Riv 2. THYRATRONS.

# STRAND LIGHTING

# CONTROL

STRAND ELECTRONIC CONTROL

for

B.B.C. RIVERSIDE STUDIO NO.2

Technical Description.

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THE STRAND ELECTRIC & ENGINEERING CO., LTD.
*Head Office and Showrooms* 29 KING STREET COVENT GARDEN LONDON W.C.2

# STRAND ELECTRONIC CONTROL.

## for

## B.B.C. RIVERSIDE STUDIO NO.11.

### Technical Data.



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1) General.

The output of this electronic control is 115v UDC, with a variable load having a maximum of 2kw. per circuit and is obtained from a three phase 120v supply. The current in the supply neutral is the sum of $\sqrt{3}$ times a phase current in any one circuit. Because of the preponderance of harmonics in this system, it must be remembered that the positioning and size of the neutral does not conform to the usual three phase standards.

Throughout this description and on all drawings, the letter "p" will denote a circuit number, and the letter "q" will represent the respective preset or phase colour (if applicable).

The 120v three phase supply is coloured Red, White and Blue, this being the vector rotation. It is split into three by B.B.C. switchgear, and hence feeding banks one, two and the auxiliary independently.

Bank one and the auxiliary will work as a pair, but bank two and the auxiliary will only work if the 120-160v D.C. supply is working in bank one as well.

2) The following is the sequence of events when the supply is switched on.

a) The bias voltage (in bank one only) of 120-160v D.C. is made live and formed from the full-wave rectification of a 3 ph. delta-delta transformer. It is

It is smoothed by a choke input circuit, giving a good regulation and a max.permitted ripple of 1v peak to peak.

b) The phase shift voltage is produced by 3 separate transformers, T14/R.W. & B, connected in ~~delta~~ star-star. The output voltage being 2.5v. per phase, and 4.33 line voltage. The phase shift is such that the output voltage of the grid transformers T11/P/Q is 90$^{\circ}$ lagging on the respective anode voltage. The grid transformers are connected between phases, with the ratio of 1:10, thus giving a secondary output of 43.3v.

c) All the filaments are heated up via transformers T12/P.

d) The heater transformers T.13, supplies 6.3v to a variable resistance and thence a delay valve which controls a relay that operates the anode isolating contactor. The variable resistance R.105 is set to give a contact closing delay of 75 secs.± 15 secs.

e) The static side of the anode isolating contactor is made live.

Before the control can be used, the auxiliary bank must be switched on, as it supplies the 15v. D.C.and the 50v. A.C. necessary to operate the relays and faders.

Having now livened the whole of the control, it will be found that after the delay has warmed up, the contactors can be brought in by operating either the D.B.O. key switch and/or the Dead Patch switch. Once the D.B.O. contactors are closed, the board is ready for use.

3) Theory of a single valve.

The valves used in this installation are "soft", i.e. the envelope is filled with an inert gas. The grid can only prevent the valve from conducting, so that once donduction has commenced, the valve will continue to conduct, until such time as the anode voltage falls below a certain value, or the anode circuit is interrupted.

If the grid is held sufficiently -ve. with respect to the cathode, the valve will not conduct. If this voltage is reduced (i.e. made more + ve), a point will be reached when the valve will conduct. If A.C. is the applied anode voltage, it will conduct until the anode voltage falls to the deionising value (approx. 15v) on the positive half cycle.

The term "control ratio" is obtained from the relation of the applied anode voltage, at the time of firing, (ionising) to the grid voltage. An example of this is as follows:-

Va = 200v. Vg- 5v.
Control ratio = 40:1

It can now be seen, that by using very small grid voltages of low current value, large voltages and currents can be controlled.

From fig.1 it can be seen that, with A.C. 100v + ve. occurs twice, once as the voltage rises, the other as the voltage falls. If, therefore, a steady D.C. is applied to the grid, the valve will always fire on the rising side of the curve. To obtain control of the falling side, the D.C. will have to be modulated with A.C. This is done by means of the phase shift (T14/q) and grid transformers (T11/p/q). The output of the latter is 43v. and can be seen in fig.1. When no D.C. is applied, the grid voltage oscillates about zero, thus the valve conducts for 60% of the cycle. The positive peak of the modulated grid voltage has been shifted in phase, so that it coincides with the zero voltage of the falling +ve half cycle. By moving the A.C. control voltage zero potential -ve, with respect to the cathode, control over the whole of the anode + ve half cycle can be obtained.

