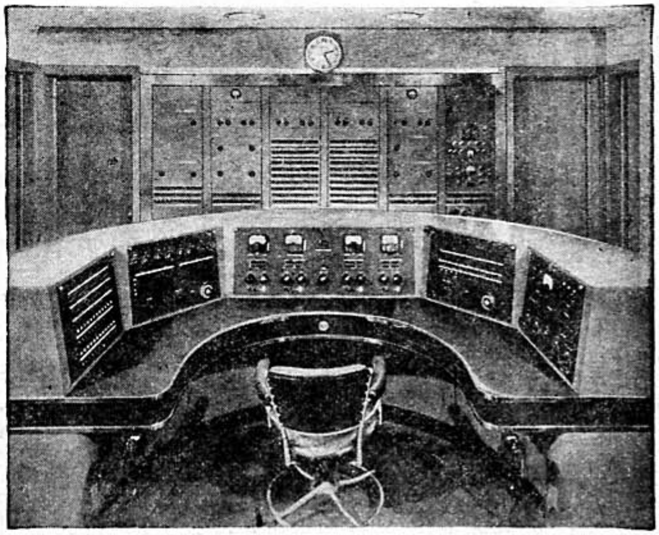
BROADCAST EQUIPMENT

PART III
MASTER CONTROL-ROOM FACILITIES

By DON C. HOEFLER



This typical control room is at Radio Station WLS, Chicago.

Courtesy Radio Corporation of America

THE transmitting equipment of a modern broadcasting station is usually located in the suburbs of the city which it serves, to obtain better coverage. The absence of tall buildings and other metallic structures which would otherwise reflect and absorb the emitted R.F. energy, allows for a greater primary service area.

The FCC requires that the station's main studios must be located within the city proper. This imposes no hardship, for it is the most practical arrangement from the standpoint of accessibility to the staff, artists, and sponsors. It does, however, require a central point for the superintendence of all incoming and outgoing audio signals, before reaching the transmitter. Such a spot is located adjacent to the studios and is known as the Master Control Room. It is here that all incoming programs from the adjoining studios, remote lines, network lines, or radio receivers are received, amplified to their proper level, and fed to the transmitter program line. The equipment used is often identical or very similar to that previously described for the studio control booth.

THE LINE AMPLIFIER

The line amplifier is of the same type as the studio amplifiers, but its function is to bring the amplitude of the program up to the level required to feed the program line, which is usually 0 db. Naturally, the same careful designing to minimize noise and distortion must be observed throughout the speech equipment. To prevent the picking up of stray electrostatic and electromagnetic fields by the equipment wiring and program lines, they must be thoroughly shielded. All plugs, sockets, and other connections, must be so made as to guarantee firm contact, as the most inconsiderable variations in contact resistance will produce seriously objectionable noises in the output.

Thermal-agitation noise is due to the random motion of electrons within a conductor. This effect is made worse by the fact that it increases directly as the band-width of the amplifier, as such noises usually contain practically every frequency within the audible spectrum. Fortunately, thermal agitation noise decreases very rapidly as the input resistance of the amplifier is lowered, and thus may be partially offset in this way. Shot effect results from the fact that the electron stream from cathode to plate is composed of a series of particles rather than an absolutely uniform flow. The electrons arrive at the plate with some irregularity, to form a noise component in the plate current. However, the presence of an adequate space charge in the tube tends to smooth out these irregularities to such an extent as to practically eliminate shot effect when complete temperature saturation exists. This is sometimes accomplished by operating the filament voltage of the input tube, which is the most important in this respect, above its rated value, thus insuring a plentiful electron supply and a more uniform plate current.

Carbon resistors are another source of similar noise, and should never be used at points carrying a low program level. Such noises increase rapidly with the value of the resistance. The amplifier tubes must be extremely quiet in operation, are usually of the non-microphonic type, and cushion-mounted. If a monitoring loud-speaker is operated nearby, it often becomes necessary to surround the first tubes with a blanket of cotton batting, in order to insulate them from acoustic feedback.

Tube sockets are very important, for if firm contact is not made at all times, or if there is a great tendency toward oxidation, more troublesome noises may be introduced. The sockets and grid cap contacts should be cleaned with carbon tetrachloride or crocus cloth at least once every three months to insure noiseless operation. Whenever possible, the input transformer is center-tapped to ground, and is always very heavily shielded. The amplifier is mounted as far away from all A.C. fields as possible, and the associated transformers and chokes should be rotated to the angle of minimum coupling. The power supply must be completely filtered, and decoupling filters must prevent undesirable feedback between stages.

