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The BBC Riverside Television Studios: Some Aspects of Technical Planning and Equipment

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BRITISH BROADCASTING CORPORATION

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FOREWORD

THIS is one of a series of Engineering Monographs published by the British Broadcasting Corporation. About six are produced every year, each dealing with a technical subject within the field of television and sound broadcasting. Each Monograph describes work that has been done by the Engineering Division of the BBC and includes, where appropriate, a survey of earlier work on the same subject. From time to time the series may include selected reprints of articles by BBC authors that have appeared in technical journals. Papers dealing with general engineering developments in broadcasting may also be included occasionally.

This series should be of interest and value to engineers engaged in the fields of broadcasting and of telecommunications generally.

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CONTENTS

PREVIOUS ISSUES IN THIS SERIES

No.	Title	Date
1.	*The Suppressed Frame System of Telerecording*	JUNE 1955
2.	*Absolute Measurements in Magnetic Recording*	SEPTEMBER 1955
3.	*The Visibility of Noise in Television*	OCTOBER 1955
4.	*The Design of a Ribbon Type Pressure-gradient Microphone for Broadcast Transmission*	DECEMBER 1955
5.	*Reproducing Equipment for Fine-groove Records*	FEBRUARY 1956
6.	*A V.H.F./U.H.F. Field-strength Recording Receiver using Post-detector Selectivity*	APRIL 1956
7.	*The Design of a High Quality Commentators' Microphone Insensitive to Ambient Noise*	JUNE 1956
8.	*An Automatic Integrator for Determining the Mean Spherical Response of Loudspeakers and Microphones*	AUGUST 1956
9.	*The Application of Phase-coherent Detection and Correlation Methods to Room Acoustics*	NOVEMBER 1956
10.	*An Automatic System for Synchronizing Sound on Quarter-inch Magnetic Tape with Action on 35-mm. Cinematograph Film*	JANUARY 1957
11.	*Engineering Training in the BBC*	MARCH 1957
12.	*An Improved 'Roving Eye'*	APRIL 1957
13.	*The BBC Riverside Television Studios: The Architectural Aspects*	JULY 1957

SUMMARY

Riverside Studios in Hammersmith, comprising two film stages together with the necessary ancillary accommodation, were purchased by the BBC in 1954. The premises have been converted to form two television studios with the associated technical, production, and general accommodation and facilities required to form a self-contained unit served by the main television studios at Lime Grove and the scenery manufacture and property facilities at the Television Centre. The studios are known as Riverside Studio No. 1 (R1), with a floor area of 6,000 sq. ft and Riverside Studio No. 2 (R2), with a floor area of 4,200 sq. ft.

The original intention was to use R1 as a replacement studio and it was brought into service on 26 September 1956 in place of the light entertainment studio, Studio 'G' at Lime Grove, whilst the latter was being re-equipped. It is now apparent, however, that R1 will continue to be used as the principal light entertainment studio even after the return of Studio 'G' to service. R2 was brought into service on 30 July 1956.

The planning of the Riverside premises and the technical installation represent the outcome of experience gained in the operation of television studios for a considerable number of years, yet include certain novel features—untried in previous BBC studios—where it has been thought necessary to gain direct experience for the future. The facilities offered at Riverside are more comprehensive than those available at any of the earlier BBC studios.

This Monograph deals with the engineering equipment at Riverside Studios and should be read in conjunction with Monograph No. 13 which deals with the architectural aspects of the planning and building of the premises.

TERMINOLOGY

Waveform Terminology (As agreed by the British Standards Institution)

1.	BLANKING LEVEL	In the video signal, the boundary level between the picture information and synchronizing information: the reference level of the video signal.
2.	BLACK LEVEL	In positive transmission, the minimum permissible level of the picture signal.
3.	WHITE LEVEL	In positive transmission, the maximum permissible level of the picture signal.
4.	PEDESTAL	In the picture signal, the separation in level between the black level and the blanking level.
5.	SYNC. LEVEL	The level reached by the tips of the synchronizing pulses.
6.	PEAK WHITE	The level in the vision signal corresponding to white.
7.	FRONT PORCH	The interval of time immediately preceding the line synchronizing signal during which the video signal is maintained at blanking level.
8.	BACK PORCH	The interval of time immediately following the line synchronizing signal during which the video signal is maintained at blanking level.
9.	FIELD	In monochrome television: a sub-division of the complete television picture consisting of a series of sequentially scanned lines spaced equidistantly over the whole picture area, the repetition rate of the series being a multiple of that of the picture.
10.	PICTURE	In monochrome television: the displayed television image containing the whole of the transmitted information.
11.	PICTURE SIGNAL	The signal which conveys the picture information, as generated by the scanning device.
12.	VIDEO SIGNAL	The combined picture and synchronizing signals.
13.	VISION SIGNAL	The signal produced by the modulation of the vision carrier by the video signal.

General

14.	S.P.G.	Synchronizing Pulse Generator.
15.	MIXED SYNCS. MIXED BLANKING	Pulse Signals—containing field and line components.
16.	MASTER OSCILLATOR FREQUENCY	Usually twice line frequency in a 405 line system 20,250 cps. from which the various components necessary for synchronizing the system are generated after division.
17.	GENLOCK	A system of locking a local S.P.G. to a remote S.P.G. so that the pictures from either source are coincident in time. It is a necessity for 'inlay', mixing or superimposing, local and remote picture signals.
18.	RASTER	The scanned patch on a cathode-ray tube.
19.	FOLDBACK	The feeding of one, or more, studio loudspeakers with sound not originating in the studio itself, simultaneously with the mixing of that same sound into the studio programme output.

1. Introduction

The BBC started the first regular public high-definition Television Service in the world from Alexandra Palace in 1936. This service was maintained until September 1939 when it was closed down upon the outbreak of war.

Television broadcasting was re-started in June 1946 and it was not long before it was realized that the two studios at Alexandra Palace were inadequate, both in size and facilities, to meet the rapidly expanding needs of the service.

After several possibilities had been examined, land was acquired at the old White City Exhibition site in West London on which to build the main Television Studio Centre and administrative headquarters. It was not, however, possible to commence work on this new site at once, because of the national policy of restriction on capital expenditure.

It was, nevertheless, essential to provide additional studio space and, in 1950, the Lime Grove Film Studios of the Rank Organization were acquired by the BBC. Between that time and 1953 four studios were equipped and central presentation facilities provided, thus allowing all Television Studio Operations to be transferred to these premises.[1] Of the four studios at Lime Grove, however, only one, Studio 'E', was equipped on a permanent basis; the other three being, as a matter of necessity, developed on austerity lines, using equipment originally built for outside broadcasts.

In 1954, the Shepherds Bush Empire was purchased and quickly developed, again on an austerity and temporary basis, as a Television Theatre to satisfy the growing demand for a studio suitable for the spectacular type of production requiring the presence of an invited audience.

By this time the planning of the new Television Centre on the White City site was proceeding rapidly. It was clear, however, that before this project could be completed it would be necessary to re-equip the three austerity studios at Lime Grove and to provide a further studio to give some scope for the immediate future expansion of programme hours and complexity; possibly even to provide additional studio space for an alternative programme.

It was therefore decided to equip two new studios, one as a replacement studio which could be used in place of the studios at Lime Grove whilst each in turn was refurbished; the second as an additional studio. It was with this object in view that the BBC purchased, in 1954, the Alliance Film Company's Riverside Studios in Crisp Road, Hammersmith. The choice of this particular building was no doubt tempered by its reasonable proximity to Lime Grove and to the new Television Centre but, in choosing a film studio building, it is clear that some advantages are gained at the outset.

Planning was put in hand immediately upon taking possession of the premises with the object of providing, with the minimum of alteration, two television studios to be known as Riverside 1 or R1 and Riverside 2 or R2 together with the basic ancillary accommodation and facilities. Consideration was to be taken of the fact that the studios would be able to draw upon supplies and services from the Television Studios at Lime Grove and the scenery workshops at Television Centre. The final layout of the premises is shown in Figs. 1 and 2.

At first sight it may be thought that there is little difference between a film studio and a television studio and that, as a result, all that is necessary in converting the one to the other is the addition of technical accommodation and the installation of the necessary equipment. The fundamental difference in the operation of the two media should not be lost sight of however; on the one hand, film making is essentially a non-continuous process with short studio takes, whilst, on the other, television demands a continuity of performance which is inevitably the governing factor in studio technique. The extent of the alterations to the building consequent upon these differing techniques, before the installation of television plant was practicable, was greater than had at first been expected.

In considering the replanning of the Riverside premises, it was necessary to discard many features which, on first sight, may appear to have been made to measure. The studio floors for example, though adequately strong and level for the operation of film cameras mounted on rails, were not sufficiently sturdy or level for use by television cameras, which are required to move smoothly, freely and continuously from one set to another.

The complexity of modern television studio productions demands a considerable amount of rehearsal time. It therefore becomes an economic necessity to reduce to a minimum the time required to change the scenery between productions and to carry out the lighting for the new production so that a quick turn round can be achieved. In practice rehearsals at Riverside commence at approximately 10.00 a.m. on most days and it is therefore frequently necessary to carry out studio rigging overnight.

For this reason separate scenery transit docks have been built adjacent to both studios.

The normal film studio lighting and scenery handling facilities which existed at Riverside were unsuitable for such streamlined rigging operations. A new lighting system has therefore been provided which incorporates a network of remotely operated electric hoists. These provide a grid of short rigging barrels over the whole studio and are intended for the suspension of both illuminators and light scenery.

The conventional method of suspending heavier scenery by means of rolling skids running on steel joists is retained.

The lighting installation is most comprehensive and provides the lighting supervisor with facilities for setting the initial lighting with the minimum labour and maximum speed. Moreover, it provides for the flexible control of all illuminators used so that the lighting of a scene may be altered during the progress of the production, to achieve any desired pictorial effect on the transmitted picture. In this operation the closest co-operation with the producer and those in control of the camera equipment is necessary and the positions of the lighting control consoles in the technical areas have been chosen with this point in mind.

Special lighting effects, hitherto impossible with the less flexible lighting systems used in earlier studios, may now

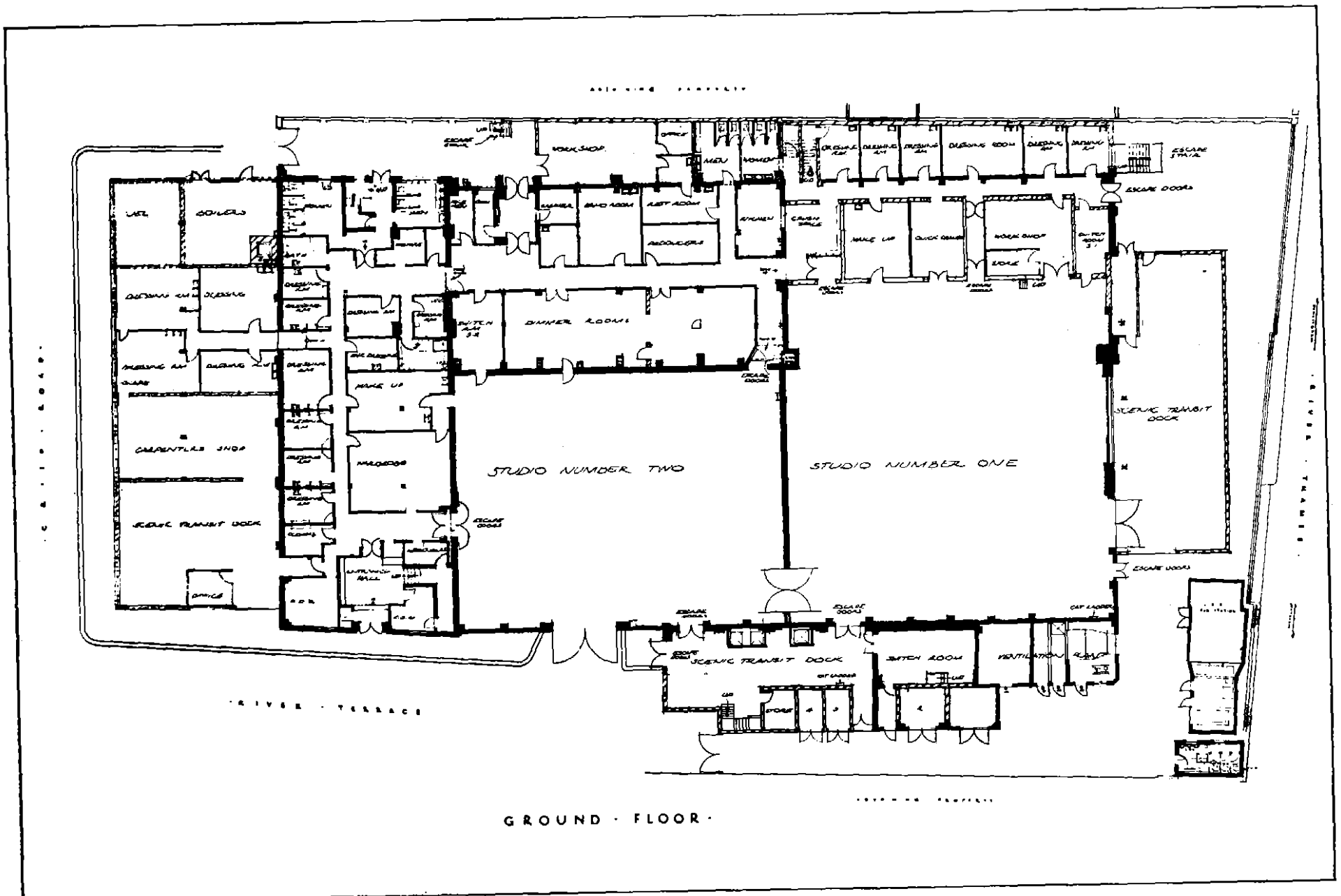


Fig. 1 — Riverside Studios—Ground Floor Plan

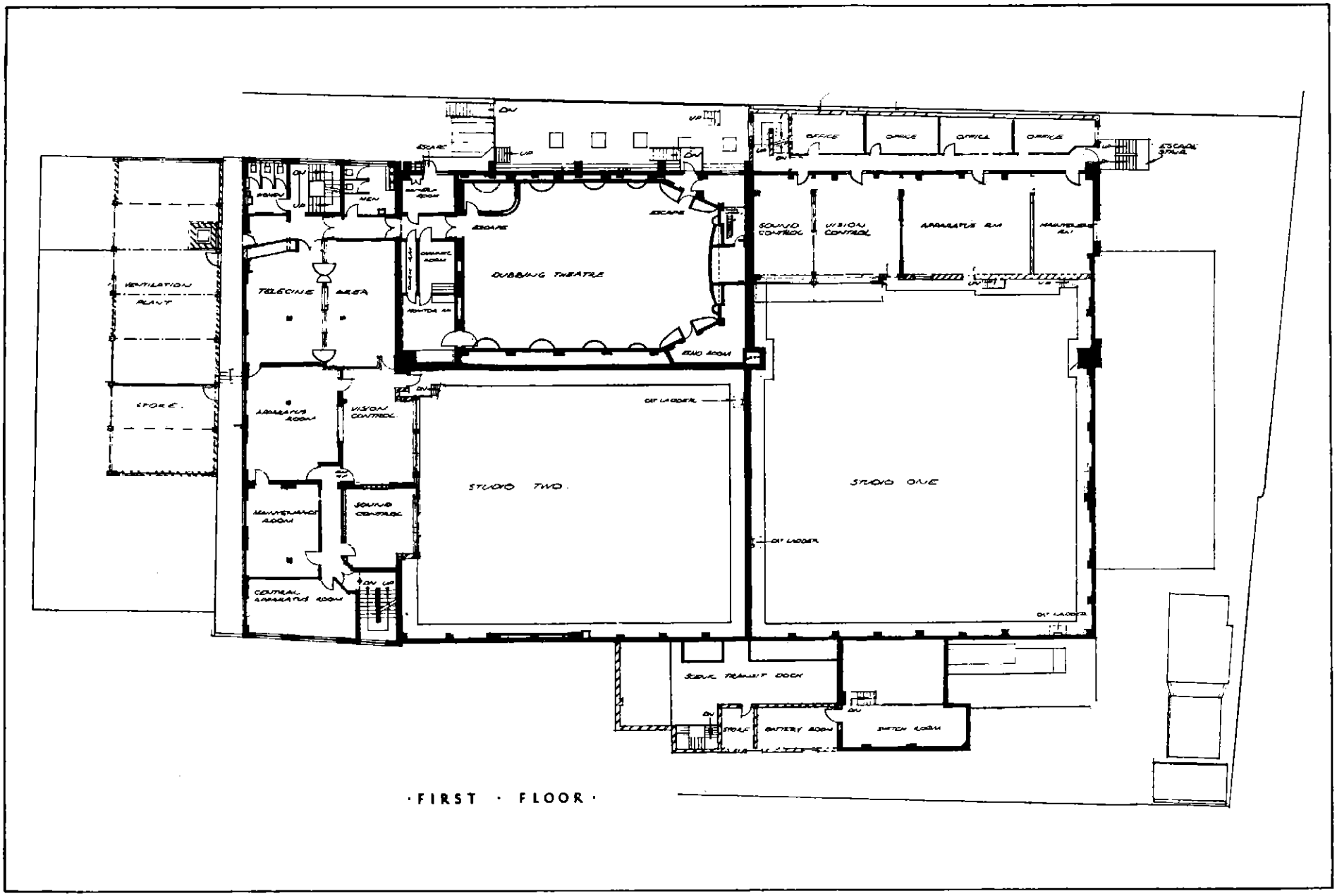


Fig. 2 — Riverside Studios—First Floor Plan

be confidently attempted. The ability to switch lights in groups is normally used for scene-to-scene changes, thus reducing the heat generated by the lighting and consequently easing the ventilation problem.

