Modulation Equipment

In many respects the arrangement of components is less critical in audio than in r.f. equipment; nevertheless, certain principles must be observed if difficulties are to be avoided. The selection of suitable modulation equipment for any of the transmitters in the preceding chapter is not difficult, if the fundamental principles of modulation as described in Chapter Five are understood. If the transmitter is to be plate-modulated and the power input to the modulated stage is to be of the order of 100 watts or higher, a Class-B modulator invariably will be selected. A pair of modulator tubes of any type capable of the required power output may be used. The tables in this chapter give the necessary information on the most popular tube types. The grid driving-power requirements also are given, so that from this point on the speech amplifier tube line-up can be selected according to the principles outlined in Chapter Five.

The apparatus to be described is representative of current design practice for speech amplification, with various output levels to drive high- and low-power Class-B modulators. In some cases the power output will be sufficient to modulate low-power transmitters directly, without additional power amplification. Also, practically any of the speech amplifiers shown can be used to grid-modulate transmitters up to the highest power input permitted in amateur transmitters.

Speech-amplifier equipment, especially voltage amplifiers, should be constructed on metal chassis, with all wiring kept below the chassis to take advantage of the shielding afforded. Exposed leads, particularly to the grids of low-level high-gain tubes, are likely to pick up hum from the electrostatic field which usually exists in the vicinity of house wiring. Even with the chassis, additional shielding of the input circuit of the first tube in a high-gain amplifier usually is necessary. In addition, such circuits should be separated as much as possible from power-supply transformers and chokes and also from audio transformers operating at fairly high power levels, to prevent magnetic coupling to the grid circuit which might cause hum or audio-frequency feed-back.

If a low-level microphone such as the crystal type is used, the microphone, its connecting cable, and the plug or connector by which it is attached to the speech amplifier, all should be shielded. The microphone and cable usually are constructed with suitable shielding. The cable shield should be connected to the speech amplifier chassis, and it is advisable — as well as frequently necessary — to connect the chassis to a ground such as a water pipe. Heater wiring should be kept as far as possible from grid leads, and either the center-tap or one side of the heater transformer secondary winding should be connected to the chassis. In a high-gain amplifier the first tube preferably should be of the type having the grid connection brought out to a top cap rather than to a base pin, since in the latter type the grid lead is exposed to the heater leads inside the tube and hence will pick up more hum. With the top-cap tubes, complete shielding of the grid lead and grid cap is a necessity.

The units described in this chapter have been designed to give the required power output as simply and economically as possible, while still observing good design principles.

A 10-Watt Class-B Modulator for Low-Power Transmitters

A receiving-tube modulator, with a speech amplifier for either crystal or carbon microphones, is shown in Figs. 1301–1303, inclusive. It is suitable for modulating transmitters of 20 watts input or less, such as the low-power equipment frequently used on the very-high frequencies. Type 6A6 tubes are used throughout in the audio circuits, and an inexpensive power supply is included so that the unit is complete and ready for connection to the transmitter.

Fig. 1302 shows the circuit diagram of the speech amplifier-modulator. One section of the first 6A6 is used as the input amplifier for a crystal microphone, the other half being a second speech-amplifier stage. Carbon microphones, which need less gain, are transformer-coupled to the

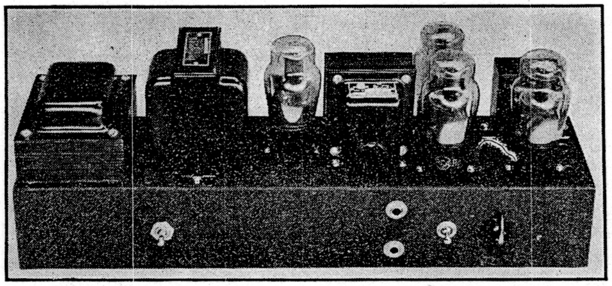

Fig. 1301 — A 10-watt audio unit complete with power supply. Three dual-triode 6A6 tubes provide a four-stage amplifier with Class-B output. Any of the popular types of microphones may be used.

second section of the first 6A6. The type of jack shown at J_2 in the circuit diagram must be installed if a double-button carbon microphone is to be used. J_2 may be the same as J_1 if a single-button microphone is to be used exclusively.

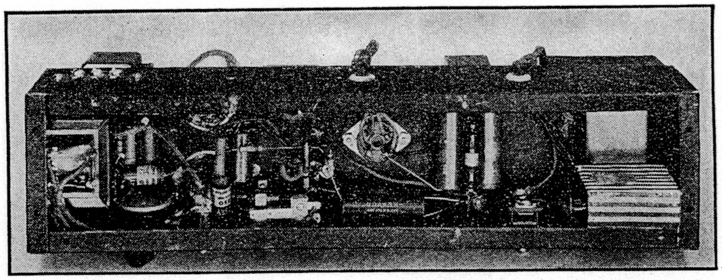

Fig. 1303 — **The below-chassis wiring is visible in this view of the 10-watt modulator. The microphone input leads are kept short to reduce hum pick-up.**

The gain control is connected in the grid circuit of the second section of the first 6A6 tube, which is resistance-coupled to the driver. The driver tube, also a 6A6, has its two sections connected in parallel.

The modulation transformer specified is designed to work between 6A6 plates and a 6500-ohm load; the impedance ratio actually used will, of course, depend on the load into which the modulator will work. A milliammeter can be connected across R_1 to measure the Class-B plate current.

The power supply is of the condenser-input type. Using the components specified, it will deliver 350 volts at 90 ma. A switch in the transformer center-tap lead is used for turning the plate voltage on and off without affecting the filament supply.

The power transformer is submounted at the left end of the chassis. Next to it is the filter choke, L_1, followed by the rectifier tube and T_3, the modulation transformer. The driver tube is at the extreme right, with T_2, the driver transformer, behind it. The Class-B tube is to the rear and in line with the speech-amplifier tube. For convenience in wiring, the audio tube sockets should be mounted with the filament prongs facing the right-hand end of the chassis.

The plate-voltage switch is on the front of the chassis toward the left. The microphone switch, gain control and microphone jacks are grouped at the right.

The bottom-view photograph shows the layout for the components mounted below the chassis. T_1 is mounted at the left end. Wiring to the driver tube socket and the transformer secondary winding should be completed before the transformer is bolted in place, as it is difficult to reach the connecting points with a soldering iron afterwards. Short leads between

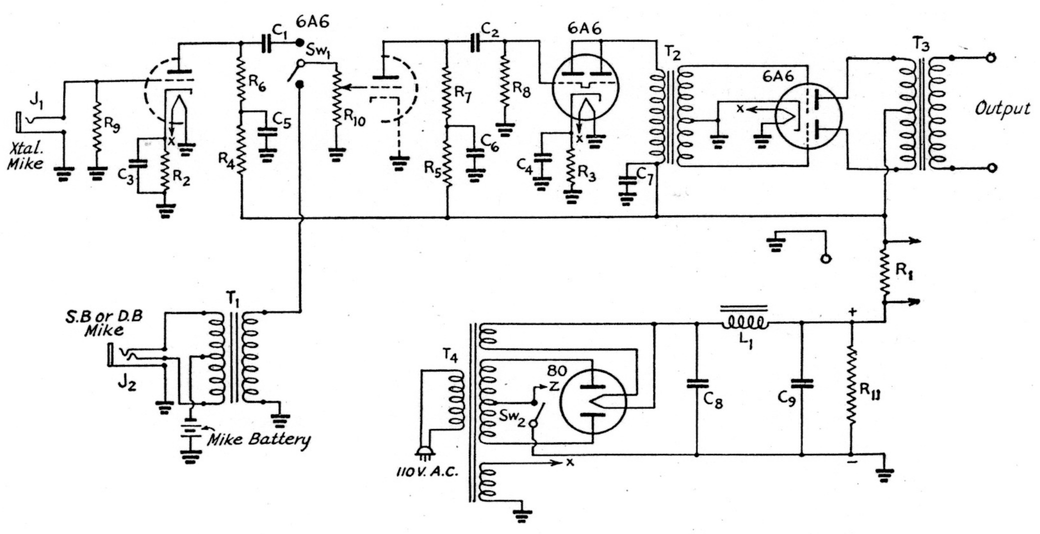

Fig. 1302 — **Circuit diagram of the complete 10-watt Class-B audio modulator system for low-power transmitters.**

