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George M. Beale
130 25th Ave.
San Francisco, Calif.

Matching Speakers of [illegible]*

Connecting two or more speakers to an amplifier is fairly simple if the units have identical impedances and all are to share the power output equally. It is a different matter, however, if the impedances are not equal and if the various speakers require unequal shares of the power.

Take the most complex case involving n speakers, each of which has a different share of the power, all to be connected to one universal output transformer. Assume that one side of each voice coil is connected to the zero tap, and that the other side is connected to some other tap.

Now, taking speaker 1, and forgetting the others for a moment, the impedance it reflects back to the primary of the transformer is $R_L R_1/T_1$, where R_L is the load impedance the amplifier should see, R_1 is the impedance of voice coil No. 1, and T_1 is the transformer tap to which the speaker is connected. This must be so, since if, for instance, we connected a 4-ohm speaker to a 2-ohm tap, the amplifier would see 4/2 or twice its correct load impedance. Similarly, speaker 2 reflects an impedance of $R_L R_2/T_2$, etc. All these reflected impedances in parallel form the amplifier load, and if the matching is correct the following equation is true

$$1/R_L = \frac{1}{R_L R_1/T_1} + \frac{1}{R_L R_2/T_2} + \cdots\cdots + \frac{1}{R_L R_n/T_n} \qquad (1)$$

Simplifying, $T_1/R_1 + T_2/R_2 + \cdots\cdots + T_n/R_n = 1 \qquad (2)$

The audio voltage developed across the transformer primary will be the same regardless of what is connected to the secondary, as long as the reflected impedance is the correct value, and therefore, in an ideal transformer, the voltage from any secondary tap will be constant regardless of what impedance is connected across it. For example, the voltage across a 2-ohm [illegible] 2 ohms across it, pro[illegible] the complete speaker netw[illegible]nts [illegible] proper load impedance [illegible] the amplifier. Now

$$P_1 = E_1^2/R_1 \qquad (3)$$

where P_1 is the power desired in the speaker, and E_1 is the audio voltage across the speaker. But, if we had only one speaker, then $R_1 = T_1$ and $P_1 = P_T$ where P_T is the total power output of the amplifier.

Since E_1 is [illegible] same in both cases we can write

$$P_T = E_1^2/T_1 \qquad (4)$$

Dividing (3) by (4)

$$P_1/P_T = \frac{E_1^2/R_1}{E_1^2/T_1} = T_1/R_1 \qquad (5)$$

Since $P_1 + P_2 + \dots\dots P_N$ must equal P_T then

$$P_1/P_T + P_2/P_T + \dots\dots\dots + P_N/P_T = 1 \qquad (6)$$

Substituting Eq. (5) in Eq. (2) we again obtain Eq. (6), which proves our derivation.

Rearranging Eq. (5) we obtain the simple result $T_1 = R_1 p_1$ where p_1 is per cent of power output desired in speaker 1, and finally $T_K = R_K p_K$ for speaker k. With this equation the most complicated speaker networks can be easily set up. For instance, say we have three speakers, 4, 6, and 8 ohms. The first is to get 50 per cent of the power, and the other two 25 per cent each:

$T_1 = 4 \times .50 = 2$ ohms; $T_2 = 6 \times .25 = 1.5$ ohms; $T_3 = 8 \times .25 = 2$ ohms.

Thus, the 4-ohm and 8-ohm speakers would be connected to the 2-ohm tap, the 6-ohm speaker to a 1.5-ohm tap, the amplifier would be loaded correctly, and each speaker would have the desired share of the power.

The transformer taps available may not correspond exactly with those calculated, of course, in which case the nearest value should be chosen.

* *By Richard W. Crane in "Electronics."*

-W TESTING OF AMPLIFIERS*

(...on ... issue)

High

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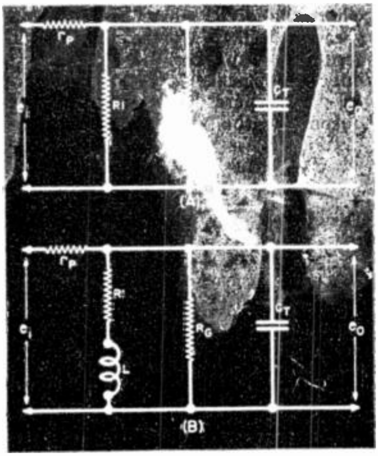

Fig. 8 Equivalent circuits at high frequencies for a resistance-coupled amplifier. (A) Uncompensated. (B) Compensated.

capacitance shunting the load resistor R_1. An equivalent circuit is drawn in Fig. 8, and all the shunting capacitance is grouped together and denoted by C_T. Analysis shows that the greater portion of C_T is due to the inter-electrode capacitances of the input and output tubes, with the remainder added by the wiring of the circuit. The latter can usually be decreased very easily, while the former is taken care of by using tubes carefully designed for low inter-electrode capacitances.

