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Hewittic Rectifiers

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Hewittic Rectifiers

For Sundry Applications

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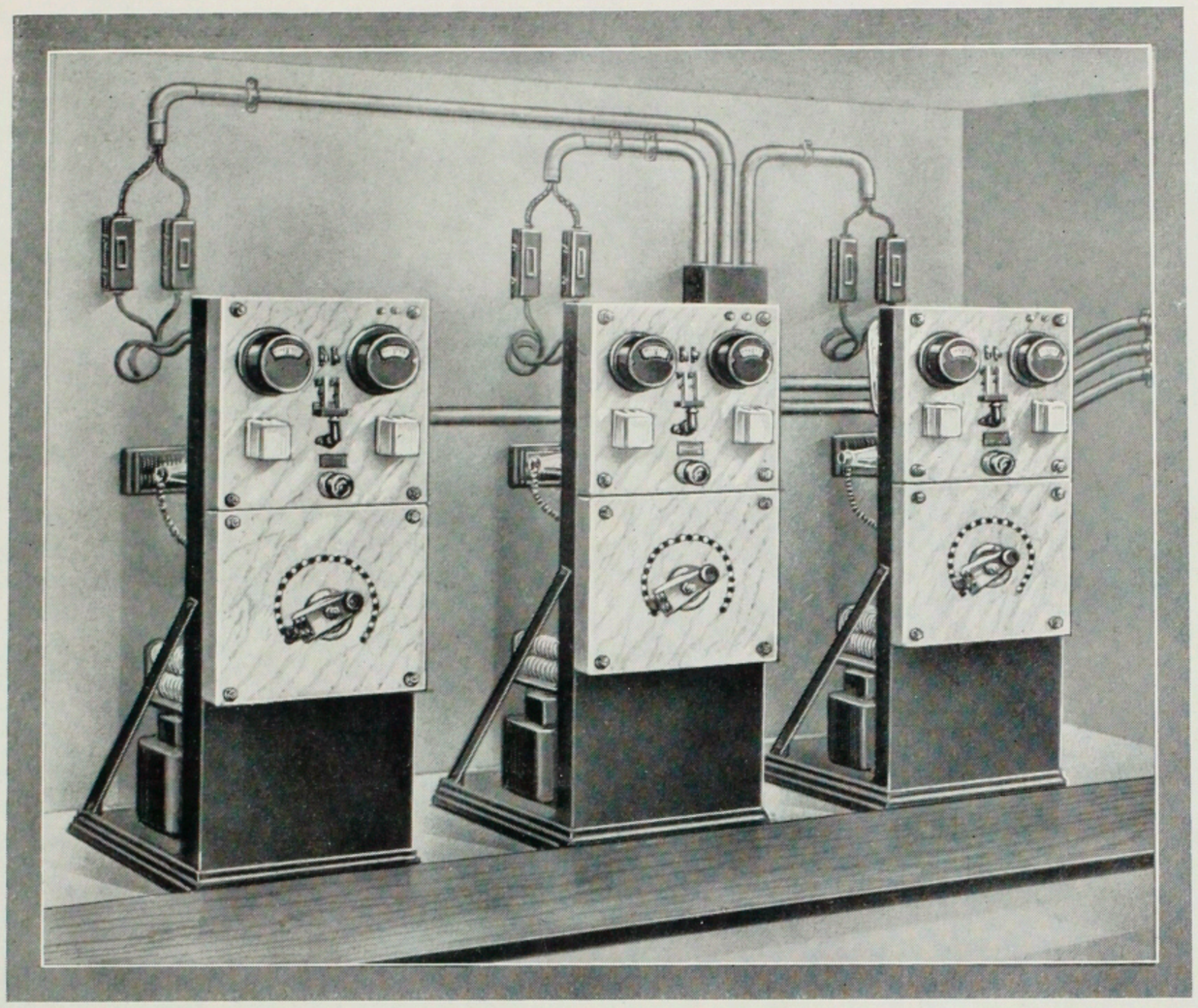

The rapid development of the Rectifier may be gauged by the accompanying illustrations, showing the largest individual Installations supplied by the Hewittic Electric Co. in the two respective years 1920 *and* 1925.

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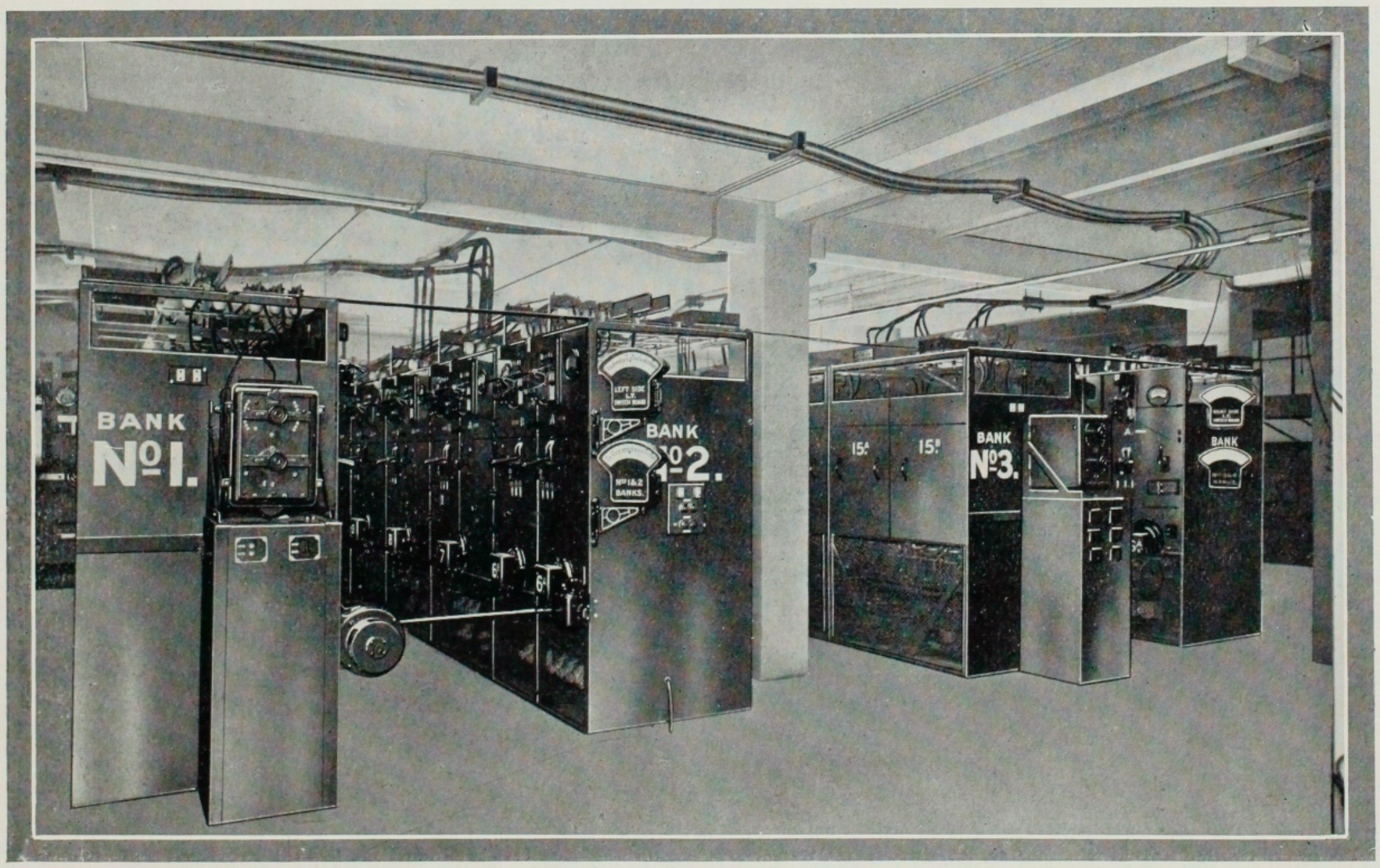
BATTERY CHARGING INSTALLATION OF THREE 40 AMPERE UNITS (1920).



2,000 KW. INSTALLATION ON PUBLIC SUPPLY MADE UP OF FOUR 500 KW. BANKS (1925).

HEWITTIC RECTIFIERS

The need for Converting Equipments is increasing every day. Alternating Current is being used more and more for Distribution purposes, whilst at the same time the need for Electrical energy in the form of Direct Current is continuously growing. Merely to cite some of the purposes for which Rectifiers are more generally employed, viz.: the charging of Batteries, the operating of automatic lifts, the feeding of cinema arcs, the feeding of D.C. motors as generally employed in most factories specially where speed regulation is of importance, will at once give the reader evidence of this fact.

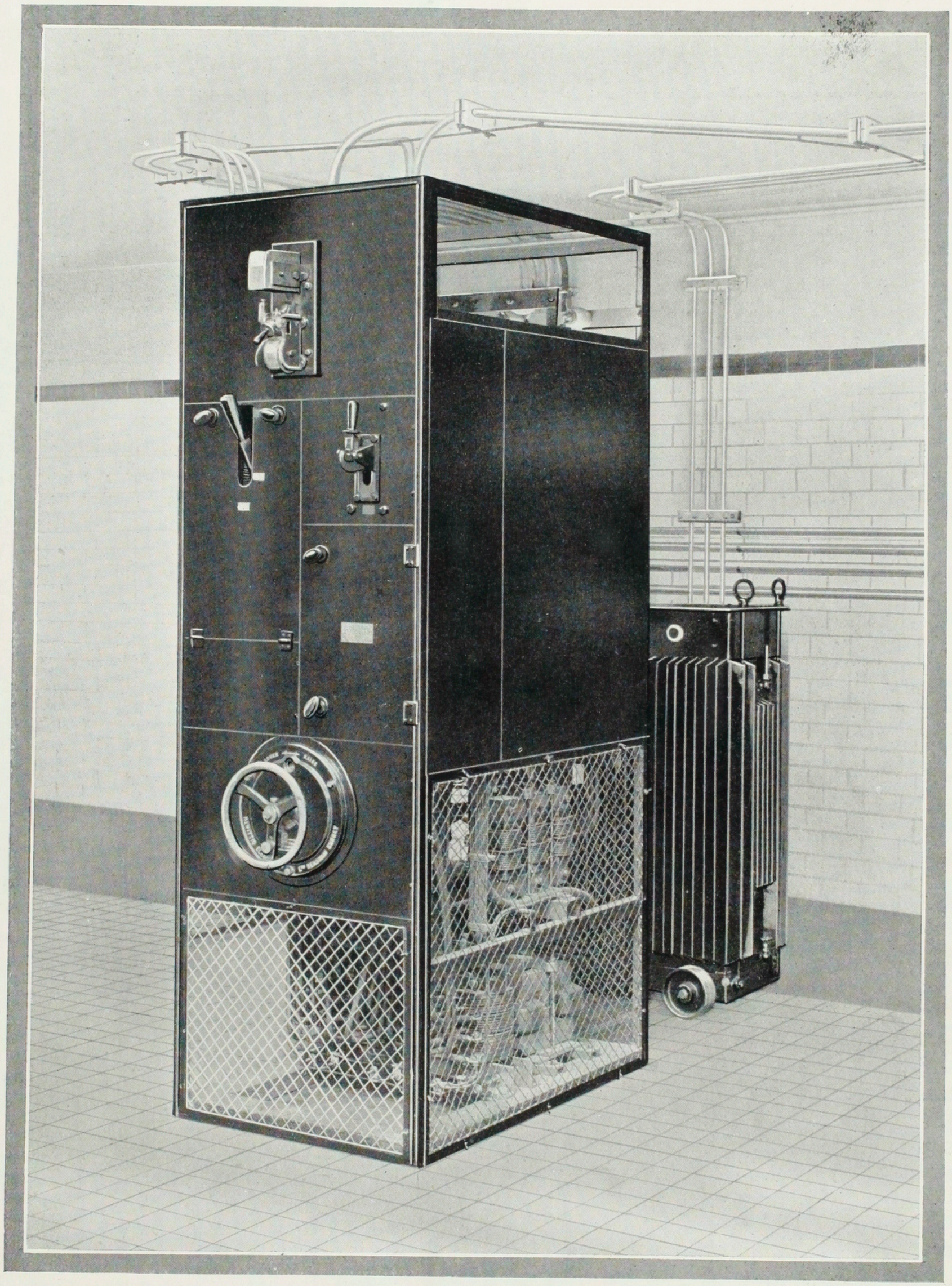
As the demand for Converting plant has increased, in just the same way the manufacture and design of the Rectifier has developed to meet it; and Rectifiers are now being used throughout the country for all purposes wherever it is desirous to convert A.C. to D.C.

For Rectification is indeed the obvious means of Conversion; in fact, the Rectifier merely does directly and in one step what it sets out to do. Its method is indeed an exact interpretation of the object in view. From alternating current it is desired to convert into uni-directional current, probably also at a different voltage. The alternating current is stepped through a Transformer, and passed through a one-way valve (the Rectifier Bulb) whence it issues in the continuous form required. Nothing could be simpler than this way of achieving the object in question and consequently no other Converting Equipment can approach the Rectifier in simplicity of principle, construction, operation and control.

The demand for Direct Current, as it will be at once realized, varies very considerably according to various requirements—in the matter of quantity, in the matter of voltage, in the matter of voltage regulation, etc., making Rectifiers of particular value as they can be made in efficient and economic units, whether from the point of view of initial outlay, maintenance and running costs, in small or large capacities.

Rectifiers have been in use extensively now for over twenty-five years, during which time enormous developments have taken place. From being used for only comparatively small capacities, in fact, up to only about 40 amperes, as was the case for a good many years, they are now being used for capacities totalling hundreds and thousands of kilowatts for feeding D.C. systems, in Factories and on Public Supply.

Alongside this development towards larger and larger sizes, the Hewittic Company has also worked towards developing the Rectifier at a cheap figure for smaller and smaller capacities to meet the growing demand for quite small sets, and in the following pages it is proposed to deal with the more general type of Rectifiers as now manufactured by the Hewittic Company.



50 KW. RECTIFIER EQUIPMENT.

Principle of the Rectifier

The object of the Rectifier is to change Alternating Current into Continuous Current, and its function is therefore mainly that of a one-way valve.

There is a distinct ratio between the D.C. pressure obtained and the A.C. pressure of the supply into the Bulb, and therefore a Transformer forms also an essential part of every Rectifier Equipment.

The Rectifier Bulb

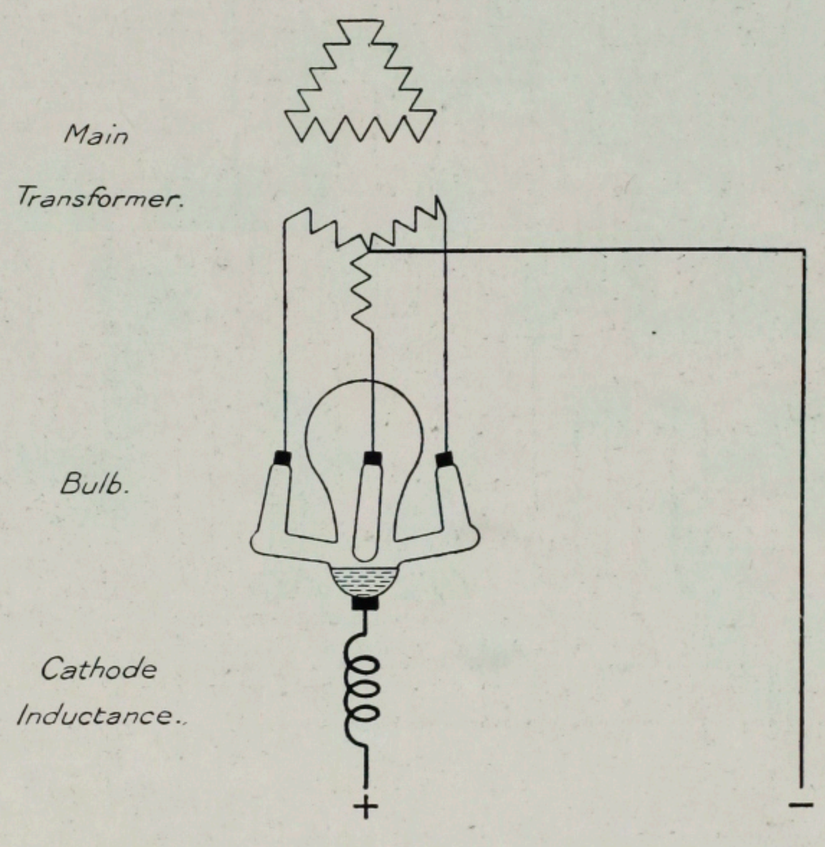
The Rectifier Bulb comprises a highly evacuated glass vessel fitted with graphite anode electrodes for the A.C. inlets and a mercury cathode electrode for the D.C. positive outlet. The fact that, when the Bulb is in operation, electrons are emitted from the mercury pool and flow thence to the anodes, causes the current to traverse the Bulb in one way only.

The current enters alternatively by one or other anode, but always passes through the cathode in the same direction, the latter constituting the positive pole of distribution.

Connections

As will be seen from the adjoining diagram, which shows the main connections of a 3-phase equipment, the free ends of the Transformer secondary are joined to the anode electrodes. The cathode of the Bulb provides the positive D.C. pole and the neutral point of the Transformer winding furnishes the negative D.C. pole.

