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THE BRITISH BROADCASTING CORPORATION

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Basic Circuit

The Thyratron Control System as Used in Studio R.2

1. Introduction

This studio has installed for lighting purposes a Strand Electric Thyratron system which has been specially developed for use in television studios. It consists of 304 studio lighting circuits plugged by jacks into sockets for 144 channels. Eight out of every twelve channels has a thyratron dimmer, the remainder being controlled by contactors, each channel has 3 independent control circuits. There are in addition four 5 kW motorized resistance dimmer channels. The complexity of the system is justified by the flexible facilities available giving much better control of lighting and lighting cues and permitting alterations to be made during transmission. It will also enable the total studio load to be reduced by reducing the lighting power used on any set when it is not actually being used for production purposes.

2. The Basic Circuit

The system is driven by three phases, supply 415 volts, which comes from a special switch station in another part of the building. This is transformed by a voltage regulated transformer to 120 volts R.M.S. per phase, which is regulated $\pm$ 1%. Each of these phases is then taken to the anode of a group of Thyratrons which have common grid and cathode circuits. These Thyratrons, Type XR16400, are directly heated, each group of three having a common heater transformer which is centre tapped to form the tapped load. This is then decoupled by a filter circuit (which was introduced to reduce singing noises from lamps), before going to the jack panel. The grids are energised individually with approximately 70 volts peak to peak of A.C. super-imposed on D.C. control voltage. This D.C. voltage is varied by the individual circuit faders and also by the master faders and the cross-over fader. The A.C. component of this grid energising voltage is so phased as to lag 90%, with respect to the individual anode supply.

In operation the variation of the D.C. control voltage raises or lowers the peak of the grid waveform with respect to neutral and so causes the valves to fire at an earlier or later time. This change in conduction time alters the main current through the valve and consequently the current through the load. It should be noted that the onset of the current is extremely rapid and this sharp edge to the waveform can and does give rise to trouble on any nearby equipment, particularly microphone circuits.

3. Operational Instructions

a) Current Available

The total connected load possible if all channels are fully loaded. greatly exceeds the capacity of the mains and mains transformer. Under normal circumstances it is unlikely that the capacity of the latter will be exceeded. The load in use should be checked from time to time on the ammeters mounted on wall adjacent to the control desk. The permissible maximum per phase is 450 amps., which is equivalent to 110 kW of lighting when using thyratrons and 160 kW when switched only circuits are in use. This discrepancy is due to thyratron losses.

b) Summary of Patching Jacks

The patching field circuit jacks are arranged in four sections as follows:-

Section L	Bars L1 to L22, control channels 1 to 36.
Section M	Bars M1 to M22, control channels 37 to 72.
Section N	Bars N1 to N17, plus N19 and N21, control channels 73 to 108.
Section F	Outlets 1 to 48, floor and gantry, control channels 109 to 144.

Each studio bar is represented by four circuit jacks at the patching table, i.e. Bar L1A, L1B, L1C and L1D, thus the total circuit jacks of the first section is 88 and of the second section 88, of the third

/section

section 76 and of the fourth section 48. Normally circuits are plugged into channels of their own section but jumpers consisting of jack plugs at one end and panel sockets at the other, allow circuits to be transferred from their section, or control channels that are free to be made available outside their section. It should be remembered that when transferred to a circuit outside its section, a change of phase may be introduced where switched only channels are concerned .

c) Section Master Controls

There are two master switches mounted to the bottom left of each section of the patching field.

The black switch "Sect. Dead" has normal action and when put down switches off the section. This it does by bringing out any channel contactors on the patching panel plus the dimmer bank main contactor responsible for that section. The latter extinguishes the section pilot lamps. Once this switch is returned to normal all contactors of that section are restored to the state called for by the switching at the control desk or at the test panel.

The amber switch "Load Test" is sprung off and has to be held down to operate. This switch controls the contactor feeding the ammeter test sockets. The procedure, when more than one circuit jack is to be plugged into a channel, is to insert the jacks into the test sockets. When the amber switch is depressed these will be switched full on and the studio lamps will light. The ammeter will read the load and provided 17 amps is not exceeded for dimmers and 25 amps for switched only channels, the jacks can be transferred to their intended channel sockets.

d) Fusing

The load test circuits are fused (25 amp) at the jack field, and spare fuse bridges are carried on the centre panel so that rapid replacement is possible. The switched only channels and the four 5 kW dimmers are each provided with a single pole HRC (25 amp) fuse along the top

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3 d) Cont'd

of the patching field. The electronic dimmers are provided with 3 HRC fuses per channel (i.e. one per valve anode) on the centre sections of the dimmer banks.

e) Test Panel

The switched only channel contactors can be operated locally from the centre of the jack field without the need for using the lighting control desk. This test panel should be kept locked and its master switch (under the lid) kept off while illumination control is taking place at the lighting desk. When lantern rigging or other electrical work is in progress the test panel is brought into service.

f) Lighting Control Desk

This consists of two wing sections joined by a centre plotting table and master control section. The whole is intended to be used by the operator perched on a stool or standing very much as a draughtsman functions when using a large drawing board.

The desk wings house the control channels 1-36 on the top left, 37-72 bottom left, 73-112 on the top right, and 113-144 bottom right. An exception is the four 5 kW dimmers which will be found on the centre master section. The four main groupings correspond to sections, L, M, N and F on the jack field and in the studio. Unless deliberately patched otherwise particular studio areas will be found in the same region of the control desk.

g) Switched only Channels

Each channel consists of three two-way and off type switches, one white, one red, one blue. Each of these colours represents a separate preset. The centre position of the switch gives - channel off. The top position - channel subject to top master blackout, and bottom position - channel subject to bottom master blackout. Which of the three presets is operative is determined by the preset selector switches on the centre panel and is indicated by a coloured pilot lamp above each control wing.

h) Switch and Dimmer Channels (2 kW Max.)

Each channel has three two-way and off switches and three dimmer levers coloured white, red and blue respectively. The three repeats correspond to the three presets. The two-way and off switches give in the "up" position - channel subject to the top master blackout. In the centre position - channel "off", and in the bottom position - channel subject to the bottom master blackout. The bottom position also makes the channel subject to the master faders (see R below). Which of the presets is operative is determined by the centre panel selector switch and is indicated by the wing pilot lamp. The dimmer is of the electronic type and is held on only so long as a particular preset dimmer lever is in circuit. Movement of a dimmer lever whose preset is "on" takes immediate effect in respect of any studio lamp patched thereto.

i) Switch and Dimmer Channels (5 kW Max.)

There are four 5 kW channels and these are situated on the centre panel, as they are not subject to any presetting. Each channel has an "on-off" tablet switch and a dimmer lever operating a resistance lever dimmer through motorised servo mechanism. In this case for dimmer lever movement to take effect, the driving motor must be running at a suitable speed.

j) Master Controls - Switching

The centre section of the Control Desk houses the master switches associated with lighting control on the left and B.B.C. auxiliary controls, such as waveform monitor and talk back, on the right. These latter do not form part of the lighting control proper and will not be described herein. The main master lighting controls are summarised in the sections below.

k) Dead Blackouts

D.B.O. key switch cuts all circuits irrespective of the position of their individual switches with the exception of the last four switched only circuits (i.e. circuit nos. 133, 134, 139, 140) which have been left independent of blackout to be used for working lights.

l) Master Blackouts

Top - three tablet switches, white, red, blue, each of which, when depressed cuts any individual channels, both dimmer or switch type, of that preset colour whost switches are in the up position.

Bottom - three tablet switches, white, red, blue, each of which, when depressed cuts any individual channels, both dimmer or switch type, of that preset colour whose switches are in the down position. Note: A preset blackout will only take immediate effect if its particular colour preset is in use and therefore shown on the wing pilot lamps. Any of the above blackouts can be made subject to local switching "on set" via the studio ring circuit by putting the particular master blackout switch in the up position. Needless to say the appropriate colour preset must be in use for this to take effect.

m) Preset Selector Switches

There are two rotary switches, one either side of the centre changeover dial. The left-hand switch determines the colour preset to be brought in on the left-hand side of the master changeover and the right-hand selector does the same thing in respect of the right-hand side. Thus the white preset could be connected to the left side and the red preset to the right. Movement of the horizontal master changeover switch would then bring one or the other into service. If the same colour happens to be connected to both sides of the changeover switch, a warning lamp is brought on immediately over the selector switch incorrectly placed.

n) Changeover of Switched Only Channels

The changeover of switched circuits is governed by the master cross fader for the dimmers. This is set travelling to the left or the right by means of a horizontal changeover switch (see also Q below).

