

ENGINEERING AND METALLURGICAL RESEARCH BY BABCOCK & WILCOX, LIMITED, AT RENFREW.

THOUGH the research and development work that is being conducted at the Renfrew laboratories of Messrs. Babcock and Wilcox, Limited, is for the improvement of boiler design, much of it is of wider significance. For example, of four items that can be classed as developments in design, the first covers improvements in the design of ultrasonic apparatus for examining welds; the second relates to pressurised combustion, and involves the use of a gas-turbine; the third is concerned with the difficulty of making a satisfactory junction between austenitic and ferritic steels; and the fourth, though it will lead to a saving in the weight of superheater elements, is fundamentally a finding of some importance in the design of return bends in pipes subjected to internal pressure. In the field

out at the Renfrew laboratories has some bearing on design.

Ultrasonic Testing.—It has been found that existing commercial methods of ultrasonic testing give good results in the detection of faults of comparatively large area, such as slag inclusion, cracks or laminations in steel plates, but have limitations in, say, the critical examination of welded joints, where any flaw is minute. Some promising attempts are being made to develop an ultrasonic testing apparatus that will give a picture of the flaw instead of the conventional trace on a cathode-ray tube. In one method the ultrasonic transmitter consists of a regular pattern of crystals, and a single-crystal receiver is located on the other side of the test specimen. Thus, by rapid scanning with the multiple crystals, after the manner of a television raster, a pattern of spots, which is, in effect, a picture of the flaw, shows up on the oscilloscope screen. This equipment is still in the experimental stage and has the limitation of requiring access to both sides of the specimen.

A second method which is being developed makes

tinsel, in the manner described, so as to produce a zone of tinsel which will appear bright under the light of an electric lamp; but where the beam is interrupted by a flaw there is no reaction of the tinsel, which therefore remains in random positions in suspension and appears relatively dark under the light of the lamp. By this means, therefore, a picture of the flaw is produced.

For items such as butt-welded pipe joints which are accessible only from the outside, developments are taking place in the application of the shear-wave technique, a sharply-refracted wave being emitted at a shallow angle into the pipe, whence it is reflected from the joint. Fig. 2 shows an operator using this technique. An effort is also being made to overcome the difficulty of steadily moving the two crystal units by hand around the periphery of a joint; a simple rig enables the operator to move the units with a regular motion.

These experiments are an important part of the work of the electronics laboratory. The staff here are engaged on a number of projects and their work is regarded as a most useful service to the works and the research department.

Pressured Combustion.—Work is being carried out to determine the combustion characteristics of solid fuel that is burnt under pressure, since it is possible that there are advantages to be derived, particularly in an improved rate of combustion. In this way it will be practicable to investigate the possibilities of pressurised boilers and various combinations of steam and gas-turbine cycles. The work is in two parts: small-scale tests are being made on unit combustion chambers, using air from a 460-h.p. compressor, and a larger plant has been built in which a slugging cyclone combustion chamber (described later in this article) delivers hot gases to a Derwent III jet engine. The engine is shown in Fig. 11, on Plate XLVI. At the time of our visit, a few weeks ago, this plant had had an initial run of an hour and a half. Examination had shown that the turbine blades had not been damaged; in view of the absence of any form of fly-ash separator between the Cyclone combustion chamber and the turbine this result is remarkable, though, of course, it is too early to speculate on the possibilities.

Thermal-Fatigue Testing of Austenitic/Ferritic Junctions.—Very high superheat temperatures require the use of alloy steels of the austenitic (stainless) type, and considerable difficulty is experienced in service with the joints between these steels and ferritic low-alloy steels, due to their differing coefficients of expansion. In a welded joint there can be no gradual transition between the two types of steels: there is a clear-cut division between the two metallurgical structures. Searching for the most effective joint, more than 150 types of welded and mechanical joints have been investigated. The mechanical joints are specially noteworthy, though it is not possible to describe them at this stage of development. The joints are tested principally by thermal fatigue, i.e., they are subjected to rapid cycles of alternate heating and cooling. The apparatus used for this purpose is shown in Fig. 12, on Plate XLVI. It is a modified tensile-test rig, and the specimen, which consists of two pieces of ferritic metal with a piece of austenitic material welded between them, is held under constant tension. An enclosed heating element surrounds the bar specimen and slides up and down automatically at intervals so as to heat and cool the joints alternately. A blast of air rapidly cools each joint as soon as the heat is removed. The tests are carried out until failure occurs.

Return Bends of Superheater Tubes.—The conventional assumption that, because the return bends of superheater tubes thin during bending, an allowance should be made for this in determining the thickness of the tube, has been shown to be erroneous. It has been found that the maximum stress in a bend of uniform thickness is not on the outside but on the inside. This is, however, offset by the thickening of metal which takes place on the inside of the bend, and a large number of bursting tests confirm that the close-radius bends are actually stronger than the straight tubes from which they are made. Fig. 13, on Plate XLVI, shows three superheater tubes which have failed in the straight



FIG. 1. MAIN LABORATORY BUILDING.

of measurement, too, there are 13 techniques which may be of value elsewhere; they deal with methods of measuring the following parameters: gas temperature (the method being based on the velocity of sound through the gas); Young's modulus of elasticity (a resonance method which is simply and quickly applied); salts in condensate; thermal fatigue; pressure fatigue; tensile strength at elevated temperatures; bursting strength of tubes under steam pressure; stress analysis of the internal, as well as the external, surfaces of drums; strength of joints subjected to differential expansion; coal samples; calorific value; fusion temperature of ash; and the viscosity of slag. In the more practical matter of improved methods of construction, studies are being conducted on tube expanding and welding, in addition to the improvement, already mentioned, of joining austenitic and ferritic steels. Finally, considering methods of examining or observing, experiments in this connection are being undertaken on corrosion and fouling, and welds, and on the phenomena of combustion and the separation of steam from water.

These numerous channels of research spring from a scientific approach to the basic materials and phenomena with which Messrs. Babcock and Wilcox are concerned; namely, steels, welds, coal, ash, slag, water, steam, gases, combustion, the separation of steam from water, and corrosion and fouling. In this review of the work, the classification adopted above is retained, though the individual items are not dealt with in the same order. The new building, first occupied in 1950, is shown in Fig. 1, on this page.

DESIGN DEVELOPMENTS.

Ultrasonic testing apparatus, pressured combustion in association with a gas turbine, junctions of austenitic and ferritic steels, and return bends in tubes—these are the four facets of the work which may be regarded as developments in designs, though, of course, all the research work carried



FIG. 2. ULTRASONIC TEST OF BUTT-WELDED PIPE JOINT.

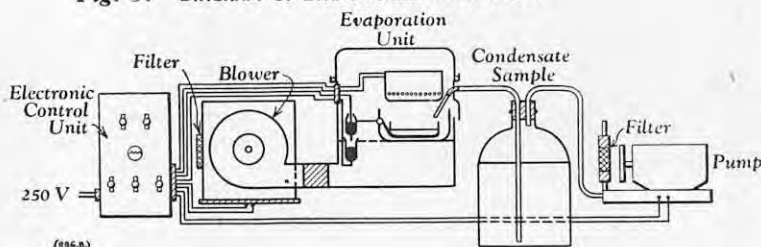
use of the fact that, if an ultrasonic beam is allowed to pass through a liquid containing fine tinsel particles in suspension, the particles, which are in the form of very small plates, position themselves so that they are normal to the beam. Thus, if the beam first passes through a weld containing a flaw, that part of it which is uninterrupted acts on the

THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED.



FIG. 3. COAL-SAMPLING ROOM.

Fig. 5. DIAGRAM OF EVAPORATION APPARATUS.



part remote from the bend. A considerable saving in material will result from this interesting finding.

MEASUREMENT TECHNIQUES.

Young's Modulus Determined by Resonance.—Fig. 14, on Plate XLVI, shows an electronic apparatus that has been developed for determining Young's modulus of a metal without applying tensile stress. A rod of the metal is suspended horizontally at its ends from two glass-silk loops, as shown at the left of the illustration. One loop is attached to the diaphragm of a loud-speaker, while the other is attached to a gramophone pick-up. The loud-speaker diaphragm is caused to vibrate, and its frequency is varied until the rod begins to resonate, the resonance being detected by vibration of the pick-up, which gives a signal on a cathode-ray oscilloscope. Young's modulus is then readily determined from the frequency of resonance.

Hot-Rupture and Steam-Rupture Testing.—Tubes are tested for tensile strength at elevated temperatures and also for steam pressure until they burst. Fig. 15, on Plate XLVI, shows a bank of hot-rupture testing machines. Samples of pipe and superheater tube are submitted to tensile stresses of different values and at different temperatures so as to give a range of results. The tension on each specimen is kept constant until failure occurs, which may take anything from a few hours to several thousand hours. The specimens are heated by electric furnaces, which surround them; the temperatures range from about 850 deg. to 1,200 deg. F., and are thermostatically controlled to within 2 deg. C. There are 72 testing units continually in use.

Steam-rupture tests are carried out on samples of superheater tubes. There are three steam rupture testing plants, one of which is shown in Fig. 17, on Plate XLVII, and each is capable of testing six specimens. Steam is fed from an autoclave at pressures up to 2,000 lb. per square inch, and at any required

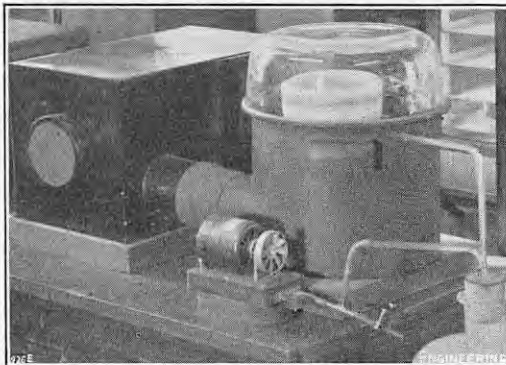


FIG. 6. WATER EVAPORATION APPARATUS.

temperature, until the tubes burst. Under the conditions of this type of test, in which the steam remains practically static, hydrogen from the steam tends to accumulate in the tubes. As, however, palladium has the property of allowing hydrogen to escape through it, a disc of this material is fitted in each tube. When required, the tubes can be surrounded with a flue-gas atmosphere, so that the influence of external scaling can be taken into account.

Hot-rupture and steam-rupture testing are part of the work of the investigational laboratory of the mechanical testing section. Thermal-fatigue testing is also carried out here, but this has already been described under the heading "Thermal-Fatigue Testing of Austenitic/Ferritic Junctions."

Stress Analysis.—The application of electric strain gauges to the inside surfaces of welded pressure vessels, for the investigation of stress systems in the vessels under pressure, has been one of the chief problems of the engineering research section of the Renfrew laboratories. The difficulties of eradicating the effect of the pressure on the



FIG. 4. SLAG-VISCOSITY APPARATUS.

action of the gauges, and of making a satisfactory seal at the point where the gauge leads pass into the vessel, have been successfully overcome. The techniques which have been developed permit the use of strain gauges on the inside surfaces of vessels which are water tested up to 2,000 lb. per square inch. One of the obstacles to achieving reliable results has been the fact that, if the surface to which the gauge is fixed has, say, a slight groove or tool mark, the gauge is pressed against it when pressure is built up in the vessel, and the calibration of the gauge is thereby upset. The stress systems in such parts as drum-heads, welded nozzle connections, etc., are extremely complex, but it is only on the basis of a thorough understanding of the stress distribution that pressure parts can be properly designed and not made by trial and error. The tedious job of taking readings from numerous strain gauges at increments of increasing pressure is therefore worthwhile. A typical set-up for this type of investigation is illustrated in Fig. 18, on Plate XLVII. The British Welding Research Association have recently published a report on part of an investigation into the stress systems in a welded boiler drum. The investigation was carried out at Renfrew in 1946-47 and the report is entitled "Experimental and Analytical Determinations of the Stress Systems in a Welded Pressure Vessel."

For stress analysis on drum-heads fitted with nozzles, the trouble of having to build special drums and subjecting them to pressure has been avoided by means of the simple apparatus shown in Fig. 19, on Plate XLVII. Since tensile stresses predominate in a drum-head under pressure, a flat plate under tension approximates to a drum-head of infinite radius; a flat plate, with a welded nozzle, is therefore used in this way. Though the tension is in one direction only—whereas it is radial in an actual drum-head—this apparatus has yielded quite valuable preliminary results.

The engineering research section's test bay in which this class of work is carried out is shown in Fig. 16, on Plate XLVII. On the left an experiment

THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED.

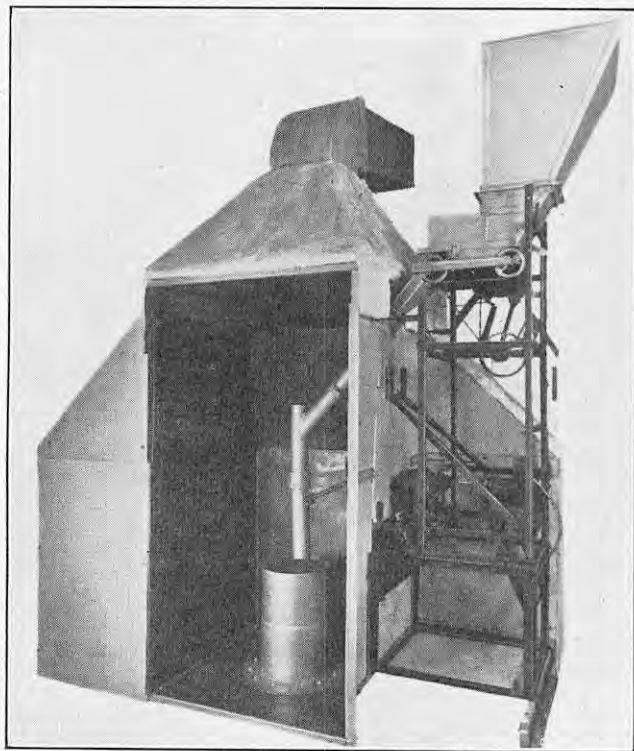


FIG. 7. SPREADER-TYPE COMBUSTION-POT FURNACE.

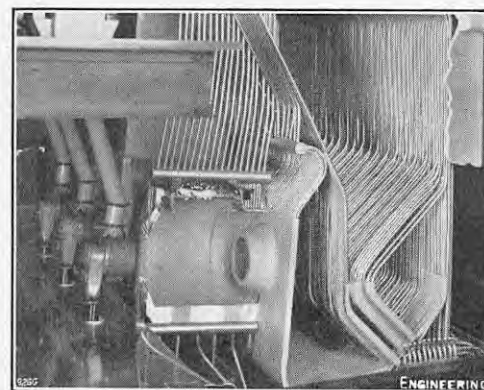
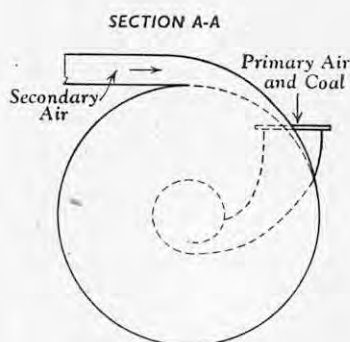
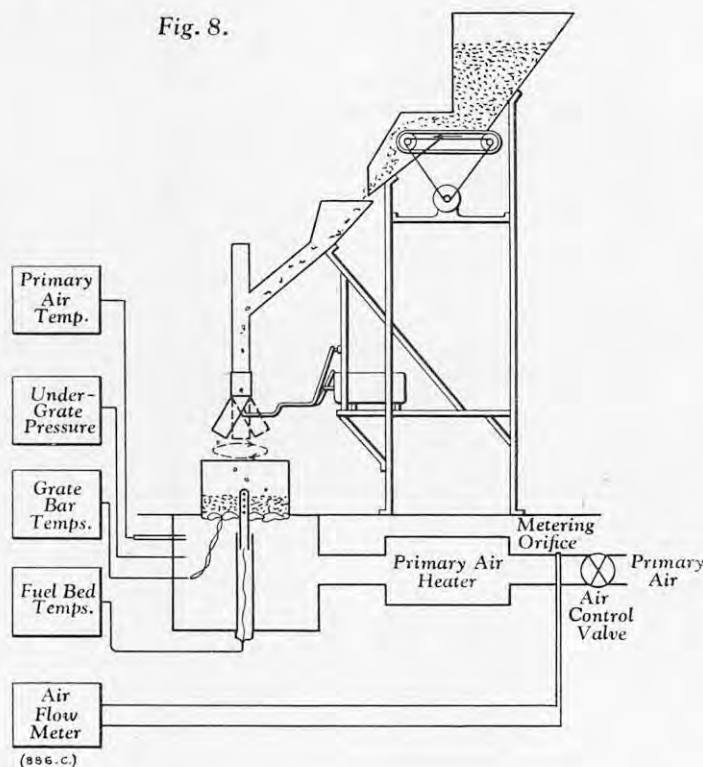
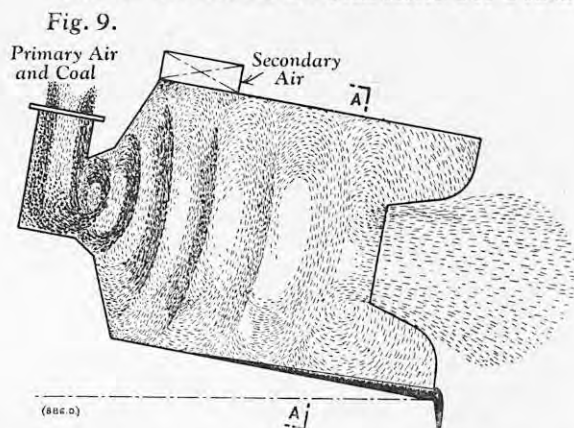


FIG. 10. MODEL OF CYCLONE FURNACE.

is being conducted on tube expansion, and on the right a flow test is being carried out on a superheater section.

Fatigue of Vessels Due to Pulsating Pressure.—Welded drums and similar parts subjected to pressure operate under extended fatigue conditions during their working life, from the time they are first tested in the makers' works to normal service operation when the pressure fluctuates and is periodically reduced to atmospheric pressure. These conditions are simulated, and the drums, etc., tested to destruction, by means of the hydraulic plant shown in Fig. 20, on Plate XLVII. This equipment gives a fluctuating pressure of up to 2,000 lb. per square inch, but as the rate of fluctuation cannot be varied from a fixed value of six cycles per minute a high-speed Werner and Pfleiderer hydraulic fatigue equipment is now being installed. It will apply pressures of 4,500 lb. per square inch at rates up to 80 cycles per minute. Fig. 21, on Plate XLVII, shows welded joints that were tested to failure with the existing plant.

Gas Temperature Determined by the Velocity of Sound.—Experiments have been carried out which give grounds for hoping that it will be possible to measure the temperature of gases by determining the velocity of sound through them. The advantages of this method, particularly in boiler investigations, are likely to be four-fold; namely, that it will not be necessary to introduce instruments directly into the gas passages, that it will measure the average temperature in the selected zone, that it will be applicable to temperatures below 1,100 deg. C. (the sodium-line reversal method is restricted

to this minimum), and that it will measure the temperature of gases which are not under black-body conditions and are freely radiating to comparatively cool surfaces (a situation where normal thermocouple equipment cannot measure the true gas temperature).

In the design and operation of large boiler plant, a knowledge of the true gas temperatures in various parts of the boiler is of inestimable value. Normal thermocouples, as already indicated, are not suitable. High-velocity suction pyrometers have been developed in the laboratories which give reliable gas-temperature measurement, but owing to the large size of boilers in use to-day, traverses of the gas passages cannot be made. Thus, a need was felt for a method of measuring gas temperature without the introduction of instruments into the gas passages. Work has been done on the sodium-line reversal method in which a light from an incandescent lamp is projected through the gas and the resultant light is examined spectroscopically. When the colour temperature of the lamp is below that of the gas, the spectrum shows the characteristic bright-yellow sodium line emitted by the traces of sodium in the gas, which changes to a black line when the temperature rises above that of the gas. It is then a simple matter to determine the temperature of the lamp filament at the point of reversal. The sodium-line reversal method, however, has several disadvantages, particularly the fact that it cannot be used for temperatures below about 1,100 deg. C., as previously mentioned. It is for these reasons that experiments are being conducted with the velocity of sound method.

Coal Sampling and Analysis.—The work of the fuel testing section is here considered in three parts, namely, coal sampling and analysis, ash and slag, and water-purity research. The accuracy of boiler efficiency tests depends in part on the accuracy with which samples of coal are analysed. In the coal-sampling room, which is shown in Fig. 3, opposite, samples are first dried in an oven and then ground in small mills. Between successive grindings the sample is sub-divided by means of a rotary sampler. The man on the right of Fig. 3 is shown using a sampler. It consists of a wheel carrying a number of boxes or compartments, which pass in turn beneath a hopper through which the ground coal falls. Coal falling into any compartment can be directed into the inner or outer of two concentric conical hoppers by a spring flap which may be fixed in the up or down positions. Thus, with alternate flaps in the up position, half the sample will fall into each hopper; with every third flap in the up position, one-third of the sample falls into one hopper and two-thirds into the other; likewise, a quarter or sixth may be obtained with a high degree of accuracy. Weighing of the coal samples is carried out in a separate balance room.

Calorific value is determined by bomb-type calorimeters of fairly conventional design but with several refinements. For example, by using a telescope, it is possible to read the temperature shown by the thermometer from outside the draught-proof cabinet to within about 0.001 deg. F. Also, to prevent errors due to slight sticking of the mercury, a rubber "flapper" blade, driven by a motor,

delivers a series of gentle taps to the thermometer without the operator approaching the apparatus or opening the cabinet.

Investigations are also being carried out in this section on the grindability of coals and on the minimum rate of air required for the combustion of cokes.

Fusion Temperature of Ash and Viscosity of Slag.—The normal method of determining ash fusion temperature is by making a cone of finely powdered ash bonded with Dextrine and observing the temperature at which it sags and melts. Experiments are now being made in the use of small cones only about 3 mm. or 4 mm. high, which is considerably smaller than the British Standard size. These miniature cones, which are similar to the standard German cones, represent an appreciable saving in the time required for fine-grinding the ash samples.

Interest in the viscosity of molten slags has been stimulated by slag-tap furnaces, and new equipment has recently been made for studying this property. Fig. 4, on page 798, illustrates this equipment in use. It takes the form of a furnace in which a platinum crucible, containing the molten slag, rotates. The viscosity is measured by the torque on a platinum cylinder which is suspended in the slag by a length of piano wire.

The properties of slag deposits which form on the outside of boiler tubes are being studied with the object of increasing the periods that large boilers can be kept in operation. For this work, a Newton Victor X-ray diffraction apparatus has recently been installed for the crystallographic examination and identification of these deposits. In addition, to facilitate the exchange of information on this subject with the firm's outside representatives, accurate water-colour paintings are prepared showing the colours and formation of typical deposits.

Water Purity and Salts in Condensate.—An apparatus has been designed in the laboratory for evaporating quantities of condensate to dryness so that the salts can be measured accurately. This work is important in connection with the treatment and control of feed and boiler water. With highly-rated high-pressure boilers, salts carried over in the steam can cause difficulties by depositing on turbine blades. Routine tests of steam purity are made by electrical conductivity methods, but these methods must be calibrated and checked by complete analysis. The evaporation to dryness of large quantities of condensate, to measure salts which may be present in quantities of less than 1 part in a million, presents difficulties, since condensed steam will dissolve sufficient quantities of most materials normally regarded as insoluble (including glass and many metals) thus obscuring the original dissolved material. Moreover, evaporation must be carried out in a dust-free atmosphere and without ebullition, to avoid dissolved solids being carried away with the steam.

The apparatus which has been designed at Renfrew is shown in Fig. 6, and diagrammatically in Fig. 5, on page 798. The condensate is contained in a platinum basin and is heated at the surface by a radiant heater, thus avoiding boiling. The whole unit is mounted in a dust-tight enclosure which is supplied with filtered air from a blower to assist in evaporation. The platinum basin is mounted on a balance pan, and when sufficient water has been evaporated to allow the pan to rise, an electric contact is made which causes the basin to be replenished from the main specimen bottle by displacement with air from a pump. Thyatron control gear supervises the replenishing of the basin, and when the bottle is empty it shuts down the entire unit. The apparatus can deal with 5 litres of condensate in about 25 hours, operating entirely unattended. It was fully described in an article by J. E. Rayner and D. Logie, "The Gravimetric Determination of Solids in Steam Condensate," which appeared in the *Journal of the Society of Chemical Industry*, vol. 69, page 309 (1950).

METHODS OF CONSTRUCTION.

Tube Expanding.—The normal method of fitting tubes in boiler drums and headers has always been by expanding, which makes a simple and reliable joint. Increase in boiler pressures, however, with a consequent thickening of tubes and of the walls

of pressure vessels, has introduced factors which were not previously present, and has necessitated a complete re-examination of the technique of making expanded joints. The engineering research section has made a close study of this problem, thereby improving the tools and methods, increasing the knowledge of the complex factors which affect the expanding process, and adding to the reliability of the expanded joints.

Welds.—Some of the steps that are being taken to improve the quality of welded joints have already been described. Thus, developments in ultrasonic testing apparatus will facilitate the more thorough examination of welds; improvements in the technique of stress analysis have given guidance in the design of welded joints, particularly between nozzles and pressure vessels; and tests of hydraulic fatigue (i.e., due to pulsating pressure) reveal the strength and soundness of welded joints. In addition, an improved equipment is being developed in the electronics laboratory to control the rate of feed of electrodes in automatic machines for welding longitudinal and circumferential butt joints.

Reference has also been made to the problem of making satisfactory joints between austenitic and ferritic steels. A solution to this problem will probably lead to a new form of mechanical joint.

COMBUSTION RESEARCH.

The activities of the combustion research section are mainly in connection with the development of new combustion processes, and the determination of the most suitable process for a given fuel. Pressurised combustion has already been referred to. Research work is also done on problems arising from combustion, such as the causes and prevention of fouling, and the corrosion of boiler heating surfaces. Extensive facilities are available for carrying out work on these or any connected problems. Small-scale laboratory research is carried out in an independent laboratory. For pilot-scale work, or small full-size projects, the combustion bay, a part of which is shown in Fig. 22, on Plate XLVIII, presents ample facilities. For large full-scale investigations the Renfrew boilers are available, the high-pressure boiler being permanently operated as an integral part of the research department, and either of the other two being available if required. These boilers are described later.

"Burnability" of Fuels.—For pilot-scale work on what might be termed the "burnability" of a fuel, the standard method is the combustion pot, by which actual fuel-bed conditions can be investigated on a small scale. The arrangement is shown in Figs. 7 and 8, on page 799. The pots, 11 in. in diameter, stand on grates formed of actual grate bars, and, in addition, different types of pot furnace are made to simulate spreader or travelling-grate stoker conditions. Provision is made for continuously weighing the pot throughout the whole of the combustion process, and thermocouples indicate the temperature at any depth of the fuel bed.

Slurry Utilisation.—Modern boilers burn fuel which would have been considered unsaleable a few years ago, and the general fuel situation in Great Britain is such as to encourage the development of new methods of dealing with inferior fuels. Some interesting work is in progress on the burning of washery slurry on a small Oldbury stoker for shell-boiler firing. This work has by no means reached finality, but results obtained so far give grounds for believing that this material can be added to the national fuel assets instead of—as at present—actually costing about 2s. 6d. per ton to throw it away in slurry ponds or dumps, where it is liable to cause further nuisance by being washed into rivers by rain.

A New "Cyclone" Boiler Unit.—A new 60,000 lb. per hour boiler fired by a slagging cyclone, and incorporating certain novel features, is being built in the boiler house adjacent to the existing high-pressure boiler, and is expected to be ready this year. It will enable cyclone combustion tests to be carried out on British and foreign coals and will provide valuable information on the behaviour of the cyclone and boiler over a wide range of conditions. Fig. 9, on page 799, shows diagrammatically the principle of a cyclone furnace, from which the slag runs off continuously, and Fig. 10 shows a model of a cyclone fitted to a Radiant boiler.

Corrosion and Fouling.—One of the chief problems arising out of the combustion of commercial fuels is the fouling and corrosion of heat-absorbing surfaces. Several test rigs have been constructed, incorporating sections of heat-absorbing surfaces operating under full-size conditions, and in this way the various factors in the problem are isolated and studied. One of these, consisting of a small furnace, brickwork passages to represent boiler passes, and a section of a tubular air heater, is shown in operation on the left of Fig. 22, on Plate XLVIII. There is also a test rig for investigating the erosion of superheater tubes and an equipment for gas analysis. A considerable amount of work has also been done on the research department's experimental boiler to determine the effect of combustion conditions and of minor constituents in the fuel on deposit formation.

To confirm the results obtained from the pilot and large-scale tests at Renfrew, observations are being made on boilers at large power stations.

CHEMICAL SECTION.

The chemical section is responsible for the quality control of all material entering the works, control of pickling procedure, corrosion and surface-protection problems, and certain aspects of the behaviour of metals at high temperatures. Routine analysis alone involves the examination of some 10,000 specimens, which, with an average of four elements per sample, and duplicate testing, involves 80,000 determinations a year. Physical methods save much valuable time in routine analysis, and interesting techniques used in the laboratory include the following.

Spectrographic and Colorimetric Analysis.—The technique employed here is to photograph the spectrum of the light emitted by a high-tension spark between a silver electrode and the specimen under test. The light from the spark passes through a prism in the spectrograph and is resolved into a spectrum which is recorded on a photographic plate, as many as 24 spectra being recorded on the same plate. The spectra consist of a series of lines, the positions of which in the wavelength scale are characteristic of the elements present, and their densities are a measure of their quantities. For a qualitative analysis each spectrum may be compared with the spectra of pure elements, and for quantitative analysis the densities of the lines are measured by photo-electric means, on a sensitive densitometer.

Colorimetric methods for the determination of alloying elements in iron and steel (silicon, manganese, nickel, molybdenum, etc.) involve the preparation of solutions of each specimen using standard methods and reagents, according to the elements to be determined. Each solution has a characteristic colour, the density of which depends on the quantity of the element concerned. By photo-electric comparison with suitable standards, using colour filters, the amount of the particular element present can be readily estimated. Miscellaneous analyses, which may amount to 20,000 determinations a year, require procedures which vary as widely as the specimens themselves, and new, improved and more rapid methods are constantly being investigated.

Corrosion and High-Temperature Sealing.—The protection of metal surfaces against corrosion during transit and, in particular, under service conditions, presents a major problem. Developments in the production of protective coatings are constantly under review, materials being subject to heat-resisting and acid-resisting tests which have been standardised in the laboratory. Those materials considered to be superior to products currently in use are recommended for trial under service conditions.

Investigations into the sealing characteristics of metals at elevated temperatures form part of the more extensive departmental programmes. The method and apparatus employed are based upon some years of experience and are designed to permit results, when taken in conjunction with other aspects of the investigation, to be extrapolated to approximately 100,000 hours' service conditions. Each test specimen consists of a tubular section machined from a solid bar of the material being investigated; it is suspended in the centre of an

THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED.

(For Description, see Page 797.)

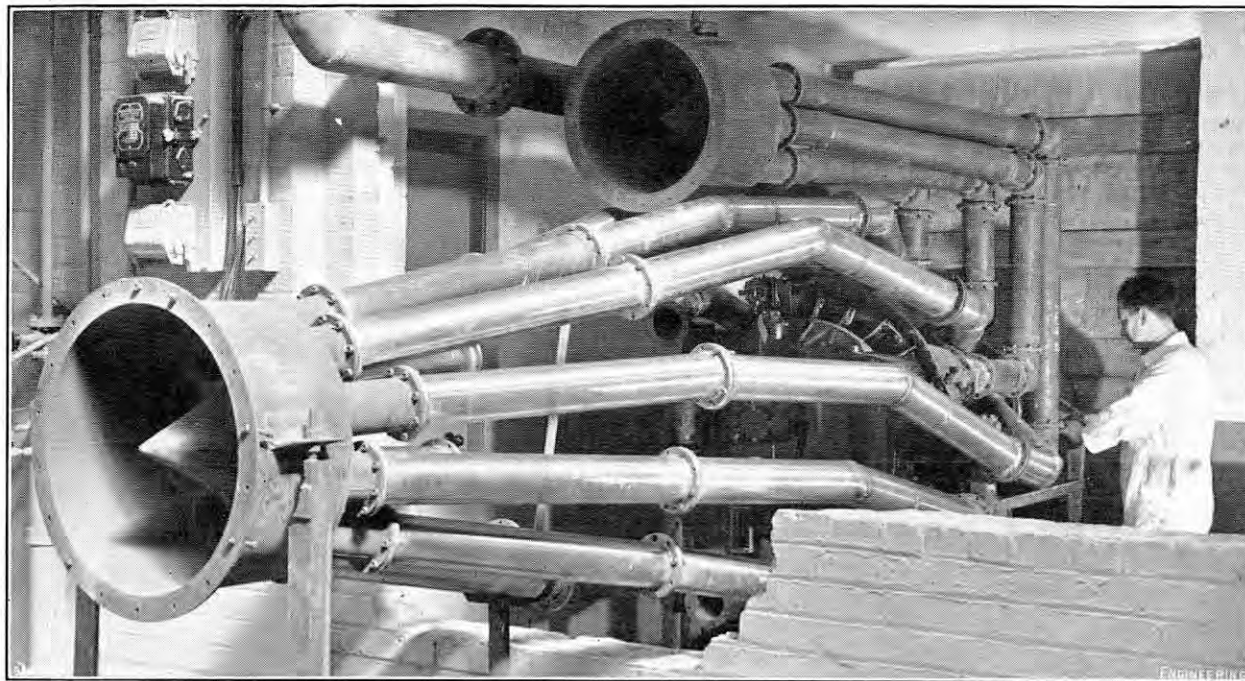


FIG. 11. "DERWENT III" JET ENGINE FOR PRESSURISED-COMBUSTION TESTS.

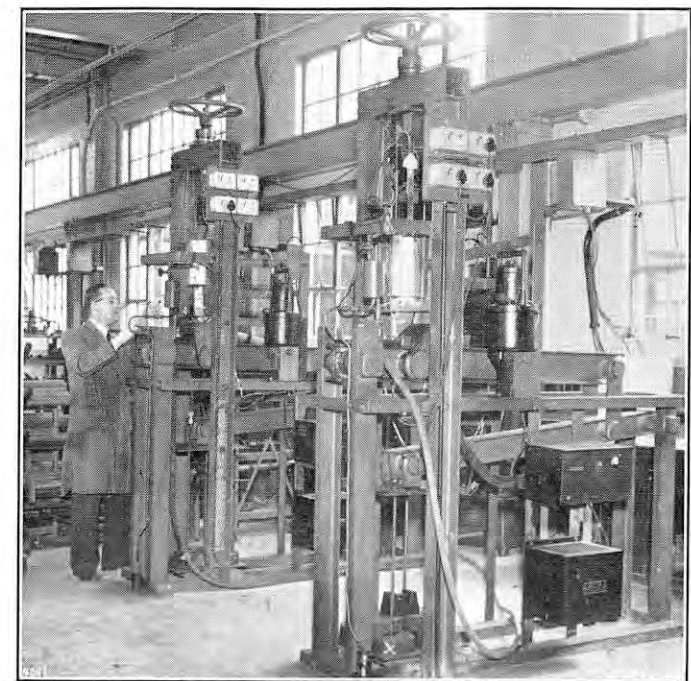


FIG. 12. THERMAL-FATIGUE TESTING MACHINES.



FIG. 13. SUPERHEATER TUBES TESTED TO FAILURE.



FIG. 14. DETERMINATION OF YOUNG'S MODULUS BY RESONANCE.

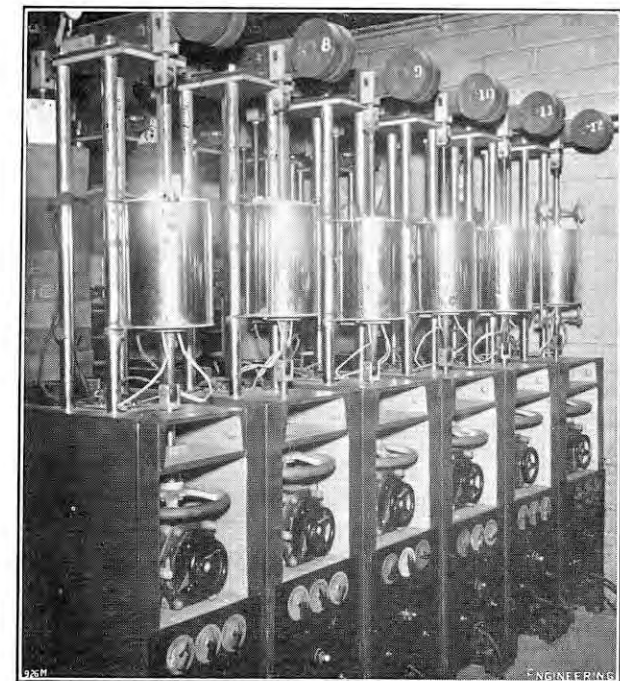


FIG. 15. HOT-RUPTURE TESTING MACHINES.

THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED.

(For Description, see Page 797.)



FIG. 16. ENGINEERING RESEARCH BAY.

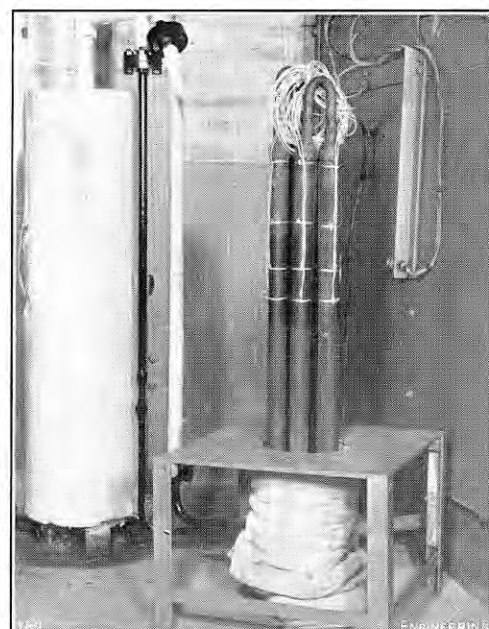


FIG. 17. STEAM RUPTURE TEST FOR SUPER-HEATER TUBES.

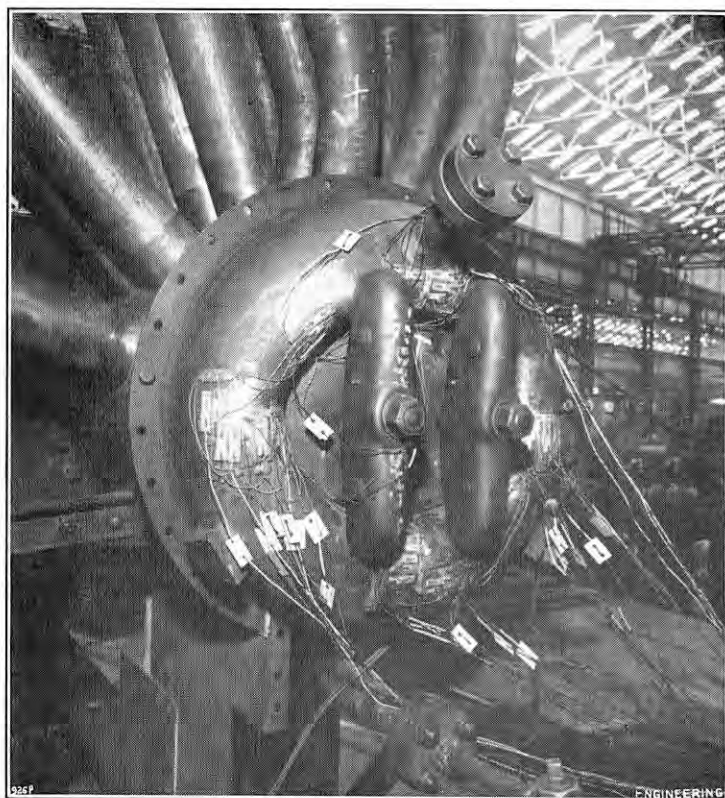


FIG. 18. STRAIN GAUGES ON BOILER DRUM FOR STRESS ANALYSIS.