Two different systems of dimming have been adopted. A magnetic-clutch mechanical system with resistance and auto-transformer dimmers is used in Studio R1 and an electronic dimmer system employing thyratron valves in Studio R2.

Alternative approaches have been provided in this and also in certain other cases so that experience can be gained prior to finalizing plans for the Television Centre, which, it is hoped, will become a standard for the future. The lighting installation is described in detail in Section 3.5.

It should not be assumed, however, that Riverside Studios were to be developed purely as a prototype for the Television Centre. In their planning, the experience gained in previously equipped studios has been extensively used and, where possible, in the interests of simplification of operation similar equipment and techniques have been adopted in both studios. In particular the studio television equipment for both is identical, as described in Section 3.2.

Before orders were placed for the camera equipment for Riverside and other studios in the London area, the BBC had decided to discontinue the use of cameras employing high-velocity tubes. The advantages and disadvantages of high- and low-velocity tubes are well known, but the major reason for the choice in this case was the greater sensitivity to be expected from cameras using the latter type. Adequate sensitivity is, of course, essential so that cameras may be operated at a lens aperture at which reasonable depth of field may be obtained without recourse to very high lighting intensity.

The total requirement for studios in the London area was just over thirty camera channels and after careful selection from those available the order was equally divided between cameras manufactured by Electric and Musical Industries Ltd, using the stable C.P.S. emitron tube, and those manufactured by Marconi's Wireless Telegraph Company Ltd, employing the $4\frac{1}{2}$-in. image orthicon tube.

Image orthicon cameras have been installed in both the Riverside studios largely because the somewhat greater flexibility of this type appeared to be most desirable in studios intended to be used for replacement purposes and consequently having to meet programme demands of every type.

The major points in favour of the image orthicon over the C.P.S. emitron are:

(i) Greater sensitivity.
(ii) Less lag (smearing on movement).
(iii) The ability to handle occasional excessive contrast ranges without undue degradation of picture.

Studio R1 has been equipped with four operational cameras, Studio R2 with only three. There is also installed in each studio a spare camera channel which is intended to be brought into service immediately in the event of a failure of one of the operational cameras. It is of interest to note that there have in practice been several occasions when four operating cameras have been employed in Studio R2 but in these instances it has been necessary to modify the procedure to be adopted in case of breakdown.

A single camera channel is available at Riverside for major maintenance, overhaul purposes, tube testing and to serve as a replacement during the clearing of any faults which require lengthy diagnosis and repair.

The vision mixing equipment installed in both studios is of new design and is very flexible. The sound mixing and control installations in both studios are of BBC design. Studio R2 is equipped with a standard Type 'A' sound installation which has been employed in BBC sound and television studios for many years. In Studio R1, however, a newly designed and entirely experimental installation, based on the BBC Type 'B' design but employing a table-top desk and quadrant-type faders, has been used to improve visibility for the operator and provide a particularly compact operating position.

A 35-mm. BBC-designed Flying-Spot Mechau telecine channel has been provided for each studio for film insert purposes. 16-mm. films must, however, be relayed from a telecine channel at Lime Grove when required. The telecine equipment is arranged so that both channels may, if desired, be fed to either studio.

The studios and telecine equipment are fed synchronously with driving pulses from a central pulse generator and timed so that the smaller studio may be used as a slave to R1. As the studios are adjacent, ability to mount a major performance in this way is of considerable advantage.

A mimic diagram type of remote control board is provided for the control of the main electricity supply switching so that a close and constant check of the supply position may be kept in the central control room. The studio lighting is supplied with a.c. and no motor-generators are used; d.c. supplies, where necessary, are obtained from metal rectifier units.

A more detailed description of certain salient points in the installation follows, but it is as yet too early to predict which of the alternative approaches to certain aspects of the installation is to be preferred, or to assess the suitability of some of the more experimental features of the installation.

2. Technical Accommodation

2.1 *General*

The Riverside Studio premises, as taken over, comprised two film stages, an orchestral dubbing suite, review theatre, property dock, dressing-rooms, scenery construction shop, canteen, offices, and various storerooms.

The dimensions of the two stages were, Large Stage 100 ft × 75 ft = 7,500 sq. ft; Small Stage 75 ft × 60 ft = 4,500 sq. ft and the height of both was approximately 25 ft.

Planning for the conversion of the building to television studios was commenced in October 1954. The larger stage became known as Studio R1; the smaller as R2, and only the minimum possible reduction of the effective acting area of each stage was permitted. Nevertheless it was impossible to avoid considerable building extension into the larger studio.

One of the major problems in planning the layout of the two studios was that of finding a satisfactory location for the associated technical areas. These comprise, for each studio: vision control room, sound control room, vision apparatus room, advance maintenance room and lighting dimmer room, together with, where possible, a studio technical equipment store. Certain auxiliary centralized technical accommodation is also required but, as space was at such a premium, this accommodation had to be reduced to the absolute minimum. The areas which have been provided are, a central apparatus room—which also serves the purpose of lines termination room—two telecine rooms, electrical intake and switch-rooms, lighting transformer cubicles, battery room, technical components store, and electricians' workshops.

The film dubbing theatre, which already existed in the premises, was retained, for, although it was not necessary to associate dubbing with the new studios, it would have been uneconomic not to retain this facility, difficult though it was to spare the space which it occupied, particularly as it was believed to be one of the finest orchestral dubbing theatres in London, and the BBC was particularly short of dubbing theatre space.

2.2 *Studio Accommodation*

The studio lighting dimmer rooms have been located together in a block between the two studios comparatively close to the power intake switchgear and lighting transformers. This arrangement permitted the lighting cabling to be kept to reasonable lengths and of moderate cross-sectional area.

A studio equipment store has been provided in Studio R1 only, but space considerations precluded its being as large as would have been desirable. Its purpose is to allow studio equipment such as camera dollies, microphone booms, cables, stands, spare illuminators, microphones, lenses, etc., to be stored convenient to the studio but in a place where they will not sustain damage during the rigging of scenery etc.

Of the group of studio technical accommodation remaining, the four principal areas are so operationally inter-dependent that they must be considered collectively.

It has sometimes been suggested that, in order to obtain the closest possible co-operation between all sections of the operational team, it would be desirable to build a large single area from which all studio operations could be controlled. Experience gained at Lime Grove in the preceding years, however, shows that this is not so; the principal objection being that the various conversations, movements and extraneous noise caused by one section disturbs another and does not permit the degree of concentration demanded. A compromise has therefore been sought in which all this accommodation is arranged in adjacent rooms on a single floor level separated by partitions containing carefully placed windows.

The purpose of the various rooms is as follows:

2.2.1 *Vision Control Room*

This is the production control room from which the producer directs artists, cameras and other production equipment and controls the continuity of the production.

The technical operations manager (T.O.M.) and the vision mixer also work from this room; both are in the closest touch with the producer throughout the production.

Particular care has been taken in planning the technical areas at Riverside to provide adequate space, not only in the basic operational positions but also in the vision control rooms, for make-up and wardrobe staff, designers, authors, composers, dance directors, and others whom it may be necessary for the producer to consult on immediate problems concerning the progress of the production. Such space has not been available in previous studios.

Other technical functions normally carried out in the vision control room include the control of special effects (inlay and overlay) which are described in Section 4.

There has been much discussion as to the correct location for the lighting control console and there is a considerable weight of opinion which favours its being placed in close proximity to the producer and T.O.M. in the vision control room. There is, however, an equally strong case for its association with the operators of the camera control units in the vision apparatus room, as it is in this area that the quality of the picture, in which the lighting plays so important a part, is the principal concern.

Bearing in mind the need for operational experience to settle such problems for the future, Riverside 2 has been planned with the lighting control console in the vision control room, whilst in R1 it is installed in the vision apparatus room.

2.2.2 *Sound Control Room*

Whilst it is vital that the sound supervisor should be in the closest touch with the producer and the remainder of the production team, it is equally important that he should be able to listen to the sound output from the studio in conditions free from distracting directions or conversations. Moreover, in order to appraise the quality of sound, or to balance the microphones he is using, he must listen at a volume level sufficiently loud as to interfere with the work of the other members of the team. A separate room, having a suitable window looking into the vision control room, is therefore provided for sound control. Its acoustic treatment is designed to provide, as nearly as possible, ideal listening conditions.

The disk reproducing units and all the amplifiers and other apparatus associated with the sound control equipment are also located in the sound control room.

2.2.3 *Vision Apparatus Room*

The camera control units form the principal items of equipment installed in this room. Again it is important that there is acoustic insulation from the vision control room. Nevertheless, it is considered that the operation of camera controls should be closely linked with the producer and the production team so that where certain pictorial effects are required, the liaison necessary to provide them is easily possible.

The room also contains the equipment concerned with vision mixing, inlay and distribution of pictures and pulses to and from the local studio equipment and the central apparatus room.

2.2.4 *Advance Technical Maintenance Room*

Although not considered as one of the basic operational areas it is essential that suitable accommodation be provided adjacent to each studio and technical area for the immediate maintenance of equipment. Whilst engineering operational crews are allocated to each particular production, the setting-up, maintenance, routine testing and repair of the technical equipment are carried out by a static maintenance crew associated with the studio concerned. In order that these crews may be kept in close touch with the studio equipment during rehearsal or transmission and have immediate access to spare units and test equipment, it has been found necessary to have a fully equipped test room and workshop adjacent to each studio control and apparatus room. Experience has shown that the attachment of maintenance staff to a particular studio over a period makes possible a measure of specialization which considerably reduces the liability of breakdown. Major overhauls of equipment must, however, be carried out in the base maintenance workshops.

2.2.5 *Arrangement of Studio Technical Areas*

Somewhat different approaches to the layout of the technical areas of the two studios have been made in an attempt to determine, under operational conditions, which basic arrangement should be adopted for the Television Centre. In each case the principal feature of the layout is the location of the studio observation window relative to the production positions. In Studio R1 the window is placed in front of the production desks; in Studio R2 the window is at the side. In the forward viewing case, shown in Fig. 3, the control room picture monitors are fixed above the window on a level with the eyes of the production team. In this position they afford good viewing, not only for those seated at the production desk, but also for the additional personnel behind. The monitors have been suspended on runners fitted to a shelf over the top of the window and the eye may pass easily from the monitors to the observation window below, through which an excellent view of the studio may be obtained.

In the case of R2, where the more conventional side viewing arrangement has been adopted, the control room picture monitors have been mounted on double-tier stands which are placed in front of the production desk. The view into the studio from the vision control room is not so good as in R1, except for the person sitting immediately adjacent to it (in this case the producer's secretary).

It may be argued that it is unnecessary to see into the studio as all the action may be seen on the picture monitors. It is, however, an advantage for the producer and the technical operations manager occasionally to glance into the studio to assess the relative positions of cameras and other studio equipment, particularly during rehearsals.

The technical areas have been arranged on the first

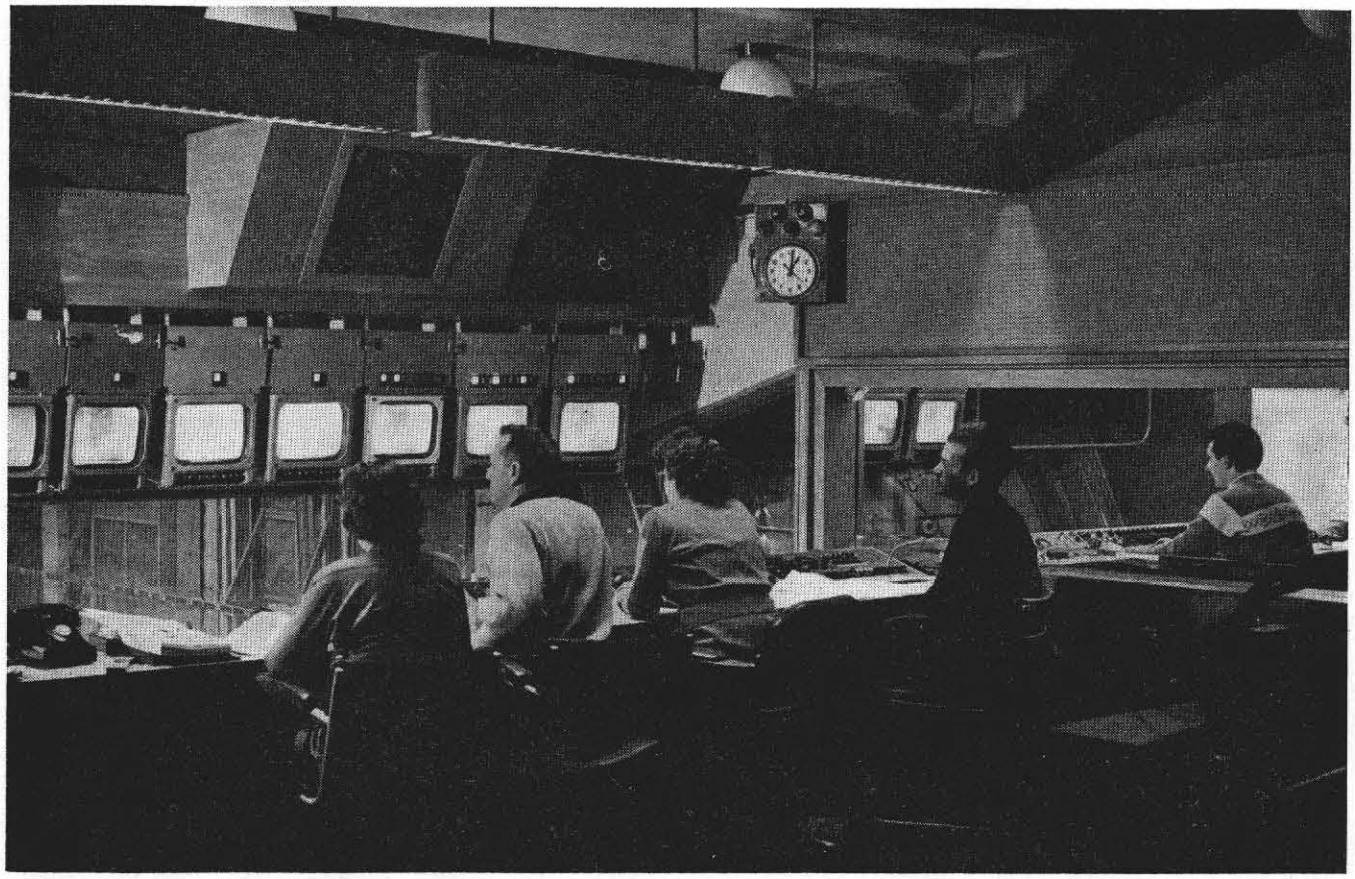


Fig. 3 — R1 Vision and Sound Control Room during rehearsal

floor in what was formerly an office block. In order to obtain the desired relation between them, it was necessary to enlarge the available space in R2 by building out the control rooms into the studio.* The sound and vision control rooms have been arranged in this case so that the respective operators face each other. The vision apparatus and maintenance rooms are located behind the vision control room in such a way that a view of the former is possible from the vision control desk, as can be seen from Fig. 2.

