THE ENGINEER

VOL. 203 No. 5278 MARCH 22, 1957

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STRIKES, ON AND PENDING

Seldom is an industrial dispute so simple and straightforward as that which has led to a strike in the shipbuilding industry ; nor are the issues involved in the engineering dispute much more involved. About a year ago, negotiation led to agreement between employers and unions in both industries upon what wage rates should be. But hardly was the ink dry upon that agreement than the unions busied themselves upon making a new claim. There was nothing very new about that piece of history either. It merely repeated the history of the year before that and the year before that and paralleled the history of wage negotiations in several other industries ; commentators in the Press, indeed, have become accustomed to referring to the "annual round of wage claims." What has happened this year is that the shipbuilding and engineering employers, whose attitude has been stiffening over the last two years, have decided that the "annual round" should not be allowed to harden into absolute custom. Nearly a year ago the engineering employers declared that any new wage claim would be rejected. Since then there have been several meetings of the two sides to express their respective views. But since the employers have stuck to their declaration it can hardly be said that there have been any negotiations ; there was, said the employers at the beginning, to be no increase in wages this year. They still say the same ; and the attitude of shipbuilding employers has not been significantly different. But the union leaders, for their part, seem to have assumed that the employers were merely striking an attitude as part of the bargaining process. How else is their explosion of anger to be explained when a few days ago they found the shipbuilding employers no more willing to negotiate than before ? It is the refusal even to negotiate that has "got their goat." Hence, perhaps, the refusal of the shipbuilding unions to accept arbitration. They seem determined that the employers shall negotiate. They demand a cash offer. Whether the engineering unions are so angry is more doubtful. They had a week subsequently to the meeting with the shipbuilders in which to re-adjust their ideas and were therefore expectant of the employers' utter rejection of their claim. There was no surprise. As we write there is still hope that in this, an industry in which labour relations tend as a whole to be good, good sense will prevail. As we go to press the fear of an immediate wholesale engineering stoppage has been temporarily relieved.

It is not possible wholly to withhold sympathy from the unions. If the annual round of wage claims has not become a custom it has become perilously close to one—perilously because if it continues the inescapable conclusion is that inflation must also continue. It has become sufficiently nearly a custom for it to be shocking both to union leaders and men to find that employers do not accept it as such. Furthermore union leaders quite rightly appreciate that a continuous pressure for higher wages brings benefits to industry as well as to wage-packets as it provides an incentive for managements to find more efficient means of manufacture. They see virtue in the "annual round." They also appreciate that as a consequence of rising wages the demand for goods is enhanced, and therefore the risk of unemployment developing is reduced. Possibly there is virtue for them in a continuous inflation so long as it is controlled. But none of these arguments justifies the making of such a remark as Mr. Hill is reported to have made that benefits to the men in shipbuilding are to be counted as more important than the national interest. Everyone must realise, however, how much easier it is for employers to justify a refusal of a wage claim on the basis of national interest than for the unions to argue that a wage increase is in that interest ! Whenever a wage claim is being discussed it will be claimed upon the employers' side to be against the national interest. Exasperation on the union side is, therefore, perhaps excusable. Yet when all has been said that can be said on the union side the case that employers now put up seems far the stronger. The shipbuilding yards have, indeed, taken as a whole, orders equivalent to five years' work. But the competition of Germany and Japan must be met ; and judging from recent figures in both those countries the rate at which a ship can be built is very substantially higher than that in Britain. The profits accruing from the present plenitude of orders need to be ploughed back into the improvement of the yards, else orders beyond five years ahead may well go elsewhere. Costs of construction need to be lowered, not raised, if competition is to be met. Capital needs to be attracted to the industry. Much the same argument applies to engineering, too. Competition abroad is growing. There is no room for raising export prices. But there are other arguments just as cogent, too. Because the engineering industry employs so large a fraction of the whole national labour force, and because an increase of wages within the industry would necessarily trigger off wage increases elsewhere it is more obvious in that industry than in others that the real benefits workers can gain from a heavier wage-packet are restricted, not by pounds, shillings and pence, but by productivity, which has not over the last few years been rising nearly as fast as wages. To grant a wage increase even approaching the 10 per cent which the unions are asking would confer on workers very little benefit since within a few months the cost of living would necessarily have risen correspondingly. It would merely provide a basis for a renewed wage claim next year! Possibly at present the export side of the industry could stand it, though inevitably with substantial loss to the profits ploughed back to expand productive capacity. But if the annual wage negotiation hardened into an unalterable custom it could not. In the belief of engineering employers the custom must be broken now at a time when a strike, if it should come to a strike, might not do irreparable damage to their export business rather than later when it certainly would.

Yet to the public, looking on and without any clear understanding of the situation, we wonder how much these arguments appeal. Not being angered by the controversy, the public, we think, is likely to take the common sense view that sooner or later there must be negotiations for a settlement; that it is obviously better to negotiate before any damage is done by a strike; and that a strike can do nobody any good and must, if at all prolonged, damage severely the interests of employers, of employed and of the nation at large. That was a point clearly appreciated by the shipbuilding employers. Whilst unprepared to negotiate they were still willing to set the case before arbitration. The unions were not. Possibly they objected because to accept arbitration instead of the "cash offer" they demanded would be to allow that there is nothing customary about annual wage negotiations. Yet surely that point has been lost already! A custom is only a custom if both sides agree that it is one. The employers do not; nor do we see how even a successful strike could alter their opinion. Both sides now appear to be holding tight to principles. They will not relent upon those principles. But are those principles really opposed? Forcibly and rightly the employers declare that wages cannot annually be allowed to rise. It is intolerable that the signing of an agreement shall be immediately followed by the formulation of a new claim. The unions assert that if a claim is made there must be negotiation about it; it cannot be turned down wholly. Is it impossible for each side to concede the other's principle? Do they necessarily conflict?

ATOMIC-POWERED TANKERS

The modern submarine with a conventional diesel engine power unit has a range of 12,000 miles at economical speed either on the surface or, using her "snort," submerged at periscope depth. But fully submerged, she depends on electric motors and storage batteries. Thus, her very low speed and small endurance place her at a serious disadvantage when fast anti-submarine vessels are in the vicinity or when she is trying to intercept a target, escorted by aircraft, reported perhaps 100 miles away. Germany believed she had found the answer to this problem in her submarines building at the end of World War II. They were to have had engines using hydrogen peroxide as an oxidant for the fuel and were to have had a range submerged of 150 miles at 25 knots. Since the war, Britain has built two submarines with engines of a similar type, for the specific purpose of training anti-submarine personnel. The United States, on the other hand, turned to atomic power as a solution and built the "Nautilus" and the "Sea Wolf." Large and unhandy though these vessels are, the Americans are evidently very satisfied with their performance as submarines and several more are now under construction or on order. None the less, it is an expensive answer to a problem which is not, after all, of the first importance for a naval power with the surface command of the sea. United States Government spokesmen do not even consider it necessary to discuss the tactical aspect. They confine themselves to saying that "the United States must have submarines which can go round the world at high speed submerged." The true reason will no doubt prove to be that a submarine is a kind of ship which can be suitably and easily constructed to try out the practicability of atomic power for marine nuclear propulsion. This seems evident from the prompt decision of Congress, immediately following the success of the "Nautilus," to provide funds for the building of a cruiser plus a 12,000-ton passenger cargo-liner, to be driven by atomic power; and for the construction of a nuclear power plant for a large aircraft carrier. Indeed, American naval authorities foresee an atomic powered navy by the 1970's.

What is the position in this country? We know from the "Nautilus" that nuclear propulsion for marine purposes is a technical feasibility and, in the absence of information from the United States, the decision was made a year or two ago to follow her example and try out a marine atomic plant in a submarine. Detailed work on the design of the shore-based prototype is now, indeed, well advanced, and some orders for machinery have been placed. A submarine with unlimited endurance submerged will no doubt be a much more efficient vessel than the conventional submarine. But in the light of the new considerations which have arisen, is she not a luxury which this country can ill-afford? There is as yet no word of the completion of guided missile trials with the "Girdle Ness," and the laying down this year of even one cruiser—to say nothing of an aircraft carrier—seems unlikely. There is thus good reason for the Royal Navy, if it is not to build new warships, to play its part in ensuring oil supplies for this country, both in peace and war, by financing forthwith a prototype atomic powered tanker. As Sir John Cockcroft emphasised recently, there is still a large gap in costs to be bridged before nuclear propulsion for ships becomes commercially attractive and we can hardly expect financial houses or the oil companies vigorously to take a hand at the present stage. Nor is there any need to delay because of the safety problem, in view of the American decision to go ahead with surface ships and the co-operation which is to be expected as a result of Mr. Sandys' visit to the United States. Oil companies are now ordering tankers of 50,000 tons to be built in this country. But if 6000 miles has to be added to the voyage from Aden to London by using the Cape route, tankers must not only be larger, but also faster and quicker to turn round. This entails considerably increased horsepower and increased fuel costs. The latter costs would be avoided in a nuclear powered ship. There seems little doubt that, apart from the very heavy initial cost, a 60,000-ton atomic powered, 25-knot tanker would be a sound solution, both economic and strategic, to this country's oil transport problem. There have been indications recently that the cost of marine reactors is likely to fall considerably in the near future and it seems unnecessary to wait perhaps five or ten years until further study and experience in a submarine have proved that nuclear power plants are commercially attractive. This might well result in Britain being left far behind in this new and revolutionary era in sea transport. Recently built R.F.A. ships for the Royal Navy have a displacement fully loaded of 26,000 tons (including 15,000 tons oil fuel) and a speed of 18 knots. A still larger vessel, driven by atomic power, would have no tactical objection. Shipbuilders and owners have pointed out recently the advantages aircraft firms derive, in undertaking experimental development, from assured Government backing. The construction of an atomic powered tanker rather than so specialised a craft as a submarine would benefit not only the Navy—which sooner or later must adopt a method of power production with such strategic advantages for all larger warships—but the whole shipbuilding and ship-repairing industry.

A Seven Day Journal

Developing Technical Education

SIR HAROLD ROXBEE COX, who is vice-chairman of the National Council for Technological Awards, addressed the annual assembly of the Nottingham and District Technical College last Friday. His theme was the development of technical education, and during his address Sir Harold emphasised the fact that, at present, there were not enough people of high quality with scientific and technical training. If the future was to be successful, he added, that situation must be changed and changed quickly. Sir Harold went on to say that not only was it necessary to educate much larger numbers of scientists and technologists, it was necessary also to ensure that they carried in their ranks a much higher proportion of the youthful talent of the country. Sir Harold then commented on the work of the National Council for Technological Awards and on the Diploma in Technology which is to be awarded to those who successfully complete the courses of study recognised by the Council. Up to the present, Sir Harold said, the Council had received fifty-nine applications for approval of courses ; it had completed consideration of thirty-seven and had given its recognition of twenty-eight. As it had been possible, he added, for some of the approvals to be retrospective, there might well be between forty and fifty candidates for the diplomas in 1958 and nearly 100 in 1959. Sir Harold also commented on the " serious deficiencies " which members of the Council had found in most of the technical colleges they had visited. No college so far visited, he said, had yet achieved the standards which the Council considered appropriate. But the Council realised that it had to be practical, and if plans were clearly in hand to provide in the near future what was deemed to be necessary, then the courses for which approval was sought were being recognised, provided they fulfilled the requisite academic standards.

Liverpool Steam Ship Owners' Association

THE annual report for 1956 has been published by the Liverpool Steam Ship Owners' Association and records that the tonnage entered in the Association was 4,755,568 tons at the beginning of 1957. Imports, it is noted, compared with 1955, decreased by 5 per cent to 104,500,000 tons, while exports increased by 8 per cent to a record total of 24,673,000 tons. In both import and export trades the amount of British shipping declined slightly and the British percentage of the total tonnage entrances dropped from 55 per cent in 1955 to 53·8 per cent in 1956. The report goes on to review the situation created by the Suez Canal closure such as the shortage of shipping space which caused a reduction in our exports, while delay in the arrival of ships caused a fall in imports. Examples of the additional voyage distances involved are quoted and related to a percentage time loss. The total tonnage which passed through the canal in 1955 is given as 115,756,000 net tons and the British share as 32,790,000 tons which, together with ships on charter, represent British participation as 40 per cent. This amount, the report comments, is a measure of the importance of the canal to our trade, and some indication of the detrimental effect of the closure on our economy. Taxation since the war, it is stated, has assisted in the decline in Britain's share of world tonnage and a price index table shows that, taking 1950 as a yardstick, costs were 45 per cent higher in 1955 and represented a level exceeding five times the pre-war cost. These facts, the report continues, illustrate the difficulties in replacing liner tonnage built pre-war which amounts to about one-fifth of the total. Due to unrealistic depreciation on investment allowances, the gap to be filled by an owner out of taxed earnings is large and thus emphasises the commercial advantage of those owners who avoid tax by trading under flags of convenience. A plea is made for taxation to be levied only on the profit remaining after deductions have been made for fleet renewal.

The Engineer
100 Years Ago
(MARCH 20, 1857)

" MACHINE AND HAND LABOUR "

" Our space will not admit us, neither is it perhaps necessary, to point out at the present day to intelligent workmen, that in the long run all improvements in machinery are as conducive to their own good as to that of others. There are few, we believe, who deny this, but the opposition of workmen to new machinery arises, and that naturally, from the knowledge that it must, for a short time at least, lessen the number of hands employed in the place where the machine is introduced. Of course, the work given to the extra hands employed in the construction of the machine itself does not affect those who work it, and it cannot be denied that the immediate and almost certain result is, that some of the attendants upon the old machinery, which is supposed to be displaced, are discharged as unnecessary.

" That even a temporary inconvenience should arise from the introduction of anything calculated in the end to benefit all, is greatly to be deplored ; but there would appear to be no remedy for the evil, except it be in workmen keeping a good look out ahead for any machinery proposed to be introduced in any branch of manufacture, and which it is known will in all probability lessen the number of hands required. If the leaders of amalgamated societies would turn their attention to this very important subject, instead of persisting in a vain endeavour to uphold a monopoly of labour without the means of doing so, they would, indeed, be affecting some good. If a careful record were kept by each trade of all that is going on in that trade, whether it regarded new inventions and discoveries tending to supersede it altogether, or whether it had reference to new machinery for abridging manual labour, and at the same time a glance was taken of the condition of kindred trades, and endeavours made to seek out the best channel into which any surplus labour might be turned ; then, indeed, might we expect to see results arrived at, which without such means are impossible of attainment."

Thermal Insulation of Industrial Buildings

LAST Friday, the Thermal Insulation (Industrial Buildings) Bill was given a second reading in the House of Commons. It is a Private Members' Bill sponsored by Mr. Gerald Nabarro and supported by Members on both sides of the House. The main purpose of the Bill is to assist greater efficiency in the use of fuel for heating factories, and thus to conserve fuel, notably coal and fuel oil. A secondary purpose is to improve comfort standards in factories and to render more effective compliance with the heating provisions of the Factories Act. Within the context of fuel efficiency in industry, it is stated that the Bill is complementary to " clean air " legislation. Only 10 per cent of the new factories in this country are said to be effectively thermally insulated. The Bill makes provision for the thermal insulation of all industrial buildings in which fuel is consumed for space heating. New industrial buildings would require to be thermally insulated after January 1, 1958, and other industrial buildings after a date to be appointed by the Minister of Housing and Local Government, but not less than four years after January 1, 1958. Power to exclude certain buildings is provided, as, for example, foundries, where thermal insulation would not be beneficial. In some explanatory notes on the Bill, it is claimed that up to 50 per cent economy in solid fuel used for factory heating may be achieved by roof insulation, the average economy probably being 25 per cent. Owing to the lack of reliable statistical data as to the total factory space in Great Britain it is difficult to state accurately the total potential saving of fuel, but the National Industrial Fuel Efficiency Service has postulated a saving of up to 6,000,000 tons of coal or coal equivalent annually. If the measure was restricted to new buildings only, the economy would be 170,000 tons of coal a year.

Commonwealth Standards Conference

THE third Commonwealth Standards Conference has just been concluded in Delhi. It was attended by more than 100 delegates from the United Kingdom, Australia, India, Canada, New Zealand and Pakistan, among them being representatives of the various Commonwealth standards organisations. The conference lasted a fortnight and, in addition to a series of general meetings concerned with the wider aspects of standards policy in the Commonwealth, there were four technical sessions on the electrical equipment of machine tools, electric cables, steel, and safety requirements for domestic electrical appliances. At one of the general meetings, a matter discussed concerned further items of industrial equipment which might be appropriately subjected to detailed technical consideration. It was agreed that the next subjects to be dealt with in this way should be standards for air receivers and cranes. In both instances, divergent statutory regulations in the Commonwealth countries complicate export and import problems, and there is particular need for co-ordination of testing procedures and design criteria. It was decided not to initiate any special Commonwealth discussions on boilers, in view of the work being done by the International Organisation for Standardisation, though a review is to be made of the extent to which Commonwealth countries are likely to be able to follow any I.S.O. recommendations. There was also some discussion during the conference about the desirability of bringing terminology in the Commonwealth and the U.S.A. more into line. It was agreed that a special study should be made by the British Standards Institution, in co-operation with other Commonwealth standards organisations, of the terminology used in welding and in building design and construction.

Index to THE ENGINEER

The Index to THE ENGINEER, Volume 202, July to December, 1956, is now ready and has been posted to all readers who have previously applied for copies. Any reader desirous of obtaining a copy who has not already applied, should write to The Manager, THE ENGINEER, 28, Essex Street, London, W.C.2 ; he will be sent a copy free of charge.

Scope for Operational Research in Industry

By STAFFORD BEER*

No. I

Last Monday, March 18, *the* 1956 *George Bray Memorial Lecture was presented before the Institution of Production Engineers in the Sheffield City Memorial Hall. We here reprint the opening sections of the lecture and its conclusion. These opening sections describe and comment upon the purposes that operational research can serve, the general principles upon which it is based, and in particular its usefulness to managements. Succeeding sections not printed here dealt with more specific tools than the basic notions here described, and entered into more detail.*

The Field of Problems.—A major tenet of the industrial philosophy which has led us into an era of higher productive efficiency has been the concept of "the division of labour." Inevitably, perhaps, this doctrine has been applied elsewhere than on the shop floor; in particular, it has been applied in the two fields which are the primary concern of this paper: those of industrial management and scientific knowledge. Doubtless the division of labour in both cases has sponsored many gains; but I venture to suggest that the blessings have been mixed. There has been some loss in unity of thought, a commodity always highly prized by the thinkers of the world. This is, I propose, the deep-lying source of some lack of cohesion in industrial affairs.

Another basic source of difficulty is discernible; this is the conflict between tradition and new ideas. The strong sense of tradition in our country is one of its greatest strengths. But we are uneasily aware that new techniques sometimes demand the abdication of ruling notions; it is not by any means easy to decide at what point such contextual conditions have to be changed. The time does come when even the most respected, tried and honoured dogmas of both management and science become so affected by the principle of diminishing returns that they are no longer serviceable. Recognising this time is a most difficult task for both the manager and the scientist.

Whenever contemporary industrial problems are being discussed, there seems to be an all-too-ready response to semi-political arguments. The "we" and "they" (depending on one's point of view) of these arguments are the Scylla and Charybdis of straight thinking. Obviously there are problems of industrial relations, and I do not seek to minimise them. But I do believe in management's right to manage, and I conceive that in right management lie the answers to our real problems—those whose sources I have just mentioned. Some appear to think that the demand is for more aggressiveness; on the contrary, it has never been true that "might is right." The real need is for more science: we are concerned here with one of its manifestations.

Is the World Flat?—It is as difficult to define the nature of our answer in operational research to these questions as it is difficult to define a spiral staircase in words. It is better to discuss the techniques we use and their applications, and to let an understanding of the work gradually emerge. I have so far implied that operational research is concerned to apply the methods of science to the problems of management; but one gathers that there is virtually no one in industry to-day who is not engaged in that task. Without attempting a definition, then, I will try to give a preliminary impression of our approach.

The area of industrial decision is in an incoherent state. It is neither a closed system nor a static one. Rather is it a dynamic interacting complex of variables, in which nothing is certain, nothing completely controllable, nothing quite describable nor fully understood. In this arena almost any question is likely to become a focus of opinion rather than knowledge, of prejudice rather than fact, of passion rather than logic. Operational research works to create a Still Centre in this turmoil. Our aim is just this: to lift controversy out of the arena of controversy.

Let us note the history of this process. The development of the technique of applying science to life is something separate from the development of science itself. It was once possible for highly intelligent men to argue bitterly on the question whether the world is flat. Eventually the application of scientific method produced an answer beyond cavil. To-day there are many questions relying for solution on judgment, guesswork or prejudice to which scientific conclusions can be reached by developing this technique of applying science. The trouble is that science itself is divided into highly organised and specalised forces, with limited and specialised objectives. The problems we need to recognise and solve lie between these orthodox targets.

Thus everyone thinks, for example, of applying the science of hydrodynamics to hydraulic engines in a works; but few think of applying it to the analogous problems of the flow of a sliver of cotton through a doubling machine, or the flow of supplies of raw steel into a rolling mill. Operational research specialises in no particular science, but in the scientific method; it concentrates on targets which lie unnoticed among the official objectives of scientific application. We try to isolate and to destroy modern equivalents of the ancient contention that the world is flat.

The Science of Decision.—This is less the age of science of which we are inclined to boast, as an age of the awe of science. Thus it is not altogether surprising that, amidst so much scientific achievement, so much that is superstitious should survive. Neither is it surprising that these confusions should occur not in the field of creations but of decisions. It is in these circumstances that we sometimes call operational research the science of decision. There is, I hasten to add, no intention to arrogate the functions of management; only to make available to management decisions about those matters that are (in the language of logicians) "decidable."

Provided that claim is not misunderstood, I think no manager will object to the scientific taking of decisions. We are all conscious of the thousands of immeasurable variables that affect an industrial decision of any importance, and of the precarious assumptions that we have to make in taking it. In the morass of probabilities "Holy is lucidity and the mind that dare explain."

Thus I hope not to arouse adverse reactions on the lines that management is an art, a matter of human relations, and something which cannot gain from scientific help. Whatever I may say later, this paper does not envisage an industry bereft of those prime qualities of management: leadership and understanding. There are always people ready to reduce an argument to absurdity, and then to complain because it is absurd. Those who would deny to management the services of science on the ground that science cannot replace management belong to this group.

[The following is the author's classification of his lecture. Our abstract is taken from his Part I and the conclusion of his Part III.]

Some rather arbitrary divisions will be introduced to aid the exposition. First, there are some basic notions in this class of work which in my opinion underlie most applications. In Part I, I shall try to bring out what these notions are; illustrations must be specific, and none of those used should be taken as indispensable. This Part is intended to display a fundamental outlook: the orientation of the operational research scientist. Secondly, in Part II, we shall review the major techniques so far available in operational research; these are the weapons in the operational research armoury that can be brought into use if the situation so requires. Without wishing to pontificate about a classification which is mainly one of convenience, I do feel that almost any piece of operational research is likely to exhibit the characteristics of Part I, and within this general context to develop a variant of one (or more) of the major techniques listed in Part II. In the final Part, III, I shall give reasons for considering the science of cybernetics as inexorably involved in the future of industrial operational research. Another long paper would be required adequately to indicate the scope for industrial cybernetics: Part III does no more than indicate why I believe that cybernetics is part of the scope for industrial operational research.

Commensurable Fact

Special Measurements.—The first requirement of management must always be to develop an understanding of what is happening, and to keep this understanding up to date. To do this, requires a yardstick, a unit of measure. In a steel works, tonnage is a favourite unit. The weekly output in tons goes down; management is told that smaller sizes than usual are being rolled. The unit of length may be used, and this figure drops; management is told that the sizes being rolled are bigger than usual. The unit of cost may be used, and this rises; management is told that there were metallurgical reasons for diverging from standard processes. And so on. Are these explanations reasons? Are they excuses? To what extent do the explanations in fact account for the discrepancies which the management is trying to evaulate?

The first need in describing and understanding industrial processes is for a unit of measurement which takes into account the many casual variables which may affect results, and removes them from the field of argument. Ultimately, the unit of profit

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will do this ; but this unit will also take into account variables outside the control of a specific area of management—such as foreign confidence in the pound sterling, which might affect an industry's price policy.

To measure the effectiveness of the production process, we need a yardstick of the productivity of the plant itself. But this measuring device must be sensitive to fortuitous changes in the products. In other words, regardless of what is being produced, it must measure the effectiveness of production. If this is to be done, we shall have to abandon traditional units of measurement, and resort to a pure number.

To be factual ; if we make a ratio of what could be done with what is done, we shall have an index of productivity or effectiveness which is independent of all those factors we wish to exclude from our judgments. This is one example of commensurable fact.

I have described elsewhere in some detail how this may be done ; the point to be made now is simply that it is both desirable and possible to create measures of what is happening which are pure measures, and impervious to special pleading. But it also leads us to consider the fundamental principles of such a technique ; these are important because they are common to most operational research.

The Isomorphic Model.—It is in fact the routine procedure in operational research to construct a model of the situation that is being examined. I use the word " model " as a piece of scientific jargon. The operational research model is not necessarily a mechanical one (although it may be) ; very often it is mathematical. The essential feature of the model is that it should be isomorphic with the situation it seeks to describe. I introduce this technical term, because there is no effective synonym ; " isomorphic " means " having the same shape or form." The model is really a hypothesis about the way a situation operates ; the model becomes more and more isomorphic with the situation as more and more real-life characteristics are built into it. In the limit, the isomorphic model will behave exactly as the real-life situation behaves ; it can then be used to predict how real life will react to a set of hypothetical conditions.

The advantages of a model are basically two. First, it is possible to predict what will happen in given conditions without putting these conditions into effect in real life—and possibly going bankrupt. Secondly, the model ought to be much more easy to manipulate than the situation it describes ; it is usually possible to obtain a prediction from the model in a day which would take perhaps a year to evaluate on the shop floor.

Now all this is, you may feel, no more than a method of research widely used by technologists, who try out their ideas on a laboratory scale. In principle, this is precisely the case. However, whereas it may be possible to try out a large scale industrial pharmaceutical process on a small laboratory trial using retorts and glass tubing, it is by no means easy to think of an appropriate model to simulate such a characteristic feature of industrial life as the breakdown of plant. It is in the creation of models for situations which are not amenable to normal scientific description that operational research specialises.

The basic tool is that of analogy. We shall try to recognise in the situation we seek to describe the operation of some natural " law " already familiar to science in some other field. And it is likely that the expression of this " law " (which is to say the chief characteristics of its working) will be known to science in mathematical terms. A mathematical formulation is then available as the basis for the model we wish to construct. The final task is to adjust the model towards isomorphism with the target situation.

It has seemed right to make the specialised meaning of this word " model " as clear as possible, because it will occur continually in this paper. For the moment, however, let us consider a model of the simplest possible form. Here is one set out to give the productivity, as a pure number, of several coils of steel strip which are being made thinner by their passage through a cold-rolling mill.

The total weight of these coils in pound (w) is divided by the density (d) of steel and the cross-sectional area ($b \times g$) of the strip. Having thus obtained the length of the material in feet, we shall divide it by the speed of the machine (v) : this is the time it will take to pass the batch of coils through the machine once. This result will be multiplied by the number of passes (p) through the machine required to do the job. If there is a certain handling time (h) associated with each pass, this time duly multiplied by the number of passes (p) and the number of coils (c) must be added. Thus we reach as a model of the objective time it will take to do a given job the simple formula :

$$t_0 = p\left\{\frac{w}{12\,dbgv}\right\} + chp.$$

This model will be isomorphic with the shop floor situation insofar as the factors which comprise it can be measured with accuracy. Some of the factors, like density, are physical constants ; others, like the number of passes, may well require statistical research for their proper estimation. The productivity model is now completed, according to the idea previously advanced that the effectiveness of the process can be measured as a ratio of the calculated to the actual time consumed. This gives :

$$P = \frac{100 t_0}{t_a}$$

where the actual time in the denominator has been obtained from an accurate shop floor record.

I again emphasise that this model is no more than a straightforward formula, and not one of the class of models developed by analogy with another science. But it does offer a concrete example of a model in which the effects (in this case on productivity) of varying certain components of the situation can be evaluated, and it does give point to the general case for measures of fact which are independent of the job-to-job variables involved.

The Notion of Probability.—Having dealt with some of the key ideas behind an operational research measure, I must turn to a second fundamental notion. This is the idea of variability. Suppose that we do obtain a real-life measure of some kind, and that we get the answer 48. Now this is something very definite ; it looks clear and distinct, it sounds crisp and scientific. It is nothing of the kind. Such a number normally has two kinds of uncertainty attaching to it. First, there is probably error in its calculation ; the sort of thing we are really entitled to say is that the answer is plus or minus (say) 2. Secondly, this is either a solitary measure, or the average of a group of such measures. In either case, our answer 48, is probably (quite apart from the error involved) simply one of a number of estimates we might have obtained, had we taken a few more instances, or done our measuring on another day.

You will see how the comforting solidity of our " 48 " collapses under scrutiny. The real truth is something we never apprehend ; it is always lurking elusively behind the measures we are able to take. Looked at like this, our answers are no longer seen as sharp points on a scale, but as areas, perhaps of considerable size, in which the point probably lies. We could shade in the area like a contour map ; the shading would be light around the edges, where the truth is least likely to lie, and darkest somewhere near the centre, where the truth is most likely to be found. In short, any figures we use in calculations are labelled with a certain degree of probability—and we would be wise to find out what that is.

Picture one of these zones of probability like a contour map, and consider how it might be described. The scale on which we are trying to read our answer runs straight through it ; let us treat this as we would treat a contour map, and produce a " profile "

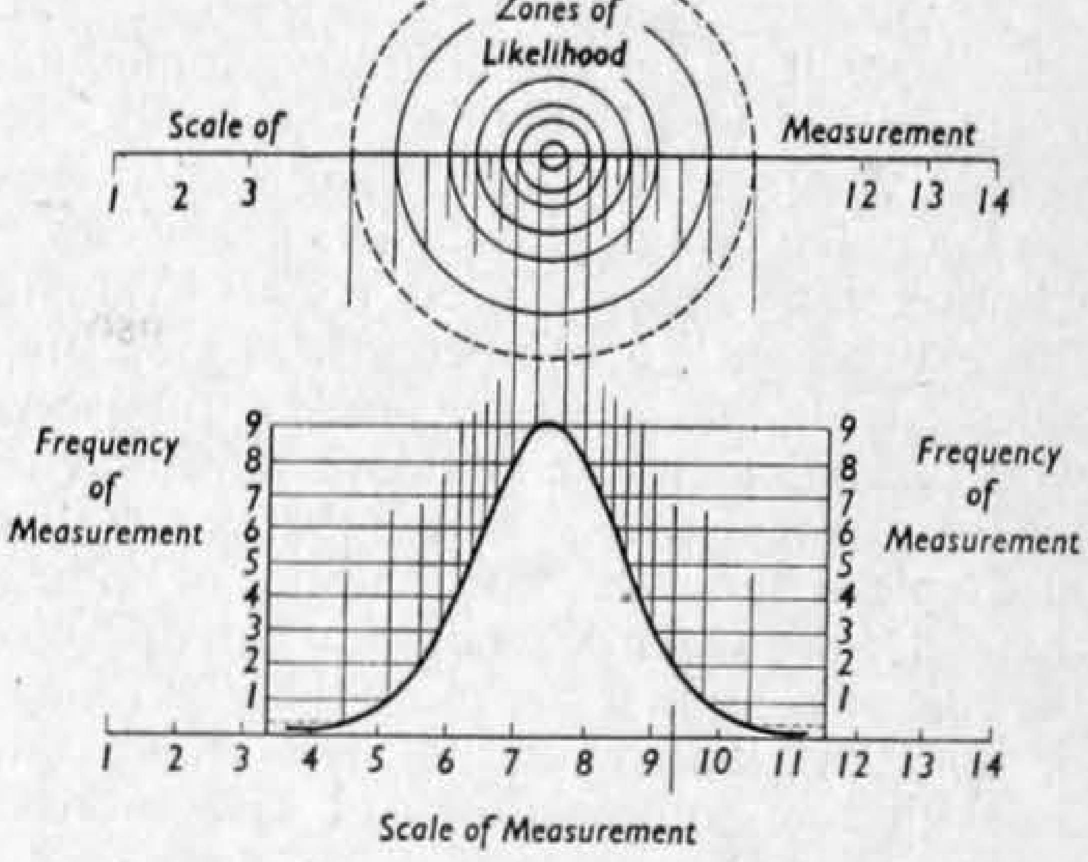


Fig. 1

of the topography. The result would look something like Fig. 1.

The " contour lines " represent degrees of probability. The most probable point, at the centre of the concentric contours, is " the top of the hill "—that is, the maximum likelihood. Alternatively, the circles can be thought of as a target board ; the practised player will tend to hit the centre and nearby most of the time ; " outers " will occur with low frequency. A diagram such as that drawn is called a probability distribution.

" Probability is the very guide of life," so remarked Cicero, who was not acquainted with modern industry. The fact is, however, that probability is certainly our best guide to the description and control of industrial processes. Thus the theory of probability has become the calculus of operational research.

Here we move on to difficult but firm ground. Fortunately, it is not necessary for us to draw little contour maps of all our situations. Mathematical statisticians have developed a vast corpus of theoretical knowledge about probability distributions on which we can draw. There are many classes of " hill " of the kind drawn above, many of which are not even symmetrical, and we are able to express these curves mathematically. A moment's reflection will show that the total area lying under one of these curves represents 100 per cent probability ; that is, our answer must lie somewhere within that area (bearing in mind that the ends of the curve never quite reach the base line). Thus, if we want a measure of the precise probability of exceeding any particular value on the scale, all we are asking for is the proportion of the total area under the probability curve which occurs to the right of a vertical line drawn at that point on the scale. Since we know the mathematical expression for the curve, we can obtain a precise measure of probability by differentiating between the limits of the value in which we are interested and infinity.

How does this measure look, and how do we handle it in practice ? Suppose that it would be useful to know the probability of finding a steel bar more than 20ft long out of a batch whose average length is 19ft. Plotting the frequency distribution of the lengths over a sample of bars would yield a probability curve ; this would be likely to have the shape of the one just drawn. That is, it would be of Gaussian form, which is often called the normal curve. The measurement required is the proportion of the area in the right-hand " tail," when the tail is cut off at 20ft. This proportion is given mathematically as :

$$\Phi(x)=\frac{1}{\sqrt{2\pi}\sigma}\int_{20}^{\infty}e^{-(x-\mu)^2/2\sigma^2}dx.$$

I mention this for people who have the vague idea that a normal curve is something imprecise that looks like a cocked hat. Obviously it is, on the contrary, something scientific and clearly defined. Secondly, for people who are convinced that statisticians always make things as difficult as they can, I mention that nobody need try to evaluate this expression ; a competent textbook provides a table that gives the answer to anyone who can calculate the standard deviation of his list of bar lengths. Doing that is a matter of simple arithmetic. For the price of finding this out, a manager or technician can discover the risk of passing a bar more than 20ft long, or for that matter one of less than 18ft. This kind of information can save money. Unnecessary inspection may be eliminated ; the setting of a saw may be adjusted to cut out waste ; the need for more accurate shearing may be uncovered.

With this simple but thought-provoking example of the use of probability theory, I end my list of the basic ideas behind operational research methods. We look at situations through the analogy of an isomorphic model ; we seek to make our measures of fact commensurable within this frame of reference ; and we handle our facts, which we know to be both sacred and imprecise, in terms of their probability.

The Control and Use of Measures

Statistical Control.—If we can create a satisfactory measure of something that appears to be insusceptible to measurement, we have taken a first and vital step. Colloquially, when a difficult situation has been mastered, we speak of " having its measure " ; there is wisdom in that phrase. But too many studies of situations, and too many managerial exercises, treat the obtaining of a measure as the climax and conclusion of understanding. A sheet of good data does not confer on its possessor magic powers over the situation it defines. Measurements are important because they breathe the life of quantity into an inert model. People who act on their first reactions to these data must in reality be assuming some sort of model in the back of their minds ; it is probably a very bad model indeed.

For example : suppose a manager to be confronted with a cost sheet that shows a deviation from standard (or average) cost of £5. Suppose that he is then galvanised into action, and begins an extensive post mortem into this manufacturing loss. Why does he do this ? He does it on the basis that " £5 is a lot of money." In fact, his model derives from his own personal economy ; were £5 missing from his wallet he knows that his reaction would be intense. Another manager, however, might do nothing at all. Why not ? Again, he may well be working on the wrong model. In the back of his mind something is saying : " this company has a turnover of £Xm per annum ; what is another £5 ? " Neither of these approaches is right ; the proper criterion of the seriousness of this particular loss is the variability of the cost natural to the process on which the loss was incurred.

Suppose that the average cost of this process is £100. If, due to the variability of the process, that average stands for a series of results varying apparently indiscriminately between £50 and £150, then it is virtually meaningless to talk about a discrepancy from average of £5. The first manager mentioned is not only wasting his time but the firm's money : his post mortem might well cost the company £50 in time and lost production. On the other hand, the natural variation of the £100 average cost might well be from £97 to £103. In this case the reported discrepancy of £5 is clearly of vital importance ; this is not because it threatens the company with bankruptcy, but because it means that the process is in some sense out of control. The manager who ignores this signal may eventually lose a more serious sum of money. The moral of this parable may be that the use of averages is dangerous, which is true. But the real answer to the problem is to set these measurements in the right operational research model (rather than some unexpressed subjective model of the man who scans them) and thus to get control of the measures themselves. Once the model is under control, it will be possible to control the real-life situation.

Again, I am placing a simple interpretation on the term " model." Later on, we must interest ourselves in complex models of situations where the inter-action of a number of casual networks has to be taken into account. But if that is the final model, we must first consider the sub-model for an individual measurement. This, as the parable indicated, is its natural variation. Now the variation itself has a " shape." It may be considered as a probability distribution. After all, if a quantity normally varies between 50 and 150 the probability of the occurrence of these extreme values is obviously likely to be low, whereas values around the 100 mark might be expected to occur with greater frequency. A statistician can readily determine the mathematical function which describes the variability of a particular measurement. For reasons explained in the last section, this means that he can quote with accuracy the probability attaching to any particular value. Let him now determine two points, one on either side of the average value, such that there is one chance in twenty that this value will fall still farther away from the average. These two values are known as confidence limits. That is to say, if a value is discovered which lies between these two points it can cheerfully be regarded as " belonging " to the population of values appropriate to this particular measurement. To regard a value which falls outside either of these points as " normal," is to accept odds of at least twenty to one against. This particular confidence level is arbitrary ; but most people would be prepared to agree that odds like this are too long. If a value comes along at this level of risk, it is suspect. We have now got a useful model. In the light of this, that £5 discrepancy will appear (as it should) as insignificant in the one case, and as significant in the other. (That word " significant " is a technical term in statistics ; it means that a value has occurred which cannot be attributed to chance variation.)

Many people will by now have realised that I am talking about something which is quite familiar to them : statistical quality control. I have had two reasons for not admitting this before now, and for developing the argument in the way I have. First, it is often supposed that statistical control can in fact only be applied to assist in the maintenance of quality in a product. Many will have seen it applied, for instance, to a key dimension on a piece which is being machined ; here the object is to keep the machine setting within acceptable bounds. But the methods can be applied to any measurement whatever. Secondly, because statistical quality control has been made easy to apply by the provision of special tables and charts, some people have come to accept it (or not) as " something that worked (or did not)." My object has been to expound, not the statistical theory which can be obtained from any elementary textbook, but the underlying and surely quite sensible principles behind the technique.

Managerial Controls.—To those who feel that it is condescending to devote so much time to this elementary explanation of something they might regard as well-known, I would like to put a question. Why, then, is this technique so little used ? I would like now to make a plea for the extensive adoption of statistical control of this type, not so much on the shop floor as by management itself.

The comparatively recent creation of management as a subject of study has led to a much wider understanding of the class of measurement it is proper to collect, and of the importance of accuracy and speed in its presentation. All this has been very much worthwhile. But it has inevitably led to the inundation of management by a sea of figures. Data pour on to the manager's desk : figures relating to production, sales, costs, wages, research, absenteeism, accidents, and so on. The more the message about the vital importance of measurement is propagated, the higher the flood waters rise. The more senior the level of management, the more threatening does this spate become —despite a certain amount of consolidation of figures as they rise to the very top. (Please note that even this obviously desirable process of consolidation, since it normally works upon averages, is unfortunately constantly swallowing the all-important information about variances.)

Clearly there is a problem here. In the first place, management desperately requires some guide as to what it ought to look at, what is important, what is significant. And, in the second place, there are fortunately still managers who wish they could spare more time from their desks to look and to think. Would not the wholesale adoption of statistical controls provide an answer?

For my example under this heading, I will take that of the productivity indices mentioned above. This is a factual example, and may answer a criticism which might be forming—that, since I feel so keenly about the quantity of information being thrust at management, I should not have advocated more !

Consider a department in which, over a period, some 20,000 machine-jobs have been carried out. The manager of this department obviously requires some measure of the effectiveness of the work. By the use of indices, as previously explained, this difficult assessment can be made relatively easy—by taking all the variables out of the judgment. Is the manager, however, to be faced with 20,000 productivity indices ? The answer is " No."

First of all, we shall build another model. So far, we have a model which facilitates the study of productivity of individual jobs.

The new model will be statistically more complex ; it will indicate the inter-relation of individual jobs, in terms of the common measure that we were at pains to invent. Whereas it would be fatal to attempt a grouping together of this vast amount of data in terms of some conventional breakdown of orders, it is a fascinating operational research job to create the departmental model of the general pattern of productivity disclosed by the measurement of indices. This new model will produce a fairly small number of productivity groups still perfectly amenable to statistical description in terms of probability. In practice, data of the extent and complexity described tend to fall into about eighty such groups.

Secondly, there is an important off-shoot of the scientific study of probability, known as sampling theory. This teaches how to choose a relatively small number of incidents, as representative of the totality. There is no need to go into the details here ; I merely emphasise the mathematical validity of the practice, and point out that by the use of properly instituted sampling techniques all the required information can be obtained by studying perhaps a mere 10 per cent of all the incidents concerned. Thus instead of evaluating indices for 20,000 jobs, only some 2000 need be evaluated—spread over eighty groups.

At this point we invoke the notion of statistical control. The control statistician has to examine the final eighty results. The great majority of these will, naturally, be in control ; that is, they will fall within the confidence limits calculated for the appropriate group. Usually we find that some five or six results are significant ; these are the ones to report to the management.

It is important to realise how far we have now progressed from our original demand for measurement of some kind. Even in the simplified productivity model quoted previously, there were eight major variables. Thus the total information involved in this departmental study of which I am speaking would consist of 20,000 sets of results, to each of which would be appended a list of eight relevant factors. Surely it is fair to say that no living person could comprehend this mass of information, far less gain a genuine understanding of productive effectiveness from it. By the use of operational research techniques, and (to this point) only those of a most elementary kind, all this is scientifically digested. The manager finally receives all that he wants to know on a single sheet of paper ; he has a statistical guarantee into the bargain, that anything which is not on this piece of paper is behaving within the normal limits of chance variation.

This example is a factual one, as I said, and it has proved perfectly practicable to install this control system as a regular, routine feature of a steelworks management.

Light Alloy Containers for Goods Transport.—A new form of lightweight metal container, designed to provide full protection for goods in transit, which is now being supplied by Tracons, Ltd., Mowden Hall, Darlington, can be folded up for return to the owner's works after use. These containers, in addition to giving a higher degree of protection to goods, are much lighter than equivalent wooden cases. Their use eliminates the wastage normal with expendable cases and when in the folded condition they occupy a relatively small space for transport or storage. They are available in four sizes with inside dimensions from 12in square by 24in long to 24in square by 50in long. Each case is built up of aluminium alloy sheet corrugated to impart the necessary degree of stiffness and fitted with steel corners. No tools are required to assemble the containers as the sides are hinged and held in position by simple retaining clips. The lid clips shut and can be locked or sealed to prevent pilfering. The containers can be either purchased or hired from Tracons, Ltd.

Further Notes on the Development of Fairground Machinery

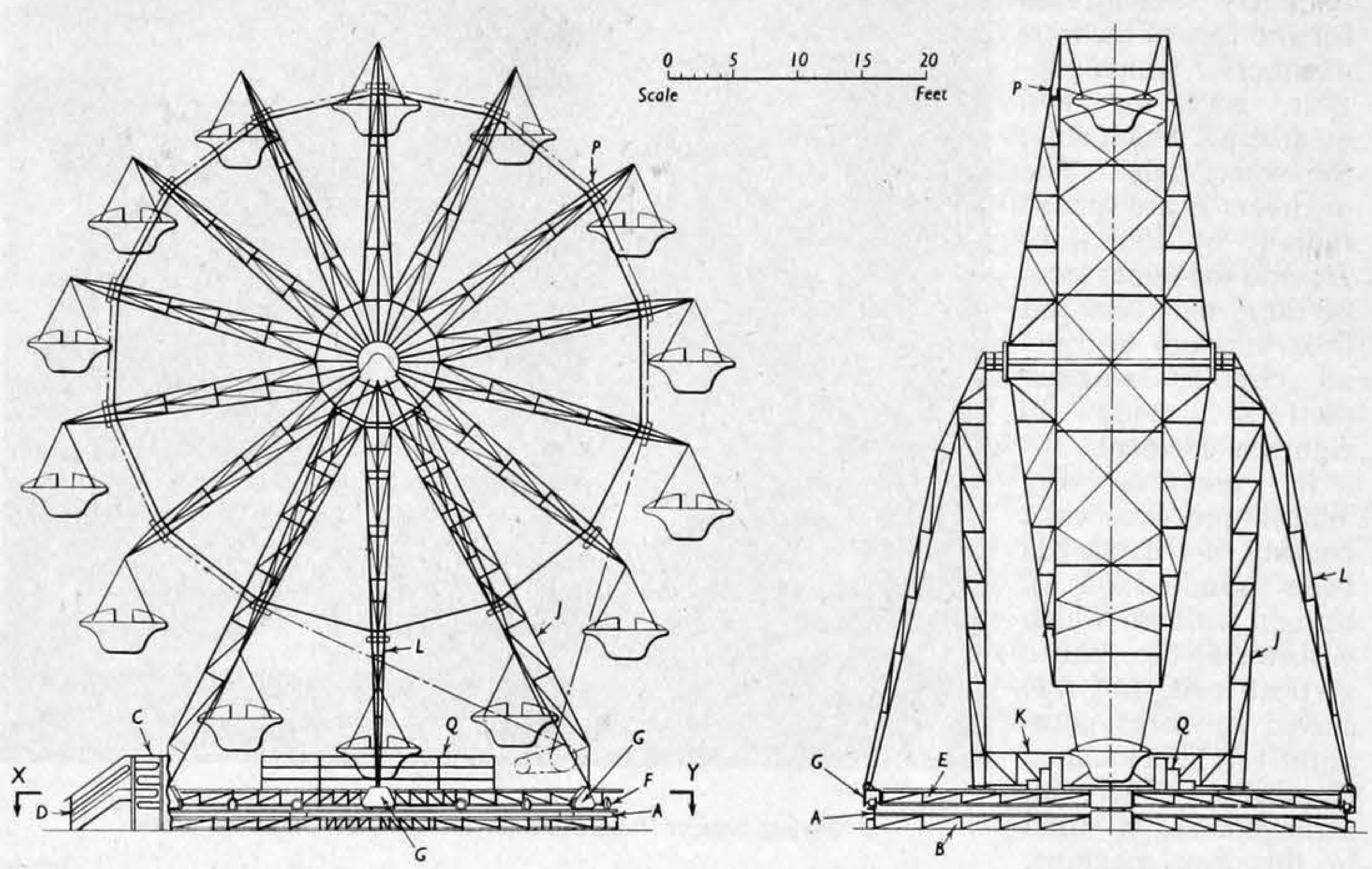
By P. W. BRADLEY

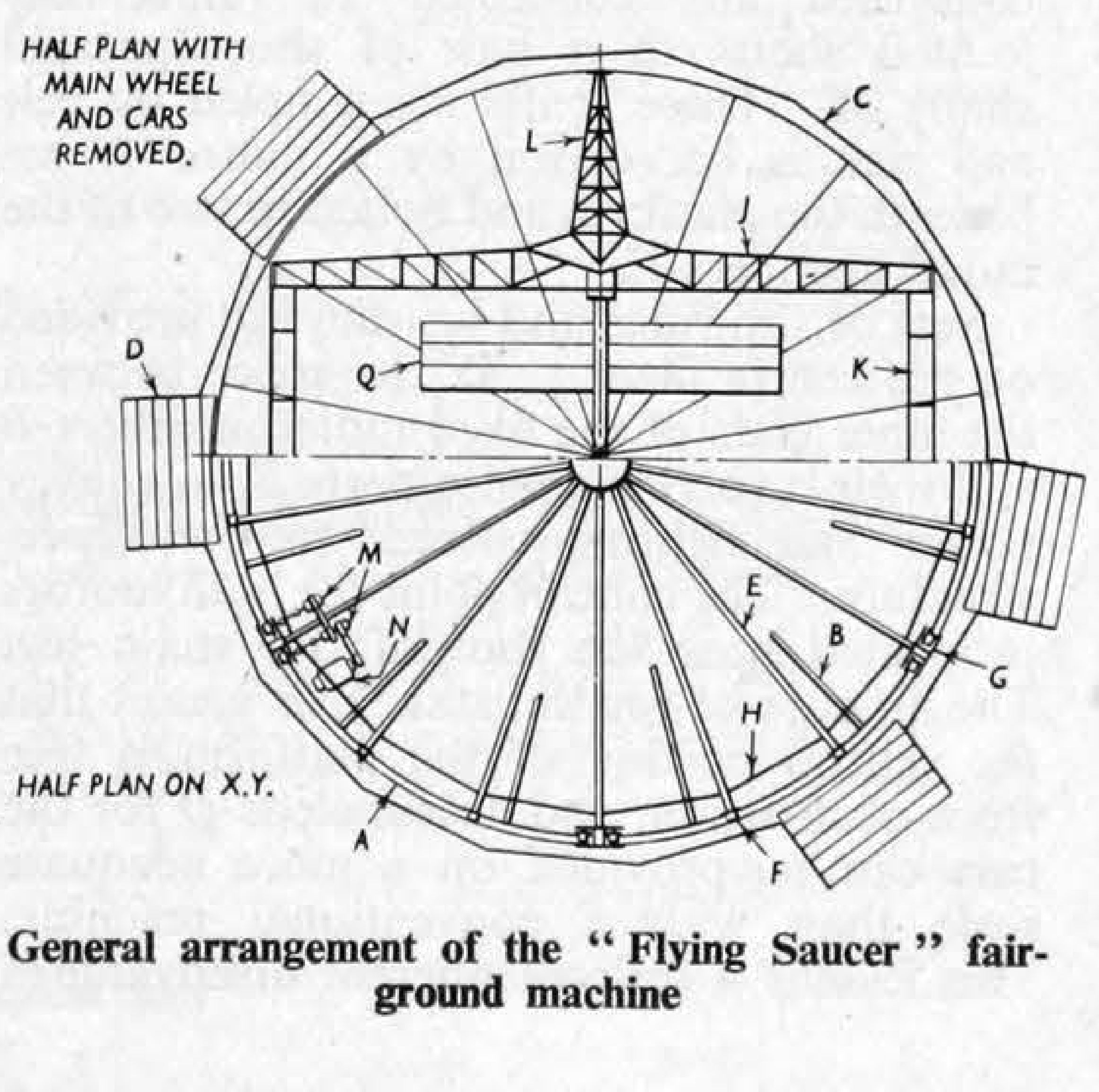
In the series of articles outlining the history of fairground machinery, which appeared in The Engineer in 1954 and 1955, numerous amusement machines were described, but it was seen that the majority amounted to elaborations of the simple roundabout or swing ; generally with supplementary motions derived either from centrifugal or gravitational forces, inclined planes, common cranks, or some combination of these. It was further noted that from the date of the firm establishment of steam power (*circa* 1880), the development tendency over a period of about sixty years lay towards increased complexity of resultant motion.

There have been various offshoots from the main stem of development ; for instance, machines depending on the common crank alone and, later, the important innovation whereby an extensive degree of passenger control was introduced. But the traditional " roundabouts and swings " had a third partner from the outset, namely, the Big Wheel, fundamentally a roundabout with a horizontal instead of a vertical axis. Of the very early invention of this device there is no doubt, evidence being Volume I of *The Travels of Peter Mundy in Europe and Asia*, published by the Hakluyt Society. It is there recorded that in 1620 Mundy (a Cornishman) visited a fair in Philippopolis, where he saw three kinds of riding device, two being crude versions of the roundabout and swing, and the third " . . . like a crane wheel at the Custom House Quay and turned in that manner, whereon children sit on little seats hung round about in several parts thereof, and though it turns right up and down, and that the children are some times on the upper part of the wheel and some times on the lower, yet they always sit upright."

During the era in which steam power reigned supreme on the fairground, the travelling Big Wheel was seldom seen, though there were isolated examples, of very heavy timber construction, including one whose cars were caused to spin about their vertical axes as the wheel revolved, through the agency of pairs of bevel gears. Generally, however, the wheel became a fixed amusement park feature, sometimes on a very large scale. The machine erected in 1894 at the Earls Court Exhibition, for instance, was about 280ft in diameter and seated 1200 riders in its forty carriages.

In the middle 'thirties, smaller wheels of American design, with up to sixteen two-seater cars and of all-metal construction, began to appear in our coastal amusement parks. Later, in the immediate post-war period, the smaller of these (the twelve-car version) became popular as a travelling proposition and as such was described in our issue of August 13, 1954. Since that article was prepared, several operators have eased the moving operation by semi-permanently building the base frame and the lower parts of the standards on a heavy road wagon. Fundamentally, however, the travelling Big Wheel remains as Peter Mundy saw it.





General arrangement of the " Flying Saucer " fairground machine

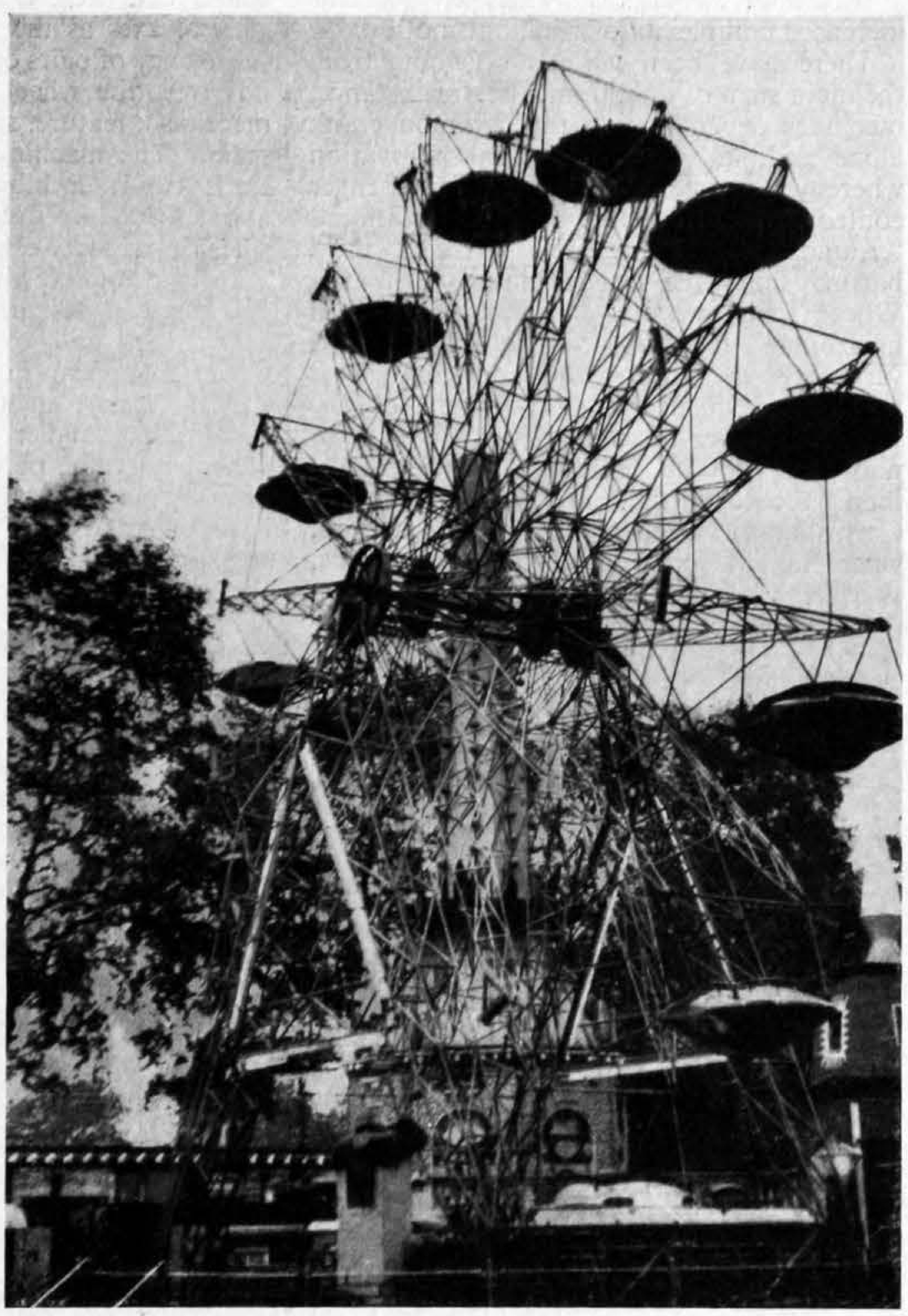
During August, 1956, however, the British Isles saw for the first time a device which may well mark a new " Big Wheel " era for our fairgrounds. It was brought over from France and erected for the last few weeks of the Battersea Park season ; it consists of a Big Wheel mounted on a large roller-bearing turntable. The resultant of the two continuous rotations is quite unlike the motion of any known previous amusement machine in being spherical. The device therefore represents a definite advance in fairground engineering design. In accordance with modern practice, welded tubular construction is extensively employed, and other components are of pressed steel. Timber is utilised only in the circular loading platform and steps.