The amplifier circuit itself must be so designed that it reproduces faithfully, without noticeable change or distortion of any kind, the program material produced in the studios or reproduced from transcriptions. In broadcasting's earliest days, speech amplifiers were nearly all impedance-coupled. Then as the quality of transformers was improved, transformer coupling attained widespread usage. With the fairly recent advances in high-gain tubes, present amplifiers are mainly resistance-coupled, with input and output transformers for impedance matching. All modern speech equipment is designed to have a substantially uniform response from 20 to 15,000 c.p.s. or better.

VOLUME CONTROLS

Since the primary service area of a transmitting station depends, among other things, upon the average degree of modulation, it is advisable to keep this as high as possible. Also, to avoid serious cross-talk and excessive background noise, the normal program line level should be limited to 0 db, with a maximum of +2 db on peaks. As the volume range of even the best program transmission circuits presently in general use is limited to 25 or 30 db, and since the dynamic range of a symphony orchestra, for example, is about 60 db, it is evident that some volume compression is necessary.

The master control-room engineer has final control over all program material before it is impressed upon the program line to the transmitter, and it is his duty to insure that the volume is at the proper level and within the specified ranges at all times. Since at best, this system restricts the fidelity of sound reproduction, because it purposely introduces amplitude distortion, it is obvious that an incompetent control-room operator can easily ruin an otherwise perfect program.

Ladder-type attenuators are most often

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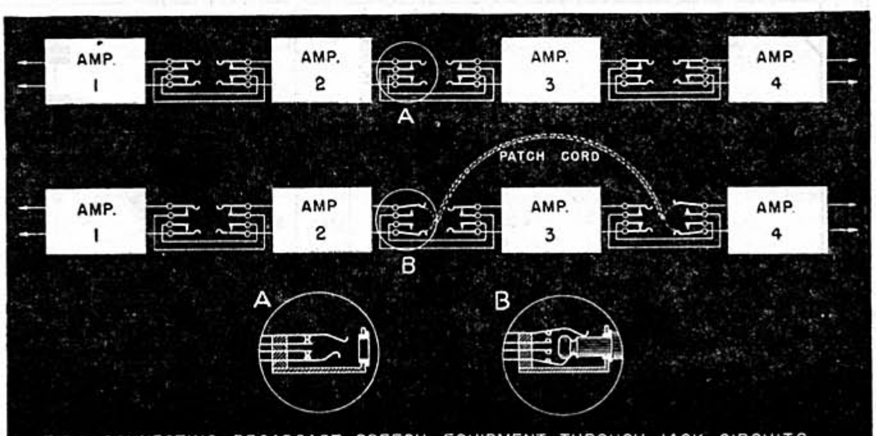