In the case of Studio R1 it was necessary to effect a compromise between the provision of technical areas of adequate size and the paring down of the studio area. It was finally decided that the vision and sound control, apparatus and maintenance rooms should be built in a single line on the first floor of a new block located at the side of the existing building but extending into the studio. The areas on the studio-floor level, beneath these four rooms, are used for make-up and wardrobe accommodation and for the studio technical equipment store.

2.3 *Central Technical Accommodation*

Central technical accommodation has had to be limited to an absolute minimum and has been located where space permitted. It was fortunate, however, that some space was available near the technical area of Studio R2, which allowed the central apparatus room, telecine rooms, and the technical component stores to be placed adjacent to this studio, thereby making it possible to integrate the test equipment, staff, and other facilities required for the efficient running of all three areas, in an economical manner.

In the case of the central apparatus room it was decided that, as this need not be permanently manned, it would be convenient for the maintenance engineers responsible for Studio R2 to make such adjustments as might be necessary and to be available if required to take emergency action.

No centralized maintenance workshops have been provided at Riverside as equipment in need of mechanical repairs or maintenance of too complex a nature to be carried out in the two advance maintenance rooms is taken to the Television Studios at Lime Grove. Some minor mechanical maintenance to studio equipment, such as camera mountings, microphone booms, etc., can be carried out in the studio equipment store in Studio R1.

3. Technical Equipment

3.1 *Central Television and Sound Equipment*

The functions of this equipment, which is located in the central apparatus room, are as follows:

(*a*) To generate the synchronizing pulses and distribute them, together with the necessary timing pulses, to the two studios and to the telecine rooms.

(*b*) To receive from the two studios video and sound signals for distribution, via balanced-pair video circuits, and P.O. telephone lines, into the distribution network. (For the present via the Television Studios central apparatus room at Lime Grove.)

(*c*) To terminate and distribute all communications from the distribution network, such as vision and sound cue-circuits and control lines.

(*d*) Remote control and monitoring of the power intake and distribution to various areas.

The synchronizing pulse generators (S.P.G.) produce four waveforms; mixed syncs and mixer blanking for the video waveform, and line and field trigger for synchronous timing of the studio cameras and telecines, etc. Fig. 4 shows a block schematic diagram of the pulse distribution system.

There are two S.P.G. units, one acting as a spare, which can be remotely changed over from the central apparatus room or from either studio.

Genlock[2] is provided to slave the studios synchronously to a remote source, e.g. an Outside Broadcast Unit or another Studio Centre, so that 'mixing' and 'superimposition' may be carried out between the studios and the remote source.

Five test waveforms are available for distribution to the studios etc.; these are:

(*a*) Grille Pattern for raster linearity and geometry checking.

(*b*) Line Sawtooth for checking the linearity of video amplifier chains.

(*c*) A 1·5 micro-second pulse ('Flag Pole') for detecting high-frequency distortions in video amplifier chains.

(*d*) Artificial Bars ('Art Bars'): A black cross on a white background, the cross widths approximately equal to line and field blanking widths. This is used as a test video signal into the distribution network.

(*e*) Stepwedge: A linear greyscale in which the number of steps in the scale can be adjusted between five and sixteen. It has switched frequency bursts which can be superimposed on the greyscale steps, and is used for checking video amplifier linearity, transfer characteristics and gamma.

Video signals and pulses are distributed within the Studios by means of two types of distribution amplifier, both designed by the BBC.

The first is for video signals and has a gain of 6 dB. This allows for losses in equalizing circuits within the studios; the equalizers are always 'padded out' to a fixed loss of 6 dB. The final stage is a 12.E.1 valve anode-coupled to a split load of four outputs, each feeding a coaxial line terminating in 75 ohms at 1-V. p.p. These units are each supplied from an individual, stabilized power supply. The amplifier has a control for adjusting the gain by $\pm$ 2·5 dB and has a 75-ohm input.

The second is the pulse distribution amplifier which is for handling 2-V. p.p. trigger, blanking and sync. pulses and has a self-contained, non-stabilized h.t. supply. Its stability is achieved by overall negative-feedback in the amplifier. This amplifier has a high-impedance input and, for this reason, several may be connected in parallel to provide a large number of separate feeds.

The video signals are transmitted via 40-lb. circuits in a multi-core cable. The transmission from the sending end

* A detailed description of the work involved is contained in Monograph No. 13.

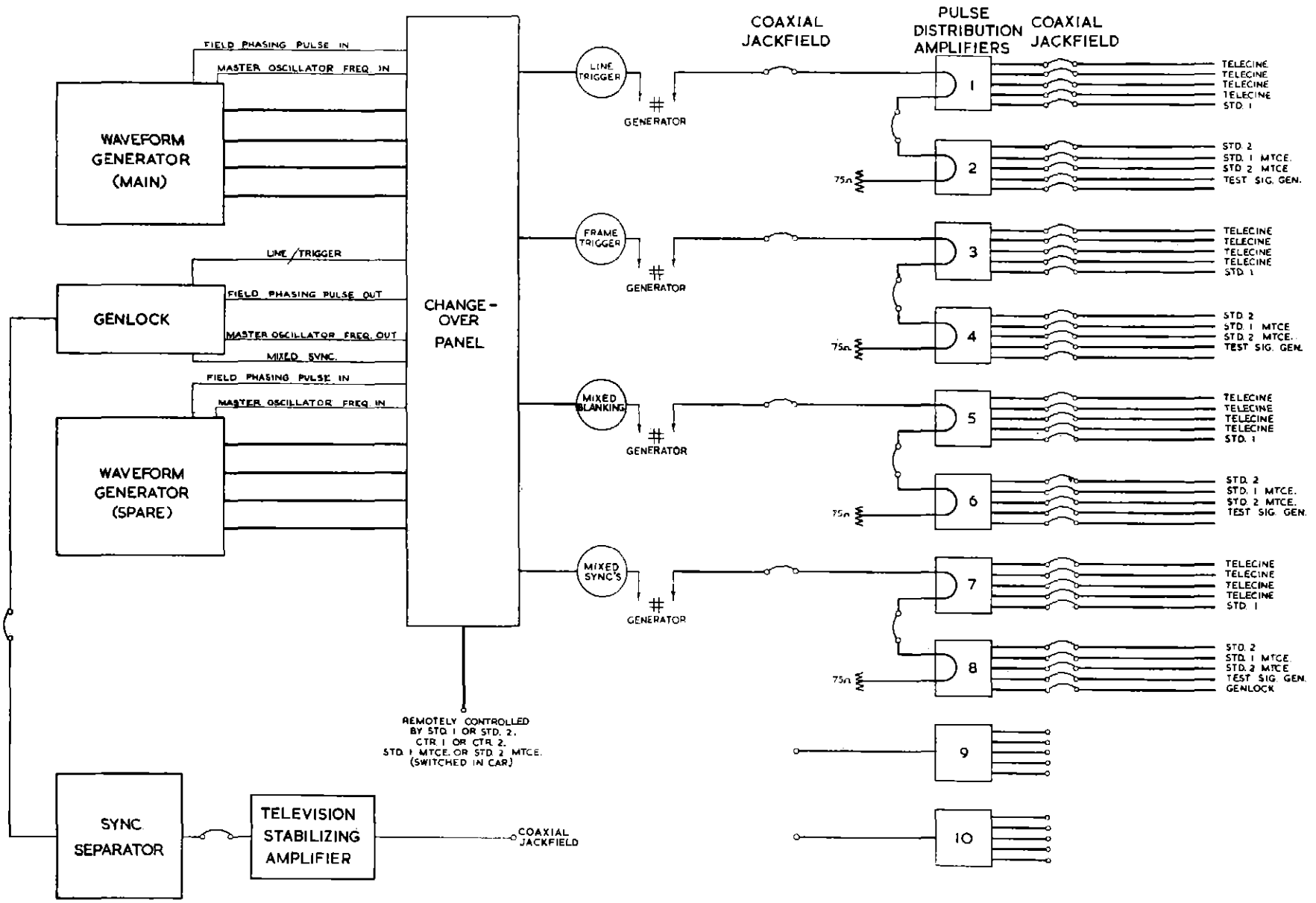


Fig. 4 — Central Apparatus Room Pulse Distribution Schematic

is a balanced 2-V. p.p. composite video signal, and this is fed into the circuit from a BBC-designed sending amplifier which has 1-V. p.p. video input, converting the standard distribution signal to a balanced signal for sending.

The receiving apparatus is a series of video gain amplifiers and equalizers. The balanced video signal is received, transformed to an unbalanced signal and amplified. The signal is equalized and again amplified, using Bode[3] equalizers; the particular frequency band being compensated is suitably phase-corrected.

The central sound equipment is similar to that used in the sound broadcasting service. The sound contributions from both studios are received and may be monitored prior to sending into the external distribution network. All circuits are 600-ohms balanced, and the sending level into the P.O. lines is + 4 dB. Sound contributions received from the external network for inclusion in composite programmes in either of the studios are equalized, 'padded out' to −42 dB and amplified in a fixed-gain amplifier for further distribution. The equipment is almost wholly of BBC design.

A high-grade check receiver for both vision and sound signals is provided for cueing purposes. The output of this receiver may be fed to either studio or to telecine.

The master pendulum clock is also situated in the central apparatus room, and operates a series of 'seconds' and 'half-minute' slave clocks. The system is accurate to within one second per day and is similar to the clock systems used in other BBC studio centres and transmitters.

3.2 *Studio Television Equipment*

The equipment in the two studios is of similar design but one less camera and no inlay and overlay equipment is provided in R2, therefore the general description will be based on the equipment in R1.

The cameras, made by Marconi's Wireless Telegraph Co. Ltd, and designated Mark III, were originally designed to meet a BBC specification. They use the English Electric Valve Company's 4½-in. image orthicon camera tube which was developed by the E.E.V. Co. in association with the Marconi Company. This type of camera tube was originally developed by R.C.A. in parallel with the 3-in. version, but their 4½-in. tube differed in that it was 'scaled up' from the 3-in. image orthicon, and had a different magnification in the image section. The E.E.V. Co.'s 4½-in. tube has an image section magnification such that lenses having a diagonal coverage of 40 mm. can be used. The tube, even at the time of coming into service in August 1953, had definite advantages over the standard type 5820, 3-in. image orthicon tube, such as improved signal-to-noise ratio, less 'edge effect' and better resolution. It also has a much longer linear characteristic below the 'knee' but flattens off more above the 'knee'.[4] The 4½-in. tube exposure is adjusted to work between 0·5 and 1·0 stop over the knee. Subsequently, in the camera chain, the signal is passed through a de-gamma circuit.

A standard complement of lenses is used on each camera, f 1·9, 2-in. (35°),* f 1·9, 3-in. (24°), f 3·5, 5-in. (14°), and f 4·5, 8-in. (9°). The control of light to the camera tube is by means of a neutral density filter-wheel which has a 10 : 1 range. This is controlled remotely from the camera control unit. The lens iris may be adjusted by the cameramen for setting depth of focus, and also for setting an average mean exposure point for working the image orthicon. The cameras are mechanically focused by means of a lever-type control on the right-hand side of the camera body which moves the tube carriage in relation to the taking lens. The rotation of the four-position lens turret is also operated mechanically, from the rear of the camera, one complete turn of the turret change handle corresponding to one lens change.

The camera has an electronic viewfinder which displays a picture on a 5-in. cathode ray tube viewed through a magnifying lens.

The camera is connected by means of a single camera cable to its camera control unit in the vision apparatus room. Fig. 5 shows a group of camera control units, which are arranged in an arc about a centre position equipped for supervisory control. A 'transmission' and a 'preview' picture monitor, for picture-matching purposes, and a waveform monitor are provided. Master gain and lift controls from each C.C.U. are made available at this centre position for use by the vision control supervisor; these enable him to over-ride if necessary the settings made by individual C.C.U. operators. The outputs from the camera control units are distributed to the vision mixer and preview monitors as illustrated in Figs. 6 and 7 which show the transmission and preview chains respectively.

Preset gain and lift controls for effects purposes are fitted in each C.C.U. and, having been previously set up, may be switched into operation either by the C.C.U. operator or from the lighting control console. Special provision has also been made for the extension of this switching facility to points in the studio so that it may be coupled, for example, to a light switch on the wall of a studio set.

Vision Mixing Equipment

The vision mixing apparatus was developed by Marconi's Wireless Telegraph Company Ltd, to a BBC specification.

In considering the operational requirements prior to the preparation of the specification an ample field of experience was available. There had, in earlier installations, been little or no standardization in vision mixing equipment and it was apparent that for the future a standard format of operational controls was essential.

The vision mixing equipments in previous use may be classified into two distinct groups thus:

(i) Mixers having separate fading and cutting controls for each available source.

(ii) Mixers of the 'A–B' type in which a single fader is used to select one or other of two main circuits to which chosen individual sources have been previously switched.

Whilst experience with an 'A–B' mixer fitted in Studio 'E' at Lime Grove had shown the limitations of this system, particularly on elaborate caption sequences, it had

* Horizontal angle—picture 4 × 3 aspect ratio.

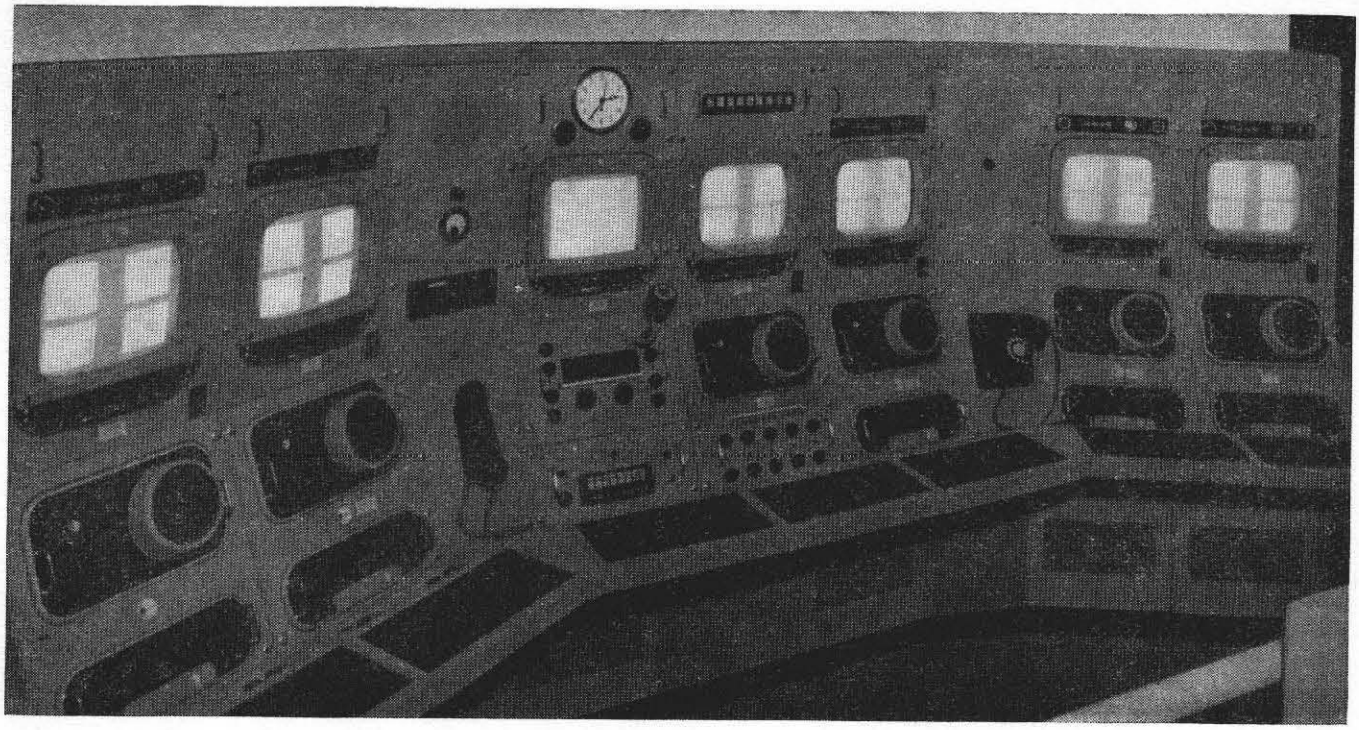


Fig. 5 — Camera Control Units in R1 Apparatus Room

also clearly illustrated the potential advantages of this system when it can be properly utilized. In particular, it offers the fairly easy application of a mode of operation whereby the picture about to be taken can be displayed to the entire production team without undue complication. On the other hand, the advantages of having completely separate controls for each source were too important to be neglected.

