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LOOSE LEAF PRICE AND DATA SHEETS

Announcements of New Sets and Accessories
Changes in Prices, Model Numbers, etc.
Circuit Diagrams and Curves of Late Model Receivers

INSERT THESE SHEETS INTO YOUR LOOSE LEAF BINDER

NOTES

Eastern List Prices of Heater and Filament Tube Sets

NOTE: RECTIFIER TUBES ARE NOT COUNTED IN LISTINGS BELOW.

MAKE	No. of Tubes	LIST PRICE
A-C DAYTON		
Batt. 98	7	79.00
AC-98	8	108.00
AC-9960	8	148.50
AC-9970	8	165.00
AC-9980	8	185.00
AC-9990	8	188.00
AC-99100	8	234.00
***ACME**		
77	6	115.00
88	7	139.50
***ALL AMER "LYRIC"**		
94-T10	9	145.00
95-T10	9	175.00
96-T70	9	147.00
***APEX (with tubes)**		
100-NU	7	95.00
140-NU	7	140.00
160-NU	8	160.00
60 Table	7	60.00
45 Battery	6	45.00
***AUDIOLA**		
8430	7	95.00
***BROWNING DRAKE**		
63 Table	9	98.00
666 Console	9	149.50
***BRUNSWICK**		
14	7	119.00
21	7	144.00
31 Phono. Comb.	7	239.00
BUSH & LANE		
20	7	125.00
21	7	169.50
30	7	169.50
32	7	179.50
40	7	179.50
50	7	197.50
60	7	199.50
70	7	207.50
90	7	217.50
10-C	7	250.00
11-C	7	290.00
12-C	7	297.50
COLUMBIA		
C-11	7	155.00
940 Comb.	7	297.50
CONTINENTAL "Star Raider"		
R-20	9	435.00
R-25	9	475.00
R-30	9	525.00
R-105	9	1,000.00
***CROSLEY**		
31	6	52.00
31, with Legs	6	57.50
41	7	70.00
41, with Legs	7	75.00
32	7	99.50
42	7	125.00
82-H	7	150.00
***DAYFAN**		
66	8	85.00
68	8	129.50
69	8	195.00
72	8	135.00
EDISON		
R-4	7	197.50
R-5	7	167.50
Comb. C-4	7	295.00
***FADA**		
Tbl.	7	99.50
***GRAYBAR**		
330	8	98.00
MAJESTIC		
90	7	95.00
91	7	116.00
92	7	146.00
93	7	146.00
101 Comb.	7	245.00
102 Comb.	7	184.00
103 Comb.	7	203.50
181 Comb	7	265.00
***MANDEL**		
Chassis	8	100.00
***PHILCO**		
Model 87 Line		
LoBoy	7	129.50
HiBoy	7	149.50
DeLuxe HiBoy	7	205.00
***PREMIER-Chas. only**		
601	6	45.00
771-M	7	66.00
745-D	7	70.00
845-D	8	74.00
PT-771-M	7	74.00
***RCA**		
33-AC, with Legs	6	54.00
33-DC—110-V, with Legs	6	64.00
18	6	80.25
60	8	98.00
64	8	550.00
66	7	225.00
***STEWART WARNER**		
35—900	7	142.50
58—900	7	165.50
Ensemble	7	123.25
Table	7	95.00
47—900	7	154.50
SPARTON		
49 Batt.	9	76.00
589	10	159.85
931	8	179.50
301	8	284.50
110	10	395.00
111	10	395.00
Comb. 101	11	795.00
Tubes included in all Sparton models.		
***STEINITE**		
Comb. 102	8	250.00
VICTOR		
R-32	8	155.00
R-52	8	215.00
Comb.	8	275.00
RE-75 Comb.	8	350.00

*Denotes this m facturer also builds screen-grid models.

Western List Prices of Heater and Filament Tube Sets

NOTE: RECTIFIER TUBES ARE NOT COUNTED IN LISTINGS BELOW.

MAKE	No. of Tubes	LIST PRICE
A-C DAYTON		
Batt. 98	7	Notcar'd
AC-98	8	Notcar'd
AC-9960	8	154.40
AC-9970	8	175.00
AC-9980	8	192.50
AC-9990	8	197.50
AC-99100	8	260.00
***ACME**		
77	6	115.00 Plus frt.
88	7	139.50 Plus frt.
ALL AMERICAN "LYRIC"		
94-T10	9	158.00
95-T10	9	190.50
96-T10	9	160.00
***APEX** (with tubes)		
100-NU	7	104.50
115-NU	7	124.50
140-NU	7	149.50
160-NU	8	169.50
60 Table	7	64.50
45 Batt.	6	49.50

MAKE	No. of Tubes	LIST PRICE
***AUDIOLA**		
8430	7	95.00 Plus frt.
***BROWNING DRAKE**		
63 Table	9	105.00
666 Console	9	149.50
***BRUNSWICK**		
14	7	119.00
21	7	144.00
31 Phono. Comb.	7	239.00
COLUMBIA		
C-11	7	155.00
940 Comb.	7	297.50
CONTINENTAL "Star Raider"	(Add	Freight)
R-20	9	435.00
R-25	9	475.00
R-30	9	525.00
R-105	9	1,000.00
***CROSLEY**		
31	6	57.00
31, with Legs	6	62.50
41	7	73.00
41, with Legs	7	78.50
32	7	105.00
42	7	130.00
82-H	7	155.00

MAKE	No. of Tubes	LIST PRICE
***DAYFAN**		
66	8	95.00
68	8	139.50
69	8	205.00
72	8	145.00
EDISON		
R-4	7	223.00
R-5	7	177.00
Comb. C-4	7	336.00
***FADA**		
Table	7	104.50
***GRAYBAR**		
330	8	98.00
MAJESTIC		
90	7	95.00
91	7	116.00
92	7	146.00
93	7	146.00
101 Comb.	7	245.00
102 Comb.	7	184.00
103 Comb.	7	203.50
181 Comb.	7	265.00

MAKE	No. of Tubes	LIST PRICE
***MANDEL**		
Chassis	8	100.00
***PHILCO**		
Model 87 Line		
LoBoy	7	139.50
HiBoy	7	159.50
DeLuxe HiBoy	7	215.00
***PREMIER**		
Chassis only.	(Add	Freight)
601	6	45.00
771-M	7	66.00
745-D	7	70.00
845-D	8	74.00
PT-771-M	7	74.00
***RCA**		
33, with Legs	6	54.00
33-DC-110-V, with Legs	6	64.00
18	6	80.25
60	8	98.00
64	8	550.00
66	7	225.00

MAKE	No. of Tubes	LIST PRICE
***SENTINEL**		
See Screen Grid Data Sheets. Other sets discontinued.		
SPARTON		
49 Batt	9	Notst'kd
589	10	169.85
931	8	189.50
301	8	294.50
110	10	415.00
111	10	415.00
Comb. 101	11	845.00
Tubes included in all Sparton models.		
***STEWART WARNER**		
35-900	7	147.00
47-900	7	159.25
58-900	7	170.50
Ensemble	7	128.50
Table	7	97.50
***STEINITE**		
102 Comb.	8	268.00
VICTOR		
R-32	8	155.00
R-52	8	215.00
Comb.	8	275.00
RE 75 Comb.	8	350.00

*Denotes this manufacturer also builds screen-grid models.

EASTERN LIST PRICES OF SCREEN-GRID SETS

NOTE: RECTIFIER TUBES ARE NOT COUNTED IN LISTINGS BELOW.

MAKE	No. of Tubes	LIST PRICE
•ACME		
78	6	130.50
88-SG	7	77.00
•ALL AMERICAN LYRIC		
94-SG	7	153.00
95-SG	7	183.00
96-SG	7	155.00
AMERICAN BOSCH		
17	6	230.00
18	6	240.00
19	6	280.00
"L"	6	230.00
"R"	6	280.00
Table 48	6	119.50
Table 48-A	6	168.50
"J"	6	240.00
Automobile	..	140.00
AMRAD		
Aria	7	198.00
Serenata	7	245.00
Symphony	7	295.00
Duet (Comb.)	7	495.00
Minuet	7	158.00
•ANDREA FADA		
15-M Chass.	7	115.00
15-MZ Chass. (25-40 cycle)	7	115.00
25	6	165.00
35-C	7	220.00
35-B	7	255.00
75	7	360.00
77 Comb.	7	675.00
•APEX (with tubes)		
11	6	124.50
14	6	149.50

MAKE	No. of Tubes	LIST PRICE
ATWATER KENT		
55-C, Chassis	6	64.00
55 Table	6	68.00
25 Cycle Chassis	6	64.00
25 Cycle Table	6	68.00
60 Chassis	7	76.00
60 Table	7	80.00
66 Chassis	7	110.00
Chass. DC, 61-C	7	76.00
Table DC, 61	7	80.00
Batt. Chassis 67	7	58.00
Batt. Table 67	7	62.00
AUTOMATIC TOM THUMB PORTABLES		
B	4	57.50
DeLuxe	4	65.00
DC	4	87.50
AC	4	95.00
BALDWIN		
Chassis	6	On req'st
Low Boy	6	198.00
High Boy	6	219.00
Model 60	6	157.50
•BROWNING DRAKE		
56	9	154.50
53 Table	9	102.50
•BRUNSWICK		
S-14	7	129.00
S-21	7	154.00
S-31	7	249.00
COLONIAL		
Cavalier	7	175.00
Picadilly	7	175.00
Modern	7	235.00
•CROSLEY		
30-S Chassis	6	62.00
31-S	6	56.50
33-S	6	112.00

MAKE	No. of Tubes	LIST PRICE
34-S	6	116.00
40-S	7	80.00
41-S	7	65.85
42-S	7	126.00
82-S	7	160.00
•DAY-FAN		
93	6	159.50
94	6	210.00
•GRAYBAR		
330 Table	8	98.50
330-F-45	8	175.25
500 Table	4	75.00
550	4	130.00
600	7	225.00
GREBE		
21950-A	6	219.50
270-C	6	270.00
285-A	6	285.00
Comb. 450	6	450.00
GULBRANSEN		
291	8	139.50
292	8	149.50
200 (Comb.)	8	235.00
HOWARD		
Consolette	6	185.00
Puritan	6	210.00
Hepplwth	6	245.00
Florentine	6	275.00
Gothic	6	275.00
KELLOGG		
523	8	175.00
524	8	225.00
525 Comb.	8	395.00
•KENNEDY		
220	7	159.00
320	7	189.00

