The WILLIAMSON AMPLIFIER

a modified design

by ROBERT B. DUNHAM

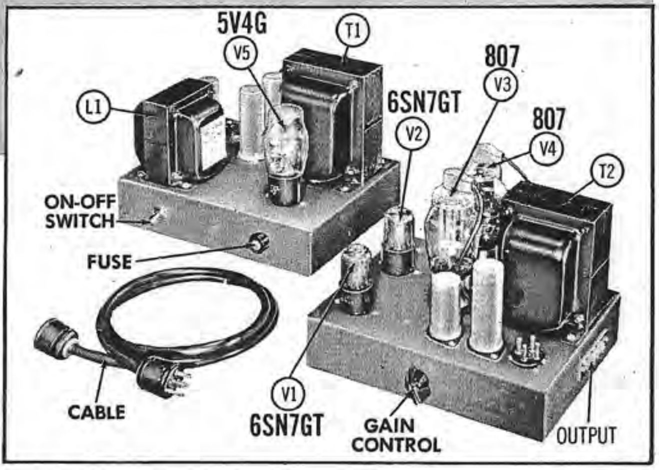

Fig. 1. Modified Williamson Amplifier With Power Supply and Cable.

In discussing the Williamson amplifier in the "Audio Facts" column in PF INDEX and Technical Digest No. 30, for January-February 1952, we mentioned that since its introduction by D. T. N. Williamson in 1947 it had become one of the most popular and well-known amplifier circuits. Its popularity certainly has not waned, on the contrary it has increased.

Many manufacturers now produce their own versions of the Williamson amplifier. For instance, one English-made amplifier, built to Mr. Williamson's specifications and carrying his signature, has been placed on the market in this country. American and foreign-made output transformers designed especially for this circuit are available, as well as various kits composed of the most important large components or complete to the last small item in some cases.

The amplifier using Stancor components, constructed by us, and described in the aforementioned "Audio Facts" article has had a great deal of rough service; but its performance has been above reproach, giving us no reason for complaint. No doubt this is representative of the results obtained by Williamson users in general.

In fact, about the only thing to be considered as a deficiency in these amplifiers was the maximum power-output rating, which was not so high as some desired it to be or thought it should be to handle adequately the high-amplitude peaks encountered when reproducing some musical selections. Various methods were tried in an effort to increase the power output. The most successful one was the use of push-pull parallel output stages which required a larger and heavier power supply.

* * Please turn to page 56 * *

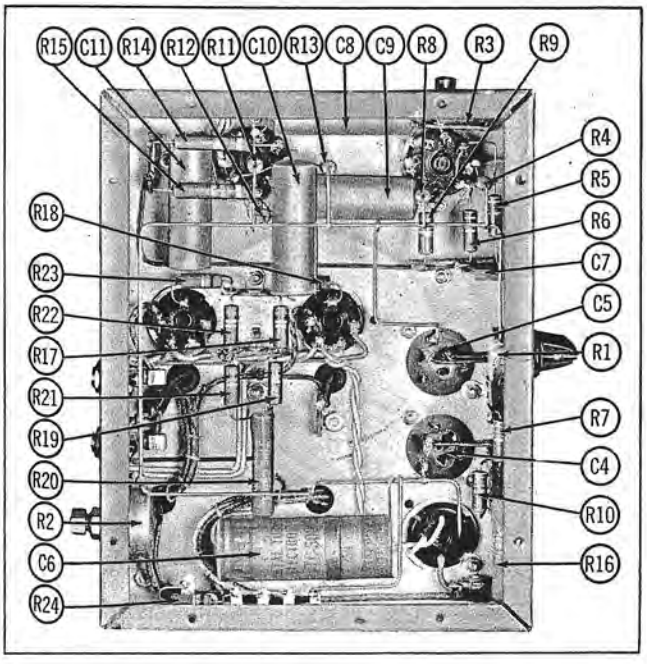

Fig. 2. (A) Bottom View of Amplifier.