FIG 1 - CONNECTING BROADCAST SPEECH EQUIPMENT THROUGH JACK CIRCUITS

WORLD WIDE STATION LIST *(Continued from page 106)*

12.290	GBU	LONDON, ENGLAND.
12.445	HCJB	QUITO, ECUADOR.
12.967	WKRD	NEW YORK CITY; North African beam, 6:15 to 9:30 am; 12:45 to 5:45 pm.
13.000	HDD	QUITO, ECUADOR; heard 3:45 to 4:30 pm.
13.085	COCH	HAVANA, CUBA.
13.22	ICA	ALLIED HEADQUARTERS IN ITALY.
14.56	HVJ	VATICAN CITY; 9 to 10 am.
15.000	WWV	WASHINGTON, D. C.; U. S. Bureau of Standards; days only.
15.11	DJL	BERLIN, GERMANY.
15.11	—	MOSCOW, USSR; 9:15 pm and 11:15 pm; 5:15 to 5:30 pm.
15.120	DKSA	"SENDER ATLANTIK."
15.130	DXR7	BERLIN, GERMANY.
15.13	KGEI	SAN FRANCISCO, CALIF.; Australian beam, 1 to 6:30 am.
15.130	WRUS	BOSTON, MASS.; North Africa beam, 1:45 to 4:30 pm; 4:45 to 6 pm; European beam, 7:45 am to 1:30 pm.
15.130	DXL6	BERLIN, GERMANY.
15.140	GSF	LONDON, ENGLAND; 10 am to 4 pm.
15.150	WNBI	NEW YORK CITY; European beam, 7:45 am to 3:30 pm.
15.150	WRCA	NEW YORK CITY; Brazilian beam, 5 to 7:45 pm.
15.155	SBT	STOCKHOLM, SWEDEN; 7 to 7:55 am; 11 am to 2:15 pm; Sundays only, 4 to 11 am; noon to 2:15 pm.
15.160	JZK	TOKYO, JAPAN; 9:15 pm to 12:15 am.
15.170	TGWA	GUATEMALA CITY, GUATEMALA; daytime transmissions.
15.180	GSO	LONDON, ENGLAND; afternoons.
15.190	WOOC	NEW YORK CITY; European beam, 7:45 am to 5 pm.
15.190	CBFZ	MONTREAL, CANADA.
15.190	KROJ	LOS ANGELES, CALIF.; Oriental beam, noon to 2:45 pm; 5 to 8:45 pm; Australian beam, 3 to 4:45 pm.
15.200	WLWLI	CINCINNATI, OHIO; Central Africa beam, 6 to 9:45 am; 5:30 to 8 pm; South Africa beam, 10 to 10:30 am.
15.20	DJB	BERLIN, GERMANY.
15.210	WBOS	BOSTON, MASS.; European beam; 7:45 am to 5:15 pm; East South America beam, 5:30 to 8:15 pm.
15.220	—	"NATIONAL CONGRESS RADIO" (INDIA).
15.225	JTL3	TOKYO, JAPAN; 10:15 to 11:15 am.
15.230	WLWL2	CINCINNATI, OHIO; North Africa beam, 6 to 9:45 am; 10 to 10:30 am; 10:45 am to 1:15 pm; 5:30 to 8 pm.
15.230	WKRX	NEW YORK CITY; Central Africa beam, 4:15 to 5 pm.
15.230	—	MOSCOW, USSR; off at 7:25 pm.
15.230	VLG6	MELBOURNE, AUSTRALIA; on at 10 pm.
15.240	TPC5	VICHY, FRANCE.
15.250	WLWK	CINCINNATI, OHIO; European beam, 8:15 am to 5:15 pm; West South America beam, 5:30 to 8:15 pm.
15.260	GSI	LONDON, ENGLAND.
15.270	HAS3	"HUNGARIAN NATIONS RADIO"; 1 to 2 pm.
15.270	WCBX	NEW YORK CITY; European beam, 7 am to 4:45 pm.
15.29	KWID	SAN FRANCISCO, CALIF.; Oriental beam, 2:45 to 3:15 am.
		SAN FRANCISCO, CALIF; South America beam, 5 pm to 12:45 am.
15.290	KGEI	
15.290	KGEX	SAN FRANCISCO, CALIF.; South America beam, 11 am to 5 pm.
15.290	KWIX	SAN FRANCISCO, CALIF.; South American beam, 11 am to 1 pm.
15.300	—	MANILA, PHILIPPINES; operated by the Japanese 11 pm to 1 am.
15.31	GSP	LONDON, ENGLAND.
15.315	VLQ3	SYDNEY, AUSTRALIA; 10:30 to 11 pm; 12:45 to 1:45 am.
15.325	JLP2	TOKYO, JAPAN; 11:30 pm to 12:30 am.
15.330	KGEX	SAN FRANCISCO, CALIF.; Oriental beam, 6:15 pm to 1 am.
15.33	MTCY	HSINGKING, MANCHUKUO; Japanese operated, 1 to 3 am.
15.330	WGEO	SCHENECTADY, NEW YORK; European beam, 7 am to 9:15 am; 9:30 am to 3:30 pm; 3:45 to 5:15 pm.
15.350	WRUW	BOSTON, MASS.; Caribbean beam, 615 to 7:15 pm; European beam, 2:45 to 6 pm.
15.350	WRUL	BOSTON, MASS.; North Africa beam, 10 am to 1:30 pm; European beam, 1:45 to 2:30 pm.
15.355	KWU	SAN FRANCISCO, CALIF.; N. E. I. beam, 7:45 to 9:30 pm; off on Wednesdays.
15.400	GRE	LONDON, ENGLAND; heard in afternoon.
15.410	PZP	PARAMARIBO, DUTCH GUIANA.
15.45	GRD	LONDON, ENGLAND; heard at noon.
15.595	—	"RADIO BRAZZAVILLE"; FRENCH EQUATORIAL AFRICA; 11:55 am to 12:55 pm.
15.620	VRR6	JAMAICA, BRITISH WEST INDIES.
15.750	—	MOSCOW, USSR; heard mornings.
15.810	LSL3	BUENOS AIRES, ARGENTINA; heard mornings.
16.000	EPA	TEHERAN, IRAN; operated by AFHQ
16.025	AFHQ	ALLIED HEADQUARTERS, NORTH AFRICA.
17.760	KWID	SAN FRANCISCO, CALIF.; South America beam, 4 to 7:45 pm.
17.760	KWIX	SAN FRANCISCO, CALIF.; South America beam, 11 am to 4 pm.
17.760	WRUW	BOSTON, MASS.; Central America beam, 7:30 to 9:15 pm; European beam, 10:15 am to 2:30 pm.
17.760	KROJ	LOS ANGELES, CALIF.; Australian beam, 9 to 11:45 pm.
17.773	OTC	LEOPOLDVILLE, BELGIAN CONGO.
17.780	WRCA	NEW YORK CITY; European beam, 10 am to 2:45 pm.
17.780	WNBI	NEW YORK CITY; East South America beam, 5:30 to 6:45 pm; Sundays only, 5:30 to 7:30 pm.
17.800	WLWO	CINCINNATI, OHIO; European beam, 8 am to 2:30 pm; West South America beam, 5:30 to 6:45 pm.
17.830	WCBN	NEW YORK CITY; European beam, 7:30 am to 5:15 pm.
17.880	WGEX	SCHENECTADY, NEW YORK; European beam, noon to 4:45 pm.
17.955	WLWLI	CINCINNATI, OHIO; Central Africa beam, 10:45 am to 1:15 pm; 1:30 to 5:15 pm.
18.000	KRO2	HONOLULU, HAWAII; afternoons and evenings.
18.135	YDA	BATAVIA, NETHERLANDS INDIES; 10 to 10:50 pm.
18.160	WNRA	NEW YORK CITY; European beam, 10 am to 5:15 pm.

