

LEEDS LOCAL SECTION.

CONDENSING ARRANGEMENTS IN CENTRAL STATIONS.

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In installing condensing plant, sufficient attention does not always seem to be given to the question of the most suitable type, or to the general arrangement of the condenser itself and its accessories, and the paper was compiled with the object of describing the leading forms of apparatus employed for the purpose, and promoting a discussion on the subject.

EJECTOR CONDENSERS.—Probably the simplest form of condenser in general use is the ejector. It comprises a conical water nozzle leading to a condenser tube, usually vertical, and contained in an outer shell which serves as a steam space. The cooling water is delivered to the nozzle under a pressure of some 7 lbs. to 9 lbs. per sq. inch, so giving it a corresponding velocity of discharge from the nozzle and in the condenser tube. The two types of ejector condensers in general use are the Korting and the Ledward. In the former, the condenser tube is perforated with a number of rings of holes, drilled obliquely so that the exhaust steam meets the central moving column of water at a suitable angle. In the Ledward ejector, the condenser tube takes the form of a series of cones.

JET CONDENSERS.—In the jet condenser the water is delivered into the exhaust steam space in the form of spray, and a pump is employed to overcome the pull of the vacuum. This may be in one and serve as a water and air pump combined; or there may be two separate pumps, one, connected to the top of the condenser, being used solely for abstracting the air and vapour, and the other, connected to the bottom, for the condensed steam and cooling water.

In some condensers the exhaust steam and the cooling water are arranged to flow in the same direction; these are known as parallel current condensers. In others the steam and the water are arranged to flow in opposite directions; these are described as counter current condensers. In the latter type both the steam and the water have their greatest temperatures at one end and their lowest at the other. In the former the cooling water must leave at a temperature lower than the lowest temperature of the steam, whereas in the latter

the water may leave at a temperature only slightly less than the highest temperature of the steam, which means that more cooling water must be used with parallel than with counter current condensers to achieve the same result. The counter current principle is frequently applied also to surface condensers.

THE EVAPORATIVE CONDENSER.—This consists of a stack of corrugated iron tubes with radial flanges exposed to the air, over which water trickles. The quantity of cooling water required is comparatively small, and, in practice, may be from one-half to two-thirds that of the steam condensed, the loss being due to evaporation. The condenser tubes being exposed to the air, the condensation of the steam is chiefly due to radiation. The usual tube surface allowed is, say, two-thirds of a square foot per lb. of steam. If the tubes are contained in a casing and cold air driven or drawn in among them by a fan, the cooling surface may be somewhat reduced. An air pump is provided for producing a vacuum in the tubes and for passing the condensed steam back to the hot well. A sump is provided below the condenser for catching such of the cooling water as is not evaporated in its transit among the tubes. This type of condenser may be erected on a roof, so saving ground space, but this of course introduces the question of draining the exhaust steam pipe, and the effect on the vacuum of the upward flow of the steam.

THE SURFACE CONDENSER.—Surface condensers are made both horizontal and vertical, and the advantage of their use is in keeping the condensed steam separate from the cooling water, so rendering it suitable for passing back to the boilers. Frequently a feed-water heater is interposed for raising the temperature of the condensed steam before it is fed back to the boilers, and this may be either separate from the condenser or combined with it.

The air and circulating pumps may be driven in any convenient way, either direct from the engine, by separate engine, or by electric motor. One objection to driving the pumps from the main engine is that, in the event of a breakdown of the pumps, the engine has to be stopped whilst the pumps are being disconnected; another is that when both air and circulating pumps are driven from the engine, the inequality of the work done by the two pumps tends to affect the governing—this is especially objectionable with alternating-current plant. Driving the pumps by a small separate engine has its advantages; they are then independent of the main engine, and can be started up before it, so enabling the main engine to be run up on the condenser.

