INSTRUCTIONS

for

INSTALLATION and MAINTENANCE

of

HEWITTIC GROUP BULB RECTIFIERS (Types G.T. & ½ G.T.)

CONTENTS

HACKBRIDGE AND HEWITTIC ELECTRIC CO., LTD.
WALTON-ON-THAMES . SURREY . ENGLAND

Telephone: Walton-on-Thames 760 (8 lines)
Telegrams: Electric, Walton-on-Thames

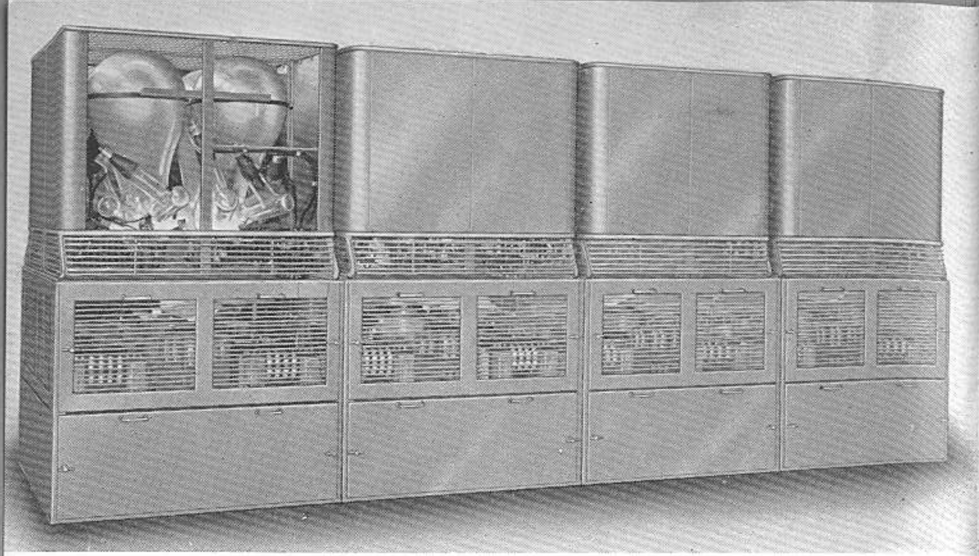


Fig. 1. A bank of Hewittic type G.T. rectifiers. Front sheeting of first unit has been removed to show bulbs.

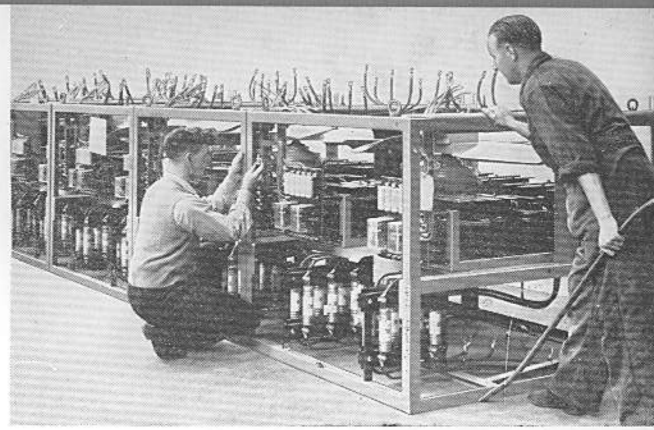
LINING UP THE CUBICLES

Rectifier units for Great Britain are usually delivered to site on the Company's own vehicles : equipments for overseas of course are suitably crated for shipping. The bulbs are always despatched in individual cases as described later.

Lifting gear is not necessary (assuming the plant to be installed at ground level) although if a mobile or other crane is available some time may be saved by its use. The cubicle bases are easily positioned by means of a couple of rollers and a pinch bar, as shown in Fig. 2. The floor should be reasonably level, the weight being borne mainly at the corners of the cubicles. Should there be any gaps at these points, suitable wedges or shims should be used and the floor grouted in to give a finished appearance to the job. As there is no vibration in use, floor bolts are not essential, but a few may be used if desired. Bolts, however, are provided for insertion in the adjacent uprights for pulling together the cubicles and forming a rigid bank.

Apart from detaching the connections between the base unit and the bulb cradles, and any jumper cables between adjacent units, nothing is removed or detached after the test run. It is necessary, therefore, merely to

Fig. 2. Lining up the cubicle bases and bolting together.



restore any such jumper cables (which will be suitably identified by engraved ferrules) and then to complete the external cabling in accordance with the working drawings supplied.

This work should be checked over, and the equipment cleaned down if necessary before installing the bulbs.

INSTALLATION OF THE BULBS

Before proceeding to handle the bulbs please read through these instructions carefully. It is impossible to refer to them whilst carrying a rectifier bulb.

It is advisable to clear the floor of all tools and scrap lengths of cable before bringing the bulbs to the vicinity of the cubicles, so that erectors do not stumble while handling the bulbs.

The next step is the placing of the bulbs in the cradles. The cradles are best placed on a low bench or a strong packing case about 2 feet high. If such facilities cannot be provided the work can proceed with the cradles on the floor although this is less convenient.

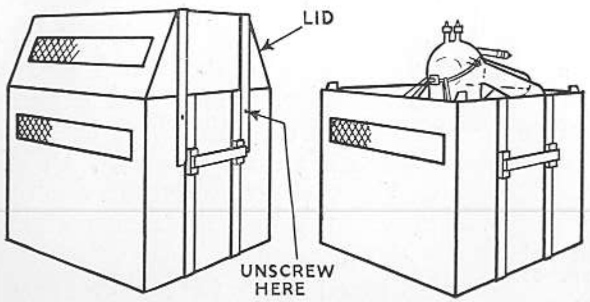


Fig. 4. Showing the method of opening a type 400/3 bulb case.

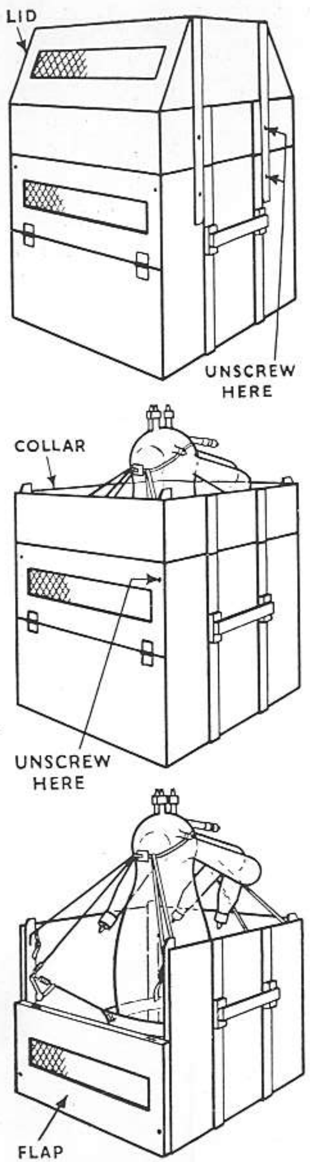


Fig. 4. Showing the method of opening a type 550/3 bulb case.