MAKE	No. of Tubes	LIST PRICE
KOLSTER		
K-43	7	175.00
K-44	7	260.00
K-45	9	500.00
•PHILCO		
"SCREEN GRID PLUS" LINE		
Table 95	8	97.00
LoBoy	8	149.50
HiBoy	8	169.50
DeLuxe	8	225.00
New "76" Line		
76 Table	6	67.00
76 Console	6	112.00
76 Lowboy	6	119.50
76 Highboy	6	139.50
76 Hiboy DeLuxe	6	195.00
•PREMIER		
724	7	On Request
•RCA		
Radio Victor		
44	4	75.00
46	4	130.00
21 Batt.	5	69.50
22 Batt.	5	135.00
Comb. 47	4	275.00
Comb. 67	8	690.00
SILVER		
60	7	160.00
60-B	7	145.00
75	7	173.00
75-B	7	158.00
95	7	195.00
95-B	7	145.00
•STEWART WARNER		
Cabin't 35, M'd 950	7	142.50
Sher'tn 58, M'd 950	7	165.50
Consolette Ens'ble	7	123.25
Table Model	7	95.00
Model 47—950	7	154.50

MAKE	No. of Tubes	LIST PRICE
•STEINITE		
70	6	118.00
80	6	149.50
•STERLING		
Troubador	7	129.50
Serenader	7	149.50
Imperial	7	187.50
STROMBERG CARLSON		
641	5	155.00
25 cy. 641	5	155.00
642	5	259.00
25 cy. 642	5	247.50
846	8	347.50
654 Combination	5	369.00
652 Low Console	5	239.00
•SENTINEL		
444	6	89.50
666	8	99.50
Comb. 666-C	8	149.50
TRAV-LER (Portable)		
Standard	5	65.00
DeLuxe	5	75.00
Aristocrat	5	100.00
WARE		
Trianon Chass.	5	125.00
Table	5	135.00
ZENITH		
52	8	175.00
53	8	250.00
54	8	370.00
55 Comb.	8	700.00
57	8	495.00
62	8	185.00
64	8	370.00
67	8	495.00
563-DC	11	250.00
Super Midget	8	145.00

•Denotes this m[illegible]acturer also builds non-screen-grid models.

WESTERN LIST PRICES OF SCREEN-GRID SETS

NOTE: RECTIFIER TUBES ARE NOT COUNTED IN LISTINGS BELOW.

MAKE	No. of Tubes	LIST PRICE
***ACME**		
78	6	130.50 Plus frt.
88-SG	7	77.00
***ALL AMER"LYRIC"**		
94-SG	7	166.00
95-SG	7	198.50
96-SG	7	168.00
American BOSCH		
16	6	205.50
17	6	237.00
18	6	248.00
19	6	290.00
"L"	6	238.00
"R"	6	290.00
Table 48	6	122.50
Table 48-A	6	172.50
"J"	6	248.00
Automobile Price not yet available.		
WESTERN CONSOLES		
140	6	174.50
141	6	154.50
149	6	194.50
AMRAD		
Aria	7	213.00
Serenata	7	260.00
Symphony	7	310.00
Duet (Comb.)	7	520.00
Minuet	7	163.00
***ANDREA-FADA**		
15-M Chassis	7	120.00
15-MZ (25-40 cy.)	7	120.00
25	6	172.00
35-C	7	227.00
35-B	7	265.00
75	7	370.00
77 Comb.	7	695.00
***APEX** (with tubes)		
11	6	124.50
14	6	149.50

MAKE	No. of Tubes	LIST PRICE
ATWATER KENT		
55-C, Chassis	6	67.00
55 Table	6	71.00
60 Chassis	7	81.00
60 Table	7	84.00
66 Chassis	7	115.00
Chass. DC. 61C	7	61.00
Tbl D C. 61	7	65.00
ARCO		Plus frt.
Chassis	8	75.00
***AUDIOLA**		
Chassis	6	85.00
AUTOMATIC TOM THUMB PORTABLES		
B	4	60.00
DeLuxe	4	67.50
DC	4	90.00
AC	4	99.00
BALDWIN		
Chassis	6	On req's
Low Boy	6	198.00
Highboy	6	219.00
Model 60	6	157.50
***BROWNING DRAKE**		
56	9	154.50
53 Table	9	109.50
***BRUNSWICK**		
S-14	7	129.00
S-21	7	154.00
S-31	7	249.00
COLONIAL (Add Freight)		
Cavalier	7	175.00
Piccadilly	7	175.00
Modern	7	235.00

MAKE	No. of Tubes	LIST PRICE
***CROSLEY**		
31-S	6	94.00
33-S	6	108.50
34-S	6	119.50
41-S	7	106.20
42-S	7	129.50
43-S	7	118.50
82-S	7	149.50
***DAY-FAN**		
93	6	169.50
94	6	220.00
GILFILLAN		
Console	8	156.50
Console	8	175.50
Console	8	187.00
***GRAYBAR**		
330 Table	8	98.50
330-F-45	8	175.25
500 Table	4	75.00
550	4	130.00
600	7	225.00
GREBE		
21950-A	6	223.50
270-C	6	274.00
285-A	6	292.00
Comb. 450	6	465.00
GULBRANSEN		
291	8	149.50
292	8	159.50
200 Comb.	8	235.00
HOWARD		
Consolette	6	195.50
Puritan	6	220.50
Hepplwth	6	255.50
Florentine	6	285.50
Gothic	6	285.50

MAKE	No. of Tubes	LIST PRICE
KELLOGG		
523	8	190.00
524	8	240.00
Comb. 525	8	415.00
***KENNEDY**		
220	7	159.00
320	7	189.00
KOLSTER		
K-43	7	188.00
K-44	7	275.00
K-45	9	522.50
***PHILCO**		
"Screen Grid Plus" Line		
Table 95	8	102.00
LoBoy	8	159.50
HiBoy	8	179.50
DeLuxe	8	235.00
New "76" Line		
76 Table	6	72.00
76 Console	6	119.50
76 Lowboy	6	129.50
76 Highboy	6	149.50
76 Hiboy DeLuxe	6	205.00
***PREMIER**		
724	7	On Request
***RCA Radio Victor**		
44	4	75.00
46	4	130.00
Batt 21	5	69.50
Batt 22	5	135.00
Comb. 47	4	275.00
Comb. 67	8	690.00
***SENTINEL**		
444	6	89.50
666	8	99.50
Comb. 666-C	8	149.50

MAKE	No. of Tubes	LIST PRICE
SILVER		
60	7	170.00
Concert Grand	7	183.00
95	7	210.00
Special Cabinets for Coast only.		
"Princess"	7	170.50
"Aristocrat"	7	195.00
"De Luxe"	7	216.00
***STERLING**		
Troubador	7	139.50
Serenader	7	165.00
Imperial	7	201.00
***STEWARTWARNER**		
Cabin't 35, M'd 950	7	147.00
Sher't'n 58, M'd 950	7	170.50
Consolette ens'ble.	7	128.50
Table Model	7	97.50
Mod. 47-950	7	159.25
***STEINITE**		
70	6	125.00
80	6	157.50
STROMBERG CARLSON		
641	5	165.00
25 cy. 641	5	165.00
642	5	277.00
25 cy. 642	5	272.50
846	8	377.50
654 Combination	5	387.00
652 Low Console	5	257.00
ZENITH (with tubes)		
52	8	225.00
53	8	300.00
54	8	425.00
55 Comb.	8	750.00
60	8	188.00
61	8	198.00
62	8	235.00
64	8	420.00
67	8	545.00

*Denotes this manufacturer also builds non-screen-grid models.

ELIMINATION OF LINE HUM

By N. EARL BORCH

MANY cases of bad a-c hum are due entirely to external causes and not to any fault in the filter system of the receiver so troubled. Although this is commonly known as "60-cycle" hum and is caused by that frequency, the hum which is heard is that of 180 cycles, the third harmonic of 60 cycles.

A 60-cycle current reverses its direction 120 times a second, the current value rising to a maximum and falling back to zero this number of times. Likewise, the magnetic field which surrounds the supply wires alternately rises to a maximum and collapses to zero 120 times a second. The third harmonic of this 60-cycle frequency, 180 cycles per second, is within the band of frequencies which are reproduced by the radio amplifier and heard by the ear.

Consequently, when any magnetic field variation at this frequency is impressed upon any sensitive part of the receiver, it may be heard as a hum in the loudspeaker. The intensity of this hum will depend entirely upon the amount of coupling between the sensitive parts of the receiver (including aerial and ground) and the strength of the magnetic field. The greater the current flowing, the greater will be the intensity of the magnetic field and the more energy pick-up may be had. Also, the closer the sensitive parts of the receiver are to the source, the greater will be the pick-up. Generally, the higher the voltage in the circuit, the greater the power consumption, and the greater are the precautions necessary to prevent interference from such a source.

Assuming that the receiver itself is entirely free from hum, the service man is required to locate the external cause and, if possible, to eliminate its effect. In the order of their importance the most commonly found causes of such hum are as follows:

1. Improperly grounded neutral power wire.
2. Receiver too close to high tension lines carrying heavy current.
3. Coupling between aerial lead-in or ground wire with some electrical circuit carrying a heavy current.
4. Poor ground connection to the radio receiver.
5. Pick-up between any of the sensitive parts of the receiver itself and a source of heavy magnetic field variation.
6. Aerial running parallel and close to high tension lines.
7. Inside aerial running parallel to and close to wiring of the building.
8. Loudspeaker leads being coupled magnetically to electrical circuit in building.

