THE BROADCASTING CHAIN

Introduction

Programmes may originate either from a studio, or group of studios connected to a dramatic control unit, or from some point external to the studio premises. They may also consist of reproductions of recorded material.

Programmes originating from a point external to the studio premises are called '*Outside Broadcasts*' and include programmes from theatres, cinemas, churches, racecourses and other places in this country and also programmes from foreign sources, e.g., from the Continent of Europe incoming by line including a submarine cable link, or from other parts of the world by line from G.P.O. Radio Terminal. In London, foreign programmes are sometimes similarly received from the B.B.C. Receiving Station at Tatsfield.

The apparatus at a Studio centre provides for the following functions :—

(a) Amplification of the programme currents originated by the microphone or record reproducer or incoming by line, including in the latter case equalisation, that is to say, compensation for such frequency distortion as may have occurred in the line.

(b) Switching to enable programmes to be mixed or selected as required.

(c) Control for adjusting the programme volume and for compressing the volume range to obtain in each case the required conditions for sending to line.

(d) Sending the programme to the line outgoing to the transmitter in the vicinity and also, if required, to lines outgoing to distant studio centres for redistribution to other transmitters.
The network of programme lines inter-connecting the various stations is known as the *Simultaneous Broadcast* (*S.B.*) system. The circuits connecting studio centres are known as *S.B. Links* and the circuits connecting transmitting stations to the local studio centres as *Transmitter Tie-Lines*.

(e) Communication by signalling lights and telephone between the control room and the studios on the premises, and by telephone between the control room and O.B. points or other stations on the S.B. system from which programmes may be received or to which they may be sent.
The network of telephone lines used for the latter purpose is known as the *S.B. Control* system.

(f) Aural monitoring of the programmes by means of headphones or loudspeakers and visual monitoring by means of programme meters.

(g) Testing and maintenance of apparatus and lines.

The apparatus in the control room at a transmitting station is much less complicated than at a studio centre. The essential function at a transmitting station is simply that of applying a programme, incoming via the transmitter tie-line from the nearest studio centre, to the local transmitter at the correct volume to ensure the required level of modulation. Although a studio is provided it is used only for testing or emergency purposes.

Introduction (*Contd*)

Normally, therefore, the functions are confined to equalisation and amplification with provision for adjusting, but not for ' controlling,' the programme volume and for both visual and aural monitoring with, of course, telephone communication with other stations connected to the S.B. control system.

The general arrangement of the amplifiers used in the broadcasting chain is shown in schematic form in the accompanying diagram, together with a programme volume chart which shows the volume at the various points in the chain for a typical case and indicates the order of the normal working gain of each amplifier.

Originating Station

The arrangements at the originating station are based on those employed at Broadcasting House, Glasgow.

Referring to the upper diagram, two types of production are illustrated, namely, one in which the whole of the production is carried out in one studio and another in which the production takes place in a number of studios, the outputs of which are mixed on a dramatic control unit. †

Studio Control Working

A large studio is shown equipped with four microphones and a gramophone desk with a small associated studio for a narrator and an adjoining studio control cubicle. Associated with this group is also shown an Echo Room.

The microphones are all of the ribbon type and their outputs are connected via flexible cords to plug points which are wired to the mixers in the studio control cubicle. The microphone in the narrator's studio and the output of the gramophone desk are similarly connected. A **mixer** incorporates individual fade controls, one for each input channel, connected to a common output circuit, so that by suitably setting the controls the various sources can be mixed or selected at will. Selection is of course the more usual function. Normally each mixer has only three input channels and for a large studio such as that illustrated there would be two three-channel mixers and a **group mixer** for selecting or mixing their outputs.

A modern type of **gramophone desk** is shown, equipped with two turntables with parallel tracking pick-ups, a microphone for compering and a mixer. The pick-up outputs are connected via gramophone correction units to two input channels of the mixer and the microphone to the third. The common outputs of the two gramophone channels are connected in parallel with that of the microphone via an attenuator which compensates for the difference in volume between the gramophone and microphone outputs. The output from the gramophone desk is connected to the mixer as stated.

The group mixer output is taken to an **announcer's desk** in the studio with which is associated a microphone for use when making announcements. The outputs of this microphone and of the mixer are brought to the two sides of a change-over switch on this desk by means of which either one or the other can be selected and connected, via a repeating coil, to the **balanced studio line** leading to the input of the ' A ' amplifier associated with this studio.

