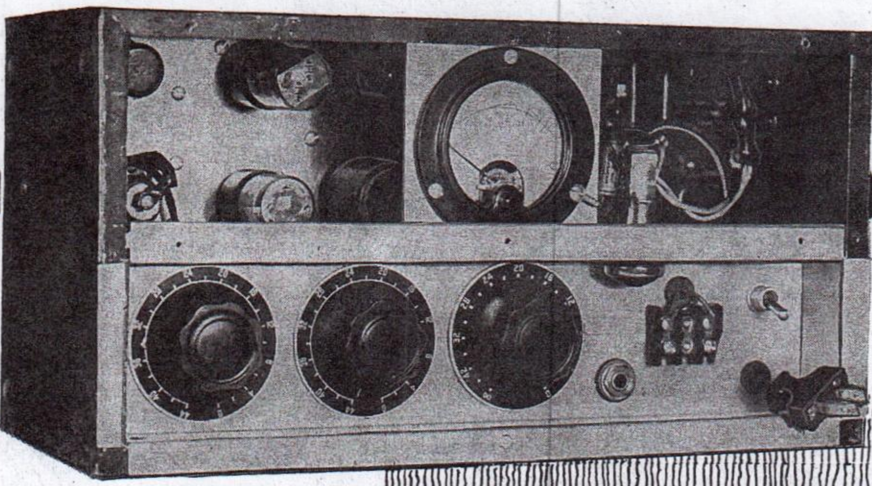
CONSTANT-OUTPUT BROADCAST AMPLIFIER



Front view of unit with upper front panel removed, showing placement of meter and accessibility of tubes.

By **ED C. MILLER**

Chief Engineer, Station KWEI

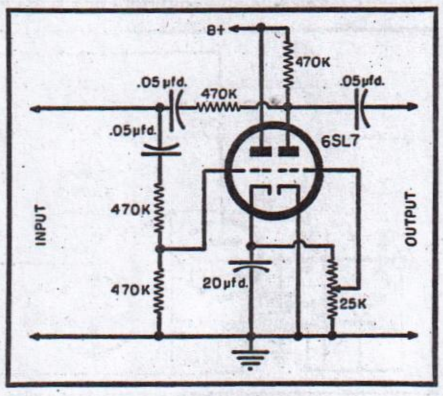
Output level of this amplifier remains constant within 1 db for input variations of up to 20 db.

IN COMMERCIAL radio broadcasting, the factors usually considered in design of equipment are: quality of response, ease of operation, and long life with minimum maintenance. Under the "ease of operation" heading comes another item which could be termed "minimum operational personnel." This is more or less true in all instances and is especially true at smaller stations where the operating margin is small. It has been exemplified over the years by the increasing use of engineers who double as announcers, newscasters, program directors, etc. In studio and control room work it has proved very successful, because the engineer is either doing the announcing or can watch the performers, and can thus anticipate any sudden increase in loudness and adjust the gain controls accordingly.

But remote-pickup broadcasts, and especially sports remotes, have continually presented two problems. The sportscaster cannot do justice to his reporting if he is endeavoring to maintain a near-constant output level from his remote amplifier. This leaves the gain-riding to the studio engineer who cannot see the play and will therefore have difficulty following the changes in incoming signal level. The second problem is electrical rather than physical. It is the possibility of overdriving the telephone line from the remote location to the control room, which may cause crosstalk in adjacent cable pairs or distortion in the broadcast loop. (The above is predicated on the use of only one man at the remote site. Because of the problems just mentioned, it has been customary to use two men—one to engineer and ride gain, the other to give the play-by-play coverage of the event. Obviously, this means increased overhead.)

The most practical solution to these problems, i.e., the use of some means of automatic volume control or amplitude compression in the remote gear, has not been overlooked. But it conflicts with two of the prerequisites of remote gear: light weight and small size. In order to achieve the quality desired with the customary variable-μ tubes, a push-pull circuit would be required and would involve at least three more tube envelopes and one more transformer than used at present in commercial remote equipment, increasing considerably its size, weight and cost.

Fig. 1. Basic compressor unit.