REMOVAL OF BULBS FROM CASES

The bulb, which is a sealed glass vessel exhausted to a high degree of vacuum and containing heavy liquid mercury, is shipped in a specially sprung case provided with wire gauze windows so that the contents may be clearly seen from the outside. The bulb is carried in a sling and is secured in position by means of spring straps. It is shipped upside down with the mercury in the domed part of the bulb, i.e., in the condensing chamber.

To unpack a Type 400/3 bulb, unscrew the wood screws on all four battens (see Fig. 3), remove the lid (do not attempt to dismantle the case) and unfasten the spring straps. Then lift the bulb clear of its supports by holding it under the bulb arms.

It will be found easiest if this part of the operation is performed by two men at adjacent sides of the crate (see Fig. 5).

To unpack a Type 550/3 bulb, unscrew the wood screws on all four battens and remove the lid in the same way as for a type 400/3 bulb (see Fig. 4). It will then be found that the top board all round the case forms a collar about 9 in. deep which can be lifted off. One side of the


Fig. 5. Lifting a type 400/3 bulb from the case.

case is fitted with a hinged flap, the hinges of which are clearly visible. The two wood screws which hold up this flap should be unscrewed and the flap opened. The bulb can now be unfastened and removed without difficulty by two men standing one each side of the hinged flap. In all other respects the handling of this bulb is the same as for a type 400/3.

Mind the Seal-off ! The seal-off, covered by a small black cap, is situated towards the end of the lower part of one main anode arm. Care should be taken not to strain this point and, particularly when turning the bulb, mercury should not be allowed to enter this arm violently. If the bulb is handled as described overleaf, mercury will not enter the anode arms.

Turning bulb into the upright position. Having lifted the bulb clear of the case, turn it slowly into the upright position, i.e., with the cathode stems pointing downwards, allowing the mercury to flow gently down the side of the condensing chamber that is free of arms, into the cathode pool, as shown in Fig. 6.

It will be noted that for this operation a third man is employed to lift up the condensing chamber whilst the other two support the bulb by the main arms.

PLACING THE BULBS IN THE CRADLES AND CONNECTING UP

Fig. 7 is a photograph of one of a pair of cradles. The front and rear cradles are identical. They comprise a light tubular framework with a pair of seating rings, and upperbands for holding the bulbs in position. At either side is a terminal board from which extend the main and auxiliary leads that connect to the bulb electrodes.

In plan view, the four bulbs in a cubicle form a square, the three arms on each bulb being remote from the centre of the square. Looking into the cradle from the open side, the left-hand bulb should be inserted first.

Fig. 6. Turning the bulb into the upright position whilst allowing the mercury to flow gently down the side that is free of arms, into the cathode pool.

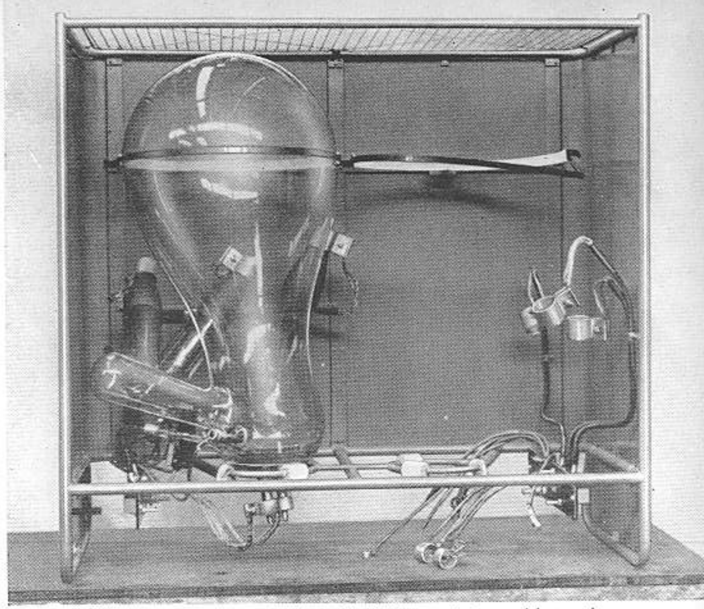


Fig. 7. Bulb cradle with the first bulb in position. Note the rear arm leaning to the right: for this reason it is better to install the left hand bulb first.

It will be noted that the arm to the rear slopes to the right and would require extra care in passing the other bulb if the right-hand one were to be put in first.

If this illustration (Fig. 7) is examined carefully before starting to handle the bulb, then as the bulb is placed in position it will be easy to locate the arms correctly.

While two men place each bulb in position, a third man should fasten the band around the condensing chamber, making sure that the asbestos cloth strip protects the glass from the metal all the way round.

If it is found necessary to rotate either of the bulbs after they are in position, the top band should be undone and the bulb lifted slightly while turning. This operation requires two men, one to hold the condensing chamber and the other to lift and rotate the bulb.

When both bulbs are in position the main and auxiliary connections should be made.

Condensing chamber position adjustment. Normally this adjustment should not have to be made. When both bulbs are in position in the twin cradle, each lower arm should be examined to make sure that it slopes

upwards at an angle of about 10° so that mercury condensing in the lower arm can easily drain back into the mercury pool. If this slope is not present, then the position of the condensing chamber relative to the cathode pool may be adjusted by means of the slot and screwed stud holding the upper band in position.

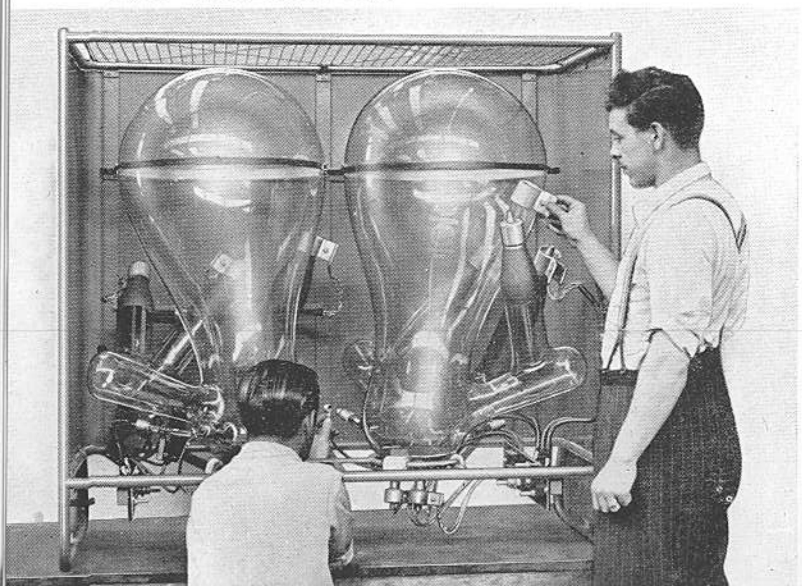
Before this adjustment is made, remove the bulb from the cradle to obviate any chance of breakage.