C_1, C_2 — 0.1-μfd. 600-volt paper.
C_3, C_4 — 10-μfd. 50-volt electrolytic.
C_5, C_6, C_7, C_8, C_9 — 8-μfd. 450-volt electrolytic.
R_1 — 25 ohms, ½-watt.
R_2, R_3 — 900 ohms, 1-watt.
R_4, R_5 — 50,000 ohms, ½-watt.
R_6, R_7 — 0.25 megohm, ½-watt.
R_8 — 1 megohm, ½-watt.
R_9 — 5 megohms, ½-watt.
R_{10} — 500,000-ohm volume control.
R_{11} — 25,000 ohms, 10-watt.
Sw_1 — S.p.d.t. toggle switch.
Sw_2 — S.p.s.t. toggle switch (see text).
J_1 — Closed-circuit jack for crystal microphone.
J_2 — 2- or 3-circuit jack for single-button or double-button carbon microphone.
T_1 — S.b. or d.b. microphone transformer (Stancor A-4351).
T_2 — Driver transformer, parallel 6A6 plates to 6A6 Class-B (Stancor A-4216).
T_3 — Output transformer, 6A6 Class-B to 6500-ohm load (Stancor A-3845).
T_4 — Power transformer, 700-0-700 volts, 90 ma.; 5 volts at 3 amperes; 6.3 volts at 3.5 amperes.
L_1 — Filter choke, 5 henrys, 200 ma., 80 ohms (Thordarson T-67C49).

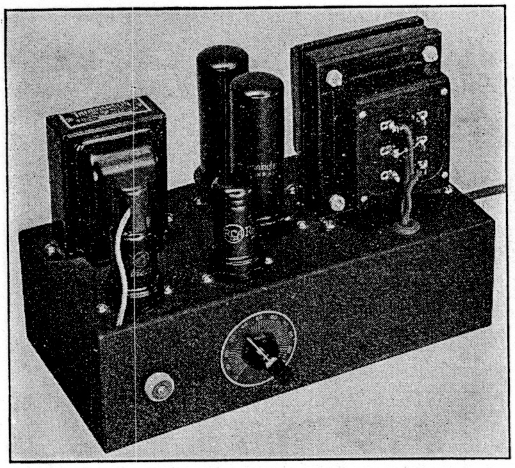

Fig. 1304 — A low-cost speech-amplifier or low-power modulator unit with a maximum audio output of 20 watts. The 6J7 is at the left near corner of the chassis, with the 6J5 to its right, just above the volume control.

the gain control, the microphone switch and the tube socket can be obtained by making the gain-control contacts face toward the switch, as shown.

The compact microphone battery (Burgess type 3A2) will be held securely in place without brackets or clips if it is wedged in between the bottom of the power transformer and the lips on the bottom of the chassis. A 3-volt battery is sufficient for most carbon microphones, and low current frequently will give better speech quality. The 115-volt a.c. and the meter leads (rubber-covered lamp cord) enter the chassis through rubber grommets. A three-contact terminal strip is located at the right end of the base (left end in the bottom view). One of the contacts is for an external ground connection and the other two are connected to the modulation-transformer output winding.

The actual measured power output of the unit shown in the photographs is 11 watts, at the point where distortion just begins to be noticeable. This order of power is ample for modulating a low-power transmitter with 20 watts or so input to the final stage.

A 20-Watt Speech Amplifier or Modulator

The amplifier shown in Figs. 1304–1306 will deliver audio power outputs up to 20 watts (from the output transformer secondary) with ample gain for ordinary communications-type crystal microphones. Class-AB 6L6s are used in the output stage, preceded by a 6J5 and 6J7.

The unit is built up on a 5 × 10 × 3-inch chassis, with the parts arranged as shown in the photographs. About the only constructional precaution necessary is to use a short lead from the microphone socket (a jack may be used instead of the screw-on type, if desired), and to shield thoroughly the input circuit to the grid of the 6J7. This shielding is necessary to reduce hum. In this amplifier, the 6J7 grid resistor, R_1, is enclosed along with the input jack in a National type J-1 jack shield, and a shielded lead is run from the jack shield to the grid of the 6J7. A metal slip-on shield covers the grid cap of the tube.

To realize maximum power output, the "B" supply should be capable of delivering about 145 ma. at 360 volts. A condenser-input supply of ordinary design (Chapter Eight) may be used, since the variation in plate current is relatively small. The current is approximately 120 ma. with no input signal and 145 ma. at full output. If an output of 12 or 13 watts will be sufficient, R_9 and R_{10} may be omitted and all tubes fed directly from a "B" supply giving 270 volts at approximately 175 ma.

The output transformer shown is a universal modulation type suitable for coupling into the

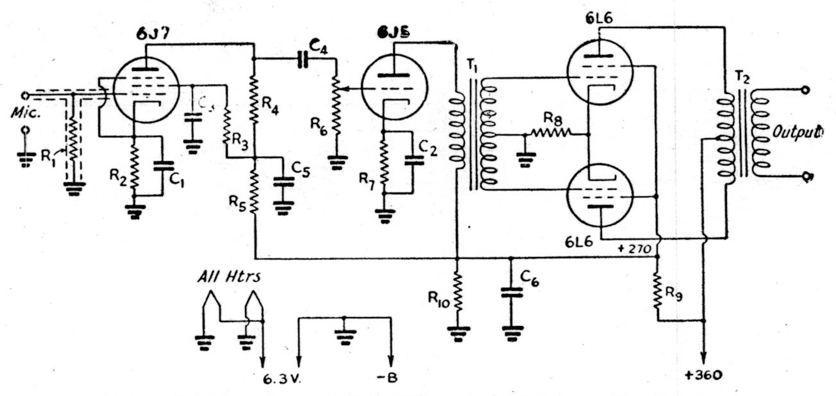

Fig. 1305 — Circuit diagram of the low-cost speech amplifier or modulator capable of power outputs up to 20 watts.

C_1, C_2 — 20-μfd. 50-volt electrolytic.
C_3 — 0.1-μfd. 200-volt paper.
C_4 — 0.01-μfd. 400-volt paper.
C_5, C_6 — 8-μfd. 450-volt electrolytic.
R_1 — 5 megohms, ½-watt.
R_2 — 1300 ohms, ½-watt.
R_3 — 1.5 megohms, ½-watt.
R_4 — 0.25 megohm, ½-watt.
R_5 — 50,000 ohms, ½-watt.
R_6 — 1-megohm volume control.
R_7 — 1500 ohms, 1-watt.
R_8 — 250 ohms, 10-watt.
R_9 — 2000 ohms, 10-watt.
R_{10} — 20,000 ohms, 25-watt.
T_1 — Interstage audio transformer, single plate to p.p. grids, ratio 3:1 (Thordarson T-57A41).
T_2 — Output transformer, type depending on requirements. A multi-tap modulation transformer (Thordarson T-19M14) is shown.

plate circuit of a low-power r.f. amplifier (input 40 watts maximum for 100 per cent modulation) for plate modulation. For cathode modulation, the r.f. input power that can be modulated can be determined from the data in Chapter Five. The amplifier may also be used for grid-bias modulation with the transformer specified.