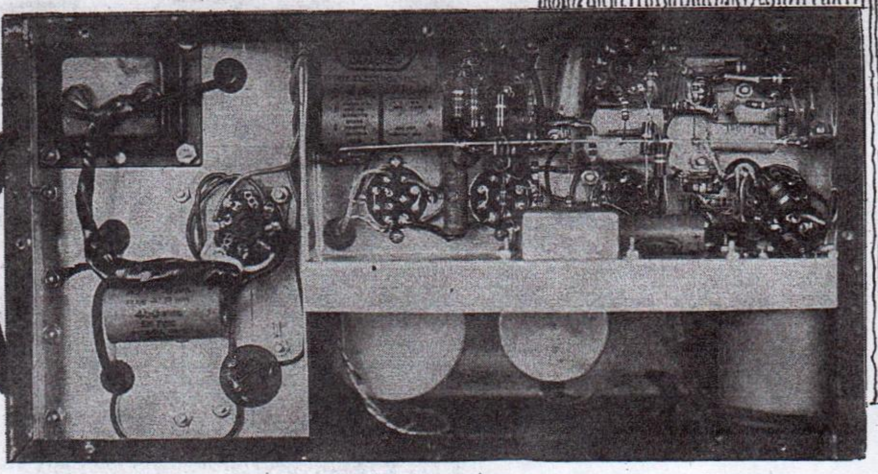
In recent months a circuit has been developed, primarily for communications and amateur use, which is known as the NRCS loss compressor. Shown schematically in Fig. 1, it is a forward-acting, high-impedance compressor, with a loss logarithmically proportional to the applied signal amplitude. It can be designed to produce an output within 1 db of the zero compression output, with an input change of nearly 20 db. Its frequency response is good, and the distortion at all levels of compression very satisfactory, but it does produce a low frequency transient with compression changes—which limits low frequency operation. In the remote equipment built at KWEI, this transient was eliminated by the push-pull arrangement shown in Fig. 2.

Considerable thought was given to the design of the remote amplifier shown in the photographs. It meets all the physical and electrical requirements deemed desirable by the engineers responsible for the quality of the broadcasts and by the sports announcers who have to use it. These include light weight, small size, good frequency response, low distortion, two individually adjustable microphone inputs, and no necessary adjustments after setup in the field.

Normally, when a two-way line is available for use as the broadcast loop, commercial announcements may be read at the main studio and cues for the sportscaster can be fed back down the line. When this is the case, one microphone input is all that is needed. But when a one-way line is used, and this method of feeding cues is not feasible, the sportscaster can allow a prearranged time for the announcer at the studio to read the announcements or be assisted at the field by an announcer. In the latter event, two microphones are highly desirable, and for that reason two inputs were provided. Controls were incorporated for both inputs to accommodate announcers with widely divergent voice strength. The output level control is not absolutely necessary but it increases the flexibility of the unit sufficiently to warrant its use.

Instead of an output meter, a meter showing the degree of compression is much more helpful in setting up the gear. To reduce the setup time for each broadcast, all controls were recessed and the line terminals and power plug were installed on the front. The pilot light is so placed that—by simply slipping out the jewel—it provides light to see the control settings and to read by in poorly lighted locations. The meter is recessed ⅜" behind the panel for protection during transportation because no cover is used. And, of course, the power supply was built into the same case.

Almost any good quality amplifier circuit could be used incorporating this type of compression; a simple straightforward circuit was selected. The main design consideration was to provide 60 volts peak-to-peak of undistorted audio at the input of the compressor, with an average audio level at the microphone. This corresponds to 20 db of compression. It is desirable to have an output of about + 15 dbm (1-mw., 600-ohm reference) available from the amplifier.



Rear view of unit with back cover plate removed to show dual chassis.

The finished equipment, shown schematically in Fig. 2, has been in use for several months, and has fulfilled all expectations. Through the use of this unit, it has been possible for an unassisted sportscaster to put out a better regulated remote than an engineer-sportscaster combination with the usual remote amplifier. After connecting the telephone line and power cable and plugging in the microphone, the man setting up the equipment at the remote location adjusts the microphone input gain control so that the compression meter needle swings to about 2 db of compression (100 μa.) when he talks into the microphone in his normal voice. He then adjusts the output control to provide the level desired at the control room. Thereafter, he can concentrate entirely on the event to be broadcast. It has been found that the 18-db additional compression is ample for most announcers even in their most excited deliveries.