Removal of grease from bulb terminals. The grease should be wiped off each electrode terminal with clean rag by gently rubbing the cap down toward the arm. On no account should the cap be twisted during this operation since twisting may damage the electrode seal.

Fitting the bulb clips. Each clip connection should be loosened before it is slid on the cap, after which the ears of the clip should be pinched together (see Fig. 8) and the knurled nut tightened reasonably by hand. The lock-nut should then be tightened against it, also by hand : under no circumstances should pliers or a spanner be used.

Tension of leads. The amount of " slack " in each flexible lead can be adjusted by rotating the electrode clip before tightening. All flexible leads should be

Fig. 8. Fitting the bulb clips.



adjusted in this way in order to ensure that no stress is placed upon the bulb. Take care that there is an adequate clearance to earth from the clip and any bare portion of the lead thereto.

If, after connecting up, it is found that a clip connection needs to be rotated slightly, in order to adjust a flexible lead, as explained above, it should always be loosened completely first, as any attempt to rotate it whilst it is clamped on the bulb may damage the seal.

Fitting of starting coils. With this type of bulb two starting coils are fitted. Their position is illustrated in Fig. 9. It will be seen that there is a thicker section on the starting arm at the point where the two starting coils are clamped.

At this point, inside the arm, the flexible stem of the starting electrode is fitted with a soft iron armature, which is attracted by the starting coils when they are energised in turn. The starting coils should be adjusted so that this armature comes between the two pole pieces of the lower coil and under the single pole piece of the upper coil. This arrangement will give the maximum pull in both directions.

With the double starting coil, the position of the tip of the starting electrode is not critical but it should be between $\frac{1}{8}$ in. below and $\frac{1}{4}$ in. above the surface of the mercury when the bulb is correctly seated.

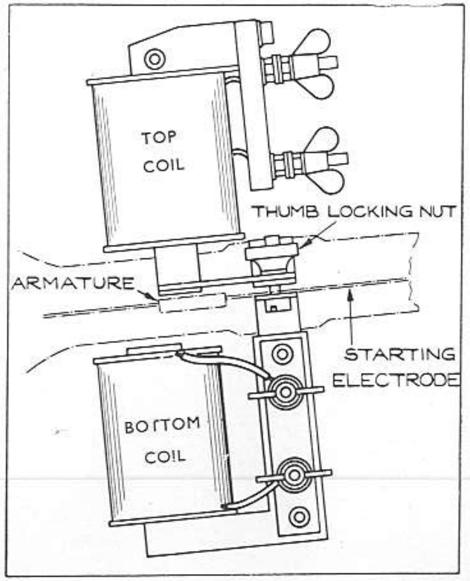


Fig. 9. Showing the arrangement of the starting coils on the starting arm.

MOUNTING THE CRADLES ON THE CUBICLE BASE

When all of the main and auxiliary connections to the bulbs have been made and the starting coils fitted, the cradles are ready for placing on the cubicle base. This operation can be carried out by two men although a third may be helpful in guiding each unit into the guide channels. The rear one is slid along these runners as far as it will go, and the front one is added and brought close to it. This forms a completely closed housing and is necessary for the uniform cooling of the bulbs. The cradles are fixed to the base by means of thumbscrews. The earthing connections fitted to the top members of the base require bolting to their terminals on the cradles.

It will be necessary to remove the detachable grilles at the base of the cradles to enable the leads from the base unit to be connected to the terminals on the cradles. Each auxiliary lead carries an engraved ferrule for identification, and connects with a terminal stud bearing a similar marking. The markings for the three main anode connections per bulb are stamped on the lugs ; the cathode connection is self-evident.

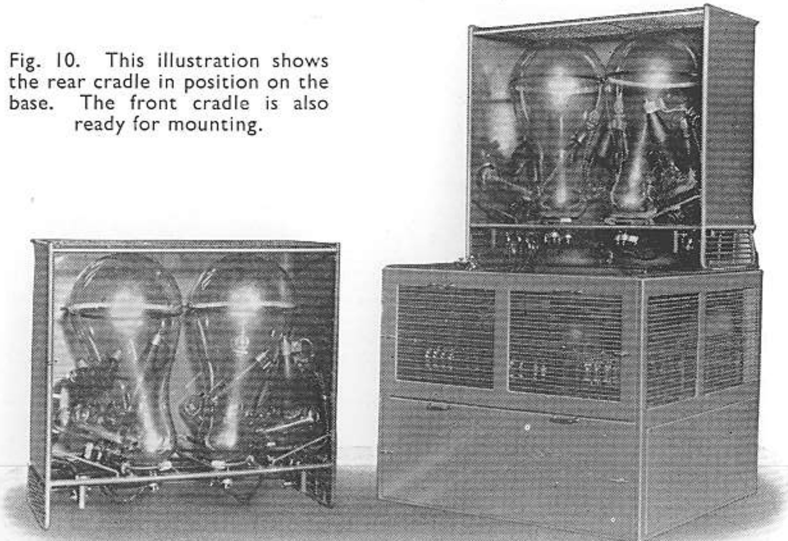


Fig. 10. This illustration shows the rear cradle in position on the base. The front cradle is also ready for mounting.

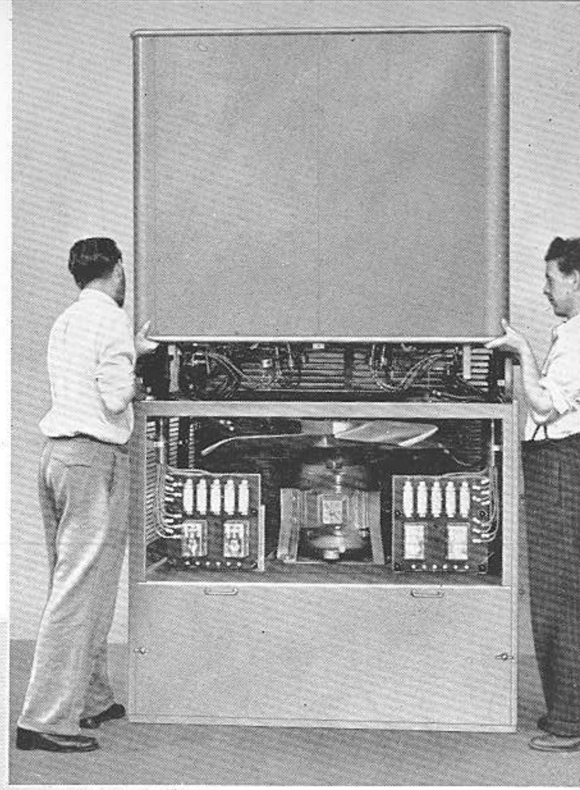


Fig. 11. The front cradle is brought into close contact with the rear unit after which both are clamped in position.

