PROGRESS IN CONSTRUCTION OF CALDER HALL "A" POWER STATION

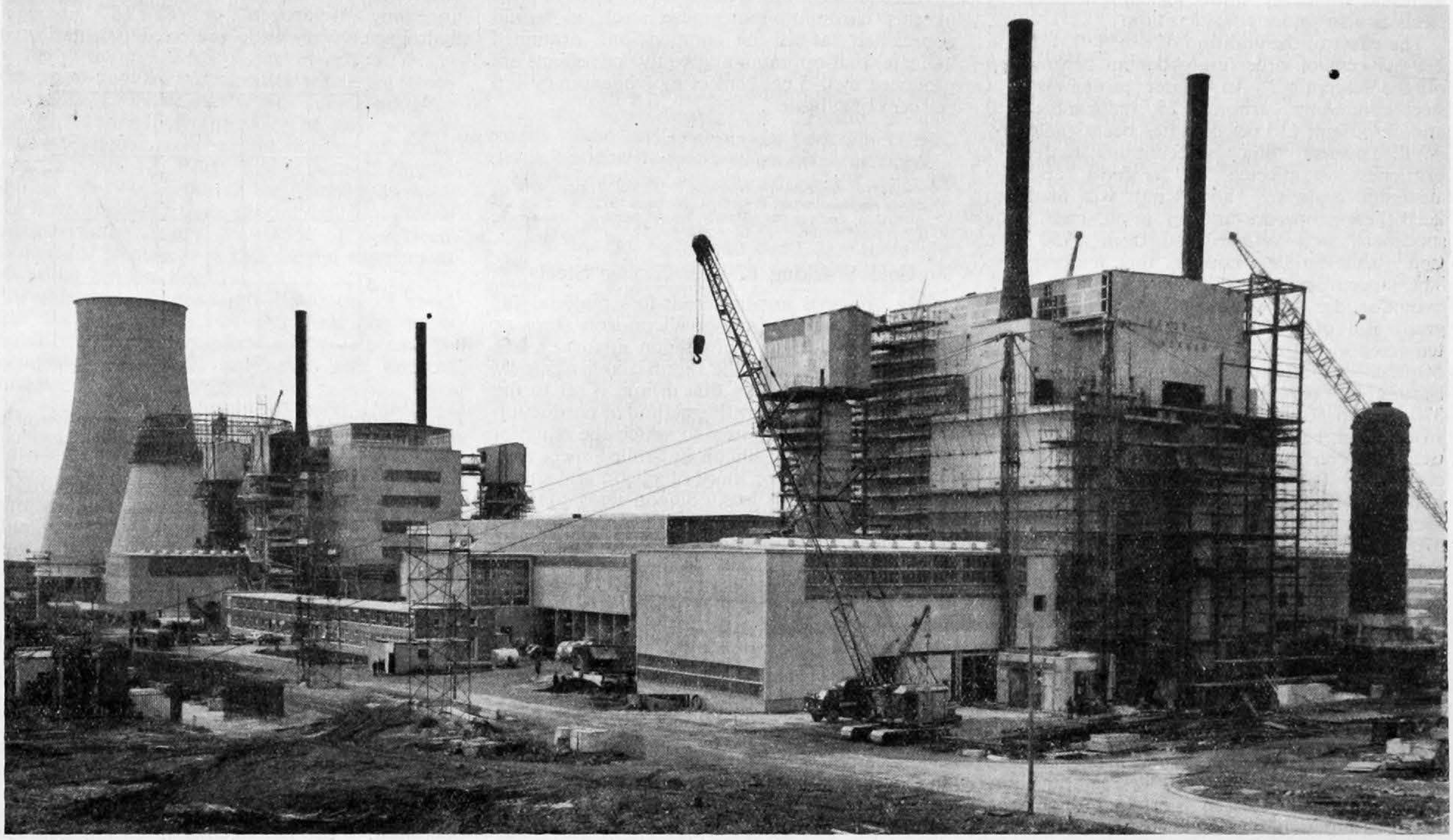
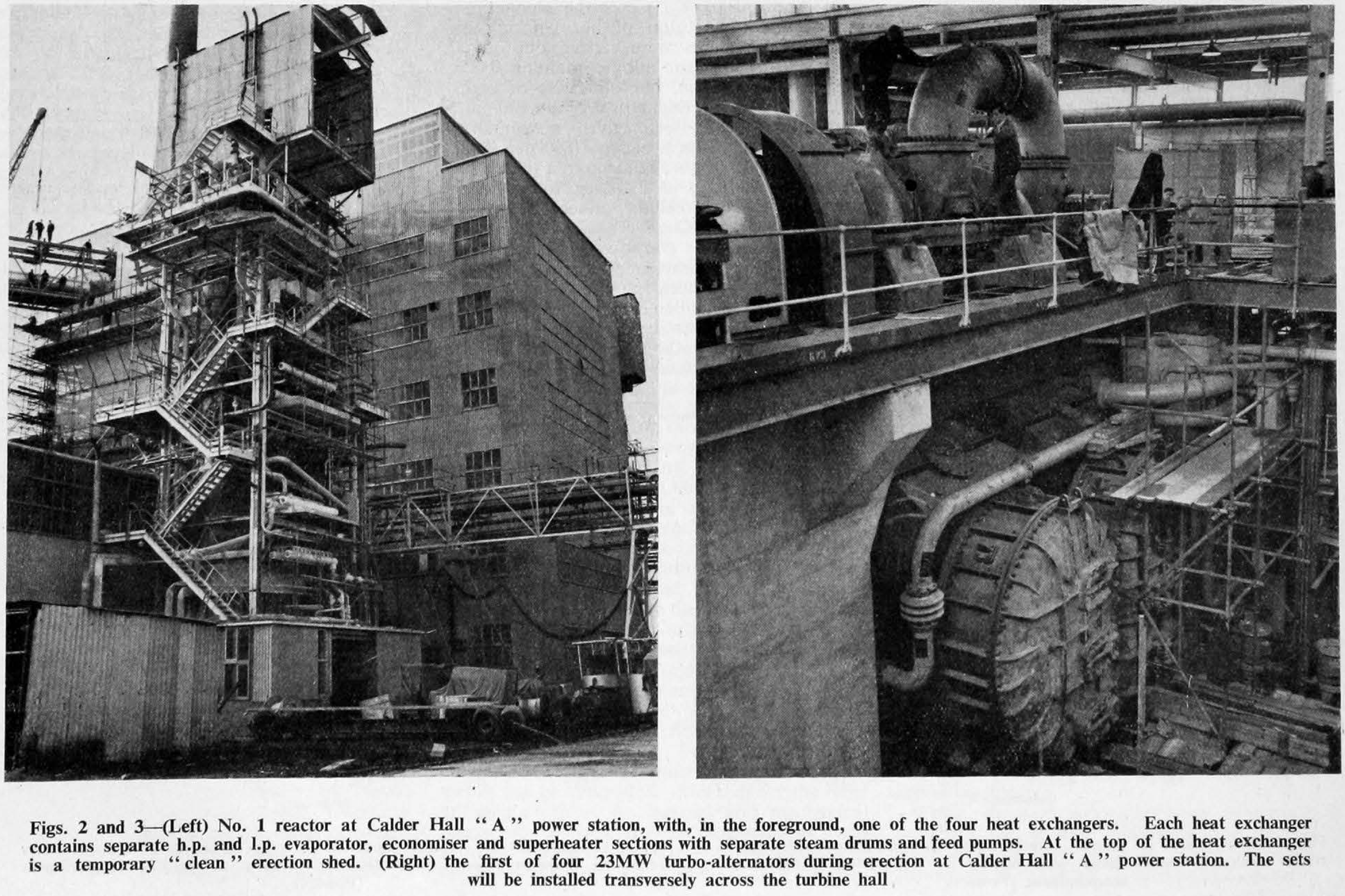