After careful consideration a vision mixing desk incorporating the advantages of both systems has been adopted. A brief description of the operation of this equipment will illustrate the degree of flexibility achieved.

The mixing desk consists of two control panels, each having seven channels, with a group control to select the panel desired, or the correct combination of both panels when this applies. In determining the number of channels an attempt was made to reach a compromise between the provision of adequate facilities and the undue complication of the equipment. Subsequent experience, however, suggests that eight channels might have been a better choice—a greater number than this would almost certainly have introduced complication in operation.

A fader and a cut button are provided for each channel on both panels and a fader and separate cut button for each panel on the group control panel. A system of indicator lights is arranged to show which group is on transmission, which faders in each group are faded up and which cut buttons have been operated.

Normally the same seven picture sources are applied to the channels on both panels, but to comply with exceptional conditions different sources may be plugged to both panels and in this way a total of fourteen sources could be handled.

When the mixer is connected in the normal manner, the four (or three) studio cameras, telecine, special effects (inlay and overlay) and outside broadcast sources are plugged to the seven channels on both panels. Two modes of operation are thus available to the operator:

(i) *Straightforward Operation*

This method is most suitable for the very fast moving or unscripted production. It will be assumed that the group fader for the one panel is faded up on the group, or the cut button for that panel operated.

It will now be possible to fade up any channel, or a combination of a number of channels, as required. Cutting may be achieved by operation of the appropriate button on the group panel. The cut buttons take control irrespective of the position of any of the faders, but a separate 'cut-mix' button may be used to switch back the control to the faders.

Special effects, such as superimpositions, may be set up at leisure on the second panel and may be previewed on a preview monitor which shows the output of the panel which is not on transmission. When required the combined picture set up on the second panel may be selected by operating the group controls. It should be noted that combinations involving a picture source already set up on one panel may be freely set up on the other without interference.

(ii) *Preselector A–B Operation*

This mode of operation is suitable only for productions or parts of productions where the speed of operation is comparatively slow and where the

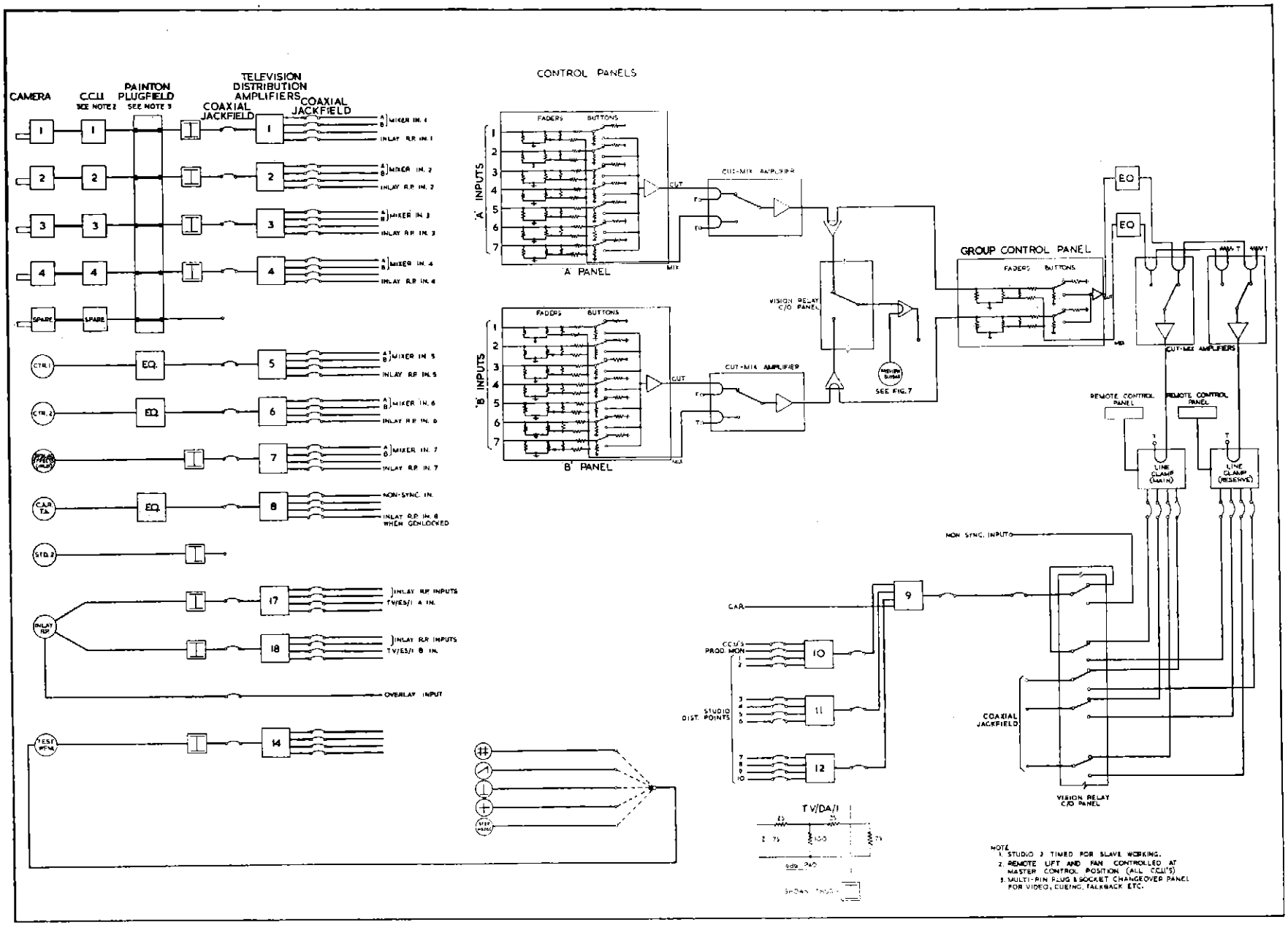


Fig. 6 — Transmission Chain

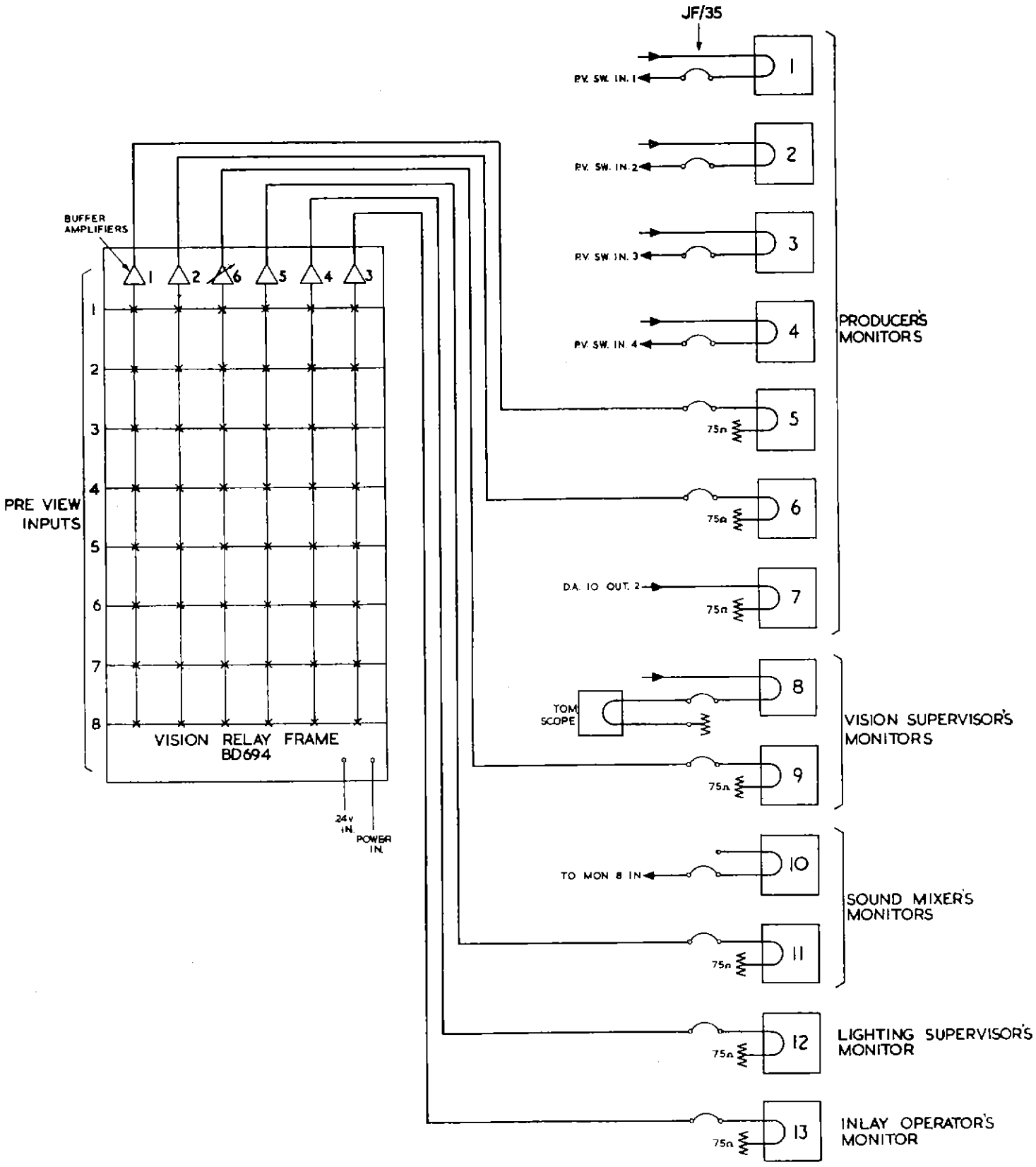


Fig. 7 — Preview Chain

sequence of operations is completely planned. The mixing or cutting from source to source is carried out on the group control, the required source, or combination of sources, having been previously set up on whichever panel is not on transmission at the time.

The monitoring arrangements are such that the output of the group not selected is displayed on a single monitoring circuit, therefore the picture next to be selected is displayed on this circuit and will be available on picture monitors not only in the vision control room but in the sound control room and apparatus room when desired. This facility has many advantages in keeping all the operational team aware of the continuity of the production.

It will be noted that the provision of two groups, each having all the required sources connected to it, offers inherent protection in case of breakdown although, of course, in this event the full facilities outlined above would be restricted.

Technical Note

Each panel controls video, composite or non-composite, signals which are fed at 75 ohms. Direct mixing and fading are accomplished by means of symmetrical bridged 'T' network attenuators using quadrant type faders. Cutting is carried out by means of self-cancelling push buttons which carry the video inputs. A cut-mix relay is used to determine whether the output from the faders or that from the cut buttons is fed to the mixer output. This relay is actuated in favour of cut on the operation of any cut button or in favour of mixing if any fader is taken to the minimum attenuation position. Alternatively, the change-over from cut to mix, or vice-versa, may be achieved by operating a separate cut-mix switch.

A small buffer amplifier mounted on the panel is used to isolate the cut circuits.

A loss of some 19 dB is sustained through the network and is made up by the gain of a cut-mix amplifier mounted in the vision apparatus room where the cut-mix relay is fitted.

The output from the cut-mix amplifier for each panel is fed to the group or combining panel and chain, which is similar in operation to the main panels described above. The final composite output is then passed through a line-clamp unit which amplifies, clamps and re-inserts clean synchronizing pulses, and sets the picture pedestal.

A spare cut-mix amplifier is provided for the group panel and is brought into circuit by relays controlled from the vision control supervisor's position at the C.C.U. console. Controls are also available at this position for bringing into service a spare line-clamp unit and for the major adjustments to it, viz. lift, gain, sync. amplitude and peak-white limiter.

In order to obtain negative pictures when required, a phase-reversing negative-picture amplifier may be brought into action and is controlled remotely from a control placed between the vision mixer and the technical operations manager.

The facilities for previewing pictures from the different sources are arranged by a relay system as shown in Fig. 7; each preview channel is isolated from the relay grid by a buffer amplifier. The inputs to the vision mixing apparatus group control panel can be monitored (see Fig. 6) and can be connected to the preview relay grid for selection. This facility is automatic and is controlled from the faders on the group control panel, when the 'A' side is 'on the air', the 'B' side is on 'preview' and vice-versa. The preview equipment was supplied by Marconi's Wireless Telegraph Co. Ltd.

3.3 *Studio Sound Equipment*

The sound apparatus for both studios is based on equipment used in the sound broadcasting services. In Studio R2 a standard Type 'A' equipment, having eight control channels, is installed. This has already been described in the *BBC Quarterly*.[5] The only modification to the standard circuits is the addition of 'balance controls' on each source to enable a close pre-set match of sound volume between sources to be effected. It is pertinent in this connection to note that there is a distinct difference in sound and television techniques. In the former, the studio manager may decide his microphone positions freely but in television the microphones are usually required out of camera shot, and it is therefore not always possible to place them in the most desirable positions for a correct balance of sound.

Pre-fade listening is also provided on each source and an auxiliary six-channel low-level mixer installed, thus making possible the use of thirteen control channels when required.

Studio R1 has been provided with much more elaborate sound control equipment, the circuit design of which is based on that of the new BBC Type 'B' equipment. The control desk, a photograph of which is seen in Fig. 8, has, however, been specially designed for the Television Service. Its layout gives a clear view into the studio over the control panel, which is of table-top design. The fader controls are of the quadrant type, which are more suitable for this operational layout than rotary faders.

Thirty-five sound sources are available. A low-level jack-field, mounted on the control desk, is used to cross-plug the required sources into two seven-way groups, and two independent channels. Each channel on both groups and each independent channel has a level-raising amplifier of 40-dB gain which is followed by a balance control and a channel fader (see Fig. 9). The 'prefade' key to the channel is prior to the balance control. Each channel fader is followed by a hybrid transformer on the two groups to provide an 'echo' output. The two outputs from the hybrids are passed through 'echo-mixture' switches which control the 'echo' to 'direct output' ratio. The 'echo' outputs of each group may be combined or may remain independent so that two forms of echo can be provided. Both an echo chamber and an artificial reverberation machine are available. The 'direct' outputs of each group are combined with the echo chain and pass through a group fader. Both echo outputs are provided with 'pre-fade', 'balance', 'channel fader' and 'echo-cut' controls. The output of each group fader is followed by a further hybrid

transformer to provide a feed to the studio sound reinforcement amplifier.

Similar hybrids on the two independent channels are provided to give 'direct' and 'sound reinforcement' feeds. The 'direct' output from the two 'groups' and two 'independent' channels are combined to feed into the main control. The main control is followed by a level-raising amplifier of 70-dB gain. The output of this amplifier is fed to line. In parallel with the feed to line is a monitoring amplifier of high-impedance input. This monitoring amplifier controls peak programme meters and feeds to loudspeaker units. A new type of programme meter,[6] in which the meter movement is of the mirror type having a spot of light travelling on a large scale instead of the conventional pointer, has been used in this studio. It is mounted immediately below the 'transmission' picture monitor used by the sound supervisor. The law of this meter is such that the scale is extended at the lower end which permits more accurate control, but its particular appeal for television use is that it may be placed adjacent to the picture monitors in the normal line of sight of the sound supervisor. The studio sound reinforcement amplifier system has two group inputs isolated by a hybrid transformer. The first group consists of the outputs of 'groups' or 'independent' channels which are individually switched. The second is of six separately switched sources comprising the studio disk reproducers, two outside sources, two telecine sound outputs and a miscellaneous source. A 'foldback' circuit is provided from the first channel of each 'group' and from the first 'independent' channel.

In order to augment the number of control channels, especially for such purposes as the control of small distinct orchestral groups etc., two auxiliary mixers are provided, each of four channels with level-raising amplifier and 'channel faders'. Any of the thirty-five sources may be fed to the auxiliary mixers, which in turn may be fed to any channel to provide 'sub' groups. A total of twenty-two control channels may therefore be employed.

The level-raising amplifiers are of a common type and are provided with switchable preset gains of 40, 50, 60, and 70 dB. Miniature twin-triode valves are used, and banks of amplifiers are fed from common power supplies. All controls are 600-ohm bridged 'T' networks, and the 'channel', 'group' and 'main' controls are of the quadrant type.