In fairly large sets on 3-phase supplies, hexaphase operation is desirable, and so the Transformer secondary is, in such cases, split hexaphase double star, feeding into a six-arm or two three-arm bulbs.



MAIN CONNECTIONS OF A THREE-PHASE EQUIPMENT.

In cases where the supply available is 2-phase, a Scott-connected Transformer group is used, giving 3-phase or hexaphase operation on the secondary.

A single-phase Equipment is arranged on the same lines, the Bulb being, however, fitted with two arms to take the two free ends of the Transformer secondary, whilst the negative is, in this case, furnished by the mid point of the Transformer secondary.

In the accompanying diagram of a single-phase Equipment, the Auxiliary Circuits have also been shown so as to make the following description of the function of the various parts clearer.

Function of Transformer

The Transformer generally has a double and sometimes a triple function, viz. :—

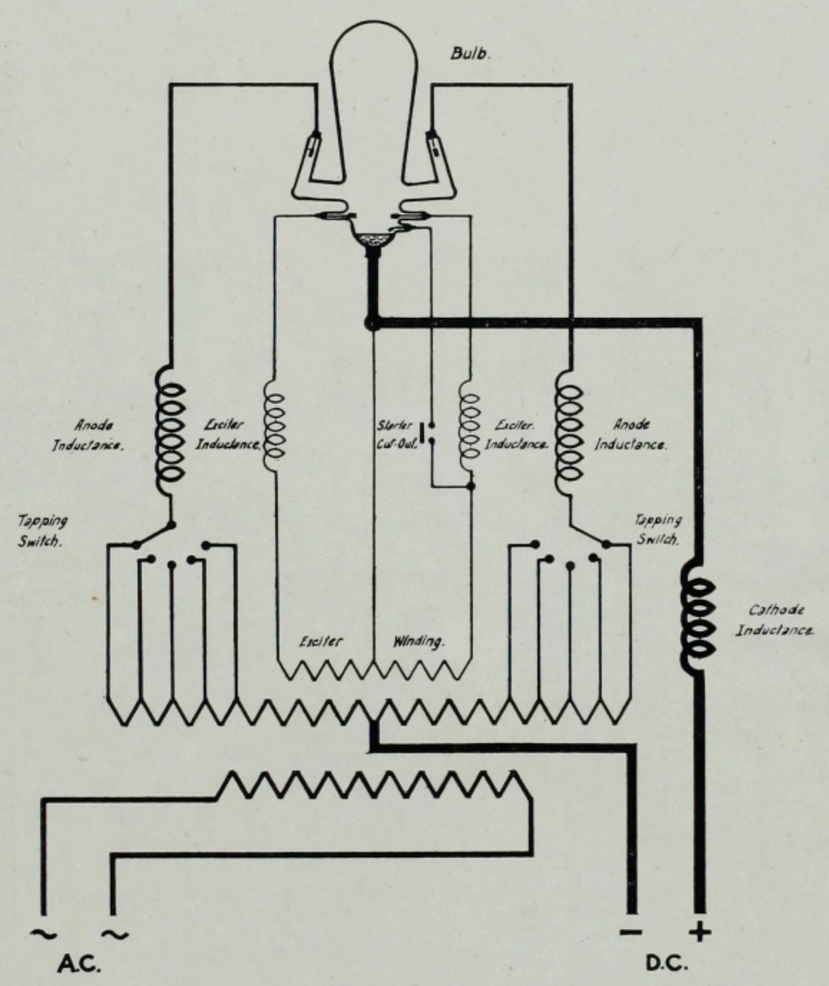
(*a*) The providing of a mid-point or neutral point in the secondary, which furnishes the required negative D.C. pole.

(*b*) The stepping down or up of the A.C. supply available to the corresponding value to give the desired D.C. pressure.

(*c*) The supplying of a means of voltage regulation as will be explained later.

Function of Cathode Inductance

It will be noted from the diagram that an inductance is inserted in the cathode circuit in series with the Bulb. This is to increase the inductance of the total circuit and reduce the pulsations to the required degree so as to make the current continuous and not only uni-directional.



CONNECTION DIAGRAM OF A SINGLE-PHASE EQUIPMENT.

Function of Anode Inductance

The diagram also shows an inductance inserted in anode circuit of the Bulb. This is not required on all Rectifiers, in fact, it is not required in most Rectifiers. Its function is to increase the D.C. voltage drop of the Rectifier from no-load to full load, which is sometimes desired, as in the case of Rectifiers for feeding projection arcs (see p. 30) or for the automatic charging of batteries (see p. 26).

Method of Starting

For the Rectifier Bulb to operate, the electron emission from the cathode must be initiated. This can be done in a variety of ways. The more general is by means of a starting electrode through which current passes when it is made join the mercury cathode by tilting the Bulb slightly away from its vertical position. On the Bulb being released back, the circuit is broken: causing a spark which ionizes sufficient mercury to enable the current to begin flowing from the anodes.

Alternatively, the same object can be achieved by means of a special starting electrode fitted with a bi-metal strip which normally dips into the Mercury and through which current passes when the Rectifier is first made alive. At once, however, the current passing through the bi-metal strips causes it to lift out of the mercury, thus breaking

the circuit and producing the necessary initial spark. Once the Rectifier is started a relay cuts the bi-metal electrode out of circuit.

Some of the smaller Bulbs are started statically by a high voltage discharge from one of the main anodes, the initial high voltage being obtained by means of a Discharge Coil.

Function of the Exciter Circuit

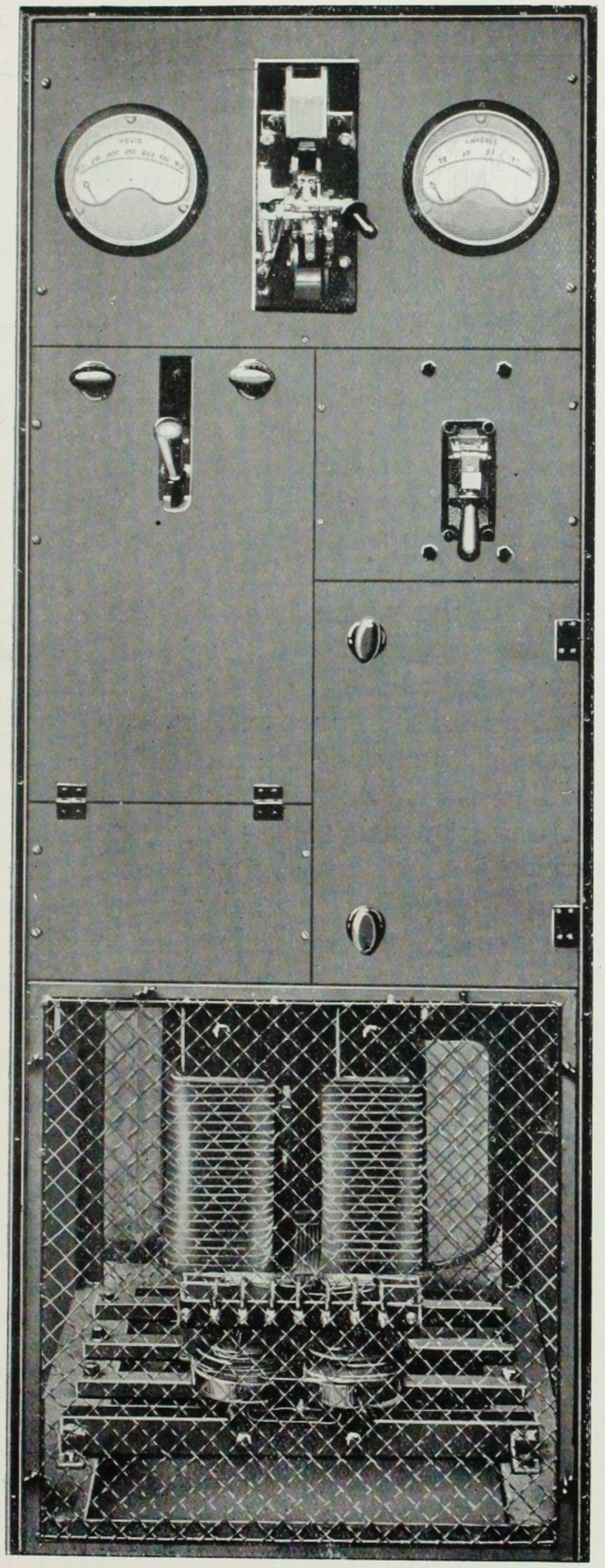
Having started the Rectifier it is necessary to keep the Bulb at a certain minimum vapour pressure to maintain the arc. This is done in one of two ways. On the smaller Equipments a Shunt load is employed. On larger sizes, say, from 10 to 15 amperes onwards, the addition of a shunt load would be uneconomic, as such load would be correspondingly greater. The same object is, however, achieved by the addition of two supplementary Anodes fitted at the base of the Bulb just above the Cathode pool and fed from an auxiliary winding on the Transformer, the mid-point of this winding being connected to the cathode of the Bulb. An inductance coil is interposed in this circuit. The consumption of this Exciter Circuit is only approximately 120 watts, no more than the consumption of the shunt load as used in the very small sets, and either type of Exciter Circuit enables the Bulb to be maintained down to and at zero load.

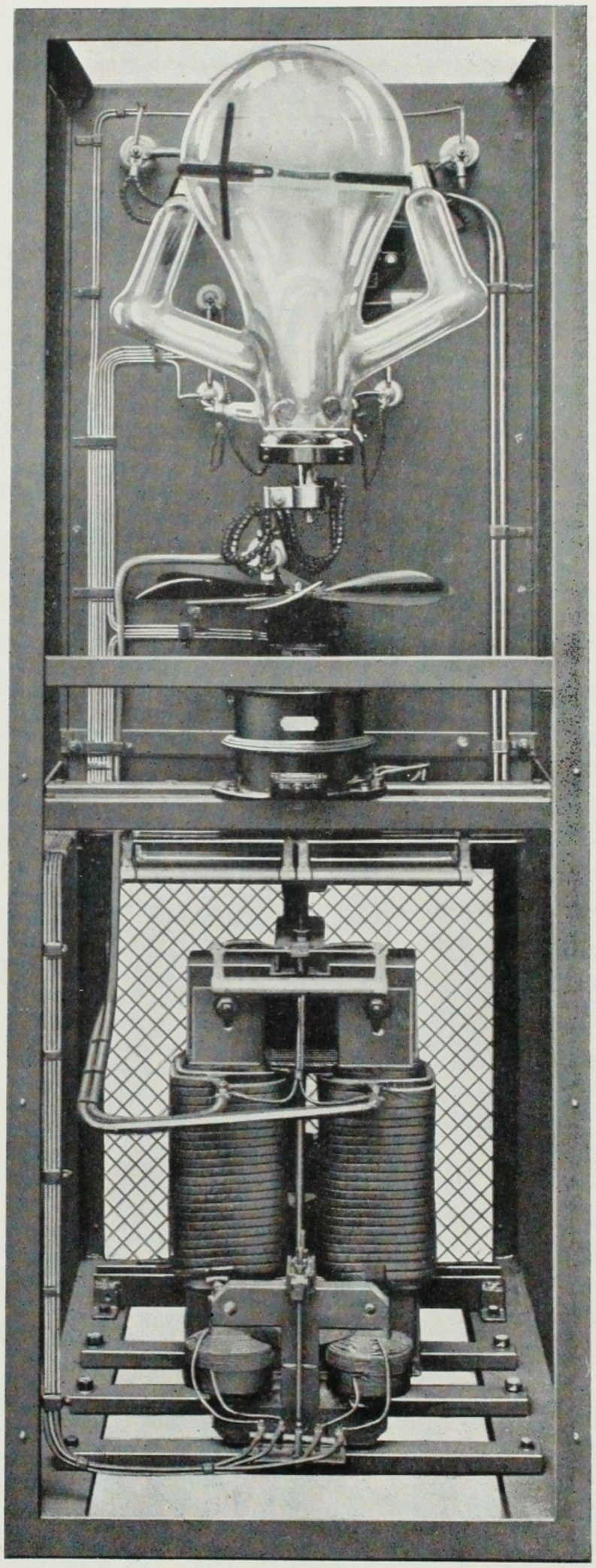
Voltage Regulation

The Rectifier Equipment has a shunt characteristic the voltage drop from no load to full load being approximately 6 to 7 per cent. As has already been explained, this can be increased to any desired extent by adding Anode Inductance. Tappings on the latter will allow the percentage inherent regulation to be altered at will.

A more usual means of regulation, however, enabling one to obtain any required range, is the equipping of the Transformer which feeds the Rectifier Bulb with tappings, the latter being controlled by a Regulator Switch.

If the capacity of the Equipment is sufficiently large an Induction Regulator is used instead to give the desired voltage regulation.





TYPICAL RECTIFIER CUBICLE.

FRONT VIEW (WITH FRONT PLATES ON). REAR VIEW (WITH BACK PLATES OFF).

Construction of the Rectifier

Cubicles

The whole of the Rectifier gear, including the Bulb, inductances and other Auxiliary gear, are enclosed in sheet steel and wire mesh cubicles forming a complete Rectifier unit.

Bulb

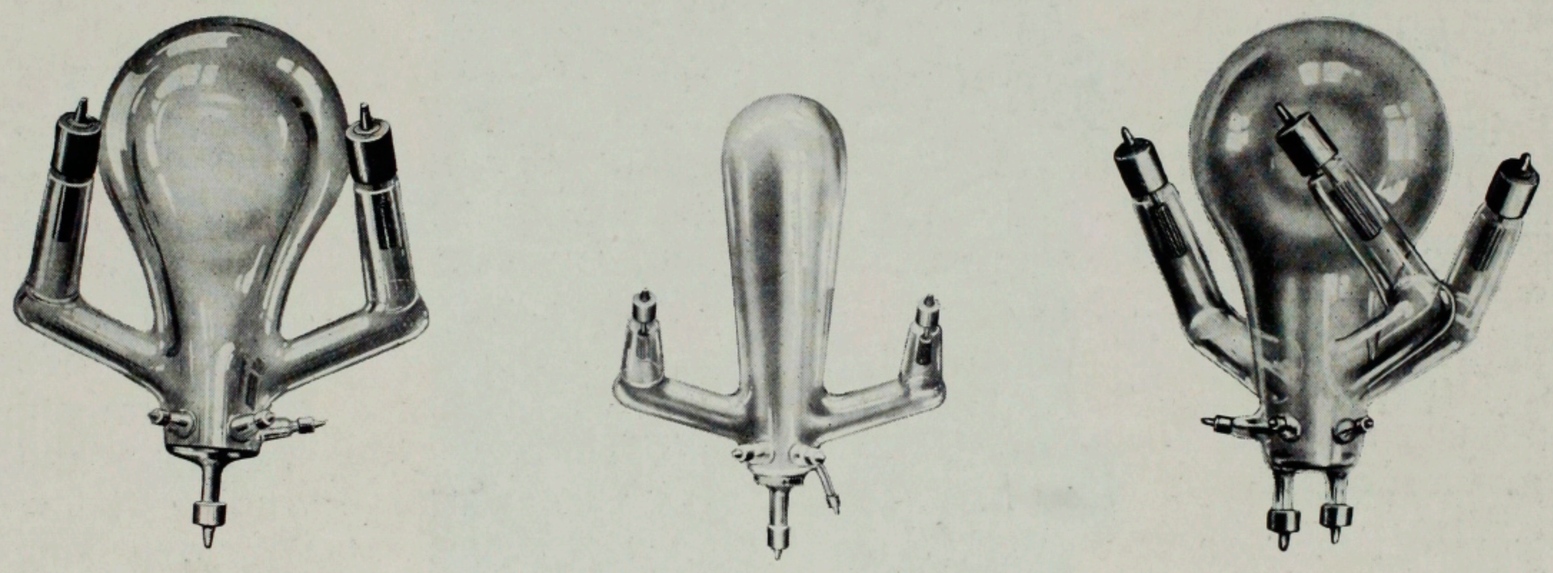
The Bulb, as has already been explained, is a highly evacuated glass vessel fitted with various electrodes equipped with metal caps to take the respective leads.

Transformer

The Transformer if for a Rectifier Equipment of under 25 kw. for operation off a low-tension A.C. supply, would be of the air-cooled type and mounted also at the base of the Rectifier Cubicles. Above that capacity the Transformer would be of the oil-immersed type, and in such case would be mounted separately from the Rectifier Cubicle.

Inductances

A Cathode Inductance is always supplied and sometimes also Anode Inductances, and further, there is an Auxiliary Inductance in the Exciter Circuit. These are of the air-cooled type and are mounted at the base of the Rectifier Cubicle.



TYPICAL RECTIFIER BULBS.

Voltage Regulation

As previously stated, Voltage Regulation is generally obtained by means of tappings on the Transformer feeding the Rectifier Bulb, these being controlled by a suitable Regulator Switch.