The example seen in Battersea Park, which is illustrated on this page, has fourteen cars, each seating four persons. The diameter of the wheel is about 50ft and its axis is about 36ft above ground level. The diameter of the base turntable also is about 36ft. The accompanying drawing shows the basic construction of the machine. The fixed base comprises a circular channel girder rail *A*, in five sections fishplated together, carried on the stepped ends of twelve radial members *B*, and between them, packed from the ground at frequent intervals. It is surrounded by a series of fencing sections *C* with, in four places, breaks for step sections *D*. Contrary to usual amusement machine practice, a fixed annular walkway is not provided.

The revolving superstructure is mounted on eighteen members *E* which radiate from the central hub. Twelve of these members carry at their outer end a single flanged roller *F* running on the circular rail *A*. To the outer ends of the remaining six (which are equidistant) are secured plate assemblies *G* which accommodate bearings for similar flanged rollers, but arranged in pairs. The six assemblies extend upwards to carry anchorages for the feet of the four members *J* which support, and the two members *L* which stay, the wheel axle. The members *E* are spaced radially by light links *H*; and the upper faces of these members and links support an overall circular wooden platform made in eighteen segments.

In previous Big Wheel practice, each bearing of the axle has been mounted on an upright column which withstood the entire vertical load, and was stayed by three comparatively light inclined members. Such an arrangement, if used in this new machine, would have demanded a second set of rollers running on a circular track within the one already described; these rollers and their track being capable of carrying the weight of the wheel and standards concentrated at two points. This arrangement has been avoided by eliminating vertical standards altogether, and instead, supporting the axle by four inclined members *J* with their feet pin-jointed to four of the roller plate assemblies *G*. The structure is rendered completely rigid by two members *K* (which locate the feet of the main legs *J* and obviate undue stress on the links *H*), and a pair of inclined stays *L* having their feet pinned to the two remaining roller plate assemblies. It will be seen that every section of the revolving superstructure which supports any load beyond platform sections has two rollers. All the principal structural members are of welded tubular construction, adequately braced and with plated extremities where necessary. The main inclined members *J* are of tapering rectangular section, while the stays *L* and the twenty-eight spokes of the wheel itself are of tapered triangular section.

The wheel is turned about its horizontal axis by normal "Big Wheel" driving gear; an endless cable passing round deep-grooved carriers *P* on the spokes, the driving pulley and a tensioning pulley. Rotation of the superstructure about the vertical axis is effected by powering a pair of flanged rollers at the foot of one of the four main legs *J*. One-quarter of the weight of the wheel and its supports is therefore utilised for adhesion, and this appears to be adequate; at the same time the simplicity of one-motor drive is retained. The axles of the two rollers concerned are connected by universally jointed shafts to a pair of short parallel shafts *M*. These shafts are coupled by belt and one is belt-driven by a motor *N* set beneath the platform and bolted to two of the radial members *E*.



"Flying Saucer" machine as installed at Battersea Park

Sets of slip-rings and brushes are provided on the centre pivot; in the space between the inner ends of the fixed radial members *B* and their revolving counterparts *E*, to convey power and lighting current to the superstructure. The control point for both motors is located near the foot of one main leg. The absence of vertical standards means that the central portion of the platform is free from obstruction, and access steps *Q* for the cars can be provided on a more adequate scale than with a conventional machine. This lessens a serious inherent disadvantage of all Big Wheel machines, namely, slowness of unloading and loading.

The fourteen cars are circular in plan; and although, as a concession to present-day imaginative taste, they depict "Flying Saucers," they are suspended so as to remain always upright, in precisely the manner of those seen by Peter Mundy over three hundred years ago.

New Roads and Vehicle Taxation

Last week in the "Seven Day Journal," we printed a brief summary, as given by Mr. Watkinson, the Minister of Transport and Civil Aviation, of the achievements up to the present, and of new construction in the immediate future, on the Government's road programme. The British Road Federation's views on the present situation have also recently been expressed, in a letter sent by its chairman, Lord Derwent, to the Chancellor of the Exchequer, Mr. Thorneycroft. The two points of view make an interesting comparison, so we give here some of the main points from Lord Derwent's letter.

The principal statistics demonstrated at a glance, Lord Derwent pointed out, the vast sums levied by taxation on road users, and the meagre amounts expended on capital road works. Between 1951 and 1956, the fuel tax alone yielded £1297 million, vehicle purchase tax £431 million, while a further £433 million was paid in annual vehicle taxes—a total of £2161 million in all. In contrast, between the years 1951 and 1955 (the latest year available), road expenditure by the central Government on new construction and major improvements amounted to less than £17,000,000. Admittedly, he added, expenditure from this source was likely to exceed £50,000,000 in the period from 1955 to 1958, but this total was still derisory in comparison with both the need for better roads and the yield from road user taxation. The Federation asked the Chancellor to give serious consideration to a reduction of fuel tax, which, it was contended, would have the desirable effect of lowering the costs of trade and industry.

The failure of successive Governments since the war, Lord Derwent's letter continued, to provide Britain with an up-to-date road system was one of the unaccountable phenomena of modern times. It was beyond dispute that by all criteria, roads, bridges and tunnels had been starved of finance to an incredible extent, and formidable arrears had accumulated. It was true that in the past year or so there had been some increase, but the pace was too slow and the scale too small, and the forward view too prescribed. The root cause of these unsatisfactory conditions lay in the absence of finance in sufficient volume and continuity. Examples of methods of financing road construction abroad were given to illustrate that point. Lord Derwent also asserted that whatever the conception of a European Free Trade Area might bring forth, modernisation and expansion of the road systems in the proposed participating countries was already proceeding at a pace, and would continue to do so to a measure that would increase still further their competitive power. It was as well to remember that the Road Research Board had commented that the present Government Road Programme was out of scale with the needs and had no hope of even keeping pace with the large increase in the number of vehicles.

Harvesting Machinery for Brown Sub-littoral Seaweeds

By PHILIP JACKSON, M.Sc., M.I.Mech.E., M.I.Chem.E., F.R.S.E. *

No. II—(*Concluded from page 402, March 15th*)

Articles on the harvesting of seaweed were published in this journal in 1947 and 1952. Until recently the research work was done by the Institute of Seaweed Research under Government sponsorship. That sponsorship has now been brought to an end. In this article the author reviews the progress made with two systems of harvesting, one in which the plants are torn by hooks from the sea bed and mechanically elevated to the surface, the other in which the plants are severed from the sea bed and lifted to the surface by entrainment in water. He suggests that both systems are sufficiently advanced for private industry to undertake further development, and indicates directions in which further progress could be made.

Resumed Investigation of the Complete Unit.—The entrainment test conditions differed from those encountered in practice, in that there was no movement of the equipment through the water and consequently no significant flow opposing the entry of plants to the suction inlet. A suction system, on the lines of that used in the static tests, was therefore fitted between an experimental trawl carrying reciprocating cutters at its rear end and a 60ft motor vessel (Fig. 7) to assess its efficacy under the more complex flow conditions associated with actual sea operations. As had been anticipated, very few plants were entrained and although the subsequent incorporation of a slow-speed conveyor between the cutters and suction inlet and modifications to the lead-in to the suction effected some improvement, the proportion of the harvest entrained to the surface was still relatively small. Since the cutting and entrainment systems had already been proved, this could only be attributed to the ineffectiveness of the intake arrangement.

* Until recently deputy director of the Institute of Seaweed Research—now in private practice as a consultant.

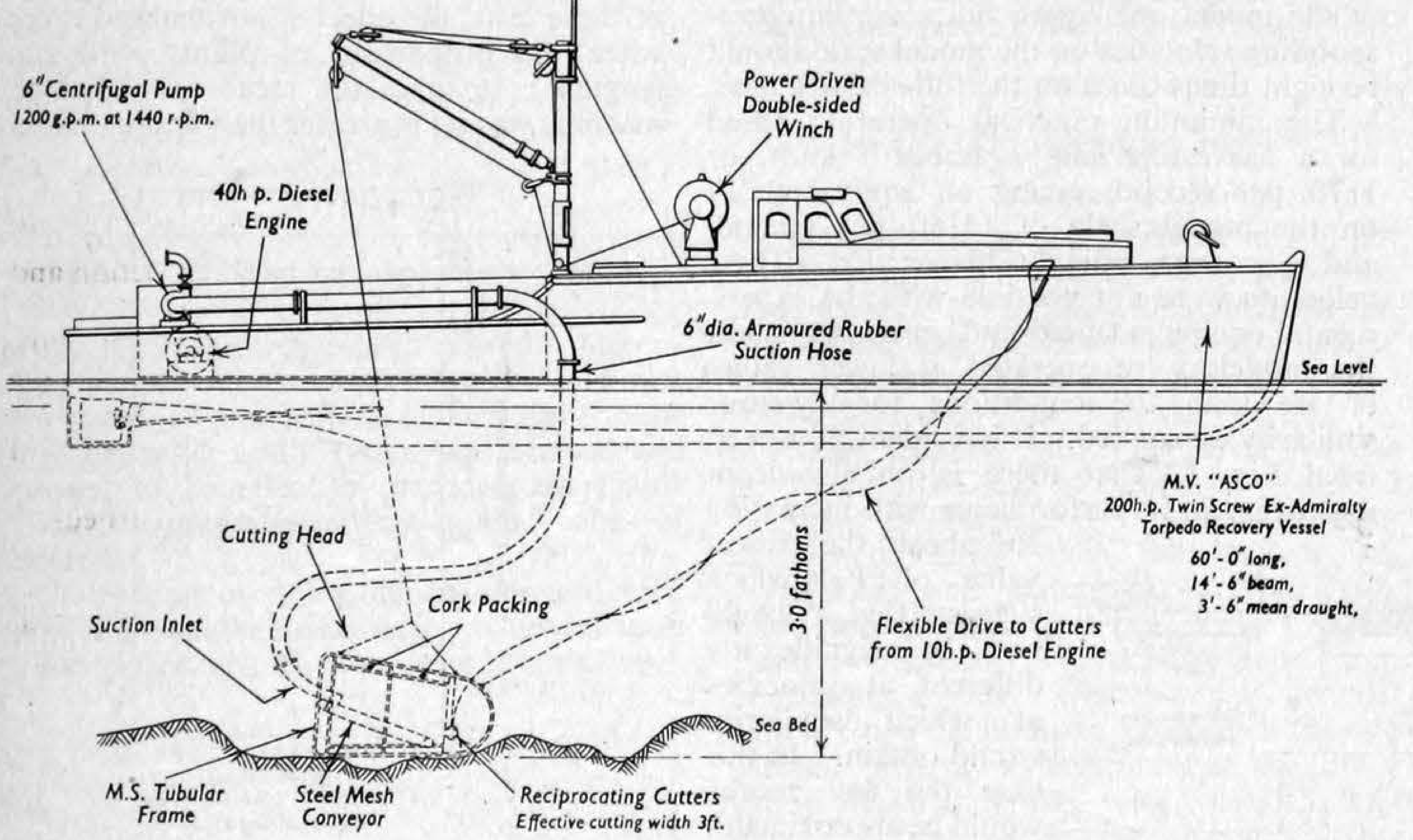


Fig. 7—Experimental suction harvester

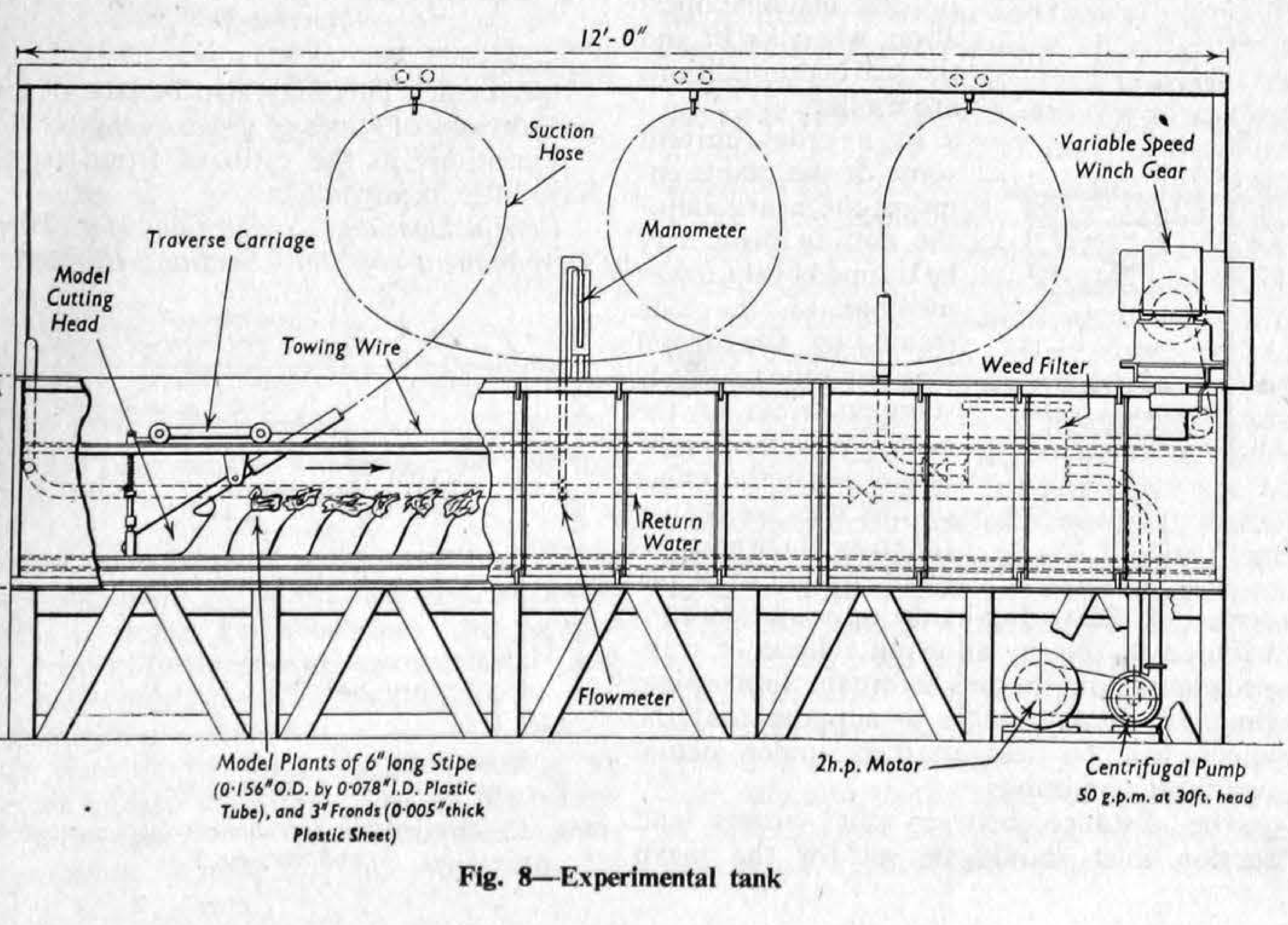


Fig. 8—Experimental tank

It was decided to study this problem in a laboratory tank before proceeding further with expensive and time-consuming experiments at sea.

Model Scale Investigations.—An experimental tank in mild steel with "Perspex" observation panels (Fig. 8) was fitted with a small-scale imitation seaweed bed of plastic plants carried on spring-loaded trip pins and arranged in staggered rows at an equivalent growth density of four to five plants per square yard and a total cover per run of about eighty plants. Short lengths of wool secured to fine cross wires were used to indicate directions of water flow within the models. Since the investigations were concerned only with the entry of plants to the suction system, the mechanism was simplified by fitting an activating bar to the models, which caused the spring pins to retract and release the plants without the use of cutters. The traction arrangement comprised a motor-driven winch gear arranged for automatic de-clutching at the end of the run. The speed of tow and flow of water through the suction inlet were controlled and measured, and the effects of changes in conditions and design features observed and recorded. The results are summarised below.

A new design of cutting head was evolved, which, on the model scale, effected a considerable improvement in the proportion of plants entering the entrainment system. Reference has already been made to the losses caused by tidal flows or cross currents opposing the inflow of water to the suction inlet ; these losses are avoided in the new design by delayed cutting so that the plants remain attached to the sea bed until the frond is near to or in the suction inlet, as shown diagrammatically in Fig. 9 (*a–e*). This also results in improved flow conditions in the cutting head. Previously the water flows had to be controlled to ensure (1) that plants were not deflected prior to cutting, or washed away when cut, by spillage from the front end of the cutting head, and (2) that once in the cutting head they entered the entrainment system ; (1) necessitated an inflow of water considerably in excess of the pump capacity, some of which had to be allowed to escape, and consequently to oppose the flow into the suction system. In the new design the plants enter the cutting head by virtue of their attachment to the sea bed, and it is therefore only necessary to admit that quantity of water which can be dealt with by the pump. Fig. 10 shows the resulting improvement in efficiency.

A few experiments were conducted to determine the optimum height of entry to the cutting head and the most effective shape and size of lead-in to the suction system. Typical results, given in Tables I and II, indicate that variations in height do not have

TABLE I—*Effect of Variation in Height of Entry to Cutting Head*

Height (in)	Entrainment (per cent)
2¼	84
2½	85
3	84
3½	89

TABLE II—*Effect of Variation in Shape and Size of Lead-in to Suction System*

(The various inlets referred to are shown in Fig. 11)

Inlet	Width (in)	Depth (in)	Area (sq. in)	Ratio of inlet to suction pipe areas	Entrainment (per cent)
1	4·5	0·75	3·37	4·3	89·5 80·0
2	4·0	1·12	4·48	5·7	93·0 82·5
3	3·0	1·0	3·0	3·8	74·5 71·1
3*a**	3·0	1·0	3·0	3·8	82·5 75·5

* As 3, but fitted with guides to concentrate the frond nearer to the inlet.

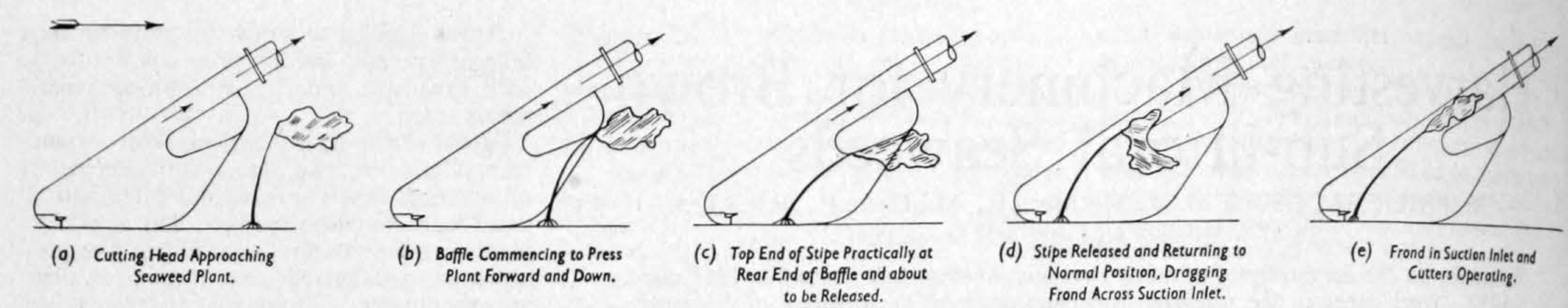


Fig. 9—Diagrammatic representation of operating principle—model cutting head

a marked effect, provided they are within the height of a typical plant stipe, but that the percentage of the total plants entering the suction system is significantly affected by the shape and size of lead-in.

Of even greater significance is the ratio of suction to forward velocities (Vs/Vt). The percentage of the total plants entering the suction inlet decreases with decreasing Vs/Vt, the effect being more marked at the lower values of this ratio, viz. below about $Vs/Vt=6$ (Fig. 12). In Fig. 13 percentage entrainment at constant values of Vs/Vt is plotted against Vs and the Reynolds number (Re). It will be seen that variations in Vs above a critical value have little effect on performance, but below this critical value percentage entrainment falls off rapidly and there is repeated choking of the suction system; the magnitude of Vs critical increases with decreasing Vs/Vt.

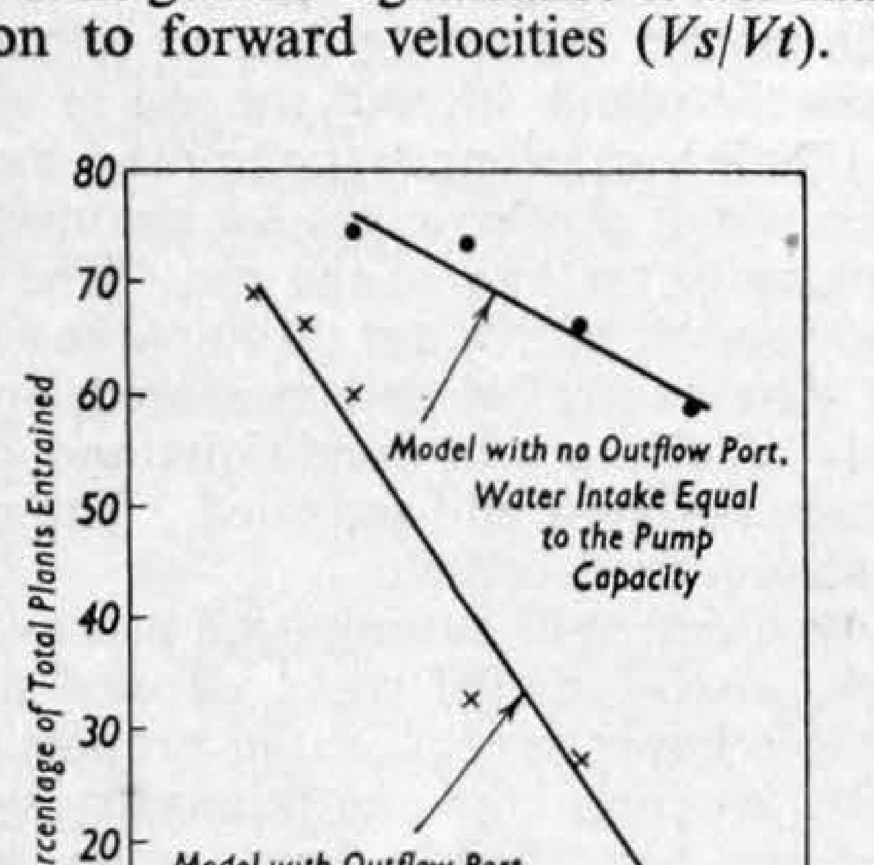


Fig. 10—Effect of outflow port

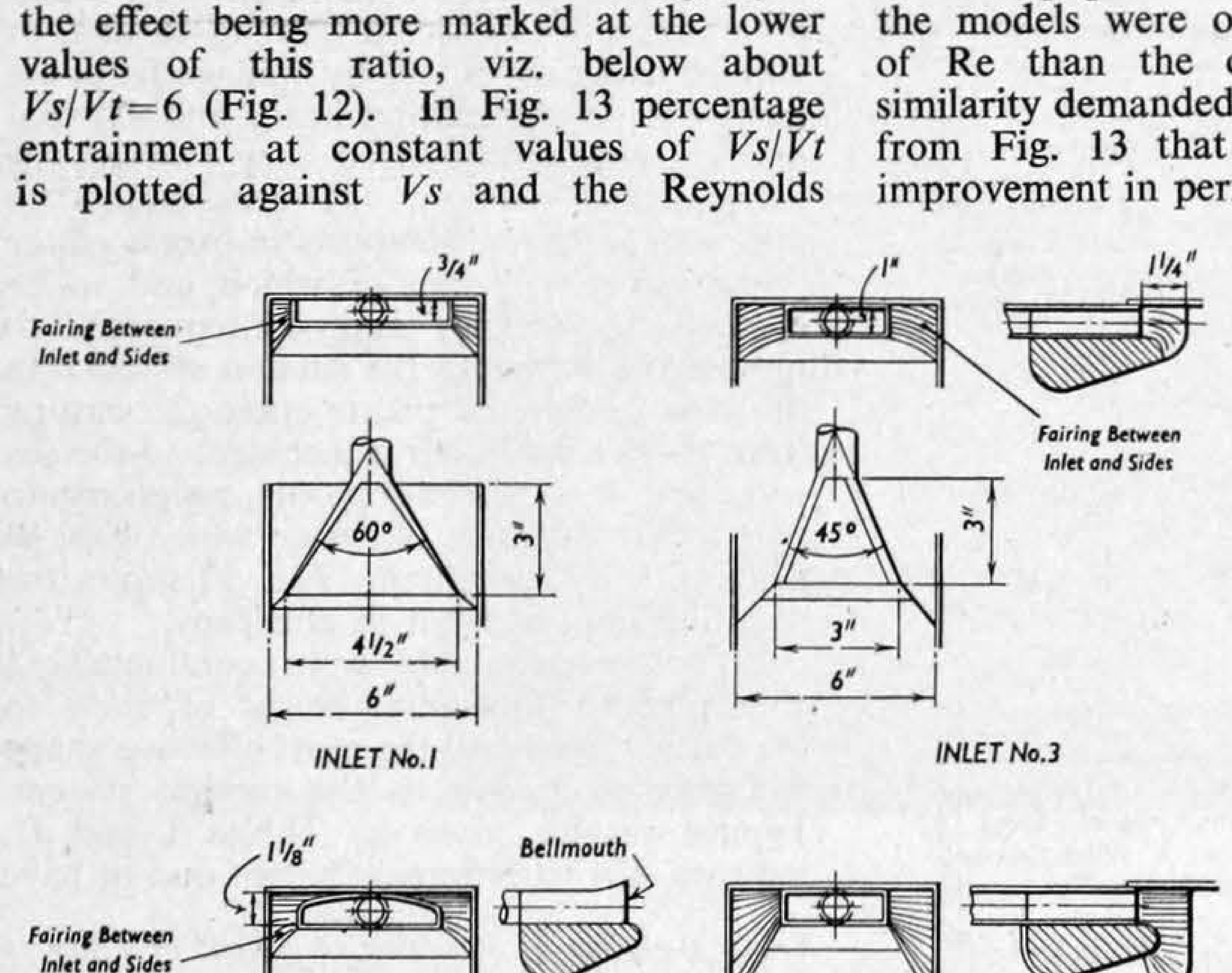


Fig. 11—Forms of suction inlet

Since the effects of gravity and surface tension may be neglected, Re may be used for similarity of flow in the model and prototype, and, since the hydraulic force effecting entry of plants to the suction system is the resultant of forces created by the pump suction and the flow of water relative to forward motion of the model, the ratio Vs/Vt should be identical on both scales. Also, since the density and viscosity of the water are identical and the linear scale of the model one-eighth full size, the corresponding velocities on the model scale should be eight times those on the full-size machine.

The minimum practical operating speed for a harvesting ship is about 1 knot, or 1·7ft per second, giving an equivalent Vt on the model scale of 13·6ft per second, and a correspondingly higher Vs. These velocities were not possible with the experimental equipment used and, in consequence, the models were operated at lower values of Re than the conditions for dynamic similarity demanded. It is evident, however, from Fig. 13 that there is no significant improvement in performance with increasing Re above the critical value of Vs, which suggests that it would not be significantly different at velocities at which similarity would obtain. In this case the test results would be approximately representative of full-size machine operation, when Vs/Vt and the sea bed conditions are similar.

In a cross current some of the plants entering the near side of the cutting head may be trapped by the lower member of the side frame or the frond may enter the relatively stagnant areas at the near-side wall. On the model scale the effect of this was to reduce the percentage entrainment by about 8 per cent, but the spring-loaded pin system contributed to this by allowing release of trapped plants from the pins before the appropriate time. It is reasonable to suppose that the effect will be less marked under actual operating conditions.

The distance between the cutters and suction inlet should be set for the mean plant size to be slightly greater than the length of stipe. Plants with stipes 25 per cent shorter than the mean increase the critical Vs from about 9ft per second to 12ft per second (Fig. 14), whereas with longer plants the performance is adversely affected at all values of Vs. Typical results with mixtures of various stipe lengths l are given in Table III :

TABLE III—*Effect of Mixed Plant Lengths*

Vs, ft/sec	Vt, ft/sec	Vs/Vt	l (in)	Proportions of stipe lengths (per cent)				Entrainment (per cent)
				1·0l	1·16l	0·8l	0·6l	
12·3	1·5	8·2	7·50	10	—	80	10	96
12·3	1·5	8·2	7·50	30	—	45	25	92
12·3	1·5	8·2	6·25	90	10	—	—	95
12·3	1·5	8·2	6·25	80	20	—	—	82

It will be seen that, under the conditions of these tests, the effect is not marked except when the proportion of plants with stipe lengths 1·16 times the mean for which the machine was set is greater than approximately 15 per cent. This may also be true of lesser proportions of stipes of greater length.

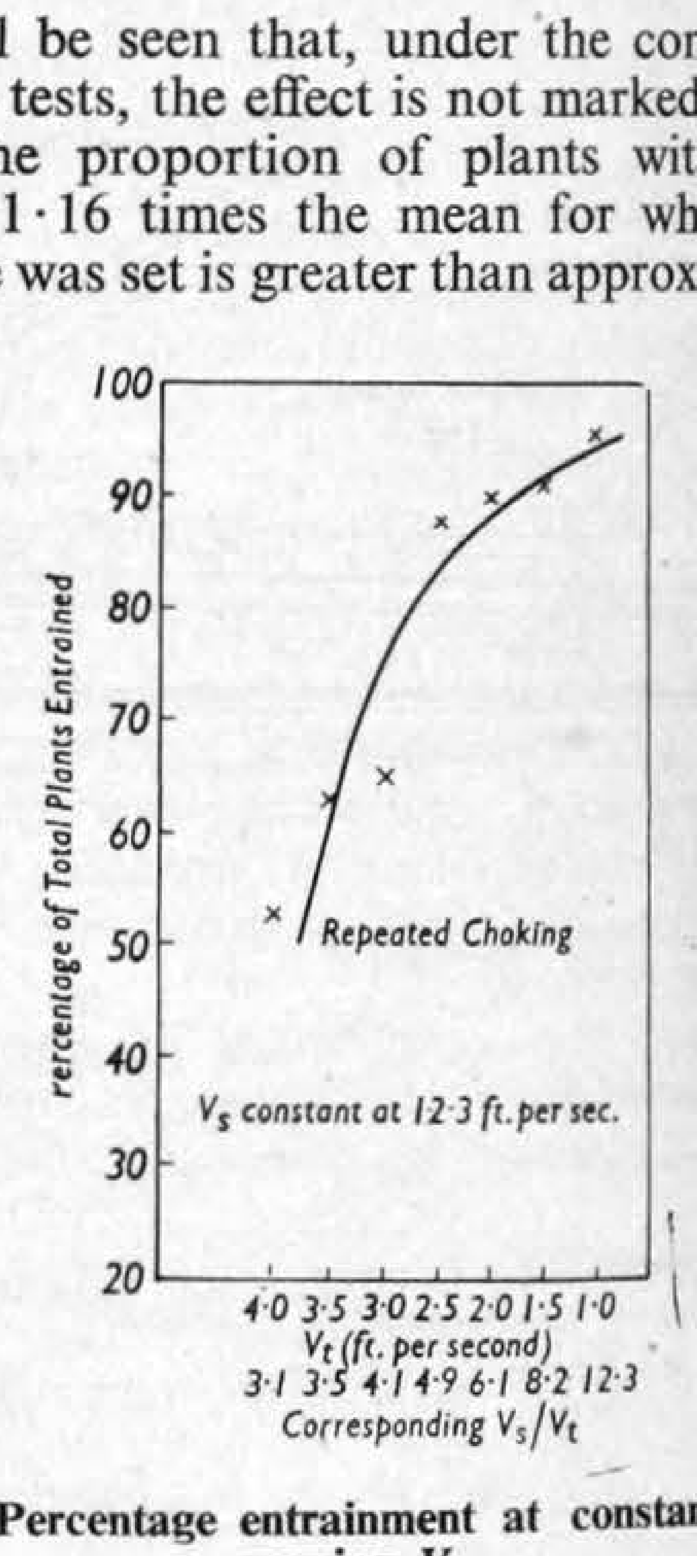


Fig. 12—Percentage entrainment at constant V_s and varying V_t

Variations in the ratio of frond to stipe have little, if any, effect.

Conclusions and Suggestions for Further Development of the Suction Harvester.—

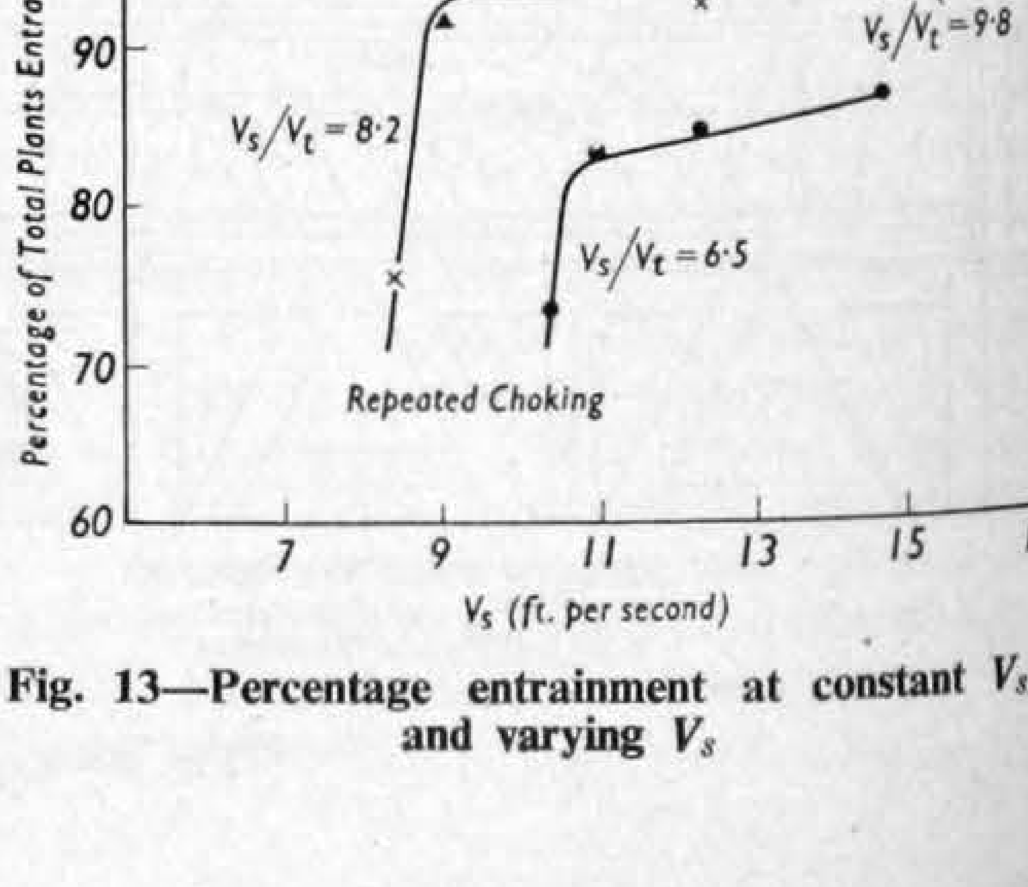


Fig. 13—Percentage entrainment at constant V_s/V_t and varying V_s

Although the development of the suction harvester has not been carried as far as the belt harvester, significant progress has been made.

Agricultural reaper type cutters, suitably protected against damage and seaweed draping, have been proved to be efficient, reliable and of reasonable capacity under actual operating conditions. Work on the entrainment system was complicated by the need to guide the plants to the suction inlet before the problem of how this was to be

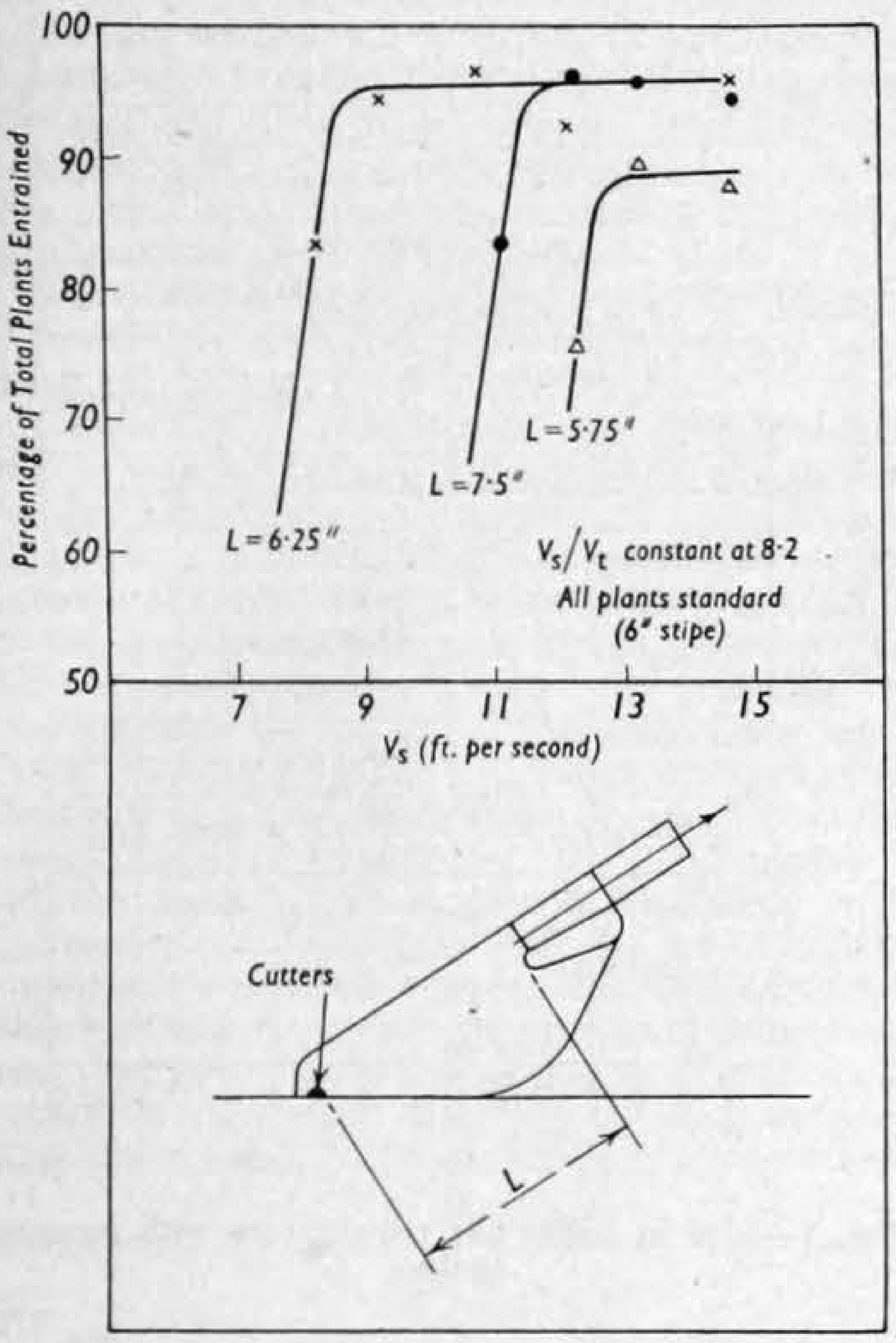


Fig. 14—Effect of variations in plant length

done in practice had been solved. Experiments were, in the first instance, therefore restricted to conditions of relatively static ambient water and a system was evolved and proved to be effective provided the plants could be presented within a few inches of the inlet.

A method of doing this was investigated and has now been proved on a model scale under ideal test conditions. In this work

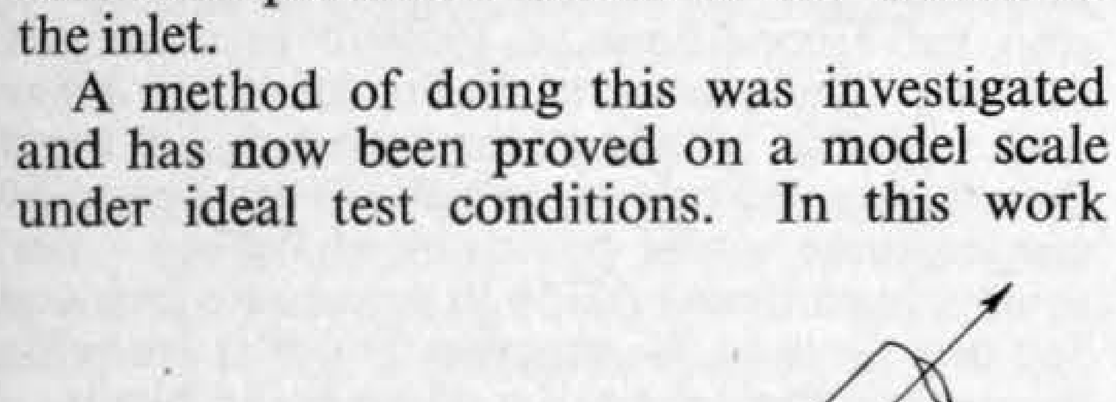


Fig. 15—Diagrammatic arrangement of shortened cutting head

tests were conducted at lower values of Re than would obtain in practice and, although there is some evidence that this is not important, further work is essential before the behaviour of the prototype can be predicted with confidence.

It remains to determine the scaling up factors and to investigate further the effects of such factors as (i) continuous versus intermittent operation, (ii) variations in plant length, (iii) irregularity of the sea bed, and (iv) tidal flows or relatively static water.

The provision of some form of mechanical assistance in guiding the plants to the suction inlet may overcome the difficulties occasioned by (i) and (ii) above by ensuring that the cut plants enter the suction inlet zone irrespective of their length. This could possibly be achieved by a finned drum or flail, mounted below the suction inlet as shown diagrammatically in Fig. 15 and by shortening the distance between the latter and the cutters to suit the shortest plant likely to be encountered.

The important effect of (iii) is that in some areas it causes a proportion of the plants to be cut at a greater distance above the holdfast than when operating on a level bed and the capacity of the unit is reduced. Under these conditions a belt harvester may well be more economic, but the effect should be investigated on a model scale and the economics of operation of the two types compared.

On the whole, and providing the outstanding problems can, in fact, be solved, the suction machine will have a number of important advantages over the belt machine.

ACKNOWLEDGMENTS

This work forms part of a programme of research and development on seaweed undertaken by the Institute of Seaweed Research to whom the author is indebted for permission to publish. The experiments on the model scale were conducted by Mr. R. Wolff.

On the Shipbuilding Strike

(Contributed)

LAST week a leading article in one of the London daily newspapers concluded with these words : " The need for modernisation in the attitudes of both sides is glaring." It is very true and those—on either side—whose thinking has become warped by obsession with the past, are not fit persons for steering the ship of industry. No good can come of everlastingly churning-up recollections of times when the worker was overworked and underpaid. It is many years since the then chairman of the General Electric Company, U.S.A., remarked that in industry to-day " what we need to deal with are not the limits to which men may go without physical exhaustion but the limits within which they may work with zest and spirit and pride of accomplishment." This is not socialism but sheer common sense well recognised by all those who have any acquaintance with civilised industry. Productiveness is the product of co-operation, which has been well defined as "a dovetailing of activities so that the good of all may not become subordinate to the irrationality of one." Those who continually utter effete catchwords or employ obsolete arguments are nothing other than obstructionists and should be completely discredited as incapable of effective leadership. They are, indeed, promoters not of industry but of animosity, a vice which has no place in a civilised community and no roots in the hearts of honest men. The merchants of animosity are not the only promoters of industrial disease. The Greeks had a fable in which there figured an individual named Callipide whose peculiarity it was that while keeping on running he made no headway. There are too many Callipides among us to-day and that they find their way into industry and politics is a reflection on those who take them seriously.

In addition to the need for modernisation of outlook there is also need for moderation of outlook. It is so much easier to talk than to think and great harm is done to their constituents by those leaders who forget the wise advice of Thomas Jefferson that when angry, a man should count ten before speaking. If very angry, he should count a hundred. Controversialists of all schools ought to have this advice by heart and to remember (as the wisest among them do) that against scurrility, counter-scurrility is useless. Offensiveness is always the mark of the second-rate controversialist and in the final result it proves to be a boomerang recoiling upon him who launched it. We can all remember expressions which, used by prominent politicians have, in but a word or two, inflicted sore injury not only on their reputation but on their cause. Had they remembered Jefferson's wise rule and acted accordingly, they would have spared themselves irreparable damage. An example of such foolishness was the threat reported to have been uttered a few days ago by a prominent trade union leader who called for " Hard cash or we strike ! " This is just violence detonated by anger and when accompanied by a refusal to arbitrate suggests a weak cause. Menaces, being among the tools of tyranny, are never an indication of strength. The very word " strike," as applied to an industrial dispute, should be quite obsolete in the conditions of industry which prevail to-day. The same is equally true of the word " lock-out " and surely with the collective intelligence of the organisations set up by both sides and in view, also, of the world conditions manifest to every citizen such things as menaces should by now be utterly discredited. Indeed, could there be a more tragic absurdity than to suppose that a gigantic strike can, under to-day's circumstances, be productive of benefits to anyone ?

There remains, of course, the fact that with the prodigious growth in the size of industrial units, whether nationalised or operated by free enterprise, the humanistic spirit tends to be submerged if not extinguished. British people in general are quick to recognise the quality of leadership. Of this quality one of the manifest signs lies in the ability of a true leader—whether he be at the top level or among the invaluable N.C.O.s of industry—to comprehend how industrial troubles, like other evils in life, have their rise " from somewhat which was thought of too little importance to be attended to." Management teaching is a theme so worked on to-day that it seems surprising that its fruits ripen so slowly. They would ripen quicker were it possible to use a supersonic test which would disclose cracks in men just as such a test will disclose cracks in material. Surely the premonitory creak in machinery calls not more urgently for attention than the premonitory creak in human relations, and it is in industries where the human aspect of management has either vanished altogether or ceased to have influence that the greatest troubles may be expected. The bigger the size of the organisation the more sensitive will it be to the lack of that co-operation which cannot flourish in the absence of good human relations. This applies to every form of industry and until the requisite constituents are available we cannot hope to be free from those conflicts which damage not only all concerned in them but the nation at large. It may be asked what quality in particular is necessary in those upon whom should fall the responsibility for leadership. An answer to this question was given long since by William Pitt on an occasion when conversation arose as to the quality most needed in a Prime Minister : " While one said Eloquence and Knowledge and another Toil, Pitt said ' Patience.' "

The Future for Nuclear Power

By SIR CHRISTOPHER HINTON, K.B.E., F.R.S.

The Axel Ax:son Johnson Lecture of the Ingeniörs Vetenskaps Akademien (The Royal Swedish Academy of Engineering Sciences) was given in Stockholm on March 15 by Sir Christopher Hinton, managing director of the Industrial Group, United Kingdom Atomic Energy Authority. The lecture was concerned mainly with the factors which will determine when power generated from nuclear fuels may become cheaper than power from conventional sources. Sir Christopher began by showing that, as a first approximation, the capital cost of nuclear power plants might be expected to fall in the same way as the cost of other prime movers. The following abstract from the lecture takes up the story from the further development of the Calder Hall type of station.

THE Calder Hall reactors are already working and our next step in this survey should, therefore, be to look at the parameters which would be selected to-day for the design of a reactor which would go into operation about the end of 1961. We should with reasonable confidence select a maximum can temperature of about 450 deg. Cent. This upward step from the temperature of 408 deg. Cent. adopted in the Calder Hall reactors, would be made possible not by any improvement in the canning material or method of can fabrication, or by improvements in the metallurgy of the uranium fuel elements, but rather by the growing confidence which experience with Calder Hall has given and by independent support of fuel elements and departure from the Calder Hall system, in which these fuel elements are stacked one on top of the other. This advance would therefore be achieved rather by improvement in mechanical design than by advances in metallurgy.

In designing the pressure vessel we should unquestionably step forward to a plate thickness of 3in. This advance from the 2in plate thickness, which was adopted as the maximum at Calder Hall, has been made possible largely by experience obtained there. It is, however, interesting to note that under present conditions, problems of X-ray examination of welds on site are starting to become severe at this plate thickness. The use of 3in thick plates makes it even more important to watch the notch test of the material, since the billet is subjected to very little work and may show unfavourable characteristics in this respect.

It is probable that one would choose to use a spherical pressure vessel, because of the more favourable stressing conditions which can be achieved in this form. This requires a completely new optimisation of the design parameters of the reactor. The conditions which we have assumed will enable us to use a sphere upwards of 60ft diameter, and we can therefore get far bigger outputs than the 35/40MW electrical, which we achieve at Calder Hall. The optimum conditions are probably arrived at by fixing the working pressure of our coolant gas at about 10 atmospheres, giving us a core diameter which will enable an output of approximately 130MW electrical to be obtained from the reactor.

The upward trend of design in relation to the average rating, maximum can temperature and gas outlet temperature, which we have thus reviewed, can be summarised as follows :—

	Bepo	Wind-scale	Calder Hall	To-day's Design
Average rating MW/T	0·15 ...	0·75 ...	1·4 ...	2·0
Maximum can temperature, deg. Cent.	200 ...	300 ...	408 ...	450
Gas outlet temperature, deg. Cent. ...	90 ...	211 ...	336 ...	380

We have thus traced the way in which the outlet temperatures which we can achieve in our heat cycle have risen between 1947 and 1961. The upward trend is very marked and will continue, but we must now project ourselves forward and ask ourselves how the further developments will arise.

It is almost certain that experience with magnesium alloys and improvements in these alloys, will give us confidence to use them up to can temperatures of around 475 deg. Cent. With continued use of cylindrical uranium bars as fuel elements, we should find that with the present average fuel element ratings we are reaching maximum uranium centre temperatures of 600 deg. Cent. If, however, we look at the way in which specific ratings are increasing we find that, with the higher internal temperature gradients, we must look forward to maximum uranium centre temperatures of 800 deg. Cent., with fuel elements of the present form. Uranium has allotropic change points at 660 deg. and 770 deg. Cent., and there is appreciable volume change at the upper change point and as it is approached. The uranium centre temperatures which we are predicting will therefore bring us into a range where volume changes at the centre of a bar may present problems. It appears, therefore, that we must depart from the cylindrical form of bar and use either a small diameter rod, a flat plate or a tubular element. All of these arrangements increase the weight of canning material per kilogramme of fuel, and, therefore, affect the nuclear physical properties of the reactor unfavourably. It is almost certain that this unfavourable effect will be so marked as to demand the use of slightly enriched fuels. Directly we accept enrichment of our fuel elements (which may be achieved by feeding by-product plutonium, from earlier reactors, back into our new systems as our agent for enrichment), we are materially increasing the cost of our fuel and, in all probability, we shall find that this more expensive fuel cannot be justified for use with a canning material, which, like magnesium, places an absolute limit of about 500 deg. Cent. on our can temperature (the melting point of magnesium is 650 deg. Cent.). At this point, therefore, we shall almost certainly find that we are forced to use a canning material having a higher melting point. For use in gas-cooled reactors, the obvious material to adopt in this way is beryllium. Zirconium, which is an alternative offering some promise in water-cooled reactors, is unsuitable, since it reacts with carbon dioxide at temperatures over 500 deg. Cent. Beryllium, on the other hand, with its melting point of 1300 deg. Cent., has no reaction with reasonably dry carbon dioxide up to temperatures of 600 deg. Cent., and it does not form compounds with uranium. It is, however, doubtful whether full advantage can be taken of the characteristics of beryllium as a canning metal while using metallic uranium as a fuel, even in the form of thin sections. In order to develop the full possibilities which appear to be open to us, it will probably be necessary to use our fuel in the form of a ceramic or semi-ceramic oxide of uranium.

The development of beryllium as a canning material still offers great problems. Stringent precautions are necessary in handling it because of its toxic properties ; metal of suitable quality is not yet produced in quantity, and a great deal of research work on its fabrication is still necessary. It does not seem probable that reactors using beryllium cans will be in operation until 1963, and that by that date we shall be achieving maximum can temperatures of about 500 deg. Cent. and gas outlet temperatures of about 425 deg. Cent. This assumes the continued use of metallic uranium as our fuel. Beyond this we have the possibility of using uranium in ceramic form and this might well lift our gas temperatures by a further 75 deg., so that by 1968 we might expect to achieve can temperatures of 600 deg. Cent. and gas outlet temperatures of about 500 deg. Cent. Such temperatures as those that I have predicted, both for 1963 and 1968, will in all probability demand an entirely new approach to the problem of can design. Hitherto we have visualised our can as a flexible envelope around a rod of fuel, which supports itself by its own strength. The higher temperatures which we are now predicting can probably be achieved only if the fuel is given external support, either from the wall of the can or by other means.

The way in which the bulk gas outlet temperatures have advanced over the last ten years is shown in Fig. 1 and our discussion of the possibilities of beryllium canning and ceramic fuel elements, support the extrapolation of the curve to the 1968/70 period. In general terms the further rises in temperature, which are predicted for even later dates, will certainly be achieved. It does not matter that to-day we are unable to say how this will be done ; in the late 1930s, when Sir Leonard Pearce was constructing Battersea " B " power station to work at turbine stop valve conditions of 1350 lb pressure and 510 deg. Cent., many engineers (of whom I was one) said that he was at the economic limit and that it was difficult to visualise that operating temperatures would be advanced further. Yet, to-day, conditions of 2350 lb per square inch and 560 deg. Cent. at the superheater outlet are being achieved in the design of modern boiler plants.

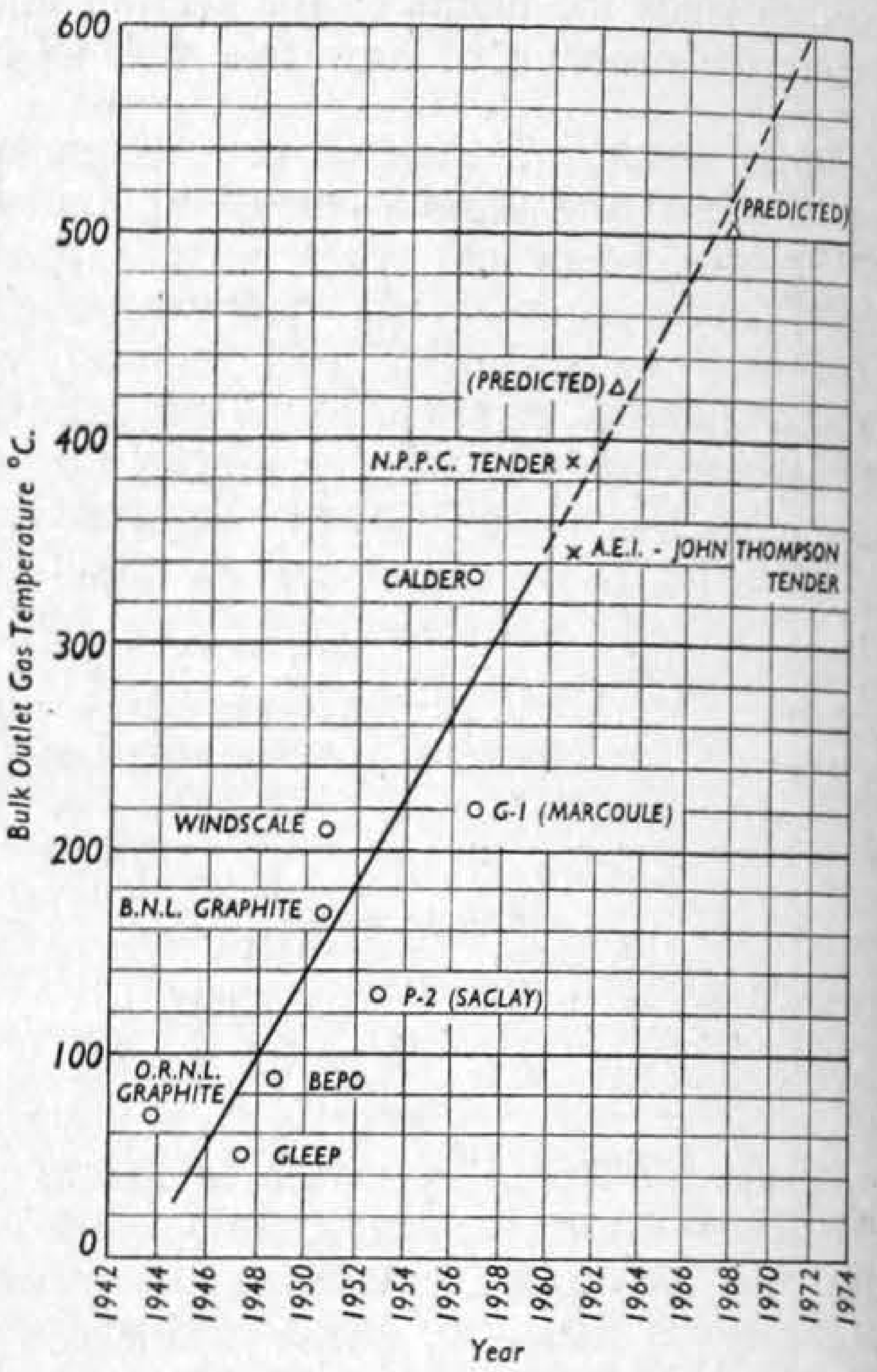


Fig. 1—Rise in outlet gas temperature with passage of time

Such advances in operating temperature will, of course, induce serious problems in connection with the design of the pressure vessel, but these can be overcome by the use of double-skin vessels with intercooling, so arranged that the outer shell is not subjected to unreasonable temperatures. This development in mechanical design will be accompanied by the use of steels having superior properties of creep strength. There is a conflict between the requirements of low-temperature notch ductility and creep strength in a steel and the solution will almost certainly be found in a low-alloy steel.

