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## BROADCAST PROGRAM PROTECTION

### Control Room and Engineering Details for Setting Up and Maintaining Satisfactory Broadcast Service

By W. A. R. BROWN\*

PROGRAM protection may be defined from the operating viewpoint as those steps which are taken to preserve the fidelity and continuity of the program. Such protection is demanded by the operating company because it is essential that the best possible service be provided to meet the competition existing in the broadcast advertising field. To satisfy this demand is one of the major functions of the operating department and many of its activities are directed to that end.

Because of the complexity of present-day broadcast systems and the oftentimes considerable physical distances separating the component units it is doubtful whether the latent possibilities of trouble, or the safeguards utilized, in such extensive systems are recognized. As an aid in visualizing the complexity of operation the component units of the National Broadcasting Company's system, local to New York, are indicated in Fig. 1. When it is considered that several programs may be in progress simultaneously, some in studios and some at outside points, and are being supplied to local transmitters and networks and that the combinations are continually shifting, the possibilities of trouble and the necessity for adequate safeguards are readily apparent.

#### Broadcasting Use of Wire Lines

The general problem of protection is of considerable magnitude as each type of unit has problems peculiar to itself and for many phases of operation it has been necessary to develop methods to cope with the problems which have arisen with the increasing expansion

*This paper describes briefly some of the precautions necessary to maintain high quality and continuity in the operation of a modern broadcasting system, including volume control, audio energy limitations of wire circuits, program switching and distribution, program monitoring and protection of a radio transmitter.*

of broadcasting. Broadcast operation is, to a certain extent, telephone communication and the problems encountered in this phase of operation do not differ fundamentally from those encountered in other communication fields. Briefly, these problems as they apply to broadcasting are: (1) that the circuits transmit the frequencies of the audio band with substantially equal attenuation; (2) that impedances be matched at junctions of individual equipment units; (3) that the audio levels be confined within prescribed limits. These are treated in accordance with standard engineering practice and need no elaboration.

In actual operation one of the first

safeguards introduced is volume control and upon the proper handling of this problem depends to a considerable extent the quality of the program. This function is exercised by the studio engineer for studio programs and by the field engineer for outside pickups. Such control is necessary because the dynamic ranges encountered are greater than can be handled by existing equipment.

The telephone lines and repeaters offer an unsurmountable obstacle, at present, to the transmission of the full dynamic ranges encountered in broadcasting. This equipment, designed before broadcasting was in general use, was intended to handle only the dynamic range of the human speaking voice, and although improved equipment is constantly being placed in service broadcasting is limited in its expression by the limitations of the telephone circuits since such circuits must be used on networks. These limitations expressed in energy levels are plus 6 db. for the upper value and about minus 25 db. as the lower figure, a range of 31 db. There are very definite reasons for confining the levels between these values. Telephone repeaters will not reproduce faithfully at levels greater than plus 6 db. and any greater level than this overloads the repeater and causes distortion of the program. On the other hand, at levels below minus 25 db. the inherent line noise of a wire circuit (induction, cross talk, etc.) becomes apparent. In order to allow a factor of safety the upper operating limit is placed at plus 2 db. leaving a range of 27 db. for normal operation. Under these conditions the dynamic range of a symphony orchestra, which is about 60 db., must be compressed into less than half its normal value. If this is to be accomplished

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\*Assistant Development Engineer, National Broadcasting Company.

successfully the average listener must not be aware that volume control is being exercised.

### Control of Dynamic Range

Volume control is not merely cutting down the peaks and bringing up the low passages after these have occurred. They must be anticipated. The gain must be gradually lowered prior to the crescendo and raised previously to the pianissimo passages. Otherwise, the peaks are distorted and the low passages lost in the noise. To compress dynamic ranges without the process being too evident to the listener is an art.

### Studio Engineer Prepared for Changes

Although an experienced studio engineer can often instinctively anticipate coming changes of volume as the music progresses, previous knowledge of the selections is a great asset. In order that the work of the engineer may be conducted as efficiently as possible he is present at the rehearsals. These may extend over 10-15 hours in preparation for one hour on the air and when the actual broadcast takes place the studio engineer is familiar with all features of the program and volume control is seldom detected by those listening. Each studio booth is acoustically treated to provide faithful reproduction and high quality monitoring and is equipped with a level indicating device for the guidance of the studio engineer in controlling volume.

