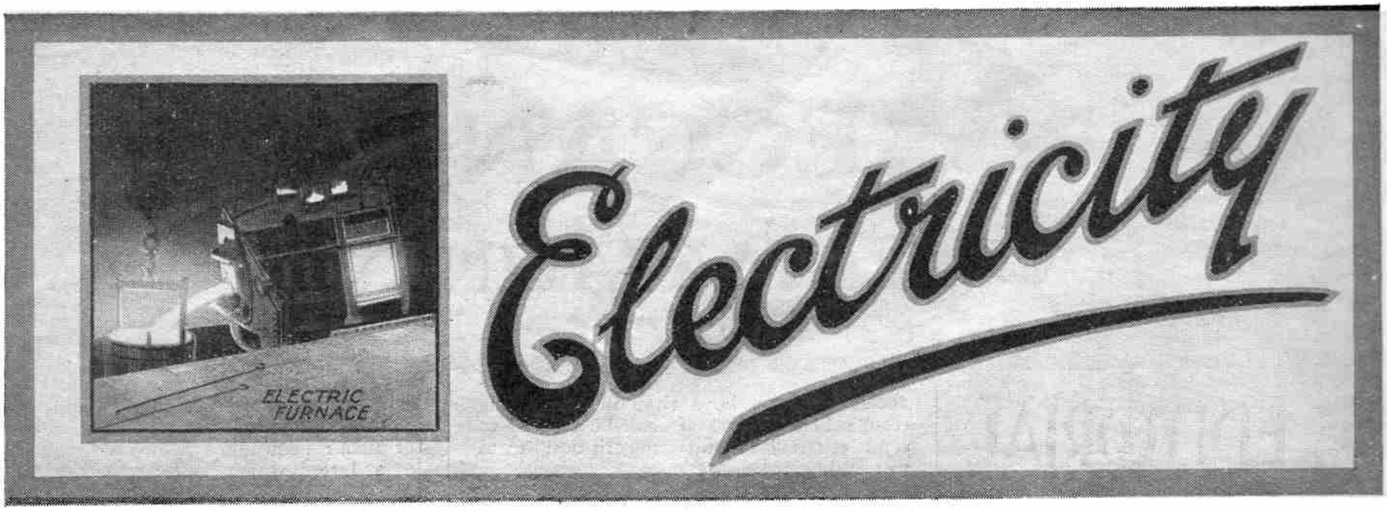


VII. ELECTRIC POWER STATIONS

FEW things are more impressive and fascinating than a large electric power station. There is an element of mystery about the huge machines working incessantly at enormous speeds and yet producing no visible result. We know that electric current of tremendous power is being produced, but that current is silent and invisible, and only makes its presence known when it lights tens of thousands of lamps and drives innumerable motors in all parts of a great city.

In this country steam is used almost exclusively as the motive force to drive the generators of a large power station. Until recent years the reciprocating engine was in general use, but now the steam turbine has taken its place in up-to-date stations. The turbines are coupled directly to the generators so that the two machines look like one. The advantages of the steam turbine are that it is capable of higher speeds than the reciprocating engine, is more silent in running, occupies less space and requires less attention.

From Coal to Steam

A large central power station consumes vast quantities of coal and requires a plentiful supply of water. For this reason it is built whenever possible on the banks of a river or canal, so that supplies of coal can be brought to its doors cheaply and easily and an ample water supply is at hand. The coal arrives in barges and is unloaded by huge mechanical grabs and deposited in a big receiving hopper. From this hopper it is taken by some form of conveyor to other hoppers close to the furnaces, and is fed into the furnaces by mechanical stokers.

After combustion the ash and clinker fall down great funnel-like chutes directly into trucks below, and are taken away and sold to be made into building and other materials. Even the gases resulting from the combustion of the coal are made to do work before they are allowed to escape through the chimney. These gases are led into an economiser chamber through which pass pipes bringing fresh water to the boilers. Here the gases part with a great deal of their heat, with the result that the water flowing through the pipes is raised to a very high temperature before it reaches the boilers, so that a comparatively small amount of heat is required to turn it into steam.

The heat produced in the furnaces is used to generate steam in a number of great boilers, from which the steam is collected in large pipes and led to the engine-room, where it is distributed to the turbines as required. Having exerted its energy in the turbines it might be thought that the steam would be allowed to escape, but no—a great deal more work is yet required of it. It passes from the turbines to a condenser in which it is cooled and condensed to water, freed from oil and grease, and then sent back to the boilers to be re-converted into steam.

