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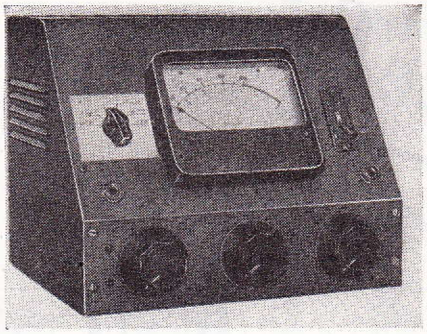
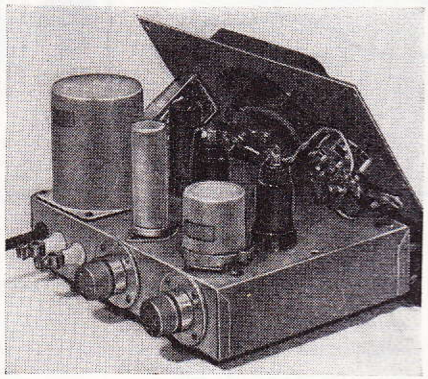


Remote Amplifier For Broadcasters

By RICHARD G. FINKBEINER

A useful addition for any broadcast studio, this unit will take care of almost all remote broadcasting work

The compact, lightweight amplifier shown above is built to the highest broadcast standards. At right is a rear view of the unit with its cover removed to show the layout of parts.



WHEN the number of remote broadcasts at WHRV in Ann Arbor, Michigan, began to increase rapidly, with some on the same day from points as far as 30 miles apart, an additional remote amplifier was needed.

A compact, lightweight, two-channel unit could meet the requirements of over 90% of all remote broadcasts handled. The bulkier four-channel amplifier was needed only for the few more elaborate pickups where three or four microphones were actually used.

Since practically all remote amplifiers on the market now meet FM broadcast standards, this amplifier should also meet these standards in full-range frequency response, low noise, and low distortion. Fig. 1 is a schematic of the amplifier.

The amplifier is basically a three-stage, resistance-coupled circuit. Mixing is accomplished in the low-level, low-impedance primary circuit of the input transformer with two attenuators. These constant-impedance T pads are designed for 30-ohm input and 30-ohm output impedances and have a 2-db attenuation per step. The resistors R1 and R2 maintain an effective 30-ohm impedance when two attenuators are used in parallel. The input transformer is a 30-ohm microphone-to-grid input broadcast quality unit.

Low noise input

A type 1620 low-noise pentode is used for the first stage of the amplifier to keep noise to a minimum. The 1620 tube is actually a 6J7 which has been hand-picked for low noise and microphonics, and, although it costs considerably more than a 6J7, its use is recommended.

A 250,000-ohm, wire-wound resistor is used as the plate load resistor of the 1620 to reduce noise further. A precision resistor is not necessary, but a small wire-wound resistor of the value required is available only as a precision unit.

Immediately following the master gain control is the second stage. These two stages have sufficient gain to permit even the lowest level broadcast microphone to be used.

Output impedance matching

A 6F6 pentode power amplifier is used in the output stage and is coupled to the telephone line through a 6F6 plate-to-600-ohm-line transformer and a 5-db isolation pad. For best results, a hand-picked 6F6, the 1621, may be used.

To understand the function of the isolation pad more fully, imagine that it is removed and the output transformer secondary is connected directly to the line. Under these conditions the proper plate load on the 6F6 is reflected only when the line impedance is 600 ohms. But the impedance of any given line may be far above or below this value, depending on its length and condition and the audio frequency being transmitted. This is where the pad comes in. Table I shows a few widely separated line impedances and the load which the amplifier sees with and without the 5-db isolation pad.