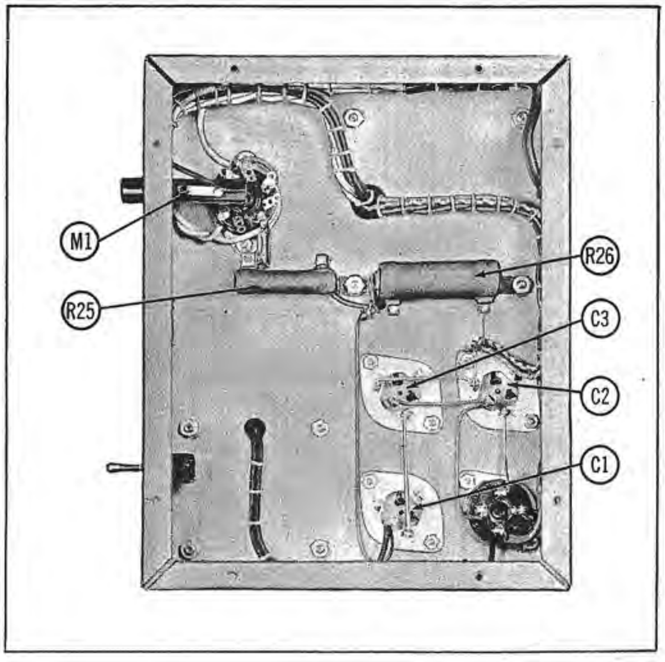

Fig. 2. (B) Bottom View of Power Supply.

The Williamson Amplifier

(Continued from page 15)

When David Hafler and Herbert I. Keroes developed the circuit[1] using an output transformer with taps on its primary to connect a portion of the load to the screens, they made it possible to increase the power output of the Williamson type of amplifier[2,3] easily and with little added demand on the power supply.

In the Williamson amplifier the beam-power output tubes are operated as triodes, since the screens are connected to the plates through 100-ohm suppressor resistors. This reduces internal plate impedance and results in very linear operation, but it does eliminate the high power capabilities of the tetrode. By connecting the screens to about 20 per cent of the load, a form of operation is obtained which is neither triode nor tetrode but is in between. Connecting the screens into the circuit in this manner has the effect of applying a large amount of negative feedback, thereby making it possible to maintain linearity of operation at higher output levels.

Since Hafler and Keroes developed this output circuit and a transformer to operate in it, several companies have brought out transformers designed for this service. In addition, some standard output transformers possessing tapped or multiple primary windings, while not exactly following the specifications set up for this circuit, do furnish improved operation when used in the correct manner.

Any such improvement in high-fidelity equipment is worth while, and we feel that the following details concerning the amplifier constructed in our laboratory and shown in the illustrations of Figs. 1 and 2 will be of interest to the reader.

In order to construct the improved unit, we selected the Stancor

[1] David Hafler and Herbert I. Keroes, "An Ultra-Linear Amplifier," Audio Engineering, Nov. 1951, p. 15, reprinted in The 2nd Audio Anthology, Radio Magazines, Inc., Mineola, N. Y., 1953.

[2] David Hafler and Herbert I. Keroes, "Ultra-Linear Operation of the Williamson Amplifier," Audio Engineering, June 1952, p. 26, reprinted in The 2nd Audio Anthology, Radio Magazines, Inc., Mineola, N. Y., 1953.

[3] David Sarser and Melvin C. Sprinkle, "Gilding the Lily," Audio Engineering, July 1952, p. 13, reprinted in The 2nd Audio Anthology, Radio Magazines, Inc., Mineola, N. Y., 1953.