The problems involved in design and construction of the pressure vessels are subsidiary to those arising in connection with the fuel element and are unlikely to be the limiting factor in fixing the temperature which can be achieved in the heat cycle.

The steam pressure to be associated with a given top temperature in the thermodynamic cycle (in other words, the amount of this temperature range which is to be used in giving superheat to the steam), must be a matter for the decision of the turbine designer, but it appears reasonable to assume that by the 1968/70 period, steam pressures upwards of 1000 lb per square inch will be used in association with the gas outlet temperatures of around 500 deg. Cent. that will be available at that time. This will demand a thorough reconsideration of the problems of boiler design for nuclear power plants.

In the boilers which have been installed at Calder Hall the gas from the reactor passes through the 17ft 6in diameter shell, giving up its heat to tubes whose heat surface has been extended by the use of the Babcock stud tube. In order to make the best use of the heat available in the coolant gas, steam is raised at two pressures and used in a pass-in turbine. Water circulation in the tubes is pump-assisted on a system similar to that used in the Lamont boilers.

The essential feature of boilers designed for use with gas-cooled nuclear reactors, is that the heat transfer surface must be suited for the conveyance of heat from a dry and perfectly clean gas to the water and that there must be no possibility whatsoever of water leaking into the gas stream. It is doubtful whether the stud tube arrangement is an ideal way of extending the heat transfer surface for use with a perfectly clean gas, and it is doubtful whether the general arrangement of heating surfaces used in the Calder Hall boilers would lend itself to the higher temperatures and pressures which we are predicting for use in 1968/70.

Similar consideration of the developments which will be called for in turbine design for nuclear power plants, should be easier to assess. The effect of the introduction of nuclear power on turbine manufacturers is to turn the clock back to the manufacture of machines suitable for use with steam pressures which were standard in conventional power stations twenty years ago. Since then rising turbine stop valve pressures have demanded the use of larger sets in order to obtain reasonable efficiencies in the high-pressure cylinder and other developments have made such increase in size feasible ; while the use of higher superheats has made it possible to avoid intolerably high steam wetness conditions at the exhaust end, without installing unduly complicated reheat arrangements. The way in which turbine sizes are related to the increases in temperature

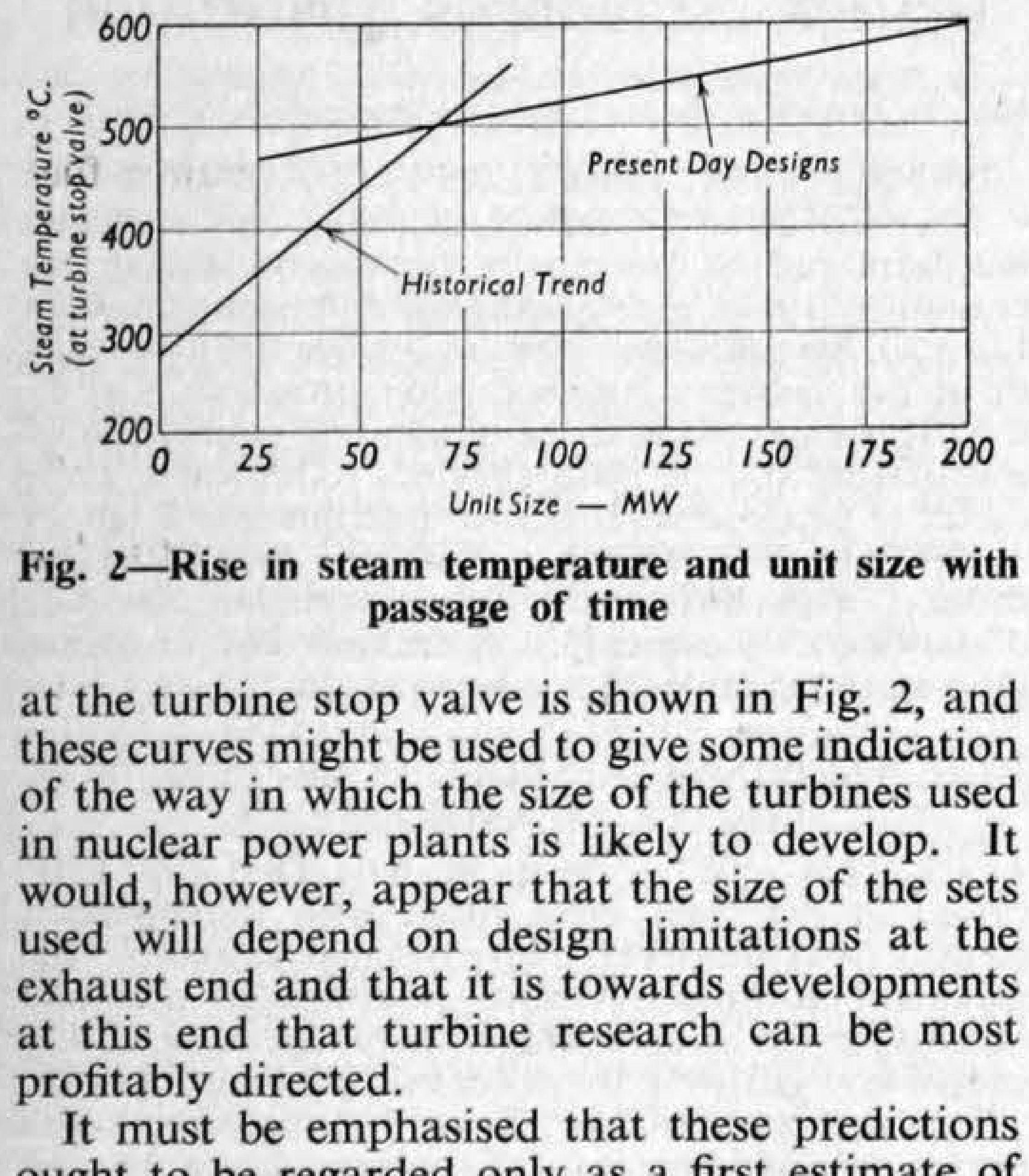


Fig. 2—Rise in steam temperature and unit size with passage of time

at the turbine stop valve is shown in Fig. 2, and these curves might be used to give some indication of the way in which the size of the turbines used in nuclear power plants is likely to develop. It would, however, appear that the size of the sets used will depend on design limitations at the exhaust end and that it is towards developments at this end that turbine research can be most profitably directed.

It must be emphasised that these predictions ought to be regarded only as a first estimate of the shape of development and that they need most careful analysis by the firms who are embarking on the manufacture of nuclear power plants. Such firms ought to realise that much of their power plant business will have been swept into this new field by the late 1960s. If, for instance, one considers the position in Great Britain at that time, it appears probable that the electricity authorities will decide on a programme under which three-quarters of the power plants constructed for domestic use will be nuclear power plants, while by the early 1970s it appears probable that nearly 100 per cent of the public utility stations built each year will be nuclear. The technology of design is advancing so quickly that manufacturing provision must be laid down on the basis of forecasts ; its provision cannot follow in the wake of technical development.

Besides the initial temperature in our heat cycle the other factor which has a major effect on the capital cost of nuclear power plants is the specific rating of the fuel elements, that is to say, the amount of heat which we can remove from the reactor per kilogramme of fuel present in it. Once again, the determination of this rating involves compromise ; rating can always be increased by a sacrifice in the top temperature that we achieve, since by doing this we can use a bigger temperature difference between our fuel element and our coolant (in this we have to remember that the important limitation in temperature is as we have already seen, metallurgy of the fuel element). Apart from this, however, specific rating of the fuel in the reactor depends on the type of heat transfer surface which can be used and on the characteristics of the cooling fluids.

Here again, we are faced with a compromise ; the heat capacity of our cooling gas can be increased by raising its pressure but, with a limitation on the maximum thickness of the steel which can be used in the construction of the pressure vessel, which contains the reacting core, such an increase in pressure will demand a reduction in the diameter of the vessel and a consequent reduction in core size. This will reduce the output of the reactor and increase the capital cost per megawatt of electrical output.

A further compromise has to be achieved in the design of the extended surface of the can ; its heat transfer characteristics can be improved by increasing the amount of material in the fins, but it adversely affects the neutron economy of the core.

The remaining factor which has to be taken into account in optimising the design is the power absorption of the blowers used for circulating cooling gases. The specific rating of our fuel elements can be increased by using larger mass flows of gas through the cooling channel, but this additional flow of coolant uses more power in the circulators.

Improvements in this field can be expected by the use of cooling gases other than carbon dioxide, which was selected because, while having reasonably satisfactory properties of heat capacity and neutron economy, it was cheap and readily available. Helium as an alternative coolant has some attractions. For the same heat output and range of temperatures it would require only slightly lower circulating power, but its complete inertness would remove some anxieties in the design of fuel elements and pressure vessels to meet the requirements of higher temperatures which we are expecting. Helium has the great disadvantage that bulk supplies are available from only a single overseas source.

Hydrogen, on the other hand, would have material advantages, but at the same time would lead to serious problems. For the same heat output and range of temperature the power required for circulation is only one-sixth of that required by carbon dioxide and this low power absorption opens up the possibilities of using higher mass flow rates. On the other hand, hydrogen forms a pyrophoric compound with uranium within a certain temperature range and its embrittling effect on steel is well known. It should not be assumed that either of these difficulties is insuperable.

We must remember that in the long run our whole approach to the design of heat transfer surfaces in gas-cooled reactors must be revised. We have already seen that up to the present our fuel elements have been designed in the form of rods which are essentially self-supporting and the can with its extended heat transfer surface has been regarded as a flexible envelope to contain this rod of uranium. But it has already been pointed out that, with rising temperatures and rising ratings, the conception of the self-supporting uranium rod must almost certainly disappear and that we shall have to move in the direction of thin rods, tubes or plates of uranium or one of its ceramic derivatives, which will not be self-supporting. Fuel elements having these characteristics have been studied in connection with liquid-cooled reactors, but little attention has been paid to the problems of heat transfer which will accompany their use in gas-cooled reactors, and there is a large field for research here which demands attention.

It will readily be seen that the specific rating of the fuel in an atomic pile reacts directly on the weight per megawatt of output and for this reason it is interesting to look at the way in which the weight per horsepower on conventional power plants has moved in the past. This is shown in Fig. 3 and on this figure an empirical curve is drawn, purely by analogy, to suggest

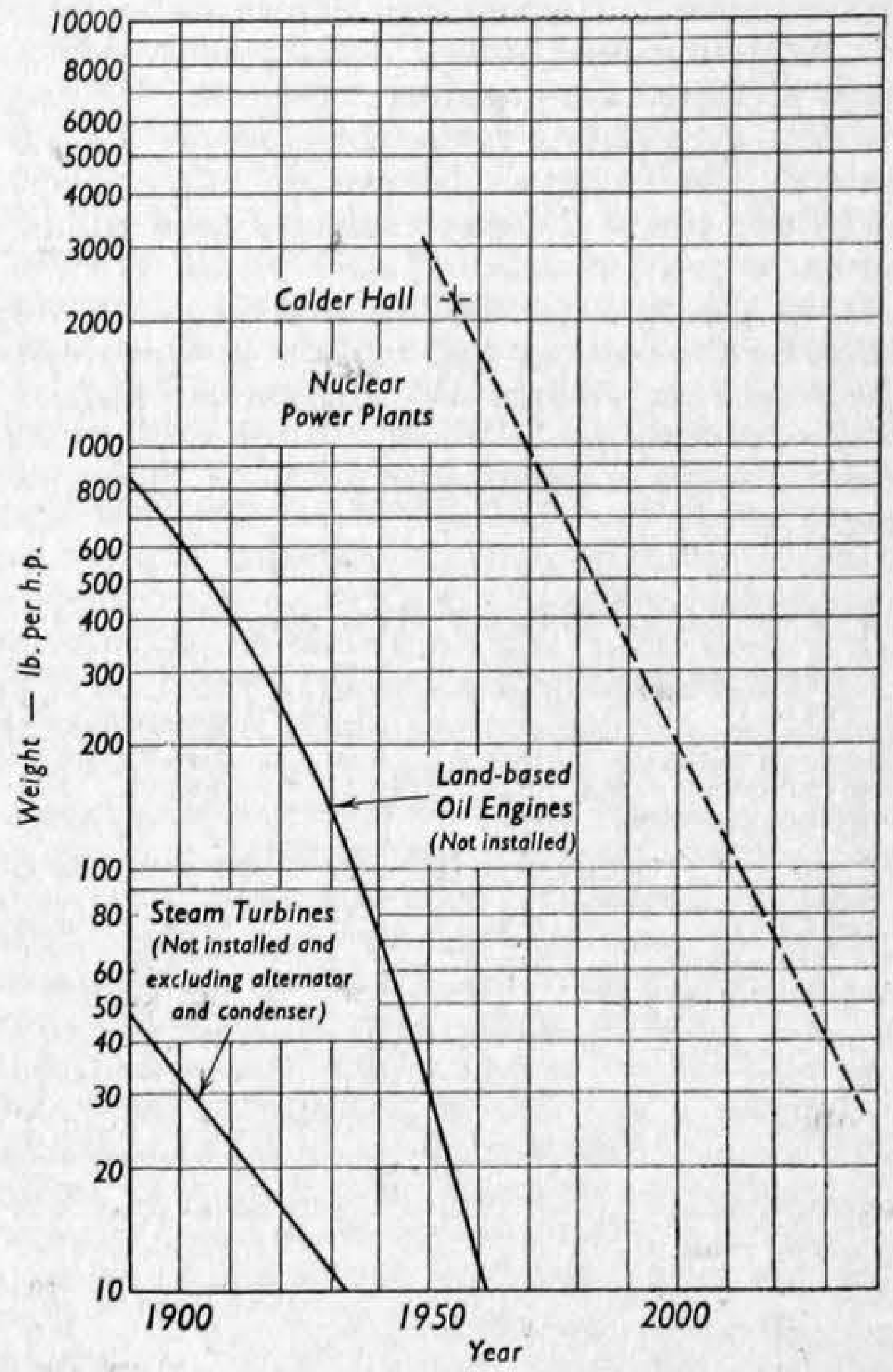


Fig. 3—Comparison of weight of steam turbines, land-based oil engines and nuclear power plants

how the weight per kilowatt of nuclear power plants may fall. That this trend is supported by the history of nuclear power plants in the last ten years, is shown by Fig. 4, which shows how the specific rating of the fuel in those reactors which have hitherto been built has increased. When we remember that there is a reasonable correlation between specific ratings of fuel and weights of reactor plant, it will be seen that this curve supports the trend of the curve shown in Fig. 3.

The Future Cost of Nuclear Power

We set out at the commencement of this lecture to examine the future cost of generating electricity in nuclear power plants. We have looked at the cost per horsepower of conventional prime movers, which have a long history behind them. We predicted the trend in the cost of nuclear power plants by analogy and set out to see how far the short history of nuclear engineering to date, supported these predictions and to

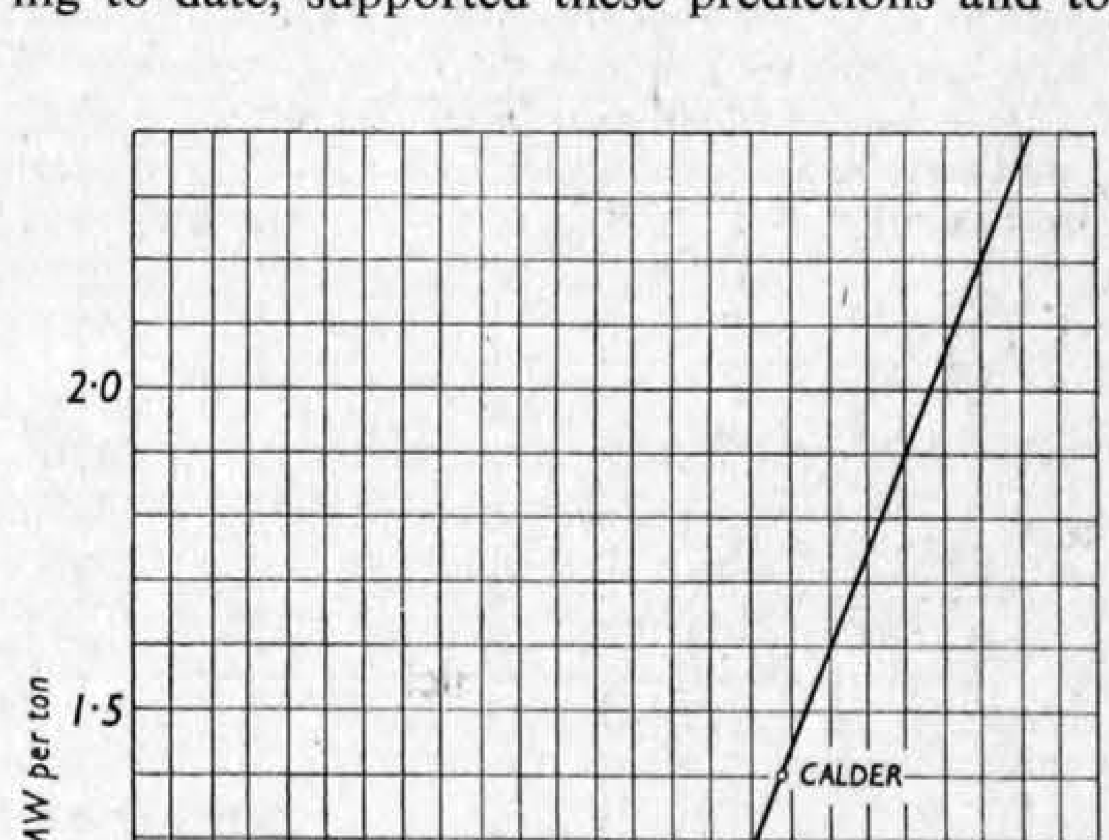


Fig. 4—Rise in fuel rating with passage of time

find what sound technological reasons we had for expecting the further developments which were predicted from general principles. We can claim to have found reasonable support for the general trend curves [shown in the paper] and these curves are replotted on Fig. 6 with a similar curve for nuclear power plants. In the light of the capital costs predicted there, we will calculate the cost per unit sent out at which it is likely that we shall be able to generate nuclear power in the future. This calculation is shown in Table I and the trend of total cost is shown in Fig. 5.

TABLE I—*Cost of Power From Nuclear Stations*

Commissioning date	1960	1970	1980	1990
		(d./u.s.o.)		
Depreciation	0·37 ...	0·30 ...	0·26 ...	0·22
Interest on fuel charge...	0·06 ...	0·04 ...	0·03 ...	0·02
Fuel replacement charge	0·24 ...	0·13 ...	0·08 ...	0·06
Operating expenses ...	0·06 ...	0·05 ...	0·04 ...	0·03
Total	0·73 ...	0·52 ...	0·41 ...	0·33
Credit for Pu in irradiated fuel	0·07 ...	0·05 ...	0·03 ...	0·01
Net	0·66 ...	0·47 ...	0·38 ...	0·32

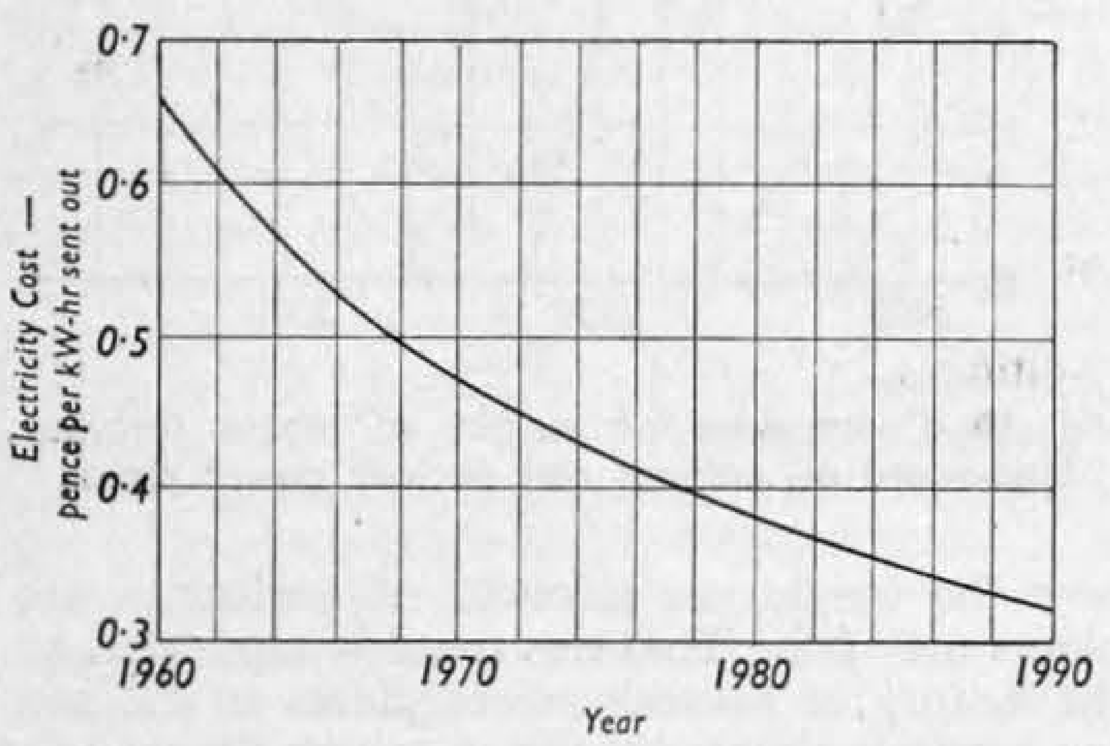


Fig. 5—Cost of electricity from nuclear power stations

The figures of Table I are based on the arguments and predictions set out in this report. We have shown how reductions of capital cost can be expected as a result of metallurgical developments and rising top temperatures in our heat cycle. Not only have we examined the improvements which will appear probable but we have seen that the downward trend in capital cost has been experienced in the past history of conventional prime movers. In Fig. 6 the past history of the capital costs of steam and gas engines are replotted alongside the curve of capital cost which we are predicting for nuclear power plants, and which has been used in arriving at the figures in Table I. In calculating the capital

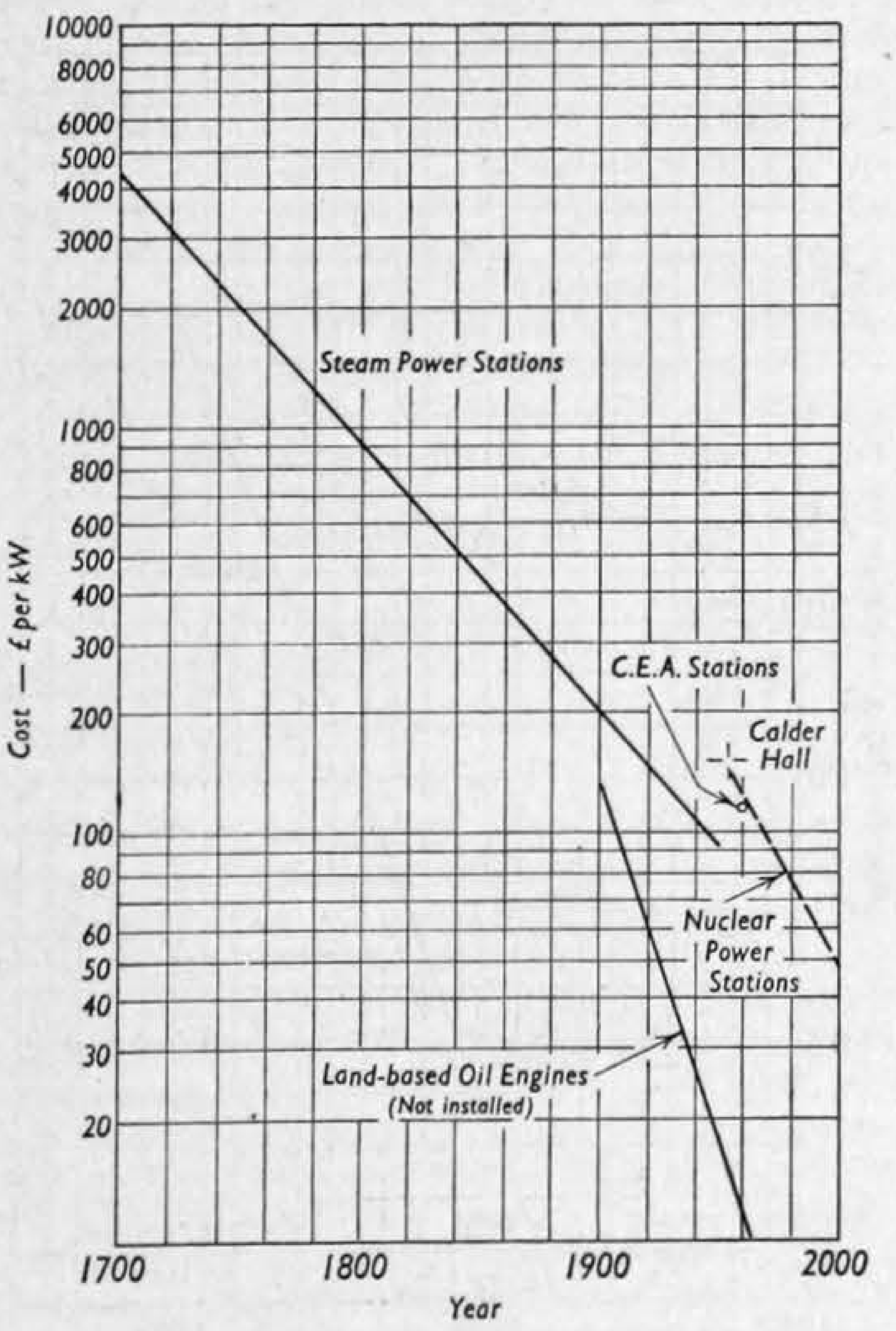


Fig. 6—Comparison of 1954 equivalent capital cost of steam power stations, land-based oil engines and nuclear power stations

charges allowance has been made for the fact that it cannot be assumed that nuclear power plants can expect always to be in the favoured position of carrying base load and in the calculations for 1970, 1980 and 1990, load factors of 70, 65 and 60 per cent respectively, have been used. The fuel charges fall because, in spite of the fact that beryllium canning and ceramic techniques push up the price per tonne of the fuel elements, compensation is obtained by the higher irradiations that we can expect.

The plutonium credit is shown as falling with the passage of time. This is because the market for this by-product plutonium is as a fuel in fast breeder reactors or other advanced types. These reactors can afford to pay a price for their fuel which enables them to produce power at the same cost as the power produced in the reactors which we have been considering. It follows, therefore, that as the cost of power from our reactors falls, these other reactors can only afford to pay less for the fuel which they have to buy. Moreover, with increasing irradiation, the content of higher isotopes in the plutonium increases and so lowers its value as a fuel.

It will, of course, be realised that the figures for the years 1970, 1980 and 1990 are not to be regarded as firm estimates. They represent a serious and careful attempt to predict the future, basing this prediction on careful analysis of trends, part of which analysis has been set out in this paper.

Let us now complete our comparison by predicting the cost at which power may be generated in conventional power plants in these years. Tremendous developments have been taking place since the war in the design of these conventional power plants, and such developments are still taking place. They are leading to increased thermal efficiencies and reduced capital costs of generators and boilers. These improve-

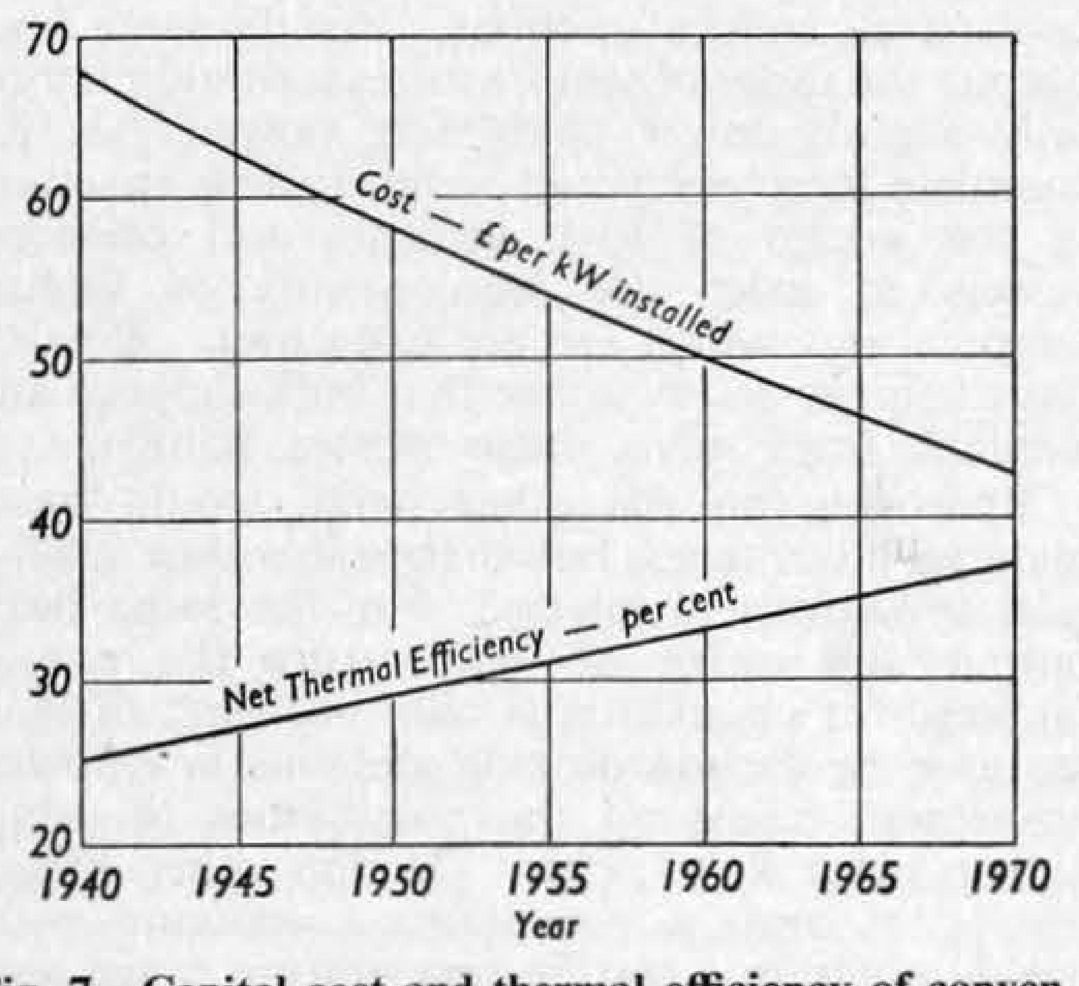


Fig. 7—Capital cost and thermal efficiency of conventional power stations

ments are shown in Fig. 7. Unfortunately, however, the cost of coal since 1925 shows a steady rise in terms of real money value (Fig. 8) and this rise in cost of coal outweighs the improvements which power plant engineers have been able to make in the design of conventional plants. Allowing for both of these factors, the estimate for the cost of generating power in conventional plants is shown in Table II.

TABLE II—*Cost of Power From Conventional Stations*
(Based on 75 per cent load factor)

Commissioning date	1960	1970	1980	1990
		(d./u.s.o.)		
Depreciation and interest on capital	0·12 ...	0·11 ...	0·09 ...	0·08
Fuel costs	0·44 ...	0·52 ...	0·60 ...	0·72
Operating expenses ...	0·04 ...	0·04 ...	0·04 ...	0·04
Total	0·60 ...	0·67 ...	0·73 ...	0·84

It can be, of course, so argued that the rise in the cost of coal since 1926 which is shown in Fig. 8, has taken place during the period in which the miners have struggled from the bottom of the industrial wage table to a point near its top and that (they having reached this point) the continued increase in cost of coal in terms of real money will stop. Against this it must be remembered that with the passage of time and with increase of demand, less favourable seams have to be worked and particularly when one remembers that there is some justification for thinking of coal costs in terms of the more expensive

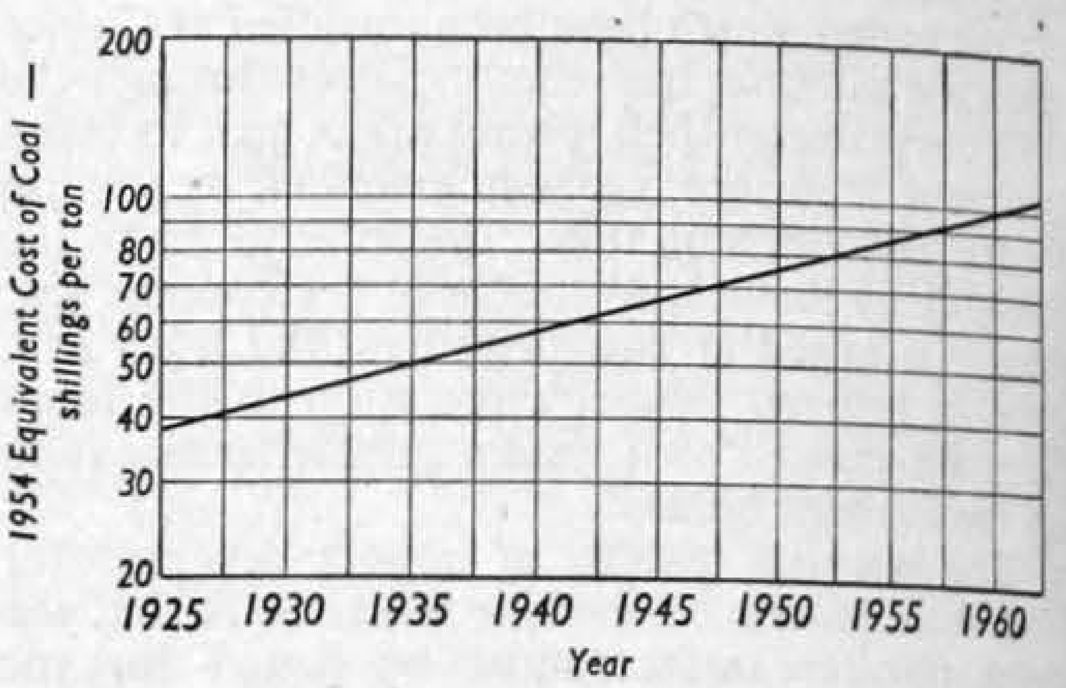


Fig. 8—1954 equivalent cost of coal

pits, when considering its marginal replacement by atomic energy, it is suggested that the figures of Table II are not unreasonable.

If this is accepted we see that the cost of electrical power sent out from the first industrial stations which will be completed in 1960/61, can be expected to be marginally higher than the cost of power produced from conventional stations completed at that date.

In the next batch of stations completed, say, by 1962/63, the advantage will probably have passed by a small margin to the nuclear station. By 1970, nuclear power will be appreciably cheaper than conventional power and this advantage increases in later years. This surely points the way in which industry must move; it has already been indicated in this paper that the rapid progress which has been predicted cannot be achieved unless preparations are made in advance. The object of the paper is to point a way through territory which is as yet unmapped; it is only by pushing with courage along such promising but uncharted paths that we can hope to make the progress which is necessary.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

SENSITIVE ALTIMETERS FOR AIRCRAFT

No. 2G.115 : 1956. Price 3s. 6d. This standard has been revised principally because of the supercession of the I.C.A.N. Standard Atmosphere by the I.C.A.O. Standard Atmosphere ; since the maximum difference between corresponding pressures is 0·05 mb., it is expected that the design and calibration of instruments will be little affected. The leaflet gives tables of permissible errors for instruments of ranges −1000ft to 35,000ft and −1000ft to 50,000ft. The method of presentation of ground pressure, but not of altitude, is restricted. A friction test involving tapping the instrument has been added.

DIAL TEST INDICATORS (LEVER TYPE) FOR LINEAR MEASUREMENT

No. 2795 : 1957. Price 3s. 6d. Dial test indicators of the lever type, fitted with a ball-ended adjustable stylus lever, are particularly suitable for making linear measurements in restricted positions and may often be used where the plunger type of dial gauges covered by B.S. 907 would prove unsuitable.

The new specification has been prepared to cover the special requirements of the lever type of gauge and provides for dial test indicators with inch or metric graduations. As in the case of other standards for measuring tools, design requirements are confined to essentials, but the desired accuracy of performance is fully specified. Methods of testing these instruments are described and illustrated in an appendix.

STEELS, SLABS, PLATES, SECTIONS, BARS AND RIVETS (RAILWAY ROLLING STOCK)

No. 24, Pt. 6 : 1957. Price 5s. This revised standard dispenses with the previous practice of allotting "specification numbers" to individual products. It is considered that products can be adequately identified by describing them and by quoting the number, part and section of the standard. Because there are many different requirements in each section, the grade numbers have been so allocated that they bear a direct relationship to the parts and sections of the standard ; requirements for rivets and rivet bars which were previously included in several specifications are now grouped together in a new section in this publication.

Each section includes requirements for the quality of the material, methods of selection for test and methods of test. Appendices give details of the form of tensile test pieces together with tables of metric equivalents. As far as possible the contents of the standard have been aligned with current British Railways practice.

Russian Coal Industry

IN March, 1956, a mission from the National Coal Board, under the leadership of Dr. W. Reid, then production member of the National Coal Board, visited the Kuzbass, Donbass and Rostov coalfields in Russia. A report of its observations has just been published by the Board.* The Donbass and Rostov fields together account for approximately 120 million tons a year, while the Kuzbass produces about 50,000,000 tons a year. The mission travelled 12,000 miles, inspected underground workings at twelve collieries, and visited central workshops, manufacturing works, research institutes, experimental engineering establishments, and welfare establishments, including hospitals and sanatoria. The mission was in the Soviet coalfields for about four weeks.

Organisation of the Soviet Mining Industry

In the U.S.S.R. the responsibility for operating the collieries and their associated activities is vested in the Ministry of Coal Industry. Detailed planning, reconstruction and new construction is handled separately by the Ministry of Colliery Construction, which was set up about three years ago. The Ministry of Coal Industry, although part of government, is more analagous to the National Coal Board than to the Ministry of Power. The Minister, his deputies and senior staff are technically qualified in various engineering professions and are responsible for a wide range of matters, including housing estates, schools and research institutes, as well as the day-to-day operation of the industry. The main managerial functions are discharged through regional "combinats" (roughly equivalent to the National Coal Board's divisions), which are in turn divided into groups of collieries in trusts (roughly equivalent to Coal Board areas). In the Ukraine, which covers the major part of the Donbass coalfield, there is a Ukraine Ministry of Coal Industry under which there are four regional departments (equivalent to the combinats elsewhere).

The Ministry of Coal Industry must prepare plans for the development of the industry as a contribution to the general five-year plan for the State as a whole. Initial plans are prepared by the combinats and Ukraine Ministry and submitted to the Minister for co-ordination and approval, the main directing body being the Collegium, of which the Minister is chairman. Having decided that a new colliery is required, the task of planning and constructing it is given to the Ministry of Colliery Construction. On completion there is a formal handing over to the Ministry of Coal Industry and acceptance is subject to that Ministry being satisfied the work has been properly carried out. A similar procedure is adopted for major reconstruction schemes. A safety organisation exists throughout the coal industry with staff at all levels of management, and each group of collieries is served by a rescue station. The Safety Inspectorate of the U.S.S.R. was originally part of the Ministry of Coal Industry, but about three years ago it was decided that it should become an independent organisation. It now reports direct to the Government through the Council of Ministers. The workmen's inspectors in the U.S.S.R. are voluntary workers and do not appear to have any substantial standing.

Production

The ten major and many minor coalfields in the U.S.S.R. produced a total raised and weighed output of 391 million tons in 1955 ; of this, 319 million tons was hard coal, 7,500,000 opencast. Brown coal opencast production was 57,500,000 tons and a further 14,500,000 tons, mostly brown coal, came from small mines operated in some cases by local councils. Reserves proved to date are 630 million tons of hard coal and 118,000 million tons of brown coal, but further exploration will undoubtedly increase these figures and such virtually unlimited resources can be compared with an estimate of 43,000 million tons (of workable reserves) in Britain. A substantial percentage of the reserves is in strata above 400 yards depth.

Flat or gently inclined seams are experienced in parts of several coalfields, but steep gradients and extensive folding are prevalent. The seam density in the coal measures is high. High gas emission is a feature of a number of coalfields and heavy makes of water are encountered, particularly in the Moscow basin. Spontaneous combustion is common. Outbursts of coal and gas are a major problem and a special commission has been established to deal with this danger. Longwall advancing and retreating accounted for more than 82 per cent of output in 1955. Substantial tonnages will continue to be produced from steep seams and several ingenious mechanisation devices have been applied to these conditions—in particular hydraulic shield supports developed specifically for seams of more than 35 deg. inclination. A high face productivity—of 50 to 60 tons per manshift—is possible with the shield system, but this may well be reduced to 2·2 tons overall. Room and pillar working represents a mere 0·5 per cent of total output ; it is, however, an essential feature of the hydraulic mining technique now coming into operation. There is a wide variety of seam thickness ; in the case of coking coal, which is not plentiful, seams as thin as 16in are worked. Conditions are static on the roadways and a high standard of fluorescent lighting is observed. Strip packing or caving is normally employed in advancing and retreating longwall faces ; the aim is to increase caving to 70 per cent of the total faces over the next five years. Generally, the impression gained from underground plans was that the layouts are simple and straightforward. Face O.M.S.† is low compared with results obtained from mechanisation in other countries ; the practice of roadways following the contour, coupled with direct loading into mine cars, has made continuous loading from power-loaded faces difficult, and will have to be reconsidered to allow maximum performance. Collieries are normally ventilated by exhausting fans, some by forcing fans. Attention is being given to the preheating of the intake air in the eastern and northern coalfields. Method study was employed at all the collieries visited and technically well-founded output standards are worked out in relation to the conditions of the separate coalfields. Preparation of coal for the market is normally confined to coking coals, but an extension of facilities is said to be contemplated.

Underground Mechanisation

Considerable effort has been put into the development and application of machinery for coal face and rock face work. This activity has been concentrated on power loaders, and the improvement of conveyors and roof supports has not been kept in pace. Of the output from seams with a gradient less than 35 deg., which represents 85 per cent of the total output, 35·8 per cent was power loaded in the first quarter of 1956. Most of the power loaders in use are based on the frame-jib design, the basic machine being the Donbass cutter loader. All the machines are cutter loaders of one kind or another, and there has been little success so far with ploughs, though their development is proceeding. It is difficult to make a comparison with British figures, as Soviet face O.M.S. figures do not include labour in roadways. In the limited number of faces seen it appeared that the face O.M.S. on the British basis was in the region of 3 to 4 tons. One fundamental of all the variants of the Donbass machine is that they cut one way only and are then flitted back along the face. It follows that stable holes need not be so deep, and in inclined seams the problem of cutting downhill does not have to be faced. The most important development for steep seam mining utilises a rotating cutting head which shuttles backward and forward along an inclined frame by means of a rack device.

General standards of face support were not good and there appeared to be very little fundamental research in progress and no widespread understanding of the problems involved. Many roadways are timber-lined and undoubtedly the use of steel lining will be increased if supplies become available. The development of tunnelling machines is well advanced. The existing machines are suitable only for softer rock and coal where they are doing exceptionally good work. A hard rock tunnelling machine is being developed, but is still at the experimental stage. Bigger locomotives and more large mine cars have failed to solve the haulage problem and there is a real indication that Soviet engineers are about to embark on a concerted drive towards modern trunk conveying. The only interesting development in the trunk conveying field was the " KRU–350," in which the belt is reinforced by steel wires instead of woven cotton.

A special institute has been set up at Leninsk to study the problems of hydraulic mining and an experimental drift mine has been constructed to carry out underground experiments. The aim is to remove the coal from the face by high-pressure water jets and transport it hydraulically from the place of work right to the surface. It is claimed that a three to five-fold increase in the overall O.M.S. can be achieved. Although development work will continue, hydraulic mining is now passing from the experimental stage to wide-scale application. Hydraulic mining is a simple and impressive system and is likely to revolutionise mining in certain classes of conditions. Productivities envisaged exceed those in any other known form of underground mining—approaching those of opencast mining.

Wages

The level of wages in the coal industry is higher than in other industries. Piecework prevails in the industry and all performance above the norm is paid for above the basic rate. Outstanding productivity brings not only monetary reward, but increased cultural and other facilities. There is no minimum wage for piece-workers. The average wages per month at one colliery were : faceworkers, £68 ; elsewhere underground, £35 ; surface, £23. Several wage systems are adopted—the simple piece rate, the progressive piece rate, the day wage with bonus and straight day wage. As an inducement to stay in the industry, there is a lump sum bonus calculated as a percentage of annual wages. Miners who have attained the age of fifty and have completed twenty years' service, receive a pension and can retire if they wish. Most men continue and receive their pension in addition to wages. The pension is at the rate of 50 per cent of the worker's annual wage. Miners get annual holidays of between eighteen and thirty-six working days, free medical attention, and sickness benefit at the rate of average wages. Some receive free coal and others pay half price. There is a virtually compulsory contribution of 10 per cent of earnings to State loans.

Mining Education and Training

Higher education is considered very important and great progress has been made in recent years. The curricula are narrower in their objectives and more specialised than in Great Britain, but the demand for technically trained people is so great that this narrow specialisation is regarded as essential. Many of the thirty universities have mining departments and the graduates of these are mainly of the research class. The technical institutes and high schools in general provide far more graduates than the universities, and a mining degree (in effect a Colliery Manager's Certificate) is obtainable at the mining institutes. There are adequate openings for all kinds of engineers in the collieries and all have opportunities of becoming colliery managers in due course. The training of junior officials and skilled workers is also receiving great attention and courses are run for all grades.

* Price 8s. post free.

† Output/man-shift.

Canadian Oil Refinery.—We are informed by the British Petroleum Company, Ltd., that B.P. (Canada), Ltd., has acquired a site of 600 acres at Ville d'Anjou, near Montreal, and plans to build there an oil refinery of 1,500,000 tons per annum capacity, which will be linked by pipeline to an oil dock in the St. Lawrence.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents.)

STATUS OF ENGINEERS

SIR,—Commenting on the report of the team which recently visited Russia under the ægis of the three senior Institutions, the leading article in your issue of March 1 rightly stresses the lesson which the report contains. You say: "If this nation is to remain in the van of technological progress and is not gradually to fall back into a second-class, impoverished and backward country, its engineers must gain heightened prestige and an improved status in the understanding of its people as a whole." Your reference to the part being played by the learned societies in carrying out this task, however, standing as it does without qualification, could be taken to suggest that the task was capable of successful completion by the activities of these bodies alone, and might thus encourage a sense of complacency which is altogether unjustified. The work which is being carried out by the learned societies in disseminating information about the profession is of the highest importance, but they would be the first to admit the limitations of their Charters when it comes to seeking "heightened prestige and an improved status." A recent editorial in the *Journal* of the Institution of Electrical Engineers remarked that ". . . the objects and purposes of the Institution, as set out in its Charter, do not include a watch on the status and personal interests of its members . . ." and referred to "a widely felt need" in many overseas territories "for some separate protective organisation to uphold and improve the status of the professional engineer."

The need is no less great at home, as the report and your leading article make clear, and it is for this purpose that the Engineers' Guild was established, as the professional association for chartered civil, mechanical and electrical engineers. The functions of the Guild and of the Institutions are therefore complementary to one another. At the present time the Guild is working to secure wider publicity for the professional engineer and acknowledgment of his part whenever reference is made to engineering undertakings; to ensure that salaries are properly related to responsibilities borne and that the highest management posts are open to engineers equally with members of any other profession; and to bring about wider recognition of the due status of the profession. In addition, it has sponsored and recently introduced a comprehensive pension scheme open to all members of the three Institutions, details of which have been given previously in your columns.

The need for all these activities is likely to increase rather than lessen in the years immediately ahead, and the well-being of every professional engineer—as well as the number of those who enter the profession in the future—will in large measure depend on their successful accomplishment. The standing of the profession can only be improved by the efforts of its members and it is to be hoped that these will find expression to an increasing degree through membership of the Guild, for both the extent of the Guild's work and the speed with which it can be pressed forward are dependent on this support.

J. G. ORR,
Secretary, Engineers' Guild.

78, Buckingham Gate,
London, S.W.1.
March 15, 1957.

AN INDUSTRIAL APPLICATION OF COMPUTERS

SIR,—I am most grateful to Mr. Room for his elegant demonstration, in his letter to you published in your March 8 issue, that there are as many as about $2 \cdot 5 \times 10^{34}$ ways in which I might traverse a rectangular mesh of 60×60 streets from my home at the south western corner (0,0), to the office in Portland Place at the diagonally opposite north eastern corner (60,60), travelling either due north or due east along successive streets of the mesh. I had estimated a mere 10^{18} alternatives, which seemed to be a sufficiently large number to discourage one from attempting an enumerative solution of the problem.

However, it has since appeared that to find the shortest route is not quite such a hopeless task as these astronomical figures might suggest. Suppose that $t(i,j)$ is the time by the shortest (northerly and easterly) route from (i,j) to (60,60), and that $N(i,j)$, $E(i,j)$ are the times to traverse the roads from (i,j) north and east to the next junctions at $(i,j+1)$ and $(i+1,j)$ respectively. Then $t(i,j)$ must equal the lesser of $t(i,j+1)+N(i,j)$ and $t(i+1,j)+E(i,j)$ at each point (except on the eastern or northern boundary where it must equal the first or the second of these expressions respectively). Using this rule, the values of $t(i,j)$ may be calculated all over the mesh if the points are taken in the order (59,60), (60,59), (58,60), (59,59), (60,58) . . . (0,1), (1,0), (0,0)—i.e. scanning successive diagonals from north west to south east, from Portland Place back home. One then proceeds from home in such a way as to minimise the time to Portland Place at each stage. Thus when one is at an internal point (i,j), one goes north if $t(i,j+1)+N(i,j)$ is less than $t(i+1,j)+E(i,j)$, and otherwise one goes east. This procedure is, of course, quite feasible for a computer. Incidentally, this method may be extended to deal with the general case where the streets may be traversed in the southerly and westerly directions, though in general in this case it may be necessary to iterate over the mesh a (not too large) number of times before the solution converges.

C. M. BERNERS-LEE

Ferranti, Ltd.,
21, Portland Place,
London, W.1.
March 16, 1957.

Literature

The Oil Engine Manual. Sixth edition. Edited by D. S. D. WILLIAMS. The Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 18s.

THAT books about oil engines should have become a substantial fraction of technological literature is the more remarkable when one considers that only sixty-nine years have elapsed since Lord Kelvin (then Sir William Thomson) reported on his examination of the Priestman oil engine, the first machine of the kind to prove successful. That was in 1888 and oil engine literature has, ever since, been building up at a constantly increasing rate. An example is afforded by *The Oil Engine Manual*, since the edition lately issued and dated 1956 is the sixth since 1939, to say nothing of a reprinting, in 1942, of the second edition. Moreover, anyone reading through the eighteen chapters (and appendix) will reach the conclusion that there is still plenty to write about, particularly as the Manual does not touch on marine engines. This limitation is doubtless fully justified, having regard to the magnitude of the task involved in any honest effort to deal with industrial applications and with engines for road vehicles and rail traction. An illustration of the inexorable and unpredictable onset of new situations is afforded by the fact that while this sixth edition of *The Oil Engine Manual* was in course of preparation there should have occurred an international eruption of grave consequence to the oil industry, an eruption reminding us all—whether oil engine builders or users—of the extent of our present dependence upon an imported fuel. No doubt the next edition of the Manual will have a lot to say not only about the consequences of this particular eruption, but about the effects of the trends dealt with in the paper read recently by Mr. M. E. Hubbard of the British Petroleum Company before the Diesel Engineers and Users Association. For these reasons the main interest of the current edition appears to lie in those details which, descriptive of contemporary engine practice, assist the forward-looking engine user to make up his mind as to the sort of engine most likely to give him the least trouble should the trends outlined by Mr. Hubbard develop into oppressive realities.

It is the manifest duty of all those who compose technical books to see to it that their writings shall be luminous rather than voluminous and that the particulars which they provide are at once accurate and informative. In the case of the present book the chapters which interested us most are those dealing with fuel-injection systems, lubrication and maintenance. These, as it happens, are among the matters more likely to occupy the attention of makers and users if, by the persistence of present trends, the problem of producing sufficient middle distillates becomes crucial. This problem is distinct, of course, from the question of the punctual transport of oil from the Middle East. If, to ensure the requisite supply of diesel fuel, the fuel specification must be "as little restrictive as possible," then the engine—as Mr. Hubbard insisted—"must be omnivorous." It is certain that all the British-built engines in the tabulation to which the Manual devotes about fifty-two closely-printed pages, will not prove equally omnivorous. Accordingly, it must surely be the desire of the engine user to seek out those engines which, should fuel quality deteriorate, are likely to prove least sensitive. On the other hand, if—as is devoutly to be hoped—the production of diesel fuel remains at such a level as to satisfy all demands, then any efforts made to render oil engines trouble-free on a less digestible diet than has previously been available will pay off in reduced maintenance cost.

When another edition of the Manual is called for it would be desirable to add some further guidance as to the maintenance of the various pressure-charging devices now so widely employed on all sorts and sizes of engines. For example, on exhaust gas turbo-chargers, pressure drop between the blower suction inlet and the air filter inlet has to be limited. Again, with this type of equipment, failure to exclude oil and dirt from the blower suction has rapid and serious effects due to fouling of the diffusers. A chapter on the care and maintenance of pressure-charging equipment, including recommendations as to the spare parts which should be kept available at remote sites, would add to the value of the Manual. In the section on valves there does not appear to be any reference to the water-cooling of exhaust valve cages, though the practice is widely used on engines intended for heavy and continuous industrial service and can contribute to reducing the trouble referred to under this heading (Chapter 8). Regarding the paragraph entitled "Fly-wheels," this might lead a reader to assume that all flywheels are keyed, though in point of fact the use of keys for positioning fly-wheels is by no means universal. Indeed, the only drawing in the manual which details (page 169) a flywheel mounting, shows the familiar bolted and spigoted construction eliminating fitted keys. With reference to the section on oil purification and the layout shown on page 139, it is a frequent practice to use an entirely separate pump for delivering lubricating oil through "Stream-Line" type filters so that the purification process can proceed whether the engine is standing or running. In further connection with oil purification it would be desirable, in another edition, to include reference to magnetic oil filters as used both on the lubricating oil and fuel oil circuits. Finally, the deliberations which, now in progress, are aimed at the revision of B.S. 649 (1949) will doubtless lead, at an early date, to important modifications in the British Standard, including the changing of the basis of rating from a twelve-hour period to continuous running.

The Theory of Vibrations for Engineers. Third Edition. By E. B. Cole. Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 30s.

The appearance of a third edition of this well-known text book in competition with the spate of recent publications in this subject shows the increased importance being attributed to the study of vibrations. Every practising engineer is becoming more and more aware that troublesome vibrations can occur in nearly every branch of engineering and with the trend towards higher speeds, not only in vehicles but also in stationary machinery and the use of smaller factors of safety, any such vibrations can soon lead to failure. This book is intended primarily for University students taking a first degree but can also be used with advantage by those engineers who wish to enlarge their hitherto rather scanty knowledge of vibration theory.

The basic principles and methods of approach are derived from very simple considerations, e.g. the first chapter deals solely with simple harmonic motion, which is, of course, completely justified as most systems can in practice be assumed to behave in this manner, at least as a first approximation. No great prior knowledge of mathematics is required, a particularly commendable feature of the book being the clear and painstaking way in which the differential equations are derived and solved. The method of solution adopted is often not the mathematically most eloquent but one which illustrates the relevance of the several physical properties involved. Much use is made of vector illustrations and method of solution for the same purpose. All the standard text book cases are dealt with, such as natural and forced vibrations of systems having one or several degrees of freedom. Damped vibrations are considered in any detail only for velocity (viscous) damping, Coulomb damping being discussed briefly in an appendix. It seems strange that other forms of damping, such as hysteresis damping have been omitted, particularly in view of the fairly strong emphasis throughout the book on torsional systems.

The chapter on the elimination and absorption of vibrations is a useful introduction to this aspect. The transverse vibration of beams is treated quite thoroughly, both the exact solution for single span, unloaded beams and Rayleigh's approximate method being given. The explanation of Dunkerley's empirical formula is very clear. There are also short chapters on whirling of shafts, longitudinal vibrations and stress waves. A number of examples, some worked out, are included, mainly from University of Liverpool examination papers. The book has been very well produced with many clear illustrations.

The Theory of Suspension Bridges. By Professor Sir Alfred Pugsley, O.B.E., D.Sc.(Eng.), F.R.S., M.I.C.E. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 42s.

Professor Sir Alfred Pugsley's work on suspension bridges has included several original contributions, the most recent of which described the development of a simple theory to account, approximately, for the behaviour of these structures, and was published in a paper presented at the Institution of Structural Engineers in March, 1953. The present volume, he says, presents a text on the whole matter that is not beyond an honours civil engineering student in his final year, and yet is also of value to research men and professional engineers with special interest in the subject. There has, up to now, been no text book published in this country covering the same subject matter.

The principal theories—the elastic theory, Rankine's theory, the modern deflection theory —are explained in a historical setting to show their relationship, and a somewhat detailed study of a single cable under load is given. The natural modes of bridge oscillations are discussed in outline and the way in which they are induced by the wind is explained, as far as is known.

The explanation of the deflection theory includes a chapter on the linearised theory, and a further chapter on the Fourier series treatment of the theory in its general form. A chapter on "Approximate methods of analysis for preliminary design" explains Steinman's approach to this problem, and the author's own theory, which we mentioned in introducing this review.

The subject matter of the book is presented in a scholarly and concise manner. Apart from the theoretical dissertations which are its *raison d'être*, the introductory chapter describes succinctly the evolution of suspension bridge design, and is of particular interest.

Industry and Press Relations. By Peter Hale. Staples Press, Ltd., Mandeville Place, London, W.1. Price 12s. 6d.