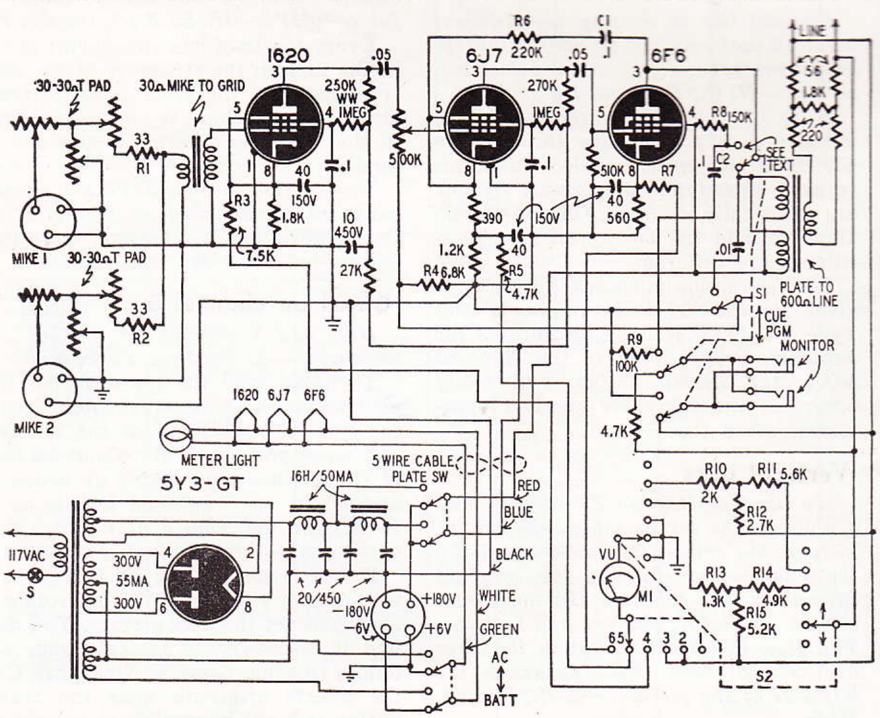


Fig. 1—The amplifier circuit. The power supply is built on a separate chassis.

the meter needle is avoided when using the CUE-PROGRAM switch.

A separate power supply

The power supply is built on a separate chassis so it may be placed away from the input transformer. It has change-over switches and batteries may be used if the power line fails. Two 90-volt B-batteries and one 6-volt "hot-shot" A-battery are required for the external battery pack. It is a worth-while standby unit for emergencies.

A two-section filter with two chokes and four capacitors is used to keep hum at the lowest possible level. The first filter section supplies the B-plus voltage for the power amplifier stage only. Both sections are used for the

TABLE II

VU Multiplier Pads			
VU Level	R10 (R13)	R11 (R14)	R12 (R15)
4	3,600-ohm series resistance		
6	450	4,000	17,000
8	900	4,500	8,200
10	1,300	4,900	5,200
12	1,700	5,300	3,700
14	2,000	5,600	2,700

voltage amplifier stages for maximum decoupling and freedom from motor-boating. In addition, the pre-amplifier stage has an additional R-C decoupling network.

The five-conductor cable which connects the power supply to the amplifier is wired in directly. This saves four connectors and makes the set-up operation quicker.

To avoid the usual difficulties with extension cords and their unreliable connections, a 25-foot line cord is wired to the power supply. One good line cord saves a great deal of troubleshooting when the a.c. doesn't seem to be getting to the supply. It also saves carrying extra extension cords.

Construction details

An old aluminum-base transcription disc is used to make the 5x8x1½-inch power supply chassis. The 7x9x2-inch aluminum chassis used for the amplifier fits into an 8x10x8-inch cabinet. It is necessary to space the panel ½ inch from the chassis to provide clearance between the back of the line switch and the output transformer. This allows the microphone connectors to extend far enough beyond the back of the cabinet so that the lock releases may be reached easily. The chassis must also be spaced up ½ inch by screws in the bottom flange to center the microphone connectors in the back opening provided in the cabinet.

Notches are cut in the control knobs and marked with white paint. The notches allow the position of the knob to be determined by touch. White cardboard stock is used for the meter range switch, and lettering is done with India ink.