A face plate type, 5 or 11 stud or more, is used for the smaller equipments, a

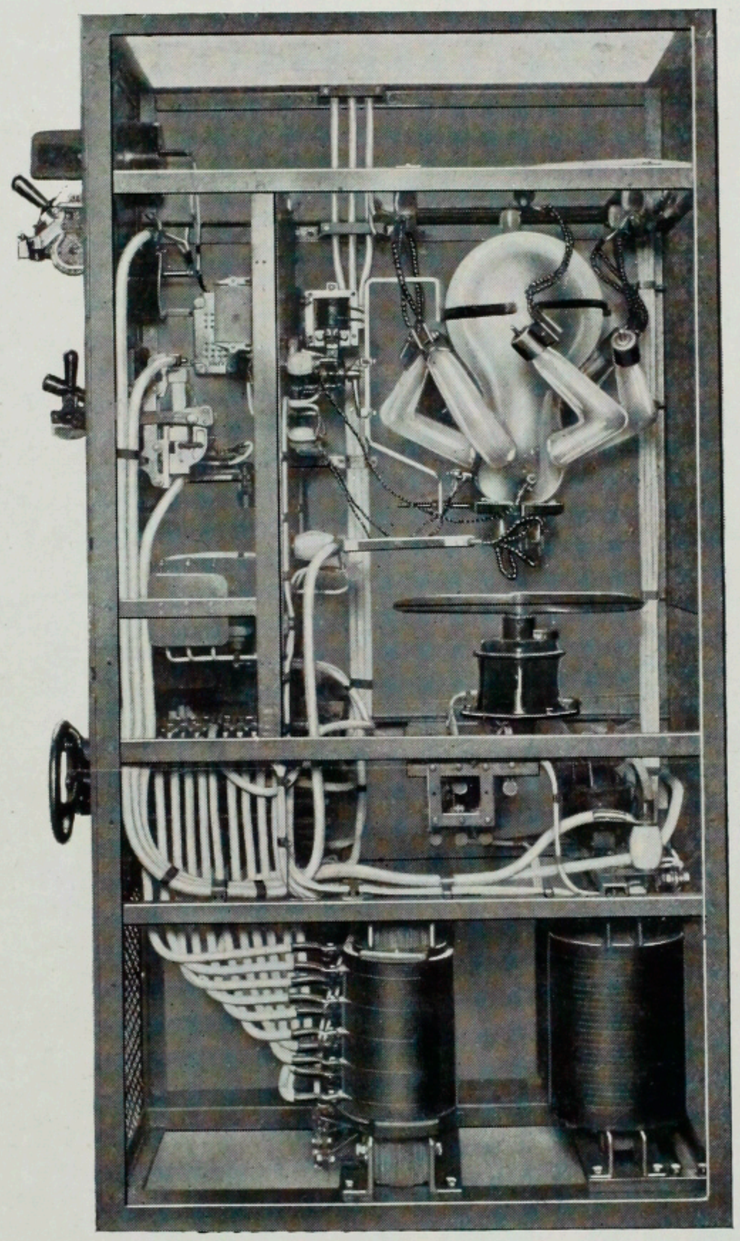
drum type of Tapping Switch is employed in the larger sets.

Whenever the Transformer is of the air-cooled type and mounted in the Rectifier Cubicle, the tappings are fitted on it, and it is used for regulating as well.

If, on the other hand, the Main Transformer is of the oil-cooled type, then a tapped Auto-transformer mounted at the base of the Cubicle is added for the purpose of regulating.

On the larger Equipments an oil-immersed Induction Regulator is employed to control the primary supply and give the necessary voltage regulation.

On very small sets, such as the I. T. Rectifier (page 27) tappings are provided on the Transformer controlled by a Wander Plug.



SIDE VIEW OF RECTIFIER CUBICLE.

Ventilating Fan Motors

Generally when the capacity of the Rectifier equipment is greater than about forty amperes, it is necessary to cool the Bulb artificially. This is done by means of a small 50-volt A.C. Squirrell-cage Ventilating Fan placed under the Bulb, the motor being self-starting and fed from an auxiliary winding on the Transformer.

Method of Starting

It has already been pointed out how, in order to start the Rectifier Bulb the latter must be rocked. This is sometimes arranged for hand operation by means of a suitable hand wheel but, more often, an electro - magnetic device is fitted which rocks the Bulb on the Rectifier being made alive and thus starts it automatically.

The other methods of starting, namely the bi-metal electrode and the high tension discharge, are also automatic in their operation : either of the devices functioning immediately the Rectifier is made alive and cutting itself out of circuit by a relay as soon as the bulb begins to function.

A.C. Switchgear

The Rectifier Cubicle is also equipped with all the necessary operating, protective and isolating switchgear on the A.C. and D.C. sides so that it forms a complete self-contained unit.

Where the Main Transformer is

mounted inside the Rectifier Cubicle the primary supply into the Equipment is controlled generally by an Iron Clad Switch fuse, when the current does not exceed approximately fifty amperes; by an oil switch fuse if the current is greater than this: and by an A.C. Clapper Switch if it is desired to make the starting and stopping operations suitable for remote or automatic control.

If the Transformer used is of the oil-immersed type mounted separately from the Rectifier: then, a separate switch is necessary to control the primary supply into the Transformer. If, however, the Transformer feeds more than one Rectifier Cubicle, as is often the case, then oil switch fuses are provided on the Rectifiers to control the low tension A.C. supply into them so that any of the Rectifier Cubicles can be isolated or run separately from the others.

D.C. Switchgear

Generally the Rectifier is also provided with D.C. switchgear comprising an overload circuit breaker on the positive D.C. and sometimes an isolating knife switch on the Negative D.C.

In the smaller sets, in order to cut down initial costs, fuses are generally used instead of a circuit breaker.

Terminals to take the D.C. leads are always provided.

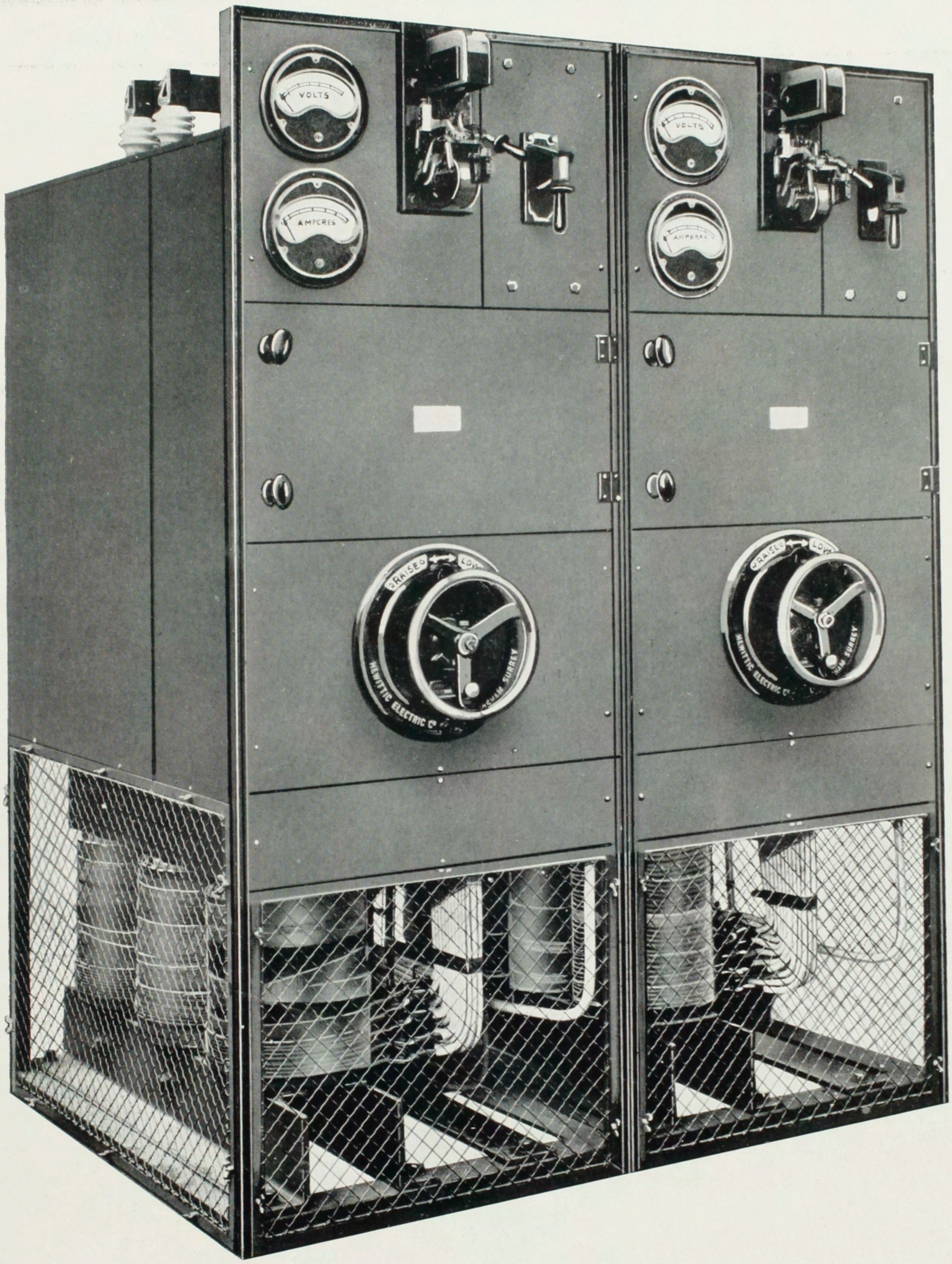
Instruments

Instruments can always be fitted to the Rectifier Cubicle on the front panel. These are generally of flush circular dial type. Where a Rectifier Equipment comprises a bank of cubicles then the instruments will be of Sector Pattern mounted on suitable swivel brackets. The instruments are always of the moving coil type.

Accessibility

So that easy access is gained to all the various parts of the Equipments, whether for inspection or adjustment, doors are provided both in the front and back of the large Rectifier Cubicles. To save floor space small lift Rectifiers, for instance, and other Rectifiers of a similar nature, are made so that everything is accessible from the front and the cubicles can therefore be placed against a wall.

Whilst the Equipment is generally assembled into standard cubicles, the relative dimensions of these can be altered and the constructional arrangement modified if it is necessary to suit any existing conditions.



TWO 25 KW. RECTIFIER EQUIPMENTS EACH ENTIRELY SELF-CONTAINED AND ARRANGED FOR REMOTE CONTROL

General Advantages of the Hewittic Rectifier for Converting Purposes

Static The Rectifier is a stationary piece of apparatus just like a Transformer; in fact, a Transformer and coils of a similar nature make up the larger proportion of a Rectifier Equipment, the remainder consisting of the Rectifier Bulb which acts as a valve. The Rectifier is, therefore, almost like a Transformer with regard to its operation, and demands little, if any, more care.

This absence of moving parts is at the root of most of the advantages which the Rectifier offers as compared with other types of Converters which are generally of a rotating type.

Simplicity of Construction There is nothing complicated in the construction of the Rectifier any more than in its method of functioning. Rectifiers are built in compact cubicles containing all the operating and protective control gear as well as the rectifying equipment proper, so that they form completely self-contained units. Every part of the gear is easily accessible. The various connections are easily followed.

Simplicity of Control Equally simple is the Control of the Rectifier. In the majority of cases automatic starting is provided so that to put the Rectifier Equipment into operation necessitates merely the closing of the Main Switch controlling the incoming supply. Even in the cases when, for the sake of cutting down the initial cost, hand tilting is provided, the starting of the Rectifier entails merely the closing of a Switch and rocking of the bulb by means of a hand wheel provided for the purpose.

No Skilled Attendance Anyone becomes at once conversant with the method of operation of the Rectifier, and there is no need, therefore, for any skilled attendance in connection with it.

Minimum of Attendance Not only is no skilled attendance required for Rectifiers, but a very minimum of attendance of any sort is at all necessary. In most cases, in fact, the only human

control necessary is to close and open the Switch to start or stop the Rectifier respectively at the beginning or end of its operating period; and for the rest of the time no notice need be taken of it.

In some cases, as for instance in Automatic Lift Installations, not even this amount of attention need be necessary: for, as explained in the separate section concerning these, they are often fitted with an automatic switch controlling the incoming supply controlled by on-and-off push buttons from the various landing stages.

Again Rectifiers can be arranged when desired so that they start and stop automatically when the D.C. load is closed, by means of an interlock in the control gear of the latter. Attendance is thus entirely eliminated and only a very minimum of inspection is demanded.

Inherently Automatic

As stated above, the need for attendance can be cut down completely with a Rectifier Equipment—even for starting and stopping. In this connection it is of interest to note that, owing to the fact that the Rectifier is itself inherently automatic, the control gear necessary to make it function entirely automatically in accordance with any definite requirements is of the simplest kind, due to the nature of the simple function which it has to achieve. It is, therefore, definite in character and correspondingly reliable, and further, is quite inexpensive.

Flexibility

Alternating Current scores heavily over Direct Current owing to its flexibility. But Rectifiers enable one to achieve just as high a degree of flexibility with Direct Current as is possible with Alternating Current, so that the user can enjoy the advantages of both. With the Rectifier one regulates the D.C. voltage by regulating on the A.C. supply, and can, therefore, obtain any desired range of voltage regulation as economically and as effectively as with Alternating Current.

Reliability

The plant, being static and extremely simple in its details and method of functioning, is inherently highly reliable: being almost trouble-proof under normal circumstances and being fitted with all the necessary protection against abnormal contingencies.

Efficiency

The efficiency of the Rectifier is high both in small and large sets. It remains high at low loads just as at high loads; in fact, there is seldom more than three to four per cent. between the full load and quarter load value. A high overall efficiency is therefore obtained with highly fluctuating loads: whilst here, again, the Rectifier once more scores as, being static, it is not at all affected by sudden variations of load.

Unit Construction

As stated above, with Rectifiers a high efficiency is maintained in small sets as well as in large ones, so that small Rectifier units prove economical from a running point of view. They are also quite economical from the initial cost point of view. Rectifiers are, therefore, particularly suit-

able for installing to deal with existing requirements likely to grow: as further units can be progressively added to meet increasing demands without detriment to the overall efficiency of the complete plant when made up of a number of components.

Change of Periodicity

In many places the periodicity of the supply does not conform with the now accepted standard of 50 and therefore the supply is liable to be altered later on in accordance with the modern tendency. Rectifier Equipments, however, designed for a particular frequency will operate equally well on any higher periodicity, only minor adjustments being required on the change over, and full utility of the plant being retained on the new supply.

Generally, therefore, Rectifiers manufactured by the Hewittic Company for operating on supplies above 50 cycles are designed for the standard frequency. If the Rectifier is arranged for a forty cycle supply then, of course, it will operate on 50 should the supply be changed over.

Nature of Supply

In some cases not only is the periodicity of the supply liable to be changed, but also the supplies are changed from single to 3-phase. In such cases, if the Rectifiers are of small capacity, they can be retained in their original single-phase form, operating across phases or between phase and neutral of the new 3-phase supply.

Where the capacity is too large to allow this, if the change is envisaged in the first place, the Rectifier can be designed suitable to operate as a single phase and again as a 3-phase unit later, only very minor modifications being necessary on the change over.

Silence

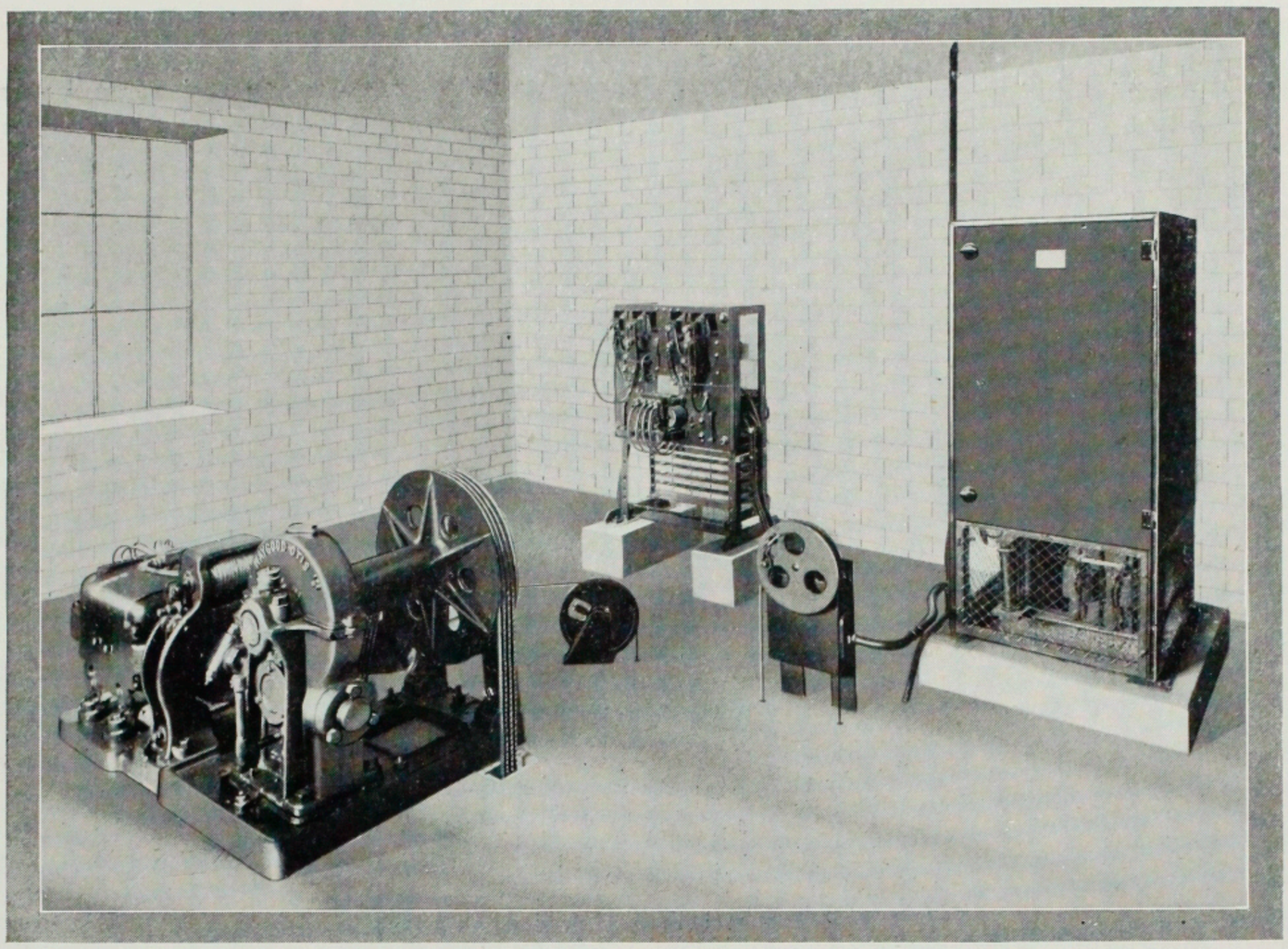
Noise is often a very serious consideration when determining where to install a Converter; and here again the Rectifier shows to considerable advantage as, being static, it is free from the objectionable note obtained from moving machinery.