As the cross fader takes at least two seconds to travel - possibly more - and the switching changeover must be instantaneous, the normal procedure will be that at the centre point of fader travel, the switching preset on one side will be exchanged for that on the other side. For example,

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travelling from white on the left to red on the right, at the centre point, red will be added and white will be subtracted. Should, however, a lap change be desired, the switch immediately below the master change-over switch should be pushed in, and this will ensure that as soon as the master fader begins to leave the left side, the right side will be switched in and only when nearly home on the right side, will the left side be subtracted. Another form of switching change which will also switch any dimmer channels is described in S below.

o) Master Controls - Dimming

Master controls are: cross fader switch, cross fader dial, master fader left, master fader right, speed regulator and motor switch, left preset selector switch and right preset selector switch.

p) Speed Regulator and Motor Switch

Both the cross fader and the master fader (also the 5 kW dimmers) are built into a remote bank with master motor drive in the dimmer room. All movement of these devices is subject to the motor drive being switched on and to an appropriate choice of speed.

The speeds available are 2 secs, 3, 4, 5, 6, 10, 15, 20 and 30 secs., the fastest being speed 8 with the speed regulator in the top position.

For most normal purposes, speeds 4 and 5 and 6 are recommended. Slower ones should only be chosen for deliberate effect. The very fast speeds (7 and 8) may cause the faders and dimmers to hunt somewhat. The motor speed should always be put back slower or switched off immediately a fast change has had time to take effect.

Never leave the regulator on the red lines engraved between the speed stations. The correct method of stopping the driving motor is to use the "motor on" switch as this also disconnects the dimmer servo mechanism.

q) Cross Fader Switch

This switch feeds a pair of clutches, to drive the cross fader potentiometer from left to right or vice versa. When the switch is in the centre

3 (q) cont'd

position, the fader stops immediately. The position of the fader is indicated by the dial immediately above the switch and this should normally be left fully to the left or fully to the right. Confusion will result if the individual channel dimmers are operated with the fader held at any intermediate position. The cross fader switch need not be left on to one side or the other as the changeover dial will always show on which side the fader was last driven. The speed of changeover can be set on the speed regulator. Very slow speeds can be obtained either by inching the motor using the motor on switch or by stopping the cross fader by centring its switch.

r) Master Faders

The master fader left and master fader right are situated on the remote fader bank and are operated through servo mechanism which causes them to hunt with the control lever for position. Normally speaking, these faders are left in the "full on" position and only used to take out specific groups of lighting. The groups are selected by putting the dimmer channel switches in the bottom position.

s) Preset Selector Switches

These rotary selector switches determine which colour preset shall be on which side of the cross fader. The two sides are interlocked and should the selector be placed to the same colour preset as is already in use on the other side, then a warning red lamp will light over the selector. Using the fastest speed on the motor regulator the quickest changeover will be two seconds. Should a quicker changeover be required, the selector switch not at present in use should be set to the fourth neutral position and left there. The other selector switch may then be moved from one preset to another and direct switching both of the switched only and of the dimming circuits will take place. The switching of the latter will take into account the various positions to which the individual dimmer control levers may be set.

t) To Switch on for Patching

The main isolator feeding the patching field and the main isolator feeding the auxiliary fader bank should both be closed, the object of the latter is to provide the necessary low voltage DC for control of patching contactors. Electronic bank main switches need not be on and the Section Dead switches should be off.

u) Patching Routine

Clear all jacks by replacing them on the table top. Flexes should be carefully guided through the bushes and the jacks stood up vertically. Only slight weight is provided to return the cords in order to avoid cord wear and until the newness is worn off the braiding, great care should be exercised. Return of cable can be assisted by holding the jack immediately over the bush and allowing the cable to drop vertically. When patching, always make sure the appropriate "Sect. Dead" switch is in the down position. Whenever more than one circuit is to be patched to a control channel the circuits should first be inserted in the test sockets and the "Load Test" tablet lantern switch held down while the ammeter reading is noted. For electronic circuits, the red line should never be exceeded and for switched only, the green line. Using patching schedule, circuits should be plugged up and generally speaking it is only necessary to use the ammeter test sockets when more than one circuit is to be patched into one channel. When arranging patching schedules, crossing of leads should be avoided as far as possible, as this makes the panel confusing to read. Circuits may be patched out of their division by crossing the panel margins or by using the jumpers but usually it will be better to patch circuits into channels nearly opposite them thus ensuring that a particular area of the studio is always represented by a particular area of the control panel.

v) Patching Schedules

It is preferable to plan the main patching layout on paper in advance.

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Subsequently small modifications would be made either to make the lighting easier to control or to fulfil some new lighting need. (See BBC Patching Schedule PID/VM3/266). Whether patching is planned in advance or carried out directly, two schedules should be prepared alongside and scrupulously kept up to date. One schedule lists the control channels in numerical order. Thus quick reference can be made either by circuit or by channel.

w) To Switch on Dimmer Control

The two main isolators feeding each dimmer bank should be closed and these will provide the heater and electronic control voltages. The auxiliary dimmer bank and patching field must always be switched as well to ensure that the left and right master contactors on each dimmer bank which operate on 15 volt can be switched in from the control desk. Make sure the test panel master switch is off and that the lid is closed, and locked. The left bank supplies grid control voltage to both banks, it is essential therefore that if only one bank is required the left bank be used. There is a two minute time delay on the left and right bank contactors to prevent load being connected to cold thyratrons.

x) To Switch on Control Desk

Place all channel tablet switches in the "centre off" position and all dimmer levers in the "up" position. Place the changeover switch to the right and push the master fader levers to the top. Put all the master blackouts and the DBO in the down position, i.e. "on". Drive motor at speed 6 to ensure the change has taken place. Set the white preset on the left side of the changeover and the red preset on the right and since the master fader is on the right, operation on the red preset, i.e. the one with the channel numbers, will produce immediate results.

y) <u>To Switch on Lights Individually</u>

Channels may be switched on by merely pushing the appropriate red switches down and should any dimming be required, the circuit dimmer lever can be used.

z) <u>To Raise or Dim Lights Individually</u>

The circuit switch should be down and the dimmer lever pushed down or up to the extent required. There will be a very slight lag in response which may cause one to overshoot the required intensity. Other circuits may be added as required and the combined result plotted by reading scale to the right of each dimmer lever. The motor speed has no effect on any individual dimmers except the four 5 kW.

a.1) <u>To Raise or Dim Group of Lights</u>

A general fade-out or fade-in of a group, requires use of the master fader for the side of the changeover fader at that time in use. Provided all the channel switches for the particular preset colour are down, the master fader will take out everything except the switched only circuits. To leave some channels behind, those individual switches should be put in the up position. Switches should be transferred from the down to the up position, as rapidly as possible in order to avoid flicker of light.

a.2) <u>Dimming of Groups in Rapid Succession</u>

As there is only one master fader to each side, resort will have to be made to one of the presets. Thus one group of lighting could be faded out, using the master fader and immediately after, changeover can be made by means of the cross fader, to another preset which will have the second set of channels to be taken out, already set at zero.

It is possible to use the presets instead of the master faders for fading out groups, by merely setting levers (of the circuits to be removed), to the zero position on the preset concerned. However, it is a pity to tie up presets for this purpose unless the master fader has already been used.

3 a.2 Cont'd

When a fair time is available between the fading or bringing in of successive groups and no similar repeat cues are required, it is of course possible to use the fader and immediately after switch the channels off. Return the fader and then pick up a further set of channels. Alternatively the fader when down could have a new set of channels switched to it. Thus one group is taken out and another brought in. As the channel 2 way and off switches can be set differently for each preset it is possible to use a change from one preset to another not only to vary individual channel intensities but also to vary the groups locked on to the master fader or to the top and bottom master black outs.

a.3) Cross Fade from one Group to another

This is always carried out using the presets. One set of intensities being arranged on one preset, and one on another.

a.4) Switching from one Area to Another

This can be carried out by putting one preset selector switch to neutral and switching on the other (i.e. the one to which the dial points). Such switching changes will not only put the lights on and off but on dimmer channels, give any intensities which may be set up. Three presets could correspond to three areas.

If a greater number of areas is required, up to six may be catered for by careful selection of the circuit switches, thus the white preset top and bottom blackouts can be used separately or in combination and the same action performed in respect of the other presets. Stage type switching cues will however restrict this usage because the circuit switches may be required to select for a group movement.