Amplifier performance

Frequency response, noise, and distortion measurements were made with the aid of a General Radio noise and distortion meter.

The first frequency response curve was made without inverse feedback so the amount of correction necessary could be determined. Adding a feedback network, consisting of R6 and C1, gave the second family of curves shown in Fig. 2. The final curve is flat within 1 db from 20 to 15,000 cycles.

Feedback also gave a substantial reduction in the total harmonic distortion of the amplifier. For example, at an output of 10 VU the distortion at 1,000 cycles was 1.3% without feedback, and dropped to 0.3% when feedback was added. A graph of distortion *versus* frequency is shown in Fig. 3.

In making the noise measurements, the fact that most of the noise is contributed by the first stage had to be taken into account. With the master gain control half on, an over-all noise level of 55 db below 10-VU output was measured with a 6J7 in the first stage and of 70 db below 10 VU with a 1620 tube. Running the master gain as low as possible keeps noise at a minimum in this as in any other remote amplifier.

This amplifier is very stable if a few lead dress precautions are followed. To prevent coupling between the grid lead of the second-stage 6J7 and the meter terminals, dress the lead as close to the tube as possible and away from the front panel. Also, keep the 1620 grid lead away from the meter range switch. In some cases a small shield may be needed between these tubes and the meter and its range switch. No deflection should be noted on the VU meter with the master gain wide open and the amplifier in its case.

Materials for Amplifier

Resistors: 3—33, 2—56, 2—220, 1—390, 1—560, 1—1,200, 1—1,300, 2—1,800— 1—2,000, 1—2,700, 2—4,700, 1—4,900 (handpicked 4,700, 10%), 1—5,200 (handpicked 5,100, 10%), 1—5,600, 1—6,800, 1—7,500, 1—27,000, 1—100,000, 1—150,000, 1—220,000, 1—270,000, 1—510,000 ohms, 2—1 megohm, ½ watt; 1—250,000 ohm wire-wound; 1—500,000-ohm potentiometer; 1—30/30-ohm T pad, 2 db per step.
Capacitors: 1—.01, 2—.05, 4—0.1 μf, 600 volts, paper; 1—10 μf, 450 volts; electrolytic; 1—40x40x40 μf, 150 volts, electrolytic.
Transformers: 1—30 ohms to input grid; 1—6F6 plate to 600-ohm line.
Miscellaneous. VU meter, jacks, switches, microphone connectors, chassis, tubes, sockets, hookup wire, and shielded wire.

Materials for Power Supply

Capacitors: 1—20x20x20x20 μf, 450 volts, electrolytic;
Transformers and chokes: 1—power, 300-0-300 volts, 55 ma; 2—16-henry, 50-ma chokes.
Miscellaneous: Chassis, tubes switches, plug.

