association with Pintsch Bamag.

Waste heat boilers and fume cleaning plant including conditioning towers-Head Wrightson Iron & Steel Works Engineering Ltd.

Electrostatic precipitators-Head Wrightson Iron & Steel Works Engineering Ltd., in association with Research Control.

Ladle transfer and converter servicing cars—Distington Engineering Co. Ltd.

Casting ladles—B. Thornton Ltd.

Conveyors, bins and dolomite block raw material stockyard-Moxey Conveyor & Transporter Co. Ltd.

Dolomite plant: control panels, presses, pan mills, cone crushers, scale car, tar pumps and gas heaters-Laeis-Werke AG. Jaw crusher-Armstrong Whitworth (Metal Industries) Ltd. Electric control gear-Allen West & Co. Ltd. Cabling-Watson Norie Ltd.

Foundations-Sir Robert McAlpine & Sons Ltd.

Gas mixing station—Reavall & Co. Ltd.

Building-Wright Anderson & Co. Ltd.

General fabrication-Consett Iron Co. Ltd.

Insulation-Newalls Insulation Co. Ltd., Fibreglass Ltd., R. B. Hilton.

Cast iron pipe—Stanton & Staveley Ltd.

Valves, joint rings, etc.—Bells Asbestos & Engineering

Valves-J. Blakeborough & Sons Ltd., The Bryan Donkin Co. Ltd., Glenfield & Kennedy Ltd., Hopkinsons Ltd.

Temperature regulators—Spirax- Sarco Ltd.

Chemical dosing plant-Wm. Boby & Co. Ltd.

Ventilation equipment-Sturtevant Engineering Co. Ltd.

Water pumping equipment—Harland Engineering Co.

Water piping-E. Dixon Barker & Sons Ltd.

Steam mains-Stewarts and Lloyds Ltd.

Steam accumulator plant—Steam Storage Co. Ltd.

Pumps-Mather & Platt Ltd., Plenty & Son Ltd., Mirrlees (Engineers) Ltd.

Pneumatic tube system—Lamson Engineering Co. Ltd.

Overhead cranes-Wellman Smith Owen Engineering Cpn. Ltd., Clyde Crane & Booth Ltd., Adamson Alliance Co. Ltd., Herbert Morris Ltd.

Mobile charger-Blaw Knox Ltd.

Control cabins-Solano Air and Heat Systems Ltd.

Weighing equipment-Henry Pooley & Son Ltd., Richardson Scale Co. Ltd.

Air compressors—Ingersoll-Rand Co. Ltd., Worthington-Simpson Ltd.

LD bearings-Skefko Ball Bearing Co. Ltd.

Electric brakes-Brookhurst Igranic Ltd.

Lance hoist-Felco Hoists Ltd.

Winchgear-Clarke, Chapman & Co. Ltd.

Oxygen plant-British Oxygen Co. Ltd.

Main electrical equipment—The English Electric Co.

Electric motors-AEI Ltd., English Electric Co. Ltd., Maudslay Motor Co. Ltd.

Electric switchgear-A. Reyrolle & Co. Ltd., Whipp & Bourne Ltd.

Electric transformers and reactors—C. A. Parsons & Co. Ltd.

Instrumentation-George Kent Ltd., Elliott Brothers (London) Ltd.

Rectifier equipment-Hackbridge & Hewittic Electric Co. Ltd.

Switchboards-Baldwins & Francis Ltd.

## CONSETT Developments

#### KALDO CONVERTERS THE

By IAN LAMBERT\*

The two 120 ton LD converters, the associated waste heat boilers, and gas cleaning plants, together with two 120 ton Kaldo converters supplied and installed at Consett Iron Co. Ltd. by Head Wrightson & Co. Ltd., collectively represents one of the largest oxygen steelmaking plants of its type in the world housing both LD and Kaldo converters within the same building.

This article will consider various aspects of design, manu-

Fig. 1. Perspective drawing of the LD converter

Brick retaining ring

4 Self-aligning fixed roller bearing

5 Spur wheel cover and oil bath

2 Pouring spout

Lifting lugs

by Head Wrightson Iron & Steel Works Engineering, Ltd., in association with Pintsch Bamag, AG, Köln. While space does not permit detailed discussion, it is necessary to appreciate that heavy engineering of this type requires not only well equipped manufacturing facilities, but a comprehensive background of research embracing both welding technology and thermal engineering.

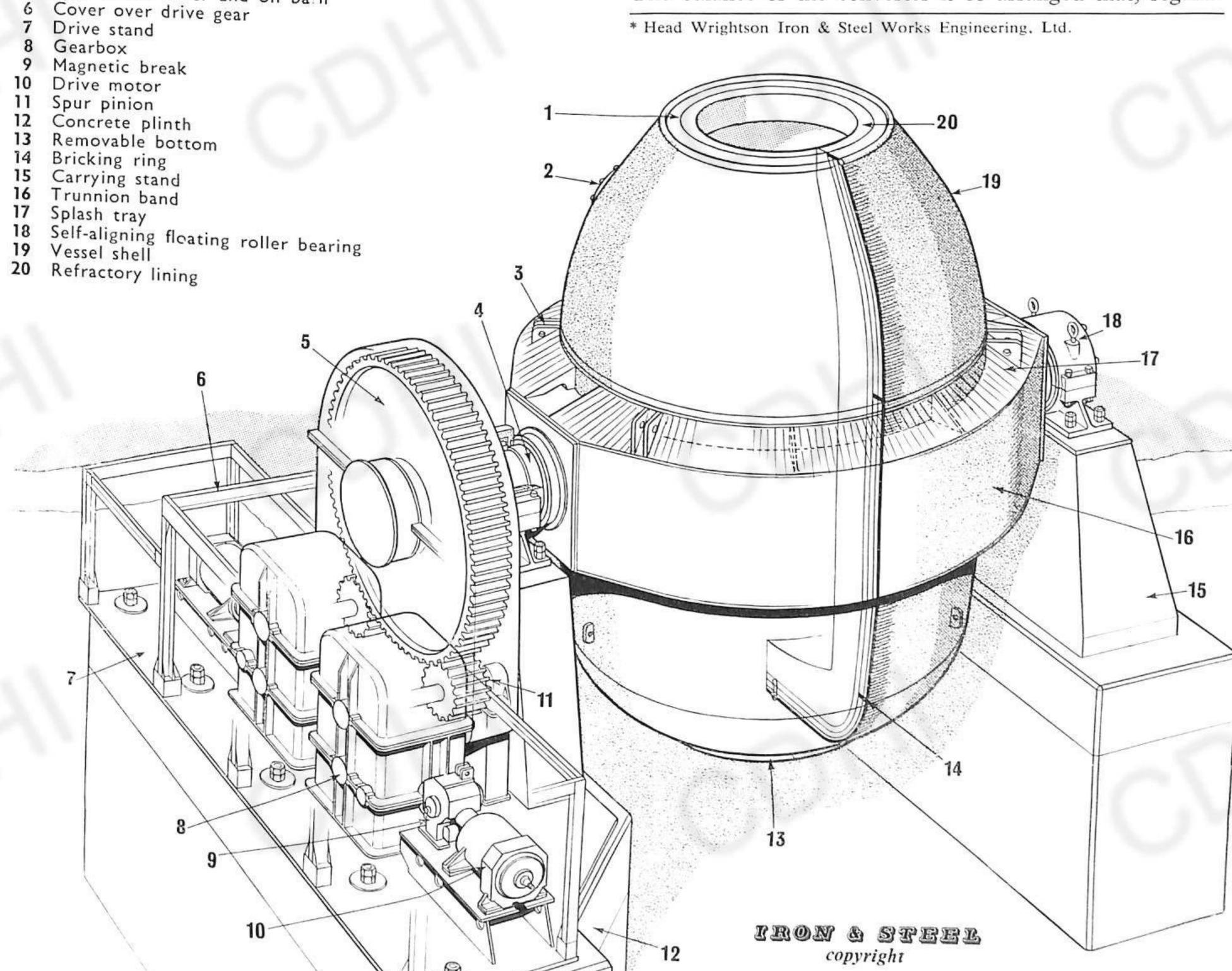
facture and site erection of the two types of converter and

their respective lance equipment, as supplied and designed

#### THE 120 Ton LD CONVERTER

An appreciation of the general arrangement of the converter can readily be seen by referring to the artist's impression, Fig. 1.

The balance of the converter is so arranged that, regard-



less of the state of wear of the lining or volume of charge, a positive moment tends to return the vessel to the upright position. In the event of an electrical power failure, the electromagnetic brakes will be automatically applied and the vessel held in position. At the discretion of the operator, the brakes can be released and the furnace will gravitate towards the upright position.

The converter shell and trunnion band are of integral construction, the band forming a box section homogeneously welded to the barrel portion of the vessel: this section is reinforced by two radial stiffeners and several longitudinal shear members which are profiled to facilitate free circulation of air within the trunnion band. The tangential heat stresses of the inner wall (shell temperatures have been recorded up to 350°C) are compensated by the tensile stresses of the outer wrapper plate. Trunnions are fitted into two forged steel sleeves specially designed to eliminate high stress concentrations.

The vessel is provided with a removable cast steel bottom to facilitate rebricking (this introduces standardization with the Kaldo converter which is discussed later in this article). The bottom is held in position by specially designed wedges which fit tangentially, each wedge being secured by a toggle operated locking frame.

The overall dimensions, etc., of the converters are reproduced below:

Vessel shell: inside diameter, 19 ft 5 in; length, 29 ft.

Trunnion band section: bearing centres, 28 ft 8 in; weight approximately, 114 tons.

Carrying stand (non-drive): approximately 25 tons.

Carrying stand (drive): approximately 48 tons.

Drive specification: two combined bevel and helical reduction gear units (each capable of tilting the converter) engage with a large fabricated spur wheel. Total maximum transmitted torque is  $1.41 \times 10^6$  ft lb. Each gearbox is driven by 150 h.p. d.c. motor.

Tilt speeds (rotation is in both directions): 0.1 to 1 r.p.m. in graduated steps.

Main support bearings: trunnions supported in self-aligning spherical roller bearings size 240/900.

As already mentioned, the trunnion band was integrally fabricated with the vessel shell and for convenience of manufacture, the shell was partially fabricated while horizontally mounted on temporary trunnion stands, see Fig. 2. After completion of all welding operations, including radiography, the band section was removed to a gas fired furnace and fully stress relieved at a soaking temperature of 650°C. Following the stress relieving operation, the trunnion

holes were bored and the whole band again mounted on the temporary support stands; this time, however, the band was pivoted in the vertical position and rigidly secured in readiness for insertion of the first trunnion pin. It is interesting to note that both the drive and non-drive trunnions (weighing 11 tons and 5 tons respectively, see Fig. 3) were inserted into the bore using the liquid nitrogen process which, because of its unique application, is described below. With the band securely located in the vertical position (and it should be emphasized that this positioning is critical) a temporary platform was erected above the trunnion bore on which a movable copper nitrogen container was placed. The fully machined trunnion was secured by an overhead crane and meticulously centralized over the trunnion bore, the pin was carefully raised without lateral movement just sufficiently to allow the nitrogen container to be rolled into position below the suspended pin; liquid nitrogen was pumped into the container at a controlled rate from a tanker which was standing by. The pin was lowered into the bath and cooling/contraction commenced down to an approximate temperature of  $-190^{\circ}$ C. The interference fit was scheduled at 0.033 in — that is 0.001 in per inch of trunnion diameter. From time to time the freezing operation was interrupted for micrometer readings to prove the shrinkage - experience indicated that a diameter shrinkage of 0.070 in was acceptable, see Fig. 4. When sufficient shrinkage was obtained, the pin was finally withdrawn from the bath, the container rolled away and the pin lowered directly into the trunnion bore where it remained undisturbed for five days. The photograph shows the freezing-in of the small non-drive trunnion (Fig. 4).

Approximately 75,000 ft<sup>3</sup> of free nitrogen were used and the whole operation took approximately 110 min, the larger mass pins taking an average of 14 min longer than the smaller pins.

Owing to the large overall dimensions of the LD converter, and the additional projection of the trunnions, it was considered most convenient to transport each converter to site in three sections — the centre, or trunnion band, section, and the upper and lower cone sections — for final assembly and welding.

The assembly work at site consisted of marrying up the three sections of the converter, following which the circumferential welding was executed under carefully controlled conditions and the resultant welds subjected to 100% radiography testing.

Concurrently with this welding operation the converter drive and carrying stands were erected on the monolithic concrete plinths. The completed vessel shell was lifted on

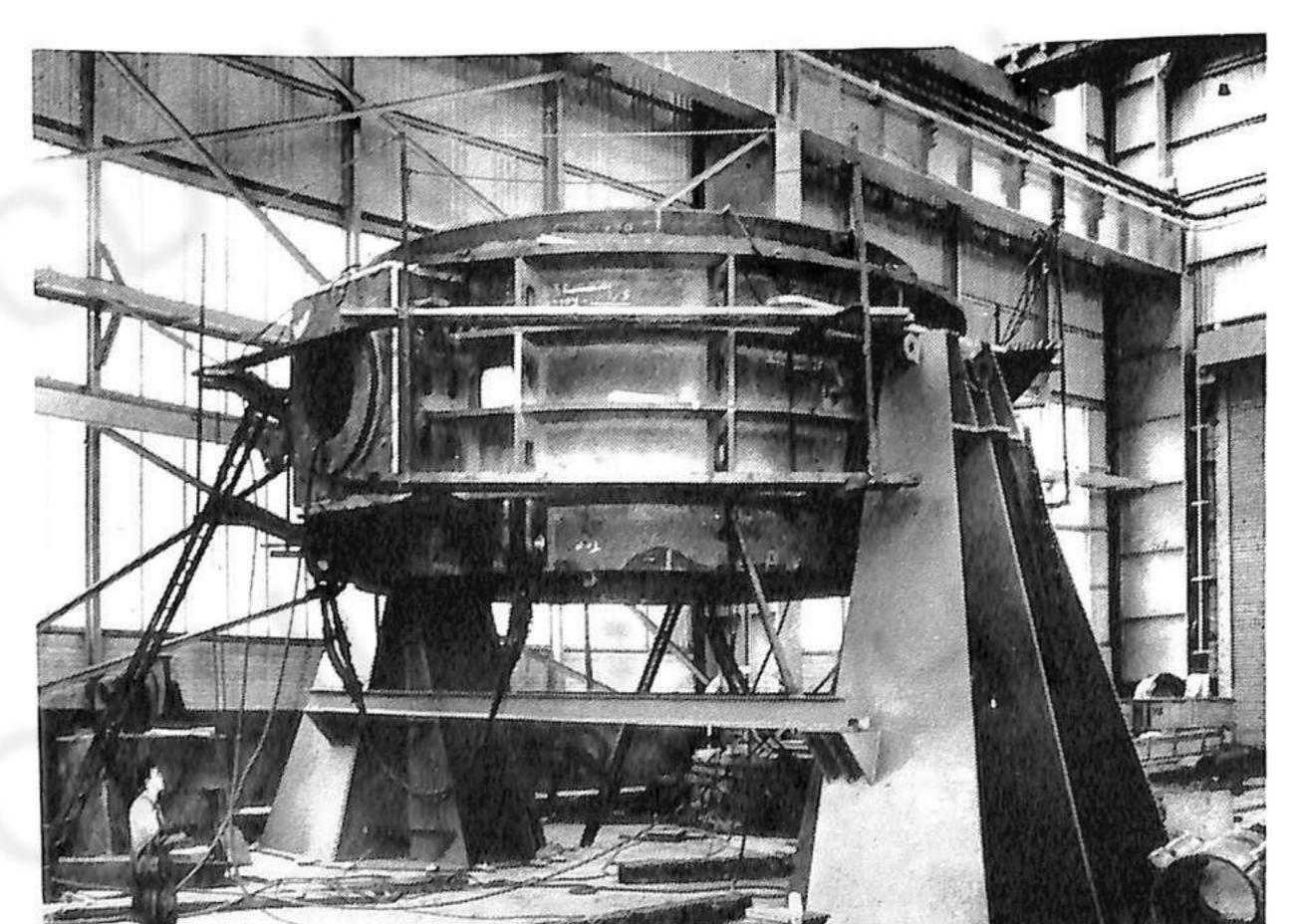


Fig. 2. Trunnion band and centre section of an LD converter mounted on temporary trunnion stands during fabrication

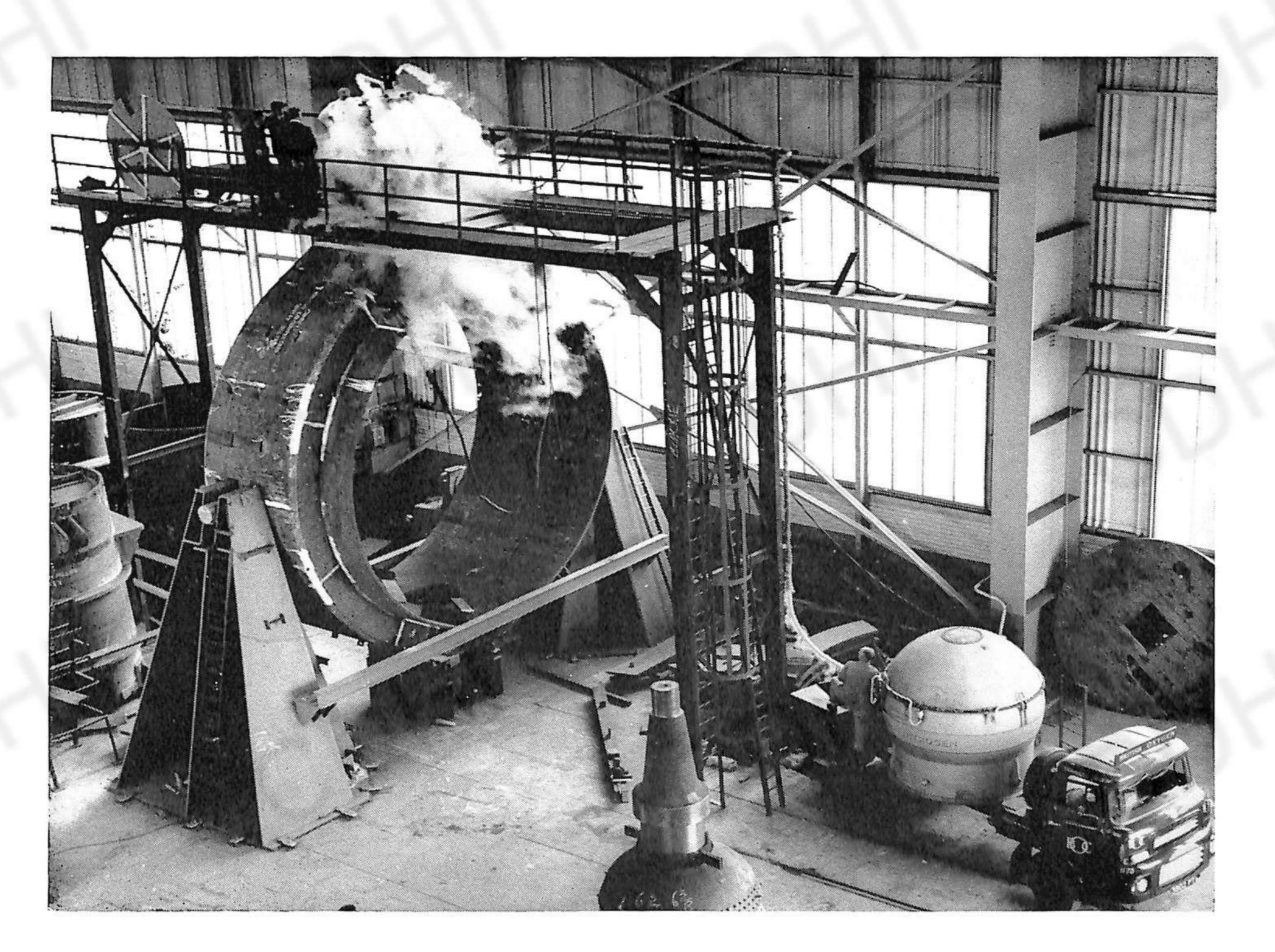


Fig. 3 (above). Liquid nitrogen is used to shrink the trunnion pin into the trunnion band of the LD vessel

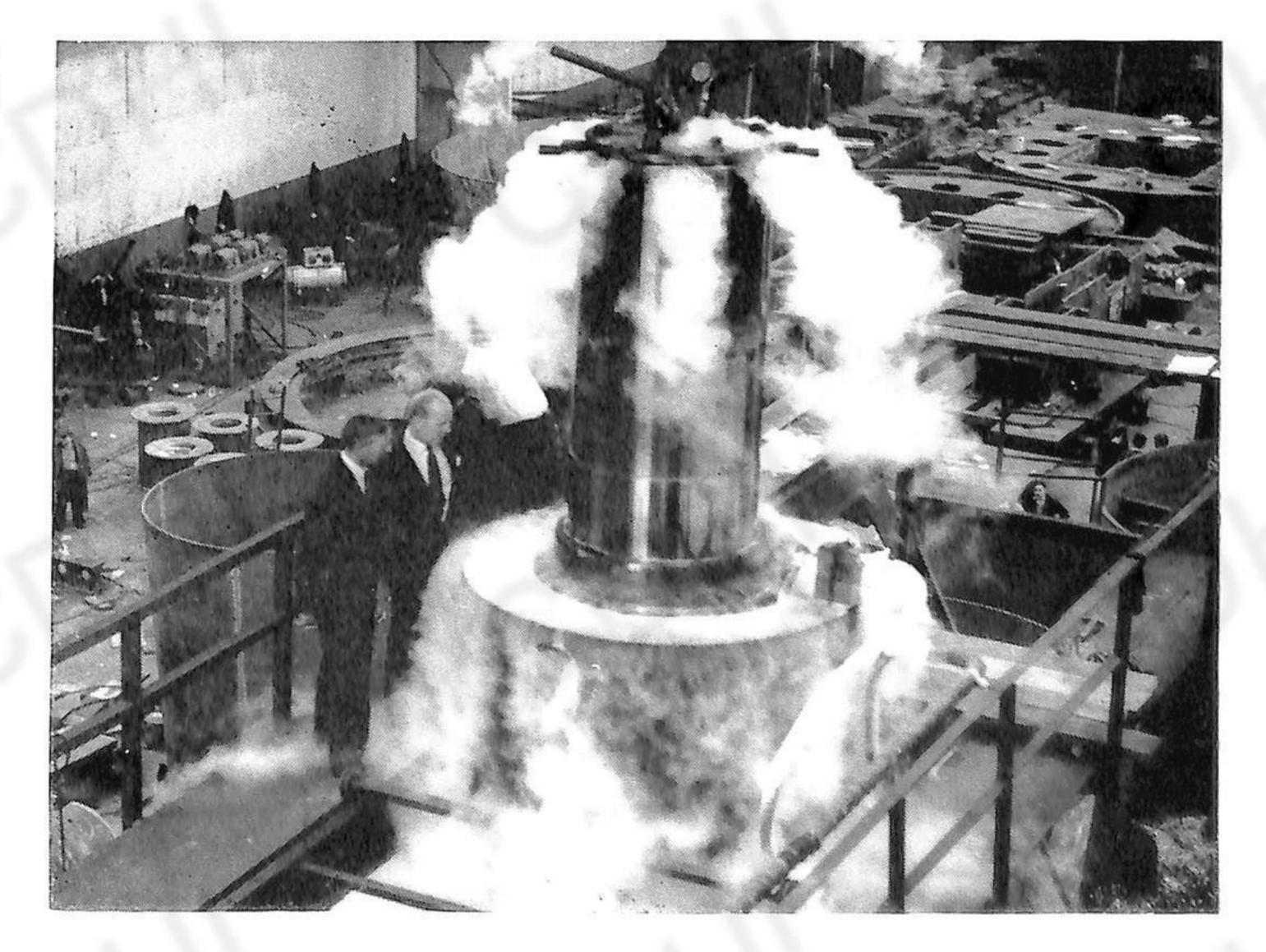


Fig. 4 (right). Close up of the shrinking in operation

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to a temporary supporting structure which was in turn mounted on rollers, as can be seen by reference to Fig. 5. At this stage the bearings were fitted, using the oil injection method, the bearing housings assembled and the vessel, on its temporary supporting structure, was slowly winched into position and landed on the converter stands. After the necessary aligning and levelling, the 20 ton spur wheel, gearboxes, and drive units, were then fitted and connected up.

#### LD LANCE SYSTEM

The arrangement of the LD lance system can be seen by reference to Fig. 6. A breakdown of the principal components in this system is given below:

Three oxygen lances: one operational, one standby, and one spare.

One main winch: 146 ft 6 in floor level.
One auxiliary winch: 146 ft 6 in floor level.

One 5 ton monorail hoist: 146 ft 6 in floor level.

One 5 ton stationary hoist for carrying the standby LD lance: 146 ft 6 in floor level.

One valve station: 121 ft 3 in floor level. One lance clamp: 69 ft 6 in floor level.

One hose connection and lance changing platform.

Two handling blocks to assist in the changeover to the

standby lance and to complete hose changing: 146 ft 6 in floor level.

#### The Oxygen Lance

Correct lance design represents an important facet of an LD installation, with particular emphasis on nozzle profile. The upstream nozzle pressure must be established within close limits to ensure adequate penetration by the jet, and at the same time the oxygen flow rate should be of a magnitude to allow metallurgical reaction to take place at the correct time.

The oxygen lances supplied to Consett Iron Co. Ltd., are of interesting construction, as can be seen by reference to Fig. 7, being water cooled and having an overall length of 58 ft. The outer water jacket is of cold drawn seamless steel tubing approximately  $8\frac{1}{2}$  in diameter, the intermediate sleeve is of heavy quality steel tubing approximately  $6\frac{1}{2}$  in diameter. The oxygen delivery tube forms the inner water jacket and is of solid drawn copper,  $4\frac{1}{2}$  in inside diameter; this inner tube is connected at the tip of the lance to the outer water jacket by a specially designed copper nozzle with a reduced throat diameter of 2.52 in.

The cooling water flows down the inner water wall of the lance and up via the outer wall at a velocity of 11 ft/sec, and is conveyed to and from the lance by means of flexible rubber hoses suitable for a working pressure of 120 lb/in<sup>2</sup>.

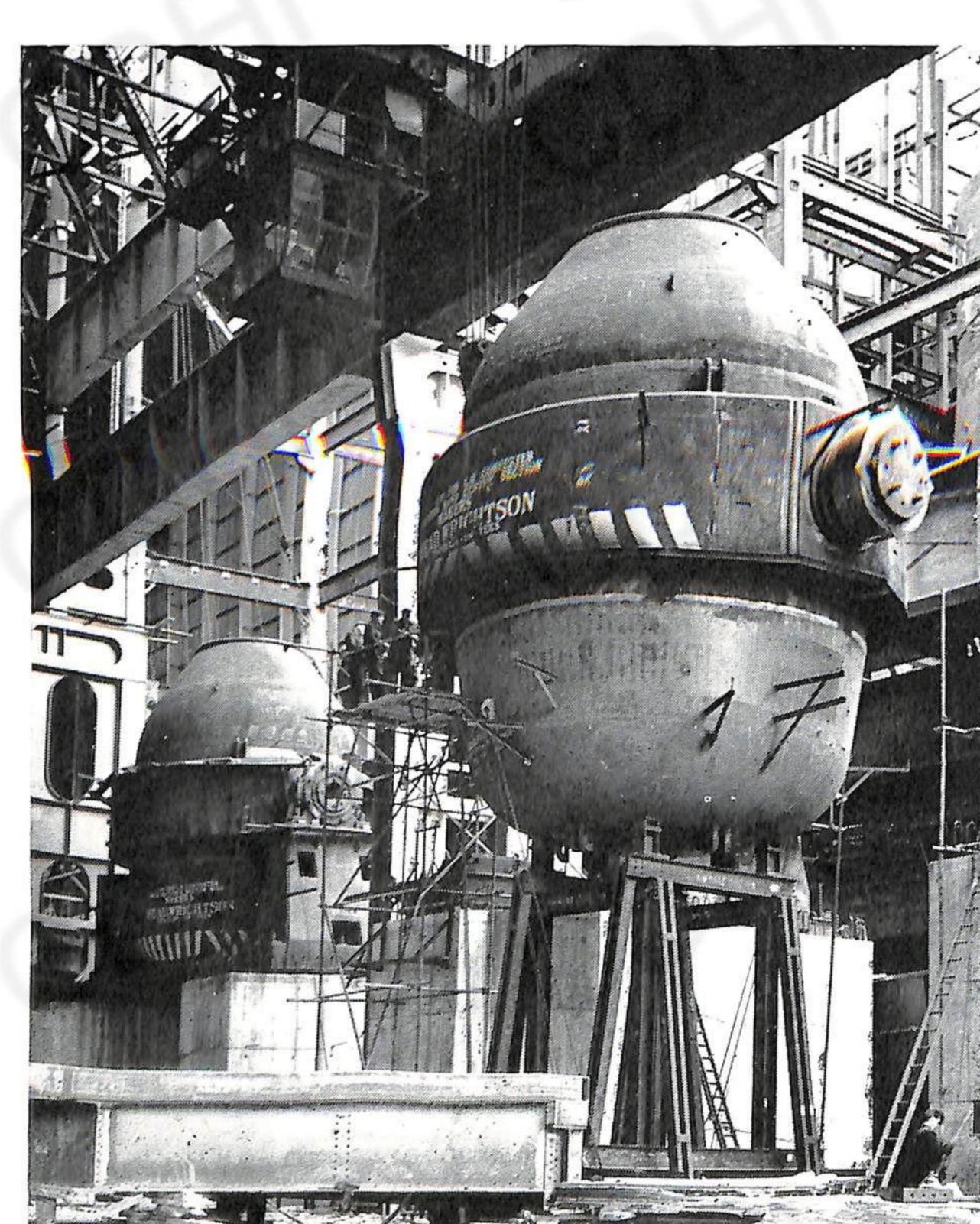
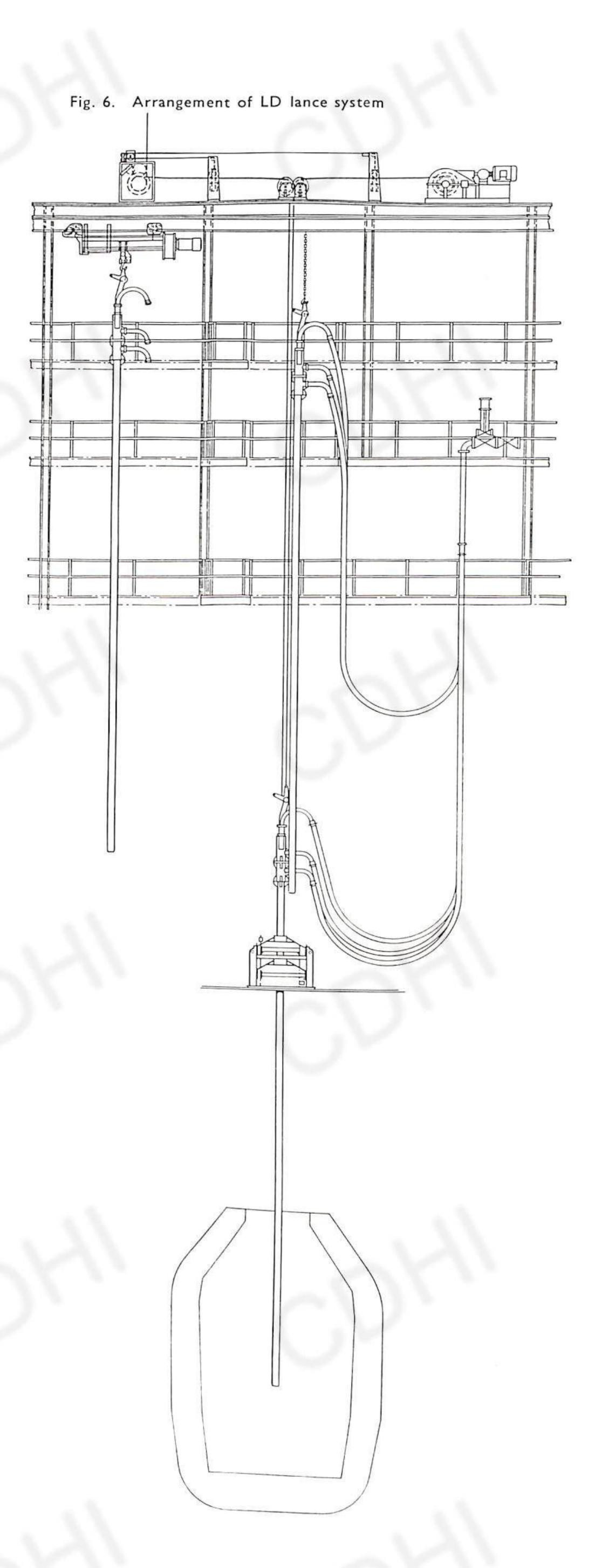
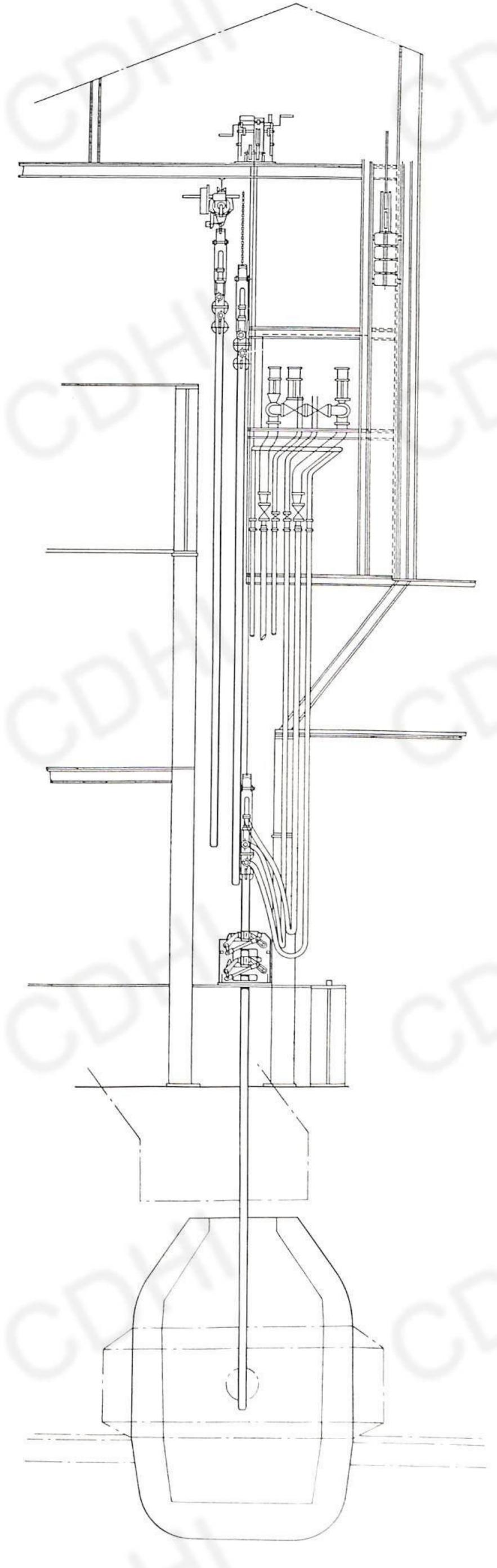
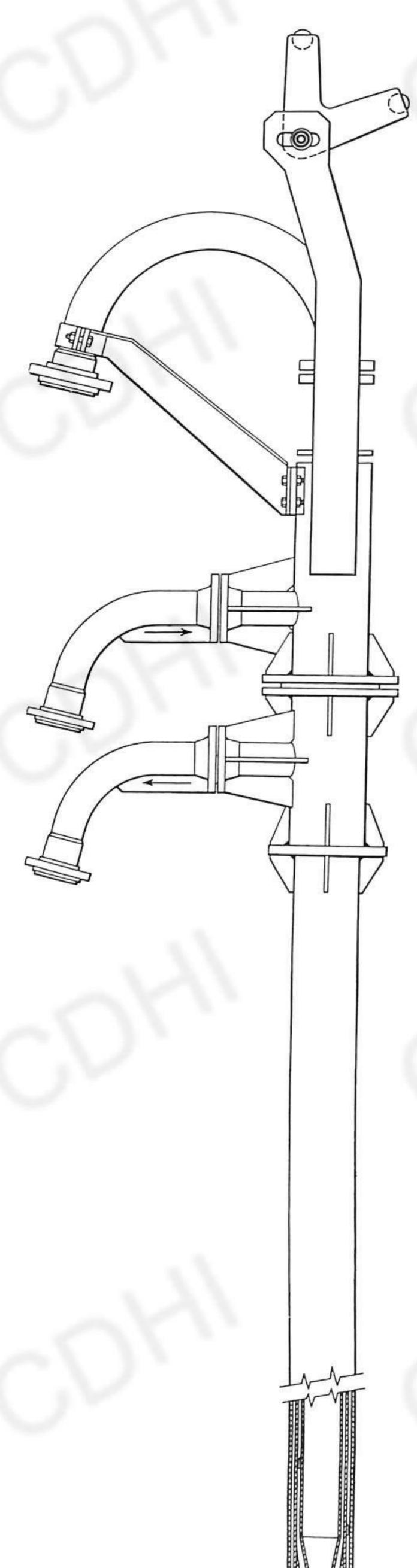


Fig. 5. Rolling the LD vessel into its final position on a temporary trestle during erection at Consett





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Oxygen is supplied to the lance by means of flexible neoprene hoses, the oxygen flow rate being designed for 14,000 s ft<sup>3</sup>/min with a lance inlet pressure of 180 lb/in<sup>2</sup>. The velocity of the oxygen at the nozzle throat is increased to supersonic speed due to the design of the nozzle divergence, which is based on pressure differential and thermal gradient considerations.