Foundations

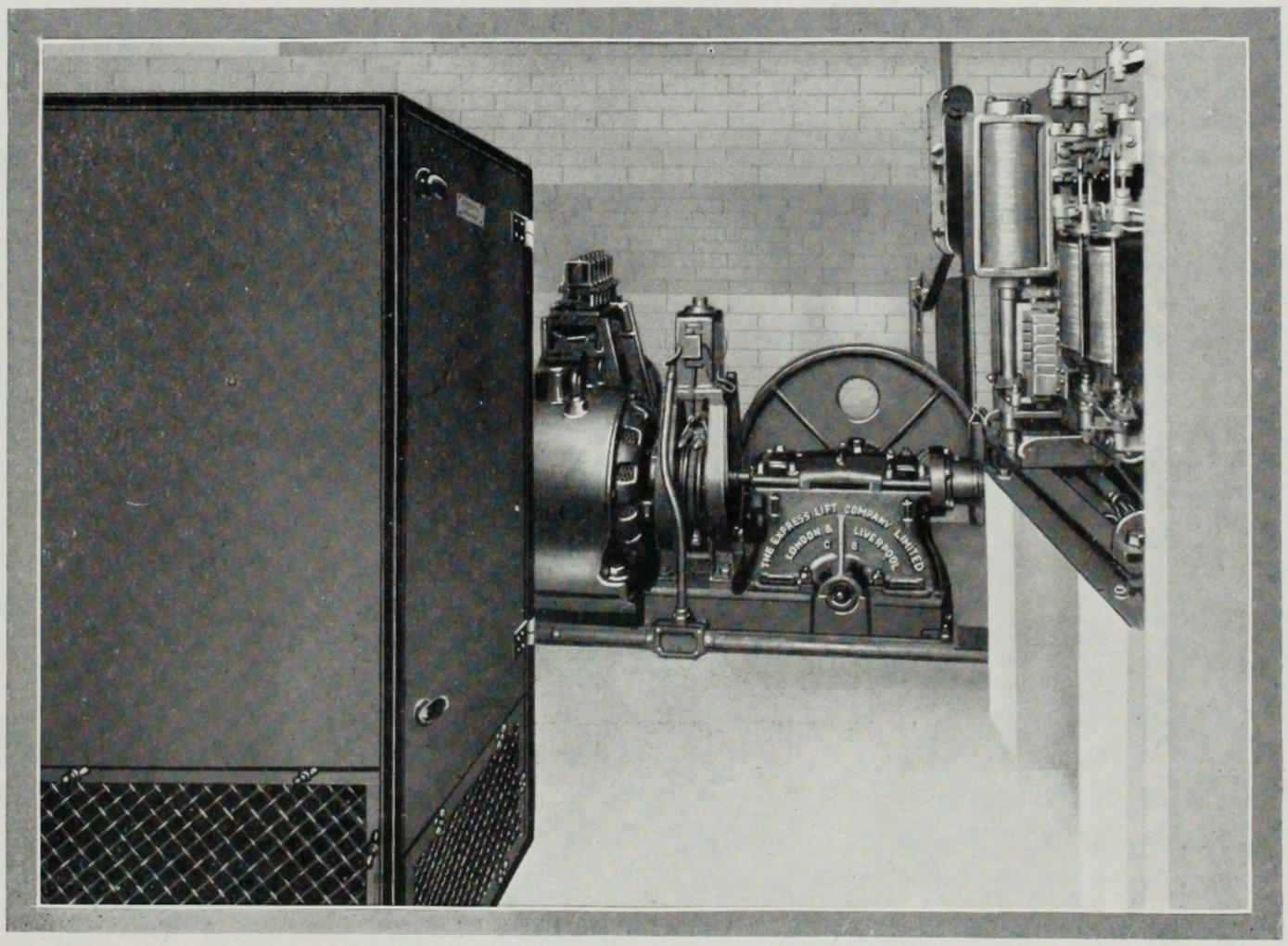
Rectifiers require no special foundations. They are built in comparatively light and compact sheet steel cubicles, which can be laid directly on the floor. In the case of larger capacities, where the Transformer is mounted separately, the latter is mounted on rollers. The Equipments can therefore be installed in any convenient place without the necessity for any heavy lifting tackle. Some of the smaller sets as used for charging batteries, operating magnets, etc., can actually be placed on a table or shelf.

The above are the chief advantages which the Rectifier presents generally as a Converter, but according as it is considered from particular points of view, further advantages arise which make it particularly adaptable for certain requirements.

The most general of these will be dealt with under separate headings in the following pages.



TWO TYPICAL AUTOMATIC LIFT INSTALLATIONS WITH HEWITTIC RECTIFIERS.



Hewittic Rectifiers for Lift Installations

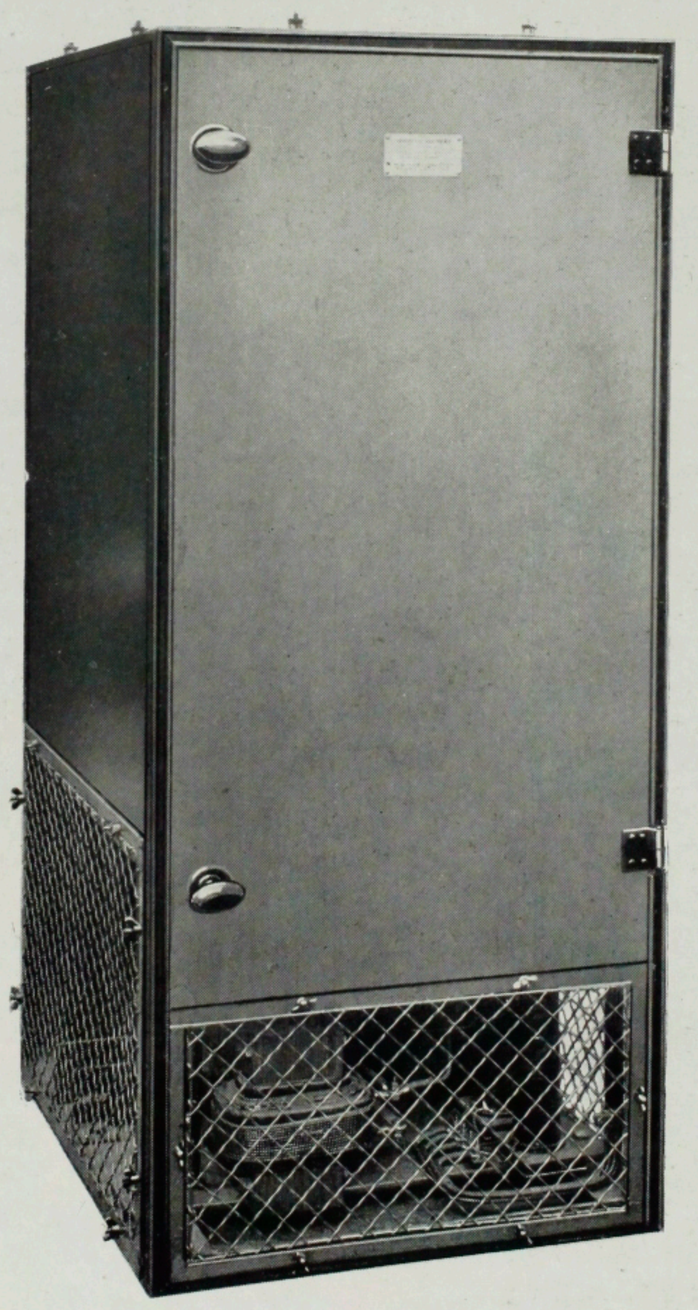
One of the most general uses for the small type of Rectifier is in Automatic Lift installations. In this connection it is probably true to say that the Rectifier offers the only type of converting Equipment suitable, and the choice lies only between the use of a Rectifier and D.C. motor and control gear or alternatively A.C. gear throughout.

Advantages

As silent operation is an important requisite in most Lift installations, the use of Rectifiers in those places where only an A.C. supply is available has become almost general. The use of the Rectifier also avoids the high starting current of A.C. Motors. Moreover, it enables standard lift gear to be employed on all supplies, D.C. and A.C., the Rectifier simply being added in the latter case.

Construction

Rectifiers for this work are mounted in totally enclosed sheet steel and wire mesh cubicles, as shown in the accompanying illustration, the Transformer, Rectifier coils, A.C. and D.C. switchgear being all mounted within it. The Bulb is always fitted with an automatic starting device, so that all that is necessary to operate the Rectifier is to make it alive.



TYPICAL LIFT RECTIFIER. (CLOSED).

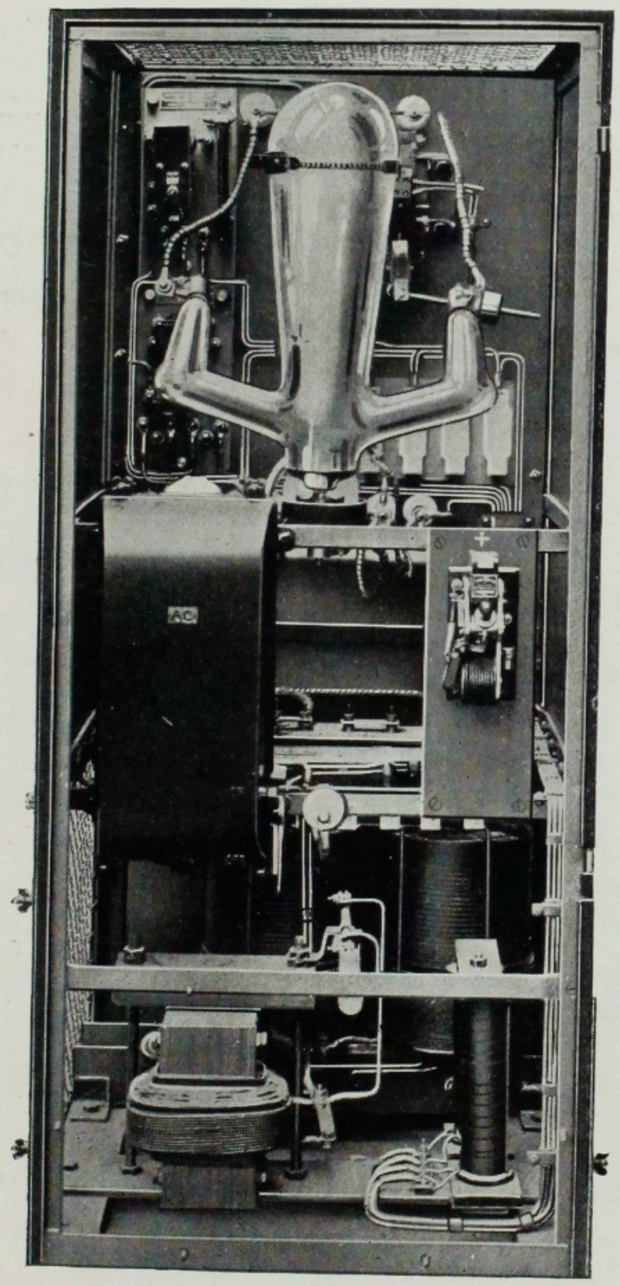
Operation

A Switch-fuse is provided on the incoming side, and if this is closed the Rectifier will strike up and operate, maintaining at no load on its Exciter Circuit, and dealing with whatever load is switched on.

This is the method generally adopted in case of Lift installations in fairly frequent use, specially as the no-load losses on the Rectifier are low.

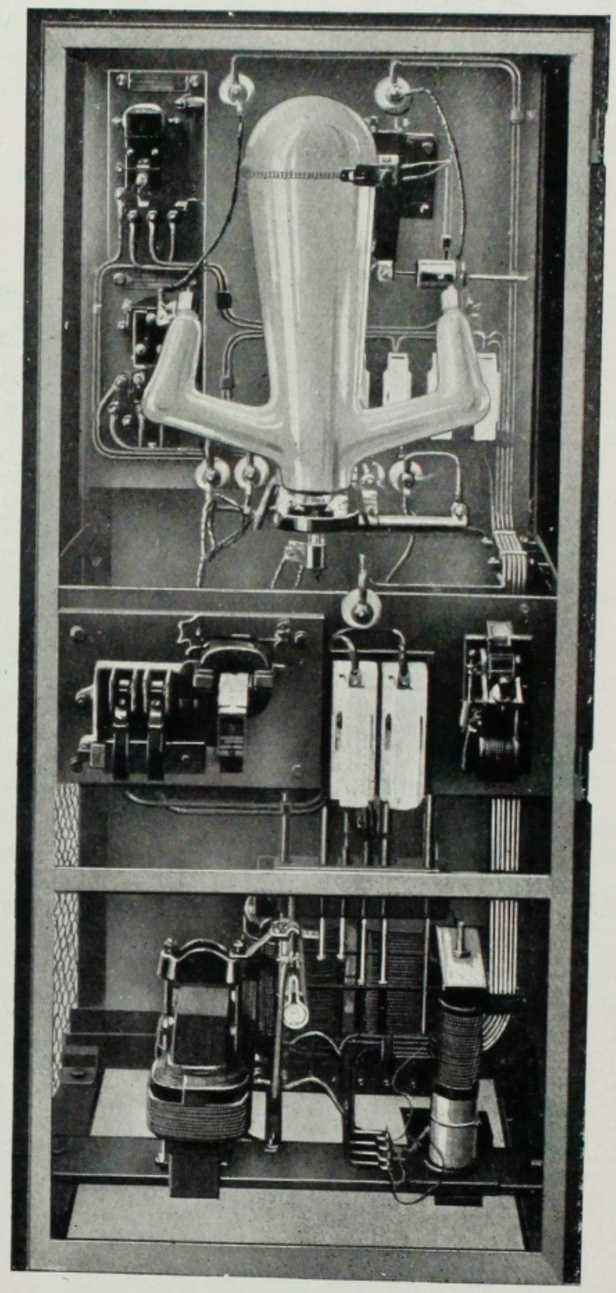
Push Button Control

If, however, the lift or lifts fed from the Rectifier are only operated at rather infrequent intervals, then it is advisable to cut down the no load losses on the Rectifier during the periods when the latter is not needed. In such cases an automatic A.C. Clapper Switch is fitted instead of the Iron Clad Switch fuse to control the primary supply into the Rectifier, the operating coil of this being fed from the A.C. supply and governed by the lift controls.



TYPICAL LIFT RECTIFIER. (OPENED UP)
FITTED WITH A.C. SWITCH FUSE.

In this way the Rectifier functions only whenever the lift is actually in operation.



TYPICAL LIFT RECTIFIER. (OPENED UP)
FITTED WITH AUTO-CLAPPER SWITCH

Voltage Characteristic

This type of Rectifier is not provided with any means of voltage regulation, as this is not necessary owing to the nature of the load. It thus has a Shunt Characteristic with an inherent regulation of approximately 6 to 7 per cent. Primary tappings are provided in the Transformers to allow for variations in the supply voltage.

Starting Current

The Rectifiers are rated for the requisite continuous output, and are suitable to withstand 100 per cent. momentary overloads as required to cope with the starting current of the motor or motors.