3.4 *Studio Talkback and Communications*

The talkback system is shared between Engineering and Production requirements. The equipment is built up in part from standard BBC equipment, but includes the

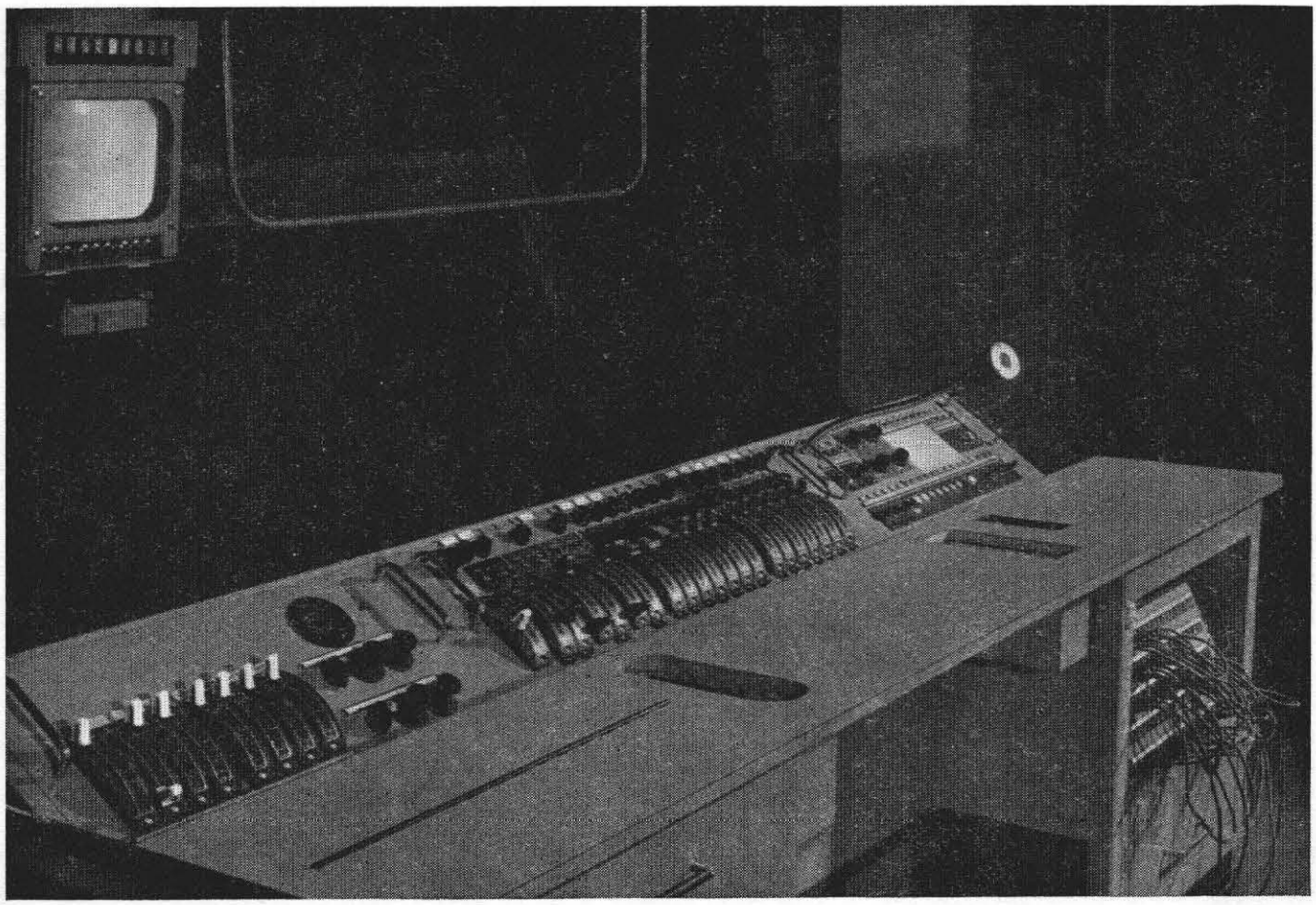


Fig. 8 — R1 Sound Control Desk

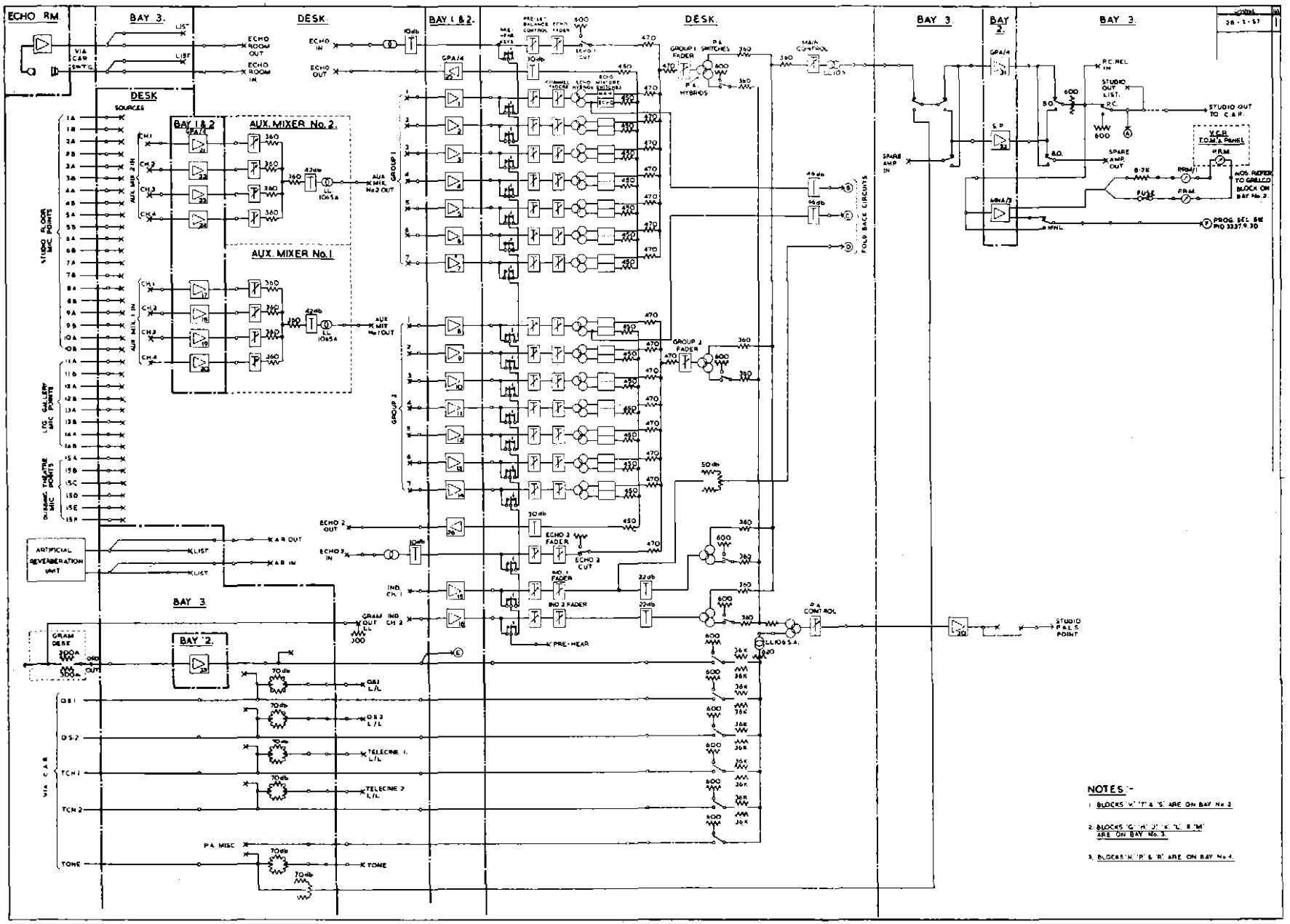


Fig. 9 — R1 Sound Control Room Block Schematic

camera channel equipment supplied by Marconi's Wireless Telegraph Co. Ltd.

There is, firstly, an overall talkback chain which carries the voice of the producer by headphones to the entire studio crew; cameramen, sound floor staff, studio manager, etc. In this chain a moving-coil microphone is followed by a level-raising amplifier and power amplifiers feeding 20-ohm circuits which are available at points around the studio and, via the camera cable, to the camera crew's headphones. It is also available on low-level loudspeakers fitted to the lighting console, sound control desk and camera control units in the vision apparatus room. This channel, under normal operating conditions, is open the whole time. The producer may also speak to the cast or floor staff by means of a loudspeaker during rehearsal, or when the studio microphones are faded out during transmission. This talkback chain has a parallel microphone which can be switched into circuit by the technical operations manager. Separately, he also has the facility to speak to individual camera crews, and the vision apparatus room. The sound floor operators, who normally receive general talkback, may have their circuit switched by the sound supervisor at his control desk and thus receive instructions from him. When this operation is carried out the key operating the circuit supplies a burst of 1,000 c/s tone during the 'make' and 'break' operations. This is to indicate to sound floor operators that instructions are about to be given by the sound supervisor. As the sound supervisor frequently has both hands occupied he may also actuate the sound talkback circuit by means of a foot switch.

The principal microphone boom has a reverse talkback channel to the sound supervisor. This circuit enables the senior sound floor operator to discuss sound operational difficulties with his supervisor direct from the floor during rehearsals.

The camera crews can receive individual instructions from their appropriate camera control unit operator and from the vision control supervisor. This equipment operates at 'telephone level' using headsets with carbon-granule microphone inserts attached.

The general talkback can be fed to the telecine suite for giving instructions which are heard in the telecine rooms over a small loudspeaker. It is also available to the other studio or an outside source, should either be contributing to the studio production. The studio manager usually receives his instructions by a radio link. A Pye Telecommunications v.h.f. amplitude-modulated transmitter operating in Band I transmits the general talkback. The instructions are received on a BBC-designed miniature superheterodyne receiver[7] which will fit into the jacket pocket. A pair of lightweight headphones are available, and their lead acts as the antenna. Return, or reverse, talkback facilities are available from the studio manager to the producer, but are used only under special programme circumstances, such as during ballet productions when there are only a limited number of studio microphones in operation. The studio manager then carries a miniature transmitter, similar in size to the receiver. Its antenna is the microphone lead, the microphone itself being of the crystal type. Under normal circumstances, of course, the studio manager talks to the control room by means of the studio microphones.

A separate talkback circuit is available to the lighting supervisor for relaying information to electricians on the lighting gallery who may be operating lighting equipment independent of the lighting console, such as carbon arcs, lighting effects, etc.

A simple telephone system with a number of fixed parallel points around the studio floor and the lighting gallery is available for the lighting electricians to communicate with the lighting supervisor.

The producer has a further method of communication with the studio, by means of green 'cue' lights. The producer's control panel is fitted with a number of switches controlling relays, with mains current contacts which operate 240-V 15-W green cue lamps. These cue lights are placed to 'catch the eye' of the artists concerned, and are particularly useful when, for example, dialogue must fit in with recorded effects.

Each camera has two red 'live' lights, one fitted on the top of the camera and the second adjacent to the 'taking' lens. These lamps are operated only when the camera is taking a picture for transmission, i.e. when it is faded, mixed or cut in the vision mixing unit (see Section 3.2).

The lamps operate immediately the appropriate quadrant fader leaves the minimum contact, or the 'cut' push-button is made.

3.5 *Studio Lighting Equipment*

A great deal of consideration was given to this subject as these studios were the first in the BBC to be provided with comprehensive lighting systems and it was clear that the experience gained from their use would be of great value when planning the Television Centre.

The equipment is divided into the following parts:

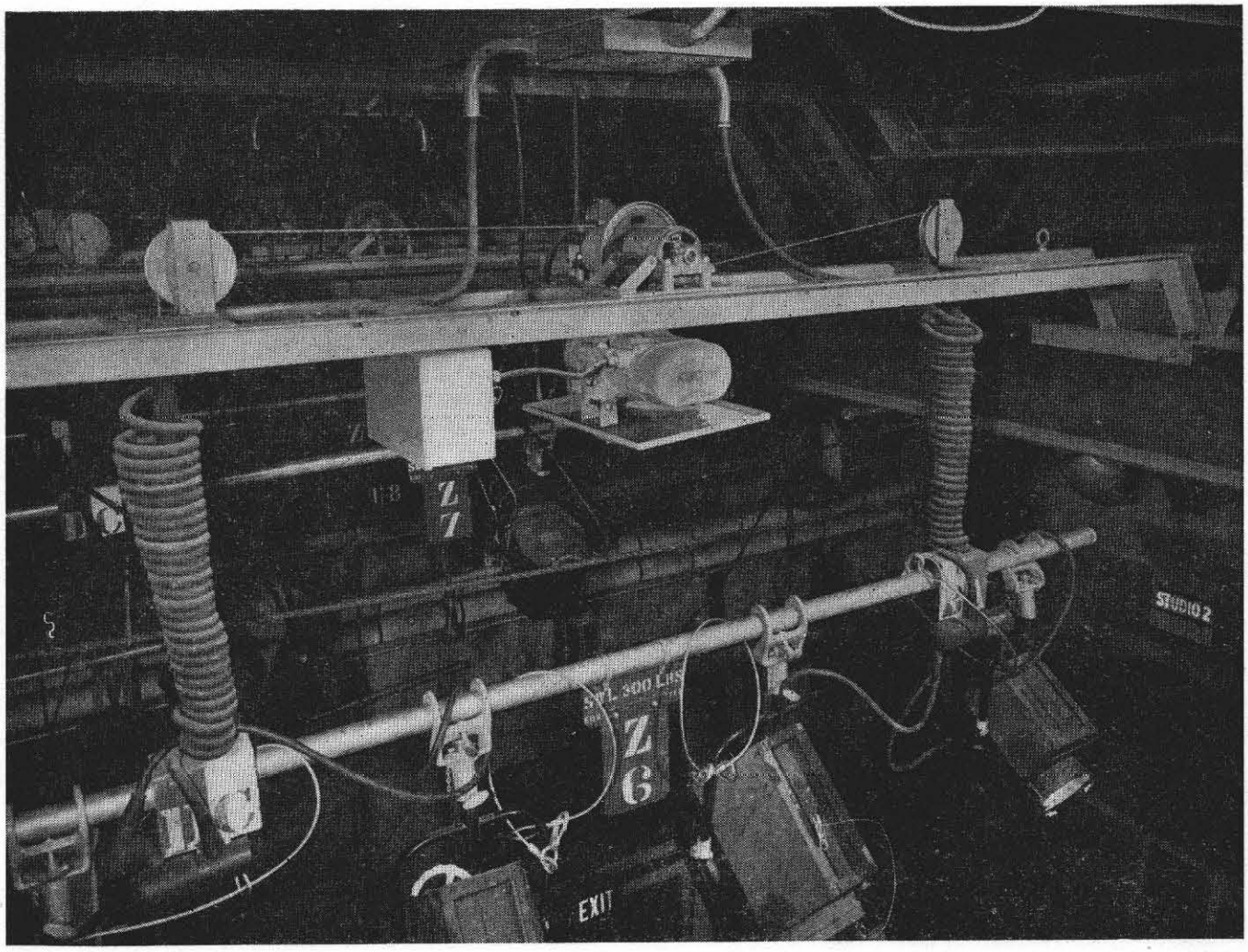
(*a*) Mechanical handling of illuminators.

(*b*) New designs of illuminators.

(*c*) Studio lighting control systems.

Past experience had shown that the handling of lighting equipment seriously delayed the setting of studios prior to rehearsal. Two things were important, firstly, to simplify the handling of the illuminators by the introduction of mechanical devices and, secondly, to supply an adequate number of illuminators to reduce their movement to a minimum.

The mechanical handling units were developed from a prototype and manufactured by Messrs Geo. W. King of Stevenage. The production units utilized a small commercial electric hoist of the type shown in Fig. 10. Each unit is capable of lifting a load of 300 lb. which is normally made up of four illuminators suspended on an aluminium barrel 8 ft 8 in. in length. A second barrel of equal length can be cleated below to suspend additional illuminators or scenery when desired. The units are fixed 24 ft above the studio floor in rows across the width of the studio. The ends of the unit barrels are approximately 2 ft apart, and they are spaced 6 ft apart along the length of the studio. An auxiliary group of units is fixed lengthwise



(Photo courtesy George W. King Ltd)

Fig. 10 — Complete Hoist Unit showing self-coiling cables and batten for holding illuminators

down each side of the studio. A total of sixty-two hoists have been provided in R2 and seventy-nine in R1.