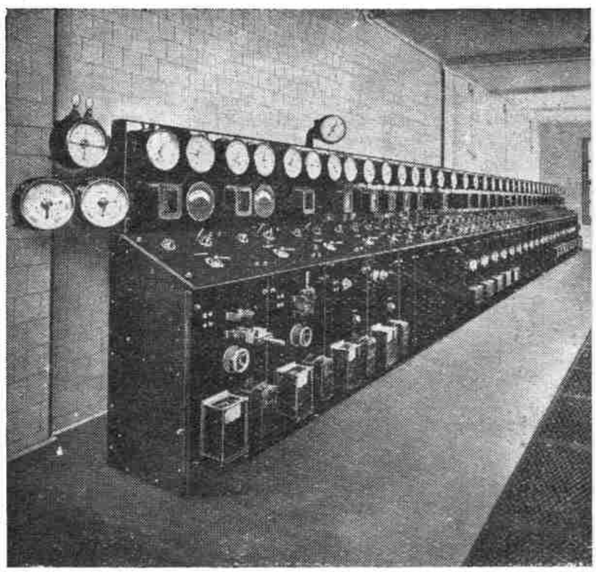


Photo courtesy] [*Messrs. Metropolitan-Vickers Ltd.*

The Switchboard at a Power Station

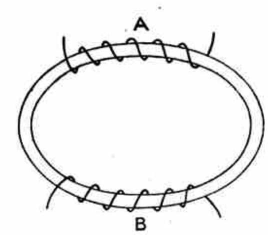


Diagram showing principle of Transformer

This condensed water is quite warm, and therefore less heat is required to turn it into steam than would be the case if the boilers were constantly fed with fresh cold water.

Silent Giants at Work

Perhaps the most striking feature of a large power station engine-room where the generators are turbine-driven is the silence. There is none of the clash and clatter one usually associates with rapidly moving machines. The giant turbines, turning at the rate of perhaps 1,000 revolutions per minute, are uncannily quiet, and as one listens to their purring hum it is difficult to realise their enormous power. The generators, too, run very quietly, although they may be developing current capable of supplying the whole of the electrical requirements of a great city.

The current generated is conveyed by heavy copper cables to what are called "bus bars," two of which run along the entire length of a large main switchboard. One receives the positive cable from the generators and the other the negative cable.

The kind of current to be generated at a power station—continuous or alternating—is largely determined by the size of the area supplied. Generally speaking, continuous current is generated for small supply areas and alternating current for larger ones, but there are exceptions, and in many cases both kinds of current are generated at one station.

Continuous Current : Three-Wire System

If continuous current is generated it is usually at a pressure of from 400 to 500 volts, the average being about 440 volts. The distribution is generally on what is known as the three-wire system, which employs two parallel circuits with a common return. Three separate wires are used. The two outer wires are connected respectively to the positive and negative bus bars and carry current at the full voltage of the system. Between these wires is a third and smaller wire connected to a third bar, smaller than the main bars, and not connected to the generators but to earth by way of a large copper plate buried in the ground. The mid-wire is connected to the positive and negative outer wires respectively by two machines called "balancers." If we suppose the pressure between the outer wires of the system to be 440 volts, then the pressure between the third wire and either of the outer wires will be 220 volts—that is exactly half.

Balancers

Board of Trade regulations prohibit the use of current at a pressure exceeding 250 volts for electric appliances of all kinds intended for ordinary domestic purposes. In a three-wire system such as we are describing, all such appliances would be connected between the mid-wire and one of the outer wires, thus receiving current at 220 volts. It is clearly impossible to ensure that the appliances connected with the positive side of the system shall always take the same amount of current as those connected with the negative side. There is always liable to be a greater load on one side than on the other, and the function of the balancers to which we have just referred is to adjust these differences.

The balancers are machines capable of acting either as dynamos or motors. So long as the current demands on each side of the system exactly equal one another, the balancers have nothing to do and they run light as motors. Let us suppose, however, that a heavy load is thrown on the negative side. The voltage on that side accordingly drops and the voltage on the positive side rises. The balancer on the positive side then runs as a motor and drives the negative side balancer as a dynamo, and thus the excess demand on the negative side is immediately supplied. There are other methods of balancing, but the one we have described gives a sufficiently good idea of the principle involved.

The half-pressure of 220 volts in such a three-wire system is confined to appliances for domestic use, and electric motors for driving trams or machinery of any kind are connected across the outer wires, thus receiving the full voltage of the system.