Generally speaking the relationships of industry with the technical and trade press are happy enough. But sometimes the relationships of industrial firms and organisations with national and local newspapers are not so good. The reason often lies in misunderstanding on both sides. The technical man is irritated to find in the press accounts of his work that are inaccurate or distorted or which appear to concentrate attention on matters of minor importance ; the reporter and his editor are equally irritated by any appearance given that the attentions of the press are unwelcome or by attempts to deny information to the press. This book attempts to explain to industry what national and local pressmen want of them and how best they should be handled. It pleads in particular for the generation of a spirit of mutual confidence and shows the steps that can be taken to that end and to help the press to become accurate and well-informed. Its purpose, quite rightly, is to explain the press to industry not industry to the press. For our part we cannot attempt any further comment. There is a great deal of difference between the trade and technical press on the one hand and the national and local press on the other. The book has almost nothing to say about the former. Our impression is, however, that the press in general would be helped in its dealings with industry were it widely read by managements.

Technical Reports

High-Conductivity Copper Alloys. The Copper Development Association, 55, South Audley Street, London, W.1. Gratis.—This booklet, one of a series produced by the C.D.A., deals with four copper alloys—cadmium copper, chromium copper, silver copper and tellurium copper—which have many applications in industry, where high electrical and thermal conductivity are required. The composition, production, physical and mechanical properties of these alloys are discussed. A great deal of useful information is given in twenty-five tables and two equilibrium diagrams. Typical applications of the four alloys are illustrated photographically.

Spannbetonbau. By W. Herberg. Vol. I. Leipzig : B. G. Teubner Verlagsgesellschaft, Goldschmidtstrasse 28, Leipzig, C.1. Price DM.21·80.—The first of two volumes of Dr.-Ing. habil. Herberg's treatise on prestressed concrete has now been published. The book begins by surveying the history of prestressing from the paper by Mandl (1896) and Doehring's patent (1888) until the present time. It proceeds to detail the theory, materials used, testing, and design calculations. The main data of the principal bridges, buildings and containers are listed in an appendix. Consideration of construction and practical applications are deferred to the second volume.

Strassenfahrzeuge mit Gasturbinenantrieb. By K. Leist and K. Graf. Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, No. 242. Cologne and Opladen : Westdeutscher Verlag, Ophovener Strasse 1-3, Opladen (RHLD). Price DM.17·20.—In No. 71 of the Forschungsberichte the problem of the small gas turbine was discussed, with special reference to its possibilities for road transport, its fuel consumption and running costs, as well as means for improving its economy. The present treatise deals with questions of the design of turbine-driven vehicles. The large power-weight ratio of the turbine, the absence of unbalanced inertia forces, a large air and fuel consumption, and the possibility of splitting up the power unit into its various components, are some of the main factors which differentiate this problem from that of the petrol and diesel engine. The subject is discussed in detail with reference to examples of lorries, buses and cars which have been developed to date in many countries all over the world.

The completed Chainat barrage from upstream. The approach jetty for the lock is shown in the foreground with the sector gates and the bridge for the gates operating machinery further back

Construction of the Chainat Barrage in Thailand

The Chainat barrage, on the Chao Phya River, was inaugurated last month. It is the first large-scale civil engineering structure of its kind to be built in Thailand. Construction was planned and supervised by Keir and Cawder, Ltd., and an account of the constructional problems involved is given here.

THE central plain of Thailand is a fertile agricultural region drained principally by the Chao Phya River, which debouches into the Gulf of Siam close to Bangkok. The river and its associated streams and canals also form the principal routes of communication through the region, which is largely undeveloped, with few roads. Thus the rice crop is brought to Bangkok by boat, and rafts of teak, bamboo and mai yang wood are floated down from the northern forests, sometimes taking four years to reach their destination.

The Chainat barrage has been built about 100 miles upstream from Bangkok, Chainat still being in the plain. Its purpose is threefold, affecting irrigation, navigation and flood control, but the principal benefit is derived from its effect on irrigation. All this is achieved by raising the river level at Chainat by about 30ft, and installing sluice gates capable of discharging up to 6500 cumecs, and a lock for navigation.

The barrage thus raises the river sufficiently to supply irrigation waters all the year round, in an extensive system of canals commencing upstream from Chainat. Double cropping is to be introduced in some areas as a result of the improved supply of water, which will be felt over a total area of nearly 3,500,000 acres. The main canals of this system are large, one of them, for instance, having a capacity of 7400 cusecs. Navigation all the year round is also now possible, but not on the Chao Phya itself. The Noi and Subhan rivers are both left-bank branches of the main stream, which branch out from it upstream from the dam. The Noi rejoins it again lower down, but the Subhan continues as a separate stream to the sea ; there are connections, by canal, between these streams.

Chainat barrage was inaugurated, after four and a half years of constructional work, on February 7 by the King of Thailand, King Bhumibol Adulyadej. The illustration which we reproduce at the top of this page shows the completed barrage.

Design of Barrage

The barrage was built at a site where the river forms a loop. It was constructed across the neck of the loop, and when completed the course of the river was changed, to flow through the barrage, an earth dam being built across the old course.

The design of the earth dam, barrage and navigation lock and the control works of the irrigation system have been carried out by the Thai Royal Irrigation Department with the help of American engineers on loan from the American Bureau of Reclamation. The whole project is substantially the same as that recommended by the British engineer, Sir Thomas Ward, before the first world war.

In 1951, after international tender, the task of managing and supervising construction of the barrage was entrusted to Keir and Cawder, Ltd. The Royal Irrigation Department provided assistant staff, labour, materials and equipment. A loan of approximately 18,000,000 dollars was obtained by the Thai Government from the International Bank for Reconstruction and Development for the purchase of materials and equipment from abroad and to pay for managing, supervising and technical services. The principal dimensions for the completed barrage are listed in the table.

A good impression of the scope and layout of the work is given by the accompanying illustration of a diorama of the dam. The extent of cofferdamming to carry out foundation work in the neck of the loop is clearly shown, and the position of the earth dam, which is not shown, is indicated by the two bunds, one on each bank of the river, which the earth dam connects together. Apart from the main works, flood embankments have also been built along the river banks upstream from the dam ; they have

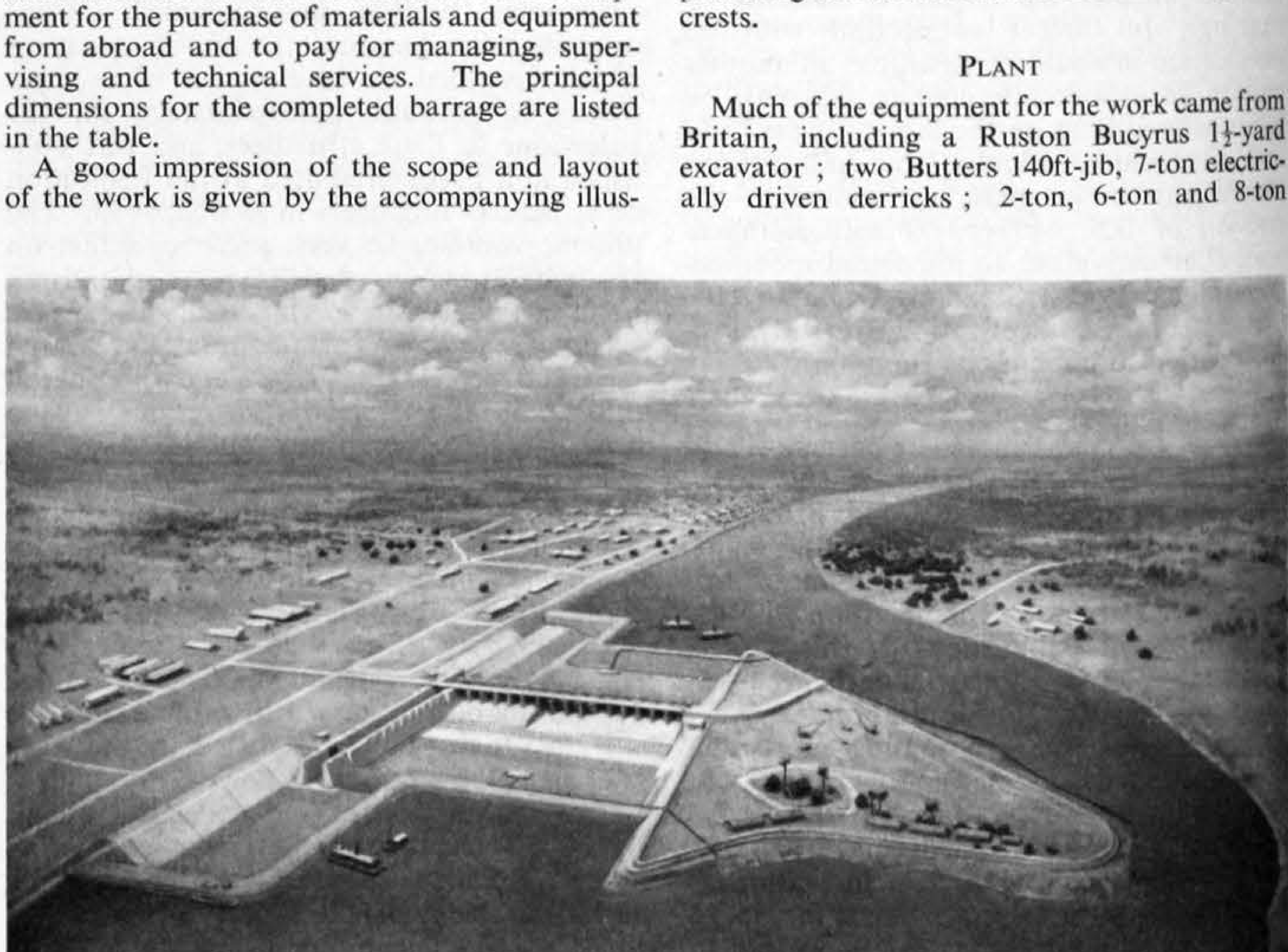
Principal Dimensions of Chainat Barrage and Lock

Barrage :	
Span of principal openings	12·5m
Number of openings	16
Designation of sluice gates	Sector gates
Height of gates	7·5m
Width of piers	2·5m
Length of barrage	237·5m
Height of barrage	14m
Width of highway bridge spanning barrage :	
Carriageway	6m
Footpath	1·25m
Flood capacity of barrage	6500 cumecs
Total length of new river channel above and below barrage	900m
Maximum upstream water level, above sea level	16m
Minimum downstream water level, above sea level	7·5m
Lock :	
Maximum head across lock	8·5m
Length of lock, between gates	165m
Width of lock	14m
Total length of lock basin	265m

the dual purpose of limiting the flooded area and providing convenient routes for roads along their crests.

Plant

Much of the equipment for the work came from Britain, including a Ruston Bucyrus 1½-yard excavator ; two Butters 140ft-jib, 7-ton electrically driven derricks ; 2-ton, 6-ton and 8-ton



Diorama of the Chainat barrage. The stage shown is with the main works complete, but with the dam still "in the dry" as during construction. To complete the work, the cofferdams were dug away, and an earth dam built across the river, between the bunds shown on the right. Note the discharge points from the well-point drainage.

The barrage is shown at an advanced stage of construction, with the lock in the foreground. The extent of the area dewatered by well-points is clearly shown

Neal's mobile cranes; Ruston narrow-gauged diesel locomotives ; Blackstone diesel generating sets; Gwynnes pumps and Meadows diesel engines with 12in Sigmund pumps ; B.S.P. pneumatic hammers and piling frames ; pneumatic tools and Arpic compressors ; Fleming and other dredgers and a large number of machine tools for the workshop. The main land excavating equipment comprised Le Tourneau self-propelled, 15-yard scrapers with caterpillar pushers, Caterpillar " D8 " tractors and scrapers, self-propelled scrapers, Lima 1½ yard and P.H. 3½ yard draglines and dump trucks from America. Also from America came wellpoint equipment and additional air compressors. Machine tools, deep well and other equipment came from Europe. Reinforcing steel, rubber water stop and elastic filler came from America and Japan, while cement came from Japan or was of local manufacture.

Much of the equipment was quite new to Thailand. For example, Scotch derricks, electrically driven wellpoint and deep-well equipment were used for the first time in Thailand on the Chainat dam.

Most of the materials and equipment having arrived in Bangkok was sent in barges up to Chainat which is 250 miles by river north of Bangkok. The scrapers and trucks were driven up by road, which was at that time only a rough waterbound earth track, and was impassable for several months of the year. The river also for several months was so low that it became too shallow for the barges to pass.

Excavation and Dewatering

One of the major problems of the constructional work was that of dewatering the barrage site. The extent of this problem will be apparent from the following description of the method of construction employed, and from the above illustration showing construction in progress at the site.

The excavated area in which the barrage was built was 10m to 15m deep ; it was excavated by 7 cubic yard self-propelled rubber-tyred scrapers, push loaded by caterpillar tractors, and eight 1½ cubic yard draglines and face shovels loading dump trucks: 3½ yard draglines were also used. Rooters were required to break up some of the very hard layers of clay at the high levels. The new river channels were cut partly by land excavators and partly by suction, bucket and dipper dredgers which discharged most of the materials into the river. Some of the spoil excavated was used in the earth dam and the remainder was used to raise the level of the river banks and approach areas. A total of 3,000,000 cubic metres of sand, silt and clay was excavated, including about 1,000,000 by dredgers.

As the original ground level of the site was below maximum river flood level the whole working area was surrounded by an earth bund approximately 2·50m high and over 4km in length. A further 3km of embankment, 2m to 3m high, were constructed within the working area to form high level site roads, discharge canals and additional protection against flooding.

The ground below the top 8m of overburden was found to be highly permeable and as the site was surrounded by the loop of the river, dewatering of the construction pit made necessary an extensive system of wellpoints with up to 1500 1in risers, varying from 12ft to 27ft long and spaced at 2ft 6in centres, in order to allow the excavating equipment to work and in order to place the deep foundations. Pumping continued day and night for four years and, at times, during the high flood seasons, ground water was pumped out at the steady rate of 1,000,000 gallons per hour.

The wellpoint pumps discharged into open tanks inside the construction pit ; water from these tanks was then pumped up to a discharge level above river flood level by a battery of 8in and 12in open pumps. Owing to the high permeability and elaborate system of wellpoints required to control the ground water, which in some cases completely ringed the working areas with up to four lines of wellpoint headers, it became necessary to work in small areas, especially at the low levels, thus restricting the activities of the excavating equipment. Also, during the rainy season, the rubber-tyred scrapers and dozers as well as the dump trucks were unusable on the wet, slippery ground, and it was necessary to plan the work accordingly. Some muck was shifted by 60cm-gauge locomotives and wagons loaded through a hopper by a dragline.

Main Structure of Barrage

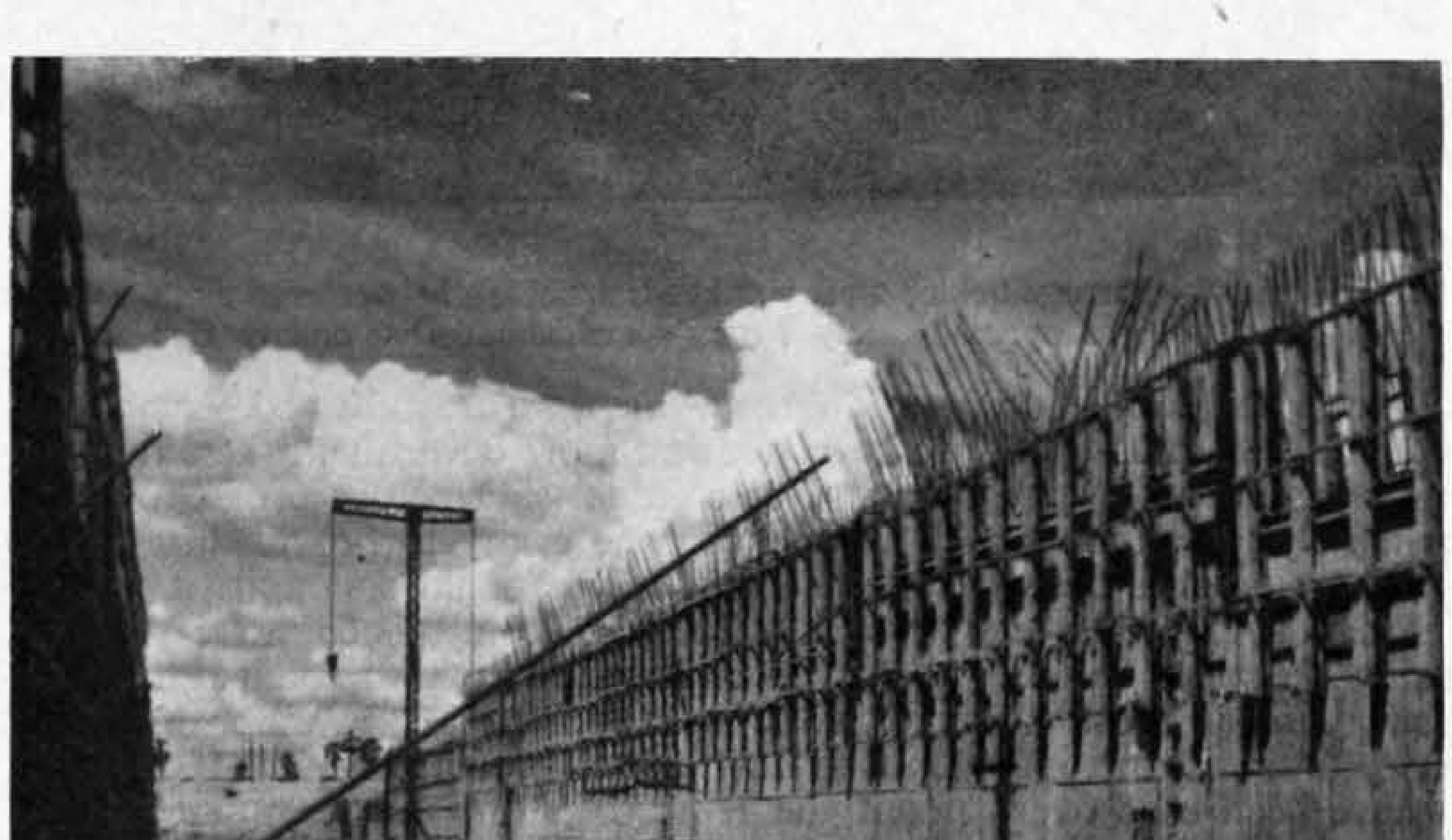
The main structure of the barrage is of reinforced concrete. The sixteen control gates are radial gates supplied by Dortmund Union of Germany and operated by electrically-driven winches on an overhead reinforced concrete service bridge. The gates may also be operated by hand in case of emergency. The reinforced concrete highway bridge spanning the barrage was designed for 20-ton truck loading.

Four rows of steel sheet piles from 4m to 10m long were driven, by double acting pneumatic hammers, under the foundations. The main reinforced concrete barrage foundations vary in thickness between 1·50m and 4·75m and are 27m wide. The upstream apron, 40m wide, is also of reinforced concrete 30cm thick, and the downstream spillway apron, also 40m wide, varies in thickness from 1m to 2·60m. All foundations and apron blocks were jointed with 9in wide rubber water stops cast *in situ*. There is an additional apron 30m wide downstream, made of 1m concrete cubes laid on a graded sand and stone filter. These cubes are joined with *in situ* concrete, with a large number of water pressure release valves between the blocks. A layer 1m thick of large stone rip-rap 20m wide was placed on the bed of the river to prevent erosion, and the bed of the river upstream of the earth dam and the barrage was covered with a layer of clay dredged into position to seal off the porous strata beneath the structures. The banks were protected with reinforced concrete slabs cast *in situ* at a slope of 1 in 1½ and laid on stone filters. Water pressure release valves similar to those used in the barrage aprons were provided at approximately 4m centres in all these slope slabs. Penetrometer tests carried out on the foundation material showed that bearer piles would not be required for any of the structures.

Navigation Lock

The floor of the lock is 3m thick and is heavily reinforced ; the walls are 6m thick at the bottom and nearly 15m high. The double-leaf steel mitre gates were supplied by Fried Krupp of Germany ; they are 14·2m high downstream and 7·5m high upstream, and are electrically-operated from separate control houses and can be operated by hand in case of emergency. Float chambers in the lock walls are used to indicate water levels and are connected to the controls to prevent operation of the gates against a difference in head. The lock takes approximately ten minutes to fill or empty at the maximum head. The filling and emptying ports along the bottom of the lock walls are connected by culverts running through the lock walls and the discharge is controlled by radial valves operated from above.

There is a 6m wide double bascule bridge over the lock which was also supplied by Fried Krupp. The main structure of this bridge is steel,



Construction of the lock in progress. Note the 6-ton crane with a 50ft jib made on the site

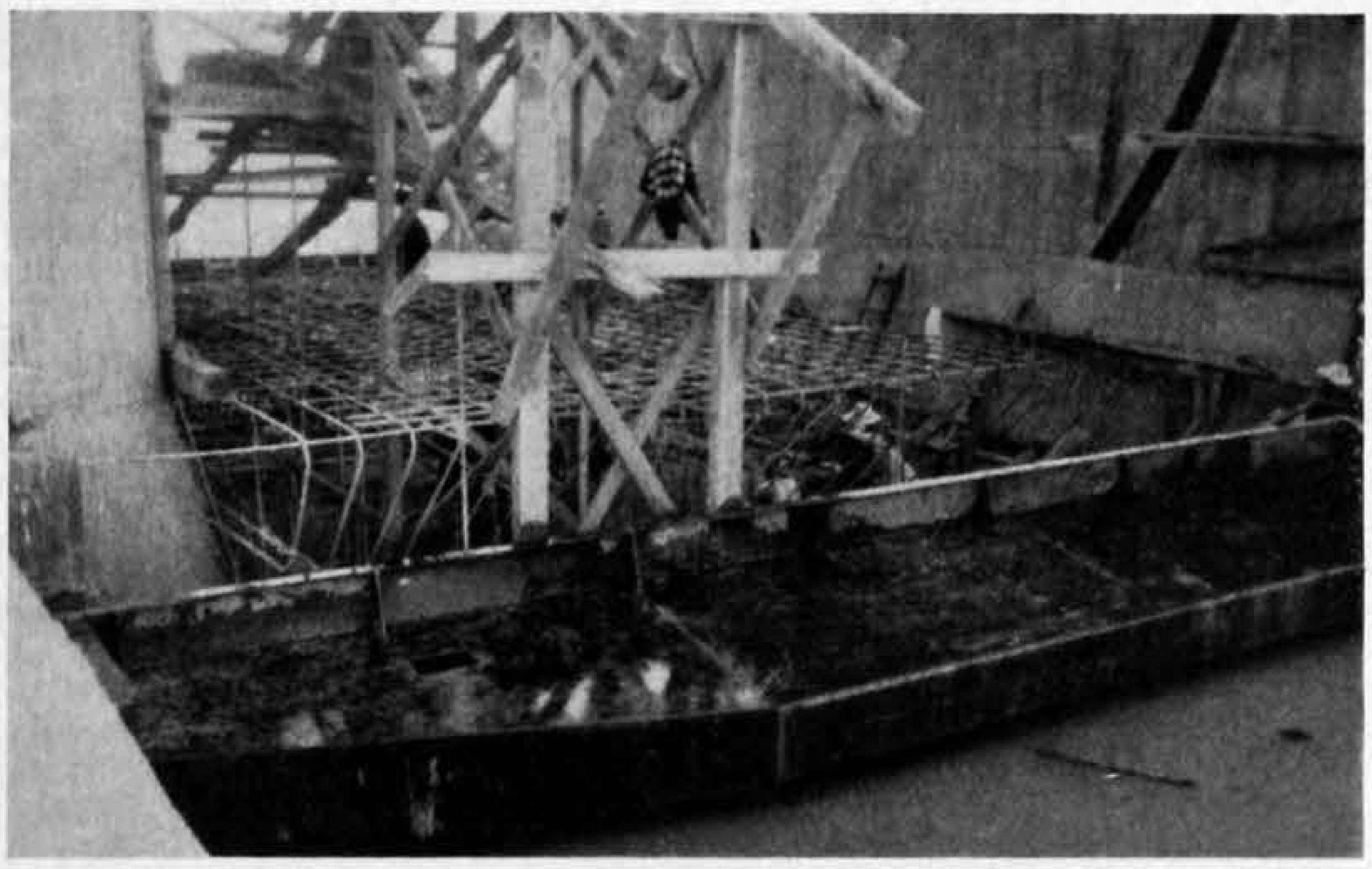
the counterweights consisting of waste lengths of reinforcing bar contained in reinforced concrete boxes ; the decking is timber covered with a protective bituminous carpet. The bridge is controlled electrically but can be operated by hand if necessary. As in the case of the radial gates, the lock gates and bascule bridge section were shipped to Bangkok partly fabricated in units not exceeding 10 tons in weight. The final assembly and riveting were completed in the final positions.

Reinforced concrete piled jetties 150m long were built upstream from the lock to ensure safe approach and mooring for boats and rafts and to prevent them from being drawn into the barrage sluices. The reinforced concrete piles (35cm square and 14m long) were driven by three 10-ton drop hammers on steel piling frames.

Concrete Quality Control

In all, about 150,000 cubic metres of high-quality reinforced concrete were used in the various structures. The concrete was subjected to careful quality control by the site laboratory which was set up to test materials. Pneumatic immersion vibrators were used to give compaction. Moderate heat Portland cement was used for most of the heavy foundations ; no system of cooling was necessary. Curing of the concrete was achieved by spraying water on sacking laid on the concrete, or by ponding water on horizontal surfaces. The effects of shrinkage were reduced by casting alternate blocks and allowing a waiting period of not less than five days between the casting of adjacent blocks.

The granite aggregate was quarried from nearby hills, crushed and graded and brought to the site by barges and dump trucks. River gravel was also used and this was combined with the stone and river sand to give a dense, workable mix. The stone, sand and cement were brought from the stockpiles in narrow gauge wagons hauled by 6-ton diesel locomotives. The concrete was then taken from the mixing stations in narrow gauge wagons which were pushed by hand, the concrete then being tipped directly into the work from overhead gantries. Much of the concrete was placed, using 1 cubic yard bottom-opening buckets lifted by 140ft jib derrick or by a 50ft hammer-head crane. This special hammer-head jib was designed and built on site and fitted to a standard Neals mobile crane. It is shown in the illustration of construction at the lock.



Building up the barrage behind steel bulkheads spanning between the piers. Each bulkhead weighs approximately 7 tons, spans about 15m and is 1½m deep

Most of the formwork comprised cantilever posts and sliding panels. Facings were mostly of 1½in thick teak and the frames were of mai yang wood. Each lift was approximately 1m, although higher lifts of 1½m to 2m were sometimes used. The cantilever posts were designed to get three lifts of 1m each before raising the posts to the new positions. Posts made for use on the lock wall construction in 1953 were still in use in 1956 and panels were known to have been used over forty times, the only repair to them being surface planing after about ten uses. Concrete bonding surfaces were prepared by hand chipping. All the indented bar reinforcement, of which approximately 7000 tons were used, was cleaned of scale and rust by sand blasting.

River Diversion

Following the completion of the main barrage in early 1956, the old river bed had to be closed off. During the low river period, the last bunds separating the construction pit from the river were cut and the river was partly diverted through the central deep section. This deep section was incorporated in the four central spans of the barrage to ease the construction of the earth dam. The general spillway level was 9m above sea level, whereas the natural river level at the lowest period was +7·50m. The central section was at +5m and was designed to take the whole of the flow during this dry period. Thus flow past the end of the earth dam while under construction was kept at a minimum and the head against the earth dam was kept to a minimum until the core was placed and compacted.

To construct the earth dam an earth cofferdam was first pushed out at level +10 across the old river, using bulldozers, dump trucks and rubber-tyred scrapers. When this was completed a second cofferdam was then pushed out parallel to it and downstream. The area between these cofferdams was then pumped out in sections, cleaned of soft material and filled with sand and clay which was compacted by sheepsfoot rollers, tractors and rubber-tyred scrapers.

The earth dam so formed was then built up to keep pace with the rising river. The deep section through the centre four vents of the spillway was then closed with steel bulkheads spanning horizontally between the piers, one of which is illustrated. A reinforced concrete ogee weir was then constructed in the four centre openings, bringing the sill level to +9. The steel bulkheads were then removed and the barrage was complete.

A small power house was built on the left bank of the river to accommodate a 400kW Francis turbine generator to supply power for the sector gates, lock gates, bascule bridge, general lighting, and maintenance workshops.

Site Conditions

An average labour force of about 2500 men and women was employed continuously on the work. They worked day and night shifts. Mainly they were Siamese, but most of the skilled workers were Chinese. The women worked side by side with the men, sometimes under the hardest conditions, excavating where no machine could go, and the women, we are informed, were found to be better and more cheerful workers than the men. To maintain satisfactory progress on the contract it was necessary to provide up to five fully-qualified civil engineers and a similar number of foremen from this country.

A large construction camp was built at the site—on "stilts," as is the custom. A water works was built to filter and chlorinate a water supply taken from the river or from the wellpoint pumps. Fuel oil was brought by barge in drums or pumped direct from lighters to 50-ton storage tanks. A temporary 1000kW diesel power house was set up to supply the construction camp. The workshop was equipped with modern machine tools, including lathes, drills, shapers, planers, plate bending rolls, shears, a forge hammer, injector reconditioning and weld apparatus, and everything necessary to maintain the large amount of construction and transport equipment.

Much of the work has been done on the system of canals required to lead the water from the impounded river to the irrigation areas ; these canals are provided with hundreds of regulators and small locks. The whole irrigation project, including the Chainat headworks, is estimated to cost approximately £20,000,000, the last of the canal system being due for completion in 1959.

Standards for Punched Cards

The British Standards Institution reports satisfactory progress with its plans for standardising the shape, size and content of punched cards used with machine tools and in office calculating equipment. A new committee charged with preparing punched-card standards recently held its first meeting at British Standards House. It is a highly representative committee of over fifty members, who reflect the widespread interest in, and support for, standards of this kind. The committee includes representatives of all the major manufacturers of office-accounting machinery ; paper-makers and printers ; engineering and management associations; machine-tool makers and instrument manufacturers ; the aircraft, automobile and electrical industries ; big industrial organisations and the nationalised industries ; and government departments, universities, research associations and libraries. Because of the size of the committee and the range of interests concerned it was decided to set up three sub-committees to begin drafting standards. Each of these sub-committees is to meet this month.

Sub-committee 1 will concern itself with the physical dimensions of punched cards : length, width and breadth and their tolerances. It will aim for unified sizes and will also try to secure common dimensions and forms for the holes to be punched. This sub-committee will also consider the qualities and properties of the cards.

Sub-committee 2 will be working chiefly in the interests of users of punched cards and will concentrate on evolving a standard form of coding suitable for general interpretation. It has already been agreed to base such a code on the Roman alphabet and to use the numbers one to nine. This sub-committee will also be responsible for reviewing lay-out, that is the presentation of the columns and rows on the cards.

Sub-committee 3 will be exclusively concerned with punched tape where it is hoped to evolve standards for tape having a suitable number of channels and will consider the problems associated with the five, six, seven and eight-channel systems. In addition to considering the quality of the tape itself this sub-committee will be responsible for the reels on which the tape is wound and the containers in which the reels are stored.

The initial move for establishing standards for punched cards came from the Machine Tools Trades Association (now represented on the new B.S.I. committee) which drew attention to the assistance that standard punched cards would offer not only to makers and users of machine tools but also in mechanised office work. In the factory, punched cards or punched paper tape are inserted in such machine tools as jig-borers and planers to provide high-precision control over machinery. In the office, suitably punched tape or cards are fed into computers which then automatically work out particulars of employees' wages and similar calculations. It is to ensure that blank cards or paper supplied by any one firm should fit into any punching machine and, subsequently, into any office computer or machine tool, that standards are now being considered.

Maudslay Scholarship.—With the aid of funds provided by the trustees of the Maudslay Scholarship Foundation, and administered jointly by the Junior Institution of Engineers and the Maudslay Society, scholarships and prizes are offered to young engineers for the purpose of assisting them in their technical education and practical training. The councils of the Institution and the Society have announced the following rules for the award of the Maudslay scholarships and prizes for 1957 :—The value of any one scholarship will not exceed a total sum of £400, which may be awarded as a single sum or in annual instalments over not more than four years. Applicants for the Maudslay scholarship who are unsuccessful may be awarded Maudslay prizes of a maximum value of £50. The scholarships and prizes will be awarded by selection. Candidates must not be more than twenty-seven years of age (i.e. must not have passed their twenty-eighth birthday on March 30, 1957), must be engineers or training to be engineers and must have attained the same standard of education or engineering training as is required for membership of the Junior Institution of Engineers in the appropriate grade. Further information can be obtained from the Secretary of the Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1.

Synthetic Fluids for Transformer Cooling

By P. D. WILMOT, B.Sc., A.Inst.P.,* and N. G. H. THOMAS, B.Sc.†

No. II—DESIGN AND APPLICATION OF "PYROCLOR" FILLED TRANSFORMERS

(Concluded from page 412, March 15)

In situations where fire resistance and economy of space are necessary transformers filled with synthetic fire-resistant fluids (askarels) have been, and are still, widely used in North America and a number of countries in Europe. The principal transformer askarel is a blend of hexachlorodiphenyl and trichlorobenzene, named "Pyroclor" in the United Kingdom. In No. I of this article the properties of "Pyroclor" were discussed; below we discuss the design and application of transformers filled with this fluid.

SINCE "Pyroclor" consists of a mixture of chlorinated hydrocarbons it is not surprising that, like many other chlorinated fluids, it should be a solvent for many materials toward which mineral oil is inert. If they are polar, such materials when in solution ionise to a greater degree than they would in oil since the permittivity of "Pyroclor" is greater than that of oil; therefore, the dielectric quality of the fluid is more easily affected. A very wide variety of investigations have been carried out by Monsanto Chemicals, Ltd., by means of an accelerated test technique to determine what materials should be used, and practical application of the results has shown that the method gives a reliable indication of their suitability. The results are summarised in Table I and the method is described in the Appendix. The results are typical rather than comprehensive. A considerable amount of the work was carried out in close co-operation with the manufacturers of the various products, who will be able to assist in the choice of compatible materials.

TABLE I—*The Suitability of Various Materials for Use with "Pyroclor"*

Application	Material	Recommendation
Surface coatings	Kaolin core-plate finish	Entirely suitable
	Polyurethane coatings	Entirely suitable
	Shellac	Entirely suitable
	Flash varnishes ...	Usually suitable
	Stove finishes	Usually suitable
	Silicone finishes ...	Suitable, provided adequately cured
	Epoxy resins	Suitable, provided adequately cured
	Oil-bound finishes ...	Unsuitable
Gasketing materials	Cork	Entirely suitable
	Isocyanate rubber ...	Entirely suitable
	Silicone rubber... ...	Suitable if adequately cured
	Nitrile rubber	Suitable, although slightly attacked
	Leather	Suitable, although curing agents are leached out and lower dielectric quality of the fluid
	Neoprene	Not very suitable, but has been used
	Butyl rubber	Suitable, although slightly attacked
	Natural rubber... ...	Unsuitable
	GR–S	Unsuitable
	Polyvinyl chloride ...	Unsuitable
Fibres and tapes	Cotton	Entirely suitable
	Acetylated cotton ...	Entirely suitable
	Paper...	Entirely suitable
	Nylon	Entirely suitable
	Rayon	Entirely suitable
	Cellulose acetate ...	Entirely suitable
	Terylene	Entirely suitable
	Glass...	Entirely suitable
	Asbestos	Entirely suitable
Structural materials and fillings	Asbestos	Entirely suitable
	Glass-bonded mica ...	Entirely suitable
	Glass...	Entirely suitable
	Ceramics	Entirely suitable
	Melamine resin ...	Suitable if adequately cured
	Polyester resin	Suitable if adequately cured
	Phenol formaldehyde resins	Suitable if adequately cured
	Amino formaldehyde resins	Suitable if adequately cured
	Wood	Suitable if free of natural resins
	Natural resin	Unsuitable
	Bitumen	Unsuitable

In general, "Pyroclor"-resistant materials are no more expensive and no less readily available than oil-resistant materials. In fact, transformer production could easily be standardised using products which are resistant to both fluids thus making for greater versatility and flexibility in the factory.

The authors have found that the processing of a material prior to test may affect its behaviour; for example, such products as wood contain volatile materials which may be leached out by the fluid and affect the dielectric quality of the fluid adversely, but a simple drying treatment before exposure to the fluid would overcome this defect. Similarly, with thermosetting plastics materials, if the degree of cure is inadequate, the unreacted chemical residues may dissolve in the dielectric and cause deterioration. In such cases, a "post-stoving" treatment (heating for a few hours in an air oven at 100 deg. to 120 deg. Cent.) is often adequate to prevent this deterioration. Where the less expensive, although not entirely resistant, synthetic elastomers are employed for gaskets, it is good practice to arrange that as small an area as possible of the surface of the gasket is exposed to the fluid. The slight swell produced does no harm and may even improve the efficiency of the seal.

Most of the products listed in Table I are insulating materials. The metals commonly used in transformers are not attacked by the "askarel." Mild steel is generally employed for tanks, and copper, tin, zinc and aluminium are all resistant to attack. Care should be taken to ensure that no rust or oxide is present in the system, and it is customary to sand or shot-blast the interiors of tanks and cooling tubes before assembly.

TRANSFORMER DESIGN

For successful transformer design using "Pyroclor," it is desirable to keep the volume of fluid to a minimum because it is more costly than oil. In America a considerable amount of redesign has been carried out for some "askarel" units, examples of which have been described by Burnham and Maunder; single-phase units have been reduced to three-quarters, and three-phase 500kVA, 27,000/216Y-volt units to two-thirds of their original sizes.[1] Even without radical redesign, useful economies can be effected by rounding the corners of tanks or by using tanks having cruciform shapes; in many cases considerable economy has been effected merely by filling "dead" space with wood, blast-furnace slag and even glass marbles. Further, cooling tubes having oval or star cross sections have been used in order to reduce fluid volume. On the Continent corrugated sides and fins are often used with the fluids in place of tubes. A reduction in overall size is also of value from the space-saving point of view, and where such saving is especially important, as with railway traction, forced circulation with air-blast cooling has been adopted.[1]

Since the density of "Pyroclor" is roughly twice that of mineral oil, the transformers are correspondingly heavier. Water floats on the fluid surface, and it is therefore good practice to bring connections into the transformer through the tank walls below the fluid surface or to sheathe them with solid insulation where they pass through the surface.

Because of its chemical constitution "Pyroclor" does not suppress arcs as effectively as mineral oil, and therefore on-load tap-changing under the fluid surface is not adopted. It is usual to incorporate some form of interlock that makes switching impossible whilst the windings are energised. When on-load tap-changing is required contactors may be housed externally, either in air boxes or in small mineral-oil-immersed switches.[2]

In recent years, welded tank designs have become popular, particularly with "askarel." This is mainly due to the high chemical and thermal stability of the fluid which needs no attention throughout the entire life of the transformer.

Using sealed conditions a "top hat" type of construction, with an air or nitrogen-filled space, may be adopted to allow for the expansion of the fluid. Sealing is frequently so arranged that the gas is under a slight negative pressure when cold. On the other hand, the transformer may be built to "breathe" making use of the conservator principle. With mineral oil the conservator functions partly to ensure that the temperature at which the oil is exposed to atmospheric oxygen is not so high as to promote oxidation. "Pyroclor" does not oxidise and this problem does not arise, but, since at the maximum operating temperatures the trichlorobenzene present in the liquid has a measurable vapour pressure, a conservator will prevent losses by evaporation. Silica gel breathers should be installed at the outward end of vent pipes.

THE USE OF "PYROCLOR" TRANSFORMERS

A transformer filled with mineral oil is cheaper to build than its "Pyroclor" equivalent, even when the measures mentioned above are adopted. However, this does not necessarily mean that the total cost of the whole installation is greater. In many applications, a separate substation furnished with expensive fire-fighting equipment is required if mineral oil is to be employed. This is not the case with "Pyroclor" and hence there is a significant saving of expense on this account, as has been demonstrated in numerous practical examples, not only in America and on the Continent of Europe, but also in the United Kingdom in recent years.

From the point of view of fire-resistance alone the air-cooled transformer may be as effective as "Pyroclor," but air-cooled units are generally even more expensive to make and, whilst the "Pyroclor" unit occupies no more space than the mineral oil equivalent, the air-cooled unit is larger and requires careful maintenance to ensure freedom from dust and moisture even in ordinary situations. In dusty and otherwise contaminated atmospheres the air-cooled unit must be enclosed and equipped with forced-circulation equipment. Such an arrangement adds to expense and to size and, furthermore, the air breathed by the system must be filtered—which itself involves additional maintenance work to ensure that the filters are kept in good order.

Air-cooled transformers are not recommended for use at voltages above 11kV, whereas units operating at voltages as high as 120kV have been built with "askarel." Although the impulse-strength of "askarel" transformers is not quite as good as that of their mineral-oil equivalents it is very much better than that of air-cooled units of the same rating. Noise levels, too, are much lower with "askarel" than with air. For these reasons, therefore, the "askarel" transformer has proved a strong competitor against the air-cooled unit.

GENERAL APPLICABILITY OF "PYROCLOR" TRANSFORMERS

So far we have dealt with the advantages of using "Pyroclor" transformers in circumstances which would necessitate fire-resistance where, for example, safety is an overriding consideration. On the other hand, an extension of this reasoning leads to the conclusion that "Pyroclor" fillings are eminently suitable for any district or factory distribution system. The fact of their fire-resistance permits them to be sited at the load centre in any convenient position near the equipment they serve. Distribution systems of this kind allow considerable saving in costs by eliminating long low-voltage cable runs and the line losses which these introduce. At the same time separate substations fitted with fire-fighting equipment, pebble drains, &c., are not required. Apart from the savings in installation costs, therefore, a great degree of flexibility in plant

* Formerly with Monsanto Chemicals, Ltd. Now with the Mond Nickel Company, Ltd.
† Monsanto Chemicals, Ltd.

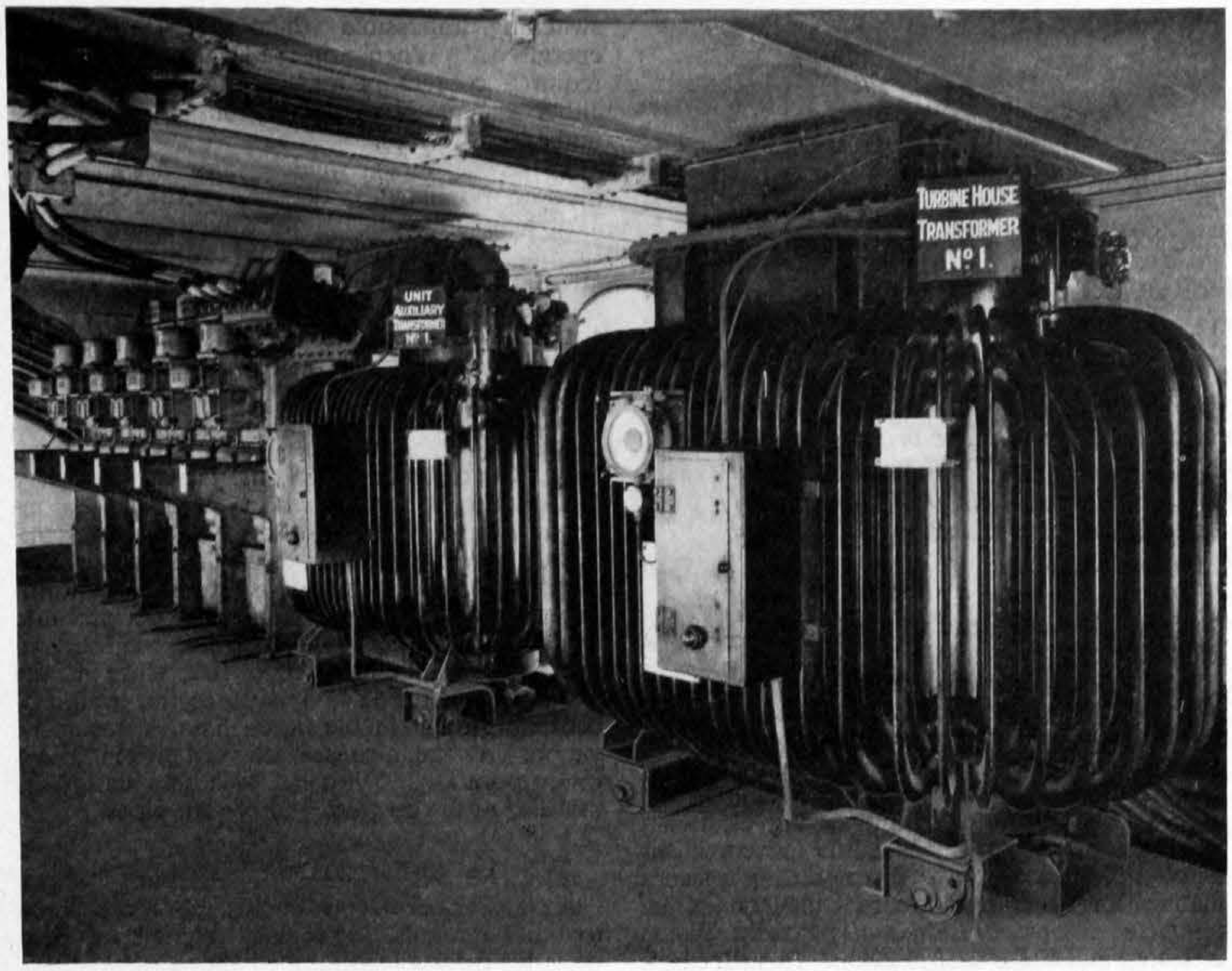


Fig. 12—Two Metropolitan-Vickers indoor 6·6kV/400V transformers of 900kVA and 500kVA capacity installed in the basement of the Central Electricity Authority's Trafford power station where they have been in continuous operation since 1941

layout is achieved, and with the continuing increases in the price of copper and the cost of labour these savings are becoming more and more significant. These considerations of using "askarels" to the best advantage have led to the development of the "unit type" of distribution system which has become popular in factory layout in America and on the Continent, the transformer and its associated h.t. and l.t. control gear being placed in any convenient position on the factory floor beside the equipment they serve. Furthermore, over the years, reductions in line-losses represent an important saving.

There are many applications where fire-risk is great and space is limited. A typical "askarel" unit for use with dielectric furnaces has been described by Burnham and Maunder: rated at 12,000kVA, this transformer is water-cooled, sealed and equipped with an expansion chamber.[1] The mining industry employs "askarel" transformers in America and in France, where that industry's research laboratories have tested and approved a sealed pressurised "anti-firedamp" design for underground workings.

"Askarel" units are much used in public buildings such as shops and theatres. In London one is installed in an Oxford Street store and in Paris the Opera uses "askarel" in its substation transformers. Electrified railway systems offer great possibilities for "askarel" units and in both France and America they are being employed both on traction and in distribution.[3] In one case, on the Paris Metro, where the atmosphere was too dusty for an enclosed air-cooled unit to be run without requiring a great deal of attention, it was eventually decided to immerse the whole unit in "askarel" and it has operated without requiring maintenance service. Two other typical installations are illustrated in Figs. 12 and 13.

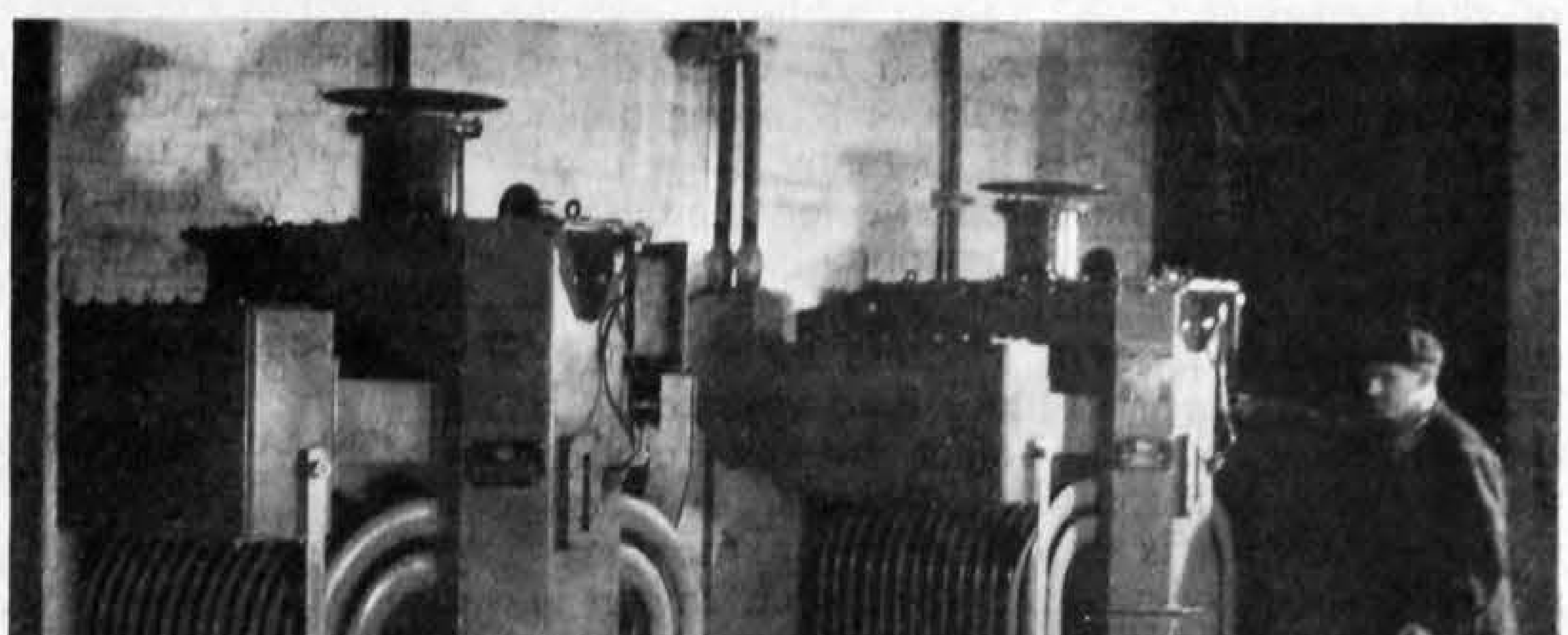


Fig. 13—"Pyroclor"-filled transformers made by South Wales Switchgear, Ltd., and installed at the Thames Mill of the Bowater organisation at Northfleet

In America, "askarel" filled transformers have given extremely satisfactory trouble-free service on the railway systems since 1933, supplying heating and lighting services to the railway cars.[4] One manufacturer has produced an entirely sealed design with expansion chamber, forced circulation and air-blast cooling for main-line locomotives.[1]

APPENDIX

Method of Test of Materials for use with "Pyroclor"

The shape and quantity of materials available varied considerably with the particular application. Wire insulation, for example, was already on the wire, while gasketing materials were supplied in sheets. Therefore, test specimens were fashioned in several ways according to the application; gaskets were cut into strips, wire coiled into helices, insulating boards cut into plaques and surface coatings painted on metal bases. Such specimens were then immersed in 100 ml and 200 ml quantities of clean "Pyroclor" in clean bottles fitted with ground-glass stoppers. Control specimens of the materials and of bottles of "Pyroclor" from the same source were also set up. Controls and test specimens were aged for one week at 100 deg. Cent. in an air-oven and at the end of this period all items were examined for physical change.

The power factor of the fluid at 100 deg. Cent. and 1000 c/s and its volume resistivity at 500V d.c. at the same temperature were measured, both the control and the sample exposed to the material being examined. The tests on the solid specimens depended on the application: gasketing materials and papers were subjected to tensile strength tests, surface finishes to scratch tests, and insulating surface coatings and insulating boards to breakdown strength measurements.

The results were analysed in the following way. The physical entities which are observed in making resistivity and power factor measurements are ions and, therefore conductivity is to be regarded as the fundamental property. If attacked, the material may introduce ionisable material into the fluid and the difference between the conductivity of the control and of the fluid exposed to the material is thus a direct measure of this attack. The relation between the surface exposed to fluid and the volume of fluid used naturally varied from test to test, and a normalising factor was therefore introduced. When the conductivity difference was multiplied by the volume of fluid and divided by the surface-area exposed, the effect for all substances on the basis of one square centimetre immersed in 1 ml of fluid could be studied.

This method assumes that there is complete ionisation of the impurities, and the assumption is not so in all cases. With ionisable materials the ionic concentrations involved are so low that little recombination can occur and in that respect the method of correlating results gives useful information, but for non-ionisable material in solution electrical measurements are of little value. Nevertheless, it is the ionisable impurities which lead to a lowering of dielectric quality, which are important in this application, particularly since hydrogen ions, which will bring about acidic attack, fall into this category. The tests on the solid specimens are complementary to the electrical measurements. The classification "completely suitable" has been given to materials with which no significant change was observed. Other results have been examined in the light of the application before deciding on whether the material should be rejected.

It is appreciated that this method of test is not thorough-going: the time of ageing for a degree of degradation which is regarded in any application as the limit, should be examined as a function of ageing temperature, but pressure of work forbade this. Results, however, have shown that reliable data can be obtained by this less-involved method of test.

References

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[2] Turner, H. R., and McLachlan, W. T., *General Electric Review*, 101, 726 (1933).
[3] Burnham, L. H., *Railway Electrical Engineer*, 29, 160 (1938).
[4] "Pyranol Transformers," General Electric Publication No. GEA-2048E.

Proposal for a Cement Works in Qatar.—We are informed by the Government of Qatar that preliminary results of a detailed geological survey being conducted in that country by Associated Drilling Supply Company (Overseas), Ltd., indicate that adequate natural resources exist in Qatar for the manufacture of high-quality Portland cement. The indications are that reserves immediately exploitable are sufficient for at least fifty years' working at a production rate of 200 to 300 tons of cement per day by the dry process. Cheap fuel is available near at hand as the main limestone area is within 20 miles of the centre of gravity of the Qatar Petroleum Company's Dukhan oilfield, from which natural gas can be made available. Indications are that sweet water will also be found within reasonable distance of the proposed site for a cement factory, the establishment of which might lead to a wider scheme of industrialisation aimed at providing employment for Qataris in industries other than the oil industry.

Line Production of Die Castings

Particulars of an interesting flowline system for the manufacture of die castings which has been developed and installed at the works of the Wolverhampton Die Casting Company, Ltd., have been received from that company. The notes trace the preliminary investigations and how the basic plan was carried out in the works.

A FEW years ago the Wolverhampton Die Casting Company, Ltd., Wolverhampton, decided to develop new techniques by which it would be possible to introduce modern flowline production methods into the manufacture of die castings. These techniques have been successfully developed and the firm has issued some interesting information, both on the investigations into basic problems and on the layout introduced as a result of this work.

As a preliminary to the detailed planning, prior to a visit by the firm's executives to the United States to examine production methods there, a survey was carried out of existing methods of production, including an examination of every stage where avoidable cost might be incurred or the quality of castings might suffer. The firm points out that the existing methods are considered as efficient as possible under the batch handling method common throughout the industry. Further, a majority of jobs, mainly those where quantities do not justify line production methods, will still continue to be dealt with in this way. Briefly summarised the summary of existing methods showed that raw material, in the form of " Mazak " ingot, was melted in a number of service pots in the foundry, whence it was ladled by hand to the individual die casting machine holding furnaces. Castings were produced at operator-controlled machines, the operator being responsible for the timing of casting sequences. The castings, attached to their sprues and runners, were placed upon a bench, and, when sufficiently cool, were broken off the runners and loaded into stillages. The scrap sprues and runners were removed by hand to a central remelting shop.

The stillages were then transported by truck to the various trimming departments for their finishing operations, such as pressing, drilling, and tapping, On each of these operations, which might well number up to ten, the casting had to be removed from, and replaced in, the stillage, for transportation to the next operation. It was general practice to cast the full quantity required regardless of the speed at which castings could be finished ; consequently, many of the castings remained in storage for some weeks before they received their final finishing.

Quite apart from the obvious points at which cost savings could be made, these methods had two particular forms of imperfection in the casting :—Faults attributable to the operation of the die casting machine, and damage during handling, in the form of indentations on the face of the castings. The incidence of casting faults was varied. Whilst one operator could produce nearly 100 per cent good castings, another operator could have as much as 5 or 10 per cent scrap from the same die. Usually this fault occurred with the variation in shots per hour attained by operators, with the consequent variation in temperatures and other working conditions. It was realised that the only method of overcoming this difficulty was to have the die casting process controlled automatically.

Most damage to castings was caused by mishandling of a kind which was extremely difficult to control, and much of which was not evident until the casting had been polished. Many of the operations were of a fast nature, and the natural tendency was for operators to handle castings carelessly. The only solution was felt to be to present each casting separately to an operator at a controlled rate through all phases of production.

On consideration of all the points which emerged from the investigation a layout was developed under which each of a number of die casting machines has its own finishing line for subsequent operations. Each of the finishing lines is capable of dealing not, of course, with one product only, but with a particular type or class of product. On the completion of orders for a particular job the tooling on the line is capable of rapid change to meet the operations required on the next production run. In order to achieve maximum utilisation of capital equipment, it has always been the policy of the company to operate the expensive die casting machines on a night and day basis. On the other hand, the bulk of the finishing operations can be efficiently and economically performed by female labour, which, of course, precluded night-time operation. Consequently, the conveyor linking the die casting machines with the finishing lines had to be capable of storing a complete night's work in the " as-cast " condition, and, correspondingly, finishing lines had to be capable of working at twice the speed of the casting machines in order to dispose, during daytime, of a night and day's castings. During storage the castings are hung on the conveyor complete with sprues and runners, until the first trimming operation which separates them. Thereafter, the castings are passed from operation to operation, singly upon a belt conveyor.