If the neutral of the power wire is improperly grounded the line will be in an unbalanced condition and bad hum is often heard from the loudspeaker, particularly coming in on the carrier wave from the broadcast station. This condition may be checked by means of a test lamp, which should be rated at 220 volts. One connection from the lamp is made to the nearest water pipe, and the other connection alternately touched to the two or three wires of the service to the building. In the case of a three-wire service, the neutral wire should be the center one at the service switch, the two outside leads being known as the "hot" leads. When the lamp is connected to one of the hot leads and the water pipe it should glow at full brilliancy, just as it will when connected from one of the hot leads to the neutral. If, when connected between the hot lead and the water pipe it does not glow, the neutral wire is not grounded, and if it glows dully, the resistance between the neutral and the water pipe is too high and a new

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wire should be run in. This work should comply with local city ordinances pertaining to it.

If the receiver is located close to a circuit carrying a heavy electric current, the resultant magnetic field may be dense enough to induce a current into exposed sensitive parts of the receiver. (If the receiver is thoroughly shielded, this is rarely the case.) This condition may be determined by means of a compass. If the needle movement is erratic, upon bringing it near the receiver or the walls of the room, a different location must be found for the receiver in order to stop the hum.

Wherever possible, the aerial lead-in and ground wire should be run outside the building and far enough away from its walls to be separated at least one foot from all electrical circuits, particularly so if the wiring is of the open skeleton type, with porcelain knobs and tubes used to insulate the wires from surrounding walls and floors. If hum is had from receivers in apartment houses having built-in aerials, the erection of a separate aerial will be found necessary.

Many receivers will give a hum if no ground wire is used. This may be due to a poor neutral ground as explained above or to the electrical characteristics of the receiver itself. Sometimes this is reduced by reversing the attachment plug on the power input to the receiver. A pipe is not always a good ground, and, in all cases where possible, an independent ground should be used.

Line hum is sometimes confused with the hum from the commutator of a high-voltage alternator which is connected to a substation by means of a transmission line without an intermediate transformer. A very heavy field usually surrounds lines of this character and great care is necessary in the installation of a receiver if hum is to be avoided. The frequency of such commutator hum is greater than 180 cycles and the intensity of the sound remains constant while a portable receiver is carried along parallel to the line. Thus it can be identified and distinguished from the ordinary line hum.

There are several other misconceptions about so-called line-hum which should be corrected. One favorite contention of radio men is that in an overloaded transformer the vibration of the core laminations sets up a fluctuating magnetic field which causes a hum in neighboring receivers. Another contention is that a hum is produced by a phase displacement in the supply line.

The latter is obviously impossible if no frequency is at hand to beat with the fundamental or its harmonics. In a very few localities where several supply frequencies are used, such as 25 and 60 cycles, such beat frequencies might be produced and heard as a hum. But such localities are very rare. The author has verified this theory by a series of practical tests in which severe phase displacement was purposely introduced, but could cause no hum.

In order to test the former contention as well as to determine under what conditions a line hum may be introduced, the author made an exhaustive series of tests over a long period of time in a power company's laboratory. These tests were made on a large number of commercial transformers of from 1½ to 25 kw capacity, with single and banked connections, single and triple phase. Loads of from 10 to 300 per cent of full load were applied and the transformers operated until they were so hot that they could not be touched with the bare hand.

These tests showed that even when the core hum could be heard for several hundred yards, no hum could be picked up by a receiver placed within four feet of the transformer. Furthermore no line hum could be produced if any possibility of magnetic coupling were removed and if the neutral power wire were properly grounded.

Circuit Analysis of Stromberg-Carlson No. 846 Receiver

THIS is a seven-tube receiver with three stages of tuned r-f amplification, power detector and two stages of transformer coupled a-f amplification, the last of which is in push-pull. In the r-f stages '24 tubes are used, '27s as detector and first audio and '45s in the power stage. An additional '27 tube is used as an automatic volume control and one '80 is employed to supply the rectified voltages for the plates, grids and screen grids, while another supplies the voltage to the field winding of the dynamic speaker.

The antenna inductance is high, resonating the antenna circuit below the broadcast frequency spectrum, so that variation of inductance or capacity in the antenna will have no effect upon the alignment of the tuned circuits which follow. Across the primary of the first transformer, or antenna coil, are connected a 20,000 ohm potentiometer and a 10 ohm resistor. The moving arm of the former goes to ground, shunting out a portion of the potentiometer and decreasing the antenna pickup, hence the sensitivity of the receiver, as it shunts. The 10 ohm resistor is so located as to avoid an absolute shunting of the coil. In order to prevent the overall sensitivity curve from changing shape as the sensitivity is reduced, a 500 ohm resistor in series with a .00025 μf condenser is connected between the ground and the other junction of the coil and potentiometer.

The three r-f grid circuits are identical and are tuned by means of three of the gang condensers. An unusual feature in these circuits is the .00025 μf condenser which keeps the bias voltage out of the secondary coil. The bias is supplied to the grid, through 5 MΩ grid resistors, from two points in the automatic volume control output circuit for the first two stages and direct from the cathode resistor in the case of the third. A 390 ohm resistor in each of the first two cathode leads supplies the minimum bias to the first two tubes, a 600 ohm bias resistor supplying the grid of the third tube.

The three r-f plates are supplied from a tap in the voltage divider; the screen grids from another tap. Each plate, screen grid, cathode and grid bias supply lead is bypassed to ground through a .3 μf condenser.

The linear power detector has a grid circuit similar to those of the r-f tubes except for the grid condenser. In this case the grid bias is supplied direct from a 15,000 ohm resistor in the cathode circuit. A connection from the junction of the cathode resistor and the grid return, to the grid resistor of the automatic volume control tube, and to the extreme negative end of the voltage divider serves as the grid return of the volume control tube and provides a return path for the plate circuit of the detector.

The output of the detector is filtered through a choke and two bridging condensers and supplied to the grid of the first a-f tube through an audio transformer, across the secondary of which is connected a 250,000 ohm potentiometer for manual volume control. A phonograph pick-up jack and pick-up switch are inserted at this point. Grid bias is supplied the first audio tube by means of a 1500 ohm resistor between cathode and ground. The grid return passes through the secondary of the transformer and the pick-up switch to ground.

Transformer coupling is again used between the first and second a-f stages. Although the grid return seems to go to the negative end of the voltage divider in this case, it returns direct to the fila-

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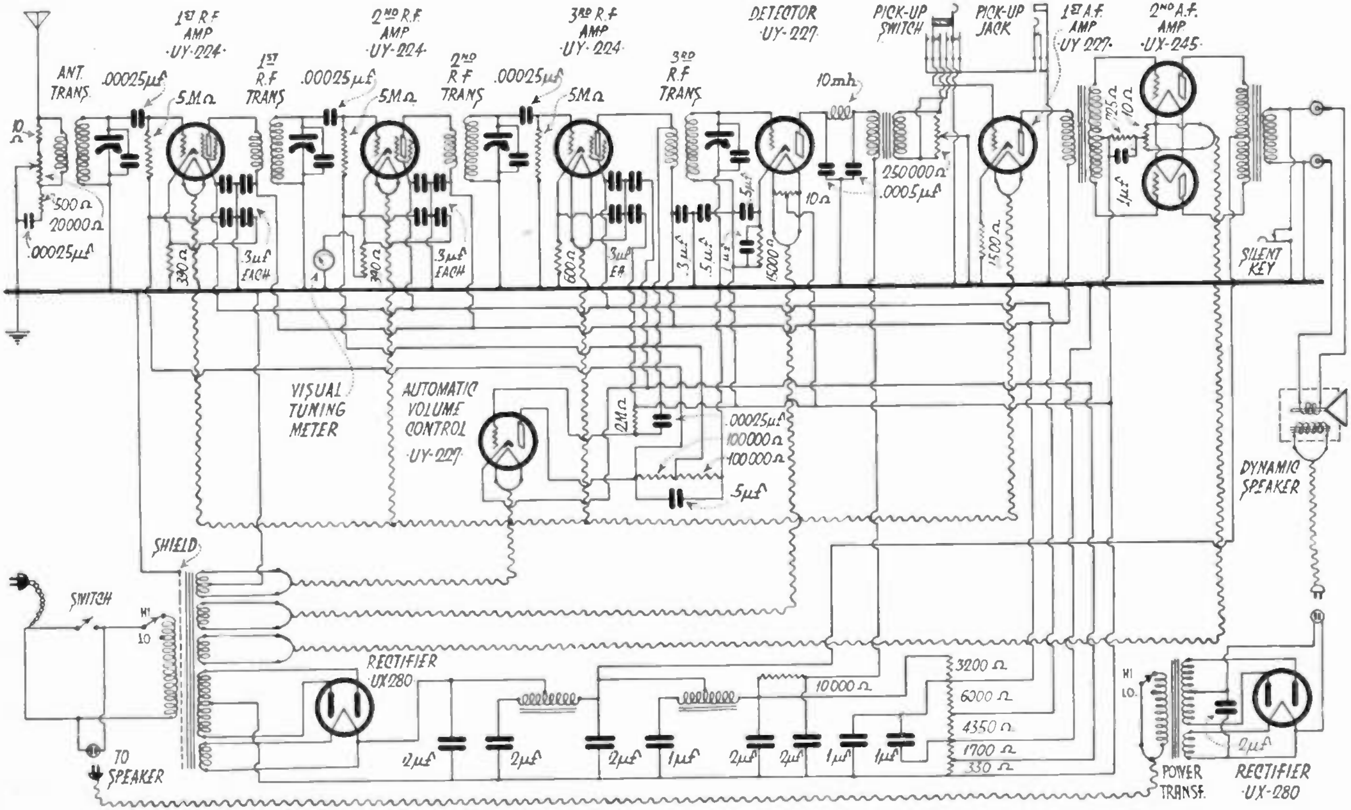
Circuit Diagram of Stromberg-Carlson No. 846 Receiver



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ment center-tap through the 725 ohm resistor between the latter and the transformer secondary center tap. The connection from the transformer secondary to the voltage divider merely provides a path for the plate current as in the case of the detector biasing arrangement.

The output transformer is incorporated in the set proper, and a shunting switch is connected across its secondary so that the signal may be kept out of the speaker while the tuning meter is being adjusted.