† Since the date of this instruction ' Dramatic Control ' units have been re-christened ' Production Control ' units. Throughout this instruction, therefore, wherever the words *Dramatic Control* appear please read *Production Control.*

Studio Control Working (*Contd*)

To facilitate communication between the control cubicle and the studio during rehearsals, a microphone is provided in the control cubicle for **talk-back** purposes. Loudspeakers are provided both in the studio and control cubicle but in the normal condition only that in the control cubicle is working, reproducing the programme from the studio. When the talk-back switching is operated, the studio output is disconnected and the talk-back microphone is connected to the studio line in its place, while the loudspeaker in the control cubicle is silenced and that in the studio is connected in circuit and reproduces the speech from the control cubicle picked up by the talk-back microphone.

The **' A ' amplifier** has two outputs, No. 1 being used for the direct programme connection and No. 2 for echo purposes when required. The No. 1 output is connected via the fade unit and control potentiometer in the studio control cubicle to the ' B ' amplifier input switching, by means of which it is made available to any of the control positions for connection to the input of the associated ' B ' amplifier as described below. However, by a plugging operation the fade unit and potentiometer in the studio control cubicle can be short-circuited, as shown by the dotted connection in the diagram, and the No. 1 output of the ' A ' amplifier extended directly to the ' B ' amplifier input switching. (The latter arrangement corresponds to that employed at the older studio centres where studio control facilities are not provided.) Similarly, where echo is to be superimposed upon the direct programme source this can be effected either by means of the fade unit in the studio control cubicle or by means of that on the control position. The diagram illustrates the method of connection where echo is added in the studio control cubicle. The No. 2 output of the studio ' A ' amplifier is connected to the loudspeaker unit in the echo room, in which there is also a microphone with its output connected, via a balanced line, to the input of another ' A ' amplifier, called in the drawing an **echo ' A ' amplifier.** The No. 1 output of the echo ' A ' amplifier is connected to the spare input channel of the two-channel fade unit in the studio control cubicle. A **fade unit** performs the same function as a mixer and by means of it the direct and echo sources can be mixed at the required relative levels. The output of the fade unit is connected to the input of the control potentiometer in the studio control cubicle and the output of the potentiometer is connected to the ' B ' amplifier input switching.

Dramatic Control Working

A dramatic control unit is used where the production involves the use of a number of studios or other programme sources.

A **12-channel unit** is illustrated in which the input channels are arranged to provide two groups each of five connected to **group mixers** as shown and two channels independent of the group mixers. Any of the channels in the two groups can be used either for a direct programme source or for an echo source.

A typical studio is shown with its output connected to an ' A ' amplifier, the two outputs of which are connected to channels 9 and 10, that is to say, to two of the channels in one group. For the purpose of the example, we have imagined an O.B. source to be required for the particular production, and in this case the direct and echo outputs are connected to channels 1 and 2, that is to say, to two channels in the other group. The group mixers each comprise two separate fade controls ganged on a common control switch, one for the

Dramatic Control Working (*Contd*)

direct sources and one for the echo sources in the particular group. By the operation of relays, or in some cases of keys, associated with the channels to which the echo sources are connected, the output connections of these channels (numbers 1 and 9 in the drawing) are connected to the echo halves of their respective group mixers, whereas the channels (numbers 2 and 10 in the drawing) which are plugged up to direct programme sources remain connected via the normal wiring to the halves of their respective mixers intended for direct programme sources.

The outputs of the direct programme halves of the group mixers are connected to two inputs of the **DCA amplifier** which is provided in order to make good the mixing loss, so that the programme in its output will be at approximately the same volume as that normally present in the output of the ' A ' amplifier associated with any studio.

The outputs of the echo halves of the group mixers are connected to the inputs of the **ECA amplifier** and are mixed in this amplifier, the common output of which is fed to the loudspeaker amplifier in the associated echo room. The output from the echo room microphone is fed back to another input of the DCA amplifier, via the **echo ' A ' amplifier** and switching which secures the complete suppression of the echo room output excepting only when one of the echo sources is faded up on the dramatic control unit, and thereby ensures that the echo room will not contribute any background at other times.

The outputs of the channels not included in the two groups (numbered 11 and 12 in the diagram) are connected as shown to the Nos. 3 and 4 inputs of the DCA amplifier. The common output of the DCA amplifier, in which all the four inputs are mixed, is brought back to the **control potentiometer** in the dramatic control cubicle and the output side of the potentiometer is connected to the ' B ' amplifier input switching.