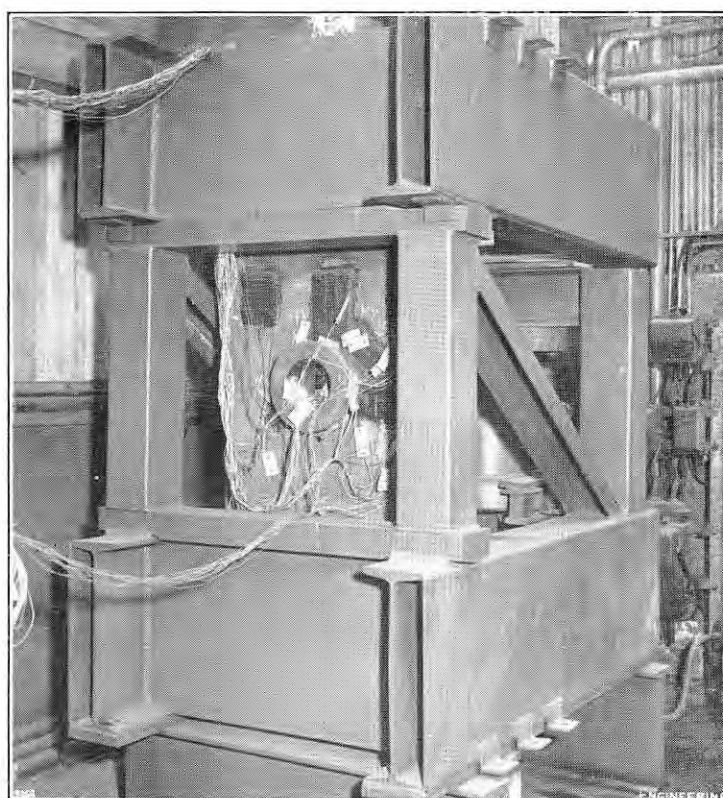


FIG. 19. STRESS ANALYSIS OF NOZZLE WELDED INTO FLAT PLATE.

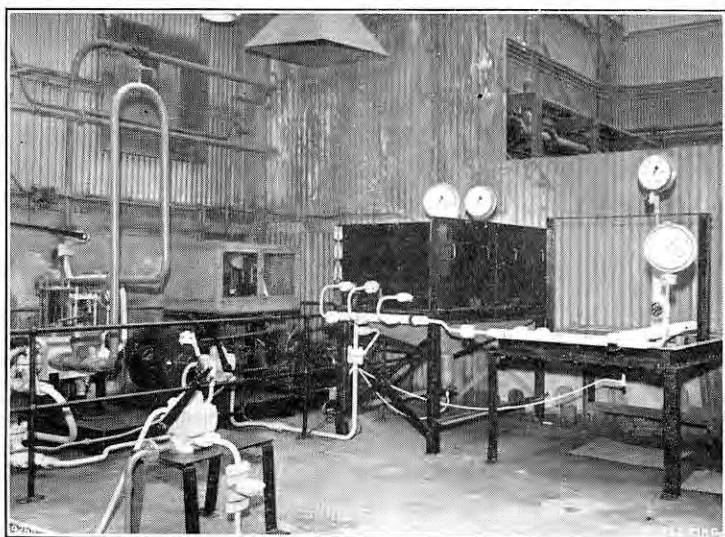


FIG. 20. APPARATUS FOR HYDRAULIC FATIGUE TESTS.



FIG. 21. WELDS TESTED TO FAILURE BY CYCLIC STRESS REVERSAL.

THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED.

(For Description, see Page 797.)



FIG. 22. PART OF COMBUSTION BAY.



FIG. 23. TESTING FOR HIGH-TEMPERATURE SCALE.



FIG. 24. VICKERS PROJECTION MICROSCOPE.

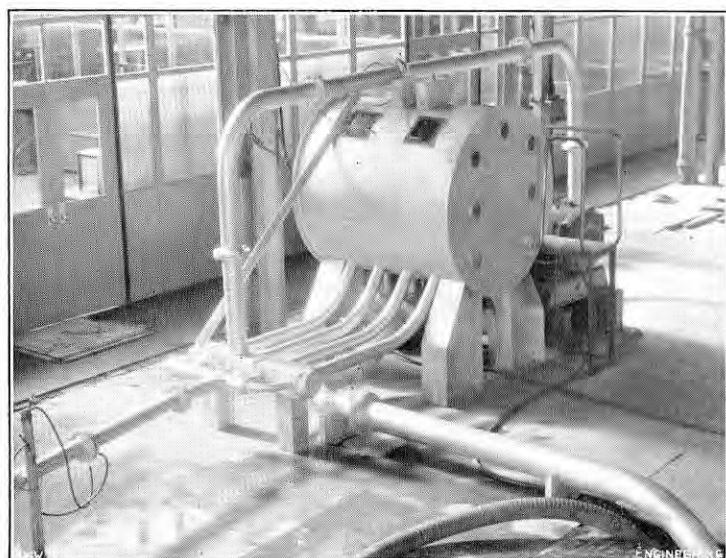


FIG. 25. DUMMY BOILER DRUM FOR STEAM-SEPARATION TESTS.



FIG. 26. TURBULENCE IN DUMMY BOILER DRUM.

THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED.

(For Description, see Page 797.)

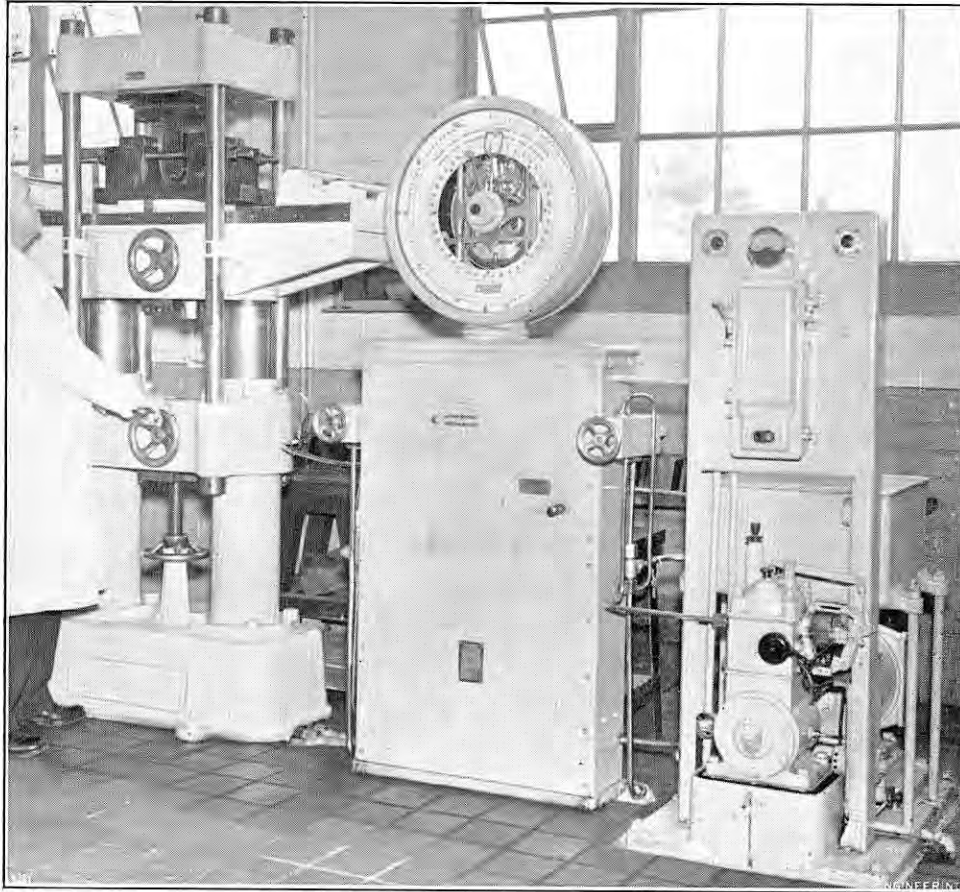


FIG. 27. AVERY 100-TON TESTING MACHINE.

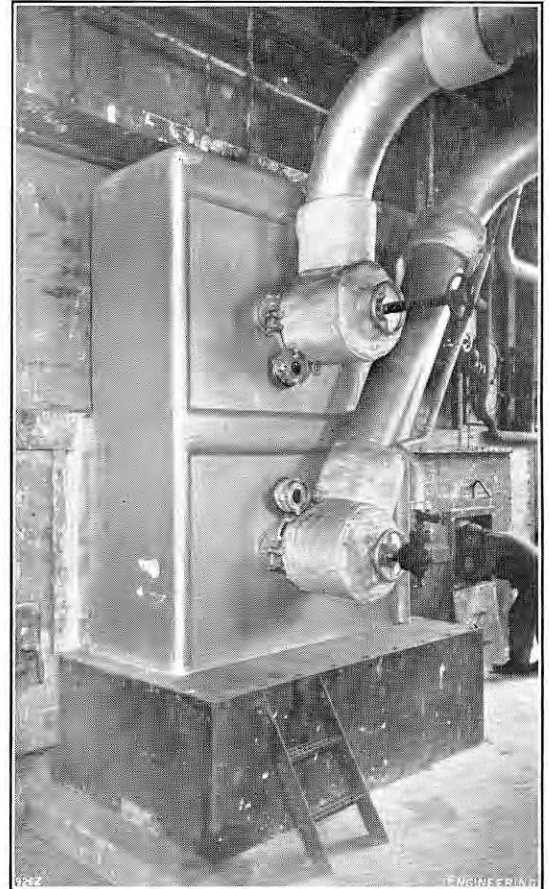


FIG. 28. BURNERS OF F.H. BOILER.

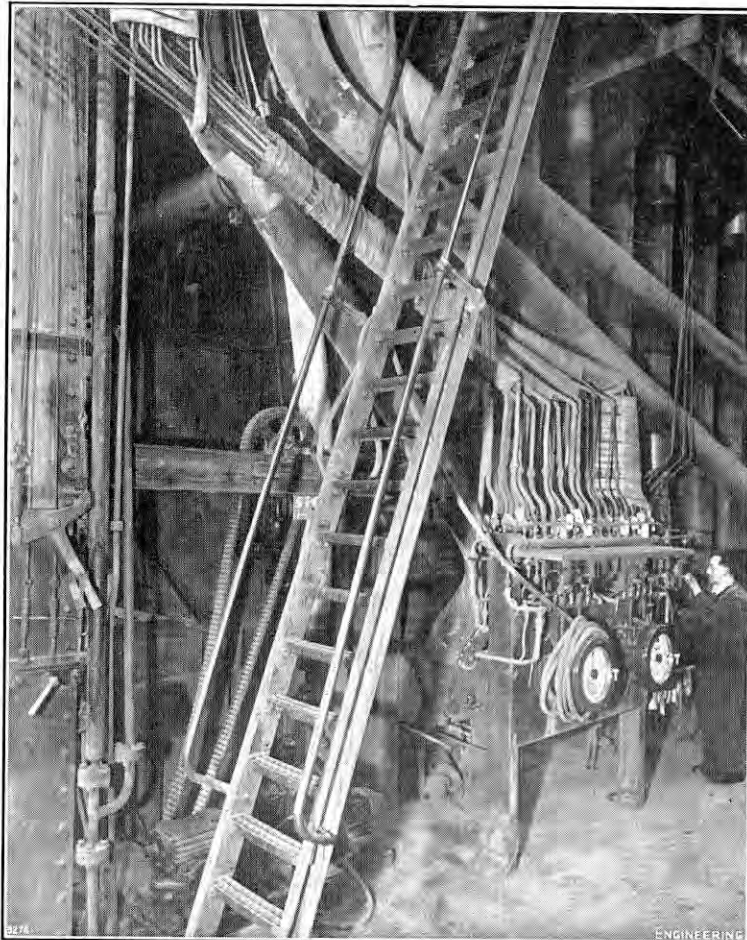


FIG. 29. PART OF H.P. BOILER AT FIRING-FLOOR LEVEL.

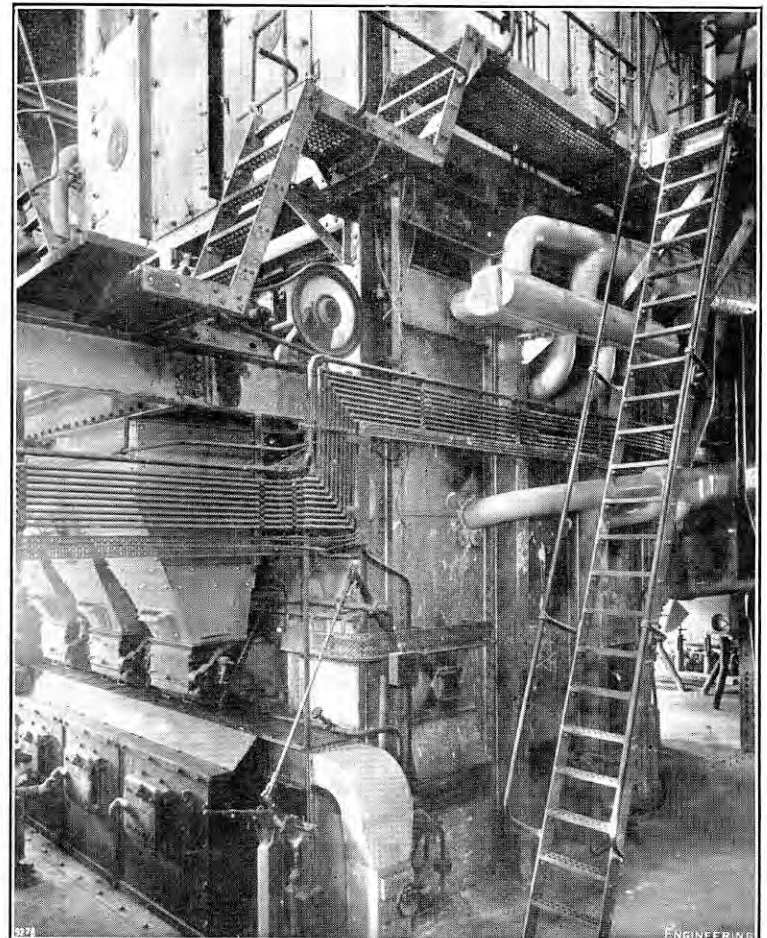


FIG. 30. CROSS-TYPE BOILER.

electric furnace, flue gas being passed all round it from a gas burner, with provision for injecting other gases as required. The furnaces are arranged in two groups of six, some of which are shown in Fig. 23, on Plate XLVIII, each group having a travelling balance so that the specimens can be weighed periodically. Full provision is made for continuous measurement of the furnace temperatures and for indicating and recording the CO₂ content of the flue gases.

METALLURGICAL SECTION.

The work of this section can be classified into three categories: routine examinations, investigations of service troubles, and research and development.

Routine Examinations.—Most of the work comprises the macroscopic and microscopic examinations of sections from the test plates employed for the acceptance of welded pressure vessels,* and control of works metallurgical processes such as case-hardening. The volume of work of the former category is sufficiently great to require the development of mass-production methods of specimen and photographic preparation, and considerable progress has been made in this direction. For the preparation of specimens, in addition to the normal equipment of a preparation room, such as polishing wheels, liners, etc., an electrolytic polishing unit is available with thermostatic control for the bath, to eliminate risks with such solutions as mixtures of acetic anhydride and perchloric acid. Mounting may be in plastic cements, and iron plating is often used to preserve the edge of the specimen intact, this being particularly valuable if an examination of scale is desired. For examination and photomicrography of specimens, Vickers and Reichert projection microscopes and a Leitz metallograph are available, the last two being fitted for automatic recording of numbers on the negative. The Vickers microscope, which is shown in Fig. 24, on Plate XLVIII, has been fitted with a light intensity meter, developed in the department, which allows a constant negative density to be obtained. Further developments are in hand to provide shutter operation by a light integrator, giving automatic control of exposure.

The photographic department is well equipped for all types of photography, including laboratory, studio, outside and 16-mm. cinematograph work.

Investigation of Service Troubles.—This aspect of the work covers the metallurgical considerations of any trouble encountered in service, and close collaboration with the Service Department is maintained to provide advice and guidance in any trouble which may arise on clients' plant, in accordance with the company's policy. The troubles investigated are as varied as the company's products, and the range of work encountered necessitates a wide variety of modern equipment. Sometimes unprecedented trouble arises, due in part to the general trend towards higher pressures and temperatures. In such cases, it might be necessary to initiate a comprehensive investigation, when the work would then fall into the next category.

Research and Development.—In addition to the research work suggested by service investigations, programmes of a more long-term nature are undertaken. These are mainly concerned with the behaviour of materials at elevated temperature and the development of suitable material for the progressively higher temperature products envisaged for the future. Investigation of the properties of such materials includes stress-carrying capacity, scale resistance, and general microstructural stability. The structural stability of materials is investigated by measuring the changes in magnetic susceptibility, impact strength and resistivity. The first is measured by means of a ferrometer, and the impact strength is measured by Izod tests, with modifications for working on hot specimens. Change in resistivity is measured by conventional voltage-drop measurements. Since the change in resistivity is influenced by the degree of spheroidisation of the carbides in a specimen, a measure is obtained of the stabilising influence of carbide-forming elements such as chromium.

Although the general emphasis of research is

directed towards high-temperature properties, other features are also considered. Extensive work has been carried out on the minimum amounts of residual elements known to influence the hot-working properties of steel, such as copper, tin and nickel. A report on this work is shortly to be published. Investigations of heat-treatment procedures such as Martempering and Austempering have been made to improve the quality of tools, and an extensive range of heat-treatment furnaces and quenching baths is available for this work.

SEPARATION OF STEAM FROM WATER.

In the engineering research section, a dummy boiler drum, shown in Fig. 25, on Plate XLVIII, has been set up for steam-separation tests. With the increase of boiler pressures and capacities, the amount of steam released per cubic foot of boiler drum has also risen. Thus, as it is important to eliminate carry-over of solid salts in the steam, attention has been directed to the avoidance of turbulence in the drum and to the complete separation of the steam from the water droplets. It is also essential to ensure that water entering the downcomer tubes from the drum does not carry bubbles of steam. The dummy boiler drum has riser connections through which air and water are pumped at velocities corresponding to those of the steam and water in an actual boiler and producing comparable turbulence, as shown in Fig. 26, on Plate XLVIII. Inspection windows enable the behaviour of various steam-separating devices to be studied. Photographs have also been taken under comparable conditions inside the drum of the experimental boiler at Renfrew, a toughened-glass window being fitted for this purpose.

ROUTINE TESTS, MACHINE SHOP, FURNACE ROOM AND BOILERS.

The routine-test laboratory deals with general testing work in connection with quality control and customers' acceptance tests. It is equipped with a Denison 30-ton single-lever tensile-testing machine, an Avery 100-ton universal testing machine (shown in Fig. 27, on Plate XLIX) and Izod impact-testing machine. Much of the work consists of tests carried out on some of the pieces cut from the boiler test plates. Other work includes hardness testing on stoker-chain bushes, for quality control of case-hardening, and on rollers and mandrels for tube expanders, a 100 per cent. examination of which is carried out, amounting to about 6,000 tests a month.

The machine shop is well equipped for serving the laboratories. Eighteen men are employed on a double shift, producing practically all the department's requirements. The furnace room contains heat-treatment furnaces ranging from one of 9 cub. ft. capacity, capable of a working temperature of 1,000 deg. C., to a furnace of 1 cub. ft. capacity and a working temperature of 960 deg. C.

The research department has one full-size boiler permanently at its disposal, and there are two other units which can be used as required. The first-mentioned is a high-pressure boiler which is a modification of the standard Babcock C.T.M. type, with an evaporative capacity of about 40,000 lb. of steam per hour at 1,500 lb. per square inch and 850 deg. F. It will shortly be fitted with new fans and feed pumps, to increase its capacity to 100,000 lb. per hour, thus permitting tests to be made at ratings considerably in advance of commercial practice. One of the works' boilers, which can be used when required, is shown in Fig. 30, on Plate XLIX. It is a standard cross-type unit of 40,000 lb. per hour rating at 400 lb. per square inch and 550 deg. F., and is fired by a Babcock-Detroit spreader stoker with a Rotograte. The other works' boiler, shown in Fig. 29, on Plate XLIX, was installed this year. It is of the "F.H." integral-furnace type, with an evaporative capacity of 60,000 lb. per hour at 400 lb. per square inch and 550 deg. F. Fired by pulverised fuel, it is notable in that it has been designed specifically for experimental work on fuel mills. For this purpose it is well equipped with pulverising plant, for either direct-firing or the bin-and-feeder system, with arrangements for alternative fuel mills, the standard adopted being a Babcock E type. Fig. 28, on Plate XLIX, shows the burners of the F.H. boiler.

LIABILITY FOR DEFECTS IN SPARE PARTS.

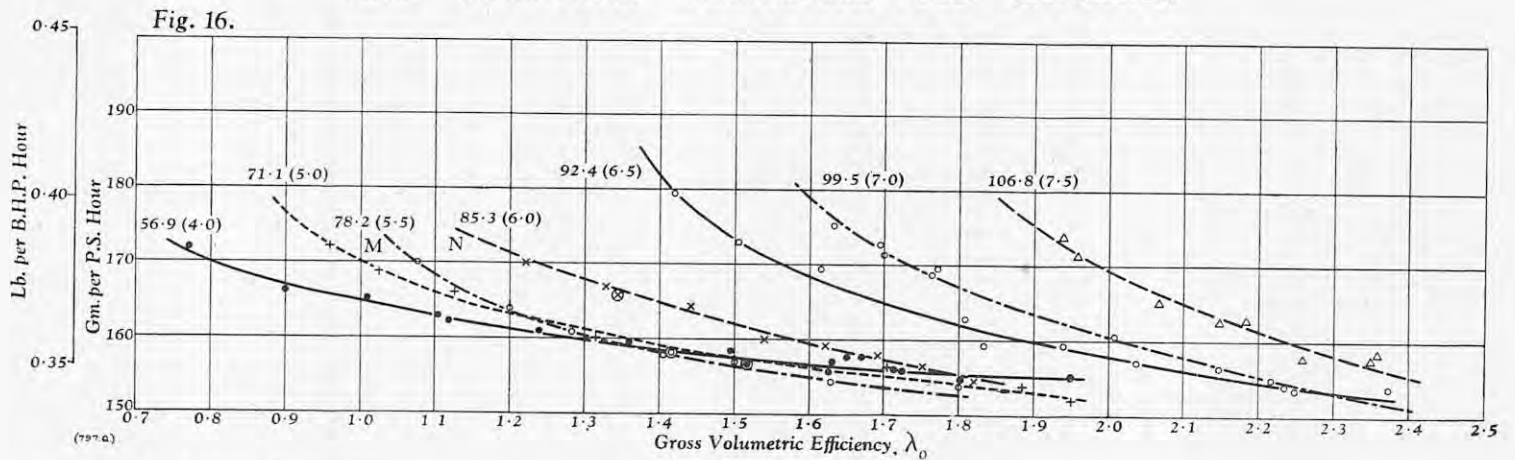
WHEN machinery is sent to be repaired, it often happens that some essential part has to be procured and fitted by a specialist, chosen either by the owner of the machine or by the repairer. If the part supplied proves unsuitable or is badly fitted, with the result that the machine, when put in motion, is damaged, is the repairer liable to the owner? This is to put the question rather baldly, because much depends, as was pointed out in a recent case, upon the exact nature of the contract between the owner and the repairer. In the case referred to (*Stewart v. Reavell's Garage*, 1952, 1 All. E.R. 1191), which was heard in April by Mr. Justice Sellers, the plaintiff, a motorist who had no technical knowledge, but a good knowledge of his Bentley car, and the power of its brakes, took it to experienced repairers to have the brake drums relined. Knowing that this was specialist's work which they did not undertake, he suggested that it should be done by a firm who advertised cast-iron linings, which, he said, would be preferable because they would consist of an unwelded circle of metal.

The price quoted by that firm being considered high, the repairers, with the plaintiff's consent, obtained a lower quotation from another firm, who advocated fitting alloy-steel linings. In recommending the acceptance of this quotation, the repairers omitted to inform the plaintiff that the alloy-steel linings would be welded. The second firm did the work as sub-contractors of the car repairers, but the alloy-steel linings were not suitable for the brake-drums, and the car was damaged in consequence. In these circumstances, the repairers were sued for damages. It was urged in their defence that they were only under a duty to take reasonable care to employ suitable sub-contractors, and were not liable for the default of the latter, but were entitled to assume without detailed examination that their work would be satisfactory. This defence, however, did not avail them. Mr. Justice Sellers said: "I find that the effect of what was said and done when the parties entered into the contract was that the plaintiff did rely on the defendants as experienced repairers to repair the brakes in a suitable and efficient manner, and it was left to them to obtain suitable sub-contractors to do the lining of the drums and to arrange for a suitable type of drum to be fitted. The plaintiff's original request for a cast-iron sleeve not being carried out, the type of lining was a matter within their province as repairers." In the event, damages assessed at 283*l.* 2*s.* 4*d.* were recovered by the plaintiff.

It is important to notice that this was not merely the case of a man sending his car to repair with instructions to get the necessary spare parts from the manufacturers. If, in such a case, the spare part proved defective, it might be said that the repairer was not liable. This point was emphasised some years ago in the case of *G. H. Myers v. Brent Cross Service Co.* (1934 1 K.B. 55), when Mr. Justice du Parc said: "I think the true view is that a person contracting to do work and supply materials warrants that the materials which he uses will be of good quality and reasonably fit for the purpose for which he is using them, unless the circumstances of the contract are such as to exclude any such warranty. There may be circumstances which would clearly exclude it. A man goes to a repairer and says: 'Repair my car; get the parts from the makers and fit them.' In such a case, it is made plain that the person ordering the repair is not relying on any warranty except that the parts used will be the parts ordered and obtained from the makers. On the other hand, if he says: 'Do this work, fit any necessary parts,' then he is in no way limiting the person doing the repair work, and the person doing the repair work is, in my view, liable if there is any defect in the materials supplied, even if it was one which reasonable care could not have discovered." In the case under review, however, the car owner did more; he emphasised that he did not want a welded brake lining, and that the brakes would be subjected to special strain. In effect, he made it obvious that he was relying on the repairer's skill and judgment to do what was necessary.

* See ENGINEERING, vol. 169, pages 344 and 373 (1950).

THE JENBACH VERTICAL OIL ENGINE.



ANALYSIS OF THE PERFORMANCE OF THE JENBACH TWO-STROKE VERTICAL OIL ENGINE.

By PROFESSOR S. J. DAVIES.

(Concluded from page 771.)

In developing the design of an engine to give satisfactory results, two courses may be followed: a purely experimental method, or a method of calculation confirmed or modified by experiment. The designers have followed the latter course, and they have placed at the disposal of the author an account of their methods. He had, however, the opportunity of carrying out certain tests which form part of a comprehensive investigation into the correlation of the performance of the blower and the conditions of exhaust, admission, and scavenging in the cylinder; such a correlation is clearly fundamental to the design of the engine under discussion. The elements of the charging system comprise the blower and its separate performance, as already described; the areas and the coefficients of discharge of the admission and exhaust ports, as well as their directions, forms and settings in relation to the piston movement; and the ratio of blower speed to engine speed, since, given certain values for the other elements, this ratio, combined with the blower capacity, will determine the scavenging pressures and the volumes of air delivered by the blower at various speeds and loads of the engine.

In order to establish, for the engine, the most satisfactory ratio of blower speed to engine speed, the blower was driven independently of the engine. The power then measured by the brake is the actual engine output plus the power to drive the blower. At a constant engine speed of 1,000 r.p.m., a range of constant torques was applied to the brake, corresponding to constant values of the gross B.M.E.P., and, at each constant torque, the air quantity supplied to the engine was varied and thus gave a range of scavenging pressures. The consumptions of air and fuel were measured, and the results are plotted in Fig. 16 as net specific fuel consumption, in both lb. per brake horse-power hour and gr. per P.S. hour,* on a base of the gross volumetric efficiency, λ_0 ; each curve has shown against it the particular values of gross B.M.E.P. in lb. per square inch and, in brackets, in kilogrammes per square centimetre. Of the results plotted, the author observed those in the two series, M and N, the remainder being taken after his departure. In addition, he carried out a short supplementary series P, in which, with a constant value of the scavenging pressure, the air quantity, and thus the gross B.M.E.P., were varied. The test data for the three series are given in Table VI. The points from series P are shown with an additional ring in Fig. 16, and are seen to be in satisfactory agreement with the curves.

If from these curves the ordinates corresponding to a series of constant values of the gross volumetric efficiency, $\lambda_0 = 0.8, 1.0 \dots 2.2$, are taken, the broken curves shown in Fig. 17 are obtained.

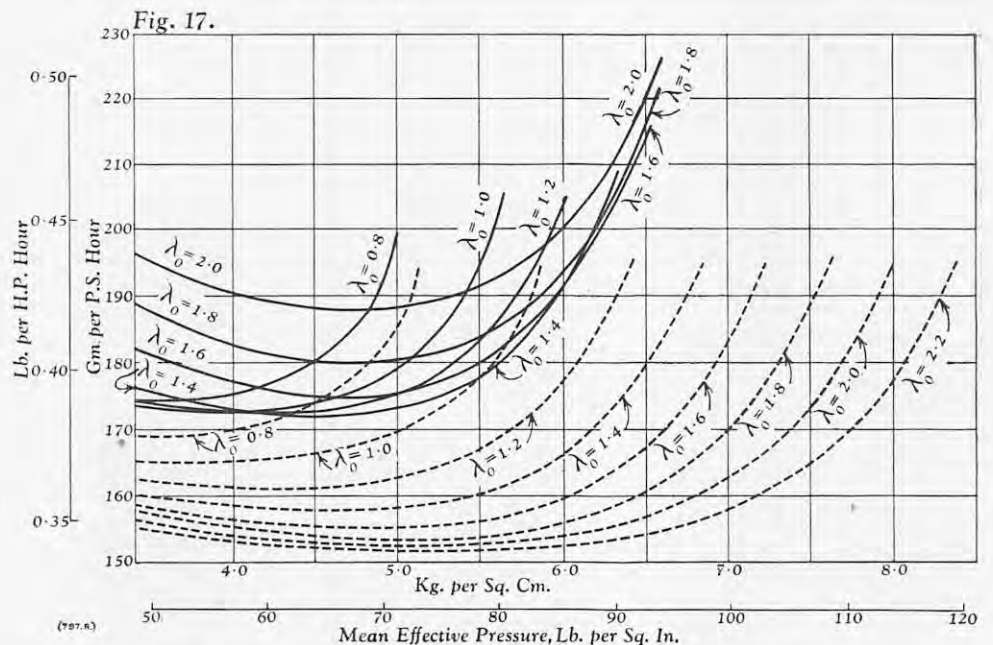


TABLE VI.

Test No.	R.p.m.	Scavenge Pressure, mm. Mercury.	Net Fuel, Lb. per b.h.p. per hr.	Gross Volumetric Efficiency, λ_0 .	Gross B.M.E.P., Lb. per sq. in.
M 1	1,000	112	0.380	1.075	78.2
M 2	997	125	0.367	1.200	
M 3	1,005	135	0.359	1.280	
M 4	1,003	153	0.352	1.410	
M 5	1,003	165	0.350	1.500	
M 6	1,020	185	0.345	1.630	
M 7	1,013	206	0.344	1.800	
N 1	1,002	134	0.380	1.220	85.3
N 2	998	138	0.374	1.325	
N 3	998	150	0.368	1.440	
N 4	998	164	0.358	1.540	
N 5	1,000	174	0.356	1.620	
N 6	991	184	0.354	1.690	
N 7	995	193	0.350	1.750	
N 8	1,003	205	0.346	1.820	
P 1	1,000	153	0.371	1.340	85.3
P 2	1,002	154	0.353	1.415	78.2
P 3	1,000	155	0.350	1.515	56.9

These form a series of curves of net specific consumption on a base of gross B.M.E.P. The values of gross B.M.E.P. are designated as $(p_e + p_L)$; that is, the actual value of the B.M.E.P. to be expected from the engine plus the value of the M.E.P. equivalent to the power to drive the blower. The values of p_L are calculated for all cases on the assumption that the adiabatic efficiency, η_{ad} , of the blower is 0.6, which, in view of the results in Fig. 12, page 771, ante, is reasonable. If these values are subtracted from the corresponding values of $(p_e + p_L)$, the results give p_e , the values of the B.M.E.P. to be expected from the engine.

The values of the specific consumption to be expected from the engine, that is, those corresponding to p_e , are designated by b_e , while the lower values to be expected when the values of the gross B.M.E.P., $(p_e + p_L)$, are taken are $(b_e - b_L)$,

so that, $b_e \propto \frac{1}{p_e}$, or $= \frac{k}{p_e}$, where k is a constant.

Similarly, $(b_e - b_L) = \frac{k}{p_e + p_L}$ and $\frac{b_e}{b_e - b_L} = \frac{p_e + p_L}{p_e}$; or, $b_e = (b_e - b_L) \frac{(p_e + p_L)}{p_e}$. The values of p_e and b_e so obtained are plotted as the full lines in Fig. 17,

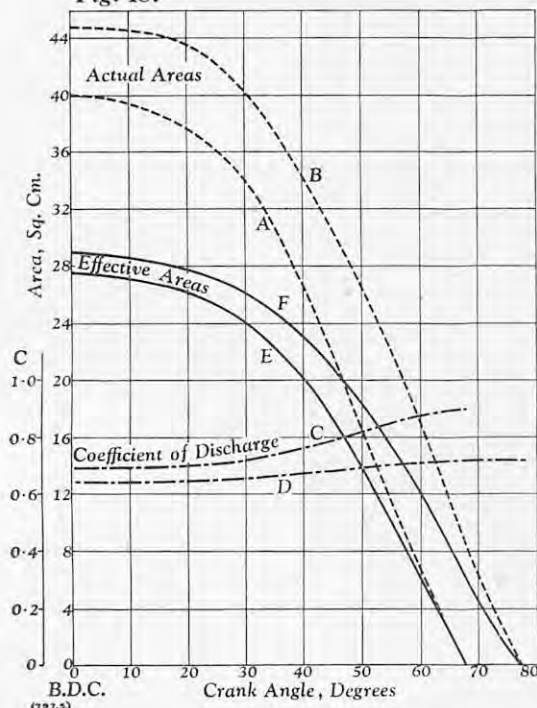
corresponding to the values: $\lambda_0 = 0.8, 1.0 \dots 2.2$. Bearing in mind that the normal maximum B.M.E.P. of the engine is 71.1 lb. per square inch (5 kg. per square centimetre), it is seen that $\lambda_0 = 1.4$ gives the best all-round solution, and one which is, in fact, in accordance with the values recorded in Table III, on page 768, ante.

In an analysis of the charging processes, the gases to be considered comprise the air supplied from the atmosphere and those resulting from the combustion of the fuel. The air supplied from the atmosphere passes first to the blower and then through a reservoir into the cylinder through the admission ports; its volume under atmospheric conditions is λ_0 times the swept volume (see Table IV, page 769, ante). A part of this air passes directly through the cylinder, out through the exhaust ports into the exhaust box, and thence to the atmosphere, and is the "scavenge air"; the remainder, of which the volume under atmospheric conditions is λ_L times the swept volume, is trapped in the cylinder, and, of this, a fraction η is combined with the fuel to form the combustion gases; the air and the nitrogen not taking part in the chemical combination pass, with the combustion gases, through the exhaust ports into the exhaust box and thence to the atmosphere. The conditions to which the air and other gases are subjected during these various operations change, of course, from instant to instant during a cycle and are principally affected by the timing of the points of opening and closing of the admission and exhaust ports, and by the changes in their effective areas.

* 1 h.p. = 1.0139 Pferdestärke (P.S.) or chevaux (C.V.).

THE JENBACH VERTICAL OIL ENGINE.

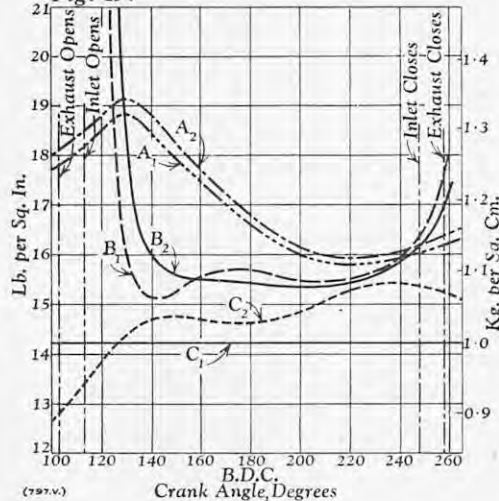
Fig. 18.



The effective area of a port at any instant is given by the product of its area and its coefficient of discharge. The area can be obtained from the geometry of the engine but its coefficient of discharge can only be obtained experimentally, and then only under static conditions. If, for example, the engine is barred round to such a position that both the admission and the exhaust ports are partly open and, with an independent and measured supply of air, the pressure and temperatures in the air reservoir, the cylinder, and the exhaust box are observed, it is possible, knowing the instantaneous areas of the opened admission and exhaust ports, to calculate the instantaneous values of the coefficients of discharge of the admission and exhaust ports, respectively. The information derived from a complete series of tests of this kind is plotted in Fig. 18. The base of this figure is in degrees of crank angle from bottom dead centre. The curves A and B give, respectively, the actual areas, f_a and f_e , of the admission and exhaust ports; the curves C and D give the values of the coefficients of discharge, c_a and c_e , of the admission and exhaust ports, respectively, calculated as described above; the curves E and F give the corresponding values of the effective area of the admission and exhaust ports, respectively, an ordinate being the product $c \times f$.

Professor List, in his comprehensive books dealing with the charging processes in internal-combustion engines,* has developed a step-by-step method of calculating the pressures, temperatures, and volumetric displacements of the gases as they pass through the engine. This method is employed by him and his staff in arriving at the desirable dimensions of the charging system of an engine and are later compared with observations from the engines when built. Such a comparison for the present engine throws light on certain aspects of its performance. Using the values for the effective areas of the admission and exhaust ports, given in Fig. 18, with the delivery of the blower arranged to give a value of 1.4 for λ_0 , the gross volumetric efficiency, and with a scavenging air reservoir of volume 30 litres, that is, ten times the swept volume of the cylinder, the pressures before the admission ports to give uniform flow were calculated. The results of this calculation are given by A_1 , the chain-dotted curve in Fig. 19. The corresponding cylinder pressures were also calculated and are given by the broken curve B_1 . The pressures outside the exhaust port were taken as constant

Fig. 19.



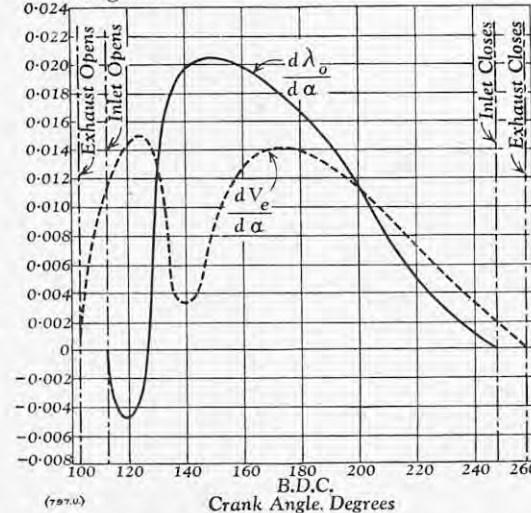
and are given by C_1 . From indicator diagrams taken, respectively, from the air reservoir, in the cylinder, and just outside the exhaust ports, the three corresponding curves, A_2 , B_2 and C_2 , were obtained. The agreement between the two pairs of curves, A_1 and A_2 , and B_1 and B_2 , is very satisfactory, and gives ample justification for the method of calculation employed in determining the elements of the design.

The variation of the scavange pressure before the admission ports during the period shown is in accordance with expectation, as is that of the pressures in the cylinder and outside the exhaust ports. During 15 deg. after the point of opening of the admission ports, it will be noticed, the pressure in the cylinder exceeds the scavange pressure, so that during this interval a corresponding proportion of the exhaust gases will escape backwards into the air reservoir. As the pressure in the cylinder falls below the scavange pressure, this mass of gas will pass again into the cylinder with the scavange air, and be conveyed towards the exhaust. The indicated pressure in the cylinder when the exhaust ports close is 17 lb. per square inch (1.2 kg. per square centimetre), which corresponds to a considerable supercharge.

From the values of these pressures and the effective areas of the ports, further calculations were made of the rate of entry of the admission air and of the rate of discharge of the gases from the exhaust ports. These are plotted in Fig. 20, in which the full curve gives, as $\frac{d\lambda_0}{d\alpha}$, the variation in the rate of entry of the admission air, and the broken curve gives, as $\frac{dV_e}{d\alpha}$, the rate of discharge of the gases, both calculated as volumes under atmospheric conditions and plotted on degrees of crankshaft. From these curves some interesting conclusions may be drawn.