The grid of the automatic volume control tube is supplied with signal frequency voltage from the third r-f amplifier plate through a .00025 μf condenser. Grid bias is taken from the 330 ohm unit on the negative end of the voltage divider. The cathode is connected to the first tap in this divider, giving it a positive potential with respect to the grid and a negative potential with respect to the plate, the latter being connected to ground, or the third tap in the voltage divider. The grid lead is bypassed to ground through a .3 μf condenser, while a .5 μf condenser bypasses the two 100,000-ohm resistors which connect the plate to ground, in order to prevent r-f coupling.

When a certain signal strength is impressed upon the grid of the control tube, plate current will start to flow. When this direct current is flowing through the two 100,000 ohm resistors a voltage drop occurs in them. As this voltage is negative with respect to ground and to the cathodes of the r-f amplifiers, it is used to add to the biases of the first two r-f tubes. It is tapered so that the bias on the first may be greater than that on the second. When a signal is received these biases increase and tend to decrease the strength of the signal supplied from the first two r-f amplifiers to the third and consequently to the control tube and detector. Finally an equilibrium is reached where the bias takes a value in proportion to the strength of the signal and the signal strength at the detector is kept substantially uniform.

Due to the fact that the peak of the audible signal has been flattened out by the automatic volume control, it is practically impossible to determine the exact resonance point by ear. It is therefore necessary to have a visual means of locating this point. The visual tuning meter in this receiver is merely a milliammeter, mounted upside-down, in the cathode circuit of the second r-f tube. It measures the plate current of this tube.

When the signal is increased the grid bias is increased and the plate current is decreased. With the meter in its upside-down position, the "off" position is at the right. When the receiver is turned on and no signal is being received, the meter needle goes over to the left, indicating maximum plate current. As the signal is tuned in, the bias increases, dropping the plate current and allowing the indicator to return to the right. When the needle reaches the maximum deflection to the right (minimum plate current) it shows that the receiver is tuned to resonance with the carrier. It is important that this means of adjustment be thoroughly understood by the user because distortion will result if true resonance is not obtained.

The power supply is conventional except for the fact that a portion of each of the two chokes is used as a reversed winding or bucking coil in order to minimize the a-c hum. Plate supply for the two power tubes is taken from the low potential side of the first choke; that for the detector from the low side of the second choke, through a 10,000 ohm resistor. A voltage divider is connected across the output of the second choke and the negative lead, the first section supplying the plates of the r-f and first a-f tubes, the second supplying the screen grids of the r-f tubes, the third serving as *B* negative for the r-f,

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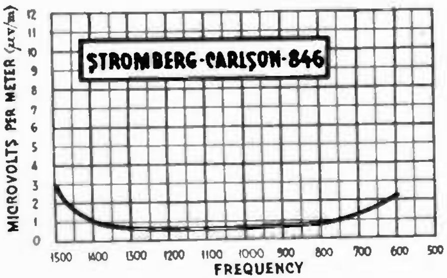
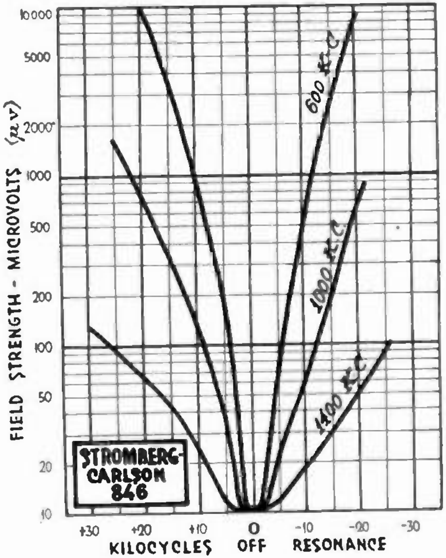
detector and a-f tubes and as *B* positive for the volume control tube (this is the ground lead). The fourth tap gives the cathode of the automatic volume control tube a negative potential with respect to its plate and a positive potential with respect to its grid, the latter being returned to the extreme negative end of the divider.

A separate power transformer and '80 rectifier tube serve to energize the field winding of the speaker. No filter, other than a single 2 μf condenser, is necessary in this power unit.



Stromberg-Carlson Sensitivity Curve

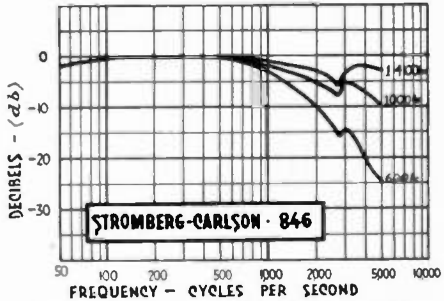
The sensitivity of the Stromberg-Carlson receiver involves a painful waste of graph paper. It almost shoves the zero line off the scale. At its weakest end, 1500 kc, a 3 microvolt per meter signal will be picked up and reproduced with average room volume (50 mw). From 1350 kc to 800 kc the curve is flat, and low enough to indicate that the receiver should pick up street-car flashes from Greenland's icy mountains to the burning wastes of the Sahara.



Stromberg-Carlson Selectivity Curves

Normal selectivity is found in the Stromberg-Carlson 846 receiver. The 1400 kc curve is a little flat, but not unusually so. With a resonant signal on 1400 kc of 10 microvolts it will be seen that a station 30 kc away would have to have a field strength of 130 microvolts in order to completely rout the selected station. This is a ratio of 13 to 1.

It was necessary to peak the receiver at 10 microvolts instead of the usual 100 due to the fact that the automatic volume control limited the output of the set at the latter figure, rendering the tests useless. At 10 microvolts the automatic volume control had not commenced to take effect, this system being unnecessary at such extremely low input voltage.



Fidelity Curve of Stromberg-Carlson

The Stromberg-Carlson has a peculiar fidelity curve. Bass notes, down to 50 cycles and possibly lower, are hardly dropped at all, and the higher frequencies begin to drop around 1000 cycles, very gradually, until at 2700 cycles they take a new lease on life and make a jump of from 1½ to 4 decibels. At 3100 cycles the 600 kc curve becomes the victim of side-band cutting and starts downward, the higher frequency curves staying up very well. The dip shown in the three curves may be the result of a sudden attenuation at 2700 cycles, but is more likely due to a resonant peak immediately following. In any event the overall average of each curve is good.

Engineering the Public Address Installation

By J. GARRICK EISENBERG

THE engineering problems encountered in the installation of a public address system differ somewhat from those met in putting in an ordinary broadcast receiver and require a more specialized knowledge. They may be classified under three heads: design, operation and acoustics.

The problems in design involve the selection of adequate equipment to suit the specific requirements of each installation. It also includes the proper matching of terminal impedances and the equalization of transmission lines.

The operating problems are concerned with the method of controlling gain, fader circuits and volume-indicating circuits. The acoustical problems to be solved are the uniform distribution of sound and the modification of echo and reverberation effects.

Selection of Equipment

THE selection of equipment for any particular installation should not be difficult as there are a number of good commercial public address amplifiers on the market. These vary from about 60 TU to 100 TU in gain, and from about 15 to 25 watts in power handling capacity. They may be purchased as individual units and assembled in rack form along with the associated meter and control panels, or the complete public address system, ready for wiring up to input and output devices, may be had at quite nominal cost.

Some variation exists in input coupling and volume control requirements, depending on the nature of the service involved. For this reason the individual unit assembly sometimes offers better flexibility in operation. In either case the equipment used is of conventional design with three stages of amplification. The output stage, and in some makes the intermediate stage also, is in push-pull arrangement.

The choice of amplifier size is dependent upon the actual power requirements of the job in hand. This translates itself into the number of speakers necessary to adequately serve the installation. Although there is no strict data available on the subject, prior experience affords a practical basis of judging comparative requirements. The table herewith may serve as a fair indication of the number of speakers and the size of amplifier required for any ordinary installation. It is drawn on the basis of indoor installations, in auditoriums in

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Table of Speaker and Amplifier Requirements

Audience	No. Speakers	Amplifier Output	Output Circuit
1500-2500	4	15 watts	2–'50s P.P.
2500-4000	6-8	15 watts	2–'50s P.P.
4000-6000	10-12	25 watts	4 '50s Parallel P.P.
6000-10,000	12-15	25 watts	4 '50s Parallel P.P.

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which the seating capacity is fairly large for the volume of the room, which is the usual condition encountered. For outdoor installations, the number of speakers and the power handling capacities of the amplifier will probably have to be increased to obtain the same results.

Electro-dynamic speakers, either cone type or straight diaphragm with exponential horn, are used; these will handle from 3 to 7 watts per speaker of undistorted energy. They should not be worked at a point too nearly approaching their maximum capacities. There is a general tendency to underpower the installation, which practice should be studiously avoided. Allowing a 25 per cent minimum safety factor against the highest estimated load conditions at any time will obviate the possibility of distortion due to amplifier or speaker overloads.

The number of speakers given in the chart is based on the minimum requirement for any given installation; the larger the number of speakers used the better will be the coverage, and the longer the speaker life. For outdoor installations as many as 16 speakers may be operated from a single amplifier; the speakers may be grouped together, two to four speakers to the group, and the several groups should be so located that the time lag between them will not be serious. This arrangement will cover a stadium or grandstand having a capacity

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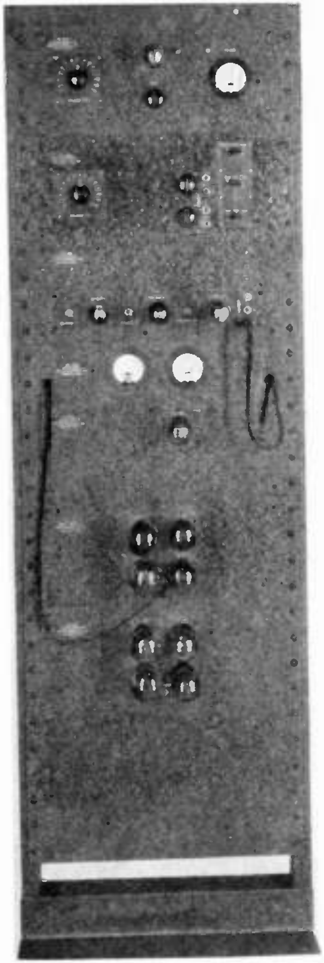
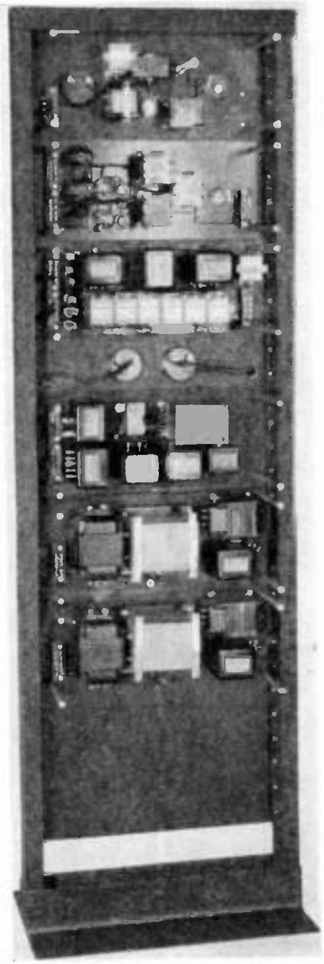


Front and Rear Views of Typical Unit Assembly System With Two 50-Watt Amplifiers in Parallel and Push-Pull.