#### Lance Main Winches

The main lance winch is electrically powered and capable of a five ton pull with duplex lance descent speeds of 40/10 ft/min. As the lance is lowered into the vessel, the instrumentation is automatically arranged to transmit a signal to the valve station controlling the opening of the oxygen valves. Full oxygen velocity is attained by the time the lance is in the normal blowing position, approximately 3 ft above the bath, although this position is a controlled variable. When the lance is fully lowered into the blowing position, a pneumatically operated lance clamp, located on the 69 ft 6 in floor level, is automatically brought into operation rigidly supporting the lance for the duration of the blow, see Fig. 6.

In the event of an a.c. power failure, the standby auxiliary winch, which is powered by a separate d.c. supply, is brought into operation and the lance withdrawn.

The 107 ft 6 in and 121 ft 3 in floor levels have been designed with a special platform contour to facilitate easy access to the lance hose connections.

The 5 ton monorail hoist runs the complete length of the building and provides facilities for handling both LD and Kaldo lances requiring removal for inspection and maintenance.

#### Burning-in of New Lining

For the purpose of burning-in a relined vessel, provision has been made in the valve station to supply oxygen, through the main lance, at a reduced flow rate. Burning-in is achieved by charging approximately 2 tons of ignited coke into the newly lined converter; oxygen is then applied through the lance at 28 lb/in² with a calculated flow rate of 1,050 ft³/min.

The resultant exhaust fumes are conveyed to atmosphere via the radiant leg of the waste heat boiler and the by-pass stack.

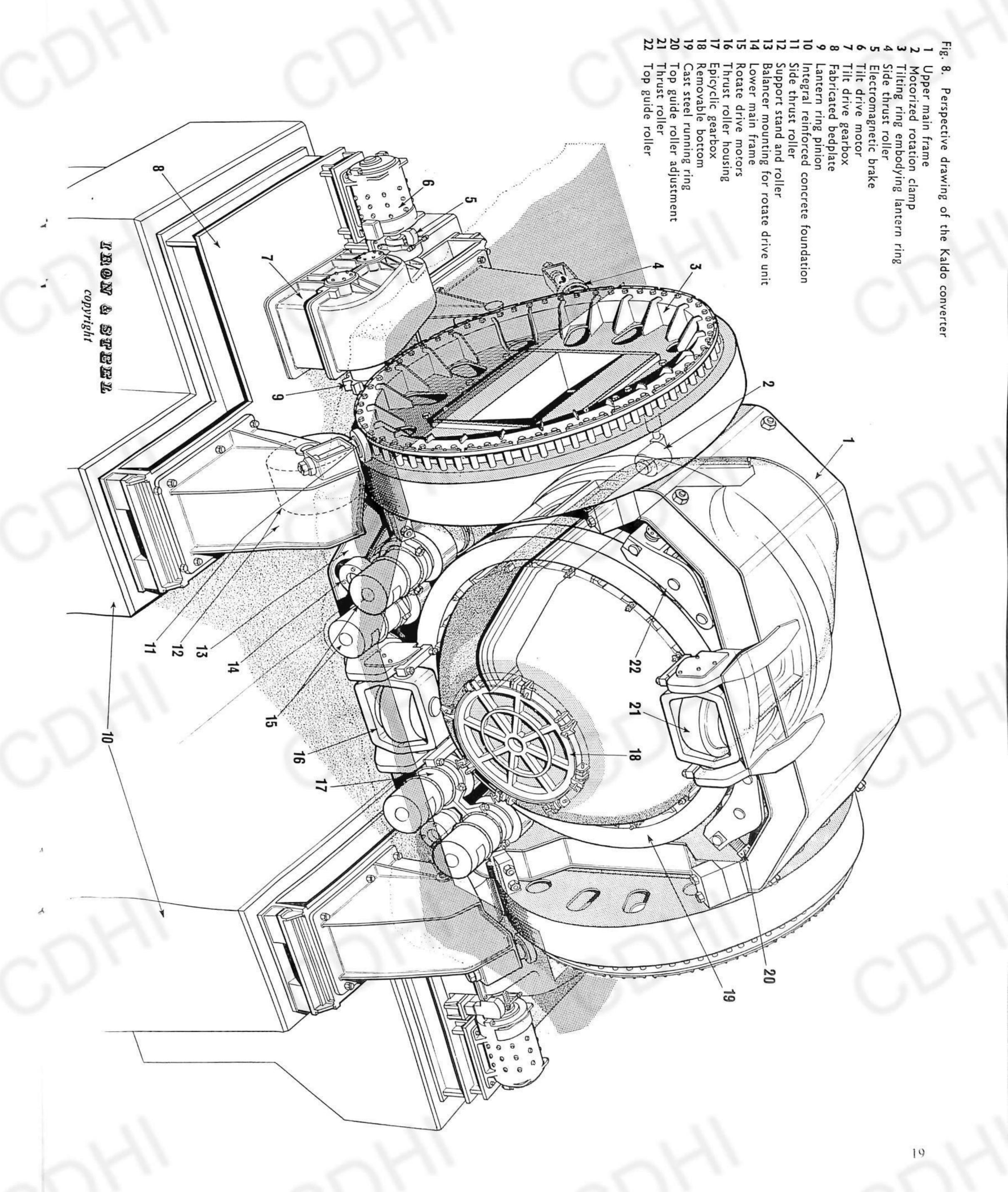
#### THE 120 TON KALDO CONVERTER

The artist's impression of the 120 ton Kaldo converter can be seen by reference to Fig. 8. The rotating vessel assembly, which is mounted on four pairs of compensated rollers, is completely encircled by two fabricated main frames of massive proportions. The frames are mounted into two tilting wheels which, in turn, are supported on the drive stands by four large tilting rollers. Tilting is achieved by means of pinions engaging with lantern rings which are an integral part of the tilting wheel assemblies. Tilting speed is controlled between 0.1 rev/min and 1 rev/min, and the vessel rotation is variable up to 34 rev/min.

The overall dimensions of the Kaldo vessels are given below:

Vessel shell: inside diameter, 18 ft; length 28 ft.

The vessel shell is provided with a removable cast steel bottom (identical with that supplied on the LD converters) to facilitate re-bricking and to ensure that the



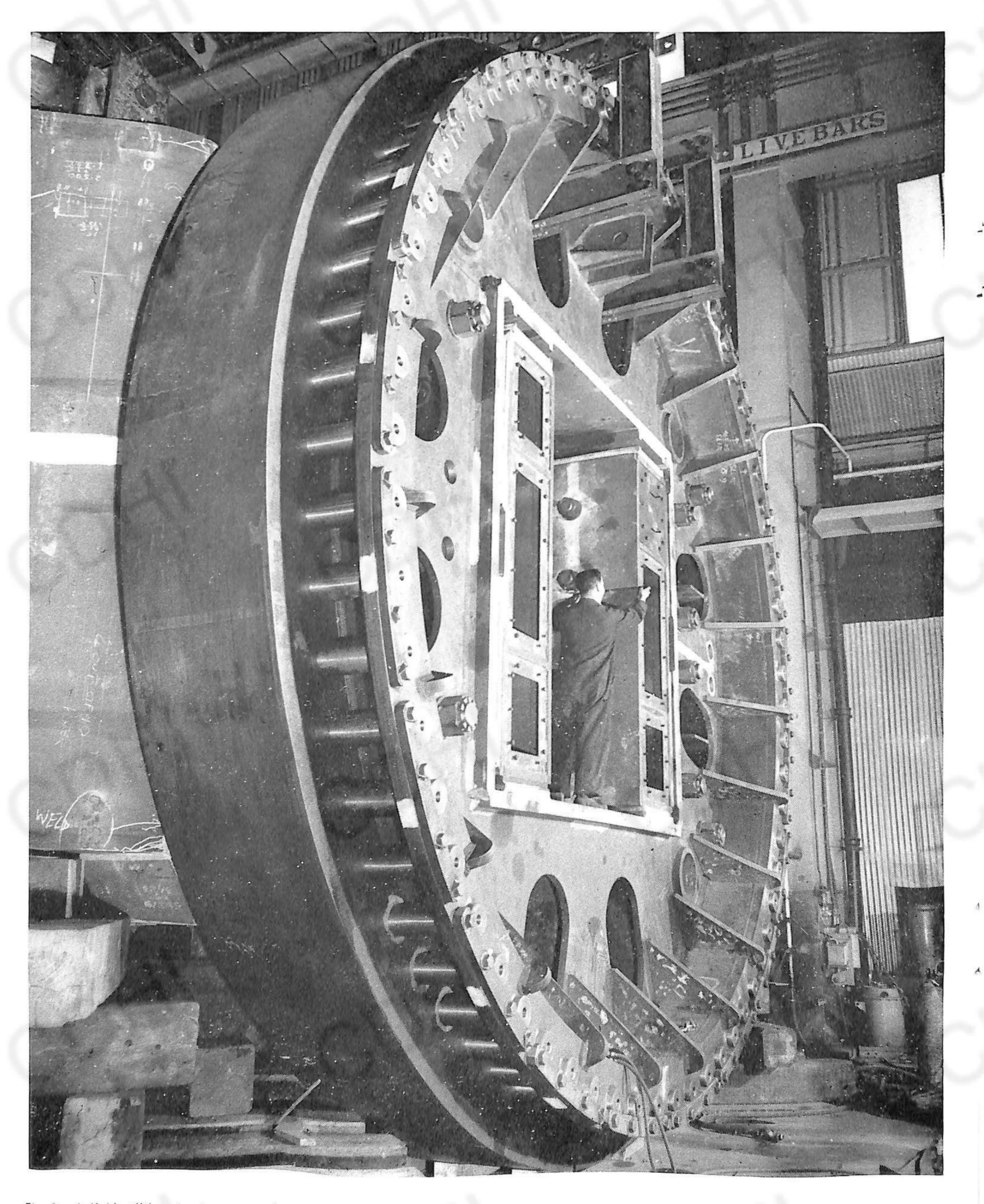


Fig. 9. A Kaldo tilting ring in course of manusacture at the Head Wrightson works

re-bricking operation is carried out with the minimum down time.

Two cast steel running rings completely encircle the vessel and are connected to the shell by a patented method whereby the radial and axial thermal expansion of the vessel are unrestricted; the connection between the rings and the vessel forms an air space to minimize heat trans-

The vessel shell itself is of all welded construction and during manufacture was subjected to 100% radiography and full stress relief. The main frames, tilting wheels, and drive stands, together with all minor welded fabrications, were similarly subjected to radiography or magnaflux testing to prove the weld quality. Stress relieving was also undertaken for these components.

Prior to despatch to site the whole tilting assembly was shop erected: Fig. 9 shows the cast steel running rings located in the main frame assembly, and Fig. 10 illustrates method of attaching the cast steel rings to the shell.

Rotation of the vessel is achieved by four friction drive rollers (each driven by epicyclic gearboxes with flange mounted motors) in contact with the rear cast steel running ring. Four non-drive rollers, and two fully compensated thrust rollers form additional support for the rotating assemblies. Electrical power is transmitted to the rotate motors via a slip ring unit which is mounted externally to to make use of the cranes to erect directly on to the the converter on the operating platform. The cables carry- converter foundations.

ing the power to the rotate motors are ducted through the lower main frame. Cooling air for the motors is similarly ducted through the frame.

Two specially designed screw jacks, fitted with slipping clutch devices, are mounted on the upper portion of the main frame. Before tilting the furnace these screw jacks bear down on to the upper cast steel running ring, securely containing the vessel against the rear thrust rollers so that the tilting operation may be commenced.

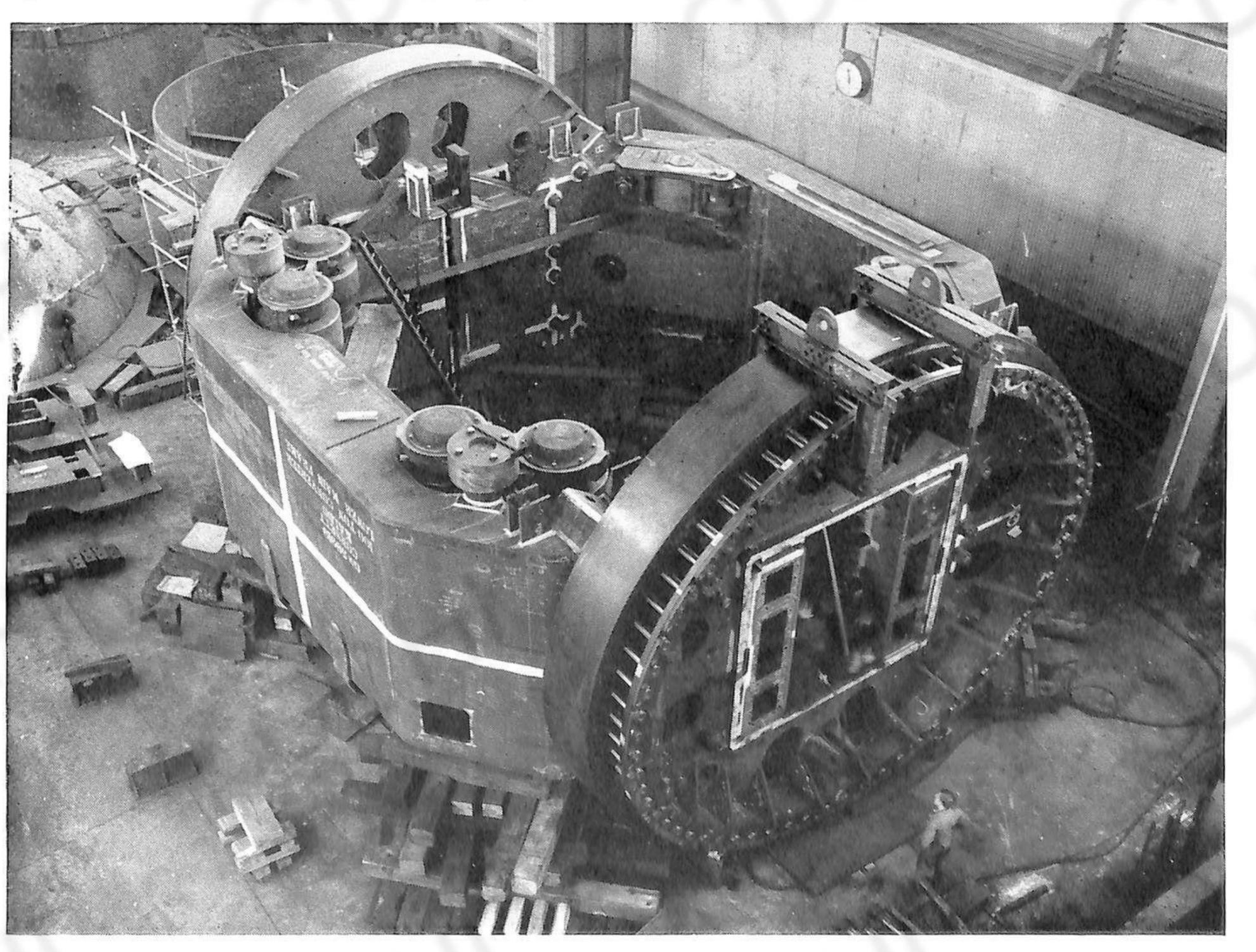
#### Site Erection of Kaldo

As with the LD converters, special consideration was also necessary in devising the erection scheme for the Kaldo converters owing to the large and extremely heavy components to be handled (the heaviest partial assembly weighed more than 150 tons) and to the disposition of the converter relative to the charging bay.

On arrival at the site, the offloading of the converter subassemblies was undertaken in the charging bay by means of the heavy duty overhead ladle cranes which, because of their large lifting capacity (main hoist 160 tons), were well equipped to perform this duty.

Reference to the accompanying plant layout drawings, however, will show that the converter location is outside

Fig. 10. Kaldo main frames and tilting wheels during shop erection at Teesdale works



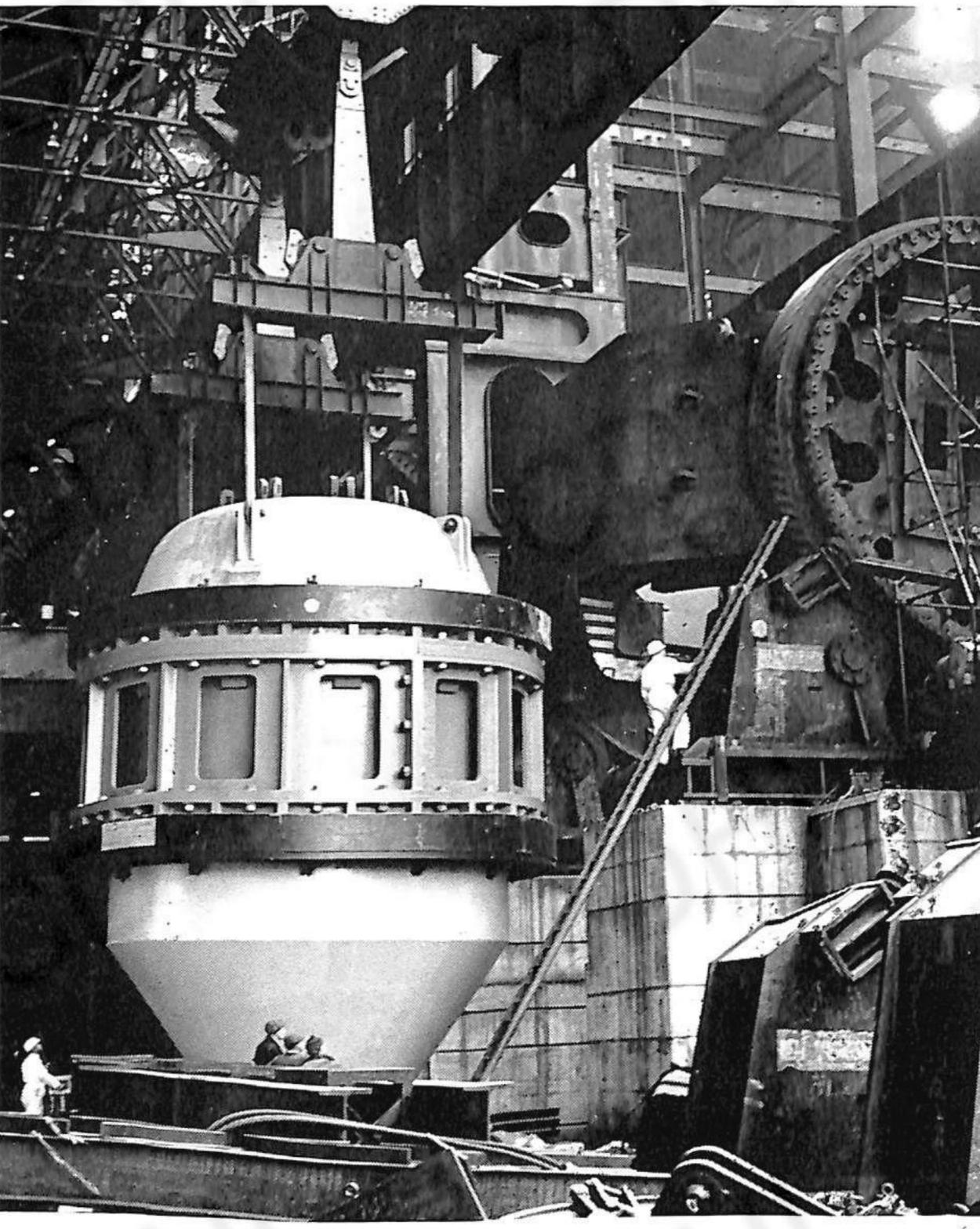


Fig. 11. Preparing to insert the Kaldo vessel into the main frame assembly

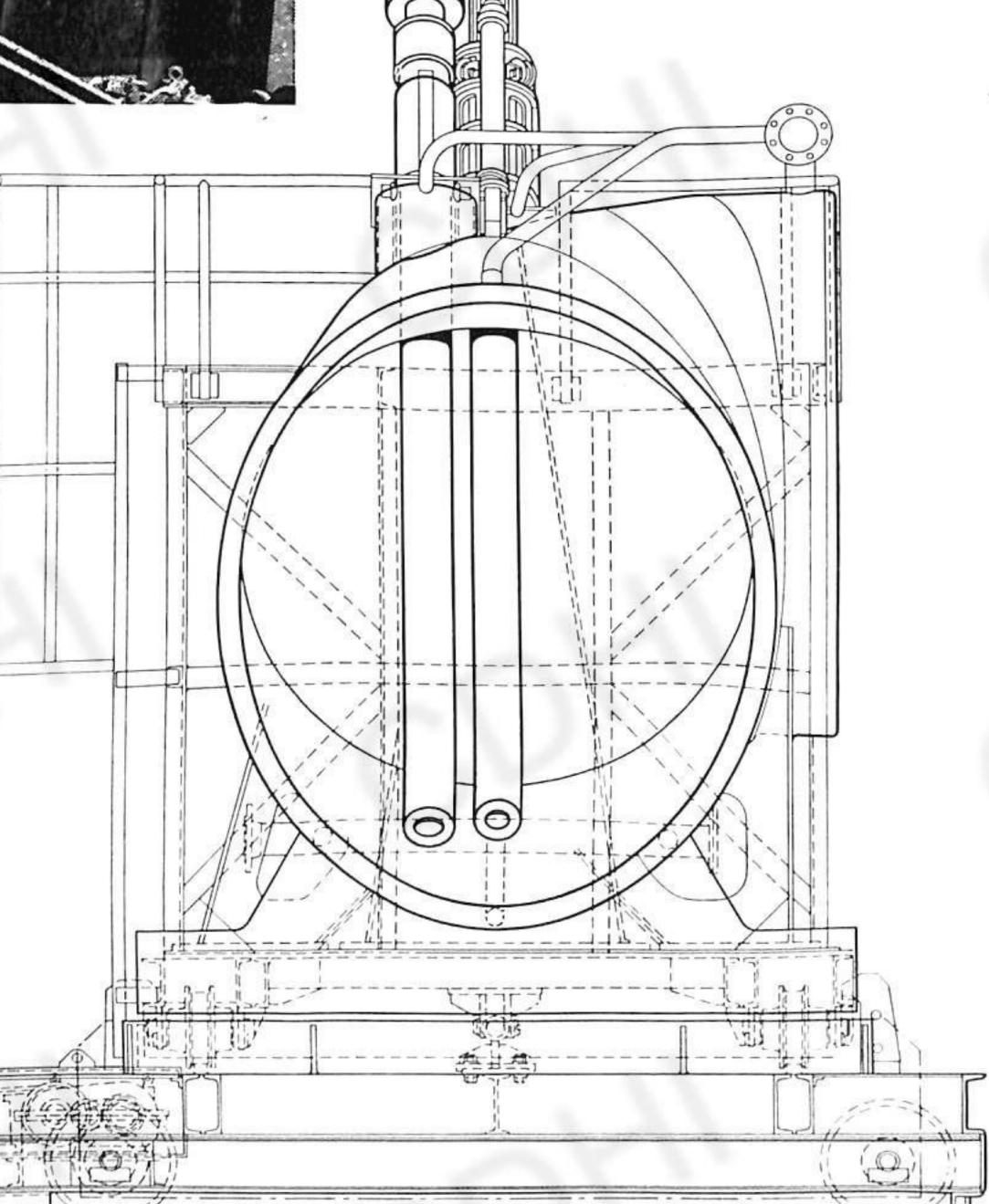


Fig. 12. Arrangement of hood and lances on Kaldo converter

An erection plant was, therefore, devised in which the complete converter (apart from vessel shell and running rings) was erected in the charging bay and subsequently transferred, by rolling on temporary tracks, on to the fabricated supporting base frames mounted in readiness on the reinforced concrete foundations.

The vessel shell, complete with running rings, etc., formed one of the last items to be erected, and this was moved into position at ground level by means of special roller paths. Hoisting of the vessel into its final position was carried out by means of a specially designed lifting rig mounted above, and supported on, the converter tilting rings, and it only remained for the screw jack clamping units to be fitted to secure the vessel in position and so complete the erection of the converter.

#### KALDO LANCE HOOD AND CARRIAGE

The Kaldo lances (oxygen and additions) are mounted in a water-cooled hood, which is supported on a traversing rail carriage. This arrangement can be clearly seen by reference to Fig. 12.

The oxygen lance is of similar composite construction to the LD lance already described, and is water cooled using approximately 180 gal/min of water with an inlet pressure of 120 lb/in2. The oxygen lance is pivoted externally to the hood and swings through an arc which is variable not only to withdraw the hood clear of the vessel mouth,

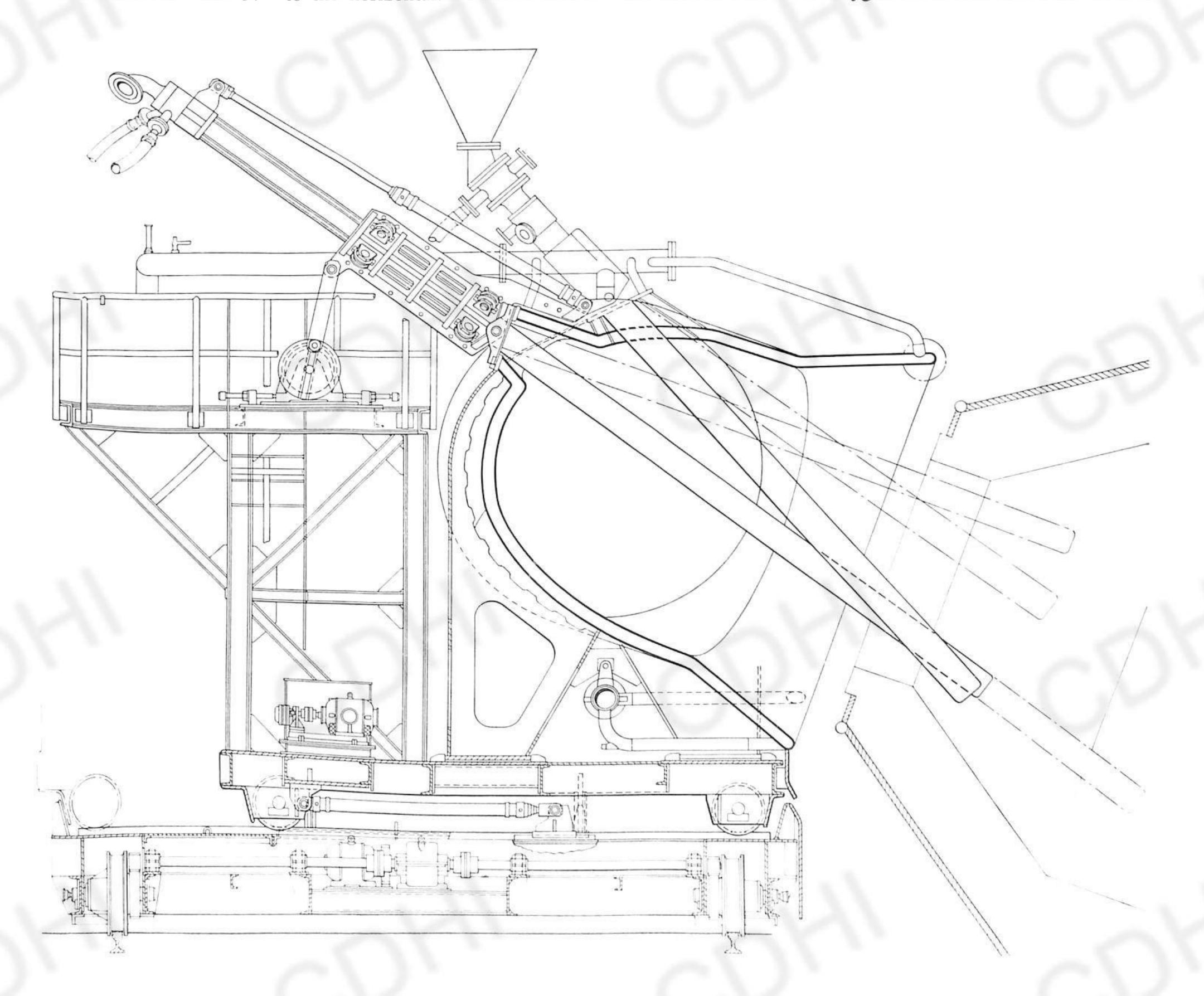
cam mechanism is incorporated to oscillate the lance approximately 17 times per minute if required.

The oxygen flow is 6,000-7,000 S ft<sup>3</sup>/min with an inlet pressure of 90-100 lb/in<sup>2</sup>; oxygen velocity at the copper nozzle is 650 ft/sec, the diameter of the nozzle being  $5\frac{1}{2}$  in nominal bore.

Additions are conveyed to the furnace by means of a water-cooled lance, the materials for which are introduced to the lance via a hopper charged from an overhead storage bunker. The additions gravitate into a pressure chamber of patented design which is located at the upper extremity of the additions lance. The pressure chamber develops a local velocity of 52 ft/sec and the additions are accordingly projected into the bath of the furnace, the velocity being accelerated during its journey through the lance. The compressed air is supplied from the normal services and the unit is given a maximum rating of 1,000 ft<sup>3</sup>/min with an outlet pressure of 15 lb/in2. The lance is pivoted externally to the hood to facilitate setting to an optimum operating

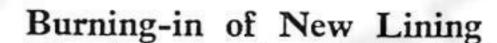
Oxygen, cooling water, and compressed air, are delivered to the lances by means of flexible neoprene and rubber hoses, supported on a frame mounted on the lance access platform (Fig. 13).

To facilitate tilting of the Kaldo converter, it is necessary between 21° and 37° to the horizontal. A motor-driven but also to retract the oxygen lance into the hood. This is



accomplished by means of a hydraulically operated cylinder mounted parallel to the oxygen lance as can be seen by reference to Fig. 10.