Considering first the admission of the air, the full curve shows at the beginning a negative loop, which is the result of the passage backwards of a certain volume of the exhaust gases, as mentioned above; next, the rate of entry of the air increases rapidly and, at 37.5 deg. after the opening of the admission port, reaches its maximum, and then decreases to zero at the point of closing of the admission ports. The area of the negative loop is about 4 per cent. of the total net area representing the volume of the air. The broken curve forms two loops; the former is brought about by the high pressure in the cylinder at, and immediately following, the point of opening of the exhaust ports, and the latter results from the acceleration of the exhaust gases outwards under rapid entry of the air. The excess in the rate of entry of the air over that of the rate of discharge of the exhaust gases from 200 deg. onwards brings about the progressive increase of the pressure in the cylinder. The integration of the areas under the curves gives the volumes of the air and exhaust gases to be 4.215 litres, corresponding to $\lambda_0 = 1.405$ for the swept

Fig. 20.



volume of 3 litres, a close approximation to the measured values.

Professor List, in his books, uses three efficiencies with reference to the parts of the complete charging process: λ_r , defined as the ratio of the volume under atmospheric conditions of the trapped or combustion air to the swept volume, and termed net volumetric efficiency in Table IV, he calls the delivery efficiency; λ_g , defined as the ratio of the volume under atmospheric conditions of the total charge in the cylinder at the beginning of compression to the swept volume, he calls the charging efficiency; and λ_s , the proportion of the pure air in the total charge in the cylinder at the beginning of compression, he calls the scavange efficiency. It is clear that $\lambda_s = \lambda_r \div \lambda_g$. In the calculations, $\lambda_s = 0.845$; $\lambda_r = 0.6$; $\lambda_g = 0.71$. λ_s is also given closely by $1 - \frac{CO_2'}{CO_2''}$, in which CO_2' is the percentage of CO_2 in the gases during compression and CO_2'' is the percentage in the undiluted exhaust gases. In the experimental curve of Fig. 15, page 771, ante, $CO_2' = 1.5$ and $CO_2'' = 9.5$, giving $\lambda_s = 1 - \frac{1.5}{9.5} = \frac{8.0}{9.5} = 0.842$, a value that is in good agreement with the calculated one.

Earlier, in dealing with point Z in Fig. 8, page 769, ante, which gives the composition of the cylinder charge, the proportion of oxygen by volume was found to be 0.904 of that of pure air. This value, while it gives a criterion of the efficacy of the scavenging process, leaves out of account the composition of the exhaust gases that have to be dealt with.

The author has added the outline of this analysis at the end of his report on the engine since, apart from its intrinsic interest in relation to the subject of two-stroke engines, it gives confirmation that the designers, in their work, have not depended upon trial and error, but have reasoned scientifically from the elements of the design and, by calculation, have arrived at what they consider to be the best compromise among these elements. The results of the tests set out above indicate how well they have succeeded in their object.

AIRCRAFT EXPORT POSSIBILITIES.—The British aviation industry are well aware that they have, at the present time, a unique opportunity for developing the export of civil air liners, provided that they can guarantee reasonable delivery dates. The Government are equally aware of the possibilities, and they are trying to avoid conflict between the needs of the export market and the heavy demands of the defence programme, it is stated in the June *Bulletin for Industry*, issued by the Information Division of the Treasury. The Comet, already in operation, is the first jet air liner in the world, and the Viscount and the Britannia, when they enter service, will be the first propeller-turbine air liners. In the fairly near future, many of the world's air-line fleets will be due for replacement, and it is expected that there will be extensive orders from overseas for turbine-engined air liners. Although the capacity of the aircraft and aero engine industries is increasing rapidly, however, there are still serious shortages, particularly in skilled labour.

* Der Ladungswechsel der Verbrennungskraftmaschinen: Part I. H. List and G. Reyl; Part II. H. List. Springer-Verlag, Vienna.

OPEN DAY AT THE NATIONAL PHYSICAL LABORATORY.

THE National Physical Laboratory's annual open-day exhibition was held this year on May 23, when a large number of guests, representative of science and industry, were afforded an excellent opportunity of seeing something of the work of the establishment. The activities of the Laboratory now cover such a wide field, however, that little more than an impression of their extent can be gained in a visit lasting a single day. Besides the fundamental research, which appears to grow in diversity and complexity with the years, there is the ever-increasing volume of routine test work, and the work of maintaining standards and determining physical constants with high accuracy. In the last-mentioned category, there have recently been precise determinations at the Laboratory of the dielectric constant of air and the unit of electrical resistance.

To accord with changing requirements, certain of the older buildings at Teddington have recently been put to new uses. Aerodynamics having largely migrated to the realm of higher speeds, the old aerodynamics building has been modified internally and is now given over to electronic computing, for which there is an ever-increasing demand. The engineering building, largely forsaken by its former occupants, most of whom have now moved to the Mechanical Engineering Research Laboratory, at East Kilbride, has become an outpost of the Physics Division. A central workshop and drawing office have also been established, and the routine test work has been centralised in the former glass-testing building. Some new accommodation is also being provided. The work of the Laboratory is now shared by ten Divisions, an electronics section, which originated in the Radio Division, and the central Test House. It is not possible to make specific reference to the work of all of these, but a few of the many interesting exhibits are mentioned below.

AERODYNAMICS.

Among the present work of the Aerodynamics Division is an investigation, in the high-speed wind-tunnels, of the formation and movement of shock waves on the surface of an aerofoil moving at high subsonic speeds. These changes in the flow pattern can cause rapid variations in the hinge moments and efficiency of control surfaces affixed at or near the trailing edge, with the result that an application of the control at high speeds may produce a result differing widely from that obtained at lower speeds. These phenomena are of great importance in flight. Their causes are being investigated in the high-speed tunnel building where a demonstration was given of the work which is at present concentrated on a 10 per cent. thick aerofoil with a 25 per cent. control surface. To investigate the effects of turbulence in the boundary layer, provision has been made for fixing the transition to turbulent flow close to the leading edge by allowing a small quantity of air to flow into the boundary layer through a line of small holes along the span.

If the boundary layer on a wing or other body moving at a high speed encounters a shock wave, it may thicken and separate from the surface, and this may modify the shock wave. Such occurrences, also, have important effects on the characteristics of wings and have been studied at the N.P.L. for several years. Recently, however, a small wind-tunnel has been built in which greater ranges of Mach and Reynolds numbers than had previously been possible can be covered in the experiments.

ENGINEERING.

As already mentioned, most of the staff and the bulk of the equipment of the former Engineering Division at Teddington have now been transferred to Scotland and, except for certain sections which still await transfer there, the remainder of the work formerly classed as engineering has been taken over by other Divisions. It includes researches on elasticity and the physics of the solid state which are now the responsibility of the Physics Division. Among the exhibits of interest shown by the section

concerned was one demonstrating the effect of local skin-buckling on the flexural rigidity of a strut. In a letter published in our issue of March 14, 1952 (page 340, *ante*), Mr. H. L. Cox and Mr. D. L. R. Bailey drew attention to the fact that, under certain types of loading of a strut, instability in bending can occur under an abnormally low load. An example cited was a strut clamped at one end and loaded through a prop, the far end of which was held in the original line of the strut. The Euler load for such a strut is $k \left(\frac{\pi^2 EI}{l^2} \right)$ where k , which is unity for a simply-supported strut, varies between 0 and $\frac{1}{4}$ as the ratio of the lengths of the prop and strut varies from zero to infinity. When the two are of equal length, $k = 0.14$, approximately.

In the demonstration, the strut consisted of a thin-walled brass tube of square cross-section, each side being $1\frac{1}{2}$ in. long. The strut was mounted vertically and clamped at the base, a short square plug being inserted there to prevent local collapse at the clamp. The load was applied vertically downwards on the upper end through the prop, and the value of k was varied by changing the lengths of the strut and prop while maintaining the sum of their lengths constant. With a value of k equal to 0.12, approximately, local skin-buckling of the loaded strut immediately precipitated bending in the first Euler mode; at lower values of k , however, bending preceded buckling. The advantage of the method, in such a case, is that the effect of local skin-buckling on flexural rigidity may be investigated without the use of very long struts, which are difficult to make accurately. Had the strut been simply supported, for example, k would have been unity and a strut almost three times as long would have been necessary to reduce the critical bending load to the appropriate order.

Among the other exhibits in the former Engineering Building was a torsionmeter which was developed by the Ship Division for use on ship trials. Commercially manufactured torsionmeters are fitted to many ships as part of their permanent equipment and are generally satisfactory if suitable precautions are taken. The N.P.L. instrument was not designed as an alternative to these, but purely as a readily portable and adaptable instrument for the use of the research staff. The principle on which it operates is similar to that of commercial types of torsionmeter, in that the angular deflection of a length of shafting is measured by electrical inductance gauges. The major practical difference is that the deflection is transmitted from one end of the gauge length to the other by means of a small tube lying parallel to the shaft instead of by a cylindrical shell concentric with it. This has permitted the size and weight of the instrument to be reduced very considerably. The instrument is carried on hardened-steel points bearing on the shaft, and is clamped to it by chains. By screw adjustment of the chains and points, any shaft with a diameter between 14 in. and 22 in. may be tested.

The angular movement is converted into a longitudinal movement by an ingenious method. A cylindrical mild-steel tube, which forms part of the torque-transmitting tube, is machined with two sets of opposed helical slots which are disposed symmetrically about its central cross-section. A short length in the centre is left unslotted and serves as a mounting for a small laminated armature. When the tube is twisted, the angles of the helices change, one increasing and the other decreasing, so that, while the tube remains unaltered in length, the central section moves axially. This displaces the armature relatively to the open cores of two inductances which are mounted on the ends of the tube and separated from the armature by small air gaps. For example, a twist of 10 min. alters the air gaps by equal and opposite amounts of 0.0015 in. The relation between the torsion and the change in the ratio of the inductances, which is measured by means of an alternating-current bridge supplied by an oscillator of 1 kilocycle per second frequency, is approximately linear. The oscillator also controls a ring modulator into which the out-of-balance signal from the bridge is fed after it has been amplified. A galvanometer, connected to the modulator output, indicates the out-of-balance component at a phase approximately

that of the oscillator and, thus, the effects of resistance changes in the inductances are minimised. The amount of torsion is indicated by the setting of the potentiometer used to balance the bridge, the potentiometer having been calibrated directly by optical measurement of the torsion when the rig was twisted statically. It was found that one scale division of the potentiometer corresponded to a torsion of 1.7 seconds, approximately.

ELECTRICITY.

The Electricity Division has been making highly accurate determinations of the dielectric constant of benzene and showed the apparatus used for this purpose. The reason for such work is that measurements of the dielectric constants of pure liquids provide information about their constitution and it is convenient to have one liquid as a standard. Benzene is widely used for this purpose, and also as a standard when other physical properties have to be measured. The apparatus shown consisted of a measuring cell the capacitance of which was measured first when the dielectric medium was air and then when the cell was filled with benzene. The ratio of the capacitances was the dielectric constant of benzene. Precautions had to be taken, however, to ensure that none of the lines of force passed through solid insulating material in the cell. The cell shown was designed specially to ensure this. It consisted essentially of electrodes in the form of concentric tubes of platinum, fitted with a guard ring and mounted in a glass container. The benzene, supplied in a highly purified condition, was distilled directly into the cell after it had undergone treatment to remove traces of dissolved gases and water. The preliminary measurements of capacitance were made at a frequency of 1,000 cycles per second and at temperatures ranging from 5 deg. to 30 deg. C.

LIGHT.

In reviewing the exhibits at the Laboratory's Jubilee Exhibition in 1951 (*ENGINEERING*, vol. 171, page 714), we gave a description of a novel method for the manufacture of diffraction gratings which had been suggested by Sir Thomas Merton and developed by the N.P.L. with considerable success. Examples of the Laboratory's work in this field were again on view and it was stated that the new diffraction gratings are finding a ready application in the important field of infra-red spectroscopy, where they are replacing costly prisms.

More recently, on page 333, *ante*, we gave a short account of the Laboratory's work on the deposition of transparent conducting films on glass, and the use which might be made of the electrical resistance of such films when it was desired to keep window glass free of frost or mist by heating it in cold weather. Samples were on view of glass coated with a layer of gold about one-quarter of a millionth of an inch thick. The deposition of such a film by any one of several well-known standard methods presents no difficulty, but the electrical resistance is almost invariably much higher than would be expected from the amount of gold in the film, and, although the latter is by no means opaque, it absorbs a considerable amount of light. By the method invented at the N.P.L., however, films can be made of the same thickness with about one-tenth of the resistance of the others and less than half their optical absorption, and the results in any one case are closely reproducible. A glass window, coated with such a film, is reasonably transparent and can be heated strongly by the passage of an electric current at a moderate and safe voltage, with the result that the de-icing of aircraft windows under relatively severe weather conditions is possible without difficulty or risk.

METALLURGY.

The exhibits in the Metallurgy Division included examples of tensile-test specimens prepared in a novel way. In general, such specimens are produced by ordinary machining methods, because their cross-section is large enough for the influence of the thin surface layer, strained in the machining operation, to be disregarded. When, however, a tensile testing machine was acquired by the Division for which the standard specimen was only $\frac{1}{8}$ in. in diameter, surface effects could no longer be ignored; indeed, experiment showed that, on

soft materials, ordinary machining was ruled out. The problem of making specimens of the requisite shape was solved by adopting an electrolytic machining process, the specimen under manufacture being the anode of a cell of the following unusual form.

The specimens require to be produced in the standard form with an accurately uniform cylindrical shank and ends having the requisite curvature. To produce this, the blank is rotated rapidly and moved slowly to and fro along its axis at a steady rate while a jet of electrolyte plays on it. The spray which whirls off is caught by a glass cylinder surrounding the blank and is returned to a storage vessel. An electric current passed between the blank, as anode, and a cathode in the jet causes the blank to be dissolved slowly, and the rotation and reciprocation of the specimen ensure that the process is uniform and the desired shape attained. The latter can be checked by means of a microscope mounted above the blank. If the current is large enough and the electrolyte suitable, a truly electro-polished surface is produced which is free from irregularities even when viewed under a high-power microscope.

METROLOGY.

Mention has already been made of the employment of radio waves as yardsticks. Their value for this purpose derives from the fact that even short radio waves are long by comparison with light waves. The optical wavelengths generally used in interferometric measurements of length range from 17 to 25 millionths of an inch and have been measured accurately in terms of the standard yard and metre. Owing to the difficulty of counting interference fringes, however, such minute waves are somewhat unsuitable for measuring distances greater than about 1 yard or 1 metre. Radio waves ranging from about 4 mm. to 12.5 mm. in length, that is, about 10,000 to 20,000 times as long as the optical waves mentioned above, would, however, be very suitable for determining longer distances with a corresponding relative accuracy. The possibility of using such waves for this purpose is being explored at the Laboratory and, recently, radio waves 12.5 mm. ($\frac{1}{2}$ in.) long, generated by a Klystron valve, were successfully applied to measure a distance of about 5 ft., the error in the measurement being not more than 0.0001 in., approximately. The technique which has been developed shows considerable promise of extension to distances of the order of 100 ft., or more.

In an experimental test-rig shown in the Metrology building, radio waves generated by a Klystron oscillator at a frequency of 24,000 megacycles per second, accurately determined from the frequency of the standard quartz oscillator, were radiated from two horns which faced one another at opposite ends of the room. Two receiving horns were mounted on a carriage supported on rails between the transmitting horns. As the carriage was displaced in the line of the transmitting horns, the amplitude of the signal, consisting of a mixture of the two signals received, varied between maximum and minimum values as the relative phases of the components arriving at the receiving horns changed with the displacement. The object of the experiment in this case was not to measure the displacement of the carriage but to determine the velocity of electromagnetic waves *in vacuo* from a knowledge of the carriage displacement, the wave frequency and the refractive index of air. The last-mentioned quantity had been determined accurately by experiments with a cavity resonator; the displacement of the carriage over a known number of signal minima was measured by means of a calibrated micrometer and slip gauges. Preliminary experiments with a different experimental set-up, but employing the same basic principles, gave a value for the velocity in close agreement with that obtained previously at the Laboratory by Dr. Essen using a cavity resonator (see *ENGINEERING*, vol. 170, page 442 (1950)). Owing partly to the longer base which can be used for measurement and also to the elimination of uncertainties as regards the effective electrical-diameter of a cavity, which is not quite equal to the physical diameter, it is hoped that it will be possible to determine the velocity of propagation of electro-magnetic waves with greater accuracy than formerly.

CENTRALISED MAINTENANCE AT THE WORKS OF MESSRS. STEEL, PEECH AND TOZER, ROTHERHAM.

(Concluded from page 767.)

In the previous instalment of this article, we gave a plan of the central maintenance shops, and described the allocation of the different departments in its four main bays. Fig. 5, on page 806, shows the portion of No. 1 bay in which the making and testing of chains are carried on. This section of the plant is responsible for the manufacture and testing of most of the chains used in the steelworks and, obviously, is vital to the smooth running of the plant. Some 4,000 tackles are in use on the plant and these have to be maintained according to the statutory regulations. At the intervals required by the Factory Acts, chains are put through a regular procedure, comprising inspection, repair if required, annealing, testing, and stamping with the working load and chain number. Records are kept systematically of all these operations. Apart from this, inspections are made at intervals of the chains in use and any that are suspected to be defective are taken out of service and distinguished by a metal "unsafe" tag, which is removed only after a satisfactory repair has been made by the chain-smiths. The section is equipped with a hydraulic chain-testing machine, to be seen in Fig. 5, which is capable of testing up to 75 tons; a gas-fired annealing furnace; two blacksmiths' fires; a 5-cwt. hammer; and chain storage facilities.

The blacksmiths' shop, also in No. 1 bay, is equipped with a 15-cwt. hammer, a 5-cwt. hammer, a gas-fired furnace for heavy billets, and five blacksmiths' fires. The fires are metal units with down-draught equipment. Each hearth has its own blast fan, and the exhaust from the hoods is drawn through a common underground duct by a large fan, discharging to a chimney outside the building. The hammers are of the electro-pneumatic type. Each is placed on a concrete block mounted on a Mascotte pad, and there is a filling of about 6 in. of sand round each unit to isolate the vibration of the hammers from the body of the shop. Jib cranes are installed for handling heavy pieces. Heavy steel slabs are laid round the hammers and anvils to protect the concrete floor against accidental damage by hot forgings.

The locomotive repair section is provided with all necessary facilities for repairing and rebuilding steam cranes as well as steam and Diesel locomotives. The inspection pits are fitted with fixed electric lights to give an even illumination, as free from shadows as possible.

In No. 2 bay, allotted to the boiler-smiths, the equipment includes a hydraulic bending press, plate rolls, shears, and drilling machines. In this shop is produced a high proportion of the plating work and welded construction required within the main body of the plant.

The machine shop is equipped with a wide variety of machine tools, transferred from the existing maintenance workshops within the steelworks. It occupies No. 3 bay, and is illustrated in Fig. 6, on page 806. A number of new machines have been added and so the shop is capable of great adaptability; but no attempt has been made to equip the shop to undertake very heavy work, as there are other shops in the steelworks which can deal with such special jobs. Level with the cab of the overhead travelling crane to be seen in Fig. 6 is the access walkway, referred to on page 767, *ante*, provided for the convenience of the crane drivers, which is constructed between the main stanchions of the shop, as shown in Figs. 7 and 8, on page 807.

THE CENTRAL STORES.

The central stores is situated at the north end of the building housing the central maintenance workshops. The departmental area comprises two bays measuring 175 ft. by 60 ft., one bay 125 ft. by 60 ft., and a fourth bay 162 ft. 6 in. by 60 ft. Storage space is available on two floors, and a series of light wells are let into the first floor in order to provide natural light on the ground floor. Fig. 7, on Plate L, shows one of these wells and

conveys a good impression of the spacious provision made for storage. All items on charge are held in Sankey-Sheldon adjustable steel bins or racks suitable to their shape and size. Exceptionally bulky materials receive special attention and are maintained either in well-defined areas within the stores or in the open spaces adjacent to the building, a part of which is illustrated in Fig. 8, on Plate L, where they are painted and supported on specially-constructed concrete bearers to keep them off the ground. These bearers can be seen in position under the parts stacked beside the left-hand access road in the illustration. A complete barrier is constructed between the workshops and the stores, so that withdrawals can be made only at certain points.

Advantage has been taken of the level of the site to provide natural loading and unloading bays, thereby avoiding double handling of materials. In addition, a special ramp has been prepared to allow light trucks from the steelworks to run up to stores floor levels. Because of the size of the works, most items are delivered directly to consumers by a routine daily delivery service. Separate walled-off areas have been allocated for receipts by road and rail and subsequent inspection, assembly prior to road deliveries from the stores to consuming departments, and what are termed "pedestrian" issues. Weighing machines are provided at the receipts and issues points.

Over each loading and unloading dock is a 1-ton mono-rail lifting block. Movement of items from one floor to another is effected by means of an electrically-operated hoist. For lateral transport, fork-lift and Collis trucks are used. To maintain control over materials, stock records are held separately, in visible index form, in the central stores office.

A separate building houses the bulk quantities of all lubricating oils used on the works, an arrangement which is expected to result in great economies in usage and distribution costs. The building measures 120 ft. by 50 ft. and is of simple steel-framed construction. The brick walls are 14 ft. high and are continued with Robertson sheeting above that level. Oil is stored here either in barrels or in bulk tanks, according to the rate of usage. The tanks provided comprise three of 500 gallons capacity and eight of 250 gallons, all of these being of mild steel, and two galvanised tanks of 500 gallons capacity, for holding paraffin, etc. These tanks are supported on a concrete platform 3 ft. 8 in. high, extending over the entire length of one wall of the oil stores. Barrels are transported by a fork-lift truck. Such allied items as waste, grease and paint are also held in this store.

The wagon repair and pattern shops occupy adjacent sites on ground to the south of the central maintenance workshops, each being housed in a building measuring 150 ft. by 50 ft. The wagon shop, which is illustrated in Fig. 9, on Plate L, is provided with a 5-ton electric overhead travelling crane of 47 ft. span, which is controlled from the shop floor by pull ropes. A rail track passes into the shop, and, in addition, there are lay-by sidings for wagons awaiting repair. The first 60 ft. in length of the pattern shop (Fig. 10, on Plate L) is devoted to storage, on the ground floor, of timber, and, on the first floor, of patterns. The shop is used both for normal joinery work and for pattern-making, and therefore is equipped with modern woodworking machinery and refuse-collecting plant. Heating of both these shops is provided from the main boiler house by an effectively lagged pipeline. At the side of the pattern shop is a structure, measuring 75 ft. by 25 ft., that contains the building repair section and stocks of such items as cement, etc. Here there is also a cyclone house for dealing with the wood refuse from the wagon and pattern shops.

ADMINISTRATION BUILDINGS.

The main administration building is a two-storey structure, 475 ft. long and 30 ft. wide, which provides accommodation for various essential facilities. On the ground floor, to the right of the entrance, are part of the main offices, and on the left various washplaces, etc., the time office, the mechanical workshop, a library and lecture room, and the stores entrance and office. On the first

floor are the precision workshop, mess room, lavatories, and the remainder of the main offices, which are situated over the office rooms on the ground floor.

The engineers' and stores' offices comprise the offices of the plant inventory department, the planned-maintenance planning engineer and his staff, and other senior engineering executives. The office walls are covered with Panalac sheathing, supplied by British Plastics, Limited, of Blaydon-on-Tyne, and fixed by Plyware, Limited, of Widnes, with Sankey-Sheldon adjustable metal and glass partitions to divide the office areas. The floors are made of Monophalt mastic asphalt, laid by Highways Construction, Limited, Manchester. The first floor of the office block, and, incidentally, the floors of the central stores, are supported on pre-cast concrete beams. The principal facing material of the building is rustic brickwork. The windows are set in cast stonework, with stringers and coping of similar material.

A novel feature of the interior decoration is that the internal walls are covered with aluminium sheets coated with coloured plastic material—the Panalac referred to above. These sheets have a hard surface, coloured according to requirements. In this particular building, the offices, lecture rooms and library are a light rose colour, the mess room is cream, and the lower portions of the walls in the amenity rooms are covered with a black marble surface, the upper portions being cream.

For many years it has been the company's aim to provide up-to-date amenities, but building restrictions and planning problems have prevented an earlier fulfilment of this ambition. Great progress, however, has been made in this direction during the post-war years and facilities are now available for about two-thirds of the workpeople employed. Amenity centres have been erected at carefully chosen sites on the works and contain heated lockers (one per man), lavatory accommodation, showers and washing facilities, drinking fountains, mess room, and clocking facilities. The whole scheme has the support of the Works Council at Messrs. Steel, Peech and Tozer, whose members have considered and discussed it. At the amenity centre within the central maintenance workshops, lockers are provided for 640 persons and there is a mess room capable of seating 260.

The training centre has a workshop fully provided with the necessary machinery and tools, a library and a lecture room. The lecture room is equipped with apparatus for showing films, film strips and lantern slides. The centre is in the charge of fully qualified staff, and facilities are available for providing practical training for the many grades of apprentices and operatives employed by the firm.

The precision workshop is appropriately equipped for the repair of instruments, gauges and other delicate mechanisms. The increasing use of instruments and recording devices in the steel industry has brought attendant problems concerning their maintenance, and it is believed that the precision workshop will fill a long-felt want.

To provide heating for the central maintenance workshops, central stores and nearby fabricating department, a boiler house measuring 50 ft. by 60 ft. has been erected on a site to the east of the workshops. The building contains three boilers, supplied, with the heating equipment, by the Brightside Foundry and Engineering Company, Limited, Sheffield, which serve the workshops and stores. These comprise a reconditioned Davey Paxman "Economic" boiler, which was the first to be installed, and two new Cochran boilers, 9 ft. in diameter and 23 ft. long. They are fitted with burners to use either fuel oil or coke-oven gas, or a mixture of both, the gas being supplied through 16-in. and 18-in. mains (indicated in Fig. 2, on page 766, *ante*) from a coke-oven plant some miles distant. The fuel-oil tanks are fitted with electric heaters to bring the oil to a suitable temperature and viscosity before feeding to the burners. As ancillary equipment there is an Alley and McLellan air compressor capable of delivering 300 cub. ft. per minute at 100 lb. per square inch pressure.

Heating for the workshops is by high-pressure hot water, at a temperature of 312 deg. F., which is circulated by centrifugal pumps situated in the

CENTRALISED MAINTENANCE IN STEELWORKS.

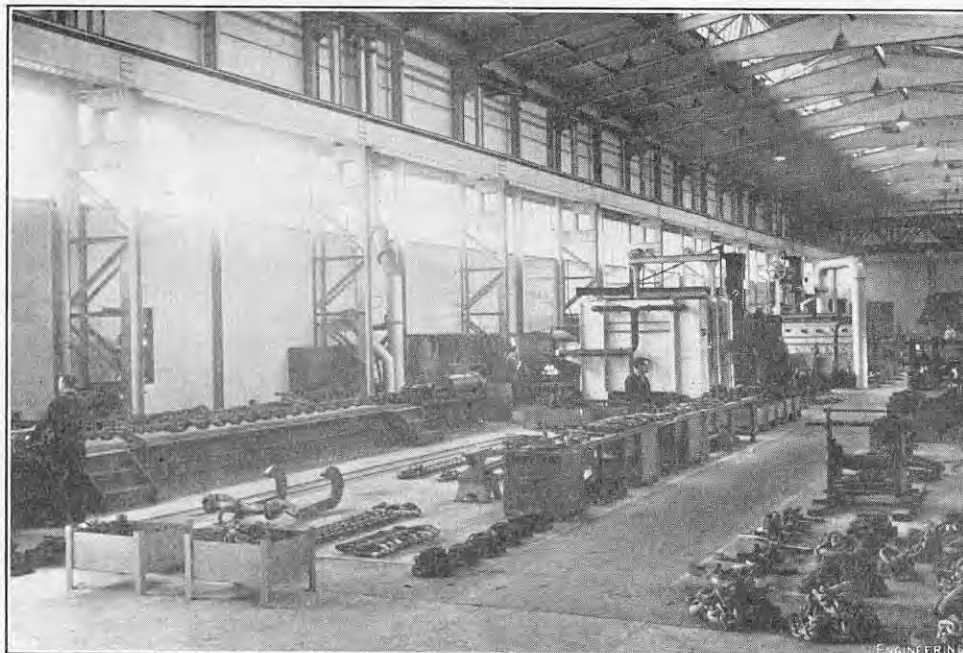


FIG. 5. CHAIN-TESTING SHOP.



FIG. 6. MACHINE SHOP.

boiler house. Warm air is passed into the main shops through overhead downstream units, the output of which is designed to keep the interior of the building at a temperature of 60 deg. F. when the outside air temperature is 32 deg. F. The offices are heated by convector-type radiators, together with a heater battery with a duty of 6,000 cub. ft. of air per minute, raising the temperature from 30 deg. to 100 deg. F. All air is filtered through renewable metal-cotton wool filters.

POWER, LIGHTING AND VENTILATION.

The electric power supply is taken from the high-tension main of the British Electricity Authority. It is received as alternating current at 6,600 volts, and two transformers reduce the voltage to 440, alternating current, for distribution to the machines. The lighting circuits distribute alternating current at 240 volts. In the main workshops, the lights are fixed above the level of the cranes. The roof lighting consists of three lines per bay, each line having alternate tungsten-filament and mercury-

vapour lamps. In the stores and administration buildings, tungsten and fluorescent lamps are used, as required by circumstances.

The main workshops are fitted with Robertson ventilators, each provided with a flap that can be closed by chains and counterweights. Fresh air can be drawn from outside and distributed to the workshops, a feature which, no doubt, will be particularly useful during summer months.

The buildings described above constitute, in effect, a self-contained and modern engineering works, operated independently of the day-to-day maintenance of the steelworks. Some 400 men are employed on a two-shift basis and they work under what are claimed to be almost ideal conditions. The design of the workshops and the many new machines that have been installed mean that there can be more systematic production of the many varieties of spares required to keep the plant in operation. The company are confident that notable advantages will be derived by reason of the action it has taken in providing central maintenance workshops. In

CENTRAL MAINTENANCE WORKSHOPS OF STEEL, PEECH AND TOZER, LIMITED.

(For Description, see Page 805.)



FIG. 7. UPPER FLOOR OF STORES.



FIG. 8. OUTSIDE STORAGE SPACE.

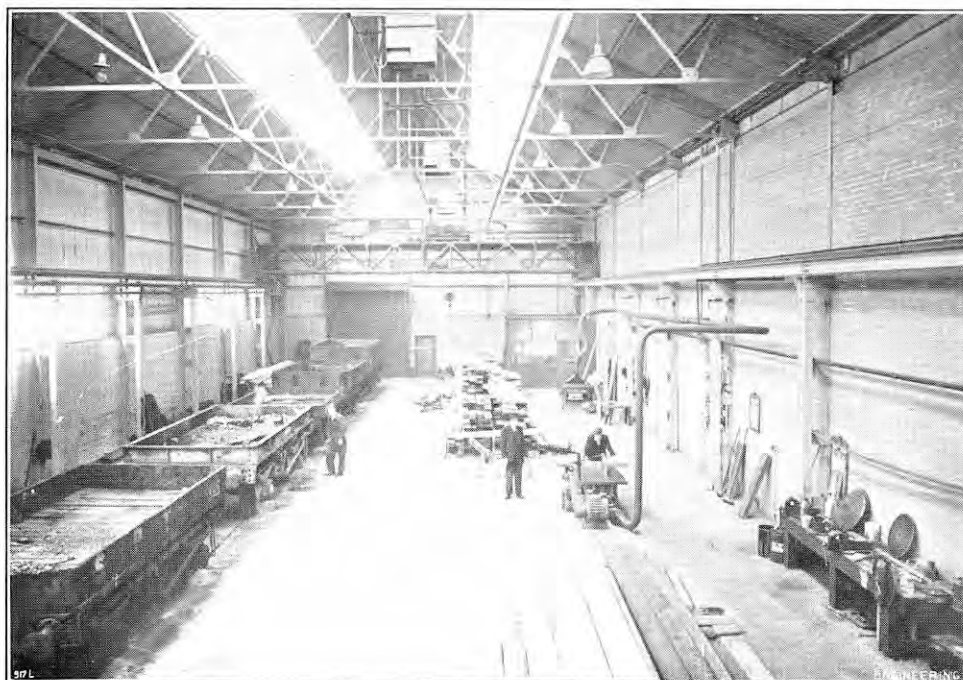


FIG. 9. WAGON REPAIR SHOP.

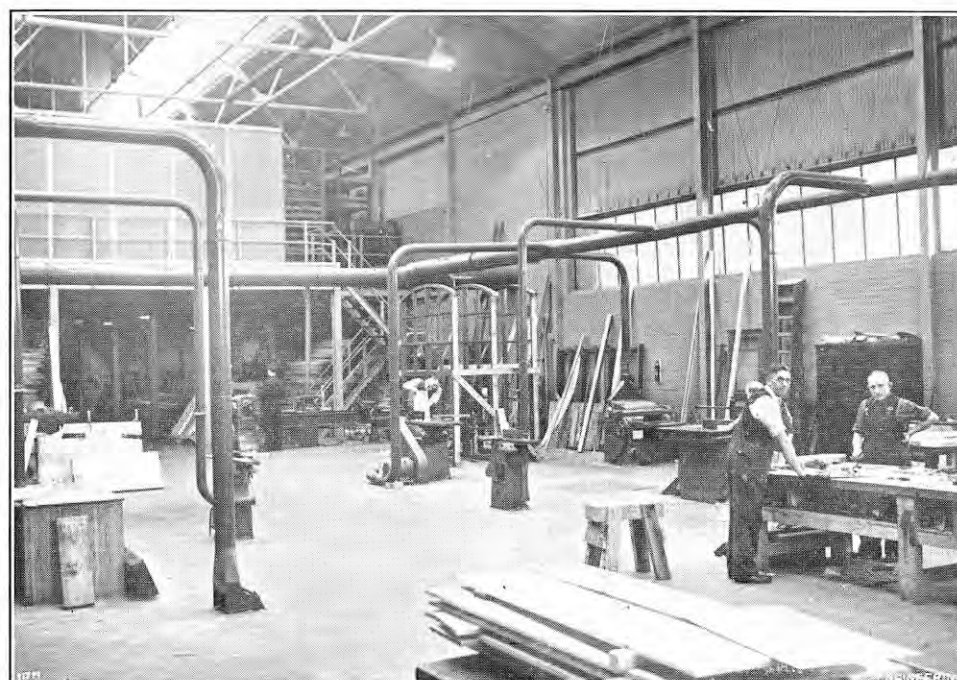
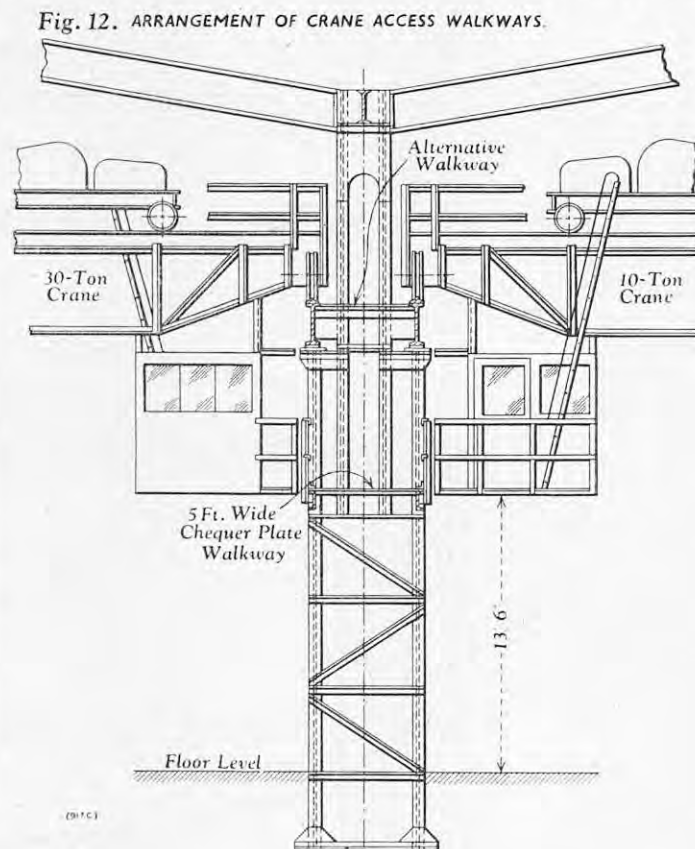


FIG. 10. JOINERS' AND PATTERN SHOP.

CENTRALISED MAINTENANCE WORKSHOPS OF STEEL, PEECH AND TOZER, LTD.



FIG. 11. WALKWAY FOR ACCESS TO CRANES.



(20' C)

Fig. 12. ARRANGEMENT OF CRANE ACCESS WALKWAYS.

particular, it is expected that there will be an all-round improvement in the use of labour and materials, since careful planning should decrease waste; that time and money will be saved by the prior preparation of materials and instruction of the maintenance fitters; and that the repair load will be evened out and the amount of emergency work decreased. Moreover, a closer control of costs should be achieved, which means that adequate financial provision can be made in advance for future maintenance work, and the risk of breakdowns should be lessened, thus contributing to the greater productivity of the plant. Provision has been made in the design of the central workshops to deal with electrical repair work also, though at present this is mainly dealt with elsewhere. Eventually, it will be transferred to the new shops.

In the course of this article, reference has been made to several of the contractors who have been responsible for various features of it. There are, however, several others of whom mention may be made. For example, the contract for the general building work was placed with a local firm, Messrs. Arthur Cooper and Sons, Limited, of Greasborough, Rotherham, that for the electrical work with Messrs. F. H. Wheeler (Sheffield), Limited, of Sheffield, and that for the extensive road-surfacing with Tarslag, Limited, of Wolverhampton. The whole of the overhead electric travelling cranes were supplied by the Butterley Company, Limited, of Derby; the windows and patent glazing by Messrs. Mellowes and Company, Limited, Sheffield; and the precast concrete "stonework" by Kingston Concrete Products, Limited, Hull, except for that of the main entrance, which was provided by the Empire Stone Company, Limited, of Leicester.

LECTURE COURSES ON ROAD MATERIALS AND CONSTRUCTION.—During the autumn and winter of 1952 to 1953, lecture courses, on the fundamental properties of road materials and their application in modern practice, will be held at the Road Research Laboratory. Courses in soil mechanics will be held from October 14 to 24, and from October 28 to November 7; courses in concrete, from November 18 to 27 and from December 2 to 11; and courses in tar and bituminous materials, from January 6 to 22, 1953, and from January 27 to February 12. The fee for each course is 10 guineas. Application forms may be obtained from the Director, Road Research Laboratory, Harmondsworth, Middlesex.

ANNUALS AND REFERENCE BOOKS.

The Anglo-American Year Book, 1952.

Edited by MISS PHYLIS HAMLIN and published by the American Chamber of Commerce in London, 7, York Buildings, Adelphi, London, W.C.2. [Price 25s. net.]

THE 40th edition, that for 1952, of *The Anglo-American Year Book*, has recently been published. All the familiar sections are to be found in the new edition and, as heretofore, the book opens with lists of personnel and data regarding the United States Cabinet, the American Embassy in London, the British Cabinet, and British official bodies in the United States. Probably the most useful feature for industrial and business firms in Great Britain is the commercial directory. This consists of an alphabetical list of British and United States business firms and each entry followed by the reference "see" has a representative on the opposite side of the Atlantic. The address of the representative can then be turned up in its alphabetical order. Other useful features include lists of the members of the American Chamber of Commerce in London and of the names and addresses of American citizens residing in Great Britain, a classified-trades list covering members of the American Chamber of Commerce and certain other firms, data regarding Anglo-American organisations and clubs, and chapters on such subjects as "American Law for Britons," and "English Law for Americans."

Engineering Industries Association Classified Directory and Buyers' Guide, 1952-53.

Fourth edition. The Standard Catalogue Company, Limited, 26, Bloomsbury-way, London, W.1. [Price 32s. 6d.]

It is probable that most readers of *ENGINEERING* are familiar with the *Engineering Industries Association Classified Directory and Buyers' Guide*, the fourth edition of which has been issued recently. It contains a complete record of members of the Association and their products, and is distributed to chambers of commerce and trade commissioners throughout the world and to other trade organisations. As in previous volumes, it is arranged in two sections. Part I contains an alphabetical list of members' names, addresses, and telephone numbers, with a brief summary of their products. Part II is a classified list of products and processes, with the names of their manufacturers, arranged in alphabetical order. This section of the book includes nearly 200 pages, and, as might be expected, covers a wide range of activities, with a reasonable degree of sub-division and with adequate cross references. Most organisations require, from time to time, information on where they can obtain certain engineering services, and for such purposes the Directory will be found to be a valuable guide.