These above suggestions would only be applicable so long as lap change between studio areas was not required. If however, while Scene I is in progress, we wish to take a preview of Scene II area, it will be necessary to set the board in such a way that the Scene II area can be added while the Scene I is in progress. This can be done by using bottom master and the top master, thus if Scene I were set on the bottom

/master

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and Scene 2 on the top we could have both together by simply ensuring that both masters were closed at the required time, provided of course no circuits were common to both scenes. If we then want to go on to the 3rd Scene with a similar lap change, the procedure would have to be as follows:-

Set lighting for Scene I on white preset bottom master.

Set lighting for Scene II on white preset top master and also on red preset top master.

Set lighting for Scene III on red preset bottom master and also on blue preset bottom master.

Set lighting for Scene I on blue preset top master.

We can now change from one area to another using a lap change as follows:-

Scene I switch in White Preset and bottom master.

Preview Scene II add top master.

Scene II switch in Red Preset and top master.

Preview Scene III add bottom master.

Scene III switch in Blue Preset and bottom master.

Preview Scene I add top master.

Scene I switch in White Preset and bottom master, etc., etc.

It can be seen that this switch set-up would allow lap changes forward or back in any order between the three groups of lighting corresponding to three studio scene areas. In the event of time being available, rapid manual selection of circuit switches might increase the number of those areas.

The difficulty of obtaining a lap change on presets only applies to the 96 electronic dimmers. If the switched only channels are the only ones in use, then the "lap change" under the cross fader is pushed in. When this is done there will be a lap over (superimposition of circuits) for the duration of the cross fader travel. By setting the motor speed, this could be as short as 2 secs or as long as 30 secs. Indeed, the cross fader could be stopped half way and the laps indefinitely prolonged.

a.5) Switching Locally on Set (Set practicals)

Any preset master blackout can be operated from an ordinary SP tumbler switch on studio set. The local switch should be plugged in via the studio ring and is in effect in parallel with the relevant preset master blackout on the centre panel. Provided that particular colour preset is "on" the lighting group will respond to the local switch. As the "on set" control voltage is 15-17 D.C., care should be taken that the external switch contacts are clean and connections are good.

a.6) Dimmer Setting

Whenever possible, individual dimmer intensities should be set up in advance and be brought in by a group master switch, or by a master fader or by a preset, because the setting up of a large number of dimmer intensities in a hurry, is likely to lead to inaccuracies. When properly set, the board should rely on its presets and group masters aided by occasional movement of individual dimmer levers when absolutely necessary.

a.7) Manual Operation

Emphasis has been placed on group controls but it must be remembered that as the dimmer levers are arranged for fingertip operation, provided that patching places circuits likely to be required together, side by side, then a considerable amount of work can be carried out manually. Where a circuit does not change intensity on any preset, the three preset dimmer levers should be exactly aligned side by side.

a.8) T.V. Lighting Control Technique

Generally speaking, the main advantages that centralised control can bring are:-

(i) Saving of time in bringing lighting in and out of use.

(ii) Ease in which any lighting not required at the time can be switched off. This saves current but, above all, cuts down heat in the studio. It can also minimise "spill" caused by light from sets not in use.

(iii) The balancing of lighting intensity by means of dimmers, i.e. a large lantern can speak with a soft voice when necessary.

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3 (a.8) Cont'd

(iv) The performance of lighting effect changes of the stage type, both on dimmers and by switching.

The above remarks apply to Tungsten lighting only.

a.9) The electronic type of dimmer tends to be wasteful of electric current unless some care is taken. The main source of waste is the filament heaters which have to be "on" the whole time the bank is in service, whether the studio lights are full on or blacked out - their likely states most of the time. It is not possible to cut the heaters whenever channels are out of use for two reasons, the first being the obvious switching elaboration plus the complication of the 2 mins. preheat time. The second is that good valve life seems to depend on minimum filament switching.

It follows from this that dimmer banks should only be switched on when their use is likely and once on, should be left on until after transmission. Therefore, all the rigging and rough setting is carried out using the switched only channels worked from the test panel. Only when lighting proper begins should the electronic banks be switched on.

On smaller productions, it will be desirable to switch on only the master dimmer bank and thus halve the heater demand. This bank normally feeds patching channels on the left wing on the control desk, i.e. sections L and M of the patching field. These dimmers could be spread over the full studio area by means of the jumpers and in any case the full set of switched only channels will be available over the entire field.

4. Valve Circuit: Detailed Description

Reference should be made to Drawing PID.3340.7.1H and to photographs of the waveforms appearing in this section which are labelled 1 to 12. The three valves in each circuit act as switches which are controlled in time by the applied grid potential. As is typical in thyratron operation, the switches close rapidly but cut off slowly as the anode

/voltage

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voltage is reduced. Each grid is arranged so that it fires at the corresponding period for each of the three valves and as the control voltage is raised towards zero, so the firing point occurs earlier in the cycle. This can best be illustrated by reference to Drawing PID.3340.7.1H where Graph 1 illustrates one phase of the three phases supplied with operations of the two phases. Also on this section is a line E to F which allows for the anode cathode voltage change which is caused by the cathodes following the three phases. The limit lines of the grid excursion for firing are also indicated, whilst the variations G and H show how this is modified by the change in anode cathode voltage. Beneath this is a diagram of the grid energising waveform of which the one labelled 90 degrees lag is the one which is used in this equipment. The effect on this waveform (which is grid to neutral), of the cathode excursion is shown by the dashed line. In operation, this sine wave is raised gradually by the change in D.C. potential from the control circuits until the peak of it intercepts the grid firing curves at each point when the valve will fire. This is shown for about 160 degrees. Further raising of the voltage will bring the firing point earlier and earlier in the cycle until at the maximum output the firing point is at approximately 50 degrees, when the rapid onset of current increases until the curve E to F is met at each point. It follows this graph and then follows round the sine wave from F towards B in which the anode voltage is too low to continue the arc. At some time after this the next valve can then fire. Under no conditions may two valves be allowed to fire at the same time as this will put an extremely low impedance across two of the phases of the supply and the fuses will be blown. Graph 2 of this drawing will illustrate this firing point, curve A being the applied anode waveform, curve B being grid to neutral waveform (including the D.C. component). Curve C illustrates the cathode to neutral waveform (and the current waveform through the cathode) for approximately maximum output. It will be seen that on the point of firing the waveform is very very steep. Very shortly, it follows another straight line (see E to F on Graph 1) and then follows the normal sine wave. Curve D is the summation of curve C in antiphase with curve B

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giving grid cathode waveform. Each actually appears on each valve. Whilst the valve is firing, the grid voltage is zero but when the valve arc is extinguished, the curve follows the two loops as shown. (See photograph No. 3).

The 1 M.H. chokes in the anode are included to reduce the surge current should any fault develop in the valve or should two valves fire at the same time. Whilst this does not normally occur, it does at present occasionally occur soon after switching on from cold particularly if the valves have not been used for several days. In the common cathode load of each circuit is a choke of .6 M.H. and capacitor of 24 M.F.

These components were included to reduce the sharp wave fronts from the circuit which were causing the filament of the Tungsten lamps to emit a high pitched singing noise. The values were arrived at empirically as singing had to be judged subjectively but could not be completely eliminated without losing control of the valves. Increasing the inductances causes the peak EMF to momentarily raise the cathode voltage sufficiently to extinguish the arc.

The grid to cathode capacitor of .001 M.F. is to reduce any surges which might appear at the grid and cause erratic firing. In each grid, there is a 150 K resistor to limit the grid current. The DC component flows back through the control circuit and has a marked effect upon all other circuits which are in operation. This mainly occurs in the potentiometer labelled "Set Black Level". The 250 uF condenser helps to reduce this. Most of the interactions of these circuits are believed to be due to different causes which will be explained later. Before the valve fires, but when the grid is positive with respect to cathode, conventional current will flow into the grid. With some valves this will cause relaxation oscillations to occur with associated grid components and will be visible on an oscilloscope (See Photograph No. 11)

When the grid voltage is sufficiently positive for the valve to strike, the anode, grid and cathode are tied together by the arc with a total anode

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to cathode difference of approximately 11 volts. Consequently, the current from these electrodes also follows that of the anode. The cathode current and waveforms seen have been previously explained. The grid current will also tend to follow the anode current, with some distortion introduced by a 150 K resistor and 4 M.F. capacitor. (See Photograph No. 4)

Various waveforms have been photographed apart from those mentioned above. They should all be self-explanatory and are therefore attached for maintenance purposes.