To test the network response, the repetition frequency of the square-wave generator is turned up to somewhere between 1000 and 2000 cycles and fed into the amplifier. Two output square waves are shown in Figs. 9A and 9B along with the frequency response curves of the amplifiers tested. Inspection of the oscillograms shows

...that with frequency attenuation and ...ase phase distortion, each corner of a square wave is similarly affected. Increasing phase distortion will cause the

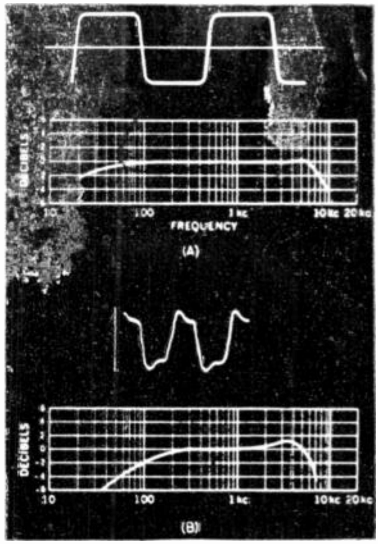

Fig. 9. Fidelity curves and wave shapes showing the attenuation at the high frequencies. (A) No phase distortion. (B) With phase distortion.

square wave to assume an assymetrical shape. Fig. 10 is a good picture of a square wave passed through an amplifier that had excessive phase distortion with some frequency distortion. Many times both appear simultaneously and are easily separated. This need cause little concern, since correct-

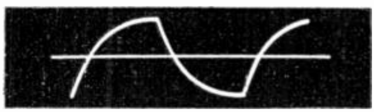

Fig. 10. Wave showing excessive phase and frequency distortion at high frequencies.

* *By John Williams in "Radio News."*

ing one type of [illegible] well, in [illegible] eral, also c[illegible] of the ot[illegible]

One wa[illegible] to wider the flat[illegible] po[illegible] tion of response curves of resistance coupled amplifiers is [illegible] amount of [illegible]ductance [illegible] 1 mh.) in [illegible] with the load [illegible] R_L. (See Fig. 3B.) This tend[illegible] form a resonant circuit with [illegible] and [illegible] neutralize [illegible] capacitive [illegible]. If the [illegible] cor-

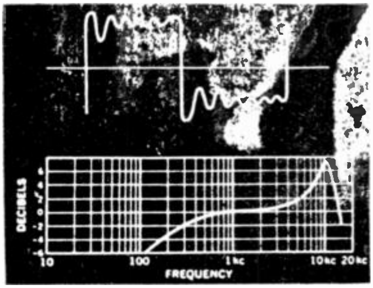

Fig. 11. Fidelity curve and wave shape of output signal showing excess gain at high frequencies and a pronounced underdamping.

rectly, this neutralization will occur at the high frequencies. For those who desire more information, references at the end will furnish the desired formulas.

Transformer-coupled amplifiers are sometimes troubled with a sudden rise in gain at the high frequencies due to the resonant circuit formed by the secondary winding and the distributed capacitance of the turns of wire. In Fig. 11, we have the pattern obtained when a square wave is passed through such an amplifier. The oscillations here are plainly visible. These oscillations can be stopped by sufficient damping of the circuit. A resistor across the secondary winding of the transformer corrects the undesired results very nicely.

Without going into too much detail, a great deal of which would be repetitious, output patterns of square waves at the high end are shown in Fig. 12. Each type is explained by its associated captions.