Also, both oxygen and additions lances are regulated so that they automatically return to the highest points in their respective arcs of travel prior to retraction of the oxygen damage to, the furnace refractory by the lances during the operation of withdrawing the hood clear of the converter mouth.



The burning-in of the Kaldo lining is achieved by the provision of a separate water cooled oxygen lance mounted in a refractory lined fume hood, which is lowered on to the mouth of the upright vessel (Fig. 14). The fume offtake is ducted directly to the by-pass stack. Burning-in is carried out in a manner similar to that described for the lance, thereby preventing fouling of, and consequential LD plant, i.e. approximately two tons of ignited coke are charged into the converter, and oxygen applied via the burning-in lance at 28 lb/in<sup>2</sup> with a flow rate of 1,050 ft<sup>3</sup>/min.

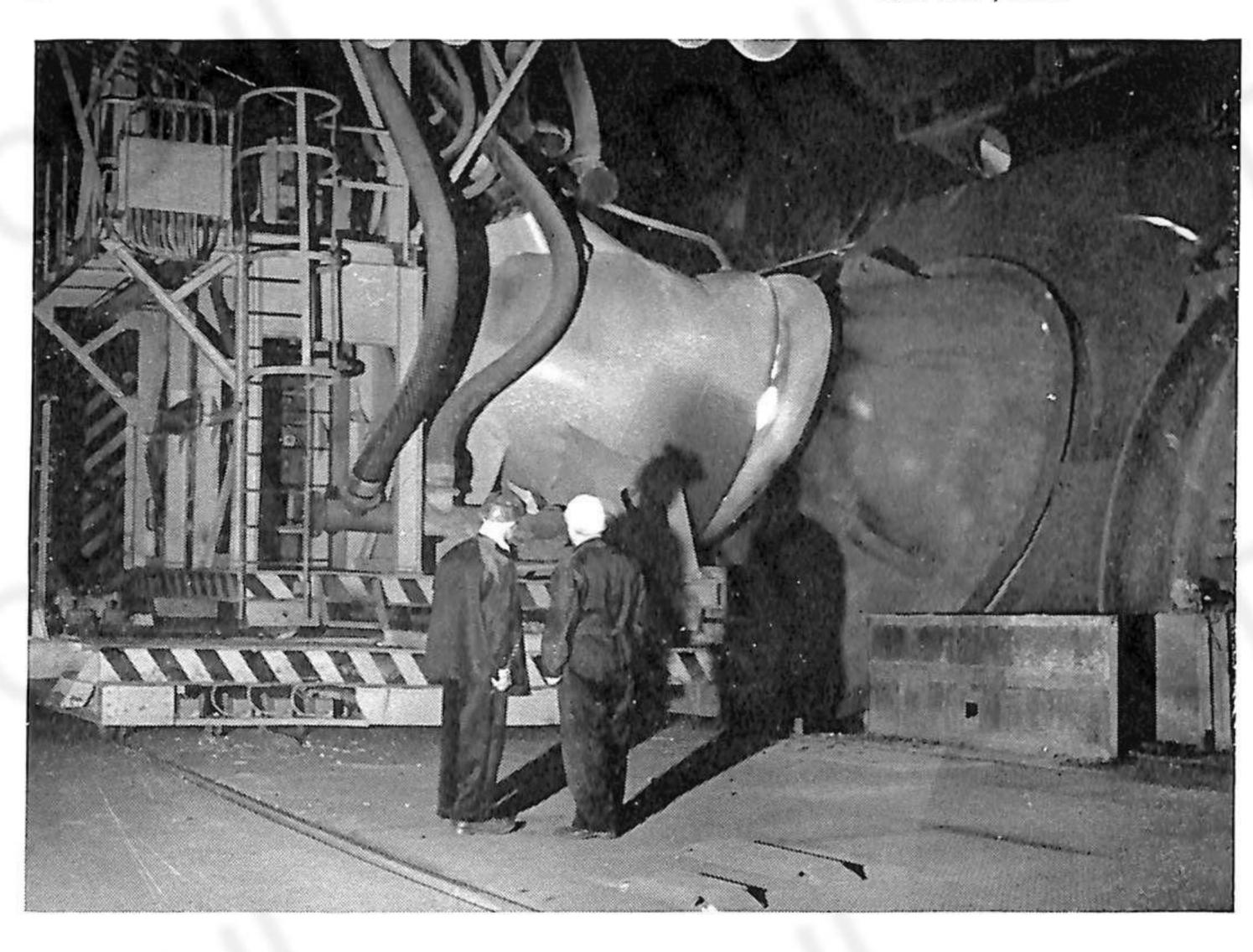


Fig. 13. One of the Kaldos in the operating position

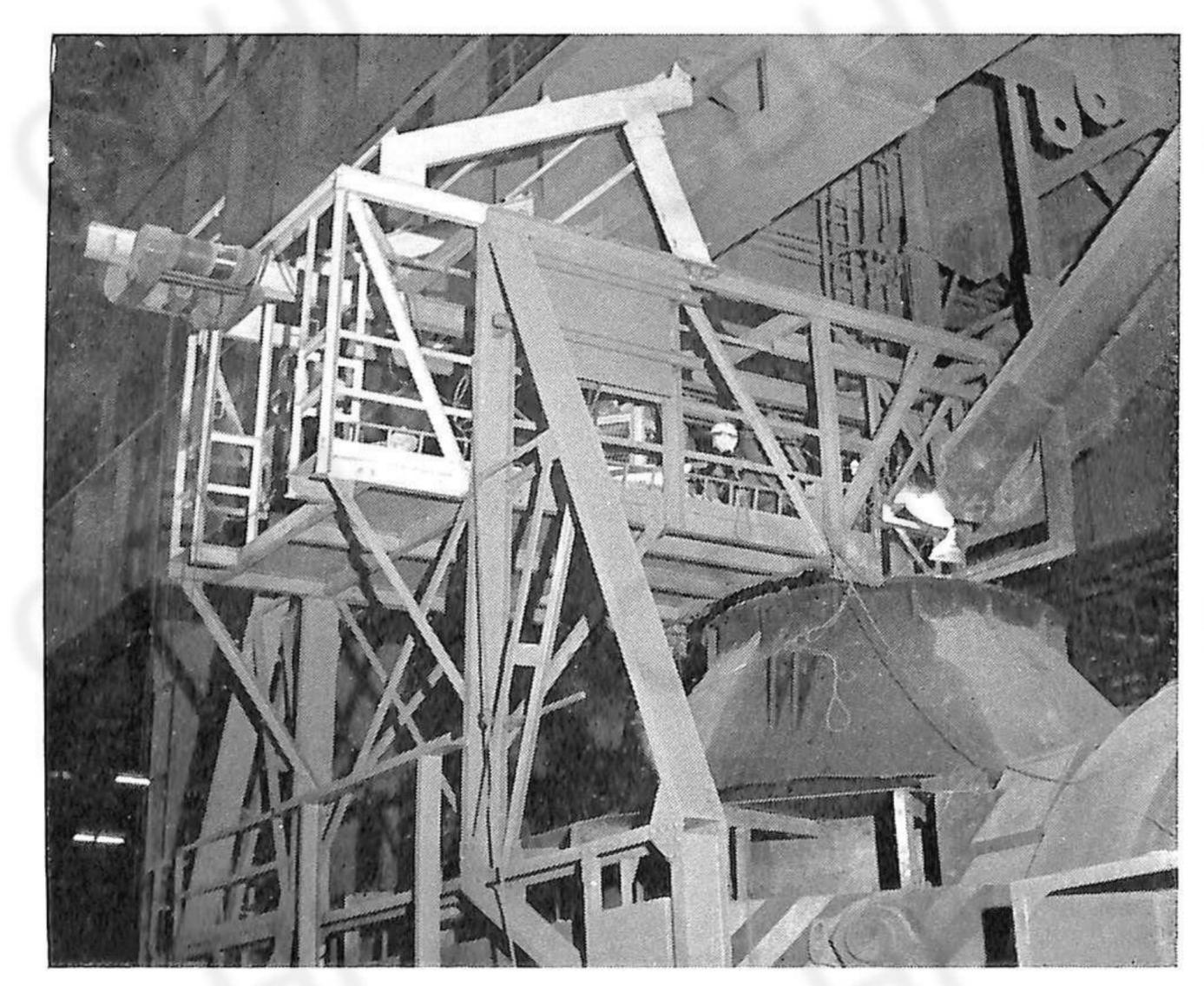


Fig. 14. Rebricking rig for relining a Kaldo converter at Consett

## Waste Heat Boiler Continued

It was with this fundamental outlook that designs were investigated for cooling the flue gases from the LD converters at the works of Consett Iron Co., Ltd.

There was a further factor which had to be taken into consideration. The plant needed to be "tailor made" to integrate with the existing power plant at the site.

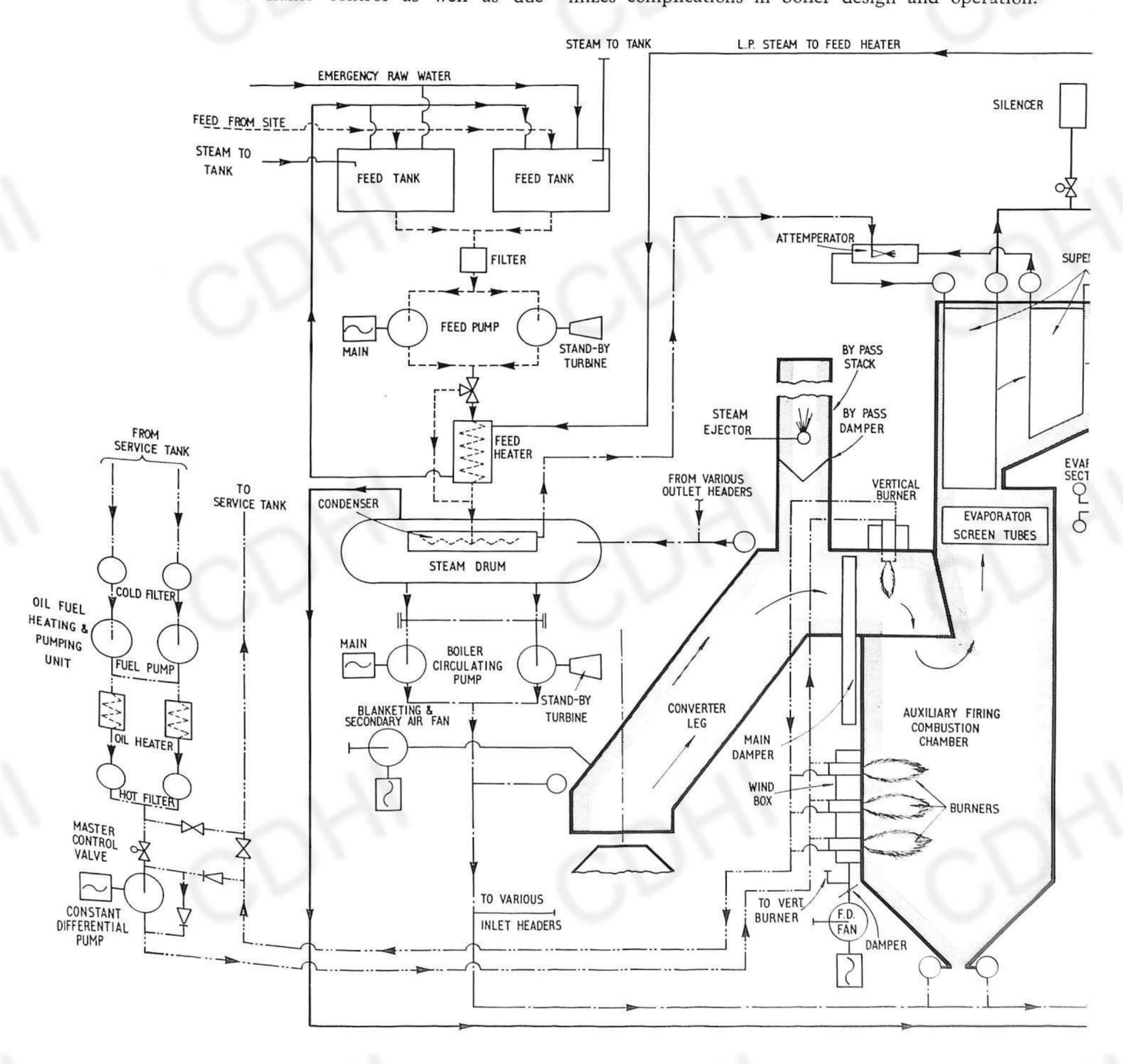
In designing the gas cooling plant it had to be fully taken into account that the heat released from the converter would not be generated at a uniform rate. The gas flow rises very sharply at the commencement of the blow to a peak condition well in excess of the mean rate, and both high and variable heat fluxes are experienced. In a still atmosphere the flame length could theoretically be over 100 ft, so that suitable flame control as well as due

attention to the path length available for the flame were necessary.

After due consideration to all the above aspects, the design chosen was a medium pressure boiler which would generate steam at approximately the same pressure as the steam from the existing site boilers. Its design is basically that of a conventional boiler which intermittently receives additional heat from the LD converter.

An auxiliary firing system, burning fuel oil, is included in the boiler. The auxiliary heat input varies to complement the heat input from the converter and maintain the site steam supply at the required level.

The amount of oil firing is chosen to restrict the load changes on the boiler to an acceptable amount. This minimizes complications in boiler design and operation.



# CONSETT Developments

# WASTE HEAT BOILER

By E. M. WOOLLEY\*


In the oxygen steelmaking process large quantities of dust are evolved. It is not permissible to discharge these gases directly into the atmosphere due to the consequent air pollution. In order, however, to be able to extract the dust from the gases, they must first be cooled to a temperature acceptable to the dust extraction plant.

In selecting the method of cooling, consideration must be given to the safety of personnel and to the prime purpose of the plant being the production of steel. Coupled with this is the economic aspect of the heat liberated in combustion being capable of generating steam and thus reducing considerably the money which would otherwise be spent in burning conventional fuel. Ideally, therefore, the plant which is installed should combine operational safety, assurance of steel production at all times, and a process which by fuel saving would pay for itself within a few years.

\* Head Wrightson & Co. Ltd.

Fig. 1. Perspective drawing of waste heat boiler

- Converter
- 2 Lime chute
- 3 Oxygen lance 4 Converter leg
- 5 Main damper and operating gear
- 6 By-pass duct
- 7 By-pass damper
- 8 By-pass stack
- 9 Steam ejector 10 Baffle tubes
- 11 Auxiliary firing chamber water wall tubes
- 12 Evaporator screen tubes
- 13 Superheater tubes
- 14 Superheater/evaporator tubes
- 15 Conditioning tower
- 16 Forced draught fan
- 17 and 18 Forced draught trunking
- 19 Auxiliary firing burners (horizontal)
- 20 Auxiliary firing burners (vertical)
   21 Constant differential oil pump
  - 22 Steam drum
- 23A Steam drum internals
- 23B Steam condenser/economiser
- 24 Circulating pump
- 25 Standby circulating pump 26A Distributing headers
- 26B Collecting headers
  - 27A Downcomer circulating numb suctions



# Waste Heat Boiler Continued

It was with this fundamental outlook that designs were investigated for cooling the flue gases from the LD converters at the works of Consett Iron Co., Ltd.

There was a further factor which had to be taken into consideration. The plant needed to be "tailor made" to integrate with the existing power plant at the site.

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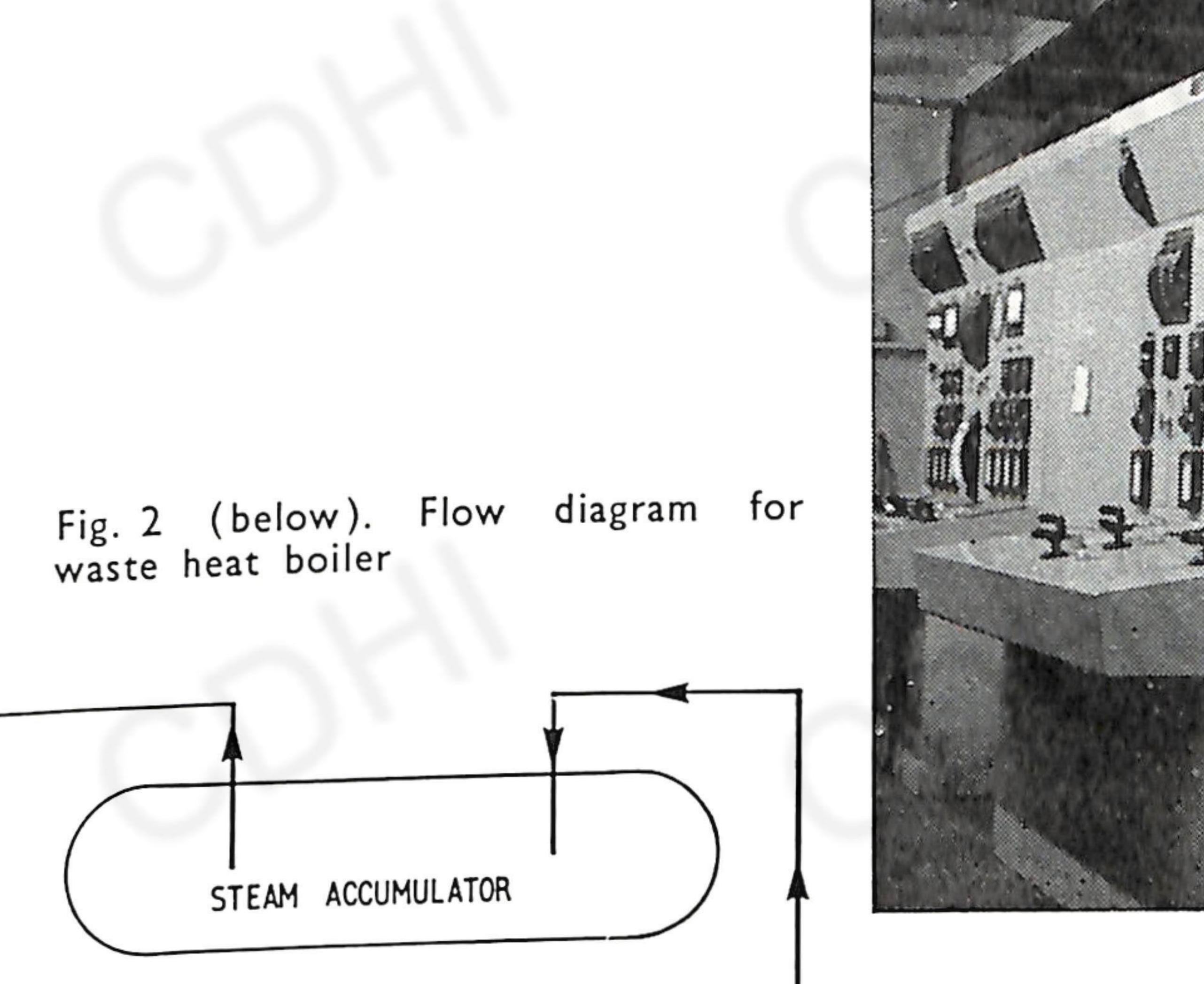
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
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100 ft, so that suitable flame control as well as due mizes complications in boiler design and operation.

Fig. 3 (right). Instrument panel in waste heat boiler control room





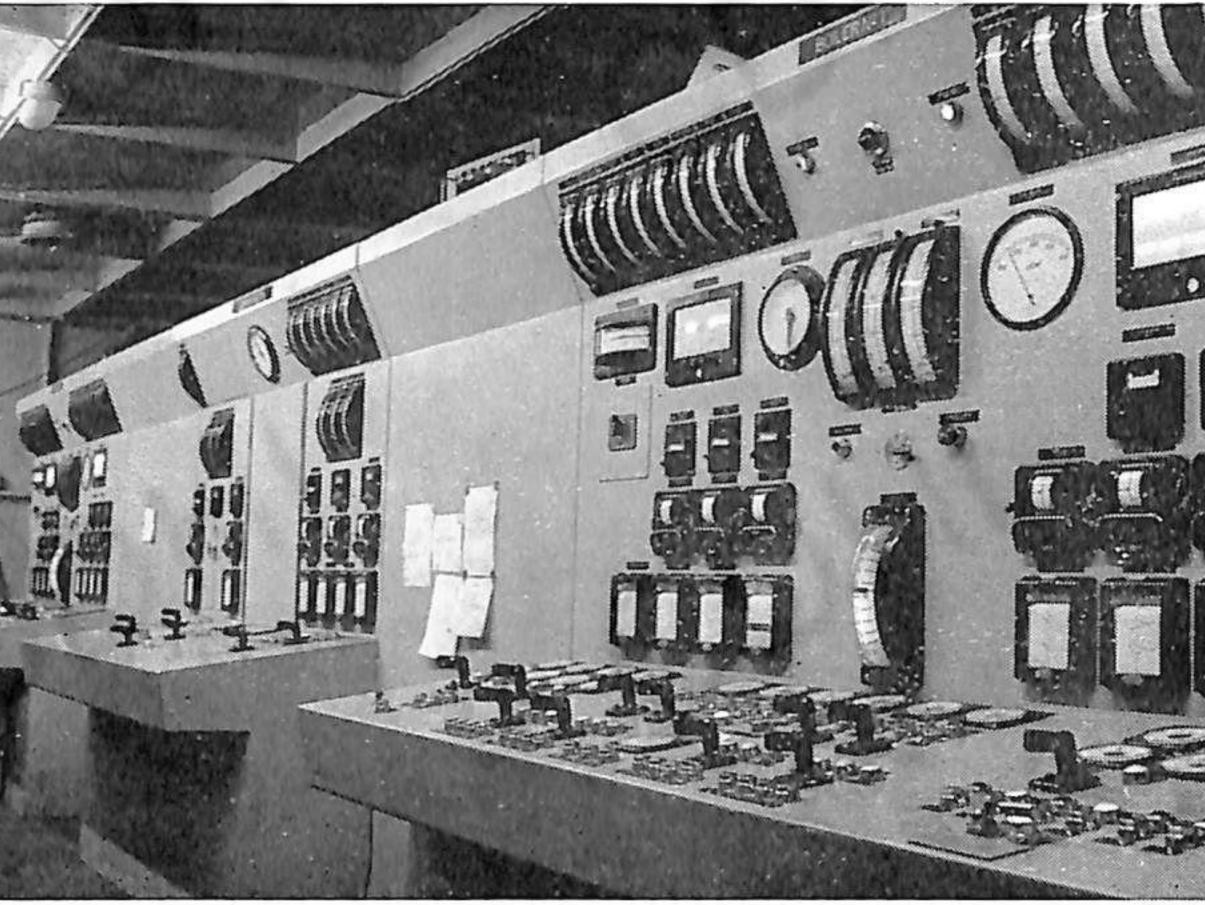
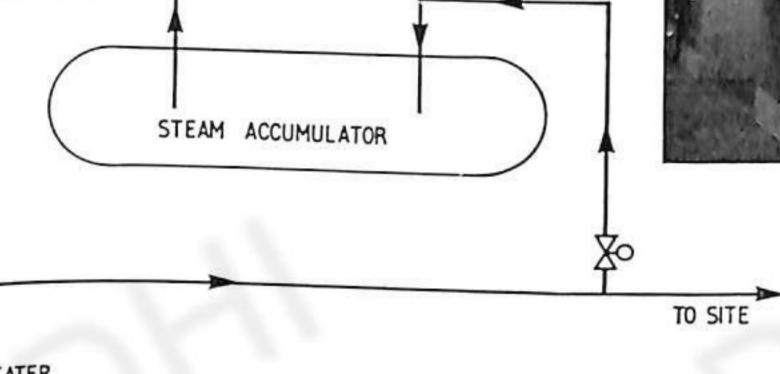
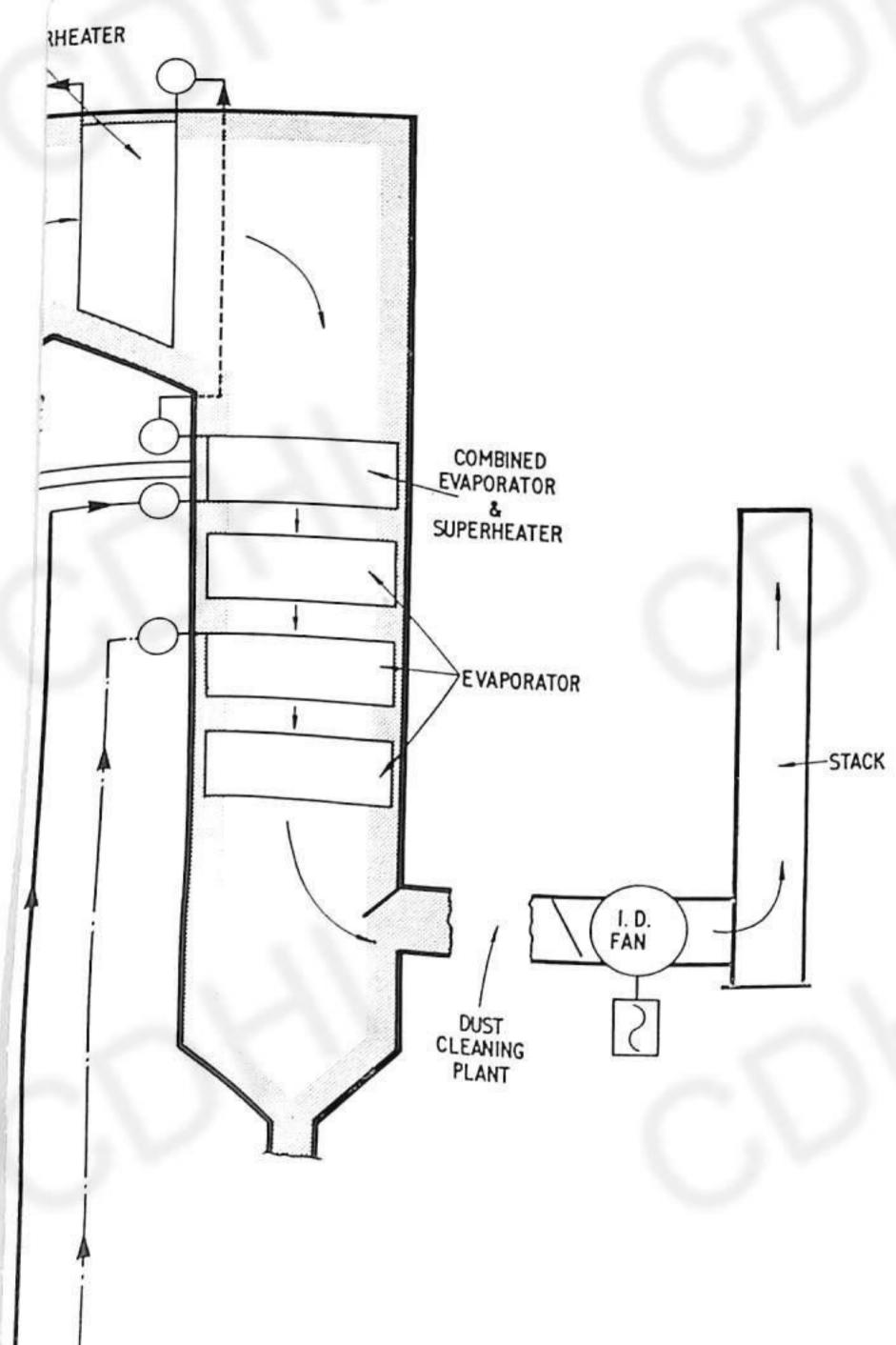


Fig. 2 (below). Flow diagram for waste heat boiler





At Consett, with the auxiliary fuel firing level chosen, it is possible to avoid a system incorporating a steam accumulator operating in series with the boiler. Such a system would have incurred an undesirable thermodynamic loss through the steam accumulator, and required a higher pressure boiler.

With the high heat fluxes experienced in this waste heat boiler it is desirable to keep the steam pressure as low as possible. Among other advantages this enables the tube wall thickness to be kept to a minimum, with consequent reduction in the overall temperature gradient through the tube walls, thus providing a greater relative flexibility.

A further reason for selecting a boiler for cooling the gas is the advantage from a safety angle that it is preferable to cool the water walls of the ducting by treated boiling water circulated through the system by the well known "La Mont" method of assisted circulation rather than by low quality cooling water well below the boiling temperature, such as is used in a water-cooled stack.

There are three main factors supporting the previous sentence, when the cooling system receives the high heat fluxes experienced in this plant. With the low quality cooling water system (a) the life of the plant could be relatively short due to scaling and thermal stresses from local overheating, (b) the system has a much larger temperature variation along its path length than in evaporative cooling; also the film conductance is much lower in those zones where surface boiling does not occur, and finally, (c) in the event of a tube leakage, the inflow of water into the gas stream lacks the throttling device advantage of the "La Mont" system. This last item is explained in greater detail in the next paragraph.

In the "La Mont" system, water is pumped continuously around the circuit, the amount of water flowing through each tube being matched to the particular heat load which that tube receives under the peak condition from the converter. The rate of flow of water into the tube is controlled by an orifice plate protected by a strainer located at the entry to the boiler tube from the inlet header. This orifice also acts as a safety device. Should a leak occur in the tube wall, the pressure drop within the tube will cause the boiling water to flash into steam. The steam generated will

## Waste Heat Boiler Continued

set up a choking action in the orifice, thus restricting the leakage of water from the tube.

In the waste heat boiler design chosen for Consett, the gases are given a long and tortuous path before meeting the cross flow tube banks. This ensures that all the dust is completely frozen and will not adhere to the cross tube banks. It was also decided to incorporate flame length control in the selected boiler design by the use of secondary blanketing air. A further advantage gained from installing a waste heat boiler between the converter and the gas cleaning plant is that it acts as a more effective buffer than a water cooled stack. With the variation of the auxiliary firing to match the heat input from the converter, combined with cross flow tube bank cooling, fluctuation of the flue gas temperature at the gas cleaning plant is minimized.

This, however, does not occur with the water-cooled stack. In the latter case, the temperature at the water sprays varies rapidly from almost ambient to a relatively high gas temperature. In addition, the instrumentation has little time to set the water sprays in operation at the required rate.

#### PLANT OPERATION

Plant operation during a steelmaking cycle can be followed by referring to the flow/plant diagrams (Figs. 1 and 2).

The complete plant has been designed to operate automatically. On the failure of any plant auxiliary, standby equipment is automatically brought into operation and any safety actions required are made automatically. Warning signals on the control panel inform the boiler operator which item of equipment has failed (Fig. 3).

A very carefully selected number of safety interlocks scan the control system and give the "signal" to the automatic controls to go into action when required.

In addition to automatic control, remote manual control can be undertaken at the control panel and as a final safe-guard local mechanical control can be used. As an illustration, in normal operation the boiler water level in the steam drum will be controlled entirely automatically by a three-element control combining signals from three sources, namely, the water level in the drum, steam flow from the boiler, and feed water flow into the boiler. Alternatively, this can be controlled by a remote manual control at the panel, assisted by the guidance of the critical drum pressure gauge reading or, finally, there is a hand-operated valve which can be used for water level control. Such precaution may be considered over-elaborate, but as the installation has been designed for maximum safety and reliability, these precautions are justified.

Just prior to the converter blowing commencing, the main damper at the top of the converter leg opens to an intermediate position. The interlock system then checks and makes sure, by action if necessary, that the superheater tubes are being amply cooled by sufficient steam generated from the auxiliary firing and are, therefore, safe to accept the peak heat flux from the converter. Oxygen can, therefore, be supplied safely to the converter and the lance is lowered into the converter. A secondary air fan comes into action as soon as the flames from the converter have entered the converter leg. The air from this provides three services: it gives a blanketing action to the flue gas at the change of direction in the converter leg; it characterizes the flames' length; and it also assists in producing higher oxides of the dust particles, consequently facilitating their removal.

The adjustment of the oil firing rate is controlled so that its output modulates with the heat input from the con-

verter to meet the steam export requirements to site. (There are two sources of signals to achieve this result, one source being a "back up" to the main signal.) When, however, the heat input from the converter exceeds the site requirements, i.e. more steam is generated in the boiler than is required at site, then the surplus steam is passed to the steam accumulator. When the oil firing is modulating with the heat from the converter, it is not necessary that the two heat sources when summated should precisely equal the site requirements; some slight excess can, therefore, exist which can be trimmed and sent to the steam accumulator, thus simplifying controls.

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The oil-firing equipment has been installed with a special burner design controllable over a range of 10:1. This permits smooth adjustment of the auxiliary firing rate by a single master control valve.

At a predetermined level of converter heat input, the main damper fully opens and the I.D. fan controls move to a suitable rating to accommodate the peak heat input from the converter with a suitable proportion of excess air. The excess steam above that required by the site is passed to the steam accumulator. The heat stored in the accumulator is discharged, during the off blow period, to a feed water heater, where it is condensed. The condensate returns to the feed water tank where it serves to dilute the total dissolved solids and also provide additional heating. If at any time the steam accumulator fails to operate, or receives an abnormal peak, the surplus would then be automatically discharged to atmosphere through a steam silencer, sized to pass the entire steam from the boiler at a low noise level.

When the converter blow is finishing, the main damper partially closes to a safe intermediate position. When the blow is complete and the oxygen supply has been stopped, the main damper closes fully and the boiler continues steaming under a control system operating as a conventional boiler plant.

The automatic control system is such that the blow can be interrupted and restarted as frequently as the steelmaker chooses and the boiler plant will automatically come into line giving correct cooling to the gases and sending to site the steam required, as indicated by the steam pressure.

In the event of any emergency occurring, such as the failure of the I.D. fan, the by-pass damper in the by-pass stack would open automatically, the steam ejector in this stack would come into operation giving an initial draught boost, the flue gas from the converter being discharged to atmosphere under natural draught condition, assisted by the steam ejector.