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of from 10,000 to 15,000. For very large stadiums two or more amplifiers should be used, their input circuits being paralleled; each amplifier will of course feed its own banks of speakers independently.

Transmission Line Design

WITH the proper equipment selected, the real engineering problem is the design of a suitable transmission line between amplifier and speakers. These are usually separated by some considerable distance and coupling them together means the attentuation of a good many of the higher audio frequencies, due to the capacity and impedance of the line. Another factor is the introduction of certain peak or resonant frequencies, since this line forms the equivalent of a shunt-tuned circuit. Finally, there is the consideration of proper terminal impedances, in order to obtain maximum undistorted energy transfer.

The mathematics of this latter problem, incidentally, are the same as for power output considerations for a vacuum tube, since with moving coil speakers the impedance of the load does not vary materially with the frequency. The line terminal impedances should be equal at either end. They should be kept as low as possible to prevent pick-up of parasitic noises and shunt losses introduced by the line.

The usual practice is to connect the moving coils of the various loud speakers in series parallel so as to smooth out the inequalities of individual speakers. This results in a terminal impedance at that end of the line, of about 15 ohms for the average type of speaker.

As output transformers which satisfy all the conditions necessary for maximum undistorted output from the amplifier and maximum energy transfer through the line are not generally available, it is usually necessary to compromise by adopting a lower stepdown ratio

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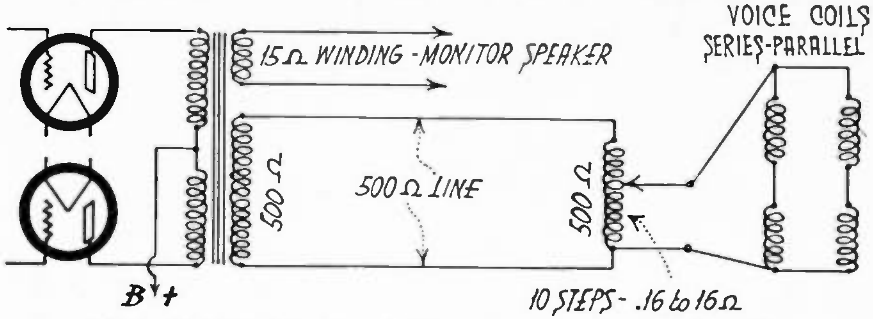

Fig. 1. Matching Impedances With an Autoformer in a 500-Ohm Line

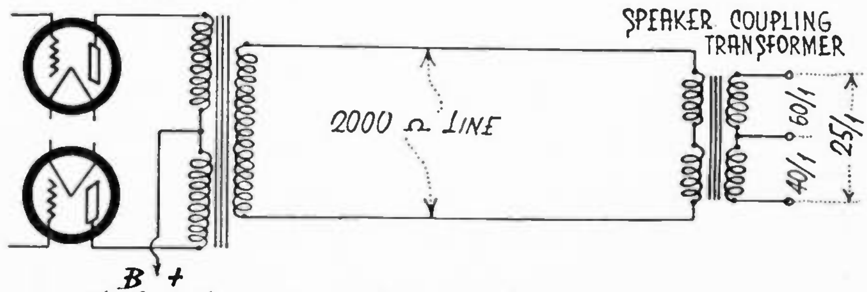

Fig. 2. Ordinary Input and Output Transformers as Output Couplers

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in the transformer than is indicated by the theory. Thus in practice the line terminal impedances are usually about 500 ohms and the speaker end of the line terminates in an autoformer which represents a primary impedance of 500 ohms to the line. This is tapped to match the speaker impedances as shown in Fig. 1. Special transformers and autoformers are made by several manufacturers for this purpose.

Another arrangement which uses ordinary output and input transformers as line coupling devices is shown in Fig. 2 for a line whose terminal impedances are 2000 ohms. Some sacrifice of quality and energy must be expected with this arrangement.

In installations for schools, apartment houses, and hospitals the output circuit is usually split up so that a number of speakers in different locations may be fed independently and at different volumes. To accomplish this, individual line transformers must be provided at each speaker location. Their arrangement across the line is the same as for the multiple input (mixing) circuit. A 500 ohm potentiometer is shunted across each line transformer to regulate the volume to the desired amount. Output volume from the amplifier itself should be checked with a monitoring speaker,

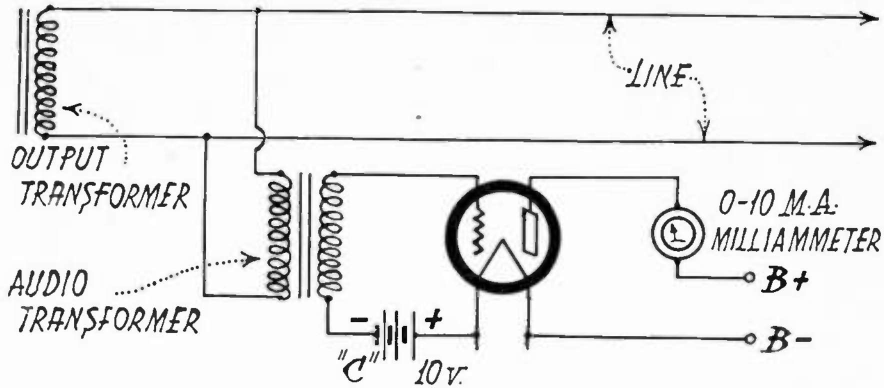

Fig. 3. Volume Indicator Circuit

and in addition, a visual check should be provided in the form of a volume indicating meter. This is bridged directly across the line and affords a much more accurate criterion of levels when used in conjunction with the monitor speaker. Such a device may be purchased as a complete unit, or it may be constructed at low cost. A typical circuit arrangement is shown in Fig. 3. The usual circuit monitoring facilities, such as ammeters and voltmeters, should be provided of course.

Design considerations for coupling high ratio transformers are the same as for other types. Sufficient copper must be used to guard against excessive power losses, and this holds true of the transmission line also. Runs to the speakers should always be kept as short a possible, and in order to prevent power losses, the line should be constructed of No. 8 or at smallest, No. 10 wire. Lead covered twisted pair, or ordinary rubber covered twisted together and run in conduit, may be used.

The requirements for large wire size adds to the capacity of the line, and therefore increases the attenuation of the higher frequencies. To offset this an equalizer circuit may be designed to flatten out the line characteristic. Further modification of the line is desirable —sometimes absolutely essential for good quality—through removal of resonance

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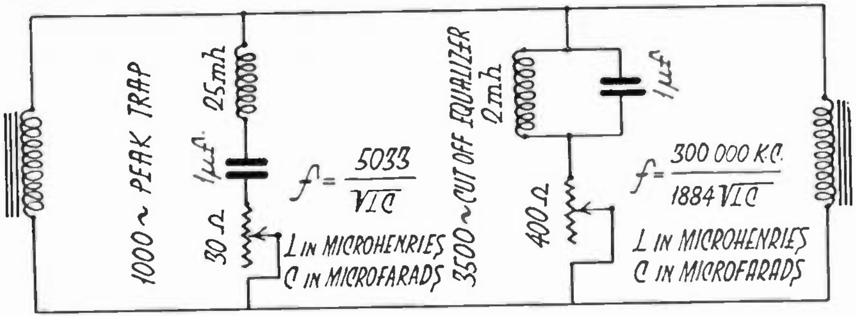

Fig. 4. Trap and Equalizer Circuit

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peaks introduced by the impedance-capacity network of the line. These result in severe exaggeration of output at the offending frequency, which usually cause speaker blasting; the fault, however, as pointed out, is not a speaker defect but is ordinarily due to the resonance effects mentioned. Trap circuits tuned broadly to the resonant frequency will cut down these peaks, the degree of absorption being made variable through use of a variable resistance in series with the trap.

A typical arrangement showing the use of such a circuit, for trapping out a bad peak at 1000 cycles, together with an equalizer circuit designed to smooth out a line having a cut-off at about 3500 cycles, is showr in Fig. 4; the mathematics of design are given in the sketch.

The characteristics of the line may be determined in the usual manner through use of a beat frequency oscillator and vacuum tube voltmeter; the run is plotted as a graph, volts output against frequency, the input level being constant at all frequencies. If desired, the run may be coördinated on log paper, frequency in cycles against DB, so as to obtain the true audibility characteristic. Equalization can then be calculated for the conditions indicated.

If a beat frequency oscillator is not at hand the frequency runs may be made with constant amplitude phonograph records covering the entire range of commercial audio frequencies which are now available from Victor. Taking the output at mean speech frequency (about 500 cycles) as a constant of amplitude, the overall output characteristic can be readily plotted against this. A vacuum tube voltmeter is necessary to measure the output; a suitable meter for this purpose was described in the March 1929 RADIO. The schematic of the set-up for this alternative method of making frequency runs is shown in Fig. 5.

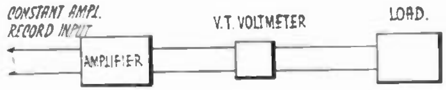

Fig. 5. Method of Measuring Line Frequency Characteristics

A small portable phonograph turntable and an electric motor are the only additional pieces of equipment necessary. The records are made for reproduction speeds of 33⅓ revolutions or 60 revolutions a minute, and the motor should be chosen accordingly. Although the process may seem involved, the correct engineering of the transmission line is absolutely essential for high quality natural reproduction from the system. The individual components of the system may themselves be above reproach, but improper line matching impedances, or unbalanced lines will invariably result in poor, often unintelligible quality. Careful attention to the factors outlined here will eliminate these causes of distortion.

