The Interview Amplifier

C. G. McPROUD

Design and construction of a small amplifier intended for use with a standard tape recorder for one specific use—interviews.

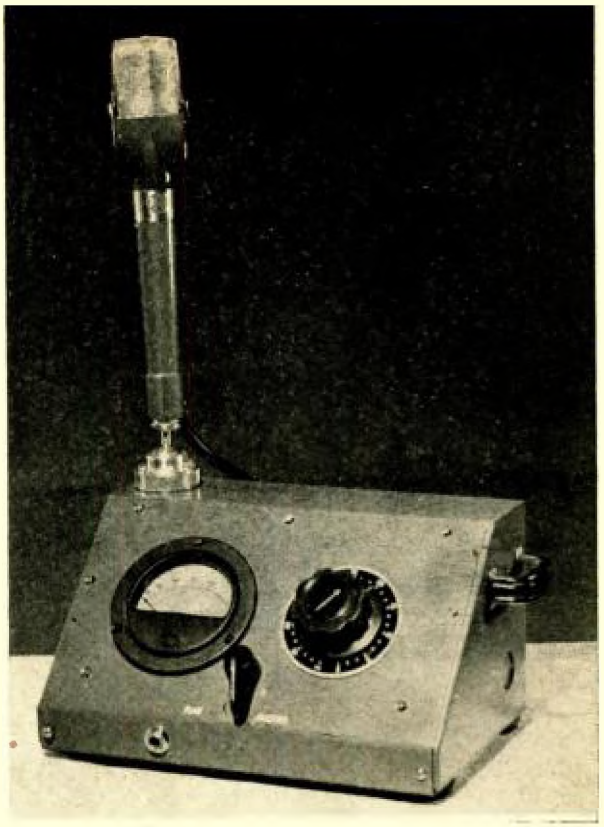

Fig. 1. External view of the amplifier unit with attached microphone on ball-and-socket swivel head.

SOME MONTHS AGO it became necessary to instruct a non-technical writer and radio commentator in the intricacies of operating a standard tape recorder. It was planned to use this recorder to interview agricultural authorities throughout the country on subjects of interest to the farmer for later broadcasting. This individual happens to be the publisher of Æ—one Ladd Haystead, who in his more lucrative moments serves as counselor to the Committee on Agriculture of the American Petroleum Institute, in addition to handling public relations work for a number of other important clients.

Mr. Haystead—an outstanding authority on agriculture—is a complete stranger to electronic devices. His preoccupation with the mechanics of maintaining a satisfactory recording level, operating the necessary controls and push switches, and watching the VU meter, detracted from his role as interviewer to the extent that he was almost unable to "draw out" his speaker, usually a man not familiar with the microphone. Since the equipment was to be used for only one purpose, it seemed desirable to arrange a unit which served essentially as an enlarged microphone stand, yet incorporated the amplifier, the VU meter, a gain control, and as few other controls as possible.

The equipment to be described fulfills these requirements satisfactorily. Including the recorder mechanism, it is still too large for convenience, but it is capable of producing high-quality tapes which are dubbed to disc masters, pressed, and heard over some 325 stations. In addition to providing an easily-controlled amplifier unit, the device is so arranged that it is relatively impossible to make any mistakes in interconnecting the three separate units.

Units of System

The basic equipment consists of a standard tape recorder, without any modifications. This unit—a Magnecord PT6-AH—is in wide use throughout the country, and in case of failure of any kind, it was thought that the nearest broadcast station could serve as a repair center. To date the only trouble encountered is the loosening of the function switch knob—which was duly tightened at a Santa Fe, New Mexico, station. The amplifier consists of three stages, the VU meter, and switching to permit recording or playback. A Magnecord equalizer is used for recording, and the playback equalization is incorporated in the first stage of the amplifier in a manner almost identical to the amplifier normally used with the Magnecorder. Since the recorder is used only at the 7½-in. speed, the equalizer is "permanently" mounted in the amplifier case. The function switch arranges the circuits for the desired operation; for recording, the microphone is connected to the input transformer, the output is fed through the equalizer to the tape head, the VU meter is connected across a part of the output winding, and the speaker is disconnected. For playback, the VU meter is disconnected, the head is connected to the input transformer, the frequency response is modified to provide the necessary bass boost, and the speaker is turned on.