Conclusions

This installation was intended as an experiment in the use of thyratrons for Television Studio dimming and, as such, has served its purpose. As a system it is proving its worth in greatly adding to the flexibility of lighting facilities. The means of dimming itself has not proved entirely satisfactory suffering as it does from the following disadvantages relative to other available dimming systems.

1. Inefficiency The heater wattage amounting to 250 watts per circuit added to the on-load voltage drop, and the poor power factor of the system add up to an efficiency little more than 60% before dimming takes place.

2. Hum Interference Interference on vision has been reduced to negligible proportions by care in installation and recent curative measures, Similar measures for audio circuits have not proved adequate, and it has been found that if microphone and lighting leads lie parallel on the studio floor, a serious hum level is generated. Apart from this serious hum fields are created in the studio whenever earth neutral faults occur in the building, and great care must be taken to eliminate these as soon as they occur.

3. Lamp Filament Vibration The nature of the thyratron waveform is such that, having a very steep time of rise of current, the filaments of

/certain

Conclusions (3) Cont'd

certain lamps tend to vibrate. By the installation of smoothing circuits, this effect can be reduced but not eliminated.

4. Variations in Dimmer Law The matching of thyratron dimmer circuits is possible at low anode voltages only within specific fairly wide limits. This results in a variation in dimmer law which means that equal grid voltage settings for equal loads on different channels does not result in equal light out. Furthermore, there is a variation in dimmer law with the life of the thyratrons.

5. Interaction The striking of a large number of thyratrons at any instant in time causes a very short term regulation of the supply voltage waveform. Thus if a number of channels are dimmed, the light output from those which it is desired to hold constant varies. There is a further effect in this particular installation which might possibly be eliminated at appreciable expense in future installations, and that is the regulation of the control volts in common impedances which causes a further interaction.

6. Fuse Blowing This installation is subject to anode fuse blowing which the valve manufacturers are still investigating and are not yet able to explain.

7. Replacement Cost The thyratrons are a costly replaceable item with a finite life, the extent of which has not yet been determined.

By comparison with the electromagnetic clutch driven resistance and auto-transformer dimmers which have been installed in Riverside I as a further experiment, thyratrons do not show up well. Their advantage of a low space requirement is offset by the disadvantages listed above. None of these seven criticisms can be levelled at the Riverside I installation. The only troubles that have occurred on this latter equipment in the short period it has been in service, have been the occasional failure of individual relays to operate. These faults have been rapidly cleared without serious consequences.

APPENDIX A

Description of Waveforms

No. 1

Top Waveform

This is the voltage applied from anode to neutral showing a great dip at the time of firing of each thyratron on that phase. This pip is actually due to the impedance of the voltage regulating transformer and of the 415 volt three-phase supply before this transformer. Due to the sudden onset of current when each thyratron conducts there is this instantaneous voltage drop at the instant of conduction.

Bottom Waveform

This is the waveform from cathode to neutral. Note that, due to the three cathodes being tied together, a waveform is shown for each of the three phases. Note that, due to the conduction of the thyratron, there is a steep wavefront to this current.

No. 2

Top Waveform

This waveform shows the voltage across the 4 mfd. smoothing condenser and shows the waveform of the current which is flowing in the common control circuits. Notice that each waveform has a small pip on it which occurs at the instant of firing of each of the three thyratrons.

Lower Trace

This is the 50 cycle A.C. energising applied to each of the grids from the phase changing transformer. Notice that again a small pip is visible at the instant of firing of each grid.

No. 3

Top Trace

This is the waveform from grid to cathode on a particular valve. Notice that there is a flat portion which occurs when the valve is conducting and these two electrodes are tied together by an arc. Just before this period commences, there is a short positive pip which indicates that the grid must be positive with respect to cathode by a few volts before firing starts. After the conductive period, the grid goes negative on a 50 cycle

/sinewave

No. 3 Top Trace (Cont'd)

sinewave whilst the cathode being tied to the others of that circuit, goes positive during their conductive periods. This results in this peculiar waveform, the derivation of which is given earlier in the text.

Lower Trace

This is the anode to cathode waveform of one valve, the horizontal portion again indicating where the valve has fired. Notice the sudden drop at the start of this period.

No. 4

Top Trace

This indicates the magnitude and direction of the grid current flowing through the grid resistor as it is the voltage appearing across this resistor. When the valve fires, there is a large change in current but when the other two valves fire, only a small pip appears, being coupled from the cathodes by the grid cathode capacity. Notice the similarity of the grid current and cathode current which are both derived during conduction from the voltage applied to the anode, remembering that all three electrodes are tied together by means of the arc. The negative portion of grid current is due to the inductances in the anode supply.

Lower Trace

This trace is the voltage across the secondary of the grid energising transformers. Notice that as the voltage across the 4 mfd. condenser is not included, the pips due to the conduction of the valves are greatly reduced.

No. 5

Top Trace

This is the waveform anode to neutral when the valve is only passing half the normal current. Notice that the pip mentioned on Trace No. 1 is now later in the cycle as this delay is the means of adjusting current. Also, note that the amplitude is less.

Bottom Trace

This is the waveform under similar conditions from cathode to neutral.

No. 5 Bottom Trace (Cont'd)

Notice that after each valve has finished conducting, there is a portion during which no conduction occurs by any of the valves.

No.6

Top Trace

This is cathode to neutral at full load.

Bottom Trace

This is the voltage actually applied across the lamp, i.e. it is on the lamp side of the smoothing circuit. Notice that there is very little difference between these two phases.

No. 7

These two traces are repeats of No. 6 but with the lamp voltage reduced to approximately one half.

No.8

This trace is taken across the filter circuit with a 2 kW lamp being fully energised.

No.9

As trace 8 but with 1 kW lamp.

No.10

As trace 8 but with 500 watt lamp. Notice that the oscillation is not very damped and consequently, the first ring sometimes causes one of the cathodes to go above its corresponding anode and so extinguishing the arc. This causes the waveform to flicker at this point, although it is not visible on a lamp.

No.11

This waveform is from grid to neutral when the valves are not firing, i.e. when the section deads are off or when an anode contactor is open. Note that at the positive peak there is a relaxation oscillation caused by the grid cathode path and the associated grid components. This is quite usual in thyratron circuit which fires in the positive grid region and causes no trouble.

No.12

This is a repeat of the top trace of No. 1 but when the valves are only partially conducting. Notice that the pip due to the impedance of the supply is now both smaller and later in the cycle.

APPENDIX B

Quick Fault Finding

INDIVIDUAL CIRCUITS

No Light	Check circuits by using load check. Ammeter on patch panel. Check anode fuses but do not replace more than once.
Reduced Light, i.e. 1 or 2 valves out	Replace anode fuse or master fuses on centre of dimmer bank.
Reduced Light but repeated blowing of anode fuses	Check for overload.

LEFT OR RIGHT WING OF EITHER VALVE BANK

One or two valves out to every dimmer	Check contactor fingers, i.e. does the contactor close completely.
Wing completely dead including heaters	Check valve heater fuses.
Wing dead but heaters on	Verify that Patching Sect. Dead 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 mins. will result, before contactors 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, (beneath contactor) is closed and making contact. Relay O.K. then examine 300 amp. contactor.

WHOLE DIMMER BANK AT FAULT

No light, i.e. no valves, or the identical valve to each circuit out (valve not conducting)	Check bank isolator and fuses
Dimming abnormally erratic	Check phase shift fuses on bank centre panel but put the appropriate Patching "Sect. Deads" down first.

BOTH DIMMER BANKS AT FAULT

All Circuits up at low light output whether switched on or not	Check D.C. output fuses centre panel on Left Bank.
If low light output on all circuits with dimmers up	Check 2 phase input fuses to D.C. rectifier on centre panel left bank.