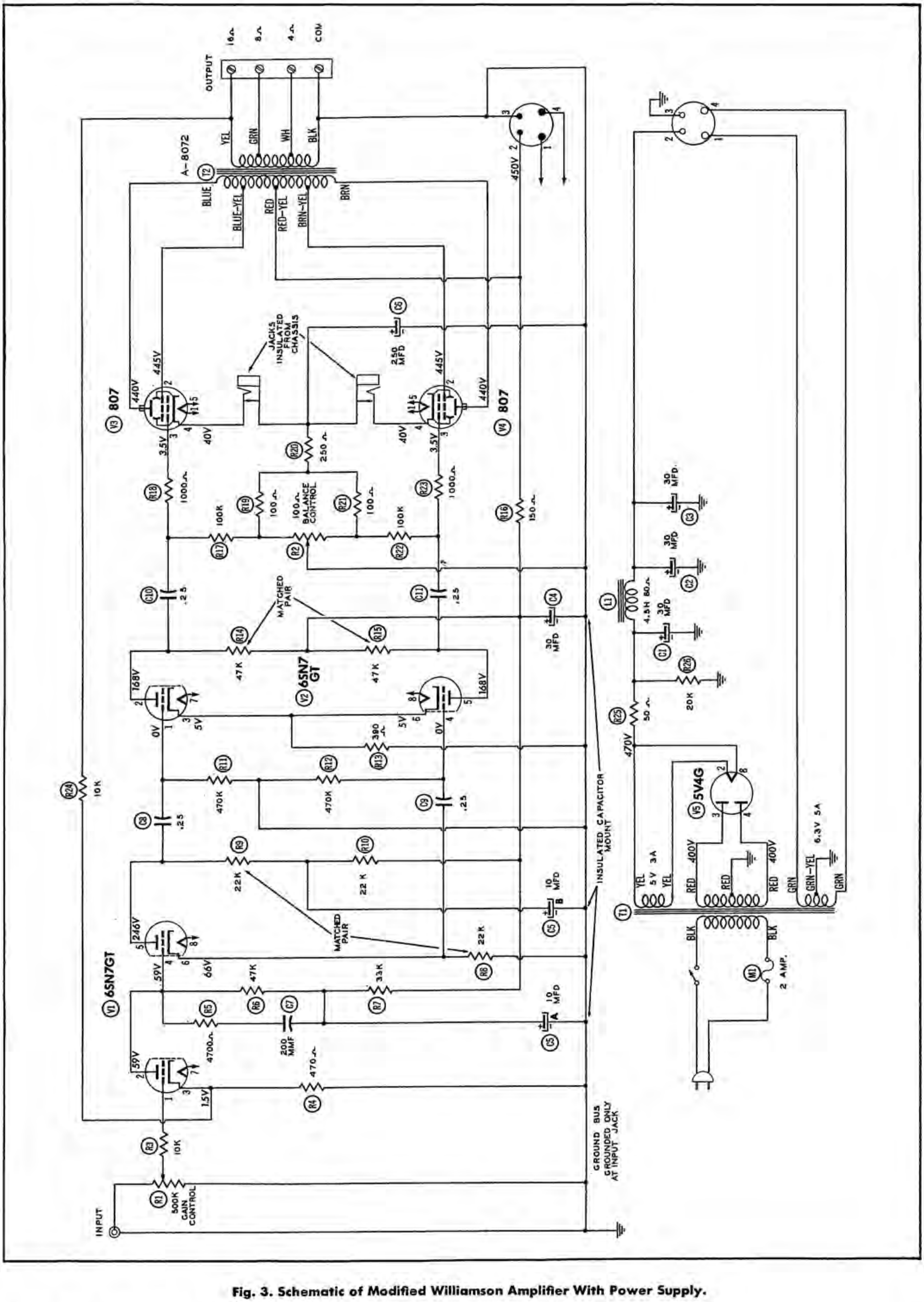

Fig. 3. Schematic of Modified Williamson Amplifier With Power Supply.