Physically, the amplifier is mounted in a cabinet 9 in. wide, 6 in. deep, and 5 in. high, furnished as a standard unit by The Langevin Co. The RCA ribbon microphone, type KB-2C, is mounted on a ball-and-socket joint originally intended as a swivel head for a camera tripod, but modified somewhat for this purpose. When in use, the microphone is raised to an upright position; for carrying, it is folded down against the case and held secure by the drawstring of a small velvet bag being tied to the case handle. The carrying case for the amplifier contains the power supply,

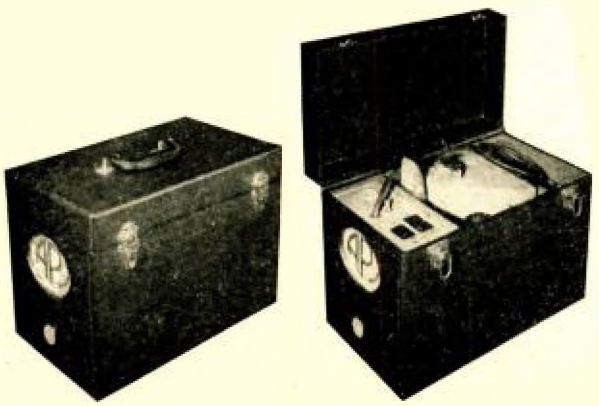

Fig. 2. The carrying case provides space for power supply, amplifier, tape reels, monitor phone, etc.

space for the amplifier unit, and a compartment for several reels of tape, the monitor headphones, and a stop watch. *Figure* 1 shows the amplifier unit in operating position, and *Fig.* 2 shows two views of the carrying case. The speaker is built into the power supply box, and the grille in the end of the case protects the cone from damage. The cabling consists of a short lead from the microphone to the amplifier, a lead from the amplifier to the recorder, and power cables from both recorder and amplifier. Power is furnished from 115-volt a.c. lines.

Electronic Requirements

In the record position, the amplifier was required to have adequate gain to work from the microphone. Since the recording head is specified as having an impedance of 60 ohms, it was most convenient to use the microphone strapped for 50 ohms output, and to use a 30 to 50-ohm winding on the input transformer. The output impedance designed to feed the Magnecord equalizer and the head is 500 ohms and the necessary recording equalization is most readily obtained from a standard equalizer, which can be changed from one speed to another without too much trouble in case such a change becomes necessary. It is not expected that such a change will be made in the field, and neither the extra equalizer nor the 15-in.-per-sec. capstan and idler roller is carried with the equipment.

For playback, the input impedance remains at 50 ohms, a satisfactory match for the 60-ohm head. The gain needed for playback is of the same order of magnitude as that for recording, but the low end must be boosted appreciably. This boost is about 20 db from 1000 cps to 100, following the 6 db/octave slope. The speaker used has a voice-coil impedance of 3.2 ohms, and it is fed from a 2-ohm tap on the output secondary.

Since there is no need for using the amplifier as a public-address system, the function switch has only two positions—record and playback. In either position, all circuit switching is accomplished with one operation. No provision is made to indicate on the amplifier panel as to whether or not the recorder is turning, since it is normally used in the same room with the amplifier—usually within six or eight feet of the amplifier. The standard VU meter is connected across a portion of the output secondary to give the correct indication without the use of any multiplier.

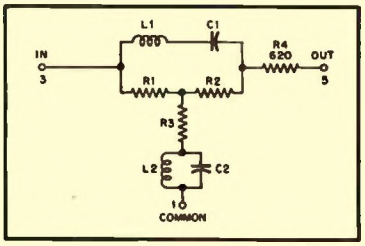

Fig. 4. Schematic of high-frequency equalizer used for recording. Low-frequency equalization, provided in amplifier, is used for playback.

The power supply provides the necessary plate and filament voltages for the amplifier as well as for the bias oscillator in the recorder case. The function switch feeds voltage to the bias oscillator only in the record position. Separate filter circuits in the power supply provide adequate isolation and improve regulation of the amplifier voltage in the two conditions of operation.

Amplifier Design

The amplifier is of straightforward design, being simplified from the basic Magnecord PT6-J amplifier unit. Less power is required than is provided by the original unit, so the output stage is a single 6V6. It is driven by a 6J7 with the gain control in its grid circuit, while the first stage is a low-noise pentode, the 5879. The over-all schematic of amplifier and power supply is shown in *Fig.* 3.