Bulletin de l'Association Technique Maritime et Aéronautique, No. 50 : Session de 1951.

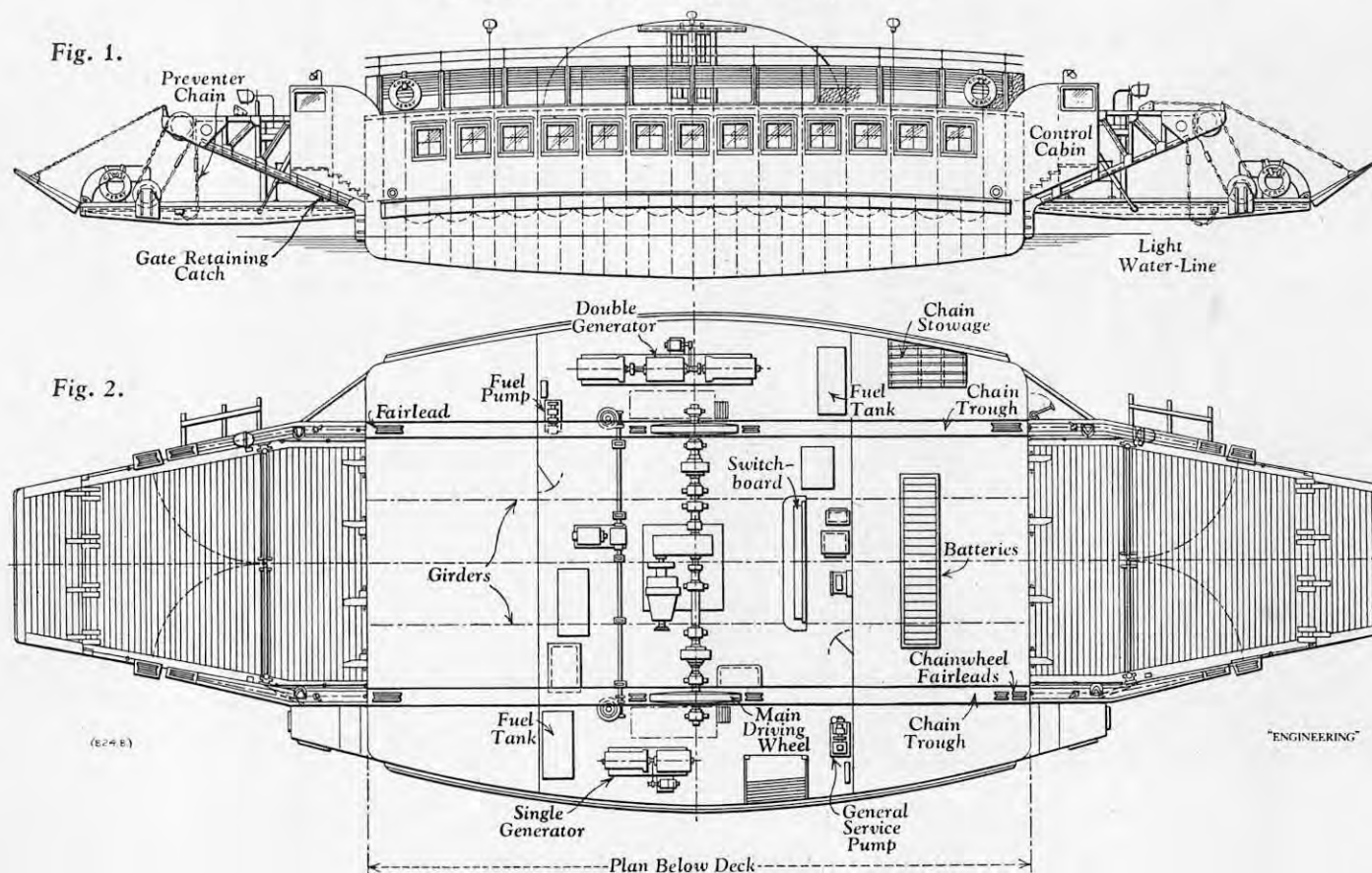
Published by the Association, at 1, Boulevard Haussmann, Paris 9e, France. [Price 5,000 fr., plus postage.]

LIKE the *Transactions* of the Institution of Naval Architects, those of the corresponding French association cover a wide range of subjects connected with ships and marine machinery; but the inclusion of aeronautical topics within the purview of the Association adds a further variety to the papers, though in the present volume, only about 20 per cent. are directly concerned with aircraft matters. There is the customary assortment of papers on hull construction, welding, ship-model testing, etc., among which mention may be made of one by Dr. J. Laurent, Director General of the Laboratoire Central d'Hydraulique, describing a simplified apparatus for towing models at high speeds, up to 18 in. per second. Another paper of particular interest is that of Mr. S. Eustaze, recording the results of a large number of wind-tunnel tests of different forms of funnels for ships, in the endeavour to evolve a design that will keep smoke clear of the decks. This is a subject which has engaged the attention of naval architects for many years, especially in France, whence some extremely bizarre designs have emanated, but it is evident that finality is not yet in sight.

FUELLING VEHICLE FOR "COMET" AIR LINER.—An articulated semi-trailer fuelling unit, suitable for use on the roads in the Singapore and Bangkok territories, has been designed by the Shell Petroleum Co., Ltd., St. Helen's-court, London E.C.3, for fuelling Comet air liners at Singapore and Bangkok. The new vehicle, known as the Thornet, comprises a semi-trailer tank unit with a fuel capacity of 1,800 gallons, for use at Singapore, and 1,500 gallons, at Bangkok. The tractor for use on the airport comprises a Sturdy Star petrol-engined chassis, supplied by Messrs. John I. Thornycroft & Co., Ltd., Thornycroft House, Smith-square, London S.W.1, which has been provided with a fifth-wheel attachment at the rear to enable it to be hitched to the tank unit. A pumping unit and split transmission power take-off developed by Messrs. Thompson Brothers (Bilston), Ltd., is fitted to the chassis. In operation, the tank unit will be hauled between the fuel-supply depot and the airport by a conventional tractor, the Thornet tractor operating only on the airfield. Two Thornet fuellers will be used together to fuel a Comet air liner at up to 400 gallons per minute. The Comet will normally require to take on up to 3,000 gallons of fuel at Singapore or Bangkok, and the delivery should, therefore, be easily completed in 10 minutes. By providing additional bulk units adjacent to the two Thornets, 6,000 gallons could be transferred in less than 30 minutes.

DIESEL-ELECTRIC CHAIN FERRY FOR COWES, ISLE OF WIGHT.

J. BOLSON AND SON, LIMITED, POOLE.



DIESEL-ELECTRIC CHAIN FERRY.

IN Figs. 1, 2 and 3, on this page, we illustrate a Diesel-electric chain ferry constructed by Messrs. J. Bolson and Son, Limited, of Poole, Dorset, for the crossing of the River Medina between Cowes and East Cowes, Isle of Wight. The ferry pontoon is 52 ft. 6 in. long, with a moulded breadth of 38 ft. 9 in. and an extreme breadth of 39 ft. 9½ in., and a moulded depth amidship at the side of 6 ft. 7½ in. At the ends are prows, with lifting flaps, giving an overall length of 107 ft. As the shipping traffic in the river is sometimes congested, the overall length of the ferry had to be restricted, and the flaps are therefore designed to be lifted into the vertical position. The width of the carriageway is 20 ft. The gates are secured by remote-controlled locks, operated from the control cabins, in addition to the manually-operated gate bolts and catches. There is a control cabin at each end of the ferry.

The complete Diesel-electric machinery equipment, with the necessary auxiliaries, was supplied by Messrs. Metropolitan-Vickers Electrical Company, Limited. There are two main generating units, consisting of Ruston and Hornsby type 3VRHZ three-cylinder 36-h.p. Diesel engines, running at 1,200 revolutions per minute and driving 15-kW generators. The engines are of the four-stroke marine type and are not supercharged. One set comprises two engines, mounted on a common bedplate with a single 15-kW compound-wound generator, coupled to the two engines by interlocked friction clutches. On the same bedplate is a 3-kW belt-driven 115-volt auxiliary exciter generator, which also serves for battery-charging. The other set, also mounted on a combination bedplate, consists of one engine, one 15-kW generator, and a 3-kW auxiliary generator. The battery is of the Nife nickel-cadmium alkaline type, with 88 cells, and has a capacity of 400 ampere-hours at the 5/10 hour rate.

The 110/116-volt direct-current series-wound propulsion motor, which delivers 45 h.p. at 500 r.p.m., drives through a double-reduction gearbox, which has an output speed of 18 r.p.m., to the main chain-wheels, port and starboard, which are fitted with slipping clutches to provide easy means of compensation between the wheels. In normal operation, the ferry is propelled by one generator set, in conjunction with the batteries. A single generator can supply 50 per cent. of the power required, the balance being provided by the battery, which takes the shock load when the ferry starts a journey. It is recharged by the generator while the ferry is stationary for loading or unloading; thus, the generator operates under a sensibly constant load, all fluctuations being absorbed by the battery. Should



FIG. 3.

the battery fail, a second generator can be brought into use. The third generator is a stand-by unit. In an emergency, the ferry can be operated for a few trips on the battery alone.

The 15-kW generators are connected through double-pole circuit-breakers and a combined "start-run" isolating switch to propulsion bus-bars, to which the battery also is connected similarly by a double-pole circuit-breaker. The exciters feed, through double-pole re-wirable fuses, the separately-excited field of the respective 15-kW generators through a shunt field rheostat. Tapped from this supply are double-pole isolating switches, connecting, through a change-over switch, either No. 1 or No. 2 exciter to the auxiliary supply panel. The propulsion motor has a speed range of about 5 to 1, with five notches in each direction. Speed is changed by inserting or removing resistances in the armature circuits by means of contactors, actuated by two master controllers, one at each end of the ferry. If both controllers are inadvertently moved from the "stop" position, the equipment is automatically shut down and the brakes applied. The

control gear is so designed that a rapid reversal can be made from full speed in one direction to full speed in the other without undue current peaks.

The ramps are operated by lifting motors of 12½ h.p., running at 1,000 r.p.m., which are mounted on one bedplate with an electro-magnetic brake and a worm reduction gear with a double output-shaft extension. Two further worm reduction gears, driving vertically upward, reduce the final speed to 12½ r.p.m. These gears were supplied by the Northern Manufacturing Company, Limited, Gainsborough. The lifting motor is controlled by a reversing automatic starter, operated by pushbuttons from either end of the ferry. The brake is applied when the "stop" button is pressed. Electric starting is provided for the Diesel engines. A four-panel switchboard controls the 15-kW generators, the 3-kW generators, and the battery and auxiliary feeders for pumps and lighting. The auxiliaries comprise a 2-in. Hamworthy bilge and general service pump, driven by a 1½-h.p. motor and delivering upwards of 40 gallons a minute, and a Mono fuel-oil transfer pump.

THE TRANSATLANTIC LINER "UNITED STATES."

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY, NEWPORT NEWS, VA., U.S.A.

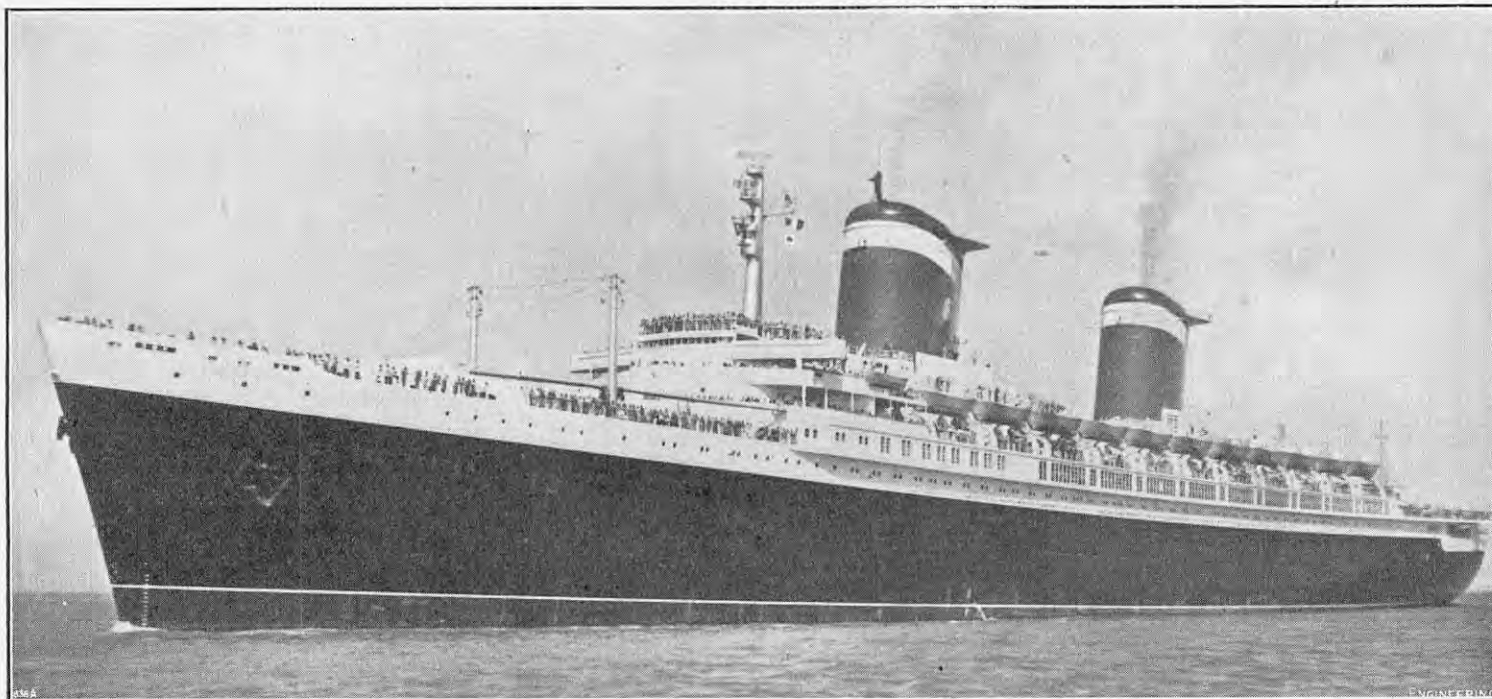


FIG. 1.



FIG. 2.

THE TRANSATLANTIC LINER
"UNITED STATES."

THE new Atlantic liner United States, which we illustrate in Figs. 1 and 2, above, was laid down in February, 1950, in the yard of the Newport News Shipbuilding and Dry Dock Company at Newport News, Virginia, and was launched on June 23, 1951. She is due to leave New York on her maiden voyage on July 3 and to reach Southampton on July 8. Thereafter she will maintain a fortnightly schedule between New York, Le Havre and Southampton.

Very little technical information about the United States has been released, mainly for reasons of security, as she has been built as much for troop-carrying purposes as for peace-time passenger traffic. On that account, her owners, United States Lines, have had the assistance of a Government subsidy of some 60 per cent. of her cost, which is stated to be 73 million dollars—about 26,000,000l.; some considerable part of this, no doubt, is attributable to the remarkable rapidity of her construction. Her length is stated to be 990 ft., and her gross tonnage 53,330. The propelling machinery consists of four sets of geared turbines, two of which drive five-bladed propellers and the other two sets, propellers with the more orthodox number of four blades. The vessel's trial speed, according to report, is in excess of 34 knots, at which speed her

machinery developed 158,000 shaft horse-power. The speed was measured by the Raydist system, which fixes the ship's position in relation to a floating radar buoy and is claimed to be accurate to within 0.02 per cent.

A feature of the construction of the United States is the extensive use that has been made of aluminium alloys. The superstructure, over a length of more than 600 ft., is constructed of this material, and it is also used for the funnels, which are 55 ft. high above the deck, for the 24 lifeboats and their gravity-type davits, the ventilating ducts, interior partitions, radar mast, ladders and handrails, and all the furniture. It is claimed, indeed, that "the only wood used in the ship is that in the pianos and the butcher's chopping-block." The bulkheads and partitions are lined with Marinite panels— asbestos fibre with an inorganic binder—which is stated to be completely fireproof.

Exceptional precautions against fire have been taken in the design. In addition to the usual smoke-detection equipment, heat-detection protective systems are provided in the switchboard rooms, galleys, and elsewhere; and there is a remote-controlled CO₂ discharge system, pressure-operated, which brings into operation sufficient cylinders of compressed CO₂ to fill any compartment in which a fire might originate. There is also a central damage-control room, constantly manned, to which are brought all the safety controls, fire alarms, watertight-door and fire-screen indicators,

and emergency communicating equipment, as in a warship. A considerable amount of weight has been saved by the use of alternating current for most electrical services; direct-current supplies are provided, however, for the cargo winches and other auxiliaries for which precise speed control is essential. For the general lighting system and various fractional-horse-power motors, there is a low-voltage supply, with alternative feeders to all parts of the distribution network. For emergency purposes, there are Diesel-driven generators which come into operation automatically in the event of a failure of the main supply, with storage batteries to maintain continuity of the electrical services while the emergency generators are taking up the load.

All the usual navigating appliances are provided—gyro-pilot, echo sounder, Pitometer log, etc.—practically the whole equipment being in duplicate. The two radar systems may be operated singly or simultaneously, on either long or short range; and a radio-telephone service is available from every stateroom in all the three classes of passenger accommodation. Many of the ship's operational telephones are "sound-powered," requiring no batteries or other external source of power, but being actuated solely by the vibrations set up by the voice speaking into the mouth-piece. The engine-room telegraphs incorporate an audible signal which continues until the reply telegraph is operated.

All reports agree that the vessel is notably free from vibration. Regarding her maximum trial speed, no precise statement has been made, but Captain Rex L. Hicks, chief of construction in the Maritime Administration, is quoted in the *New York Times* as having stated that "the S.S. United States has exceeded the known speed of any merchant ship or large naval craft by a substantial margin." In any case, the detail is rather of popular and dramatic interest than of permanent technical significance, as, no doubt, she will be able to beat the trial speed in a year or so, when the machinery is fully run-in and the engine-room complement under the chief engineer, Mr. William Kaiser—previously "chief" of the America—have had time to make the adjustments that are always needed in a new ship. Arguments and domestic recriminations may continue, in the atmosphere of pending elections, about the amount of the Government subsidy, which President Truman has asked the United States Attorney-General to investigate; on which Mr. John M. Franklin, president of the United States Lines, has commented that the vessel could have been built in a foreign yard for only 25 million dollars and that, apart from the subsidy, his corporation had paid 30 million dollars for her. There is no doubt, however, that the United States mercantile and naval fleets have acquired an outstanding ship, of which her owners and builders, and Messrs. Gibbs and Cox, the naval architects, may well be proud.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

REDUCED ALLOCATION OF STEEL FOR SHIPBUILDING.—The recent announcement by the Civil Lord of the Admiralty of a slight reduction in the allocation of steel for shipbuilding, in the third quarter of this year, has caused disappointment among local shipbuilders, who had hoped for some improvement. Apart from the general complaint concerning the inadequacy of the allocation, shipbuilders have been handicapped by the irregular deliveries of steel supplies. When plates and sections do not arrive in proper sequence, serious delays in construction may be caused.

MECHANICAL ENGINEERING RESEARCH BOARD.—The contract for the hydraulics research laboratory required by the Mechanical Engineering Research Board has been placed with Speirs, Ltd., building and public works contractors, Glasgow. The laboratory, which is estimated to cost 600,000l., will be situated at Birniehill, near East Kilbride, and eventually will accommodate the research work now in progress in temporary quarters at Thorntonhall.

THE LATE PROFESSOR A. C. LAWSON.—Dr. Andrew Cowper Lawson, a world authority on earthquakes, died at Berkeley, California, on June 16, at the age of 90. Dr. Lawson, who was born at Anstruther, Fife, in 1864, was Professor Emeritus of Mineralogy and Geology in the University of California. He was on the staff of the Canadian Geological Survey from 1882 until 1890, and became Professor of Mineralogy and Geology at the University of California in 1890. Professor Lawson was made a Master of Arts of Toronto University in 1885, and was awarded the Ph.D. degree of Johns Hopkins University in 1888. He served as President of the American Seismological Society from 1909 to 1910.

LEWIS PEAT DEPOSITS.—A survey group of the Scottish Peat Committee, led by Mr. D. M. Macarthur, director of the Macaulay Soil Research Institute, Aberdeen, left Stornoway on June 13 after a two-days examination of the peat deposits and peat-utilisation schemes on Lewis. The group were primarily concerned with the possibilities of peat as a fuel. They included representatives of the Geological Survey of Great Britain, the Fuel Research Station at Greenwich, the North of Scotland Hydro-Electric Board, the Seaweed Research Association, Musselburgh, and the secretary of the Scottish Peat Committee, Mr. S. Hetherington.

INVESTIGATION OF LEAD AND ZINC MINES.—The directors of Bangrin Tin Dredging and Siamese Tin Syndicate, Ltd., have formulated proposals which may lead to the re-opening of the lead and zinc mines at Leadhills and Wanlockhead. The plan provides for de-watering the modern Glencrieff section of the Wanlockhead mine, to enable major sampling to be undertaken, and the installation of a pilot mill. Sampling operations would also be extended to Leadhills. If adequate ore reserves are revealed, the aim would be to erect a full-scale mill with a capacity of not less than 400 tons of ore per 24 hours.

COMPLETION OF LOCH RECAWR DAM.—To mark the completion of the Loch Recawr dam, a commemorative plaque was unveiled there on June 18 by Mrs. Templeton, wife of Mr. W. H. Templeton, water convener, Ayr. Loch Recawr, on the Ayrshire-Kirkcudbrightshire border, is one of the main sources of Ayr's water supply. With a capacity of 489,000,000 gallons, it can provide 5,000,000 gallons a day.

CLEVELAND AND THE NORTHERN COUNTIES.

TYNE SHIPBUILDING.—Five ships, two swim barges and a dock gate will comprise the Tyne's shipbuilding output for July, bringing the river's output for the first seven months of the year to 12 ships, totalling rather more than 95,000 gross tons, against 108,000 tons in the corresponding period last year. Next month's launches will aggregate nearly 38,000 gross tons. On July 7, Vickers-Armstrongs Ltd., Walker, will launch the 12,500-ton City of Exeter, the second of four sister ships for the Ellerman and Bucknall Lines. On the same day, Swan, Hunter, and Wigham Richardson Ltd., Wallsend, will have ready for launching the 12,500-gross tons tanker Dagland for A/S Ocean of Oslo. On July 8, Swan, Hunters' Neptune Yard, Walker, will launch the cargo ship Stylehurst for the Grenehurst Shipping Co., and on July 9, John Readhead & Sons, Ltd., South Shields, will put into the water a 6,190-ton cargo ship for William France, Fenwick & Co., Ltd., London. On July 22, Clelands (Successors), Ltd., Willington Quay, will launch a 1,000-ton coaster for

C. Salvesen & Co., Leith, and on the same date Vickers-Armstrongs, Walker, will launch a 65-ton dock gate for T. W. Greenwell & Co., Ltd., Sunderland.

RIVER WEAR SHIPBUILDING.—Only two launches are expected on the River Wear in July. They will be the motorship Diplomat, which Wm. Doxford & Sons, Ltd., are building for T. & J. Harrison, Ltd., and the Africa Palm, by Short Brothers, Ltd., for the Palm Line.

THE SCREW COLLIER "JOHN BOWES."—It will be exactly 100 years, on June 30, since the John Bowes, the first iron screw collier built in Britain, was launched at Jarrow-on-Tyne by Palmer's Shipbuilding and Iron Co., Ltd. The John Bowes, planned by Charles Mark Palmer, despite opposition from those who said that the idea was impracticable, was 150 ft. long and carried 600 tons. She carried twice as much as the sailing colliers in operation at that time, and was named after the senior partner of a colliery-owning firm of which Charles Mark Palmer was a member. For a time, the John Bowes carried chalk as ballast when returning from London to the Tyne for coal, but later John McIntyre, the manager of Palmer's yard, designed water-ballast tanks which were installed in the ship. The John Bowes had a speed of 9 knots. The last years of her career were spent under the Spanish flag. Before she foundered off the Spanish coast on October 13, 1933, after a career lasting 81 years, the ship had been renamed Villa Selgas.

RIVER-WEAR TRADE STATISTICS.—At the monthly meeting of the River Wear Commissioners, it was reported that coal and coke shipments, to the end of April, at 1,078,838 tons, were 5 per cent. higher than in 1951, but 27 per cent. below the 1938 figures. Imports at 140,306 tons were 4 per cent. above last year and 39 per cent. more than pre-war; while exports of general merchandise at 33,128 tons were 10 per cent. more than in 1951 and 16 per cent. more than in 1938.

BLYTH COAL TRAFFIC.—During May, 1952, coal shipments from Blyth (Northumberland) amounted to 587,574 tons, an increase of 21,293 tons on May of last year. For the first five months of the year shipments were 2,032,028 tons compared with 2,559,785 tons in the corresponding period of 1951 and 2,378,002 tons in that of 1938. The reduction, this year, was caused by a six weeks' strike of teeners and trimmers which began in February. Shipments to foreign ports, so far, amount to 232,451 tons against 149,186 tons last year.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL PRODUCTION STATISTICS.—The British Iron and Steel Federation record in their *Statistical Year Book* that, of the 706 steel furnaces in this country, 183 are in Sheffield, 108 being of the electric type. There are 198 electric furnaces in the British Isles. The Sheffield area's production of alloy steel, last year, was 621,200 tons, an increase over the previous year of 13,800 tons. The national production was 950,600 tons. Deliveries of semi-finished steel, in the Sheffield area, last year, fell from 818,000 tons to 695,500 tons, which put the Sheffield area's output below South Wales's output of 706,500 tons. Of last year's national output of 15,638,500 tons of crude steel, Sheffield contributed 2,136,500 tons.

STEEL RESEARCH.—An electric-arc furnace has been brought into operation at the Sheffield laboratories of the British Iron and Steel Research Association. It has been specially designed for research work. Some completely new features have been incorporated in the furnace, which has a capacity of ten cwt., compared with the small capacity of up to 25 lb. of the laboratory furnaces used formerly. Dr. A. H. Leckie, head of the Association's Steelmaking Division, states that the objective is to cheapen electric steelmaking and possibly to extend its use to types of steel which, at present, would be too expensive to produce in an electric furnace.

THE MIDLANDS.

BREAKDOWN OF BEAM ENGINE.—The breakdown of a beam engine, 48 in. cylinder diameter by 9 ft. stroke, driving a rolling mill at the works of the Harts Hill Iron Co., Ltd., Brierley Hill, Staffordshire, has brought the whole works to a standstill. The 26-ft. cast-iron beam, which weighs about 14 tons, broke in two near the trunnions, and the inner part of the beam, falling inwards, caused severe damage to the wooden spring beams. Some part of the parallel motion struck the cylinder cover and smashed the stuffing box. The engine is upwards of 100 years old (its exact age is unknown), but it is to be repaired. Work has started on the removal of the broken beam and two large steel plates have been acquired for making a new one. The biggest problem has been to obtain two pieces of pitch pine, each 14 in. square and 20 ft. long, for the spring beams, but suitable timber has now been found.

THE USE OF DERELICT LAND.—At a meeting of the Midland Regional Board for Industry in Birmingham, on June 17, it was stated that work had started on the reclamation of some of the derelict land in the Black Country. Some of this land, rendered derelict by mining and other industrial activities, has been cleared and used for building factories and houses, but over 9,000 acres still remain. Mr. Barry Kay, regional controller for the Board of Trade, said that, at present, 15 firms were in need of a minimum of 150 acres for factory extensions. The use of agricultural land for this purpose was highly undesirable, and some of the derelict land was to be reclaimed instead. The cost of clearing, levelling, and, in some instances, draining would be high, but the need was urgent. The possibility of Government financial aid was mentioned, but it was pointed out that any question of subsidies for firms willing to develop difficult land was, at present, mere conjecture.

BLAST-FURNACE BREAK-OUT.—No. 5 blast-furnace at the Bilston steelworks of Stewarts and Lloyds, Ltd., has had to be blown out as the result of the iron breaking through the lining near the tap-hole. The furnace is being repaired, and will be blown in again as quickly as possible.

ROLLED SECTIONS FROM OLD RAILWAY RAILS.—The Haybridge Steelworks (1945), Ltd., Wellington, Shropshire, is overcoming the shortage of billets for re-rolling by using old railway rails. The use of old rails for this purpose is not new, but in the Midlands it has previously been confined largely to mills producing bedstead angles and similar light sections, not requiring to be machined. At the Haybridge works, old rails are being used for rolling down into small rounds, squares, flats and hexagons. In spite of the high carbon and manganese content of the rails, the finished bars and sections have proved satisfactory for the manufacture of nuts and bolts, agricultural equipment, and certain types of forgings.

SALE OF A BLACK COUNTRY FACTORY.—The factory at Coseley, Staffordshire, recently occupied by Tarslag, Ltd., of Wolverhampton, has been bought by the Wellington Tube Co., Ltd., of Great Bridge. The site area is about 12 acres, and 31,400 sq. ft. are occupied by buildings. The Coseley factory will be operated as a branch of the purchasers' main works at Great Bridge.

ALL-ELECTRIC COLLIERY IN NOTTINGHAMSHIRE.—The first sod was turned by the Minister of Fuel and Power, Mr. Geoffrey Lloyd, on the site of the first of the two 3,000-ft. shafts of the all-electric colliery at Bevercotes, near Ollerton, North Nottinghamshire. It is expected that the prolific yields which have distinguished other collieries in the Dukeries will be repeated at Bevercotes. The colliery will be working on coal reserves estimated to be worth about 400,000,000l. Much of the coal mined will be destined for export through the Humber ports. An annual output of 1,250,000 tons of saleable coal is expected. The colliery is the first to be planned in the East Midlands since nationalisation and it will take ten years to complete, at a cost of 5,500,000l. The freezing process of sinking will be adopted to counter the substantial flow of water which is expected.

SOUTH-WEST ENGLAND AND SOUTH WALES.

AVONMOUTH-SWANSEA PETROLEUM SERVICE.—The Regent Oil Company's new tanker, Regent Jane, which was launched at Bristol on April 9, has made her maiden voyage from Avonmouth to Swansea. She has been built to transport refined spirit between these two ports and will carry cargoes of 350 tons of high-grade petroleum products for discharge to the company's new distribution depot at Swansea.

CENTENARY OF CHEPSTOW BRIDGE.—Chepstow railway bridge, claimed as one of the best designed by Brunel, will attain its centenary on July 14. The bridge made possible the first through connection from Paddington to Swansea.

SOUTH WALES PORT FACILITIES.—In a two-days visit to South Wales, members of the recently-formed Ports Efficiency Committee visited the docks at Newport, Cardiff, Barry, Port Talbot and Swansea. The committee was set up early in March this year by Lord Leathers, Minister for the Co-ordination of Transport and Fuel and Power, to inquire into port facilities and the possibility of speeding up the turn-round of ships. The committee came to South Wales as the result of representations of the Cardiff Port Development Association.

RIVER POLLUTION IN GLAMORGAN.—The Pollution and Fisheries Committee of the Glamorgan River Board,

who met at Cardiff on June 20, heard details of a joint campaign undertaken by the River Board and the South Western Division of the National Coal Board to clean up the County rivers. The River Board wanted to see flocculation or froth-fotation plants installed at all the colliery washeries, but the Coal Board pointed out that each plant cost 50,000*l.* It was estimated that it would cost 850,000*l.* to have flocculation plants at all the collieries affecting the Glamorgan rivers. Collieries with a short expectation of life are to be equipped with settling ponds.

REDUNDANCY AND SHORT-TIME WORKING.—Fears of redundancy have been causing grave alarm among factory employees in the Amman Valley. Local authorities in the district, after discussing the problem of unemployment in the Valley and the rehabilitation of disabled miners, prepared a memorandum to the Government departments concerned, suggesting that, as a short-term policy, the Amman Valley should be permitted to participate in the Government's expanding armaments programme. The Merthyr factory of Hoover (Washing Machines) Ltd., where 300 employees were recently declared redundant because of reduced imports into Australia, has started a four-day week for the remaining 800 operatives.

COMPLAINTS OF DUST AT COLLIERY. The 1,000 miners employed at the Lady Windsor Colliery, Ynysybwl, have tendered 14 days' notices terminating their employment. Notices were tendered because of complaints of alleged inadequate methods of dust suppression at the colliery and the bad state of the supply roads.

NOTICE OF MEETING.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF INDUSTRIAL ADMINISTRATION.—*London Graduate Section*: Thursday, July 10, 7 p.m., Management House, 8, Hill-street, London, W.1. "The Presentation of Data as an Aid to Efficiency," by Dr. B. P. Dudding.

LAUNCHES AND TRIAL TRIPS.

S.S. "FORESTER."—Single-screw cargo vessel, built and engined by John Readhead & Sons, Ltd., South Shields, for Thos. and Jas. Harrison, Ltd., Liverpool. Second vessel of an order for two. Main dimensions: 452 ft. by 59 ft. 9 in. by 35 ft.; deadweight capacity, 10,400 tons. Triple-expansion steam reciprocating engine working in conjunction with a low-pressure Bauer-Wach exhaust turbine. Speed in service, 12 knots. Trial trip, May 14.

M.S. "IRISH HEATHER."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for Irish Shipping Ltd., Dublin. Main dimensions: 204 ft. by 35 ft. by 14 ft. 6 in.; deadweight capacity, 1,360 tons on a mean draught of about 14 ft. Polar marine oil engine, developing 960 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Launch, June 10.

S.S. "BRITISH SKILL."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 610 ft. between perpendiculars by 81 ft. by 44 ft. 6 in. to upper deck; deadweight capacity, 28,500 tons. Compound double-reduction geared turbines developing 12,500 s.h.p. at 112 r.p.m. in service; and two Babcock and Wilcox oil-fired water-tube boilers, also constructed by the shipbuilders. Trial trip, June 10, 11 and 12.

M.S. "CLUTHA RIVER."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for the British Empire Steam Navigation Co., Ltd. (Managers: Houlder Brothers & Co., Ltd.), London, E.C.3. Main dimensions: 557 ft. overall by 70 ft. by 39 ft. 6 in. to upper deck; deadweight capacity, about 18,000 tons on a draught of 30 ft. 6 in. Hawthorn-Doxford six-cylinder opposed-piston oil engine, developing 7,600 b.h.p. at 114 r.p.m. in service. Speed, 15 knots. Trial trip, June 10 and 11.

S.S. "LORD WARDEN."—Twin-screw vessel, with accommodation for 1,000 passengers and 120 motorcars, built and engined by William Denny and Brothers, Ltd., Dumbarton, for the Dover-Boulogne service of the Southern Region of British Railways, London, S.E.1. Main dimensions: 361 ft. 6 in. overall by 59 ft. by 17 ft. 9 in. to main deck; gross tonnage, 3,333. Two all-impulse steam turbines with double-reduction gearing, designed by Pametrada, and developing a total of 8,000 s.h.p. at 270 r.p.m. Steam supplied by two Babcock and Wilcox oil-fired water-tube boilers. Service speed, 20 knots, fully loaded. Launch, June 16.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

General Requirements for Metal-Arc Welding of Mild Steel.—The general requirements for the metal-arc welding of mild steel under normal conditions of manufacture and service are set out in a new specification, B.S. No. 1856. It is divided into sections relating to such matters as the parent metal and the electrodes, details of butt and fillet welds, the information required by the welding organisation, the welding equipment and electrodes employed, welding procedure, workmanship, the qualification of the welding operators, and the heat treatment, inspection and testing of the finished welds. The compilers point out that the requirements of the specification are not all applicable to certain forms of construction and that the specification does not stipulate the allowable stresses in welds or methods for their testing. For specific applications, such as tubes, boilers and pressure vessels, reference should be made to the appropriate specification, where such exist. Where no specification is available it is stated that the present specification can itself be used, provided that such additional requirements as are necessary, including the permissible stresses in the welds and the tests to be applied, are agreed between the purchaser and the contractor. [Price 5*s.*, postage included.]

Distillation Receivers.—The first edition of B.S. No. 605, which specified the requirements for Crow distillation receivers only (i.e., receivers having a conical lower portion) was first issued in 1935. In a revision, now issued, it has been decided to omit the stoppered receivers previously specified since the demand for them is very small. It has moreover been decided to add two cylindrical receivers which are widely used in the petroleum industry. The new edition specifies Crow receivers of 25, 50 and 100 ml. capacity and cylindrical receivers of 100 and 200 ml. capacity. A standard method for the determination of capacity, and clauses relating to material, construction and graduation are contained in the publication. [Price 2*s.*, postage included.]

Hydrant Systems.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have now issued, in final form, Code of Practice C.P. No. 402.101. It deals with the installation of hydrant systems in buildings or within the site boundaries of buildings, and draws attention to the various bodies which should be consulted in the planning and design of the building to be equipped. Details of components, such as pipes, couplings, hoses, hose reels, nozzles, hydrants and valves, and a list of the British Standard Specifications to which they should conform, are given. Recommendations are made on water supplies, on the design and location of indoor and outdoor hydrants, and on sizes and types of hose, delivery-hose couplings, branch pipes, nozzles and piping. The Code concludes with data on inspection, testing and maintenance. [Price 2*s.*, postage included.]

Sprinkler Systems.—Code of Practice, C.P. No. 402.201 covering sprinkler systems has now been issued, in final form, by the Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1. It deals with the general principles for the provision of automatic sprinkler installations in buildings. The need for systems to comply with the requirements of the Fire Offices' Committee's rules for automatic sprinkler installations is recognised, and, where relevant, sections of the rules are referred to. Lists of fittings and components are given, with the appropriate British Standard Specifications. The design section of the Code includes general information on the installation of the three types of systems, namely, the wet-pipe, the alternate wet- and dry-pipe, and the dry-pipe. Temperature ratings of sprinkler heads are given, and methods of operation are described. Recommendations cover the operation of alarms, pressure gauges, valves and supply connections, piping, multiple-jet sprinklers, and water supplies. Notes are included on systems suitable for dealing with oil fires, and also on special precautions for systems liable to freezing. The Code concludes with data on inspection, testing and maintenance. [Price 2*s.*, postage included.]

INTERNATIONAL RADIO AND ELECTRONICS EXHIBITION OF INDIA, 1952.—The Radio and Electronics Society of India, Fateh Manzil, Opera House, Bombay, informs us that the International Radio and Electronics Exhibition, which, as announced on page 508, *ante*, was to have been held at Bombay in November, has been postponed indefinitely owing to insufficient support.

PERSONAL.

SIR ANDREW M. BRYAN, B.Sc., M.I.Min.E., F.R.S.E., a member of the National Coal Board, London, and **PROFESSOR J. P. KENDALL, Professor of Chemistry in the University of Edinburgh,** had the Degree of Doctor of Laws conferred upon them by the University of Glasgow on June 18, at an honorary graduation ceremony.

Following the appointment of Mr. J. HODGSON as chief ship surveyor in succession to Mr. R. B. SHEPHEARD, C.B.E., B.Sc., the General Committee of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, have appointed Mr. H. P. SOUTHWELL, at present principal engineer surveyor for the North-East Coast area, to succeed Mr. Hodgson. He will have the title of assistant to the chief surveyors (establishment) and will be responsible for surveying staff problems throughout the world. Mr. J. M. MURRAY, M.B.E., B.Sc., principal surveyor for research on the chief ship surveyor's staff, has been appointed an assistant chief ship surveyor.

SIR DANIEL FENNELLY, Under-Secretary, Ministry of Materials, retires on June 30, and is to be succeeded by Mr. H. O. HOOPER, C.M.G.

MR. J. G. BEAN, formerly manager of the Stanlow installations of C. C. Wakefield & Co. Ltd., has been appointed chief production engineer for the entire Wakefield Group of companies. Mr. J. C. CRAGG, B.Sc., F.Inst.Pet., has been made manager of Stanlow and Mr. R. G. PILSBURY, assistant manager.

MR. JOHN AYRES, M.I.E.E., M.I.P.E., general manager of Petters Ltd., Staines, has been appointed managing director of that company. Mr. A. E. CARRODUS, who resigned from the board of the National Gas and Oil Engine Co. Ltd., towards the end of May, has been appointed to the board of Petters Ltd., as sales director.

MR. PETER SPEAR, B.Eng. (Sheff.), has been appointed director of the research and development department of Rubery, Owen & Co. Ltd., Darlaston, South Staffs.