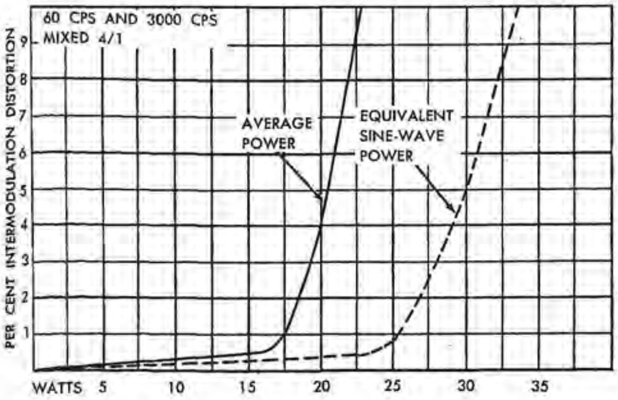

Fig. 4. Intermodulation Distortion Versus Power Output.

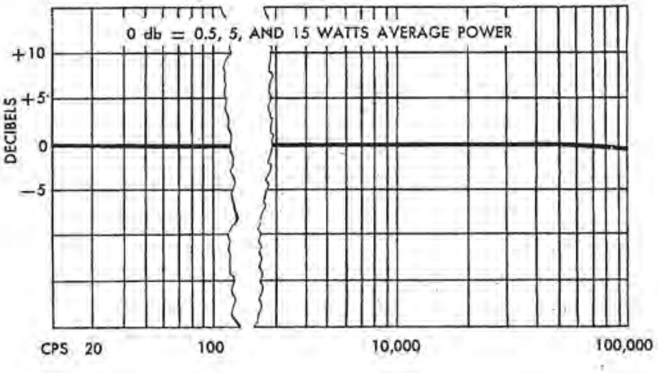

Fig. 5. Frequency Response at 0.5, 5, and 15 Watts Output.

A8072 high-fidelity output transformer (which was made by the Chicago Standard Transformer Corporation particularly for this type of service) and the power transformer, the filter choke, and two punched chassis (which were furnished by them for use in the Williamson amplifier).

The amplifier was assembled and wired according to the circuit shown in Fig. 3. A study of the schematic will reveal that very few modifications were actually made in the original circuit. After some discussion of these modifications we will then consider some of the things concerned with the construction and wiring.

Starting at the input R3, a 10,000-ohm resistor has been inserted in the grid circuit for increased stability when the input control is set at or very near maximum. R5 and C7 are connected across the plate load of the first stage to give a rolloff of the higher frequencies and minimize instability due to capacitive load effects. The values of C8 and C9 were increased from .05 mfd to .25 mfd in order to increase low-frequency stability.

C6, a 250-mfd 50-volt electrolytic capacitor, was connected from the cathodes of the output tubes to ground to reduce distortion, especially at the higher power levels. No suppressor resistors are employed in the screen circuits of the 807 type tube. The output transformer is connected directly to the screens and plates as shown in the schematic. The feedback resistor R24 has been increased in value to 10,000 ohms to maintain the 20 db of negative feedback to the input cathode.

No changes were made in the power supply, but it can be noted that a 5V4G has replaced the 5U4G. We have used a 5V4G in the Williamson for some time because it heats up to operating level in just about the same time required by the rest of the tubes. This eliminates the high-voltage surge present during the warm-up period when a filament type of tube, such as the 5U4G, is used. Also the increase in DC voltage available from the supply, because of the decreased drop across the 5V4G, improves operation. This is particularly helpful when line voltage is low.

The graph shown in Fig. 4, with the percentage of intermodulation distortion plotted against power output, clearly indicates the extended power output with low distortion. (Both average power and equivalent sine-wave power are shown to avoid confusion.) We have convinced ourselves that the listening qualities at low levels have also been improved.

It hardly seemed worth while to show the frequency-response curve (Fig. 5), since it is so flat at all power levels.

The amplifier chassis, as received, had a cutout for a three-terminal output strip as used with the Stancor A8054 transformer. Since the A8072 used has output taps for 4, 8 and 16 ohms, the cutout was enlarged to accommodate a four-terminal strip. We also installed a conventional phono jack in the hole punched for the microphone-cable connector originally used. This provided for the use of a phono plug and jack so commonly used in the sound systems.