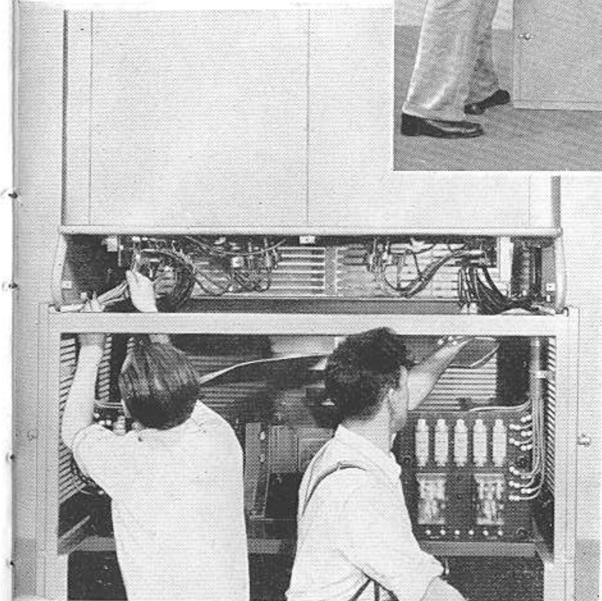


Fig. 12. Connecting the main and auxiliary leads to the cradle terminal boards.

When starting up for the first time, the front sheet may be left off if desired, for the better examination of the striking up of the bulbs and for observing the steady running on the exciters. Once this is assured, the sheets should be fitted to complete the ventilating system and to protect the bulbs from possible damage.

THE GENERAL PRINCIPLE OF THE MERCURY VAPOUR RECTIFIER

The mercury arc rectifier consists essentially of a highly evacuated vessel containing a mercury pool known as the cathode, and a number of electrodes known as anodes which are sealed into the arms forming part of this vessel. These anodes are usually made of graphite.

Its principle of operation depends upon the fact that, under suitable conditions, a stream of electrons can be drawn from the surface of the mercury towards the anodes, whereas under the same conditions there is no such flow from the anodes to the mercury pool.

The conditions referred to are that the rectifier must be evacuated to a very high degree of vacuum, that a " hot-spot " must be created and maintained on the mercury pool, and that the rectifier must be maintained within certain limits of temperature. (See " Operating Temperature ").

The " hot-spot " is initiated by drawing a small arc between a starting electrode and the surface of the mercury. This is just a momentary arc because immediately this " hot-spot " is created, there is a source of free electrons which enables the exciter anodes to strike up. These anodes are connected to the secondary winding of the single phase exciter transformer which gives an open-circuit voltage of 70 volts from either anode to the mid-point of the winding.

It will be seen that the exciter anodes are alternately at a positive potential to this mid-point, and therefore to the mercury pool which is connected thereto. As each anode becomes positive, a stream of electrons is drawn to it and passes round the circuit external to the bulb. This constitutes an electric current identical with the current generated by a machine or circulated by a battery. The two anodes, conducting alternately constitute a small rectifier, as the pulses of current from the cathode to the mid-point of the transformer are all in the same direction.

The early conception of an electric circuit, viz., that the current flowed from the positive pole of a battery or generator, through the external circuit to the negative pole, clashes with the modern electron theory.

Within the rectifier the electron stream is necessarily described as flowing from the cathode to the anodes. Externally, however, the current is spoken of as flowing from the cathode, via the load circuit to the mid-point of the transformer, which is always the negative terminal of a rectifier using this type of connection.

If an alternating potential is applied to the main anodes, and there is a complete external circuit, then there will be a similar electron stream to those anodes. Each anode conducts until the potential on the one connected in the succeeding phase reaches and exceeds its own falling potential, and thus the stream, or arc, transfers from anode to anode in synchronism with the alternations of the source of supply. In consequence of the retentivity of vision, all of the arms of a glass bulb type of rectifier appear to be conducting simultaneously, when operating on a 50 or 60 cycle supply.

It was stated earlier that a high degree of vacuum must be maintained in the rectifier. The Hewittic air-cooled glass bulb is a permanently evacuated vessel which does not need pumps and gauges for maintaining and checking the vacuum once the bulb is made and sealed, and since there is no consumption of either the mercury or the electrodes, it follows that the bulbs will run for an indefinite period without maintenance.

If the bulb is overloaded much beyond the combination of time and current specified as the overload capacity, then the anodes will reach such a temperature that they become capable of emitting electrons under the stress of the reverse voltage. This constitutes a " backfire " and may result in the blowing of a number of the anode fuses. Also the associated D.C. circuit breaker is liable to trip on reverse current, assuming that there is a possible feed back from some external source.

Similarly, if the fan should fail at any time while the

bulbs are carrying more than about a third of the rated load, condensation would not keep pace with the vaporisation of the mercury from the pool. The vapour pressure in the bulb would thus increase and this could reach a point where a "backfire" might occur. The fans, however, are driven by 3 phase squirrel cage motors of a very robust type, and failures are almost unknown.

At the other end of the temperature scale, there is the possibility of some surging if load is suddenly applied to a rectifier while the bulb is very cold (see page 22). This can cause momentary high voltages from the transformer and other inductive coils. To prevent damage to insulation, surge diverters are fitted between the outer ends of each phase, and the outgoing or load side of the interphase transformer and fan choke (where the latter is fitted). The fan choke ensures that below about a quarter of full load the fan merely crawls thus avoiding excessive cooling.

Starting and Maintaining Circuits

The full starting and excitation circuits are given in Fig. 16, but starting will be more readily understood from the simplified diagrams shown in Figs. 13, 14 and 15. These deal with this operation in three stages. In actual practice it happens so quickly that the eye cannot follow what takes place: the supply is switched on, and, to the accompaniment of the click of the starting relay, the bulb is "running on the exciters".

Stage 1. The exciter transformer gives an open circuit voltage of 70 volts from either 1 or 3 to the mid-point. Immediately this is energised, current flows via contact 6 of the exciter relay, through the protective resistor, R, to the lower starting coil (5.7) through the second contact of the relay (7.8) and the coil fuse to (2).

The starting electrode is immediately pulled into contact with the cathode pool. It will be seen that such contact constitutes a short circuit across this lower coil so that practically the whole of the voltage drop in this circuit occurs across the resistor.

Stage 2. The top starting coil, being in parallel

with the resistor, now receives sufficient current to pull the starting electrode from the mercury pool. This draws a small arc from the surface of the mercury.

Stage 3. The free electrons resulting from this arc enable the exciter electrodes to strike up and remain energised. It will be seen from the diagram, Fig. 15, that the circuits to the exciter anodes pass through the coils of the starting relay, as well as the exciter chokes. As soon as the bulb is running on the exciters the relay operates, and isolates the starting coils and the starting electrode. This usually happens too quickly to be observed and is the normal running condition the whole time the rectifier is in service.

On the full wiring diagram, Fig. 16, will be seen a set of small surge diverters connected across the exciter chokes and transformer. These serve a similar purpose to those connected to the main anode circuits.