During the early investigations much thought was given to the method of feeding metal to the die casting machine holding furnaces. It was finally decided to employ the " Birlec-Tama " method of metal feeding which had been used with some success in the United States and is manufactured in Great Britain by Birlec, Ltd. It makes use of low-frequency electrical induction furnaces. In the plant, as equipped at the moment, two main melting furnaces of 60kW capacity are employed, one at each end of the line of die casting machines, as shown in Fig. 2. Each machine is equipped with a 20kW holding furnace and the whole system is interconnected by a series of resistance heated launders, along which the molten metal flows and finds its own level. With this installation labour costs are restricted to the feeding of the main melting furnaces only and it has been found that metal losses during melting are as low as 0·3 to 0·4 per cent, whilst the whole system is particularly cool and clean in use. The Schultz model GJ. 21in die casting machines manufactured by the Vincent Engineering Company, Ltd., installed on the production line, are equipped with electronic control of the casting cycle.

Three kinds of conveyors are used—for storage, trimming and metal reclaiming purposes. The storage conveyors used for linking the die casting machines with the trimming lines are of the " Flowmaster " indexing design, as made by Fisher and Ludlow, Ltd. An individual conveyor attached to each machine has a length of 389ft and its length is accommodated by arranging the run in several loops above the trimming lines. The conveyor is equipped with handing " trees," steel rods with a number of staggered branches, on to which each complete spray of castings is hung in such a way that castings cannot touch each other. As soon as the casting machine operator has loaded a " tree " this moves away into close-packed storage in the roof space, and an empty " tree " takes its place. Two of the die casting machines and their storage conveyors are illustrated in Fig. 1.

The first operator on the trimming line can call

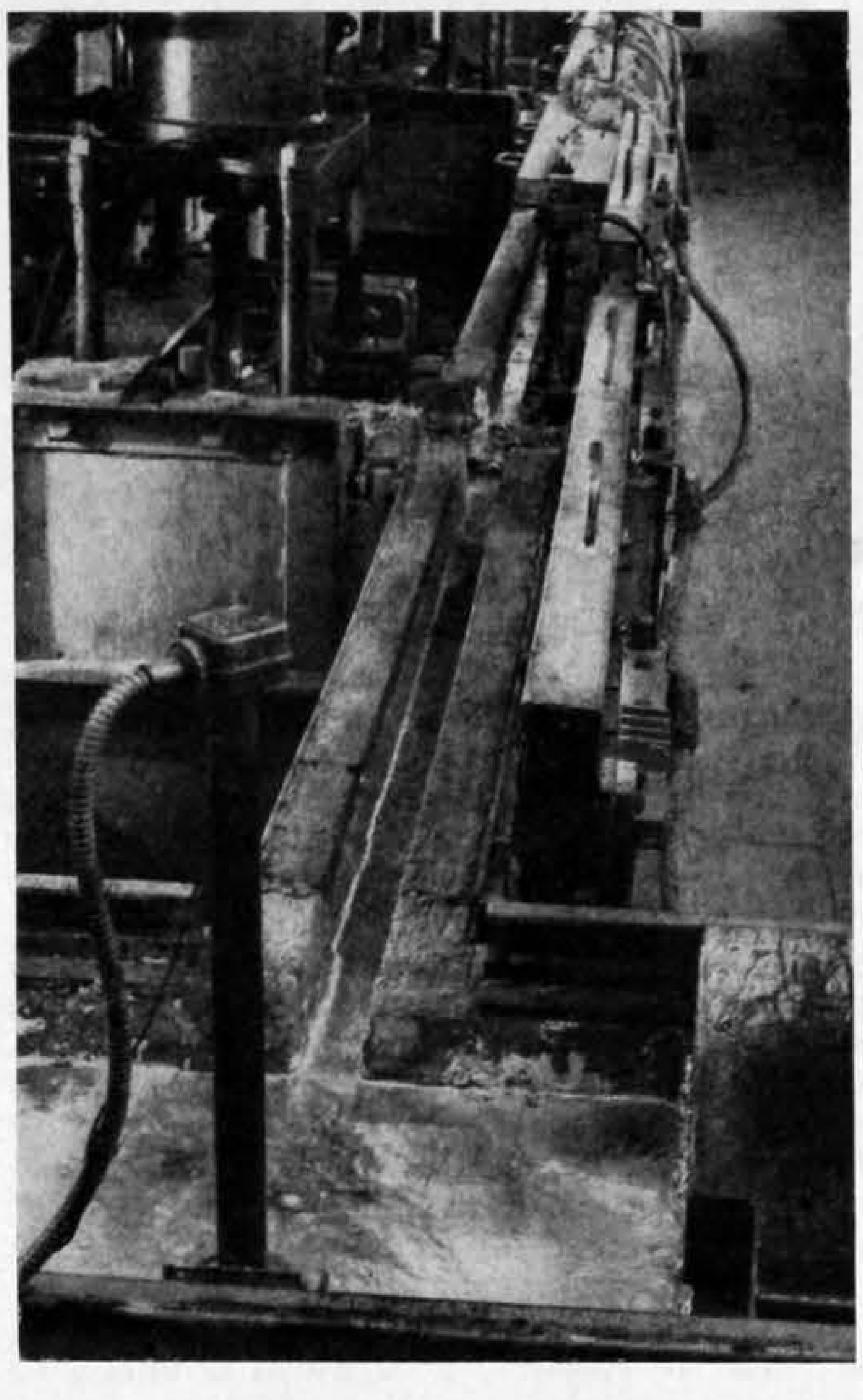


Fig. 2—Metal melting furnace in foreground feeding induction holding furnaces of a line of three die casting machines through resistance heated launders. The launder covers have been removed to show flow of metal to the machines

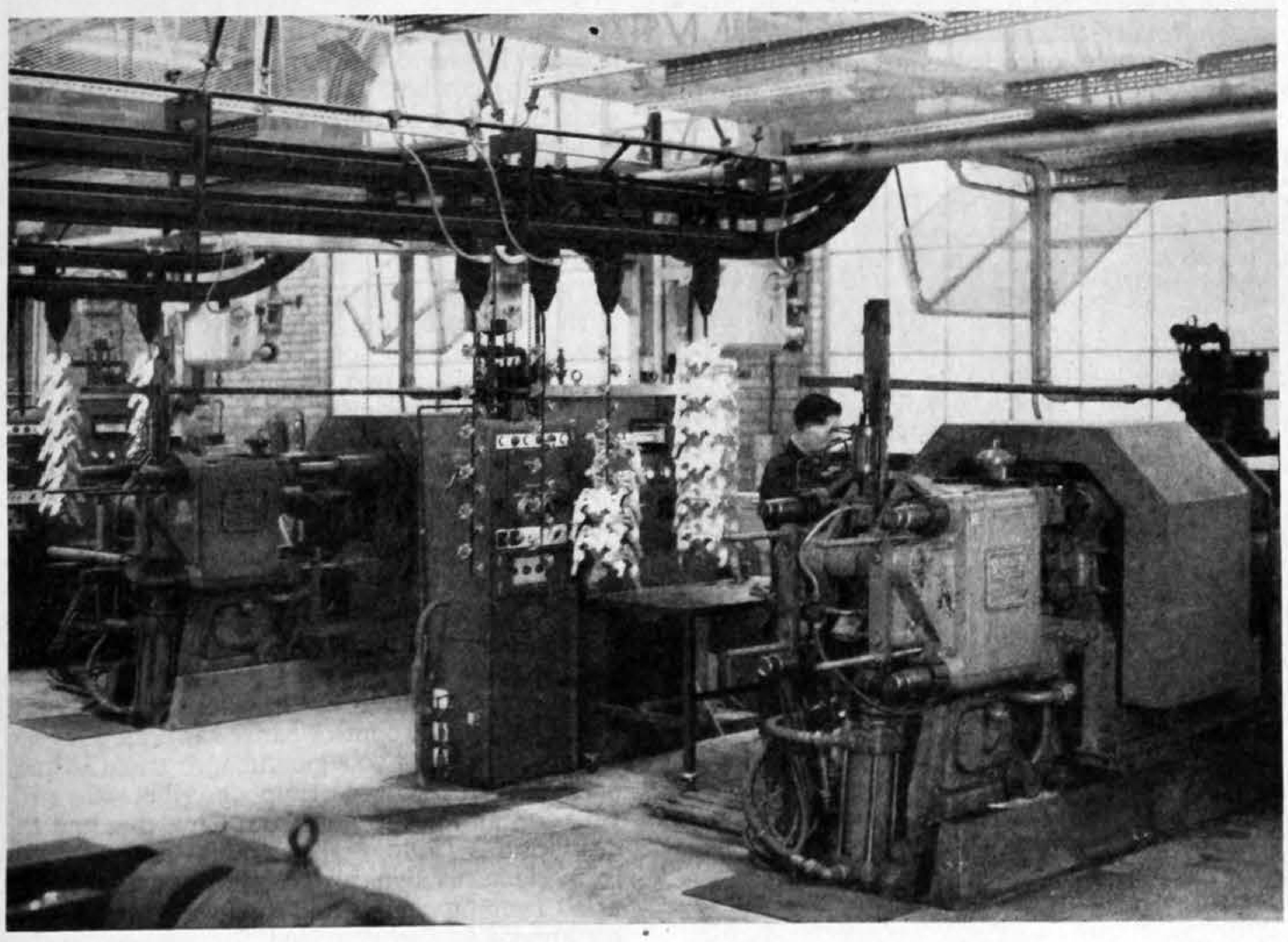


Fig. 1—Line of electronically controlled die castings machines. As castings are produced on these machines they are suspended on overhead conveyors for transfer to the trimming lines

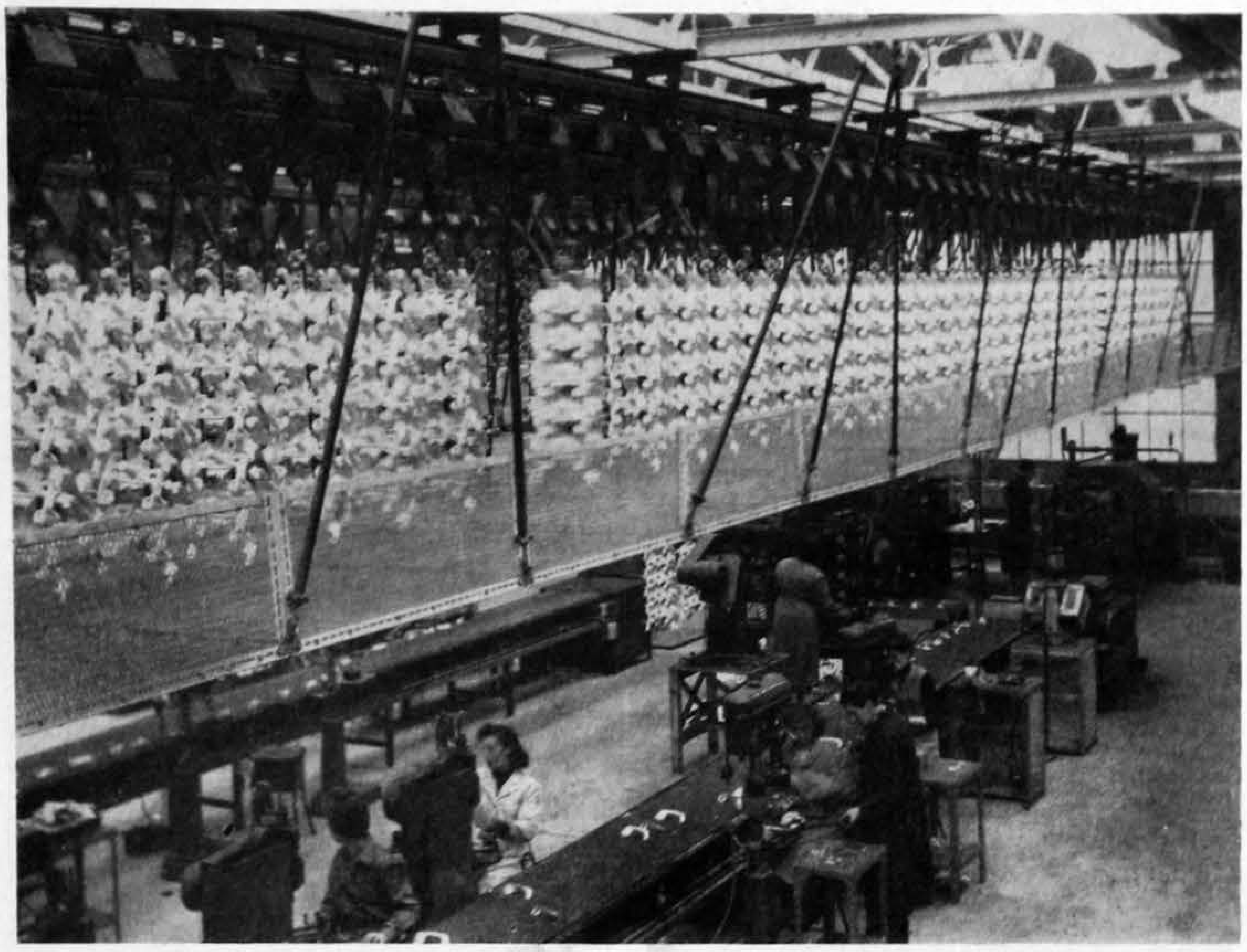


Fig. 3—Overhead storage and transfer conveyor feeding the die casting trimming lines of floor below

carriers either from the bulk store of castings from the night shift, or direct from the casting machine, according to the time of day. This means of storing the night shift's work from the casting machine not only allows female labour to be used on the trimming lines, but also provides buffer stock against minor die breakdowns or variations in production rates.

When a spray of castings has been removed from the storage conveyor for the first trimming operation its subsequent progress is along a fabric belt conveyor through the trimming stations to be seen in Figs. 3 and 4. The first operation is almost invariably the pressing of the actual casting from its sprue, runners and vents. The casting itself is dropped on to the belt conveyor, along which it passes through subsequent operations, whilst metal trimmed off passes down a short conveyor on to a metal reclaiming conveyor. This latter conveyor is housed in a large subway, 6ft wide by 7ft high, which runs the entire width of the shop, with hatches at the head of each trimming line. This subway also carries the water, compressed air and other services to the die casting machines.

It is stated that the provision of this metal reclaiming conveyor presented a considerable problem: a number of different types were inspected and found to suffer various disadvantages. The normal wire mesh belt was found to wear quickly and was rather easily distorted by the type of scrap with which it was required to deal. The slat conveyor, favoured by many plants in America, was prone to jamming through portions of scrap working their way through the slats. Eventually, Fisher and Ludlow, Ltd., devised a conveyor, some 137ft long, and so constructed as to elevate from the subway to floor level at one end, which it was felt would overcome all these disadvantages. This conveyor deposits the metal for reclaiming in the vicinity of the main remelting house.

In the planning of the trimming lines it was necessary to ensure that each was adaptable to as large a range of castings as possible. In full production, the average length of run of components suitable for this form of production is little more than one week, at the end of which time the die must be changed, and consequently, all the tools, and many of the operations on the trimming lines. This fact raises many problems not normally associated with line production methods, where, once it has been set, a line may be expected to run for perhaps many months.

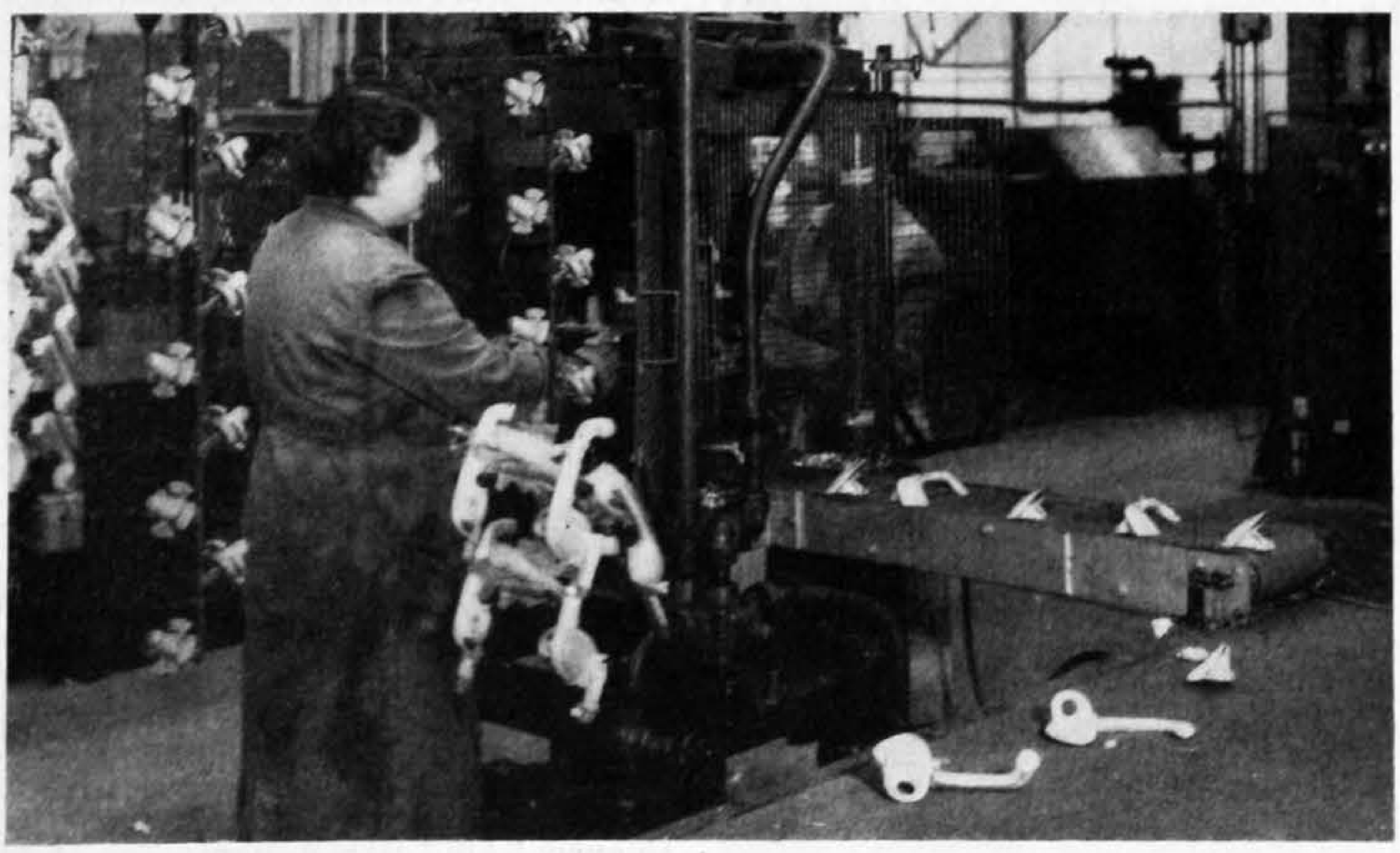


Fig. 4—Castings being removed from feed conveyor at first stage of trimming line. Here the sprue is removed and the casting placed on a belt conveyor leading through subsequent trimming stations

The problem has been met by the selection of suitable machinery for each line, training of operators to a variety of tasks, and careful planning of the production programme. In connection with this planning investigations are now being carried out into the possibility of using the Powers-Samas punched card system, at present used for the company's payroll and costing system. It is possible to classify every die casting job by the number and type of operations to be subsequently performed upon it, and since each line has been laid out in regard to length, machinery, number of operators, &c., common to a group or range of jobs, the possible assistance which might be gained from this system is readily apparent.

A further practical contribution to the problem of planning has been the provision of a die casting machine without its attendant conveyors and production lines. This machine has attached to it a number of finishing machines—presses, drillers, tappers, &c., capable of dealing with certain stock jobs of a fairly continuous nature, but provided with only one or two operators who work the machines progressively. Whilst production is proceeding normally on the flowlines the larger castings from this machine are diverted to the normal finishing departments of the main works. In case of stoppage on a flowline, the operators are diverted to the spare machine and standing time is thereby avoided.

The five main advantages which have been achieved by this flowline method of production are summarised by the firm as follows :—

The whole production of each job, from raw material to finished component ready for dispatch, is under immediate supervision ; the efficiency of tooling and technique for each and every operation is continuously checked, since subsequent operations are dependent upon it ; castings reach final inspection with the minimum of delay, and faults can therefore be corrected as they occur ; by presenting each casting singly and at a controlled rate, the possibility of damage is reduced to negligible proportions, even at a rate of flow of 500 to 600 per hour ; and labour cost for transport of castings between operations is virtually nil.

Colour-Light Signalling Installation at Cowlairs

A COMPREHENSIVE scheme of colour-light signalling is controlled from a new signalbox at Cowlairs. The total route mileage covered by the scheme is $6\frac{1}{2}$ miles and involves the Glasgow Queen Street High Level/Edinburgh Waverley main line, and certain branches, also the approach to Queen Street Station which, due to a tunnel, overhead bridges and a severe gradient from the station, is one of the most difficult termini to operate in the country. All important steam trains have to be "banked" from Queen Street with the consequent additional burden on line capacity. Cowlairs Junction is the main junction serving the diverging routes to East, North, and West Glasgow for both passenger and freight working. It also serves important motive power and carriage and wagon depots.

The signalling installation is controlled from a route interlocking panel in the new signalbox, and there are some forty multi-unit colour-light signals of two, three and four aspects, with two-aspect position light shunt and call-on signals. The Cowlairs box controls fifty-two individual points and 216 individual route switches doing the work of 245 working levers formerly installed in eight mechanical boxes.

The control panel at Cowlairs Junction is in the form of a separate control desk and illuminated diagram on which a series of white lights illuminated along the route which has been cleared for a train provide an indication to the signalman that the route has been correctly set. The layout of the control panel has been designed for operation by two signalmen, or three at busy periods. Storage type train describers are provided on all lines to and from Cowlairs, and the descriptions follow the trains automatically from signal to signal. Telephones are provided at all running signals and two-way loudspeaker equipment is also provided for communication with shunters at various points and also with enginemen of engines leaving the engine shed.

Automatic Ultrasonic Inspection

THE development of an automatic ultrasonic non-destructive technique for testing materials was recently announced by Kelvin and Hughes, Ltd., Livingston College, Knotts Green, London, E.10. This development introduces a system, termed "Autosonics" by the firm, which is designed mainly to replace manually operated equipment on large production lines; it speeds the testing process whilst at the same time giving consistently accurate results which are not dependent upon the skill of the operator.

As is now generally known ultrasonic inspection uses a beam of high frequency waves to detect the presence of discontinuities or flaws in a material under test. An acoustic transducer is coupled through probes to the surface of the material by liquid and transmits sound into the material as a sequence of energy pulses. These pulses are reflected from the opposite surface of the material and returned to the probe—the time taken being dependent upon the velocity of sound in the material and its thickness. This sequence of events is displayed as a trace on a cathode-ray tube and the presence of any discontinuity in the material is indicated as an intermediate vertical deflection between the vertical traces that indicate the ultrasonic transmission signal and the reflected signal from the lower boundary of the material. This deflection enables the operator to establish the position of the defect on the material from the relative position of the probes and the trace on the cathode-ray tube.

The "Autosonics" automatic method of inspection was developed to overcome the limitations of manual ultrasonic inspection, which calls for constant vigilance of the operator in viewing the cathode-ray tube whilst manipulating the probes. Further, manual inspection is relatively slow and is more suited to sampling or individual part inspection than to continuous control of quality in a production line. The new technique embodies a series of sensitive and stable circuits designed to maintain constant vigilance and operate automatic alarms when defects are found, and if necessary provide a constant record of work inspection.

For the application of the technique electronic circuits are incorporated in four sections of the equipment—a flaw detection section, an automatic gain control section, an automatic flaw alarm and recording section, and a system fault alarm section. These sections can readily be set to replace the operator and carry out his functions quickly, positively and accurately. To facilitate initial adjustment of the equipment a novel method of display has been introduced on the cathode-ray tube display screen. By this method, in a single channel equipment, there are two sections of the trace which are brighter than the rest, and they define the position of the electronic "gates" essential to the operation of the succeeding automatic circuits. These "gates" have a twofold purpose—first, they select defect indications from all or only a selected strata in the cross section of the material; and secondly they select only those defect indications which are greater than a preset amplitude.

The flaw detection section of the equipment generates ultrasonic waves which are transmitted into the material, as a sequence of energy pulses by an inspection probe, coupled to the surface of the material by a liquid. It also amplifies the reflected pulses, and presents the complete sequence of events as a trace on the cathode-ray tube screen. The automatic gain control section maintains the sensitivity of inspection constant by monitoring the amplitude of a selected echo pulse, and, wherever necessary, alters the gain of the amplifier to compensate for any change in it. The automatic flaw alarm and recorder section operates warning lights, bells or klaxons when a flaw indication is obtained on the cathode-ray tube screen. It can be adjusted to respond to indications from defect signals in any section, or only to signals from separate narrow strata which can be set anywhere in the cross-section. Sensitivity can be adjusted so that it will respond to small or large indications ignoring those which are less than the preset level. Finally, the output from this section can be used to operate various recording systems which are arranged to provide a plan position indication of any defect present in a plate. The system fault alarm section has been introduced so that in the event of the selected monitor signal falling below its control level for any reason, such as a fault developing in the circuit, an alarm will operate and the scanning machinery will be stopped. This alarm will continue to operate until the fault is corrected, and only then can it be reset for the inspection process to continue.

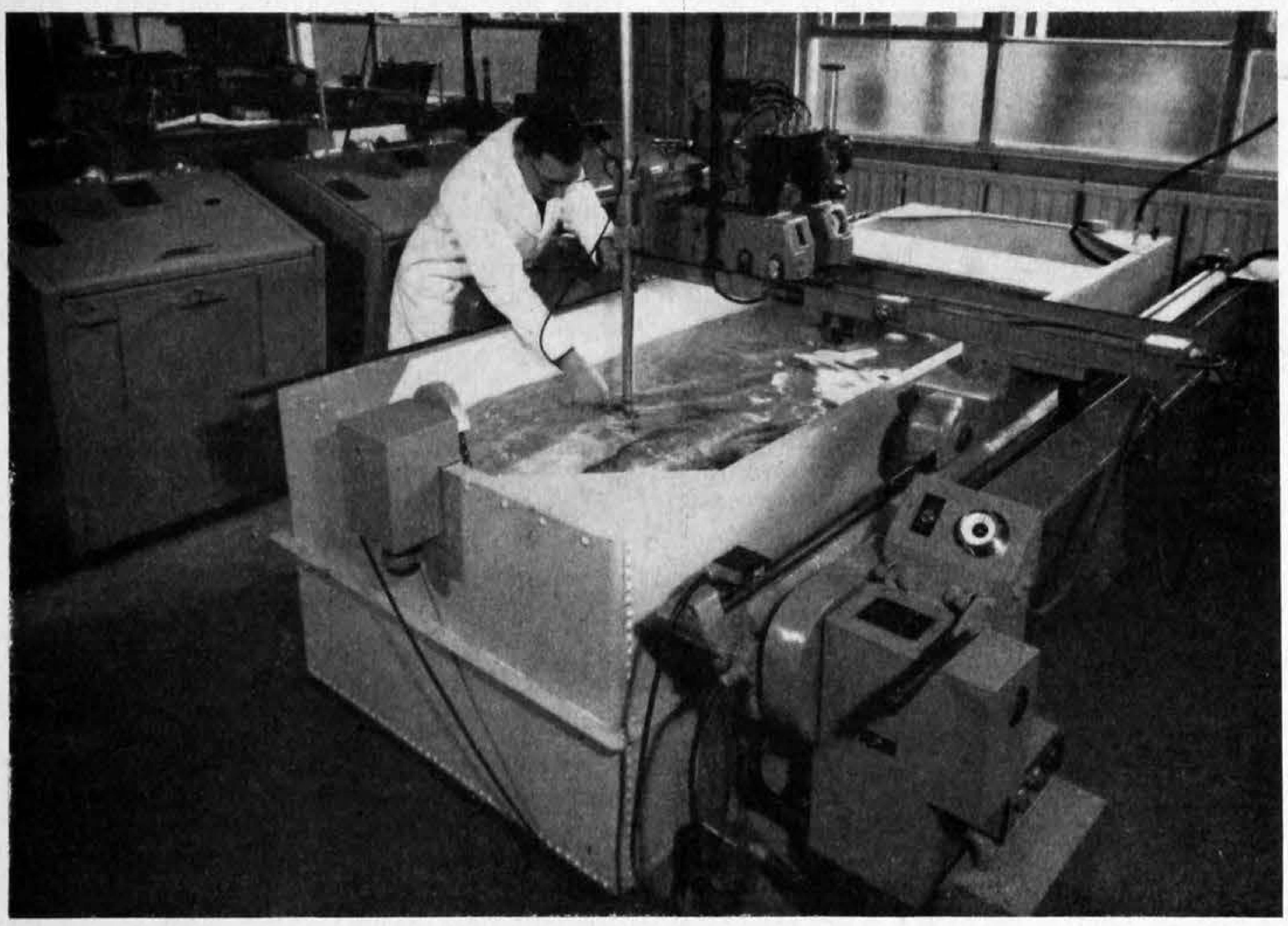


Fig. 1—Demonstration unit for automatic ultrasonic inspection in which the immersion testing probe is mounted on a carriage and traversed over the work. Defects in the workpiece are automatically recorded

In applying these techniques three ways can be used to maintain the essential accurate contact between the probe and the specimen. For contact testing a thin film of liquid is provided between the probe and specimen to serve as an acoustic coupling; in gap testing a small gap between the probe and specimen is filled by a constant flow of liquid. In immersion testing there is a considerable distance between the probe and the specimen and both are immersed in a tank of liquid.

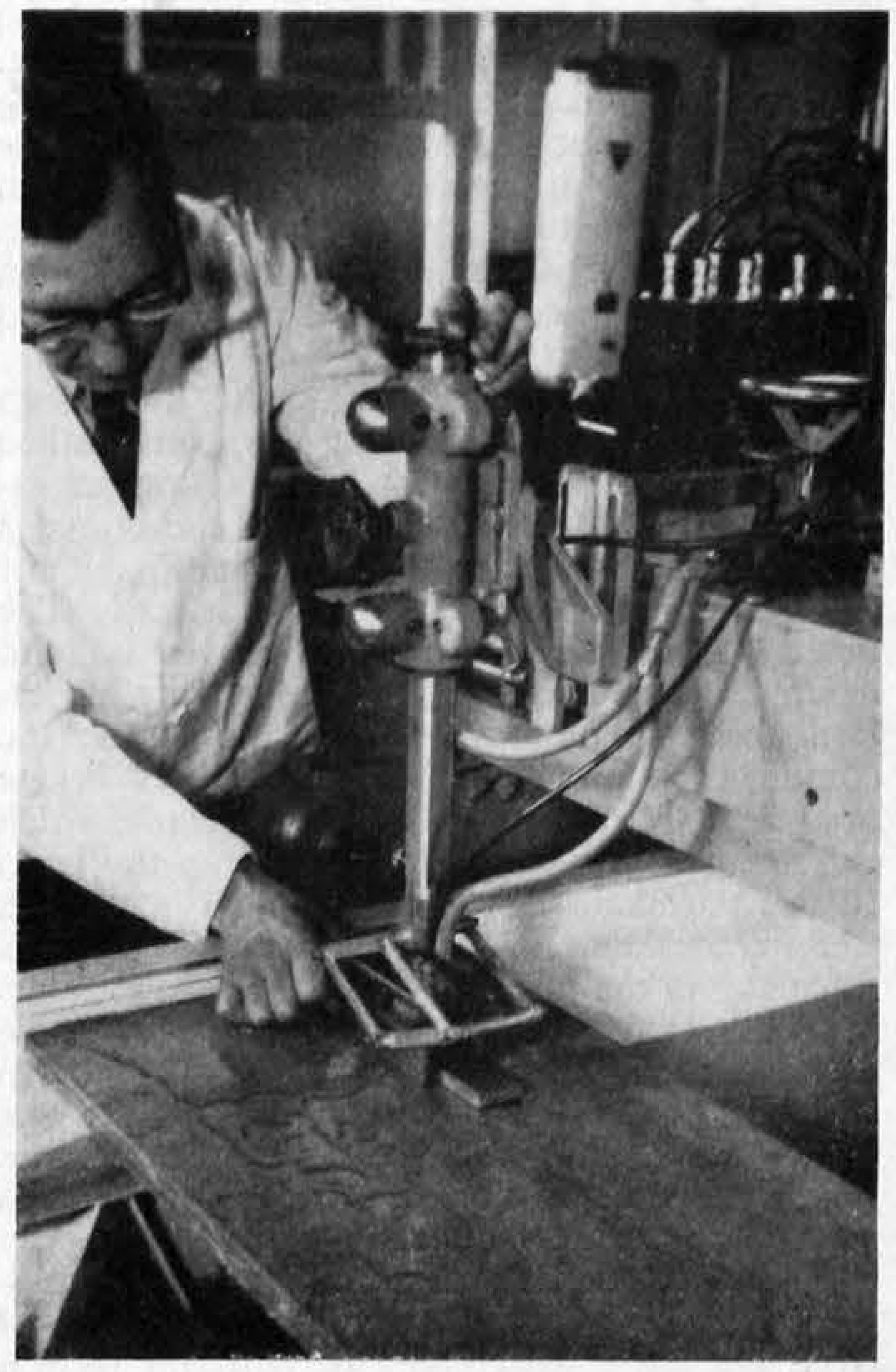


Fig. 2—Contact testing probe mounted on carriage which traverses it over a plate irrigated with liquid pumped up from the tank

A range of mechanical testing equipment has been developed for application of autosonic techniques particularly to long lengths of material of constant section and large areas of constant thickness. A typical demonstration installation for immersion testing large parts is illustrated in Fig. 1. It consists essentially of a large tank along the length of which there can be traversed an overhead bridge. A carriage

Fig. 3—Pedestrian controlled unit for "Autosonic" testing. The contact probe is irrigated by liquid fed from a tank on the carriage and the equipment is coupled to an automatic defect recording apparatus

on this bridge can be traversed across the width of the tank, and on it there is mounted a probe support column which is adjustable for height. The work is immersed in the tank and by setting the speeds of the longitudinal bridge traverse and the carriage drives the probe can be arranged to traverse over a large plate in a predetermined pattern ; or longitudinally or transversely along a narrow workpiece or a section such as a welded seam which has to be inspected for defects.

For demonstration purposes the immersion testing probe to be seen in Fig. 1 has been installed on one side of the bridge for inspecting an extruded billet. On the other side of the bridge is the contact testing probe shown in Fig. 2 for testing laminated steel plates for defects. The billet is rotated as the bridge moves up and down the tank longitudinally. For plate inspection the workpiece remains static whilst the combined longitudinal and transverse bridge movements carry the probe over the work, which is irrigated by liquid pumped up from the tank. In this particular case the equipment is coupled to an automatic recorder on which a continuous trace shows the position and size of any defects in the specimen. By installing one of these traversing bridge equipments fitted with a gap scanning probe and means of irrigation at the end of a steel plate production line the firm states that it would be possible to provide a continuous record of production quality.

A semi-automatic pedestrian-controlled equipment which can also be used for inspection of large plates or workpieces of constant section is shown in Fig. 3. In this case the probe is mounted on a hand-propelled carriage which incorporates a tank and provision for maintaining a supply of liquid in front of the probe as it is traversed over the area to be inspected. The carriage can also be readily applied to a conveyor line for continuous testing of components. For inspecting small production parts such as billets used for drop forging purposes a sequence testing unit can be arranged in which the parts are applied in quick succession to a head incorporating static probe and irrigation system. All of these equipments can be used in conjunction with automatic recording and defect marking apparatus.

The ultrasonic equipment made by the firm has a frequency range of 0·5 to 10 Mc/s, and for special requirements to frequencies up to 25 Mc/s ; the inspection range being up to 25ft. Probes, which are available as common or combined instruments, or for separate transmitter and receiver systems, are made in widths from $\frac{1}{4}$in to 6in with pulse lengths down to 3 cycles at half power level. The dead zones of the equipment are 0·10in at 2·5 Mc/s test frequency for targets equivalent to a $^{3}/_{64}$in diameter flat bottom hole in aircraft materials, and 0·010in at 2·5 Mc/s for gross laminar type defects. The automatic monitoring flaw alarm systems are adjustable from 0·10in below the top surface of the material to 25ft both in location and width. The inspection speeds available with the new equipment which are quoted by the maker are interesting when compared with manually operated equipment.

It is stated that the traversing speed used for targets equivalent to a $^{3}/_{64}$in flat bottom hole can be up to 100ft per minute, and for gross defects up to 400ft per minute.

Electronic Digital Computer

AN electronic digital computer capable of being applied to the solution of a variety of mathematical problems in research and engineering, has been made by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17. It is known as the " Metrovick 950," and it was developed and built in the company's electronics department, where it has been in experimental use since it was completed a few months ago. Two points of interest about the design of the computer are, first, the use of printed wiring on the plug-in boards and, secondly, the extensive use of transistors instead of thermionic valves.

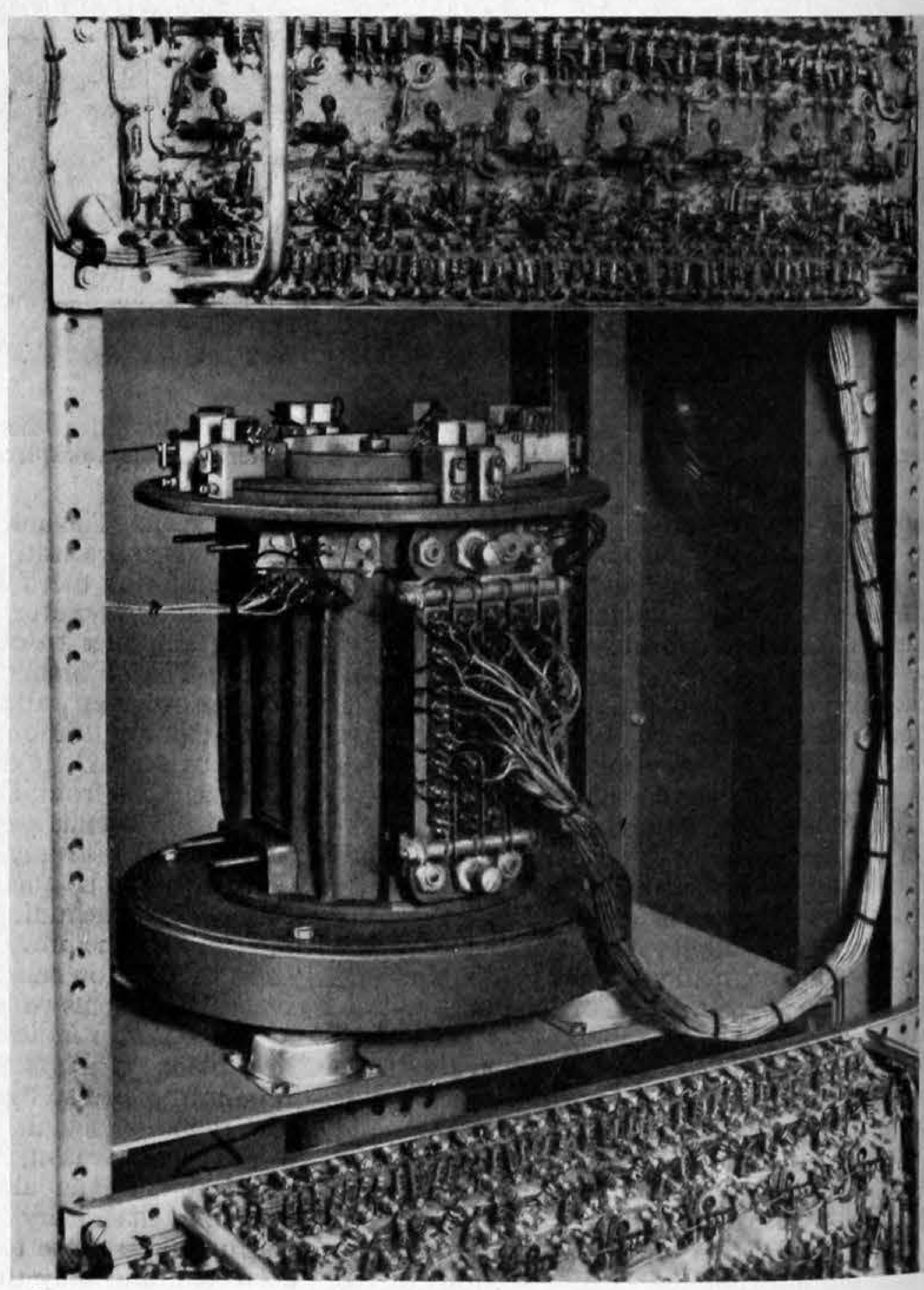
Like other electronic computers, the " Metrovick 950 " is basically a device which will do arithmetic at high speed. Each problem set for it must first be stated in mathematical terms and then the process of solving must be reduced to a series of simple arithmetical operations. A list of instructions, called the " programme," coded into the machine causes it to perform these operations and combine them in the necessary sequence. Though they are simple, the arithmetical operations into which the problem is resolved are very numerous and often highly repetitive. Accordingly, an essential requirement is that the machine should not require " instructions " every time it performs an operation : the time taken for instruction would be far greater than the time taken by the machine in carrying out the operations. It follows that the electronic computer needs a " memory " to store data and instructions. In the " Metrovick 950 " the memory, or store, is a cylindrical drum (illustrated here) coated with magnetic oxide, on which information is " written " in the form of magnetised spots on circumferential tracks. The numbers and the instructions are both represented in the store by the magnetised spots and represented in the circuits by corresponding electrical impulses. The pulses occur in a regular series with a pulse or digit frequency of 57 kc/s. One number or an instruction is normally represented by thirty-two digits, and this is called a " word." For convenience in coding and in operating with such pulses, the " Metrovick 950," like most other electronic computers, works in the binary notation, in which each digit represents a power of two instead of a power of ten as in the decimal system : each digit has only two possible values, 1 and 0, and can, therefore, be represented simply by the presence or absence of a pulse in a regular series. The necessary conversion between decimal digits and binary digits is done in the computer.

Functional Parts

The five basic parts of the computer are described below : they are, the input equipment, for feeding information into the machine ; the store, for holding instructions and data ; arithmetical circuits, for performing the calculations ; output equipment, for giving the results ; and the control unit, for co-ordinating the whole machine so that instructions are obeyed correctly and in the right order.

The input of numerical data and the programme of instructions are coded into five-hole punching on a paper tape, which is fed into the computer and is there read off photo-electrically at high speed. Numbers are punched as decimal digits, each digit being represented by a particular five-hole combination. Each instruction is coded as a combination of decimal digits and is punched in the tape in that form. Conversion from decimal form into binary notation of thirty-two digits takes place in the computer.

The magnetic-surfaced rotating drum already



" Metrovick 950 " digital computer. Most of the circuits consist of plug-in boards with printed wiring and transistors instead of thermionic valves. (Right) The magnetic drum of the computer. One of the four sets of read/write heads is in position in front of the drum. Another set has been removed from the left to show the drum surface

mentioned constitutes the main store. A total of 4096 "words" can be stored on its 128 separate circumferential tracks, each track storing thirty-two words. The location of any word on the drum is called its "address." The mean access time to any address on the drum is one-half of a revolution period, that is, 10 milliseconds.

Besides the main store of 4096 words, several stores with capacities of one or two words are needed in the arithmetical unit. These stores are usually referred to as "registers." Two-word registers are necessary since the product of two thirty-two-digit numbers is a sixty-four-digit number. The registers take the form of regenerative tracks on the rotating drum. Pulses are written on the drum surface at a writing head and read off some time later at a reading head elsewhere on the drum periphery. By writing them in again at the writing head, a continuously circulating pattern of pulses is produced, the number of pulses depending on the spacing of the writing and reading heads. Another store holding eight words on a regenerative track is provided to enable instructions to be modified after they are taken from the main store and before they are obeyed.

The arithmetical circuits, which use transistors, include an adder-subtractor unit and a multiplier. Multiplication in the binary scale is merely a series of additions and shifts. For one multiplication the "Metrovick 950" multiplier performs eight additions in parallel and does this operation four times, the sum of the four answers being the product required. In this way the sixty-four-digit product of two thirty-two-digit numbers is formed in four eight-word periods.

Output is by means of five-hole punched paper tape or a printed page; the punched tape output (twenty-five characters per second) is four times as fast as the page printer but the printer is useful, especially during the development of a computer programme, when immediate inspection of results is needed.

The basic timing of the computer is controlled by signals obtained from the tracks on the magnetic drum. Transistor circuits control the sequence of operations and the flow of instructions and numbers.

All the operator's controls are conveniently arranged on a panel with a desk table in front. Two cathode-ray tube monitors enable the contents of any track of the main store, the *B*-store, and all arithmetical registers to be examined. A set of thirty-two keys is provided which enable a number or an instruction to be set up, and further keys enable this to be placed in any register as required. According to requirements, instructions may be obeyed continuously at high speed, or singly when a start key is depressed.

The computer is housed in a steel frame which has overall dimensions of 14ft 5½in length, 4ft 10in width (over the control table) and 6ft 1½in height. It is assembled in three units, namely, control desk, control and power supply rack, and computing rack, each of which is designed to pass through a standard doorway, 2ft 6in by 6ft 6in.

The computing rack is divided into two sections: the drum store bays contain the magnetic drum store and all its associated circuits; the transistor bays contain the circuits associated with the logical functions of the computer. All these circuits, which comprise basic waveform generators, staticisers, arithmetical units, coincidence units, &c., use transistors and are produced on "Bakelite" boards 8in by 7in by the "printed circuit" technique. On one side of each board are mounted the components; on the other side of the board are the connections to these components and the printed circuits which link the components electrically. The printed boards are carried in ten panels and are plugged into sockets connected in the permanent wiring. This arrangement permits quick removal of the boards for servicing. The whole of the section of the machine in which printed boards are used has transistors as switching elements in place of the more conventional thermionic valves.

As can be seen from the first illustration on page 456, the input tape reader and the output tape punch are on the control desk. The output printer is carried on a wheeled trolley and is connected to the computer by a multi-core cable.

Test programmes are used to check the performance of the machine. During these tests the voltages can be varied to identify any components which may be drifting outside satisfactory working tolerances. Spare plug-in units are available for quick replacement of faulty components.

The control and power supply unit contains the mains input terminals which are in the plinth at the back of the unit; it also carries all the contactors and relays associated with the power packs. The equipments are mounted on panels of the G.P.O. pattern and lift-off doors in the frame give quick access to them. The cathode-ray tube monitor chassis is also mounted in this unit and can be withdrawn on rollers for servicing. Cooling air is drawn by fans through filters in the plinth and is discharged through the top covers. Because of the use of transistors which operate at low voltages and need no filament supplies, the total power consumption of the computer is kept down to 3kVA.

Other "Metrovick 950" computers are now being built; one is for use in the company's research department at Trafford Park, and another is for the A.E.I. research laboratories at Aldermaston, Berks.

Incidence Indication for Aircraft

THE human or automatic pilot of an aeroplane maintains a climb, a cruise, or a let-down by reference to the indicated air speed or, in some instances, to the flight Mach number. This well-established parameter is not, however, ideal when really accurate flying is envisaged: for example, the optimum cruise speed of a long-range transport will vary significantly through a flight, and the best approach speed for a carrier-borne aircraft—which is quite critical—will depend upon the all-up weight. The cruising transport can determine its desired speed at frequent intervals from a knowledge of fuel consumed and the characteristics of the aeroplane, but for deck-landing aircraft it will probably not be possible to do more than define two speeds, one for the machine "heavy" the other "light." Objections such as these can be overcome by the use of an instrument detecting angle of attack, and many such have been evolved. Research and prototype aircraft are frequently seen with weathercock vanes mounted on long probes, and this rather primitive technique points out the difficulties involved, namely, those of finding a situation where the direction of flow is exactly opposite to that of the motion of the aircraft at all times, and of the lack of sensitivity of any device with moving parts.

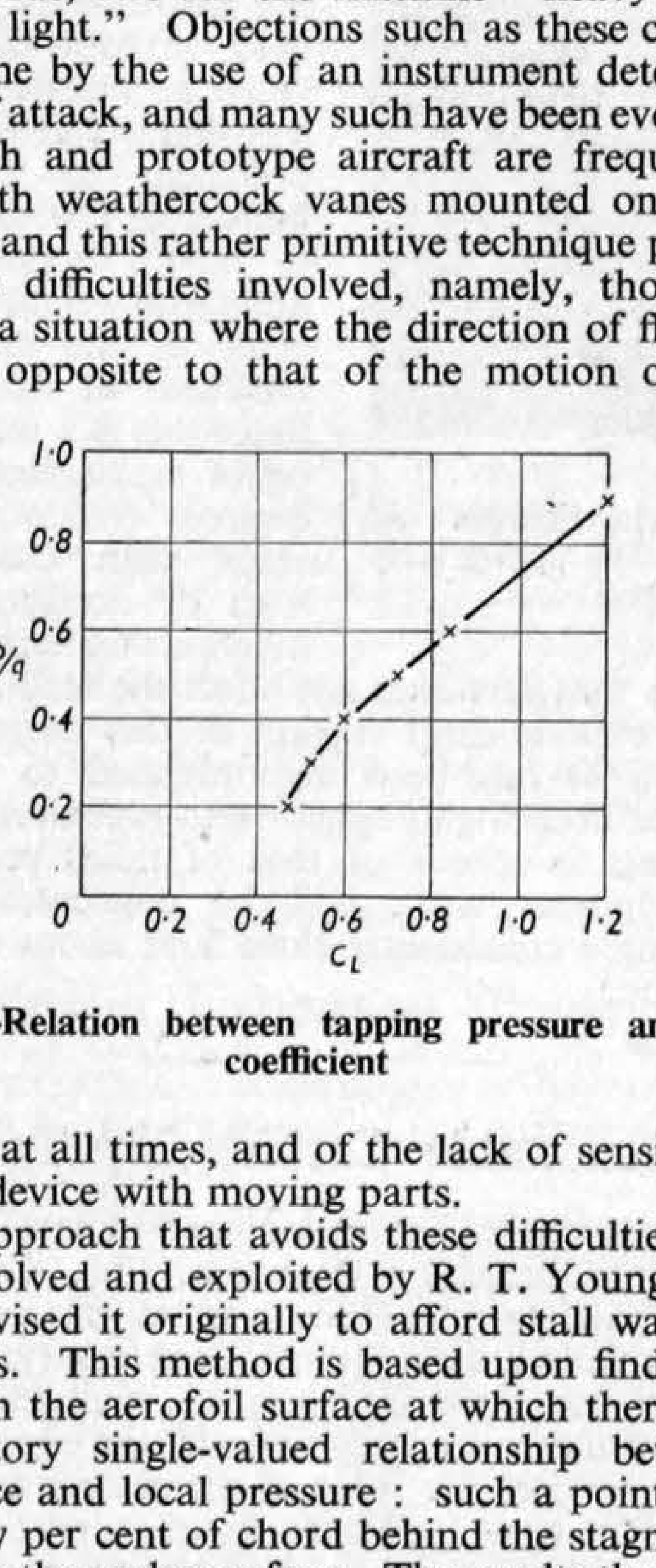


Fig. 1—Relation between tapping pressure and lift coefficient

An approach that avoids these difficulties has been evolved and exploited by R. T. Youngman, who devised it originally to afford stall warning to pilots. This method is based upon finding a point on the aerofoil surface at which there is a satisfactory single-valued relationship between incidence and local pressure: such a point may lie a few per cent of chord behind the stagnation point on the under surface. The results that may be obtained with a suitably chosen tapping point are shown in Fig. 1. It will be realised that the departure from linearity is not undesirable, since the speed varies inversely as the square of the lift coefficient.

The early applications of this principle were to fulfil the functions of a sensitive air-speed indicator with only a limited range of indication, particularly for use by aircraft of the Royal Navy. The mechanism shown in Fig. 2 was developed for the "Sea Hawk" fighter. For this aircraft, the optimum approach speed corresponds to

$$\frac{p}{q}=0\cdot 6,$$

and, therefore, the links mounted on the p and q capsules have leverages in the ratio 6 : 10 on the lever arm. Mounted on this lever are a set of wipers, contacting a potentiometer and a set of contacts: the contacts are arranged to vary the sound signal heard by the pilot, the signal being a continuous high-pitched note when the aircraft is close to the correct approach speed—$1\cdot 15V_s<V<1\cdot 27V_s$—a broken high note at higher speeds and a broken low note (a most disturbing noise, to our impression) as the stall

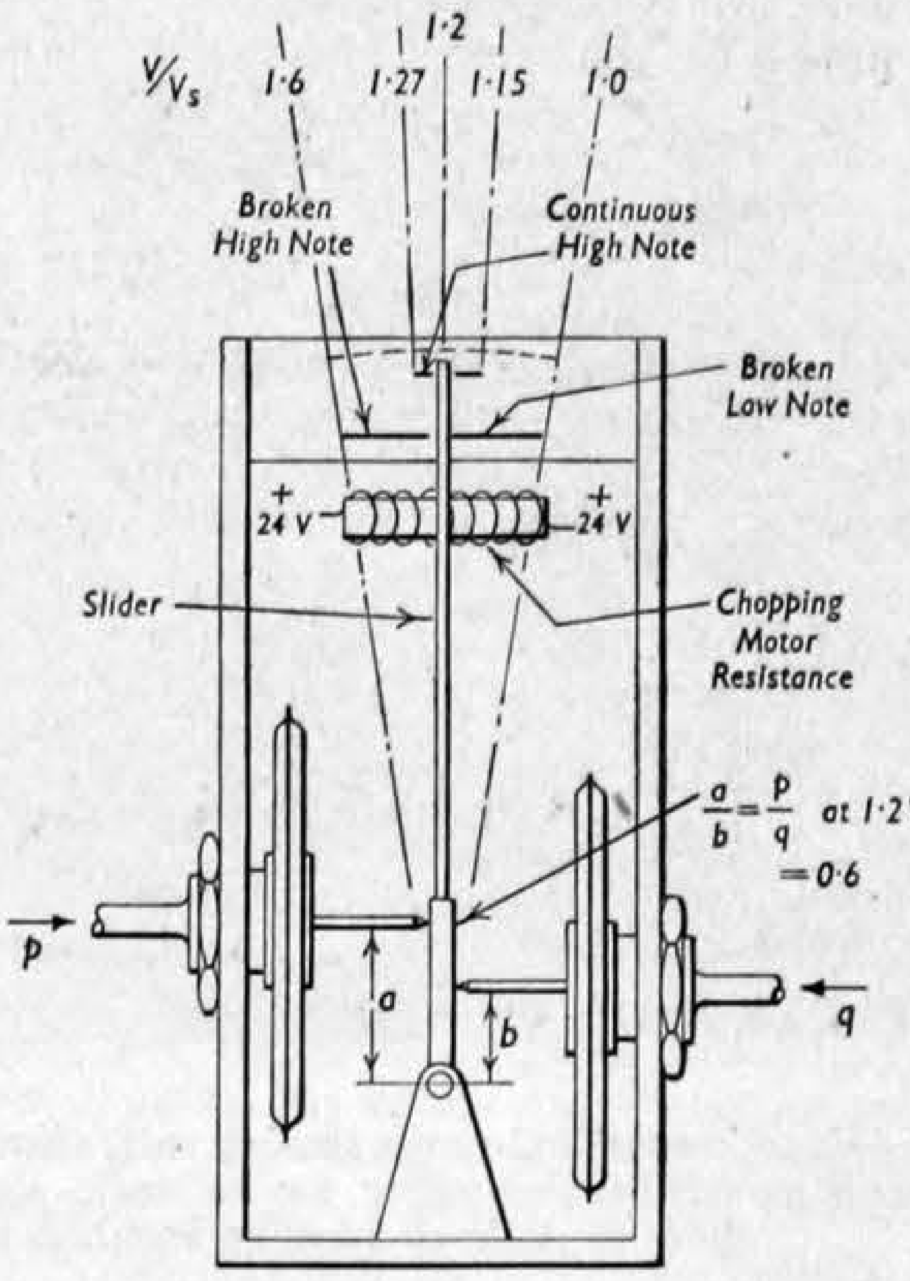


Fig. 2—Approach speed sensing device

is approached. It was found, however, that to secure sufficient sensitivity the load on these sliding contacts had to be exceedingly low, and therefore a servo-sensing unit was evolved to take its place. This is shown in Fig. 3: the capsules are coupled directly together and the effective areas now are in the ratio 6 : 10. The link between the capsules carries one of a pair of contacts, the other being mounted on a screw which is driven through gears, not shown, by a reversible motor. When the contacts are made, the motor drives the screw upward, and when the contacts are open, downward: thus, the motor continually hunts about an equilibrium position for the pressures prevailing. Hence, a synchro

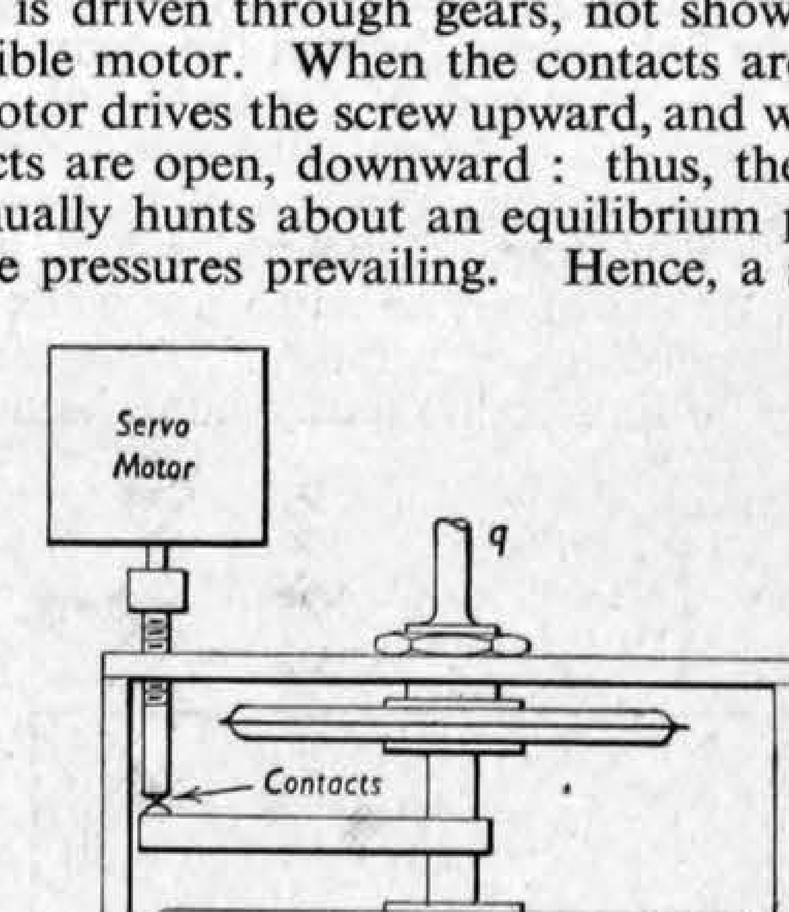


Fig. 3—"Bang-bang" approach speed sensing device

driven off the motor can transmit information corresponding to p/q, and control a sound source or, for instance, a set of light signals.