MR. A. KENNETH CLYDE, A.R.T.C., A.M.I.E.E., A.F.R.Ae.S., has been appointed assistant chief engineer of Tiltman Langley Laboratories Ltd., Redhill, Surrey.

DR. D. V. ATTERTON, who has been at the University of Cambridge for the past eight years, has been appointed to the newly-established post of research and development manager, Foundry Services Ltd., Long Acre, Nechells, Birmingham, 7.

MR. N. MCPHERSON has been appointed a director of Aluminium Corporation Ltd., and not of the British Aluminium Co., Ltd., as erroneously stated on page 747, *ante*. Mr. McPherson will continue as general manager of Aluminium Corporation.

MR. C. H. CHAPLAIN, manager, publicity department, The British Thomson-Houston Co., Ltd., has been elected chairman of the publicity committee of the British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2. Mr. V. J. FAULKNER, publicity manager, Crompton Parkinson Ltd., has been elected vice-chairman.

MR. G. A. JACKSON has been appointed manager of the spare-parts division of E.M.I. Sales and Service Ltd., Wadsworth-road, Perivale, Middlesex, in succession to the late Mr. E. S. RANN.

MR. A. C. LEWIS retires from the position of contracts representative, for Northern Scotland, of the Marconi International Marine Communication Co. Ltd., Chelmsford, Essex, on August 31. This work will then be taken over by Mr. V. G. OASTLER, manager of the company's Aberdeen depot since 1948.

The Ministry of Housing and Local Government announce that Mr. JOHN LAING has joined the Bailey Committee on House Interiors. Sir DONALD BAILEY is the chairman and the other members are the DOWAGER MARCHIONESS OF READING, Mr. S. BUNTON, Sir LUKE FAWCETT, Mr. A. J. FILER, Mr. J. H. FORSHAW, Dr. F. M. LEA and Mr. H. J. MANZONI.

A North-Eastern Section of the INSTITUTION OF THE RUBBER INDUSTRY has been formed. Mr. W. G. VENNELL has been elected chairman and Mr. P. B. EDGAR, secretary and treasurer.

HOLMAN BROS. LTD., Camborne, are opening an East Africa branch at Nairobi on July 1. The address is P.O. Box 2044, Nairobi. Telephone: 84-25. Telegraphic Address: Airdrill Nairobi. The branch will serve Kenya, Tanganyika and Uganda, where the firm has been represented previously by GALEY AND ROBERTS, LTD. The manager of the branch is Mr. J. B. PASSMORE. Others on the staff are Mr. H. S. WARWICK and Mr. P. H. V. WELLS, D.S.O.

DARHAM INDUSTRIES LTD., manufacturers of road tank vehicles, have completed extensions to their works on the Dragonville Estate, Durham. The extensions are expected to employ an additional 200 men.

The Central Publicity Department of IMPERIAL CHEMICAL INDUSTRIES LTD. has moved to the North Block (Ground Floor) of Thames House, Millbank, London, S.W.1. (Telephone: VICTORIA 4486.) Written communications, however, should continue to be addressed to Imperial Chemical House, Millbank, S.W.1.

JUBILEE OF MESSRS. HEENAN AND FROUDE, LIMITED, WORCESTER.

(For Description, see Page 825.)

812

ENGINEERING.

JUNE 27, 1932.

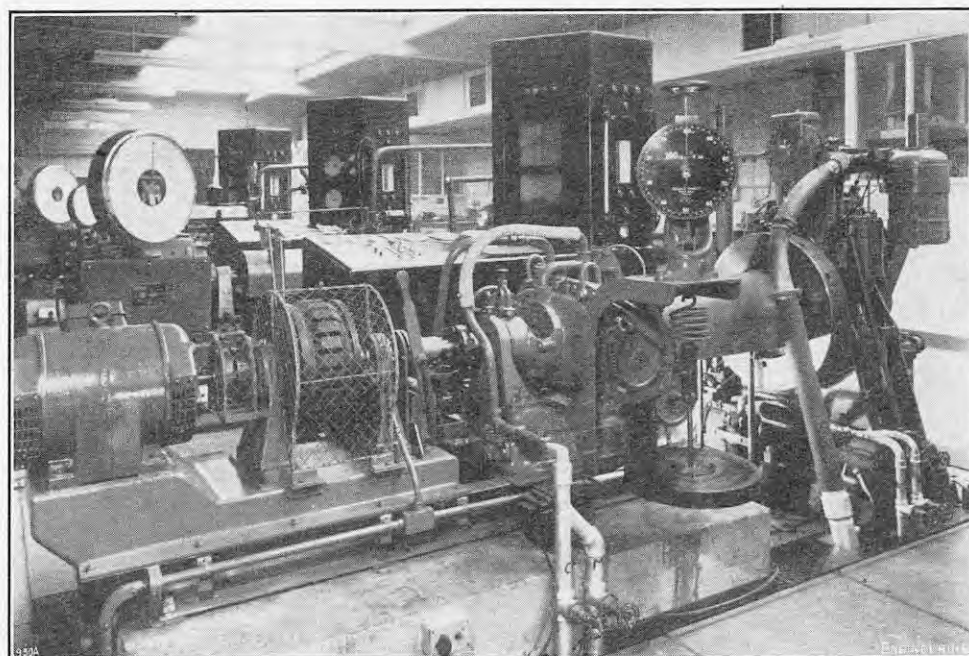


FIG. 1. TYPICAL DYNAMOMETER INSTALLATION.

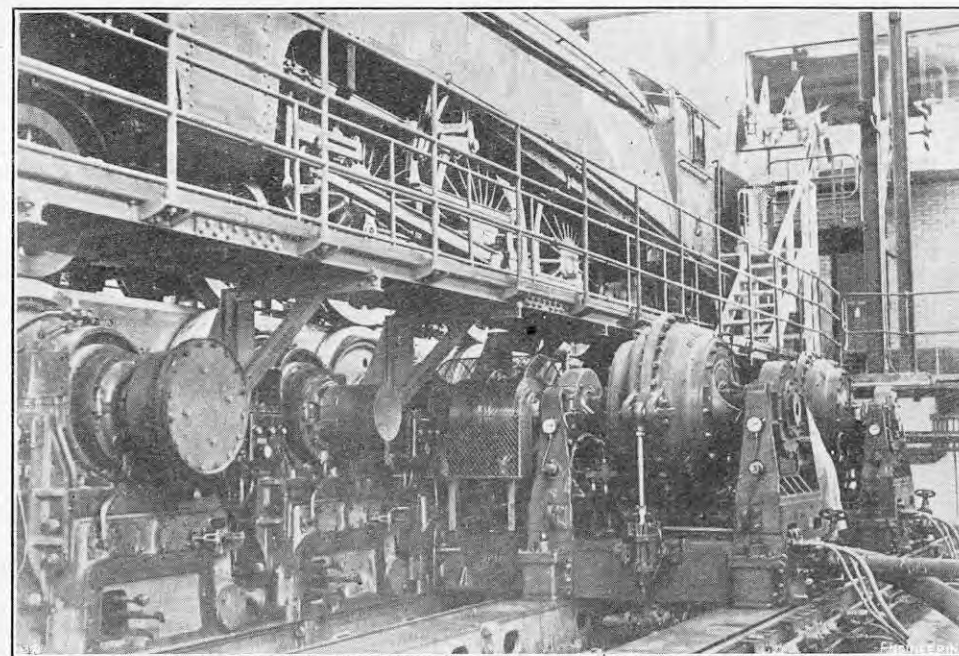


FIG. 2. LOCOMOTIVE-TESTING PLANT.

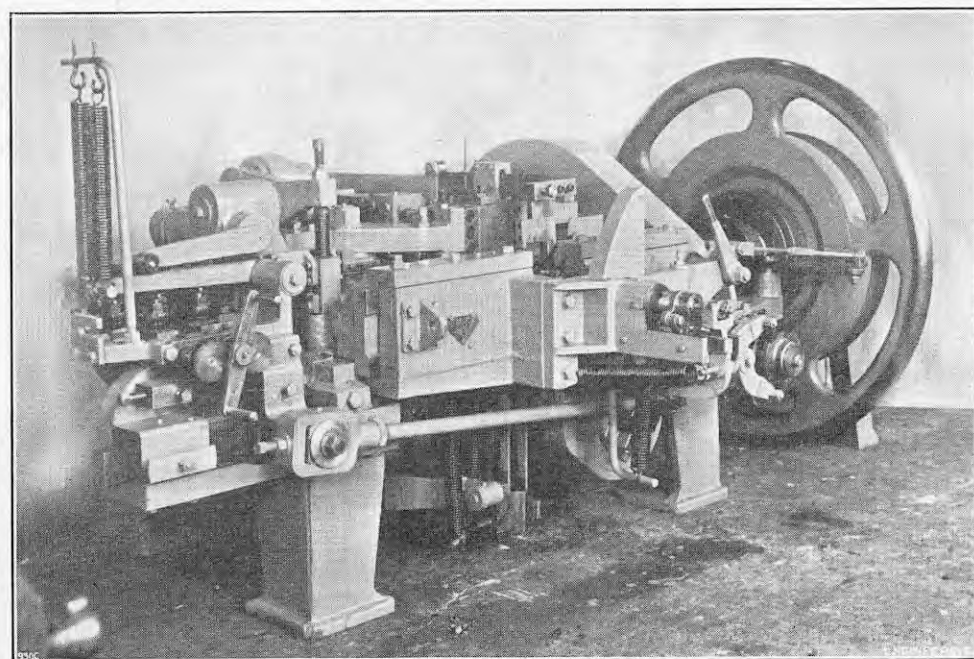


FIG. 3. AUTOMATIC CHAIN-FORMING MACHINE.

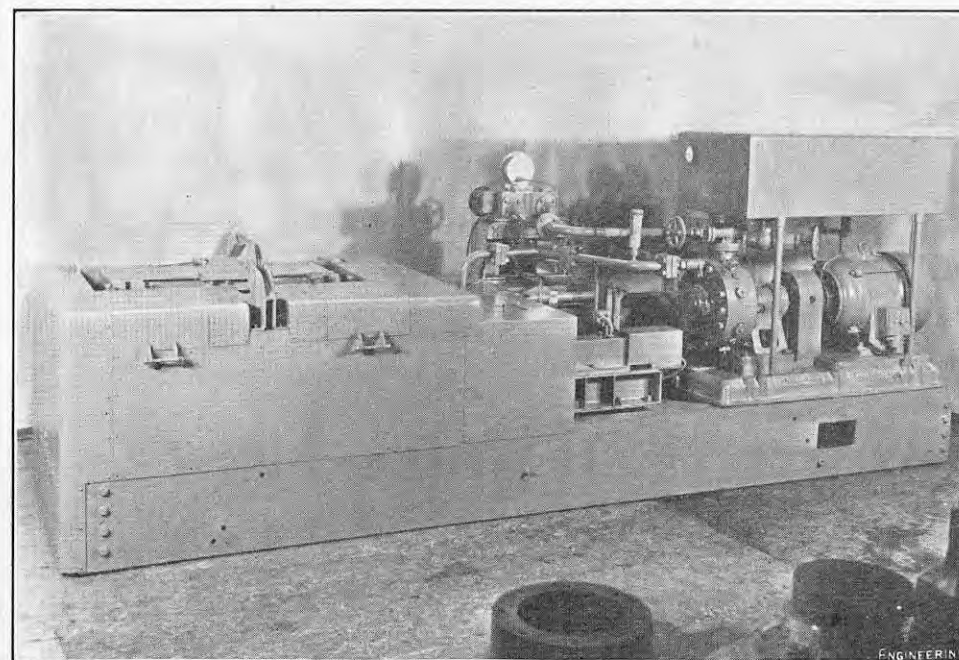


FIG. 4. HYDRAULIC PRESS FOR SCRAP METAL.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND,
LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to ENGINEERING Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

SUBSCRIPTIONS.

ENGINEERING may be ordered from any newsagent in town or country and from railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2s. 3d. post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2½ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10s. for the first four lines or under, and 2s. 6d. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30s. per inch. If use is made of a box number the extra charge is 1s. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33½ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

CONTENTS.

	PAGE
Engineering and Metallurgical Research by Babcock and Wilcox, Limited, at Renfrew (Illus.)	797
Liability for Defects in Spare Parts	801
Analysis of the Performance of the Jenbach Two-Stroke Vertical Oil Engine (Illus.)	802
Open Day at the National Physical Laboratory	804
Centralised Maintenance at the Works of Messrs. Steel, Peech and Tozer, Rotherham (Illus.)	805
Annuals and Reference Books	807
Diesel-Electric Chain Ferry (Illus.)	808
The Transatlantic Liner "United States" (Illus.)	809
Notes from the Industrial Centres	810
Notice of Meeting	811
Launches and Trial Trips	811
British Standard Specifications	811
Personal	811
Boiler Research at Renfrew	813
The Report of the Air Registration Board	814
Notes	814
Letters to the Editor.—The Forces and Pressure Distribution in Brake Shoes (Illus.)	815
The Economics of Fuel and Power. Early Ferranti Alternator Sets	815
Obituary.—Colonel W. C. Devereux, C.B.E. (with Portrait)	816
Conversazione of the Institution of Civil Engineers	816
Summer Meeting of the Institution of Mechanical Engineers	817
Reclamation Projects in the United States	818
Cargo Liner for Royal Mail Lines, Limited	819
Forthcoming Exhibitions and Conferences	819
Labour Notes	820
Heavy-Duty Fork-Lift Truck (Illus.)	821
Shipyard Re-organisation for Welded Prefabricated Construction (Illus.)	821
The Jubilee of Heenan and Froude, Limited (Illus.)	825
Heating and Ventilation and the Coal Problem	827
Trade Publications	828
Books Received	828
Five One-Page Plates.—THE RENFREW LABORATORIES OF BABCOCK AND WILCOX, LIMITED. CENTRAL MAINTENANCE WORKSHOPS OF STEEL, PEECH AND TOZER, LIMITED.	

ENGINEERING

FRIDAY, JUNE 27, 1952.

VOL. 173.

No. 4509.

BOILER RESEARCH AT RENFREW.

WHEN Messrs. Babcock and Wilcox, Limited, invited the technical Press to visit their laboratories at Renfrew a few weeks ago, the existence of a problem in deciding what to release and what to withhold was apparent to the visitors; and, indeed, it will now be apparent to readers of the article which appears on page 797 of this issue. During the tour of the laboratories, we were shown a very wide range of research and development work, and the details of particular projects were willingly explained to any member of the party who expressed a special interest. In a few cases these details are not for publication at present, but the restriction on publication in all such cases is properly based either on the disinclination—natural to the scientific mind—to talk about a project while it is still little more than an idea, or on a reasonable commercial ground that a certain development must not be announced before it has matured. Excepting these few cases, the information now given in the article is not confined in its interest to designers and makers of boilers: each item of the work, though it is part of a policy for improving boilers, may possibly contribute to progress in other fields.

As the incoming tide advances the water's edge edge across the beach so research and development result in progress in the technology of engineering: the water in one place may be temporarily arrested by a combination of circumstances but is eventually borne on by neighbouring areas of water that have progressed more favourably. Likewise, a technical obstacle in one branch of research may be over-

come by applying, and perhaps modifying, the result of research in another branch. Herein lies the value of a broad outlook when industrial firms consider the question of publishing details of the progress and results of research. Any danger of a competitor, at home or overseas, benefiting gratuitously from the information they publish is more than offset by the goodwill they earn in the engineering world and by the encouragement they give to the unfettered flow and interchange of information. Votaries of the liberal arts are fond of deriding the specialisation of technologists; but the best technologists are equally catholic in their tastes. Their minds range freely; and it is just such a review as we have been enabled to give of the Renfrew work that presents them with a new opportunity. Precise quantitative results find no place in such a review; in due course they will doubtless provide material for a number of technical articles.

The pattern that we have followed in presenting the report on page 797 is intended, in effect, to place everything over a common denominator. An analysis of the separate items of research showed us that the majority of them related to methods of measuring certain quantities, properties, etc. In addition, there were four subjects that could be classed as important developments in designs; designs, moreover, not of boilers, but of an instrument, a heat-engine principle, and two methods of construction, all of which will evoke interest outside the boiler-making industry. This simple classification, which we hope will enhance the value of the review, is not based on the organisation of the laboratories. Visitors to Renfrew, in fact, will find that a tour will take them through the chemical laboratory, fuel-testing laboratory, mechanical-testing laboratory, combustion research laboratory, routine testing laboratory, machine shop, furnace room, engineering research bay, combustion research bay, metallurgical research laboratory, photographic section, electronics laboratory, hot-rupture test houses, steam test laboratory, and a boiler-house where one boiler is used wholly for research work and two, though available for experimental work, normally operate as works boilers.

The organisation of research and development follows, to some extent, this division of functions. Since 1936, the management have regarded the whole programme of work as a single unit. Previously, though such work was not lacking, it was not co-ordinated as a central unit. There was a mechanical test house and a chemical laboratory, their work being supplemented by independent investigations which were carried out by individual departments on problems relating to their special interests. In 1936, however, these various branches of experiment and research were brought together in the research department, divided into mechanical, metallurgical, and fuel sections, and located in well-equipped laboratories in the Renfrew works. Since then, the scope and activities of the department have grown, and as the Renfrew works was itself expanding, it was apparent that new premises were needed for the research department. The main building of these new premises is illustrated in the article, and the recent visit of the technical Press was its "house-warming."

The research station is in High-street, Renfrew, about 1½ miles from the main works, and occupies a site with a frontage of 285 yards and an area of 5½ acres. The main block is a two-storey building with a floor area of 22,000 sq. ft. Behind the main building is a combustion-research building with a floor area of 5,000 sq. ft., and additional single-storey buildings with a total floor area of 22,000 sq. ft. are being constructed as extensions to the laboratories. Remote from the main block there is an old golf-clubhouse which, though originally scheduled for demolition, has been retained and is used for temporary laboratory accommodation

pending the building of the new extensions. At present it houses the pot furnaces and scaling-test apparatus. The boiler plant on which experiments can be carried out by the research department is in the main works, where the output of steam can be usefully employed. Certain other work, such as hot-rupture tests and electronic development, is being done in the header factory until sufficient accommodation is available in the new research station. The department employs 205 persons. Apart from general administration, it is divided into six sections, each under a section leader, as follows: chemical, fuel testing, mechanical testing, combustion research, engineering research and metallurgical work.

Research development, experiment and the like are words that are loosely applied; their meanings are correspondingly vague. They mean, in fact, what the context requires them to mean, and in this context—dealing with the work of Messrs. Babcock and Wilcox's laboratories—no one is likely to misunderstand the inevitably frequent use of the word "research." It connotes work that is intended, however long-term the intention, to yield results of commercial value in the business of making and selling boilers and allied equipment. Such work, it is often said, is what this country lacks. Investigations that are more fundamental are undertaken in universities and colleges, in national research establishments and in the laboratories of research associations. Reports from these institutions are widely publicised and are well received at home and overseas. Industrially, however, they are only useful when they have been translated into data for the design office and the shops, and not all reports can be so translated, owing to their remoteness from practical issues. A laboratory run by a firm is on a different footing. Every line of inquiry must eventually pay, otherwise it is suspended. If more and more work of this nature were instituted in the United Kingdom, the country's future would be safe.

THE REPORT OF THE AIR REGISTRATION BOARD.

ONE of the major tasks, during the past year, of the Air Registration Board, which is the authority in the United Kingdom responsible for granting Certificates of Airworthiness and for framing airworthiness requirements, has been the granting of a normal category Certificate of Airworthiness to the de Havilland Comet air liner. This aircraft, of course, introduced new airworthiness problems in connection with the power-operated flying controls, dive brakes, the bogie undercarriage, the jet engines, and the high cruising altitude and flight speeds. In these circumstances, the following comment is interesting. "It is pleasing to report that the Comet has suffered from no more than minor teething troubles, rather less than are often encountered in more orthodox aircraft." This comment was made in the Board's fifteenth annual report, for the year ended March 31, 1952, by the Chairman, the Rt. Hon. Lord Brabazon of Tara. The licensing of the Comet, the report stated, had given prominence to the need for the United Kingdom to expand the manufacture of transport aeroplanes for our own operators and for the overseas markets.

The defence programme, it appears, has had little effect on the Board's activities. Recent experience of modern aircraft, however, had called attention to the fatigue problem; in the last few years, new materials have been used, and the utilisation of aircraft has increased greatly. Extensive programmes of fatigue research have therefore been introduced and are still in progress. With the object of reducing casualties in severe ground-impact crashes, and in order to obtain more data on

applied forces and on the behaviour of aeroplanes in crashes, the Board arranged with the Ministry of Civil Aviation to carry out first-hand investigations immediately after accidents. The trend towards coach-type travel with closely-spaced seats, has led the Board to conclude that, although backward-facing seats offer better protection against crash injuries, considerable improvements can be made to reduce the hazards of forward-facing seats.

The question of fuels for aircraft gas turbines was discussed at the 1951 International Civil Aviation Organisation (I.C.A.O.) Airworthiness Division meeting. Most countries supported the British view that it would be desirable to make the use of kerosine mandatory for civil turbine-powered aircraft, but the United States, having in hand an extensive fire-test programme, were not desirous of making an immediate decision. Since the meeting, the fuel supply position has deteriorated, and in the United States and certain other countries, aviation kerosine might not always be available. The Board, however, would strongly oppose the use of fuels with a flash point lower than that of kerosine. The progress in setting up international standards, however, has been disappointing. A Standing Performance Committee has been set up to try and resolve the technical issues holding up agreement on performance standards, and it is hoped that its work will be completed in 1953. There were no major developments in British civil airworthiness requirements during the year. The Board adopted a policy of not licensing individual engineers for the overhaul and repair of the larger modern transport aircraft and engines. Such work will be the responsibility of approved overhaul and repair organisations possessing the necessary equipment. In the opinion of the Board the current radio requirements, issued recently, need further revision, and the Institution of Electrical Engineers are at present engaged on this work.

In 1951 legislation was introduced whereby the maintenance, according to approved schedules, of radio installations in commercial aircraft was rendered compulsory. This has led to considerable work for the Board, in approving schedules submitted and in an advisory capacity. Owing to the scarcity of licensed radio maintenance engineers, only about 50 per cent. of the operators concerned had submitted schedules for approval.

In addition to the Comet, the prototype de Havilland Ambassador has been granted a normal category Certificate of Airworthiness during the year. Eight piston engines and six gas turbines have been type-tested. Investigations of new gas-turbine installations suggest that they will lead to a marked decrease in field maintenance work and a corresponding increase in maintenance carried out in the shops. A new composite-construction propeller blade has been type-tested successfully, and a total of 14 variable-pitch and 24 fixed-pitch propellers have been approved during the year. Much work has been carried out on helicopter power plants. About 300 types of instrument have been approved during the last 12 months, making a total of nearly 2,600 approved instruments. Some of these have required extensive design surveys. The intensive flying of aircraft now called for by the Board has made possible a much more satisfactory evaluation of the equipment than would otherwise have been possible. Electronic systems and complicated electrical systems are often unsatisfactory and the report suggests that their design should be arranged so that as many of the components as possible should "fail safe"; their individual accuracy should not be critical to the overall accuracy.

Other activities of the Board referred to in the report include the investigation of American very high-frequency omni-directional radio range equipment which was undergoing trials by the United Kingdom authorities in comparison with the Decca

Flight Log equipment. The Board are studying means for eliminating serious electrical interference with radio equipment caused by the use of rectified alternating-current systems in aircraft, but the problem has not yet been solved. The work of the flight test section on prototype aircraft has decreased during the latter part of the year, enabling the section to undertake revision of the test schedules for a number of series aeroplanes. A new procedure for performance checks is expected to yield a large amount of statistical data on fleet performance. The Board has undertaken research work, on behalf of the Ministry of Supply, on air-frame and engine de-icing systems, and it is hoped that further work will be done for the Ministry by members of the staff no longer engaged upon the investigation of prototype aircraft.

NOTES.

MOTOR INDUSTRY EXPORTS.

At a Press conference held by the Society of Motor Manufacturers and Traders on Tuesday, June 24, the Society's director, Mr. R. Gresham Cooke, said that, in spite of the imposition of import cuts by Australia and New Zealand, the two largest markets for the motor industry, the level of exports remained high, and the United Kingdom was still the largest exporter in the world of cars and commercial vehicles. During May, some 32,000 cars, 13,500 commercial vehicles, and 11,500 agricultural tractors were shipped overseas; these figures were larger than the monthly averages during 1951, of 30,000 cars, 11,500 commercial vehicles, and 9,500 agricultural tractors. The value of the cars exported during May, 1952, was 11½ million, as compared with 9½ million per month during 1951. There had been an outstanding increase in the number of cars exported to the United States and Canada; just over 3,000 cars had been shipped to the United States, nearly twice as many as in the corresponding period last year, and just under 3,000 to Canada. Finland, South Africa, Belgium, Brazil and Sweden were also buying more British cars. The Society's conference followed closely on an announcement by the Minister of Supply, Mr. Duncan Sandys, that the number of cars available for the home market should no longer be a fixed quota of 60,000 a year, but should be related to the industry's output of cars. The industry had undertaken to export 80 per cent. of the cars produced, 70 per cent. of the light commercial vehicles, and half of the heavy commercial vehicles. Assuming that the present rate of production continued, a yearly rate of 90,000 cars and 77,000 commercial vehicles would be available for the home market. This was still less than the 1951 rate of 110,000 cars a year, which had been reduced earlier this year. Allocations of steel to the industry would in future be linked more closely to export performance. Commenting on the official statement, Mr. Gresham Cooke said that during the earlier part of the year production had fallen owing to the shortage of steel supplies. It was expected that more steel would become available towards the end of the year, and that the industry's output would rise accordingly. The British motor industry were making every effort to maintain and increase exports at competitive prices.

A HUNDRED ALCHEMICAL BOOKS.

The authorities of the Science Museum, South Kensington, London, S.W.7, are proposing to hold a series of special exhibitions of historical books and documents relating to science and technology. The first of these, which was opened on June 25, is entitled "A Hundred Alchemical Books." The exhibition illustrates both the practical and the symbolic sides of alchemy in the era of printed books, while a selection of Nineteenth and Twentieth-century books on alchemy is also on view. The books on exhibition, a number of which are of great rarity, have been drawn mainly from the Science Library, but many of the most beautiful specimens are from the library of the Museum of the History of Science, Oxford, including the loan collection of H.S.H. Prince von Kniphausen of Denmark, from the collection of Mr. G. Heym,

and from the libraries of a few other persons and institutions. To engineers an interesting book is a treatise on "Distillations" published in English by George Baker and printed in London by Peter Short in 1599. This particular copy of the book belonged to James Nasmyth, as is recorded by the great engineer on the flyleaf, together with the date 1836. Nasmyth adorned the book with some finely-drawn pen-and-ink marginal sketches of stills and other apparatus, but, on page 219, there is a tiny sketch of his steam hammer. Other books of great metallurgical interest include Agricola's "De Re Metallica," published by Froben at Basle in 1556; Lazarus Ercker's book in German on the principal mineral ores and methods of mining, printed at Frankfurt-am-Main in 1580; Giovanni Pantheo's "Voarchadumia" published in Venice in 1530, probably one of the earliest printed books on gold refining; and "De Natura Rerum," by Theophrastus of Hohenheim, generally known as Paracelsus, published by Bernard Jobin, at Strasbourg in 1584. The Exhibition will remain open to the public until September. Admission is free and the Museum is open from 10 a.m. until 6 p.m., on weekdays and from 2.30 to 6 p.m., on Sundays.

ELECTRONICS SYMPOSIUM AND EXHIBITION.

The fourth electronics symposium and exhibition to be organised by the Electrical and Electronics Section of the Scientific Instrument Manufacturers' Association of Great Britain, Limited, is being held at the Examination Hall, Queen-square, London, W.C.1, from Tuesday, September 2, to Friday, September 5, both dates inclusive. The arrangements for this year's meeting will largely follow those of previous symposiums, the last of which was held in September, 1950. On the afternoon of Tuesday, September 2, Mr. G. H. Hickling will deliver the first of the series of papers to be read during the four days of the symposium, and will speak on "Electronic Control Systems for Large Astronomical Telescopes." Two papers will be delivered on Wednesday morning, September 3, namely, "The Development of Resistive Elements and Wave-Guide Attenuators from a Semi-Conducting Ceramic," by Mr. J. M. Herbert, and "Electronics in Strain Measurement," by Mr. D. L. Johnston and Mr. D. W. Hobbs. On the afternoon of the same day, Dr. G. Mole will read a paper on "Electronic Instruments Developed by the Electrical Research Association for Research in the Electrical Industry." On the morning of Thursday, September 4, papers will be read by Mr. J. R. Boundy on "Electronic Measurement and Control for Industry", and by Mr. D. K. Das Gupta and Mr. R. J. Russell-Bates on "Electronics in Temperature Control." In the afternoon of that day, Dr. B. E. Noltingk will deliver a paper entitled "The Application of High-Power Ultrasonics." The morning of the last day, Friday, September 5, will be devoted to an open discussion of instrument users' problems. Time will be allowed for discussion after each paper. The exhibition of electronic instruments and equipment will indicate the advances which have been made in this connection during recent years, and particularly since the previous exhibition in 1950. A wide range of electronic equipment for use in industry is expected to be on view. Entrance to the symposium itself will be by ticket (which will admit also to the exhibition), obtainable on application to the secretary, Scientific Instrument Manufacturers' Association, 20, Queen Anne-street, London, W.1. Admission to the exhibition alone is by trade card.

ACCIDENT ON A SLIPPERY FLOOR.

In our issue for March 21, on page 370, under the title of "Two Cases of Employer's Liability," we commented on the case of *Latimer v. A.E.C., Ltd.* (1952), All. E.R. 443, in which Mr. Justice Pilcher held that the owners of a factory were liable in damages for injuries sustained by a workman who fell on a slippery floor. Owing to a downpour of rain of unprecedented character, the factory was flooded, and oil pumped to machines through channels in the floor mixed with the water. In the result, the floor was left in a slippery state. The judge held that, while the factory owners had not been guilty of any breach of the Factory Acts, they were guilty of negligence at common law in

allowing the plaintiff to work in the factory when they knew it to be in a potentially dangerous condition. Commenting on this, we ventured the opinion that, "In view of the fact that the condition of the floor was brought about by an exceptional storm, it is fairly obvious that the judge's decision cannot be cited as an authority for the proposition that an employer must close his factory whenever there is a shower of rain." That this comment was justified appears from the fact that the Court of Appeal has reversed the judge's decision (1952 All. E.R. 1302). Lord Justice Singleton said: "It seems to me that the learned judge has put on the defendants a higher duty than employers owe to their workmen at common law. The duty of an employer is to act reasonably towards his men and to take care, in the way that a prudent employer would, to see that his workmen are not exposed to unnecessary risks, and that obligation extends to the building in which they work, to the plant, and, in some cases at least, it covers the providing of a proper system of work. On the facts of the present case, the defendants have done all they could to put the factory in a proper condition. The judge so found. Later in his judgment, Lord Justice Singleton said: "I do not think that the finding that the defendants were negligent and in breach of the duty they owed to the plaintiff, by reason of the fact that they did not close down the premises, can stand."

THE PATERSON ENGINEERING COMPANY, LIMITED.

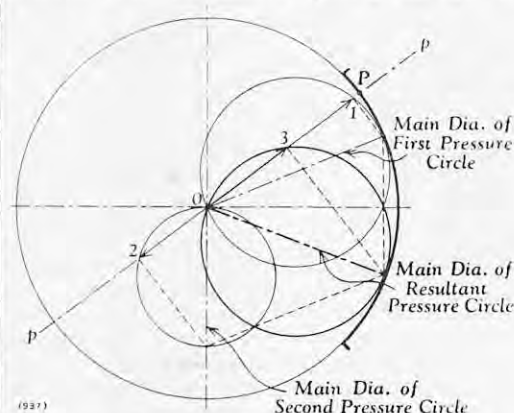
On Monday, June 23, we had the pleasure of participating in a jubilee of especial interest, namely, the 50th anniversary celebration of the foundation of the Paterson Engineering Company, Limited, manufacturers of water-softening apparatus. The function was held in the ancient hall of the Worshipful Society of Apothecaries, in Black Friars-lane, off Queen Victoria-street, London, E.C.4, where the guests were received by Sir William Paterson, the founder and chairman of the company, and Lady Paterson. Sir William (whose knighthood dates from 1944) came to London from Scotland in 1897, to take up an appointment with a firm of paper-mill engineers. Realising the importance of water purification, however, he started his own business on May 1, 1902, with the modest capital of 700L, making his own drawings and handling all the correspondence himself. Until 1910, the company was concerned mainly with the filtering and softening of water, but, in that year, Paterson decided to enter the wider field of water purification for public drinking supplies. The first installation that he put into service for this purpose was for the Weardale and Consett Water Company, in Co. Durham; the first of many, of increasing size and importance. This new development flourished so rapidly that, in the early 1930's, the company was reconstituted as a limited liability company. It has now become what is probably the largest undertaking of its kind in the world specialising in water treatment. The celebration on June 23 was particularly notable for the presence, in the Apothecaries' Hall, of Lord Waverley, chairman of the Port of London Authority, and Sir Alexander Gray, Professor of Political Economy and Mercantile Law in the University of Edinburgh; old fellow students of Sir William Paterson, who had accompanied him to London in the 'nineties to seek their respective fortunes. Also in the gathering was Sir William's elder brother, now (we understand) in his 89th year. Lord Waverley recalled, with a wealth of entertaining detail, how he had consulted his friend, William Paterson, on the design of what was known eventually as the "Anderson" shelter; the detailed design of which, he emphasised, was due to Sir William. It was patented—in the names of William Paterson and O. C. Kerrison, now secretary of the company—to prevent commercial exploitation when this might have been a serious handicap, and eventually the patent was made over to the nation. Lord Waverley's speech (during which he displayed the original model of the Anderson shelter—which, surely, ought to be deposited in the Science Museum) and that of Sir Alexander Gray, recalling the struggles of their youth, were acknowledged by Sir William; briefly, as was understandable, for there are some occasions when elaborate speeches are not merely inappropriate, but impossible.

LETTERS TO THE EDITOR.

THE FORCES AND PRESSURE DISTRIBUTION IN BRAKE SHOES.

TO THE EDITOR OF ENGINEERING.

SIR,—Since sending you the MS. of my article entitled "An Analysis of the Forces and Pressure Distribution in Brake Shoes," which you published in your issue of April 4, 1952, on page 418, I have been able to prove that the pressure distribution on hinged shoes could be represented by a single circle. As shown in the article, the resultant pressure at any point is the vector sum of the pressures related to the virtual movements of the brake shoe about the brake-post pivot and the shoe hinge. Thus at the point P, in the accompanying diagram, the resultant pressure $O3 = O1 + O2$. But $O1$ is the component or projection of the main diameter (i.e., the diameter passing through the



brake centre O7) of the first pressure circle in the direction $p-p$, and $O2$ is the component, in the same direction, of the main diameter of the second pressure circle. Hence $O3$ is the component, in the direction $p-p$, of the vector sum of the main diameters of the two component pressure circles. As the same argument applies to any radial line $p-p$, it is obvious that the locus of the points 3, representing the resultant pressure distribution, is a circle the main diameter of which is the vector sum of the main diameters of the two component pressure circles.

I would like also to call your attention to a small error in formula 17, on page 421. The formula should read as follows:

$$T = t \mu S c \left(\frac{1}{a - \mu b} + \frac{1}{a + \mu b} \right)$$

Yours faithfully,

J. HIRSCHHORN.

3, Alpha-road,
Willoughby, New South Wales.
June 8, 1952.

THE ECONOMICS OF FUEL AND POWER.

TO THE EDITOR OF ENGINEERING.

SIR,—Sir John Hacking's reply, on page 752, ante, to my letter published in your issue of May 30, on page 689, is, if I may say so, typical of the attitude of most senior executives of the British Electricity Authority. They appear to be on the defensive where matters of fuel efficiency are concerned, whereas what is wanted is a more positive attitude of enthusiasm towards the enormous possibilities which still lie open to improve this efficiency.

It is good to know that the Pimlico district heating scheme is being studied with great interest, but how often do we hear any reference to this subject in speeches and official pronouncements from their spokesmen? Many engineers with experience of back-pressure plant consider the Battersea-Pimlico scheme unnecessarily elaborate and expensive, and suggest that a few more installations on the lines of the Whitechapel scheme, where L.C.C. flats are being supplied with heat from a local brewery, would

give a better idea of "consumer reaction." This is a splendid example of the type of enthusiastic approach I am advocating, which at present seems to be confined to private enterprise.

I do not think that many gas engineers would disagree with my "generalised figures," which are considerably more conservative than those quoted in the *Gas Journal*. My analogy of the furniture factory was quoted to demonstrate the absurdity of regarding as a heat loss the use of a material having a potential calorific value for a purpose other than heat production. It would indeed be a loss to the nation if all our valuable coal-tar products were to be consumed in Sir John's furnaces, even though the heat in them was thereby made available, whether at 19 or 30 per cent. efficiency.

Yours faithfully,

H. M. PEACOCK,
M.I.Mech.E., M.Inst.F.

20, Kylestrome House,
Ebury Square, London, S.W.1.
June 17, 1952.

EARLY FERRANTI ALTERNATOR SETS.

TO THE EDITOR OF ENGINEERING.

SIR,—We are anxious to find out if there are any Ferranti steam-driven alternator sets still in existence, working or otherwise. The type we are particularly interested in, with a view to its preservation, is the vertical cross-compound type with the alternator directly mounted on the crankshaft and the cylinders fitted with the four-grid valve arrangement, controlled by quick opening and closing cams. These engines were built about the period 1900 to 1904, and were installed in a number of electricity generating stations throughout the country and also at some private plants. Unfortunately, our records of that period are very sketchy, and it has occurred to us that some of your readers may know of the existence of such an engine. We have found one still working in Lancashire, of an earlier design, which was fitted with four slide valves per cylinder, rope-driving a weaving shed and still doing the job that it was bought to do over 50 years ago.

Yours truly,
A. W. G. TUCKER.

Ferranti, Limited,
Hollinwood, Lancashire.
June 19, 1952.

THE XYLONITE GROUP.—To commemorate the 75th anniversary of the foundation, in 1877, of their parent company, the British Xylonite Company, Limited, the Xylonite Group, 9, Conduit-street, London, W.1, have issued an illustrated booklet describing the early history of the organisation, the expansion and foundation of member companies, and their present activities. The history of the early struggles is presented in a particularly interesting way, in the form of extracts from the private journal of Mr. C. P. Merriam, son of the founder of the British Xylonite Company, Limited, Mr. L. P. Merriam, and managing director of the company from 1894 to 1927, when he was succeeded by his son, Mr. C. F. Merriam, the present chairman of the company, who, in his turn, has just retired from executive duties. In addition to the parent company, the Xylonite group includes BX Plastics Ltd., Bexford Ltd., Hallex Ltd., Cascelloid Ltd., Expanded Rubber Co. Ltd., Scintillex Ltd., Plastic Cutters Ltd., British Xylonite Co. (Canada) Ltd., British Xylonite (Australia) Pty. Ltd., and British Xylonite Incorporated (U.S.A.).

GENERATING PLANT PROGRAMMES.—Speaking at the British Electrical Power Convention at Bournemouth on Wednesday, June 18, Lord Citrine said that 1,113 MW of new generating plant had been commissioned in this country during 1951 and the figure likely to be achieved during 1952 would be between 1,150 MW and 1,400 MW. It was difficult to persuade the Government that the rate of production must be expanded in succeeding years and that approval for this expansion must be given now. The present limit of 1,550 MW per annum should be appreciably raised in order to meet the steady growth of load before obsolete plant could be replaced. To achieve speedier erection and greater economy, a semi-outdoor form of construction was being adopted at the new Ince station. The employment of 60-MW and 120-MW sets supplied by unit boilers as the future standard would also help to reduce the size of the buildings.

OBITUARY.

COLONEL W. C. DEVEREUX, C.B.E.

THE news of the sudden death of Colonel W. C. Devereux, at Ascot, on June 21, will be received with regret by engineers and metallurgists in many parts of the world. Wallace Charles Devereux, who was managing director of Almin Limited and chairman of International Alloys Limited, and other companies, and of the Fulmer Research Institute, was born on March 9, 1893, and educated at King Edward's Grammar School, Aston, Birmingham. After studying and practising metallurgy for some years, he was appointed superintendent of National Aircraft Factory No. 1, during the war of 1914-18. At the end of the war, Devereux continued his metallurgical work and realising the importance of forged-aluminium alloys, formed High Duty Alloys Limited, in 1927, to carry out research and development work leading to the commercial production of new high-strength alloys needed by the aircraft industry. During the early part of the war of 1939-1945, he was appointed, by Colonel Moore Brabazon,



THE LATE COLONEL W. C. DEVEREUX, C.B.E.