If the unit is to be used to drive a Class-B modulator, it is recommended that the Class-B tubes be of the zero-bias type rather than a type requiring fixed bias. A suitable output transformer must be substituted for this purpose; data may be found in transformer manufacturers' catalogs.

The frequency response of the amplifier is ample for the range of frequencies encountered in voice communication. It may be extended for high-quality reproduction of music by using higher-priced audio transformers.

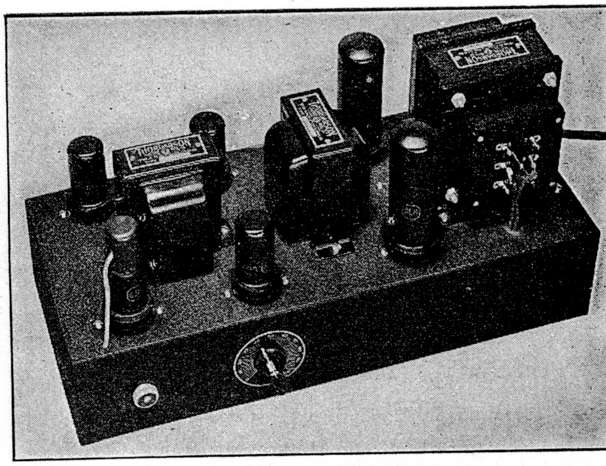

Fig. 1308 — A 40-watt speech amplifier or modulator of inexpensive construction. The 6J7 and first 6J5 are at the front, near the microphone socket and volume control, respectively. T_1 is behind them, and the push-pull 6J5s are at the rear of the chassis behind T_1. T_2, in the center, the push-pull 6L6s, and T_3 follow in order to the right.

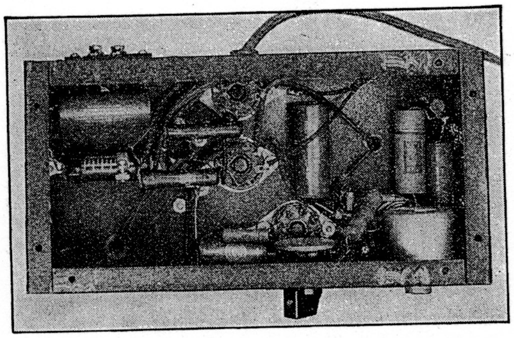

Fig. 1306 — Bottom view of the 20-watt speech amplifier or modulator chassis. The most important constructional point is complete shielding of the microphone input circuit up to the grid of the 6J7 first amplifier.

A 40-Watt Output Speech Amplifier or Modulator

The 40-watt amplifier shown in Figs. 1307–1309 resembles in many respects the 20-watt amplifier just described. The first two stages are, in fact, identical in circuit and construction. To obtain the higher output, however, it is necessary to drive the 6L6s into the grid current region (Class AB_2 operation), so that a driver stage capable of furnishing sufficient power is required. A pair of transformer-coupled 6J5s in push-pull is used for this purpose, inserted between the single 6J5 stage and the push-pull 6L6s. Decoupling is provided (R_9 and C_5) to prevent motorboating because of the higher over-all gain of the amplifier.

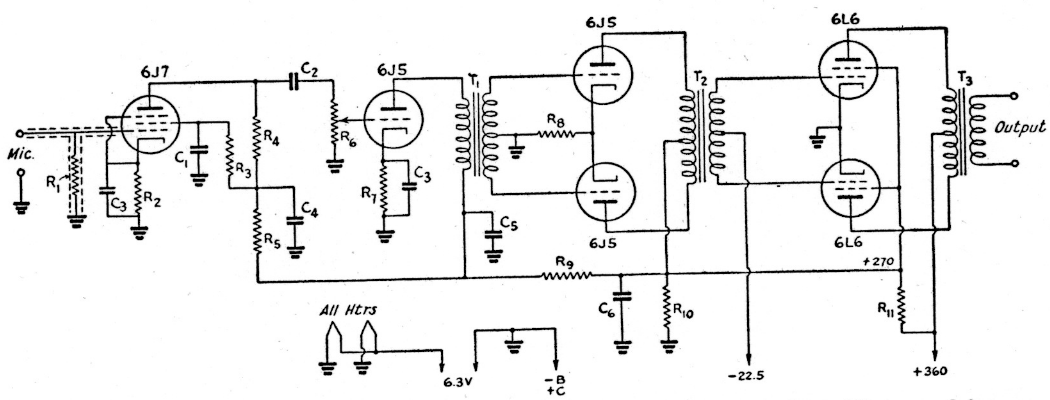

Fig. 1307 — Circuit diagram of the Class AB_2 push-pull 6L6 40-watt output speech amplifier or modulator.

C_1 — 0.1-μfd. 200-volt paper.
C_2 — 0.01-μfd. 400-volt paper.
C_3 — 20-μfd. 50-volt electrolytic.
C_4, C_5, C_6 — 8-μfd. 450-volt electrolytic.
R_1 — 5 megohms, ½-watt.
R_2 — 1300 ohms, ½-watt.
R_3 — 1.5 megohm, ½-watt.
R_4 — 0.25 megohm, ½-watt.
R_5 — 50,000 ohms, ½-watt.
R_6 — 1-megohm volume control.
R_7 — 1500 ohms, 1-watt.
R_8 — 750 ohms, 1-watt.
R_9 — 12,000 ohms, 1-watt.
R_{10} — 20,000 ohms, 25-watt.
R_{11} — 1500 ohms, 10-watt.
T_1 — Interstage audio, single plate to p.p. grids, 3:1 ratio (Thordarson T-57A41).
T_2 — Driver transformer, p.p. 6J5s to 6L6s Class AB2 (Thordarson T-84D59).
T_3 — Output transformer, type depending on requirements. A multi-tap modulation transformer (Thordarson T-19M15) is shown.

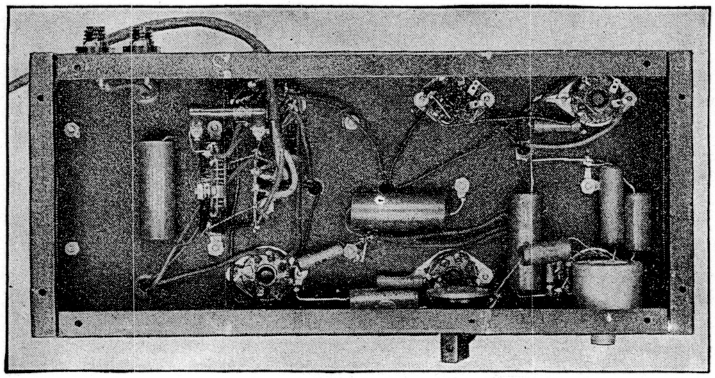

Fig. 1309 — Underneath the chassis of the 40-watt speech amplifier-modulator.