Referring to fig.1 the continuous line (A.C.control voltage) is shown below the 5v-ve cut-off line, and therefore the valve will not conduct, since at no time is the control voltage above 10v-ve. A chain line shows the resultant position of the modulated control volts in reducing the D.C. by 15v. Part of the A.C. control volts is now less than 5v.-ve., and reaches this value at point x. The valve will now donduct and continue until the anode volts reach approx.zero and will do so for each + ve half cycle, giving a conduction time "A". A further decrease of 15v D.C. will raise the control voltage to the dotted position. The valve will now commence to conduct at point Y, giving a conduction time "B", and so on until full output voltage is reached.

4) Operation of three valves per circuit.

A three phase supply is used, and withone thyratron per phase, this gives half wave rectification to a U.D.C. (uni-directional current) of approx. equal R.M.S. voltage to that of the supply phase voltage. (A moving iron, or dynamometer instrument is required to read U.D.C.) The greatest advantage with this system is that it offers no phasing problems with socket outlets in the studio.

Only one valve is conducting at any one time, otherwise there would be a dead short between two phases. If two anode fuses blow, and there is no apparent reason for their failure, a "back fire" in one of the valves can be assumed.

The load is taken from the centre tap of the common heater transformer winding. This is done because the valves are directly heated, and the load current passes through the filaments. If the load was taken off one side, there would be unequal current distribution in the filament causing serious harm. To reduce voltage drop in the heater transformer, caused by the load passing through it, the filament voltage is only 2.5v, thus offering a low impedance path to the load current. (The load current also reduces the reflected impedance in the primary).

Having used half wave rectification, there is no balancing out of current in the neutral, therefore, the neutral must be able to carry the total lamp load, i.e. $\sqrt{3}$ times phase current.

Each valve is protected by a fuse and a choke. The fuse will blow with continuous heavy current, whilst the choke will reduce large transients. These heavy transients are always present when switching on cold lamps, as their cold resistance is approx. ⅓rd. of their hot resistance.

The smooth D.C. control voltage is applied to one side of the grid transformer secondaries (T11/p/q), the other individual side having the correct phase modulation for the valve it is to control. This voltage is then fed via the grid resistor to the grid capacitor, and a voltage appears across it as a charge.

At a critical voltage, the grid will allow a few electrons to reach the anode, from the cathode, and when sufficient velocity is reached, the gas will ionise. At this point, the cathode potential will rise, driving the grid more positive by the positive feedback obtained via the short CR, supplied by the grid capacitor (C103/p/q) and resistor (R101/p/q).

The positive feedback is passed through the grid transformer (under fault conditions it may cause the latter to burn out) into the control line. If this feedback is permitted, "talk" between circuits and valves will occur. To prevent this, each control line is decoupled by capacitor C102/p.

In practice it is found that a delay is required when switching from one dimmer preset to another, so the decoupling capacitor has been increased in value, thus offering a delay in the rise and fall time of the control line voltage, (i.e. time is required to charge and discharge the capacitor when the control line voltage varies).

All lamps made in this country are designed for 50 c/s. operation, and thus, when used on 150 c/s U.D.C. they "sing". This is caused by magnetostriction in the "lead in" wires, together with the inductive forming of a coiled filament. To reduce this noise, a filter system (C101/p and H11/p) is introduced into each lamp circuit, thus tending to smooth the output somewhat.

5) Basic Control.

The cross fader (R112) consists of two potentiometers connected back to back across 120-160v D.C. This voltage is adjustable by taps on the main rectifier, and affects the full-on voltage of the lamps.

Across this floating supply (see fig.2) is connected the blackout pot., the wiper of which is connected to the neutral, so that the correct bias can be applied to the valves when the levers are in the "off" position, (i.e. when all levers are down, the wiper is adjusted so that all valves are just cut off).

Two master faders are fed from the cross fader, each having one end connected to + ve. The other end of the master faders being connected to their respective cross fader wiper, and the common connections of the control units. The master fader wiper feeds its master blackout switch, which in turn feeds the respective control unit switches, via the preset relays.

Each circuit has two control units, providing between them the required grid voltage. When the right preset is being used, the left preset must be at full + ve potential, and vice versa. This achieved by the function of the cross fader always ensuring that, as the voltage across the left strips rises, the voltage across the right strip falls, or vice versa. This ensures a smooth proportional change from one preset to another.

The grid control voltage is taken from the mid-point of two equal resistors (R 102/p/q) connecting the wipers of the left and right control units together. They, in conjunction with the control line decoupling capacitor (C 102/p) offer the required switching delay.

6) Three Scene Preset.

The Cross, Left and Right faders, are remotely operated from the control desk, and will be found on the Auxiliary Bank.