Controller of Repair and of American and Dominion Aircraft Supplies, but in the spring of 1942 he asked to be released to resume control of High Duty Alloys Limited.

In July, 1945, Colonel Devereux relinquished his positions as chairman and managing director of High Duty Alloys in order to devote himself to the scientific development and application of aluminium alloys over a wider commercial field than formerly. He founded Almin Limited (the Associated Light Metal Industries Group) which, during the subsequent seven years, undertook the manufacture of some outstanding aluminium structures, including the aluminium roof of the Dome of Discovery building at the South Bank Exhibition, the telescopic gangways for the ocean terminal at Southampton and the all-aluminium aircraft hangars at London Airport. He was a founder of the Fulmer Research Institute at Stoke Poges, an establishment intended to meet the needs of industry for laboratories which could carry out research on a sponsored basis for individual companies. Created a C.B.E. in 1949, Devereux was Honorary Colonel of the 114th (County of London) Army Engineer Regiment, Royal Engineers (T.A.). He was elected a Fellow of the Royal Aeronautical Society in 1933 and had served on the Council. He was also a Fellow of the Royal Society of Arts, a member of the Institution of Naval Architects, of the Society of Automotive Engineers and of other institutions in this country and in the United States.

CONVERSAZIONE OF THE INSTITUTION OF CIVIL ENGINEERS.

By long-established custom, the President of the Institution of Civil Engineers receives the members and their ladies at a conversazione in the Institution towards the end of June—a time which may have been selected initially for any one of a variety of reasons, but which happily coincides with the peak period of the strawberry season and enables him to regale his guests with that delectable fruit, which has come to be regarded as an invariable accompaniment to the musical programme, the floral decorations, and the display of scientific and technical exhibits of interest to civil engineers, which, on these occasions, transform the normal classical austerity of the Institution building. The function was held this year on Thursday, June 19, when the President, Mr. A. S. Quartermaine, with Mrs. Quartermaine and members of the Council, received their guests in the Great Hall. A piano-forte recital was given by Miss Sheila Randell in the theatre of the Institution from 9.0 p.m. to 9.30 p.m. and again from 10.0 p.m. to 10.30 p.m., and, in the course of the evening, the light orchestra of the Corps of Royal Engineers, conducted by Major A. Young, A.R.C.M., P.S.M., rendered selections in the entrance hall and the Great Hall.

The exhibition of engineering models and scientific apparatus, as always, well represented the wide range of the interests and activities of the oldest professional engineering institution. One end of the library was occupied by a model, to the scale of 1:2,500, of the River Thames between Westminster and Woolwich, and at Tilbury, lent by the Port of London Authority (whose chief engineer is Mr. W. P. Shepherd-Barron, M.C., M.I.C.E.) and showing the docks, quays and principal buildings. In addition, to mark the 150th anniversary of the opening of the first of London's enclosed docks, a series of prints was exhibited, illustrating stages in the development of London as a port.

Mr. J. A. S. Rolfe, M.I.C.E., contributed a model representing a section of a coast line, constructed in a water tank and provided with a wave generator working in conjunction with a recently-developed wave measurer and recorder. The apparatus was designed to develop a train of mixed waves of two fundamental frequencies, either of which could be varied over a wide range. It consisted of a long strip of plate, hinged at the top and dipping into the water, which was actuated by two hydraulic cylinders, the pistons being attached to the rear surface of the plate. The hydraulic pulses were produced by a geared drive to the pistons from a small electric motor. The wave recorder, developed in the Institute of Oceanography by a research team directed by Dr. G. E. R. Deacon, F.R.S., consists of a valve oscillator in which part of the tuned circuit is a vertical wire through the water surface. The rise and fall of the surface causes a variation of the frequency of oscillation, which is displayed on a cathode-ray oscilloscope.

A model of the Morwell electric power station of the State Electricity Commission, Victoria, Australia, exhibited by Mr. H. D. Watson, M.I.C.E., of Mitchell Engineering Limited, showed two of the eight boiler units, which are designed to burn pulverised brown coal. Each unit will have a maximum continuous rating of 235,000 lb. of steam per hour at a pressure of 1,300 lb. per square inch at the superheater outlet and a temperature of 932 deg. F., when using feed water at 380 deg. F. The brown coal to be used as fuel contains about 63 per cent. of moisture and has a calorific value of 4,280 B.Th.U. per lb. It will be pulverised in Kramer mills, four to each boiler, and dried by a gas return circuit from the furnace, which is fired tangentially from the corners.

An exhibit which attracted particular attention was a working model of the Rapier W.1400 walking dragline excavator, the largest machine of its kind in the world, which was constructed for Messrs. Stewarts and Lloyds Minerals, Limited, for stripping overburden to a depth of 100 ft. from the ironstone beds at Corby, Northamptonshire. The model, made to a scale of $\frac{1}{4}$ in. to a foot, was lent by Dr.

E. L. Montagnon, M.I.C.E. The dragline weighs 1,670 tons and has an all-welded jib 282 ft. long, of tubular construction. The bucket weighs 25 tons and holds 20 cubic yards; it can excavate 27 tons of spoil in each working cycle of 61 seconds, dumping the load 104 ft. above the level of the machine. The dragline is operated by 14 electric motors of 225 h.p. each, and can be controlled from either of two cabins, one on each side of the superstructure at the front.

The Government of Northern Rhodesia showed a diorama of the Nkana copper mine, which produced, in 1951, 12,700 tons of blister copper and 90,000 tons of electrolytic copper. Adjoining this exhibit was a model, shown by Mr. W. Storey Wilson, B.Sc., M.I.C.E., of Messrs. Holloway Brothers (London), Limited, of a compressed-air caisson forming the foundation of the pump house for the circulating-water system of the Uskmouth electricity generating station. The caisson is 160 ft. long and 110 ft. wide, with a weight of 42,000 tons, and was sunk under compressed air to a depth of 70 ft. below high-water level, on the north bank of the River Usk. It was stated to be the largest caisson ever sunk by this method.

The University of Bristol, through Professor A. G. Pugsley, O.B.E., M.I.C.E., showed a model of the new building now in course of erection on St. Michael's Hill, Bristol, for the Faculty of Engineering. It will consist of a central block enclosing two courtyards, with two large wings, and will house the mechanical, civil, electrical and aeronautical engineering laboratories, the geology, mathematics and theoretical-mechanics departments, the engineering library, etc. Work on the building began in August, 1949, when Professor Andrew Robertson, F.R.S., cut the first sod, and the foundation stone was laid by Mr. Winston Churchill, Chancellor of the University, on December 14, 1951.

Mr. F. W. Appleby, M.Sc., M.I.C.E., exhibited an instrument for recording continuously the run-off from rainfall data, based on the similarity between slip flow and flood development in natural channels. The essential part of the instrument was a device to register heat flow and heat storage, whereby a corresponding impulse of heat input in a given time might be adjusted to produce a unit output temperature curve of a form following the unit hydrograph of the drainage basin under examination; the device was, in effect, a thermo-electric model of the catchment area.

A collection of breathing apparatus for use in sewers, under water, and in similar situations was shown by Mr. R. W. Gorman Davis, of Messrs. Siebe, Gorman and Company, Limited; it included the "P.S." carbon-monoxide detector, comprising a pump and a tube containing silica-gel impregnated with potassium pallado-sulphite, which changes colour in the presence of carbon monoxide, the concentration of the gas being shown by the length of the stain on the indicator material.

A neat design for a sluice gate was shown in model form by Messrs. C. P. Sandberg. It was designed as a segment of a vertical cylindrical shell in tension, the water load being transmitted to grooves in the piers or abutments by trains of rollers. The model, in which brass foil was used for the gate, had been tested under load by Professor C. M. White at the Hawksley hydraulic laboratory, Imperial College, and was found to be fully stable and not subject to any self-induced vibrations.

Eight small dioramas were exhibited by Sir Alexander Gibb and Partners to illustrate various developments in hydro-electric engineering; they included the Carsfad dam and power house of the Galloway Water Power Company, the Pitlochry station, the Cliff Quay thermal power station at Ipswich, and the Captain Cook graving dock at Sydney, New South Wales. Next to these exhibits was one contributed by Mr. P. G. Mott, A.M.I.C.E., survey manager of Hunting Aerosurveys, Limited, illustrating the uses of photogrammetric surveying in connection with reservoir and irrigation engineering. An adjoining exhibit of considerable historical interest was the Brassey Shield, presented, in 1851, to Thomas Brassey, the railway contractor, by the promoters of the Great Northern Railway. It bears the portraits of ten prominent civil engineers of that day, and twelve illustrations of the principal works executed by Brassey.

A large model, constructed mainly of Meccano parts, was exhibited by Mr. F. R. Bullen, M.I.C.E., to show the main constructional features of a large workshop at Stockton-on-Tees, erected for the Power Gas Corporation, Limited. The design was unusual in that, in the transverse bays, the second and fourth rows of columns were tapered and designed as vertical cantilevers, whereas the first, third and fifth rows were hinged and were intended to take only vertical reactions and small lateral forces. In the longitudinal bays, the roof members were simple joist rafters, spanning from ridge to eaves. The estimated saving in weight was 10 per cent., and, in addition, further economies in cost were made possible by the extensive use of rolled sections and welding.

Typical of the variety which is expected in these annual exhibitions was an apprenticeship indenture of 1825, shown by Mr. M. K. Rice-Oxley, M.I.C.E.; it may be remarked that it did not contain the much-debated "salmon clause," limiting the number of days in the week on which the apprentice might be fed on salmon. Next to it was a mechanical sieve for laboratory test sieves and an apparatus for the measurement of wind velocity, both exhibited by Mr. M. G. R. Smith, M.I.C.E., the Western Region gallons a day.

Mr. J. Rawlinson, M.Eng., M.I.C.E., chief engineer of the London County Council, contributed an interesting model, made by the staff of the architect's department of the L.C.C., of the Northern Outfall Works of the London main drainage system; it showed the original works constructed between 1860 and 1890, the activated-sludge plant constructed between 1930 and 1940, and additional plant now in process of completion, which will eventually provide for the treatment of 200 million gallons per day.

An exhibit by the Forest Products Research Laboratory of the Department of Scientific and Industrial Research showed transparencies illustrating some of the work of the Laboratory; and the Crown Agents for the Colonies showed a selection of postage stamps portraying subjects of engineering interest.

Two models of 8-ton open forging-hammer foundations were exhibited by Mr. J. H. A. Crockett, B.Sc. (Eng.), and Mr. D. B. O'Neill, B.Sc. (Eng.); the particular features of these were that they were fully-controlled in respect of oscillation fatigue and were designed to be constructed in Freyssinet stressed high-quality grouted concrete. They were mounted on steel and rubber springs and were provided with friction dampers.

The Road Research Laboratory of the Department of Scientific and Industrial Research showed a series of models to demonstrate the burning of black cotton soil to provide road material, and the effect of a rise in the water table in reducing the supporting power of sand. In the latter model, a model lorry rested on a layer of sand in a cylinder; when the water rose to a certain level, the lorry sank in the sand. It may be noted that a model similar in principle, with a house in place of a lorry, is to be seen in the Soil Mechanics Laboratory at Delft, Holland, where the problems that it illustrates have been the subject of extensive observation.

Other exhibits included a model of a wind tunnel for the College of Aeronautics at Cranfield, in Buckinghamshire; one showing the main structural details of the new hangars to be erected for British European Airways at London Airport; shallow seismic refraction equipment, contributed by Dr. H. Q. Golder, for determining the depth of soil to bedrock, and a working model showing the operation; and a selection of photographs of civil engineering projects in the colonial territories, lent by the Central Office of Information on behalf of the Colonial Office.

QUENCHING OF STEEL.—A booklet, under the title of "Some Notes on the Quenching of Steel," has been issued by Edgar Vaughan and Co., Ltd., Legge-street, Birmingham, 4. After describing briefly the mechanism of heat treatment, the relative merits of water and oil quenching and methods of procedure are outlined. The qualities required in a quenching oil are discussed, and special types of salt bath for low-alloy steels and high-speed steels are described.

SUMMER MEETING OF THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meetings of members of the Institution of Mechanical Engineers are annually welcomed for several reasons, not the least of which is that they give the wives of members a chance—for many, perhaps, their first chance—of understanding why it is that an engineer's lot, unlike a policeman's, is such a happy one. No great feat of endurance is demanded in following technical expositions; the two papers are usually of a general character, the visits to works are social as much as educational occasions, and the evening functions require nothing more from the guests than a readiness to enjoy hospitality and entertainment provided by others. The choice of works visits is so varied that most members have difficulty in deciding which to forgo. At Bristol this year, 44 visits had been arranged for two and a half days, and if we cannot mention them all there is good reason for referring to two works, at which some members spent a whole day. At the Filton works of the Bristol Aeroplane Company, the Brabazon aircraft was inspected and the first Britannia aircraft was seen under construction, both in the famous assembly hall. Work on the Britannia is being expedited in the hope that it will be finished in time for the Society of British Aircraft Constructors' autumn exhibition. At the Swindon works of the Western Region of British Railways, the locomotive-testing plant, built in 1905 but now, perhaps, more useful than ever, was seen in use, measuring the performance of an ex-L.N.E.R. 2-6-2 locomotive. Further reference is made to this visit later in this article.

The meeting opened on Tuesday, June 17, with the Rt. Hon. the Lord Mayor of Bristol, Alderman V. J. Ross, J.P., supported by members of the reception committee, welcoming the President, Sir David Pye, C.B., M.A., Sc.D., F.R.S., member of the Council and the Institution, with their ladies, in the Embassy Cinema at Bristol. A report of this ceremony was given on page 783 of last week's issue of *ENGINEERING*. At the general meeting of the Institution which followed, Mr. Alex. B. Cooper, B.Sc., M.I.Mech.E., presented a paper on "Mechanical Engineering Around Bristol."

MECHANICAL ENGINEERING AROUND BRISTOL.

Mr. Cooper dealt particularly with aircraft engines, paper-converting machinery, mechanical-handling plant, brewing equipment and paint-making machinery. It was in the West Country, he said, that Newcomen was born and his engine utilised, and where Boulton and Watt found conditions ripe for the development of Watt's invention. It was there, too, that Trevithick, "that erratic genius," developed his many inventions; some of his boilers were made by Nicholas Holman, the founder of the firm now known as Holman Brothers. The first steamship to cross the Atlantic under her own steam, the Great Western, was built by Patterson in Bristol under the guidance of Brunel. The Clifton suspension bridge was designed by Brunel when he was only 24, though it was not until after he had died that the work was put in hand by some members of the Institution of Civil Engineers who wished to complete "a monument to their late friend, Brunel . . . at the same time removing a slur from the engineering talent of the country." Bristol had always been prominent in the building of road vehicles of all kinds. The earliest steam omnibuses to run regularly in any numbers in London were built there about 1906 by Messrs. Brazil, Holborow and Straker. It was there, too, in 1897, that the first electric tramway was opened, thanks to the initiative of the late Sir George White, the founder of the Bristol Aeroplane Company. Bristol also had historical associations with the metal industries; in 1740 Champion produced zinc for the first time in Europe. The industries of the city were very diversified, and constituted a source of strength in hard times.

Some of the high lights of the work of the Bristol Aeroplane Company were referred to by Mr. Cooper. The engine division started with the famous nine-cylinder Jupiter engine in 1920, which developed

355 h.p. for a dry weight of 700 lb., and was successfully developed to the Pegasus design of 1944, which, with the same swept volume of 1,753 cub. in., was rated at 1,000 h.p. at take-off for a dry weight of 1,180 lb. The Burt McCullum single-sleeve valve was adopted in 1926; the Hercules and Centaurus engines were present-day designs of this type. Variable-pitch propellers were made by a subsidiary company. During the war it was possible to put only a very limited effort into advanced projects. Nevertheless, in 1945, the first Bristol gas-turbine, the Theseus, was run. It was the first propeller turbine to pass the 100-hour test of the type specified by the Ministry of Supply. The Proteus propeller turbine, with a maximum output of 3,500 shaft horse-power, was now under intensive development.

The paper-converting machinery with which Mr. Cooper dealt included slitting machines; guillotines; all-rotary and sheet-fed printing machines; cutting, folding and joining machines; and a bag-making machine which has an output of 4,000 bags a minute. This, he said, was the fastest bag-making machine in the world and produced well over a million bags in a normal working day. The ticket-issuing and change-giving machine so familiar to passengers on the London underground railways was also made by a Bristol firm. Other special-purpose machines made there included one for moulding and packing butter and margarine, a label-punching machine, and a plant for producing the rectangular cardboard boxes in which superior brands of cigarettes were packed in twenty-fives, fifties and hundreds.

In the mechanical-handling field there were several interesting machines made in the Bristol area. Coal for large power stations and iron ore for steelworks were being unloaded at rates of up to 300 tons an hour by a novel crane which carried a hopper or "pouch" in a forward position on its travelling portal. The hopper was fed by the grab of the crane, and material from it was discharged to a conveyor belt or to railway wagons. A certain type of wagon tippler was capable of unloading a train of wagons at the rate of one a minute, which was equivalent to 900 tons an hour, assuming an average wagon capacity of 15 tons. In connection with plant for brewing and paint-making, Mr. Cooper mentioned a bottling unit and the various types of paint mills. To conclude his paper, he gave an illustration of the proposed engineering building at Bristol University, to which Sir Philip Morris referred at the Institution dinner, as reported below.

DEVELOPMENT OF COMMERCIAL VEHICLES.

The Automobile Division paper, which was discussed at a meeting at the Royal Hotel, College Green, on Wednesday, June 18, was given by Mr. A. W. Hallpike, M.I.Mech.E., on "The Development of Transport and Commercial Vehicles in Bristol." The paper was mainly a history of the Bristol Tramways and Carriage Company, though Mr. Hallpike also recalled the early work of several other firms, including Messrs. Brazil, Holborrow and Straker; the Victoria Wagon Company; Messrs. Harris and Hassell, who built a chassis under the name "B.A.T."; and the Douglas Company, of Kingswood, famous for their horizontally-opposed twin-engined motor-cycle and the recently-designed Vespa motor-cycle. The first tramway in Bristol was opened in 1875. The seating capacity of a car was 32, but, according to a contemporary report, "by dint of squeezing it can be made to carry twice that number." Horses were changed four times a day. Electrification was started in 1895 and was completed by 1900. The motor era, as far as the company was concerned, began in 1906.

Finding that its foreign-made motor vehicles were difficult to maintain, the company had established their own works, before the first World War, but it was not until after the war that production reached appreciable proportions. Mr. Hallpike reviewed the subsequent development of design, and gave a description of the modern "Lodekka" bus, a double-deck vehicle with more than ordinary ceiling height in both decks by virtue of a sunken central gangway in the lower deck. The transmission is arranged to one side of the longitudinal centre-line.

Three social events were arranged for the three evenings. On Tuesday, there was the civic reception to which we referred last week, and on Wednesday the Institution dinner was held.

THE INSTITUTION DINNER.

Speaking at the Institution dinner, Sir Philip Morris, C.B.E., M.A., LL.D., vice-chancellor of the University of Bristol, said that at the University they had decided that their biggest single investment in the future would be a new school of engineering. This decision was based not on transitory factors, such as the location of industry or transport facilities, but on a belief in what was going to be really important in the future. The new building would be the home of future industrial scientists. He did not recognise any fundamental difference between laymen and technical men in university affairs. If fundamental science were to flourish it would depend in large part on voluntary support from industry. Firms in industry would be divided into two classes—those who knew what the University was doing, and those who did not know but who supported—he was glad to say—the work of the University. The Institution of Mechanical Engineers, like the University, was an academic institution. They both served a common cause; they were great partners in ensuring security and long-term progress.

The toast of "The City and County of Bristol" was proposed by Dr. R. W. Bailey, F.R.S., vice-president of the Institution, who spoke of the tradition of enterprise and hospitality in Bristol, and of the engineering-education work done by Professor Andrew Robertson and continued by Professor J. L. M. Morrison. Replying to this toast, the Lord Mayor, Alderman V. J. Ross, J.P., recalled his boyhood memories of the late Sir George White founding the Bristol Aeroplane Company, and gave an assurance that in Bristol they were keenly interested in developing a new city centre, after the war damage, which would be based on sound lines. The toast of "The Guests" was proposed by the President, Sir David Pye, C.B., M.A., Sc.D., F.R.S. He said that the members and their ladies were deeply grateful for all the work that had been done in preparing for their visit. In particular, he thanked Mr. R. F. Lyne, O.B.E., who was Lord Mayor of Bristol when the visit was first discussed, and Mr. G. H. Beauchamp, B.Sc., A.M.I.Mech.E., and Mr. J. G. Remington, A.M.I.Mech.E., the two honorary local secretaries who had worked together in arranging the details of the summer meeting. Replies on behalf of the guests were made by Sir Philip Morris, whose remarks are noted above, and by Mr. W. R. Verdon Smith, M.A., chairman of the reception committee, who speculated, as only a lawyer could, on future summer meetings and the subjects that might be discussed at them so as to introduce that lighter side to the deliberations of engineers which, he understood, distinguished the summer meetings from the technical meetings of the winter session. The dinner was ended formally, and in customary fashion, with the President calling on the gathering to honour the toast of "The Institution."

The conversazione on Thursday evening was held at the Victoria Rooms by invitation of the Western Branch committee. The guests were received by the chairman of the Branch, Professor J. L. M. Morrison, D.Sc., and Mrs. Morrison, and during the evening the guests visited the Zoological Gardens.

SWINDON LOCOMOTIVE WORKS.

On Thursday, June 19, the largest party of members, with their ladies, visited Swindon locomotive works, and also spent a short time in the carriage works. The first British gas-turbine locomotive, built by the Metropolitan-Vickers Electrical Company, was inspected (later in the day it hauled the train in which the party returned to Bristol), and a tour was then made of the principal shops. The locomotive-testing plant, which was seen in use, is being employed on tests that are principally concerned with thermal efficiency. Such tests at Swindon are always conducted at constant rates of evaporation and combustion, the speed being varied as required by a special technique. A report on the Swindon methods will be published later.

RECLAMATION PROJECTS IN THE UNITED STATES.

WHEN, just over a century ago, the first settlers entered the part of the American Continent known as the Western United States, they found it a vast land of rolling prairies, sandy deserts, grassy plains and high mountains. Although the topography of this great area is so diversified, it has one outstanding common characteristic, namely, dryness. In most of the 17 Western States, the rainfall is scanty and irregular. The stream flow is erratic, high when the snows melt, dwindling to little or nothing later in the year. To grow crops and maintain homes, water had to be diverted from the streams and rivers and stored behind dams to ensure a stable supply; for this reason, and because they were the obvious means of transport and communication, the rivers became the centres of development. Measures were taken to conserve and put the waters to use by simple dams and canals commensurate in size with the needs of early settlers. By the turn of the century, however, as the population increased, greater development of water resources was necessary. In some districts, the water resources had been developed as far as possible by private enterprise but large untapped land, water, forest, mineral and other resources awaited use. To deal with the situation, the Reclamation Act was passed by Congress in 1902. This legislation extended the aid of the Government in the further development and conservation of Western water resources, and the United States Department of the Interior, Bureau of Reclamation, in co-operation with other Federal agencies, the States themselves and, where possible, private enterprise, embarked on an immense programme of development of the water resources of the Western States. Multiple-purpose "reclamation projects" were authorised, embracing irrigation, hydro-electric power, municipal water supply, flood control, protection from silt and salt water, recreation facilities, fish and wild-life protection measures and other benefits. Under these projects, water is being transported for great distances: in the California Central Valley project, as far as 500 miles. Projects such as the Missouri River Basin development are being planned and built on a scale which takes in the whole width of the river basin.

There are at present about 21,000,000 acres under irrigation in Washington, Oregon, California, Montana, Idaho, Nevada, Utah, Arizona, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas constituting the 17 Western States, and some 5,000,000 acres of this total are irrigated by reclamation projects. Hydro-electric power has become of major importance, both in project development and in meeting economic and social needs. Revenues from the sale of power repay the costs of power-station construction and help to meet irrigation development costs which may exceed the farmer's ability to pay. Reclamation projects have provided 96 dams, with 82,780,000 acre-ft. of storage capacity; 35 power plants, with over 3,000,000 kW capacity; 16,000 miles of canals; 3,000 miles of transmission lines; 5,000,000 acres with full or supplementary irrigation; and 9,000,000 people with water and power. The power revenues per annum total 33,000,000 dols. Between 1916 and 1949, they have contributed 2,000 million dols. to Federal taxation. Crops produced with reclamation water average more than 500,000,000 dols. a year in value. These figures may be compared with the total reclamation capital investment to date of 2,000 million dols.

These reclamation projects have involved the construction of the world's four highest dams: the Hoover Dam (Arizona-Nevada), 726 ft.; the Shasta Dam (California), 602 ft.; the Hungry Horse Dam (Montana), 564 ft. when completed; and the Grand Coulee Dam (Washington), 550 ft. The world's four largest concrete dams are the Grand Coulee Dam, containing 10,585,000 cubic yards; the Shasta Dam, 6,541,000 cubic yards; the Hoover Dam, 3,250,000 cubic yards; and Hungry Horse Dam, 2,900,000 cubic yards. The world's largest hydro-electric power plant will be at Grand Coulee, with a capacity of 1,974,000 kW when fully

completed; and this project will also have the world's largest pumping plant, with a capacity of 528,400,000 gallons per hour. The Alva B. Adams tunnel, in Colorado, is 13 miles long and is the longest irrigation tunnel in the world; and the Central Valley project, in California, is claimed to be the longest man-made water system, having a length of 500 miles. The Missouri River Basin project is the largest irrigation project, covering 6,000,000 acres; it is also the greatest peace-time construction project ever to be undertaken, for it embraces an area of 530,000 square miles.

About half of the irrigation deemed possible under present methods, concepts and legislation has now been carried out, but only a small fraction of the potential hydro-electric power has been harnessed. There are still, according to the Bureau of Reclamation, 16,000,000 acres of irrigable land not yet dealt with, 11,500,000 acres needing supplementary irrigation, and 50,000,000 kW of unused Western potential power. The programme of construction and new project investigations aim ultimately at the full development of Western resources. The construction rate for 1950 was valued at 387 million dol., this sum being greater than the total investment for the first 30 years of reclamation history.

Among the main projects under construction, the Missouri River Basin scheme is one of the more important. This project will develop the 2,500-mile length of one of the world's greatest rivers. It covers more than 150 separate but inter-related schemes, including the construction of about 100 dams, some 40 power plants and thousands of miles of canals and transmission lines. When completed, it will add an irrigated area of over 6,000,000 acres, and will increase electric power capacity by about 2,500,000 kW. It is computed that it will ultimately support upwards of 750,000 more people in the basin. At the same time, the project will provide municipal water supplies, add 760 miles of navigable river channel, reduce the danger of floods, and facilitate the development of lignite coal, oil-shale and other mineral resources. The aim of the project is to stabilise the economy of an area equal to one-sixth of the United States, an area which produces half the American requirements of bread, a quarter of the wool, and a significant part of the meat and butter. The Missouri River Basin works are being constructed jointly by the Bureau of Reclamation and the Army Corps of Engineers. So far only a small part of the project is completed.

The Columbia Basin Project is based on the Columbia River in the State of Washington, which is the foremost power stream of the United States. The central feature of the project is Grand Coulee Dam, the largest concrete structure ever built; it is four-fifths of a mile long and 550 ft. high. At the foot of the dam is the largest power plant in the world, which, on July 31, 1950, had a power capacity of 1,434,000 kW, but eventually will have a 1,974,000 kW rating. On completion of the scheme, water will be pumped from the 151-mile reservoir formed by Franklin D. Roosevelt Lake at the rate of 144,000 gallons per second into the Grand Coulee, a river canyon formed during the ice age. Here it will be stored in a reservoir 27 miles long, from which it will flow through tunnels and siphons and 4,000 miles of canals to water 1,000,000 acres of land. Hungry Horse Dam, now under construction on the South Fork of the Flathead River in Montana, will be a primary structure in the development of the Columbia River Basin. Its power plant will have a capacity of 285,000 kW, and water from its reservoir may be used to irrigate 44,000 acres. Its main purpose, however, is to store water and regulate the flow downstream for a series of other dams.

The Central Valley Project in California is in an advanced stage of completion of the primary works. It is designed to protect a rich and highly developed agricultural and industrial area from crippling water shortages, and to extend and support the rapid growth of this area. Works under construction or in service will provide irrigation for 1,000,000 acres, and hydro-electric generators already in service at Shasta and Keswick Dams provide 450,000 kW to pump water and provide energy for farms, cities and industry. The Central Valley of California, some 500 miles long and about

120 miles wide, is entirely surrounded by mountains, except for a gap in its western edge. There is a considerable amount of water at its northern end, and very little at its southern end, and the main purpose of the project is to transfer water from north to south, a distance of about 500 miles. The Shasta power plant, backed by a storage capacity of 4,500,000 acre-ft. and having a generating capacity of 379,000 kW, will provide much of the power for pumping water drawn from the Sacramento, San Joaquin and other rivers, to feed great canals. The Tracy pumping plant, situated approximately at the centre of the scheme, is designed to have six 22,500-h.p. electrically-driven pumps to lift 2,000,000 gallons of water per minute 200 ft. to the headworks of the Delta-Mendota Canal. Other dams and canals feed water by gravity. Up to the end of 1950, about 340,000,000 dol. had been invested in this project, or a little more than half of the total investment estimated for the full authorised development.

The Hoover Dam, with a height of 726 ft. above the bed of the Colorado River in the narrow confines of Black Canyon, is the key structure in the control and development of the lower Colorado River. Although built by the Bureau of Reclamation in the early 1930's, installation of the last of its turbo-generators has only just been completed, giving the plant a rated capacity of 1,332,000 kW. The reservoir will store twice the average annual flow of the Colorado. The dam protects Pacific South-West farmlands from flooding and at the same time provides for much-needed irrigation. The southern Californian metropolitan area also receives water through an aqueduct 240 miles long branching from the Colorado River at Parker Dam, downstream from Hoover Dam. The Davis Dam is a large earthfill structure nearing completion 67 miles downstream on the Colorado River from Hoover Dam. It will provide a regulating reservoir which will permit a large discharge of water through the generators at Hoover Dam in hours of peak demand. The power plant at Davis Dam will have a capacity of 225,000 kW.

CARGO LINER FOR ROYAL MAIL LINES, LIMITED.

THE single-screw motorship Ebro, which was built at the Govan yard of Messrs. Harland and Wolff, Limited, has completed her trials and has now been delivered to her owners, Royal Mail Lines, Limited, Leadenhall-street, London, E.C.3. A sister ship, the Essequibo, is now fitting out at the same yard and is due for delivery this coming autumn, both vessels being intended for the owners' London, Bermuda, West Indies, Spanish Main and Central America cargo and passenger service. The Ebro has a length between perpendiculars of 415 ft., a moulded breadth of 58 ft. 6 in., and a depth moulded to the shelter deck, of 38 ft. 4 in.; the gross tonnage is 5,855. There are continuous shelter, main, and lower decks, and the vessel is divided into five cargo holds, machinery space, and fore and after peaks, by seven bulkheads, No. 3 hold being fitted out as a deep tank for the carriage of edible oils. Particular care has been taken in the design to ensure rapid handling of the cargo and the equipment includes 12 electrically-operated cargo winches and associated derricks for loads up to 10 tons and an additional heavy derrick at the fore end of No. 2 hatch for handling lifts up to 30 tons. The officers and crew are accommodated amidships, in accordance with the latest Ministry of Transport regulations, and accommodation is also provided for 12 passengers in eight single-berth and two double-berth cabins.

The propelling machinery consists of a Harland and Wolff-B. and W. two-stroke cycle, single-acting opposed-piston Diesel engine having six cylinders with a bore of 620 mm. and a combined stroke of 1,870 mm. The engine is arranged to operate on heavy fuels as well as Diesel fuel, and is coupled directly to the propeller shaft. In accordance with the builder's latest practice, the columns, bedplate, frames, etc., are of welded-steel construction; the thrust block is incorporated in the after end of the bedplate. Fresh-water cooling is employed for the cylinders, the water being circulated through the engine by a plunger-type pump driven from a forward extension of the crankshaft, a similar pump driven from the same crankshaft extension circulating sea water through the heat exchanger. All other pumps, with the exception of the boiler-feed pumps, are electrically driven, direct current for this purpose, and the ship's services generally, being provided by three 135-kW Diesel-driven generating sets.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

THIS list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

WORLD EXHIBITION OF PHOTOGRAPHY AND SCIENTIFIC PHOTOGRAPHIC APPARATUS.—Thursday, May 15, to Thursday, July 31, at Lucerne. Details from the general secretary, Weltausstellung der Photographie, Reuss-Steg 11, Lucerne, Switzerland.

TRIESTE INTERNATIONAL TRADE FAIR.—Sunday, June 29, to Sunday, July 13, at Trieste. Agents: Italian Chamber of Commerce, 652, Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHITEhall 5521.)

SECOND INTERNATIONAL CONFERENCE ON HOT DIP GALVANISING.—Monday, June 30, to Friday, July 4, at Düsseldorf. Organised by the Zinc Development Association, Lincoln House, Turl-street, Oxford. (Telephone: Oxford 47988.) See also page 655, *ante*.

ROYAL AGRICULTURAL SHOW.—Tuesday, July 1, to Friday, July 4, at Newton Abbot. Organised by the Royal Agricultural Society of England, 16, Bedford-square, London, W.C.1. (Telephone: MUSEum 5905.)

SYMPOSIUM ON CONCRETE SHELL ROOF CONSTRUCTION.—Wednesday, Thursday and Friday, July 2, 3 and 4, at the Royal Institute of British Architects, 66, Portland-place, London, W.1, and the Institution of Civil Engineers, Great George-street, London, S.W.1. Organised by the Cement and Concrete Association, 52, Grosvenor-gardens, Westminster, London, S.W.1. (Telephone: SLOane 5255.) See also page 649, *ante*.

CONFERENCE ON BEARING CAPACITY OF PILES.—Monday, July 7, to Wednesday, July 9, at Paris. Apply to the secretary, Société Internationale de Mécanique des Sols et des Travaux de Fondations, Gloria-strasse 37, Zürich 44, Switzerland.

INTERNATIONAL CONFERENCE ON SAFETY IN MINES RESEARCH.—Monday, July 7, to Saturday, July 12, at Buxton. Attendance by invitation only. Communications to the director, Ministry of Fuel and Power, Safety in Mines Research Establishment, Research Laboratories, Portobello-street, Sheffield, 1.

INTERNATIONAL SEAWEED SYMPOSIUM.—Monday, July 14, to Thursday, July 17, at Edinburgh. Apply to the director, Institute of Seaweed Research, Inveresk, Midlothian, Scotland.

ELECTRONICS EXHIBITION.—Tuesday, July 15, to Friday, July 18, at the College of Technology, Sackville-street, Manchester, 1. Organised by the North-Western Branch of the Institution of Electronics. Apply to Mr. W. Birtwistle, 17, Blackwater-street, Rochdale, Lancashire. See also page 793, *ante*.

WELDING DESIGN AND ENGINEERING SUMMER SCHOOL.—Wednesday, July 16, to Sunday, July 20; and Sunday, July 20, to Friday, July 25, at Ashorne Hill. Organised by the British Welding Research Association, 29, Park-crescent, London, W.1. (Telephone: LANGham 7485.)

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, FOURTH INTERNATIONAL CONGRESS.—Monday, August 25, to Friday, August 29, at Cambridge. For further information, apply to the secretary of the Association, Swiss Federal Institute of Technology, Zürich, Switzerland.

19TH NATIONAL RADIO AND TELEVISION EXHIBITION.—Tuesday, August 26, to Saturday, September 6, at Earl's Court, London, S.W.5. Organised by the Radio Industry Council. Apply to the secretary of the Council, 59, Russell-square, London, W.C.1. (Telephone: MUSEum 6901.)

FRANKFURT AUTUMN FAIR.—Sunday, August 31, to Thursday, September 4, at Frankfurt-on-Main. Agents: LEP Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. (Telephone: CENTral 5050.)

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION.—See page 815.

SUMMER SCHOOL ON PHOTO-ELASTICITY.—Monday, September 1, to Thursday, September 11, at University College, London. Apply to the secretary, University College, Gower-street, London, W.C.1. (Telephone: EUSTon 4400.) See also page 795, *ante*.

59TH ROYAL NETHERLANDS INDUSTRIES FAIR.—Tuesday, September 2, to Thursday, September 11, at Utrecht, Holland. Agent: Mr. W. Friedhoff, 10, Grosvenor-place, London, W.1. (Telephone: WELbeck 9971.)

FLYING DISPLAY AND EXHIBITION.—Tuesday, September 2, to Sunday, September 7, at Farnborough. Open to the public on September 5, 6 and 7, only. Organised by the Society of British Aircraft Constructors, Ltd., 32, Savile-row, London, W.1. (Telephone: REGent 5215.) See also page 745, *ante*.

19TH INTERNATIONAL GEOLOGICAL CONFERENCE.—Monday, September 8, to Monday, September 15, at Algiers. Convened by the Comité Algérien d'Organisa-

tion du XIX Congrès Géologique International. Apply to Professor R. Lafitte, Faculté des Sciences, Algiers.

WELSH INDUSTRIES FAIR.—Wednesday, September 10, to Saturday, September 20, at the New Pavilion, Sophia-gardens, Cardiff. Particulars from the offices of the Fair, 17, Windsor-place, Cardiff. (Telephone: Cardiff 23049.)

SWISS FAIR, LAUSANNE.—Saturday, September 13, to Sunday, September 28, at Lausanne. For further information, apply to Comptoir Suisse, Place de la Riponne 5, Lausanne, Switzerland.

INTERNATIONAL MACHINE TOOL EXHIBITION.—Wednesday, September 17, to Saturday, October 4, at Olympia, London, W.14. Organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. (Telephone: HOLborn 4667.) See also our issue of July 13, 1951, page 51.

MODERN BUILDING PLANT EXHIBITION.—Thursday, September 18, to Wednesday, September 24, at the Sophia Gardens Field, Cardiff. For further information, apply to the Ministry of Works, Lambeth Bridge House, London, S.E.1. (Telephone: RELiance 7611.)

ASLIB (ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX).—Friday, September 19, to Monday, September 22, Annual Conference at The Hayes, Swanwick, Derbyshire. Apply to the secretary of the Association, 4, Palace-gate, Kensington, London, W.8. (Telephone: WESTern 6321.)

NORTH-WESTERN BUSINESS EFFICIENCY EXHIBITION.—Monday, September 22, to Saturday, September 27, at St. George's Hall, Liverpool. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENTral 7771.)

SYMPOSIUM OF MINERAL DRESSING.—Tuesday and Wednesday, September 23 and 24, at the Imperial College of Science and Technology, Prince Consort-road, South Kensington, London, S.W.7. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (Telephone: MONarch 2096.) See also page 211, ante.

COMMERCIAL MOTOR SHOW.—Friday, September 26, to Saturday, October 4, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

FOURTH INTERNATIONAL CONGRESS ON INDUSTRIAL HEAT AND APPLIED THERMODYNAMICS.—Saturday, September 27, to Saturday, October 4, in Paris. Apply to the general secretary of the Congress, 2, Rue des Tanneries, Paris, 13e.

18TH INTERNATIONAL NAUTICAL EXHIBITION.—Saturday, September 27, to Sunday, October 12, in Paris. Agents: Home and Overseas Trade Fairs, 40, Gerrard-street, London, W.1. (Telephone: GERRard 5947.)

16TH METZ TRADE FAIR.—Saturday, September 27, to Monday, October 13, at Metz. Agents: Home and Overseas Trade Fairs, 40, Gerrard-street, London, W.1. (Telephone: GERRard 5947.)

IRON AND STEEL EXPOSITION.—Tuesday, September 30, to Friday, October 3, at the Public Auditorium, Cleveland, Ohio, U.S.A. Organised by the Association of Iron and Steel Engineers. Apply to Mr. Albert W. Erickson, Junr., at the Association's offices, 1010, Empire Building, Pittsburgh 22, U.S.A. See also page 486, ante.

PLASTICS EXHIBITION.—Saturday, October 11, to Sunday, October 19, at Düsseldorf. Agents: John E. Buck & Co., 47, Brewer-street, Piccadilly, London, W.1. (Telephone: GERRard 7576.)