BROADCAST EQUIPMENT

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used at this point, due to their flexibility and very desirable frequency and impedance characteristics. A very low noise level, usually —150 db. or better, is essential in volume controls.

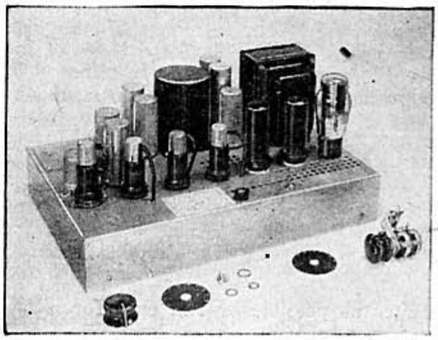
Dust and dirt are the most troublesome causes of noise, and a regular schedule for cleaning faders should thus be established by the station staff. Once a week is satisfactory for most installations. The contacts are cleaned by applying a light grade of good machine oil to them, rotating the dial throughout its range, and if any dark streaks appear, wiping off the contacts with a soft cloth. This procedure is repeated until the contacts are absolutely clean. Finally the contacts are lubricated with an extremely thin film of oil.

For the control-room engineer to "ride gain" properly on the transmitter program line input, he must be aware of the exact program level at every instant. This is accomplished with the aid of a volume indicator, as is used in the studio control booth, connected across the output of the line amplifier and mounted near the volume control panel. If the volume indicator is connected directly across the line, there may be a discrepancy of several decibels between the readings given for the same actual power level, as the program frequencies vary, due to the distributed capacitance of the line. Therefore, the meter must always be isolated from the line by means of a suitable resistance network.

This is often accomplished in practice by having the output transformer work into a pad which feeds the line. The meter may then be placed across either termination of the pad. If it be placed across the pad input, a better isolation may be obtained, although the reading will be higher than the actual line level by the value of the drop across the pad. Therefore, the meter is usually connected at the line end of the pad, and the results obtained by this method have been found to be satisfactory for most purposes.

SWITCHING APPARATUS

All the inputs and outputs of the component parts of the speech equipment are brought out to shorting-type jacks. This allows maximum flexibility and enables a program which has been interrupted due to equipment failure to be resumed with a minimum of delay. For example, if amplifier 3 of Fig. 1 should become defective, it may be bridged out of the circuit by inserting a patch cord into the output jack of amplifier 2 and into the input jack of amplifier 4, as shown. Likewise, stand-by equipment may be brought out to jacks, and substituted for faulty equipment when trouble occurs.



Standard RCA program monitoring amplifier.

All these equipment connections are brought out to a central jack panel, making long interconnecting leads unnecessary. In a short line, the lumped distributed capacitance is small enough to make the shorting effect negligible at the higher audio frequencies, and thus making equalization unnecessary.

MONITOR AMPLIFIER

When it was previously mentioned that separate speech equipment was used for monitoring purposes, the question may have arisen as to why a monitoring loud-speaker could not be connected directly across the studio amplifier or line amplifier outputs. This could be and sometimes is done, but for purposes of transmission a level of 0 db is required, while a level of at least +22 db is needed to properly drive the monitoring loud-speaker.

Then the main program amplifier must be designed to provide sufficient output to operate the loud-speaker satisfactorily, and its output is stepped down through an attenuation network to 0 db. However, separate amplifiers are desirable for monitoring purposes, as they transmit in one direction only, and serve to isolate the loud-speaker circuits from the line and to prevent any short- or open-circuit in them from affecting it. Use of an amplifier is more expensive, but adds to reliable and trouble-free operation—always very important items in the operation of a broadcast station.

This principle of using a vacuum-tube amplifier for purposes of isolation is seen very often in broadcast practice, as economy is entirely disregarded in favor of performance. The equipment is often so designed and installed that it may be connected through the jack panel, and substituted for a defective piece of regular program amplifier equipment. The RCA 82-C1 pictured above is a typical example of such apparatus.

(To be continued next month)