Batteries of Accumulators

One of the many problems with which central power stations have to contend is that of a constantly fluctuating demand for current. In a system supplying power and light, for instance, the current demand increases very rapidly at a certain time on winter afternoons, because, as the daylight fades, vast numbers of electric lamps are switched on within a very brief period, while the motors driving machinery in factories and workshops are still running at the full. The same thing happens when a fog descends on a city, or in summer when an approaching thunderstorm quickly darkens the sky and lights are switched on accordingly. A sudden and heavy demand for current may also arise in a system supplying power for tramways. If one of the cars has a serious breakdown it holds up all the cars behind it and a long string of cars quickly forms. As soon as the breakdown is repaired all these cars start practically at the same time, and consequently the current demand is momentarily far in excess of the normal.

If a power station is to deal successfully with situations of this kind it obviously must have a reserve of current beyond that normally required. In the case of power stations generating continuous current such a reserve may be provided by means of a large battery of accumulators. The battery is charged during periods of small demand and then, when an abnormally heavy load comes on, the current from the battery is available to take a share of the load and so relieve the generators. Of course, such a battery of accumulators cannot be used where alternating current is generated unless that current, or part of it, is converted to continuous current. In our June issue we gave an illustration of a large power station battery.

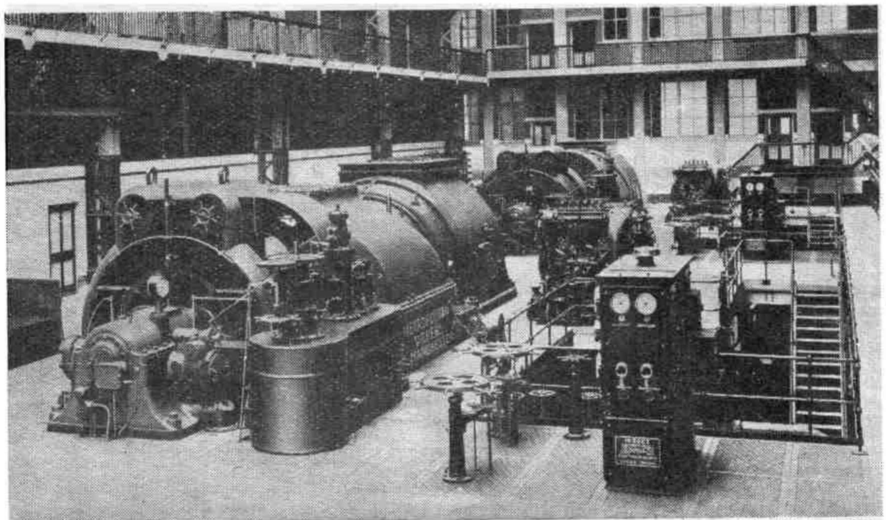


Photo courtesy] [*Messrs. Metropolitan-Vickers Ltd.*

Turbo-Generators at a Typical Power Station

Alternating Current

We have already said that alternating current is generated at stations supplying very large areas. This current is generated at pressures of from 2,000 volts upwards. The highest pressure at present employed in this country is about 11,000 volts, but in the United States and in other countries where current has to be transmitted very long distances pressures more than ten times as great are in regular use. Pressures such as this are, of course, very much too high for lamps or motors, and the object of using them is to secure economy in transmitting current through very long cables.

Electrical power is measured in watts. In the case of continuous current the number of watts is obtained by multiplying together the pressure or voltage of the current and its rate of flow or amperage. Therefore, so long as the product of voltage and amperage remains the same, it makes no difference so far as electrical power is concerned whether the current is of low voltage and high amperage or high voltage and low amperage.

In transmitting a current through a long cable a considerable amount of loss occurs through the heating of the cable. This heating is due to the current flow, not to the pressure, and therefore the heavier the current the greater the loss. From this it will be seen that by decreasing the current flow and increasing the pressure by a corresponding amount, the electrical power will remain the same, yet at the same time the loss in transmission will be greatly reduced. It also follows that the use of current at high pressure and low amperage allows of the use of cables of smaller cross-section, and thus a great saving in copper is effected.

In the case of alternating current the calculation of the watts is not quite so simple, but the same principle holds good.

Work of Transformers

Alternating current at pressures of from 2,000 to about 11,000 volts is produced without any difficulty direct from the generators, but where pressures of 100,000 volts and upwards are necessary, direct production is not practicable owing to the great liability of the insulation to break down. In such cases the alternating current is generated at a moderate pressure and raised to the required pressure by means of transformers.

The principle of the transformer was discovered by Faraday in the course of his long series of electrical experiments. He wound upon an iron ring two insulated coils of wire, as shown in the accompanying diagram. Coil A was connected to a battery and Coil B to a galvanometer. When the current was switched on or off in Coil A secondary currents were generated in Coil B. Similarly, if Coil B was used as the primary, then secondary currents were generated in Coil A.