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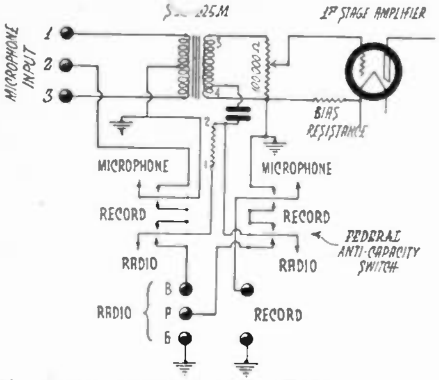

Fig. 6. Circuit for Coupling Radio, Phonograph, or Microphone Input to Public Address Amplifier

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Input Circuits

BECAUSE of the wide range of services which public address installations may cover, a number of different input circuits are described; provisions may be made for coupling the system to a microphone amplifier, to phonograph or radio receiver output, or the equipment may be used for talking picture reproduction. A circuit which permits the coupling of microphone, radio, or phonograph pick-up to the amplifier through a three-posi-

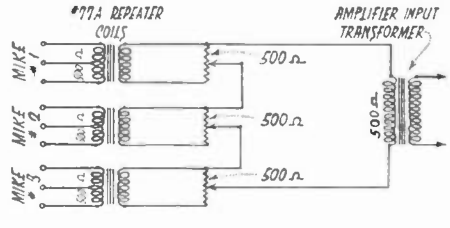

Fig. 7. Typical Mixer Circuit

tion switch is shown in Fig. 6. This is made up from a standard Federal two-position anti-capacity switch by bending the inner contacts so that in the center position (normally neutral) they complete the record pick-up circuit in the manner shown. The input transformer is an SM 255-M. The gain control consists of a 100,000 ohm potentiometer shunted across the secondary of the input transformer. This type of input circuit is suitable for the usual school auditorium and hospital installation.

In certain other installations it is desirable to have a number of microphone control stations which may be cut in at will. Fig. 7 shows the arrangement in such cases. The individual mikes are fed through separate transformers (1:1 telephone repeaters) each with a separate volume control of 500 ohms across the secondary, into the primary of the input transformer. This is the conven-

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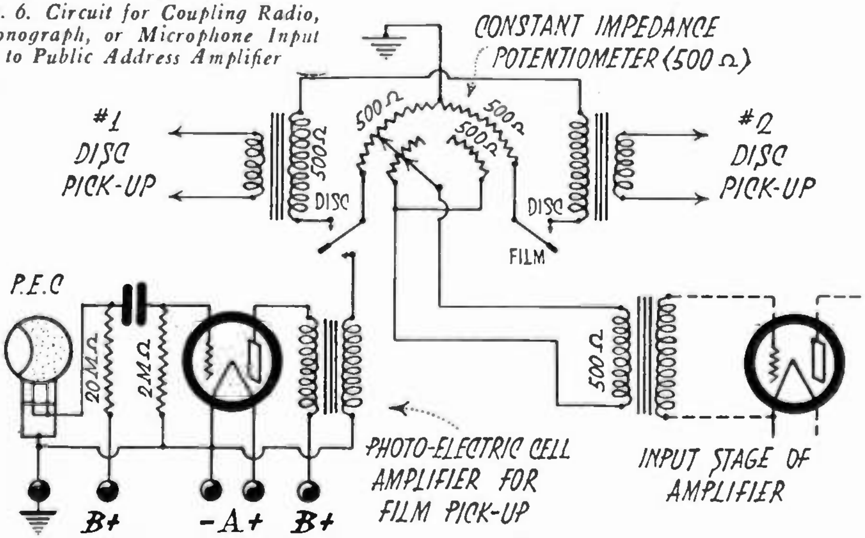

Fig. 8. Typical Fader Circuit

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tional "mixer" circuit used in broadcast work and in talking movies.

Where the microphones are located any considerable distance from the amplifier—say in excess of 200 ft.—a two-stage auxiliary amplifier may be necessary to boost the microphone pick-up. In this case the output transformer of the amplifier should have a 500 ohm secondary, and the various windings will be connected together in the same manner.

A typical input circuit for use in sound picture installations is given in Fig. 8. This connects in the output from either a disc pick-up device, or the photo-electric cell amplifier of the film pick-up system. Provision is made for fading smoothly from one projection machine to the other (at the change of reels) by incorporating two individual gain controls in a single unit so that changeover occurs without any perceptible lapse in program. This arrangement is called a fader, and it takes the place of the conventional volume control. As indicated, the disc pick-up device feeds into a transformer whose secondary winding is of the order of 500 ohms. These devices incidentally are of low impedance for this special service, and vary from 1.7 ohms to about 400 ohms at mean musical frequency (800 cycles); they are supplied with the special coupling transformers.

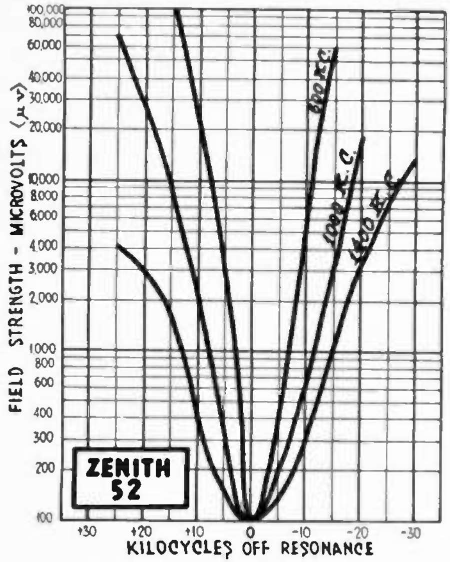
The fader circuit is a double potentiometer arrangement, which maintains a constant impedance of 500 ohms across the line regardless of changes necessary to volume control. This insures that the quality will be held constant throughout such volume changes as are necessary; the usual arrangement causes a noticeable throttling of the lows during such changes. The zero point for the fader is at dead center; rotation to right or left cuts in the pick-up circuit desired. Volume is usually cut down at the start and end of each selection and skilful operation of the fader will permit overlapping of the two records so that the change will not be noticeable. The arrangement is applicable to any installation where a continuous musical program may be desired. Fader units similar to the one described are available on the market from several resistance manufacturers.

Disc pick-up transformers are sometimes designed to feed directly into the grid circuit of the amplifier. In such cases a standard microphone transformer can be used as the line coupling device; the high side will then go to the pick-up transformer secondary of course, and the low impedance (microphone) winding to the line. A second transformer will be necessary to couple the line into the input circuit of the amplifier. The advantages of this low impedance coupling circuit are freedom from extraneous pick-up, and a smoother control of input volume. As mentioned, these arrangements are not necessarily confined to talking picture installations, and may find considerable application in other types of service.

Acoustical Considerations

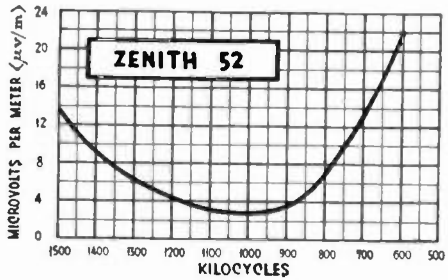
REGARDLESS of the excellence of the electrical installation, the actual sound produced depends upon the acoustical conditions in a room or auditorium. The size and shape of a room determines the sound distribution. In a large deep room the volume necessary to give understandable sound in the rear may be uncomfortably loud in the front of the house. Under such conditions the speakers should be placed as high up as is practicable, and angled downward towards the rear of the house. This will keep the front sections out of the direct wave front and will considerably relieve the effect of excessive loudness.

PERFORMANCE CURVES OF ZENITH 52



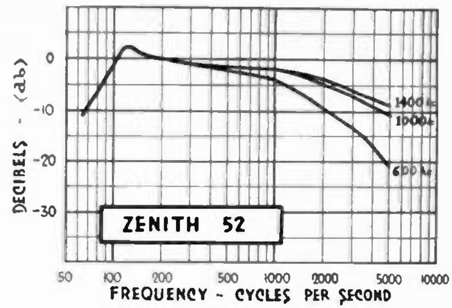
Zenith Selectivity Curves

Selectivity is certainly a feature of the Zenith receiver. Whether the tuning arrangement be labeled a band-pass filter or merely a tuned plate circuit, the five tuned circuits surely do the trick. The rather broad shoulder of the 600 kc curve seems to indicate that the tuned plate idea gives something similar to a band-pass effect. The closeness with which the 1000 kc curve, and even that of 1400 kc, resemble the 600 kc curve is indicative of good engineering design. According to the 1400 kc curve, a station on 1420 kc would have about one chance out of thirty of interfering with a station on 1400 kc. For the higher frequencies this may be considered unusually good selectivity, and as most stations operating on these frequencies are less powerful and are capable of a much less percentage of modulation than the low frequency stations, the Zenith's actual ability to cut out the interference on the high frequencies should be excellent.



Zenith Fidelity

The Zenith sensitivity curve, while well down within the boundaries of good sensitivity, climbs a little too high on each end to rate a compliment. In some respects it is better to have equalized sensitivity over the whole frequency scale than excellent sensitivity at one end or in the middle with a falling off at one or both ends. With a scale as gradual as this, however, it will readily be seen that even on 600 kc, where the sensitivity is poorest, the receiver gets well down into the average noise level; so perhaps the criticism of this cup-shaped curve is not justified.



Sensitivity of the Zenith Receivers

The fidelity curve of the Zenith 52 takes on a peculiar shape. The little peak at 120 cycles looks as if it might be due to a residual hum in the receiver, but tests proved that this was not the case. The audio-frequency system seems to be so resonated that it will pass this particular frequency with slightly greater strength than higher and lower frequencies. The reason for this may be an effort to overcome a weakness in the speaker or merely to build up these notes because of a natural human desire to hear them. They are not strengthened enough to be objectionable; in fact, 2 db will barely raise them out of their proper place; and when it is considered that the average ear is less sensitive to notes of this frequency than those of the middle register, another reason for thus resonating the circuit presents itself. The attenuation of the high notes is very gradual, dropping only 10 db at 1000 and 1400 kc and 21 db at 600 kc. This latter attenuation is due to side-band cutting in the r-f circuit.