In both these instruments the equilibrium position for a certain incidence is a function of the pressures p, q, and the spring rate of the capsules. If it be imagined that the aircraft performs a manœuvre at, say, $2g$, then both pressures would be doubled and the equilibrium position would alter—unless the lift coefficient was that at which the spring force was zero. Thus, it can be seen that, except for one particular angle of attack, the output cannot be perfectly independent of aircraft weight or acceleration. However, by building bellows with special non-linear characteristics, it is possible to suppress this characteristic over at least the high lift range of incidence.

However, the spring characteristic will influence the output of the sensing unit if it is desired to use the device throughout the speed range of the aeroplane, and for this application the unit illustrated diagrammatically in Fig. 5 has been built and tested. This device is free of those defects in the earlier versions which were due to their responding to some function of the nature $p-Bq$. The two pressures are fed into capsules mounted at right angles, and rigid links run to a point on the intersection of the axes of the capsules. The two links are pivoted to a third, which runs to a point moving along an arc centred on the intersection aforementioned. On one of the capsule links an electric contact is arranged to change from make to break as the end of the link passes through the centre of the locus of the outer end of the third link. This contact controls a relay which reverses an electric motor ; the motor, through worm gearing, drives the anchorage of the third link in one direction or the other, so as to move the pivot towards the centre of rotation. Thus the arm carrying the link continuously hunts about the position in which the linkage forms a triangle of forces for the pressures existing in the capsules. Clearly, this position is defined by

$$\tan\theta=\frac{pA_1}{qA_2}$$

where q=dynamic head of airstream, $\frac{1}{2}\rho V^2$
p=tapping pressure.
A_1, A_2=capsule areas.

Since the ratio, and not the difference, of these pressures actuates the instrument, there is in theory a liability to position error affecting the static pressure. However, in practice it is found that such errors can be discounted, and the case of the instrument may even be vented to the aircraft interior. The attitude taken up by the third link can either be used to control a signalling system like that described for the deck-landing aid, or may be transmitted by synchros to an indicator in the cockpit : in the latter case the scale will be compressed at the high speed end, but this can be countered by calibrating in terms of V/V_s where V_s=stalling speed. Thus, a uniform scale presentation is available, and distant reading instruments can be used without difficulty. Once an installation for a given aircraft has been designed, to calibrate individual instruments it is only necessary to know the weight and the error of the air speed indicator at one point. Since this is a null method of measurement, the desired freedom from error with change in load or acceleration is inherent: experiment has shown that yaw does not affect the readings.

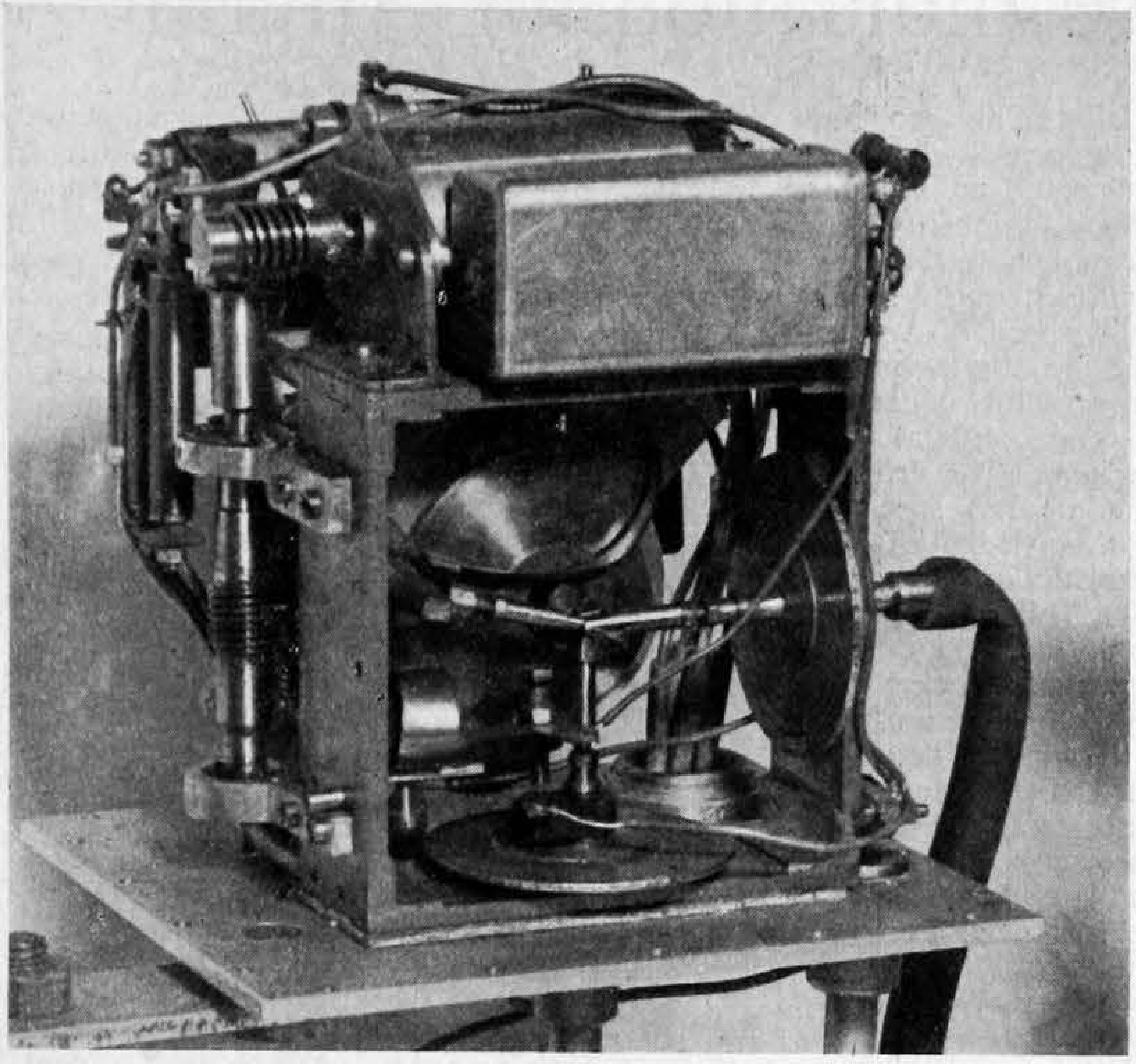


Fig. 4—Experimental full-range sensing unit, showing the resolving linkage. At the rear is mounted a transmitter for an audio signal device. The spring strip above the linkage takes up backlash in the worm drive

An experimental version of this device (seen in Fig. 4) has been demonstrated to us and showed itself highly sensitive to pressures corresponding to speeds of tens of miles per hour. Development work will be concentrated on securing a consistently close hunt about the null position.

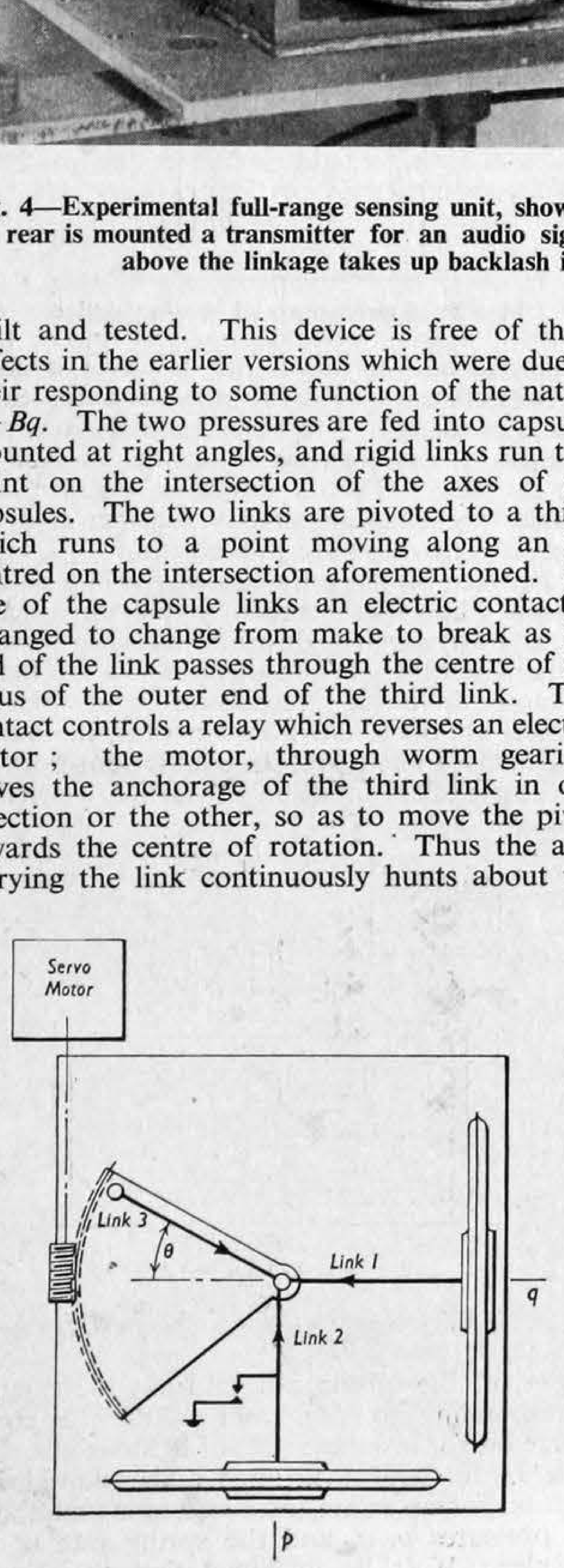


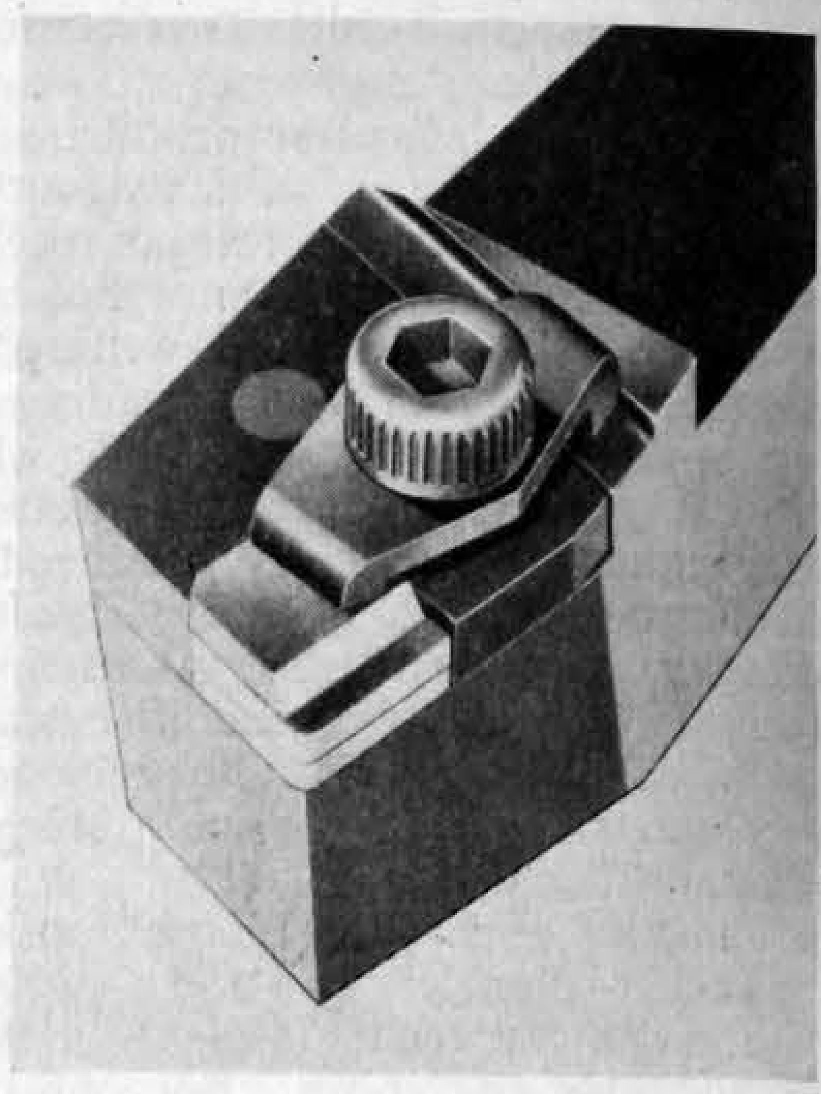
Fig. 5—Full-range incidence indicator

Renewable Carbide Tip Tools

A NEW range of carbide tipped tools which has been introduced by Wickman, Ltd., Coventry, is designed to render the normal procedure of re-sharpening carbide tips unnecessary by the use of mechanically clamped multi-edge tips which are thrown away when all the edges are no longer serviceable. One of the standard tools is illustrated here. It consists of a carbon steel shank or holder on which a square carbide tip and a separate chip curler are accurately positioned and clamped in a recess in a dowelled locating piece. The recess is designed to accommodate two cutting tips, the lower one of which acts as an anvil for the cutting tip and provides a wear resistant face to prevent abrasion of the holder face by swarf. As each cutting edge becomes dulled the tip is released and turned round or over to present a new sharp cutting edge until all the eight edges on a square tip, or the six edges on a triangular tip, have been used. The old tip is then discarded and replaced by a new one. When it is not required to use a chip curler the tips can be held by reversing the clamp plate which has a deeper step on one end.

The makers state that this new design eliminates the time involved in re-grinding or lapping tools and the cost of diamond wheels. As the tool does not have to be removed from a machine to renew the cutting edge, tool settings remain undisturbed, and unproductive tool re-setting time is greatly reduced. It is also pointed out that the tips are not subjected to stresses, set up in brazing, which can shorten effective tool life.

The tip seating in the holder for these " Econo-tips," as they are known, is arranged to give a 5 deg. negative cutting rake and the normal 5 deg. front to back angle. Four models of tips

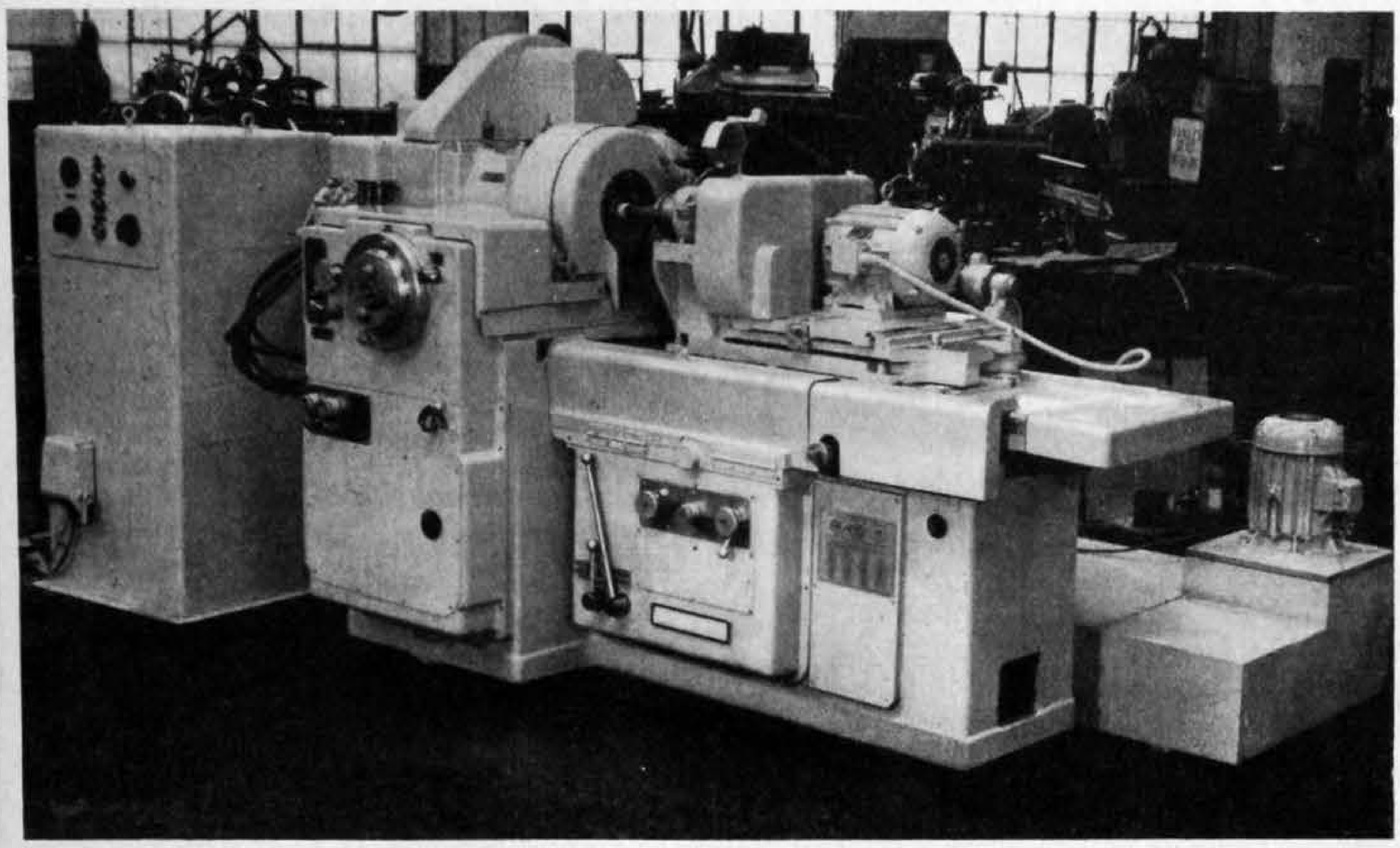


Carbide tipped tool fitted with mechanically clamped multi-edge carbide tips and a chip curler. Each tip has eight cutting edges which are used in succession; the tip is discarded when all edges are work chilled

are available giving approach angles of 15 deg., 30 deg., or 45 deg., with square tips, and 0 deg. approach angle with triangular tips. The tips are made at present in two degrees of carbide—Wimet grade " N " for machining cast iron, non-ferrous and general purpose cutting ; and Wimet grade " X.L.2 " for cutting steel at high speeds.

Tips are made in two qualities. In the " precision " quality, they are ground both on the thickness and on the cutting edges for finish turning purposes ; in the " utility " quality they are ground only on the upper and lower faces, the cutting edges being left in the sintered condition. These " utility " tips, which are intended for roughing cuts, are more economical than those of precision quality, and they are stated to reduce the cost of tips by 50 per cent.

EASTERN REGION MODERNISATION WORKS.—We are informed that civil engineering work in preparation for the Eastern Region electrification of the Colchester-Clacton-Walton lines is making good progress. The electrification is due for completion next year and is to be carried out on the new high-voltage a.c. system. At a later stage there will be a link-up with the extension of electrification from Chelmsford to Ipswich. The engineering work involves the alteration of twenty-one bridges (including raising sixteen of them), the cutting back of station awnings, alterations to the track layout of seven stations, provision of load gauges and notices at level crossings, lengthening of sidings at Colchester and Walton, and the provision of an additional siding at Clacton. The steam locomotive shed at Clacton is to be adapted as a temporary inspection and maintenance depot for electric rolling stock. A long steel footbridge over the main line and sidings at St. Botolphs has already been raised and new parapets erected. Other bridges completed are Moler's Bridge between Hythe and Wivenhoe and a footbridge at the latter station ; Barker's Bridge between Thorington and Great Bentley has also been raised, as has Thorpe Park Farm Bridge between Thorpe-le-Soken and Kirby Cross. The parapets of the Alresford Road Bridge between Wivenhoe and Alresford stations and the Frinton Park Estate Bridge at Walton station have been built up and similar work will commence shortly on the Weeley by-pass and Alresford by-pass bridges. A fifth bridge at Colchester has to be altered in the same way. Larger works involving the reconstruction of bridges are either in progress or to be carried out at Cooks Green, Ipswich Road at Colchester, Bentley Tye, Brook Street near St. Botolphs, and Anglesea Road and High Street at Wivenhoe. Extensive drainage work has been completed at Thorpe-le-Soken where the Holland Brook has been diverted to a new course so that the track embankments could be strengthened. The civil engineering work is being carried out under the general direction of Mr. A. K. Terris, B.Sc.(E.), M.I.C.E., chief civil engineer, Eastern Region, British Railways.



Internal grinding machine with fully automatic grinding cycle arranged for both gauge and diamond sizing

Automatic Internal Grinding Machine

An internal grinding machine with a fully automatic cycle now being made by Keighley Grinders (M.T.), Ltd., Keighley, Yorks, is arranged for both gauge and diamond sizing and can be used for grinding holes from ¼in to 6in diameter to a maximum depth of 6in. Work can be up to 12in diameter.

The new machine, which is illustrated above, has a rigid cast bed on the precision vee and flat slideways of which the table and wheelhead slides are fully supported. The table has a maximum travel of 24in and, in addition to an adjustable working stroke from $^1/_{32}$in to 6in at infinitely variable speeds, up to 360in per minute, it has a rapid traverse speed of 420in per minute. Its working stroke and traverse speeds are controlled by grinding and dressing stroke dogs and an adjustable cam on the front of the table. Movement of an automatic dressing equipment is controlled by a cam at the rear of the table.

Movement of the workhead assembly is continuous and independent of the table traverse and its cross feed is operated by a cam and roller mechanism. This workhead is positioned by a nut and screw, the screw also serving to provide wheel wear compensation which is adjustable from 0in to 0·006in in diameter. The feed cam controlling the feed rates for rough and finish grinding is operated hydraulically with automatic locking during the wheel dressing feed stroke.

The workhead which has a swivel movement up to 30 deg. is specially designed to accommodate heavy fixtures. Its spindle runs in precision double-row taper roller bearings and is fitted with a 9⅝in diameter flange and has a 3in bore. A range of workhead spindle speeds up to 1000 r.p.m. is obtained through pick-off pulleys, or a four-speed motor drive can be fitted if specially required. A hydraulic fixture-operating gear built into the spindle provides a push and pull action over a 2in stroke, and is adjustable for pressure. Means are provided on the workhead for fitting a gauge sizing equipment.

In the standard wheelhead the spindle is driven by an endless cotton band from a 3 h.p., 3000 r.p.m. motor which gives a range of grinding spindle speeds from 5000 to 20,000 r.p.m. An alternative wheelhead with a swivelling base for use with tapered quills and incorporating a layshaft, providing spindle speeds up to 28,000 r.p.m., is also available. A hydraulically operated wheel dressing equipment is mounted on compound slides and incorporates a micrometer adjustment to eliminate backlash. The dresser arm is controlled by a servo-mechanism actuated by a cam on the machine table.

The machine is fully automatic in operation and engagement of the cycle starting lever first causes the worktable to move in at rapid traverse speed until the grinding wheel reaches the work, when the rate is reduced to grinding speed and the table reciprocates on a stroke adequate to cover entire length of the bore. At this stage roughing feed commences and continues until a predetermined size is reached when, if gauge sizing is being employed, the gauge contacts the rear of the bore. Continuing the automatic cycle, the wheel then leaves the bore and table speed is reduced for dressing immediately the rear end of the grinding wheel approaches the diamond position. To ensure that the wheel is fully trued, dressing takes place during both the outward and the inward strokes and the diamond automatically retracts as the wheel re-enters the bore. Table reciprocation at a lower speed then continues and fine feed is engaged. When the machine is operating on diamond sizing and the finish size is reached, the wheel is backed away from the bore, the table is returned at maximum traverse rate and the wheel guard is lowered automatically to complete the cycle. If gauge sizing of the work is being used the gauging mechanism is brought into effect as the finish size is approached. The gauge contacts the rear end of the bore which it enters as size is achieved, it is then retracted automatically and the wheel backed away from the bore, the table returned and the guard lowered as in diamond sizing. With either sizing wheel, compensation is automatic at the end of each grinding cycle.

Solvent Extraction Plants

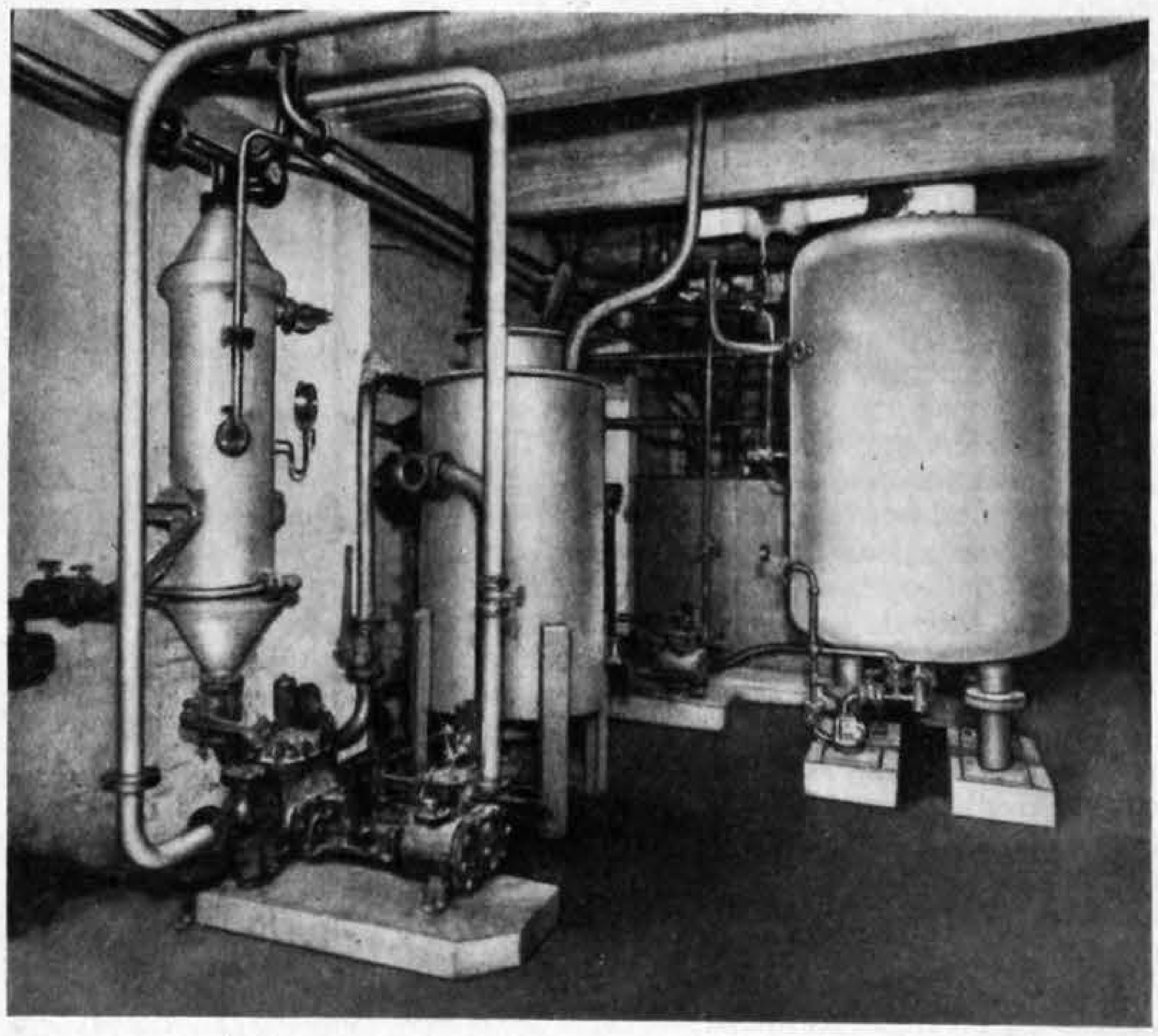
A dehydrating and degreasing solvent extraction plant for the treatment of raw animal wastes which uses the Wacker-Chemie process, has been designed by Iwel, Ltd., London. Our illustration shows an Iwel solvent extraction plant, including, from left to right, preheater, separator and still. Intermediate handling is eliminated with this equipment, and so are the offensive odours normally associated with the cooking and extraction processes. By using the solvent extraction process, more fat is made available, since the residues contain by weight about 4 per cent of fat compared with 9 to 12 per cent fat contained by cooked and mechanically extracted residues. This extraction of a higher percentage of fat means that the protein content and the keeping qualities of the meal are improved, while the grinding, screening and sacking processes are made easier.

The material used is raw animal carcass, &c., and the process consists of seven main stages, while the solvent is a non-inflammable hydrocarbon, perchlorethylene. The raw material is charged into the extractors which are vented, until the material is heated, then the pressure is raised as may be required. After drawing off the "pre-cook" fat the solvent is pumped in, resulting in a considerable drop in the boiling point and the establishment of "Azeotropic" distillation. With the reduction of the boiling point of the combined water and solvent a large increase in the volume of water vapour occurs. With a perchlorethylene to water ratio of 3 to 1, the boiling range is from 185 deg. to 212 deg. Fah., according to the amount of water present in the mixture. Towards the end of the degreasing stage the vapour temperature rises above 212 deg. Fah. as the moisture content is lowered, and at 221 deg. Fah. all moisture having been eliminated, the unit is shut down and the jacket steam shut off. After a short settling period the strong mixture is drawn off and allowed to settle in a separate vessel for about twenty minutes before filtration and distillation is commenced. The material which remains as a residue in the extractors is washed and dried and the finished meal discharged.

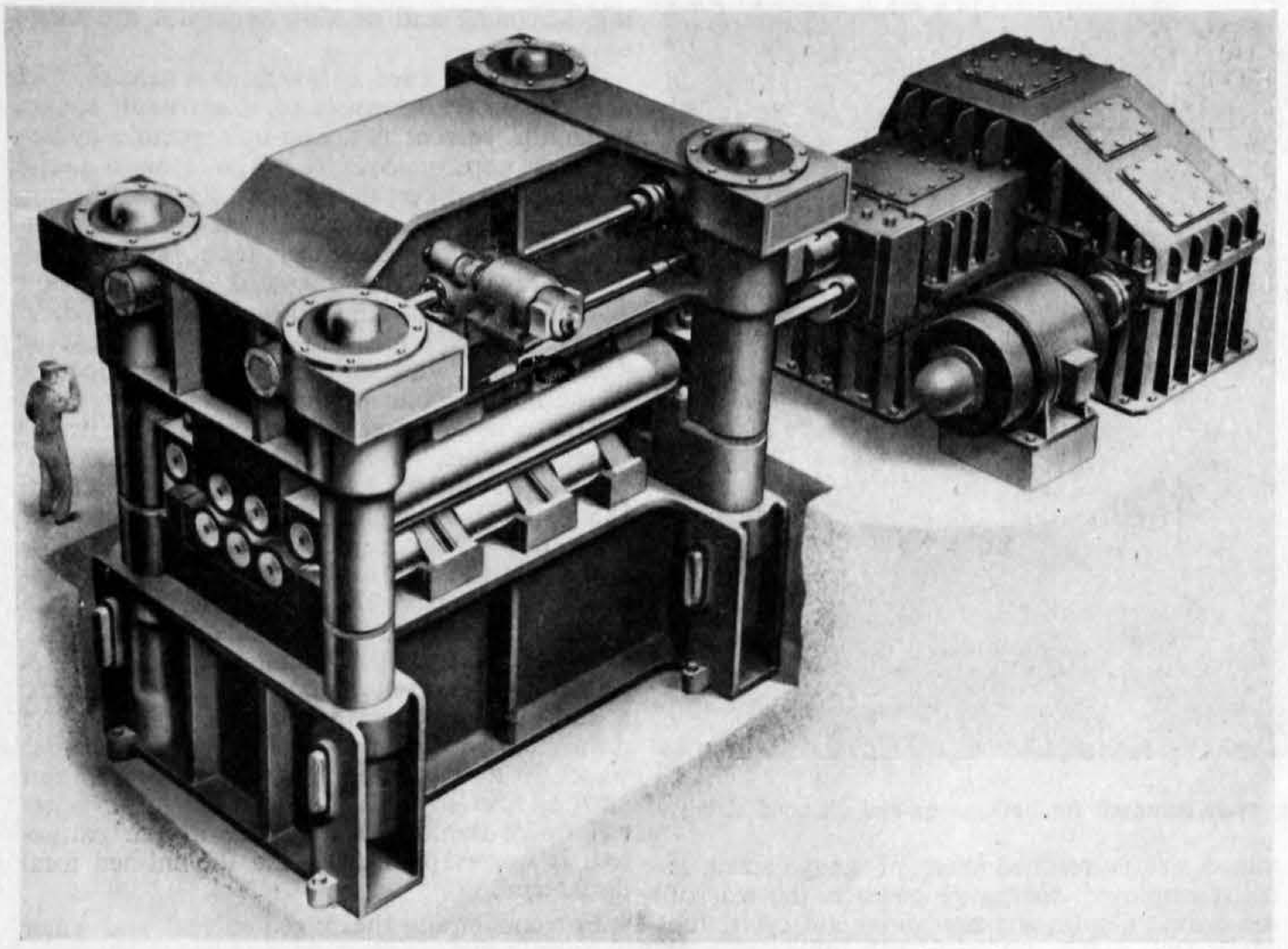
For condensing the mixed solvent and water vapours a condenser of normal tubular pattern is used. It condenses the steam and solvent vapours, creating a vacuum effect between the extractor and the solvent separating system, and cools the condensate, before it is passed into the solvent separators, to the temperature at which maximum separation is possible. The tallow produced is of clean bleachable quality of high titre, with lower free fatty acids than can normally be obtained without deodorisation treatment.

There is also an improved solvent extraction plant, which is intended to treat previously cooked greaves for the production of low-oil-content meals, designed for operators of existing rendering plant; the solvent used is a fractional petroleum spirit, chosen for its penetrative powers, but alternative chlorine solvents may be employed. A distillation unit is embodied for the recovery of the solvent from the end products and the overall solvent loss is claimed to be not more than 0·8 per cent by weight of the raw materials treated. A high-speed circulating heater obviates the burning or deterioration of the tallow and a special filter floor ensures rapid operation.

Apart from the treatment of animal wastes, the plants can be used in the recovery of palm oil from tinplate waste and of paraffin wax from waste paper.



Solvent extraction plant showing from left to right, preheater, separator and still



Levelling machine for ships' plates up to 2in thick by 12ft wide

Heavy Plate Levelling Machine

PARTICULARS have been received of a new leveller for heavy ships' plates developed by Head Wrightson Machine Company, Ltd., Middlesbrough. The first of these machines is now being built for Swan Hunter and Wigham Richardson, Ltd. The machine is designed to handle plates up to 2in thick by 12ft wide and an impression of its size can be obtained from an artist's impression we reproduce above.

The maker points out that as the average length of ships' plates to be handled is about 25ft, the output of such a machine can be increased by reducing to a minimum the number of levelling passes required. In order to make this possible and to extend the range of thickness of plates which can be handled on one machine, the diameter of the levelling rolls has been reduced as much as possible, and by using three banks of backing rolls across the face width of the working rolls it has been possible to use a roll diameter of 15in. The backing rolls are carried in special heavy-duty roller bearings mounted in steel housings.

There are seven levelling rolls of hardened alloy steel, four arranged in the top assembly and three in the bottom assembly. The two top outer rolls have a diameter of 18in and are supported, whilst the two centre top and three bottom rolls have a diameter of 15in and are supported by backing rolls of the same diameter. All the roll adjustments are motorised and a main screwdown gear is provided for raising the whole of the beam carrying the four top rolls. The two top outer rolls have independently adjustable roll settings. The backing rolls are so arranged that, in addition to giving maximum support during the forward and reverse action of the leveller, they also allow scale to fall clear into trays in the base of the machine.

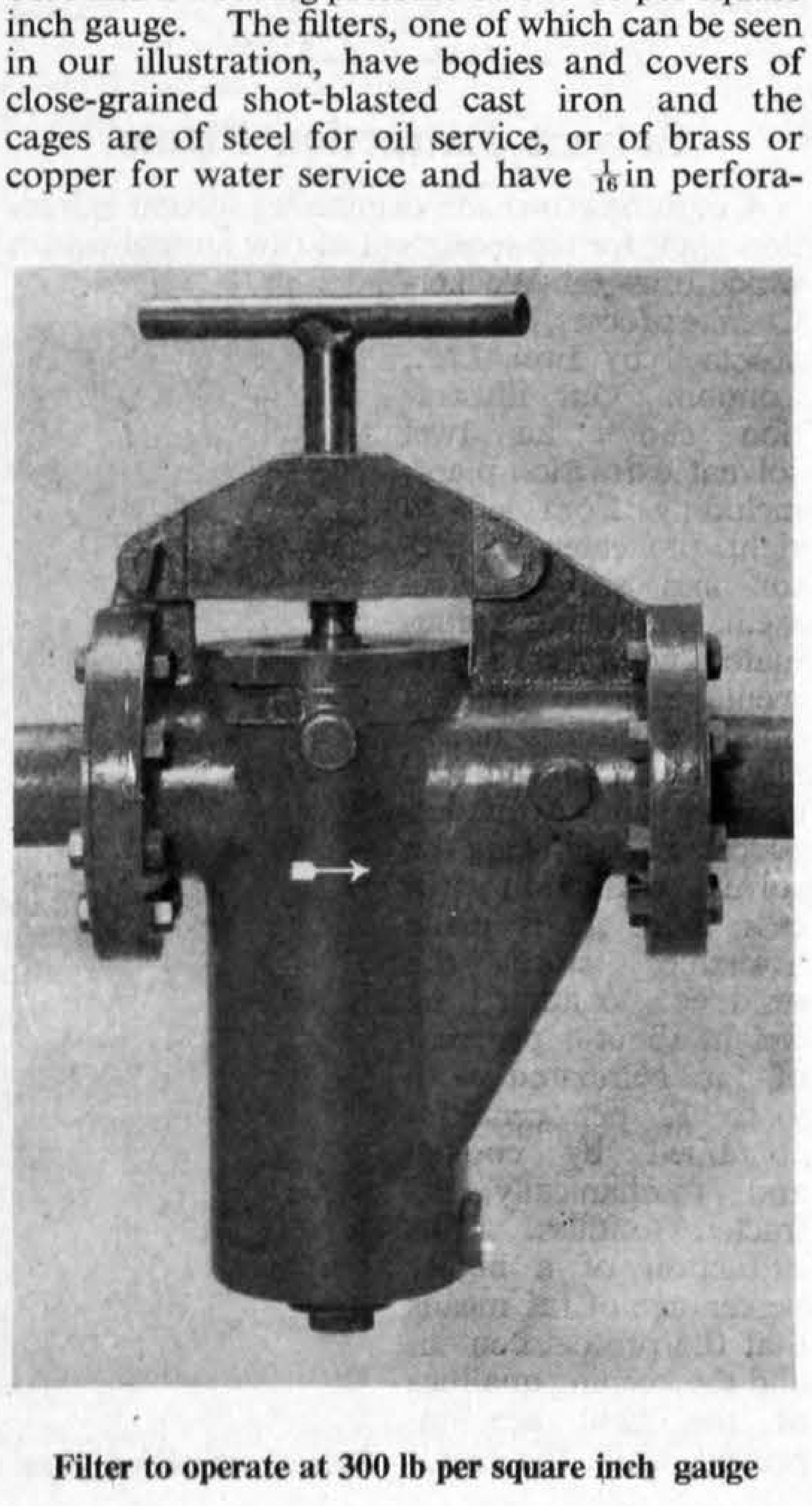
The top and bottom assemblies of the machine are made up of steel castings forming the beams and side housings, and they are mounted on substantial forged steel corner posts incorporating worm gearing for adjustment of the top assembly, which is hydraulically balanced.

The main drive is by a two-speed slipring induction motor capable of developing 350 h.p., to give levelling speeds of 15ft to 30ft per minute. Speeds of up to 60ft per minute can be provided for the machine if required. The five centre levelling rolls are individually driven from a totally enclosed, triple reduction gearbox through universal joint spindles, the top entry and exit rolls being arranged as idlers.

A floor-mounting contactor control panel, which houses the control gear for starting up, running and protection of the equipment, has push buttons, and indicator lamps for the various controls are mounted on the front. The controls for occasional adjustments, such as change of speed and alteration of main roll settings, are housed in a floor-mounting control desk. Duplicate control stations on the entry and exit sides of the machine give means for fine adjustments of the outer rolls during levelling of the plate.

Oil and Chemical Filter

A NEW filter, designed initially to meet the requirements of the oil, chemical and food industries, is being manufactured by Plenty and Son, Ltd., Eagle Iron Works, Newbury, Berkshire, in standard sizes ranging from 2in to 8in bore and a working pressure of 300 lb per square inch gauge. The filters, one of which can be seen in our illustration, have bodies and covers of close-grained shot-blasted cast iron and the cages are of steel for oil service, or of brass or copper for water service and have $\frac{1}{16}$in perforations. Finer or coarser filter elements are available in other metals.



Filter to operate at 300 lb per square inch gauge

Servicing does not call for the use of tools, and there is virtually no spillage when removing the filter cage for cleaning. The synthetic "O" ring joint is self sealing under vacuum or pressure. Gas pockets cannot form. The filter surface area is approximately $12\frac{1}{2}$ times that of the pipe so that there is a low pressure drop. On both sides of the body and at both inlet and outlet there are vent and gauge connections.

A hinged strong-back and a captive hand screw serve to hold the cover, which is spigoted into the body, in position. The "O" ring joint is recessed into the body and the joint can be broken without the use of force, all that is required is the removal of a drop nose bolt which allows the cover to be hinged back. This bolt has a flat formed in it which engages with lugs cast on both body and cover and is used to ease off the cover without damaging the joint. The filter cage has a handle for easy withdrawal and after replacement the cover only requires hand tightening and is self locking.

Track Circuiting Equipment for British Main Line Electrification

IN preparation for the 50 c/s a.c. electrification of the Crewe to Manchester line, the London Midland Region of British Railways has placed an order with Westinghouse Brake and Signal Company, Ltd., for the supply and installation of "Westatic" track circuiting equipment which has been specially developed to meet the requirements of this form of traction. The section from Wilmslow to Slade Lane Junction has been selected for this first installation. It entails the provision of twenty-two double-rail and thirty-six single-rail track circuits, the general principle being to adopt the former for the berth tracks, up to 4000ft in length, and the latter for the overlap tracks which do not exceed 1800ft in length.

Equipments designated "A.C.2" and "R" will be used for the berth and overlap track circuits respectively. A characteristic of both of these arrangements is that they operate directly from an a.c. signalling supply of the same frequency as the traction, and make no use of moving parts except for the associated relays.

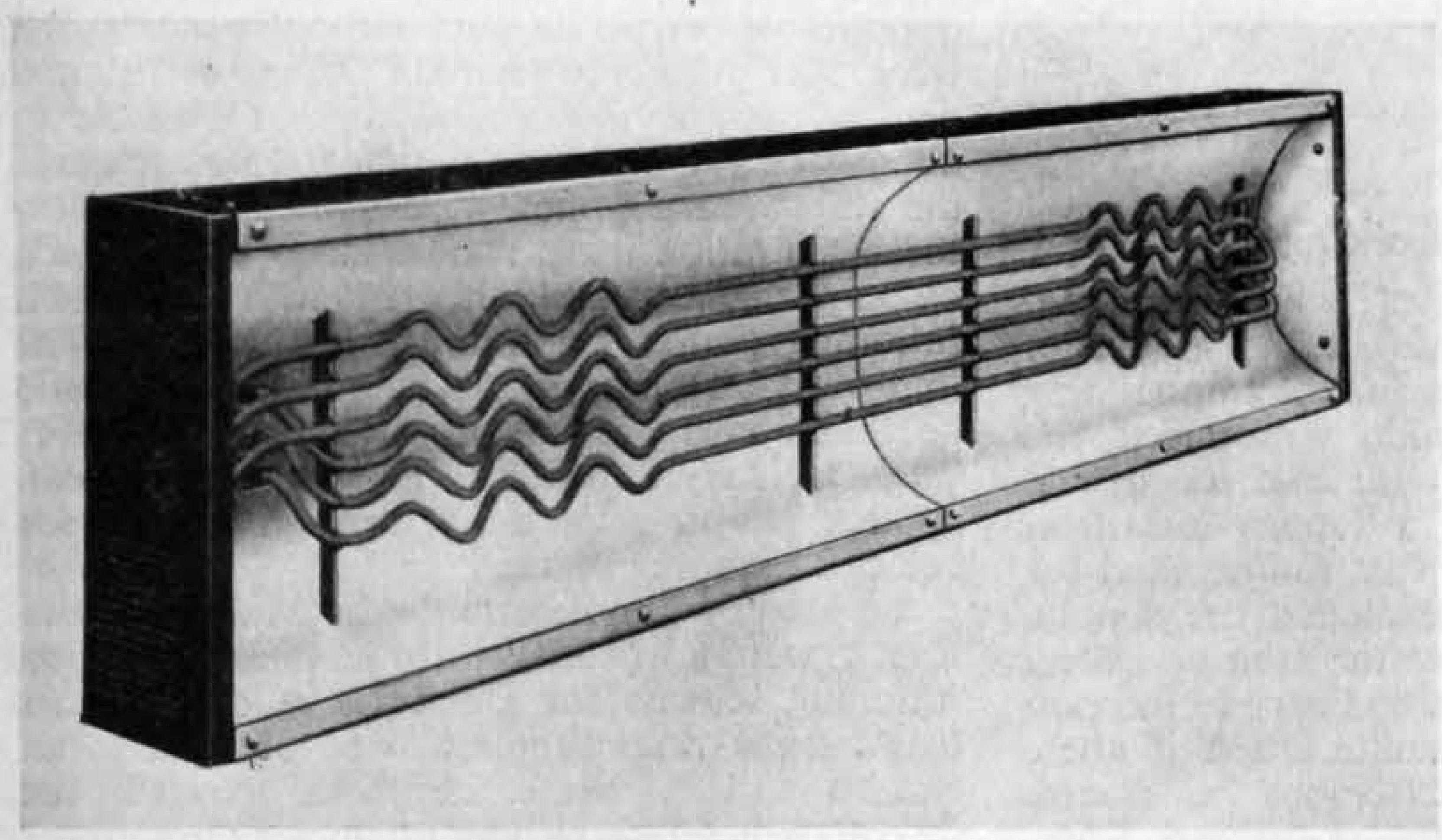
The "A.C.2" track circuit operates with a distinctive frequency of 75 c/s on the rails, the feed being derived from a small static 50 to 75 c/s frequency converter provided individually for each track circuit, with an adjustable resistor as the regulating element. A standard d.c. track relay is used, connected to the rails through a combined frequency discriminator and rectifier unit. This discriminator is arranged to accept the 75 c/s track circuit frequency in preference to the unwanted 50 c/s traction frequency, any residual break-through of the unwanted frequency being limited at all times to a safe value by means of magnetically saturable elements which cannot lose their protective quality. The impedance bonds used with these track circuits have closed magnetic circuits and offer high impedance without resonating elements, so giving a simple and compact design.

The shorter single-rail track circuits will operate with "R" equipments in which a d.c. current is fed to the rails from a transformer/rectifier unit of special construction. Here, the principle is to limit the extent to which the a.c. traction voltage drop along the length of the single return rail can be rectified by the feed unit, for this would otherwise increase the d.c. feed to the track circuit and so lower its train-shunt sensitivity. A self-proving circuit has been incorporated for this purpose to operate automatically whenever the unwanted a.c. traction voltage approaches an unsafe value. Discrimination at the relay end between the track circuit and traction voltages is achieved by means of an a.c.-immune d.c. relay of special construction so that no separate discriminator unit is required with this kind of track circuit. The simple elements which provide this discrimination within the relay are built into the magnetic circuit; they cannot deteriorate in any way and they provide complete protection against false operation from any 50 c/s voltage whatever its value.

High-Intensity Infra-Red Projector

In using infra-red heat for the curing of coatings, such as latex, on continuously moving strips of material, uneven curing has sometimes been experienced near the outer edges of the material because of the cooling produced by air movement. To overcome this difficulty, Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17, has developed a new high-intensity infra-red projector.

It is based on a standard " Metrovick " infra-red projector with an anodised aluminium reflector in a lightweight metal casing and tubular sheathed elements operating at red heat. But the elements in the new projector, instead of being straight, have crimped ends (as illustrated) to provide a greater intensity of heat on the outer edges of the material being heated. These new projectors can be supplied in the same lengths as the standard infra-red projectors —that is, from 18in up to 7ft. This change in the straight element is the outcome of considerable field experience in this class of application, and the extra heat produced by the crimping of the elements is just sufficient to make up for the cooling effect on the outer edges.



Infra-red projector with crimped elements to give intensified heating near the end thereby counteracting the cooling effect of air movements

The element itself is constructed by inserting a magnesium tube into an outer sheath of non-scaling, non-corrodible alloy and introducing within the magnesium tube a helical coil of heat-resisting wire. The magnesium is then converted by a special process into solidly packed magnesium oxide. This process ensures centralisation of the spiral and an even thickness of insulation between spiral and sheath. The element sheath is insulated from the live spiral and may be earthed so that there is no danger of electrical shock through touching the sheath.

Corrosion-Resistant Paints

The anti-corrosive paints of E. and F. Richardson, Ltd., Buckingham, have now been supplemented by " Semprene-Adcora " for use in extremely corrosive conditions encountered in, for example, the chemical industry. These coatings are manufactured by Semtex, Ltd., from Du Pont " Neoprene " or " Hypalon " and solidify on the surface by polymerisation rather than evaporation. High film thicknesses can be built up with few coats, up to 0·02in being obtainable with one coat of some grades. Except possibly for interior coatings, the paints are not difficult to apply to surfaces that have been wire brushed or sand-blasted. The anti-oxidants in the neoprene coatings inhibit the drying of oil paints, so they cannot be over-painted with such finishes.

The order of corrosion protection expected by the suppliers is indicated by the following three claims for laboratory examples :

(1) Semprene-Adcora brush applied to an ill prepared mild steel panel has been immersed for several weeks in a 50 per cent solution of hydrofluoric acid and showed no signs of breakdown.

(2) One brushed coat of the maintenance coating, P.4. was not destroyed, nor was the underlying metal attacked, after seven days' immersion in 80 per cent sulphuric acid.

(3) Mild steel panels treated with three dip coats of P.4. were subjected to hydrogen peroxide alongside epoxy based paints. Whilst neither of these two coatings could be called suitable for this service, the epoxy coating was destroyed in minutes whilst initial signs of breakdown did not occur on the neoprene maintenance coating (designed for protection against fume and occasional spillage only) until the test was stopped and the panel allowed to dry over the weekend, and even then, there were no apparent signs of attack to the underlying metal.

The abrasion resistance has also led to interesting applications. A 0·01in layer has been found to eliminate erosion of laminated plastic surfaces, such as radomes and antennae, on aircraft flying through rain. This finish is now being employed for the protection of leading edges, which subject the finish to the most severe conditions.

The coatings available at present include :

(*a*) P.4.—A one pot maintenance coating in black for brush or spray application, giving a slightly above conventional film build.

(*b*) P.6.—A two part high solids coating for more severe conditions, also in black but capable of giving a film build of up to twenty thousandths in one coat, the average being in the order of ten thousandths.

(*c*) P.7.—A primer for use with P.6. and P.8. over concrete, wood and steel, &c.

(*d*) P.8.—A reinforced grade of P.6., the abrasion resistance and build of which is even greater (for certain specialist purposes).

By the middle of the year it is expected that other colours and coatings will be available.

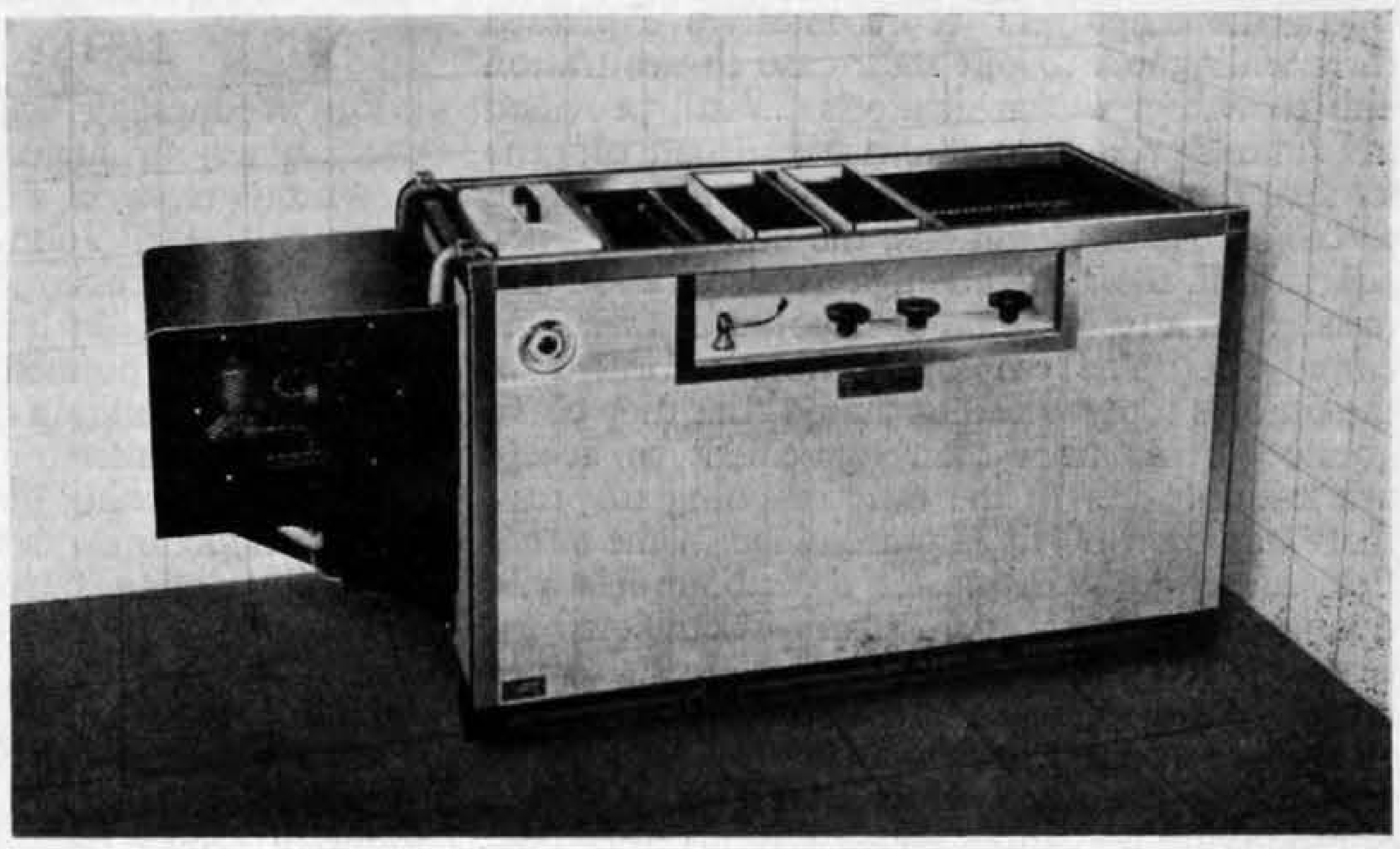
Textile Processing Technique

A notice from the Department of Scientific and Industrial Research states that the British Rayon Research Association, at Wythenshawe, Manchester, has developed a new textile processing technique which incorporates a fluid bed. This is an efficient means for conveying heat and so of potential value in any textile process involving heat transfer such as cloth which is wetted and dried several times while being processed. In current practice the fabric is dried by passing it through a machine using hot air blown by fans, or over heated rollers. For each method the equipment is costly, and occupies a large amount of floor space, some hot air dryers having an overall length of 120ft, while the thermal efficiency is low.

The fluid bed technique evolved at the British Rayon Research Association consists essentially of a column containing very small particles (at present glass beads called ballotini are being used) through which air is blown. Heaters are placed directly in the bed and the temperature, which is accurately controlled, is uniform throughout so that the fabric is dried evenly and simultaneously on both sides. By this system it is claimed that the fabric is dried four or five times more rapidly than by present methods. As an example it is stated that in the drying, dyeing and baking of crease-resistant resin finish on cloth, the moisture can be dried off and the resin baked on in one operation of twenty seconds duration compared with the four minutes required at present. Another advantage claimed for the fluid bed technique is that it makes the dyeing of man-made fibres easier since the process is continuous whereas at present, fibres such as Nylon and " Terylene " have to be impregnated with dye by pressure vessels in a batch process.

X-Ray Processing Equipment

The accompanying illustration shows an X-ray processing equipment, Model No. 56, complete with water jacket cooling, which has been designed by Kodak Ltd., Victoria Road, Ruislip, Middlesex, in conjunction with Frigidaire, Ltd. for use in the tropics. In order to obtain the correct processing temperature of 68 deg. Fah. it is often necessary in tropical and sub-tropical climates to cool the chemical solutions to be used, and this equipment, it is claimed, will maintain the solutions at the required temperature in room temperatures of up to approximately 90 deg. Fah.