This standard starting relay (Type Wx) has an

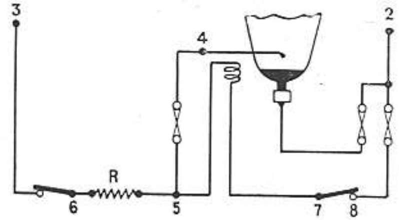


Fig. 13. Energising the lower starting coil.

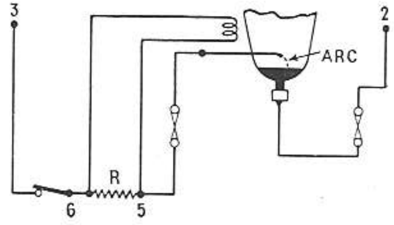


Fig. 14. Energising the upper starting coil.

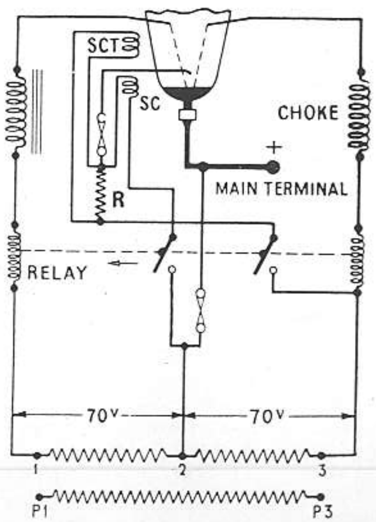


Fig. 15. The complete exciter circuit (running condition).

additional pair of normally open contacts. These can be used to give a remote indication that a bulb has not struck up with the rest, or for control purposes).

The value of the current circulating in the exciter circuit is governed by the exciter choke, and this is correctly adjusted whilst in the test department. The load is mainly inductive and the energy consumption for the largest bulbs is only about 200 to 250 watts.

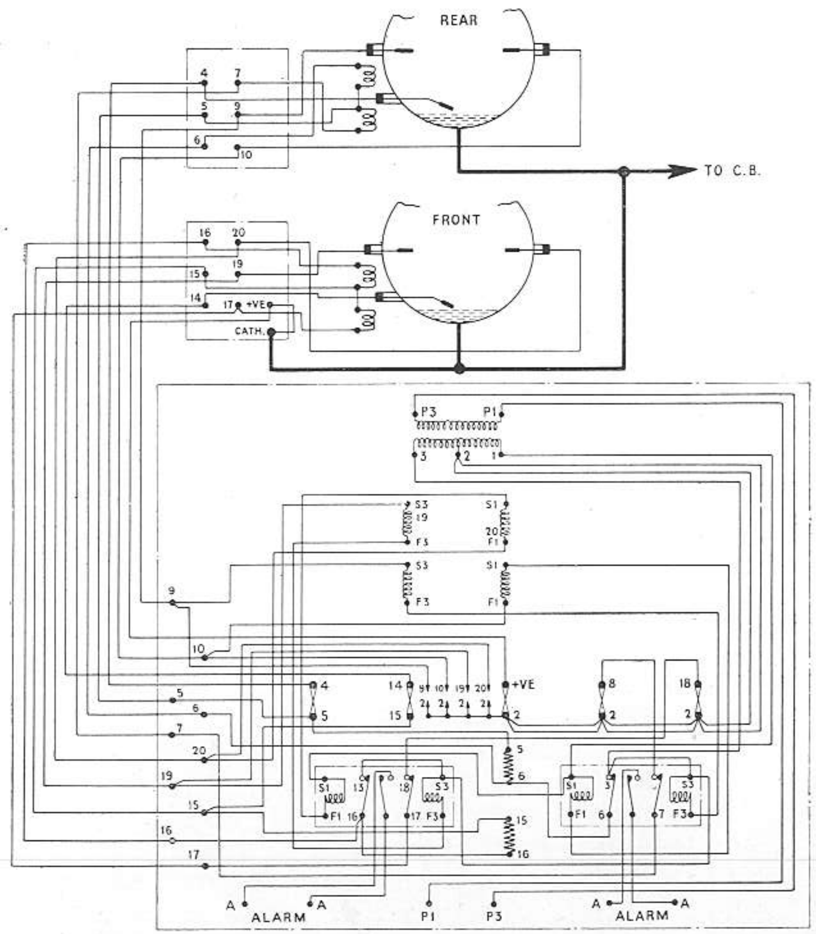


Fig. 16. Diagram of exciter connections.

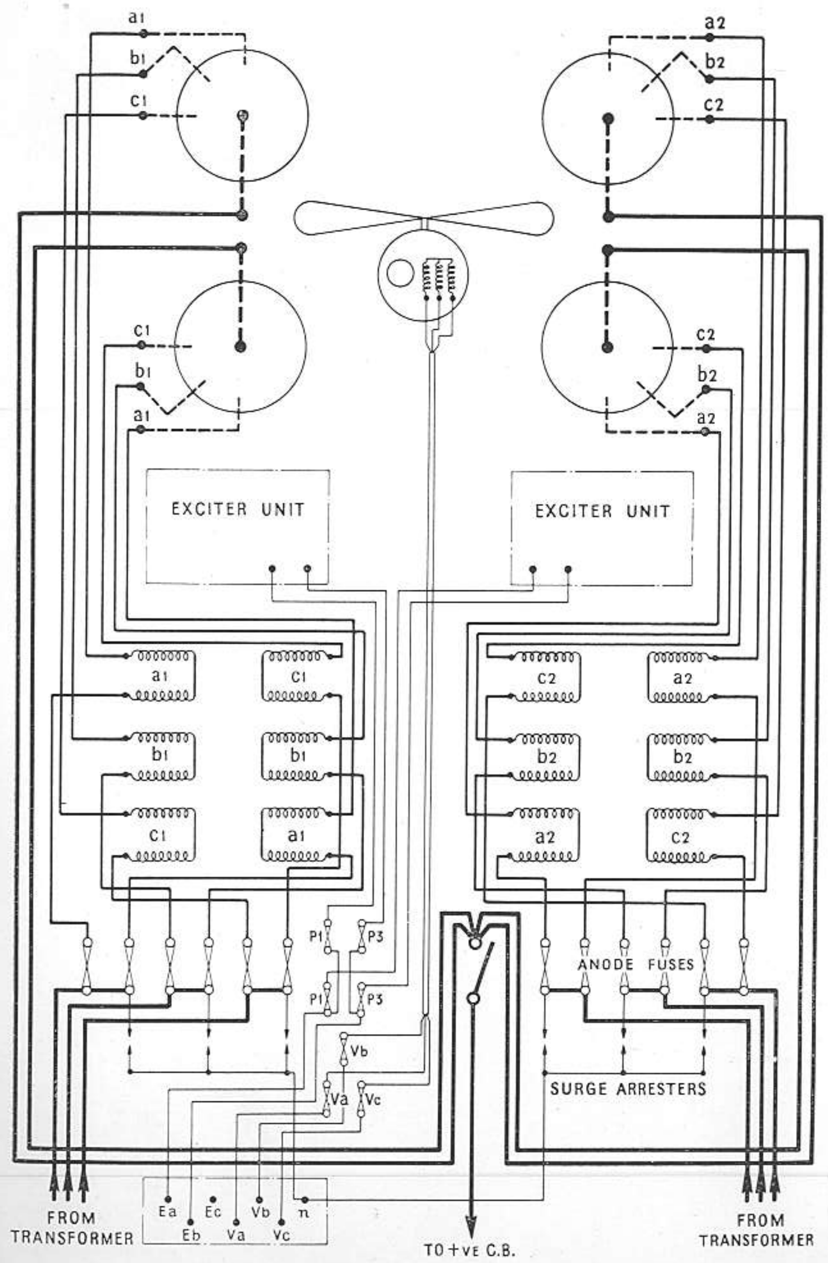


Fig. 17. Typical main wiring diagram for a four bulb cubicle.