The programme is monitored in the D.C. cubicle by loudspeaker and provision is made for **talk-back** and **light cueing** in both directions. During rehearsals the studio loudspeakers are used for the talk-back but during transmissions the housephone circuits are used.

Some of the older stations use a **six-channel dramatic control unit** with the channels arranged in two groups of three connected to a single group mixer, the output of which is connected via the DCA amplifier to the ' B ' amplifier input switching. In this case where echo is required, a separate echo room is necessary for each echo source. The No. 1 output of the ' A ' amplifier is connected, as in the case illustrated, directly to the programme input channel of the dramatic control unit, but the No. 2 output is connected to the loudspeaker amplifier in the echo room and the output of the echo ' A ' amplifier is then taken to another input channel of the dramatic control unit. (The arrangements for providing echo are thus similar to those shown in the diagram in the case of the studio equipped for studio control working, except that the D.C. input channels replace the fade unit input channels.)

Outside Broadcast

The **microphones** in this case may be either of the ribbon or of the moving-coil type. Where more than one microphone is to be used the microphone cables are terminated upon a **mixer**, by means of which the microphones can be selected or mixed as required and the necessary adjustment made to compensate for the differing volumes where microphones of both types are in use together. The mixer output is connected to the input of the **O.B. amplifier.**

Outside Broadcast (*Contd*)

A **line volume meter** is shown connected across the amplifier output for indicating the volume sent to line. However, in the new O.B. apparatus a programme meter is incorporated as a part of the amplifier itself and is not connected in the manner shown.

Where the circumstances require, the arrangements at the O.B. point may be considerably more complex than those illustrated. For example, an additional amplifier is being provided to permit of the control of the programme from some location other than that in which the main O.B. amplifier is installed. In every case, of course, duplicate amplifier equipment together with its power supply equipment is provided.

The **lines** used for O.B.'s are provided by the G.P.O. and are tested in advance by the Lines Department in order to determine the volume at which the programme shall be sent to the line, whether and in what positions intermediate amplifiers, known as **repeaters,** are needed, and to determine the equalisation necessary both at the repeater points and at the receiving end of the line in order to compensate for the variation with frequency of the loss occurring in the line.

In the diagram we have shown one repeater with a line volume meter for measuring the output sending level. In the new equipment, as in the case of the new O.B. amplifiers, a programme meter is incorporated in the repeater itself. The repeater is provided in duplicate and incorporates equalisation for the preceding section of the line.

At the receiving station an **equaliser** is inserted to provide correction for the distortion occurring in the final section of the line. After the equaliser comes the **' D ' amplifier,** the gain of which is adjusted so as to bring the volume in its output to approximately the same as that normally present in the output of a ' B ' amplifier at the particular station. The output of the ' D ' amplifier is shown connected (via the ' B ' amplifier input switching) to one of the input channels of the fade unit on the control position, and to reduce the volume to approximately the same as that of other programme sources at this point, an attenuator is included in the circuit.

Where an O.B. source is to be used with **echo,** in the case of control room premises of the new type, a **separator amplifier** is used which provides two outputs corresponding to the Nos. 1 and 2 outputs of an ' A ' amplifier. In the drawing the connection is shown dotted and the outputs are taken to two channels of the dramatic control unit. At the older stations the ' D ' amplifiers are themselves provided, like the studio ' A ' amplifiers, with two outputs and the separator amplifier is unnecessary. The new practice has been adopted because it is found that only very rarely is it necessary to provide echo on an incoming source of programme and it is therefore more economical to provide a small number of separator amplifiers for this purpose rather than to equip all ' D ' amplifiers with two outputs.

Control Position

Facilities Provided. The control position in the control room is equipped either with a two-channel **fade unit** or with a combination of three two-channel fade units comprising a four-channel fade unit, followed by a **control potentiometer** the output of which is connected to the input of the **' B ' amplifier** Any of the programme sources available can be connected by means of the ' B ' amplifier input switching to the input channels of the fade unit and by suitable operation of its controls the programme sources so connected can be selected or mixed as required.