X-ray processing equipment with water jacket cooling plant

The cooling unit is an air-cooled, hermetically-sealed, rotary compressor condensing unit, suitable for a.c. only, and is housed in a ventilated sheet metal cover supported by brackets at the water jacket end of the processing unit. Cooling is effected by means of two sets of direct expansion coils, which lead from the cooling unit into the water jacket in front of and behind the inner processing tanks. An adjustable thermostat is provided. As the cooling unit, illustrated here, only controls the temperature of the processing solutions, it is recommended by the manufacturers that where the temperature of the wash water exceeds 80 deg. Fah., a " Frigidaire " cabinet cooling plant should be used in conjunction with a specially modified processing unit. This plant is designed to cool 25 gallons of wash water an hour from an initial temperature of 90 deg. Fah. to a final temperature of 68 deg. Fah. This equipment is available with either " Perspex " or stainless steel tanks.

Tactical Transport Aircraft

The United States Army is to acquire for evaluation five " Caribou " aircraft built by De Havilland Aircraft of Canada, Ltd., Toronto. The first DHC-4 is expected to fly in 1958 and deliveries to U.S.A. to commence in 1959.

The aircraft is intended to realise short-take-off-and-landing qualities for carrying troops to the scene of battle ; landing strips as short as 800ft are the design objective. It will also be able to handle 2½ tons of freight or twenty-two stretcher cases. A cruising speed of 18 m.p.h. will be attained at about 50 per cent of take-off power, the engines being Pratt and Whitney " Twin Wasp " R.2000 radials of 1450 h.p. The gross weight of the aircraft is to be 24,000 lb ; the wing span is to be 95ft, the aspect ratio 10, and double-slotted flaps will extend over the full span, the outer trailing portions acting as ailerons.

Industrial and Labour Notes

Shipbuilding and Engineering Disputes

The strike in the United Kingdom's shipbuilding and ship repair yards, recommended by the Confederation of Shipbuilding and Engineering Unions after the rejection of a wage claim, started last Saturday. As recorded in our last issue, the claim was for a 10 per cent increase. At the beginning of this week, it was stated that the shipyard strike was complete and that work on over 300 ships was at a standstill.

In a final effort to avert the strike, the Minister of Labour, Mr. Iain Macleod, invited representatives of the Shipbuilding Employers Federation and of the Confederation of Shipbuilding and Engineering Unions to further talks last Friday. Then, the employers' representatives expressed their willingness to put their case to arbitration and to accept the arbitrator's award, provided the unions would do likewise and call off the strike. But, as the Minister of Labour explained to the House of Commons, the unions remained adamant in their attitude against arbitration and insisted on a resumption of negotiations with the employers. The employers were informed of the union's reply and then stated that they could go no further than their agreement to accept arbitration. Up to the time of going to press, there has been no apparent change in the situation, although the Minister of Labour has said that " a number of informal discussions are taking place," and " such discussions are often more fruitful than the more formal meetings."

At the beginning of the week, the executives of the unions affiliated to the Confederation of Shipbuilding and Engineering Unions were considering details of the strike action in the engineering industry, which, it was announced last week, would begin to-morrow, March 23. The claim here is for a 10 per cent increase, and was finally rejected last week by the Engineering and Allied Employers' National Federation. The Minister of Labour, in a statement last Monday, said that although the two disputes were closely linked, the engineering industry's dispute appeared to differ from that in shipbuilding in that, as he understood, strikes might be directed " against parts and not the whole of the industry." He proposed, therefore, to invite the parties to discussions with his Ministry. Union leaders went to the Ministry of Labour on Tuesday morning, but stated afterwards that, so far as they were concerned, the situation was unchanged. Later in the day, there was a conference of executives of the unions forming the Confederation. Afterwards, Mr. H. G. Brotherton, president of the Confederation, stated that there would be strikes, starting from to-morrow, in " certain sections " of the engineering industry. These stoppages would be gradually extended over the next fortnight, so that the whole of the industry would be involved by April 6, if no settlement was reached meanwhile.

Iron and Steel

The Iron and Steel Board has announced that British steel output reached a new record figure during February. The production of steel ingots and castings averaged 432,100 tons a week, which indicates an annual output rate of 22,470,000 tons. Pig iron production in February, averaging 267,600 tons a week, was at an annual rate of 13,916,000 tons.

The Board says that steel making capacity is expected to increase further during this year and there should be capacity available for the production of 22,400,000 tons. Despite the fact that there is still some uncertainty about future oil supplies. it is hoped that fuel difficulties will not check expanding production. The Board also comments on the " substantial changes in the requirements of steel by different users." It is stated that there has been an easing of demand in some of the finishing industries, but that the full ingot output continues to be required.

The total steel deliveries from United Kingdom mills in January have been estimated provisionally at 311,300 tons a week, an increase of 1·6 per cent compared with January last year. The Board comments that it would be unwise to draw firm conclusions from the figures for one month only, though it suggests that the January deliveries emphasise the continued strong demand from shipbuilders, the collieries, the railway wagon building programme, and from many sections of the engineering industry. Steel deliveries to the motor-car industry remained exceptionally low in January, though there are indications that they will show some increase in succeeding months. The Board adds that the demand for plates and heavy sections continues to be strong. Despite greater output and a marked increase in consumers' stocks last year, the demand for these products is still in excess of available supplies.

Steel for Shipbuilding

On Wednesday evening of last week, there was an adjournment debate in the House of Commons on steel supplies for the shipbuilding industry. Mr. John Rankin introduced the subject by expressing the wish that the debate " might have been held in a happier industrial climate." He pointed out that the demand for steel in shipbuilding still exceeded the supply, and said he understood that the Iron and Steel Board was pressing the steel industry to increase plate production. Mr. Rankin asked if there were any definite proposals before the Board.

The Civil Lord of the Admiralty, Mr. Galbraith, replied to points raised during the debate. He said that in the latter part of 1954 and the beginning of 1955 some ground had been lost in the supply of steel to the shipbuilding industry. Since then, however, persistent efforts had been made to improve supplies, and those efforts had met with some success. Deliveries in 1956 were 20 per cent higher than they were in the trough between the end of 1954 and the beginning of 1955, and were 14 per cent up on 1955 as a whole. In fact, Mr. Galbraith stated, last year 738,000 tons of plate and heavy sections were delivered to the shipbuilding industry, which was more than had been delivered in any year since the present system of recording began in 1948. Mr. Galbraith went on to say that, in order to press on towards its maximum output, the shipbuilding industry could absorb this year an additional 75,000 to 100,000 tons of steel. He had confidence that that need was going to be met, although, he remarked, it would be unrealistic and unfair to suggest that that was going to be the end of all the difficulties. The difficulties in the supply of steel were going to continue until the productive capacity of the steel mills caught up with the growing demand for plate and sections ; that was a demand which affected not only the shipbuilding industry, but other industries using the same kind of steel.

Integration of European Trade

Some comments about the proposals for the integration of European trade were made last week by Sir George Nelson, Bt., in his chairman's address at the annual meeting of the English Electric Company, Ltd. He said that any arrangements which could be made to stimulate the growing market in Europe would be to the benefit of some manufacturers in this country.

Industry and commerce as a whole, Sir George continued, had given a positive, though guarded, welcome to the proposals, but it could not be denied that there were dangers in them. The plan could not work satisfactorily if any of the countries adhering to the proposed free trade area should adopt or continue practices of open or concealed subsidy or differential export pricing amounting to dumping. Many difficulties and inequalities, Sir George said, had to be overcome ; for example, genuine differences in the cost of production in the various countries arising from their different design standards and from variations in the level of earnings, in hours of work, in the incidence of social costs, and so on. Perhaps, Sir George went on, the greatest difficulty lay in an attitude of mind. Under the plan, he wondered, would British engineering manufacturers be likely to have as genuine a chance of tendering to Continental utilities as the Continental manufacturers would have in this country ? If that could not be ensured, Sir George observed, the plan could not succeed.

Petrol and Fuel Oil

The Paymaster-General, Mr. Maudling, announced in the House of Commons last Monday that the Government had reviewed petrol rationing and other restrictions on oil consumption, and had decided that the improved supply prospects warranted some relaxation. Supplies of petrol, he said, although increasing, were still likely to remain short of normal demand and it was, therefore, not possible to abolish petrol rationing at once. Nevertheless, the improved supplies were sufficient to allow the basic ration for private cars to be increased by 50 per cent to 300 miles a month in the next rationing period beginning on April 17. The improved supplies, Mr. Maudling said, would be taken into account in assessing claims for supplementary allowances and in dealing with applications in respect of passenger and goods vehicles requiring petrol.

Supplies of gas-diesel oil, Mr. Maudling continued, were now sufficient to enable the coupon rationing scheme for Derv fuel and the other cuts on gas-diesel supplies to be brought to an end on April 1. But stocks in the hands of the oil companies must be built up during the summer to meet next winter's demands, and with that end in view the companies had been asked to limit their sales to customers to minimum current needs. It was still necessary for consumers to exercise all possible economies ; otherwise it might become necessary to prescribe a measure of under-delivery by the companies. Fuel oil supplies, Mr. Maudling added, were still below normal and stocks must be rebuilt before next winter. Although, therefore, there was no longer any danger of an increase in the present level of cuts, they must remain in force for the time being, subject to one minor relaxation in regard to oil fuel for space and water heating, where the present cut of 25 per cent would be reduced to one of 10 per cent with effect from April 1.

Industrial Psychology

The National Institute of Industrial Psychology, which was founded in 1921, has just published its thirty-fifth annual report. The report records the discussions between the Institute and the Department of Scientific and Industrial Research which led to the D.S.I.R. offering a general grant towards the cost of long-term research.

The report gives some account of the progress made by the Institute in such aspects of its work as vocational guidance, personnel selection and industrial investigations. It is stated, for example, that in its industrial investigations the Institute seeks to apply " the results obtained from basic research into the complex problems of the relationships of human beings to one another and to their surroundings when at work." During the past year, investigations have been predominantly concerned with three matters, namely, the training of operators, the study of employees' attitudes to their work, and selection and allocation problems. The Institute says that requests for surveys of the attitude of employees to their working life have increased, the organisations concerned having ranged in size from a voluntary body employing thirteen people to an industrial firm with 5000 employees. The " attitude surveys," the report adds, make it possible to diagnose the general state of morale and reveal any aspects of organisation, policy or practice which are hampering the adjustment of people to their jobs.

There is also reference in the report to the numerous requests for assistance in selection problems which the Institute has received. Some of these requests involved no more than coaching a member of the staff of a firm in the use of standard tests of intelligence and aptitude. In other cases, however, detailed studies were necessary to take into account the requirements for each post under review and to determine a procedure for the selection of operatives.

Kuibyshev Hydro-Electric Power Station

No. II—(*Concluded from page 423, March 15*)

A general description is given of the Kuibyshev hydro-electric scheme, now in operation on the Volga River in the U.S.S.R. The scheme is very large, and will generate about 11,300 million kWh annually when the plant installation, which will have a capacity of 2,100MW, is complete. Our article is based on information obtained from several Russian publications; it concludes with some information about the design and construction of the generating plant at Kuibyshev.

APART from the interest due to their size—the turbines at Kuibyshev are thought to be the largest Kaplan machines in the world*—the generating sets exemplify contemporary Russian trends in design and manufacture. In particular, the turbines have been designed with as much standardisation and simplification as possible in manufacture. The overall size and capacity of the design was governed by rail transport facilities and by the machine tools available, the largest practical capacity being chosen. The number of machine sets in a scheme like Kuibyshev has a considerable influence on its overall economy, and any saving in the width occupied by a set, or in the number of sets, reduces constructional costs appreciably. Some of the main figures for sizes and capacities are listed herewith in Table II. To give an idea of their size,

TABLE II—*Kaplan Turbines at Kuibyshev*

Output at a head of 19m	108·5MW
Output at a head of 22·5m	126MW
Maximum flow through turbine	700 cumecs
Diameter of turbine runner	9·3m
Operating speed	68·2 r.p.m.
Number of runner blades	6
Number of guide vanes	32

the Russian engineer, Kovalev, quotes the following figures: centrifugal force on each runner blade at runaway speed, 1400 tons; axial hydraulic pressure on a runner blade, 1500 tons; effort needed to turn a blade when the turbine is in operation, 2340 tons. Design and manufacture of the turbines was carried out by the Leningrad Metallurgical Works. (LMZ).

Turbines of this category are required on the majority of the schemes now being developed in Russia. The particular case of the Kuibyshev station called for twenty similar turbines. Seventeen substantially identical machines were also needed, however, for the Stalingrad power station lower down the Volga, and further investigation showed that a total of eighty-five turbines would eventually be required in this series. Hence there was much to be gained in designing for economy in manufacturing and for standardising components for the turbines.

The principal improvement stressed by Russian technical publications describing this work is that of the extensive use of welding, and of large welded assemblies to replace large steel castings. We have not attempted to compare these measures with corresponding practice in Great Britain. But in view of the technical interest of these large machines, the Russian assessment of the manufacturing problem is briefly described. It is pointed out that there are actual savings in the weight of metal needed for the welded construction, but a more noteworthy saving is obtained in machining. Other economies have been introduced by reducing inter-dependent tolerances, substituting cheaper materials wherever possible, and by mechanical simplification; for instance, cutting out a flanged joint in a shaft and making it in one piece. It is claimed that the productivity of the labour engaged on this work is two or three times higher than on other, general purpose, turbine manufacture.

Various metals have been used for the turbine blades; recent work aims at discarding stainless steel for the runner blades and replacing it by a low-alloy carbon steel, which is much easier to work, with sheets of stainless steel welded on to the blade. Copper-alloyed steel is also to be used for runner blades.

The turbine top cover, speed ring and guide vanes were cast in the first few sets, but welded construction was then used instead for these components. The speed ring of the turbine is a combination of casting and welding. The top and bottom rings and seventeen stay vanes were cast, and then welded into eight fabricated "sectors." The completed assembly is 4·5m high, 14m in diameter, and weighs 175 tons. The steel liner of the runner chamber—the discharge ring—is fabricated from pressed sheet. This method of construction is an innovation in the Soviet Union, and was introduced to give a close fit round the runner blades by pressing, without machining. Erection was carried out in a jig. Apart from machining, a weight saving of 37·8 tons (the total weight of the fabricated version is 89·3 tons) is claimed for each machine built in this way.

Some figures may perhaps be quoted to give an idea of the manufacturing problem. There are 50,000 parts in each complete turbine. The overall weight of the turbine is 1500 tons. The runner weighs 423·8 tons. The weight per kilowatt of capacity, 12·3 kg is considered an improvement over earlier work. Table III gives figures quoted to show the advantage of welded components over cast ones. The turbine components

TABLE III—*Comparison of Cast and Welded Methods of Manufacturing Certain Components of the Kuibyshev Turbines*

	Weight, tonnes		Labour, man-hours	
	Finished	Blanks	Mechanical assembly	Including machining time
Cast	376	527·3	21,542	16,218
Welded	303·2	338·1*	14,664	10,754

* Standard expenditure of material 479·8 tonnes.

Economies from welded components:

Weight reduction	72·8 tonnes
Saving of material	47·8 tonnes
Saving in assembly time	6878 man-hours (including 5464 hours machining time)

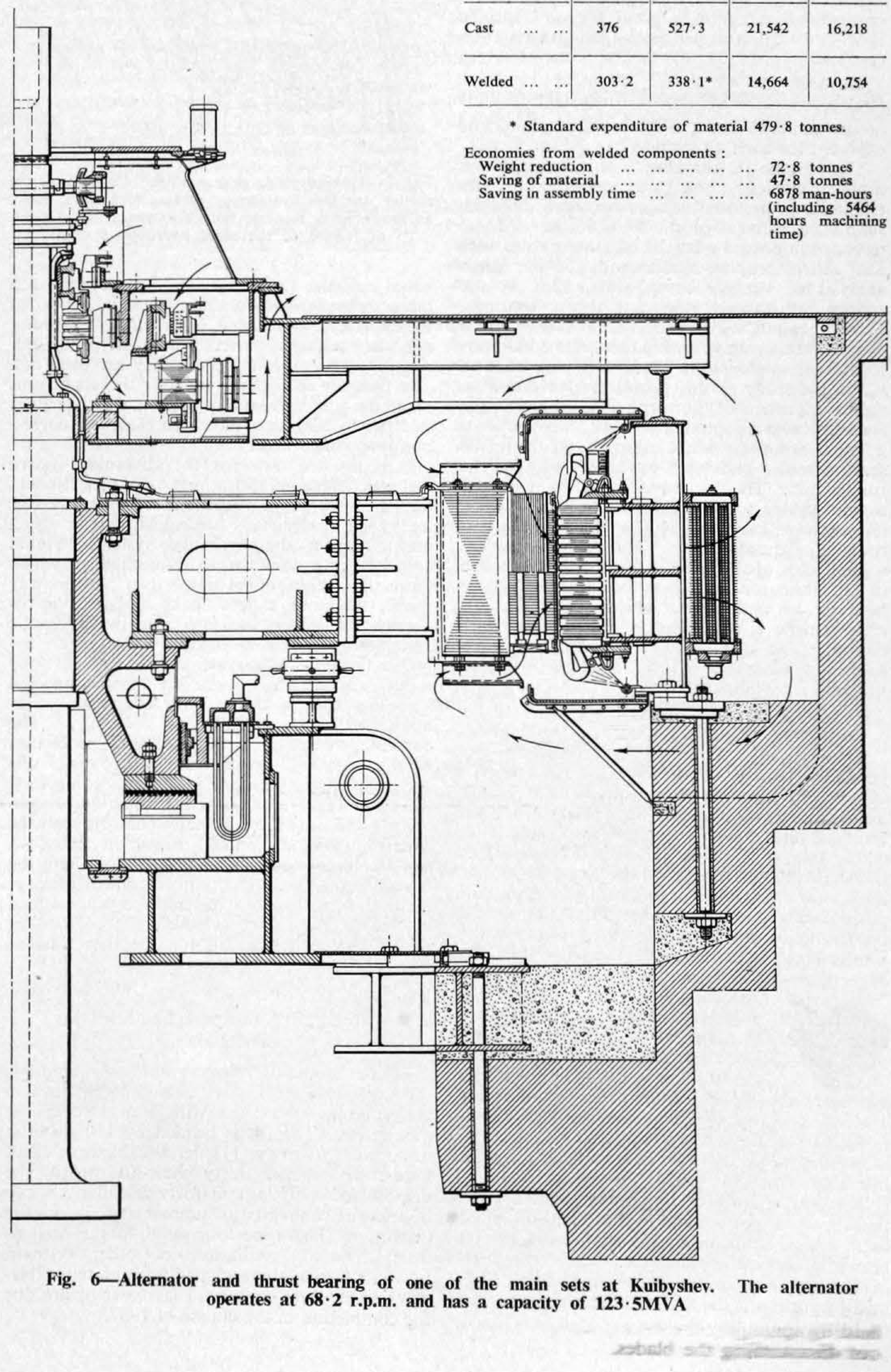


Fig. 6—Alternator and thrust bearing of one of the main sets at Kuibyshev. The alternator operates at 68·2 r.p.m. and has a capacity of 123·5MVA

* Kaplan turbines at McNary dam, U.S.A., are of 82MW capacity and have a runner diameter of 7·15m. These machines are cited as the largest examples outside Russia. The Shcherbakov turbines have runners 9m in diameter, but have a capacity of only 65MW.

making up the total weights shown are as follows: "foundation" parts (i.e. discharge ring, &c.); top and bottom rings of speed ring; turbine cover; regulating ring; thrust bearing housing; and runner cone.

Turbine and Alternator Design

Hydraulic design of these turbines received attention comparable to the manufacturing aspect which we have already described. Scale models of 250mm and 460mm runner diameters were constructed and tested. Modifications introduced to improve on earlier designs included reshaping the intake, spiral chamber and stay vanes, and deepening and modifying the draught tube, which extends to a depth of 2·38 times the runner diameter. Efficiencies predicted from the model tests stood at "optimum" values of 87 to 88 per cent. However, the makers were sufficiently confident of the design to guarantee a peak efficiency of 93·5 per cent. The specific speed is quoted as 118 to 170 r.p.m., but this is according to a Russian formula $n_1'=\frac{nD_1}{\sqrt{H}}$ which, briefly, considers the specific speed in an analogous way to the generally accepted formula, but defines a reduction, under similar conditions to a head of 1m and a rotor diameter of 1m. A corresponding figure is given for a "specific flow" of 1850 litres per second, and a cavitation coefficient of 0·72 to 0·75. According to $N_s=\frac{N\sqrt{P}}{H^{5/4}}$, the specific speed is 656, in metric units at the standard head, a figure which would be expected for such a turbine.

The turbine runner also, was redesigned and a higher efficiency, and better cavitation characteristics over previous designs are claimed for the six-bladed runners of the new design. Model tests and improved methods of computation were also introduced, we understand, for the stress analysis of various components, such as the runner hub, speed ring and thrust bearings. The runner hub, for instance, weighs 82 tons, and is complicated in shape and in the stress conditions to which it is subjected. A model was built to aid in the study of this problem. Nevertheless, the arrangement of the turbine is, generally, the standard one adopted by LMZ. There is a guide bearing above the runner, and the blade servomotor is built into the upper part of the runner hub. The thrust bearing is situated close to the turbine top cover (to reduce the vertical size of the set) and is shown in the accompanying drawing of the alternator. This illustration gives a good idea of the general form of construction of the alternator and shows the spider and guide bearing, as well as the thrust bearing. The arrangement is a variant of the "umbrella" design. The turbine guide bearing is water-lubricated with rubber-insert seal, according to the maker's standard design.

Governing and Control Gear

The governing system for the turbine appears generally to follow orthodox design, but is claimed to have higher sensitivity then earlier examples, largely because of the need to transmit most of the power generated along the long 400kV line to Moscow. The pendulum actuator is electrically driven by a synchronous motor, the motor in its turn depending on a generator positioned above the oil reservoir of the turbine on the main shaft. The servomotors for the runner blades and the guide vanes are operated by a hydraulic system at a pressure of 25 kg to 27 kg per square centimetre, and are controlled by valves 250mm in diameter. Two screw pumps each deliver oil at the stated pressure at a rate of 25 litres per second, and there is a reservoir of 32 cubic metres of pressure oil. The governing system envisages a rise in turbine speed of 35 per cent when load is shed from the full-load condition; the guide vane servomotors are capable of closing the guide vanes in a minimum time of five seconds.

The servomotor for the runner blades is in the upper part of the runner hub, and oil is fed to it down the inside of the shaft from the oil reservoir above the generator. Thus, the bearings at the blade roots have rubber sealing rings held by springs; the seals can be removed without dismantling the blades.

There are two servomotors for the guide vanes, each 800mm in diameter and together capable of an effort of 227 tons. One of them has a locking device which keeps the guide vanes closed when the turbine is stopped and when there is no pressure oil in the servomotor system. There are shear pins in the linkage system, which rupture if a vane jams. On some of the earlier turbines, each guide vane was fitted with an emergency servomotor; the arrangement is shown in Fig. 7. Under normal conditions, should a vane jam, the shear pin holding the vane top plate to the regulating linkage will break. Should the main servomotors fail, oil under high pressure may be introduced, from an emergency oil-pumping system, to the emergency servomotors. The pressure is high enough for the shear pins on all the guide vanes to be broken, which enables each emergency servomotor to close its corresponding guide vane.

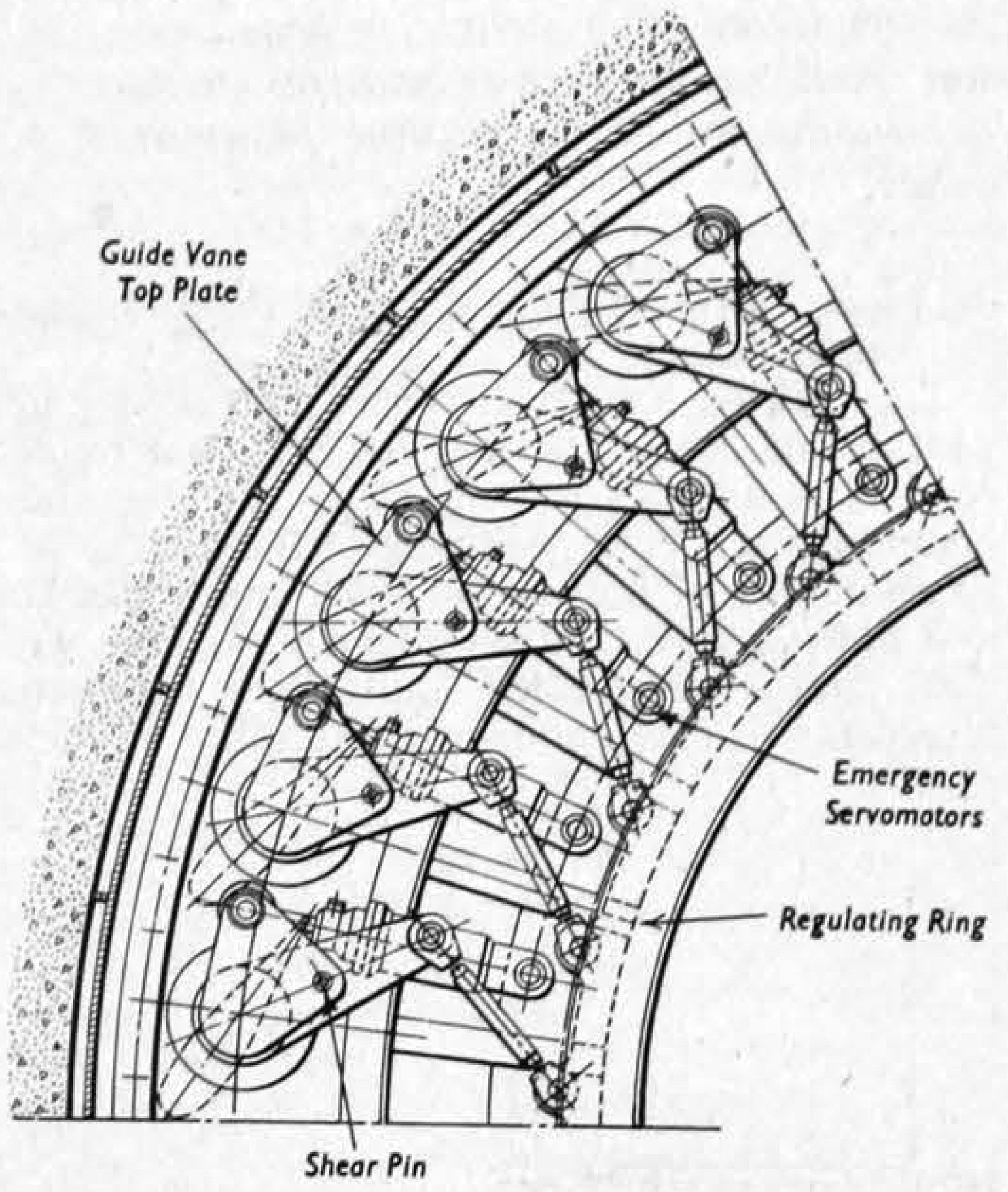


Fig. 7—Turbine guide vane control. On some of the earlier turbines, emergency servomotors were fitted, as shown here, to close the guide vanes in the event of failure of the main hydraulic system

It is pointed out that the governing system includes several modifications on earlier Russian designs. For instance, manual control valves and their associated mechanisms have been omitted from the hydraulic system, manual control being confined to a mechanism which limits the opening of the main valve. At runaway speed, the guide vanes can be closed by introducing oil under pressure into the hydraulic system through an emergency valve which by-passes the governing system.

The sequences of operation in starting and stopping the machines, are controlled automatically, either locally or remotely. The control system includes electrical protection of the sets, load adjustment on groups of sets or individual sets, and relays controlling various safeguards against hydraulic and mechanical abnormalities. These controls can be effected from a control centre in Moscow, using a high-frequency carrier system along the transmission line. The remote control of large hydro-electric generating sets is again claimed as one of the recent achievements of Russian power engineers, utilised for the first time at Kuibyshev.

Mountain Transport Facilities in Switzerland

Besides mountain railways and postal omnibus services, there are in Switzerland at present 340 undertakings concerned with transport in the mountains. The list is headed by 170 ski-lifts; in addition there are 118 aerial cableways of all kinds. In summer thirty chair-lifts are at the disposal of tourists, and forty installations can be used as chair-lifts in summer and as ski-lifts in winter. There are four sleigh-lifts as well as four lifts and installations of other systems. Eleven ski-lifts, three chair-lifts and ten cableways either were completed last year or are due for completion in the course of 1957.

Galvanometer Relay

In the galvanometer relay of which we show an illustration, the value of the output currents is determined by the positions given to two cadmium sulphide photocells placed into the path of the light spot.

Current from the cells energises a sensitive polarised relay fitted with two windings. Once a relay contact closes, it is preserved until an opposite current causes the second contact to close instead.

The instrument, which is manufactured by A.O.I.P., 8–14, Rue Charles Fourier, Paris (13e), is made in three versions. The first (the "Model RG.L.") requires a minimum power to operate the relay of 10^{-14}W and can switch currents up to 0·5A and 220V. Its accuracy is stated to be ±2mm of scale deflection. Each cell is individually controlled by an external knob. The distance between the cells can be adjusted to between 2mm and 140mm.

Galvanometer relay

This relay, which is designed for use in the laboratory, can be employed either as an on-off instrument or for reversing the output current.

The second version (the "RG. I.") is an industrial one with the same electrical characteristics, but with a safety device to indicate a failure in the supply or an internal fault. As in the laboratory device, the light spot is always visible on a ground glass screen. Several photocells can be fitted with a corresponding increase in the number of contacts. In a design suitable for panel mounting (the "Model RG.A.") the light spot is not visible; output current is reduced to 0·5A, 25V. When the instrument is in operation the fact is shown by an indicator light.

German Machinery Production

According to provisional figures issued by the Verein Deutscher Maschinenbau-Anstalten (VDMA), machinery production in the Federal Republic, including West Berlin, last year reached a value of 17,500 million DM., of which about 5900 million DM. were exported. This amounts to an increase of 18 per cent in total value and 23 per cent in exports, compared with 1955. The industry employed nearly 800,000 at the end of the year (740,000 at the end of 1955). New orders, it is reported, have slightly receded in relation to the development of production. Credit restrictions at home reduced capital investments, thus causing many machine-building firms to turn more intensively to the export market, a tendency which is likely to continue in even stronger form.

German Loudspeaker System at Paris Opera

On February 9, the new sound installation at the Paris Opera came into use with a gala performance of "The Martyrdom of St. Sebastian," by Debussy. The electro-acoustic system was installed by Telefunken, Berlin, and comprises forty-eight invisibly mounted loudspeakers in the auditorium, operated by eight high-fidelity amplifiers. In addition, there is a sound effects studio equipped with magnetic tape apparatus, which permits the recording and reproduction of all kinds of background sounds for which previously a multiplicity of very expensive devices had been necessary.

Progress of the Tennessee Valley Authority

BY OUR AMERICAN EDITOR

No. I

A MAJOR expansion of the T.V.A. power system, intended primarily to supply the large nuclear works in the area of the U.S. Atomic Energy Commission, was planned after the outbreak of hostilities in Korea in 1950. The fiscal year 1956 has brought to near completion this extraordinary six-year programme which added 6,000,000kW of generating capacity to the T.V.A. power system. During the past year there was placed in operation 1,469,500kW of generating capacity, only a little less than the record of 1,734,300kW completed the year before. The total installed capacity has been increased from 2,993,610kW at the end of fiscal year 1950 to 9,279,485kW at the end of fiscal year 1956. The past year brought a new record in power generation of 57,500 million kWh, and a new record of sales to the Atomic Energy Commission. The Oak Ridge and Paducah atomic works, which together obtain from T.V.A. more than twice as much power as is consumed in the city of New York, took 56 per cent of T.V.A.'s total sales. While the virtual completion of the defence power expansion overshadowed other events, the general programme of integrated resource development produced notable chapters. The reservoir conditions witnessed great extremes. A severe mid-winter drought combined with heavy demand for power to draw down a number of major reservoirs to record low levels. The drought was followed by unusual winter and spring rains, restoring lake levels to normal or better conditions. Moderate floods on the Tennessee, lower Ohio and lower Mississippi rivers were regulated, averting nearly 1,000,000 dollars of damage. Traffic on the Tennessee River waterway continued its sharp climb. In fertiliser development and agriculture steps were taken to provide more effective research relationships between the scientists of the T.V.A. and those of the fourteen land-grant colleges testing T.V.A. fertilisers on the soils of the various regions. Farmer education schemes in fertiliser use were widened. The use of power by the Valley region's 1,500,000 consumers continued to rise at a steady rate approaching 15 per cent a year. The average residential consumer now uses more than twice as much electricity as the average for the United States.

Despite the great six-year increase in generating capacity, the use of power in the Valley region for all purposes was swiftly moving toward the present production ceiling, mainly because since 1953 T.V.A. had not begun construction of any new generating capacity. Proposals to authorise the issue of T.V.A. power revenue bonds were before Congress, but early action upon them grew increasingly doubtful. If peak loads of the 1957–58 winter were to be met, a further delay in construction could not be permitted. The T.V.A. Board, therefore, turned to the use of revenues from power operations to finance the addition of new units to existing steam and hydro-electric plants. However, the power revenues of the Authority, like the revenues of most other power systems, are sufficient to provide only a part of the capital that will be needed in future years to build the generating capacity required to keep pace with the economic growth of the Valley power region. The continuing ability of the T.V.A. to serve this growth will depend on the availability of other sources of capital.

Construction Progress

In terms of generating capacity added to the power system, the fiscal year 1956 was the second largest construction year of the Authority. Construction forces added 1,469,500kW of installed capacity to the T.V.A. power system, an increment second in size only to the 1,734,300kW added in fiscal year 1955. At the end of the year, the system capacity had reached 9,279,485kW. This capacity consisted of 5,702,250kW in steam power stations and 3,577,235kW in hydro-electric plants, reflecting the extent to which demands for power in the region—in particular the demand of Federal defence agencies—have outrun the hydro-electric power resources of the region. The additions to capacity installed during the year consisted of eight large generating units at four steam-electric stations and two units at hydro-electric plants.

With the major hydro-electric sites of the region already developed, power construction over the past few years has been largely devoted to steam power stations. Several important factors are favourable to the development of steam-electric generation in the region, and T.V.A. has been able to build one of the most efficient steam-electric systems in the country. Ample and economical supplies of coal are available in the region and in nearby areas. The multi-purpose development of the Tennessee River has provided reservoirs ensuring plentiful supplies of cooling water. The Kingston station in full operation, for example, requires 967,000 gallons of water per minute. The navigation channel helps to provide economical transportation for fuel. The large size of the system and the rapidity with which power demands in the region have grown make possible the installation of large and efficient generating units.

At the Kingston steam power station two generating units, each of 180MW capacity, and rated at 200MW each of capability, were placed in operation during the fiscal year. This brought the plant to its full complement of nine generating units, four of 135MW capacity and five of 180MW. The total installed capacity at the station is now 1440MW, which is believed to make it the largest steam power station to be operating anywhere. The capability of the plant is 1600MW. During the year an underwater dam was built across the Clinch River as a means of lowering the temperature of the cooling water used by the station, thus increasing the power capability of the plant. The dam, crossing the Clinch River just below the mouth of the Emory River, diverts the cooler water flowing along the bottom of the Clinch, making it available for the steam condensers. As a result, about 15,000,000kWh of additional electricity can be produced each year. The top of the dam is 11ft under the minimum water level that can occur at times of extreme drawdown of the Watts Bar Reservoir in preparation for major flood control operations. The 11ft clearance is ample for navigation, Approximately 17,000 tons of rock were placed to form the dam at a total cost of around 29,000 dollars. At the end of the year, work was continuing on supplemental structures, site improvement, and permanent railway connections in the station area.

Although the ninth 135MW generating unit at the Shawnee steam power station (Figs. 2 and 3) was in operation early in the fiscal year, the tenth and final unit, scheduled for operation during the year, was seriously delayed. The delivery of important turbine parts was held up by a five-month strike at the works of the manufacturer. Other parts were transferred to other units to replace damaged equipment. At the end of the year, the unit had been rescheduled for operation at reduced load in September, 1956, using a replaced turbine spindle from unit 1. When in full operation, the station will have an installed capacity of 1350MW and a capability of 1500MW making it the second largest station in the T.V.A. system. Most of its output goes to the Paducah, Kentucky, plant of the U.S. Atomic Energy Commission.

The four-unit, 720MW capacity plant at the Colbert steam power station (Figs. 4 and 5) was virtually completed in the fiscal year. Two generating units were in operation at the beginning of the year, and the third was operating at reduced load. Early in the year, the manufacturer decided that the generator rotor should be replaced and a rotor consigned to the John Sevier steam power station was installed. By the end of July, 1955, the unit was in full operation. The fourth unit was placed in commercial operation in November. Rail coal unloading facilities were completed during the year and the first coal to be shipped by rail, coming from Alabama mines, was handled in October, 1955. The bulk of the coal used at the plant is delivered by barge from western Kentucky and Illinois fields.

At the John Sevier steam power station (Fig. 1) three 180MW generating units were in operation during the fiscal year, adding 540MW of capacity to the system. The capability of the three units

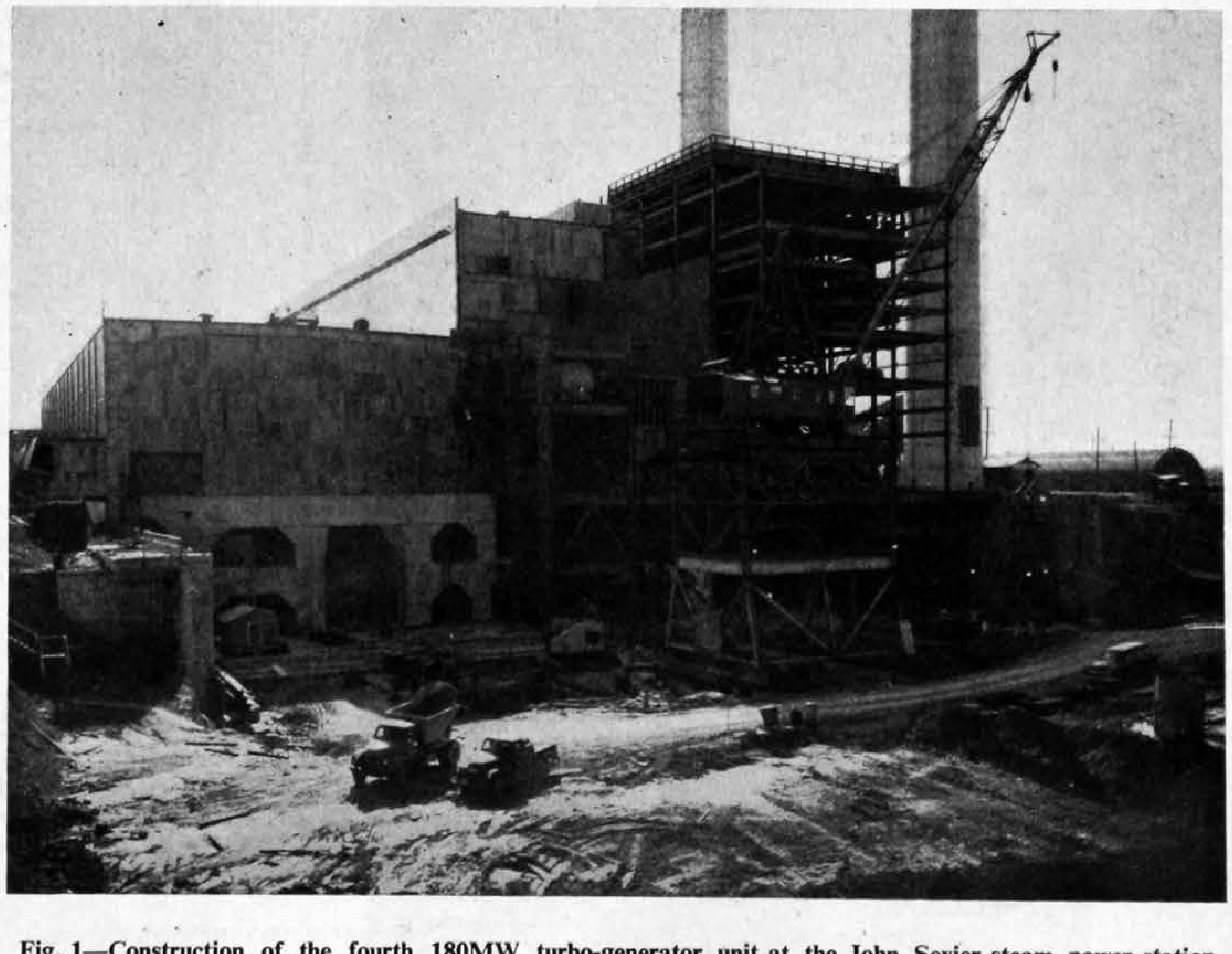


Fig. 1—Construction of the fourth 180MW turbo-generator unit at the John Sevier steam power station in Tennessee

STEAM POWER STATIONS OF THE TENNESSEE VALLEY AUTHORITY

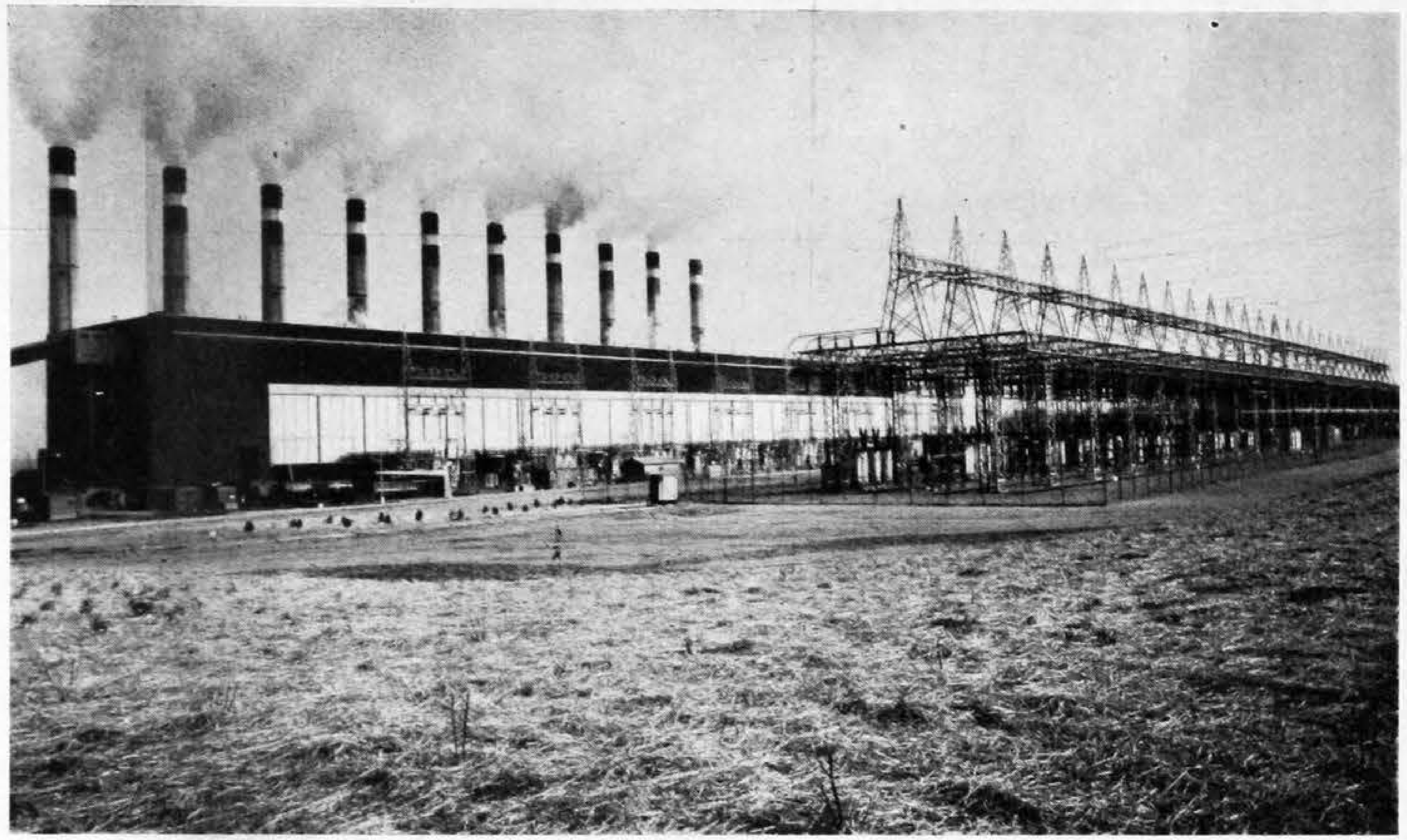


Fig. 2—Shawnee steam power station in Kentucky with switchyard in foreground

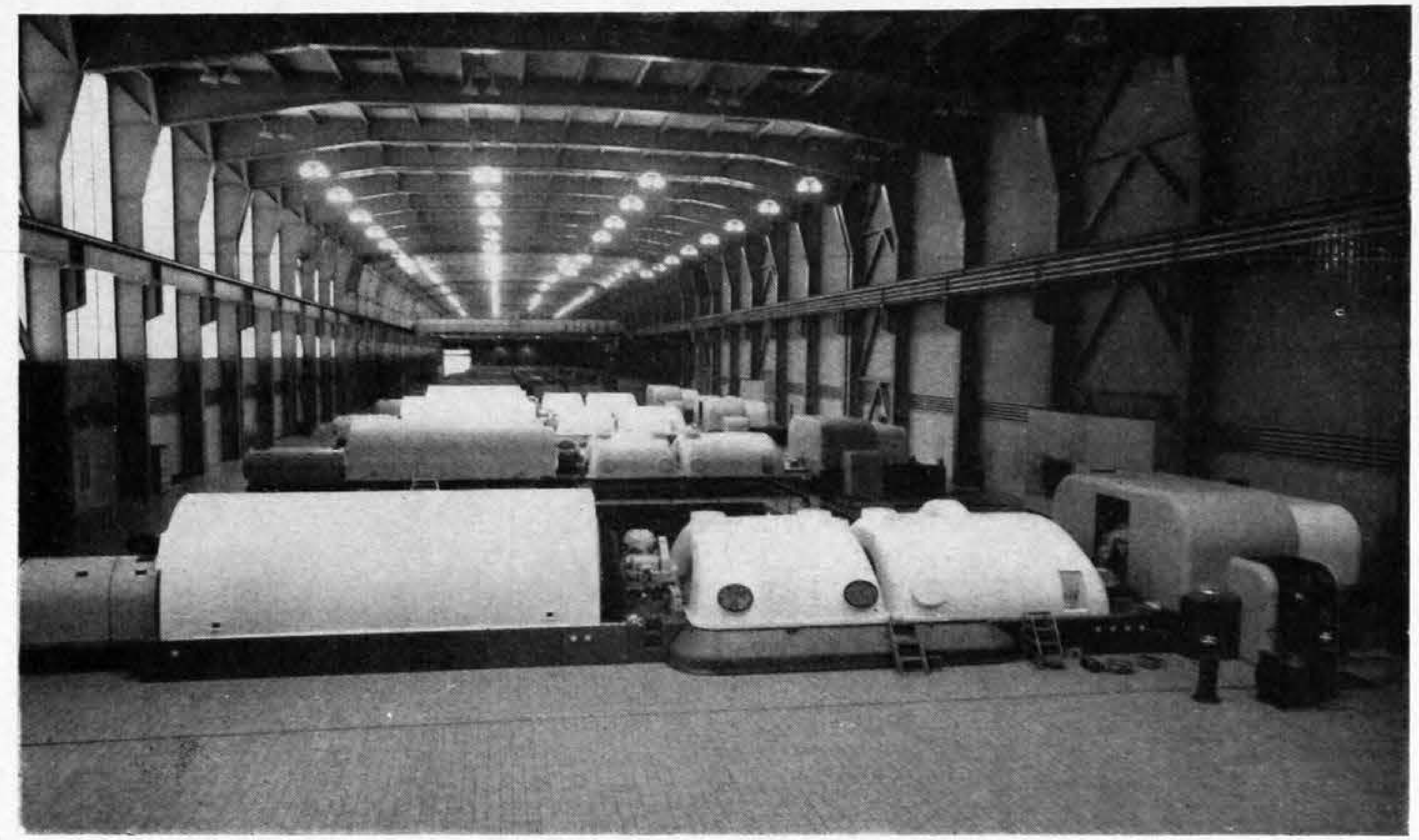


Fig. 3—Ten turbo-generators at the Shawnee steam power station with a total capacity of 1350MW

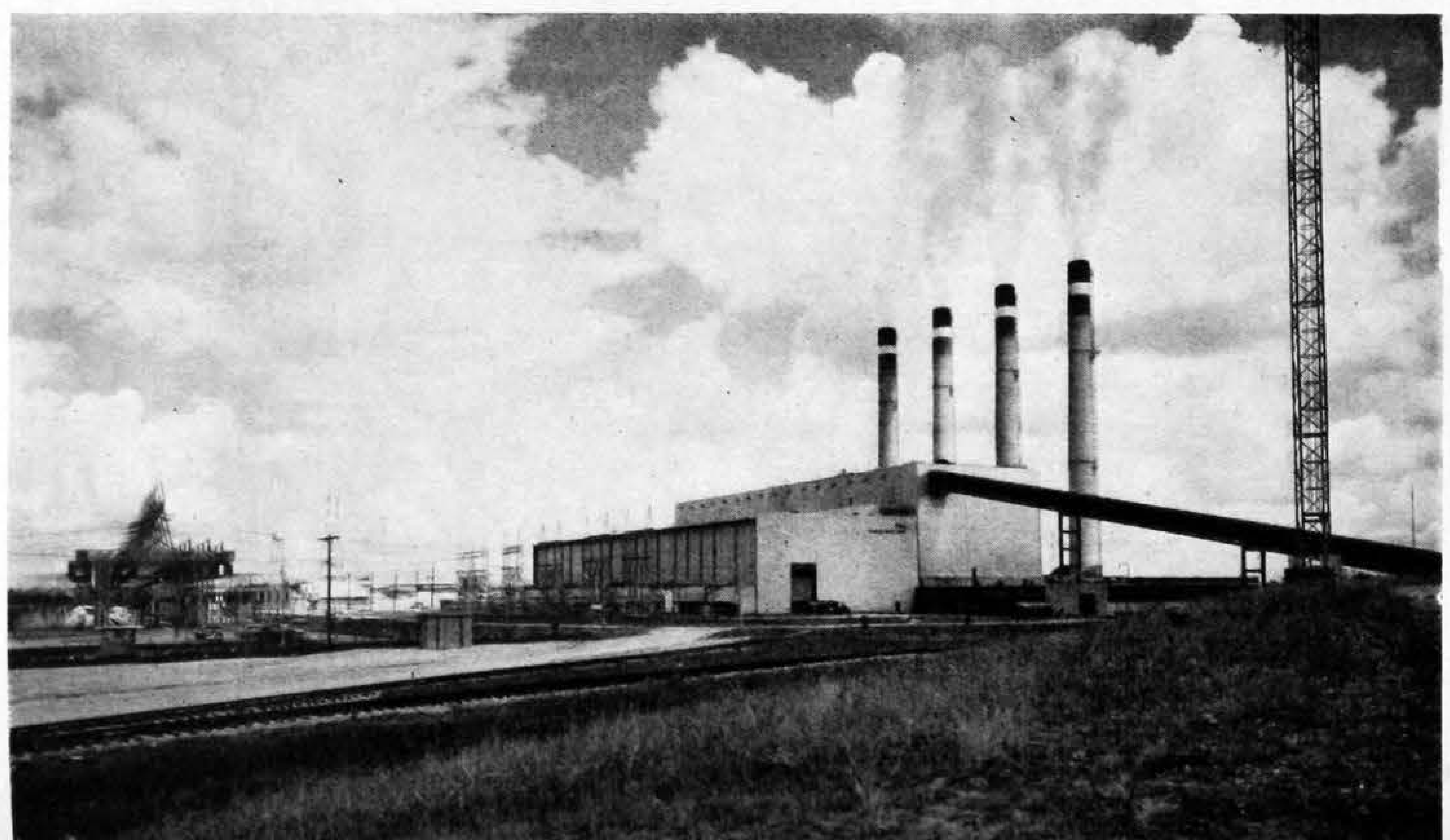


Fig. 4—Colbert steam power station in Alabama, with switch and transformer yard in foreground

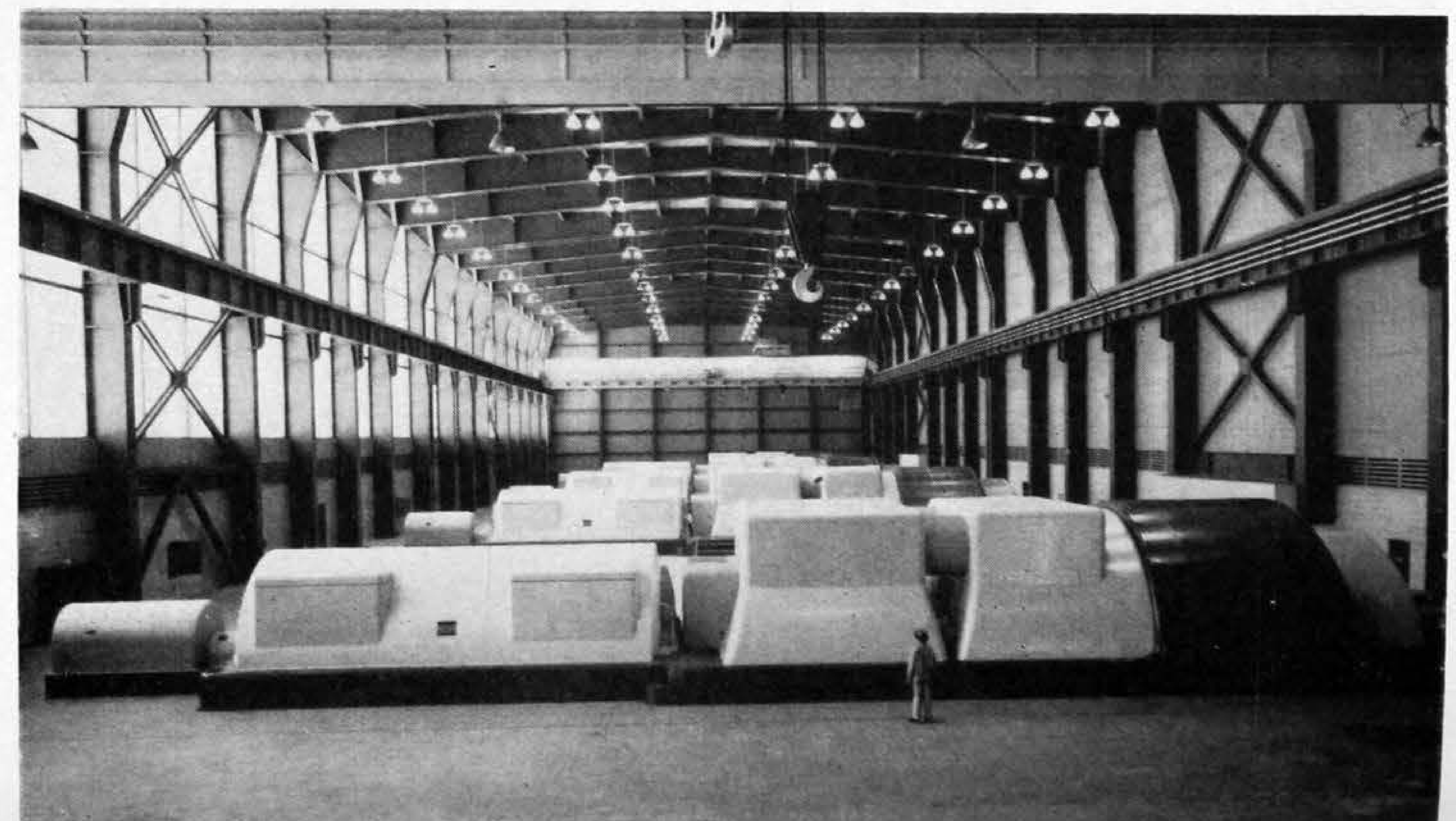
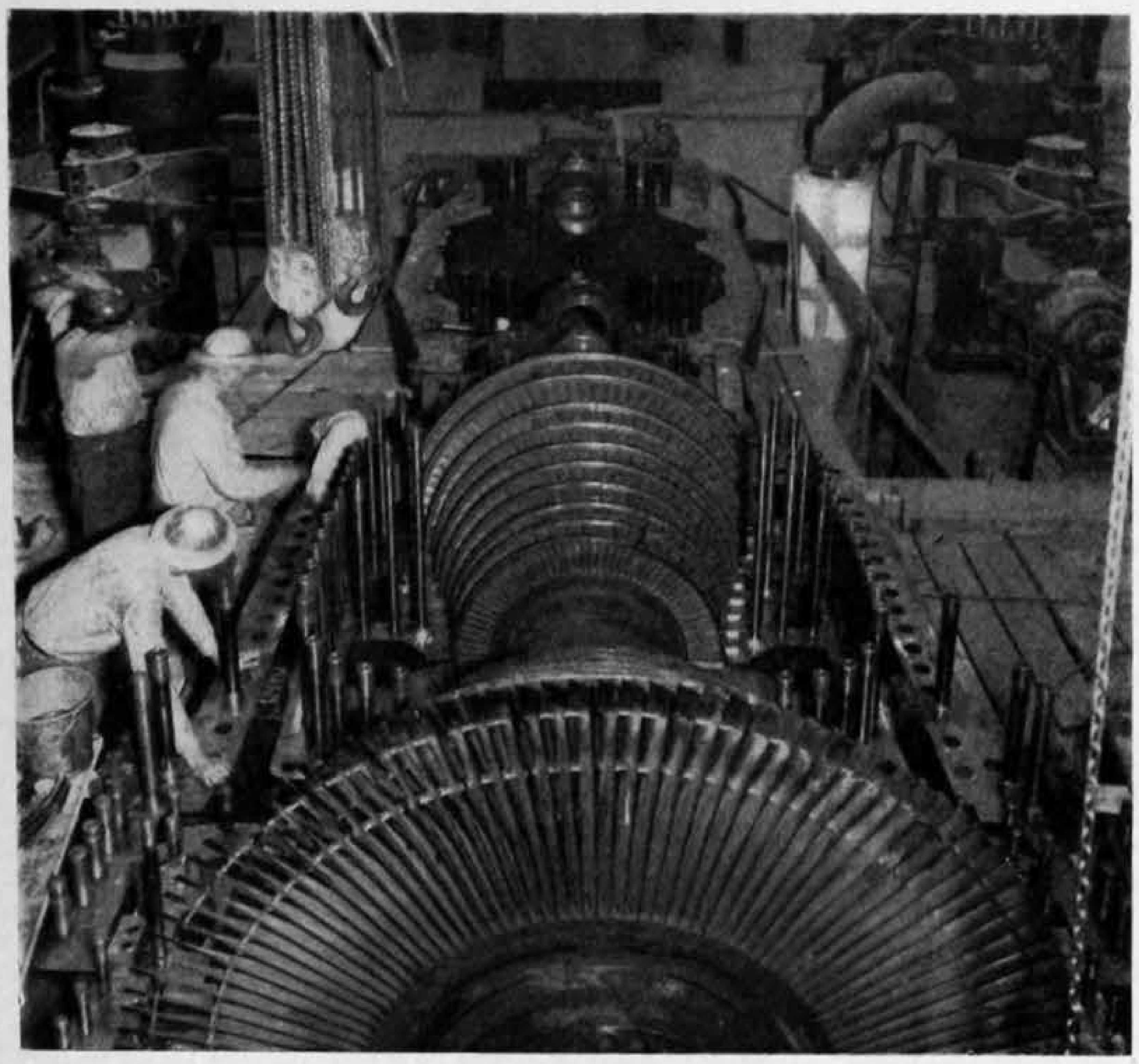
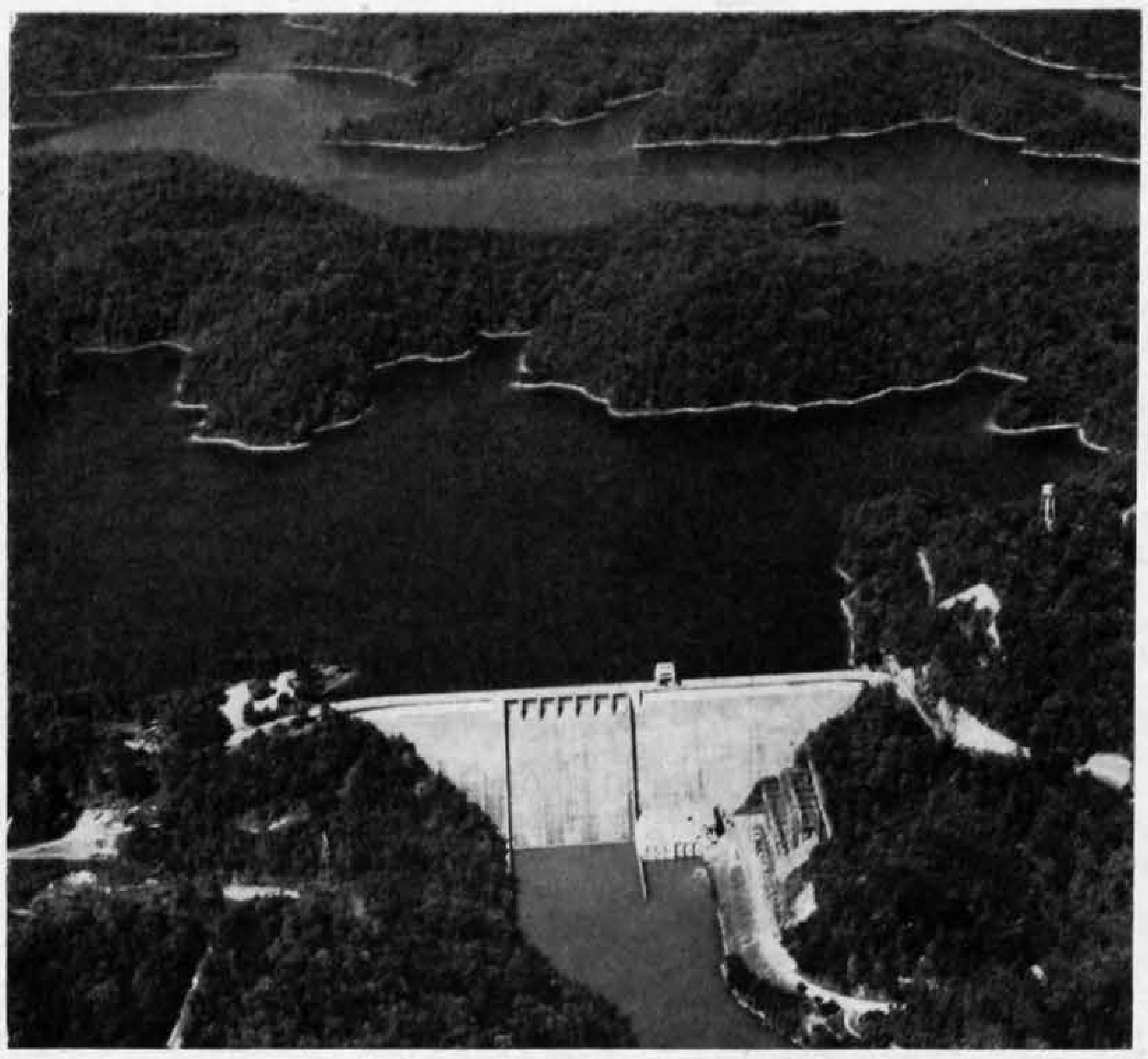


Fig. 5—Four turbo-generators at the Colbert steam power station with a total capacity of 700MW





Figs. 6 and 7—(Left) Erection of intermediate-pressure section of second 225MW turbine at the Gallatin steam power station in Tennessee. (Right) The Hiwassee dam and reservoir of the T.V.A., on the Hiwassee River in North Carolina with one 57·6MW turbo-generator and one 59·5MW pump-turbine

is 600MW. Operation during the year disclosed this station to be the most efficient one on the system, with a net plant heat rate of 9220 B.Th.U. per kilowatt-hour. In April, 1956, the Authority began the construction of a fourth 180MW unit at the John Sevier steam power station, constituting the first " new start " in nearly three years. Rock excavation for the power station was nearly completed and a start made on the placement of concrete by the end of the year.