As mentioned previously, any amplifier that meets a few simple requirements can have this compressor built

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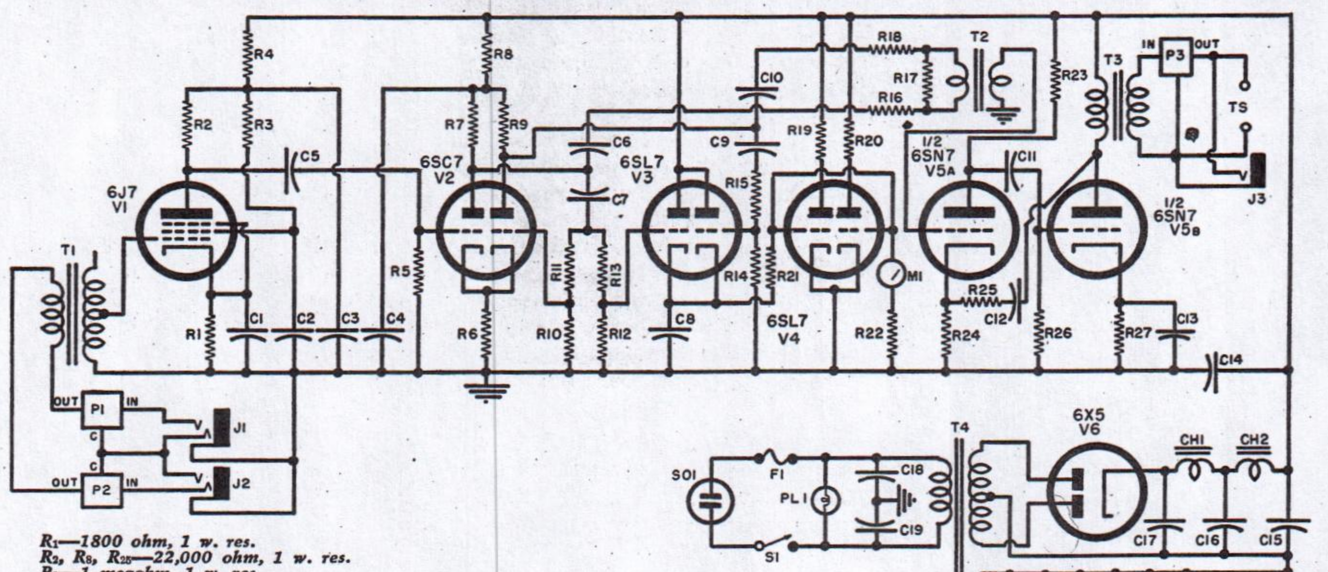
Fig. 2. Circuit diagram and parts list for the complete remote broadcast amplifier.



R_1—1800 ohm, 1 w. res.
R_2, R_8, R_{25}—22,000 ohm, 1 w. res.
R_3—1 megohm, 1 w. res.
R_4—47,000 ohm, 1 w. res.
R_5, R_{11}, R_{12}, R_{13}, R_{14}, R_{15}, R_{16}, R_{18}, R_{19}, R_{20}, R_{26}—470,000 ohm, 1 w. res.
R_6—1000 ohm, ½ w. res.
R_7, R_9, R_{23}—100,000 ohm, 1 w. res.
R_{10}, R_{22}—15,000 ohm, ½ w. res.
R_{17}—33,000 ohm, ½ w. res.
R_{21}—10,000 ohm, 1 w. res.
R_{24}, R_{27}—470 ohm, 1 w. res.
P_1, P_2—50 ohm low-level variable T pad
P_3—500 ohm variable T pad
C_1—50 μfd., 25 v. elec. cap.
C_2—.5 μfd., 600 v. cap.
C_3, C_{16}—16 μfd., 450 v. elec. cap.
C_4, C_{14}, C_{17}—8μfd., 450 v. elec. cap.
C_5, C_6, C_7, C_9, C_{10}, C_{11}—.05 μfd., 600 v. cap.
C_8—20 μfd., 50 v. elec. cap.
C_{12}—.04 μfd., 600 v. cap.
C_{13}—50 μfd., 50 v. elec. cap.
C_{15}—20 μfd., 450 v. elec. cap.
C_{18}, C_{19}—.005 μfd., 600 v. cap.
J_1, J_2—3-way microphone jack
J_3—Phone jack
SO_1—A.c. socket
T_1—Input trans., 100 ohms to grid
T_2—Interstage trans., 20,000 ohms plate-to-plate to grid
T_3—Output trans., 10,000 ohms to 500 ohms
T_4—Power trans., 575 v. c.t. @ 40 ma., 6.3 v. @ 3.0 amp.
M_1—0-200 μamp. 3" meter
CH_1, CH_2—30 hy., 40 ma. choke
S_1—S.p.s.t. toggle switch
F_1—2 amp., 3 AG fuse
PL_1—S-6 117 v. pilot light
TS—Output terminal strip

Personals

ROBERT C. CHEEK, formerly assistant division sales manager of the Electronics Division of *Westinghouse Electric Corporation,* has been promoted to the newly created post of assistant manager of engineering. After joining *Westinghouse* in 1939, Mr. Cheek acted as a consultant on power system problems, and later, as a specialist on carrier and microwave applications. In 1949, he was named "outstanding young electrical engineer" by the ETA KAPPA NU.