A 6 × 14 × 3-inch chassis is used for the 40-watt amplifier. The photographs show the arrangement of parts. As in the case of the 20-watt unit, complete shielding of the microphone input circuit is essential. The amplifier has ample gain for crystal microphones.

This unit may be used to plate-modulate 80 watts input to an r.f. amplifier. For cathode modulation, the input that can be modulated will depend upon the type of operation chosen, as described in Chapter Five; with 55 per cent plate efficiency in the r.f. stage, for instance, the input may be of the order of 200 watts, making an allowance for the small amount of audio power taken by the grid circuit.

A high-power Class-B modulator can be driven by the unit; data on suitable modulator tubes are given later in this chapter. Zero-bias tubes should be used, because they present a more constant load to the 6L6s than do relatively low amplification-factor tubes which require fixed bias for Class-B operation. A suitable Class-B driver transformer should be substituted for the universal modulation transformer shown.

The power supply should have good voltage regulation, since the total "B" current varies from approximately 140 ma. with no signal to 265 ma. at full output. A heavy-duty choke-input plate supply should be used; general design data will be found in Chapter Eight. The heater requirements are 6.3 volts at 3 amperes. Bias for the 6L6 stage is most conveniently supplied by a 22.5-volt "B" battery bloc; a small-sized unit will be satisfactory, since no current is drawn.

A Push-Pull 2A3 Amplifier with Volume Compression

Ideally, a Class-B modulator should be driven by an amplifier having exceptionally good voltage regulation, to minimize distortion (see Chapter Five). For average amateur work, the 6L6 amplifiers just described will give entirely satisfactory results as drivers for Class-B stages when operated well within their capabilities, especially with zero-bias Class-B tubes. However, somewhat better performance can be secured by using triode drivers, especially when the grid power requirements of the Class-B stage are modest enough to make the use of triodes such as the 2A3 practicable. The amplifier shown in Figs. 1310–1312, inclusive, has an output (from the transformer secondary) of 6 watts with negligible distortion, and thus is suitable for driving Class-B stages of 100 to 250 watts output.

The amplifier also incorporates an automatic volume-compression circuit to maintain a high average percentage of modulation (Chapter Five). The side amplifier and rectifier, combined in the 6SQ7 tube, rectifies a portion of the voice current. The rectified output of this circuit is filtered and applied to the Nos. 1 and 3 grids of a pentagrid amplifier tube, thereby varying its gain in inverse proportion to the signal strength. With proper adjustment, an average increase in modulation level of about 7 db. can be secured without exceeding 100 per cent modulation on peaks.

The amplifier proper consists of a 6J7 first stage followed by a 6L7 amplifier-compressor. The 2A3 grids are driven by a 6N7 self-balancing phase inverter. The operation of the 2A3s is purely Class A, without grid current.

The amount of compression is controlled by means of the potentiometer, R_{20}, in the grid circuit of the 6SQ7. A switch, S_1, is provided to short-circuit the rectified output of the compressor when normal amplification is required.

The construction of the amplifier resembles that of the unit shown in Fig. 1301, the tubes and output transformer being mounted on the rear edge of a 17 × 4 × 3-inch chassis to save panel height in relay-rack mounting. Looking at the amplifier from the front, the 6J7 first amplifier is in the upper left corner, with the 6L7 to its right. The 6SQ7 is below the 6L7.

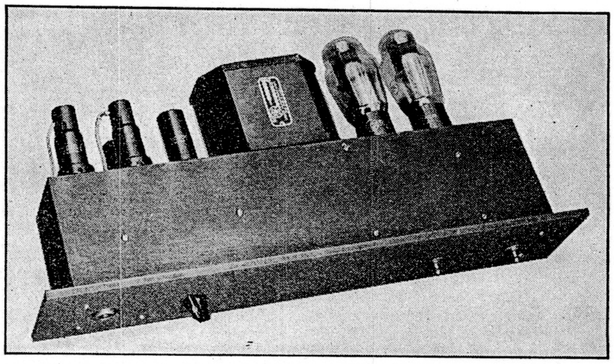

Fig. 1310 — A push-pull 2A3 speech amplifier having an output of approximately 6 watts. A volume-compression circuit is included.

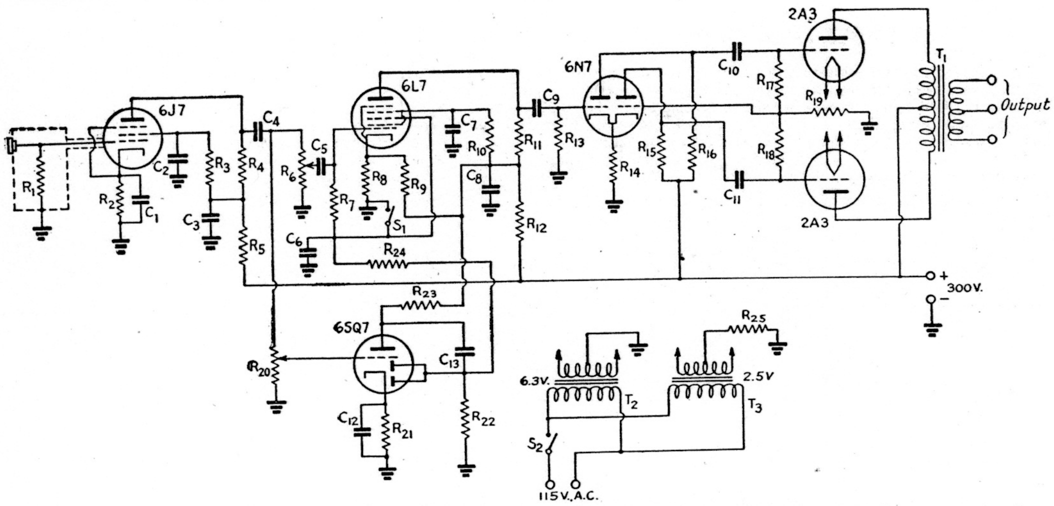

Fig. 1311 — Circuit diagram of the push-pull Class-A 2A3 speech amplifier with automatic volume compression.

C_1, C_{12}—10-μfd. 50-volt electrolytic.
C_2, C_4, C_5, C_6, C_9, C_{10}, C_{11}, C_{13} — 0.1-μfd. 400-volt paper.
C_3, C_8—8-μfd. 450-volt. electrolytic.
C_7 — 0.5-μfd. 400-volt paper.
R_1 — 5 megohms, ½-watt.
R_2, R_8 — 1200 ohms, ½-watt.
R_3, R_7 — 2 megohms, ½-watt.
R_4, R_{13}, R_{22}, R_{24} — 0.5 megohm, ½-watt.
R_5 — 50,000 ohms, ½-watt.
R_6, R_{20} —0.5-megohm variable.
R_9 — 0.25 megohm, 1-watt.
R_{10}, R_{11}, R_{23} — 0.1 megohm, ½-watt.
R_{12} — 10,000 ohms, ½-watt.
R_{14} — 1500 ohms, ½-watt.
R_{15}, R_{16} — 0.1 megohm, 1-watt.
R_{17}, R_{18}, R_{19}—0.25 megohm, ½-watt.
R_{21} — 5000 ohms, ½-watt.
R_{25} — 750 ohms, 10-watt.
T_1 — Output transformer to match pp. 2A3s to Class-B grids. (UTC PA-53AX).
T_2 — Filament transformer, 6.3 volts, 2 amperes.
T_3 — Filament transformer, 2.5 volts, 5 amperes.