Substantial progress was made toward the installation of the first two generator units at the Gallatin steam power station (Fig. 6), on the Cumberland River, Tennessee. As in the case of Shawnee, a prolonged strike at the works of the manufacturer caused considerable delay in the delivery of the two 225MW generators, and as a result initial operation of both units had to be rescheduled to begin in the fiscal year 1957. The coal-handling facilities were completed during the year, and stocking of coal began. Deliveries to the end of the fiscal year totalled about 245,000 tons, which is nearly the planned storage for the two-unit plant. Near the end of the year two additional units were authorised for the station, but construction had not been started.

Engineering activity in connection with the Johnsonville steam power station was almost entirely concerned with design studies for the installation of four additional units, all of which were authorised for construction toward the end of the 1956 fiscal year. The Johnsonville station was the first of the large modern steam-electric plants which the T.V.A. has constructed since 1949. It has, at present, six generating units of 1125MW capacity each. The new units will be larger, of 135MW capacity.

Construction activities at the Widows Creek were directed toward completion of additions, revisions, and design changes suggested by operating experience. The plant, like the present Johnsonville installation, has six 1125MW capacity units with 125MW capability. This makes the installed capacity 675MW and plant capability 750MW. All units operated at or above capacity during the year.

For the second consecutive year, the Authority had no dam under construction, but two generating units were added at existing dams. The most notable of these was the reversible pump turbine unit installed at the Hiwassee dam (Fig. 7), on the Hiwassee River, North Carolina. It was in commercial operation in May, 1956. When the Hiwassee dam was completed in 1940, it had an installation of one 57,600kW generating unit of conventional design, with space left for a second unit to be added. When time came for the new unit to be installed, the T.V.A. decided that the pump turbine unit would be feasible at this site from the standpoint of power economics. Similar units had been used in Europe ; in the United States such a unit had been installed in one of the western projects of the Bureau of Reclamation. The T.V.A. unit, however, is the largest that has been built to date.

When operated as a generator, the unit has a capacity of 59,500kW, making the total power installation at Hiwassee more than 117MW. It is operated as a conventional generator, with water passing through the hydraulic turbine turning the generator. In reverse operation, however, the generator operates as a motor of 102,000 h.p., turning the turbine which then acts as a pump. As a pump, the unit takes water from the reservoir of the Apalachia dam, which extends to the toe of the Hiwassee dam, and pumps it back up into the Hiwassee reservoir. In a test operation, the unit pumped 4000 cusecs against a head of 238ft, well above the design capacity of 3900 cusecs at 205ft. This operation helps to maintain the head of water for power generation at the site and provides additional water to run through the Hiwassee turbines.

The Hiwassee dam is the third highest dam in the T.V.A. system, rising 307ft above the lowest point in the foundation. It is exceeded in height only by the Fontana dam, which is 480ft high, and the Watauga dam, with a height of 318ft. The other hydro-electric unit placed in operation during the year is at the Nottely dam. It is a 15MW unit installed at a project built initially for storage on the Nottely River in North Georgia. In addition to supplying water to the Hiwassee and Apalachia hydro-electric plants downstream, the Nottely project now contributes electrical energy to the system.

Major transmission line construction was completed during the year to connect the John Sevier, Kingston, and Gallatin steam power station to the system and provide capacity for supplying the heavy defence loads, primarily those of the A.E.C. Two 161kV lines, one 59 miles long and the other 78 miles long, were built from John Sevier to Knoxville ; a 37-mile line was constructed from John Sevier to the Cherokee hydro-electric plant. Two 161kV lines, each about 7 miles long, were completed from Kingston to the A.E.C. plant at Oak Ridge. Also finished during the year were two 161kV lines, each about 35 miles long, from Gallatin to Murfreesboro and from Gallatin to a new 250MVA primary substation built at Radnor, near Nashville. Construction was also started on 161kV facilities to increase the power supply to the Huntsville, Alabama, and Rockwood, Tennessee, areas.

During the year the Authority replaced copper conductor with aluminium conductor on its Norris-Pineville, 154kV line, with a net profit of 91,000 dollars from the salvaged copper. The line was built as an emergency project during World War II to connect with the American Gas and Electric system. After the war, the conductor was larger than needed for the loads to be carried. Because of the high price of scrap copper it was decided to replace the copper conductor with aluminium. Aluminium conductor was also used to replace copper on the 154kV line running from Wilson dam to Decatur, Huntsville, and Guntersville, Alabama. The transmission lines in operation at the end of the year are summarised in the following table :—

By voltage classes				By States			
Kilovolts	Circuit miles			States	Circuit miles		
	1955	1956	Increase		1955	1956	Increase
154	4,996	5,296	300	Alabama...	1,341	1,342	1
110	177	177	0	Georgia	69	69	0
66	2,064	2,186	122	Kentucky	1,148	1,179	31
44	2,863	2,850	13*	Mississippi	1,155	1,155	0
33	—	—	—	North Carolina	85	85	0
12 and below...	124	125	1	Tennessee	6,413	6,791	378
				Virginia	13	13	0
Total...	10,224	10,634	410	Total	10,224	10,634	410

* Decrease.

The growth in generation and transmission capacity to meet increased loads required the expansion of communication services over the 10,600-mile transmission system linking the generating plants and connecting these plants with the major load areas. These services include telephone, telemetering, pilot relaying, facsimile, teletype and supervisory control facilities. They operate over power line carrier and telephone line carrier circuits, open wire lines, and microwave radio. More than 5000 miles of communication services were added to the telemetering and load control systems. Additions of microwave radio channels brought the total to 732 miles at the end of the year. Additional fixed wireless stations were added and several were moved to improve mobile coverage of the service area.

(To be continued)

Personal and Business

Appointments

HOLDEN AND BROOKE, Ltd., has announced that Miss N. Watson and Mr. H. R. Wilshaw have been appointed directors.

MR. J. I. BERNARD, M.I.E.E., has been appointed director and secretary of the British Electrical Development Association.

CLAYTON DEWANDRE COMPANY, Ltd., has announced the appointment of Mr. S. J. Barnes, general manager, as a director.

MR. R. YUDOLPH, sales manager of the building chemicals division of Evode, Ltd., has been appointed a sales director of the company.

SHEEPBRIDGE ENGINEERING, Ltd., states that Mr. E. A. Cooke, M.I.Mech.E., has been appointed scientific engineer to the Sheepbridge group.

THE COVENTRY GAUGE AND TOOL COMPANY, Ltd., states that Mr. E. Crabtree has been appointed technical sales representative for the Midlands area.

ROTO-FINISH, Ltd., has announced that Mr. J. C. Hendey, A.M.I.Prod.E., has been appointed methods and costing investigator in its sales department.

MR. K. J. TRUDGEN has been appointed representative of the control gear division of G.W.B. Furnaces, Ltd., for London and the Home Counties.

MR. H. A. ROBINSON has been appointed agent in the counties of Northumberland, Durham, Cumberland and Westmorland for Thos. Marshall and Son, Ltd.

THE MINISTRY OF SUPPLY states that with the agreement of the Secretary of State for Air, Air Vice-Marshal G. P. Chamberlain has been appointed deputy controller of electronics.

MR. H. H. LUSTY, A.M.I.E.E., manager of the publicity department of Metropolitan-Vickers Electrical Company, Ltd., has been elected a member of the BEAMA publicity committee.

MR. P. BRIGGS, A.M.I.Mech.E., has been appointed controller of the Yorkshire Division of the Central Electricity Authority, in succession to Mr. G. A. Vowles who is retiring at the end of March.

BLACK AND DECKER, Ltd., has announced that Mr. F. Andrew Field is leaving the company to take up an appointment as managing director of Eutectic Welding Alloys Company, Ltd., Feltham, Middlesex.

THE INSTITUTE OF TRANSPORT has announced that Sir Reginald Wilson, chairman of the Eastern Area Board of the British Transport Commission, and a member of the Transport Commission, has been elected president.

MR. R. D. A. CRAFTER has relinquished his duties as education officer of the Institute of the Motor Industry (Inc.) and has been appointed assistant education officer to Preston Borough Council. He has been succeeded at the Institute by Mr. Paul L. Allen.

MR. W. R. OWEN has been appointed manager for the north-east region of Honeywell-Brown, Ltd. He has been succeeded as manager of the Sheffield office by Mr. A. Hague. Mr. Halstead and Mr. Gabe have been appointed managers of the Middlesbrough and Cardiff offices.

DR. D. H. FOLLETT has been appointed keeper of the department of electrical engineering and communications at the Science Museum, South Kensington, in succession to Mr. F. St. A. Hartley, who has retired. Mr. J. A. Chaldecott has been appointed to the posts vacated by Dr. Follett.

THE NATIONAL COAL BOARD has announced the following appointments :—Mr. W. V. Sheppard has been appointed director-general of reconstruction at national headquarters in succession to Mr. H. E. Collins, who has been appointed a member of the National Board. Mr. J. M. Pumphrey has been appointed chairman of the northern (N. and C.) division in succession to Mr. H. W. Hembrey, who has been appointed a member of the National Board. Mr. J. Brass will succeed Mr. Pumphrey as production director of the division on April 15.

VICKERS, Ltd., has announced the following appointments, effective from April 1 :—Mr. A. P. Wickens, M.I.Mech.E., has been appointed managing director of Vickers-Armstrongs (Tractors), Ltd., and ceases to be a director of Vickers-Armstrongs (Engineers), Ltd., and general manager of the Elswick, Scotswood and Wakefield works of that company. Mr. J. R. Kelly has been appointed general manager of the Elswick, Scotswood (excepting the tractor business) and Wakefield works of Vickers-Armstrongs (Engineers), Ltd. Mr. J. G. Lloyd has been appointed a director of Vickers-Armstrongs (Engineers), Ltd., and general manager of the Crayford, Dartford and Thames ammunition works of that company. Lieut.-Commander R. B. Lakin has been appointed managing director of George Mann and Co., Ltd.

Business Announcements

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the alterations and extensions to its Edinburgh branch office have now been completed.

VICKERS-ARMSTRONGS (SHIPBUILDERS), Ltd., states that Mr. Austin Kelly, naval architect, has retired from the service of the company on reaching normal retiring age.

THE ELGAR MACHINE TOOL COMPANY, Ltd., states that it has opened a Midlands office at 19, The Parade, Leamington Spa, Warwickshire (telephone, Leamington Spa 2645/6).

BAILEY METERS AND CONTROLS, Ltd., states that it has taken up accommodation in its new plant at Purley Way, Croydon, Surrey (telephone, Croydon 4191), and that all correspondence should in future be addressed to Purley Way.

MR. J. L. ALLAN, representative in Scotland of Richard Sutcliffe, Ltd., for nineteen years, has retired, but remains with the company in a consultative capacity. Mr. A. Burrell has been appointed district technical manager for Scotland.

W. H. DORMAN AND CO., Ltd., Stafford, states that its executive directors, Mr. Darby Haddon, Mr. J. W. Whimpenny and Mr. G. S. Tucker, will shortly undertake a prolonged tour of Canada in order to consolidate the firm's interests there.

CHAMBERLAIN INDUSTRIES, Ltd., states that it has appointed Electricals, Ltd., 14, Claremont Place, Newcastle upon Tyne, 2, as sole agents for the sale of the small hand and motorised bending machines up to 4in capacity, in Westmorland, Durham, Northumberland, Cumberland and Tees-side.

JENOLITE, Ltd., has announced the formation of a new company, Jenolite Industries (Northern), Ltd., for the distribution and servicing of its products and processes in the industrial centres of the North of England. The address of the new company is Clare Hill Works, St. John's Road, Huddersfield, Yorks (telephone, Huddersfield 7975).

Contracts

WESTLAND AIRCRAFT, Ltd., has received an order for a fourth " Whirlwind " helicopter from Fison-Airwork, Ltd. It will join one machine on order and two already delivered in Nigeria, working under charter to the Shell-B.P. Petroleum Exploration Company.

DORMAN LONG (BRIDGE AND ENGINEERING), Ltd., has received the contract from the Crown Agents for Oversea Governments and Administrations, on behalf of the Government of the Federation of Malaya, for the building of the new Klang Bridge near Port Swettenham, Malaya. The value of the contract is £835,000. The structure will be a double-deck steel bridge, with steel and concrete approaches. The bridge will carry a 22ft roadway and two 3ft footways on an upper deck, the approaches to which discharge the traffic well back from the river banks. A 10ft cycle track and two 5ft footways will be carried on the lower deck, with connections direct to the river banks. The river crossing will consist of two steel side spans each of 161ft and a central span of 282ft. The river piers will be founded on caissons sunk under compressed air and the abutments on the river banks and the approach trestles will be founded on piles. The approaches and road construction will be sublet to Gammon (Malaya), Ltd. The consulting engineers are Messrs. Coode and Partners.

Miscellanea

CORRECTION.—In our issue of February 15, page 273, we described the Forster Perspektiv-Automat. This instrument is made by F. Forster, 218, Randenstrasse, Schaffhausen, Switzerland, and not by F. Kuhlmann, as stated by us in the article.

PATENT NO. 757,858 : FLUID PRESSURE SEALING MEANS FOR PISTONS.—Under this heading in our issue of March 8 we printed an abstract for a British Patent Specification. Short Brothers and Harland, Ltd., has drawn our attention to the fact that owing to a Patent Office misprint the number of the Patent is incorrectly quoted. The true number is 767,858.

RUST PROTECTION OF STEEL CHIMNEYS.—A liquid metallic coating for rust-proofing steel surfaces subjected to high temperatures, such as steel chimneys, is now being made by Southern Metalife, Ltd., James Street, Harrogate, Yorks. It is stated that " Metalife ATR," as the liquid metal is known, withstands all temperatures up to 550 deg. Fah. It is applied cold by a paint brush or spray gun and dries to leave an anodic metal skin on the steel surface, which gives cathodic protection to the chimney.

RIDER CONTROLLED ELECTRIC FORK TRUCK.—A new addition to the range of electric fork trucks made by Lansing-Bagnall, Ltd., Basingstoke, is a rider controlled machine, with a standard capacity of 2300 lb at 20in centres on 36in long forks. The machine has a turning radius of just over 49in, and can be driven at speeds of up to 5 m.p.h. It is designed to lift up to a maximum of 10ft and the mast can be tilted 10 deg. backwards and 2 deg. forwards, power for the lifting and tilting motions being provided by a motor-driven hydraulic pump.

WATER-REPELLING TREATMENT FOR MASONRY.—A treatment which is claimed to make brickwork and masonry water-repellent has been developed by Evode, Ltd. A colourless solution based on a silicone resin, " Evosil," penetrates into masonry, we are informed, to form a barrier against water. In soft brick, the depth of penetration is about $\frac{3}{16}$in. Porosity of the building material is not affected, it is stated, and one treatment will last for many years, giving complete protection against driving rain, and reducing the effect of efflorescence.

THIN-WALLED BEARINGS FOR HEAVY ENGINEERING APPLICATIONS.—The range of thin-walled bearings made by the Glacier Metal Company, Ltd., Alperton, Middx, has been extended to give standard sizes up to 12in bore. The new bearings are made in two standard wall thicknesses—those from 6in to $8\frac{7}{8}$in diameter being 0·142in thick, and those from 9in to 12in diameter being 0·172in thick. Individual bearings are available in widths up to $6\frac{3}{4}$in but wider bearings can be provided by using two standard bearings side-by-side with a gap between to form an oil groove. The bearings are supplied with a wall thickness accuracy which enables them to be fitted without need for machining or scraping.

EXPERIMENTS TO REDUCE EVAPORATION LOSS FROM RESERVOIRS.—Experiments are being carried out in Northern Nigeria with hexadecanol, a material for preventing evaporation of water in open reservoirs. Hexadecanol is an extract of whale oil first discovered in Australia, and has been successfully used there and in Rhodesia for this purpose. It is believed that loss of water by evaporation in Northern Nigeria is about 6ft per year. Specially designed rafts are being made for use in the experiments which will be carried out, in the first instance, at the Bosso Dam. The work is being done by the Public Works Department and the Geological Survey Department, and a Government chemist.

HEAVY-DUTY PORTABLE COMPRESSOR.—A portable air compressor designed to supply four tools now made by Bristol Pneumatic Tools, Ltd., Fishponds, Bristol, has a free air delivery of 230 cubic feet per minute at a working pressure of 100 lb per square inch. Its double-acting, two-stage, compressor is driven through a heavy-duty, single-plate clutch by a Dorman engine developing 60 b.h.p. at 1400 r.p.m. A large capacity intercooler with removable sections to facilitate cleaning and maintenance incorporates an automatic drum valve which is controlled by the pilot unloader of the machine. The output of the compressor is automatically controlled, and total unloading is effected by the pilot unloader which maintains the supply of air between the maximum and minimum pressures and has a 15 lb per square inch differential. This pilot unloader also operates the engine speed control, and a " time lag control " re-sets full engine speed before the compressor comes on load.

DEATH OF MR. R. H. WHITELEGG.—It is with regret that we have to record the death of Mr. Robert H. Whitelegg at the age of eighty-four, on March 9. Mr. Whitelegg received his initial training in the works of the London, Tilbury and Southend Railway and later worked for the Metropolitan Railway Carriage and Wagon Company, Ltd., and Nasmyth Wilson and Co., Ltd. He returned to the London, Tilbury and Southend Railway in 1900 and succeeded his father as chief of the locomotive department ten years later. He left this railway, after its amalgamation with the Midland Railway in 1913, and held various posts in industry until 1918 when he became chief mechanical engineer to the Glasgow and South Western Railway. In 1923 he resigned from the office of mechanical engineer, Kilmarnock, of the former L.M.S.R. after the grouping of the railways, and joined Beyer Peacock and Co., Ltd., as general manager and engineer-in-chief, a post he held for seven years. Mr. Whitelegg later became a partner in the firm of Whitelegg and Rogers from which he retired in 1941. Mr. Whitelegg will probably be best remembered by railway students for the tank locomotives he introduced on the L.T. and S. Railway in his office as chief of the locomotive department. One of these 4-4-2 locomotives the " Thundersley " was described in our issue of March 17, 1911.

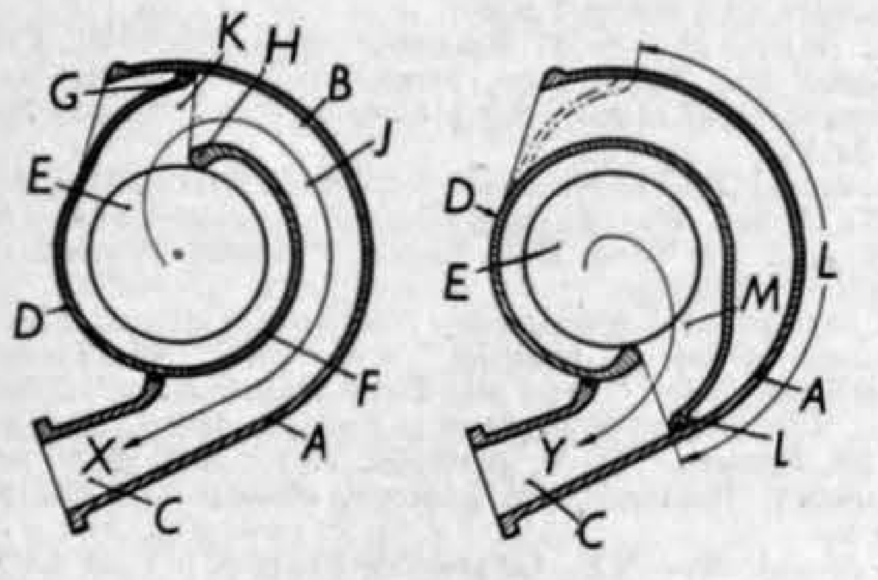
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

769,041. May 6, 1955.—INDUCTION PIPES, the Daimler-Benz Aktiengesellschaft, of Stuttgart-Unterturkheim, Germany.

The invention aims at providing a simple device for altering the effective length of an engine induction pipe. In the drawing, *A* is an outer part or housing with an inner cylindrical surface *B*. The outer part *A* is formed with a tubular branch *C* which is adapted for being connected to an engine cylinder or to a manifold which can serve a number of engine cylinders. An inner cylindrical part *D* within the part *A* is rotatable and receives the air or gaseous mixture axially at *E*. A cylindrical wall portion *F* which is substantially concentric to the axis constitutes the main portion of the inner part *D*. The cylinder is divided at one point in its periphery and at one side of the division a wall portion *G* is bent outwards approximately



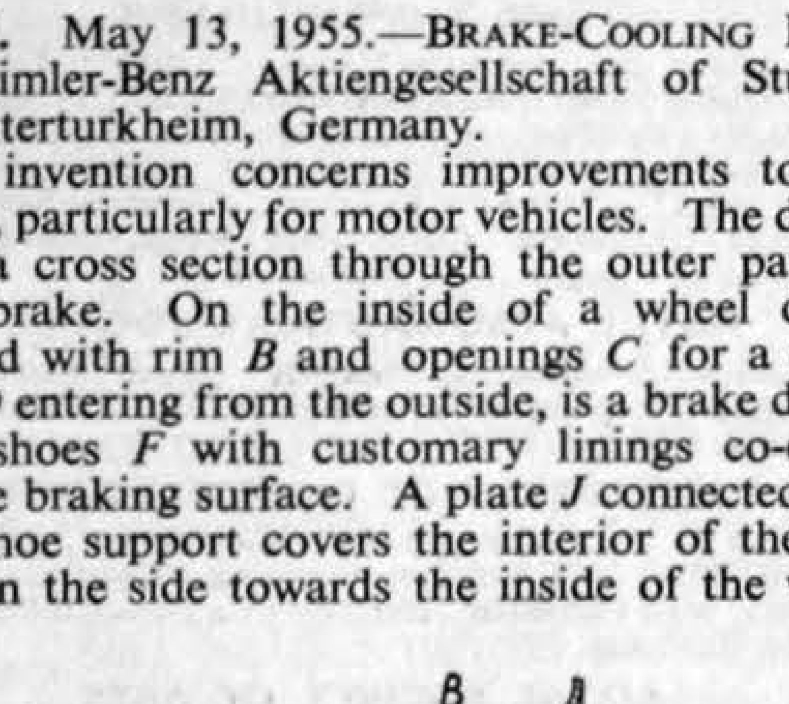
No. 769,041

tangentially, in order to bear against the inner surface *B*. At its outer edge, the wall portion *G* is fitted with a gas-tight seal which rubs against the cylindrical surface *B* so that gas-tight communication is afforded between the parts *D* and *A*. When the induction pipe is adjusted to maximum effective length, as illustrated in the left-hand view, the wall portion *G* of the rotatable inner part *D* co-operates approximately with the outer end *K* of the part-cylindrical housing wall. The air or gaseous mixture entering the pipe *E* axially passes over a relatively long path, in the direction of the arrow X into the branch leading to the engine. When the inner part *D* is turned in the clockwise direction, the wall *G* takes up an opposite end position, as shown in the right-hand view, namely the position *L*, and the communication passage *K* comes into the position *M*, so as directly to connect the interior of the part *D* with the branch *C* of the admission. Thus, the air or gaseous mixture can pass directly into the branch. The length of the air or gas path can in this way be shortened by the length of the passage *J*. While the left-hand view shows the position of adjustment for low engine speeds, the position shown in the right is intended for high engine speeds.—*February* 27, 1957.

ROAD TRANSPORT

769,170. May 13, 1955.—BRAKE-COOLING MEANS, Daimler-Benz Aktiengesellschaft of Stuttgart-Unterturkheim, Germany.

The invention concerns improvements to brake cooling, particularly for motor vehicles. The drawing shows a cross section through the outer part of a wheel brake. On the inside of a wheel disc *A*, provided with rim *B* and openings *C* for a current of air *D* entering from the outside, is a brake drum *E*. Brake shoes *F* with customary linings co-operate with the braking surface. A plate *J* connected to the brake-shoe support covers the interior of the brake drum on the side towards the inside of the vehicle.



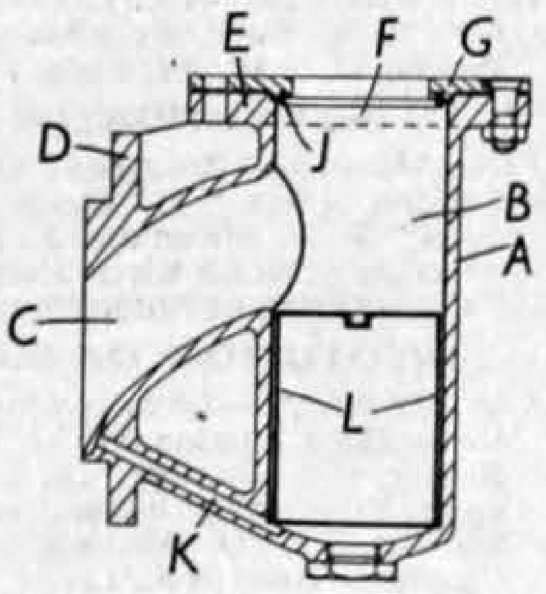
No. 769,170

The brake drum carries external fins *K* between which are formed air-conducting passages *L* closed on the outside by a cover sheet *M*. The fins may be arranged so that these passages extend parallel to the axis of the brake drum or may be helically or otherwise disposed. Air from the outside of the vehicle flows away on the opposite side at *N*. In addition to this external air flow an internal air flow is provided which enters the interior of the drum through pennings *P* and flows axially to the opposite side through the gap *R* between the brake shoes and the inner, braking, surface of the drum and between the individual shoes in the region of their mountings and the brake-operating cylinder. Thence it is delivered to the outside by radial blades *S*, on the air-outlet side of the brake drum which may be similar to turbine blades. By the relative constriction of the air passages and the design of the blades, the inner and outer cooling effects should be co-ordinated.—*February* 27, 1957.

MARINE ENGINEERING

769,155. May 11, 1955.—A SHIP'S OUTBOARD-EXHAUST VALVE, N. V. Bronswerk, Grasweg 30, Amsterdam, The Netherlands.

The invention relates to a valve construction which can be applied on ships, as an outboard-exhaust valve, if desired, and also used as a non-return valve and as a tonnage-valve. As the drawing shows the valve housing *A* is provided with a cylindrical chamber *B* and with a laterally connected outboard-outlet conduit *C*, which is preferably bent down and surrounded by a flange *D*, which is directly fixed onto the plating or skin of the ship. The top flange *E* of the valve housing surrounding the inlet conduit *F* is connected to an intermediate flange *G* by countersunk bolts, the lower side of the intermediate flange being provided with an annular rubber seat *J*. A conduit *K* of small cross-section connects the outlet *C* with the lower part of the cylindrical chamber *B*. During the movement of the valve, the throttling action in this narrow conduit will damp the movement of the valve on the seat *J*. In the bottom of the chamber *B* a draining and inspection opening is provided, which can be closed by a screw-plug. A closed



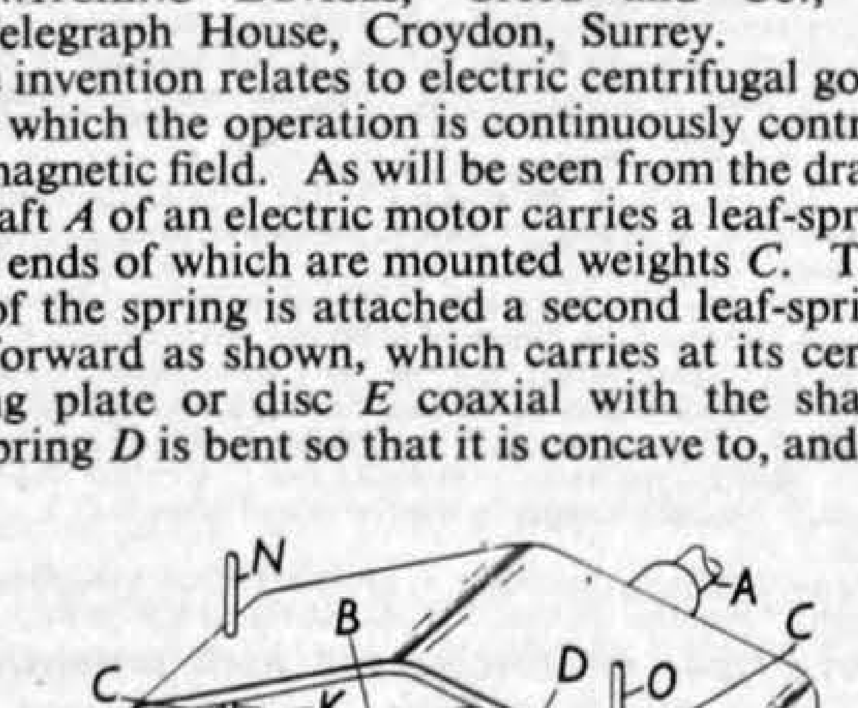
No. 769,155

cylindrical valve *L* is slidable in the cylindrical chamber *B*, and has a buoyancy such that it will rise when the outer or sea water enters the chamber *B*, so that it will first close the lateral outlet *C* and then will seal with its head against the seat *J*. Preferably the cylindrical valve *L* is filled with foam rubber or the like, so that it cannot sink when damaged. By the application of a mechanism comprising a locking rod, passing through the inspection opening in the bottom of the cylindrical chamber and pressing the valve *L* against the seat *J*, the valve can be used as a tonnage-valve. Other variations are possible within the scope of the invention.—*February* 27, 1957.

ELECTRICAL ENGINEERING

768,986. May 6, 1955.—SPEED-RESPONSIVE ELECTRIC SWITCHING DEVICES, Creed and Co., Ltd., Telegraph House, Croydon, Surrey.

The invention relates to electric centrifugal governors in which the operation is continuously controlled by a magnetic field. As will be seen from the drawing the shaft *A* of an electric motor carries a leaf-spring *B* at the ends of which are mounted weights *C*. To the ends of the spring is attached a second leaf-spring *D* bent forward as shown, which carries at its centre a bearing plate or disc *E* coaxial with the shaft *A*. The spring *D* is bent so that it is concave to, and clear



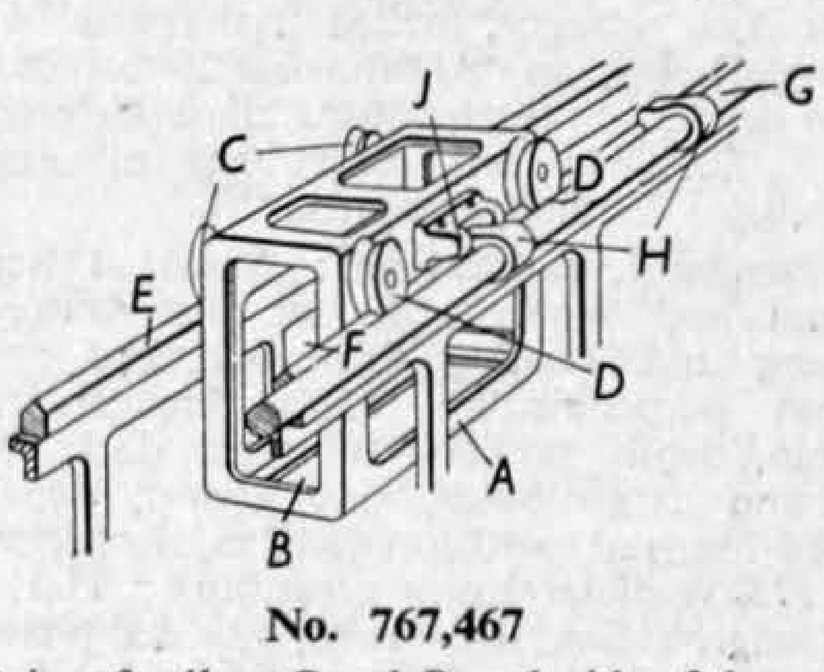
No. 768,986

of, the end of the shaft. When the shaft rotates, the weights *C* tend to swing outwards so as to straighten the spring *B*, and this causes the disc *E* to be thrust forwards into contact with a central pin *F* mounted on a leaf-spring *G* of magnetic material fixed at one end to a block *H*. The contact set comprises a fixed contact *J* mounted on a block *K*, and a movable contact *L* carried by the spring *G*. The pin *F* is adjustable axially by means of a screw *M*. The fixed contact *J* and the spring *G* are respectively connected to the conductors *N* and *O* which may be connected to the terminals of a resistor in series with the field winding of the motor according to known practice. An electromagnet *P* is mounted with its poles facing the spring *G*. In this case, the electromagnet *P* attracts the spring *G* and effectively reduces the force holding the contacts *J* and *L* together. When the shaft starts to rotate, the weights swing outwards and the plate *E* comes into contact with the pin *F*, and the spring *G* is then pushed forward until the contacts open. Thus the above-mentioned resistor, which is initially short-circuited by the closed contacts *J* and *L*, is inserted in the circuit when they open, thereby reducing the speed of the motor. It will be seen that the magnetic field produced by the electromagnet *P* assists the centrifugal force, and by adjusting the current in the electromagnet the speed at which the contacts *J* and *L* open can be precisely adjusted while the motor is running.—*February* 27, 1957.

MACHINE TOOLS

767,467. February 23, 1955.—CONVEYORS FOR FEEDING WORKPIECES TO MACHINE TOOLS, Adam Opel Aktiengesellschaft, a German Company of Russelsheim-am-Main, Germany.

The drawing shows a perspective view of a conveyor according to the invention. A carriage *A* of rectangular box shape has apertures on all faces to allow the tools to pass through. In the main, the chips drop through the bottom opening *B* and are led off by a conveyor belt or a shaker channel in the usual



No. 767,467

way. Pairs of rollers *C* and *D* each side of the carriage run on the guide rails *E* and *F*. The rollers are substantially on a level with the top of the side apertures in the carriage so that the tools may be entered below the level of the rails. The carriage is automatically advanced from one machining position to the next by a shaft *G*. The shaft *G* first of all carries out a rotary movement so that one of a number of regularly spaced cam projections *H* engages between lugs of a catch *J*, thus coupling the shaft and the carriage with each other. The shaft then moves longitudinally and advances the carriage to the next machining position. After the advancing movement, the shaft *G* is turned back again to disengage the cam *H* before being moved back to its initial position.—*February* 6, 1957.

MINING ENGINEERING

769,020. June 8, 1954.—APPARATUS FOR THE DRESSING OR CONCENTRATION OF COAL, Westfalia Dinnendahl Gröppel Aktiengesellschaft, Bochum, Germany.

The invention relates to a means for the dressing or concentration of coal, ore or other minerals by means of a heavy liquid in a revolving drum. As shown in the drawing the drum *A* is supported on rollers *B*, and is set in slow rotation by a drive *C*.

No. 769,020

The drum is conically tapered towards the outlet end for the floating material. It has lifting blades or scoops *D* at one end for the sunk material and lifting blades or scoops *E* at the other end for the floating material. The material to be dressed is delivered to the drum by way of a chute *F*. In the region of the lifting blades *D*, are cover plates *G* on both sides of the delivery chute *F*. The material to be dressed, separates in the bath into a floating material and a sinking material. The sinking material is deposited upon the bottom and is there engaged by the lifting blades *D* and thrown into a discharge chute *H*. The floating material passes to the other end of the drum, and is here lifted out by means of the blades *E* and carried away by a chute *J*. By means of the cover plate *G* the material fed in is guided foward into the drum and the floating material is prevented from spreading out on each side as soon as it is fed in and thus being picked up by the blades *D*.—*February* 27, 1957.

Launches and Trial Trips

DONEGAL, cargo liner; built by Alexander Stephen and Sons, Ltd., for the Avenue Shipping Company, Ltd.; length 432ft, breadth 58ft 9in, depth 39ft 6in, deep load draught 27ft 1¼in, deadweight 9900 tons; five cargo holds, derricks to lift 5 tons and 10 tons and one 30-ton derrick, electric winches; three 200kW diesel-driven generators; Stephen-Doxford oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m.—Launch, December 19.

NORTH EMPRESS, cargo liner; built by the Blythswood Shipbuilding Company, Ltd., for Palamedes Compania Naviera S.A. of Panama; length 485ft, breadth 67ft 6in, depth to upper deck 41ft 10in, draught 27ft 6in, deadweight 12,350 tons on open shelter deck draught, loaded trial speed 16 knots; six cargo holds, one 50-ton, one 25-ton and twelve 10-ton derricks; three 300kW diesel-driven generators; Scott-Doxford diaphragm oil engine of 7200 b.h.p.—Launch, December 20.

CLOVERBANK, cargo liner; built at Belfast by Harland and Wolff, Ltd., for the Andrew Weir Shipping and Trading Company, Ltd.; length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded to upper deck 38ft 6in; five main cargo holds, one 25-ton, two 10-ton, twelve 5-ton, and two 3-ton derricks, electric winches; three 175kW diesel-driven generators; Harland and Wolff single-acting, two-stroke, opposed piston diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke.—Launch, December 21.

VOLVATELLA, oil tanker; built by Hawthorn, Leslie (Shipbuilders), Ltd., for Shell Tankers, Ltd.; length overall 660ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, deadweight 31,000 tons; thirty cargo oil compartments, one main cargo pump room, four cargo pumps, two 550kW, 450V, 60 c/s, geared turbine-driven alternators, one 150kW diesel-driven alternator; one set of Hawthorn, Leslie geared turbines of 14,500 maximum s.h.p., taking steam at 600 lb per square inch and 850 deg. Fah. from two Babcock and Wilcox integral furnace water-tube boilers.—Trial, December 20 and 21.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX

Fri., March 29.—Royal Society of Arts, 8, John Adam Street, Adelphi, London, W.C.2, "The Reorganisation of a Special Library," H. C. Richardson, 6 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Sat., March 23.—N. LONDON BRANCH: Visit to Ponders End Gas Works, 10 a.m.

Wed., March 27.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "Safety in Electrical Installation," S. J. Emerson, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., March 27.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Disc Recording," G. F. Dutton, 6.30 p.m.

CEMENT AND CONCRETE ASSOCIATION

Tues., March 26.—Technical College, Mold Road, Wrexham, "An Introduction to Prestressed Concrete," R. C. Blyth, 7 p.m.

CHADWICK PUBLIC LECTURES

Thurs., March 28.—Royal Society of Health, 90, Buckingham Palace Road, London, S.W.1, "Problems of Hygiene in Civil Aviation," Sir Harold Whittingham, 5.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Thurs., March 28.—N. SECTION: Hotel Metropole, King Street, Leeds, "The Application of Back Pressure and Pass-Out Generation," J. R. Wilkins, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, March 22.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Street Lighting from a City Engineer's Point of View," Granville Berry, 6 p.m.

Mon., March 25.—LEEDS CENTRE: E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, Annual General Meeting, 6.15 p.m.

Tues., March 26.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, Extraordinary General Meeting to Consider Special Resolutions Concerning the Constitution and Title of the Society, 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, March 22.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, Annual General Meeting, 7.30 p.m.

Mon., March 25.—W. AND E. YORKSHIRE BRANCH: The University, Leeds, Annual General Meeting, 7.30 p.m.

Wed., March 27.—LEICESTER BRANCH: Bell Hotel, Leicester, Annual General Meeting, 7 p.m.

Thurs., March 28.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, Annual General Meeting, 7.30 p.m.

Fri., March 29.—MOBILE PLANT GROUP: Imperial Hotel, Temple Street, Birmingham, Discussion on "Torque Convertors," 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., March 27.—LONDON BRANCH: Constitutional Club, Northumberland Avenue, London, W.C.2, "Latest Practices in Shell Moulding and Coremaking," D. H. Scott, 7.30 p.m.

INSTITUTE OF FUEL

Wed., March 27.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "A Survey of Dust Deposition in the Neighbourhood of a Power Station," G. England, C. J. Crawshaw and H. J. Fortune; "Certain Aspects of the Deposition of Dust," D. G. Lucas; "Instruments for Measuring Small Quantities of Sulphur Dioxide in the Atmosphere," W. G. Cummings and M. W. Redfearn, and "Routine Surveys of Atmospheric Pollution by Dust and Sulphur Dioxide Around Power Stations of the Central Electricity Authority," W. D. Jarvis and L. G. Austin, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., March 26.—85, Minories, London, E.C.3, "Developments in Marine Electrical Installations with particular reference to A.C. Supply," A. N. Savage, 5.30 p.m.

Thurs., March 28.—LLOYD'S REGISTER JUNIOR LECTURE: 85, Minories, London, E.C.3, "An Introduction to Nuclear Power," P. T. Fletcher, 5.30 p.m.

Fri., March 29.—MERSEYSIDE AND N.W. SECTION: College of Technology, Byrom Street, Liverpool, "The Control of Steam Temperature in Marine Watertube Boilers," E. G. Hutchings, 7 p.m.

INSTITUTE OF METALS

Tues., March 26.—S. WALES LOCAL SECTION: Department of Metallurgy, University College, Singleton Park, Swansea, Annual General Meeting, 6.45 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., March 26.—N.E. CENTRE: Three Tuns Hotel, Durham City, "The Work of the Motor Industry Research Association Proving Ground," A. Fogg, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 26.—ROAD (B): Great George Street, Westminster, London, S.W.1, "The Design of Neath and Briton Ferry Viaducts," R. P. Mears and E. E. Pool; also Films on "Construction of Neath River Bridge and Approach Viaducts," and "Construction of Briton Ferry Viaduct," 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., March 25.—LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, Presidential Address, Sir Gordon Radley, 6.30 p.m. ★ N.E. CENTRE: Neville Hall, Newcastle upon Tyne, "Earth Electrode Systems for Large Electric Stations," J. D. Humphries, 6.15 p.m. ★ N. MIDLAND CENTRE: Town Hall, Leeds, "Nuclear Energy in the Service of Man," T. E. Allibone, 6.30 p.m. ★ S. MIDLAND RADIO AND TELECOMMUNICATION GROUP: James Watt Memorial Institute, Great Charles Street, Birmingham, "The B.B.C. Sound Broadcasting Service on Very-High Frequencies," E. W. Hayes and H. Page, 6 p.m. ★ W. UTILIZATION GROUP: S. Wales Institute of Engineers, Park Place, Cardiff, "2/1 Pole-Changing Machines," R. F. Burbidge, "Coal Winding Electrically," G. Davies, 6 p.m.

Tues., March 26.—JOINT MEASUREMENT AND CONTROL, AND RADIO AND TELECOMMUNICATION SECTIONS: Discussion on "The Performance of D.C. Amplifiers with special reference to the Use of Transistors," opened by K. Kandiah and G. B. B. Chaplin, 5.30 p.m. ★ N.W. MEASUREMENT AND CONTROL GROUP: Engineers' Club, 17, Albert Square, Manchester, Discussion on "Breakdown on Dielectrics," opened by C. G. Garton and J. H. Mason, 6.15 p.m. ★ S. MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, Discussion on "The Teaching of Filter Theory," opened by R. O. Rowlands, 6.30 p.m.

Wed., March 27.—SUPPLY SECTION: Savoy Place, London, W.C.2, "Earth Electrode Systems for Large Electric Stations," J. D. Humphries, 5.30 p.m. ★ N. LANCASHIRE SUB-CENTRE: N.W. Electricity Board, Duke Street, Barrow-in-Furness, Discussion on "Progress in Switchgear," opened by C. H. Flurscheim, 7.15 p.m. ★ S.W. SCOTLAND SUB CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The B.B.C. Sound Broadcasting Service on Very-High Frequencies," E. W. Hayes and H. Page, 7 p.m. S. CENTRE: R.A.E. Technical College, Farnborough, "Frequency-Modulation Radar for Use in the Mercantile Marine," D. N. Keep, 7.30 p.m. ★ The University, Southampton, "Flat Pressure Cable," J. S. Mollerhoj, A. M. Morgan and C. T. W. Sutton, 7 p.m.

Thurs., March 28.—E. MIDLAND CENTRE: Masonic Hall, Pinchbeck Street, Spalding, "The 275kV Line from Staythorpe to Sheffield," J. D. Pierce, 7.15 p.m. ★ E. ANGLIAN SUB-CENTRE: Assembly House, Norwich, "Highland Water Power: The Developments of the North of Scotland Hydro-Electric Board," C. L. C. Allan, 7.30 p.m. ★ N. LANCASHIRE SUB-CENTRE: N.W. Electricity Board, Finckle Street, Kendal, Discussion on "Progress in Switchgear," opened by C. H. Flurscheim, 7.15 p.m. ★ S.E. SCOTLAND SUB-CENTRE: Central Hall, Edinburgh, "Nuclear Energy in the Service of Man," T. E. Allibone, 7 p.m.

Fri., March 29.—S. CENTRE: S. Dorset Technical College, Weymouth, "Nuclear Power," H. A. Roberts, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Tues., March 26.—39, Elmbank Crescent, Glasgow, "Civil Engineering Contributions to Shipbuilding," J. Paton and W. G. N. Geddes, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., March 26.—SCOTTISH BRANCH: 25, Charlotte Square, Edinburgh, "Testing of Heating and Air-Conditioning Plants" W. C. Ramsay, 7 p.m. ★ LONDON ASSOCIATE MEMBERS, GRADUATES AND STUDENTS BRANCH: Junior Institution of Engineers, Pepys House, 14, Rochester Row, London, S.W.1, "Air Filtration, Why and How," G. H. Vokes, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, March 22.—N.E. BRANCH: The University, Palace Green, Durham City, "Surveying, including the Use of Instruments and Drawing Office Materials," 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 22.—1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, 6 p.m.

Mon., March 25.—YORKSHIRE BRANCH: Visit to Hepworth and Grandage, Ltd., St. John's Works, Bradford, 2.30 p.m. ★ Technical College, Bradford, "The Use of Shot Peening to Reduce Weight," W. R. Berry, 7.15 p.m.

Tues., March 26.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "Some Important Problems Concerning the Small Utility Car," D. Giacosa, 6 p.m. ★ E. BRANCH: Dujon Restaurant, Bedford, "The Application of Electronic Instruments to Mechanical Engineering," R. B. Sims and P. Briggs, 7.30 p.m. ★ BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "A Review of Hydrokinetic Fluid Drives and Their Possibilities for the British Motor Industry," J. G. Giles, 6.30 p.m.

Wed., March 27.—INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Are We Satisfied with the Progress of the Diesel Engine for Future Development?" 6.45 p.m.

Thurs., March 28.—N.W. INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: Engineers' Club, Albert Square, Manchester, "Automatic Machinery for Large Batch Production," G. H. Asbridge, 6.45 p.m. ★ WESTERN A.D. CENTRE: Royal Hotel, Bristol, "A Review of Hydrokinetic Fluid Drives and Their Possibilities for the British Motor Industry," J. G. Giles, 6.45 p.m. ★ E. MIDLANDS GRADUATES' SECTION: College of Further Education, Avenue Road, Grantham, Opening Meeting, 7.15 p.m. ★ N.W. GRADUATES' SECTION: L.C.P.T., 24, Hatton Garden, Liverpool, Discussion on "Some Engineering Problems in Reactor Design," opened by S. A. Ghalib, 7 p.m.

Fri., March 29.—GENERAL MEETING IN CONJUNCTION WITH THE LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Rotary Shaft Seals: The Sealing Mechanism of Synthetic Rubber Seals Running at Atmospheric Pressure," E. T. Jagger, 6 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Tues., March 26.—10, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 10.15 a.m.

Tues. to Thurs., March 26 *to* 28.—10, Upper Belgrave Street, London, S.W.1, Spring Meeting.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, March 22.—N.E. GRADUATE: Roadway House, Oxford Street, Newcastle, "The Development of Earth Moving Tractors," C. Hunt, 7 p.m.

Mon., March 25.—N.W. REGION: Reynolds Hall, College of Science and Technology, Manchester, "Application of the Computer in Management Control," K. Tylden-Pattenson, 7.15 p.m.

Tues., March 26.—S. REGION: Education Block, Morris Motors, Ltd., Hollow Way, Cowley, Oxford, Annual General Meeting, 7.30 p.m. ★ Town Hall, Luton, "Human Aspects of Automation," 7.30 p.m.

Wed., March 27.—Shrewsbury Technical College, Shrewsbury, Annual General Meeting, 6.45 p.m. ★ Cadena Cafe, Worcester, Film, "Steel and Tube Manufacture," 7.30 p.m.

Thurs., March 28.—S. REGION: Polygon Hotel, Southampton, "CO_2 Process," D. V. Atterton, 7.15 p.m. ★ N. MIDLAND REGION: Ruston Club, Lincoln, Annual General Meeting, 7 p.m.

Sat., March 30.—N.E. GRADUATE SECTION: Visit to Vickers-Armstrongs, Ltd., Tractor Division, Scotwood, Newcastle, 10 a.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Thurs., March 28.—Caxton Hall, Westminster, London, S.W.1, "Atmospheric Pollution," R. L. Brown, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., March 25.—MANCHESTER SECTION: Grand Hotel, Manchester, "Some Chemical Characteristics of Modern Factice Types," C. F. Flint and C. B. Featherstone, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, March 22.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Structural Aspects of the 'Big Top' Site Development," R. Bolsover and E. J. Spillett, 6 p.m. ★ S.W. COUNTIES BRANCH: Duke of Cornwall Hotel, Plymouth, "Law and the Engineer," S. P. Whittington, 6 p.m.

Thurs., March 28.—11, Upper Belgrave Street, London, S.W.1, "Some Recent Highway Bridges in Ceylon," H. C. Husband and K. H. Best, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 22.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Gas Chromatography," H. W. D. Hughes, 7 p.m.

Fri., March 29.—INFORMAL MEETING, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Making Use of Russian and Czech Scientific and Technical Information," E. Gros, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., March 27.—24, Dale Street, Liverpool, "Further Developments of the Hydrofoil Boat," Christopher Hook, 6 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., March 29.—Engineers' Club, Albert Square, Manchester, "Nuclear Engineering," J. Diamond, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, March 22.—ANDREW LAING LECTURE: Literary and Philosophical Society, Newcastle upon Tyne, "Structural Steels for Warship Building, with Some Notes on Brittle Fractures," Sir Victor Shepheard, 6.15 p.m.

Wed., March 27.—TEES-SIDE BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The 'Stork' Engine," A. Hootsen, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., March 26.—READING BRANCH: Great Western Hotel, Reading, "Prospects and Problems in Air Transport," P. G. Masefield, 6.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Sat., March 30.—Houldsworth Hall, Manchester, "The Application of Town and Country Planning to the Coal Mining Industry, with particular reference to a New Colliery," R. C. Wright, 10.30 a.m.

ROYAL SOCIETY OF ARTS

Wed., March 27.—John Adam Street, Adelphi, London, W.C.2, "London Airport," Sir Alfred LeMaitre, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., March 28.—LEICESTER GROUP: Leicester College of Technology, The Newarke, Leicester, "A Review of Some New Techniques," C. H. Leigh-Dugmore, 7 p.m.

SOCIETY OF INDUSTRIAL RADIOLOGY

To-day, March 22.—Grand Hotel, Bristol, "Modern Trends in Non-Destructive Testing," R. S. Sharpe, 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., March 26.—Manson House, Portland Place, London, W.1, "Process Development and Plant Design: The Role of Instrumentation, with particular reference to the Application of Computers," S. T. Lunt, 6.30 p.m.

Advanced Engineering Courses

Postgraduate Course in Nuclear Power. THE IMPERIAL COLLEGE of SCIENCE and TECHNOLOGY, London, S.W.7. Full-time course of one year's duration, commencing October, 1957. Fee for the session of three terms, £64.