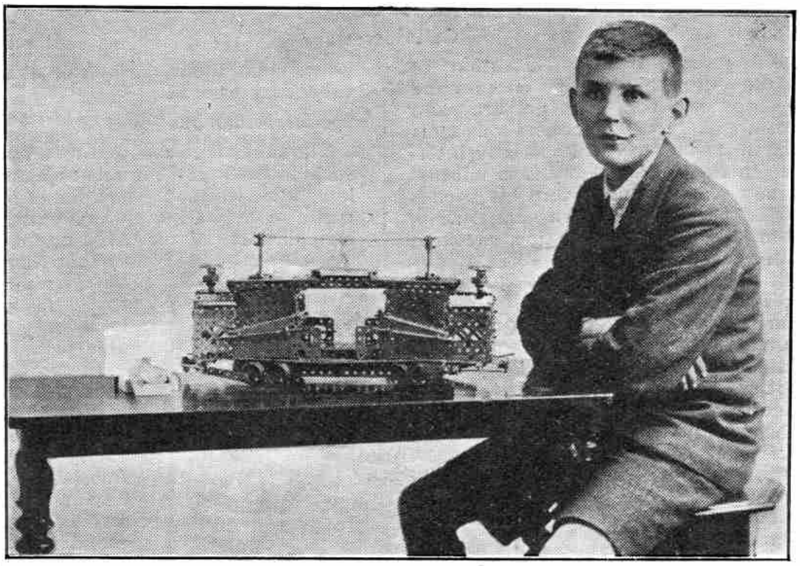
In all transformers the electro-motive forces set up in the secondary coil are nearly proportionate to the relative number of turns of wire in the two coils. If the primary coil has 100 turns and the secondary coil 2,500 turns, then the electromotive force in the secondary circuit will be nearly 25 times as great as that used in the primary circuit. A transformer wound in this manner thus raises or steps-up the voltage of the current supplied to it, and it is called a "step-up" transformer. By reversing the arrangement and having more turns of wire on the primary than on the secondary, we are able to lower the voltage of the original current, and a transformer that does this is called a "step-down" transformer.

Transformers thus enable us to raise or lower the voltage of an alternating current as required, but it should be clearly borne in mind that this does not alter the total power of the current. If the voltage is increased the amperage is correspondingly reduced, and *vice versa*, so that the power of the current is not changed, except for certain inevitable losses of energy that occur in the transformer itself.

The step-down transformer plays an important part in reducing the high transmission voltage of an alternating current to a voltage suitable for industrial and

(*Continued on page 270*)

Staffordshire Reader's Success



Our illustration shows Master John W. Bagnall, of Stafford, who recently won the First Prize in a model-building competition organised by Messrs. W. H. Smith & Son. John is eleven years old and is keenly interested in engineering, which is scarcely surprising, as his father is an engineer. His greatest interest, however is in railways, and he has a thorough knowledge of the many different types of locomotives all over the world. His prize-winning model is of a Mexican Railway Loco shown in the accompanying photograph.

Electricity—*(cont. from page 239)*

domestic purposes. In a large town the current from the power station is led along underground cables to sub-stations distributed at various points, and generally underground. From the various sub-stations the current is distributed as required by a network of underground cables. At each sub-station the current passes through a step-down transformer so that its voltage is lowered to the required point. The current is then ready for use, but of course it is still alternating current, and if it is desired for certain purposes to have a continuous current supply, the alternating current must be converted. This may be done by means of an electric motor and a dynamo coupled together. The motor is constructed to run on the alternating current from the transformer and it drives a dynamo that generates continuous current. There is also a machine called a "rotary converter" which is largely used and which does the work of both motor and dynamo.

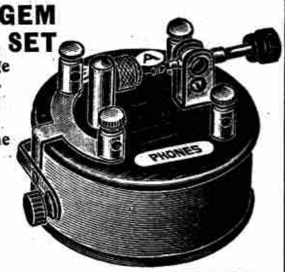
In this article we have dealt with power stations in which the source of power is steam. Another source of power is that of water. Water power is only used to a very small extent in this country, but in many parts of the world, particularly in America, enormous hydro-electric power stations have been constructed. Next month we shall describe some of these hydro-electric schemes, and especially those in which the immense volume of water passing over the Falls of Niagara is harnessed and made to produce current supplying light and power for huge areas.

NEXT MONTH :—

Harnessing Niagara : Hydro-Electric Power Stations

Stamps for Sale

(See also page 262)



Variable Gears—*(cont. from page 267)*

top tube or the handlebars are the usual alternatives, and though the former position is becoming increasingly popular, the gear-lever situated on the handlebars avoids the necessity of taking one hand away from the task of steering in order to change gear.

NEXT MONTH :—

RE-ENAMELLING A CYCLE