All resistors and capacitors were mounted on terminal strips or on rigid mounts whenever possible, and some of the long leads were cabled. The cabling of these leads is not absolutely necessary; but knowing that this particular unit would receive considerable rough use, it was done to insure consistent, dependable service. The No. 14 solid wire ground bus also aids in this respect, besides preventing ground loops.

One- and two-watt resistors were used because of their ability to stand up under heat of soldering and also because they are less likely to change value or become noisy with hard usage as readily as lower-wattage resistors might.

All pairs of resistors and capacitors were carefully matched. Although R8 with R9 and R14 with R15 (as indicated on the schematic) are the most important ones, the matching of all pairs of coupling capacitors and grid resistors will do no harm;

H-4103

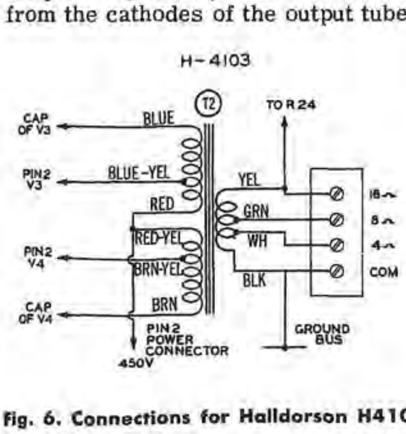

Fig. 6. Connections for Halldorson H4103 Output Transformer.

S-148A

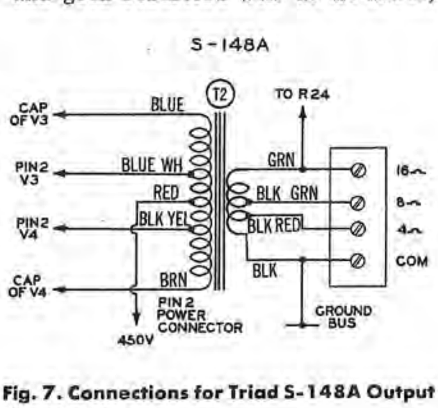

Fig. 7. Connections for Triad S-148A Output Transformer.

PARTS LIST

TUBES

V1	6SN7GT	V3	807	V5	5V4G
V2	6SN7GT	V4	807		

CAPACITORS

	Cap.	Volt.	Aerovox	Cornell-Dubilier	Mallory	Sprague	Note
C1	30	475	AFH1-56	A054	FP258*	TVL-1810	*15-15/475
C2	30	475	AFH1-56	A054	FP258*	TVL-1810	Parallel
C3	30	475	AFH1-56	A054	FP258*	TVL-1810	Sections
C4	30	475	AFH1-56	A054	FP258*	TVL-1810	
C5A	10	450	AFH2-47	B037	FP231	TVL-2750	
C5B	10	450	AFH2-47	B037	FP231	TVL-2750	
C6	250	50	PRS50/250	BRH5025	TC50025	TVA-1312	
C7	200	500	14680002	5W5T2	MC237	1FM-32	
C8	.25	600	684-25	CUB6P25	PT6025	6TM-P25	
C9	.25	600	684-25	CUB6P25	PT6025	6TM-P25	
C10	.25	600	684-25	CUB6P25	PT6025	6TM-P25	
C11	.25	600	684-25	CUB6P25	PT6025	6TM-P25	

CONTROLS

	Resistance	Watts	IRC	Clarostat	Centralab	Mallory
R1	500K	1/2	Q13-133	AG-60-Z FS3	B60	
R2	100Ω	2	W100	43-100	V121	