Fig. 1—Calder Hall "A" power station under construction, November 17, 1955. No. 1 reactor, immediately to the right of the cooling towers, is due to produce power by the end of 1956 and No. 2 reactor, on the extreme right, should reach the same stage six months later. Besides producing plutonium the two reactors will provide enough heat to generate steam (in eight heat exchangers) for four 23MW turbo-alternators which are being installed in the turbine hall between the two reactors



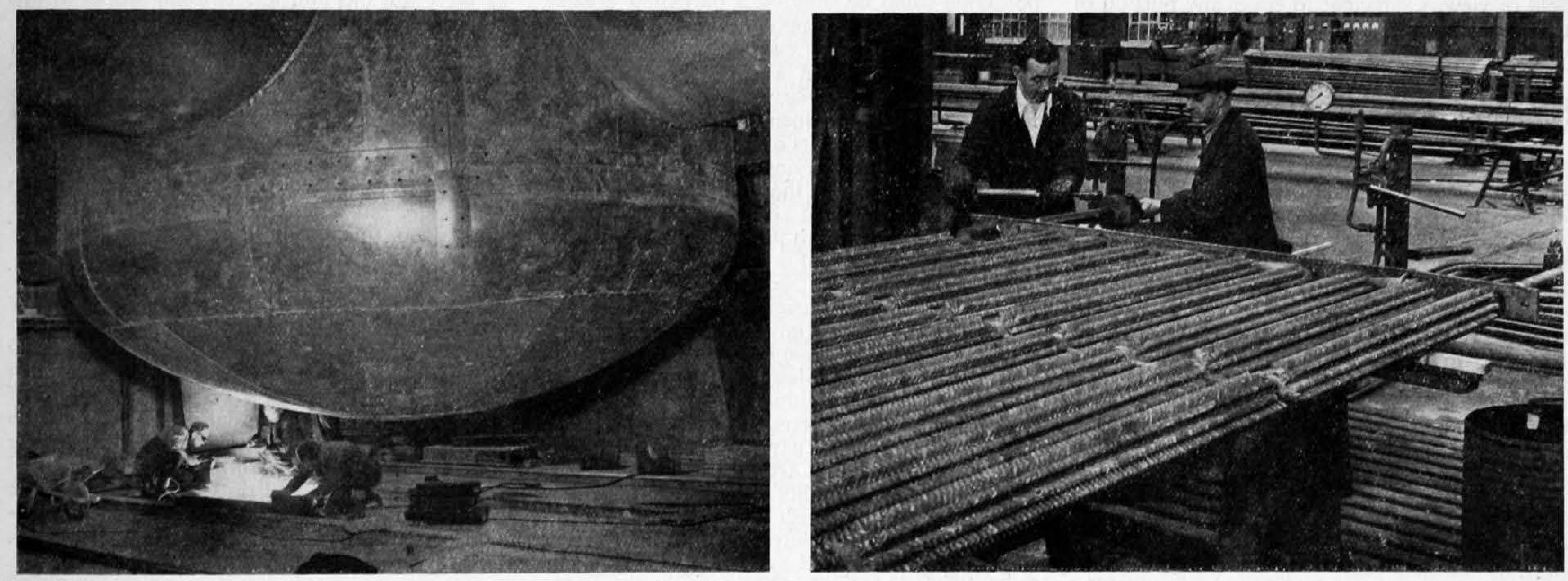
Figs. 2 and 3—(Left) No. 1 reactor at Calder Hall "A" power station, with, in the foreground, one of the four heat exchangers. Each heat exchanger contains separate h.p. and l.p. evaporator, economiser and superheater sections with separate steam drums and feed pumps. At the top of the heat exchanger is a temporary "clean" erection shed. (Right) the first of four 23MW turbo-alternators during erection at Calder Hall "A" power station. The sets will be installed transversely across the turbine hall

Progress at Calder Hall Power Station

The present stage of progress in the construction of Calder Hall power station is illustrated and described in outline here. No. 1 reactor is approaching completion, the graphite matrix having been built up in the pressure vessel ready to receive the uranium fuel elements and control rods. No. 2 reactor is due to reach the same stage in about six months' time ; three of its four heat exchangers are in position. The first turbo-alternator is being erected. Work has started on the second station, Calder Hall " B."