As two control units must always be connected for any one circuit, a 3 scene preset board is provided with two dummy units. This enables an operator to accidently select a preset already in use, without causing any trouble. (He must not, however, cross fade to preset which is already in use). A warning light informs that a preset already in use has been selected.

If "snap" changes are required between presets, the preset selector on the opposite side of the cross fader to that being used, is set to a dummy unit, leaving all the presets available on one switch.

Each preset is brought in by a coupler strip, (housed in a wooden box below the control desk) and actuated by six 3,000 type relays. ON NO ACCOUNT SHOULD THESE RELAYS OR COUPLERS BE OPERATED BY HAND, EXCEPT WITH THE MAIN SUPPLIES OFF.

The master blackout switches operate relays which feed the control unit bars from the preset relay contacts.

Under normal conditions, two of the coupler strips per bar will be in the operated position.

7). <u>Dead Patch and Blackout.</u>

The dead patch switch operates the contactor controlling the anodes of valves in the respective patching area, of which there are four. The D.B.O. (in the form of a key switch) operates all the contactors together with the 5 kw. and switched only circuits.

Each preset has two blackout switches, (one for channel switches in the "up" position, the other for "down"). The "mid" position is "off", "down" is "normal", and "up" connects the respective electronic and switched only blackout relays to the practical ring main (15v D.C.) around the studio floor.

The blackout switches are always live, their outputs being selected by the preset selector switches. The electronic channels are kept separate so that there is no time delay in waiting for the blackout relays to come in, when changing to a new preset.

Switched only channels have their connections broken down to individual wires, thus preventing feedback between presets. The blackout coupler relays facilitate dead patching.

Secondary control of switched only channels is provided on the patch panel. If, however, the master switch is left in the on position, the desk operator cannot over-ride the patch panel.

The "Lap Change" switch operates the switched only circuits in the selected preset. The actual changeover taking place at two different predetermined positions in relation to the cross fader. One is that the new selected preset comes on as the cross fader starts to travel, and the old lighting extinguishes as the cross fader ends its travel. The second conditions of operation, is for the new light to appear when the cross fader is at 25% of its travel, and the old light to go out when 75% of its travel is reached.

8) <u>Motor Speed.</u>

When the "Motor" switch is on, a relay closes and energises the motor field. At the same time a potentiometer is made live and thus by any one of the speed relays being operated, the armature will be fed, via a series field winding, with a constant voltage. The motor is a 50v d.c. compound wound machine, having constant speed characteristics for varying loads, at speeds in proportion to the applied armature p.d.

The motor turns a uni-directional shaft

supplying motive power to the clutch plates for 4,5kw. resistance dimmers, two master and one cross fader.

9) Faders and 5kw. Dimmers.

The cross fader is operated by a switch on the control desk. This feeds two relays via wiper travel limit switches on the cross fader framework. The relays are to reduce the current that would be passed by the switch, as double clutches are used to obtain the required torque. Also mounted on the cross fader frame are four limit switches which operate the switched only circuits. (See section 7, para 4.) A meter indicates the position of the cross fader.

Two separate polarised relays operate the left and right master faders. These are controlled with dimmer levers on the centre section of the control desk, by feeding a selected voltage from a potentiometer-winding. A similar potentiometer on the fader frame feeds back a voltage, and the two meet at the polarised relay. If these two voltages are not equal, a current flows in one or the other direction, and the relay operates. The clutches drive the dimmer until a state of balance is reached.

The 2,000 ohm. resistance is to prevent the wiper becoming temporarily disconnected from the strip, due to dust or a broken winding. If dust is present, the dimmer will agitate until the obstacle is removed. If the strip is broken, the dimmer will move to the full-on position.

The rectifier across the clutch coils is to suppress the field discharge.

TROUBLE-SHOOTING.

| | |
|---|---|
| No light. | Check circuits by using load check. Check anode fuses but do not replace more than once. |
| Reduced light, i.e. 1 or 2 valves out. | Check anode fuses, and valves. |
| Reduced light, but repeated blowing of anode fuses. | Check for overload. |
| One or two valves out in adjacent circuits. | Check contactor fingers, i.e. fingers not making good contact. |
| Wing completely dead (including heaters). | Check valve heater fuses. |
| Wing dead, but heaters on. | Verify Patching Sect. Dead switch is on. If "on" then put "off" and "on" deliberately to check by ear that the bank contactor works. If contactor is not working, check valve time delay fuses (pair). If fuses are withdrawn or replaced, some delay up to 2 min. will result, before contactor can be closed. If fuses O.K. then the back centre covers must be removed. If time delay valve is not glowing, then replace. Valve not at fault, then check relay is closed and making contact. Relay O.K. then examine 300 amp. contactor. |
| Dimming erratic. | Check phase shift fuses on bank centre panel, but put the appropriate Patching "Sect Dead" down first. |