By measurements on the original amplifier provided by the manufacturers of the recorder, it was observed that when the VU meter indicated "zero" level, a 3.0-volt signal was supplied to the input terminals of the equalizer, with a response curve which was essentially flat to that point. The required equalization—of the high end only—is furnished by the fixed equalizer, having a constant-impedance configuration, as shown in *Fig.* 4. The equalizer consists of a series resonant circuit and a parallel resonant circuit combined with three resistors to fix the amount of equalization, which is of the order of 22 db. The equalizer is followed by the "constant-current" resistor of 620 ohms, and the entire unit is encased in a housing with a 6-pin plug in the base. To isolate the output tube from the equalizer, an 8-db pad was inserted between the transformer and the equalizer socket.

The output transformer used is provided with taps at impedances of 8, 15, and 500 ohms. Between the 8 and 15-ohm taps, the impedance is 2 ohms. To simplify the switching, the 8-ohm tap is grounded, and the VU meter is connected from the "0" tap to the 15-ohm tap, using the conventional 3900-ohm resistor between the transformer and the meter to preserve ballistic action.

Checking the calculations, it is seen that at zero on the meter, 3.0 volts should be applied to the input terminals of the equalizer. Having determined the necessary output connections to simplify the switching, a few calculations are in

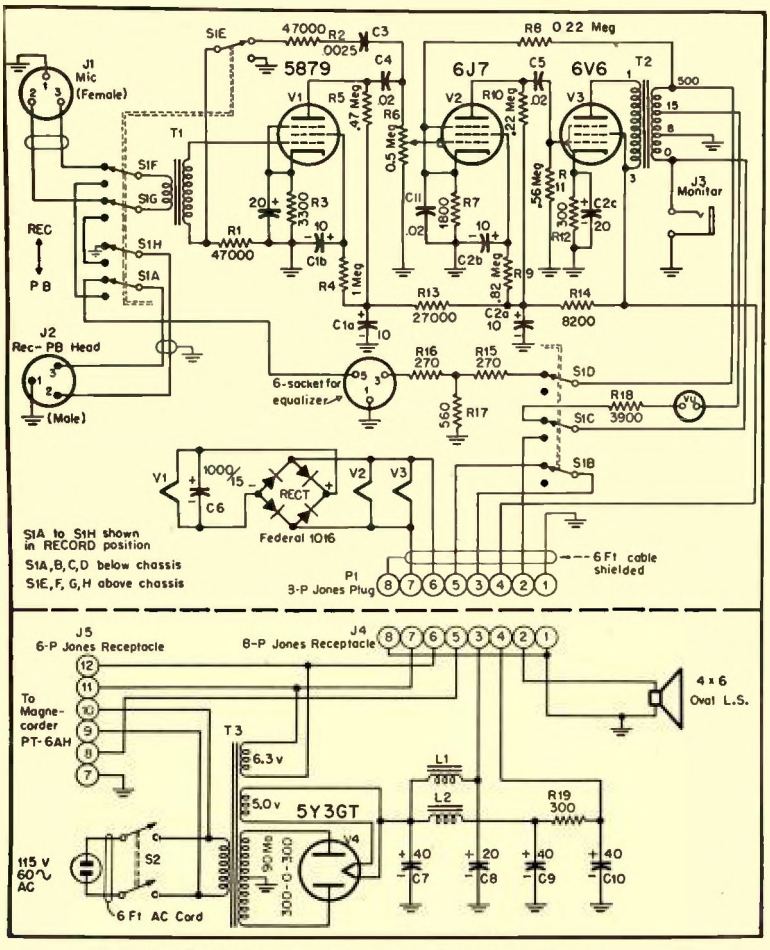

Fig. 3. Over-all schematic of amplifier and power supply.

order to complete the output circuit. The impedance between the 8- and 500-ohm taps is

$$Z_2 = (\sqrt{500} - \sqrt{8})^2$$
$$= (22.40 - 2.83)^2 = 19.57^2$$
$$= 382 \text{ ohms.}$$

When the standard VU meter indicates zero on the scale, the voltage applied to its terminals through a 3900-ohm resistor is 1.228 volts (using a steady tone). With this voltage appearing across the 15-ohm winding, the voltage across a 382-ohm winding is determined by the following means.