Control Position (*Contd*)

The control is performed by reference to a **programme meter** the amplifier of which is connected in the output of the ' B ' amplifier. The programme is also aurally monitored by means of checkphones connected to one output of a **trap-valve amplifier** which again is connected in the output of the ' B ' amplifier. If it is desired to monitor a programme as radiated, the checkphones can be transferred to an output of the **CPL amplifier** which is connected in the output of the **check receiver.**

The **control potentiometer** has 25 studs numbered from 0 to 24. The total loss range covered between studs 24 and 1 is 50 db and the loss on stud 0 is infinite. Over the range from stud 24 to stud 4 the loss is 2 db per stud, and the potentiometer is normally set, for the purposes of the line-up (see **Line-up of System,** below) at stud 14 so as to introduce a loss of 20 db. This setting is known as the *mean* controlling position. The 10 studs above and below this, which each correspond to a loss of 2 db, constitute the *control range* of the potentiometer. The remaining 10 db of loss is introduced in larger steps between studs 4 and 1 and is suitably graduated to provide a gradual reduction in the volume before the final fade out. In use the control potentiometer enables the gain of the circuit to be adjusted so as to obtain the correct volume in the output of the ' B ' amplifier whatever the volume at which the programme is received, and provides for the compression of its dynamic range as described below (see **Control of Programmes.**)

In the case of programmes which are controlled in the studio control cubicle or in the dramatic control cubicle, as soon as the particular programme source has been selected on the fade unit, the control potentiometer is set in the position for *maximum* volume. In the case of an O.B. controlled at the O.B. point, and in the case of a programme originating at some other studio centre and incoming via the S.B. network, the programme will not need to be controlled in the control room and the control potentiometer must be set in the *mean* controlling position.

Control Cubicle. Where the programme has not been previously controlled, the control will normally be performed in the control cubicle, to which it is transferred by the operation of the cubicle change-over switching. In this case the input connections to the fade unit on the control position are transferred to those of the fade unit in the cubicle, and the ' B ' amplifier input connection is transferred from the output of the potentiometer on the control position to that of the potentiometer in the cubicle.

The headphones provided in the cubicle are normally connected to the '*Housephone*' (H.P.) output of the trap-valve amplifier which is also used for supplying headphone points in the studios, studio control cubicles, listening rooms and offices. Monitoring in the cubicle, however, is normally carried out by loudspeaker, the input of the loudspeaker amplifier being connected to the '*Loudspeaker*' (L.S.) output of the trap valve amplifier. There is also a programme meter in the cubicle, which is connected *in series* with that on the control position. (The programme meters in the studio control and dramatic control cubicles can also be connected in series with that on the control position, when required, by means of a plugging operation.)

Pre-Fade Listening. In new control rooms pre-fade listening is provided so that the engineer on control, either in the control room or in the cubicle, can listen to any of the programme sources connected to the fade unit prior to fading it up on the ' B ' amplifier

Control Position (*Contd*)

input. The purpose of this facility is to enable the engineer on control to fade-up on a particular cue in a programme already running, or in the case of a new programme about to start to receive a verbal cue from the announcer immediately prior to the commencement of the programme.

The arrangement of the switching is shown in schematic form, although in practice the switching operations, like other programme switching operations previously mentioned, are performed by relays. The input of the **PFL amplifier** can be connected at will across any of the input channels of the fade unit, and at the same time the headphone circuit is switched from its normal connection to the output of the PFL amplifier. The release of a PFL key restores the normal condition of the connections.

Sending to Line

Where the programme is to be radiated, i.e., is not merely being rehearsed, the output of the ' B ' amplifier is connected to line via the **' C ' amplifiers** associated with the various S.B. links or transmitter tie-lines to which the particular programme is to be fed, the necessary connections being established by means of the ' C ' amplifier input switching. Connections to line are generally made via a screened repeating coil in order to preserve the balance of the line to earth.

In the diagram a typical **S.B. link** is shown including a Post Office **repeater** at some intermediate point. The actual provision, of course, depends upon the transmission equivalent of the particular circuit, and in some cases there will be more than one such repeater.

Intermediate B.B.C. Station

At a B.B.C. intermediate station there is an **equaliser** followed by a **' D ' amplifier,** in the output of which may be connected a **programme meter** amplifier, and the programme is fed to line via the **' C ' amplifiers** associated with the outgoing S.B. links to the stations taking it. In the diagram we have shown a **transmitter tie-line** containing no Post Office repeaters.