Al[illegible]ough the [illegible] far has [illegible] confined [illegible] entire[illegible] to wide [illegible] audio am[illegible] response of R.F. and I.F. [illegible] likewise be [illegible]mined to [illegible]. Many gen[illegible] used by [illegible] have provision for exter[illegible] modulation [illegible]d of the [illegible] sine-wave [illegible] square-wa[illegible] [illegible] can be used [illegible]dinary am[illegible]de modulation of [illegible]nerator o[illegible] R.F. and I.F. fre-

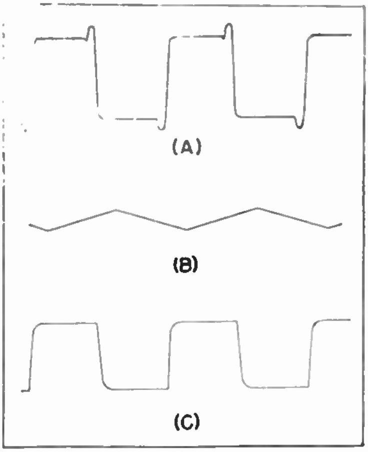

Fig. 12. Unusual output wave shapes obtained from faulty amplifiers. (A) Shows good high frequency response; however, with slight underdamping of oscillations. (B) Both the low and high frequency response of the amplifier are unsatisfactory. (C) Shows some attenuation of high frequencies and large phase distortion.

quencies. The instrument can then be used in the regular way for testing. For example, the generator could be connected to the plate of an I.F. tube through a .1-μfd. condenser and the output across the diode detector analyzed. Then the generator could be shifted to the grid of the I.F. tube in the receiver, and again pick up the output from the diode detector. Any departure will indicate distortion and can be accordingly corrected.

One precaution must be observed in using an ordinary oscilloscope for re-

(*Continued on page* 14)

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FOR SALE—R.C.P Model 663 electronic multitester in original carton used once. Best offer takes it 36 watt amplifier, astatic microphone model T-3 with stand and cable Norman Jacobson, 1697 Andrews Ave., Bronx, New York City.

WANTED—Rider's Manuals, from vol. 5 up, complete in good condition Charles Fischer 760—10th Ave., New York City.

WANTED—Radio receiving tubes, all types, advise best discount off list Can use P.A. and sound equipment Radion Co., 148-29 Jamaica Ave Jamaica 2 N. Y.

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WANTED—Late Sprayberry or N R I complete radio course. Must be in fair condition State lowest price Ralph Andrea, Jr 107 Franklin Ave., Rochelle Park N J

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FOR SALE—Western Electric motor KS 5161 1/5 h.p., 1200 r.p.m., 110 v., 60 cycle type Y 33B One motor generator set, 110 v 200 m.a d c by Electric Specialty Co One a c-d c 110 v turn table motor Levines Radio Shop 625 Main St., Worcester, Mass

FOR SALE—25 w P A amplifier good condition w/2 mike and 1 phone input Have Amperite PGH chrome dynamic mike w/ new type unit, chrome floor stand Low price C. W. Schecter, Scenic Drive, Rt 2, Muskegon, Mich.

FOR SALE OR SWAP—1936 Dodge or Plymouth custom radio like new Univex 8mm. camera in original packing. Want radio tubes record players, pickups, or cash Leo Stein 7 Monroe St Mount Vernon N Y

WANTED—Phono motors crystal pickups, midget radios tubes (all 5 v. rectifiers, all tubes 12 v or over). Give full details and prices Leading Radio Service, 114 East 3 St., Mount Vernon N. Y.

FOR SALE—Triplett 1671 vibrator tester, Oxford universal test speaker tubes, used all tested are 26, 27 36, 56 58, 38, 79 71A, 45 etc radio correspondence course Royce Saxton's Radio Shop Rt. 1, Pontiac Illinois

WANTED—Superior Model 1280 combination tester with cover State condition and lowest price Delbert Shaffner Deepwater Missouri

WANTED—G E JFM-90 FM converter; Hallicrafters S-29 communications receiver, radio test equipment George G. Chandler, Assoc Eng U S N P O Box 73 Back Bay Sta Boston 17 Mass

URGENTLY NEEDED for WERS use—National one ten receiver. State condition and price in first letter C W Schecter, Scenic Drive Rt 2 Muskegon Mich.

FOR SALE—A Model K Presto recorder type 4A cutting head built in playback, DB meter, cuts up to 12" records, in perfect condition, 33 1/3 r.p.m. $90.00 V. Howerdel, 102 Hancock Ave Jersey City N J.