$$\frac{E_1}{E_2} = \frac{\sqrt{Z_1}}{\sqrt{Z_2}}$$

$$E_1 = \frac{E_2\sqrt{Z_1}}{\sqrt{Z_2}} = \frac{1.228\sqrt{382}}{\sqrt{15}}$$

$$= \frac{24.0}{3.88} = 6.2 \text{ volts.}$$

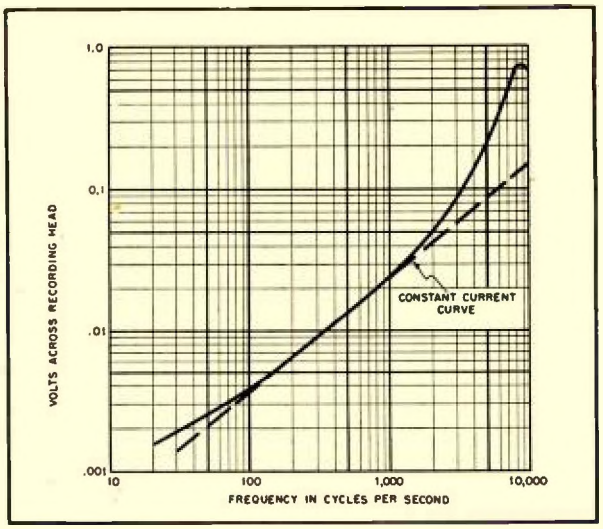

Fig. 6. Voltage across recording head for constant zero indication of VU meter.

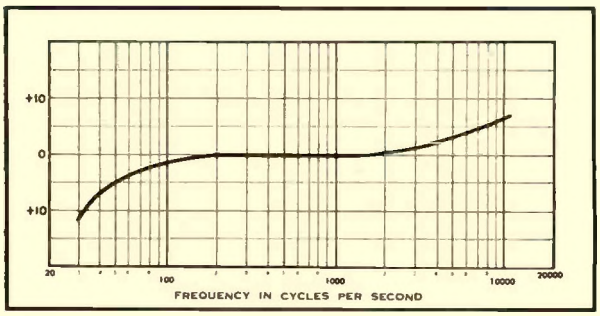

Fig. 5. Frequency response, input to tape output. This involves the amplifier for two operations.

The ratio between the required 3.0 volts and the indicated 6.2 volts is 2.064, which represents 6.3 db. There is, however, a mismatch between the 500-ohm pad provided between transformer and equalizer, and the voltage appearing across the 500-ohm load and the 382-ohm source is somewhat higher than that calculated, being some 7.4 db higher than the required 3.0 volts. The 8-db pad was assembled from standard preferred-value resistors to approximate the necessary loss and impedance. Final matching of VU meter indication and the signal voltage at the input of the equalizer may be done by small changes in the series VU-meter resistor. In this particular instance, however, the 3900-ohm resistor gave a zero indication with 3.05 volts at the equalizer.

The rated primary impedance is 5000 ohms—normal for the 6V6. With a 7-volt signal being required across the 382-ohm secondary, the signal across the primary is

$$E_p = \frac{7.0\sqrt{5000}}{\sqrt{382}}$$
$$= 25.3 \text{ volts.}$$

In calculating amplifier gains, it is usual to assume a gain of approximately 15 times for a pentode output stage. Thus the signal voltage required at the grid of the 6V6, for normal output, is 25.3/15, or 1.69 volts. To determine the needed gain for the first and second stages, it is first necessary to start with the available input signal. The average microphone has an output of the order of −52 db, according to the specifications, for a sound pressure of 10 bars. Normal speech is somewhere in the vicinity of 0.4 bars, however, which is 28 db below 10 bars. Thus the voltage output from a microphone is about 52 + 28, or −80 db, based on a reference of 1.73 volts across 500 ohms, presumably. Referred to 30 ohms, for the microphone to be used, the reference zero is