As will be remembered, the safety of the "La Mont" system is greater than other cooling methods, due to the use of boiling water which is supplied to the heated tubes through orifice restrictions.

## DESCRIPTION OF BOILER

The waste heat boiler has been designed by Head Wrightson Processes Ltd., in conjunction with A.B. Svenska Maskinverken (Fig. 4). The tube surfaces were fabricated by A.B. Svenska Maskinverken and erected by Head Wrightson Teesdale.

The waste heat boiler plant comprises two boilers serving separately two 120 ton capacity LD converters, with one converter in use at a time. It is possible, however, if required at a later stage, to operate two converters simultaneously by incorporating some additional equipment in the boiler plant. The blowing time is 22 minutes.

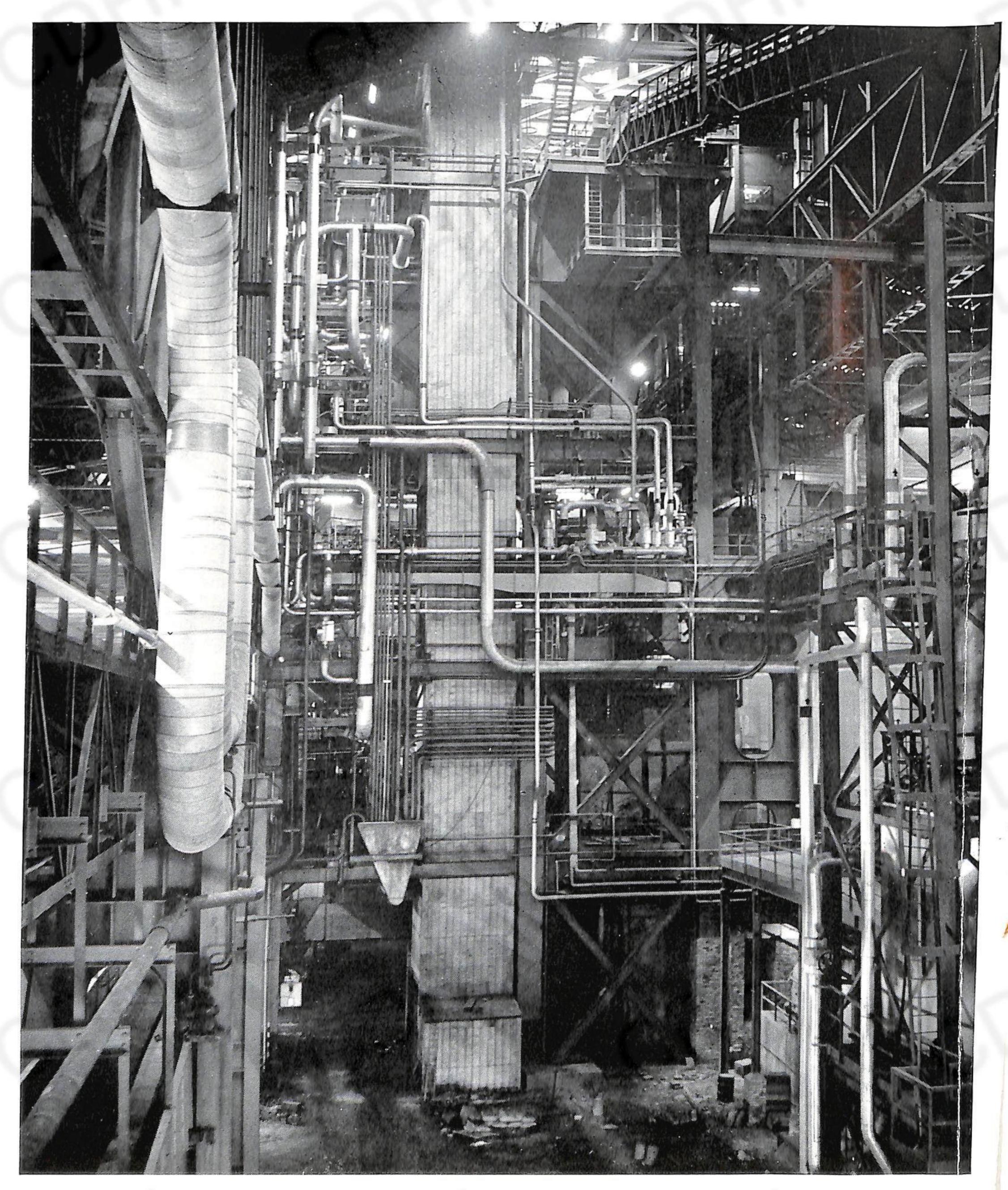


Fig. 4. General view showing arrangement of piping on side of boiler

It accepts the waste heat of one 120-ton capacity LD converter. The blowing time is 22 minutes. As initially installed, only one converter will be in use at a time. It is possible, however, if required at a later stage, to operate two converters simultaneously, by incorporating some additional equipment in the plant.

The boiler exports steam to the site main at a pressure of 420 lb/in² and a temperature of 775°F (413°C). Auxiliary firing can maintain a steam delivery rate of 174,000 lb/hr without the assistance of any heat from the converter. This capacity has been chosen because, integrated with the steam from the existing boilers, it meets the site total steam requirements. The waste heat boiler steam to site can also be varied within an agreed range in accordance with site demand.

The boiler incorporates a separate combustion chamber (Fig. 5) for the auxiliary fuel firing, and this design has several notable advantages, which are given below:

- 1. The chamber can be designed to suit ideally the auxiliary fuel being used, and high shearing gas velocities across the flames are avoided.
- 2. A tortuous and long path is given to the gases from the converter before they reach the first bank of cross flow tubes. This ensures adequate cooling of the gas so that the dust is well frozen before meeting the cross flow banks. It also provides a point of low gas velocity in which the heavier dust particles can be deposited and be collected in a hopper at the bottom of the combustion chamber.
- 3. When the main damper at the top of the converter leg is shut, the boiler operates as a conventional installation with the combustion chamber as the furnace housing the auxiliary firing equipment. The boiler is of the controlled assisted circulation type, in which natural circulation has been augmented by a pumping system with the following beneficial results:
- (a) It permits the use of small bore tubes with consequent reduced thermal stress, so increasing the factor of safety.
- (b) The water supplied is matched to the calculated heat absorption of each individual circuit by control orifices. The orifice plates also improve circulating stability so that wide fluctuations of heat absorption do not result in overheating of the tube metal on account of variable external fouling of the heating surfaces.
- (c) It assures uniform heating in the drum shell and pressure parts during the rapid start-up and shut-down operation. This results in uniform expansion throughout the large complex furnace structure

- associated with a unit of this capacity and, in consequence, minimizes expansion stresses.
- (d) In the event of tube leakage the unit can remain in commission under adverse loading requirements, and then be shut down safely in the approved manner. This procedure has no ill effects on the boiler or remainder of the circulating system, since the flow of the water to the burst tube is restricted at the inlet by the orifice plate.

#### Dust and Slag Removal

The dust content in the converter gases is very high, and due to the high temperature of the gas in the converter leg, much of the dust is molten in the early part of the leg. Under these conditions, it is normal for some slag build-up to occur, and this factor has been allowed for in the design of the heat transfer surface of the converter leg. Provision has also been made, however, for dust and slag removal. The converter leg is equipped with a number of inspection doors and lancing doors to permit the entire surface to be swept by the use of percussion air lancing equipment.

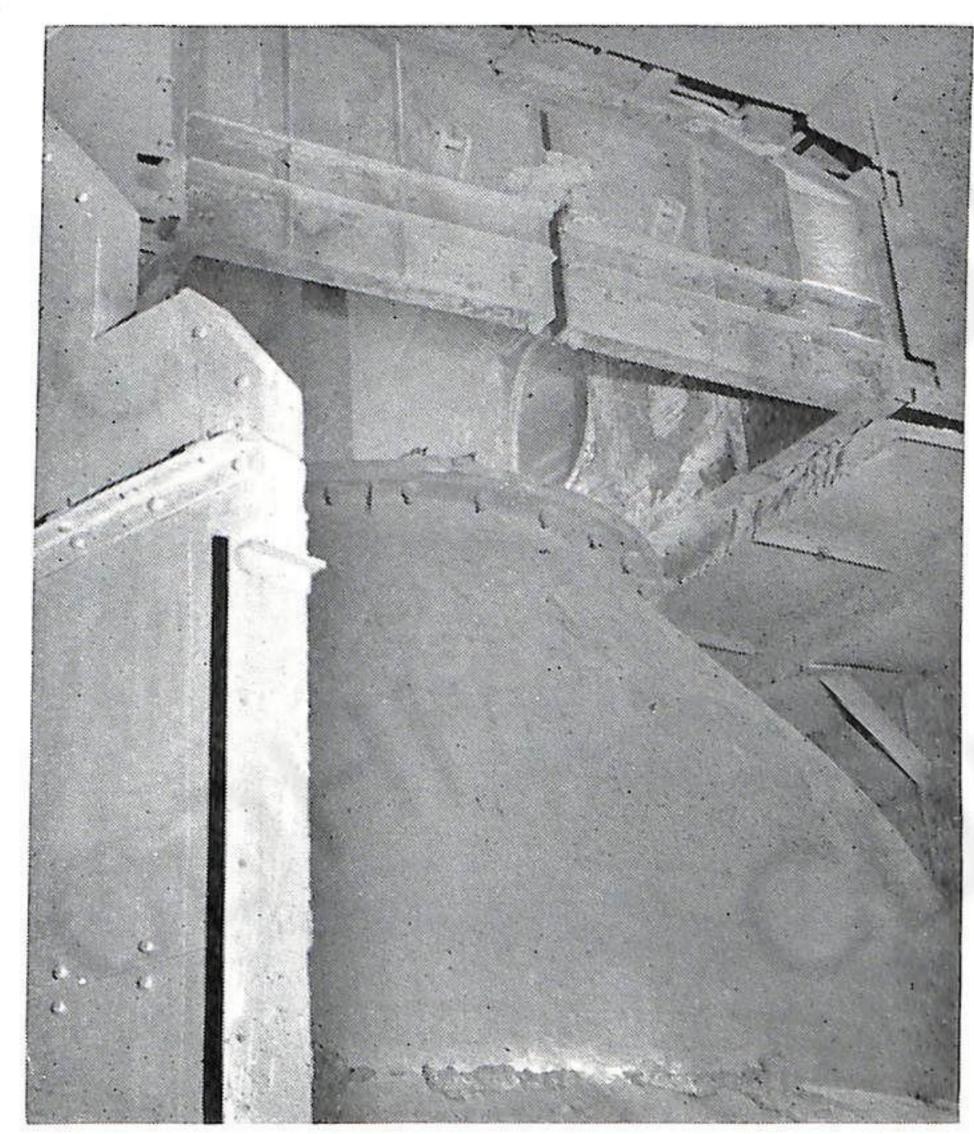


Fig. 5 (above). Entrance to waste heat boiler radiant leg showing hinged doors to allow easy access for rebricking of converter

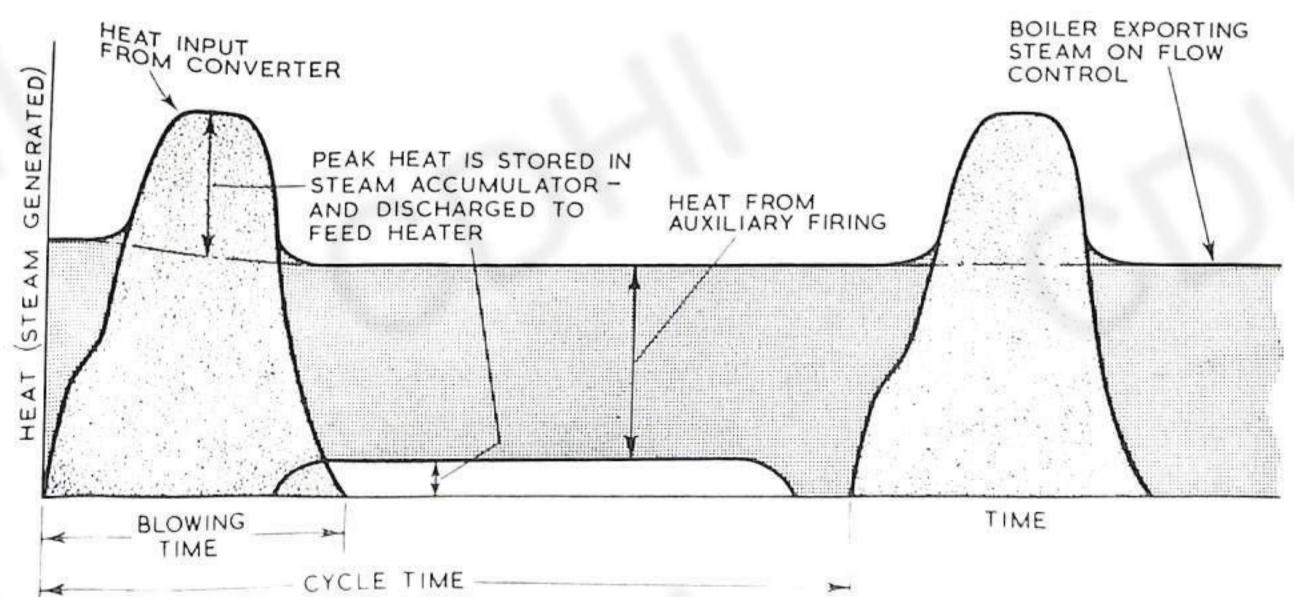
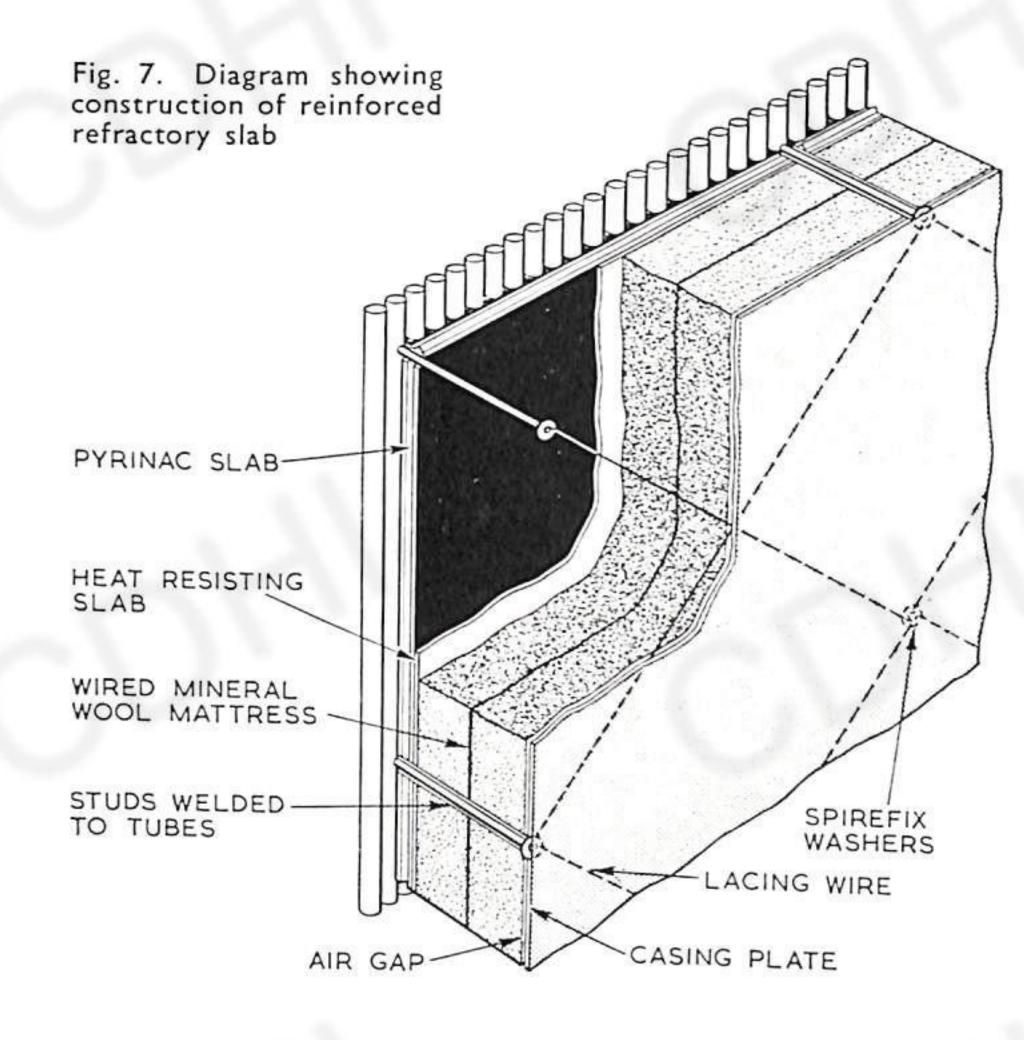


Fig. 6 (left). Heat cycle for converter and auxiliary firing



In addition, blanketing air is provided, which as well as the air blanketing effect, helps to raise the dust to the higher oxide state, thus facilitating removal due to its chemical properties.

Dust is removed from the combustion chamber through a bottom hopper, the low gas velocity assisting dust fall-out.

The first evaporator and second and third stage superheaters are freed from dust by the use of retractable sootblowers. The superheater stages are of platen construction, i.e. in a vertical position with a wide spacing between platens to avoid dust build-up, or "bird nesting".

The tube banks in the back and vertical leg are kept clean by the use of shot cleaning which is on a timed cycle or a continuous cleaning programme.

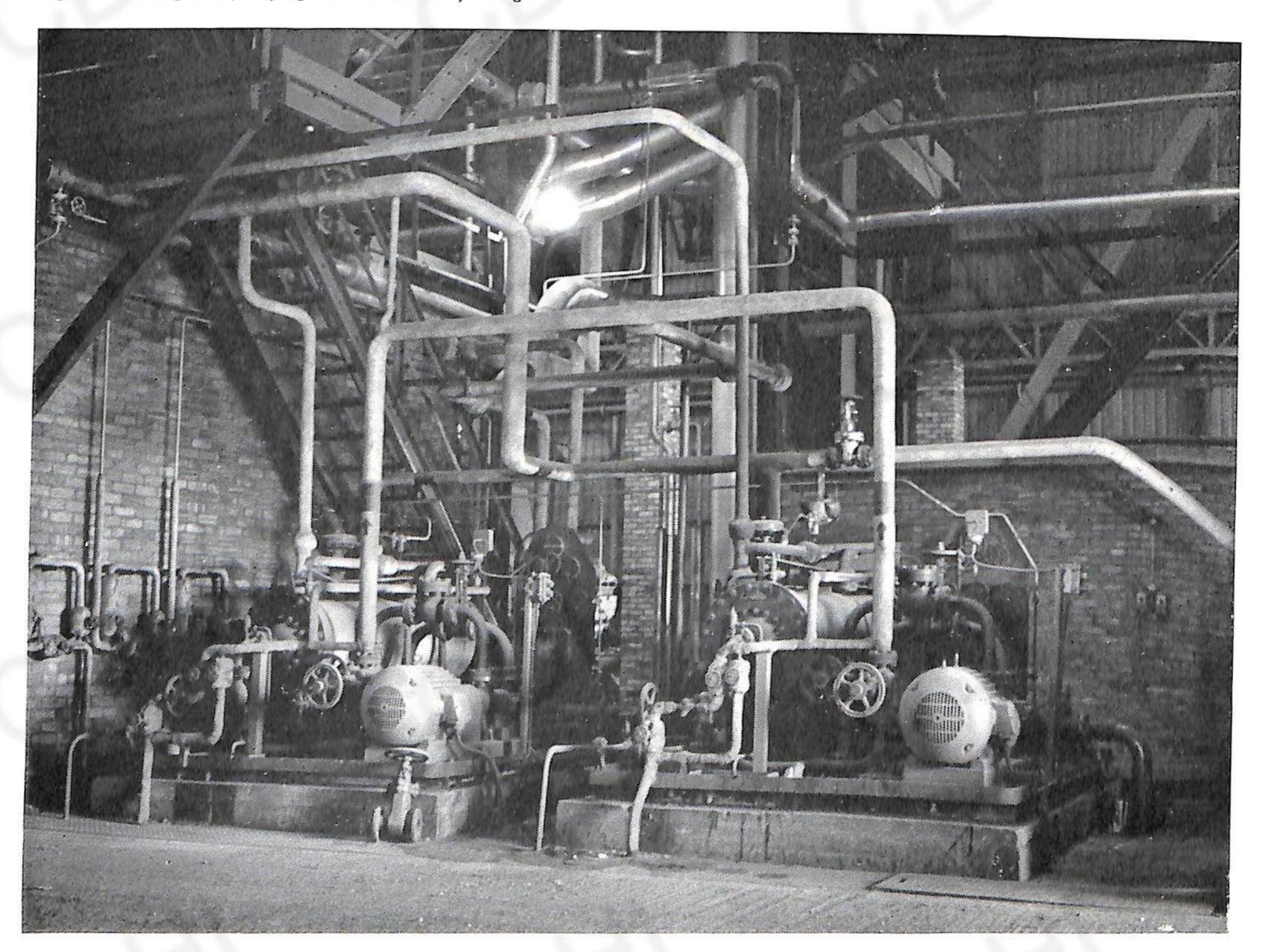
In all the gas passages, the cross sectional areas have been designed to give low gas velocities to minimize erosion.

#### AUXILIARY EQUIPMENT AND SUB-CONTRACTORS

#### Steam Accumulator

This has been designed and supplied by The Steam Storage to Head Wrightson's requirements. The accumulator, of standard design, is of sufficient capacity to absorb steam at the maximum input rate and store the peak surplus steam generated during the blow in excess of the steaming rate of 174,000 lb/hr. Steam is stored by con-

Fig. 8. Heating and pumping unit for auxiliary firing



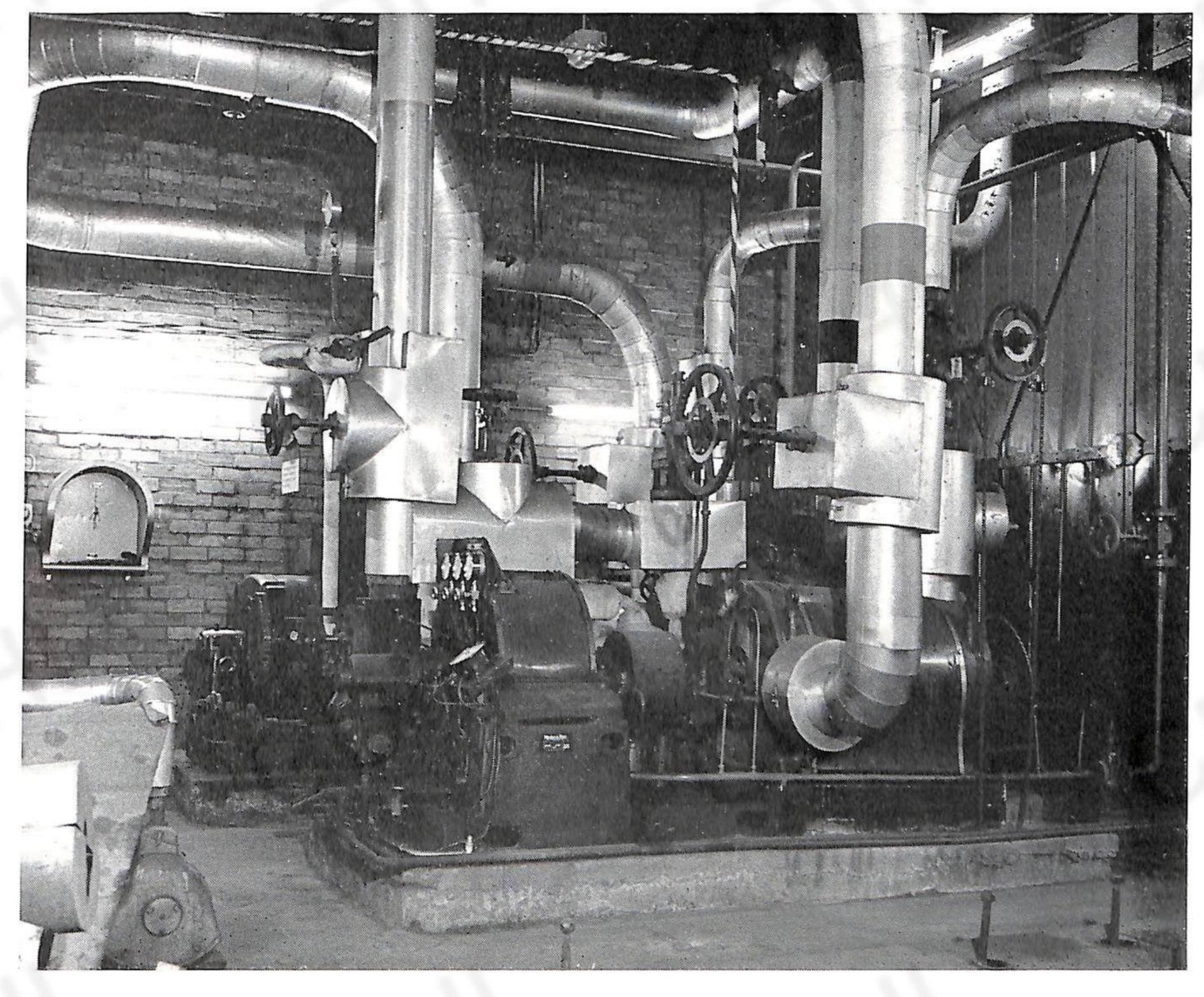


Fig. 9. Main and stand-by feed pumps for waste heat boiler

densing into a suitable quantity of water which is retained the pipework and its protective cladding of aluminium in the steam accumulator. This stored heat is then released by being discharged at a lower pressure from the accumulator by the water flashing off the steam due to a reduction of pressure. This released steam is utilized to heat the feed water entering the boiler during the off-blow period (Fig. 6).

#### Feed Heater

This has been designed, manufactured and supplied by Worthington-Simpson, Ltd. The heater is of standard design, incorporating an automatic by-pass system for use during the blow, and on the occurrence of any tube leakage. The tubes are of 'U' construction in cupro-nickel.

#### Instrumentation and Controls

The overall control system has been designed by Head Wrightson Processes, Ltd., in collaboration with Evershed & Vignoles. The general operation of the controls has been described at the beginning of this article.

## **Boiler Setting and Insulation**

The insulation of the boiler employs the patent Pyrinac system of reinforced refractory slabs (Fig. 7), supplied and fitted by R. B. Hilton & Co., Ltd., suitably backed with mild steel sheet or asbestos and layers of mineral wool. Newalls have been responsible for the insulation of

#### Boiler Auxiliary Firing

As already mentioned, in the auxiliary firing system, the burners have to be adjusted over a large range quickly and smoothly. This fact led to the selection of the Peabody constant differential pressure burner. This is an atomizing oil burner, having a control range of 10 to 1 without shutting off individual burners or changing burner nozzles. The fuel preparation plant is also of Peabody design, and consists of two Simplex electrically-driven steam heated pumping units (Fig. 8), which discharge oil at a pressure of 500 lb/in2 into a common ring main supplying oil to either boiler front loop, each consisting of a closed circuit in which the individual Peabody constant differential pump maintains the predetermined pressure differential across the group of burners. This constant pressure differential, by maintaining a constant tangential velocity in the swirl chamber of the burner, can achieve the large turn down ratio. The oil burning equipment is protected by gas pilots which, in turn, are monitored by electronic detectors for safety protection.

#### The Draught System

The draught equipment has been supplied by Davidson

& Co., Ltd., and comprises one induced draught, one forced draught and one blanketing/secondary air fan per boiler, all being of the backward aerofoil high efficiency type.

The induced draught fan is 118 in dia and is fitted with 'Sirocco' radial vane inlet control gear, working in conjunction with a damper, both of which receive an appropriate signal from the control system. The fan is positioned on the outlet side of the electrostatic precipitator, and handles gas at 350°F (177°C).

The forced draught fan is 67 in dia and takes air from high level in the boiler house, thus assisting in the ventilation of the building and recovering some of the boiler casing heat loss, and other heat rising within the building. This fan supplies the necessary air for combustion of the oil and for the gas pilots. Instruments are provided to meter the air in the F.D. ducting.

The blanketing air fan supplies air at a high relative pressure to nozzles which impart a high velocity to the air jets in the converter leg. The proportion of the air through each of these jets can be varied. Davidson's have also designed and fabricated the ducting for the forced draught and blanketing air fans.

#### Main and By-pass Dampers

These have been designed to Head Wrightson Processes' specification by Blaw Knox. The main damper is of fabricated steel construction, water cooled, with a plastic refractory protective lining on its boiler side, and clad with spheroidal graphite iron wear plates on the side which faces the converter. When the converter heat flux is in excess of the mean rate the damper is fully open and clear of the heavy, dust laden gases.

The by-pass damper is water cooled and consists of a pair of fabricated steel, swivel type dampers, which are normally closed. These dampers are supported by double bearing blocks located at each outside corner of the stack base. When fully open the two swivel type dampers hang vertically in recesses at the sides of the base of the stack.

Both the above dampers are operated automatically and can, in addition, be operated by remote manual control at the instrument panel.

#### Pump

The main boiler circulating pumps have been designed and manufactured by Hayward Tyler. Although the boiler pressure is not high it was considered that the glandless pump was the safer choice for the main pump. The standby pump is driven by the Hayward Tyler-Terry horizontal G type steam turbine, which uses steam instead of electricity as alternative driving force (Fig. 9).

The boiler feed pumps have been designed and manufactured by Mather & Platt, whose pumps are standard equipment at the site. In the pump design considerable attention was given to the selection of suitable characteristics to ensure as high an efficiency as possible throughout the working range, with an adequate reserve capacity.

Two identical pumps are provided, one for main duty and one for standby. The main is driven electrically and the standby with steam. The standby comes into operation automatically on a loss of feed line pressure, and takes full load within 10 seconds from a cold start.

To summarize, the following list gives most of the subcontractors for the waste heat boiler and the items they supplied:

Blaw Knox, Ltd.—water cooled dampers; Clyde Blowers, Ltd.—shot cleaning equipment; Davidson & Co., Ltd.—forced draught and blanketing air fan; Evershed & Vignoles, Ltd.—instruments and controls; Hayward Tyler & Co., Ltd.—boiler circulating pump; R. B. Hilton and Newall's Insulation Co., Ltd.—boiler setting refractory and insulation; Hopkinsons, Ltd.—retractable soot blowers, boiler mountings and valves; Hugill Forge & Engineering Works, Ltd.—stairways and galleries; Mather & Platt, Ltd.—feed pumps; Steam Storage Co., Ltd.—steam accumulator plant; Stewarts & Lloyds, Ltd.—external pipework; Worthington-Simpson, Ltd.—feed heaters; Copes Regulators, Ltd.—desuperheater; Peabody, Ltd.—oil firing.

#### Acknowledgment

The author would like to thank the Consett Iron Co., Ltd., and their consultants, the International Construction Co., Ltd., who have the initial responsibility for the whole of this project of which the boiler plant forms an inseparable part, for their careful scrutiny throughout the contract, and collaboration with this text.

