The Modern Boiler-House.

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Few departments of engineering practice have seen more radical changes than that of steam raising. Stokeholds of ships and power stations have been transformed. Where dirt, confusion, and inefficiency often reigned there is now order and method, and brawn and muscle have made room for skill and trained intelligence. Science has come into its own, and the modern boiler-room reflects the progress of the time. Installed in well-lighted and spacious buildings, the boilers and all their accessories are the objects of the care of the engineer-in-charge as much as the main machinery itself. Water-tube boilers, superheaters, economisers, air heaters, mechanical stokers, pulverised fuel systems, forced and induced draught fans of many types have taken the place of tank boilers fired by hand, while new forms of gauges and indicators keep continuous records of the fuel consumed, the analyses of the gases, the temperatures of gases, steam, and water, and, in some instances, steam-flow meters are fitted which make the approximate test of a boiler a comparatively simple matter.

The most advanced boiler practice is to be found in the electric power stations. Of such stations there are in Great Britain nearly six hundred concerned with the public supply of electric current, but the majority of them are small. Those at Barking, Manchester, Birmingham, Glasgow, Newcastle, and a few others are of considerable size; but it is in the United States we see the rise of the so-called super-power station—a super-power station being essentially a very large plant comprising a part of a regional system wherein the more efficient plants are linked up. Electricity is used in America to a far greater extent than in the old world, and as much current is generated in the United States as in all the countries of Europe combined. Some striking figures and diagrams regarding the electrical industry is given in the January issue of the *Electrical World*, where it is stated that the power distributed in the United States last year amounted to 54,413,000,000 kilowatt hours, the corresponding figure for Great Britain being 6,681,000,000 kilowatt hours. Other interesting details regarding the super-power stations were also recently given by Mr. W. H. Patchell in his honorary members' lecture to the Junior Institution of Engineers. Mr. Patchell has himself been connected with power station work for the last forty years, and he was the pioneer of the very large boiler.

Modern power station boilers are invariably of the water-tube type, among the most popular being the Babcock and Wilcox and the Stirling. Pressures in such boilers have gradually advanced until to-day 300 lb. and 400 lb. per square inch is common, while there are stations using steam at 500 lb., 600 lb., 800 lb., and even 1200 lb. pressure. Boilers are also made in very large units. Copper, brass, wrought iron and steel have all been used for boiler tubes, which formerly were made from sheets rolled and welded; but thanks to the invention of the German metallurgist, Mannesmann, boiler tubes now are of solid drawn steel, and with such tubes failures are infrequent.

The stoking of the boilers is done by one of two types of mechanical stokers known as chain-grate stokers and under-feed stokers, or the coal is pulverised and blown into the furnace by jets of air. In chain-grate stokers the coal is fed from a hopper on to an endless chain of short fire-bars linked together, the grate travelling slowly into the furnace at about 2 to 6 inches per minute. With such stokers, firebrick arches are employed to reflect the heat from the fire and assist the combustion of the gases. The ash falls off the chain grate at the back of the furnace and is conveyed away by various means. The size of a large chain grate may exceed 20 feet square. In an under-feed stoker the coal is fed into the furnace by retorts and is thrust up under the already burning coal, the fuel being agitated by reciprocating fire-bars. Thick fires are the practice with under-feed stokers. Many types of mechanical stokers are in the market, and the choice is determined largely by the class of coal to be burned.

The most interesting development in boiler firing is the comparatively new system of using coal dust. In this case the coal is crushed, then passed through a magnetic separator to remove pieces of stray iron, and, after being dried in steam or hot-gas driers, is pulverised in mills to such a fineness that most of it will pass through a sieve with a mesh of $\frac{1}{100}$ of an inch. From the mill it is conveyed to bunkers, from which it is delivered to the burners. In a plant using pulverised fuel the lower drum of the boiler may be some 20 feet or more above the ground floor, the walled-in space beneath the boiler constituting the furnace or combustion chamber. So large are some of these combustion chambers that it would be possible to place a two-storeyed double-fronted villa in one of them. The coal dust is injected into the chamber through nozzles pointing downwards from a position corresponding to the cornice of a ceiling. The very high temperatures reached have called for improvements in refractory materials for the walls of the combustion chambers, but a promising experiment has been made by forming the walls of water-tubes with longitudinal fins welded on them. With pulverised fuel the ash falls as minute drops of liquid slag. A screen of water-pipes placed about a foot apart across the bottom of the combustion chamber cools these drops, and the ash reaches the floor as fine dust, which is easily dealt with.

An integral part of every modern boiler is the super-heater through which the steam passes on its way to the engine. Super-heating is now in use in ships and locomotives as well as in power stations, and there is a rough rule that 10° F. super-heat leads to an economy of 1 per cent. in the fuel.

After the gases have passed among the boiler and super-heater tubes they are still at a moderately high temperature, and are therefore caused to flow through an economiser for heating the feed water and through a pre-heater for heating the air for the furnaces. Finally, at the top of the boiler-house, they are drawn into the induced draught fan and ejected into the chimney-stack.

A modern boiler-house is a steel-framed structure of three or four storeys, perhaps 100 feet in height. Platforms at intervals support the various sections of the plant, and gratings and ladders give access to the stop-valves, gauges, burners, and other fittings. Roomy and well lighted inside, the buildings are designed by architects especially qualified in such work, and the exteriors are both pleasing and appropriate.