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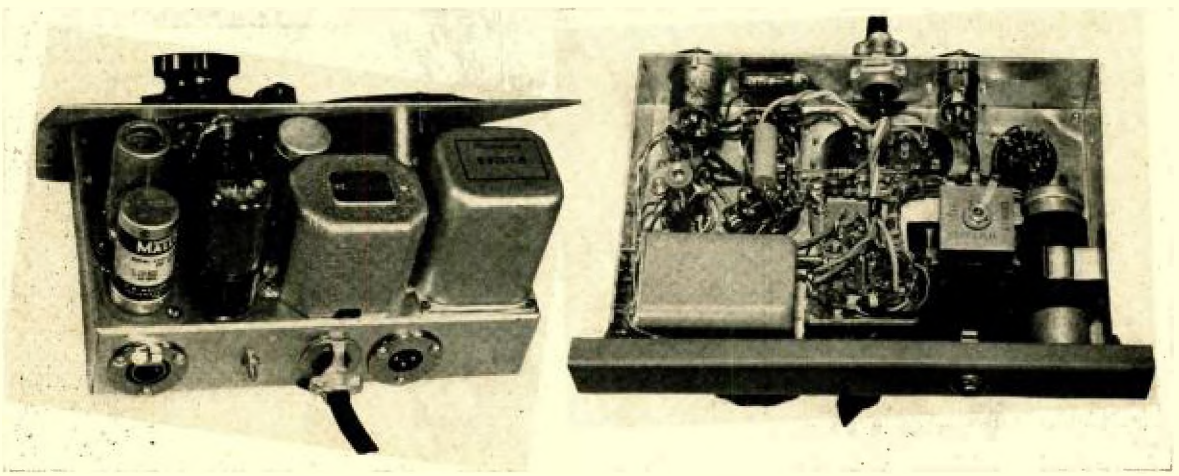

Fig. 8 (left). Top view of amplifier chassis, to show placement of major components. Fig. 9 (right). Under-chassis view of the amplifier.

$1.73\sqrt{30}/\sqrt{500}$, or 0.423 volts. Eighty db below this value is .0000423 volts, or 42 microvolts. The input transformer has a step-up ratio of 30/50,000 ohms, which gives a voltage gain of 40.8, the square root of the impedance ratio. Therefore, between the grid of the first tube and the grid of the output stage, it is necessary to have a voltage gain of 1.69/.00172, or approximately 1000. This is easily obtained by using two pentodes, one the low-noise 5879, and the other a 6J7. This will allow for more than enough gain for recording, and for the addition of some inverse feedback. The signal from a playback head is somewhat less than that from a microphone, and an additional 20 db of gain is required for the low-frequency equalization, so both pentodes are used in circuits which give stage gains of approximately 100, as observed from amplifier charts in the Tube Handbook.

The low-frequency equalization is provided by a feedback loop around the first stage, as used in the Magnecord amplifier. The circuit is simple, and lends itself to minor modification, as required, to obtain the desired playback characteristic. The network C_3, R_2, and R_1 gives the necessary low-frequency boost by reducing feedback to a minimum at low frequencies. When the reactance of C_3 equals the resistance $R_1 + R_2$, the curve is 3 db from "flat," and above this frequency the response is essentially flat. One section of the switch disconnects the feedback network R_2-C_3 from R_1, and grounds the lower end of the input transformer secondary, removing all feedback from the first stage.

In order to provide direct current for the heater of the first stage, a selenium rectifier and a filter capacitor are mounted in the amplifier. In the circuit shown, the voltage at the heater terminals of the 5879 is 6.0 when the a.c. heater voltage is 6.3. The use of d.c. on this heater reduces the hum below audible modulation on the tape.

It is noted that there are quite a number of sections to the function switch. Since the input and the output of the amplifier both have to appear on the switch, some precautions must be taken to avoid unwanted oscillation. The switch is composed of two decks, being shielded by the section of the chassis between them. In the record position, the microphone receptacle is connected to the input transformer by S_{1F} and S_{1G}; S_{1A} and S_{1H} connect the recording head to the output of the equalizer; S_{1D} connects the output transformer winding to the input of the isolation pad. The remaining two sections, S_{1C} and S_{1B}, connect the VU meter and apply B+ to the bias oscillator, respectively. In the playback position, the tape head is connected to the input transformer through switch sections S_{1H}, S_{1A}, S_{1F}, and S_{1G}—with the interconnections between the switch decks serving to provide isolation be-

tween input and output of the amplifier. S_{1B} connects the equalizing network around the first stage, and S_{1C} turns on the speaker. To reduce the number of wires in the interconnecting cable, the rectifier and filter for the d.c. filament supply to the 5879 are mounted in the amplifier case.