FAULTS OVER BOTH DIMMER BANKS AND PATCHING FIELD

No action of any kind except valve heaters	Check accessory Isolation and fuses. Check 15 volt rectifier output fuse on auxiliary bank.
Erratic action generally (low volts)	Check 15 volt rectifier 3 phase input fuses.*
No Action on Master and Cross-over Faders	Check 50 volt rectifier output fuses * and Motor Fuses.* (Is Motor Switch on)
Coarse action on Master and Cross-over Faders (poor sensitivity)	Check 50 volt 3 phase input fuses. *

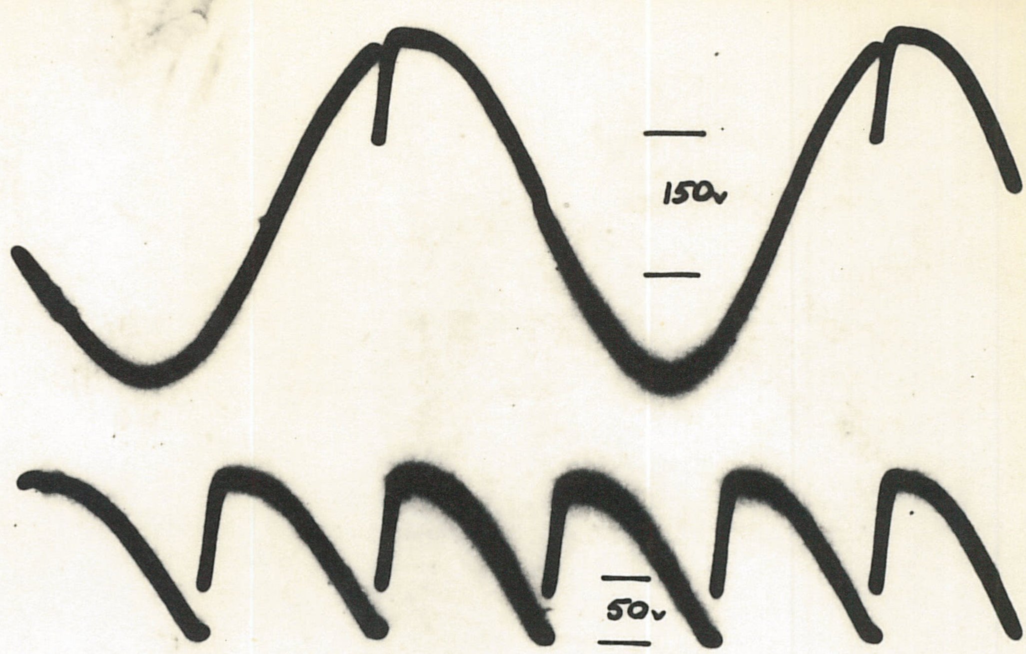
CONTROL DESK FAULTS

Failure of any one or two of the six dimmer blackouts. (top & bottom White, Red, Blue), or Dead Blackout	Work switch several times, if still faulty remove back of left desk wkg. Inspect the group of seven 20 amp relays, avoid damaging the wire contact relays at the same time.
Uncertain Working of Presets and/or their pilots	Inspect the relays under the metal cover in the left desk but do not remove cover unless installation is completely switched off first. Generally speaking, they should only be checked for armature movement and contact cleaning achieved by working them. To do this, the main switch 500 amp. 3 phase must be open.

* Concealed behind small door in safety cover.

GH/RMT
24.1.57

1



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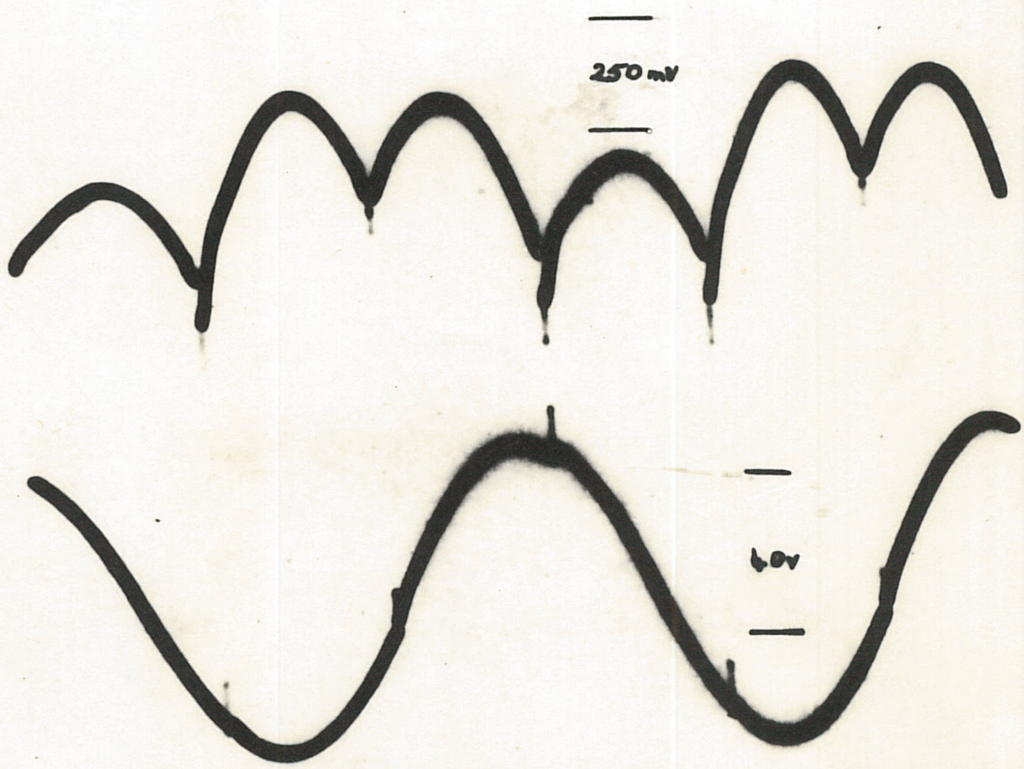

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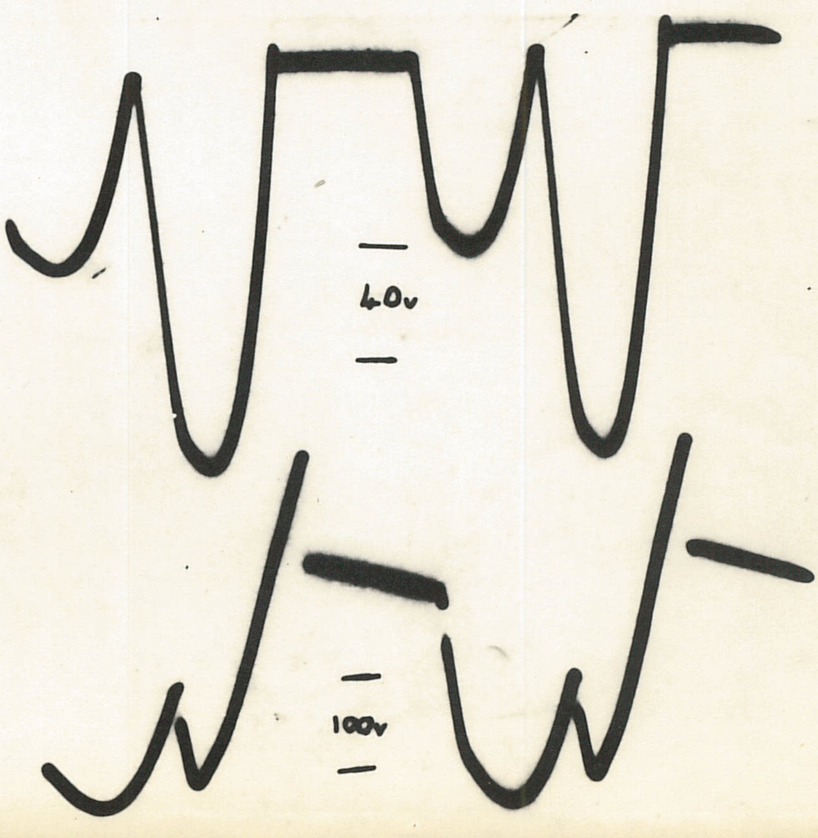