ISOLATION FEATURES

Where an equipment comprises a number of cubicles, facilities are usually provided for isolating any one of the cubicles without interrupting supply from the remainder. (Care must be taken to ensure that these are not overloaded as a result of the reduction in plant capacity).

Cathode isolator operation. The cathode isolator is only a slow-breaking device and must not be withdrawn unless there is at least one other cubicle in parallel to take up the load. With another group unit or a second rectifier remaining in service there is no appreciable voltage difference across the isolator contacts at the moment of parting so that a simple link can be employed.

Isolating a cubicle. The cathode isolator (common to the four bulbs) is usually located in the centre of the row of anode fuses (see Figs. 19 and 21).

This must be withdrawn first, thus diverting the load to other cubicles, after which the 12 main anode fuses may be withdrawn. The auxiliary circuits are rendered dead by removing the excitation and the fan fuses.

All of the equipment above the sub-base (anode fuse compartment) is now completely isolated, and after the lower front cover has been replaced, maintenance can be carried out including bulb changing, without any risk to the operators. In some cases the relative positions of the cathode isolator and anode fuses may be different but the operation of the isolation features as described above will still render the bulb compartment safe.

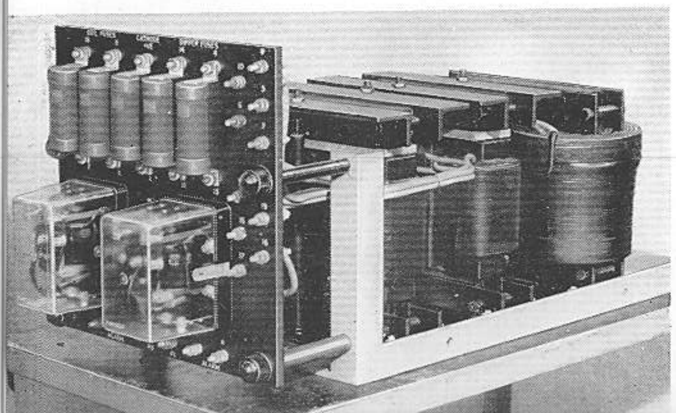


Fig. 18. A general view of the removable exciter unit.

Some exciter relays carry an additional pair of contacts for alarm or control purposes. According to the manner in which they are employed, steps may require to be taken to maintain operation of the plant or to prevent an alarm being given that the bulbs are not operating.

Restoring to load. To replace the unit on load the fan and exciter fuses should be inserted, upon which the four bulbs should strike up and remain running on the exciters. The anode fuses are then replaced and finally the cathode isolator, upon which, load will be picked up. Sharing with the remaining cubicles may not be uniform until the bulbs in this cubicle approach the temperature of those that remained in service.

If the alarm apparatus has been rendered inoperative for this cubicle it should be remembered to attend to this item at once, upon restoring the cubicle to service.

Units for operation at 1,500 or 3,000 volts are not fitted with isolation features, the cathode link being bolted in position, as are also the main anode fuses.

Balancers. In large 3-wire rectifiers, group unit cubicles can be used as balancers, with two bulbs each side of the midwire and fitted with two isolators. Before operating these isolators it is essential to see that another group is connected in a similar manner across the three wires and taking load, so that the midwire voltage is maintained.

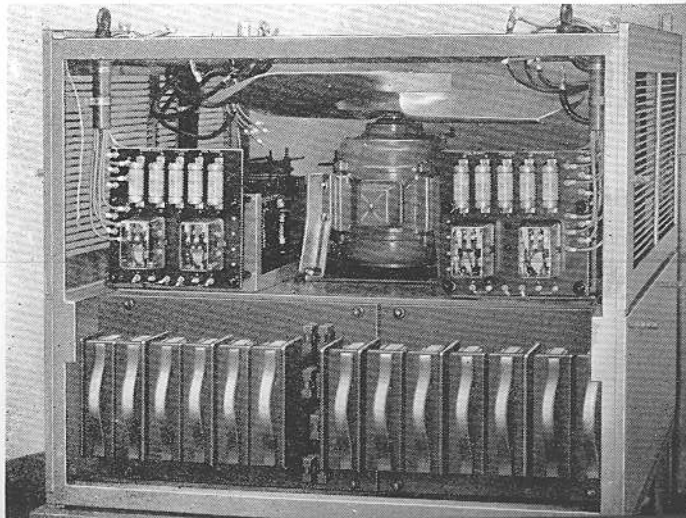


Fig. 19. A view of the base showing the main and auxiliary isolation features.

SWITCHING ON FOR THE FIRST TIME

The front sheet of each cradle should be left off until a trial run has been made to ensure satisfactory operation of each bulb on its exciters. The D.C. circuit breaker should be kept open so that no load is picked up until this trial run has proved satisfactory.

Where possible it is advisable to put the trips of the A.C. switchgear on a light instantaneous setting in case an unobserved fault exists.

Upon energising the main transformer it is usual for all of the bulbs to strike up almost instantaneously and remain running steadily on the exciter arcs. Should some of the bulbs re-strike a few times this does not necessarily indicate that something is wrong: it may be due to low ambient temperature. If this re-striking persists, it would be advisable to check that the voltage is not unduly low. The exciter transformer should give 70 volts from either terminal 1 or 3 to the mid-point 2 on open circuit. If this is low, then either the main transformer is on a plus tap or the supply pressure is below the declared pressure. In either case, a change of transformer tap will remedy this trouble. (Note: the taps being in the primary side of the transformer it is necessary to change to a *lower* tapping to *increase* the secondary volts).

Checking exciter current. If running on the exciters is still unsteady, it is advisable to check the current. This is always done in the cathode connection, where the flow of current is continuous, whereas in the anode leads it is a succession of intermittent pulses, being neither alternating current nor continuous current.

The left hand exciter unit feeds the front and rear bulbs on the left-hand side of the cubicle, the right-hand unit similarly feeding those on the right.

The lower series of terminal numbers is associated with the bulbs at the rear, and those greater by 10 apply to the front bulbs. (See Figs. 16 and 20).