FOR SALE—Delco auto radio with separate loud speaker, good condition, $20 RCA station allocator new [illegible] battery charger new rectifier 4 amps $12 Paul [illegible] W 21 St Erie [illegible]

WANTED—Experienced outside man with car (and test equipment desirable but not essential) Can use test equipment tubes small radios in any condition Riders manuals [illegible] Radion 148 29 [illegible] Ave Jamaica N Y. Jamaica [illegible]

FOR SALE—[illegible] of Eimac 150T's [illegible] ment transformers for same. [illegible] unused, [illegible] original cartons. What am I offered Joseph J. [illegible] Rugby St Philadelphia 19, Pa

FOR SALE—Hickok OS7 oscillator [illegible] output meter self-contained, a.c. operated, portable carrying case, first $25.00 takes it G E phono induction motor, heavy duty, variable speed. Neo Radio Service 4923 Henderson St., Chicago, 41, Illinois.

WANTED—Any quantity of the following tubes, must be perfect and boxed. 1R5, 7B7, 7A8, 5Y3, also 12SA7, 12A8, 12K8, 12SQ7, 12 SK7, 35Z4, 35Z5, 50Y6, 50Z7, 45Z5, 12SJ7, 12K7, all 117 v. tubes Details and prices to Leo Stein, 114 East 3rd St Mt Vernon, N. Y.

FOR SALE—1 R C P. Model 411 supertester $12.00, 1 Weston Model 565, 3 meter set analyzer. Both in good operating condition, make offer. Victor H. Berger, 300 Grandview Ave., Gordon Heights, Wilmington, Delaware

WANTED—Supreme Analyzer Model 585 Rider's Manuals 1-8, oscillators, d.c. milliampere meters 0-100. Will Sell or Swap 4 Majestic 90c chassis and pwr. pks., Brunswick radio chassis super 9 tube jobs, all in playing condition. Louis A. Goldstone, 1279 Sheridan Ave., Bronx 56 New York City.

FOR SALE — LogLog deciting slide rule, Keuffel & Esser model 4091-3 complete with leather-fiber case and manual of instruction. Dexter Kurs, 4525—45 St., Long Island City 4, New York.

WANTED—Automatic record changing, record player unit. Prefer Garrard or Capehart State make, model, condition and cash price. Dexter Kurs, 4525—45 St., Long Island City 4, New York.

FOR SALE—One Supreme No. 85 tube checker with adapters $20; a.c. volt meter W. E Model 528, No. 1769 $8.00; Majestic turntable and motor from phono radio, $10 Davis Drug Co., Camden, Tenn

FOR SALE—Rider's auto radio service manual, vol. 2, $4.00, Philco radio manual [illegible] $2.50, Braymer and Roe Rewinding [illegible] Motors, $2.75 Post paid Like new [illegible] Hanson Gary Minnesota

[illegible] LE—Best offer takes Weston Model [illegible] tube checker Has volt and ohm [illegible] and short check for condensers. [illegible] adapter but not filament, A-1 condition [illegible] Radio Service New [illegible]

WANTED—Phonomotor (78 rpm) and small [illegible] for phono player. Will swap [illegible] parts and tubes or will pay [illegible] Gutch 1481 Shakespeare Ave., [illegible], New York

WANTED—Copies of "Electro[illegible] [illegible]y, 1930 Jan., 193[illegible] [illegible] 3 State condition [illegible] [illegible] 72 N Fenton A[illegible] [illegible]

WANTED—Cheap amateur CW and phone [illegible] and transmitter State price [illegible] F A Witkowski, 35 Daymond St., Trenton 10 N. J

FOR SALE—Triplet No 1200 VOM, twin meters, needs slight repairs, measures 1000 v a.c. and d.c. and 3 megs resistance, also Ranger pocket VOM Model 735 with Ranger Model 640 free point tester. 2 Emerson midget radios, one a.c the other ac-dc, not batteries Best offer Joseph Marsh 34 Hartwell St New Brunswick N J

FOR SALE—Good used tubes older type 50c each, send for list. Pioneer genemotor $8.00; R C, R N, QST, S.W.E., R. & T magazines, 15c each Harry Kay, Rt 2, Box 255, Imlay City, Mich

TRADE OR SALE—Hickok Model 4780 capacity tester, brand new. Will sell or trade for 12 v. tubes or new table radio. Best offer. Miller Electric Service Ellenville, N Y