These can raise or lower their banks of illuminators singly or in groups and are operated from a control panel on the studio floor. This system cuts down the number of floor-stands required and the fixing of illuminators from the lighting gallery is reduced to a minimum. The cables feeding the 115-V a.c. supply to the illuminators are self-coiling so there is no problem of taking up slack at whatever height they are positioned. All the three-pin plugs and sockets are rubber moulded and moulded to the end of the cables; this has proved economical both in installation and subsequent maintenance.

All couplers and special fittings have been made to avoid the use of spanners.

A group of pantograph units, similar to those used in American studios, is also being used so that small illuminators may be suspended below the level of the parent group. Fig. 11 shows a typical rehearsal scene in the studio. Two new pattern illuminators were considered to be necessary for two reasons. In the first place the economic weight which the hoist units could lift, and the total loading which could be applied to the roof structure, demanded the design of lightweight units. Secondly, although the existing 'spotlight' efficiencies were good, there was a serious need for a 'broad source' illuminator which was light in weight, efficient, and economically priced.

Four companies were invited to submit designs for 5-kW, 2-kW and 500-watt spotlights. Two companies' products, those of the General Electric Co. Ltd and Mole Richardson (England) Ltd, were chosen for overall efficiency. The weight of a 2-kW spotlight was reduced from approximately 44 lb. for the standard model to 28 lb. for the lightweight version. The BBC was prepared to forego some of the robustness of the standard model, as the lightweight illuminator would receive very much less handling.

The 'broad source' illuminators were a joint development effort by the BBC, the G.E.C. and Mole Richardson. Although their respective products vary in detail design, the performance is very similar. The units now referred to as 'scoops' consist of a deep-spun concave reflector-housing 17-in. in diameter with a G.E.S. lamp-holder

to carry 500-W internally silicon-coated, or 1000-W tungsten, lamps and 'spill rings'. Although no originality for this type of illuminator is claimed, it is mechanically better than others in existence and the use of internally silicon-coated lamps is new. These give a good, diffused, base light, and with the 2-kW spotlights arranged alternately, form the main complement of illuminators fitted to the hoist units. A small number of 5-kW spotlights is also used, but these are generally fitted on the lighting gallery rail. There are in addition a number of 500- and 200-W spotlights, effects illuminators and carbon-arc lamps.

The control of the light output of the illuminators in the two studios is achieved by different systems. In Studio R1 an arrangement similar to that used in a large number of London theatres, but more comprehensive in its control facilities, has been installed. The light output is controlled largely by variable resistances, but a small number of auto-transformer dimmers are also used. Both are operated by an electro-magnetic clutch system.

In Studio R2 the light output of the illuminators is controlled by xenon-filled thyratrons.

The R1 lighting control equipment was designed and manufactured by the Strand Electric and Engineering Co. Ltd, and utilizes their control system 'C'. Fig. 12 is an illustration of the control console.

There are 166 control channels each with its own dimmer. 138 of these control 1000/2000-W circuits and four control 5-kW circuits, both groups of channels being of the resistance type. In the remaining twenty-four circuits 2000-W auto-transformer dimmers are used. The 1000/2000-W resistance circuits can operate illuminators of either 1000- or 2000-W loading without much difference in their light dimming curves, most of the light output control for television scenes being at the top end of the control from 115 to 95 volts. The transformer dimmers are required for circuits which may have to control illuminators with loads varying from 200 to 2000 W.

The 166 dimmer circuits are routed to the studio via a relay-controlled patching panel and the studio has 348 socket outlets, most of which are on the hoist units. The 348 socket outlets are arranged to cover the studio in three sections, each section being confined to one of the three phases of the supply. As the lighting forms the major part of the complete studio electrical load, the distribution has been planned in this way in an effort to keep the phase

Fig. 11 — R1 Rehearsal Scene showing typical Lighting Equipment, etc.

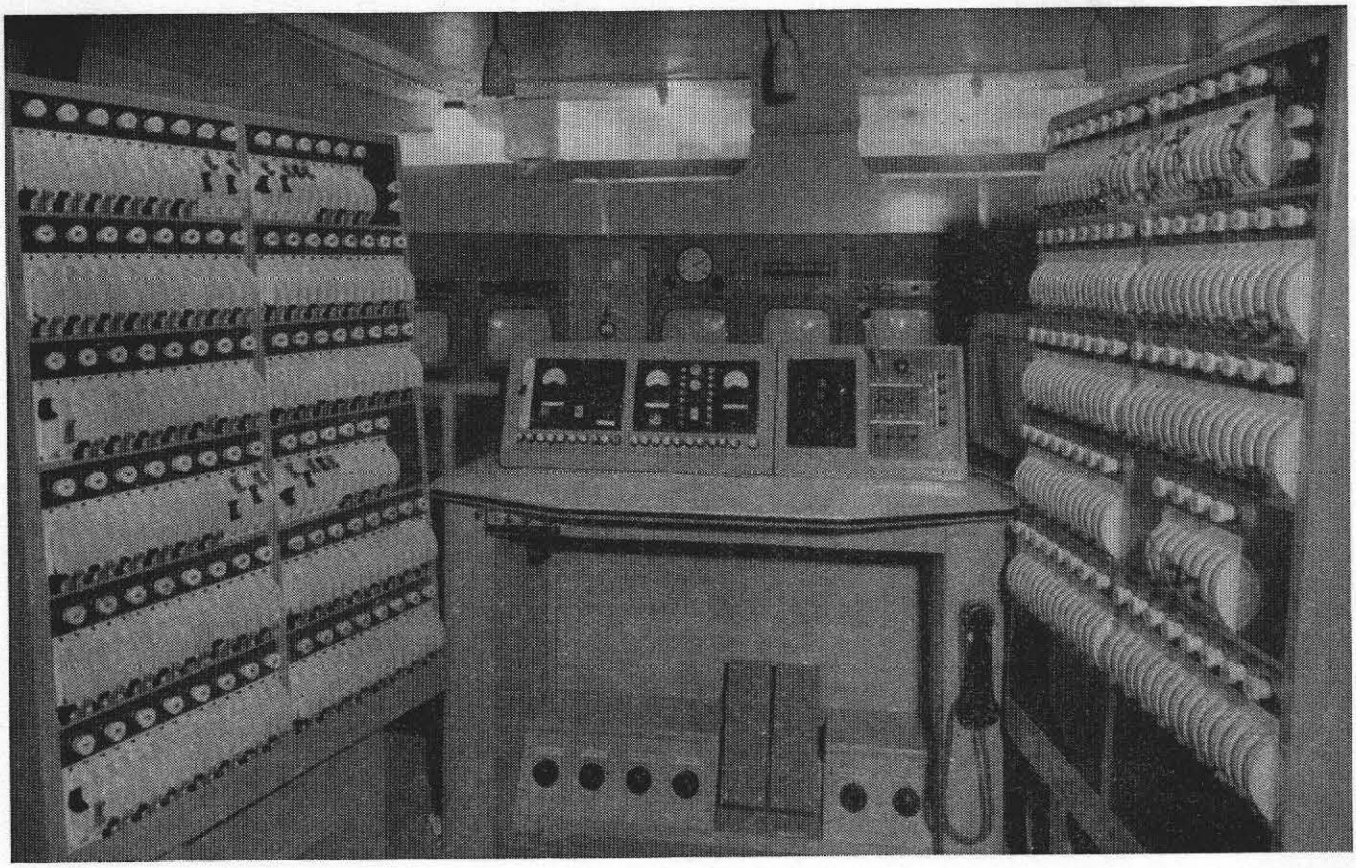


Fig. 12 — Lighting Control Console in R1 Apparatus Room

loadings balanced. It is a compromise, however, as the artistic effects of the studio scenes dictate the final lighting load, and hence the balance. This method of sectionalizing the studio into phases somewhat limits complete flexibility of control, as certain of the dimmer circuits can only be patched to a particular section of the studio socket outlets; it does, however, avoid inter-phase voltages of a dangerous order should there be a fault.

Once the illuminators have been selected on the relay patch panel, they are controlled by the appropriate channel on the control panel shown in Fig. 12. Each unit consists of a double-touch 'organ piston' type push, known as the channel switch. Immediately beneath this are two edgewise dimmer levers, one for the 'black' channel and one for the 'red' channel and means are provided for selection of the setting to be used. The two levers are to give two different light output levels for each channel. The double-touch button on its first 'push' connects the channel to the clutch system; this is denoted by the illumination of the button. A second 'touch' disconnects the channel, and extinguishes the light in the push-button. The action of operating the push causes the electromagnetic clutch to engage with the continuously rotating wheel adjacent to the appropriate control resistance or auto-transformer in the dimmer room (Fig. 13). The wheels referred to above are fitted to shafting, the end of each shaft being coupled to the next by a chain-drive, and finally to a variable-speed uni-directional motor drive. The action of moving any edgewise dimmer control will cause its associated dimmer unit to take up the appropriate position either with the channel switch in the 'on' or 'off' position.

This system is backed by very comprehensive 'servo' and 'relay memory' devices which enable the lighting supervisor to set up to twenty different lighting arrangements and 'call' the appropriate one by the touch of a button on a twenty-way push-button unit. The change from a scene set on the 'black' channels to one set on the 'red' channels may be achieved by a fade down or cut to blackout followed by the reverse operation or, alternatively, by a mixture of the two lighting scenes. The speed of the fades or mixes can be controlled at the console by varying the speed of the motor driving the shafting.

Thus elaborate lighting scene changes, such as 'sunset', can be arranged to take place partly by adjusting the brilliance of the illuminators, and partly by controlling the electrical output of the camera or cameras taking the scene (see Section 3.2). The principles of this system have been dealt with in articles by F. Bentham[8][9]. A control panel located on the studio floor enables the studio electrician to switch on any circuit during the setting-up period without the lighting console having to be manned.

The lighting control equipment fitted in Studio R2 was also constructed by the Strand Electric Co. in conjunction

with the Mullard Valve Company who co-operated in testing a prototype three-channel unit using their type XR1.6400 xenon thyratron.

The total number of channels in this studio is 144 and these may be patched to 304 socket outlets in the studio.

The sub-division of channels differs from the pattern in Studio R1 and is as follows:

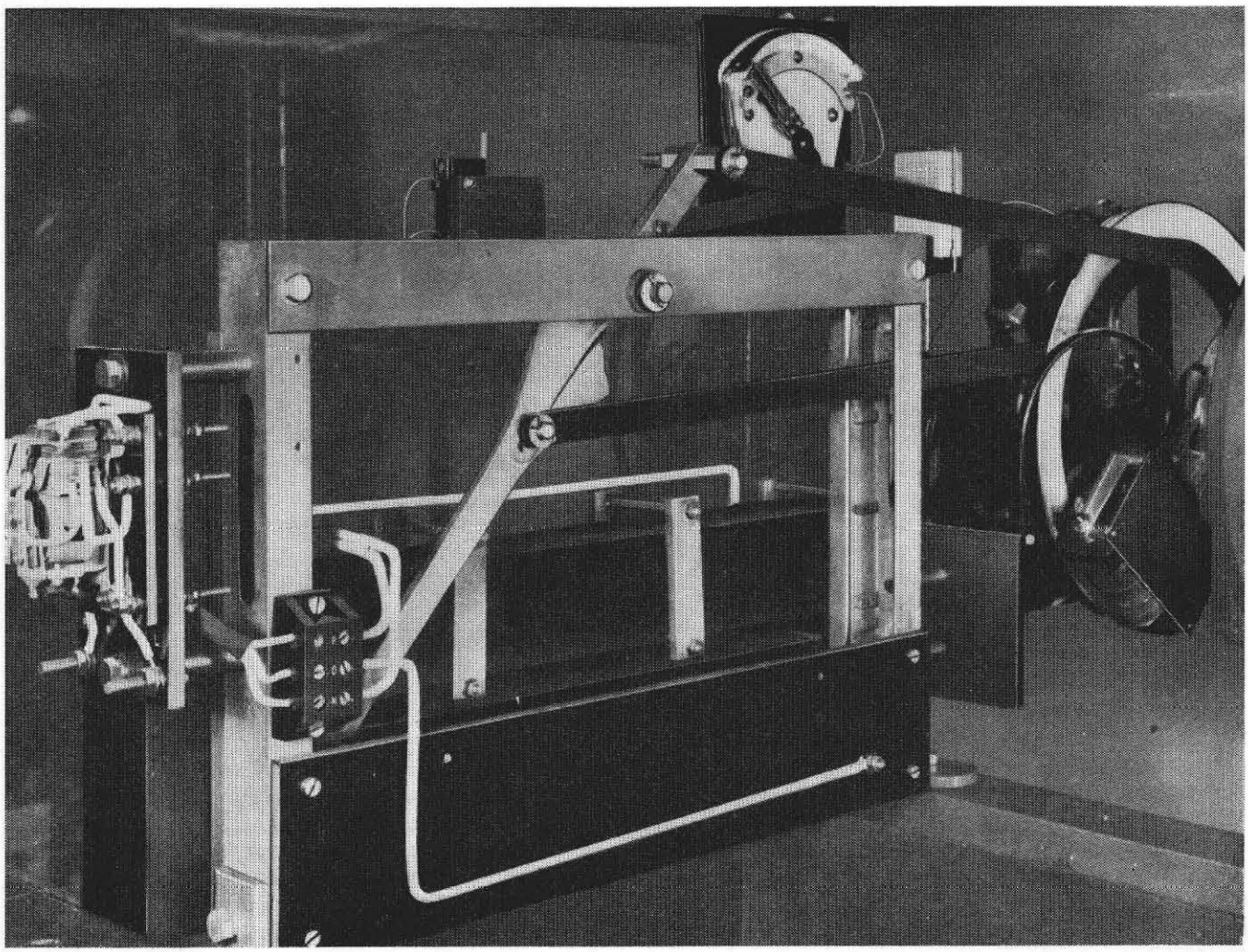
(*a*) 96 electronic dimmer channels, maximum load 2 kW.

(*b*) 48 switched (relay) channels without dimming facilities, maximum load 3 kW.

(*c*) 4 5-kW resistance dimmers wired direct to four socket outlets in the studio.

The electronic dimmer channels are identical in circuit details. Each circuit has 3 thyratrons which share the load (illuminators) in the common cathode circuit. The anodes of the thyratrons are fed from the secondary of a star-connected transformer; one anode per phase. The anodes are at 122 V to neutral and the output at the cathodes is 115 V under normal load conditions. The grids of the valves are energized by an a.c. potential of 70-V p.p. and lagging in phase by 90° compared with the anode supply. This potential is superimposed on a d.c. bias which, when varied, decides the part of the cycle during which the valves conduct. The d.c. bias is controlled direct from a control desk. The control is very different in type from the R1 system as this thyratron equipment requires a control bias the whole time the illuminators are giving a light output, thus the control is less flexible. Each channel has three edgewise faders and three switches corresponding to circuits 'red', 'yellow', and 'blue'. This arrangement allows for three preset moves; with the channel switch in the 'up' position passing the control circuit on, or, in the 'down' position, to make the control individual to its fader. When the control circuit has been passed on, the master control can be operated between the red, yellow and blue channels, allowing cuts and fades to blackout; mixes can also be carried out. There is a facility for coupling the master control to a motor drive which can control fades or mixes and offers eight preset speeds ranging from two to thirty seconds.