The 6N7 is followed by the output transformer, the latter being placed in the middle of the chassis in order to distribute the weight evenly. The 2A3s and the power and output terminals are at the right.

In the underneath view the input circuit is at the left, the grid resistor and connector socket being shielded by the National JS-1 jack shield. The lead to the 6J7 grid is shielded, as are also the top caps of this tube and the 6L7. The compressor control, R_{20}, is mounted beside the 6J7, and is screwdriver adjusted; a midget control should be used, since the space is rather limited. The other parts are mounted as close as possible to the points in the circuit to which they connect. The filament transformers should be kept well separated from the wiring in the low-level stages, particularly that of the microphone input and grid circuits.

Adjustment of the compressor control is rather critical. First set R_{20} at zero and adjust the gain control, R_6, for full modulation with the particular microphone used. Then advance the compressor control until the amplifier just "cuts off" (output decreasing to a low value) on peaks; when this point is reached, back off the compressor control until the cut-off effect is gone but an obvious decrease in gain follows each peak. Because of the necessity for filtering out the audio component in the rectifier output, there is a slight delay (amounting to a fraction of a second) before the decrease in gain "catches up" with the peak. When a satisfactory setting is secured, as indicated by good speech quality with a definite reduction in gain on peaks, the gain control, R_6, should be advanced to give full output with normal operation. Too much compression, indicated by the cut-off effect following each peak, is definitely undesirable, and the object of adjustment of the compressor control should be to use as much compression as possible without over-compression.

The amplifier requires a plate-voltage supply of 300 volts at 75 ma. A well-filtered condenser-input power supply using receiving-type components is suitable; a two-section filter is desirable to minimize hum.

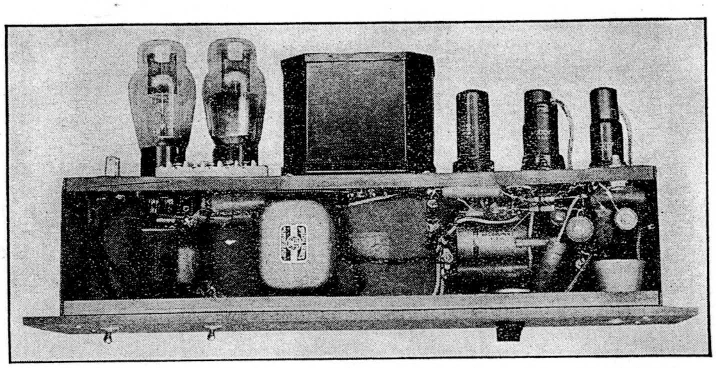

Fig. 1312 — Bottom view of the 2A3 volume-compression speech amplifier.

TABLE I — RESISTANCE-COUPLED VOLTAGE AMPLIFIER DATA

Data are given for a plate-supply of 300 volts; departures of as much as 50 per cent from this supply voltage will not materially change the operating conditions or the voltage gain, but the output voltage will be in proportion to the new voltage. Voltage gain is measured at 400 cycles; condenser values given are based on 100-cycle cut-off. For increased low-frequency response, all condensers may be made larger than specified (cut-off frequency in inverse proportion to condenser values provided all are changed in the same proportion). A variation of 10 per cent in the values given has negligible effect on the performance.

High-frequency cut-off with pentodes is approximately 20,000 cycles with a plate resistor of 0.1 megohm, 10,000 cycles with 0.25 megohm, and 5000 cycles with 0.5 megohm. With triode amplifiers, the high-frequency cut-off is well above the audio range.

	Plate Resistor Megohms	Next-Stage Grid Resistor Megohms	Screen Resistor Megohms	Cathode Resistor Ohms	Screen By-pass µfd.	Cathode By-pass µfd.	Blocking Condenser µfd.	Output Volts (Peak)[2]	Voltage Gain [3]
6A6, 6N7, 53	0.1	0.1	—	1150[1]	—	—	0.03	60	20
		0.25	—	1500[1]	—	—	0.015	83	22
		0.5	—	1750[1]	—	—	0.007	86	23
	0.25	0.25	—	2650[1]	—	—	0.015	75	23
		0.5	—	3400[1]	—	—	0.0055	87	24
		1.0	—	4000[1]	—	—	0.003	100	24
	0.5	0.5	—	4850[1]	—	—	0.0055	76	23
		1.0	—	6100[1]	—	—	0.003	94	24
		2.0	—	7150[1]	—	—	0.0015	104	24
6C5 (also 6J7, 6C6, 57, 6W7, 7C7 as triodes)[4]	0.05	0.05	—	2100	—	3.16	0.075	57	11
		0.1	—	2600	—	2.3	0.04	70	11
		0.25	—	3100	—	2.2	0.015	83	12
	0.1	0.1	—	3800	—	1.7	0.035	65	12
		0.25	—	5300	—	1.3	0.015	84	13
		0.5	—	6000	—	1.17	0.008	88	13
	0.25	0.25	—	9600	—	0.9	0.015	73	13
		0.5	—	12,300	—	0.59	0.008	85	14
		1.0	—	14,000	—	0.37	0.003	97	14
6C6, 6J7, 6W7, 7C7, 57 (pentode)	0.1	0.1	0.44	500	0.07	8.5	0.02	55	61
		0.25	0.5	450	0.07	8.3	0.01	81	82
		0.5	0.53	600	0.06	8.0	0.006	96	94
	0.25	0.25	1.18	1100	0.04	5.5	0.008	81	104
		0.5	1.18	1200	0.04	5.4	0.005	104	140
		1.0	1.45	1300	0.05	5.8	0.005	110	185
	0.5	0.5	2.45	1700	0.04	4.2	0.005	75	161
		1.0	2.9	2200	0.04	4.1	0.003	97	350
		2.0	2.95	2300	0.04	4.0	0.0025	100	240
6C8G (one triode unit)	0.1	0.1	—	2120	—	3.93	0.037	55	22
		0.25	—	2840	—	2.01	0.013	73	23
		0.5	—	3250	—	1.79	0.007	80	25
	0.25	0.25	—	4750	—	1.29	0.013	64	25
		0.5	—	6100	—	0.96	0.0065	80	26
		1.0	—	7100	—	0.77	0.004	90	27
	0.5	0.5	—	9000	—	0.67	0.007	67	27
		1.0	—	11,500	—	0.48	0.004	83	27
		2.0	—	14,500	—	0.37	0.002	96	28
6F5, 6SF5, 7B4	0.1	0.1	—	1300	—	5.0	0.025	33	42
		0.25	—	1600	—	3.7	0.01	43	49
		0.5	—	1700	—	3.2	0.006	48	52
	0.25	0.25	—	2600	—	2.5	0.01	41	56
		0.5	—	3200	—	2.1	0.007	54	63
		1.0	—	3500	—	2.0	0.004	63	67
	0.5	0.5	—	4500	—	1.5	0.006	50	65
		1.0	—	5400	—	1.2	0.004	62	70
		2.0	—	6100	—	0.93	0.002	70	70
6F8G (one triode unit), 6J5, 6J5G, 7A4, 7N7	0.05	0.05	—	1020	—	3.56	0.06	41	13
		0.1	—	1270	—	2.96	0.034	51	14
		0.25	—	1500	—	2.15	0.012	60	14
	0.1	0.1	—	1900	—	2.31	0.035	43	14
		0.25	—	2440	—	1.42	0.0125	56	14
		0.5	—	2700	—	1.2	0.0065	64	14
	0.25	0.25	—	4590	—	0.87	0.013	46	14
		0.5	—	5770	—	0.64	0.0075	57	14
		1.0	—	6950	—	0.54	0.004	64	14
6L5G	0.05	0.05	—	1740	—	2.91	0.06	56	11[5]
		0.1	—	2160	—	2.18	0.032	68	12[5]
		0.25	—	2600	—	1.82	0.015	79	12[5]
	0.1	0.1	—	3070	—	1.64	0.032	60	12[5]
		0.25	—	4140	—	1.1	0.014	79	13[5]
		0.5	—	4700	—	0.81	0.0075	89	13[5]
	0.25	0.25	—	6900	—	0.57	0.013	64	13[5]
		0.5	—	9100	—	0.46	0.0075	80	13[5]
		1.0	—	10,750	—	0.4	0.005	88	13[5]

[1] Value for both triode sections, assuming both are working under same conditions. In phase inverter service, the cathode resistor should not be by-passed.
[2] Voltage across next-stage grid resistor at grid-current point.
[3] At 5 volts r.m.s. output.
[4] Screen and suppressor tied to plate.
[5] At 4 volts r.m.s. output.