LAST week we visited Calder Hall in Cumberland, to see the progress that has been made in the construction of Britain's first atomic power station, since work on the preparation of the site was started in the spring of 1953. It will be recalled that the engineering design of the station was described in some detail by Sir Christopher Hinton in a paper* presented at the Geneva Conference on the Peaceful Uses of Atomic Energy, last August. In the present article, therefore, we shall attempt to indicate progress of construction rather than to describe the station in any detail.

It should be appreciated that one of the main reasons for choosing Calder Hall as the site for an atomic power station to generate electricity as a by-product in the production of plutonium was because the site adjoins the Windscale plutonium factory. The Calder Hall project could, therefore, make use of the existing services, technical skill and " know how " already established at Windscale. It was possible, for example, for Mr. H. G. Davey to assume responsibility, as general manager, for the works at Calder Hall as well as at Windscale.



Figs. 4 and 5—(Left) the bottom of the reactor pressure vessel casing. Carbon dioxide for cooling the reactor core is pumped at 100 lb per square inch into the bottom of the pressure vessel through four inlet ducts, part of which can be seen. (Right) a heat exchanger section rigged for hydraulic testing. The surface area of about 30,000 square feet of the complete heat exchanger is made up of several million welded studs of aerofoil section

Two stations, " A " and " B," of similar output are under development at the Calder Hall site. Station " A," illustrated in Fig. 1, is already far advanced ; work has been started on station " B," where the foundations for one reactor are nearly completed, while site preparation for the second reactor is in hand. While No. 1 reactor is nearing the final stages of construction, the commissioning process has started. According to the present programme, it should be producing power by the end of next year. No. 2 reactor should reach the same stage about six months later. The first of the four 23MW turbo-alternators (Fig. 3) is at present being installed in the turbine hall which is between the two reactor buildings.

Calder Hall " B " will be a station of similar layout to the " A " station, with a turbine hall between the two reactor buildings. The two stations are being built " in tandem " on the same longitudinal axis. Station " B " will lie to the right of station " A " as it appears in Fig. 1, and it is due to be commissioned in 1958/59.

Each reactor is a graphite-moderated, pressurised pile, cooled by carbon dioxide in a closed cycle. After abstracting heat from the reactor core the carbon dioxide enters four heat exchangers in parallel where steam is generated for the turbines. The graphite lattice containing the uranium fuel rods and the control rods weighs 1000 tons and is contained in a cylindrical pressure vessel made by Whessoe, Ltd. A " diagrid " structure built up of " I "-section beams, forming a rectangular lattice or honeycomb bounded by a circular ring girder, carries the weight of the graphite core. The pressure vessel which is about 60ft high and 40ft in diameter, is built up of 2in mild steel plate welded on site to produce five sections—the bottom dome, the two central ring-shaped sections, the " diagrid " and the upper dome. These sections were lifted by a 100-ton crane and lowered through the roof of the pile vault, the final welding being done *in situ.* All butt welds were radiographed and all important fillet welds were examined by crack detection methods. Stress relieving of the completed pressure vessel was effected by applying radiant heat, involving an electrical load of 1½MW, raising the temperature to over 550 deg. Cent., maintaining this condition for about eight hours and then allowing the vessel to cool slowly. A pneumatic pressure test and a vacuum test at 0·1 atmosphere pressure were then applied. The weight of the graphite and " diagrid " is taken by brackets directly through the walls of the pressure vessel on to ten inverted " A "-frames, which rest on the base of the thermal shield. The bearing face of each support leg is radiused to allow for radial expansion of the pressure vessel and " diagrid."

The entire pressure vessel is surrounded by a thermal shield built up of 6in thick steel plates laid edgewise to form a lining to the octagonal reinforced-concrete biological shield which is 8ft thick.

The octagonal plan form for the biological shield was chosen because it allowed for shrinkage of the concrete ; alternate sides were poured first and, after the concrete had been allowed to set the remaining sides were poured, completing the octagonal structure. A dry mix was used, with Cumberland Whinstone for aggregate, vibrated after pouring. Daily samples were taken during concreting to ensure that a mix of 158 lb per cubic foot would be maintained. The biological shields were constructed by Taylor Woodrow Ltd., the main contractor for the civil engineering work on site.