CIRCUIT ANALYSIS OF ZENITH SERIES 50

THESE receivers consist of two r-f stages, detector and three a-f stages, the second and third of which are in push-pull. Type '24 tubes are used in the r-f stages and detector, '27s in the first and second audio stages and '45s in the last a-f stage. An '80 serves as rectifier.

The use of the antenna compensator condenser is optional, a plug and jack arrangement being provided to short it out at will. An r-f choke is connected across antenna and ground, and the antenna is connected to the grid of the first tube through the antenna coil. A five-gang condenser is used to tune the two r-f and detector grid circuits, and the two r-f plate circuits, giving five tuned circuits with only two r-f stages, which explains the good selectivity shown by the curves.

Grid bias for the two r-f tubes is supplied by the voltage drop from a 400-ohm resistor between the two cathodes and ground. A 50,000 ohm resistor between the detector cathode and ground furnishes the bias to the detector grid. Both of these resistors are by-passed. The r-f plates receive their positive potential from the low potential side of the dynamic speaker field winding, the latter being used as an a-f choke in the positive high voltage line. The voltage is passed through two r-f chokes in each plate lead, one of which is coupled to a choke in the secondary circuit. Screen grid voltage for the r-f tubes and detector is taken from a potentiometer which is connected between a tap in the voltage divider and ground. This potentiometer serves as volume control.

The detector plate, first audio plate and the plates of the two second audio tubes are fed from the same line as the r-f plates, the detector voltage passing through the 250,000 ohm plate resistor, the first a-f plate voltage going through a 100,000 ohm feeder resistor and the voltage for the pair of '27s in the second stage passing only through the primary of the audio transformer.

The first a-f stage is resistance coupled, a 100,000 ohm resistor being used in the grid circuit. A 4000 ohm resistor between cathode and ground supplies the grid bias to this tube. The second stage is transformer coupled, the plate voltage being isolated from the transformer primary by means of the above mentioned resistor and a fixed condenser which passes the audio frequencies to the transformer. The other side of the primary is returned to the cathode. Grid bias is supplied to the push-pull '27s from the voltage drop in a 2000 ohm resistor between the two cathodes and ground.

Transformer coupling is also used between the second and third a-f stages and the two '45s obtain their grid bias from a section of the voltage divider between the extreme negative end of the rectifier output and ground. Plate voltage is supplied these tubes direct from the high potential line before it passes through the speaker field winding. The output transformer is mounted on the speaker which is connected into the circuit by means of a five-prong plug and a tube socket.

The power unit contains a transformer with two 2½ volt filament secondaries, one 5 volt secondary for the '80 filament and the high voltage secondary. A three-element Mershon condenser supplies the necessary capacity for filtering and a choke and the speaker field winding complete the filter.

The automatic tuner unit consists of a system of levers which are geared to the condenser shaft. When any lever is pushed down, the condenser shaft is rotated, stopping at a previously located point which marks the frequency of the desired station. It takes the place of the usual tuning dial, eliminating the necessity of carefully determining the exact point of resonance. It is a simple arrangement and fool-proof.

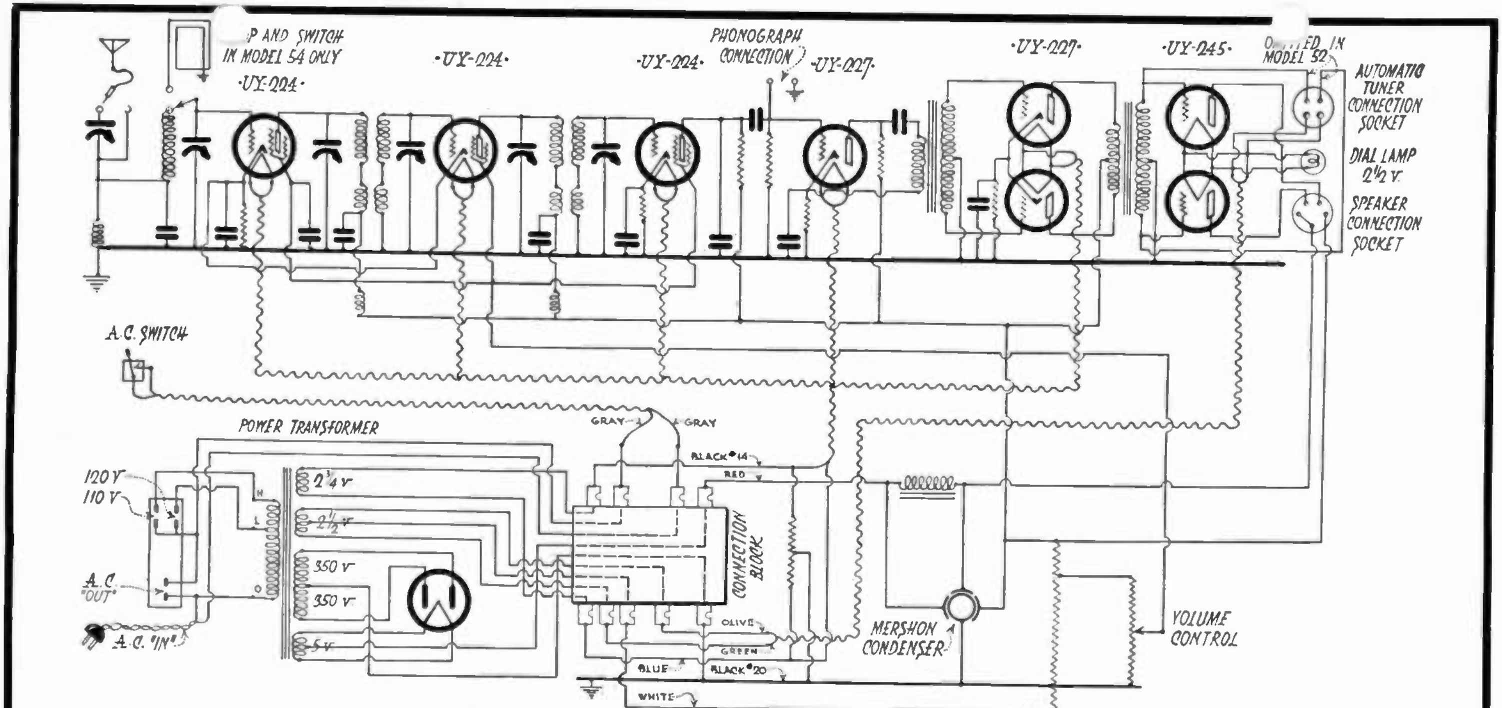


Fig. 1. Circuit Diagram of Zenith Series 50 Receivers

Position of Tube	"A" Volts	"B" Volts	Control Grid Volts	Screen Volts	Screen Current	Cathode Volts	Normal M. A.	GridTest M. A.
1RF	2.3	173	1	54	.3	2.	2.	3.9
2RF	2.3	173	2	54	.3	2.	2.2	2.9
DET.	2.3	85	4	36	.0	5.	.0	.5
1AF	2.3	55	1.5	....	..	4.	1.2	1.5
2AF	2.3	153	13	....	..	13.5	3.4	5.
2AF	2.3	153	13	....	..	13.5	3.4	5.
3AF	2.1	250	49	....	..	......	23.	27.5
3AF	2.1	250	49	....	..	......	23.	27.5

NORMAL VOLTAGE READINGS OF ZENITH 50 SERIES

Finding What's the Matter With a Defective Tube

By P. S. LUCAS

WHEN trouble in a radio set has been found to be due to a defective tube, the question often arises as to what is the matter with the tube. Test may show that its emission is "up" and that it oscillates well, yet it does not give the amplification that is to be expected from a tube of its type. An emission test merely indicates that the filament is in good condition and the oscillation test that the degree of vacuum is normal, no more and no less. They tell nothing about mis-spacing of the elements, for example, which seriously affects the plate impedance and amplification factor, and consequently the tube's performance.

It is impracticable for the average radio service shop to be equipped with apparatus for testing plate impedance and amplification factor. There is, however, another tube characteristic called "mutual conductance" which tells aplenty about both and which can easily be measured in any tube with apparatus that may be simply and cheaply constructed.

Mutual conductance, when divorced from its harem of technical terms, is merely a measure of the change in plate current that is produced by a change in grid voltage. Consequently it tells all that need be known about a tube: whether there is sufficient emission from the filament or cathode, what is the area, nature and temperature of this electron-emitting surface, whether the plate has sufficient area, whether the grid-mesh is fine enough, and whether the elements are correctly spaced.

All this can be learned with the instrument here described by putting the tube in the socket, adjusting the filament voltage to the required standard, connecting the specified grid and plate voltages, and adjusting the calibrated knob until a minimum signal from an oscillator is heard in the phones. If the scale reading at this point does not correspond to that given in the table of mutual con-

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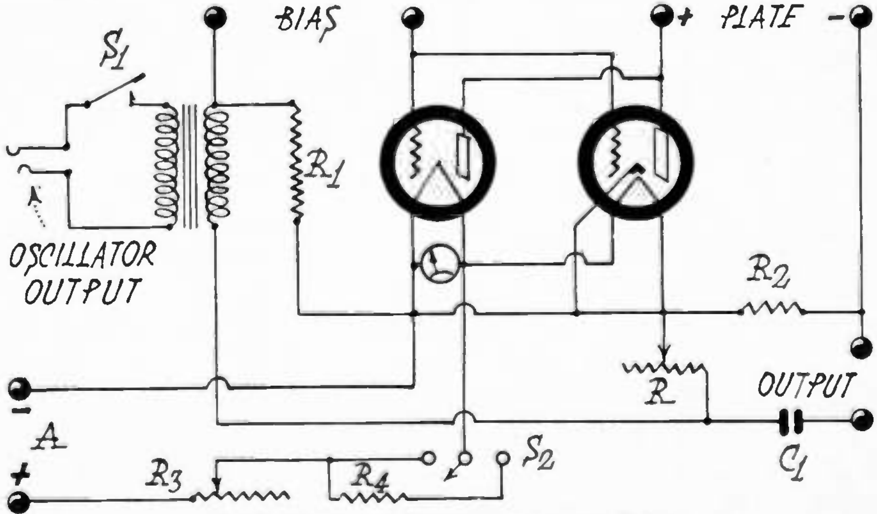

Circuit Diagram of Mutual Conductance Bridge

(Continued from Third Column Above)
ductances, the tube will not "match" normal tubes in a critical circuit. Whether it is the fault of emission, faulty spacing of the elements or what have you, the result is the same, for the mutual conductances must be matched!