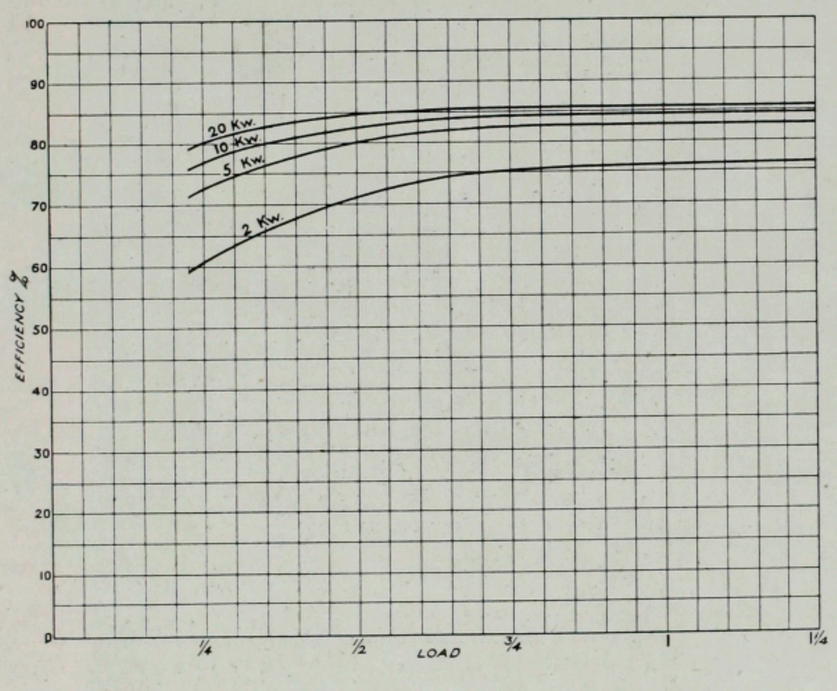
Efficiency

The attached curves show the efficiencies of small Rectifiers up to 30 kw. delivering 440 Volts and 220 Volts D.C., these being the D.C. pressures generally required.

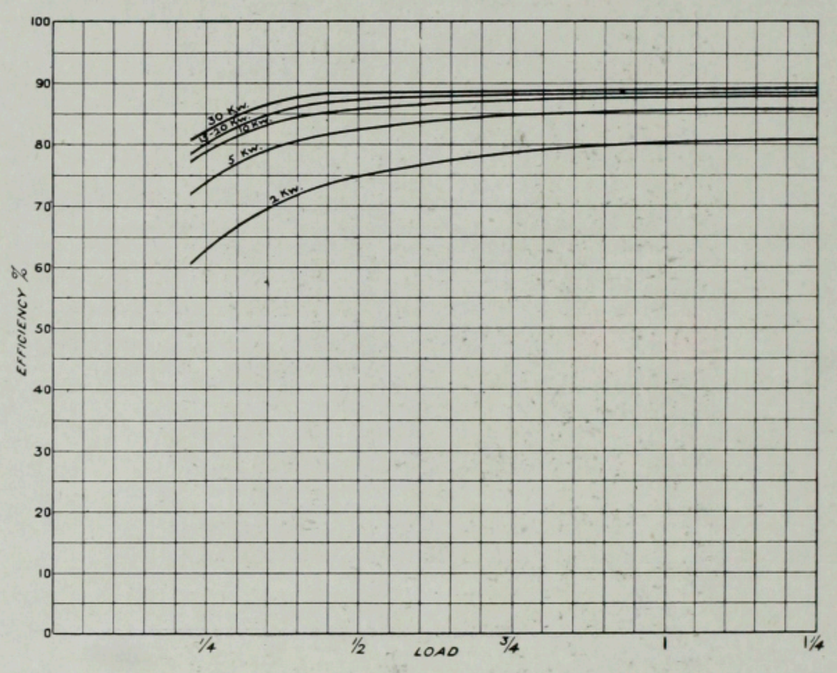
No Load Losses

The approximate No-load losses for small equipments of this type would be as follows —

Capacity	*Single-Phase*	*Three-Phase*
1 kw. ...	260 watts	300 watts
2 kw. ...	300 „	400 „
5 kw. ...	400 „	500 „
10 kw. ...	500 „	700 „
15 kw. ...	800 „	900 „
20 kw. ...	900 „	1,000 „



RECTIFIERS DELIVERING 220 VOLTS D.C.



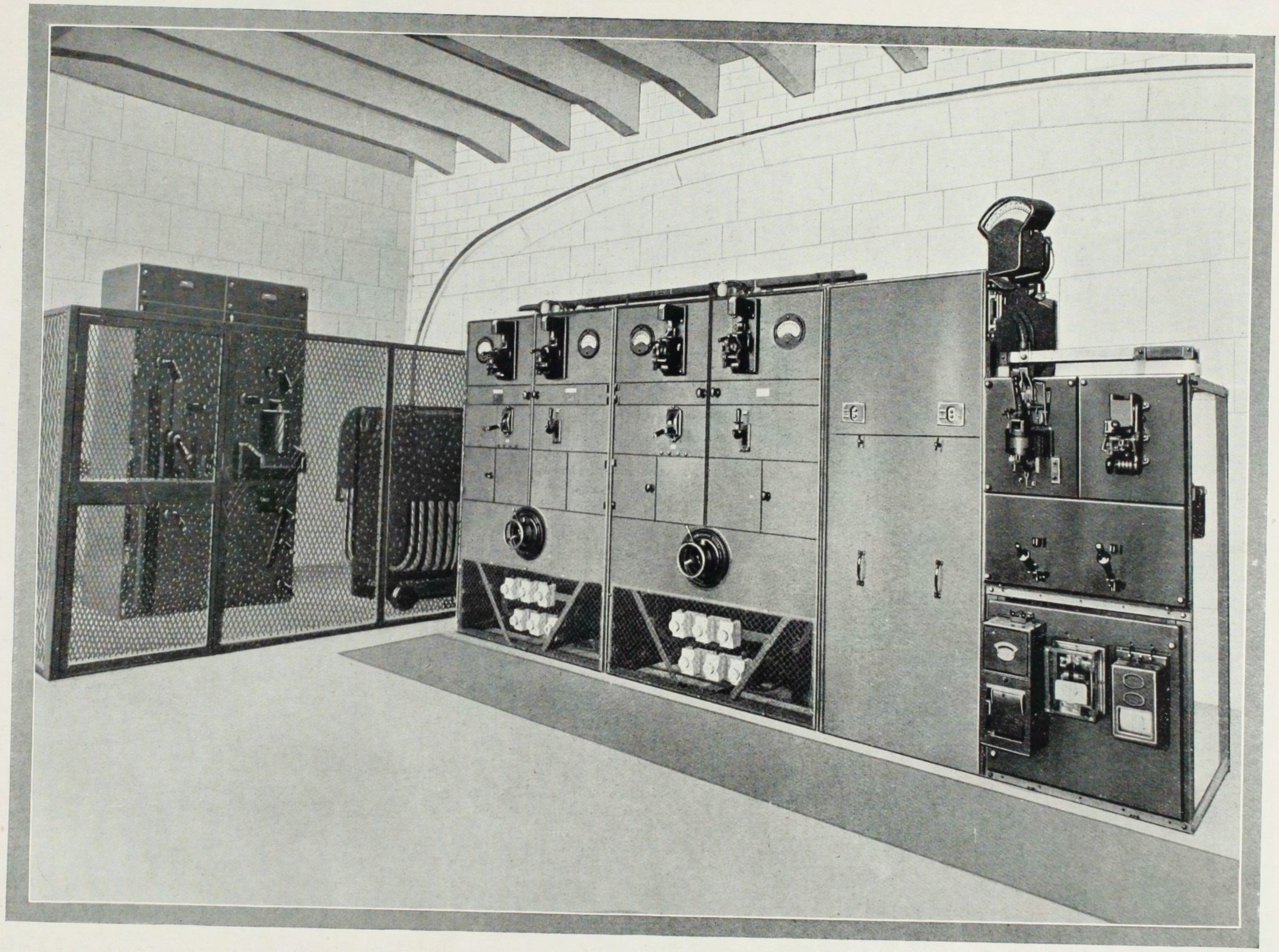
RECTIFIERS DELIVERING 440 VOLTS D.C.

In the majority of Lift Installations, the capacity required varies from 1 H.P. to 25 H.P., in which case the equipments are exactly as described and illustrated in this section.

On the other hand, in many cases the capacity required is in the nature of 50 kw., 100 kw. and over. In such cases the equipments would, of course, be similarly arranged to those described in Section IX.

The foregoing equipments have been described under the heading of Lift Rectifiers, as this is one of the duties for which they are very generally required.

It will, however, be realised that this type of equipment would be suitable to feed any type of motor load, to operate D.C. solenoids, or carry out any similar type of duty.

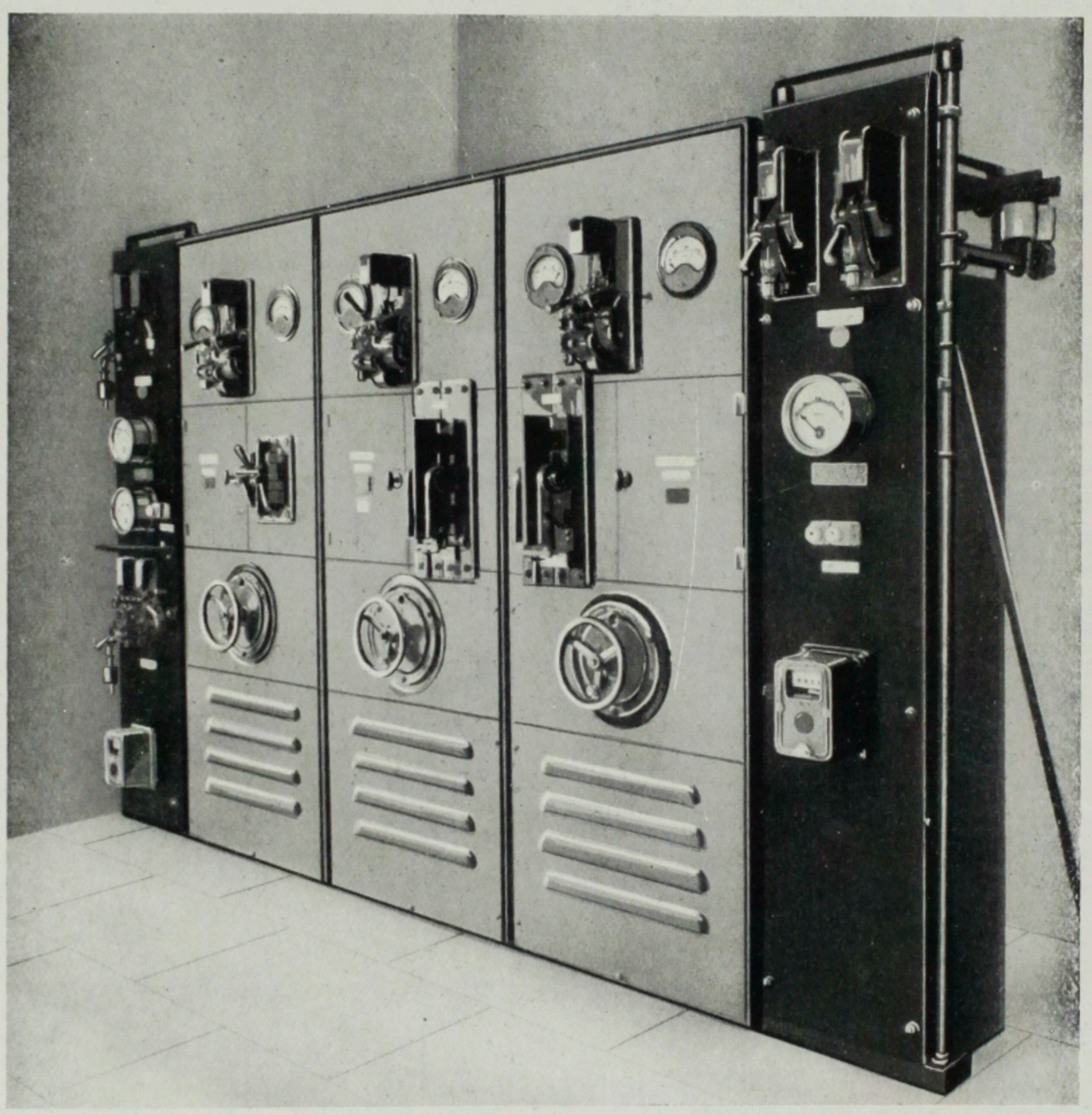


FULLY AUTOMATIC RECTIFIER SUBSTATION FEEDING A PIER CRANE LOAD

Rectifiers for Cranes, Hoists, etc.

The most casual consideration of the General Operating conditions of hoists, cranes, etc., at once points to the eminent suitability of Rectifiers for this particular type of work.

The load is of an exceptional fluctuating nature—the load factor is generally extremely low. With its characteristic almost flat efficiency curve, coupled with the fact that the Equipment is static and therefore is entirely unaffected by sudden load fluctuations from zero right up to well over normal full load: the Rectifier answers the stringent requirements of this particular type of work in a way that no other Converting Plant can approach.



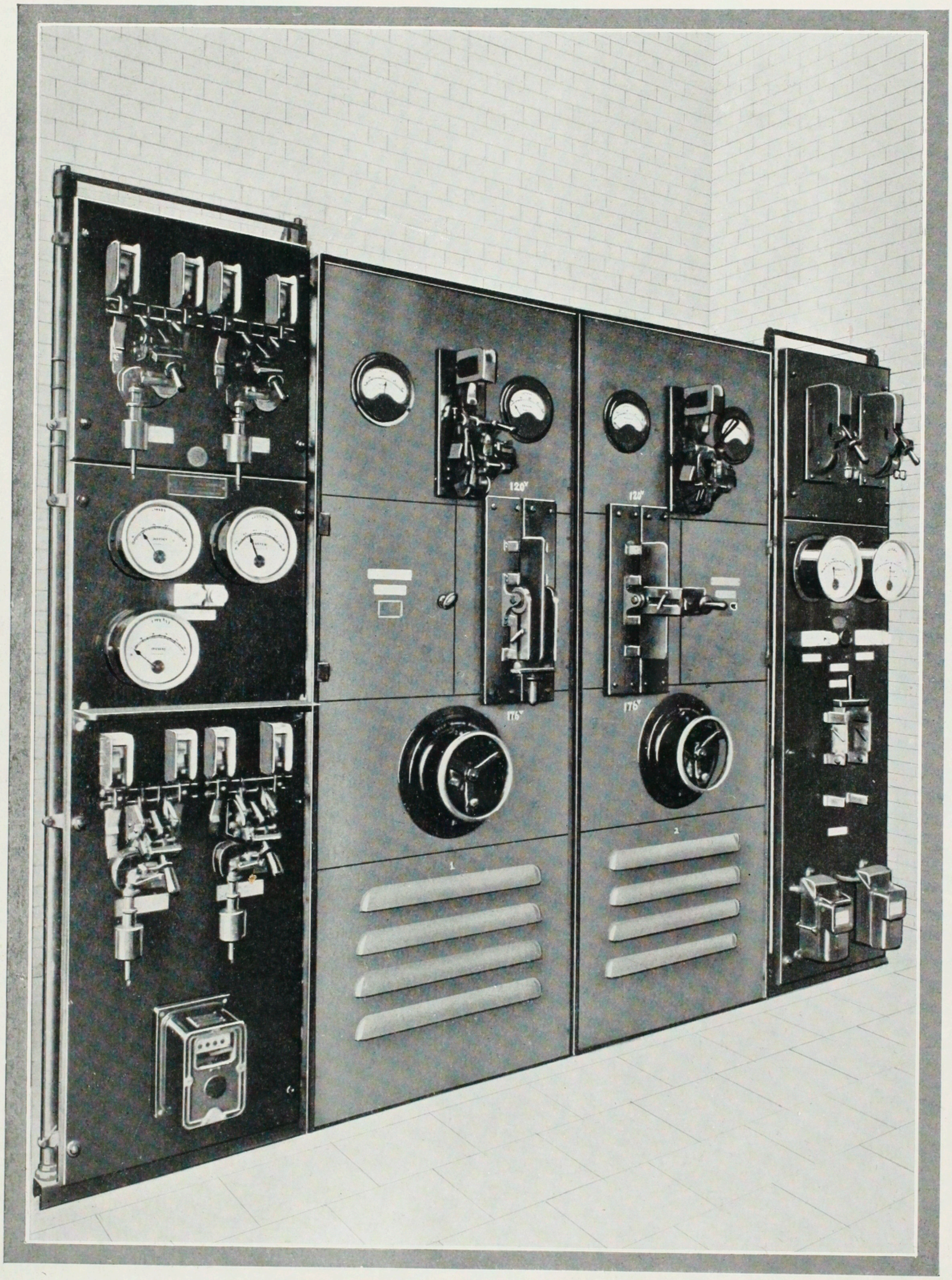
RECTIFIER SUBSTATION FEEDING CRANES AND RAILWAY SIGNALS

Further, not only does the load vary, but often for long periods there is no load at all on the converter feeding such an Equipment. It is therefore of importance that the no load losses of the Converting plant should be as low as possible, and this is again the case with Rectifiers.

What is more, the Rectifier can be controlled from any particular point with a minimum amount of extra gear, and maximum of simplicity; and it responds to such control almost instantaneously. It can therefore be arranged to be switched on and off to operate only just as and when it is required.

The start and stop push buttons themselves can in fact be replaced by interlocks on the operating mechanism of the cranes.

The Equipments for this type of work are not in any way special, being similar to the Lift Rectifiers (Section V) for small sizes and to the Works Rectifiers (Section IX) for larger sizes. It is, however, often considered advisable for this type of work to add an Auto-Reclose Circuit Breaker controlling the D.C. Output which opens on faults or abnormal overload conditions and recloses automatically as soon as normal conditions are restored.



BATTERY CHARGING INSTALLATION AT A RAILWAY WORKS.

Battery Charging with Hewittic Rectifiers

The Charging of Batteries was one of the first functions for which the Hewittic Rectifier was used ; and there is no doubt that the Rectifier shows to very great advantage in this particular field.