TABLE I—RESISTANCE-COUPLED VOLTAGE AMPLIFIER DATA—*Continued*

	Plate Resistor Megohms	Next-Stage Grid Resistor Megohms	Screen Resistor Megohms	Cathode Resistor Ohms	Screen By-pass μfd.	Cathode By-pass μfd.	Blocking Condenser μfd.	Output Volts (Peak)[2]	Voltage Gain[3]
6R7, 6R7G, 7E6	0.05	0.05	—	1600	—	2.6	0.055	50	9
		0.1	—	2000	—	2.0	0.03	62	9
		0.25	—	2400	—	1.6	0.015	71	10
	0.1	0.1	—	2900	—	1.4	0.03	52	10
		0.25	—	3800	—	1.1	0.015	68	10
		0.5	—	4400	—	1.0	0.007	71	10
	0.25	0.25	—	6300	—	0.7	0.015	54	10
		0.5	—	8400	—	0.5	0.007	62	11
		1.0	—	10,600	—	0.44	0.004	74	11
6S7	0.1	0.1	0.59	430	0.077	8.5	0.0167	57	57[5]
		0.25	0.67	440	0.071	8.0	0.01	73	78[5]
		0.5	0.71	440	0.071	8.0	0.0066	82	89[5]
	0.25	0.25	1.7	620	0.058	6.0	0.0071	54	98[5]
		0.5	1.95	650	0.057	5.8	0.005	66	122[5]
		1.0	2.1	700	0.055	5.2	0.0036	76	136[5]
	0.5	0.5	3.6	1000	0.04	4.1	0.0037	52	136[5]
		1.0	3.9	1080	0.041	3.9	0.0029	66	162[5]
		2.0	4.1	1120	0.043	3.8	0.0023	73	174[5]
6SC7	0.1	0.1	—	750[1]	—	—	0.033	35	29
		0.25	—	930[1]	—	—	0.014	50	34
		0.5	—	1040[1]	—	—	0.007	54	36
	0.25	0.25	—	1400[1]	—	—	0.012	45	39
		0.5	—	1680[1]	—	—	0.006	55	42
		1.0	—	1840[1]	—	—	0.003	64	45
	0.5	0.5	—	2330[1]	—	—	0.006	50	45
		1.0	—	2980[1]	—	—	0.003	62	48
		2.0	—	3280[1]	—	—	0.002	72	49
6SJ7	0.1	0.1	0.35	500	0.10	11.6	0.019	72	67
		0.25	0.37	530	0.09	10.9	0.016	96	98
		0.5	0.47	590	0.09	9.9	0.007	101	104
	0.25	0.25	0.89	850	0.07	8.5	0.011	79	139
		0.5	1.10	860	0.06	7.4	0.004	88	167
		1.0	1.18	910	0.06	6.9	0.003	98	185
	0.5	0.5	2.0	1300	0.06	6.0	0.004	64	200
		1.0	2.2	1410	0.05	5.8	0.002	79	238
		2.0	2.5	1530	0.04	5.2	0.0015	89	263
6SQ7, 6B6G, 7B6, 2A6, 75	0.1	0.1	—	1900	—	4.0	0.03	31	31
		0.25	—	2200	—	3.5	0.015	41	39
		0.5	—	2300	—	3.0	0.007	45	42
	0.25	0.25	—	3300	—	2.7	0.015	42	48
		0.5	—	3900	—	2.0	0.007	51	53
		1.0	—	4200	—	1.8	0.004	60	56
	0.5	0.5	—	5300	—	1.6	0.007	47	58
		1.0	—	6100	—	1.3	0.004	62	60
		2.0	—	7000	—	1.2	0.002	67	63
6T7G	0.1	0.1	—	1950	—	2.85	0.0245	44	27[5]
		0.25	—	2400	—	2.55	0.0135	58	32[5]
		0.5	—	2640	—	2.25	0.008	64	33[5]
	0.25	0.25	—	3760	—	1.57	0.012	57	37[5]
		0.5	—	4580	—	1.35	0.0075	69	40[5]
		1.0	—	5220	—	1.23	0.005	80	41[5]
	0.5	0.5	—	6570	—	1.02	0.008	62	42[5]
		1.0	—	8200	—	0.82	0.0055	77	43[5]
		2.0	—	9600	—	0.70	0.004	86	44[5]
56, 76	0.05	0.05	—	2400	—	2.8	0.08	65	8.3
		0.1	—	3100	—	2.2	0.045	80	8.9
		0.25	—	3800	—	1.8	0.02	95	9.4
	0.1	0.1	—	4500	—	1.6	0.04	74	9.5
		0.25	—	6400	—	1.2	0.02	95	10.0
		0.5	—	7500	—	0.98	0.009	104	10.0
	0.25	0.25	—	11,100	—	0.69	0.02	82	10.0
		0.5	—	15,200	—	0.5	0.009	96	10.0
		1.0	—	18,300	—	0.4	0.005	108	10.0

[1] Value for both triode sections, assuming both are working under same conditions. In phase inverter service, the cathode resistor should not be by-passed.
[2] Voltage across next-stage grid resistor at grid-current point.
[3] At 5 volts r.m.s. output.
[4] Screen and suppressor tied to plate.
[5] At 4 volts r.m.s. output.