The duties of the field engineer are fundamentally the same as those of the studio engineer—volume control, microphone placement and musical balance—but often complicated by additional factors such as poor acoustics, limited space and crowds. Under the varied conditions surrounding outside pickups the field engineer must often draw upon his fund of experience in coping with the varied problems, analyse many factors and make decisions quickly. Initiative is essential.

Because of the varying lengths of the wire circuits on these Nemo pickups the average levels of the programs entering the main control room will often differ considerably. This would cause abrupt changes of level when switching and in order to eliminate this and to have these program levels conform to those of the studio outputs the program is routed through a Nemo monitoring booth. This is essentially a re-

peater station and the primary function of the studio engineer there is to monitor the program and make sure it is passing that point and is being fed to the control room at the proper level for distribution.

### Contact Between Studio and Field Engineers

Prior to the start of the program, he checks with the field engineer for the purpose of setting levels. The general practice is for the field engineer to place a sufficiently high level upon the line to insure a good signal-to-noise ratio at the monitoring booth. The studio engineer there regulates the level for program distribution to the control room. After the program has started he checks levels again with the field engineer and remains in constant telephone communication with him. Under certain conditions he may act in an advisory capacity to judge balance and quality when the field engineer may be hampered by excessive noise. His regulative functions are slight as volume controlling is logically done by the field engineer.

These Nemo booths have similar acoustic treatment and equipment as the studio booths. The latter can be used for outside programs but, because of the demand for studios for rehearsals, seldom are.

The main control room is the nerve center of a broadcasting system and upon the efficient performance of the duties connected with its operation rests in large measure the success of network broadcasting. Responsibility for the operation of studios and the distribution of programs to networks and local transmitters is centered here. A typical layout, showing program distribution and monitoring circuits, is given in Fig. 2.

The distribution phase of operation requires a given program to be dispatched to designated points, at the proper level, and at a definite time. This requires (1) an interlocking system for transferring at will the outputs of various studios to one or more distribution channels, and (2) facilities for checking the program at important points. A dual system is used by the National Broadcasting Company with master controls and indicating lights at the master control desk and such duplicate controls and lights in each studio as are necessary for operation of that particular studio. With

this system the switching is normally performed in the studios but is under the supervision of the control room supervisor who can detect and correct errors. The indicating lights on the master control desk show each operation involved in the switching of each studio and the supervisor can tell at a glance the status of any particular studio.

### Announcer Controls Switching

The actual switching is performed by the announcers in the studios. This is because the announcer is the contact between the program and the public and, as it is desirable that this contact be as precise and rapid as possible, the best coordination of thought and action is obtained by having the announcer do his own switching. The switching facilities in each of the studios appear as rows of push-buttons and lights on a small panel. The push-buttons permit the connecting or disconnecting of the output of that studio to, or from, any combination of distribution channels. The lights indicate which channels are being utilized, both by this and other studios, and whether the announcing or program microphones are in operation. As an aid in operation, and to supplement the indicating lights, headphone monitoring of programs in all studios is available to the announcer.

Studio operation is carried out in accordance with a carefully prepared schedule which is in the possession of all personnel. Thus, the announcer in any studio has all the essential information regarding the distribution of that program and is in a position to set up or release the required program channels and make local announcements. As an additional check, certain of these lights and buttons appear in the monitoring booth on the mixing panel of the studio engineer who is in a position to view the activities of the studio and can release the channels if necessary.