Circulating pumps may also be either of the reciprocating, screw, or centrifugal type. The first-named are usually the more efficient, especially when new, but require some attention when running. Where the source of water supply is more than, say, 10 ft. to 12 ft. below the level of the pump, the reciprocating pump, owing to its power of lifting, is more or less imperative. The screw pump is sometimes used where the suction head is very low indeed, and the delivery head does not exceed, say, 10 ft. When the suction head does not exceed say, 10 ft. the centrifugal pump is to be preferred, which, though not so

efficient as the reciprocating type, maintains its initial efficiency, has no valves to be damaged by impurities and foreign matter in the water, runs smoothly, and delivers a constant stream of water, and lends itself admirably to being driven direct by an electric motor.

There are many more or less efficient forms of air pumps to be had, and probably the "Edwards" air pump is one of the best known in this country. The action is direct and mechanical, and, owing to the form of the plunger and chamber, the water is displaced quietly and smoothly.

Another excellent air pump is the "Parsons" compound single-acting air pump, which may be used either as a wet or as a dry pump; in the latter case a small quantity of water is let into the pump chamber by means of a pipe and valve—which water both primes, lubricates, and fills up clearances. Water only is used as a lubricant. In the event of the circulating water pump failing whilst the air pumps are in use there would be no trouble from flooding, as they would be working under ordinary conditions.

One frequently hears that the maintenance of high vacuum involves the use of abnormal quantities of cooling water and cooling surface, abnormally large capacity air pumps, prohibitive initial and working costs, etc. However, with properly designed condensing arrangements, and cooling water at a moderate temperature, there is no difficulty in maintaining a vacuum of 28 inches. All that is necessary, assuming the cooling water to be at a moderate temperature, is that the type of condenser adopted be selected intelligently and with due consideration of the local conditions.

A great deal may be done by the use of properly designed and efficient air pumps, such as those described above. With the steam turbine the gain per inch at the higher vacuum is so great that a vacuum closely approaching the barometric column is aimed at, and obtained in regular working by not depending upon the main air pump alone to abstract the air and vapour. One well-known firm of condenser builders use with surface condensers a small auxiliary air pump, whose function is to deal only with the air and vapour, the main air pump dealing with the condensed steam. Probably the simplest and most efficient method at present in use for the purpose is the Parsons Vacuum Augmentor. It comprises a pipe passing from the main condenser to a small auxiliary condenser; the pipe is fitted with a cowl at its top end, to prevent water in the form of condensed steam falling into it from the main condenser tubes, and, in a contracted portion of the pipe is placed a small steam jet, which draws from the main condenser the air and vapour left by the main air pump, and delivers it to the auxiliary condenser, where it is condensed and led thence to the common air pump. A water seal is provided to prevent return of air and vapour to the condenser. The injection water for the auxiliary is obtained from the main supply by means of branch connections, so that the same circulating pump suffices. The jet compresses the air and vapour, reducing its volume, so that the vacuum in the air pump may be considerably less than that in the condenser, which means that the air pump may be smaller. There are no moving parts in this arrangement, the minimum

of attention is necessary, and the steam consumed by the jet is but small, being about one per cent. of the total full-load consumption of the plant. A vacuum within 0.33 in. of the barometer has been attained.