Interconnecting Cables

The cabling between the various units is arranged so that there is no possibility of making any incorrect connections. The microphone cable is just long enough to run from the microphone to the jack J_1, and since the microphone remains permanently mounted on the top of the case, there is little reason for disconnecting this lead at any time during normal operation. The power cable from the amplifier to the power supply is attached to the amplifier chassis, and is plugged into the power supply receptacle, using an 8-prong Jones plug. The power supply cable from the recorder terminates in a 6-prong plug which mates with a receptacle on the power supply case. The remaining lead from the recorder terminates in a Cannon plug, which connects into the amplifier chassis.

The power supply cable from the amplifier is a 7-wire shielded cable, with the shield connected only at the plug end. A separate lead is used for the common ground connection. The 6-wire lead from the recorder carries ground, B+, 6.3 volts for the bias oscillator filament, and 115 volts for the recorder motors.

A rubber-covered a.c. line furnishes the main power connection from any convenient 115-volt outlet.

Construction

While any convenient case can be used, the one employed is available as a standard model, and is readily adapted to this application. The front apron is

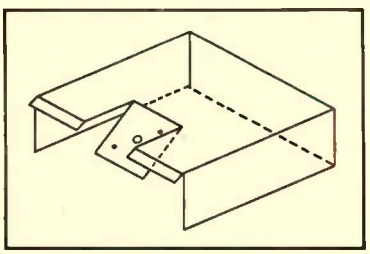

Fig. 7. Sketch of chassis arrangement to provide for shielding between two decks of record-playback switch.

cut down both sides and across the bottom so that a chassis can be slid into position. The front panel is made to overlap the bottom of the case, and the chassis is attached to the front panel permanently. The switch shield and mounting is made by cutting two saw slots and bending a portion of the top surface down, as shown in *Fig. 7*. This requires some nicety of calculation, because the spacing between the chassis and the front panel must be just right to mount the switch, using the spacers and tie bolts of the switch to hold it to

the bent-down portion of the chassis, and with the mounting bushing of the switch being just flush with the underside of the front panel. While this may sound difficult, it must be remembered that the spacers between the switch section and the chassis may be cut readily to make the switch fit properly.

The input transformer is mounted under the chassis on a bracket, making the connections reasonably near the switch for ease in wiring the playback equalizer components. The gain control is above the chassis, and permits a short lead direct to the grid of the 6J7, as shown in *Fig.* 8. The coupling capacitor C_4 is in the small space between the gain control and the front of the chassis.

The general underchassis arrangement may be seen in *Fig.* 9. The 5879 heater supply is under the VU meter, which requires some odd cut outs in the chassis to miss the terminals. In planning for the parts placement, the original drawings were made in three dimensions, with the case angles projected, so that everything clears—but not much. Most of the wiring is made directly from point to point, with resistors and capacitors connected to socket terminals where possible.

The capacitor C_8 is the one visible on the corner of the chassis in *Fig.* 8. R_{16}, R_{17}, and R_{18} are mounted on the three unused terminals of the 6-hole socket for the equalizer. The socket for the 5879 is a Vector. 1½ in. high, and mounts R_3, R_4, and R_5. This socket is riveted to a metal electrolytic capacitor mounting plate, and is flexibly mounted on the chassis by means of four grommets, using the Amphenol kit available for this type of mounting. When a socket is so mounted, flexible leads must be used to make connections to it—the so-called "antenna hank" is ideal for this purpose. R_1 is directly mounted on the input transformer terminal panel.

The microphone is mounted on the ball-and-socket camera tripod top by means of an adapter, since the microphone handle has a 5/8-27 thread and that of the swivel is 1/4-20. The lower part of this type of ball-and-socket unit is removed and discarded. Four holes are drilled in the ring for 3-48 screws, and the unit is then attached to the top of the case, with a coil spring under the ball. This spring is of the type used for spring mounting a record changer, and is about 5/8-in. in diameter. There is enough friction to hold the microphone in any position it is placed, yet it can be laid down against the case for carrying. A slot in the ring of the ball-and-socket head permits the microphone to be laid flat against the case in only one position; in all other directions, the microphone can only be lowered to about 30 deg. from horizontal.