THORNTON W. CHEW, for the past four years vice-president in charge of engineering for Stations KFMB and KFMB-TV in San Diego, has now joined the *John Poole Broadcasting Company,* Hollywood, Calif., as director of engineering and operations. He will supervise the construction and operation of Station KBIC-TV, Sacramento, and Station KPIK-TV, Los Angeles, as well as a third yet unnamed television station to be built in Fresno, California.

G. MILTON EHLERS brings to his appointment as chief research engineer of *Aerovox Corporation,* New Bedford, Mass., over a quarter of a century of experience in the field of electronic components. Holder of various patents for both components and processes, Mr. Ehlers has served in such positions as: director of research, *Globar Corporation;* chief ceramic engineer, *Centralab Division* of *Globe-Union, Inc.;* and—most recently—president, *Herlec Corporation.*

ELBERT W. MARLOWE, who has been with *Union Switch & Signal*—division of *Westinghouse Air Brake Co.,* Swissvale, Pa., since 1945, has been appointed section engineer, Air Traffic Control and Navigation. He served as supervising engineer, Research Section, during the past year. In World War II, Mr. Marlowe worked as an electronic engineer for both the Naval Ordnance Laboratory in Washington, D. C., and the University of California at Los Alamos.

FRANK J. POWERS has been named head of the Industrial Engineering Department of *CBS-Columbia Inc.,* Long Island City, N. Y., TV/radio receiver manufacturing subsidiary of the *Columbia Broadcasting System.* Mr. Powers held a similar post at the *Burndy Engineering Company,* and also has held managerial posts with *Federal Radio & Telephone Corporation* and the *Sperry Gyroscope Company.* He is a graduate of Union College in electrical engineering.

JOHN A. RANKIN, the director of engineering of *The Magnavox Company,* Fort Wayne, Ind., since 1951, has now been elected vice-president as well. He is in charge of development, design and engineering for the production of all civilian and military equipment. Prior to joining *Magnavox,* Mr. Rankin served as an executive engineer in the radio and electronic industries; he held prominent positions with *Belmont Radio Corporation* and *RCA Industries Labs.*

New Tubes

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tors and dealers held in Chicago's Opera House in July, Mr. C. F. Adams, Jr., president of *Raytheon Manufacturing Company,* described a television "memory tube" that can store a complete television program for two months or more.

The high frequency system by which TV pictures can be shot across the Atlantic Ocean permits the reception of only a small portion of the total image at a time; hence the information is put into the "memory tube" at a relatively slow rate. However, when the tube has been given a complete picture, it can be played back over regular TV stations within a few seconds.

TV PICTURE TUBES

Two cathode-ray tubes for television —Type 24CP4 and Type 24CP4A, its aluminized counterpart — have been placed in production by *The Rauland Corporation.* Both are rectangular, glass, magnetic focus and magnetic deflection, direct-view picture tubes featuring an electron gun which is used with an external single-field ion trap magnet and an external conductive coating that acts as a filter capacitor when grounded. For more information, write *The Rauland Corporation,* 4245 North Knox Avenue, Chicago, Ill.

Broadcast Amplifier

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into it; but, obviously, the best results will be obtained if the complete remote gear is designed as a unit. For those who would like to duplicate the one pictured, or design a similar type of unit, here are some factors to be considered.

The first two stages (6J7 and 6SC7) should be able to amplify the full microphone input—with a normal level of speech—to 60 volts peak-to-peak at the plates of the 6SC7 without distortion and with good linearity. As this is the maximum signal level that can be applied to the compression circuit without introducing distortion, it isn't necessary to have much surplus of distortionless gain in these stages. With the parts values shown, an average of 8-db attenuation is required between the microphone and the input transformer; this allows plenty of latitude for use by various announcers, and has proved more than ample at Station KWEI. The third stage is a push-pull high-impedance cathode follower rectifier with series-limiting resistors in the grids.