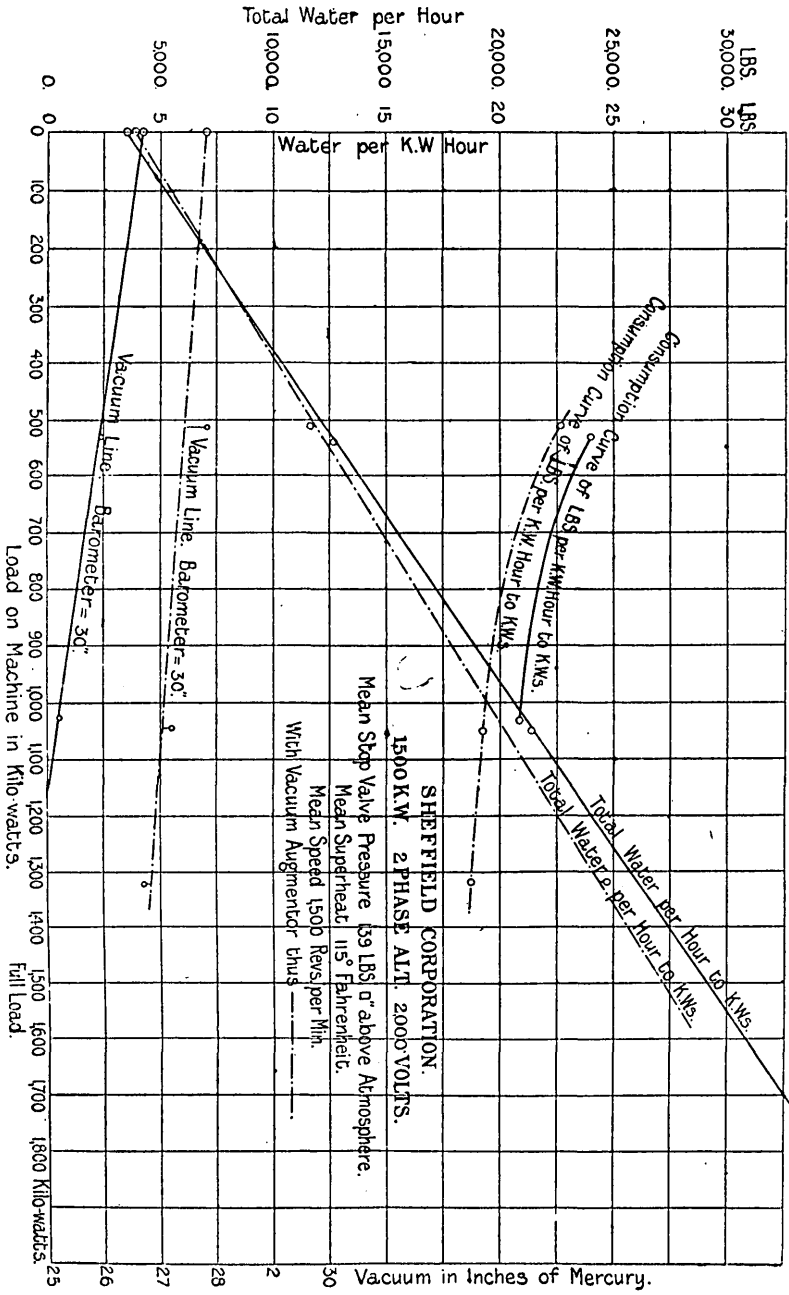
Whether to adopt one large common condensing plant for a station, or a number of smaller ones, is a question concerning which no hard-and-fast rule can be given. The former saves in initial cost and attendance. If, however, several condensing plants be installed, it means that breakdown of one, or even two of them, does not necessarily seriously affect the economical running of the engines, as, by means of inter-communication pipes and valves, it can be arranged for any engine to run on another condenser.

COOLING WATER.—Before deciding upon the type of condenser to adopt, one of the most important considerations is the water supply available. Its quantity and temperature, at various times and seasons, should be ascertained, as well as its quality. Fortunately for many central lighting stations the quantity available is greatest, and its temperature lowest, in the winter-time, when loads are heavy. Where there is always an ample supply of cooling water to be had, the average and the maximum temperature should be ascertained, as upon these will depend the proportions of the condensing plant. Whatever the conditions as to quantity and temperature, the water should be analysed, in order that its composition and probable effect on the condensers, pumps, etc., may be known. If cooling towers are used, the surrounding atmosphere should be taken into account, for since the same water is used again and again, it may take up impurities from the atmosphere, chemical action resulting, and so converting what was originally harmless water into a corrosive medium.

Many devices have been adopted for re-cooling the injection water, including ordinary open reservoirs, reservoirs with spraying arrangements, cooling towers, etc.

The general principle in all cooling towers is to spray or otherwise split up the warm water by distributors and baffling devices into small particles which become cooled by contact with a current of air. It is usual to deliver the warm water to the tower at a considerable height by means of a circulating pump, from whence it falls by gravity through the various baffles, into a sump immediately below the tower, from which it is pumped back to the condensers and used over again—the process being repeated indefinitely. In some cases the air is circulated through the baffles by means of a fan, in others by natural draught. The former type are compact, but a certain amount of power is absorbed in driving the fan, and, in general, the author prefers the natural draught towers, which, if properly arranged, will satisfactorily cool the water.