ENGINEERING INDUSTRIES ASSOCIATION, LONDON REGIONAL DISPLAY.—Tuesday and Wednesday, October 14 and 15, at the Horticultural Hall, Vincent-square, London, S.W.1. Apply to the secretary of the Association, 9, Seymour-street, Portman-square, London, W.1. (Telephone: WELbeck 2241.)

"THE MODEL ENGINEER" EXHIBITION.—Monday, October 20, to Wednesday, October 29, at the New Horticultural Hall, Vincent-square, London, S.W.1. Apply to the offices of the Exhibition, 23, Great Queen-street, Kingsway, London, W.C.2. (Telephone: CHAncery 6681.)

EXHIBITION OF MACHINERY AND APPARATUS FOR FOOD-PROCESSING, CHEMICAL AND PHARMACEUTICAL INDUSTRIES.—Tuesday, October 21, to Wednesday, October 29, at Rotterdam. Organised by the Royal Netherlands Industries Fair, Rotterdam, Holland. Agent: Mr. W. Friedhoff, 10, Grosvenor-place, London, W.1. (Telephone: WELbeck 9971.)

MOTOR SHOW.—Wednesday, October 22, to Saturday, November 1, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1.

20TH NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING.—Monday, December 1, to Saturday, December 6, at the Grand Central Palace, New York. Organised by the American Society of Mechanical Engineers, 29, West 39th-street, New York 18.

LABOUR NOTES.

THE railwaymen's wage claim for an all-round increase of 10 per cent., which was presented to the Railway Executive towards the end of last month, was rejected by the Executive on Monday last, after a short meeting between representatives of the two sides of the industry. It is estimated that the annual wage bill of British Railways would have been increased by between 17,000,000*l.* and 18,000,000*l.* a year, if the claim had been granted in full. The men's proposals appear to have been rejected mainly on the ground that the rise in the cost of living, since the last increase in wages, did not justify the new demand. In this connection, it may be noted that railway employees received an all-round wage increase of 8 per cent. in November last and that this was ante-dated to September 3, 1951. The award was made on the recommendation of the Railway Staff National Tribunal on November 7, 1951, and added an additional 14,200,000*l.* to the Executive's annual wage bill. At mid-April, the level of the interim index of retail prices had risen by six points since mid-November last year and by seven points since the middle of the previous September.

In a statement issued by the Railway Executive after last Monday's meeting, it was announced that representatives of the Executive had met officials of the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association, in connection with the joint claim of the three unions for a 10 per cent. increase in rates of pay and for enhanced payments for time worked between noon and midnight on Saturdays. The union officials were informed that the Executive had declined the claim. They expressed their disappointment with the Executive's reply, the statement continued, and intimated their intention of referring the matter to the next stage of the industry's negotiating machinery.

This means, presumably, that the claim will be presented at an early date to the Railway Staff National Council, which is a formal body comprising representatives of the Railway Executive and an equal number of officials from the three railway unions. Should the two sides of the Council be unable to agree, the dispute may be referred to the Railway Staff National Tribunal, the body which recommended the previous increase. The Tribunal consists of one representative from each side and an independent chairman. In all, some 352,000 members of the railway staff in the conciliation grades and some 90,000 salaried employees are affected by the unions' claim.

Special interest was taken in the fate of the railwaymen's claim as it was the first of the new series of wage demands to be considered. Altogether, wage demands have been made, or will be presented shortly, by unions representing between six and seven million workpeople. The Confederation of Shipbuilding and Engineering Unions presented a claim, on behalf of some 2,500,000 engineering employees, to the Engineering and Allied Employers' National Federation yesterday, and, at the time of going to press, the discussion on this demand was expected to be continued to-day. The amount of the claim had not then been announced but it is unlikely to have been for a smaller amount than 30*s.* a week all round. A claim for an overall wage increase of 30*s.* a week for persons employed in the coal-mining industry was presented to the National Coal Board yesterday by the National Union of Mineworkers. Three road passenger transport wage claims and one on behalf of workpeople in the agricultural industry are also under consideration.

Wages, prices and inflation were among the wide range of economic problems which, it is understood, were discussed at a meeting in London on Tuesday last between Mr. R. A. Butler, the Chancellor of the Exchequer, and members of the Trades Union Congress economic committee. The meeting was held, at the request of the committee, to enable the Chancellor to explain in more detail some of the points he had made in a statement to the National Joint Advisory Council about six weeks previously. The committee had also asked for information about the economic situation generally. Mr. Butler was accompanied by Sir Walter Monckton, Q.C., the Minister of Labour and National Service, and Sir Godfrey Ince, permanent secretary to the Ministry. Mr. Lincoln Evans, C.B.E., general secretary of the Iron and Steel Trades Confederation, led the deputation, and other members of the committee present included Sir Vincent Tewson, and Mr. Arthur Deakin, C.H.

No official statement was issued after the meeting, beyond an acknowledgement that the subjects discussed covered a very wide field. The committee was known, however, to be especially anxious to learn on

what basis the Chancellor had founded his recently-expressed opinion that there would be a greater stability in prices, and what practical steps were to follow his statement that the Government would do everything in its power to keep prices from rising further. The trade-union leaders are understood to have contended that, while the prices of raw materials are tending to decline, the prices of food are definitely increasing, and that the effects of the cuts in food subsidies introduced by the Budget have not yet been felt in full. It is their opinion that prices generally have reached such a level that demands for compensatory wage increases are inevitable. In particular, they are desirous of obtaining definite guarantees that the Government will take specific measures to curb price increases.

In his recent statement, Mr. Butler emphasised that the present time, when the prices of raw materials and many other important goods had reached their peak, and, in some cases, passed it, provided an excellent opportunity of trying to stabilise prices generally, and that, in this connection, moderation in the presentation of new demands for wage increases was essential. There is little doubt that he re-iterated this view at his meeting with the economic committee. Mr. Butler re-introduced his proposal for setting up a joint committee, comprising representatives of the T.U.C. and employers' organisations, to sit as a permanent advisory body for the consideration of problems concerning wages and production. It is understood, however, that this suggestion is not very acceptable to the T.U.C. A factual report of the meeting will be submitted to the T.U.C. General Council and to the annual congress of the T.U.C. at Margate, in September next.

Durham County Council held a special meeting on Monday last, at which it was decided to accept a report by its emergency committee, recommending that the closed-shop dispute should be submitted to arbitration by referees to be appointed by the Minister of Labour. It was made clear, however, that such arbitration is entirely voluntary and that any award will be morally and not legally binding on both sides. The Council stipulated that the joint emergency committee of the professions must agree beforehand that the terms of reference must be confined to the question of the Council's payments of extended sickness benefit, and that the resignation notices tendered by the teachers shall be withdrawn before the case is submitted to arbitration. It was announced later that a meeting would be held in London yesterday, between the joint emergency committee of the professions and representatives of the Council and the Ministry of Labour. The Engineers' Guild is one of the professional bodies represented on the joint emergency committee.

Eleven collieries in the South Yorkshire coalfield were brought to a standstill at the end of last week, owing to a strike of overmen, deputies and shotfirers. The strike started on June 17 at Silverwood Colliery, Rotherham, and was reported to have spread steadily during the remaining days of last week, until, at its peak, 17 pits were affected, some only partially. Mainly, perhaps, as the result of intervention by the National Union of Mineworkers, many members of which in the South Yorkshire area were rendered idle by the dispute, the colliery officials returned to work on Monday last. It was reported that work was resumed in some instances, at Silverwood Colliery in particular, under strong protest. The strike was a protest by members of the National Association of Colliery Overmen, Deputies and Shotfirers against an alleged failure by the National Coal Board to offer reasonable increases in response to a wage claim by the Association.

It was stated last Monday on behalf of the North-Eastern Divisional Coal Board that the loss of coal, owing to the strike, amounted to approximately 73,000 tons, and that over 600 colliery officials had taken part in the stoppage. Some feeling has been caused among the miners as a result of the strike and the executive of the Yorkshire area of the National Union of Miners passed a resolution expressing "moral indignation" at the dispute, which had caused substantial financial loss to members of the union working at the pits concerned. Mr. E. Jones, the union's secretary for the Yorkshire area, suggested, after the meeting of the executive council, that steps would be taken to obtain for members of his union an *ex-gratia* payment from the National Coal Board to compensate those who had suffered loss of bonuses. It had been proposed, Mr. Jones stated, that rank and file miners should be trained to undertake some of the duties now performed by overmen, deputies and shotfirers, so that production could be maintained at a high level in the event of any similar stoppage in the future.

HEAVY-DUTY FORK-LIFT TRUCK.

SHELVOKE AND DREWRY, LIMITED, LETCHWORTH.



HEAVY-DUTY FORK-LIFT TRUCK.

At the recent Mechanical Handling exhibition at Olympia, one of the most impressive of the many fork-lift trucks on view was the six-wheeled Freight-lifter, illustrated above, which has been developed by Messrs. Shelvoke and Drewry, Limited, Letchworth, Hertfordshire, for handling heavy or bulky loads both inside industrial premises and outside on rough ground. It is fitted with a 70-h.p. petrol or Diesel engine, and has a wide track and self-aligning suspension to give good stability. Power-assisted steering is provided, and conventional driving controls are fitted. The standard mast provides a lifting height of 12 ft., but alternative masts are available giving lifts up to 20 ft. It is fitted with 48-in. standard forks, the overall width between them being adjustable manually within the range 36 in. to 59 in. The Freightlifter can carry a maximum load of 18,000 lb. at 24 in. from the heel of the forks, 15,000 lb. at 33 in., or 12,900 lb. at 48 in., using non-standard forks. The lifting speed is 35 ft. per minute and the maximum road speed, forward and reverse, is 22 m.p.h. The truck, which has a turning radius of 14 ft. 3 in., can turn in 12 ft. 6 in. intersecting aisles. When fitted with a standard mast, the truck, unladen, weighs 9 tons 2 cwt. It has a length of 13 ft. to the heel of the forks, an overall width of 7 ft. 1½ in., and a height of 16 ft. 1 in. with the 12-ft. lift mast fully extended and 10 ft. 1 in. with the mast retracted.

The frame of the Freightlifter is a stiff and robust welded-steel structure, heavily braced to resist distortion under arduous loadings and provided with counter-weights to ensure stability. The mast assembly is built up from deep-section steel channels, rigidly braced, and extends on heavy-duty roller bearings. A low-pressure lifting ram, 6½ in. in diameter, is mounted at each end on self-aligning ball-and-socket mountings. Twin multiple hoist chains are fitted. The fork carriage is of welded steel construction and runs on roller bearings, and carries heavy-duty forks, 6 in. wide by 3 in. deep. If desired, the carriage can be equipped with a hydraulically-operated side-shifting mechanism, giving a 5-in. lateral movement of the forks on either side of the centre, or with a side-tilting mechanism giving a tilt of 5 deg. in either direction. The truck can also be supplied with crane-jib, shovel, ram, or rotating-head attachments. The mast has a

tilting range of 3 deg. forward and 10 deg. back; sensitive control of the mast tilt is obtained by an overhead hydraulic double-acting ram, fitted with universal couplings and supported on a superstructure.

Hydraulic pressure for operating all the motions of the mast and carriage is supplied by a hydraulic vane pump, driven, through gearing, from the engine. The control valve assembly is mounted on the oil reservoir. The control levers are spring-loaded so that they return the valves to the neutral position when released, thereby unloading the pump. An automatic relief valve is included in the hydraulic circuit to prevent damage from overloading.

The truck is provided with a 16-gallon fuel tank, flexibly mounted. The power unit of the Freightlifter may be either a 70-h.p. Shelvoke and Drewry four-cylinder petrol engine, or a 70-h.p. Perkins P6 six-cylinder Diesel engine. A 14-in. diameter Borg and Beck dry-plate clutch is fitted, and power is transmitted through main and auxiliary gearboxes providing four speeds, forward and reverse. The gears are in nickel chromium steel, case-hardened and ground, and the gear shafts run in heavy ball and roller bearings. The final drive to the driving axle is through hypoid gearing and a differential. Fully-floating flanged axle shafts of high-tensile steel are employed. The wheel hubs and differential are supported in large taper roller bearings.

A separate engine-driven vane pump supplies pressure for the hydraulic booster that provides power assistance for the steering. The latter reverts to direct mechanical operation when the engine is not running. A double-roller steering box is fitted. The steering axle is mounted on a central trunnion bearing, providing three-point suspension. The stub axles are steel stampings. Hardened steel swivel pins and bushes with button-type thrust bearings are fitted. The truck has pneumatically-tyred twin front wheels and single rear wheels. The latter are provided with foot-operated hydraulically-actuated brakes, independently adjustable, assisted by a vacuum servo unit with an auxiliary vacuum tank, so that servo action is still available when the engine is not running. A mechanical transmission brake is actuated by a hand-brake lever. The truck has a 12-volt electrical system, comprising a dynamo, with a C.A.V. voltage regulator and a 64-ampere-hour battery.

SHIPYARD RE-ORGANISATION FOR WELDED PREFABRICATED CONSTRUCTION.*

By CLEMENT STEPHENSON, A.M.Inst.N.A.

THE increased adoption of electric welding in the shipbuilding industry in the "competitive thirties" was due to its main virtue—the saving of steel, with its resultant reduced hull weight and corresponding increased deadweight, coupled with its added advantage of obtaining watertightness under all conditions of stress. Hull construction, during this period, was carried out in the main on the same lines as with the all-riveted method, namely, plate-by-plate erection, and welding was treated more as a convenience than as a new method of construction. The advent of the second World War and the subsequent lack of recruitment into this trade, finally made the shipbuilder turn to welding as a new method of construction.

With this turn of events, it was soon realised that, with welding as the main joining medium, the previous method of erection plate by plate and welding *in situ* was inconvenient, and it became necessary to study new constructional methods. Fanned by the efforts of the United States shipbuilding industry during the war, the method of prefabrication was developed and has been found, both technically and economically, to justify adoption on a large scale. The object of this paper is to illustrate how the establishment of Messrs. William Doxford and Sons, Limited, approached the problem of plant re-organisation to deal effectively and economically with this new method of construction.

The establishment, as it existed prior to 1951, consisted basically of two separate building yards, known as the East Yard and the West Yard (see Fig. 1, on page 822). Each had three building berths, the East Yard being capable of building vessels up to 20,000 tons and the West Yard, vessels of about 10,000 tons. Each yard had its platers' shop, frame furnaces, scribe boards, punching and shearing machines, plate rolls, etc., and was fed from a common stockyard. The East Yard berths were served by an overhead crane gantry system, each berth being covered by nine 3-ton electric cranes, while the West Yard craneage consisted of 3-ton derrick cranes.

The principal outcome of prefabricated construction is the considerable reduction in the period of erection on the berth, and, where manpower was more or less limited, it was obvious that, for a given steel tonnage output, some of the existing berths were surplus. The output of the six berths under the existing conditions was in the region of 22,000 tons of steel per year, the average berth time in the East Yard being about 180 days and in the West Yard 235 days; and it was estimated that, with the adoption of prefabrication, this output could be maintained on three berths with slightly reduced man-power.

Efficient prefabricated welded construction requires large under-cover area, to provide ideal welding conditions; large area for pre-berth storage of sub-assemblies; and a simplified flow of material from the stockyard, routed via the platers' shops and prefabrication shed, to the storage area and the berth with the minimum of handling. In a yard where the contour is such that there is a fall of some 72 ft. from the boundary to the head of the building berths, it was soon realised that a layout of the required "ideal" type was impossible and, due to these unique conditions of declivity, it was necessary to turn to the West Yard area for development.

Pursuing the policy of maintaining production on three berths instead of six, the three West Yard berths were considered surplus and these, together with the area covered by the attendant platers' shop, scribe boards, furnaces, beam machines, etc., were scheduled for re-development. The area occupied by the machine shops, etc., was redesigned to accommodate three prefabricating sheds as large as the space would permit, with the open ends facing the head of the berths, and laid out as shown in Fig. 2. Material was arranged to enter at the west end by transverse overhead gantry from the stockyard, and, on completion of prefabrication, to be taken out by overhead crane and thence by rail track to the pre-berth storage area. This was arranged on the area which had been originally Nos. 1 and 2 berths in the West Yard, sub-assemblies being handled by a travelling electric crane running down the centre of the area. The general layout is shown in Fig. 3, on page 823, and the storage area in Fig. 4.

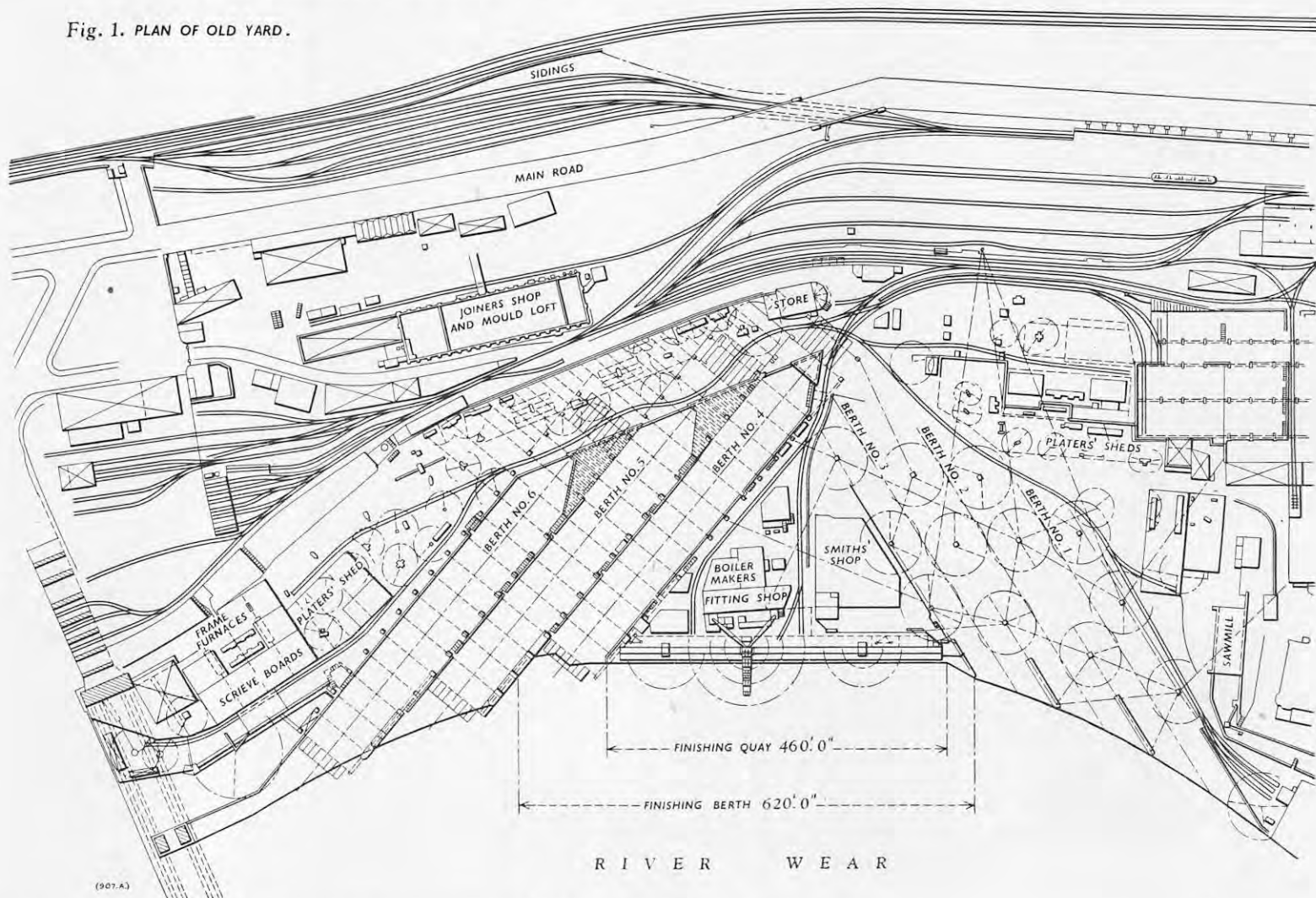
PREFABRICATING SHEDS.

The area to be utilised by the new welding sheds, covering the existing platers' shop, furnaces, etc., was about 55,300 sq. ft. and of this area some 35,800 sq. ft.—the space occupied by the frame furnaces, scribe boards, beam machines, etc.—was at a level 15 ft. higher than the remainder of the area occupied by the

* Paper read before the North Eastern (Tyneside) Branch of the Institute of Welding on Thursday, April 17, 1952. Abridged.

RE-ORGANISATION OF A SHIPYARD FOR WELDING.

Fig. 1. PLAN OF OLD YARD.



platers' shop, this change of level being in the form of a vertical wall.

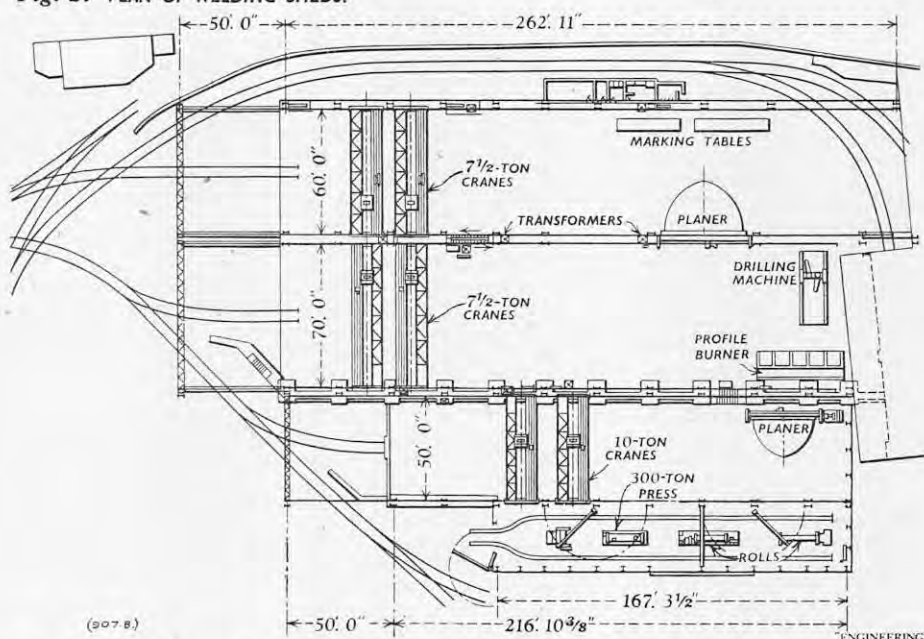
Having in mind that, while reconstruction work was being carried out, building was still to continue on the West Yard berths, it was decided to construct three welding sheds in the following order: No. 1 shed, on the area occupied by beam machines, punches, etc., work normally done by these machines to be undertaken by the East Yard machines; No. 2 shed, on the area up to the wall occupied by the frame furnaces, blocks and scrieve boards, this transfer taking place during a programme of oil tankers, when little frame turning was necessary, which could be accomplished by the East Yard furnaces; and No. 3 shed, at a lower level on the area occupied by the platers' shop, this being carried out after the last ship had been launched from the West Yard.

No. 1 shed was arranged to line up with existing engine works buildings and was made 275 ft. long by 60 ft. wide. No. 2 shed is 275 ft. long by 70 ft. wide, and No. 3 shed, covering a smaller area, 217 ft. long by 50 ft. wide. Nos. 1 and 2 sheds were to be utilised as the "heavy" sheds and No. 3 as the "light" shed, the general layout of the welding sheds being as shown in Fig. 2, opposite. Figs. 5 and 6, on page 824, and Fig. 7, on page 825, show interior views of the sheds, and Fig. 8, on page 825, shows a welded unit on the berth.

To ascertain the height of Nos. 1 and 2 sheds, some "yard stick" was necessary for the size of unit to be turned over. In general, these units would consist of panels of deck plating, tank tops, and bulkheads, with their attendant stiffening, being generally 35 ft. to 40 ft. in length. The welded seams being lengthwise, it was arranged for the sheds to have a height of 43 ft. to the crane rails, to enable such panels to be turned over with the welded seams vertical, to avoid possible cracking of the first side weld. No. 3 shed was to be used for smaller units, and the height in this case was fixed at 35 ft. from floor to crane rail. The floors of all sheds are of concrete, and loose 6 in. channels on the floor support the units, this system being adopted as more flexible than fixed supports.

It was recognised that the ideal routing for material was from stockyard to platers' shop and thence to welding shed, the latter being used entirely for welding purposes. Owing, however, to the platers' shop

Fig. 2. PLAN OF WELDING SHEDS.



being in the East Yard, it was decided to install in the sheds the minimum of machinery that could deal with material which came direct from the stockyard into the sheds via a transverse crane gantry. The machines installed for this purpose are as follow:—

No. 1 shed: One 35 ft. high-speed planing machine. No. 2 shed: One 40 ft. by 6 ft. profile-burning table with double burning heads, and one 46 ft. by 12 ft. drilling table, with two drilling heads.

No. 3 shed: One 30 ft. plate-edge planing machine and one 35 ft. by 8 ft. plate-edge burning table.

These machines are placed at the west end of the sheds to leave as much floor space as possible for fabrication lay-out, this space being approximately: No. 1 shed, 10,500 sq. ft.; No. 2 shed, 15,000 sq. ft.; and No. 3 shed, 8,750 sq. ft.

Adjoining No. 3 shed, which was to be used as the "light" shed, an extension was erected, measuring 167 ft. by 30 ft., to be used as a machine shop and to contain 16-ft. complete-circle plate rolls, 12-ft. plate rolls, a 6-ft. guillotine, and a 15-ft. 300-ton flanging press. This equipment was to deal with material for masts, derrick posts, tubular pillars, ventilator tubes, pressed minor bulkheads, etc. All welding sheds are served by overhead electric travelling cranes, two in each shed. The crane girders extend 50 ft. beyond the covered-in sheds to enable assembled units to be loaded on to bogies for transport to the storage area.

The area allocated for pre-berth storage, formerly occupied by Nos. 1 and 2 berths in the West Yard, is considerably affected by a tide rise, often in the region

RE-ORGANISATION OF A SHIPYARD FOR WELDING.

Fig. 3. NEW YARD PLAN.

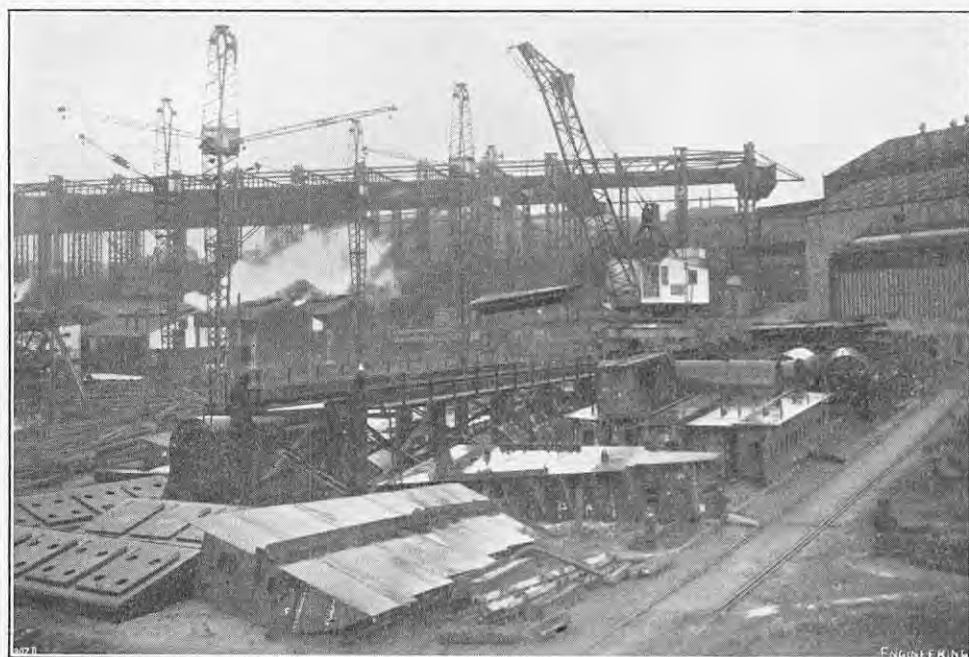
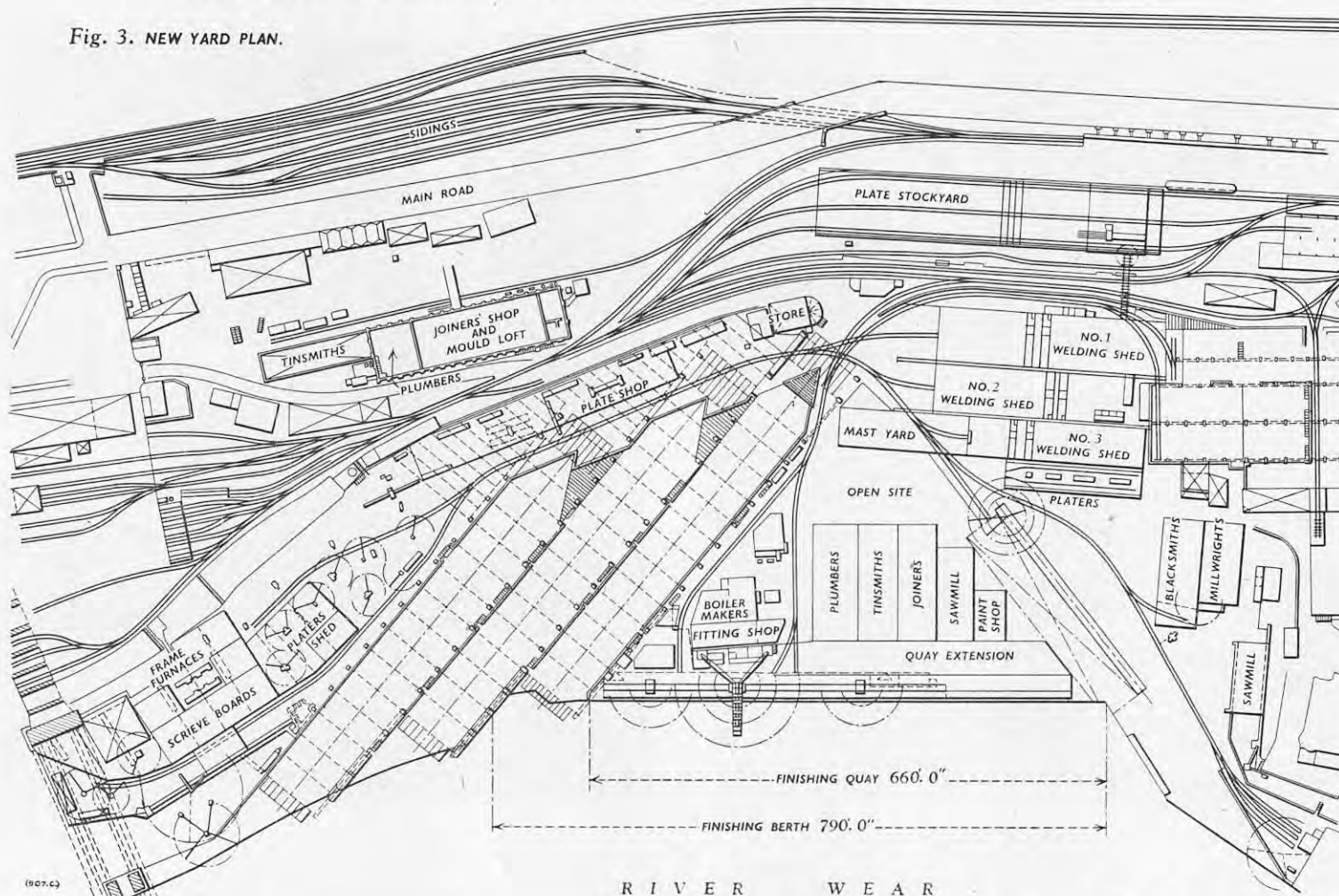


FIG. 4. PRE-BERTH STORAGE AREA.

of 14 ft., and, to obtain as much dry storage area as possible, a rubble retaining wall was constructed across the river end of these two berths. A crane gantry extends down the centre of the area and, having in mind the size of unit most common—about 35 ft. by 25 ft. and weight not exceeding 15 tons—an electric travelling jib crane of 15 tons safe working load and 25 ft. jib radius was installed. The area available for storage is about 270 ft. long by 50 ft. wide on each side of the crane track, giving a total storage area of 27,000 sq. ft., and, as the height from ground to crane rail is an average of 13 ft., it enables units to be tiered.

It was estimated that, with the three-berth programme projected, the material in progress would be about 80 per cent. of the weight of one vessel (approximately 3,300 tons), being 42 per cent., 30 per cent. and

8 per cent. for vessels on Nos. 1, 2 and 3 berths, respectively, at the laying of the keel of the vessel on No. 1 berth. Of this total, about 60 per cent. would be prefabricated, thus area was required for some 2,000 tons of sub-assemblies.

The factor governing lifting capacity is, of course, the size of sub-assembly, and the arguments as to what might be the most economical weight and size of unit have been lengthy and conflicting. In this particular case, however, no such question arose. The East Yard berths, which are in docks some 20 ft. below yard level, are at varying levels transversely, with a distance between ships of only 13 ft., each berth being served by nine 3-ton electric travelling cranes which run on longitudinal overhead tracks, 90 ft. above the berth. With a system of lifting beams, loads of 15 to 16 tons

were the maximum. To adopt any other method of craning on the berths was both a financial and almost a practical impossibility, and the whole system of lifting capacity in the development, together with the size of sub-assembly, was governed by the existing berth cranes and was not to exceed 15 tons.

Following upon this, the overhead travelling cranes in Nos. 1 and 2 welding sheds were fixed at $7\frac{1}{2}$ tons each, and those in No. 3 shed, which were to be capable of lifting a completed mast for installing at the fitting-out quay, were made of 10 tons capacity. Individual radial cranes, with electric hoist blocks of 3 tons capacity, were fitted at the planing machine in No. 1 shed and at the mast rolls and guillotine in No. 4 shed. The existing East Yard platers' shed is served by two overhead 5-ton travelling electric cranes, while 3-ton radial jibs are fitted at the countersink, plate rolls etc. Material arrives in a private siding adjoining British Railways' Sunderland to Durham line, and lying to the south of the yard boundary, on the other side of a main public road. Movement of material is carried out by rail transport and is of necessity tedious owing to the 50-ft. difference in levels of the siding and the stockyard, and the fact that the material must first come under the main road and then by zig-zag movement to the stockyard, which covers an area 460 ft. long by 90 ft. wide. The material is stored in racks.

With the new development, an overhead crane gantry with two 5-ton electric travelling cranes has been erected over the area, doing the work which was previously done by steam cranes. To facilitate the direct movement of plates from the stockyard to the welding sheds, a transverse crane gantry was erected from the stockyard to No. 1 welding shed, fitted with a 3-ton underhung electric radial jib crane with remote control. At the stockyard end of this gantry a new set of seven-roll 10-ft. plate-straightening rolls has been installed, together with an electric winch and castor tables with a view to one-man operation, and so that all plates will be rolled before leaving the stockyard.

Prior to welding being adopted, the machinery in the East Yard platers' shed consisted of two one-man punching machines, two planing machines, plate mang'les, bending rolls, two countersinking machines, two scarphing machines and two punching machines, and shearing machines. In the new scheme, one one-man punch, the scarphing machines, punches, and shears, plate mang'les and one countersink became obsolete and were scrapped. New machinery installed was two 35-ft. plate-edge burning tables, four radial

RE-ORGANISATION OF A SHIPYARD FOR WELDING.

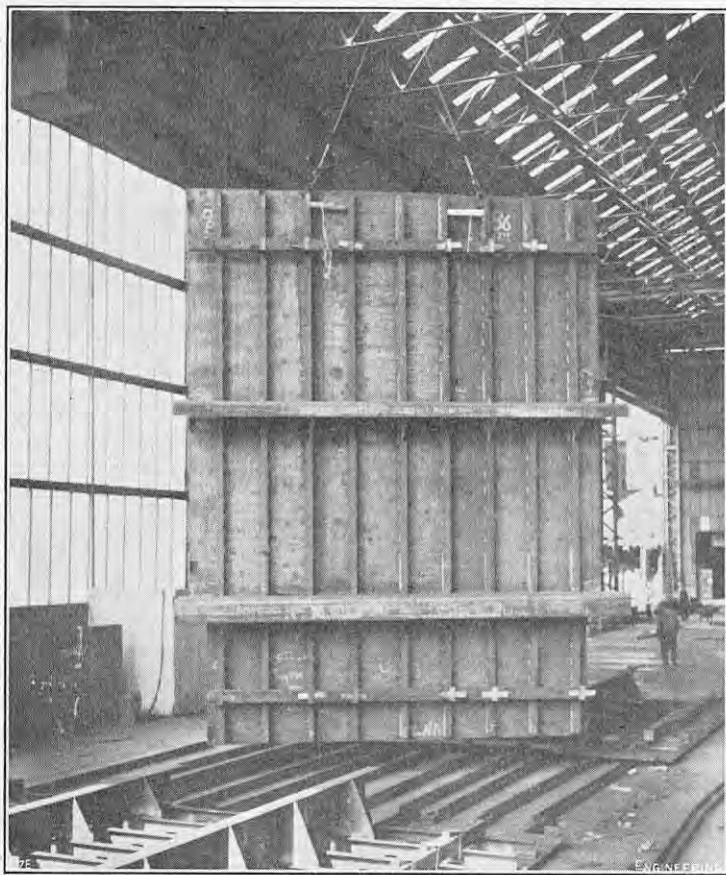


FIG. 5. LIFTING A BULKHEAD.

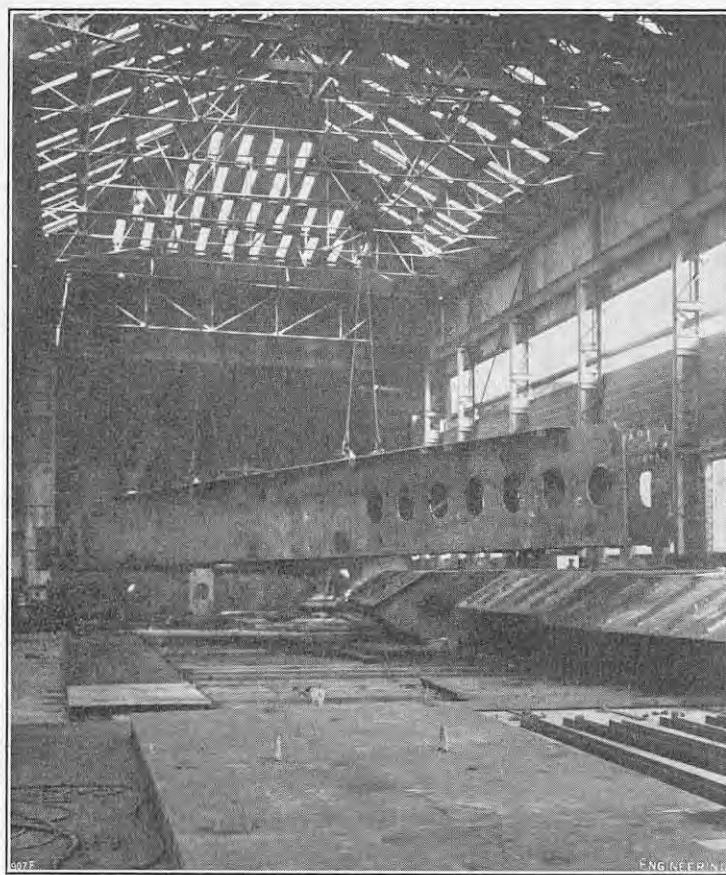


FIG. 6. LIFTING A DOUBLE-BOTTOM UNIT.

drilling machines, and one 800-ton 40-ft. flanging press.

Before the modifications, all electric welding was carried out by single-operator direct-current welding sets, the electrical network in the yard being 230 volts direct current. Throughout the past 15 years, the increased use of electric welding had considerably overloaded the network and, with the projected further increase, it was necessary either to install additional direct-current generating plant or an alternating-current network for the welding plant. The direct-current network was supplied from rotary converters at the east end of the yard. It was considered that this method was involving considerable energy losses and accordingly it was decided to install an alternating-current welding network, to convert as much of the existing shipyard machinery as possible to alternating current, and to place the existing direct-current overhead cranes and some other machinery on to a direct-current supply from a mercury-arc rectifier.

The alternating-current welding network provides for 25 six-operator 90-kVA transformers over the area of the building berths, five on the fitting-out quay, ten in the welding sheds, and one in the welding school. In addition, six points were arranged on the berths for Fusarc automatic welding machines, in such positions that two machines can be in use on any one berth. Points were arranged in the welding sheds for automatic welding plant. At present two Fusarc and two Unionmelt machines are used under cover.