The 3000-W switched circuits are also controlled from



(Photo courtesy Strand Electric & Engineering Co. Ltd)

Fig. 13 — *Strand Autotransformer Unit*

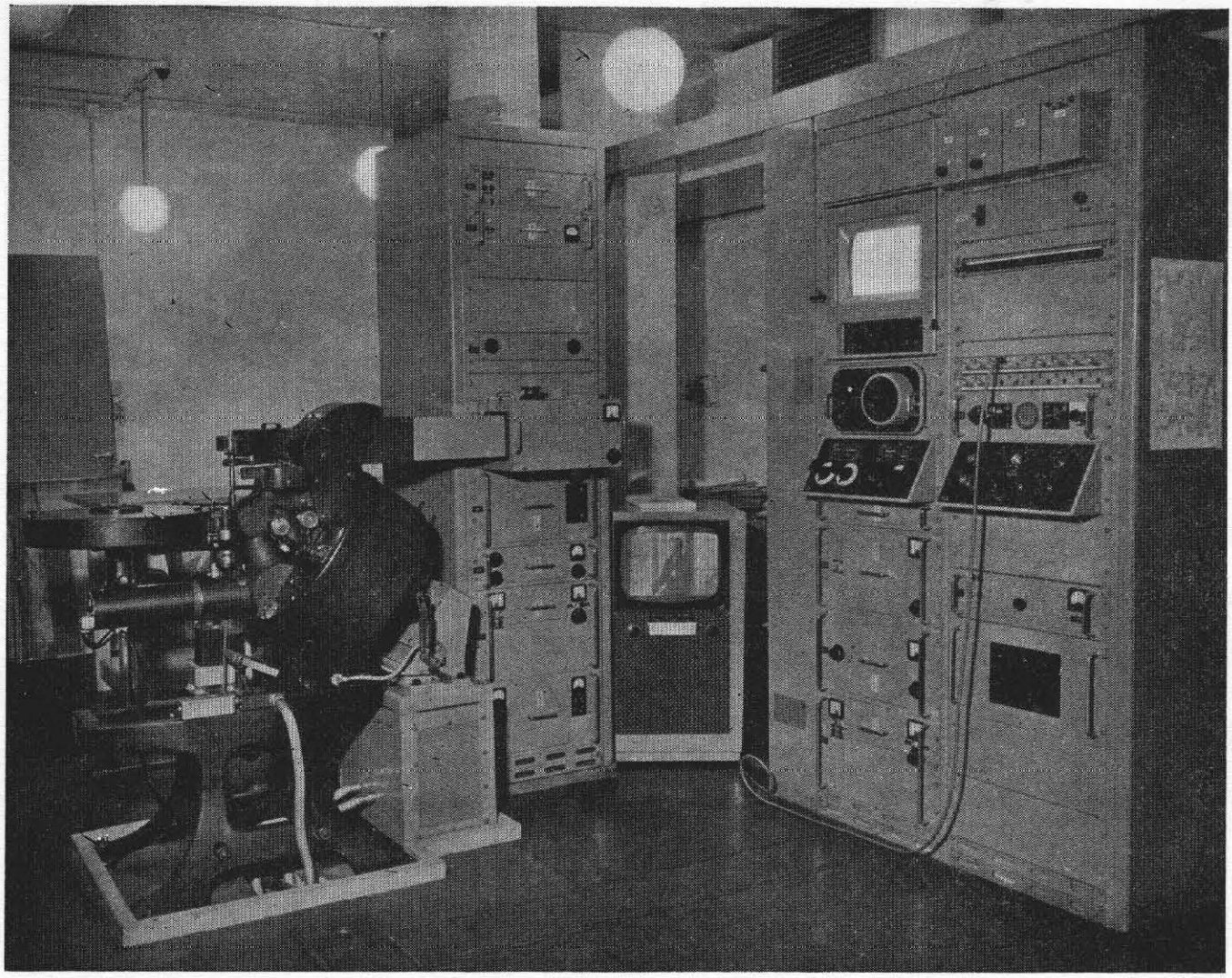


Fig. 14 — 35-mm. Flying Spot Mechau Telecine Equipment

the control room, the relays being installed in the dimmer room adjacent to the thyratron dimmer banks.

The four 5-kW resistance dimmers are controlled in a similar manner to the dimmer channels in R1.

The dimmer room of Studio R2 contains a patching panel which enables the electricians, on instruction, to connect any of the 304 studio socket outlets via jack plugs to the 144 channels arranged on sockets. This unit is in effect a giant 'Private Branch Exchange'. There are also test positions on the panel which enable the electrician on duty to check that socket outlets are correctly loaded before patching to the channels.

The waveform produced by the thyratrons is 3-phase half-wave, and causes an audible note known as 'sing' to be emitted from certain types of tungsten filaments, particularly those used in scoops. When the lamps were first illuminated the deep concave reflectors of these scoops directed the sing, which was very apparent and easily picked up by the microphones. Filters were fitted, which reduced the effect considerably, but the values of L and C chosen had to be a compromise, to avoid upsetting the dimming control characteristic.

As stated earlier, this thyratron equipment is less flexible than the system used in Studio R1. It is also less efficient. The filaments of the thyratrons are energized the whole time the equipment is in use. Its efficiency is approximately 60 per cent of the R1 system when both systems are in the fully loaded condition.

3.6 *Telecine Equipment*

Reference was made in Section 2.3 to the telecine rooms which form part of the central accommodation. This suite comprises two rooms each housing a television film scanning apparatus referred to in the BBC as telecine. These machines are of a special type developed by the BBC Designs Department for contributing film inserts into studio programmes; they are not used for television feature film programmes.

A photograph of one of the telecine channels is shown in Fig. 14, the film traction machine being on the left-hand

side of the picture and the associated electronic equipment in the three bay enclosures. The equipment may best be described in two parts as follows:

(*a*) *Film Traction Machine:* This machine is one of a number used by the BBC, and was invented by Emil Mechau and developed in Germany between the two World Wars. It is interesting to note that J. L. Baird in first televising films with a 30-line low-definition system in the late 1920's used one of these machines with a mechanical 'flying-spot' system. Two of these machines came into use again in 1938 with the BBC high-definition 405-line system at Alexandra Palace, and were used in conjunction with Iconoscope (Emitron) cameras.

A unique feature of this machine is that it will display a still 35-mm. frame, and when set in motion, will display a steady moving picture over a wide range of speeds. In the case of the Riverside channels the film is passed through the picture-gate in continuous motion at a speed corresponding to 25 frames per second, the 'light' is produced from a cathode-ray tube raster and is scanned on to the film via the mirror-drum rotating at a constant speed. This mirror-drum is very ingenious, comprising of a series of mirrors forming segments of the area of a circle and, as the drum rotates, the pitch of these mirrors is continuously varied in two planes, one inclined radially and the other tangentially, by a continuously operating cam system. This causes the light from the C.R.T. to scan each frame of film as it passes the film gate. The light, having passed through the film, is now modulated and this modulated beam is made to impinge on the cathode of a photo-multiplier cell. From Fig. 14 it can be seen that the C.R.T. is housed on the bay adjacent to the machine and the C.R.T. light beam passes through a light tunnel between the two. The crank-handle adjacent to the mirror-drum case enables the operator to pass film through the machine slowly in order to select the correct starting frame.

Although these machines in Riverside Studios are run synchronously at 25 frames per second, there are two special types in the Television Studios at Lime Grove. One of these may be switched to run at 16 frames per second for 'vintage' films photographed at that speed; the other machine can be adjusted to run at fractions of a frame speed above or below 25 frames from 23 to 27, so that the pitch of the sound from the sound track can be adjusted. This is an occasional requirement when an orchestra in the studio may be accompanying an artist recorded on the film, and the conductor is using the televised picture as a medium for accompaniment. This change in pitch can come about by small differences between the mains frequency at recording and that at the time of reproduction.

(*b*) *Flying Spot Apparatus:* This equipment has been designed for three main functions; for the scanning of 2-in. × 2-in. caption slides; as part of inlay and overlay equipment, and as the electronic part of the 'Flying-Spot-Mechau' telecines.

The C.R.T. raster is reflected via a 'change-over' mirror, which directs the light-path either into the Mechau projector or through a simple transparency scanning head for 2-in. × 2-in. slides, the modulated light in the latter case impinging on a separate photo-multiplier cell housed in the first apparatus cubicle. Each photocell is followed by a head amplifier, the output of which is switched to an equalizer and after-glow corrector. This unit, which can be switched so that either positive or negative film stock may be televised with the correct transfer characteristic, is followed by a gamma amplifier. The corrected video signal is then fed into a picture channel where mixed blanking and mixed syncs are added. A 14-in. picture monitor is fed from this unit, together with a distribution amplifier for sending the composite signal as a contribution to either studio.

The console picture monitor between the apparatus bays in Fig. 14 is used for cueing purposes.

For the reproduction of optical sound track on composite film (COMOPT) a reproducing head is provided on the Mechau machine. Alternatively either optical or magnetic unmarried sound (SEPOPT or SEPMAG) may be reproduced on a 'Westrex' machine, supplied by the Western Electric Company, which will handle 35-mm. optical film or 35-mm. magnetic coated film and is arranged to run synchronously with the projectors.

3.7 *Power Distribution Equipment*

The electricity supply is provided by the London Electricity Board (L.E.B.) on two 6·6-kV supply feeders, their substation being adjacent to the building. The incoming H.V. supplies, which cannot be paralleled, are controlled by L.E.B. switchgear which in turn feeds, through BBC H.V. switchgear, two 750-kVA 6·6-kV/415-240-V transformers. These transformers, of which one normally supplies the Studios with the other as a spare, are oil-cooled and are housed in separate brick cubicles with independent ventilation and fire-proof doors, as they are closely adjacent to other property.

The M.V. supply output is distributed via the main M.V.A.C. switchboard, supplied by Switchgear & Cowans Ltd, to an adjacent set of English Electric Superform switchgear. Distribution from this switchgear is mainly to two studio switchrooms, one for R1 technical supplies and the second for R2 and central apparatus technical supplies. The two lighting equipment dimmer rooms each receive a separate distribution, R2 direct from the main M.V.A.C. board, R1 through duplicate 150-kVA, 415/208-120-V star-connected oil-cooled voltage-regulating transformers, housed in cubicles adjacent to the main transformers. These production lighting transformers can be operated in parallel and, if necessary, provide an alternative production lighting supply for R2.

The normal production lighting supply for R2 is obtained from a 185-kVA class H air-cooled voltage-regulating transformer located in R2 lighting dimmer room.

These three transformers were manufactured by Brentford Transformers Ltd.

The two studio switchrooms also contain voltage-regulating transformers for supplies to the technical equipment; these are of the Brentford 240/240-V 30-kVA pattern. The regulated supplies are distributed to technical apparatus via Dorman & Smith circuit breakers which are housed in the end units of apparatus cubicles in the vision apparatus room (see Fig. 15). The distribution from these circuit breakers is to socket outlets which are of a non-standard pattern so that only technical apparatus can be plugged into them. The plug-top's 'live' pin is a screw-in fuse.

In the central apparatus room, there is a mimic diagram remote control board, a photograph of which is seen in Fig. 16. This board indicates the state of the main distribution circuits, which can also be remotely controlled from this point.

The battery room contains three nickel-iron-alkaline battery units:

1. 50-V supply for technical equipment, relays, signalling, etc.
2. 240-V supply for emergency lighting within the building.
3. 110-V supply for operating power switchgear.

4. Special Effects and Auxiliary Equipment

Certain equipment, which has hitherto been in use on a somewhat experimental basis, has been provided at Riverside as permanent equipment. The major facilities are these:

(i) *Back Projection*

This is, of course, commonplace in television studios and is used as required in both studios at Riverside. The lighting installation with its flexible dimming facilities, however, makes it easier for the correct balance of studio lighting to be obtained when using back projection. The d.c. needed for the projector arcs is supplied by means of portable metal rectifier units which may be placed alongside the back projection machines in the studio. These units are designed to provide a smoothed constant current output for back projection and other arc projector devices. The output of the units may be varied in steps within the range of 30 A to 150 A at a d.c. voltage of between 50 and 70 volts. Arrangements may also be made for operating two units in parallel in which case a total d.c. output of 250 A may be obtained.

The equipment employs a three-phase star-

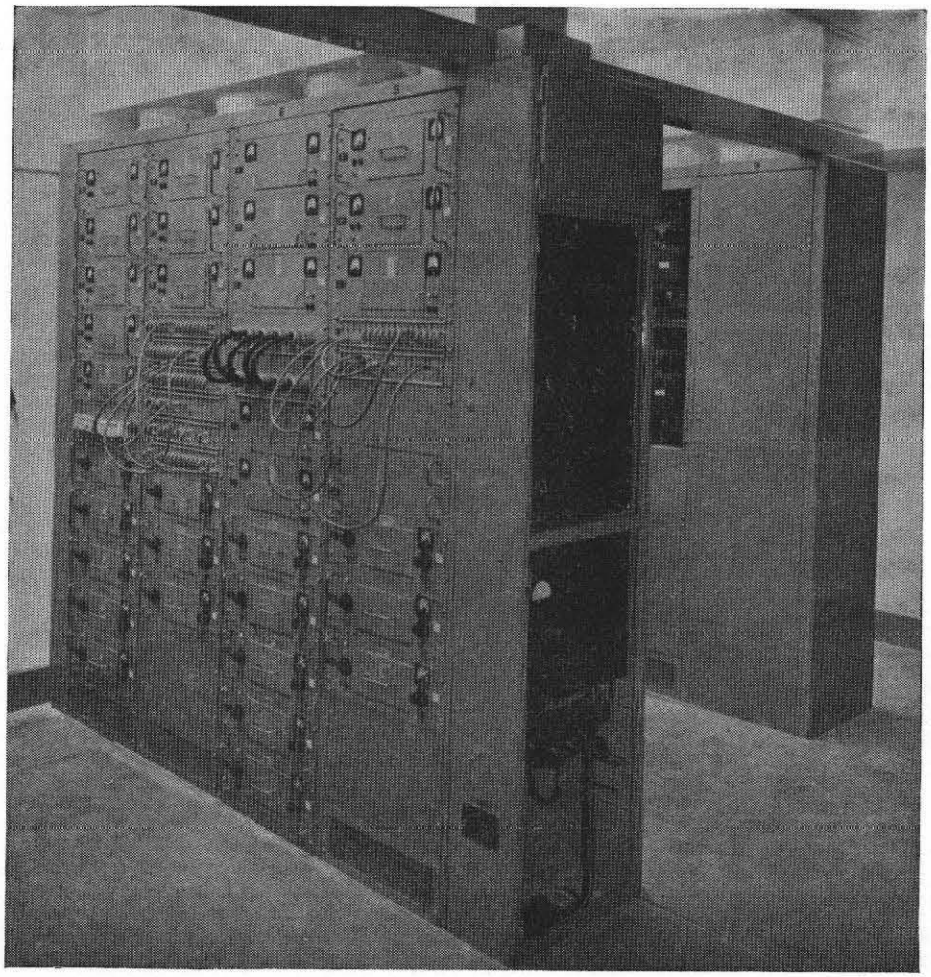


Fig. 15 — Vision Apparatus Bays in R1 Apparatus Room (the end doors have been removed to show power distribution switchgear and fuse panels)

connected arrangement of a.c. inductances and capacitors connected in series to form a semi-resonant circuit. A three-phase transformer connected in parallel with the capacitors feeds bridge-connected metal rectifiers. The d.c. output is taken via a choke smoothing circuit. In effect the d.c. output behaves as though the arc, which is, of course, of very low ohmic resistance, were connected by means of a ballast resistor to a d.c. supply of higher voltage. This results in a more efficient device, which is simple to operate.

(ii) *Inlay and Overlay*

Inlay and overlay equipment has been used by the BBC for several years; the equipment has been described in a paper[10] read before the Institution of Electrical Engineers.

Inlay provides the means for certain areas in a picture from one television source to be replaced with appropriate areas from another. A mask is used to dictate the shape of the areas concerned. It makes possible many trick effects such as the removal of a figure from a chair or the fitting of a dancer within the frame of a mirror. It is also used in conjunction with telecine to simulate the view of the passing countryside from the windows of a moving car or train.

Overlay is similar to Inlay, but in this case no physical mask is used to denote the area of the picture which is to be replaced with appropriate areas from another source. Instead pictures from a television source, which may or may not be one of the pictures involved in the overlay scene, is used to control the electronic switch and so dictate the areas to be replaced from an alternative source.

For this reason a scene of severe contrasts is desirable for operating the switch and as this is not always convenient, lift and gain controls are provided so that an artificial and exaggerated contrast may be obtained within the equipment.

Overlay is used largely for production trick effects common in 'magic' programmes where, to take an example, it is desired to show the moving shape of a dancer as a newspaper cut-out. It is also used in conjunction with telecine to give the effect of a moving background with figures in the foreground free to move and always cutting their own shapes in the background. This type of use is a simulation of moving Back Projection and is becoming less common.

Inlay and Overlay have been installed in Studio R1 only. The operational equipment has been mounted on a special desk located in the vision control room and is illustrated in Fig. 17. The new desk provides the operator with greater and more convenient space to manipulate the cut-out masks. A manual turntable has been provided over the face of the flying-spot cathode-ray tube for this purpose in place of the motorized 'wipe' mechanism used on earlier versions of the equipment.