| | |
|---|---|
| All circuits up at low light whether switched on or not. | Check D.C.output fuses. |
| Low light output on all circuits with dimmer levers up. | Check 3 ph.input fuses. to D.C. rectifier on centre panel Bank 1. |
| Crossover fader will not operate a preset. | Check that at least two coupler strips have operated when the selector is switched to the offending preset. <u>NEVER</u> operate the selector relays by hand, unless the supply is switched off. With supply off, check selector relay contacts and coupler coils. |
| One circuit fails to go right on one or more presets. | Check R102/p/q for value and tolerance. (There are 4 per circuit, one per preset plus a dummy). |
| Circuit has very fast response. | Check decoupling capacitor C102/p. |
| One or more valves refuse to go out. | Check position of "Blackout Adjust. pot. |
| Circuit comes up full at certain positions of the dimmer lever. | Check dimmer strip for dirt or gaps in winding. |
| Circuit "jumps" when dimmer not being operated. | Check valves in respective circuit. |
| Two anode fuse per circuit blow for no apparent reason. | Check valves for back-firing. |

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FIG. I.

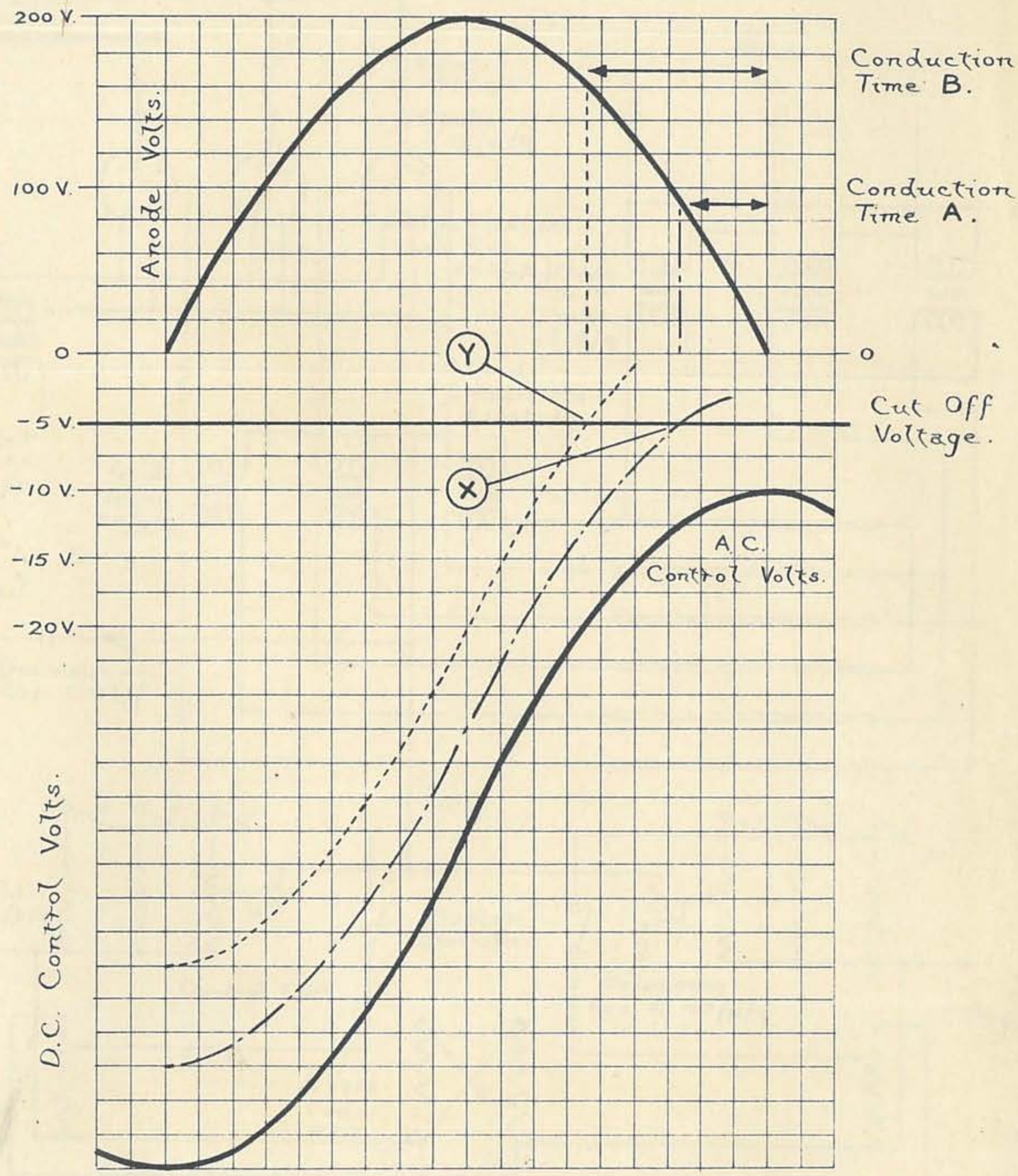


FIG. I.