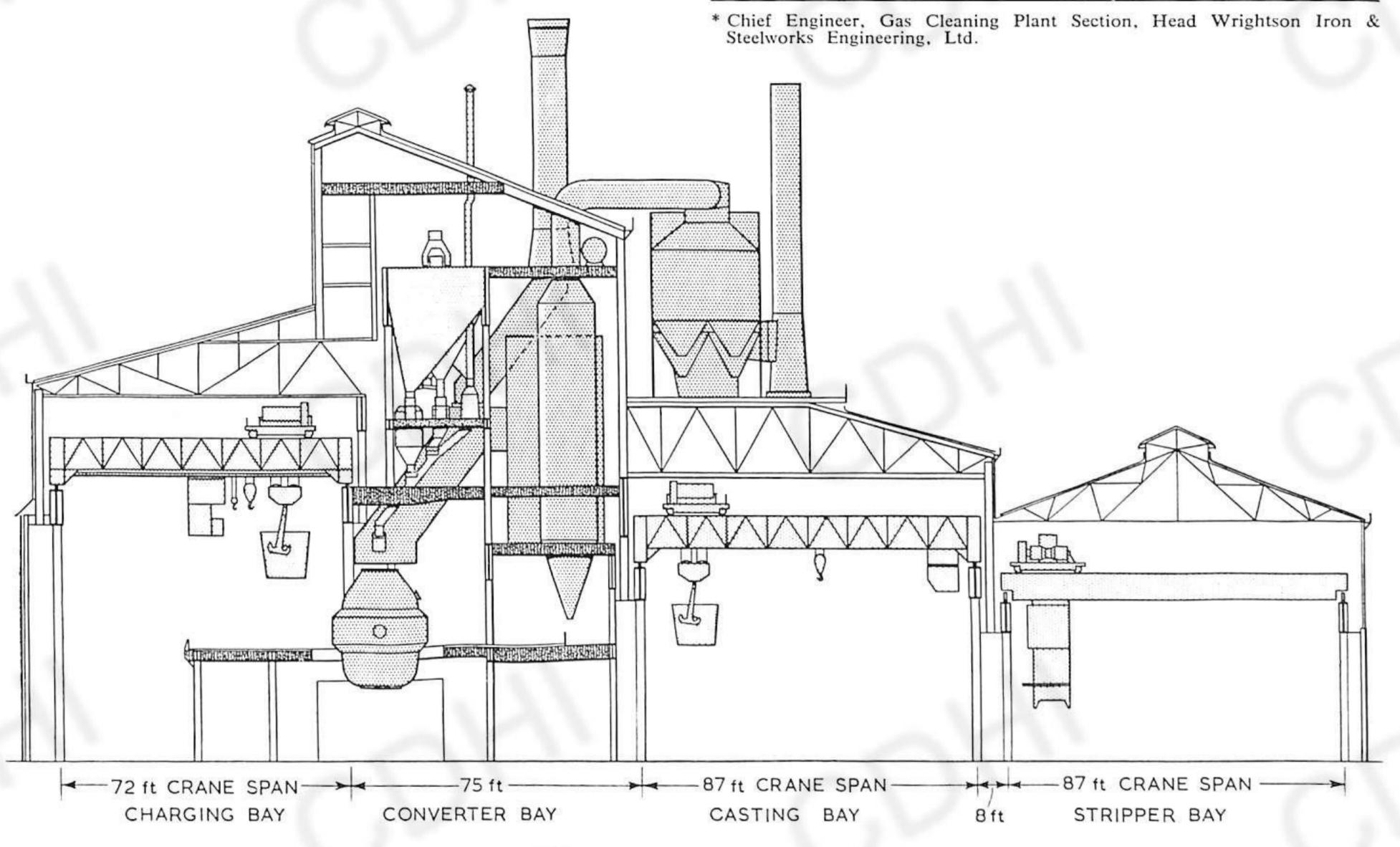
**CONSETT** Developments

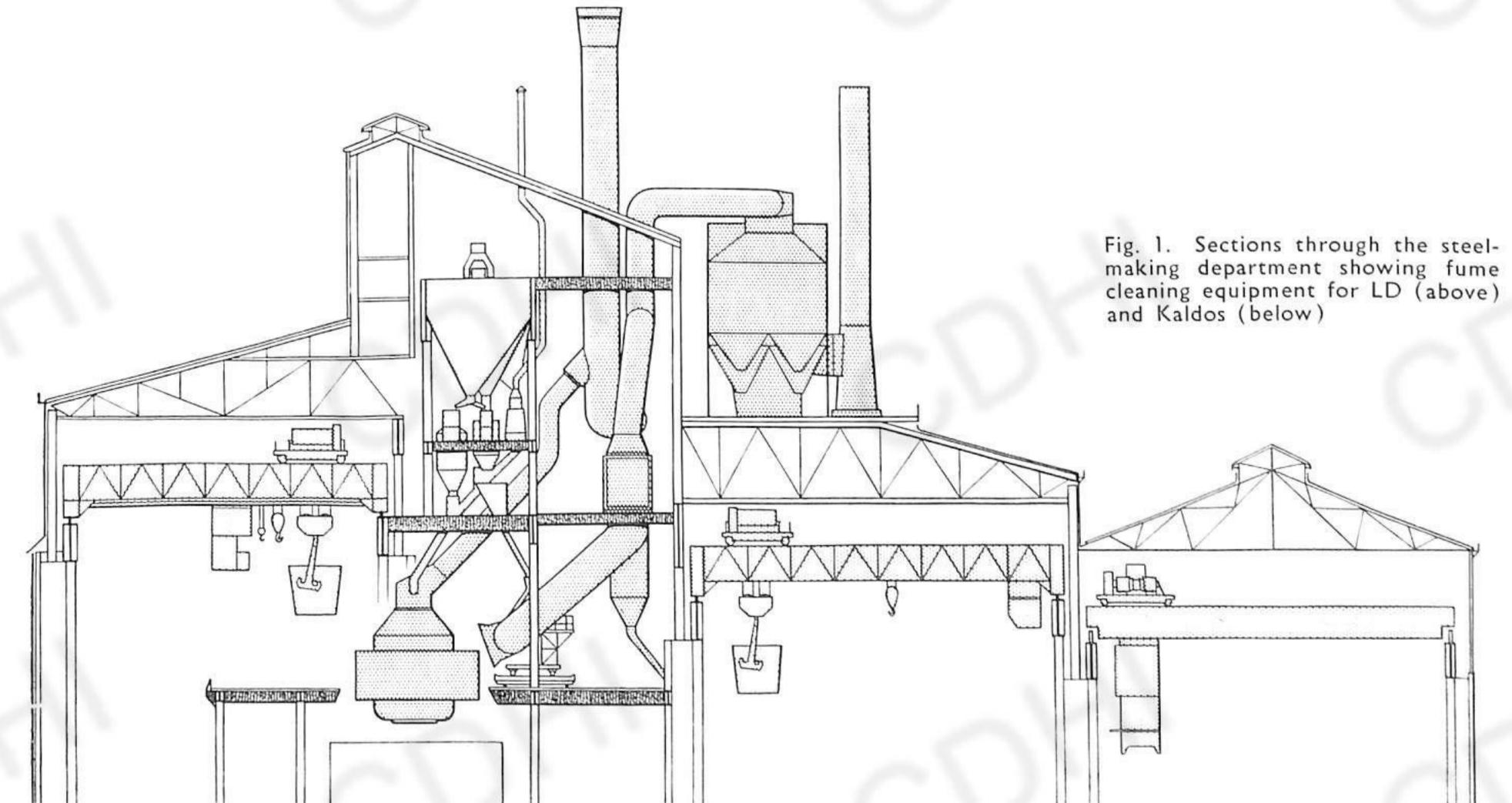
# LD and Kaldo Fume Cleaning

By G. PUNCH\*

The fume cleaning installation at Consett is of particular interest because it includes fume-cleaning equipment for both Kaldo and LD converters, operating side by side, and illustrates very well that the processes are as different from each other from the gas-cleaning point of view as they are metallurgically.

The gas-cleaning equipment of the installation at Consett comprises hoods for containing the fume-laden gases emitted by the converters, gas cooling and conditioning equipment, dry plate electrostatic precipitators, induced-draught fans, interconnecting ducting and exhaust stacks (Fig. 1). The two 120 ton LD converters each have completely separate systems but the Kaldo units utilize a common precipitator.





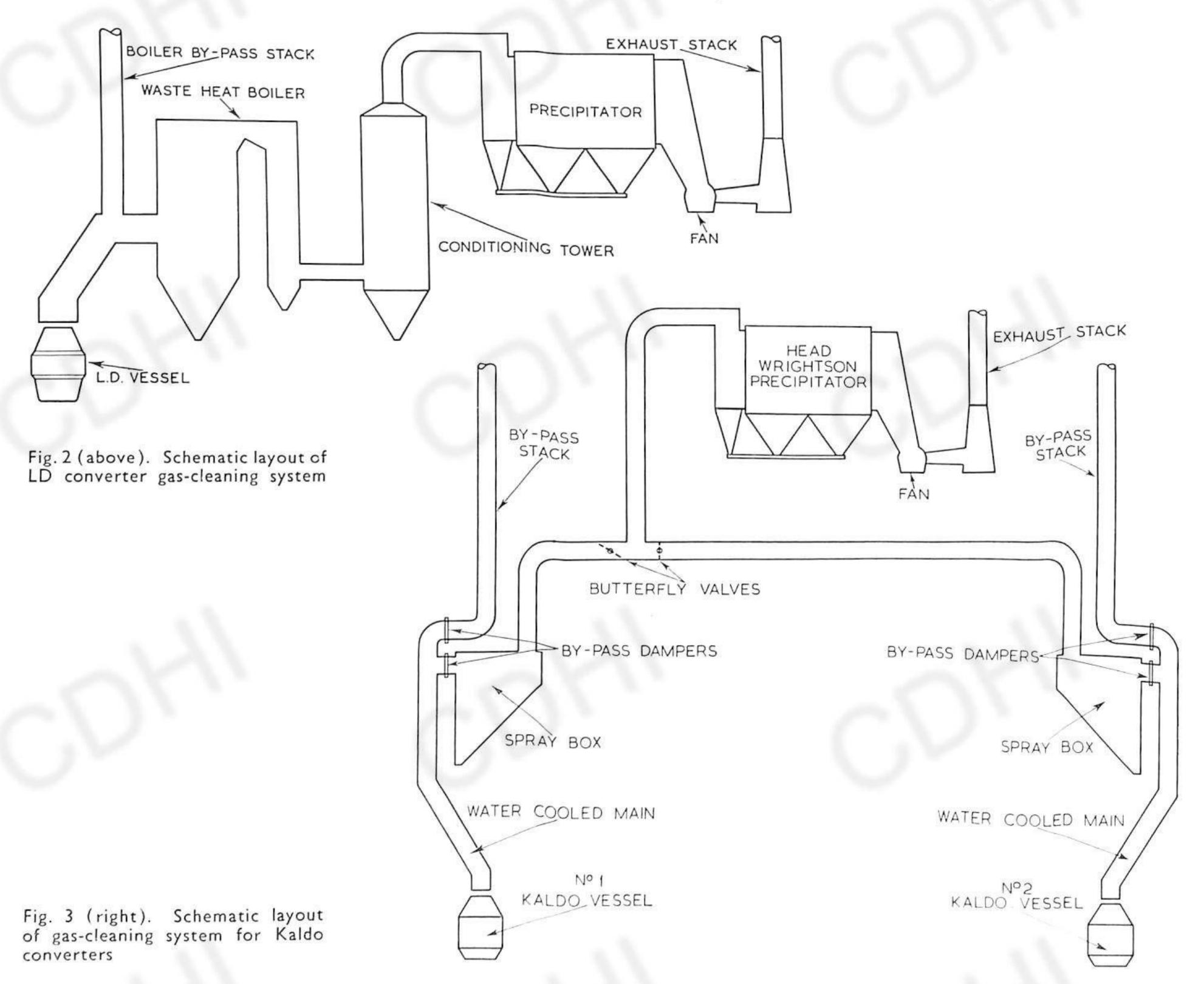
The gas-cleaning systems of the LD and Kaldo installations are similar inasmuch as they comprise equipment for collecting the converter waste gases, and cooling and conditioning them so that they may be cleaned in dry plate precipitators before being discharged to atmosphere. The systems differ in detail however, and this is entirely due to the fundamental differences between the two converter processes. In the Kaldo process, approximately 90% of the carbon monoxide generated burns to carbon dioxide within the vessel. On the other hand, the waste gases leaving the mouth of an LD converter at the peak of the blow consist of 90% carbon monoxide and 10% carbon dioxide. Thus, in addition to their high sensible heat, LD waste gases contain very large quantities of potential heat which they release into the gas cleaning system as they burn in the secondary air which is drawn into the converter hood. At Consett, most of the useful heat of the LD gases is removed by waste-heat boiler and evaporative cooling is only used for final adjustment of gas temperature and humidity. In the case of the Kaldo units, recovery is not economic and only evaporative cooling is used to prepare the gases for the cleaning process.

The LD converter gas cleaning system is shown diagrammatically in Fig. 2. Hot CO-rich gases from the converter which is being blown pass into the water-cooled fume hood, mix with secondary air induced into the hood, and burn. They then pass through a short length of water-cooled

ducting to the waste heat boiler, which they enter at a temperature of 1500°C or more and leave at approximately 650°F(345°C). From the boiler, the gases flow to the base of the conditioning tower and as they flow upwards through the tower are injected with water through high pressure spray nozzles. The rate of water injection in the tower is controlled automatically so as to maintain a temperature of 350°F(177°C) at the precipitator inlet and a water vapour content sufficient to ensure that the fume carried in the gases is conditioned and can be precipitated efficiently. The cooled, conditioned gases enter the dry plate precipitator in which they are cleaned to a final fume loading of 0.04 grains/ft³ before being discharged from the induced draught fan through the stack to atmosphere.

The fume hood and offtake ducts of the LD fume collection system are integral with the waste heat boilers and will not be described here.

The conditioning towers to which the waste gas flows after passing through the waste heat boilers are essential to the efficient operation of the precipitators. Although, on leaving the boilers, the gases are cool enough to be handled in the precipitators, they cannot be treated at maximum efficiency until their fume burden has been conditioned and its electrical resistivity reduced. By far the simplest and cheapest method of doing this is by humidifying the gas in which the fume is suspended. Water vapour conditioning must always be carried out in a closely-controlled manner



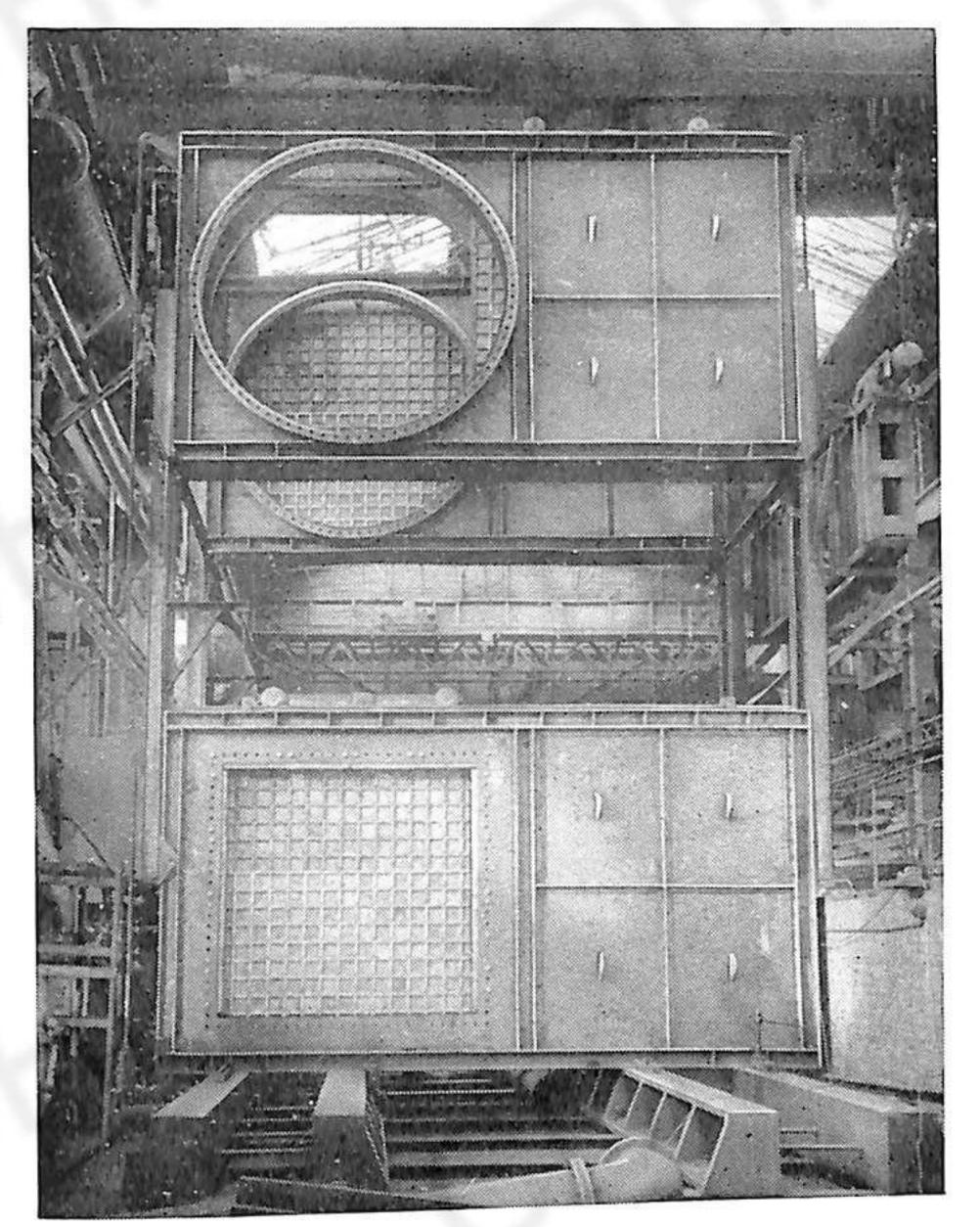


Fig. 4a. Combined damper assembly showing by-pass damper (top) open and spray box inlet dust damper (bottom) closed

in carefully-designed equipment if condensation in the precipitator is to be avoided. In the LD system at Consett, exceptional care had to be exercised because the gas temperatures after the boilers are relatively low, and the precipitator operating temperature is correspondingly closer to the dewpoint. Each conditioning tower is a fabricated cylindrical mild steel vessel 60 ft high and 15 ft diameter with a conical hopper at its lower end. Fume-laden gas enters each tower through a rectangular opening immediately above the hopper and, after being conditioned, leaves at the top end via a circular offtake.

Water is injected into the hot gas as it passes through the tower through four banks of spray nozzles. The quantity of water injected into the gas is controlled automatically by a temperature recorder-controller which senses the outlet temperature and switches banks of sprays in and out so as to maintain the desired gas temperature and humidity. The spray banks are designed so that their capacity may be varied to suit plant operating conditions, and individual spray headers can be removed for cleaning while the plant is running.

Conditioned gas at a temperature of 350°F passes through unlined ducting to the dry-plate precipitator.

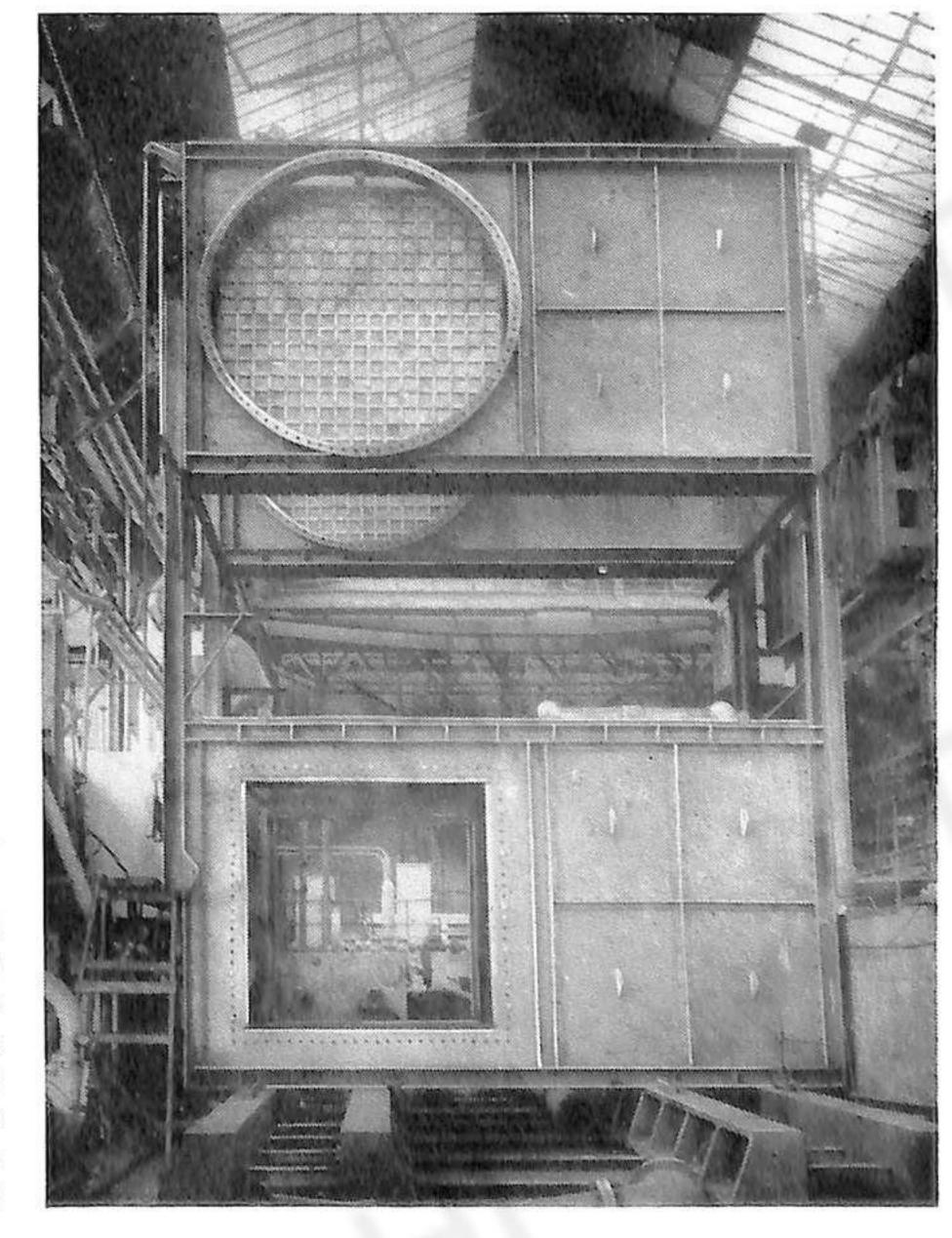
The Kaldo converter gas-cleaning installation is shown diagrammatically in Fig. 3. The two Kaldo converters have individual hoods, hot gas ducting, spray (conditioning) boxes, and by-pass stacks but they share a precipitator, fan and main discharge stack. During normal operation, the isolating dampers are open and both by-pass dampers are closed. The hood of whichever Kaldo vessel is being blown is connected to the precipitator and exhaust fan by the

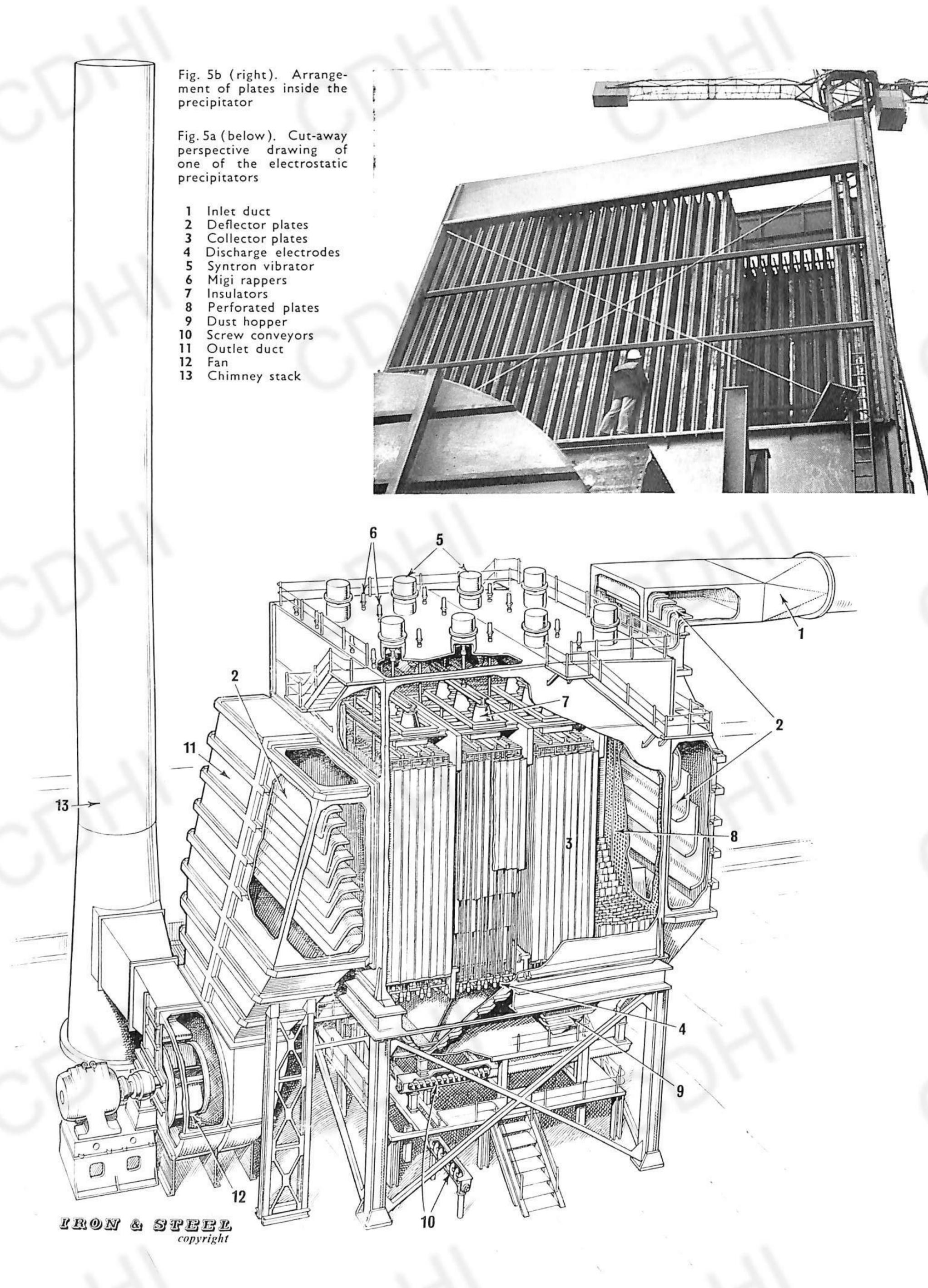
opening of the appropriate one of the two butterfly dampers and the closing of the other. When the two converters are blowing alternately, the butterfly valves are alternately opened and closed so that the waste gas from each converter is cleaned in turn by the common precipitator. Fume-laden gases at a temperature of 1500°C pass into the water-cooled hood in which they are mixed with air drawn in through the gap between hood and converter shell. Combustion of the small quantity of carbon monoxide in the gases (approximately 10%) commences in the hood and is completed in the short length of water-cooled main leading from it to the spray box.

The incandescent gases enter the spray boxes at a temperature of approximately 1500°C and water is injected into them at a maximum rate of 100 gal/min. Humidified gas at a temperature of 550°F (290°C) leaves the spray box and passes through unlined ducting to the precipitator, in which it is cleaned to a final fume concentration of 0.04 grains/ft³ N.T.P. before being discharged to atmosphere through the exhaust stack by the fan.

The spray boxes in which the Kaldo converter waste gases are cooled and humidified are placed close to the converters. Each of them consists essentially of a rectangular box surmounting a wedge-shaped hopper. The upper portion of the box consists of rectangular water-cooler panels mounted inside a structural steel framework. Each panel is made up from a number of individual water channels so as to eliminate all risk of uneven distribution of water over the panel surface, and for the same reason each channel has separate inlet and outlet water connections. Buckling of the vessel which would otherwise be caused by stresses

Fig. 4b. Combined damper assembly showing by-pass damper (top) closed and spray box inlet dust damper (bottom) open





set up by thermal expansion is prevented by freely suspending the panels within the support frame by means of special hangers and locking fastenings. The hopper is refractory-lined and is provided with a sliding plate valve from which material can be discharged from the box during "off blow" periods. There is a vertical refractory baffle suspended from the roof of each box and water is sprayed into the hot gas in the space between this baffle and the inlet at the front of the chamber. The cooling water is injected through five banks of spray nozzles at a maximum rate of 100 gal/min and a pressure of 210 lb/in2. The water supply rate is controlled by a temperature-controller which operates solenoid valves in the water supply pipes so as to vary the number of banks through which water is being injected in such a way as to maintain the design outlet temperature of 550°F irrespective of the variations in inlet gas volume and temperature which occur as the blow proceeds. Each spray bank also has a hand-operated valve with which the delivery rate of each set of nozzles can be adjusted within limits.

In the event of a failure of either the main power supply or any essential part of the collection system or its controls, the hot waste gases from whichever converter is being blown are discharged direct to atmosphere through the refractory-lined 180 ft high by-pass stack. The switching of gas-flow is accomplished by opening a sliding curtain damper in the by-pass and simultaneously closing a similar damper at the inlet to the spray-box.

The dampers in the spray box inlets and by-pass stacks are of novel design. Each pair of dampers consists of two curtains constructed from interlocking heat resisting steel segments and mounted one above the other in individual housings so as to form a single assembly.

Each complete damper assembly is mounted vertically with the upper damper fitted in the by-pass duct and the lower one in the spray box inlet duct. The damper curtains are carried on trolleys and are linked by chains running over pulleys mounted at the four corners of the assembly and a single drive motor operates the dampers simultaneously so that when one is closed, the other is opened. The frame and sheeting of the damper unit are lined with refractory to protect them from the high temperature gas flowing through the system and the casing is made up of removable panels so that access may be obtained to the damper curtains when they are in the retracted position. The method of construction and mode of operation of these dampers are illustrated in Figs. 4a and b.

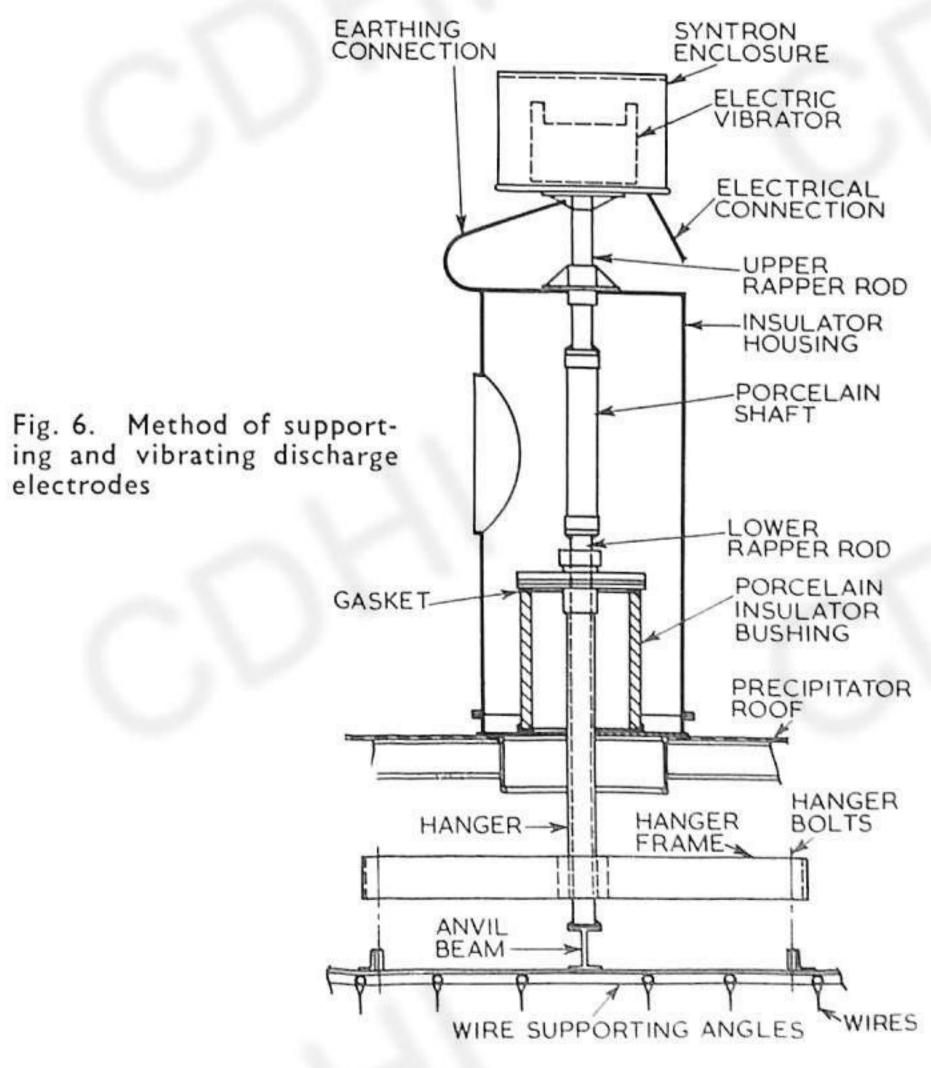
The dry-plate precipitators of the LD and Kaldo converter fume-cleaning systems are identical in size and mechanical design. They are of the Head Wrightson/Research-Cottrell "Opzel" plate design which has been well tried and proved in numerous iron oxide fume collection applications throughout the world.

One of the precipitators is illustrated in Fig. 5a. It consists essentially of a rectangular box containing the discharge and collector electrodes, mounted on pyramidal hoppers, and provided with a rectangular opening at each end, through which the waste gases flow into and out of the precipitation zones.

The rectangular precipitator shell and the pyramid hopper beneath it are of mixed bolted and welded construction, in  $\frac{3}{16}$  in and  $\frac{1}{4}$  in mild steel plate, heavily stiffened by broad flange beams and channels with all bolted joints seal-welded. A total of 152 individual collector electrode plates is suspended vertically inside the casings in four groups, each of which has 38 plates, parallel to the major axis of

the unit (and, therefore, the direction of gas flow) at a spacing of 9 in (Fig. 5b). Discharge electrode wires are suspended vertically at intervals between the plates. Each group of collector plates and discharge electrode wires forms a separate precipitation zone consisting of 37 ducts 23 ft 6 in high, 9 in wide and 6 ft long, and the four zones in series of the precipitator make up a total of thirty-seven 24 ft long precipitation ducts in which fume is removed from the gas to be cleaned as it passes horizontally through the unit. The collector plates are suspended from joists mounted immediately below the roof of the precipitator, and the discharge electrodes hang from structural steels grids supported by high-tension insulators. A heavy, bottle-shaped cast-iron weight is attached to the lower end of each discharge wire, to eliminate bending and kinking of the electrode and, by its inertia, help to prevent the discharge electrode system from swaying in the gas stream. A high-tension steadying frame immediately above the tensioning weights ensures complete stability of the discharge system by locating the individual electrodes and preventing them from moving relative to each other.

Dust collected on the plates is dislodged by magneticimpulse, gravity impact rappers connected to the plate sus-pension framework through vertical rapper bars. The rappers are enclosed in individual weathertight sheet steel housings mounted on the precipitator roof. The discharge electrodes are kept free from dust build-up by electromagnetic vibrators connected to the high tension wire supporting framework by ceramic insulators (see Fig. 6). Each insulator is located inside a weatherproof housing on the precipitator roof and its electromagnetic vibrator is mounted on the housing so as to be completely accessible from the precipitator roof. The vibrator is connected to the insulator by a steel shaft passing through a gas seal in the top surface of the insulator housing. The insulator shaft not only insulates the vibrator from the high-tension framework but transmits vibrations from one to the other. Both the plate-rapping and wire vibrating systems are novel in design and are two of the most important factors contributing to the efficient operation of the precipitators, and for these reasons they are discussed in more detail below.