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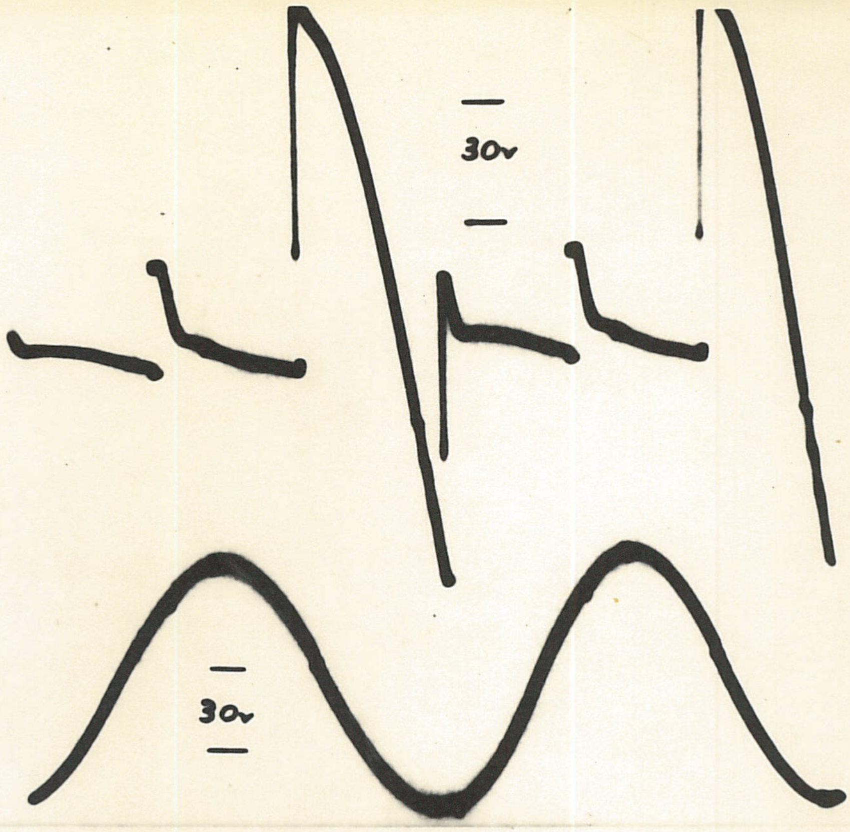

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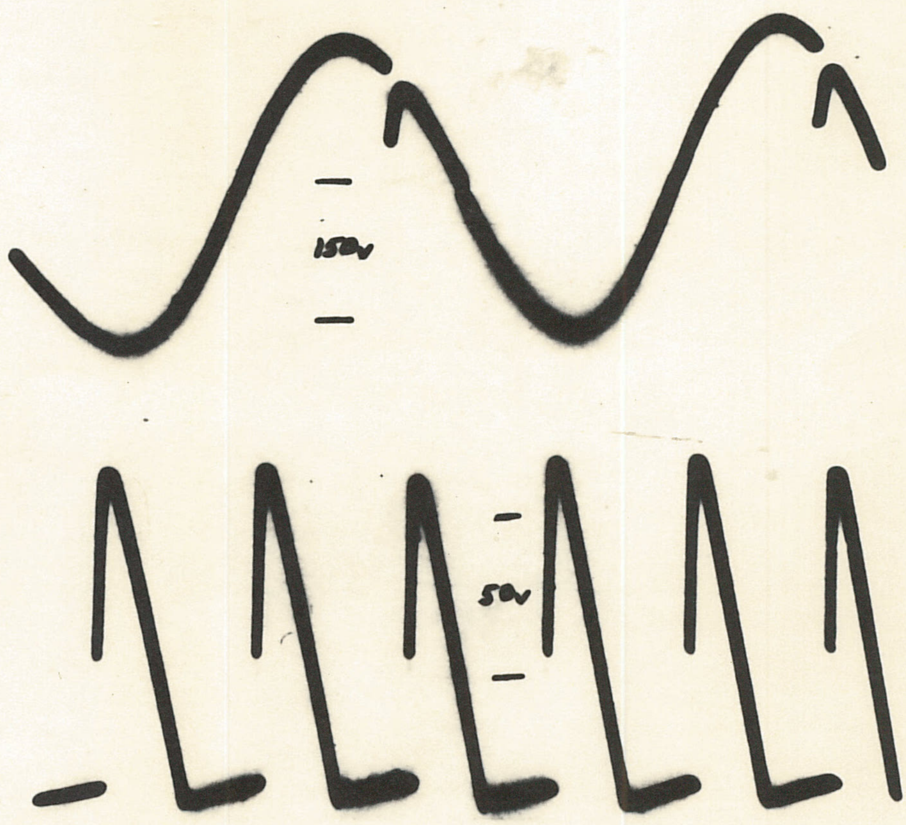

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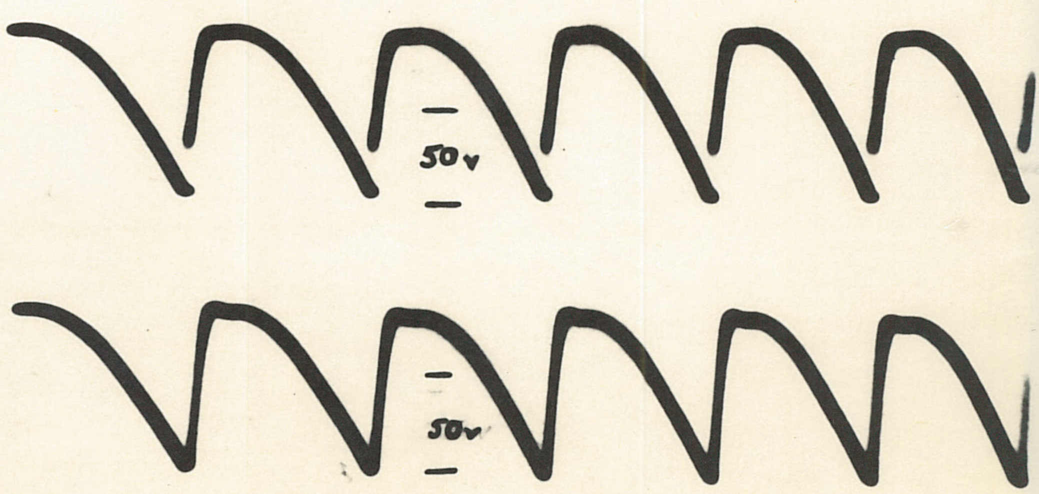

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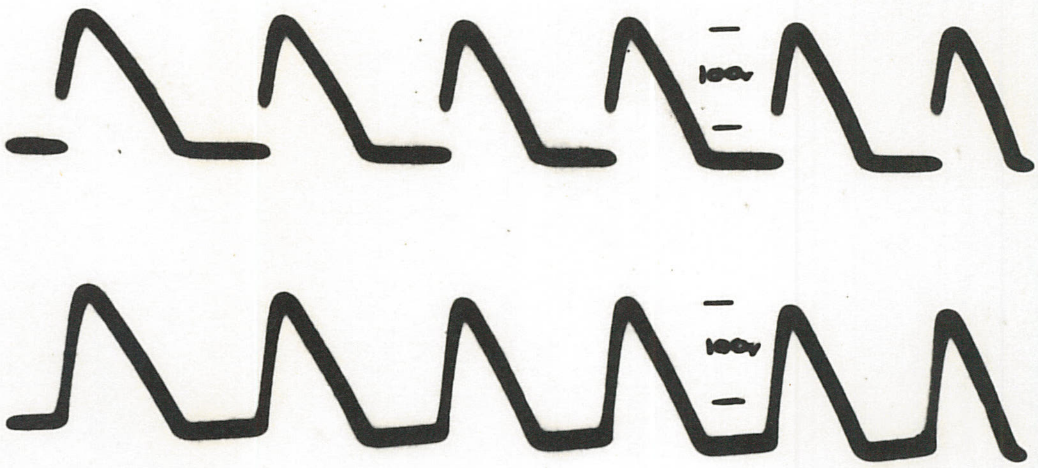

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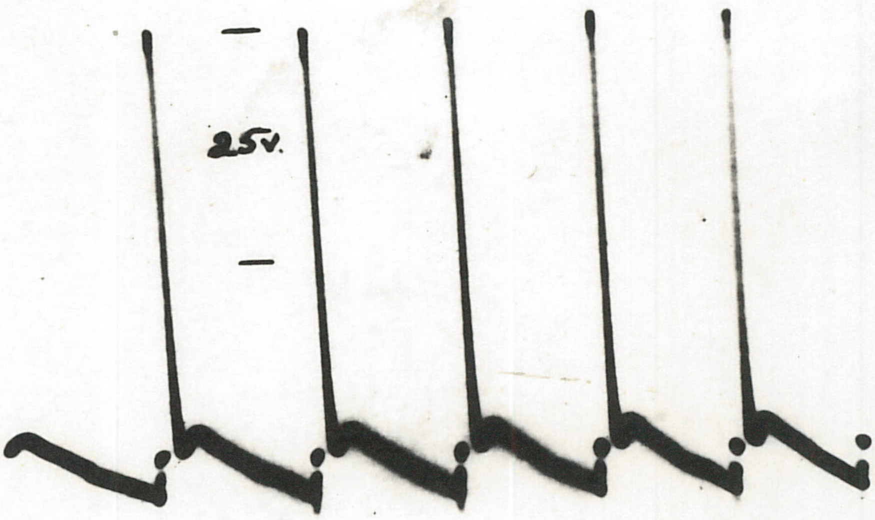