TABLE II—CLASS-B MODULATOR DATA

Class-B Tubes (2)	Fil. Volts	Plate Volts	Grid Volts App.	Peak A.F. Grid-to-Grid Voltage	Zero-Sig.[1] Plate Current Ma.	Max.-Sig.[1] Plate Current Ma.[2]	Load Res. Plate-to-Plate Ohms	Max.-Sig. Driving Power Watts[3]	Max.-Sig.[1] Power Output Watts[3]
RK59[4]	6.3	500	−17	—	—	90	—	0.9	30
HY60[7]	6.3	300	−22.5	63	75	120	5,000	4.0	22
		400	−22.5	57	75	120	6,000	3.0	30
HY65[5]	6.3	450	—	—	—	125	—	0.4	34
801-A/801	7.5	600	−75	320	8	130	10,000	3.0	45
HY31Z[4,5]	6.3	300	0	104	20	100	5,000	1.4	18
HY1231Z[4,5]	12.6	400	0	140	26	150	5,000	2.0	40
		500	0	131	36	150	7,000	1.8	51
815[8]	6.3	400	−15	60	22	150	8,000	0.36	42
		500[6]	−15	60	20	150	6,200	0.36	54
1624[7]	2.5	400	−16.5	77	75	150	6,000	0.4	36
		600	−25	106	42	180	7,500	1.2	72
HY6L6GX[7]	6.3	400	−25	80	100	230	3,800	0.35	60
		500	−25	80	100	230	4,550	0.6	75
TZ20	7.5	750	0	195	—	170	9,000	2.6	80
HY61/807[7]		400	−25	80	100	230	3,800	0.35	60
RK807	6.3	500	−25	80	100	230	4,550	0.6	75
		600	−30	80	60	200	6,600	0.4	80
HY69[5,7]	6.3	300	−25	106	60	150	4,000	0.25	30
HY1269[5,7]	12.6	400	−25	145	60	170	4,000	0.4	40
		600	−35	183	65	120	4,500	0.3	65
		500	−25	120	65	200	5,000	0.7	97
RK12	6.3	750	0	129	50	200	9,600	3.4	100
800	7.5	750	−40	320	26	210	6,400	6.0	90
		1000	−55	300	28	160	12,500	4.4	100
		1250	−70	300	30	130	21,000	3.4	106
HY30Z	6.3	600	0	171	18	180	6,000	Note 9	75
		750	0	167	22	180	8,000	"	95
		850	0	171	28	180	10,000	"	110
807[10]	6.3	400	−25	78	100	240	3,200	0.2	55
1625[10]	12.6	500	−25	78	100	240	4,240	0.2	75
		600	−30	78	60	200	6,400	0.1	80
		750[6]	−32	92	60	240	6,950	0.2	120
HK24	6.3	1000	−29	248	30	150	15,000	4.5	105
		1250	−42	256	24	136	21,200	4.2	120
809	6.3	500	−10	170	40	200	5,200	3.5	60
		750	−25	200	35	200	8,400	4.0	100
		1000[6]	−40	230	30	200	12,000	4.2	145
830-B	10	800	−27	250	20	280	6,000	5.0	135
		1000	−35	270	20	280	7,600	6.0	175
HY40Z	7.5	750	0	171	32	225	6,000	Note 9	110
		850	0	185	40	250	7,000	"	155
		1000	0	1[illegible]	45	250	9,000	"	185
RK31	7.5	1000	0	141	25	230	11,000	3.7	160
		1250	0	141	35	220	18,000	4.4	190
808	7.5	1250	−15	240	40	230	12,700	7.8	190
		1500	−25	220	30	190	18,300	4.8	185
RK37	7.5	1250	−35	282	25	235	18,000	7.2	200
811	6.3	1250	0	140	48	200	15,000	3.8	175
		1500[6]	−9	160	20	200	18,000	4.2	225
35T	5.0 to 5.1	1000	−22	—	—	—	7,200	—	150
		1250	−30	—	—	—	9,600	—	200
		1500	−40	—	—	—	12,800	—	230
TZ40[6]	7.5	1000	0	220	—	280	7,350	5.5	175
		1250	−4.5	269	—	280	10,000	6.0	225
		1500	−9	265	—	250	12,000	6.0	250
RK52	7.5	1250	0	180	40	300	10,000	7.5	250
203-A	10	1000	−35	310	26	320	6,900	10	200
		1250	−45	330	26	320	9,000	11	260
211	10	1000	−77	380	20	320	6,900	7.5	200
		1250	−100	410	20	320	9,000	8.0	260
838	10	1000	0	200	106	320	6,900	7.0	200
		1250	0	200	148	320	9,000	7.5	260
HK158	12.6	750	−25	300	50	330	4,500	17	155
		1250	−50	280	35	225	12,500	10	200
		2000	−90	340	30	180	3,200	10	265
HK54	5.0	1500	−45	300	40	198	16,800	5.0	200
		2000	−70	360	24	180	36,000	6.0	260
		2500	−85	360	20	150	40,000	5.0	275
HY51Z	7.5	850	0	148	48	300	5,000	Note 9	160
		1000	0	170	60	350	6,000	"	260
		1250	0	155	90	300	10,000	"	285
203-Z	10	1000	0	206	50	350	6,200	6.5	230
		1250	−4.5	215	60	350	8,000	6.75	300
ZB120	10	1000	0	190	70	310	6,900	5.0	200
		1250	0	180	95	300	9,000	4.0	245
		1500	−9	196	60	296	11,200	5.0	300

TABLE II — CLASS-B MODULATOR DATA — *Continued*

Class-B Tubes (2)	Fil. Volts	Plate Volts	Grid Volts App.	Peak A.F. Grid-to-Grid Voltage	Zero-Sig.[1] Plate Current Ma.	Max.-Sig.[1] Plate Current Ma.[2]	Load Res. Plate-to-Plate Ohms	Max.-Sig. Driving Power Watts[3]	Max.-Sig.[1] Power Output Watts[3]
8005	10	1250 1500[6]	−55 −80	290 310	40 40	320 310	8,000 2,500	4.0 4.0	250 300
HF100	10 to 11	1500 1750	−52 −62	264 324	50 40	270 270	12,000 16,000	2.0 9.0	260 350
805 RK57	10	1250 1500	0 −16	235 280	148 84	400 400	6,700 8,200	6.0 7.0	300 370
828[11]	10	1700 2000	−120 −120	240 240	50 50	248 270	16,200 18,300	0 0	300 385
75T	5.0	1000 1500 2000	— — —	— — —	— — —	— — —	6,800 10,000 12,500	— — —	200 300 400
8003	10	1350	−100	480	40	490	6,000	10.5	460
100TH	5.0 to 5.1	2000 2500 3000	Bias adjusted for maximum rated plate dissipation under no-signal conditions Zero bias up to 1250 v. plate				16,000 22,000 30,000	May be driven by push-pull 6L6s	380 460 500
HD203-A	10	1500 1750	−40 −67	— —	36 36	425 425	8,000 9,000	Note 12	400 500
HK254	5.0	2000 2500 3000	−65 −80 −100	400 420 456	50 50 40	260 248 240	16,000 22,000 30,000	7.0 7.0 7.0	328 418 520
810	10	1500	−30	345	80	500	6,600	12	510
1627	5.0	2000	−50	345	60	420	11,000	10	590

[1] Values are for both tubes.
[2] Sinusoidal signal values; speech values are approximately one-half for tubes biased to approximate cut-off and 80 per cent for zero-bias tubes.
[3] Values do not include transformer losses. Somewhat higher power is required of the driver to supply losses and provide good regulation. Input transformer ratios must be chosen to supply required power at specified grid-to-grid voltage with ample reserve for losses and low distortion levels. Driver stage should have good regulation.
[4] Dual tube. Values are for one tube, both sections.
[5] Instant-heating filament type.
[6] Intermittent amateur and commercial service rating.
[7] Beam tube. Class AB_2. Screen voltage: 300.
[8] Beam tube. Class AB_2. Screen voltage: 125 at 32 ma.
[9] Driver: one or two 45s at 275 volts, self-biased (−55 volts).
[10] Beam Tube. Class AB_2. Screen voltage: 300 at 10 ma. Effective grid circuit resistance should not exceed 500 ohms.
[11] Pentode. Class AB_2. Suppressor voltage: 60 at 9 ma. Screen voltage: 750, 4/43 ma. at 1700 plate volts, 2/60 ma. at 2000.
[12] Can be driven by a pair of 2A3s in push-pull Class AB at 300 volts with fixed bias.