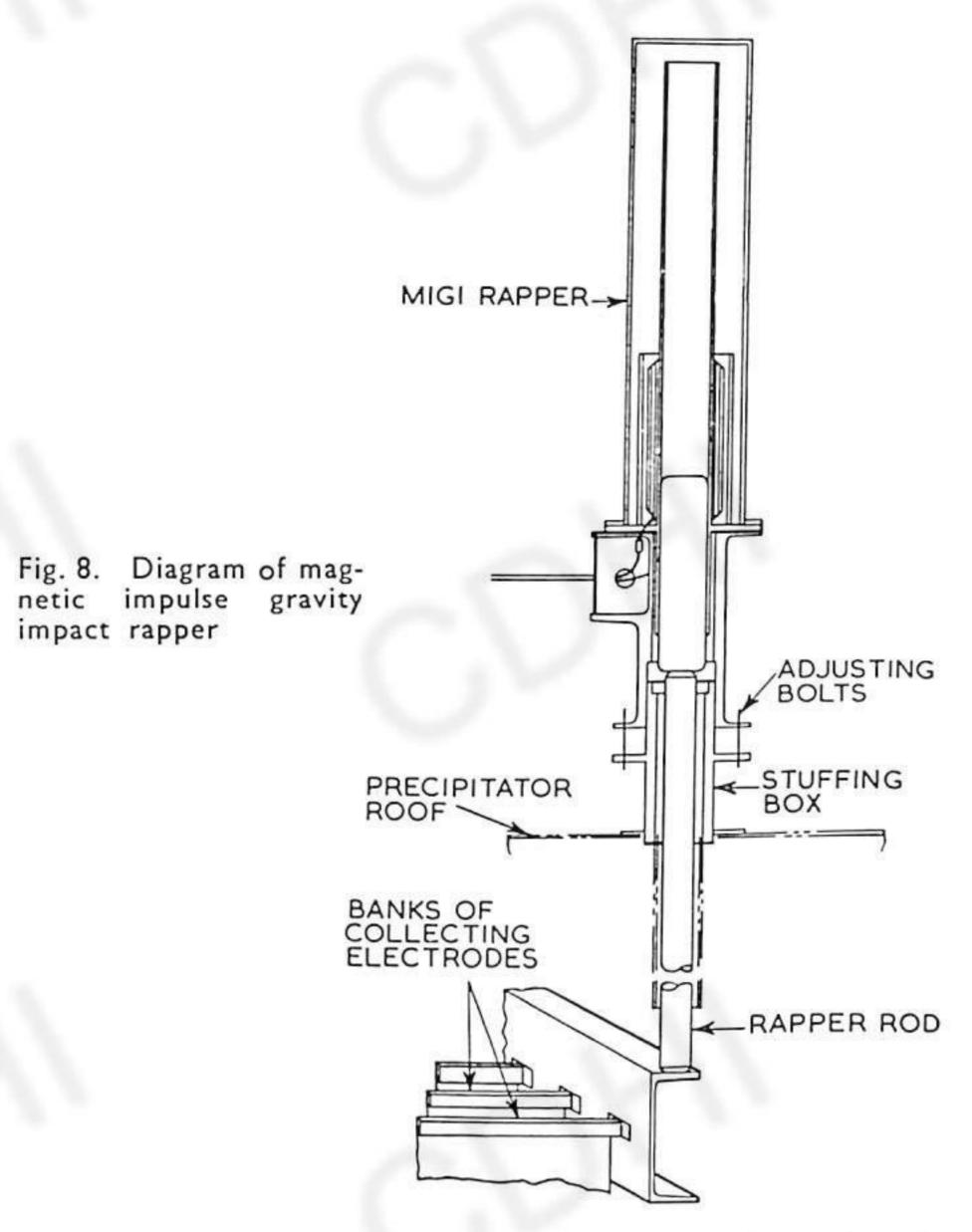


The precipitator inlet and outlet ducts are of simple box form. The former are provided with turning vanes to distribute the dirty gas entering the precipitators evenly, in spite of the sharp 90° change of direction which it undergoes at this point. Immediately before entering the precipitator proper, the gas passes through a vertical perforated plate which completely eliminates all unevenness of flow so that all the gas is treated for an equal length of time and the whole precipitator operates at a consistently high efficiency.

Ample provision is made, in the form of platforms and stairways, for easy access to all external parts of the precipitator for routine maintenance, and manholes are provided in both shell and hoppers for inspection and maintenance of the electrode systems. All manhole covers are fitted with "Castell" locks which are interlocked with the hightension supply and render it impossible for plant personnel to enter a precipitator until the whole electrical system has been earthed.

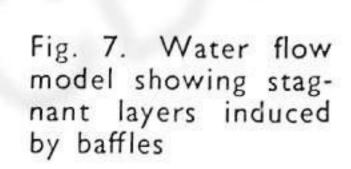
Each zone of the precipitator is energized by a full-wave transformer rectifier fitted with automatic voltage control gear. When the precipitator is in operation, gas flowing between the collector plates is subjected to an electrical discharge and the fume particles carried in it are precipitated on the collector plates. Collected dust is dislodged from the plates at intervals by rapping, and settles into the hoppers, from which it is discharged through rotary valves and screw conveyors and thence through vertical chutes to ground level for final disposal.

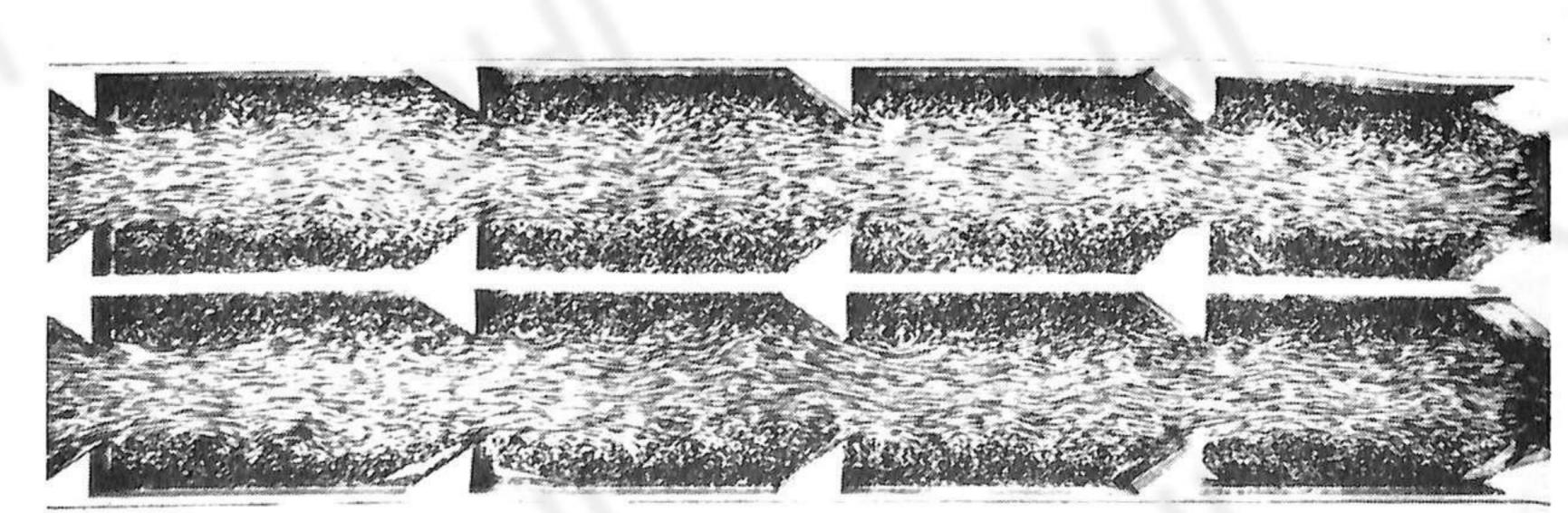
The design of an efficient electrostatic precipitator involves far more than merely creating the correct electrical conditions and basic electrode geometry, although these are obviously first essentials. The basic mechanical and electrical design will certainly ensure efficient precipitation of fine particles for a while but this will not be maintained unless the collector plates and discharge electrodes are kept reasonably clean and if these are rapped in order to remove dust build-up from them, this must be done in a controlled manner. If the vibration of the electrodes is not sufficiently strong, then insufficient dust is removed, the electrical operation of the unit is impaired, and complete breakdown may follow. On the other hand if excessively heavy or frequent rapping is carried out, dust can be dislodged from the electrodes with such violence that some of it is immediately re-entrained in the gas stream and passes out of the precipitator to atmosphere. The design of the collector plates themselves is also extremely important. If steps are not taken to prevent it, a proportion of the dust rapped off the collector plates will be re-entrained on its way down to the hoppers. Though, as mentioned above, loss of dust in this way can be reduced by careful control of rapping frequency and intensity, it will still occur, but it can be which then falls and strikes the rapper rod which is con-



reduced still further by designing the plates themselves in such a way that a substantially stagnant layer of gas is maintained close to the plate, so that dislodged dust can settle into the hoppers undisturbed by the main gas stream. This effect is obtained in the Consett precipitators by means of simple baffles attached to the plates. The baffles are of a special form developed after much research including extensive flow visualization tests and pilot and fullscale plant tests. Fig. 7 is a photograph of a water-flow model which clearly shows the stagnant gases between the Opzel baffles, through which dust dislodged by rapping can settle into the hoppers with minimum re-entrainment. The rappers of the precipitators at Consett are of the magnetic impulse gravity impact type and there are sixteen of them on each unit. A rapper is illustrated diagrammatically in Fig. 8. The device consists essentially of a totally enclosed solenoid electromagnet consisting of a steel plunger surrounded by a concentric coil, the whole being enclosed in a steel housing. A short duration pulse of current through the coil causes it to raise the plunger.

FLOW→





nected to the collector electrodes and transmits the shock of impact to them and dislodges the dust which has been collected on them. The rapping cycle of each precipitator is controlled by an adjustable timer and the intensity of the rapping blow can also be adjusted between very wide limits by altering the supply voltage and varying the amount of air-cushioning given to the rapper at the end of its stroke this latter being done by adjusting a small throttling valve at the bottom of the rapper guide tube.

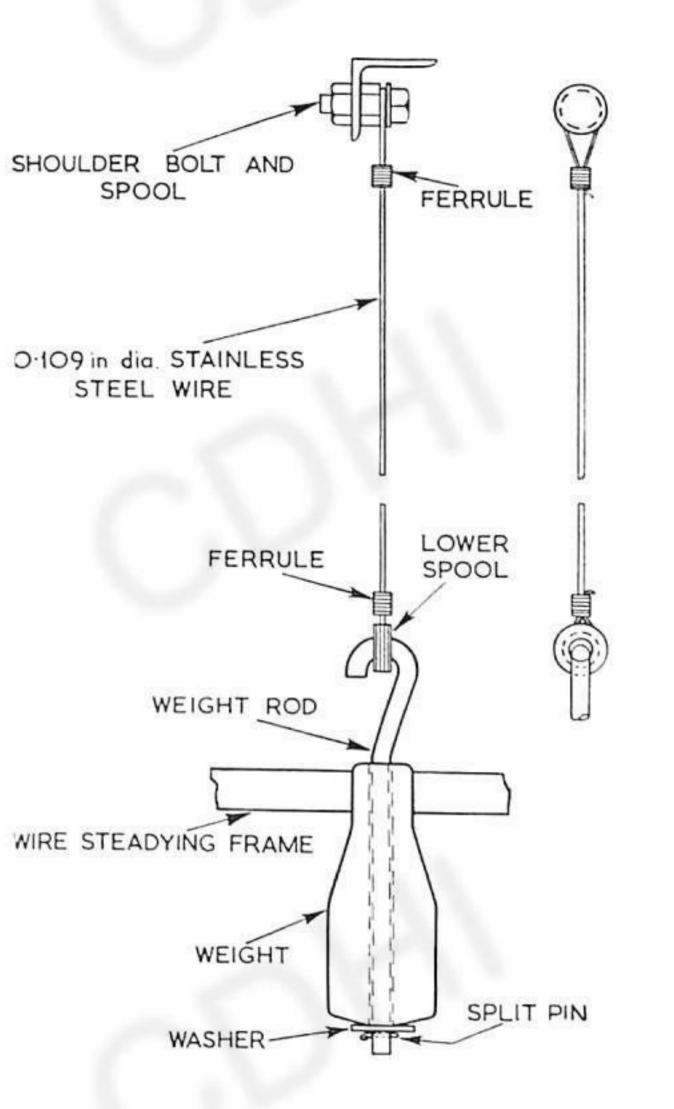
The importance of rapper adjustability is clearly shown in Fig. 9 which illustrates the effect on overall efficiency of varying the intensity of rapping (the rapping cycle being fixed). With insufficient rapping the precipitation process itself is interfered with because dust build-up on the plates upsets electrical conditions. On the other hand the fallingoff of overall efficiency to the right of the peak of the curve is due entirely to over-rapping and the unnecessarily large amount of re-entrainment resulting from it. It will be seen then, that what may at first appear to be no more than a slight refinement of a precipitator ancillary has an effect on efficiency equivalent to that of a large change in the design of the precipitator itself.

In addition to the features described above, all of which are connected with precipitation efficiency, the precipitators incorporate other refinements designed to reduce downtime for maintenance to the absolute minimum. All moving parts are outside the precipitator casing. They are not, therefore, exposed to high temperature dirty gas and are easily accessible for maintenance. Another important detail is the design of discharge electrodes. The discharge wires are of stainless steel and they are suspended from the high tension framework and attached to their tensioning weights by a simple patented arrangement as shown in Fig. 10. With this arrangement, the part of the wire near to the suspension is allowed to rotate, and no bending moments are induced when the wires are vibrated. This elimination of stress points reduces the possibility of wire-breakage, which can otherwise be very troublesome.

Fig. 10. Method of attaching discharge wires

Fig. 9. Variation of precipitator efficiency with rapper OPTIMUM

RAPPER INTENSITY





# **CONSETT Developments**

# Electrical Equipment

By F. MASON\*, A.M.I.E.E.

The main power supplies to the plant are at 11,000 volts three phase 50 cycles, taken into the main substation at the south end of the plant. Transformer and rectifier equipments are included in the substation to give power supplies at:

3,300 V 3 phase 50 cycles for large motors, i.e. 250 h.p. and above.

500 V 3 phase 50 cycles for general power supplies.

500 V d.c. for cranes and variable speed drives (except Kaldo drives).

The LD converter and waste heat boiler and the Kaldo converter electrical equipment were each considered separately for electrical purposes, though due thought was given to standardizing, as far as possible, equipment and control systems to give maximum convenience for maintenance purposes.

#### LD CONVERTERS

Duplicate power supplies at 500 V 3 phase 50 cycles are arranged to a U-shaped contactor and switch fuse panel located in a switch house on the boiler operating platform above the converter and at the north end of the LD plant section. Each leg of this U-shaped panel houses a.c. control equipment associated with one converter with common equipment controlled from the centre section. Feeds are taken from this panel to combination fuse switchboards in switchhouses on the roof level. These switchboards control power supplies for equipment associated with the precipitators. Controls for the precipitator HV equipment and electrode cleaning equipment are also located in these houses. A schematic layout of the arrangement is shown in Fig. 1. The equipment is set out to give control of main operational drives from the converter control desk or the boiler control desk dependent on the duty. Facilities are also provided to give control of all equipment local to the drive for maintenance purposes.

Further contactor panels are included in the mixer area for the control of the boiler primary fuel oil pumps and other general auxiliaries located there.

#### Converter Main Drives

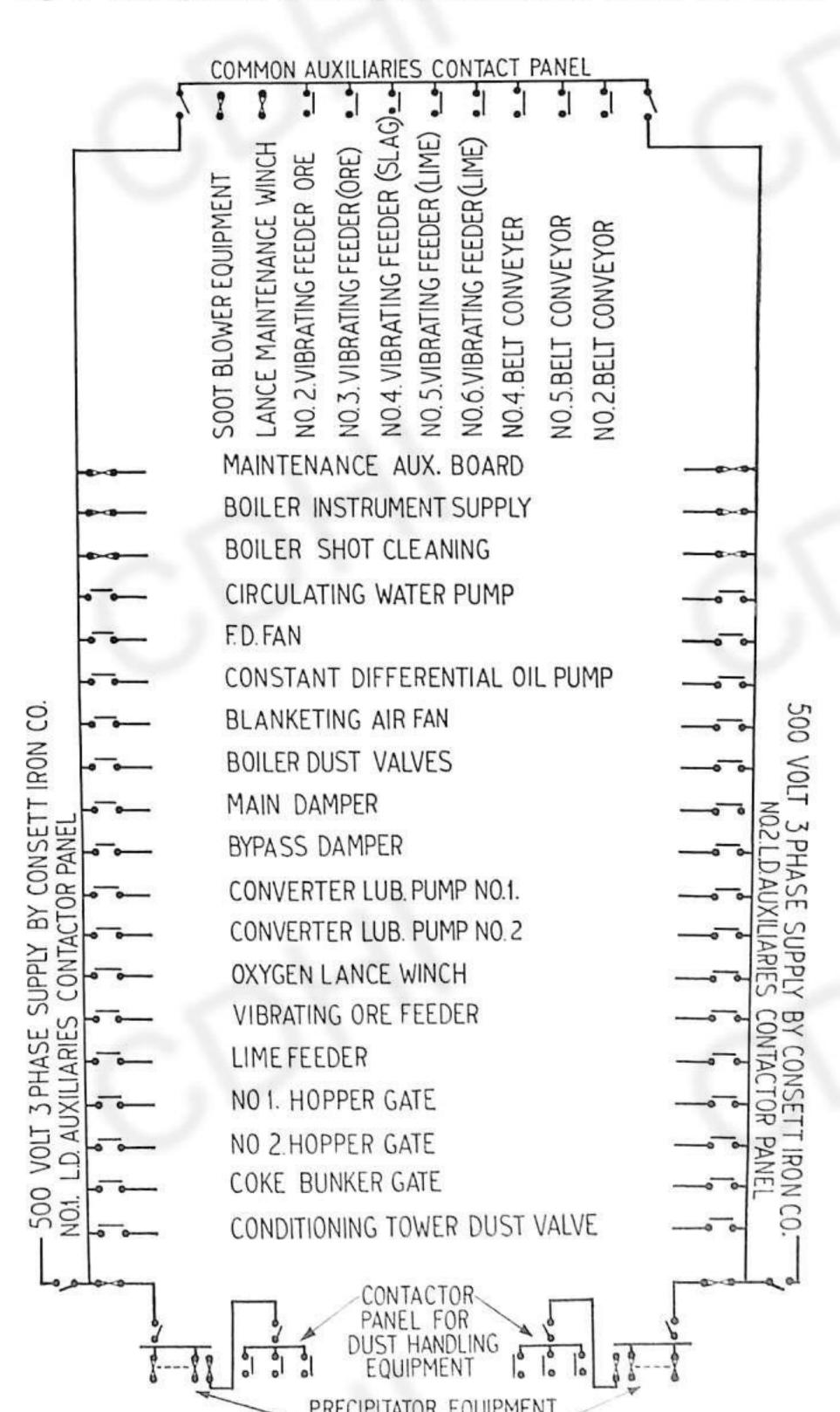
The main tilt drives for each LD converter consist of two 150 h.p. 460 rev/min d.c. mill type motors. These motors are arranged for use on the 500 V d.c. supply and speed control is obtained by means of a five-step armature series resistance. At the low speed condition an armature divert resistance is included to stabilize the speed control. This resistance also gives dynamic braking control when speed is being reduced or the drive stopped.

The main control position for this equipment is at the control desk in the converter pulpit. At this position the operator may select single or dual motor control with full

speed control or select to control the vessel tilting from either of two small subsidiary desks mounted conveniently to the slagging and pouring positions. These desks are arranged to give full speed control of the vessel.

The switchboard is arranged so that one main drive on each converter is taken from each side of a bus section switch as shown on Fig. 2, thus ensuring full duplication of power supplies to each converter. The board is extended to cater for the hot metal mixer control in a similar manner.

Fig. 1. Arrangement of U-shaped contactor and switch fuse panel



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<sup>\*</sup> Electrical Engineer, Head Wrightson Iron & Steelworks Eng., Ltd.

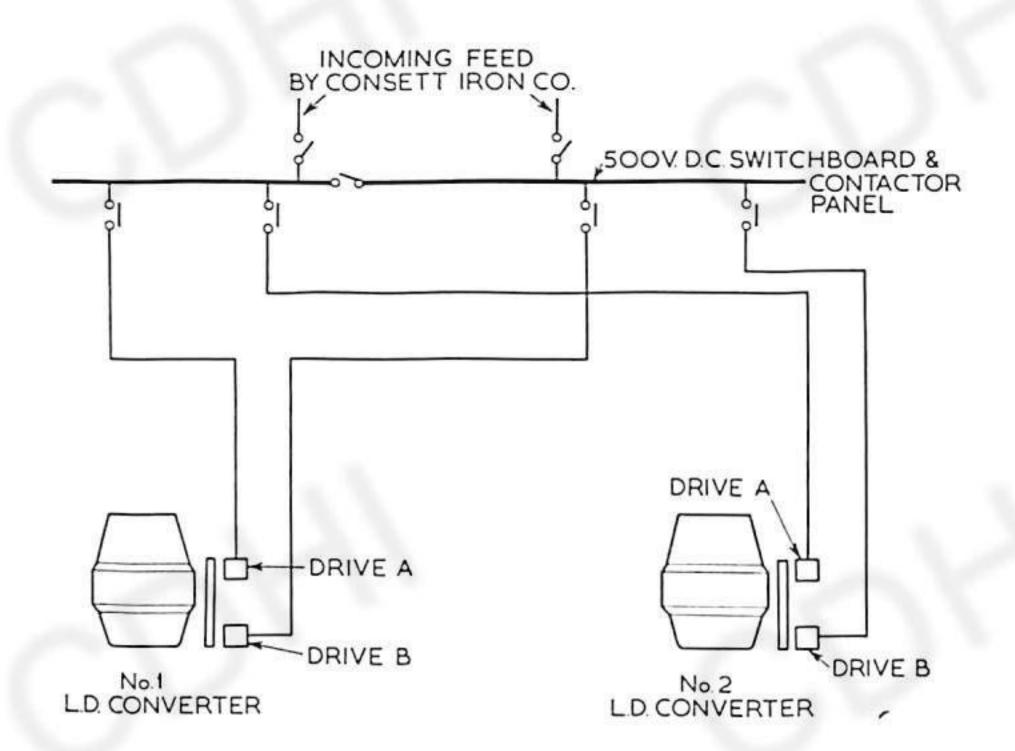


Fig. 2. Arrangement of LD converter drives

#### Main Control Desk

The control desks in the converter pulpits (Fig. 3) were Auxiliary Lance Winch designed to give the operator full information regarding If a fault occurred on the main winch due to loss of the condition of drives directly associated with the converter and the controls arranged in such a manner that the operator's movement along the desk follows the normal sequence of operations. The following operations can be controlled from each desk:

- (a) Ladle car lift, coupling and traverse.
- (b) Tilt drive lubrication.
- (c) Tilt drive control position and dual or either motor single operation; full tilt directional and speed control.
- (d) Indication is provided to show when the vessel is in the "blow" position.
- (e) Lance winch indication being provided by lamps at 1 ft, 5 ft, 10 ft, 15 ft, 20 ft, 25 ft, and 50 ft. These lamps show the level of the lance tip above a nominal datum level of metal in the vessel.

A "Magslip" servo indicator calibrated 0-10 ft gives continuous precise indication of lance position. Also included on this desk are the oxygen and lance cooling water controls mentioned later in this article. Annunciator alarms are provided to give visual and audible alarms of various possible fault conditions. Control push buttons for this are provided on the desk.

Ample drawer space is provided at one end of the desk and writing space and provision for two telephones is allowed.

The positioning of the pulpit was considered carefully to give the operator maximum reasonable vision of the pouring operation.

#### Oxygen and Water Flow Control and Instrumentation

All recording and controlling instruments are mounted on or in a cubicle type panel of folded metal construction located in the control pulpit. Indicating instruments are generally Bourdon tube pressure gauges, flush mounted on the control desk described above, the indicating signal being from a pneumatic transmitter in the associated measuring instrument.

The control system is arranged to give full automatic or manual control of oxygen flow by means of a pneumatically operated flow control valve. The automatic flow control is arranged to allow the end of the blow period

to be signalled either when a pre-set amount of oxygen has flowed or when oxygen has flowed at a pre-set controlled rate for a set time.

Provision is made on the control desk for full control of oxygen and water to the lances and indication of flow temperature and pressure conditions where necessary.

Manual shut-off valves are provided to allow isolation for maintenance purposes.

The oxygen flow valve is pneumatically controlled by a signal from the control desk and both oxygen and water automatic valves are controlled pneumatically by means of an auxiliary solenoid-operated signal from a relay panel located in the pulpit.

All automatic valves are arranged to return to a safety position in the event of loss of either the electrical or pneumatic operating medium, and to operate to the safe position in the event of any fault or danger condition which may arise.

Two lance supply systems are provided, one of these being for standby purposes. An electrical interlock is made between the lance winch and the associated lance to ensure that the correct valves are operated.

power supply or any mechanical fault, the lance could be severely damaged if allowed to remain in the vessel and dangerous conditions could be created. To obviate this danger an emergency drive is arranged on the counterweight pulley to lift the lance without operating the main winch. The starter for this winch is mounted near the drive and can be controlled from the converter pulpit. Power supplies are from the emergency batteries in the sub-

#### KALDO CONVERTERS

Duplicate power supplies are taken to a U-shaped contactor panel located in the switchhouse between the two converters and at the same level as the LD switchhouse. The arrangement of the boards and control and small power distribution equipment is very similar to that previously described for the LD converters. One difference is noted in that the precipitator equipment is common to both converters and is fed from the common section of the panel. Control facilities are also as previously described.

Control pulpit of the LD converter



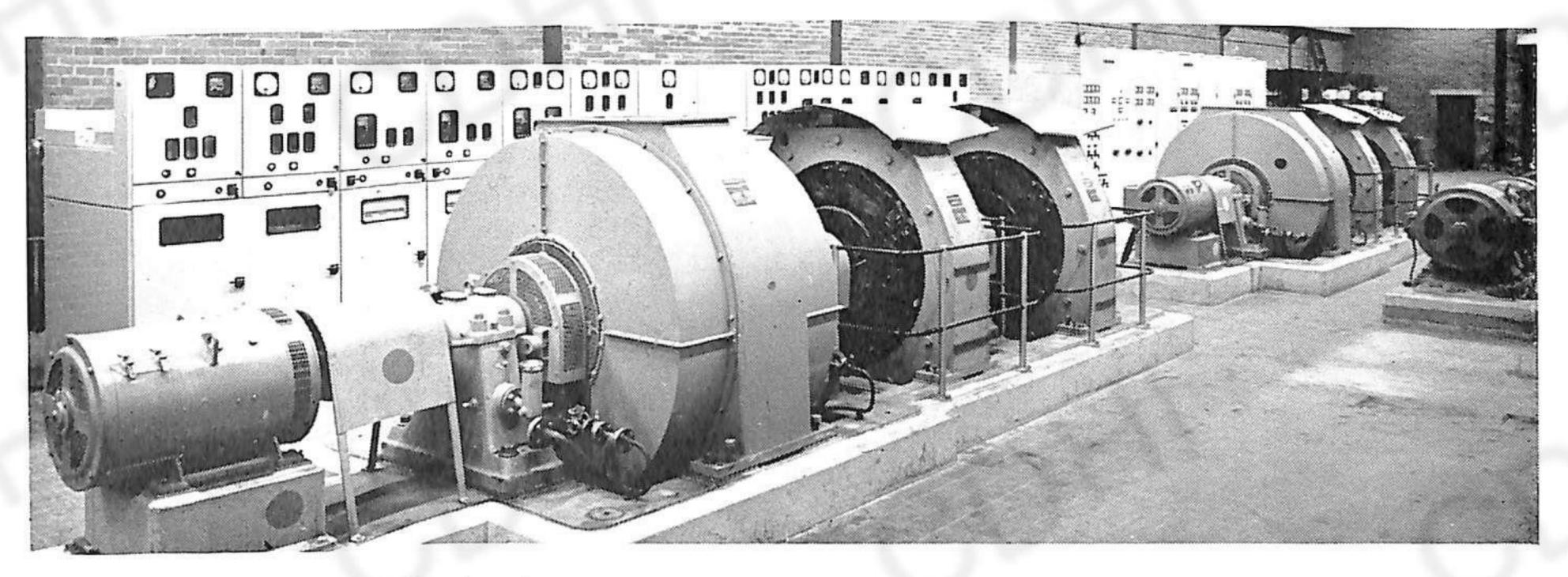


Fig. 4. Kaldo MG sets in the main sub-station

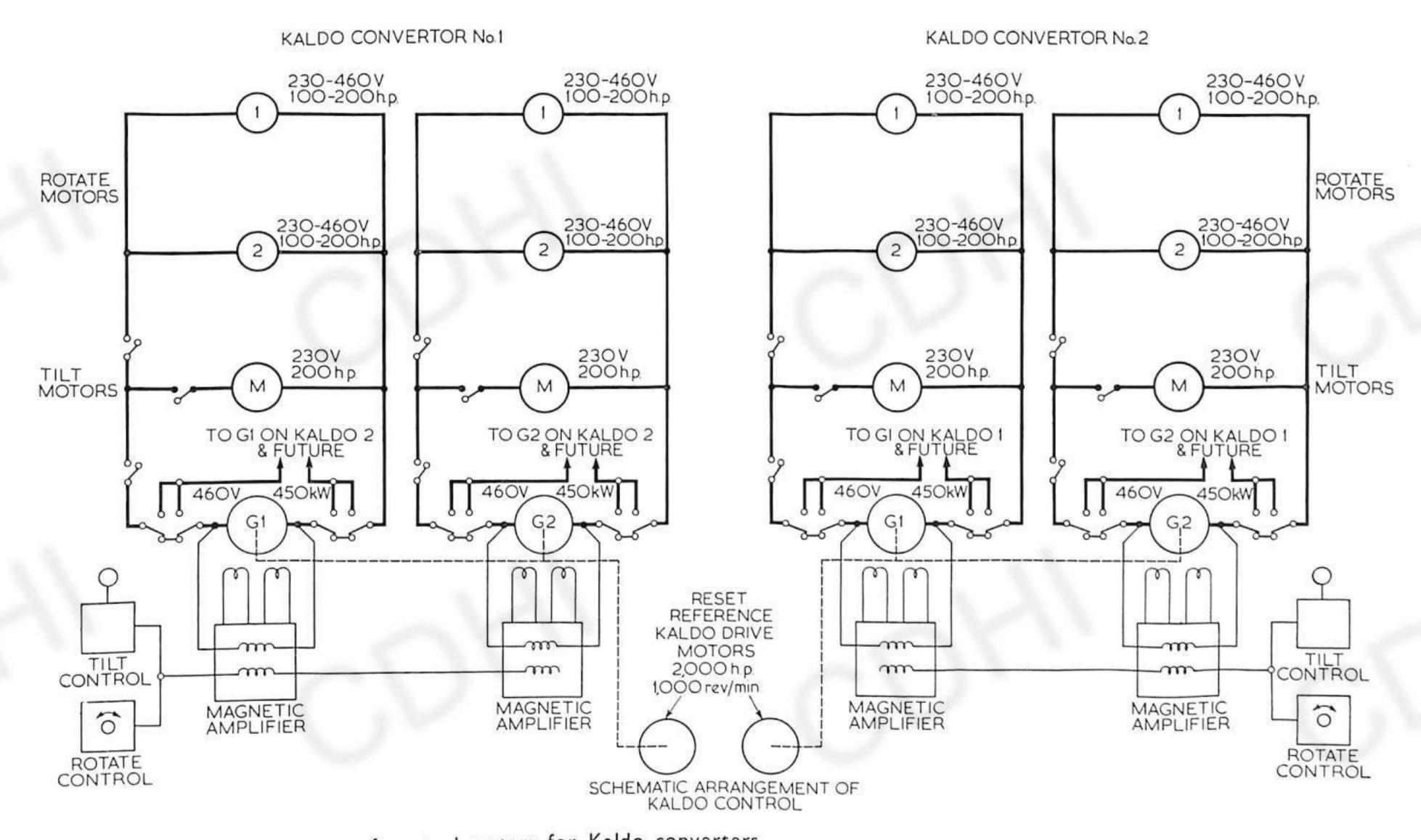


Fig. 5. Schematic arrangement of control system for Kaldo converters

#### Converter Main Drives

The driving arrangements on the Kaldo converter differ from those on the LD mainly because of the different requirements of the process. In the LD converter the oxygen emerges from the lance tip at supersonic speeds, thus having the energy required to break through the foaming slag above the metal bath. The oxygen flow in the Kaldo process is at much lower speeds and at certain stages material additions have to be made (limestone, etc.). To ensure optimum usage of the oxygen and additions it is, therefore, necessary to rotate the actual vessel while it is in a tilted position, the speed of rotation being finely controlled.

To give the required control a form of Ward Leonard speed control is provided with the generators feeding power to either the vessel tilting drive motors or the vessel rotat-

ing motors, suitable interlocking being provided to ensure that only one of these functions can operate at any time. The following drives are provided for each Kaldo equip-

- (a) Tilting drive: Two 200 h.p. 420 rev/min 230 V d.c. separately excited mill motors.
- Rotate drive: Four 206 h.p. 1,000 rev/min 458 V d.c. separately excited mill motors. These motors are flange mounted in pairs on to epicyclic gearboxes mounted in pivoted frames with the output through a gearbox to the main rotate drive rollers which are on the same frames.
- Rotate clamp motors: Two 5 h.p. 1,105 rev/min 500 V d.c. mill motors.
- M.G. sets (main): Two 450 kW generators nominally rated to give an output of 460 V d.c. at 1,000 rev/min.

These form a common M.G. set (Fig. 4) driven by a 2,000 h.p. 0.8 power factor, 1,000 rev/min synchronous motor utilizing a power supply from a 3.3 kV switchboard supplied and installed by Consett Iron Co., Ltd.