At certain of the intermediate stations, in the case of the Regional programme, a ' B ' amplifier is included in the chain in order to facilitate switching over to items contributed to the programme from the local studios. In this case the ' D ' amplifier operates in the input of the ' B ' amplifier, and the connection from the ' D ' amplifier output to the ' B ' amplifier input is made via an attenuator as previously described. The checking arrangements are similar to those illustrated for the originating station, but the programme is not controlled at this point and the control potentiometer is set in the *mean* controlling position.

Transmitting Station

At the transmitting station the programme is fed to the input of a ' B ' amplifier, via the receiving **equaliser** and the **control potentiometer.** The gain of the **' B ' amplifier** is adjusted so as to feed the programme, via the Listener Tip-up equaliser, described below, to the ' A ' unit of the radio transmitter at an adequate volume to ensure that the carrier will be fully modulated on the peak voltages. The control potentiometer in this case has a more limited range than those at the originating station.

Transmitting Station (*Contd*)

It has 26 studs with a loss per stud of 0.5 db giving a total attenuation of 12.5 db and a complete fade on the final stud. It is included in circuit primarily for fine adjustment of the gain when lining-up and is not intended for use as a means of control.

At **Daventry**, where a number of the short-wave transmitters may be required to take the same programme, the ' B ' amplifier has a lower gain than the normal ' B ' amplifier for a transmitting station, and programme is fed to the transmitters via ' C ' amplifier, one for each transmitter. The same arrangement is used at **Stagshaw**.

As a provision against breakdown of the transmitter tie-lines, a receiver tuned to the frequency of one of the other transmitters (generally to that of the Long Wave National transmitter) is provided to enable the service to be carried on by '*wireless-link*' working. In this case the output of the **re-broadcasting receiver** is connected, in place of the transmitter tie-line, to the input of the ' B ' amplifier, via the control potentiometer.

A local **studio**, equipped with a microphone and gramophone, is provided, primarily for use by the engineers for testing the transmitter, but also for stand-by use in an emergency involving a complete breakdown of the normal programme distribution arrangements. There is an **' A ' amplifier** associated with the studio, the output of which can be connected, via relay switching and the control potentiometer, to the input of the ' B ' amplifier, in place of the incoming transmitter tie-line.

The checking facilities at a transmitting station include loudspeakers in the control room and in a quality checking room. Normally the control room checking is performed in the output of the **check receiver** and for this purpose a **CPL** or **LFT** amplifier is provided. Comprehensive checking is, however, also provided to enable the outputs of the ' B ' amplifier and the check receiver to be aurally compared. For this purpose an **LCT** or **CCT amplifier** is used consisting of two separate input stages, one connected to the output of the radio receiver, and the other to the output of the ' B ' amplifier, with a common output circuit which can be switched by means of a relay to either input stage. The quality checking loudspeaker is fed from the comprehensive checking unit, but when comprehensive checking is required in the control room, control of the switching is taken over by the engineer on duty in the control room.

The precise arrangements differ slightly from station to station, but the principle of operation is the same in each case.

Listener Tip-up

Subject to the line conditions permitting, the working frequency response characteristic of the entire broadcasting chain, from the microphone input to the output of the ' B ' amplifier at the transmitting station, is maintained sensibly flat over the band of frequencies extending from about 50 to 10,000 c/s. At the present time, however, it is considered desirable somewhat to over-emphasize the upper frequencies in order to compensate for the prevalent deficiency in response of the average listener's receiver and loudspeaker at these frequencies, and it has been found in practice that the desirable frequency characteristic is one gradually rising above 1,000 c/s to about + 6 db relative to the response at 1,000 c/s at 8,000 c/s. A special network designed to give the required rising frequency characteristic is therefore inserted in the programme line between the output of the ' B ' amplifier at the transmitting station and the input

Listener Tip-up (*Contd*)

of the radio transmitter, while to make the output from the check receiver directly comparable with that from the ' B ' amplifier, compensation to counteract the tip-up correction is incorporated in the check receiver.

In the case of the Empire programmes the listener tip-up is provided in the equalisers associated with the transmitter tie-lines incoming to **Daventry**.

Equalisers and Repeaters

The transmission loss in the lines, as has been stated, varies with frequency, the upper frequencies being more highly attenuated than the lower. Equalisation is, therefore, necessary in order to secure the desired sensibly flat overall frequency response characteristic. Equalisers are networks having a loss characteristic which is the counterpart of the response characteristic of the line. The result of their use is therefore to reduce the response at all frequencies to the same as that at the frequency at which the loss is greatest. They are always inserted at the receiving end of the line.