Advantages in Construction

Quite apart from its general characteristic as compared with other types of converters or with a dynamo, such as that it takes less space, has less weight, is noiseless and free from vibration, claims little or no attention, needs no foundations nor requires any lubrication, the Rectifier still shows further advantages from the point of view of performance.

Charging Methods

The more usual methods employed for Charging Batteries are :—

The Constant Current Charge which, as its name implies, is effected at a steady current rate (the intensity depending on the type of cell) and is continued at that rate until the pressure has risen to a definite value (2.3 volts per element in the case of a lead battery), after which the current is reduced to the "finishing" rate and kept at that figure until the completion of the charge.

The Constant Potential Charge which is effected by feeding the battery at a definite D.C. pressure (not greater than 2.3 volts per element in the case of lead cells) : maintaining the pressure at that value until the current has fallen to the finishing rate of charge. The current may then be maintained constant at this latter value until the charge is completed.

This method lends itself also to the rapid partial re-charge known as a *Boosting Charge*, of use, for instance, in the case of vehicle batteries which by receiving a short supplementary charge, say, during the dinner hour, will enable the vehicle to accomplish a much longer run than would otherwise be possible.

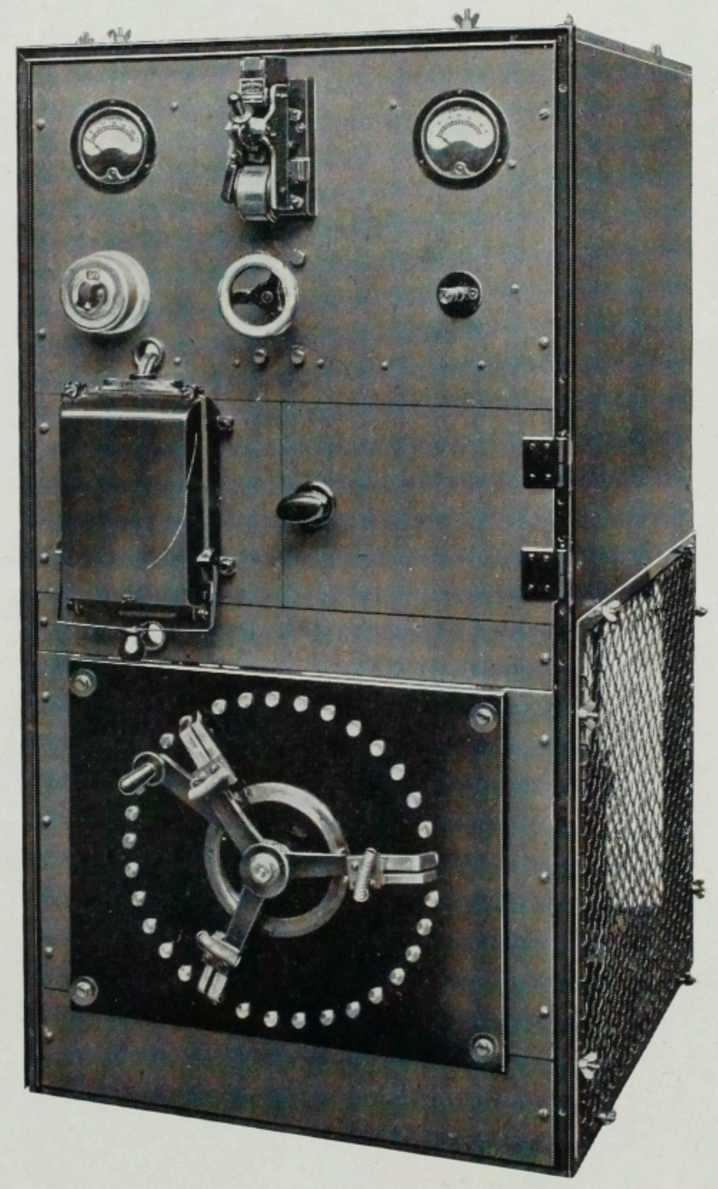
In the case of lead accumulators charged on the above lines, another method of charge is also required about once a week, the *Equalizing Charge*, which consists in charging the battery at a very low current until the specific gravity and voltage of a cell chosen as a pilot cell has remained constant for four successive hourly readings.

Advantages in Performance

All the foregoing methods of charge can be realized with a Rectifier exactly as with other types of plant, and even in these the performance of the Rectifier will show to considerable advantage: for its over-all efficiency is generally higher, and as also the Rectifier D.C. pressure can be regulated by means of an Induction Regulator or by means of tappings on the Transformer, in this manner one has the advantage of never wasting any energy in ohmic resistance.

Advantages in Operation

However, a still greater advantage accrues from the fact that with Rectifiers, the Charging of Batteries can be accomplished entirely automatically. This, as will at once be realized, is a point of the greatest import; as, for instance, in garages where the charge has to be effected in the evening or night, it allows the suppression of otherwise expensive labour.



TYPICAL BATTERY CHARGING RECTIFIER.

Automatic Charge for all Characteristics

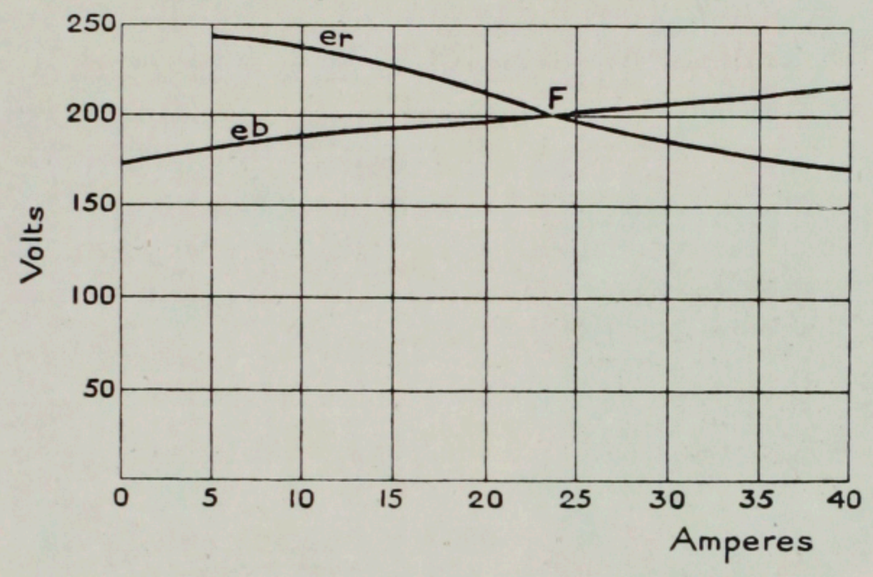
The various makes of Batteries require different charging characteristics, but the Rectifier can be arranged to follow automatically the various instructions of the different manufacturers.

One method of Automatic Charge is obtained with Rectifiers as follows:—

The Rectifier is designed to give a large drop in voltage from No load to Full load by the addition of Inductance Coils in the Anode circuits. These are so designed that one or two minutes after the commencement of the charge, with an e.m.f. per cell of say, approximately 2.1 volts per element in the case of lead Batteries, the maximum charging current is reached. The Rectifier voltage increases as the current falls, the extent of this current decrease depending on the inclination from the horizontal of the falling characteristic of the Rectifier or, in other words, on the amount of its inherent regulation.

The Rectifier can be designed for any required value in this respect to suit the requirements of any particular battery, and further, if desired, by means of tappings on the Anode Inductances, the same Rectifier can be designed to operate with various characteristics.

Arranged with such a voltage characteristic the Rectifier will charge a Battery automatically, a time switch or current relay cutting the Rectifier out of operation when the charge is completed.



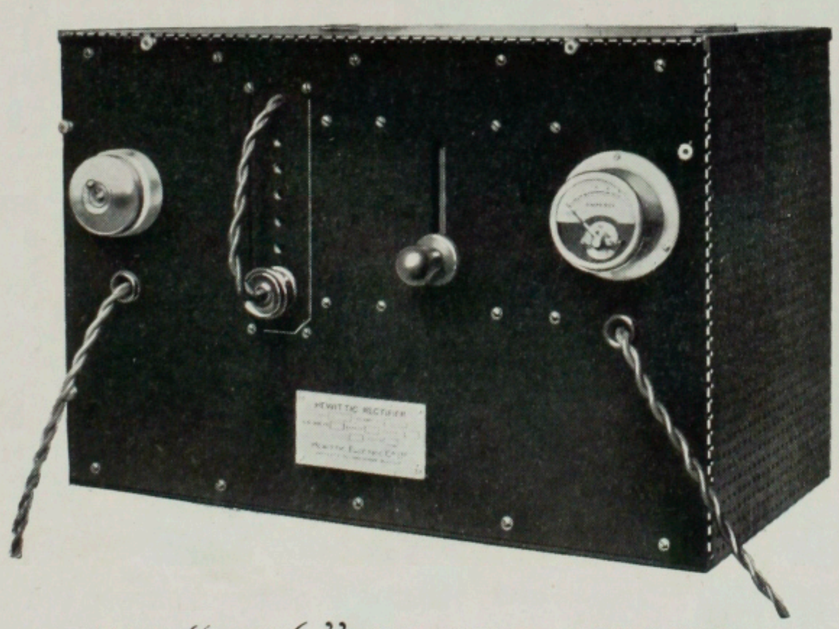
To appreciate this it is only necessary to consider, for example, the case of a typical 226 Ampere-Hour Lead Battery capable of being discharged in five hours at a rate of 45 amperes.

If the value of the e.m.f. of a battery when completely charged is plotted as a function of the current a straight line is obtained, showing that it is only the internal resistance of the Battery which varies. In the case of the example under consideration the line eb is obtained.

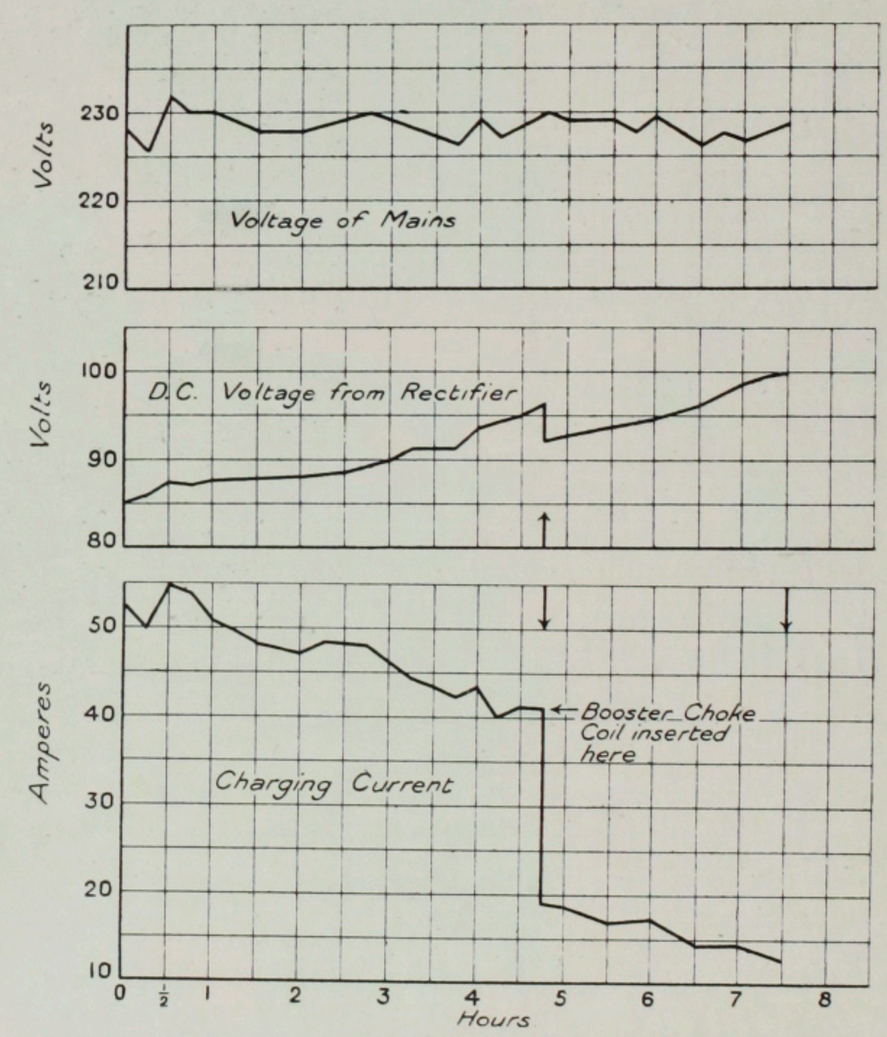
If the Rectifier characteristic is now plotted on the same figure, represented by the line er, it will be seen that it cuts the line eb at a point *F* which in this example represents 23.8 amperes; and at this point the charge is completed.

Now the line er representing the characteristic of the Rectifier can be given any inclination that may be desired, this being determined by the no load voltage of the Rectifier and the value of the self-induction of the anode coils; and therefore this line er can be made to intersect the line eb at any point chosen in advance, that is at the current value at which the charge is completed, when a relay will cut the Rectifier out of circuit.

In some cases a different charging schedule is desired. For instance, with some Batteries the charging of the Battery



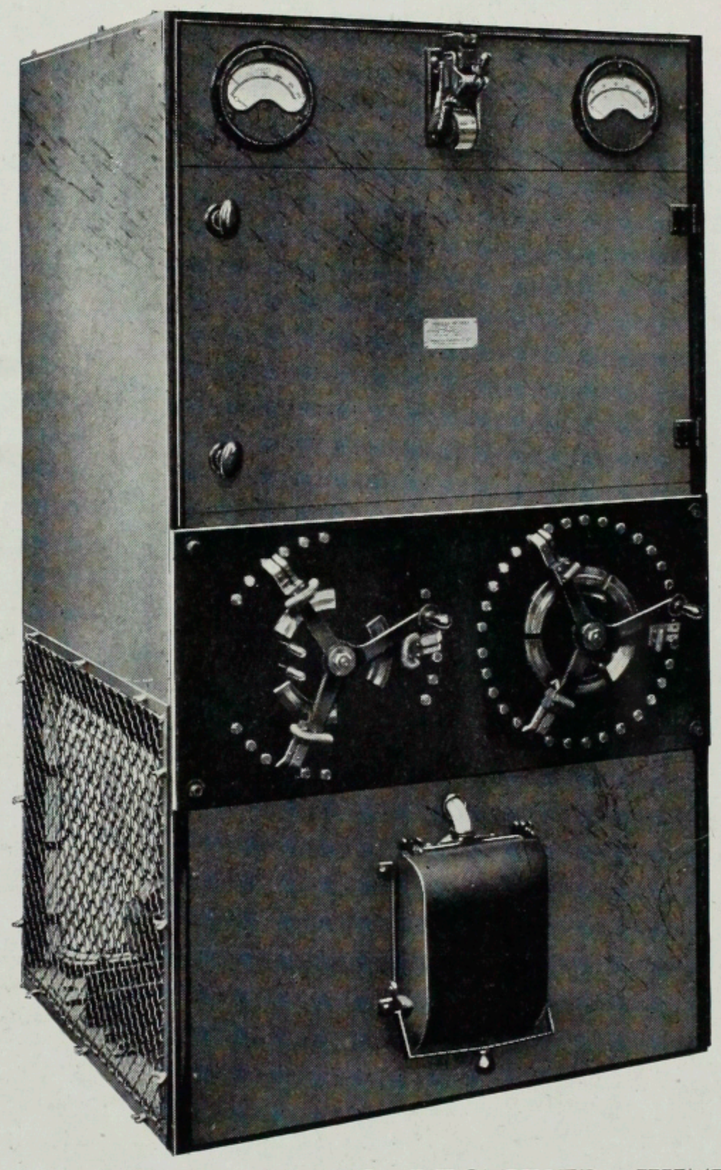
THE "I.T.6." BATTERY CHARGER.



RECORDING INSTRUMENTS CHARTS, ILLUSTRATING THE AUTOMATIC CHARGE WITH A RECTIFIER.

is due to take place up to, say, 2.4 volts per element at practically full current strength, and then the charging current is reduced to one-third of the normal value.

In such cases the desired sequence is achieved by means of a Booster choke-coil which is automatically inserted into circuit by means of a clapper switch, controlled by a Pressure Relay or Time Switch, according to the Charging Instructions. The Rectifier is finally shut down completely when the charge is completed as indicated by a Time Switch, an Ampere-Hour or Watt-Hour meter. The foregoing curves, taken by recording instruments, show the charging of a 40-cell Battery in this manner—50 ampere charging rate.



BATTERY CHARGING RECTIFIER WITH DOUBLE TAPPING SWITCH FOR COARSE AND FINE REGULATION

Construction

In common with all Rectifiers, Battery Charging Sets are provided with all the necessary operating and protective switch-gear on the A.C. and D.C. sides. On the very small sets fuses are used instead of Circuit Breakers on the D.C. side.

Instruments of a moving coil type are generally also mounted on the Rectifier Panel.

Voltage Regulation is obtained by regulating the A.C. pressure into the Bulb.

When the capacity of the Equipment is large, say above 400 amperes, an Induction Regulator would be used.