Class-B Modulators

Class-B modulator circuits are practically identical no matter what the power output of the modulator. The diagrams of Fig. 1313 therefore will serve for any modulator of this type that the amateur may elect to build. The triode circuit is given at A and the circuit for tetrodes at B. When small tubes with indirectly heated cathodes are used, the cathode should be connected to ground.

Design considerations for Class-B stages are discussed in Chapter Five, and data on the performance of various tubes suitable for the purpose are given in the accompanying tables. Once the requisite audio power output has been determined and a pair of tubes capable of giving that output selected, an output transformer should be secured which will permit matching the rated modulator load impedance to the modulating impedance of the r.f. amplifier. Similarly, a driver transformer should be selected which will properly couple the driver stage to the Class-B grids.

The plate power supply for the modulator should have good voltage regulation and must be well filtered. It is particularly important, in the case of a tetrode Class-B stage, that the screen-voltage power-supply source have excellent regulation, to prevent distortion. The screen voltage should be set as exactly as possible to the recommended value for the tube.

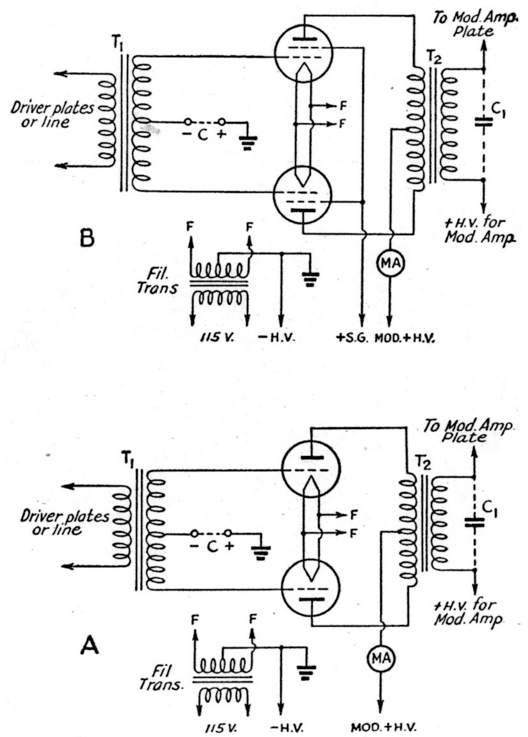

Fig. 1313 — Class-B modulator circuit diagrams. Tubes and circuit considerations are discussed in the text.

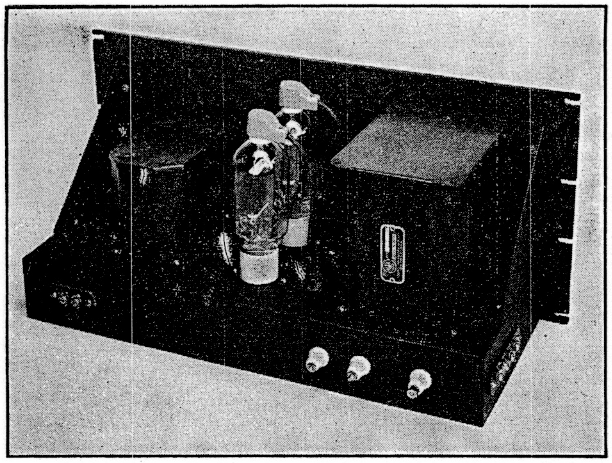

Fig. 1315 — **A conventional chassis arrangement for low- and medium-power Class-B modulator stages. The mechanical layout in general follows the typical circuit diagrams given in Fig. 1313.**

In estimating the output of the modulator, it should be remembered that the figures given in the tables are for the tube output only, and do not include output-transformer losses. The efficiency of the output transformer will vary with its construction, and may be assumed to be in the vicinity of 80 per cent for the less expensive units and somewhat higher for higher-priced transformers. To be adequate for modulating the transmitter, therefore, the modulator should have a theoretical power capability about 25 per cent greater than the actual power needed for modulation.

The input transformer, T_1, may couple directly between the driver tube and the modulator grids or may be designed to work from a low-impedance (200- or 500-ohm) line. In the latter case, a tube-to-line output transformer must be used at the input to the driver stage. This type of coupling is recommended only when the driver must be at a considerable distance from the modulator, since the second transformer not only introduces additional losses but also further impairs the voltage regulation.

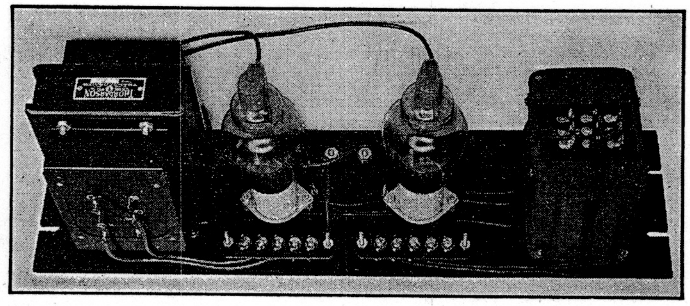

Fig. 1314 — **Chassis-less construction for a low-power Class-B modulator. Small tubes and transformers capable of an audio output of the order of 100 watts can be mounted directly on the panel, eliminating the chassis.**

The bias source for the modulator must have very low resistance. Batteries are the most suitable source. In cases where the voltage values are correct, regulator tubes such as the VR75-30, VR105-30, etc., may be connected across a tap on an a.c. bias supply to hold the bias voltage steady under grid-current conditions. Generally, however, zero-bias modulator tubes are preferable, not only because no bias supply is required but also because the loading on the driver stage is less variable and consequently distortion in the driver is reduced.

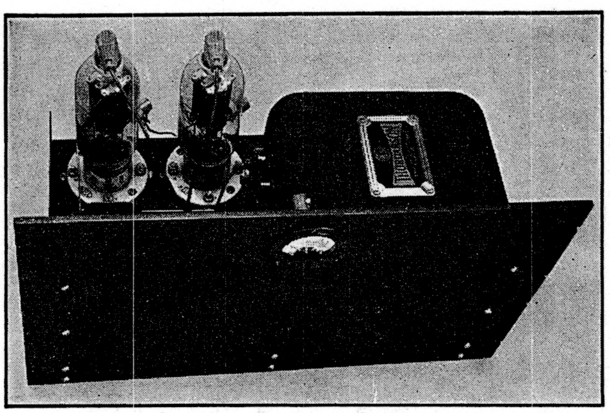

Fig. 1316 — **A chassis arrangement for a higher-power Class-B modulator. This unit has the filament transformer for the tubes mounted on the chassis. Where the input transformer is included with the speech amplifier, less chassis space will be needed. The tubes are placed near the rear, where the ventilation is good. The plate millammeter is provided with a small plate over the adjusting screw, to prevent touching the screw accidentally. A Presdwood panel was used for this modulator; with a metal panel, the meter should be mounted behind glass on a well-insulated mount (the meter insulation is not intended for voltages above a few hundred) or connected in the filament center-tap rather than in the high-voltage lead.**

Condenser C_1 in these diagrams will give a "tone-control" effect and filter out high-frequency side-bands (splatter) caused by distortion in the modulator or preceding speech-amplifier stages. Values in the neighborhood of 0.002 to 0.005 μfd. are suitable. Its voltage rating should be adequate for the peak voltage across the transformer secondary. The plate by-pass condenser in the modulated amplifier will serve the same purpose.

The photographs illustrate different types of construction which may be used for Class-B modulators. The actual placement of parts is not critical.