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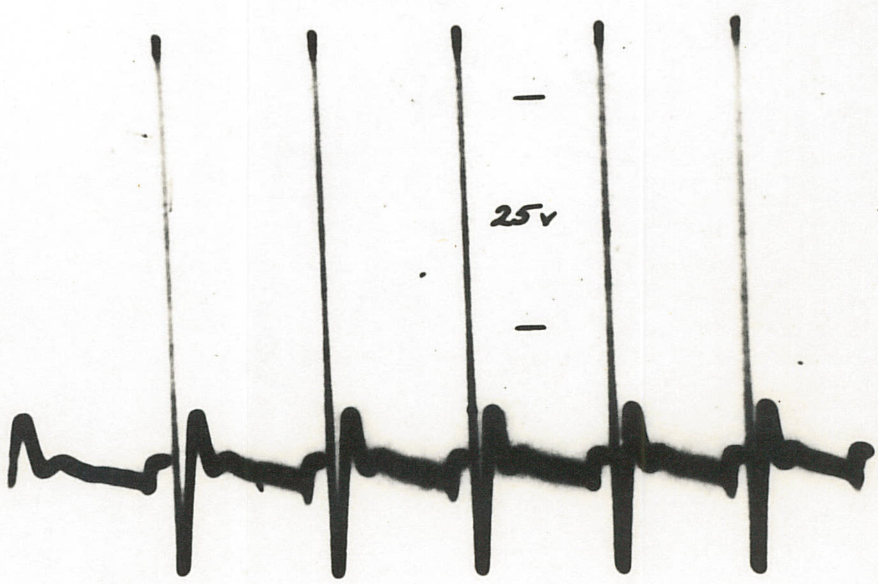

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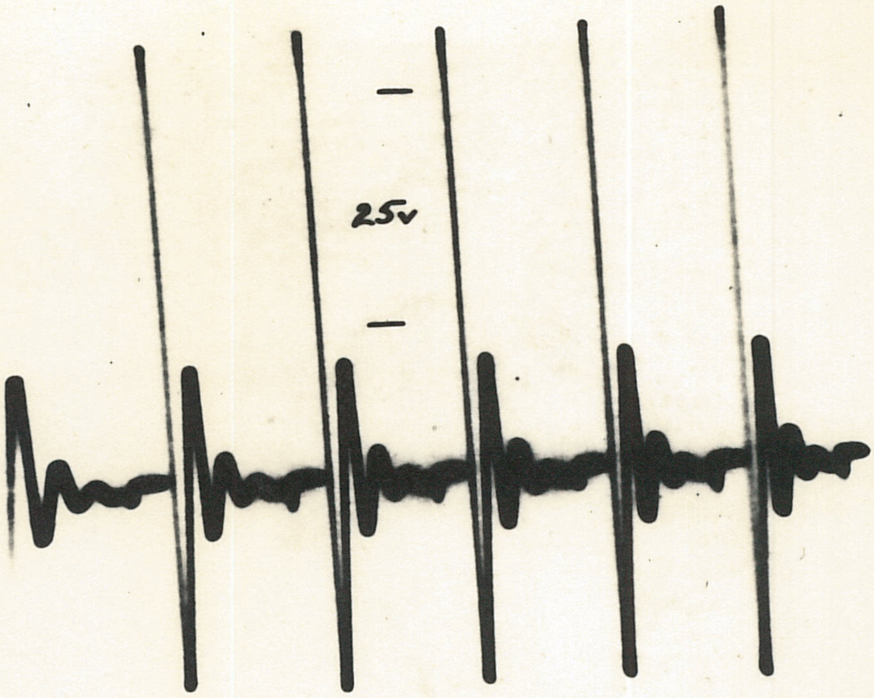

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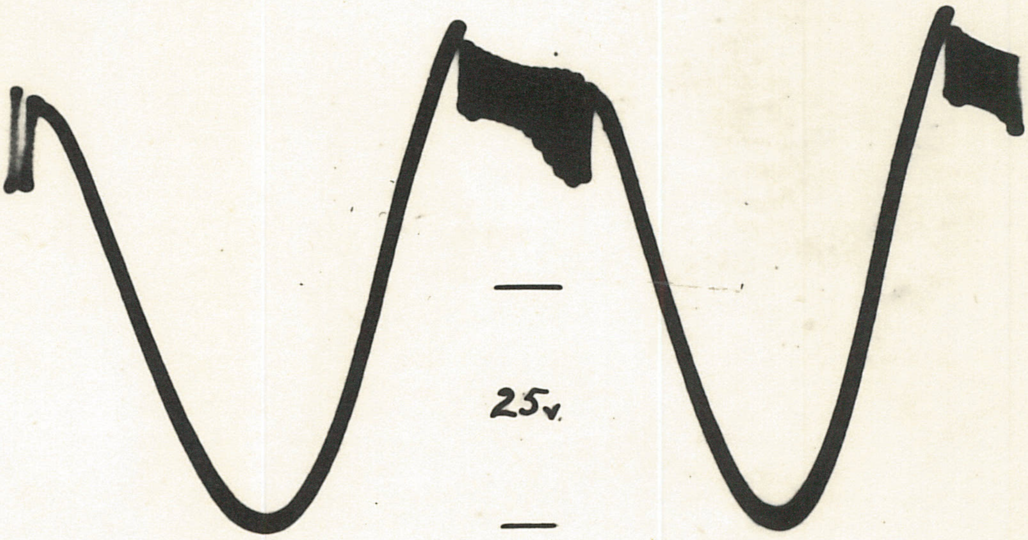

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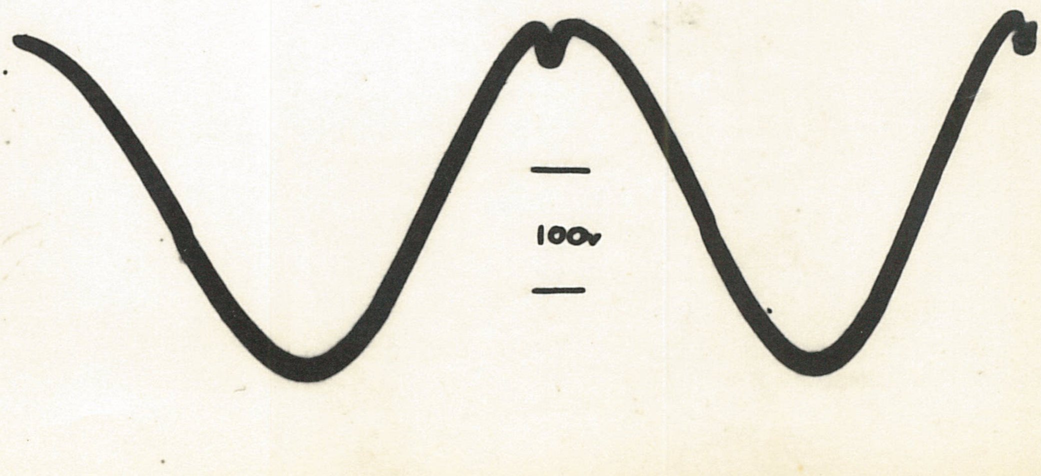


CHANGE

LEGEND

K = 2000w. Spot
S = 1000w. Scoop
P = 500w. Spot
C = 100/200w. Spot

PRODUCTION........................
PRODUCER........................
LIGHTING SUPERVISOR........................
DATE..........