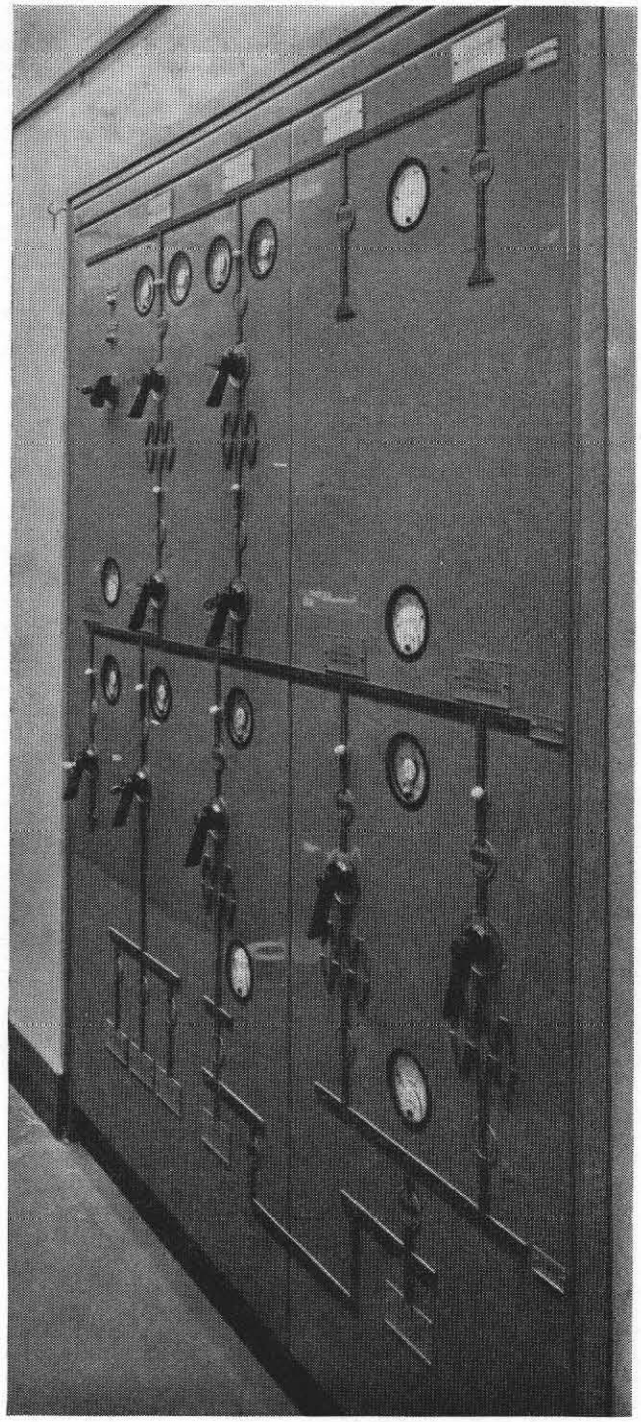


Fig. 16 — *Power Control Switchboard and Mimic Diagram in Central Apparatus Room*

The entire inlay and overlay operation is now under the control of an inlay operator and the selection of picture sources is under his control independently of the vision mixer.

Other new features of the equipment installed at Riverside include the facility for producing captions on the inlay apparatus.

Where it had formerly been common practice to

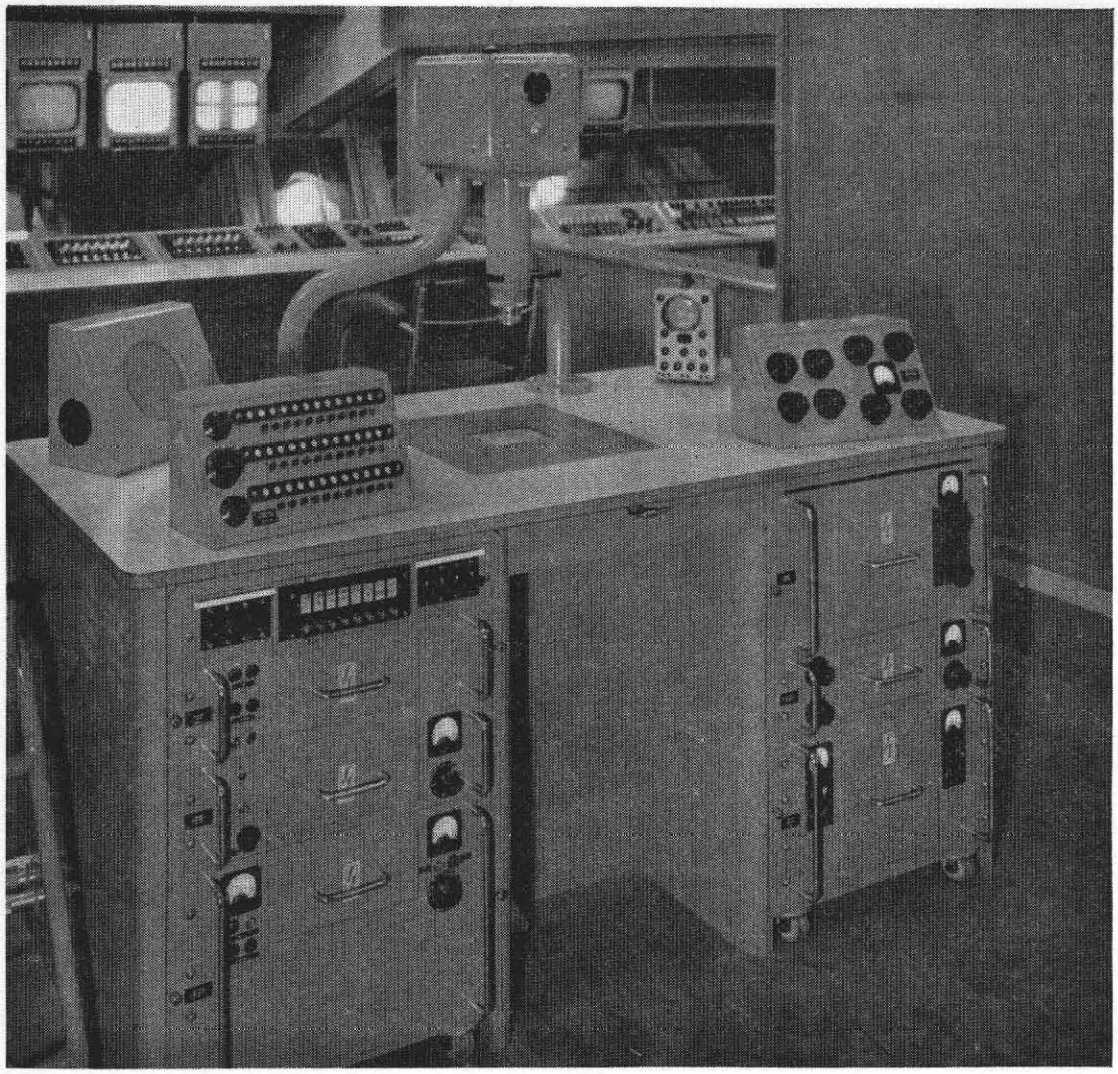


Fig. 17 — The Special Effects Control Desk in the Vision Control Room of Studio R1

superimpose a caption on a studio or telecine scene, inlay is now regularly used to produce a similar but much more professional result. The contrast and gain of the background may be set quite independently of the caption and lettering is absolutely clean cut.

Captions for this purpose are produced on either 2-in. × 2-in. or 4-in. × 3-in. slides using clear lettering on a dark background.

It is sometimes desirable to use this equipment for straightforward reproduction of captions and photographs and for this purpose a picture channel with gamma correction has been added to the equipment.

Special facilities are provided for the inlay operator to speak on a talkback circuit to one or more of the cameras involved in the operation of some special effect. The circuit is operated by means of a footswitch as the operator's hands are likely to be fully occupied at the precise moment when talkback is required.

(iii) *Studio Auxiliary Equipment*

During recent years an attempt has been made to standardize the equipment used in the BBC's studios for mounting cameras, microphones, etc. and a measure of standardization has been achieved at Riverside.

The cameras in both studios are carried on three main types of mounting, viz. crane dollies, non-crane dollies, and camera pedestals.

The only crane dolly at present available is that designed by the Motion Picture Research Council of the U.S.A., and used extensively in the film industry. One of these is normally used in each studio and provides the means for the free and continuous movement of camera and cameraman over an arc in both vertical and horizontal planes described by the crane boom which is 9 ft 5 in. in length. These cranes are propelled by a 5-h.p. electric motor through a differential gearing similar to that of a motor car. They are heavy, having a total weight including the crew of nearly 2 tons and

they require a perfectly flat floor. Lead counterweights may be applied to a weight box thus permitting adjustment to give absolute balance to the boom which is moved manually to the desired position by an operator. At present these camera cranes require a crew of four, including the cameraman, to operate them but it is hoped that, with modifications which are about to be made, this may be reduced to a total of three. The cranes have been manufactured in England by Mole Richardson Ltd under licence from the Housten Fearless Company of the United States of America.

A second dolly, in which the crane arm cannot be swivelled, is provided in each studio. This dolly is designed and manufactured by W. Vinten Ltd. It is entirely electrical in operation, the traction being provided by two $\frac{1}{4}$-h.p. motors and elevation of the crane arm by means of a single $\frac{1}{2}$-h.p. motor.

The camera and cameraman are carried, as they are on the M.P.R.C. crane, on a rotary platform at the end of the crane arm and this platform is rotated by a third motor rated at $\frac{1}{4}$ h.p. In later versions of the dolly, however, the rotation of the camera platform is not motorized but is achieved by the motion of the cameraman. This dolly is operated by a team of two, namely the cameraman, who also controls the elevation of the crane arm, and the tracker who 'drives' the dolly from a rear platform.

It will be noticed that both these dollies are power driven—this is considered to be essential not so much in actual operation of the camera but in order to move the dolly and camera from one point to another between shots at an adequate speed during a fast-moving production.

The remaining cameras are mounted on pedestals, the type at present in use having been manufactured by W. Vinten Ltd. These pedestals are provided with three pairs of wheels on a triangular base with a low centre of gravity. They may be set to either three-wheel steering (crabbing) or single-wheel steering by a foot-operated lever. The principal feature of the pedestal, however, is that the camera height may be instantly adjusted simply by lifting or lowering the camera, the weight of which is balanced by gas pressure. The camera column is supported on triple-lift hydraulic rams which are fed from a hydraulic reservoir or accumulator which is balanced by compressed nitrogen contained in two gas cylinders. The nitrogen pressure is controlled so that the weight of the camera and panning head, collectively 230 lb., may be precisely balanced. The height range of the pedestal is from 25 in. to 57 in. making the lens height excursion for the Riverside cameras approximately 3 ft to 5 ft 6 in. which is adequate for all studio purposes.

The immediate height adjustment and easy, stable movement of the pedestal provide its single operator with a flexibility of movement which simulates the simpler tracking movements of a dolly.

Microphone booms of M.P.R.C. design but manufactured under licence by Mole Richardson Ltd are used in both studios. Certain BBC modifications have, however, been incorporated in these booms. Three are used in Studio R1 and two in R2. The remainder of the microphones are mounted on stands which are of BBC standard pattern.

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APPENDIX

Composition of Technical Operations Crew

*2 Technical Operations Managers
*2 Lighting Supervisors
1 Lighting Assistant
1 Vision Control Supervisor
2 Vision Control Operators
1 Sound Supervisor
1 Boom Operator/Sound Supervisor Relief
1 Boom Operator
1 Gramophone Operator
1 Sound Floor Assistant
1 Senior Cameraman
2 Cameramen
1 Assistant Cameraman/Dolly Operator
1 Vision Mixer
3 Dolly Operators

*Two of each of these posts are necessary so that planning of forthcoming productions may be carried out whilst the crew is engaged on a current production.

A RECENT BBC DEVELOPMENT

A BALANCED LOGARITHMIC D.C. STAGE USING TRANSISTORS

by

S. D. BERRY, Associate I.E.E.

Transistors have recently been applied to the Peak Programme Meter, the standard BBC instrument for the measurement of signal volumes.

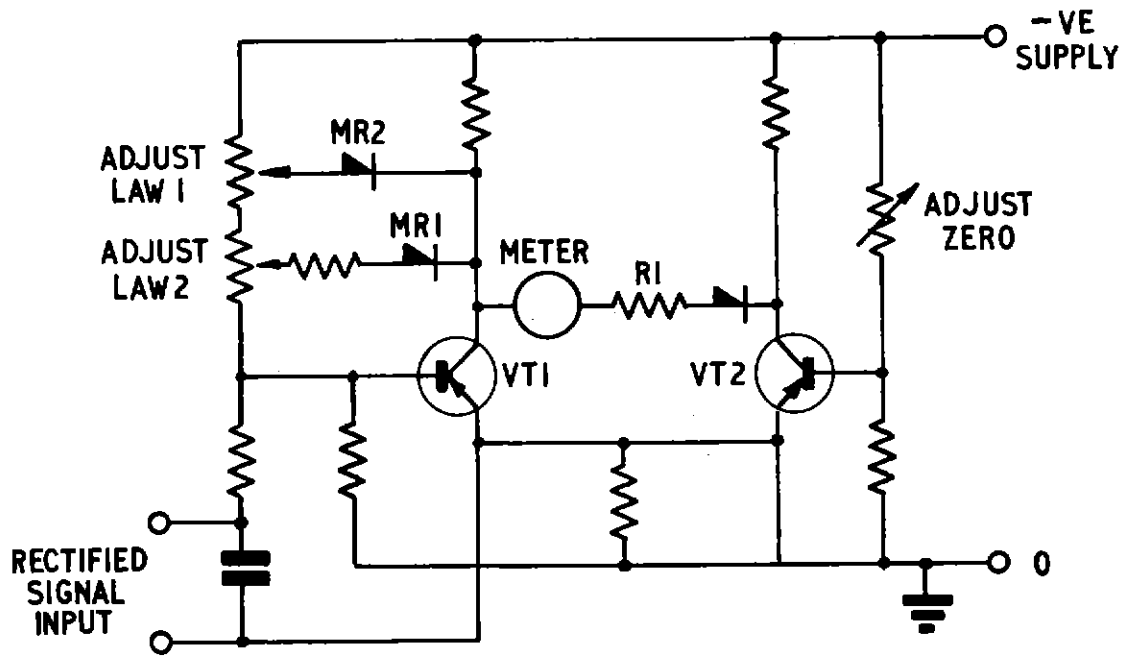
The approximately logarithmic characteristic necessary to enable the meter to be calibrated in decibels on a linear scale is obtained in existing valve apparatus by the use of a variable-mu valve for which no transistor equivalent exists. The circuit illustrated in the figure has therefore been developed.

Two transistors are used in common-emitter arrangement with a common emitter resistance and the meter connected between the two collectors. This is an adaptation of a known valve circuit for reducing zero drift which would otherwise be troublesome with transistors due to the effects of ambient temperature changes. Moreover, the circuit constants, particularly the value of R1, may be chosen so as to maintain the dissipation of each transistor approximately constant as the signal level is varied, thus avoiding the creeping of the meter reading which would otherwise take place.

A logarithmic characteristic is given to the stage by the action of the crystal diodes MR1 and MR2. The P.P.M. meter works backwards, i.e. it has a right-hand no-current zero and a left-hand no-signal zero. When no signal is applied, therefore, the transistor bridge is unbalanced to a degree depending upon the setting of the adjust zero control, so as to cause the meter pointer to take up a position at the left-hand zero mark.

When a signal current flows in the base emitter junction of VT1, base positive, the collector current of VT1 falls and the bridge moves towards balance causing a meter reading change and the potential at the collector of VT1 to become more negative. The collector of VT1 is connected to points on the potential divider supplying bias to the base of this transistor via the crystal diodes MR1 and MR2 and the travellers of the law controls. At meter zero the collector of VT1 is more positive than either point on the law control and the diodes do not conduct, but as the collector of TR1 becomes negative with respect to each law control traveller the corresponding diode conducts and negative feedback is applied to the base of the transistor. The law controls are set so that this action occurs as the meter reading is about one-third full scale for MR1 and again at about two-thirds full scale for MR2. The gain of the stage is therefore compressed in two successive steps resulting in an approximately logarithmic characteristic.

A crystal diode in series with the meter limits the meter reading to full scale if an overload signal should drive the transistor bridge through balance to a reverse unbalance condition.



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