Super-power stations each designed for an ultimate capacity of over 300,000 kilowatts, have already been erected at St. Louis, Chicago, Pittsburg, New York, Brooklyn, Detroit, Boston, Cincinatti, and one or two other places, and a few particulars of some of their boiler plants may be of interest.

What will probably be the largest station is the Crawford Avenue station of the Commonwealth Edison Co., Chicago, and it was for this station Messrs. C. A. Parsons and Co. constructed the fine 50,000 kilowatt turbo-generator, the model of which was shown at the British Empire Exhibition at Wembley, from whence it was removed to the Science Museum, South Kensington. A full description of this set is in *Engineering* for March 5. The ultimate capacity of Crawford Avenue will probably reach 800,000 kilowatts. Very large Babcock and Wilcox boilers are installed, the tubes being 15 feet long, while the steam drums are 4 feet in diameter and 32 feet long. The drums are of steel plates 1⅞ inch thick, and the riveting is of an exceptional character. Forced draught chain grates are used, the grates being 24 feet wide and 20½ feet long. Steam is generated at 600 lb. pressure and delivered to the turbines at 550 lb. pressure at a temperature of 725°. About 190 tons of steam per hour is required for the single 50,000 kilowatt Parsons set. The boiler-house also contains a reheat boiler through which the steam is caused to pass on its way from the H.P. turbine to the I.P. turbine. The steam leaves the H.P. turbine at 100 lb. pressure and at a temperature of 425° F., and enters the I.P. turbine at about the same pressure but with its temperature increased to 700° F. Economisers are used, but the feed water, before entering the economiser, has already passed through five steam heaters, with the result that it enters the economiser at 315° F. and leaves at 380° F. At Crawford Avenue full advantage is made of the modern system of 'bleeding' the turbine.

Another large plant is that of the Detroit Edison Co., which supplies electricity over a very large area and sells it to the farmer 50 miles away at the same price as to the town dweller. The company has stations at Delray, Connor's Creek, and Marysville, and a new station has recently been erected at Trenton Channel. The Stirling boilers here work at 410 lb. pressure and the steam is super-heated to 700° F. Pulverised fuel is used entirely. A section of the boiler-house shows the ash-shoot at the ground level, the boiler floor 45 feet above this, and the roof 130 feet from the ground. Standing in the huge combustion chambers, the ash-shoots are at one's feet while the boiler tubes are some 50 feet overhead. The volume of such a combustion chamber is about 25,000 cubic feet, and one boiler will supply sufficient steam for a 25,000 kilowatt machine. At present there are three 50,000 kilowatt turbo-generators installed. Electricity is generated at 12,000 volts and distributed by overhead mains at 120,000 volts.

With the reputation of having established a record in economy, the Philo Station at Zanesville, Ohio, is a station possessing many remarkable features. It forms one of the plants of the American Gas and Electric Co., and was designed "to produce a marketable commodity at the lowest possible price." The thermal efficiency of the plant worked out at 23·81 per cent. The boiler pressure is 650 lb. and the steam temperature 750° F. In addition to the main boilers there are super-heaters, economisers, air heaters, forced and induced draught fans, and a reheat boiler as at Crawford Avenue. This station is unique in that it is able to draw its circulating water for the condensers from a reservoir at a higher level than the machinery, and for ten months in the year, therefore, no circulating pumps are required. Philo is but a link in a great system supplying electricity to parts of Ohio, Indiana, Pennsylvania, and West Virginia.

All records of boiler pressures in actual use are surpassed by the 1200 lb. pressure generated in the remarkable Babcock and Wilcox boilers at Calumet and at the Edgar station, Boston. At Boston three large boilers provide the main steam supply at 350 lb. pressure, but there is a separate boiler working at 1200 lb. pressure. This very high pressure steam is first used in a 2500 kilowatt turbo-generator, from which it exhausts to a reheater and then finds its way into the 350 lb. main of the station. The steam drum of the 1200 lb. boiler is an exceptionally fine piece of work. It was made from a steel ingot weighing about 100 tons. The ingot was 'upset' until about 8 feet in diameter, a core of 23 inches was then removed from it, and by subsequent operations the ingot was drawn out into a drum 34 feet long and 4 feet in diameter, the walls of which were 4 inches thick. Such work is within the capacity of only a few firms, but it well illustrates the demands made on the manufacturer by the designer of modern boilers.

Trends in American Geology.

IN an address delivered to Section E (Geology and Geography) at the recent meeting of the American Association for the Advancement of Science, Dr. W. C. Mendenhall dealt with "Some Recent Trends in American Geology," indicating the lines along which, according to his view of the matter, effective progress in the science of geology is being made. Modern science, said Dr. Mendenhall in his opening remarks, is too broad and too complex to be comprehended by any individual, and any one of the sciences is beyond the grasp of one man. "Progress is made by the specialist or group of specialists who devote themselves to a limited field. Presently there comes out of their endeavours a generalisation which can be used by other groups. Thus the advances in different fields are linked together and a united front is maintained."

STUDY OF SEDIMENTS.

A promising development of the last few years is the revival of interest in the petrology of sediments and the organised attack that is being made on the problems connected therewith. The United States National