Below this, Regulation is obtained by taps on the Transformer feeding the bulb controlled by Regulator Switches either of the drum type or face plate type, according to the capacity of the set. Where a very large voltage range is desired and the capacity of the set does not warrant the use of an Induction Regulator, smooth regulation is achieved without an undue number of tappings by a combination of two tapping switches. Thus by having a 5-way tapping switch controlling 5 main taps and an 11-way tapping switch controlling 11 secondary taps 50 steps are obtained.

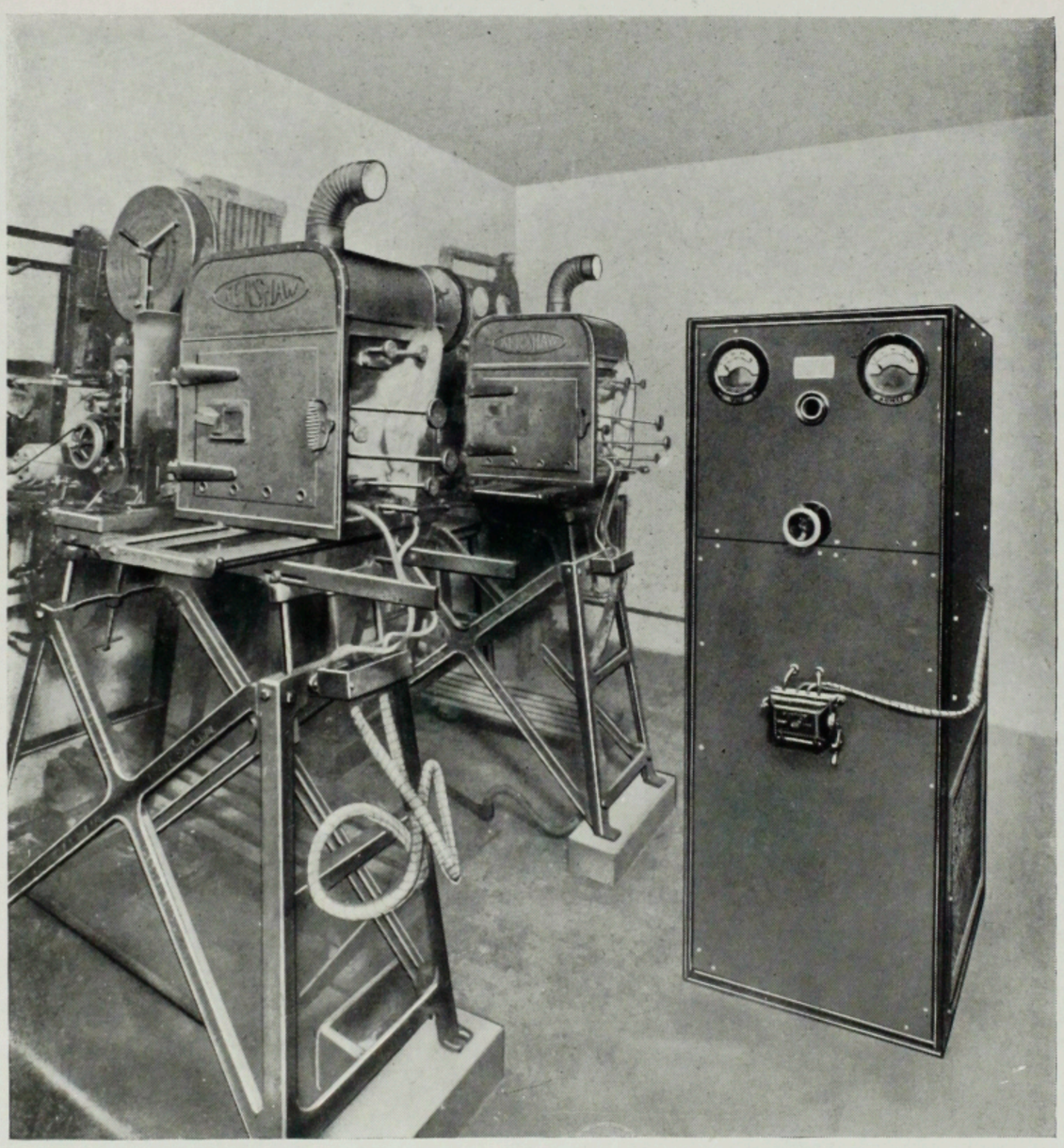
In the very small sets a wide and economic means of voltage Regulation is provided by the use of a Wander Plug controlling a number of Tappings on the Transformer, an ohmic resistance being used for fine regulation between the steps as shown in the illustration of the I.T. Rectifier.

Rectifiers for Feeding Projection Arcs

D.C. Best for Projection Arcs

The best results with Projection Arcs can only be obtained with Direct Current, and therefore whenever an A.C. supply only is available into a Cinematograph Theatre the supply is generally converted.

The Rectifier offers many considerable advantages for this type of work, quite apart from the general advantages which it enjoys as a Converter already set out in Section IV.



CINEMA INSTALLATION WITH TWO PROJECTION ARCS FED OFF A RECTIFIER.

Installation

In the first place it does not require any special installation nor foundations and occupies small ground space. It is silent in operation, and so can be placed either in the operator's cabin or in the immediate proximity of it.

Operation

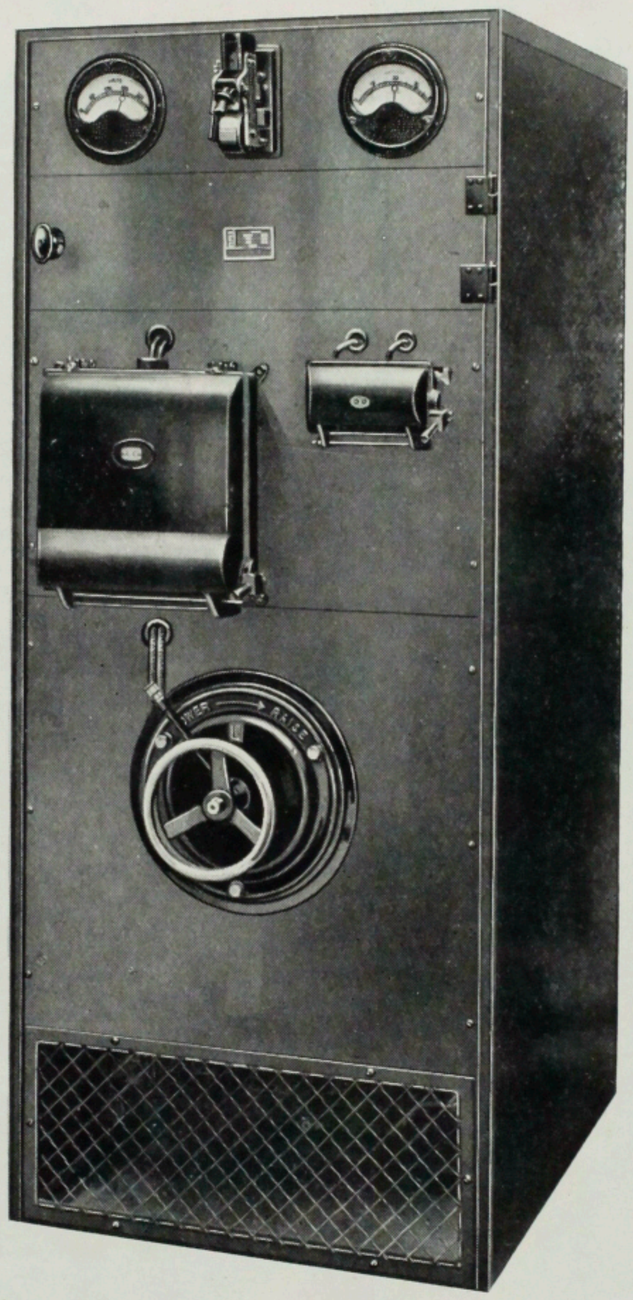
At most it requires merely to be switched on and off, or it can be arranged automatically to come into operation when the carbons of the arc are brought into contact. It has no revolving parts, needs no oil, makes no noise. It does not require any attention from the operator, but leaves the latter free to attend to the Projection Arc and the film.

Economy

Above all, however, it allows of realizing an enormous economy of electrical energy, particularly in the case of arcs of great intensity. As is well known, for an arc requiring a pressure across the arc terminals of 45 to 50 volts, a no-load voltage varying from 70 to 90 volts according to the intensity of the arc between 30 and 100 amperes is necessary in order to render the arc stable; and where the arc is being fed from a rotary machine—say, a motor generator—this difference in pressure is absorbed when the arc is operating by means of an ohmic resistance.

In the case of a Hewittic Rectifier, however, the same result is obtained by placing an Induction coil in the Anode circuit so that, whilst the Rectifier has the higher no-load pressure necessary, the excess voltage is absorbed by reactance without expenditure of energy, at the same time ensuring to the arc a stability greater than the resistance in the previous case.

The heavy series resistance losses are therefore eliminated.



TYPICAL CINEMA RECTIFIER.

When one considers that the efficiency of the Rectifier itself is not only as high but generally higher than that of a similar size motor Generator, and add to this the fact that one can do away with the Series Resistances, it will be seen that a saving of over 30 per cent. can generally be realised by the employing of a Rectifier.

Construction

Rectifiers for Cinema work are mounted in self-contained Cubicles in accordance with the standard arrangement. Anode Inductances are generally provided in order to give the required inherent regulation. The incoming A.C. supply is generally controlled by an Iron Clad switch fuse, whilst a single pole circuit Breaker controls the D.C. side.

For such cases as when the operator has to pass films of different capacities or desires, in order to obtain certain effects, to be able to vary the intensity of the current in the arc, a tapping switch is provided to afford the necessary regulation.

Instruments are generally provided on the front panel.

Hewittic Rectifiers for Feeding D.C. Systems in Factories, Works, etc.

D.C. Motors offer many advantages for certain types of work, specially where speed regulation is of importance, as, for instance, in Printing Presses. Sometimes, therefore, the retaining of D.C. motors is an absolute necessity to a works or factory ; sometimes the retaining of D.C. offers certain operating advantages ; whilst at other times the problem is merely one of cost—that is, in factories possessing already D.C. motors, the supply to which is changed to A.C.

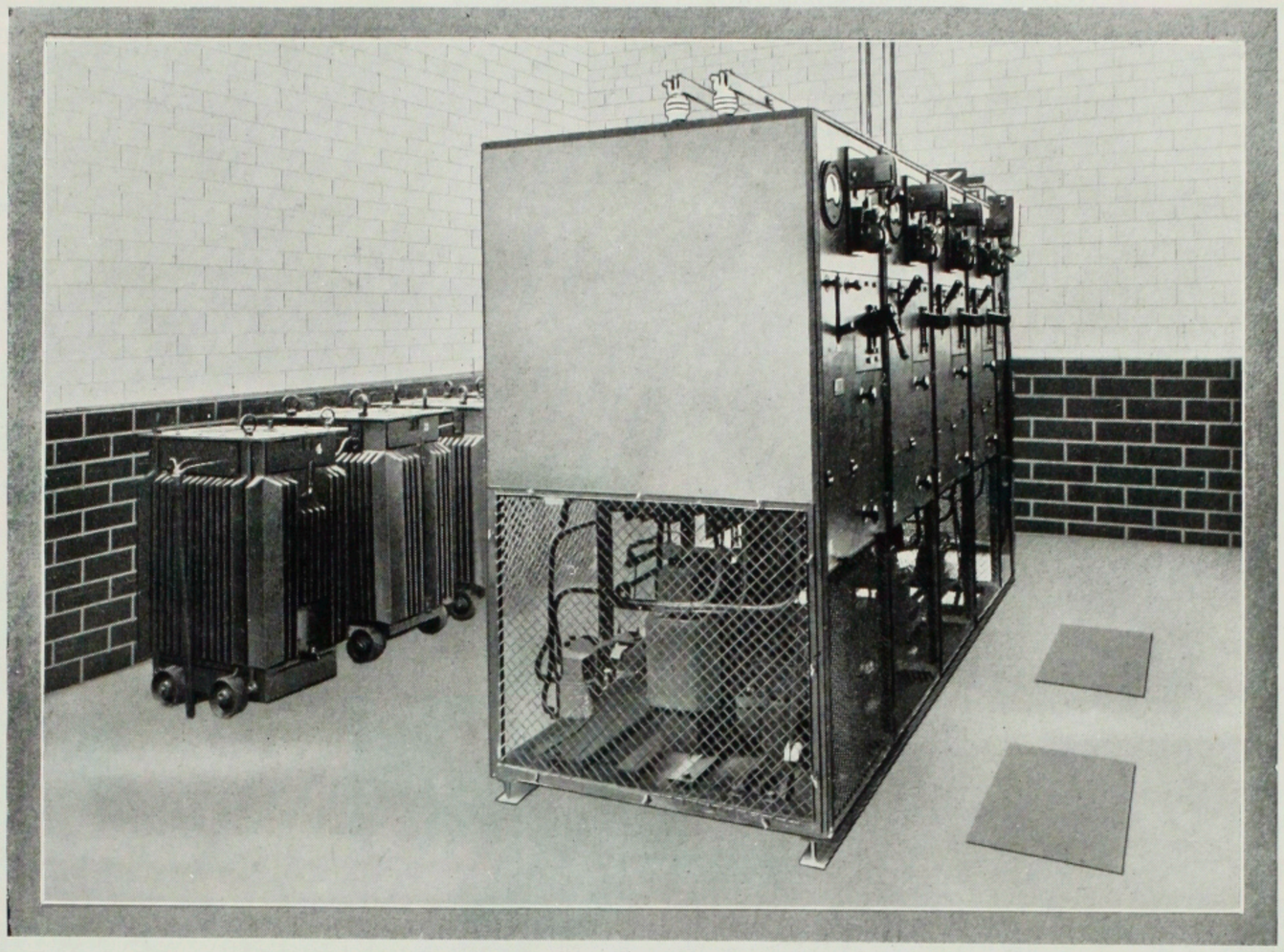
It is therefore often advantageous and sometimes necessary to install a converting Equipment at a Works or Factory, and Hewittic Rectifiers offer a most satisfactory solution in such cases.

No Attendance The plant is static, demands no supervision, and gives a high over-all all-day efficiency even if the load is of a highly fluctuating nature. The only attendance required is to switch it on and off at the beginning and end of its operating periods respectively, and this demands merely the closing or opening of the Primary switch.

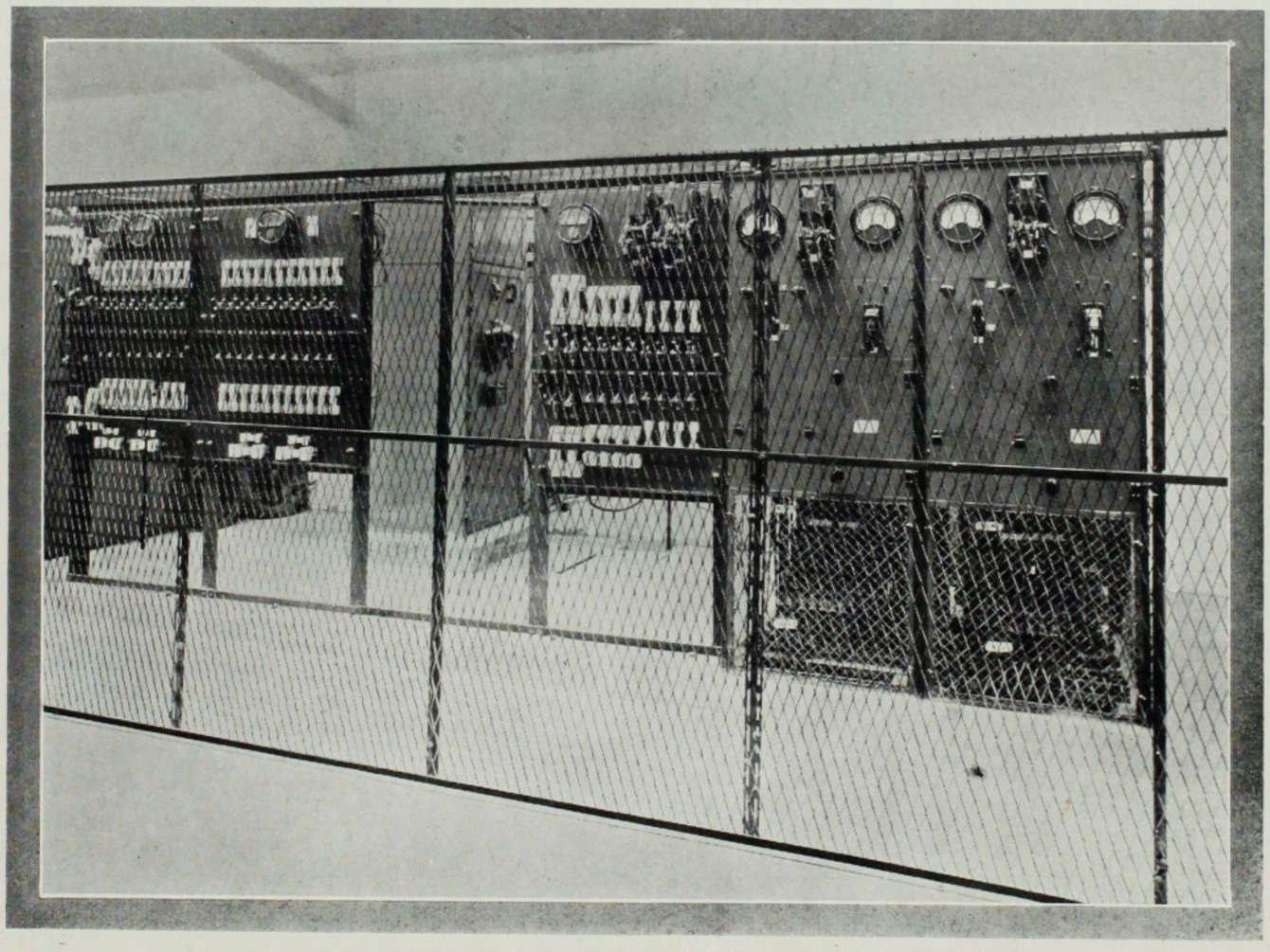
Unit Construction Its unit construction allows of only sufficient capacity being installed to deal with actual requirements, further units being added to meet growing demands. In a similar way various existing units can be cut out or operated to suit load requirements.