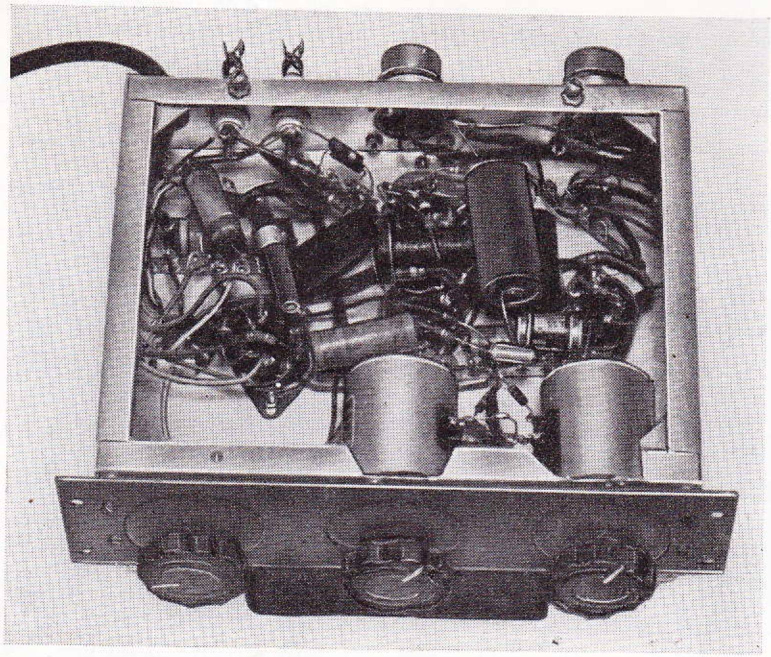
SLIDE-RULE CALCULATION

A slide rule method for solving $Z = \sqrt{A^2 + B^2}$ was described on page 69 in the July issue. This equation is very common in radio work, and its solution aroused much interest. Mr. R. F. Sturrock of Edmonton, Canada sends a method which simplifies the work to some extent. His system is as follows.

Take the equation $Z = \sqrt{18^2 + 28^2}$. Place left index at 18 on D and slide cursor to 28 on D. Note 2.42 which appears on B. Mentally add unity, obtaining 3.42, and move cursor to this number. The answer is read on D, 33.3 The proof is similar to that given in July. Mr. Sturrock notes also that the power factor may be read off on C1 when the final answer appears.

Other contributors note that another method may be used if a Log Log Duplex Decitrig rule is available. In this case set index to the larger number and push hairline to smaller one. Read angle on T under hairline. Draw same angle on S under hairline and read answer on D at index.

We are indebted to Howard T. Hoffman of St. Louis and to John T. Frye of Logansport, Indiana, for the latter method.



A look under the chassis. All of the low-level wiring is carefully shielded.

The table indicates that with a line impedance variation of 20 to 1, the amplifier works into a load variation of only 2 to 1. In practice, no line would vary over these limits, but the example shows the effectiveness of the isolation pad.

The secondary circuit must not be grounded in any manner because this upsets the balance of the telephone line, and increases the line noise.

TABLE I

Line Impedance (ohms)	Load (ohms) (Without Pad)	Load (ohms) (With Pad)
50	50	550
100	100	600
250	250	700
600	600	900
1,000	1,000	1,100

Inverse feedback is a must in any amplifier which works into a telephone line. The feedback circuit works along with the isolation pad to allow greater freedom in match between the amplifier output and the line. It also flattens the frequency response curve and reduces noise and distortion originating in the amplifier. With the circuit constants shown, there is a 16-db feedback signal at 1,000 cycles from the plate of the output tube to the cathode of the second stage 6J7.

To keep the hum level down, shielded wire is used for the heater and VU meter lamp wiring. Twisting would probably be satisfactory, but shielding is preferred. Double-ended tubes, like the 6J7, keep hum at a minimum by placing the grid circuit wiring above the chassis away from the heater terminals and wiring. All the usual hum-reducing precautions should be observed when building this amplifier.

All the low level wiring from the microphone connectors to the primary of the input transformer is shielded to prevent crosstalk and hum. The leads which run from the output terminals to the VU meter range switch should be shielded. All the wiring should be neat and kept as short as possible for best results.

Cue amplifier

An integral cue amplifier is included in this amplifier to simplify the pre-broadcast line-up by allowing two-way conversations between the studio and remote location at the simple flip of a switch. At WHRV there is at least 6 miles of telephone line between the station and any remote pickup point because the station is that distance from Ann Arbor and the line must go through the Ann Arbor telephone exchange. As a result the cue signal level is too low to be picked up with headphones across the line.

With the line switch S1 in CUE position, the output transformer becomes an input transformer, and the signal on the line is fed to the secondary winding. The induced voltage in the primary is fed in series with the lower end of the master gain control, which is connected to the grid of the second stage 6J7. From the plate of the 6J7 the signal is passed on to the 6F6, which is now a resistance-coupled amplifier, and then to the monitor jacks. The position of the master gain control has no effect on amplification.

Switching back to the PROGRAM position grounds the lower end of the master gain control, the 6F6 stage becomes a transformer-coupled amplifier, and the headphone monitor jacks are reconnected across the line output.