For successful line transmission the programme/noise ratio must never be allowed to become less than 40 db at any point in the broadcasting chain. The noise level present on an average good music line is generally round about — 70 db which, assuming a volume of + 4 db sent to line, permits of a maximum equalised equivalent of about 30 db (or a 1,000 c/s equivalent of about 15 db) before a repeater becomes necessary. But the level of the line noise is found in practice to be liable to variation. Consequently, even if the noise level at the time of measurement is very much less than — 70 db, the repeater spacing is generally worked out on the assumption of a noise level no lower than this, in order to ensure an adequate margin to safeguard against the possibility of spoiled transmissions. When the noise level has a higher value, the length of the repeater sections will, of course, have to be reduced and in bad cases it may only be possible to use the line at all by inserting at the receiving end a low-pass filter cutting off at 5,000 c/s.

Line-up of System

The actual gain settings of the amplifiers will, of course, depend upon the particular conditions and are pre-determined every morning for the ' B ' amplifier at the originating station and for all subsequent amplifiers in the chain by means of a 1,000 c/s transmission. The line-up is carried out with the control potentiometer at the originating station set in the mean controlling position, i.e., introducing a loss of 20 db. At certain of the intermediate stations there will also be a ' B ' amplifier in circuit and in such cases the associated control potentiometer is also set in the mean controlling position. At transmitting stations the control potentiometers normally work at a setting about the middle of their control range so as to provide for a range of adjustment of about 6 db either up or down for finally adjusting the volume at the input to the transmitter.

The programme volume in the output of the ' B ' amplifiers at originating stations, and in that of ' D ' or ' B ' amplifiers at intermediate stations, is normally arranged to be either **zero** or + **10 db** and the programme meters operating at these points are calibrated to give indications relative to the particular volume adopted. Where a ' B ' amplifier is used at an intermediate station, the output required from the ' D ' amplifier is respectively, either 10

Line-up of System (*Contd*)

or 20 db less than that otherwise required. The ' D ' amplifier is operated at its normal gain setting and the loss is introduced by inserting an attenuator in the lead extending the ' D ' amplifier output to the ' B ' amplifier input switching.

The volume applied to the line in the output of a ' C ' amplifier is normally + **4 db** but sometimes, if the local-end losses are unusually high, it may be rather greater than this.

The gains of ' B ' amplifiers at transmitting stations are so set that the volume in their output will be + **14 db** and the sensitivity of the programme meter at this point is adjusted so that the indications of the instrument will be relative to this volume. The equaliser for providing the listener tip-up follows the ' B ' amplifier and discriminates against the lower frequencies, introducing a loss of approximately 2 db at 8,000 c/s and of 8 db at 1,000 c/s and at all frequencies below this. The actual connection to the modulator input circuit of the radio transmitter is made via a variable attenuator so that any necessary adjustment can be made according to the local needs and the percentage of modulation specified for the line-up. At some stations a limiting device is included in circuit which automatically restricts the programme peak voltages when necessary, in order to prevent voltages in excess of that corresponding to 100 per cent. modulation from being applied to the transmitter input.

At **Stagshaw** where the ' B ' amplifier is followed by a ' C ' amplifier, arrangement is made for a volume of + **10 db** in the output of the ' B ' amplifier, where the programme meter amplifier is connected, and for a volume of + 14 db in the output of the ' C ' amplifier. At **Daventry** the volume in the output of the ' B ' amplifier is adjusted to **zero** and the transmitters are fed via ' C ' amplifiers, the gains of which are individually adjusted in conjunction with attenuators provided in the transmitter inputs to secure in each case the required percentage of modulation at line-up.

The gain setting of ' A ' amplifiers depends upon the volume available from the microphones in the associated studio, and in practice is adjusted for a typical programme to give a volume of − **10 db** in the output of the ' A ' amplifier. If the line-up has been properly carried out the programme volume at all points throughout the system can be maintained at the proper value, without disturbing the gain settings of any of the amplifiers, by suitable operation of the control potentiometer at the originating station.

The sending volume from O.B. points depends upon the transmission equivalent and the noise level of the line and is advised in each case, after a test, by the Lines Department. The maximum sending volume is normally + **4 db,** but for circuits having a small transmission equivalent, sending volumes of **zero** or − **4 db** are often used.