The power supply is enclosed in the 3½ × 6 × 8 "Minibox," most parts being mounted on a shelf attached to the case. The 4 × 6-in. oval speaker is in this case, and protected by ¼-in. hardware cloth, as shown in *Fig.* 10. To conserve space, the half-shell of the transformer extends outside the case. Two ventilating plugs are installed on the bottom of this

case, and one on the top over the rectifier tube. To permit free flow of air, another is installed in the carrying case directly below the speaker grille. The carrying case was made to order, and the power supply is simply dropped into the compartment provided—making a fairly tight fit. Since it was decided that it might be possible to damage the recorded tape if it were too close to the power transformer and chokes, the compartment for the amplifier is at the center of the case, with the tape being

Fig. 10. External view of power supply case.

spaced away from the power supply by the amplifier. Since this arrangement places the two heavier sections at the center and the end, it is advisable to order the case without a carrying handle. After determining the center of gravity, the handle can then be mounted. The case may not appear symmetrical, but it does carry easier.

Performance

The unit as constructed has already been across the country four times, and has made quite a number of recordings by this time. There is sufficient gain for all microphone work within the requirements of interview service—the gain control normally being used at about 20 on the dial plate, which is a standard attenuator scale used to give this unit a professional appearance. Actually, the calibrations of this scale approximate the attenuation of the volume control, in db. Adequate gain is also provided for playback, and the response is essentially flat from 100 to 7500 cps. *Figure* 5 shows the response from microphone input to tape output—with a rise at the high-frequency end to provide crispness in the speech. The curve of *Fig.* 6 shows the actual voltage across the recording head for constant zero-level indication on the VU meter. This curve shows the effect of the equalizer in its deviation from the 6-db/octave curve which would result from a constant-current feed of the recording head.

The amplifier unit, with its power supply and carrying case, has proven its value for use by non-technical personnel, and therefore justifies this particular design. All flexibility has been eliminated to make the operation as straightforward as possible and to reduce the possibility of error. However,

since there are no modifications to the standard Magnecorder, it is obvious that this amplifier could be used for specific applications where its simplicity and compactness was desirable, yet the recorder can be brought back to the studio and used with the standard amplifier whenever necessary.

Parts List

C_1, C_2	10–10–20/450–450–25, electrolytic
C_3	.0025 μf, mica
C_4, C_5	.01 μf, 600 v. paper
C_6	1000 μf, 15 v. electrolytic, with insulating tube and mounting clip
C_7, C_9, C_{10}	40 μf, 450 v. electrolytic
C_8	20 μf, 450 v. electrolytic
C_{11}	.02 μf, 150 v. hearing aid type, paper
J_1	Cannon XL-3-13 receptacle
J_2	Cannon XL-3-14 receptacle
J_3	Single-circuit jack
J_4	Jones S-408-AB receptacle
J_5	Jones S-405-AB receptacle
L_1, L_2	Choke, 8 H. at 40 ma. Thordarson T-20C52
LS	4×6 in. loudspeaker, 3.2-ohm voice coil
M	VU meter, B scale, Simpson Model 45
P_1	Jones P-408-CCT cable plug
R_1, R_2	47,000 ohms, ½ watt
R_3	3300 ohms, ½ watt
R_4	1.0 meg, 1 watt
R_5	0.47 meg, 1 watt
R_6	1-meg volume control, audio taper
R_7	1800 ohms, ½ watt
R_8	0.22 meg, ½ watt
R_9	0.82 meg, 1 watt
R_{10}	0.22 meg, 1 watt
R_{11}	0.56 meg, ½ watt
R_{12}, R_{13}	300 ohms, 5 watt, Ohmite Brown Devil
R_{14}	27,000 ohms, 1 watt
R_{15}	8200 ohms, 2 watt
R_{16}, R_{18}	270 ohms, ½ watt
R_{17}	560 ohms, ½ watt
R_{19}	3900 ohms, 1 watt
RECT	Federal 1016 Selenium Rectifier
S_{1A-H}	8-pole, 2-pos. wafer switch, Centralab 1418
S_2	DPST toggle switch
T_1	30/50,000 input transformer, shielded, Triad HS-5
T_2	Output transformer, secondary impedances 500, 15, 8, 2 ohms, UTC S-14
T_3	Power transformer, 300–0–300 v. at 90 ma; 5 v. at 3 amps; 6.3 v. at 2.5 amps.
Case for amplifier	Langevin Remote Control Cabinet, Type 1-A
Case for power supply	Bud Minibox, CU-2109