A minor modification must be made on the line switch S1 to prevent damage to the 6F6 when the switch is in the center or OFF position. The contact which connects to R8 must be bent so that the plate voltage is not removed from the 6F6, because this would cause excessive screen dissipation and damage to the tube. Making this change simply puts the B-plus voltage on the plate through R8 when S1 is in the OFF position.

Resistor R9 is added to allow C2, the blocking capacitor in the plate circuit of the 6F6, to charge before the headphones are connected to the plate by S1 in the CUE position. This prevents the ear-shattering click that would result if C2 were allowed to charge through the headphones. Also, loud clicks will be prevented if the line switch is changed slowly from CUE to PROGRAM position.

If more cue signal amplification is desired, the value of R4 may be increased to about 100,000 ohms maximum. If less amplification is necessary, a resistance in series with C2 should suffice.

The VU meter

The volume indicator is a standard broadcasting unit and is calibrated with the reference level of 0VU representing 1 milliwatt in 600 ohms. The VU and the db based on 1 milliwatt are identical and may be used interchangeably.

In this amplifier the meter is used with multiplier pads which give ranges of 10 and 14 VU. The former represents the level used to feed a program on an enclosed toll cable. Allowance is made for a 2-db insertion loss when an external repeating coil is used, bringing the actual line level down to 8 VU, the value recommended by A.T.&T. A 14-VU multiplier is included for feed over an open line. It allows for an insertion loss up to 6 db if an equalizer is used.

Any number of multiplier pads may be chosen from Table II to make up the VU range switch. The resistors may be mounted directly on the switch if room permits.

To facilitate maintenance and to spot tube failures with minimum lost air time, a tube check circuit is included. Since the VU meter has a full-wave rectifier, it may be used in d.c. circuits without regard to polarity. Resistors R3, R5, and R7 are chosen to give a 0-db indication when normal plate current flows through the 1620, 6J7, and 6F6, respectively.

An OFF position should be included in the range switch so that slamming

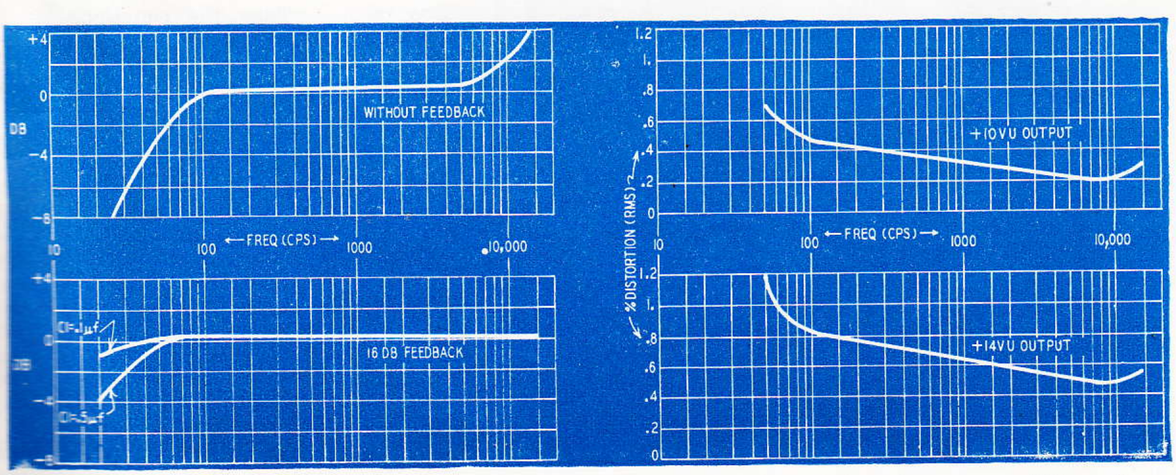


Fig. 2, left—The frequency response curves of the amplifier. Fig. 3, right—Distortion curves of the unit.