Welded construction has resulted in the production of individual plates to engineering limits either by plate-edge planing or burning, and in the re-development scheme a combination of both systems was adopted. Plate-edge planing is used for all edge preparation for machine welding, and burning is used for all edges which are to be fillet-welded. It has been found that, for automatic welding, a better fit-up is obtained with a planed edge and generally results in a better weld than is obtained with a gas-cut edge. In No. 2 welding shed, a profile burner, 40 ft. long and 6 ft. wide, has proved most successful, especially in the construction of oil tankers, where there is a repetition of parts, such as transverses, webs, etc.

Other burning tables are of the single-head type, running on trackways at the sides of the burning table. Plate-edge planing is carried out by high-speed planing machines. The burning medium varies between acetylene and coal gas with oxygen. A local oxygen factory supplies oxygen by pipeline to the yard, and a pipeline is led throughout the establishment with valves at numerous points, so that the burner may simply connect his hose as necessary. This has resulted in a

considerable saving in time previously taken in the transport of oxygen cylinders.

The introduction of welding has changed the manpower distribution in the yard, the increase in welding personnel resulting in a considerable decrease in riveters and an increase in the burning trades. One of the main features in the re-organisation was the breakdown of the squad system of plate preparation; handling being accomplished by individuals has resulted in a considerable reduction in platers' helpers. Comparison of present-day man-power with that prior to World War II is shown in the table, herewith. Unfortunately, the economy of shipyard electric welding is suffering from conditions of payment, which have not progressed with the development of welding. Payment is not always directly associated with output for different types of weld, and it is hoped that, in time, some suitable piecework price relative to output can be sensibly applied, and that the welding department will have a balanced position in the steel-working trades.

The intake of apprentice labour into the shipbuilding industry gives cause for alarm, the modern youth seeming to shun shipyards and preferring industries where mechanisation and scientific methods of production make for easier working conditions and less brain fatigue. In this respect, electric welding, with the prefabricated method of construction, does offer easier conditions of working and the facilities provided require labour with a lesser degree of skill. Accordingly, it offers working conditions more in keeping with the requirements of this age and should tend to ease the problem of labour recruitment.

Unfortunately, too, the British shipowner is by nature cautious and very reluctant to give up methods of construction which have proved so serviceable for many years. In conditions such as these, a shipbuilder cannot plan his man-power for wholly welded construction. This necessitates the retention of a certain number of riveting squads and the design must often include a limited amount of riveting to keep this trade available to the establishment. As we approach the time when the welded ship is the accepted article, the transference of riveters to welding can be completed, and further economy in construction achieved.

The planned re-organisation of the yard is at present suffering setbacks through the national economic situation, and, owing to the serious curtailment of steel supplies over the last twelve months, it has not been possible to measure with consistency the advantages of the new layout. The first vessel constructed under the new conditions was a 16,750 tons dead-weight oil tanker, having a steel weight of 4,100 tons of plates and sections. Work on this vessel was com-

menced 17 weeks before the keel was laid, and, at the date of keel-laying, 51 per cent. of the steel had been fabricated. From keel-laying to launch, the berth time was 22½ weeks, which included two holiday weekends.

The output of the welding sheds has also varied considerably due to the restricted flow of steel, and the output in tons fluctuates according to the scantlings of structures passing through. Taken over a period of 12 months, this tonnage varies from 110 tons to 170 tons weekly; as a general average, the output per week is in the region of 145 tons. The first year of working with the new layout has been generally satisfactory and it is considered that, when the Utopia of unlimited steel is approached, considerable economies will result.

Comparison of Man-Power in Shipyard Steel Trades.

Trade.	1936	1951.
Platers	125	118
Platers' Apprentices	54	16
Platers' Helpers	340	201
Riveters, Holders-up, Heaters	301	101
Riveters' Apprentices	21	11
Caulkers and Burners	37	71
Caulkers' Apprentices	30	20
Welders	18	154
Welders' Apprentices	2	48
Drillers	36	35
Drillers' Apprentices	29	2
Totals	993	777

"WASTE-HEAT RECOVERY PLANT": ERRATUM.—We regret that, in the above article in our issue of June 13, on page 744, the name of the firm for whom the plant was constructed was given incorrectly; it should be "Pasolds Limited," not "R. Pasold and Company, Limited," as it was there stated.

SHOCK-ABSORBING WAGONS.—For the conveyance of fragile materials, such as glass, china, and earthenware, British Railways are to increase their fleet of 3,500 shock-absorbing freight vehicles to over 5,100 by the end of the year. The bodies of these vehicles are permitted movement on the chassis. Instead of the two components forming a rigid unit, the body can slide backwards and forwards on the chassis, the movement being limited by rubber springs. Thus, the effects of shunting are cushioned and fragile consignments travel with the minimum risk of damage. The vehicles will be built in British Railways' workshops at Faverdale, Co. Durham, at Derby, and at Ashford, Kent.

RE-ORGANISATION OF A SHIPYARD FOR WELDING.

(For Description, see Opposite Page.)

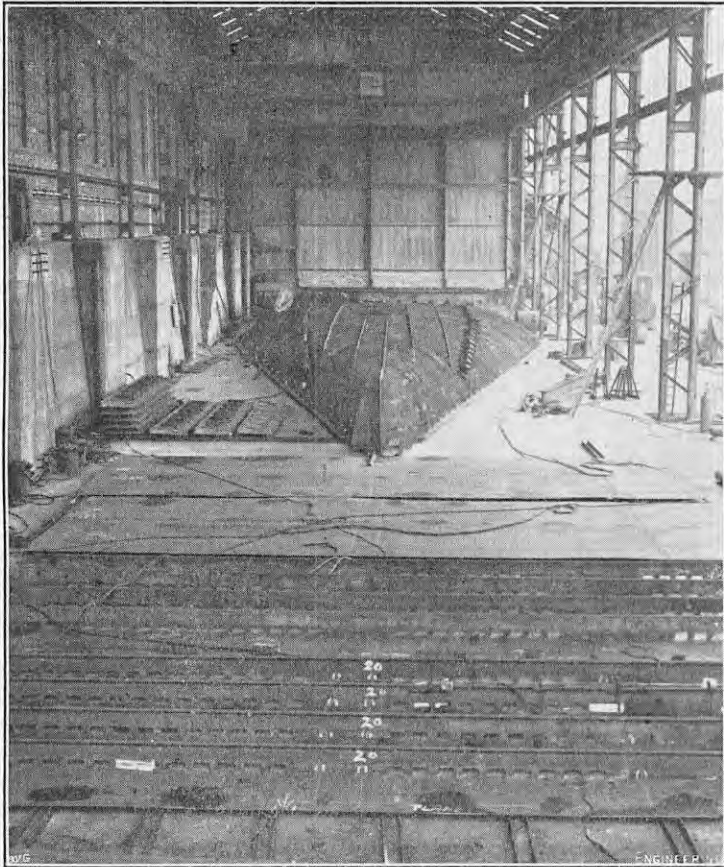


FIG. 7. NO. 3 WELDING SHED.

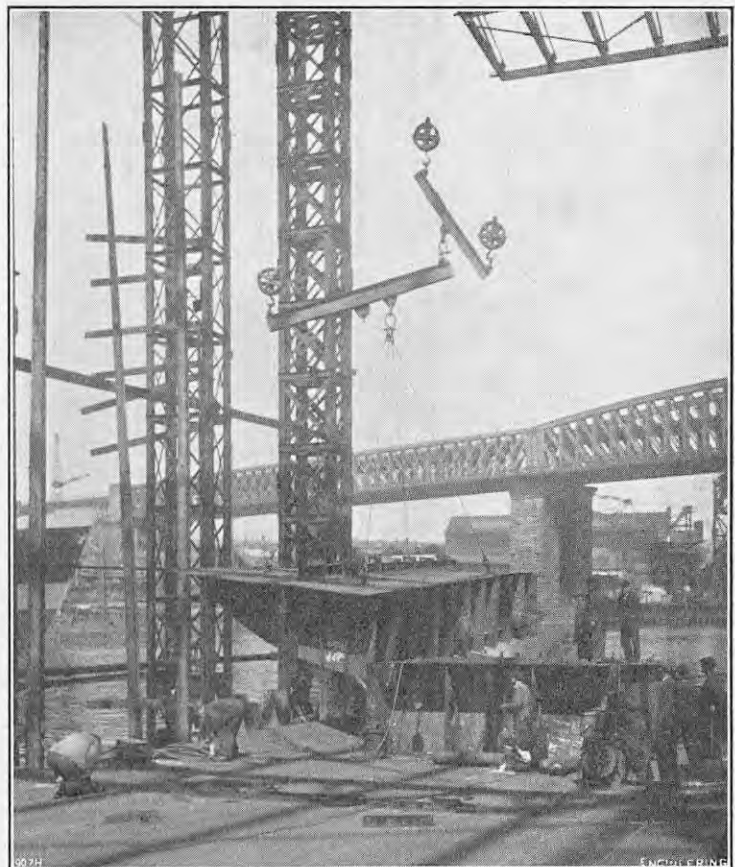


FIG. 8. PLACING DOUBLE-BOTTOM UNIT ON BERTH.

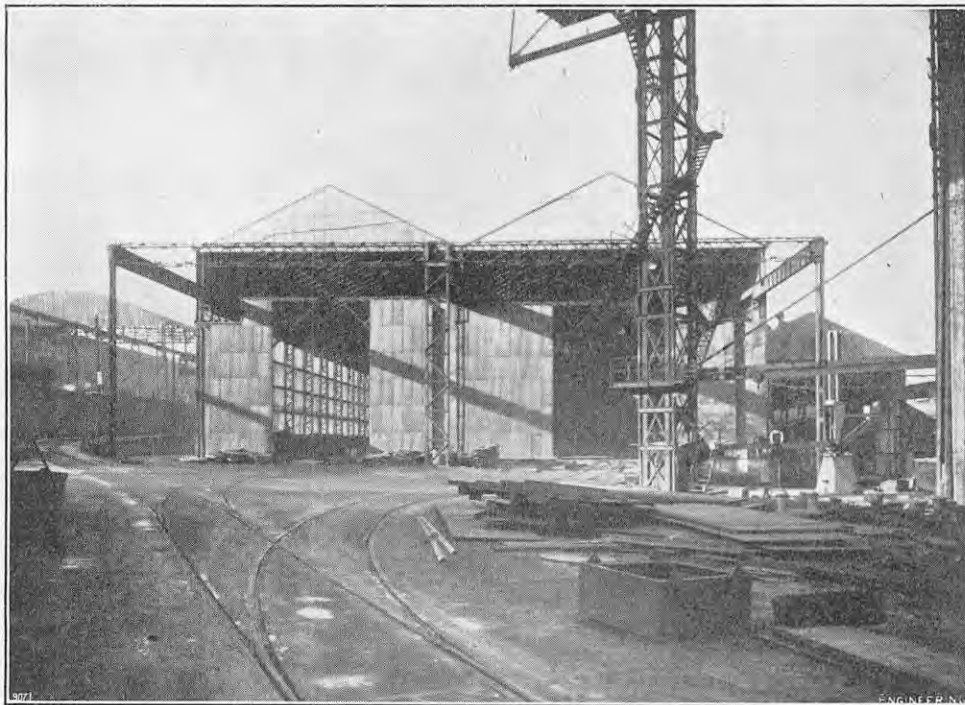


FIG. 9. WELDING SHEDS.

THE JUBILEE OF HEENAN AND FROUDE, LIMITED.

THE present year marks the jubilee of Messrs. Heenan and Froude, Limited, Worcester. The founders of this well-known firm were Hammersley Heenan, an engineer formerly in the service of the East India Railway, and Richard Hurrell Froude, son of William Froude, F.R.S., the celebrated engineer and scientist, whose name is perpetuated in the Froude Number, familiar to all students of hydrodynamics; and in the Froude ship-model testing tank at the National Physical Laboratory, Teddington. In 1880, Heenan returned from India and bought the steelworks of Woodhouse and Company, Manchester, taking his friend Froude into partnership in the following year. Additional premises were acquired later at Birmingham but, as the business expanded, these proved inadequate and a move was made to Worcester. The company of Heenan and Froude, Limited, was incorporated in 1902 and work began at Worcester in 1903. The Manchester works were disposed of in 1935.

The works at Worcester originally consisted of a large building on the east side of Shrub Hill-road, adjoining the main passenger and goods railway stations. The premises had been built in 1866 as a railway engineering and locomotive works, but the venture had failed. In 1888, the main building was adapted to house a trades exhibition, after which it passed through various hands until its acquisition by Messrs. Heenan and Froude. Its lofty and spacious construction, which derives from its original purpose, has proved a great asset in the manufacture of the larger sizes of machines now produced by the firm. The building now houses light and heavy machine shops and a light fitting shop which is illustrated in Fig. 5, on next page. Adjoining these are a tool room, pattern shop, foundry, castings store and canteen.

The foundry produces ferrous castings only, either in cast iron or high-tensile steel-mix iron, frequently alloyed with nickel, chromium or molybdenum. Years of experience and research directed to the production of castings combining high tensile strength with great resistance to erosion, necessary in hydraulic dynamometer applications, have led the firm to develop special mixtures and foundry techniques. Castings up to 10 tons in weight can be made, but the average weight is much less than this. The heavy machine-shop is well equipped with large planers, vertical boring mills, horizontal borers, shapers, drilling machines, dynamic balancing machines, and other equipment. The light machine-shop contains a variety

COMPETITION FOR APPRENTICES.—The Physical Society is following the custom of past years by organising a competition for apprentice craftsmen and draughtsmen in connection with the exhibition of scientific instruments and apparatus which will be held next spring. The object of the competition, which is open to young persons of either sex who will be less than 22 years of age on March 31, 1953, is to encourage the production of high-grade work by apprentices and learners, and the prize-winning entries will be on show at the exhibition. The following classes of work may be submitted: scientific instruments and components; tools and gauges; optical components and systems; blown-glass and silica ware; patterns and functional scale-models of scientific interest; draughtsmanship. In the first two and in the last of these classes there are junior and senior grades of entry

for persons, respectively, under or over 18 years of age on the date mentioned. Each entry must be the unaided work of the competitor and must be accompanied by a certificate testifying to this fact. First, second and third prizes of 10, 5 and 2½ guineas, respectively, will be awarded in each class and grade, provided that entries of sufficient number and merit are received. An entry fee of 5s. is payable in respect of each entry, but in the case of entries for a special prize of 5 guineas, which is awarded to a competitor who submits a specimen of his own craftsmanship together with his own working drawings, both showing merit, no fee is payable. Further particulars and entry forms may be obtained from the secretary, the Physical Society, 1, Lowther-gardens, Prince Consort-road, London, S.W.7. The closing date for the receipt of entry forms is February 21, 1953.

THE JUBILEE OF HEENAN AND FROUDE, LIMITED.



FIG. 5. LIGHT FITTING SHOP, WITH WATER-COOLERS IN COURSE OF ERECTION.

of smaller machines, including centre, turret and capstan lathes, milling machines and drilling machines. There are also various special-purpose machines and a separate grinding-machine section which contains a spline grinder.

At the rear of the building are situated a plating shop, hardening shop and smithy. The first-mentioned normally deals with plate up to $\frac{1}{2}$ in. thick, but the equipment is capable of fabricating material up to 2 in. thick. Most of the work produced is of welded construction but some riveting is also done. Considerable use is made of flame cutters for producing shaped profiles from material up to 8 in. in thickness. The equipment includes large guillotines, cropping machines, rolls, a flanging press, and a 180-ton Fielding and Platt press.

In 1937, the accommodation was extended by the erection of a large office block of modern design, facing the older building, on the other side of Shrub Hill-road. This building is 250 ft. long and 45 ft. wide and comprises a ground floor containing administrative offices and an upper floor which is entirely occupied by a drawing office. There is also a basement where official records are stored and where, also, a staff canteen is situated. An electrical shop and another fitting shop are situated behind the office block.

A further extension to the premises was made in 1947, when a factory adjoining the main factory was purchased. This has provided the firm with considerable space for expansion, the only deterrent to which at present is the difficulty of attracting suitable labour to Worcester, on account of the prevailing scarcity of housing accommodation. At present, some 1,100 persons are employed by the firm. The new part of the factory houses the experimental department and an apprentice-training school. The equipment in the former includes a Rolls-Royce Merlin engine, without supercharger, which is used for calibrating dynamometers suitable for testing low-speed high-power engines. There is a separate high-speed test bed in the factory capable of testing dynamometers at speeds up to 45,000 r.p.m.

Dynamometers are among the best-known products of Messrs. Heenan and Froude, although many other

kinds of equipment are also manufactured by the firm. The original hydraulic dynamometer, invented by William Froude in the course of his work for the Admiralty, was brought to the firm by his son. Since then, they have introduced other types of dynamometer, including electric types suitable for both direct and alternating current and "Dynamatic" types in which the braking action is produced by eddy currents. The last-mentioned types are widely used for testing aircraft engines. A Froude dynamometer, with its starting motor and Heenan Dynamatic variable-speed coupling, are illustrated in Fig. 1, on page 812. A Heenan electric dynamometer and Dynamatic dynamometer are visible in the background. The equipment shown is installed in the premises of Messrs. C. C. Wakefield and Company, Limited, at Hayes, Middlesex. Other dynamometer equipment was supplied by the firm to the Rugby locomotive-testing plant of British railways; this is illustrated in Fig. 2, on the same page. The testing plant was described in *ENGINEERING*, vol. 166, pages 462 and 487 (1948).

Besides their extensive range of dynamometers, Messrs. Heenan and Froude, Limited, also manufacture a number of special-purpose machines. These include automatic machines for the chain-making industry, one of which is illustrated in Fig. 3, on page 812, and machines for making nails, staples, and paper clips. Water-coolers and coolers for air and oil are also among their specialities. Since its inception, also, the firm has engaged in the production of refuse-disposal plant, and its municipal engineering division has designed manufactured and installed many such plants for the handling and disposal of household, trades, institutional and industrial refuse. Before 1914, most household refuse was dealt with by burning, the heat liberated frequently being used to generate steam for electric power production or for sewage pumping. In later years, however, the value of the materials recoverable from refuse was recognised and this led to an extension of the function of a refuse plant. Whereas the emphasis had formerly been on destruction, great importance became attached to the salvage of all usable articles and to the removal of fine dust, prior to the incineration of the residue. Between 1918

and 1939, the firm constructed 230 municipal plants including, in 1924, an installation for the city of Glasgow, which is believed to be the largest refuse-disposal plant in the world. It deals with nearly 700 tons of refuse daily and the heat generated by incineration is used to produce steam which supplies two 5,000-kW turbo-alternators.

Waste tins and scrap metals, paper and rags, which are all of considerable commercial value, are salvaged in large quantities, and Messrs. Heenan and Froude produce a range of presses for baling such materials. Mechanically- and hydraulically-operated presses manufactured by the firm are capable of dealing with light scrap metal of many kinds, compressing the material into bales weighing from 25 to 112 lb., according to the press employed. A hydraulically-operated double-ram press for waste metal is illustrated in Fig. 4, on page 812.

In 1936, a Heenan and Froude group of companies was formed, which includes the Worcester firm of Associated Locomotive Equipment, Limited. This company is concerned mainly with the improvement of steam distribution in the cylinders of locomotive and marine engines by means of poppet valves actuated by precision gearing. The company specialises in the production of British-Caprotti rotary-cam poppet-valve gear for locomotive and marine engines, which is manufactured at Messrs. Heenan and Froude's works. An entirely new design of this gear for locomotives, which has been developed, is fitted to class 5 locomotives of the London Midland Region of British Railways.

NATIONAL COLLEGE OF HOROLOGY.—The prospectus of the National College of Horology, which is housed in the Northampton Polytechnic, St. John-street, London, E.C.1, contains particulars of the courses held in horology and instrument technology. In a brief history, it is stated that the College was opened on October 6, 1947, and that it is financed mainly by grants from the Ministry of Education, which also supplied the majority of the funds for the initial equipment. A full-time course covering three years is provided for candidates of 16 years of age; part-time, advanced and post-graduate courses are also available.

HEATING AND VENTILATION AND THE COAL PROBLEM.*

By DR. W. IDRIS JONES.

THE fuel consumption *per capita* in Britain is approximately twice as great as it is in the rest of Western Europe. Our average efficiency of coal consumption for all purposes is about 30 per cent. The consumption of energy in the domestic field represents about one-third of the total inland consumption of coal. For this purpose, over 60 million tons a year are used of coal in the forms of solid fuel, gas and electricity and over 80 per cent. of the solid fuel is consumed in living rooms at 20 per cent. efficiency in about 12 million badly-designed open-fired appliances. Even with efficient closed domestic-heating appliances, the consumption of solid fuel is higher than it should be because of the bad insulation and design of houses.

It is extremely difficult to give an indication of the proportion of fuel used in industry for space-heating. In the case of cotton weaving, about 70 per cent. of the fuel consumed is so used, and, in the case of worsted spinning, about 40 per cent. is used, together with waste steam from power generation. Similar figures are likely to be shown in the case of other industries, such as light engineering, non-ferrous metals, leather, clothing, plastics, food, tobacco, etc. Heating and ventilation engineers, therefore, share a big responsibility in the solution of the coal problem. The simple fact is that we are spending too much both in quantity of energy and in money just to keep ourselves from shivering.

CONTRIBUTIONS OF THE NATIONAL COAL BOARD.

Deep-mined coal production has increased from 181 million tons in 1946 to 211 million tons in 1951. Further increases will be achieved by sinking new pits and by major or minor reconstruction and re-organisation of existing collieries. Every effort will be made still further to improve the position by extended coal-face mechanisation, improved materials handling, by the application of new inventions and techniques, and by stimulating a psychological change within the industry. Efficiency, like charity, begins at home. The coal industry consumes ten million tons per annum of coal to mine, raise and process the total coal got. Every effort is being made to modernise colliery boilers and improve boiler operation to reduce this tonnage, and to use low-grade fuels in order to release more better-grade fuels for the market, and plans are being made to take more power from the British Electricity Authority, who generate at higher efficiency in large plants.

Ventilation is the life blood of coal mining. Quantities of air, averaging about 5 tons and, in many cases, well above 10 tons of air per ton of coal raised, have to be drawn through the mine workings to give comfortable working conditions, and remove noxious and explosive gases and coal dust. A very gassy pit may give as much as 4,000 cub. ft. of methane per ton of coal raised. If the methane content exceeds the statutory allowance of $1\frac{1}{2}$ per cent., underground electric power either cannot be used or must be cut off. In the very gassy pits, too, the rate of advance of the coal face has to be controlled to meet the exigencies of methane evolution. There is much coal in Britain at depths of 4,000 ft. and more, and at these depths the strata temperature approaches 120 deg. F. The temperature of the ventilation air rises about 20 deg. F. by compression in the shaft at these depths. Air velocities of 4 ft. to 6 ft. per second are necessary for comfort and, if this velocity exceeds about 8 ft. per second, the air tends to whip up the dust, which is a serious occupational hazard. A large mine may have 30 miles or more of cross-linked airways underground and, on the average, about 5 kWh of electric power per ton of coal mined is necessary to force quantities of the order of 5,000 cub. ft. per second of air through these airways. Dust suppression, involving the use of water, increases the humidity and consequent discomfort at great depths of working, and this calls for a ventilation system which will enable the air to reach the coal face as cool as possible.

All these manifold ventilation problems are under intensive investigation by the National Coal Board and its various research agencies at the present time. Much is being done on the research and development side. In a number of collieries, boreholes are being drilled upwards or downwards through the strata above or below from near the advancing coal face, to drain the occluded methane away through pipes for use at the surface. Gratifying yields of rich methane, which has potential heating power and chemical values, are being obtained. In conjunction with the Ministry of Fuel and Power, the possible use of the $\frac{1}{2}$ per cent. to 1 per cent. of residual methane in the

upcast air as a fuel for gas turbines is being investigated.

RESEARCH PROGRAMMES.

Research on the testing and development of air-measuring instruments, supported by the Board, is being carried out at Nottingham University. Another problem which is being studied there is the design of a laboratory analogue computer which can be used for determining the dependence of air-flow distribution in a mine on the mine lay-out. Pioneer work on this problem had been done by the Dutch State Mines. At Nottingham University, a lamp type of analogue was first investigated, but this was found to be excessively bulky and excessively heavy on power. A unit was then devised which, by means of a servo mechanism, automatically maintains a "square law" relationship between terminal voltage (simulating air pressure) and current (simulating air flow) and which, therefore, can represent the resistance of an airway. A number of such units can be connected together and set to represent a ventilation system and, when a voltage equivalent to the fan water gauge is applied, will adjust themselves so that the resultant air-flow distribution is represented. Attention has also been paid to improved mathematical methods for solving network problems and from this has arisen the idea of a simple "resistance board" computer by means of which continuous approximation can be carried out by manual adjustment of variable electrical components.

At King's College, Newcastle, work, supported by the Board, is being done on the flow conditions in fan drifts and in small-scale ducts, pressure and velocity distributions being determined with the aid of a three-way Pitot tube. Attention is now being given to the theoretical aspects of achieving dynamic similarity in model experiments.

Another item on the research programme is a study, at Nottingham University, of atmospheric environment, with particular reference to thermal and hygro-metric conditions of the removal of heat and moisture by ventilation. Linked with this is the measurement of rock skin and virgin strata temperatures, with special reference to the rate of heat transfer from rock to air. At Cambridge, the effect of hot and humid conditions upon mental capacity for work and, at Oxford, their effects upon physiological capacity and health, are being studied also.

The present extensive mine development work has brought with it the need to ventilate long tunnels by auxiliary ventilation systems in which air is passed through long lengths of ducting. Leakage is a serious problem in such systems and, as the length increases, only a small proportion of the air delivered by the fan may reach the required point. The Central Research Establishment of the Board at Stoke Orchard has studied this problem both theoretically and practically. New methods of joining the duct sections have been devised which minimise leakage. Charts have been drawn up which enable the ventilation engineer to calculate the performance he can expect from an installation with known leakage characteristics, or to predict the reduction in air supply as a given system is extended.

On the solid-fuel side, the Board are giving close attention to the mining of increased tonnages of natural smokeless anthracite and dry steam coals, and to the production of coke for domestic purposes in their coke ovens, although spectacular increases in the output of these fuels cannot be expected for years. In addition, great efforts are being made to produce synthetic fuels of desired characteristics for space heating and cooking. The output of the phurnace plant in South Wales has been doubled to 350,000 tons annually, and, as the result of research work at the Central Research Establishment, plans are being made to build a similar plant in Kent. As the research now in progress is developed, it is hoped that these smokeless fuels will be obtainable in due course from a wide range of coals, and that their production will be accompanied by important yields of tars and gases of chemical, power and thermal interest.

On the subject of domestic heating, the Coal Utilisation Council, the Solid Smokeless Fuels Federation, the Appliance Manufacturers and the British Coal Utilisation Research Association are doing much valuable work at the present time. Desirable standards for space and water heating in new homes were set out in the Egerton report and these were accepted in the Simon report. The latter report estimated that solid fuels would supply 90 per cent. to 95 per cent. of room heating, 80 per cent. of domestic water heating and 20 per cent. to 25 per cent. of cooking requirements, and it recommended that the winter space-heating or water-heating load should be carried by solid fuel and that intermittent space and water heating for short periods should be carried by gas and electricity. The desirable standards of domestic heating recommended in these reports are still far from being achieved in most homes, but great progress has been made in the design of domestic heating appliances and a wide range is now available.

SOLID-FUEL APPLIANCES.

There are two main kinds of solid-fuel appliances which are generally suitable for warming the rooms in the average house; namely, open fires, which may burn bituminous coal or smokeless fuels, and openable stoves, which operate best on smokeless fuel and can be used either open or closed. Central heating is a common form of space heating for schools, offices, hotels and flats. The open fire is still the most popular space-heating appliance in living rooms in British homes and in recent years new fires, superior to the old varieties, have been developed. They are either intermittent or continuous in their burning, with or without convection. It is worth noting, however, that, when a purely radiant open fire is used with bituminous coals, it is impossible by standard methods to increase the room-heating efficiency above about 25 per cent. At the same time, a great excess of air is withdrawn from the room and carried up the flue, thus depressing the room-heating efficiency to less than 20 per cent. in cold weather. The more modern types of open fire or smokeless-fuel grates are purely radiant and owe their present popularity mainly to the greater controllability over combustion as compared with the ordinary grate.

The closed stove heats a room almost entirely by convection or warm air. Such a unit requires smokeless fuel, though Continental types are available which can burn a limited number of bituminous coals with little smoke emission. With such warm-air heating, comparatively high air temperatures have to be maintained to ensure reasonable comfort conditions. Such temperatures require relatively high heat outputs in Britain, where the insulation of rooms and houses is poor. This tends to offset some of the high efficiency of such convection heating appliances.

Between the two extremes, it is possible to devise a compromise appliance which is basically an open fire, giving a low directional radiant output, but retaining most of the advantages of the open-closed stove with none of the disadvantages of the normal open fire. The work of the British Coal Utilisation Research Association has indicated that such units should combine radiation and convection to give a room-heating efficiency of 35 per cent. on bituminous coal. The withdrawal of excess air from the room is reduced by throat regulation to about 2,500 cub. ft. per hour. The air withdrawn from the room up the flue can be controlled to give overnight burning of coal, if required, at less than $\frac{1}{2}$ lb. per hour.

Free-standing or inset openable stoves have been produced in a greater variety in recent years. All of the heat given off by a free-standing stove is available for warming the room; and, for the inset types of stove, warm air can be admitted into the room through grilles in the surround or taken by a duct to other parts of the house. In the latter case, however, there is a risk that the rather low radiation output of the stove will be insufficient for efficient heating of the living room. The best results with openable stoves are obtained by burning correctly-sized smokeless fuels, such as high-temperature or low-temperature cokes, anthracite, dry steam coals or carbonised ovoids.

For a small house a multiple-duty appliance is often the most economical means of providing room heating and hot water supply, but there are circumstances which favour the installation of a separate water-heating appliance. Great improvements have been made in the design of these water-heating appliances and some of them are now provided with gravity feed and thermostatic controls. Smokeless fuels of the right size are essential and, to give 250 gallons a week of water at 140 deg. F., up to 1 cwt. of fuel per week is required under correct operating conditions.

Experiments at Abbot's Langley on different heating systems have included the use of a central furnace to supply heated air for space heating. This system was found to be more expensive in capital and running costs than more conventional systems, though it had certain advantages. By applying better methods of heat insulation in house construction, it is estimated that a saving of 30 per cent. to 35 per cent. can be effected in the quantity of fuel required. Much still remains to be done in the improvement of domestic heating methods in this country. The hard core of the problem is the millions of existing houses, and for these the substitution of much more efficient appliances, particularly for room and water heating, is the first requirement. For many years to come, the main solid-fuel domestic load will have to be taken by bituminous coal.

INDUSTRIAL HEATING.

There is a vital need for increased fuel efficiency in industry. The B.C.U.R.A. have investigated the effect of coal characteristics on boiler performance, using an Economic boiler. It would appear that, if the coal burned contains approximately the correct amount of surface moisture, the rank of the coal, *per se*, has little effect on overall boiler efficiency. With high-rank coals of 6 per cent. ash there is no difference in efficiency between coals of $\frac{1}{2}$ in. to $\frac{3}{4}$ in. size and $\frac{1}{2}$ in. to 0 in.

* Address delivered at the summer meeting of the Institution of Heating and Ventilation, held at Torquay, June 14, 17, 1952. Abridged.

size, but with coals of 20 per cent. ash, efficiency with the fine coal is 4 per cent. less than with the coarse coal. The general effect of fineness depends primarily on moisture content. With other designs of boilers, the effects alter in magnitude according to the area and disposition of the heating surface; the less the area, the greater the effect. The application of these conclusions in shell-boiler practice should lead to marked coal economy.

Producer gas is used extensively for heating in the steel, glass and coking industries. In the coking industry, its use leads to the liberation of approximately double the quantity of coke-oven gas for town's purposes. The minor inconveniences and limitations long associated with its use are yielding to scientific attack. The recent successful development of the automatic control of the coal feed to the producers by B.C.U.R.A. is a major advance, leading to the production of gas of consistent quality with wide variations of load. The importance of adequate fuel-bed depth has been emphasised, and the advantage of operating the ordinary Morgan type of producer at higher gas-delivery pressures has been established. It has been shown also that the burden of cleaning the brick-lined culverts can be reduced by modifying the distillation contents in the gas producer. The use of oxygen for air enrichment is now being looked into.

A considerable amount of work is being done in this country on the use of solid fuel in gas turbines. These machines may be used in different ways in connection with manufacturing processes, to generate power from waste heat or in applications where power and heat are required, particularly if use can be made of large volumes of hot exhaust gases. A potential advantage of gas turbines is that the minimum economic size of a set should be smaller than for steam turbines, and they require little or no cooling water. A use for gas turbines where these features would be attractive, particularly if low-grade fuels could be burnt, is for power generation at collieries. Work is being done on combustion equipment suitable for this application and on the problems of gas cleaning and deposit formation.

In addition to the various points mentioned, every effort is being made by the gas industry to evolve new methods for the direct gasification of coal, though this may affect the availability of coke for the domestic market. Efforts are being made also by the British Electricity Authority on the erection of new power plants and power generating units of high efficiency, and on the development of hydro-electric power, wind power and district heating. District heating has received much attention in recent years and extensive schemes have been in operation for many years on the Continent and in the United States. Greater concern is now being manifested in Britain over the loss of about 50 per cent. of the heat content of the coal used in power stations. A start has been made by supplying a block of flats at Pimlico, London, with hot cooling water from the Battersea power station.

Of considerable interest also is the increasing use of heat pumps. Although suggested by Kelvin in 1852, these have not found much favour until recently. The town of Zürich linked its district-heating schemes with an extensive heat-pump installation in 1942. This installation provides annually 20×10^9 kilocalories, of which 13×10^9 are provided by the local river and 7×10^9 kilocalories by the hydro-electric energy operating the pump. Other large installations exist in Switzerland and in America. In the United States, heat pumps are becoming widespread as small domestic appliances, supplying heat in cold weather and cold in hot weather. In Britain, a start has been made at Norwich and at the Royal Festival Hall, London. Heat pumps may be useful at collieries for providing air refrigeration underground or heat on the surface. It may be, too, that nuclear energy will play a significant part in solving Britain's coal problem.

TRADE PUBLICATIONS.

Ring-Mounted Axial Fans.—Keith Blackman, Ltd., Mill Mead-road, London, N.17, have published an illustrated catalogue giving comprehensive technical details of their complete range of Tornado axial ring-mounted fans, which range from 6 in. to 16 in. in wheel diameter and are available for operating either under free inlet and discharge conditions, or against moderate resistance.

Bandsaws.—The Midland Saw and Tool Co., Ltd., Midsaw Works, Pope-street, Birmingham, 1, have issued an illustrated brochure describing their bandsawing machines for foundry and general purposes.

Electric Tractor Unit for Pulley Blocks.—An illustrated leaflet has been issued by George W. King, Ltd., Hitchin, Hertfordshire, giving a specification of their electric tractor unit for mechanising existing manually-traversed pulley blocks and cranes.

Cutting Fluids.—We have received from Fletcher Miller, Ltd., Alma Mills, Hyde, Manchester, a brochure giving particulars of their range of cutting fluids and their applications, with notes for the guidance of the user.

Industrial Radiology.—Solus-Schall, Ltd., 18, New Cavendish-street, London, W.1, who are the British agents for Richard Seifert, Hamburg, have published an illustrated booklet giving technical details of Seifert X-ray equipment for industrial radiology.

Drilling and Pneumatic Equipment.—Holman Bros., Ltd., Camborne, Cornwall, have issued a general catalogue, with illustrations, giving specifications of their compressors and air motors, winches, drills and accessories, furnaces for drill steels, forging hammers, hot mills, grinders, contractors' machine tools, etc.

Propeller Fans.—The London Fan and Motor Co., Ltd., 91a, Burghley-road, Tufnell Park, London, N.W.5, have sent us a catalogue of their heavy and medium-duty propeller fans, ambient temperatures from -32 deg. F. to $+125$ deg. F., which can also be supplied to order for temperatures down to -50 deg. C., and their light-duty fan designed for free air only.

Gravity Filters.—We have received from the Permutit Company, 330, West 42nd-street, New York, U.S.A., a booklet describing their gravity filters and filter accessories for water supply systems.

Vibrating Screens.—We have received from the Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, an illustrated brochure giving specifications and describing the construction of their vibrating screens, which fall into two main types—high-speed Moto-Vibro screens and slow-speed Newaygo screens. Brief details are also given of screens developed for special applications, such as screening fertiliser and for use in laboratories.

Electronic Valves.—Electronic valves and tubes for industry and communications are listed, together with brief details of their operational characteristics and limits on their use, in a catalogue issued by Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2.

Cable Testing.—Applications and general details of SenTerCel high-voltage direct-current cable-testing equipment are the subject of Bulletin F/CT.1, published by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2.

Fluorescent Tubes.—The nature, advantages and applications of cold-cathode fluorescent-tubes for lighting are described, and details of types and fittings are given, in a leaflet published by the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

Telephone Selector Equipment.—An illustrated bulletin published by the Automatic Telephone and Electric Co., Ltd., Strowger House, Arundel-street, London, W.C.2, gives details of the history, general construction, mode of assembly and applications of the Type 32A, Mark II Strowger selector, as used in automatic-telephone exchanges.

BOOKS RECEIVED.

Flexible Budgetary Control and Standard Costs. By D. F. EVANS-HEMMING. Macdonald and Evans, Limited, 8, John-street, Bedford-row, London, W.C.1. [Price 42s.]

The Corrosion Resistance of Tin and its Alloys. By S. C. BRITTON. Tin Research Institute, Fraser-road, Greenford, Middlesex. [Price 3s. 6d.]

Lexicon of Terms Used in Connection with International Civil Aviation. English-French-Spanish. The Secretary General, International Civil Aviation Organisation, 1080, University-street, Montreal, Canada. [Price 1 dol.]; and H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6s. 10d.]

Proceedings of a Second Symposium on Large-Scale Digital Calculating Machinery. Sponsored by the U.S. Navy Department Bureau of Ordnance and Harvard University at the Computation Laboratory, 13-16 September, 1949. Harvard University Press, Cambridge 38, Massachusetts, U.S.A. [Price 8 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 52s. net.]

Hydraulische Antriebe und Druckmittelsteuerungen an Werkzeugmaschinen. By A. DÖRR and O. WACHTER. Second revised edition. Carl Hanser-Verlag, Leonhard-Eck-Strasse 7, Munich 27, Germany. [Price 12.50 D.M. in cardboard covers, 14.80 D.M. bound.]

High-Speed Aerodynamics. By W. F. HILTON. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 60s.]

Standard Methods for Testing Petroleum and its Products. Twelfth edition. The Institute of Petroleum, Manson House, 26, Portland-place, London, W.1. [Price 40s., post free.]

Automobile Chassis Design. By R. DEAN-AVERNS. Second edition. Hiffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 30s.]

Ausführung von Stollenbauten in neuerzeitlicher Technik. By DR.-ING. KARL WIEDEMANN. Sixth revised and enlarged edition. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 18.50 D.M. in paper covers, 21.50 D.M. bound], and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 32s. 5d. in paper covers, 37s. 9d. bound.]

Soil Mechanics for Road Engineers. Road Research Laboratory. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 30s. net.]

Ministry of Fuel and Power. 29th Annual Report on Safety in Mines Research, 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. net.]

Hydraulics and its Applications. By PROFESSOR A. H. GIBSON. Fifth edition. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 35s. net.]

Overseas Economic Surveys. Portuguese East Africa (Mozambique). By G. EDGAR VAUGHAN. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. 6d. net.]

Strength Tests on Driven Large Diameter Aluminium Rivets. By J. C. BAILEY and A. W. BRACE. Report No. 13. The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 7s. 6d.]

Memoirs of the Geological Survey. Special Reports on the Mineral Resources of Great Britain. Vol. IV. Fluorspar. Fourth edition. By DR. K. C. DUNHAM. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 17s. 6d. net.]

Polarized Light in Metallography. Edited by DR. G. K. T. CONN and F. J. BRADSHAW. Published in conjunction with the British Iron and Steel Research Association by Butterworth's Scientific Publications, Bell Yard, Temple Bar, London, W.C.2. [Price 21s.]

British Iron and Steel Federation. Statistics of the Iron and Steel Industry of the United Kingdom for 1951. Offices of the Federation, Steel House, Tothill-street, London, S.W.1. [Price 7s. 6d.]