Constructing the Conductance Bridge

ALTHOUGH no original ideas are brought forth in this description of a home-made mutual conductance bridge, service men may find some value and a lot of encouragement from the very simplicity of the job. Mechanical specifications and panel layouts have been avoided because everyone who reads this will have his own ideas as to layout. It may, of course, be built into the present shop testing panel, space permitting, or be drawn into the design for a complete new testboard or portable test set, or it may be built into a separate unit as shown in the accompanying pictures.

Two rheostats are provided for variation of filament voltages; one for high current tubes and one for low current tubes. A s.p.d.t. toggle switch puts the two in series for the low current loads and uses the low resistance rheostat alone for high current loads. The two-range voltmeter is used simply because it was the only one available, a measurement of the plate voltage being an unnecessary annoyance if the *B* battery voltage or other power supply is known to be normal. A 4-prong and a 5-prong socket are used to eliminate the necessity of an

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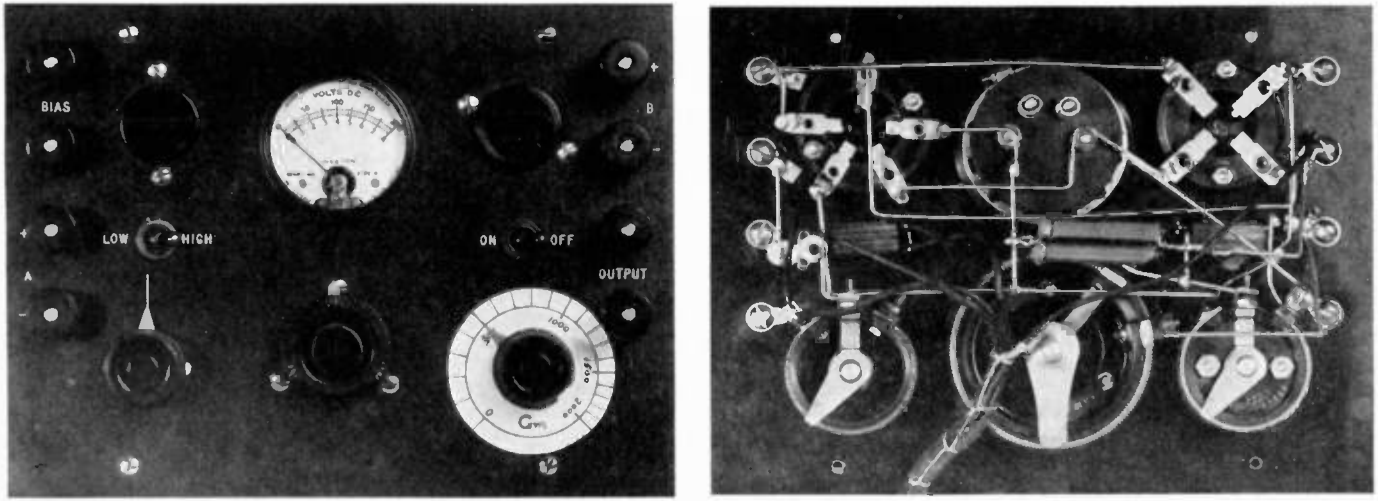

Front and Rear View of Mutual Conductance Bridge

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adapter, and the plates of the two are tied together, as are the grids and the filaments. The cathode is connected to the negative filament lead.

The two fixed resistors R_1 and R_2 are of 1000 and 100 ohms respectively and should be the most accurate obtainable. R_2 may at times be subjected to loads of over 50 ma at 425 volts, so should be chosen accordingly. The variable resistor R has a maximum resistance of 200 ohms, and is calibrated in 10-ohm sections on the dial. Each of these 10-ohm sections may be read directly as 100 micromhos of conductance, giving the bridge a range of from 0 to 2000 micromhos, which is great enough for all practical purposes, although some manufacturers rate their type '50 tubes at 2100. A 250-ohm resistor should have been employed if one could have been found that was as ruggedly built and worked as smoothly as the 200-ohm resistor listed. The excitation from the audio oscillator should be at 1000 cycles and weak enough so that a good minimum signal can be heard in the headphones.

In order to calibrate the resistor R it is necessary to use a Wheatstone bridge or an accurate ohmmeter. Every 10 ohms on the resistor may be plotted

(Continued on First Column Below)

TABLE OF CONDUCTANCES

Type of Tube	Rheostat Used	Filament		Control Grid Bias	Screen Grid Bias	Plate Battery	Mutual Conductance
		Volts	Amperes	Volts	Volts	Volts	Micromhos*
11	LOW	1.1	0.25	—4.5	—	90	425
12	LOW	1.1	0.25	—4.5	—	90	425
112-A	HIGH	5.0	0.25	—9.0	—	135	1600
'20	LOW	3.3	0.132	—22.5	—	135	510
'71	HIGH	5.0	0.50	—40.5	—	180	1500
'71-A	HIGH	5.0	0.25	—40.5	—	180	1500
'99	LOW	3.3	0.063	—4.5	—	90	420
'00-A	HIGH	5.0	0.25	0	—	45	670
'00-B	LOW	5.0	0.125	0	—	45	670
'01-A	HIGH	5.0	0.25	—4.5	—	90	740
'01-B	LOW	5.0	0.125	—4.5	—	90	740
'10	HIGH	7.5	1.25	—35.0	—	425	1600
S.G. '22	LOW	3.3	0.132	—1.5	45	135	350
S.G. '24	HIGH	2.5	1.75	—1.5	75	180	1050
'26	HIGH	1.5	1.05	—9.0	—	135	1100
'27	HIGH	2.25	1.75	—4.5	—	90	900
'40	HIGH	5.0	0.25	—3.0	—	180	200
'45	HIGH	2.5	1.5	—34.5	—	180	1800
'50	HIGH	7.5	1.25	—84.0	—	450	1800
S.G. 842	HIGH	7.5	1.25	—100.0	—	425	1200
865	HIGH	7.5	2.0	0	125	500	750

* The values of mutual conductance given in this table are not intended to be standard. For more information consult the data sheet issued by the manufacturer of the particular brand of tube under test and accept his rating. Some manufacturers express mutual conductance in milliamperes per volt; 1 milliampere per volt being equivalent to 1000 micromhos.

(Continued from First Column Above)

on the dial as 100 micromhos. The accompanying table of representative values of mutual conductance for vacuum tubes in general use was taken from the General Radio *Experimenter*, to which publication the author is indebted for the general plan of construction.

When screen grid tubes are tested the negative side of the bias battery is disconnected from its post *(Bias Negative)* and clipped to the cap on top of the tube. A screen grid battery is brought into play, the positive terminal going to the now free *Bias Negative* post and the negative tap to the *A minus* post. All other connections remain as before.

List of Parts for Mutual Conductance Bridge

- R 200-ohm G. R. variable resistor
- R_1 1000-ohm Carter fixed resistor
- R_2 100-ohm Carter B-100 fixed resistor
- R_3 7-ohm 1.5 amp. G. R. rheostat
- R_4 25-ohm G. R. rheostat
- S_1 S. p. s. t. toggle switch
- S_2 S. p. d. t. toggle switch
- C_1 Tobe 1 μf condenser, 400 volts
- 1—G. R. "X" base socket
- 1—G. R. "Y" base socket
- 1 0—8 d-c voltmeter
- 8—G. R. binding posts
- Panel and cabinet to suit.

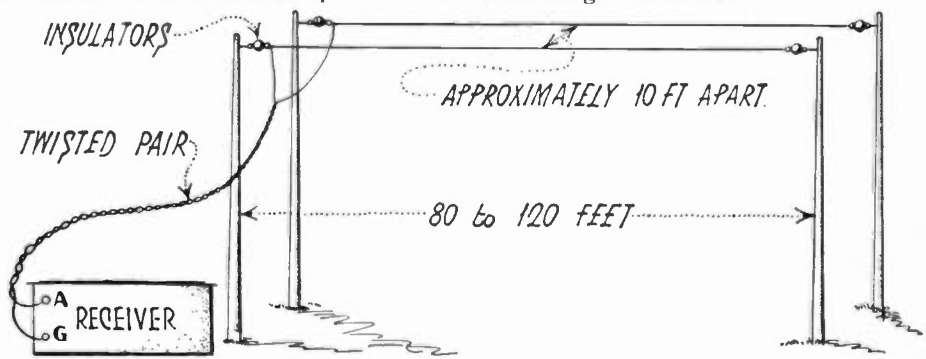
A TRANSPOSITION AERIAL

By N. Earl Borch

The type of aerial here described has been found to be effective in reducing a-c line hum from receivers in congested areas when there are many wires which carry heavy, varying currents. Its effectiveness depends upon the principle of transposition as used by telephone engineers to stop cross-talk and hum due to magnetic field intersection between parallel lines. By crossing the wires at regular intervals the induction is neutralized.

This aerial has two flat-top portions of equal length and spaced about ten feet apart. The transposition is made in the lead-in of twisted lamp cord from the two ends of the aerial to the receivers' aerial and ground binding-posts. As such a lead-in will tend to balance out any weak broadcast signal it may be necessary to use a long flat-top in order to get sufficient strength of signal. Ordinarily a length of from 80 to 120 ft. will suffice.

With this system there is no pick-up by the lead-in. The two flat-top portions must be erected away from all sources of electrostatic or electromagnetic coupling. A ground connection may be added to the ground binding post of the receiver, but this will have a tendency to unbalance the system, and should only be used with receivers having a natural hum from the filter system when no ground is used.



Transposition Aerial

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