RESISTORS

	Resistance	Watts	IRC	
R3	10KΩ	1	BTA-10000	
R4	470Ω	1	BTA-470	
R5	4700Ω	1	BTA-4700	
R6	47KΩ	1	BTA-47000	
R7	33KΩ	1	BTA-33000	
R8	22KΩ	1	BTA-22000	Matched Pair
R9	22KΩ	1	BTA-22000	Matched Pair
R10	22KΩ	1	BTA-22000	
R11	470KΩ	1	BTA-.47 Meg	
R12	470KΩ	1	BTA-.47 Meg	
R13	390Ω	1	BTA-390	
R14	47KΩ	2	BTB-47000	Matched Pair
R15	47KΩ	2	BTB-47000	Matched Pair
R16	150Ω	10	1 3/4 A150	
R17	100KΩ	1	BTA-.1 Meg	
R18	1000Ω	1	BTA-1000	
R19	100Ω	1	BTA-100	
R20	250Ω	10	1 3/4 A250	
R21	100Ω	1	BTA-100	
R22	100KΩ	1	BTA-.1 Meg	
R23	1000Ω	1	BTA-1000	
R24	10KΩ	1	BTA-10000	
R25	50Ω	10	1 3/4 A50	
R26	20KΩ	20	2D-20000	

POWER TRANSFORMER

			PRI	Section 1	Section 2	Section 3
T1	Stancor	PC-8412	117V AC	800V CT .2A	5V AC 3A	6.3V AC CT 5A
	Merit	P-3155				
	Triad	R-21A				
	Halldorson	P9404				
	Thordarson	TS-24R07-U				

OUTPUT TRANSFORMER

		Primary Impedance	Secondary Impedance
T2	Stancor A-8072	7600	4, 8 and 16Ω
	Merit A-3101	10000	4, 8 and 16Ω
	Triad HSM-189	10000	4, 8 and 16Ω
	S-148A	10000	4, 8 and 16Ω
	Halldorson HA-4103	7400	4, 8 and 16Ω

FILTER CHOKE

		DC	DC Resistance	Inductance
L1	Stancor C-1411	200	80Ω	4.5
	Merit C-3196	200	80Ω	5
	Triad C-14A	200	150Ω	6
	Halldorson C-5031	200	80Ω	4.5
	Thordarson T20C55	200	75Ω	6

FUSES

	Type	Rating	Littelfuse Fuse	Littelfuse Holder	Buss Fuse	Buss Holder
M1	3AG	2A	312002	341001	AGC2	HKP

MISCELLANEOUS

1	WM-8 Set of Stancor Chassis or, Two Chassis 7in. x 9 in. x 2 in.	
1	Toggle Switch	
2	Closed-Circuit Jacks	
3	Octal Tube Sockets	
2	5-Prong Tube Sockets	
1	4-Prong Connector Socket	Amphenol 77-M1P4
1	4-Prong Connector	Amphenol 78-PF4
1	4-Prong Connector	Amphenol 86-PM4
1	4-Prong Connector	Amphenol 86-CP4
1	Phono Jack	
2	Plate Caps 3/8 in.	
	Output Terminal Strip, AC Line Cord, Miscellaneous Hardware, Etc.	

A STOCK GUIDE FOR TV TUBES

The figures in the chart below have been revised to include production of TV receivers since the compilation of the chart which appeared in PF INDEX and Technical Digest for September-October, 1953.

For an explanation of how this chart originated and for information on its recommended use, refer to PF INDEX and Technical Digest for May-June, 1953.