Remove the cathode fuse, marked positive —2, and replace it with a suitable moving coil ammeter. Since

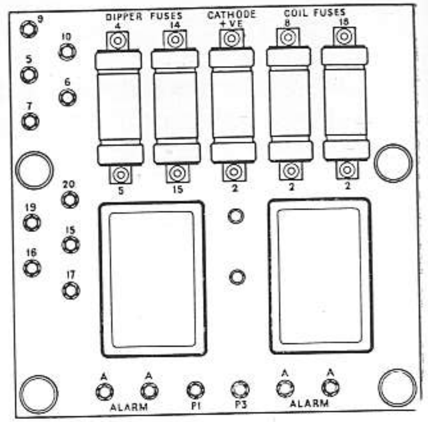


Fig. 20. Showing markings and location of components on the terminal panel of the exciter unit.

this fuse is common to a pair of bulbs it will be necessary to prevent the bulb not being checked, from striking up. This is done by removing the coil fuse 8 (in the case of a rear bulb, 18 for a front one). On no account should disconnection be attempted by removing the dipper fuse (4 or 14) as this will leave the starting coil energised: these coils are not continuously rated.

The correct current for a 400/3 type bulb is 7.4 to 7.8 amps, and for a 550/3 bulb 7.8 to 8.2 amps. To increase the current the gap in the exciter choke must be increased. Loosen the clamping bolts and add about $\frac{1}{16}$ in. of presspahn or similar material to the packing already there. Tighten the clamps before making a further test and see that they are thoroughly tight upon completion as otherwise the choke may become noisy.

Checking phase sequence. When a rectifier plant is switched on for the first time the direction of rotation of the fan must be checked: it should be clockwise when looking down on the blades, so as to blow air upwards to the bulbs. Test the draught by hand, as, due to stroboscopic effect the fan will, at certain speeds, appear to be rotating in the opposite direction.

Should the rotation be incorrect it will most likely be the result of the primary connections to the transformer being non-standard, since the fan connections are not disturbed once the cubicle passes out of the test room.

In the case of ordinary rectifiers, phase sequence is of no consequence and correction could be made by changing over two leads of the fan. This, however, is not recommended as it may lead to complications, or even a severe short circuit, should A.C. extensions and interconnections be made at a later date.

In the case of grid controlled rectifiers it is imperative

that phase rotation be correct. The fan, *connected as despatched from the works*, would serve as a reliable phase sequence indicator.

SWITCHING ON NORMALLY

The equipment should always be switched on by closing the A.C. switch, with the main D.C. circuit breaker open, so that the exciter relays can operate before the rectifier is put on load. (In some traction equipments, the D.C. switch is a high-speed breaker which is permanently latched in. In this case it is usually arranged so that all feeder breakers are open, and that they close automatically after D.C. volts appear on the bars). As soon as the D.C. switch has been closed and the rectifier begins to take load, it is a good plan to check by observation that the bulbs are each taking approximately the same load. At the same time it should be checked that all the fans are going at approximately the same speed and, if the load is varying, that they come up to full speed at approximately the same time, usually at about half load.

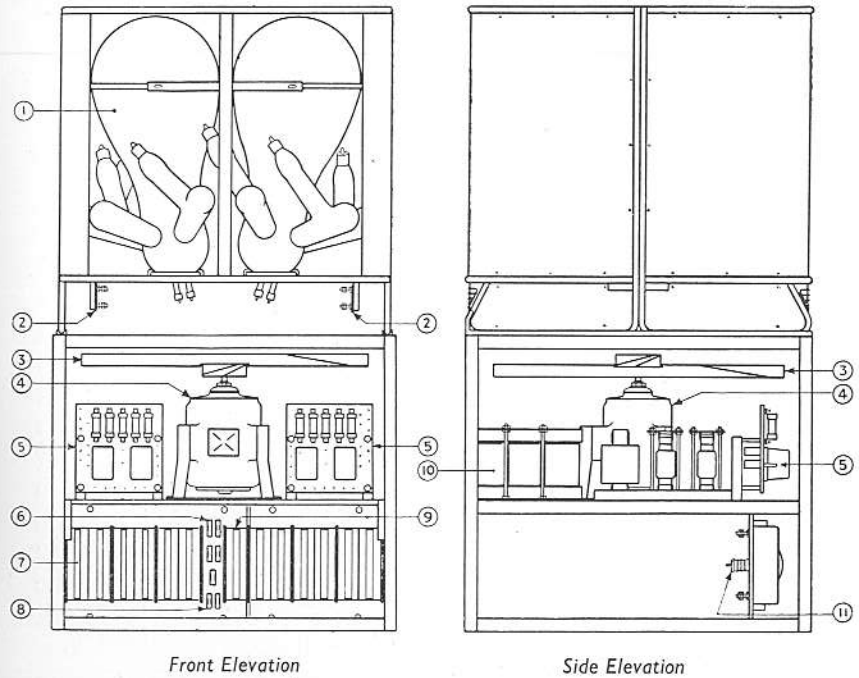
It should be noted that at very light loads the fan speed is dependent on bearing friction only, and some may be stopped while others rotate very slowly. This does not matter.

OPERATING TEMPERATURE

The best ambient temperature for mercury arc rectifiers is between 10° and 30°C (50°-86°F). Higher temperatures are permissible when an allowance is made for this in the original design of the plant.

Glass bulb rectifiers are less susceptible to low temperature than other types and, if not fitted with grids, may be operated down to 5°C (41°F). When fitted with grids for voltage control, however, they must be maintained at a temperature above 10°C if erratic operation and possible damage to the plant are to be avoided; THIS IS MOST IMPORTANT.

Therefore, whenever a grid controlled rectifier is installed in a location which may be subject to low temperatures, artificial means should be used to maintain the bulbs at a temperature not less than 10°C, both prior to starting and during operation. Where considered necessary thermostatically controlled heaters can be built into the cubicles during manufacture in the Works. This dispels any anxiety on the point and also is far more economical than keeping the whole of an unattended substation warm throughout the winter months.



SCHEDULE OF COMPONENTS

(1) Rectifier bulb
(2) Bulb cradle terminal board
(3) Fan blade
(4) Fan motor
(5) Exciter unit
(6) Exciter fuses
(7) Anode fuses
(8) Fan fuses
(9) Cathode isolator
(10) Anode chokes
(11) Surge arresters (when located in the cubicle)

Fig. 21. Arrangement drawing showing main components of the equipment.

GENERAL MAINTENANCE

The general maintenance which it is necessary to carry out is very small. Fig. 21, along with the adjacent schedule, indicates the main components of a standard type G.T. equipment.

Exciters. Provided that the exciters operate satisfactorily, no attention need be paid to the exciter relay or any other parts. It will be noted that the relay is enclosed in a dust-proof case so that unless a large amount of starting of the equipment is carried out, only occasional inspection of the contacts is required.

Dusting. The equipment will operate satisfactorily without cleaning or dusting. If dusting is carried out it should be confined to portions beneath the bulb chamber. The dust that settles in the bulb chamber above the fans will in no way impair operation.

Fans. The cubicle fans are driven by totally enclosed, low-voltage (110 volts) 3 phase induction motors and require no attention other than occasional lubrication.