In this third stage, the capacitor from the cathode of the first 6SL7GT to ground determines the compression time and, to a certain extent, the release time. Because the voltage from the cathode is applied to the two grids of the compressor tube (second 6SL7GT) in parallel, it does not have to perform any outstanding filtering job. A value of from 10 μfd. to 20 μfd. will provide reasonably fast compression and recovery. Higher values will produce a correspondingly slower action. The determining factor in choosing this capacitor is to make it as small as possible without making the compression action so fast that it becomes noticeable to the listeners. The value shown is about the optimum for speech. This type of compressor works on the principle of introducing a loss into the circuit which increases as the input increases after a given audio level is reached. In theory, the minimum loss for the service desired is 20 db and the maximum loss is about 40 db. In practice, because of the type of rectification employed, another 5 db should be added to these figures. Maximum output from the transformer T_2 will then be 60 volts minus 45 db, or a little less than .5 volts, times the gain of the transformer. Nominal output impedance is 20,000 ohms. Two triodes in cascade can bring this level up to about + 15 dbm using negative feedback.

Because of the low plate current drain of the tubes used, a power supply with resistor-capacitor filtering would no doubt work; but to be sure no ripple will be introduced from the power supply, it incorporates two chokes, with capacitor input. To simplify construction, the ground lead was a bus bar running the length of the amplifier chassis, grounded to the chassis only at the tie point nearest the input transformer. Hum and noise is

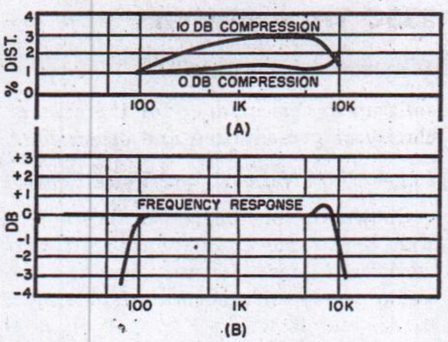

Fig. 2. (A) Distortion at 0 and 10 db compression. (B) Frequency response.

more than 60 db below the maximum signal level.

It will be noted in Fig. 1 that there are no variables other than the attenuators, which are adjusted from the front panel. All tubes were replaced individually by tubes of different manufacturers with no noticeable change in results. That there is no variable resistor in the cathode circuit of V_3 may surprise some who are familiar with the NRCS-type compressor. A potentiometer is generally used here to set the zero compression level, which is controlled in this circuit by the resistor between the plates of V_4. If R is determined by formula, it is done as follows:

$$R = \frac{.707\,(R_{12} + R_{13})}{20}$$

Then, if R_{12} and R_{13} are 470,000 ohms each, the value of R will be 33,229 ohms. This value will provide an almost flat output over the entire compression range. As the other resistors have only a 20% tolerance, a 33,000-ohm resistor was used for R. R is the dominant control over the circuit loss until the plate voltage of V_4 drops, as a result of compressor action, below 10% of the d.c. plate supply voltage. Resistor R_c in the cathode of V_3 determines the rate of compression.

Not only has this remote equipment been used for sportscasts, but also for dance orchestra remotes with equal success, allowing the announcer to emcee the show without riding gain. The distance the announcer is from the microphone and the loudness of his speech control the amount of compression and permit his voice to reduce the over-all gain of the amplifier (though the output is the same), effecting the same result as would be obtained by fading the music into the background. When the announcer stops talking, the amplifier gain returns to maximum and the music rises to the fore. Though Station KWEI has three commercial standard remote amplifiers, the one built by the engineering staff is used whenever it is available, in preference to the others.

CALENDAR
of Coming Events

OCTOBER 26-28—IRE-RTMA Radio Fall Meeting, Toronto, Ontario.

NOVEMBER 9-12—Conference on Radio Meteorology, University of Texas, Austin, Texas.

NOVEMBER 13-14—Annual Electronics Conference, Kansas City Section, IRE, Hotel President, Kansas City, Mo.

NOVEMBER 18-20 — Joint IRE-AIEE Sixth Annual Conference on Electronic Instrumentation in Medicine and Nucleonics, New York, N. Y.

DECEMBER 8-10—AIEE-IRE-ACM Joint Computer Conference and Exhibition, Statler Hotel, Washington, D. C.

FEBRUARY 4-6, 1954 — Sixth Southwestern Conference and Electronics Show, Tulsa, Okla.

MARCH 22-25, 1954—Radio Engineering Show and IRE National Convention, Kingsbridge Armory and Waldorf-Astoria Hotel, New York, N. Y.