There is a 6in space between the thermal shield and the biological shield, and this space is used for induced draught air cooling, the exhaust air being discharged 200ft above ground level from the two stacks mounted on the reactor building.

A view of the base of the pressure vessel, showing the entry ducts for the CO_2 coolant, is given in Fig. 4.

Hot CO_2 from the top of the reactor vessel is discharged to four heat exchangers† (made by Babcock and Wilcox, Ltd.), each contained in a vertical shell 18ft diameter and 70ft high, made up of $1\frac{5}{16}$in steel plate welded and stress relieved. Separate low-pressure and high-pressure steam systems are provided in the heat exchanger, each with its economiser, evaporator and superheater sections made up of 2in overall diameter mild steel tubing carrying the water and steam. The outside surface of each heat exchanger section is increased by welded-on steel studs of aerofoil section to give an effective water heating surface of 30,000 square feet. Electrically driven pumps provide flow in the evaporator sections to maintain a forced circulation rate of about four times the steam output of the section. Each evaporator is provided with a single steam drum 4ft in diameter and 18ft long, having the conventional cyclones and scrubbers. To reduce the risk of steam or water leaking into the coolant system the number of tube joints inside the pressure shell was kept to a minimum. The ends of each steam tube element go separately through a sleeve in the pressure shell so that any steam leakage at a joint must escape to atmosphere.

A typical heat exchanger section arranged for hydraulic pressure test in the maker's works is shown in Fig. 5. All the tube joints in the first heat exchanger to be assembled on site were given an abnormally high pressure test followed by a stringent vacuum test.

To prevent contamination of the carbon dioxide in the heat exchangers each section of heat exchanger was shot blasted to remove rust and dirt. After shot blasting each heat exchanger was placed in a steel transit case ready to be taken to the " clean room " at the top of the heat exchanger for installation.

The carbon dioxide coolant is circulated through the reactor and heat exchangers by four single-stage centrifugal blowers with overhung

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*See THE ENGINEER, August 27th, 1955 page 290.

†See THE ENGINEER, June 18th, 1954 page 902.

impellers. Control of coolant mass flow is effected by variation of impeller speed. Each blower is driven by a 2000 h.p. d.c. motor supplied independently from a motor generator set with Ward Leonard control giving a 10 : 1 blower speed range.

The four Parsons turbo-alternators (one of which can be seen during erection in Fig. 3) are machines of orthodox design. Each has a rating of 23MW at 11kV and 3000 r.p.m. The turbines are two-cylinder reaction machines. To suit the dual pressure steam system the low-pressure cylinder receives live steam direct, in addition to steam which has been expanded in the high-pressure cylinder. The twin exhausts from the l.p. cylinder discharge into a surface condenser operating at about 1¾in abs. After de-aeration the condensate is returned by the h.p. and l.p. feed water pumps to the economisers.

There is a separate " dump " condenser, which can handle the full-load steam production of the heat exchangers without passing through the turbines. Two natural draught cooling towers (Fig. 1), each designed to cool 3,000,000 gallons of water per hour by 10 deg. Cent., will meet the requirements of the " A " station.

Iron and Steel Institute

AUTUMN MEETING

THE autumn general meeting of the Iron and Steel Institute was held in London on Wednesday and Thursday of last week, with the president, Sir Charles Bruce-Gardner, Bt., in the chair. At the opening session of the meeting it was announced that the council had nominated Dr. H. H. Burton for election as president, to take office at the annual general meeting in 1956.

The first paper presented for discussion at the meeting was by Mr. C. Burns, of the British Iron and Steel Research Association, and was entitled " A Furnace Scanning Periscope." The paper described work with a water-cooled periscope which has been developed and which can be inserted in an open-hearth furnace and give an effective viewpoint within the furnace walls. Its field of view is sufficient to cover any portion of the furnace interior when inserted through a single aperture in the back or the front wall. The periscope can be used for still or cine photography (normal or high-speed) or for direct visual observation.