### Network Problems

Network operation has introduced many problems. One of these is local announcements at the network stations. Because program requirements make it impossible to designate a definite time for these it is necessary that notification be transmitted over the program circuits in order to eliminate the possibility of human error. This is accomplished very simply by utilizing the musical notes of chimes as a cue to indicate that the next fifteen seconds will be available to all stations for their locals. The chimes, since they are given at the conclusion of most programs, are also utilized as switching cues by individual stations and supplementary networks who are joining or leaving the chain. These supplementary networks are smaller chains which tap the basic networks at a distance from New York and which may take program service from either the basic Red or Blue networks. This

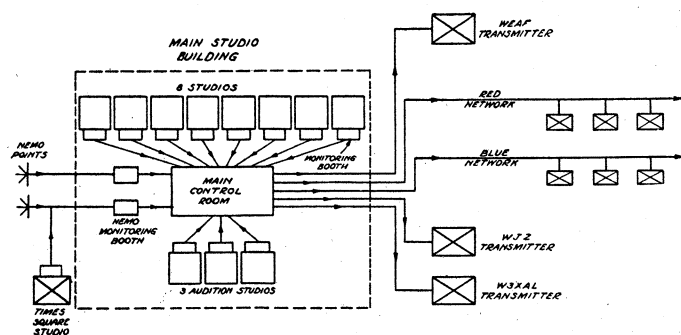


Fig. 1. Schematic diagram NBC program circuits New York.

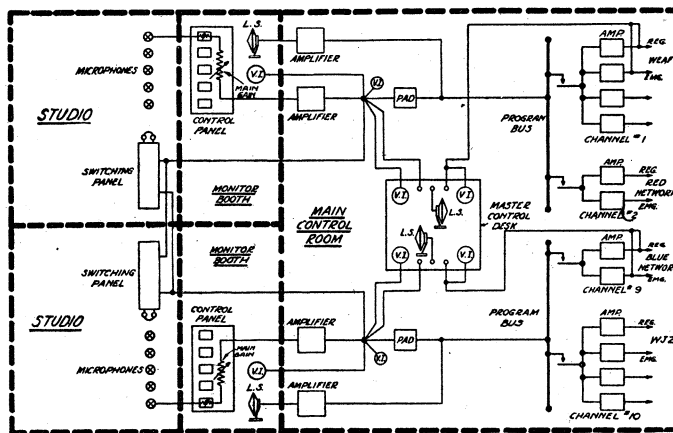
raises the problem of synchronization of two programs with the switching in order that these supplementary chains shall not be cut over to a network on which the program has already started. Since the chimes are used as switching cues the solution is to transmit them simultaneously over both networks. In actual practice when one network program has concluded the announcer for the other network takes control of both for the time necessary to give the chimes. This procedure may leave one or the other of the two networks without program for a few seconds at the end of a feature but this is preferable to losing part of a program.

Since the control room supervisor is responsible for the dispatching of programs monitoring facilities must be available for checking. These are located at the master control desk and consist of volume indicators and a loudspeaker, the former showing the output levels of the studio and line amplifiers, while the loudspeaker may be connected to either of these points. Similar monitoring of each studio and distribution channel is possible. Radio monitoring of the two local transmitters, in this case, WJZ and WEA, is also available and includes in addition to the customary radio reception a signal light to show whether the carrier is on or off and a neon lamp which indicates when the carrier is being modulated and roughly the degree of modulation. With the monitoring and switching systems centered at the master control desk, local troubles can be quickly located and usually quickly remedied for all studio and line amplifiers, channel terminations, et cetera, are located in the control room. The input and output connections of most of the equipment in each studio appear on jacks in the control room and a circuit can be quickly patched around any faulty unit. Telephone communication to each monitoring booth and telegraph circuits to all networks and local transmitters are available at the master control desk so that trouble at any point of the system is immediately detected and appropriate steps are taken to remedy it.

### Outside Wire Lines

Line trouble is, of course, beyond the control of the broadcast company. The telephone company is responsible for the maintenance of program service between network stations. In general the same methods of insuring program continuity are used by the telephone company as by the broadcast company. With networks covering most of the country all extremes of conditions are naturally encountered and the causes of interruptions are varied; for instance, a truck loaded with high explosives collided with a telephone pole, or a tornado tore the roof from a farmer's barn and dropped it on the line. Although the telephone company is responsible for the maintenance and condition of the lines, transmission characteristics of all long line networks

Fig. 2. Schematic diagram of program circuits, studios and control room, New York



are taken by the broadcast company at intervals.

The short local lines seldom give trouble. They are checked daily, however, as a matter of precaution, and rechecked prior to a broadcast. Frequency runs are also taken of the lines to the local transmitters and in these instances include the frequency characteristics of the entire circuit from microphone to antenna.