No Stand by And, further, this unit construction considerably enhances the reliability of the Works converting Sub-station, as even in case of accidental damage only a fraction of the Equipment would probably be put out of commission thereby.

When the continuity of service is of the utmost importance, as is the case in the majority of works, Rectifiers offer the most economical proposition, as the need for spare stand-by plant is eliminated. This is due to the fact that the Rectifier Equipment can be economically built into a number of separate units working in parallel without detriment to the efficiency of the whole plant and without complicating it in any way.



A WORKS SUBSTATION WITH FOUR 50 KW. UNITS.



A WORKS SUBSTATION WITH TWO 50 KW. UNITS.

Construction

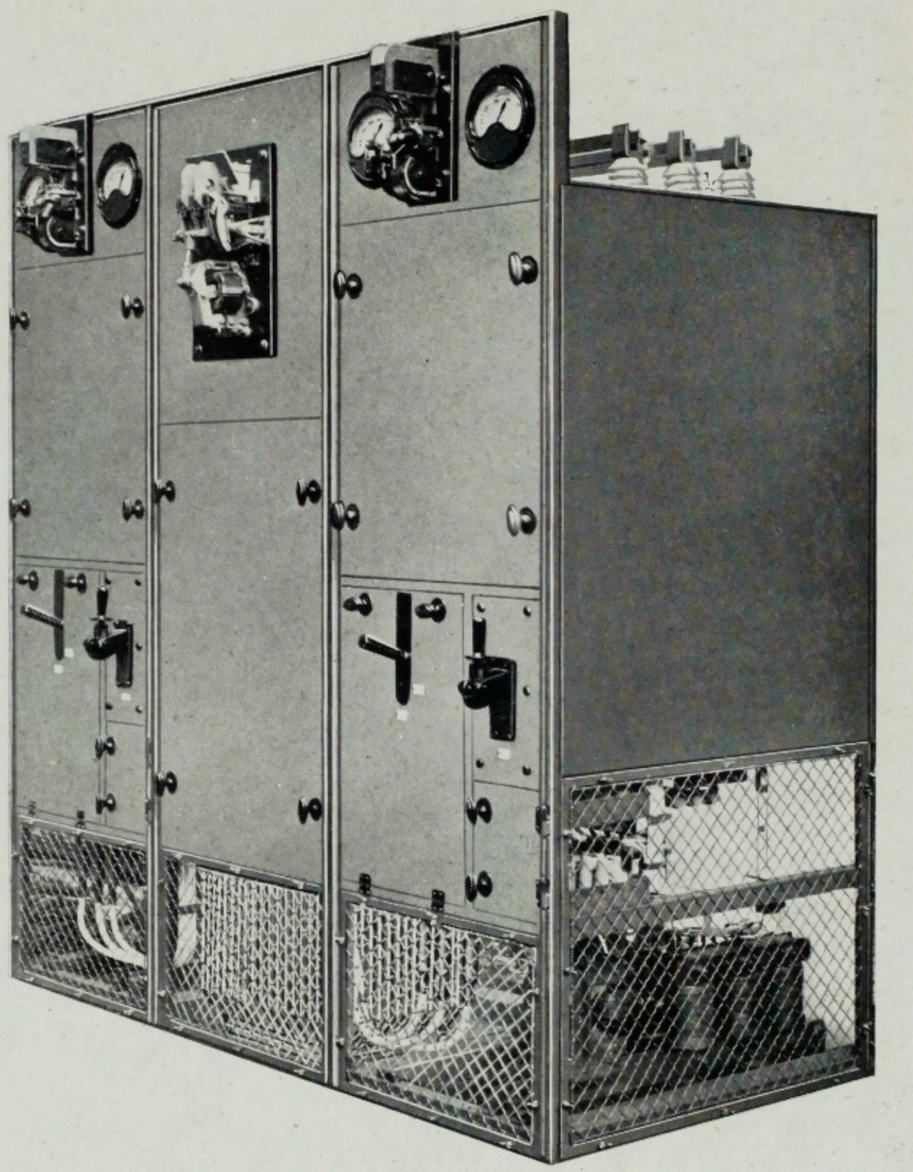
Rectifier Equipments, as used for Works Substations, are similar to those used on Public Supply Substations, as described in Publication No. 101.

They are built in single or multiple Bulb sheet steel cubicles according to the capacity of the Equipment. These cubicles contain the rectifying gear proper as well as protective and isolating switchgear on the D.C. and L.T. A.C. sides.

The Transformers, when the Equipment is over 30 kw., are of the oil immersed type mounted separately, arranged to feed one or a number of Rectifier Cubicles.

Voltage Regulation

Where the load is only a motor load it is often not considered necessary to provide means for Voltage Regulation. The Rectifier Equipment would, in such cases, have a shunt characteristic with an inherent voltage regulation of from 6 to 7 per cent. If, however, Voltage Regulation is desired, this would be obtained by means of Tapped Auto Transformers mounted at the base of the various Rectifier Cubicles and controlled by 11 stud Tapping switches or alternatively by means of an Induction Regulator controlling the Primary supply.



VIEW OF AN AUTOMATIC THREE-WIRE RECTIFIER EQUIPMENT

showing Positive and Negative Rectifier Cubicles with D.C. Instruments and Switchgear, Main Transformer (centre) and Primary Auto Clapper Switch arranged for Remote Control.

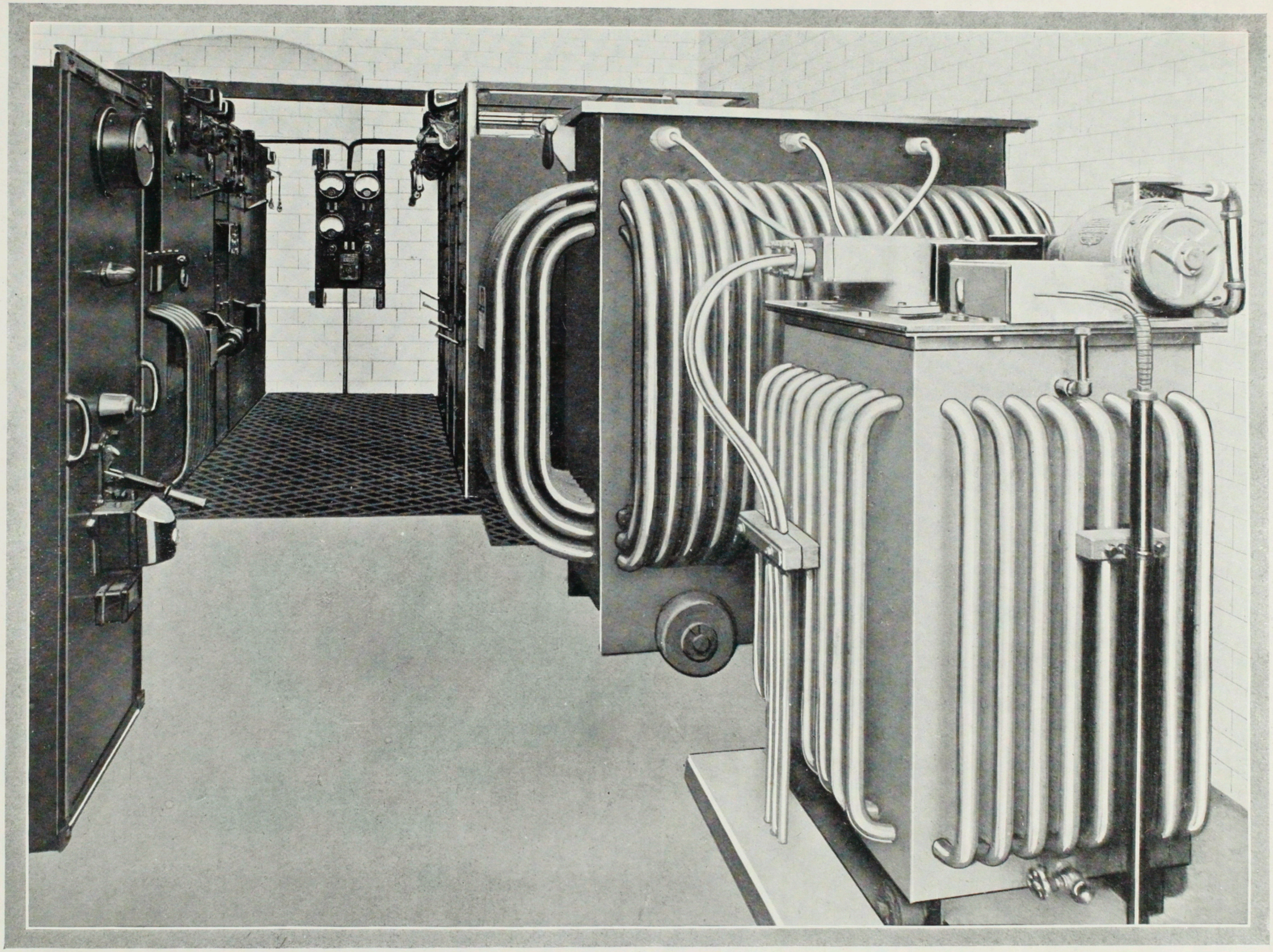
Automatic Voltage Control

Either of the above methods of Voltage Regulation can be arranged for Automatic Voltage Control, the Induction Regulator or Tapping Switches being operated by a motor governed by a pressure relay which will tend to keep the D.C. pressure constant at all loads and despite normal fluctuations in the incoming A.C. supply. Alternatively, if it is preferred the control regulation can be arranged to give the plant an over-compounding characteristic.

The Control Gear required for this is extremely simple and reliable in character, owing to the extremely simple character of its function, and is fully described in Publication No. 101.

Automatic Load Sharing Device

It often happens that Rectifiers are installed in places where other types of converting plant already exist with



RECTIFIER SUBSTATION AT A RAILWAY WORKS COMPRISING A 500-KW. TWO-WIRE EQUIPMENT AND AN 88-KW. THREE-WIRE SET.

which it is necessary that the Rectifiers will operate satisfactorily in parallel. At other times the converting Plant may be required to operate in parallel on the same busbars with existing D.C. generating plant driven by Steam, Diesel Engines or otherwise.

In any of these cases the Rectifier can be arranged to operate satisfactorily in any required ratio by means of an adjustable Master Current Relay controlling the Rectifier Voltage Regulator. This relay is a meter-like instrument, and can be readily set for any value so that the ratio of the load taken by the Rectifier and by the remaining plant respectively can be adjusted at will.

It is of interest to note here that this Load-Sharing Device is equally effective, no matter what the relative inherent characteristics of the two plants, that is to say, no matter whether they are the same or different; also in spite of the fact that the generating plant is of course unaffected by variations on the supply feeding the Converter.

Quite apart, however, from the Load-Sharing Device which insures the proper dividing of the load, it may be here noted that the Rectifier is of particular value to install in works where the converter has to run in parallel with D.C. generating plant because it is inherently unable to reverse as might happen with other plant under certain conditions of supply fluctuations which would affect the Converter, but not of course the generating Equipment.

Depending on how the generating costs compare with the Bulk supply costs, the Rectifier can be arranged to take the Peak Loads, leaving the Generating Plant to deal with the normal load, or *vice versa*, according as which works out the more economical arrangement.

Efficiency

In this connection it is of interest to note that the Efficiency of the Rectifier is, as will be seen from the attached curves, almost as high at low loads as at full loads. The curves show the value of the Efficiency for Rectifier Equipments of capacities from 50 kw. upwards, operating at different D.C. pressures.

Conclusion

The preceding pages give particulars of Rectifiers in connection with some of their more usual applications excepting for Automatic Substation on Public Supply, which are dealt with in Publication No. 101.

It will be at once realized, however, that it is impossible to deal at all exhaustively with the various applications of the Rectifier, for, in fact, it is suitable for all purposes wherever it is necessary or desirable to convert from A.C. to D.C. and in this the Rectifier is universally suitable. It operates equally well on any periodicity on single, two or three phase supplies, off any primary pressure, and, in fact, can be suitably designed for any combination of pressures, periodicities or phases.

In a similar way it can be arranged for any D.C. voltage and to give any desired amount of Voltage Regulation and for any desired total capacity.

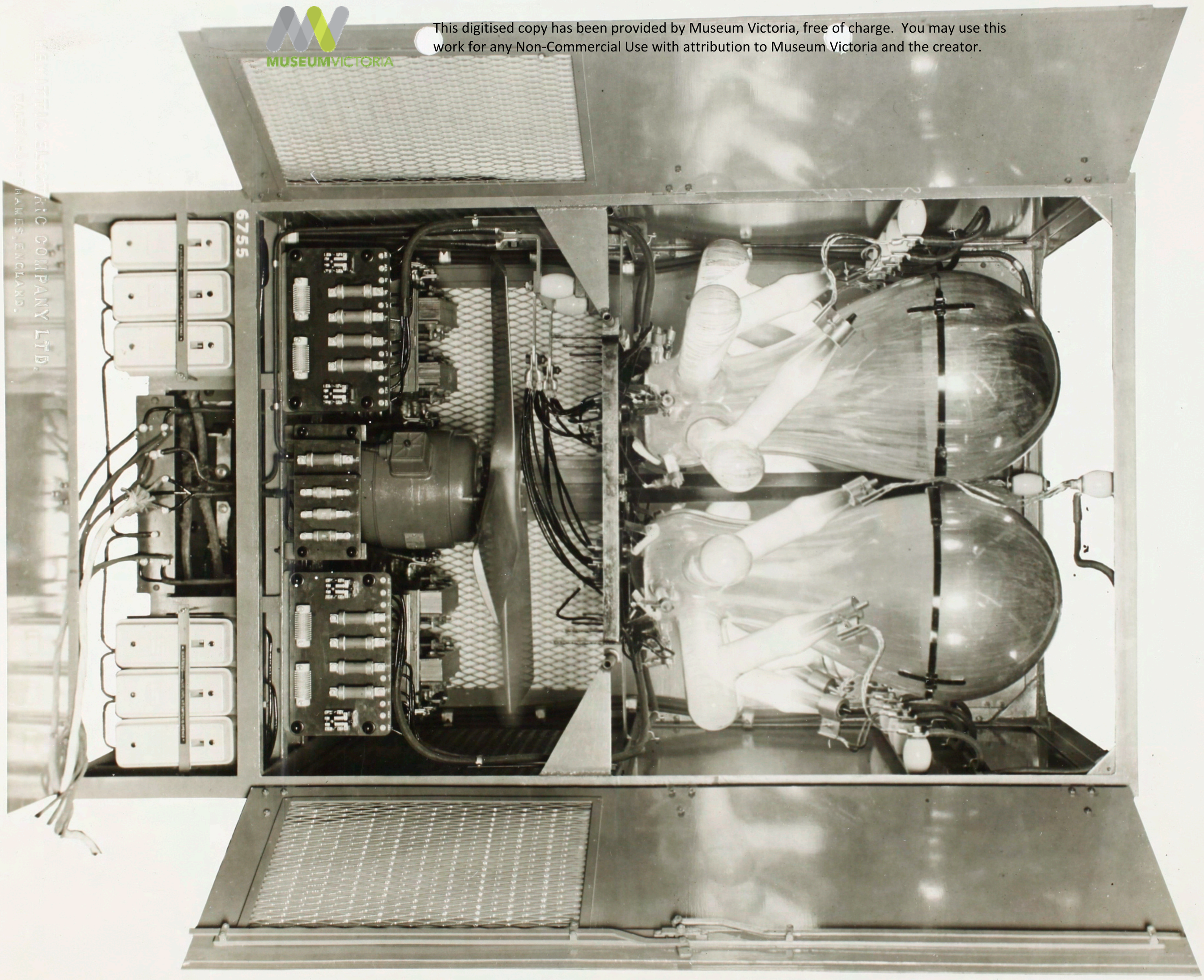
It is the most flexible of all converters and the most adaptable. Rectifier Sets are made to deliver as little as 2 amperes or alternatively for capacities of thousands of kilowatts.

In the case of large equipments the Rectifier retains its unit construction, which, whilst not taking away from its efficiency or simplicity, gives it an elasticity and reliability not possible otherwise.

And thus it is that for small and for large capacities, for lighting, or for Power Circuits or for any other use where conversion is required, Hewittic Rectifiers show to considerable advantages in almost all cases.

PHOTOGRAPH NO. RC.551

Hewittic Rectifier Group Unit with cubicle door open showing arrangement of bulbs, starting gear, etc.



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