These towers are usually some 60 feet to 80 feet in height, and, as the water is delivered to them at, say, 25 feet to 30 feet above the ground, the top 35 feet to 50 feet forms a chimney for inducing the draught of air through the baffles, and, at the same time, it discharges such vapour as escapes at a sufficient height to prevent its being objectionable. The quantity of vapour discharged is also less, as some condensation takes place in the chimney. The baffles take various forms, such as grids,



laths, drain pipes, etc., their function being to ensure thorough breaking up of the water.

SUCTION AND DISCHARGE PIPES.—Where practicable, a supply pipe should be led from the canal, or other source, to a sump, and this pipe should have a fall so that the water will gravitate from the canal to the sump. A penstock should be fitted to the sump end of the pipe, so that the canal water can be shut off when desired, for cleaning out the sump, etc. The sump end of the suction pipe should be fitted with a foot valve and strainer, the former to prevent anything which may have fallen into the sump being drawn into the suction pipe, and the latter to assist the pump by keeping the suction pipe, when once filled, charged with water.

Though they should, of course, be properly fitted, there is not the

CONDENSER TESTS.

| STATION . | HULTON COLLIERY. | NEEPSSEND WORKS . | WEST BROMWICH . | M'CHESTE |
|------------------------------------|-------------------------|---------------------------|---------------------------|---------------------------|
| TYPE OF CONDENSER . | Ledward Ejector | Parsons Surface . | Parsons Surface . | Jet. Wet & Dry Pumps . |
| TYPE OF AIR PUMP . | — | Parsons 3 Thr'w Cmp'nd | Parsons 3 Thr'w Cmp'nd | Parsons 3 Thr'w Cmp'd |
| TYPE OF CIRC. PUMP . | Gwynne Centrifugal . | Gwynne Centrifugal . | Gwynne Centrifugal . | Gwynne Centrifugal . |
| PUMPS DRIVEN BY . | B.T.H. Motor | B.T.H. Motor . | B.P. Motor . | E.C.C. Motor . |
| COOLING SURFACE . | — | 3000 Sq. Ft. | 1000 Sq. Ft. | — |
| TEMPERATURE of COOLING WATER . | 67.6° F. | 65.8° F. | 51° F. | 82° F. |
| VACUUM AT CONDENSER . | 28.17" Hg. | 27.7" Hg. | 28.2" Hg . | 26.66" Hg . |
| BAROMETER . | 30.05" Hg. | 29.9" Hg . | 29.8" Hg . | 29.5" Hg . |
| COOLING WATER PER HOUR . | 48100 gals. | 88500 gals | 50000 gals | 178500 gals |
| STEAM COND'NS'D PER HOUR . | 6996 lbs. | 29580 lbs. | 10000 lbs. | 85700 lbs. |
| COOLING WATER PER LB. OF STEAM. | 68.75 lbs. | 30 lbs. | 50 lbs. | 50 lbs.? |
| TOTAL POWER GENERATED | 314.4 K.W. | 1610 K.W. | 446 K.W. | 1822.08 K.W |
| POWER USED BY PUMPS . | 22.5 K.W. | 37.4 K.W. | 9.17 K.W. | 40 K.W. |
| % age TOTAL PWR USED BY PUMPS . | 7.1% | 2.3% | 2.05 % | 2.2 % |
| HEAD AGAINST CIRC. PUMP . | 47.5 Ft. | 20 Ft. | 15 Ft. | 40 Ft. |

same need of extreme care in the arrangement of the discharge pipes. They may also be of smaller area, and the velocity of the flow in them may be higher. It is good practice to water seal the end of the discharge pipe, when, assuming all joints are tight, some of the power for driving the circulating pump may be saved. By doing this a syphon action is set up when the pump is running, so eliminating the head due to the difference of level between the suction and discharge, leaving only the head due to pipe friction, plus, of course, that due to the condenser, etc. This method has been adopted at the Carville power-station, with the addition of a small motor-driven pump to extract the air from the pipes.