Programme volume, as explained elsewhere (see **Item 1.2**) is essentially a *voltage* measurement. In view, however, of the considerable variation in the effective impedance to programme of O.B. lines, the concern of the Lines Department is to ensure that a certain maximum value of *programme power* rather than of programme voltage to line shall not be exceeded. In the case of the new O.B. amplifier (OBA/8) the programme meter input circuit is arranged so that the meter measures the power and not the voltage sent to line, but with the earlier types of equipment where a line volume meter is used the voltage sent to line is measured. In such cases the voltage corresponding to the required power into the line impedance is calculated and the appropriate volume range setting is notified.

Before provision was made for measuring the volume sent to line at the O.B. point, the practice was to set the gain of the ' D ' amplifier at the receiving station to a suitable value

Line-up of System *(Contd)*

and to arrange with the O.B. engineer to adjust the gain of the O.B. amplifier so as to give the correct volume (— 10 db) in the input of the ' B ' amplifier. This practice has now been modified. The correct specified volume is sent to line at the O.B. point and the gain of the ' D ' amplifier at the receiving station is adjusted to give the required volume in its output circuit.

Control of Programmes

The greatest range of variation encountered in the amplitude of the sound pressure wave, is stated by Harvey Fletcher to be of the order of 70 db. In practice it is found that the maximum range of voltage variation, or contrast, in any one programme, for example, between the full symphony orchestra playing fortissimo and a solo violin playing softly, is not more than about 55 db. For the majority of musical broadcasts the range of variation probably does not greatly exceed 40 db.

In order to preserve an adequate programme/noise ratio in the signal received by listeners living near the limits of the service area of the transmitter (at distances say of 60 to 70 miles from the transmitting aerial) it is found necessary to restrict the range of variation in the amplitude of the programme voltages applied for modulating the transmitter to about 24 db. That is to say, the programme peak voltages indicated by the programme meter should not be allowed to range beyond 7 and 1 on the meter. The necessary control to secure this degree of compression is performed manually by means of the control potentiometer either in the studio control or D.C. cubicle, or in the control position or cubicle, or at the O.B. point, but obviously it is necessary to control only at one point.

The Empire programmes radiated from Daventry are still further compressed, the range of contrast being reduced from 24 db to 12 db by an automatic volume compressor device connected in circuit, in the London Control Room, between the output of the normal control ' B ' amplifier and the input of the ' C ' amplifier feeding the line to Daventry.

Working Gain of Amplifiers

Output from Microphones. The volume at the microphone output will vary considerably, depending upon the type of microphone used, the nature of the programme and the acoustic properties of the studio, etc. In practice the output from a ribbon microphone may vary in volume according to the circumstances from about — **55 db** to about — **100 db.** The volume from an S.T. & C. moving-coil microphone will, in general, be 5 db to 10 db greater than that obtained from a ribbon microphone operating under similar conditions.

O.B. Amplifiers. In the diagram the volume in the input to the O.B. amplifier has been taken for a typical case at — 60 db and the *programme power* sent to line from the output of the O.B. amplifier at + **4 db.** The programme volume (voltage) to be sent to line depends upon the effective impedance of the line to programme. If we take 150 ohms as a typical value the programme volume sent to line (corresponding to a programme power of + 4 db) will be — **2 db.** In these circumstances the O.B. amplifier is required to introduce a voltage gain of 58 db.

In an extreme case, however, the volume at the input of the O.B. amplifier might be less than — 80 db. and the volume sent to line might be greater than + 4 db. The O.B.

Working Gain of Amplifiers (*Contd*)

amplifier might thus be required to provide a voltage gain of as much as **90 db.** The new O.B. amplifier (OBA/8) has been designed to contend with this extreme condition, but certain of the older types of amplifiers still in use are restricted both in respect of the gain available and of the capacity of their output stages.

In the typical case illustrated the line is repeatered by the B.B.C. at a point at which the equalised voltage equivalent amounts to 28 db and the programme is sent into the next section of the line at a volume of − 2db, corresponding to a programme power of + 4db, if we assume the effective impedance of the line to programme to remain unchanged at 150 ohms.