B.B.C. TELEVISION

RIVERSIDE STUDIO 2

CONTROL CHANNEL PLOTTING TABLE

	AREA L		AREA M		AREA N		FLOOR AND GANTRY
LAMP CIRCUIT	L1: A B C D	L12: A B C D	M1: A B C D	M12: A B C D	N1: A B C D	N12: A B C D	F: 1 2 3 4
CONTROL CHANNEL							
LAMP CIRCUIT	L2: A B C D	L13: A B C D	M2: A B C D	M13: A B C D	N2: A B C D	N13: A B C D	F: 5 6 7 8
CONTROL CHANNEL							
LAMP CIRCUIT	L3: A B C D	L14: A B C D	M3: A B C D	M14: A B C D	N3: A B C D	N14: A B C D	F: 9 10 11 12
CONTROL CHANNEL							
LAMP CIRCUIT	L4: A B C D	L15: A B C D	M4: A B C D	M15: A B C D	N4: A B C D	N15: A B C D	F: 13 14 15 16
CONTROL CHANNEL							
LAMP CIRCUIT	L5: A B C D	L16: A B C D	M5: A B C D	M16: A B C D	N5: A B C D	N16: A B C D	F: 17 18 19 20
CONTROL CHANNEL							
LAMP CIRCUIT	L6: A B C D	L17: A B C D	M6: A B C D	M17: A B C D	N6: A B C D	N17: A B C D	F: 21 22 23 24
CONTROL CHANNEL							
LAMP CIRCUIT	L7: A B C D	L18: A B C D	M7: A B C D	M18: A B C D	N7: A B C D		F: 25 26 27 28
CONTROL CHANNEL							
LAMP CIRCUIT	L8: A B C D	L19: A B C D	M8: A B C D	M19: A B C D	N8: A B C D	N19: A B C D	F: 29 30 31 32
CONTROL CHANNEL							
LAMP CIRCUIT	L9: A B C D	L20: A B C D	M9: A B C D	M20: A B C D	N9: A B C D		F: 33 34 35 36
CONTROL CHANNEL							
LAMP CIRCUIT	L10: A B C D		M10: A B C D	M21: A B C D	N10: A B C D	N21: A B C D	F: 37 38 39 40
CONTROL CHANNEL							
LAMP CIRCUIT	L11: A B C D	L22: A B C D	M11: A B C D	M22: A B C D	N11: A B C D		F: 41 42 43 44
CONTROL CHANNEL							
REMARKS.							F: 45 46 47 48

LAMP CIRCUIT PLOTTING TABLE

	DESK UPPER LEFT		DESK LOWER LEFT		DESK UPPER RIGHT		DESK LOWER RIGHT	
CONTROL / LAMP	1	19	37	55	73	91	109	127
CONTROL / LAMP	2	20	38	56	74	92	110	128
CONTROL / LAMP	3	21	39	57	75	93	111	129
CONTROL / LAMP	4	22	40	58	76	94	112	130
CONTROL / LAMP	5	23	41	59	77	95	113	131
CONTROL / LAMP	6	24	42	60	78	96	114	132
CONTROL / LAMP	7	25	43	61	79	97	115	133
CONTROL / LAMP	8	26	44	62	80	98	116	134
CONTROL / LAMP	9	27	45	63	81	99	117	135
CONTROL / LAMP	10	28	46	64	82	100	118	136
CONTROL / LAMP	11	29	47	65	83	101	119	137
CONTROL / LAMP	12	30	48	66	84	102	120	138
CONTROL / LAMP	13	31	49	67	85	103	121	139
CONTROL / LAMP	14	32	50	68	86	104	122	140
CONTROL / LAMP	15	33	51	69	87	105	123	141
CONTROL / LAMP	16	34	52	70	88	106	124	142
CONTROL / LAMP	17	35	53	71	89	107	125	143
CONTROL / LAMP	18	36	54	72	90	108	126	144
5KW. CIR. A 1 2 3 / B 1 2 3 / C 1 2 3 / D 1 2 3	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED	3KW SW. ONLY / 2KW DIMMED

PID/VM3/266

BBC PID/VM3/266

RIVERSIDE STUDIOS PRODUCTION LIGHTING SCHEDULE

DRN		PLANNING & INSTALLATION DEPT
TCD		
CKD		
APPD		

Auxiliary Bank Wiring Diagram of Strand Electronic Control

REVISIONS 1.			
DATE		CHECKED BY	
DRAWN BY		APPROVED BY	
CHANGES			

REVISIONS 2.			
DATE	29-Nov-55	CHECKED BY	
DRAWN BY	R.Watson	APPROVED BY	
CHANGES	Title altered		

③ Dimmer fuses moved to patching panel

④ relay & switches for local control

REVISION 5

1-3-56	CHECKED BY	
T.A. Corne		

ADDITION OF CLUTCH RELAYS POSITION OF SWITCH PANEL RELAY ALTERED FUSES MODIFIED

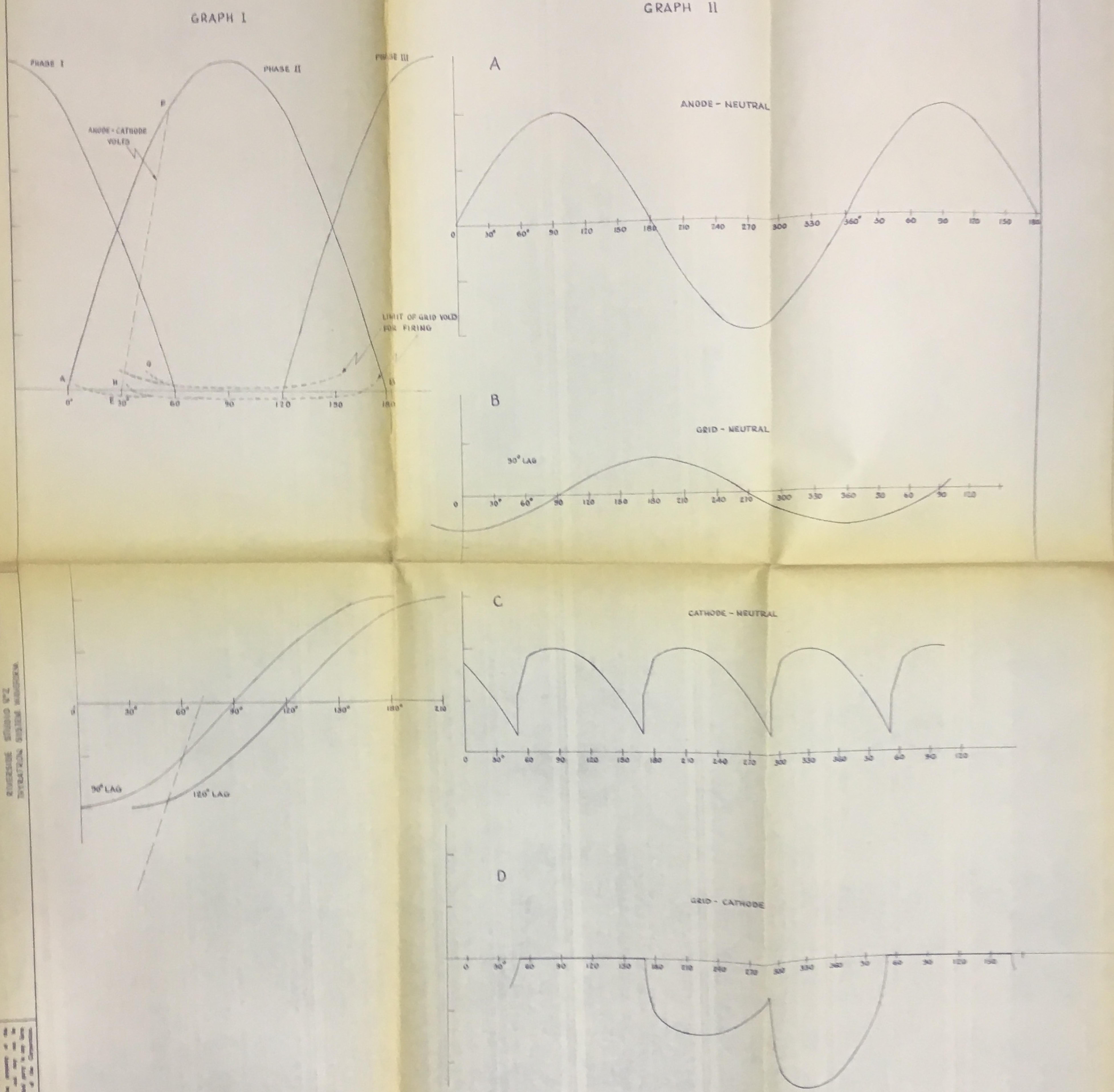
⑥ 11-3-57 R.Hollis

THE STRAND ELECTRIC & ENGINEERING Co Ltd
FLORAL STREET, COVENT GARDEN,
LONDON. W.C.2.

BBC Riverside Studio II

SCALE		DATE	PART No.
DRAWN BY		10-10-55	MATERIAL
TRACED BY	R.Hollis	1-4-57	No. OFF/UNIT
CHECKED BY			FINISH
APPROVED BY		1-4-57	

DWG No R&D. 2899



BBC

RIVERSIDE STUDIO No 2
THYRATRON SYSTEM WAVEFORM

P1D3340.7.1H