(e) M.G. set (auxiliary): One H.F. alternator with an output of 45 kVA at 400 V 3 phase 400 cycles per second and one constant voltage exciter with an output of 40 kW at 230 V d.c. These machines are mounted on a common bedplate together with a 120 h.p. driving motor to form a common M.G. set.

The main M.G. sets are connected to a change-over switchboard which allows No. 1 M.G. set to supply power under normal conditions to No. 1 Kaldo and act as a

lifier winding is trimmed to give maximum acceleration with a torque less than that which could cause any slip. Two-step control is provided to reduce the accelerating currents at the higher range of speed.

A basic diagram for the system is shown in Fig. 5.

Three control positions are provided, the main position being at the main control desk (Fig. 6). From here the rotary speed can be varied continuously up to the maximum, and speed control of the tilting motion in five steps. Control station selection is from the main desk.

Two other control desks are located at the slagging and casting sides of the converter to give the two lowest speed steps of tilt control only. No rotate control is provided on these desks.



Fig. 6. One of the control pulpits for the Kaldo converter

standby for No. 2 Kaldo. No. 2 M.G. set similarly gives standby characteristics for No. 1 Kaldo drives.

The control system is arranged to operate either one pair of vessel rotary motors or one tilt motor from each generator. The present installation consists of two Kaldo converters each with one M.G. set and the installation is arranged to allow the third Kaldo with any M.G. set acting as a standby for any Kaldo.

The control loop for the equipment is a basic Ward Leonard control system with closed loop voltage control in each direction of rotation. The generator voltage control is obtained by means of push pull magnetic amplifier equipment which accurately controls the generator fields, and hence voltages to give the required speed. Acceleration and deceleration of the drives are carefully controlled by means of an auxiliary winding in the magnetic amplifier. This serves the dual purpose of limiting surge currents and preventing "slip" between the rotate drive rollers and the running ring. This slip, if allowed to persist, could cause serious damage to the ring surface, and the magnetic amp-

The control equipment and M.G. sets are located in the main sub-station. The other equipment connected with the Kaldo drive and located in the sub-station include main generator circuit breaker and change-over panel, magnetic amplifiers control panel and M.G. sets lubrication equipment.

A supervisory alarm and control panel is also included to simplify maintenance and to give indication of any fault condition which may arise.

As the vessel is arranged to move in either tilt direction continuously it is necessary to arrange for connection to the vessel rotate and clamp drives and limit switches on the vessel carriage to be through a slip-ring assembly. A set of slip-rings comprising 25 rings, the largest of which is 11 in diameter and overall length 6 ft, is supplied for each converter to supply power to the four rotate motors, two rotate clamp motors and rotate clamp on and off limit switches. The slip-rings are of totally enclosed construction and a small quantity of air is blown through them for cooling purposes. The rings are mechanically connected to

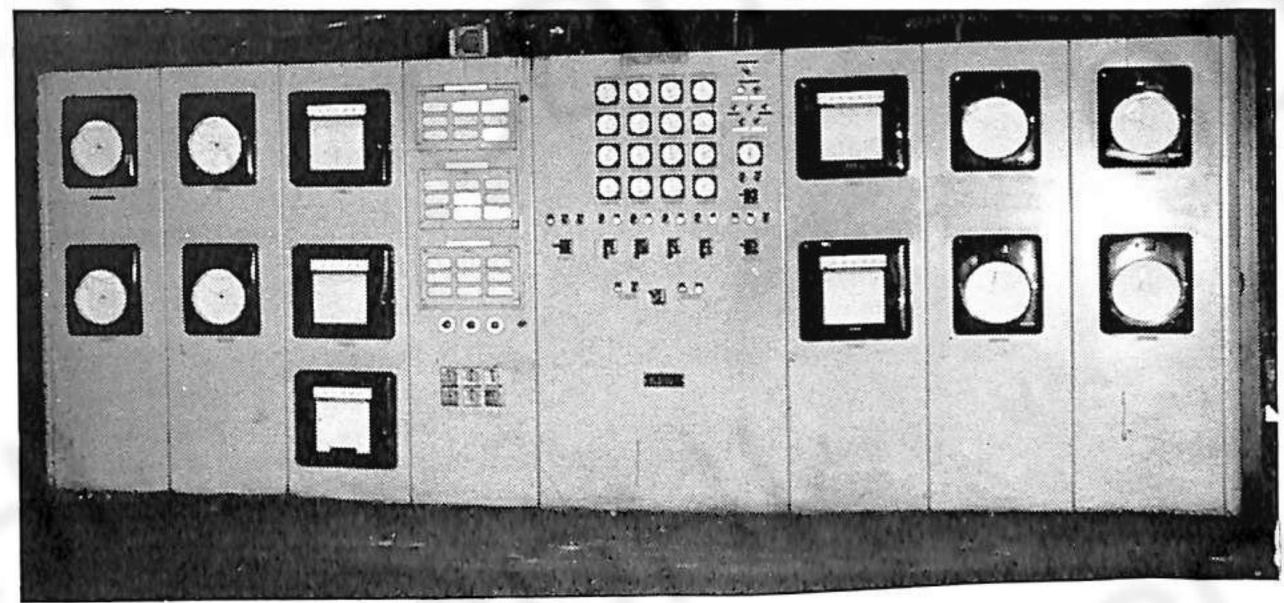


Fig. 7. Kaldo converter fume cleaning instrument panel

the converter through a Hardy Spicer universal coupling and electrical connections are completed by means of special high temperature cables drawn in harnesses through ducts in the vessel carrying frame.

The vessel carrying frame is of box section with three compartments. Air for motor cooling purposes is ducted through one of these compartments and the cable ducts noted above are formed from 8 in diameter smooth bore flexible metallic hoses which have some air bled in for cooling purposes.

#### Main Control Desks

The control desks in the converter pulpits were specially designed to give full operation indication and control facilities for all drives and equipment associated with the converter operation. The desk is of U-shaped construction with the centre section having controls for the ladle car coupling and rotate and tilt drive selection and single or dual motor control. At the left hand side of this section is a control station for auxiliary drives, lubrication pumps, etc., and the left hand side of the desk houses controls for the fume hood, cooling water for lances and fume hood, and also lime and ore additions. Indications of water flows and temperatures are included here. The right hand side of the desk houses controls for the vessel tilting and rotating drives and all oxygen valve and flow control equipment. An indicator is included to show the angle of vessel tilt with the blowing position clearly marked. Provision is made on the desk for two telephones and accept and cancel alarm signals for the alarm annunciator equipment.

#### Fume Hoods

The fumes generated during the steel-making process are collected through a hood mounted on a carriage comprising a main moving frame which travels on rails and a cross travel frame which carries the hood.

All limit switches to give full positional interlocking and to ensure that oxygen cannot flow unless the hood is in position over the vessel, are mounted on the carriages. Heat resisting butyl insulated cabling is used throughout and provision is made for flexible connections to the carriage from a junction point above the carriage.

# Oxygen and Water Flow Control and Instrumentation

An instrument panel is provided in each control pulpit to house oxygen and water controls for the Kaldo converters. These panels are of cubicle construction, arranged to form the rear wall of the pulpit, and have doors at the rear to allow for access to the instruments. An extension cubicle is provided to house all oxygen control relays and an-

nunciator operational relays. Access to the cubicle is from the control pulpit. A further cubicle type panel is provided in the charging floor at a point between the two converters. This panel houses all instruments necessary for the control of each spray box and the precipitator control equipment (Fig. 7).

Oxygen and water control to the converter is generally similar to that previously described for the LD converter, the main difference being that an extra water cooled lance is provided to blow in additions to the converter. The equipment is fully interlocked with the main drives and in the event of failure of water to either lance the oxygen is shut off. This interlock also causes the lances to withdraw, then the hood retracts and the carriage travels automatically to a safe position longitudinally.

The control desk for each Kaldo converter is of U-shaped construction and gives facilities for full control of oxygen and water and both lances and the fume hood and full control of materials addition through the additions lance including weighing of material and the control of ladle cars, etc., as described earlier.

Manual shut-off valves are provided to allow main isolation for maintenance purposes. Shut-off valves for oxygen and large water mains are pneumatically operated with auxiliary solenoid valves but small water shut-off valves are all solenoid operated. Oxygen control is all pneumatic. Control of the solenoid valves is from relay panels on the instrument panels.

All valves are arranged to fail to a safety position in the event of failure of either electrical or pneumatic power, i.e. oxygen valves close and water valves open.

#### FUME CLEANING EQUIPMENT

Three sets of precipitator electrical equipment are provided, one for each LD converter precipitator and one for the Kaldo converter precipitator.

Each precipitator has four collecting zones with two sets of electrodes in each zone. The high voltage supply for each zone is obtained from a high voltage transformer rectifier set, capable of giving two half wave outputs of 125 mA at 70,000 V peak d.c., one half wave output being connected to each set of electrodes. This ensures that the applied voltage is graded through the precipitator to suit the dust loading.

To obtain the most efficient fume cleaning it is important that the applied voltage is maintained at the maximum possible.

Under certain dust loading conditions if the voltage is too high, severe sparking will occur. To eliminate this the power input to the transformer rectifier is through a saturable core reactor with a control winding connected to the output terminals of a spark counting circuit. This reactor also limits the current to a reasonable value in the event of severe spark over. Each time a spark occurs an impulse is injected into a counting circle, the output terminal voltage of which increases as the sparking rate increases. This output voltage is compared with a reference voltage which is proportional to the desired spark-over rate and the unbalance signal is injected through a magnetic amplifier to the reactor control windings, thus controlling the precipitator voltage at the optimum value.

The high voltage transformer rectifier units each comprise a core type transformer and stacks of selenium rectifier cells in an oil filled tank of weatherproof construction mounted adjacent to the base of the precipitator.

The cubicles containing the magnetic amplifier and other control equipment are located in a switch-house near the precipitator base. Provision is made to allow for control of the precipitators from the magnetic amplifier or a remote position. In the case of the LD converters the remote position is at the waste heat boiler insrument panel and for the Kaldo converters on the common section panel.

#### Electrode Cleaning

The collecting plates and discharge wire electrodes must be maintained as clean as possible. This is done by means of magnetic impulse rappers on the plates and vibrators on the discharge wires.

The magnetic impulse rappers each consist of a solenoid

electromagnet comprising a steel plunger inside a concentric coil, the whole assembly being in a water-tight case. A short duration impulse from a condenser lifts the plunger, which drops by gravity on to a rapper bar mechanically connected to a bank of collecting plates inside the precipitator. The resultant shock on the plates releases the accumulated dust. Eight rapper units together with one common control cubicle are provided on each precipitator. The control equipment comprises transformer and rectifier equipment to charge a condenser to a selected value up to 3,000 V. A motorized selector switch connects the condenser across each coil in turn, thus ensuring all plates are rapped evenly. Control equipment including timers, voltage controllers and other equipment is mounted in a case located in the switch-house with the precipitator controls and distribution equipment. The intensity of the impulse is regulated by means of the condenser voltage control on rectifier valve) and an air equalizing valve between the solenoid core and the outer section. The impulse time interval is selected by means of interchangeable gear units on the timer motor unit.

The electrode wires are cleaned by means of electromagnetic vibrator equipment in a weatherproof case connected to the electrode frames through a porcelain shaft. The control equipment comprises a motor driven switch to select the vibrators and a variable transformer to control the intensity of vibration. The duration of vibration is limited to 0.5 sec as continuous vibration could cause breakage of electrodes. An electronic timing device is included for this duty. The control equipment is mounted in a cubicle adjacent to the rapper controls. For each precipitator eight vibrators and one control cubicle are

# **CONSETT Developments**

# Steelmaking Plant and Ancillary Services

The decision by Consett Iron Co., Ltd., to go ahead with a plant incorporating both LD and Kaldo processes, with vessels of 120 tons nominal capacity, was taken in September 1959. Working in close liaison with the development department of Consett, the International Construction Co., Ltd., prepared layouts of the plant, issued enquiries for equipment and compared tenders before official orders were issued by Consett to contractors.

A site organization was established under a resident engineer with technical and clerical staff to deal with the co-ordination and supervision of construction and to design and install all services. In addition, inspection and progress visits were made to manufacturers' works, and throughout the programme detailed inspection and progress reports were submitted regularly to Consett.

The scope of the consulting works included civil engineering, structural engineering, major operating plant, auxiliary equipment, handling facilities and all services from the preliminary discussion stages through to final commissioning, and extending to cover retention and guarantee

Over 800 drawings were prepared by I.C.C. and, in addition, all contractors' drawings were examined for approval. The service covered over 270 main orders and contracts on approximately 150 different manufacturers which resulted in a further 2,600 sub-orders being placed with about 300 suppliers, necessitating over 3,800 visits to manufacturers' works throughout the United Kingdom, Western Germany and Sweden for inspection during manufacture, for progressing, and, in some cases, to discuss designs where visits were considered quicker than having drawings sent to London for approval.

Site Preparation

Prior to embarking on the scheme which established the present oxygen steelmaking plant, Consett Iron Co., in contemplation of possible future developments, put in hand preliminary preparation work on the site; this involved the removal of some 900,000 yd3 of material. This preliminary bulk excavation was carried out by M. J. Gleeson, Ltd., during the period May 1956 to January 1957, and by levelling an area which was previously a hillside adjacent to a long-established access road to the main works, a most valuable site was made available north-east of the soaking pits serving the slabbing and blooming mill.

Following the decision to go ahead with the steelmaking plant, further site preparation was carried out south of the previously levelled area between January 1960 and June 1960 on a bulk excavation contract let to Lehane, Mackenzie and Shand during which time approximately 150,000 yd3 of material were removed to reduce the site to 2 ft 6 in below the works railway level.

This produced a total site area of about 22 acres available for building, plus a large area for a works car park.

#### Roads and Drainage

Lehane, Mackenzie and Shand were also entrusted with

the work of laying drainage for the site and constructing permanent roads and car parks to a total area of 21,700 yd2 of road surface together with 3,600 yd of underground ducts for road lighting cables and incoming power cables. Permanent roads were constructed at an early stage in the construction programme because these were not only to be used for construction purposes, but also to replace the existing access road and carry increased road traffic between Consett's fabrication department, boiler shops, fitting shops and central stores when these departments had to be isolated from the works' railway system during part of the construction of the new plant. The main road is 26 ft wide, and the minor road to the workshops area is 16 ft wide.

#### Railways

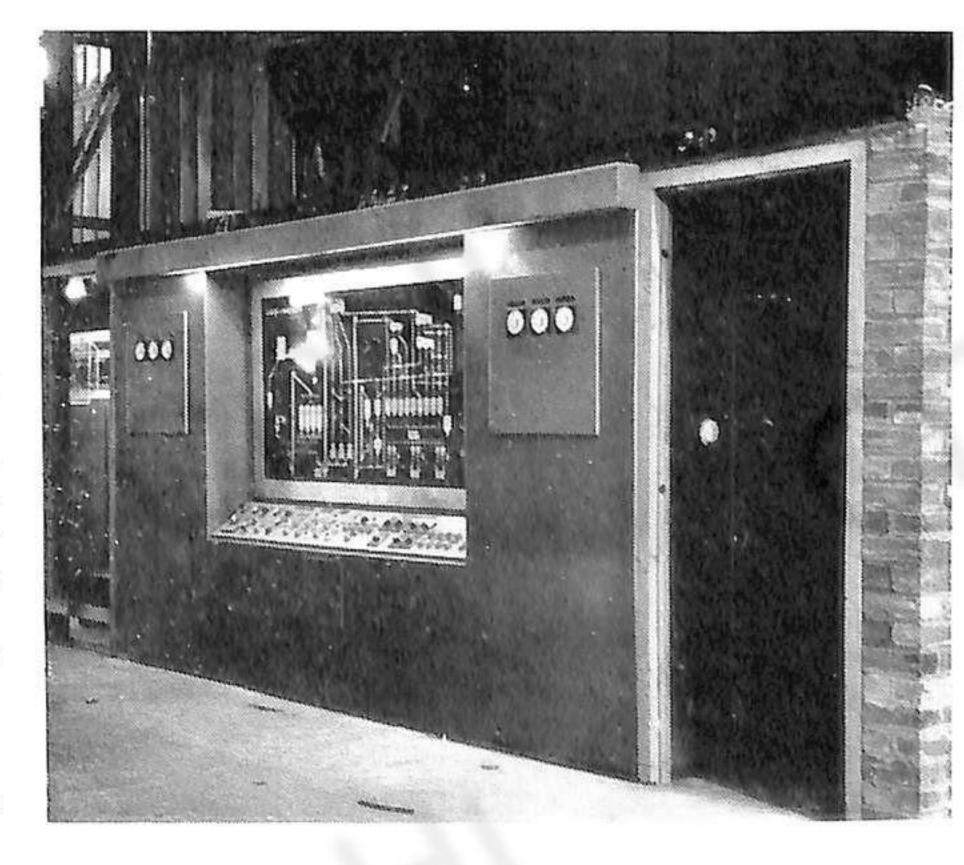
Approximately 3,500 yd of standard gauge trackwork, together with 50 turnouts and crossings, were laid by T. W. Ward, Ltd. Outside the main buildings the tracks consist of 95 lb/yd bull head rails with cast iron chairs and oak keys laid on timber sleepers except at road crossings and over the ground reception hoppers where flat bottom rails are used.

Bull head rails are also used within the main building but here steel sleepers and steel spring keys are employed instead of timber.

#### **Foundations**

A contract for the design and construction of foundations for buildings and plant was placed with Sir Robert McAlpine and Sons, Ltd., and work commenced during August 1960 and continued until February 1963 on the main contract. The approximate quantities involved were

Main panel controlling equipment in the classifying building

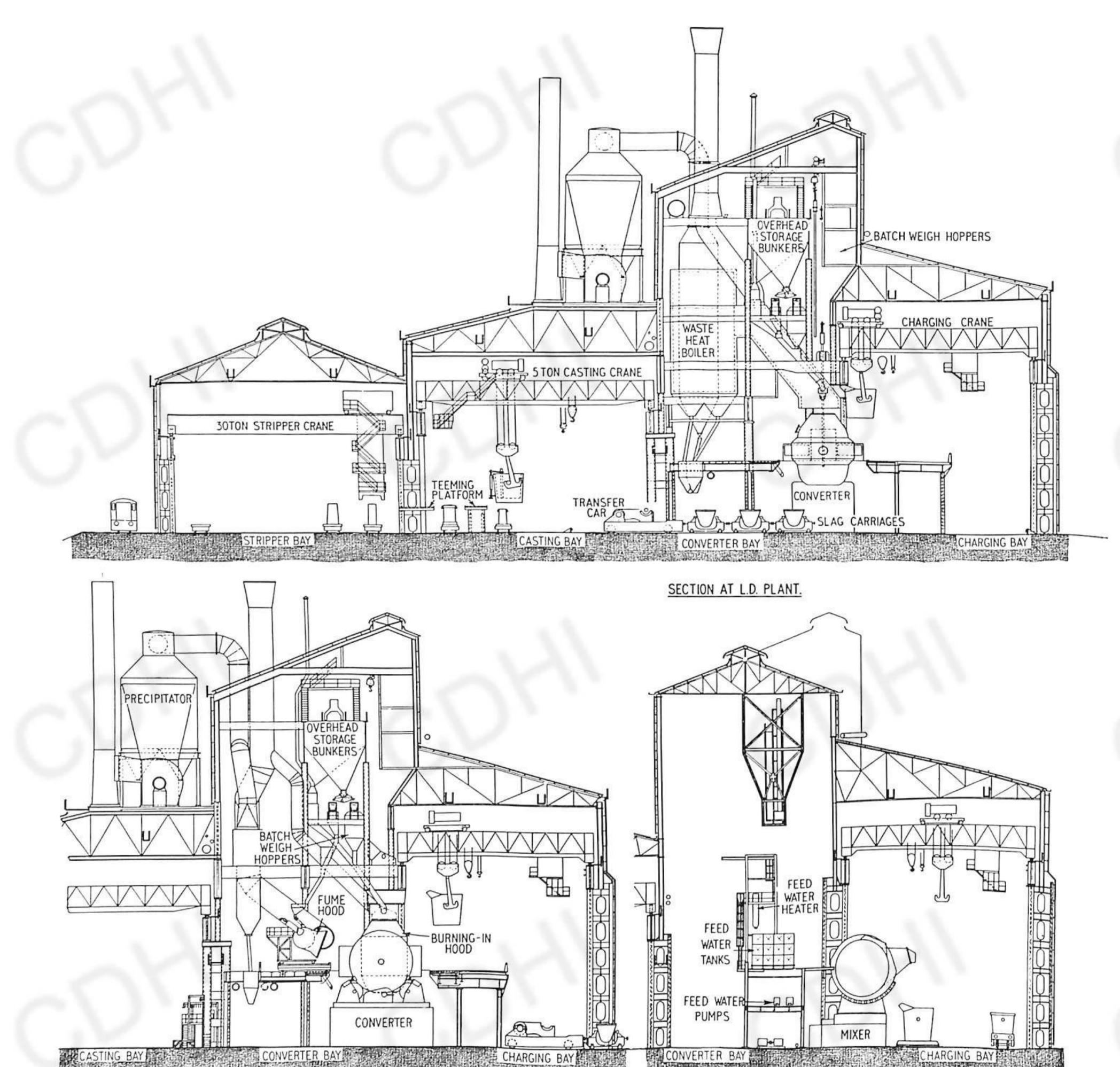


as follows: excavation—93,000 yd³, of which 53,000 yd³ was in rock; concrete—38,000 yd³, of which approximately 28,000 yd³ was in deep foundations—all reinforced except for 8,000 yd³ of mass concrete; reinforcement—1,450 tons; and H.D. bolts—4,800 of various sizes.

These quantities include for the LD and Kaldo foundations, which were constructed by Sir Robert McAlpine and Sons, Ltd., but the design of the converter foundations was

included in the main plant contract with Head Wrightson Iron and Steel Works Engineering, Ltd.

Most of the main foundations were placed in ground not previously built on by Consett and little difficulty was experienced in founding these on rock. Towards the south end of the site, however, old foundations were encountered where the new ground reception hoppers coincided with the previous site of the old Consett angle mills and excavation



SECTION AT KALDO PLANT.

SECTION AT MIXER PLANT.

Cross sections at LD, Kaldo and Mixer Plants

in this area was rather more difficult. Old coal-mine workings were known to exist on the site, but with the help of old mine survey drawings and assistance from a local mining engineer the positions of the old workings were soon established and avoided wherever possible.

As an added precaution against possible tunnels under main foundations, each main foundation was excavated to rock and then cores were taken to a further depth of at least 15 ft to ascertain the soundness of the rock. The cores were taken below each main foundation, approximately one at each corner and one at the centre, and the 15 ft depth of the cores exceeded the expected depth of coal workings in the area.

Conventional tests and checks of concrete quality were maintained throughout the job and in addition, on important items such as the main column bases, cores were taken from the actual bases.

#### Structural Engineering

A contract for the design, supply and erection of the main steel plant building was placed with Wright Anderson and Co., Ltd. and in addition, the fabrication department of Consett also supplied and erected various structures, including the building over the ground reception hoppers, which measures 220 ft long×50 ft span×24 ft to the eaves. External cladding of the main building, hopper building and dolomite plant building consists of 20 gauge Scandinavian tile on vertical faces, except for spandrel sides at high levels on the main building where 24 gauge slate black *Galbestos* box rib sheets are used; for roof coverings, 20 gauge slate black *Galbestos* corrugated sheeting is employed.

The main steel plant building covers an area of 268,425 ft<sup>2</sup> and includes 18,000 tons of structural steelwork to provide the following:

Charging Bay—735 ft long×72 ft crane span; crane track 70 ft above floor level.

Converter Bay—735 ft long×75 ft wide; six platform levels, the highest at 146 ft 6 in above floor level.

Casting Bay—810 ft long×87 ft crane span; crane track 50 ft above floor level and flat roof at 93 ft above floor level to support and give access to precipitators.

Stripper Bay—810 ft long×87 ft crane span; crane track 40 ft above floor level to line up with existing soaking pit building.

Main platforms in the converter bay are arranged as follows: charging floor — 28 ft 9 in above floor level, 39,800 ft<sup>2</sup>; alloys floor — 55 ft above floor level, 9,200 ft<sup>2</sup>; boiler control floor—69 ft 6 in above floor level, 21,600 ft<sup>2</sup>; conveyor floor — 86 ft 9 in above floor level, 13,700 ft<sup>2</sup>; conveyor floor—86 ft 9 in above floor level, 14,600 ft<sup>2</sup>.

The first two platforms are constructed of Supergrip plate, rolled by Consett, and are designed for a superimposed loading of 5 cwt/ft<sup>2</sup>.

The other three platforms are generally of open type grid construction except inside control houses, valve stations and over bunkers where *Supergrip* plate is used. These floors were designed for a superimposed load of 1.5 cwt/ft² plus local loads from equipment.

The nature of the plant necessitated much of the equipment being situated at various elevations above ground level and, in addition to the flat roof and main platform areas previously mentioned, a further 36,500 ft<sup>2</sup> of access platforms were arranged to serve cranes and lance equipment, etc.

In general, structural units such as columns and girders are of welded construction with site-bolted connections, except certain bracing connections which were riveted or welded. Notch ductile steel was used in some members such as the bottom flanges of crane girders, and in several site-bolted connections high strength friction-grip bolts were used. Problems of heavy load concentrations had to be solved by the structural designers and erection problems due to the weight of several large and heavy units also occurred where items such as 75 ft long girders weighing 55 tons had to be erected 125 ft 6 in above ground level. Ventilation of the main building is by Colt power-operated louvres built into the roof sheeting; no doors are fitted at ground level and no insulation is employed in the building cladding.

#### Cranes

The steel plant cranes operate on an electric supply of 500 volts d.c. and are allocated as follows: two 160/40/5 ton ladle cranes and one 400/10 ton crane, for scrap loading and charging, in the charging bay; two 160/40/5 ton ladle cranes and one 40/10 ton crane, for general purposes, in the casting bay; and two 200/45/30 ton stripper cranes in the stripper bay.

The four ladle cranes were supplied and erected by the Wellman Smith Owen Engineering Cpn., Ltd., and are of the four girder type with two trolleys per crane. The main trolley girders are of single web plate construction and each main girder is provided with a lattice-braced auxiliary girder. The auxiliary trolley girders are of double web plate construction. High level drivers' cabins, complete with heat insulation and air conditioning, are provided and whereas the casting bay cranes have their cabins fixed at one end of the crane, those in the charging bay can traverse across the bay independent of the trolley movements.

The two 40/10 magnet cranes were supplied and erected by Clyde Crane and Booth, Ltd., and these are of two hoist, single trolley design, with girders of lattice construction and fixed air conditioned drivers' cabins arranged at mid span.

Adamson Alliance Co., Ltd., supplied and erected the two 200/45/30 ton combined stripper and extractor cranes; the bridges of these are formed of double main beams of double plate box section type girders. Tong opening and closing is pneumatically powered. Controls for the strippers are housed in air conditioned drivers' cabins fixed to mast structures, which traverse across the bay suspended from the trolley. At present, only one stripper is fitted with a 30 ton auxiliary hoist complete with magnet reeling and control gear.

Crane rails in the charging and castings bays consist of 6 in square blooms seated directly on the top flange of the crane girders, but for the stripper bay 4 in wide 175 lb/yd rails are used to match with the existing soaking pit building which forms a continuation of the stripper bay.

#### Process Units

The main steel production units were supplied and erected by Head Wrightson Iron and Steel Works Engineering, Ltd., and their associated companies, and consist of the following:

LD Installation Two LD converters, each of 100 tons nominal capacity; two waste heat boilers equipped with auxiliary heavy fuel oil firing, each boiler designed to raise a continuous flow of 174,000 lb of steam per hour, and controls arranged to vary the steam flow to suit the power

station requirements. Waste gases from each boiler are conditioned in vertical moisture spray towers and finally cleaned in dry plate electrostatic precipitators.

KALDO INSTALLATION Two Kaldo converters, each of 120 tons nominal capacity, two fume hoods and lance carriages, and two water spray boxes for cooling and conditioning the waste gases; a single dry plate electrostatic precipitator permits any one Kaldo to operate at one time.

Lance operating and instrument equipment, control and contactor gear and electric drives complete the converter installations, with controls arranged for the vessels and lances in operating pulpits on the charging floor at each vessel. Control panels for the two boilers are located in one room between the two boilers on the 69 ft 6 in level floor and each precipitator has a separate control house.

MIXERS Two Head Wrightson inactive hot metal mixers, each of 1,000 tons capacity, are located at the LD converter end of the charging bay. One of these was purchased new for this plant and the other was transferred from the existing open hearth shop and renovated. The old mixer is of riveted construction and the new mixer has a welded shell. Both have electric drives through gearing to a final rack and pinion tilting motion and they are equipped with coke oven gas burners for heating.

Henry Pooley & Sons, Ltd., supplied and installed a 200 tons capacity hot metal ladle weighbridge at floor level under the pouring spout of each mixer; dial indicators and ticket printing equipment are situated at charging floor level.

Four steel ladle transfer cars were supplied by Distington Engineering Co., Ltd., each self propelled and controlled remotely from the vessel operating platform. The car frames are of heavy fabricated mild steel construction to form two side members, each of box section, which house

Ladles Incoming hot metal arrives by rail from the blast furnaces in existing 68 tons capacity ladles which previously served the open hearth shop, and as these ladles have to be handled in the same bay as larger charging ladles of 125 tons capacity, arrangements were made for

alternative positions of the ladle crane hooks, to suit ladle trunnion centres of 11 ft 2 in and 14 ft, and trunnion diameters of  $10\frac{1}{2}$  in and 14 in. In addition, Consett also made arrangements to re-erect a redundant 100 ton ladle crane from their obsolete Bessemer plant and positioned this over the mixers solely for use in handling 68 ton ladles. The new 125 ton ladles were purchased from Head Wrightson and steel casting ladles, of 120 tons capacity when filled to within 12 in of the top, were supplied by B. Thornton, Ltd. Both charging and casting ladles are generally of welded construction with renewable items bolted on. Cast steel trunnions were chosen and these are riveted to the ladle shells. The charging ladles are fitted with a large spout on one side to assist in charging the vessels, and the casting ladles are fitted with single stopper gear for bottom pouring.

CARRIAGES Slag from the vessels is transported in conventional slag pots on carriages which were existing in the works, and these can be positioned to receive slag, either by a works locomotive, or by attachment through a power operated coupler to the steel ladle transfer cars, which operate on tracks running under the vessels from the charging bay, through the converter bay and into the casting bay.

Four steel ladle transfer cars were supplied by Distington Engineering Co., Ltd., each self propelled and controlled remotely from the vessel operating platform. The car frames are of heavy fabricated mild steel construction to form two side members, each of box section, which house the four track wheels. End cross members welded to the side frames form a compartment at each end of the car to house the main drive at one end and hydraulic equipment at the other. Hydraulic power is available through a system of dual hydraulic cylinders and cast steel bell crank

levers to raise and lower the 120 ton steel casting ladle through a height of 7 ft to minimize ladle bottom wear due to the height from which steel is poured from the vessels. The drive is from a mill type motor through enclosed gear reduction units to pinions and spur rings on two of the track wheels. Power supply and control cables for the drive, hydraulic pump unit and coupler, are via an overhead multicore cable suitably protected from heat and reeved about a set of compensating pulleys arranged in a tower at one side of the 13 ft 2 in gauge track.

A Distington electro-hydraulic jack car was also provided to fit and remove the bottom plates of the converters. This car is not self-propelled but operates on the standard gauge slag track under the vessels and was designed to lift and lower a bottom plate with refractory, weighing a total of 25 tons, by the action of a hydraulic cylinder. A second hydraulic cylinder operates the access platform, but a single pump is used for both cylinders. Each cylinder can be separately controlled from the access platform and electric supply is via a flexible cable with plug connection. A general practice has developed of leaving the bottom on the vessel during lining breaking and re-lining periods and because of this the hydraulic jack car is usually now used only for checking the fixings of the bottom to the vessel.

Ingot casting cars which were previously used in the open hearth shop were transferred to the oxygen steel plant and these are of four wheel type developed by Consett themselves to carry four, two or one moulds of nine different sizes ranging from 3 tons 17 cwt to 23 tons. At present 8 to 10% of ingots cast are bottom poured and all teeming is done with the casting ladles suspended from the ladle cranes. Three batteries of teeming tracks are available, arranged longitudinally down the bay in double bank fashion, with access for teeming from 17,500 ft<sup>2</sup> of teem-

ing platforms supplied and erected by the fabrication department of Consett.

#### Materials Handling Plant

The contract for the supply and erection of the materials handling plant was placed with Moxey, Ltd.

Graded materials, which can be broadly described as oxides and fluxing materials, can be discharged from road or rail trucks into a battery of 16 ground reception and storage hoppers. These are arranged in two rows of eight, and can be discharged separately, as selected and controlled from the steel plant building via Moxey Schenck vibrating feeders on the hopper outlets, to a horizontal conveyor which is 36 in wide. The tops of the hoppers, situated at ground level, are covered with steel grids and the hoppers themselves are of mild steel construction. Hoppers intended for the more abrasive materials are *Gunite* lined and coke oven gas heating on the underside of the hopper plates is available to prevent hydration of dry materials.

The previously mentioned hopper pit building, fitted with sliding doors, excludes the weather from the hoppers, and the steel hoppers are enclosed in a reinforced concrete pit 198 ft long by 32 ft wide by 31 ft deep, with access stairs and maintenance hatch at one end, and an inclined access ramp at the other end which also forms an outgoing conveyor tunnel.