In the course of the discussion on this paper Mr. J. W. Till (John Summers and Son, Ltd.) said : " The instrument which Mr. Burns has described was designed primarily, I think, for scanning the roof of an open-hearth furnace from a position through the back wall. The fact that it has been possible to use the instrument successfully for observation of the flame both through the front wall and through the end wall, as well as for its original purpose, has definitely enhanced the value of the instrument. Our experience at John Summers with the instrument has been mainly from the end of the furnace. In this position observation of flame development and flame application to the charge can be undertaken readily. We have made several studies, both visually and with the aid of a cine-film, of these flames, and the results have been very encouraging to us. The differences that one can see are not always very easy to interpret, but we are of the opinion that the periscope will provide a means for studying the effect upon the flame of slight adjustments in burner position and inclination and of atomising conditions.

" During the last few years a considerable amount of work has been done on the examination of the flow pattern inside open-hearth furnaces by means of models. It is hoped that the periscope will provide a means for observing the results of the changes that may be suggested by model work, changes which will occur in flame development and flow lines of the gases which may result from the model changes. Now, in certain periods in the course of the heat there is a very heavy carry-over of slag, particularly if one is using a hot metal. This carry-over causes rapid wear on the furnace ends. The periscope has been set up at John Summers in the end wall, in a position in which the dripping from the end wall passed across the field of view. We tried to get a quantitative value of the amount of wear on the end wall by counting the drips per minute. The material that drips down approximates to the composition of slag, but it is reasonable to assume that the dripping is closely associated with the rate of wear. We have followed quite a number of casts through on lines such as this, counting the drips and associating this with the time and the particular operation of the furnace ; and we feel quite certain that the severity of wear can be observed to increase with an increase in hot metal percentage. It can be observed to increase with tar fuel compared with oil fuel, and it has also been seen that the rate of wear increased rapidly if the reversal sequence was prolonged. If, as will happen on the best-regulated furnaces, the furnaceman forgets to put the furnace over at the time you have told him to do so, if you are observing the rate of drips you will find that the rate per minute rises very rapidly—so much so that we have instituted a shorter reversal time, we have made it automatic, and we have cut down the rate of wear on the furnace end quite markedly. The wear on the main roof has not been observed in this way, mainly due to our construction, but it would seem reasonable to expect that if a hole were available in the back wall the periscope could be sited on a particular area of the roof and the dripping observed, in cases where it is known that wear is localised."

There then followed a paper by Dr. C. A. Edwards on " The Relative Merits of Low and High Sulphur Oil for Open-Hearth Steelmaking." In this paper the weights of sulphur pick-up when using fuel oil with varying sulphur contents are given, and from them the theoretical weights of tapping slag required have been calculated. The distribution of both phosphorus and sulphur between slag and metal is discussed mainly from the practical point of view. For sulphur it is concluded that the basicity of the slag cannot be the only factor that governs the (S)/[S] values, but a satisfactory degree of correlation is found when these values are plotted against the products of slag basicity and residual manganese.

On Wednesday afternoon, there was a discussion on a group of papers dealing with " The Thermodynamics of Carbon Dissolved in Iron Alloys," " The Solubility of Nitrogen in Alpha-Iron," and " The Effect of Alloying Elements on the Solubility of Nitrogen in Iron." These papers were introduced by Dr. E. T. Turkdogan, head of the physical chemistry section of the British Iron and Steel Research Association.

The first papers to be presented when the meeting was resumed on Thursday of last week were " The Strain Ageing of Alpha-Iron," by Dr. W. R. Thomas and Dr. G. M. Leak, and " The Strain Ageing of Pure Iron," by Dr. B. Jones and Mr. R. A. Owen-Barnett. The latter paper describes the ageing characteristics of two samples of pure iron containing less than 0·004 per cent of carbon and 0·002 per cent of nitrogen which were investigated after temper rolling and after tensile straining. After these treatments, the irons showed an appreciable degree of strain ageing that was almost equivalent to that of open-hearth mild steel. After temper rolling, the rate of ageing of pure iron was more rapid than in commercial steels, and was found to be complete within one month ; it was then equivalent to the strain ageing that occurred on heating to 75 deg. to 250 deg. Cent. In contrast, ageing of mild steel progressively develops over a period of years. The rapid ageing of pure iron has been explained by the ease of migration of carbon and nitrogen atoms in the α-iron lattice. Strain ageing of iron was eliminated by annealing in moist hydrogen, which reduced the carbon and nitrogen contents to almost zero values.