Type CR.12 motors are oil lubricated and the recommended oil is Shell Tellus 27, alternatively Vacuum DTE or Wakefield's Hyspin oil. Each bearing has an oil feed pipe and reservoir, which should be filled to the red line painted thereon. When first filling the top bearing oil reservoir, or on replenishing when the oil level is low, the air release screw should be removed from the bearing cap. The oil flows slowly down to the bearing oil well and it is essential that filling of the reservoir be continued until it is certain that the bearing is filled. Replace the air release screw after filling.

In the case of a half group unit, type ½G.T., two smaller fans, type W.10B9 are used and these are grease lubricated. ~~Wakefield's Speeroil S or Aero-Shell No. 4 are recommended.~~ Here the grease caps are removed, filled with grease and screwed back again on to the feed pipes. *The recommended grease is Shell Alvania No. 3*

Care must be taken to prevent the ingress of dirt when re-lubricating, and oil reservoirs and grease caps

should be wiped clean beforehand. "Topping up" of the oil wells must be given regular attention: the frequency of this may vary from 1,500 to 2,500 hours operation, depending upon local conditions.

It is recommended that motors be taken down after 15,000 to 20,000 running hours and the bearings cleaned as follows:—

Oil Lubricated Bearings. Bearings, reservoirs and pipes should be swilled out with warm, clean Shell Tellus 27 oil and drained. The reservoirs are then refilled as described on page 24.

Grease Lubricated Bearings. The old grease can be run out by warming the bearing, followed by swilling with clean paraffin or petrol and draining. The bearing is then repacked with grease and the motor reassembled.

The utmost cleanliness is essential until the overhaul is complete, as any gritty dust entering the bearing would cause rapid wear and necessitate early replacement of these precision-ground parts.

The designation of the upper bearing is R&M, XLJ3 and the lower bearing is type R&M, LJ 1⅛ (R&M type LJ25 and LJT17 respectively, in the case of half-group units).

The fan blade is made of wood, and after running for some time the wood may shrink a little. It is desirable to tighten up the hub bolts when this occurs. This point should be checked once a month for the first four months and then every six months or so when the fan motor is oiled.

All fan blades are individually keyed and fitted at the works, so that in cases where assembly is necessary on site, the blades require pushing on at the hub by hand only, after the key has been placed in position on the shaft, the top retaining screw then being fitted and tightened. On no account should the blades be hammered on to the shaft as damage to the bottom ball race may result.

Fan supply. Reference to the transformer diagram

of connections will show that the fan supply is taken through a 3-phase saturable reactor (fan choke) which is saturated by the main D.C. current. This proves a very simple way of controlling the speed of the fan in proportion to the load carried by the rectifier. It does mean, however, that the volts applied to the three phases are generally unequal by about 10 per cent. Inequality of the volts at the fan terminals, therefore, should not necessarily be regarded as meaning that a fault has occurred, either in the fan winding, or in the supply. Similarly, there is usually a small unbalance in the current taken by the three phases of the fan. If the fan motor is suspected, it can be checked easily by supplying it from a separate source and taking test measurements in the usual way. The 3-phase auxiliary supply is usually accessible for this purpose.

TRACING FAULTS

The small number of moving parts required in a glass bulb rectifier naturally results in almost complete immunity from faults or interruptions of any sort. But there may come a time when a bulb fails to strike up: the attendant will then require to know the quickest way to locate the trouble and restore it to service.

Assuming that all of the phases of the A.C. power supply are alive and of normal voltage (it may be found necessary to check this), the trouble will be found to be one of three things :—

(1) Defective starting relay.
(2) Blown auxiliary fuse.
(3) Defective bulb.

Procedure. The type W starting relay is unlikely to give any trouble for many years. The contacts are in use only momentarily at the striking up of the bulb and the whole relay is protected by a dust-proof cover. This is transparent, so that the condition of the contacts can be observed without admitting dust from the atmosphere, etc. No provision is made for adjustment—in fact the

screws are sealed, it being considered preferable to replace a defective relay with a new one and return the original one for investigation (on plants overseas this, of course, may not be practicable).

In the case of a blown auxiliary fuse the cause of blowing must be investigated before replacing the fuse, as it indicates either a defective starting coil or resistor, or a fault on the auxiliary wiring for that particular bulb. (**Warning :** The exciter circuits are connected with the positive busbar of the rectifier : if this is alive from bulbs that are continuing to operate, or from an outside source, the proper precautions must be taken to prevent an accident).

Refer to Figs. 13, 14 and 15, and also the diagram of exciter connections. If the dipper, or starting electrode, pulls into the mercury and remains there it indicates that fuse 4–5 is blown, otherwise the electrode would short circuit the lower starting coil and cause its own release. The blowing of the mid-point fuse, 2–8 or 2–18, will obviously prevent any attempt at starting up as the lower starting coil cannot be energised.

The blowing of the cathode fuse will cause the dippers of a pair of bulbs to continually make and break contact with the mercury but there will be no spark and the exciters cannot strike up.

Should the dipper of one bulb oscillate and produce a whitish spark without the exciters attempting to pick up the arc, the bulb probably has lost its vacuum.

If the bulb operates steadily on its exciters then there will be nothing wrong with the bulb itself, and any difficulty in the way of picking up or sharing load will be the consequence of a defect in the external circuits such as a blown anode fuse. Check with a voltmeter or detector and replace as required, using only the same type of fuse. Confirm also that the cubicle fan is able to draw an adequate supply of air for cooling the bulbs. It will be observed sometimes that one of the bulbs is reluctant to pick up load. This is because the available load per bulb is very low and possibly the ambient temperature

also is low. When the demand increases the bulb should start to take its due share of load.

TESTING FOR LOSS OF VACUUM

A suspected bulb should be removed from its cradle and manipulated so that mercury pours into an exciter pocket at a moderate speed. If the vacuum is unimpaired, this will produce a sharp metallic click, whereas if there is appreciable air in the bulb then it will produce only a dull leaden sound. Further, it may then be possible to trap small bubbles of air in one of these pockets and, if any are seen, there can be no further doubt as to the condition of the bulb.

CARE OF DAMAGED BULBS

As soon as a replacement bulb has been installed in its cradle the defective one should be placed in the vacant bulb case for return to the Works. Even though an arm may be broken off it may be possible to repair it at appreciably less cost than that of a new bulb. For transport purposes all of the mercury must be in the inverted condensing chamber: if any appreciable quantity is left in an arm further damage could result in the event of rough travelling.

NOTE.—When inverting a large bulb it is imperative that an assistant handles the condensing chamber. As the mercury runs to this end of the bulb the sudden transfer of weight would almost certainly cause a single operator (or even two) at the other end to lose control without such assistance. (See Fig. 6).

EMPTY BULB CASES

Where equipments are supplied for overseas service the bulb cases need not be returned, but one or two should be retained in case it is necessary to return a bulb for repair.

With equipments for installation in the British Isles the bulb cases are supplied on loan and should be returned.