	46-53 Models	52 & 53 Models		46-53 Models	52 & 53 Models		46-53 Models	52 & 53 Models		46-53 Models	52 & 53 Models
1AX2#			6AT6	4	3	6BX7#			6W4GT	32	34
1B3GT	40	44	6AU5GT	4	4	6BZ7*	3	4	6W6GT	7	12
1V2	1		6AU6	135	125	6C4	10	10	6X5GT	1	1
1X2	6	2	6AV5GT	2	4	6CB6	94	138	6X8	3	5
1X2A	4	6	6AV6	14	16	6CD6G	7	9	6Y6G	3	1
5U4G	45	47	6AX4	3	2	6CL6	1	1	7C5	1	
5V4G	7		6AX5GT	2	3	6J5	3	3	7N7	2	1
5Y3GT	3	1	6BA6	16	11	6J5GT	2	1	12AT7	15	14
6AB4*	3	3	6BC5	11	7	6J6	34	31	12AU6	1	
6AC7	9	9	6BE6	5	6	6K6GT	17	10	12AU7	44	27
6AF4*	1	1	6BF5	1	1	6S4	8	10	12AV7	4	4
6AG5	37	11	6BG6G	15	7	6SH7	1		12AX4	2	4
6AG7	3	3	6BH6	8		6SL7GT	4	3	12AX7	4	5
6AH4GT	2	3	6BK5	1	2	6SN7GT	79	87	12AZ7	1	2
6AH6	8	10	6BK7*	4	7	6SN7GTA#			12BH7	8	12
6AK5	4	4	6BK7A*	1	1	6SQ7GT	3	3	12BX7#		
6AL5	77	79	6BL7GT	6	9	6T4*			12BY7	1	3
6AN4*			6BN6	3	3	6T8	14	15	12BZ7#		
6AQ5	12	13	6BQ6G#			6U4GT#			12SN7GT	7	5
6AQ7GT	2	2	6BQ6GT	16	26	6U8	4	7	25BQ6GT	3	5
6AS4*			6BQ7*	6	14	6V3	2	4	25L6GT	6	6
6AS5	2	2	6BQ7A*	1	1	6V6GT	22	20	25W4GT	2	2
									25Z6	1	
									5642	2	2

#New tubes recently introduced.

*A stock of these tubes should be maintained in UHF areas.

The Williamson Amplifier

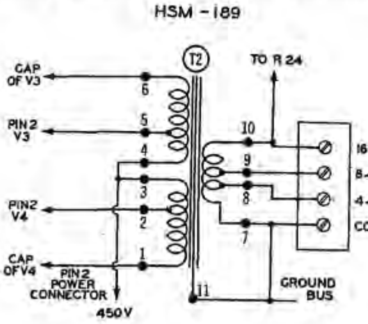

Fig. 8. Connections for Triad HSM-189 Output Transformer.

in fact, matching will aid greatly in achieving balance in the circuit and in obtaining satisfactory results under the most exacting requirements.

The 6SN7GT in the push-pull driver stage should be selected for equal output from its two sections in order to make possible the balancing of the complete circuit. A matched pair of 807's is just as important, if not even more so, for this same reason.

The Stancor A8072 transformer was used in this amplifier, but many others have been tested in this circuit with equally good results being obtained. This surely proves the merits of the circuit.

The Halldorson H4103 high-fidelity output transformer was also designed for use in this circuit. Excellent results were obtained when it was connected as shown in Fig. 6.

Triad output transformers S-148A and HSM189, designed for use in the original Williamson circuit, gave excellent results when used in this modified circuit as shown in Figs. 7 and 8 respectively.

Another output transformer, the Merit A3101, when connected as shown in Fig. 9, gave comparable results. Since the leads are not coded as to the start or finish of the windings, the plate and screen leads might be improperly connected in the first wiring. Such a connection provides a positive feedback resulting in violent oscillations. Trial will determine the correct connections.

As can be seen in the parts list included in these columns, these transformers vary as to primary

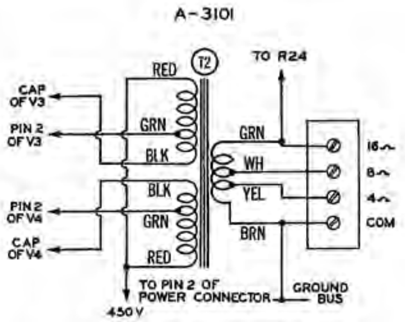

Fig. 9. Connections for Merit A-3101 Output Transformer.

impedance and placement of the taps. But improved operation, in comparison with that of the original Williamson, was obtained with every one when it was used in the modified circuit.

Results provided by an amplifier such as this further substantiate our feeling that it is no problem to find a good power amplifier to fill most any requirement.

Robert B. Dunham