The papers next discussed were entitled " A Microscopic Examination of Samples of Iron containing Siliceous Inclusions," by Mr. R. E. Lismer and Mr. F. B. Pickering, and " A Microscopical Examination of Samples of Iron containing Titanium-Bearing Inclusions," by Mr. F. B. Pickering. At the concluding session on Thursday afternoon, there was a discussion on a paper entitled " Metallography of Delta-Ferrite," which was submitted, in five parts, by Mr. Kehsin Kuo.

THE RUSSIAN IRON AND STEEL INDUSTRY

A special session, arranged by the Iron and Steel Institute during its autumn meeting, was held on Wednesday evening of last week. At it, addresses on the Russian iron and steel industry were given by Sir Robert Shone, executive member of the Iron and Steel Board, and Mr. W. F. Cartwright, assistant managing director of the Steel Company of Wales, Ltd. It may be recalled that Sir Robert and Mr. Cartwright have recently visited Russia as members of an iron and steel delegation organised by the Economic Commission for Europe. The British experts were led by Sir Robert.

Sir Robert, in his address, dealt principally with the production and economic aspects of the Russian iron and steel industry. The following is an extract from his address :—

" The two integrated plants which we visited, Zaporojhe and Rustavi, together produce 2,500,000 tons of steel a year and employ 21,500 workers. It is difficult to make exact comparisons. One of these works makes sheets and tinplate, and the other makes tubes. Broadly speaking, however, the output per man at these works would correspond roughly to the output per man at a group of the best 25 per cent of the works in this country. We have no doubt that Russia has also old and less efficient works, just as there are old and less efficient works in this country. At both the works which we visited, however, we could see clear evidence that they will improve their efficiency considerably in the next few years, just as at modern British works schemes are afoot to improve the efficiency in the next few years. It is quite clear that Russia is running neck-and-neck with us at the new plants. The Russians are not yet up to American standards, but I have no doubt whatever that they have their sights set on the target of American productivity.

" I should like to mention that the rate of expansion envisaged by the Russian steel industry is an increase from about 45,000,000 tons which they expect to produce this year to 60,000,000 tons in 1960. That rate of increase, when expressed as production of steel per head of population, is very comparable with the rate of increase in the British five-year plans covering the years 1953–1958. Both countries may well reach their targets, and thus show a similar rate of increase per head of population. The population of Russia is increasing at a moderate rate, but at a greater rate than in this country.

" Pig iron output in both countries is expected to rise more rapidly than steel production, for very obvious reasons. It is clear that the Russians will require to spend large sums in expanding their rolling mills, where they have not reached such an advanced state, probably, as in their steelmaking and blast-furnaces. They are, for example, behind in strip mill development, but they have a target of 40 to 45 per cent of their total steel output to be in the form of flat products. I do not know whether they expect to attain that target by 1960, but they accept it as a general objective."

Mr. Cartwright, in his address, described some of the technicalities of the Russian plants which the delegation visited. The major part of his talk is given below :—

" As in any other country, presumably, there is quite a big range between the best and the worst. I do not know, of course, what the range is between the worst and the best in Russia, because generally speaking we saw some of their newest and some of their best. We visited two coke plants, one about 30km outside Moscow and one at Stalino, both about four years old. The coke oven plant near Moscow is a complete unit, down to the town hall, clubs, shops and everything else ; it is one tight little community.

"The coal arrives from the Donbas in complete trains. I think that we should say that it is rather high in ash and rather high in sulphur. The average sulphur in the coke is about 1·3 per cent. At the Moscow coke works the ash was a little lower than at Rustavi, where the average ash in