' A ' Amplifiers. In the diagram the volume shown at the input to the ' A ' amplifier is − 70 db and the amplifier operates at a gain of 60 db in order to provide a volume in its output of − 10 db. ' A ' amplifiers for use at studio offices are normally designed to have a maximum voltage gain of approximately **70 db.**

' B ' Amplifiers. For the purpose of line-up it is assumed that the programme in the output of an ' A ' or ' D ' amplifier at an originating station will normally be at a volume of − 10 db, and to provide an adequate range of volume control the control potentiometer is set so as to introduce a loss of approximately 20 db. The volume required in the output of the ' B ' amplifier, at the more recent stations is **zero**, but at the older stations is + **10 db.** ' B ' amplifiers at a studio premises therefore have a maximum available gain of either **30 or 40 db.** Both conditions are illustrated. The modern practice is to make them fixed gain amplifiers with no provision for controlling the gain.

The gains of the trap-valve and programme meter amplifiers, the inputs of which are connected across the output of the ' B ' amplifier, are of course adjusted to compensate for the difference in the volume available at this point at the various stations.

' C ' Amplifiers. Programme is normally sent to line at a volume of + 4 db. Therefore at stations where the volume in the ' B ' amplifier output is normally zero the ' C ' amplifiers work at a **voltage gain of 4 db,** and at stations where the volume in the ' B ' amplifier output is adjusted to + 10 db ' C ' amplifiers work with a **voltage loss of 6 db.**

The ' C ' amplifier serves to isolate the line and prevent any noise present on it from affecting other lines taking the same programme. Its input impedance is made high so that the load impedance into which the ' B ' amplifier works will not be appreciably affected by connecting a number of ' C ' amplifiers across its output, in parallel of course with the trap-valve and programme meter amplifier inputs permanently connected there. The output impedance is made 600 ohms so that it will be of the same order as the effective impedance to programme of the line. The other amplifiers in the chain are essentially *voltage* amplifiers with input and output impedances approximately equal, whereas the ' C ' amplifier is a *power* amplifier with voltages in the input and output circuits of the same order but with a transformation from a high to a low impedance.

' D ' Amplifiers. The programme volume at the input of a ' D ' amplifier at an **intermediate station** depends of course upon the equalised equivalent of the S.B. Link which it is used to terminate. Generally this will not be greater than about 20 db although in certain

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cases it is conceivable for it to be as high as 30 db. Assuming the programme was sent to line at a volume of + 4 db, a typical value for the volume at the input of the ' D ' amplifier would be approximately − 15 db with a possible minimum value of − 25 db. The volume required in the output of the ' D ' amplifier is either zero or + 10 db. In the former case a typical value of working voltage gain would therefore be 15 db with a maximum value of 25 db, while in the latter case a typical value would be 25 db with a maximum value of approximately 35 db. Actually ' D ' amplifiers for normal use are designed for a maximum working gain of **38 or 40 db,** although at some stations certain of them, intended for use only on local lines with a low equalised equivalent, have a gain of only about 26 db.

At **originating stations,** the ' D ' amplifier is followed by a ' B ' amplifier, and the programme volume in the ' D ' amplifier output therefore needs to be only − 10 db. As has been stated, however, it is customary to operate the ' D ' amplifier at its normal gain setting, as if it were to be followed by a ' C ' amplifier, and to include a 10 db or 20 db attenuator in circuit between the output of the ' D ' amplifier and the input of the ' B ' amplifier. A typical net value for the working gain is about 12 db, as illustrated.

On repeatered S.B. links, equalisation is included in the Post Office repeater, but this is designed to take account only of the trunk circuit and does not include equalisation for the local ends connecting the B.B.C. offices with the trunk system. The equalisation will, therefore, be incomplete, as shown in the diagram, where equalisation at the repeater point is achieved only to within 5 db.

Transmitter ' B ' Amplifiers. Transmitter tie-lines are mostly unrepeatered and as they are often 15 to 20 miles in length may have an equalised equivalent of as much as 35 db. A further loss is introduced by the control potentiometer, in the normal case, in order to bring it to about the middle of its working range of adjustment. If the volume sent to the transmitter tie-line is + 4 db, that in the input of the ' B ' amplifier at the transmitting station, assuming a loss of only 4 db in the control potentiometer might therefore be − 35 db. Since the programme in its output has normally to be at a volume of + **14 db,** the ' B ' amplifier may thus be required to provide a voltage gain of the order of 50 db. It is designed for a maximum gain of **62 db.** The ' B ' amplifiers used at **Stagshaw** and **Daventry** have a maximum gain of approximately 40 db and are followed by ' C ' amplifiers with a maximum gain of approximately 10 db. The total gain available at these stations is therefore only about 50 db from the two amplifiers in series.