20-3-57.

D 777.

FIG. 2.

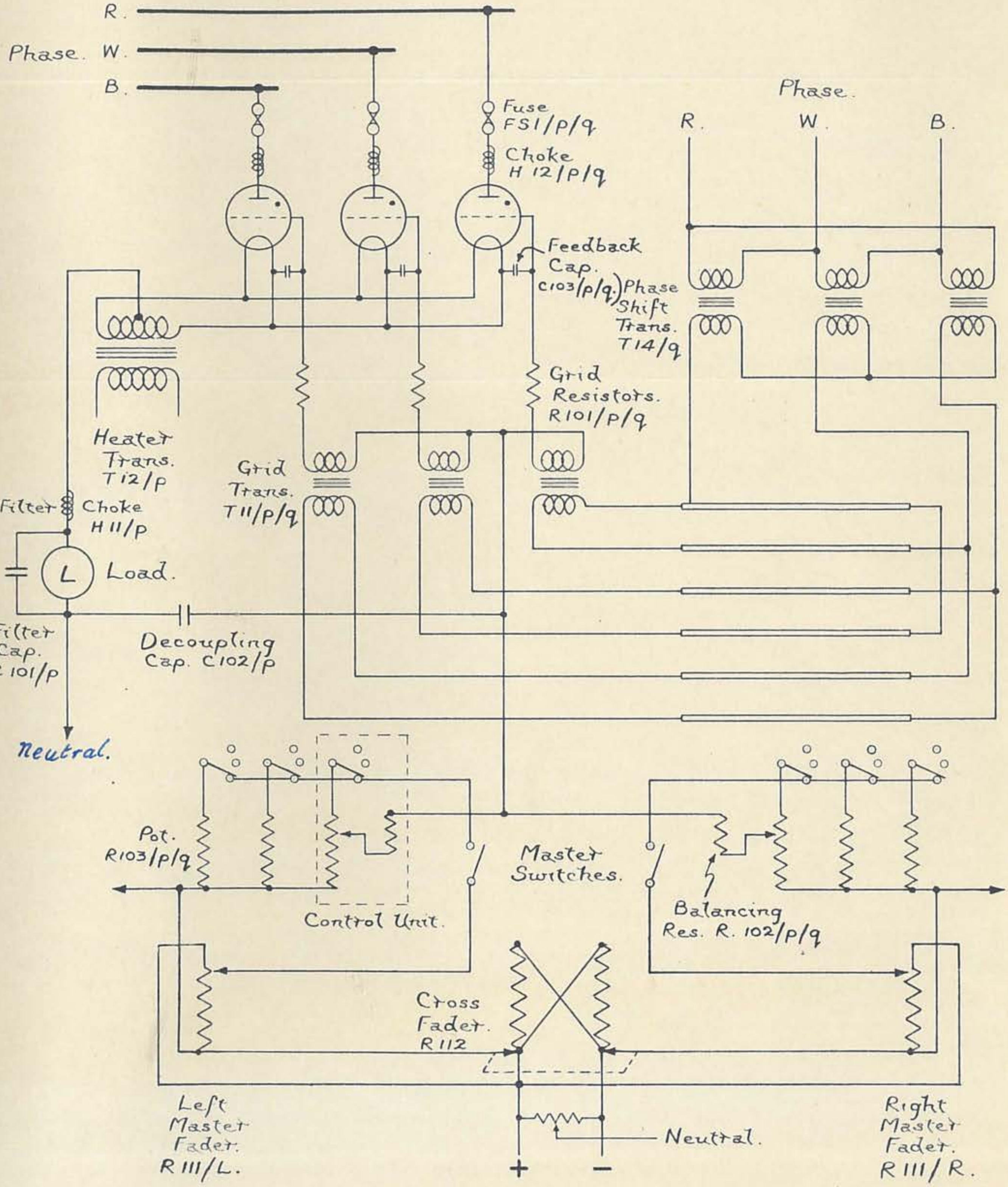


FIG. 2.

19-3-57.

D 776