### Studio Power Supply

The power supply for the studios is normally furnished from a commercial source, but storage batteries with a capacity sufficient to operate the equipment for 24 hours are held in reserve. Automatic switching facilities also furnish current for lighting purposes in event of failure of the outside source. Each studio has its separate power line and all current carrying circuits for studio or control room equipment are fused.

### Protecting the Tubes

The equipment of a modern high-power transmitter represents a very considerable investment and safeguards must be rigidly applied, especially for the water cooled tubes. Standard power plant protection is utilized to a large extent but is, of course, complicated by the requirements of the radio equipment, so that an elaborate electrical system of interlocking safeguards is necessary.

Tube protection is essential, both because their power limitations must not be exceeded and for continuity of operation, as a tube failure will often produce dangerous transient conditions among the associated equipment. Such protection requires a sustained supply of cooling water to the tubes and certain operational safeguards; for example, filament power can not be applied unless an adequate flow of water is assured and plate power can not be applied before the application of grid bias voltage. In practice this is handled by a step-to-step procedure which must be followed in placing the plant in operation and an interlocking relay system which functions in the event of failure, or overloading of any unit, re-

moving from service any units the continued operation of which would endanger equipment. Water supply protection is usually supplied by hydrostatic pressure devices, which are so connected to the interlocking system that filament power can not be applied, nor left on, when the water pressure is below a predetermined value.

The input temperature of the water must be sufficiently low so that the water will not boil when in contact with the tube anode as this would greatly reduce the heat dissipation at these points and probably result in anode punctures. Distilled water must be used at certain geographical locations to prevent scale formation on the tube anodes which occurs when water with a considerable mineral content is used for cooling. Thermometers are generally used to indicate the input and output water temperatures and when used on individual tubes will often show by a gradual temperature rise the presence of slight obstructions in the water supply of a particular tube.

Continuity of operation is provided by spare tubes which can be rapidly placed in service. This replacement process is handled by a push-button arrangement on the desk of the transmitter engineer who can remove any tube from service, replace it by a spare, and resume operation in a few seconds. Duplicate units are provided for much of the other equipment, ranging from crystals to transformers, and rapid replacement facilities are provided.

Modulation of the carrier is checked by an oscillograph and the program is monitored both in the control room and in the transmitter room, radio monitoring being used at the latter point. Thus, with a monitoring system which checks the program from the microphone to the air and the equipment safeguards utilized, program protection is assured against most causes which are likely to arise.

It has been attempted in this paper to outline briefly some of the precautions which must be taken to insure the maintenance of a high standard of program quality and continuity of operation of a modern broadcasting system.

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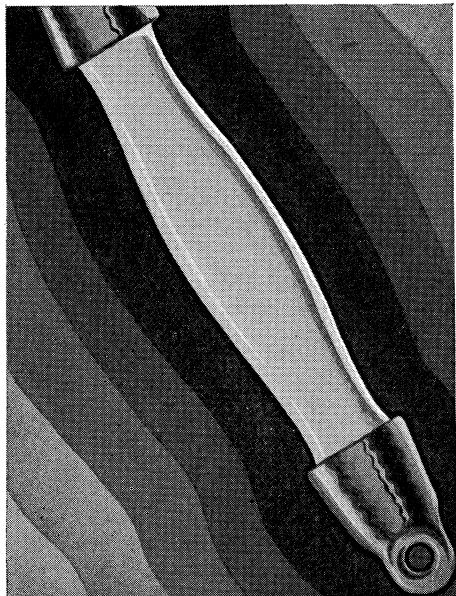
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2. Illustrations should invariably be in black ink on white paper or tracing cloth. Blueprints are unacceptable.

3. Corrected galley proofs should be returned within 12 hours to the office of publication. Additions or major corrections cannot be made in an article at this time.

4. A brief summary of the paper, embodying the major conclusions, is desirable.

5. The Club reserves the right of decision on the publication of any paper which may be read before the Club.

\* For 1930 the Chairman of the Papers Committee is Mr. F. X. Rettenmeyer, 463 West Street, New York City.



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