At the lower end of the conveyor tunnel, material is transferred from the horizontal belt on to a 30 in wide inclined belt which rises 168 ft before transferring to a 30 in wide horizontal conveyer which is fitted with two hand-operated belt-propelled trippers on the 125 ft 6 in level in the steel plant building.

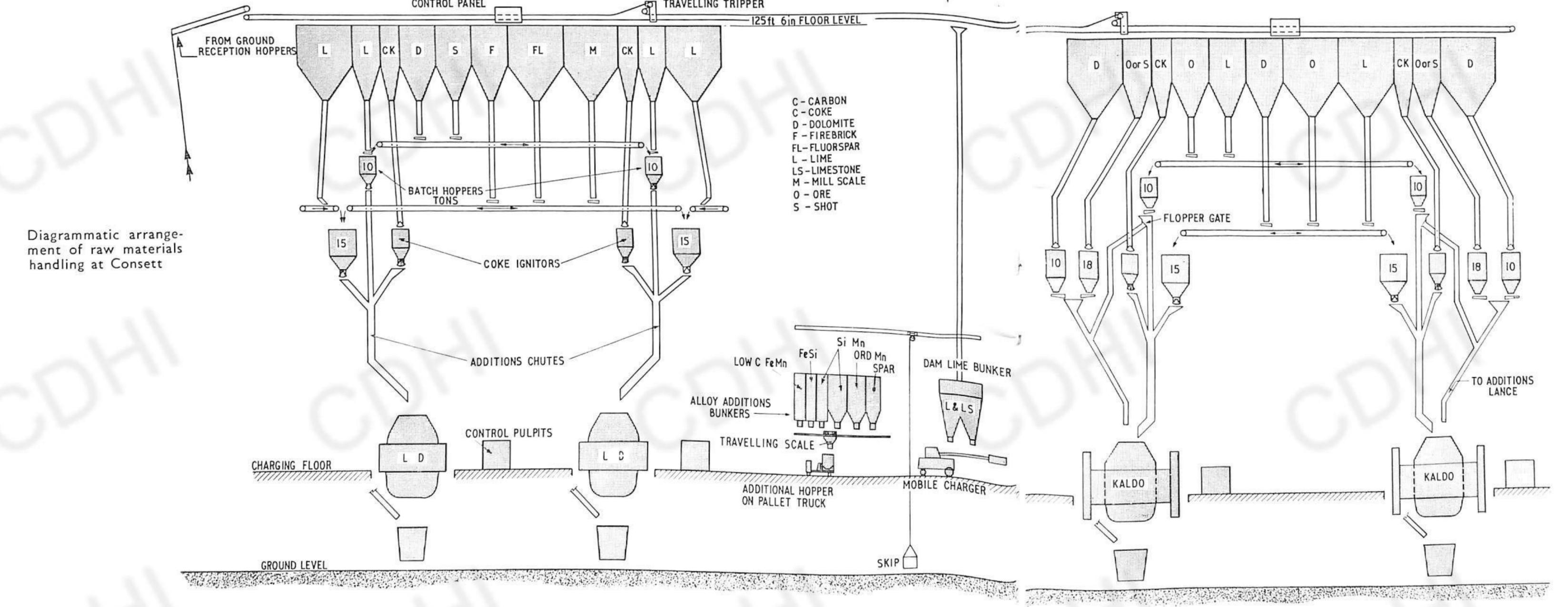
The three previously mentioned conveyors were designed to handle 620 tons of iron ore per hour, and although each material must be conveyed separately, 24 hours' supply of incoming materials can be discharged, conveyed and distributed to daily storage bunkers at the top of the steel plant building in one day shift employing two men.

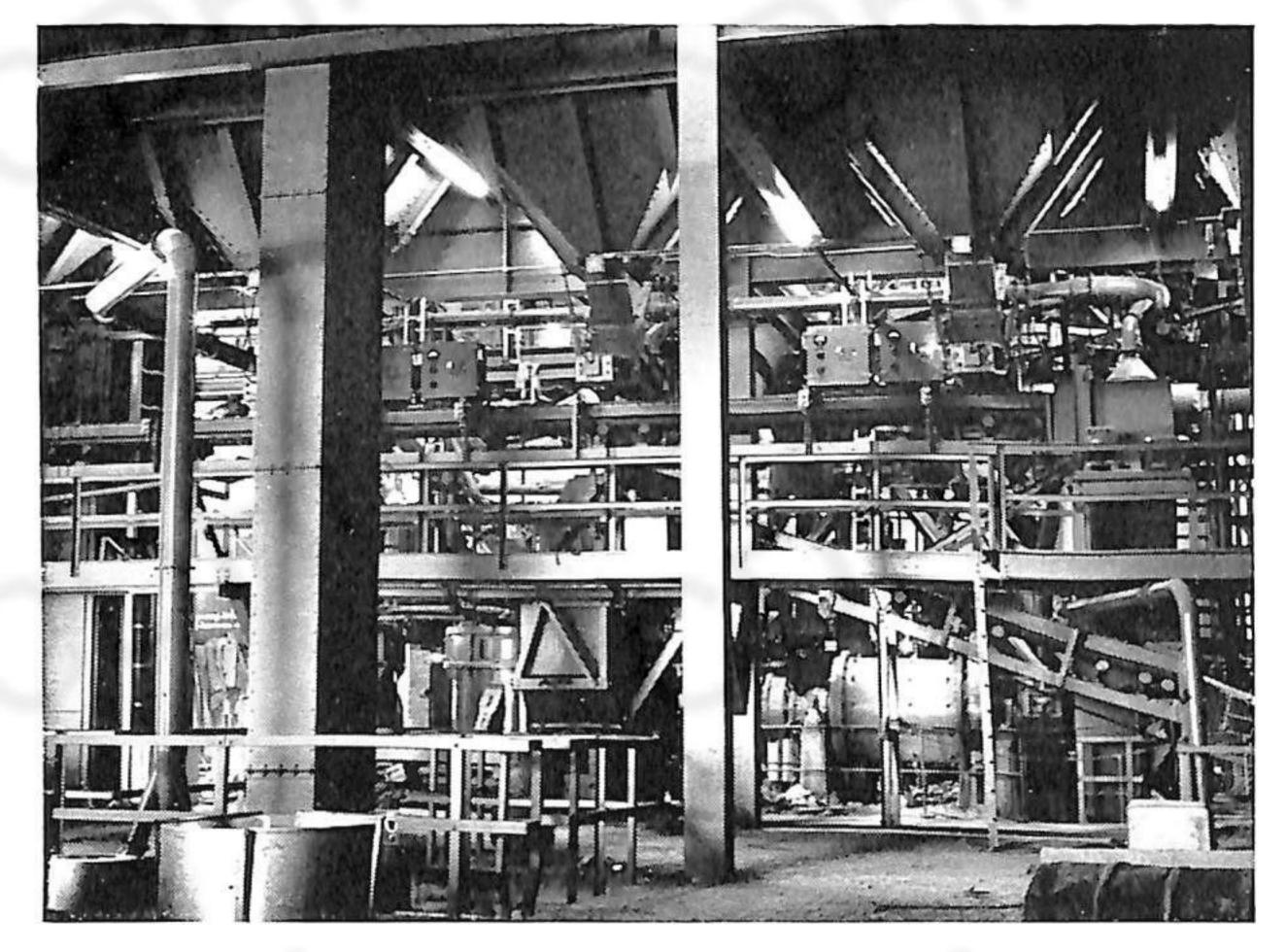
The daily storage bunkers at the 125 ft 6 in level were supplied with the main steel plant building and are constructed of mild steel. They are arranged in two sets, one set over the LD converters and the other over the Kaldo converters. One of the travelling trippers charges each set of bunkers and filling slots at each side of the conveyors are closed with rubber sealing belts.

Each set of overhead bunkers consists of eleven bunkers and of these the first three serve one vessel and the last three the other vessel of a pair. Five bunkers in the centre can serve either vessel of a pair so that eight overhead daily storage bunkers are available to serve one vessel.

Control of materials from the overhead bunkers to the vessels is arranged from the vessel operating pulpits where mimic diagrams assist in the selection of material and route. From the overhead bunkers, handling of materials is by vibrating feeders, belt conveyors and power operated gates to weigh hoppers located above each vessel. Elliott load cell weighing is provided on the weigh hoppers with indicators arranged in the vessel control pulpits, and the feed of any material to the weigh hoppers was based on 60 tons of ore per hour and 90 tons of burnt lime per hour. Above each LD vessel, two weigh hoppers are arranged, one of 10 tons capacity and one of 15 tons capacity. Both hoppers discharge via power operated gates to a common additions chute leading to the LD vessel, and this chute also takes coke, cold or incandescent, from the coke igniter.

A coke igniter equipped with coke oven gas ignition





Classifying building showing storage bunkers vibrating feeders and main conveyor; the ball mill and cone crushers are in the background. Material from the ground hoppers and primary crusher is received on the elevator in the foreground for delivery to the storage bunkers via a shuttle conveyor

pokers, smoke chimney to atmosphere, and hand operated discharge gate, is provided at each vessel for burning-in a newly laid lining with oxygen, but the general method has been to use coke and oxygen for the LD vessels only; a coke oven gas burner, with combustion air and oxygen enrichment, has been preferred for the Kaldo linings.

Above each Kaldo vessel, four weigh hoppers are arranged, two of 10 tons capacity, one of 15 tons capacity and one of 18 tons capacity. One 10 ton weigh hopper and the 18 ton weigh hopper are fed direct from the overhead bunkers via power-operated gates. Vibrating feeders on these two weigh hopper outlets lead to an additions lance which is supplied with compressed air to permit additions to be made while the Kaldo is rotating. The other 10 ton weigh hopper and the 15 ton weigh hopper are fed by conveyor from overhead bunkers equipped with vibrating feeders, but whereas this 10 ton weigh hopper can discharge via a vibrating feeder to either the additions lance or to the additions chute, the 15 ton weigh hopper is fitted with a power-operated gate on the outlet which feeds to the additions chute only. As in the case of the LD installation, the Kaldo additions chute also collects from the coke igniter and permits additions to be made while the vessel is vertically upright.

Lump lime and limestone, for use in forming a dam in the Kaldo vessels, arrives in a separate bunker via the tripper and a chute; hand-operated gates on the outlet of the dam line bunker discharge into \(^3\_4\) ton capacity boxes for charging by a mobile charger which was supplied by Blaw Knox Ltd.

Six elevated alloy additions bunkers are located between the LD and Kaldo installations, and these are normally filled from containers by a travelling hoist on an overhead runway, but containers brought up to the 55 ft level can also be charged by fork lift truck if desired. Hand-operated gates on the outlets of these bunkers discharge to a travelling weigh hopper, supplied by Howe Richardson Scale Co., Ltd., which fills alloy containers on the charging floor. The alloy containers are then transported by pallet truck to positions at the vessels where additions can be made to the ladles.

#### Ancillary Equipment and Services

Prior to wrecking the spent lining of a converter, cooling air is blown in by a Woods portable fan which is placed on the operating platform by overhead crane, and for lining wrecking an Ingersoll-Rand compressed air operated mobile lining breaker is used.

The vessels are relined in the vertically upright position with materials and men entering from the top by means of a portable relining rig supplied by Moxey, Ltd. The rig can be placed at any vessel by overhead crane and consists of an "A" frame which stands on the charging floor with an overhead runway beam cantilevered over the top of the vessel. A motorized hoist on the runway beam handles pallets of materials in a cage from the charging floor up, along and down into the vessel. When in use, the rig is pinned to the overhead crane girder for stability and from the structure of the rig a circular platform in sections is suspended by chains inside the vessel as a working platform. Raising and lowering of the working platform is managed by the motorized hoist, and catches on the platform engage with links on the suspension chains to hold the platform at the required height. Various platform diameters to suit the lining profile are available by telescoping platform members and different platform decking segments. The rig, complete with access stairways and platforms is portable and served with power through flexible cables with plug connections at each vessel.

In a separate building, built by Leslie & Co., Ltd., adequate equipment, operating in an air conditioned atmosphere, is available to give quick analysis of steel and iron samples, which are conveyed to and from six stations in the steel plant by carrier in a pneumatic tube system installed by Lamson Engineering, Ltd.

Hand-written communication between the spectograph laboratory and the vessel operating pulpits is by "Creed" transmission and tape recorders and general communication is by AEI internal telephones and Tannoy crane to ground equipment.

Nine stations are provided for ladle drying in the casting bay and one in the charging bay, with coke over gas as the heating medium in gas burners suspended from jib cranes adjacent to the main column row.

Stopper rods are dried in an infra-red oven supplied by Claudgen, Ltd., which is served by an overhead chain conveyor and hoisting block.

Scrap charging to the vessels is accomplished by overhead crane and 20 tons capacity scrap charging boxes, weighed on a Pooley weighbridge which was transferred from the old open hearth shop and is now installed at the Kaldo end of the charging bay.

A passenger and service lift of 5 tons capacity serves the six floor levels at the LD end of the converter bay.

Cooling water for the plant is served by a recirculating system which includes a Davenport natural draught reinforced concrete cooling tower, and pumping capacity available, including standby units of Harland manufacture, totals over 13,000 gal/min.

Heavy fuel oil delivered by rail tankers for use as auxiliary fuel for the waste heat boilers is heated, discharged and stored at a point approximately 1,000 yd from the steel plant, and delivery to the steel plant is via a single steel Spiracon pipeline, steam traced for temperature control, and designed to deliver 3,000 gal/hr of oil with a viscosity of 3,500 seconds Redwood No. 1 at 100°F with one pump running. Two unloading pumps and two delivery pumps, supplied by Plenty & Sons, Ltd., are available at the oil unloading and storage station. At the steel plant, the supply pipeline delivers to a daily storage tank which is heated and equipped with oil level equipment; this tank serves oil heating and pumping units included in the waste heat boiler equipment.

Steam from the waste heat boilers is supplied to the works power station over a distance of 500 yd by two 16 in o.d. steam mains which were sized to cater for future boilers and to provide a standby main with crossover facilities. Supplied by Stewarts and Lloyds, Ltd., the steam mains were designed for a working steam pressure of 450 lb/in², and a temperature of 775°F. Pass-out steam from the turbines is condensed and returned to the waste heat boilers with make-up water via an 8 in feed water pipeline.

Arrangements within the existing power station to distribute incoming steam and to pump and treat outgoing feedwater were made by Parolle Electrical Plant Co., Ltd.

General compressed air is provided at 100 lb/in² from two Ingersoll Rand compressors each capable of 1437 ft³/min; for instrumentation purposes a separate system is available.

Coke oven gas from the existing works system was piped approximately 500 yd to serve the mixers, ladle driers, coke igniters and pilot flames for the boiler oil burners. The dolomite plant is supplied with mixed blast furnace and coke oven gas from a gas mixing station situated 850 yd away.

Oxygen is supplied from three British Oxygen tonnage plants each with a capacity of 100 tons of high purity oxygen per day. The first plant was installed in 1957 to serve the open hearth furnaces and it is of the Rescol type. The other two plants are of the Tonnox I.C. type and were installed to serve the LD and Kaldo converters. Up to 30% of the capacity of the Rescol plant can be produced as liquid oxygen for storage, and the Tonnox I.C. plants produce up to 10% of capacity as liquid.

Liquid oxygen storage on the British Oxygen site consists of two tanks, each with equivalent oxygen gas capacity of 3,000,000 ft<sup>3</sup>, which were installed in 1957, and one tank of 15,000,000 ft<sup>3</sup> equivalent gas capacity installed with the second two plants, to make the total storage of liquid oxygen available equivalent to 21,000,000 ft<sup>3</sup> of gaseous oxygen, or nearly 800 tons, which can be made available to the steelworks during periods when the tonnage plants are shut down for maintenance.

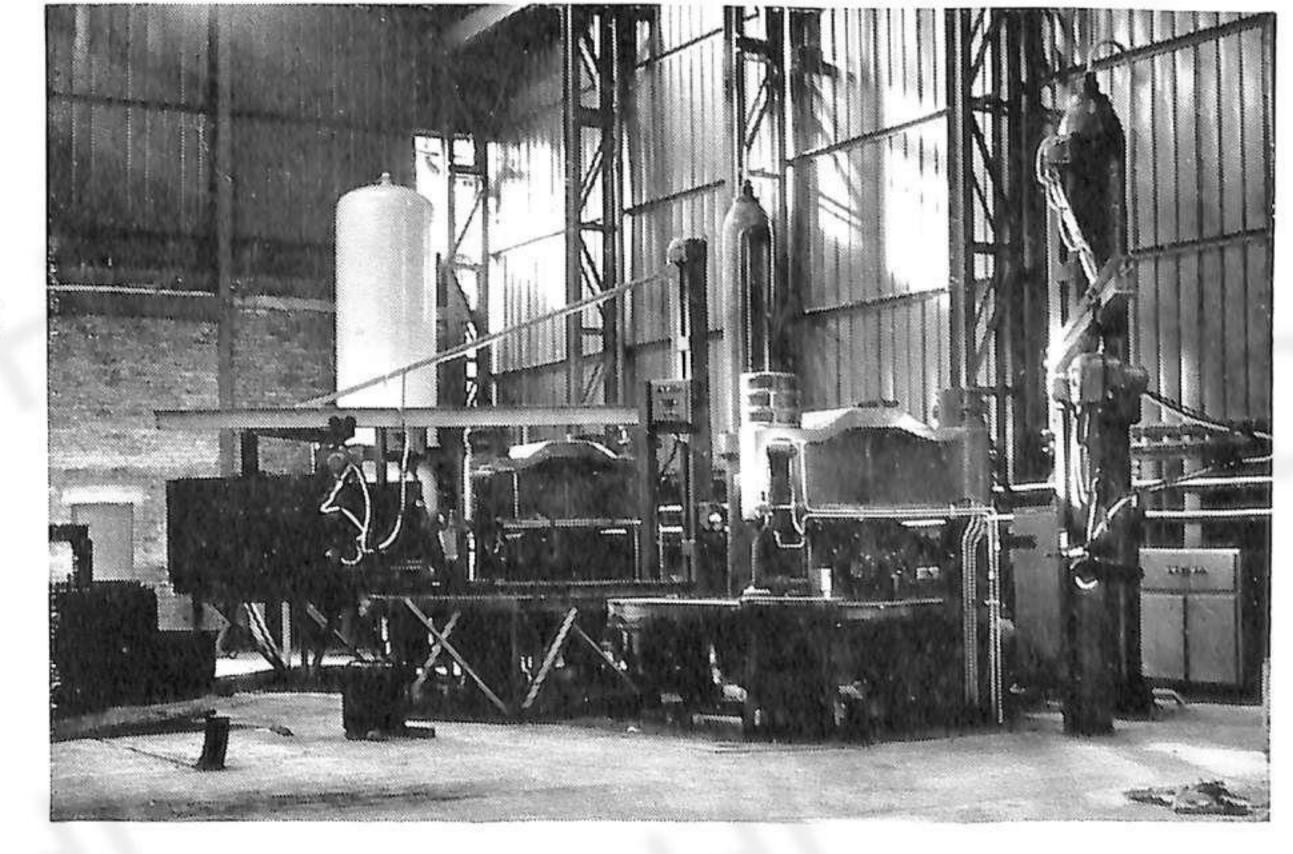
Gaseous oxygen leaving the oxygen plant is controlled for flow and pressure and metered before entering two high pressure pipelines, one to the open hearth shop and the other to a distribution centre for the oxygen steel plant. There are four high pressure gaseous oxygen vessels at the old works and eight at the new, and each vessel can release about 40,000 ft<sup>3</sup> of oxygen between its operating pressure limits.

A 24 in diameter steel pipeline carries oxygen at pressures up to 200 lb/in² from the distribution centre to the oxygen steel plant where off-takes connected to copper piping lead through valve stations to control pressure and flow as necessary to each LD and Kaldo converter.

#### Dolomite Plant

A self-contained dolomite blockmaking plant housed in

Dolomite brick presses, hydraulic accumulator and lifting equipment for brick removal



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a separate building is situated adjacent to the oxygen steel plant. The plant is of Moxey/Laeis design and produces tarred dolomite blocks weighing 90 lb each, and 19½ in or 24 in long, at the rate of 700 tons every 10 days, with provision for doubling this rate in the future by a second stage of construction.

Arranged to handle both fresh burnt and black dolomite and magnesite plus tar, the plant is fully integrated and caters for the storage of these materials, and for primary crushing, screening, secondary crushing, classifying, weighing and batching, mixing and pressing.

A gas heating system which circulates the products of combustion from mixed gas fuel serves to maintain tar

hydration of previously burnt dolomite. A dust extraction and collection system arrests dust from the various crushing, screening and handling equipment.

The preparation equipment includes one jaw crusher, five screens, one ball mill and two cone crushers linked by vibrating feeders, belt conveyors, chain elevators and chutes to deliver graded material to nine classifying bins, and one hopper for fettling dolomite. En route, overflows, reject material and tramp iron are taken care of, and flexibility in the choice of available route is maintained by power operated flapper gates.

Material selected from the nine classifying bins is collected by a travelling scale car, which can be manually temperature and heats the classifying bins, etc., to prevent or automatically controlled according to a preselected

- Vibrating feeder
- 2 Primary jaw crusher
- Bucket elevator
- Shuttle conveyor
- 5 Storage—fresh dolomite
- 6 Storage—black dolomite
- Magnetic separator and rectifier
- 8 Screen for hydrated material
- 9 Portable containers
- 10 Hopper-magnesite
- 11 Storage hopper
- 12 Vibrating conveyor
- 13 Electro-pneumatic flapper valves
- 14 Ball mill by-pass
- 15 Ball mill
- 16 Rotary feeder

17 Overflow bin

24 Scale printer

23 Scale car

- 25 Charge hopper
- 26 Pan mill
- 27 Control panel for scale car
- 28 Fettling dolomite bin
- 29 De-airing chimney

18 Vibrating screen

21 Classifying screen

22 Classifying bins

19 Cone crushers

20 Air separator

- 30 Tar boilers
- 31 Tar pumps 32 Tar storage tanks
- 33 Naphthalene tank
- 34 Overflow pit
- 35 Tar tanker

Materials flow diagram for the tar-dolomite plant

programme, for delivery in weighed batches to either of two pan mill mixers. The rolls of the pan mills are pneumatically balanced to maintain the selected grain size during mixing with measured additions of heated tar and the resultant tarred dolomite mix is discharged at floor level for use as ramming or for pressing.

Two 1,200 ton rotary presses complete with hydraulic pumping station and control equipment are available, each capable of 90 to 120 pressing movements per hour. Filling of the press moulds is a manual operation, and although suction pad block lifting equipment was provided, pressed blocks are normally palletized by hand for transporting to the steel plant in containers, by road, rail or fork-lift truck.

#### Substation and Amenity Block

A combined main sub-station, amenity and office block is situated outside the south-east corner of the main steel plant building and consists of the following:

Substation basement of reinforced concrete, constructed by Sir Robert McAlpine & Sons, Ltd., to provide a floor area of 7,650 ft2 with access by stairway and hatchway and connected to entry and exit cable tunnels.

A motor room at ground level provides 7,650 ft2 of floor area plus 10 external bays for transformers and reactors.

Above the motor rooms and transformer bays, 9,000 ft2 of floor area is occupied by workmen's amenity facilities including time office, locker room, showers and toilets, protective clothing store, mess room and attendants' accommodation.

Steel plant offices occupy 4,750 ft<sup>2</sup> on the top floor to provide 11 offices plus storerooms and toilet facilities for management and staff.

The steel frame for the building was supplied and erected by the fabrication department of Consett, and the brickwork together with all internal and external fittings and finishes was constructed by Leslie & Co., Ltd.

#### Cabling and Electrics

A main contract for the supply and installation of cables was placed with Watson Norie, Ltd.; this included incoming feeders, distribution, control cabling and lighting.

Electrical equipment was generally included in the contracts placed with the main plant suppliers and Consett's usual standards maintained wherever possible.

Both 11,000 volt and 3,300 volt switchgear was supplied by A. Reyrolle & Co., Ltd., and C. A. Parsons & Co., Ltd., supplied transformers and reactors. Medium voltage and d.c. switchgear was supplied by Whipp and Bourne, Ltd., with d.c. control gear being obtained from Brookhirst Igranic, Ltd.; a.c. control gear is of Allen West, and Baldwin and Francis manufacture.

Main drive motors for production units, including Ward Leonard sets for Kaldo main drives, are English Electric.

#### Acknowledgment

We are grateful to International Construction Co., Ltd.; and to Mr. S. Cross, resident engineer, in particular, for the information contained in the above article.

# **CONSETT** Developments

# Oxygen Services

By B. W. N. PITTS, \*M.Sc.

The increased use of tonnage oxygen by the Consett Iron Co., Ltd., in the last ten years reflects to a very great extent the rapid change in steelmaking practice in the United Kingdom.

The term "tonnage oxygen" is used to cover the on-site production of gaseous oxygen in substantial quantities—i.e. 50 tons a day upwards. Because of the lower capital cost of the plant and the lower energy requirements, it is more economic to produce oxygen as a gas than as a liquid. This, together with the scale of operation and the reduced distribution costs due to the elimination of road transport, enables "tonnage oxygen" to be made available at the operating site at a substantially lower cost than liquid twelve tons of steel by these oxygen blowing processes, the oxygen.

In 1953, Consett and British Oxygen examined the possibility of using oxygen as a means of burning additional fuel with oxygen, in order to increase the heat input and the melting rate in the furnaces. Trials using liquid oxygen

\* The British Oxygen Company, Ltd.

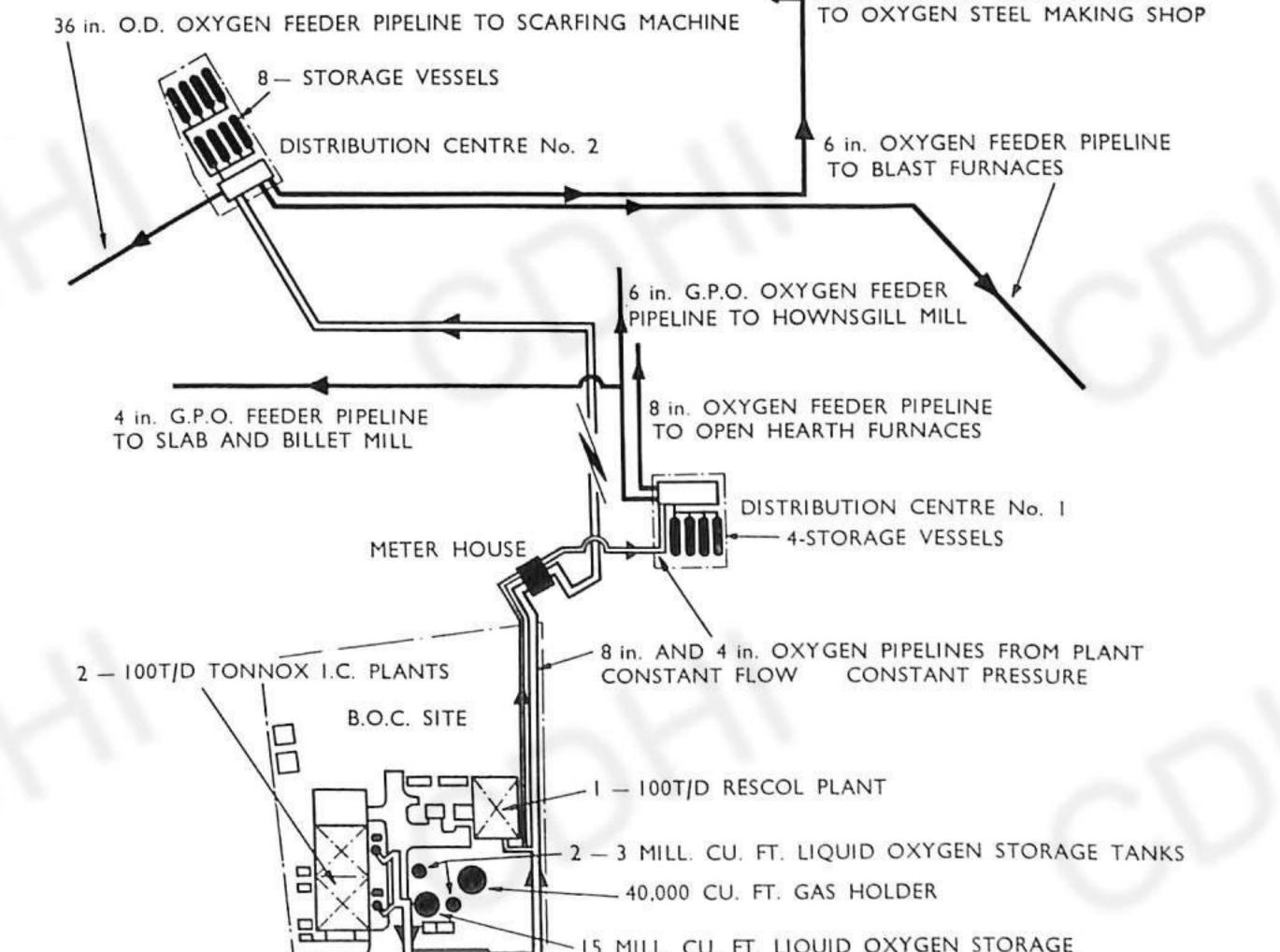
proved remarkably successful and it became clear that Consett's potential oxygen requirements would only be met by a large capacity tonnage oxygen plant installed on site. Consequently, in 1954 arrangements were put in hand by British Oxygen to install a 100-ton-a-day plant on a site adjacent to the steelworks.

Commissioned in 1957, the plant was capable of providing up to approximately 17 million ft<sup>3</sup> of oxygen per week (a ton of oxygen equals approximately 26,000 ft3). This enabled Consett to meet their substantial orders for steel without investment in additional furnace capacity. The bulk of the oxygen was for assisted combustion in the open hearth furnaces. In addition, over two million ft3 per week of oxygen were required for cutting, welding, hand scarfing and general engineering purposes in the works.

Designed by British Oxygen, the 100-ton-a-day Rescol unit has the characteristic of considerable flexibility. It may be operated as a conventional tonnage oxygen plant making all gaseous oxygen or, alternatively, it can produce a smaller quantity of liquid oxygen, or some of each. It can thus function at various levels of demand in order to meet the steelworks requirements.

As approximately one ton of oxygen is required to make new development plan called for substantial increases in oxygen capacity. Early in 1960, B.O.C. made arrangements to install two further 100 ton/day units at their Consett works. These units are of the British Oxygen Tonnox I.C. (internal compression) type which can produce up to approximately 10% of their output as liquid oxygen. Two units of this size, rather than a single 200-ton-a-day plant,

\_\_ 24 in. OXYGEN FEEDER PIPELINE



Distribution network of oxygen from BOC plant to Consett departments



were installed to ensure continuity of oxygen supply — a vital factor in the pneumatic steelmaking processes. As a further "back-up", liquid oxygen storage of 21 million ft³, or 800 tons, was also provided.

Liquid oxygen, although more expensive to produce than gas, is more economic to store. The liquid oxygen in the storage tanks is available to meet the steelworks requirements during the scheduled maintenance periods for the air separation plants and also to provide additional supplies at short notice for periods of unexpected demand.

The engineering of the gaseous oxygen storage and distribution system calls for close liaison between the steelworks and the oxygen supplier. Full advantage of the ability of tonnage plants to produce cheap oxygen can only be taken if they operate without frequent variation in the rate of output. Such fluctuations quickly upset the thermal and dynamic balance within the air separation unit and carry a heavy penalty in the cost of the product. Therefore, in addition to the liquid oxygen storage required to meet the less frequent demand peaks, oxygen has also to be stored as gas to meet short term variations between the steady output of the oxygen plants and the intermittent demand of the steelmaking processes.

As gaseous oxygen is relatively expensive to store, an economic limit is set to the amount of gaseous oxygen storage capacity. Generally speaking, storage capacity must fill and empty at least three or four times each week in order to pay for itself. It is not attractive to install storage vessels to meet demand peaks which occur less frequently than this. In fact, the costs relationship between gaseous oxygen and the storage vessels is such that it is sometimes

British Oxygen Tonnox IC plant, with open hearth melting shop of Consett Iron Co. in background

more economic to let oxygen blow to atmosphere rather than incur the capital charges associated with high pressure storage. Consett's 300 ton/day oxygen scheme will have a gaseous oxygen storage capacity of approximately 500,000 ft<sup>3</sup> of releasable volume, installed in vessels capable of operating between the line pressure of approximately 580 lb/in<sup>2</sup> and the process operating pressure.

B.O.C.'s responsibilities also include the provision of metering and distribution facilities within the steelworks. Oxygen is supplied from the plant at approximately 600 lb/in² and is measured under conditions of constant flow and pressure, thus obtaining the inherent accuracy associated with this method of metering.

Oxygen is delivered under these constant flow conditions to distribution centres where specialized control equipment supplies it at the reduced pressure and high intermittent flow rates demanded by the processes. No. 1 distribution centre was associated with the first 100 ton/day oxygen plant and located adjacent to the open hearth shop. A second distribution centre has now been provided for oxygen supplies for the new steelmaking processes. It can supply oxygen to the oxygen steelmaking plant at instantaneous peak flow rates of up to 2 million ft<sup>3</sup>/hr. These conditions would be met with Kaldo and LD converters blewing simultaneously.

From the distribution centres, complete oxygen feeder pipeline systems take oxygen to the various points of application. Though 90% of Consett's requirements will be for steelmaking processes, substantial amounts of oxygen will also be used for engineering purposes throughout the works, and for the CM-58C hot scarfing machine being installed in the slab mill. This unit is of the latest design and incorporates automatic sizing, so that the scarfing nozzles adjust themselves to the size of any bloom or slab without manual control. Medium size of slabs for this machine is approximately 14 in×21 in. All four sides of the stock are scarfed simultaneously.

The development plans of Consett, now in their concluding stages, will ensure that Consett is well placed to meet the intensive competition which the future will provide