FOR SALE—RF 05 3" oscillograph 19x crystal controlled microvolt generator, 155 Traceometer, 510x dynamic mutual conductance tube and set tester 188x FM AM Universal signal generator, 202 ac-dc multitester RCA 162C Rider chanalyst, 165 Jr. volt-ohmist, 182 dynamic demonstrator III, 164 chanalyst converter. Cash cashier or certified bank check New guaranteed All prices list plus 10% Sam S Samuels Nashville, Tennessee

FOR SALE—Supreme 560A vedolyzer, 561 oscillator, 562 audolyzer, 549P electronic multitester, RCP 423 VOM, Sprague de luxe telohmike, C-D BF-50 capacity analyzer, Jackson 652 audio oscillator, 642 Universal multitester. Cash, cashier or certified bank check. New guaranteed Prices list plus 10%. Sam S. Samuels, Nashville, Tennessee

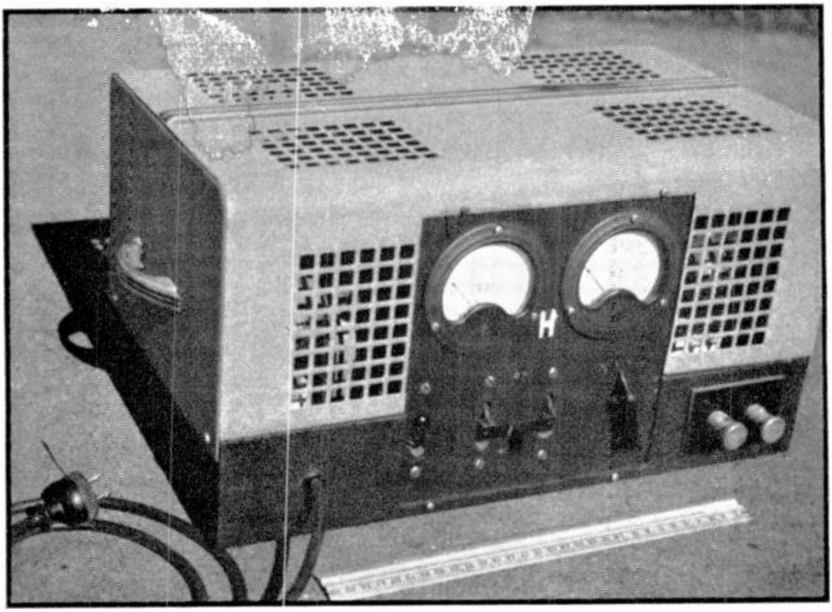
(Continued on page 14)

THERMIONIC RECTIFIER CIRCUITS*

The purpose of this article [illegible] give details and performance [illegible] teristics of five rectifier tube [illegible] which have proven satisfactory [illegible] over a period of several years. [illegible] believed that this treatment [illegible] ularly appropriate at the present [illegible] because motor-generators and [illegible] teries are [illegible]pensive, scarce, and [illegible] compared [illegible] electronic circuits [illegible] can often [illegible] used to replace th[illegible]

The electronic circuits propo[illegible] [illegible] [illegible]tations of well-kn[illegible] the- or[illegible] emphasis is placed [illegible] points: (1) the use of [illegible] tubes and components; (2) the [illegible] ment of relatively high current [illegible] (3) light-weight construction, making for portability; (4) operation from 115-v, 60 cps source of power.

One power supply employs four argon charger-type tubes in a bridge circuit with input connected directly [illegible] the a-c [illegible], and will supply [illegible] amp at 90 v d.c. [illegible] can supply d[illegible] equipment having 110 v nominal rating, and [illegible] particularly suited [illegible] operation of [illegible], electrolysis, etc. Three [illegible] B supplies include a [illegible] rectifier conn[illegible]ing directly to the a-c line and del[illegible]ng 400 ma [illegible] a half-wave [illegible] providing [illegible] common connection between a-c line and d-c load and delivering 130



High-current gas-type full-wave rectifier assembled in well-ventilated metal cabinet, and rated to deliver up to 9 amp at 90 v. D-C output terminals are at right on panel. The meters are connected to read output voltage and current. Total weight is 39 lb.—much less than an M-G set having equal capacity.

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* *By Lieut. Richard C. Hitchcock, U.S.N.R., in "Electronics."* The assertions herein are the private ones of the writer, and are not to be construed as official or reflecting the views of the Navy Department or of the Naval service at large.

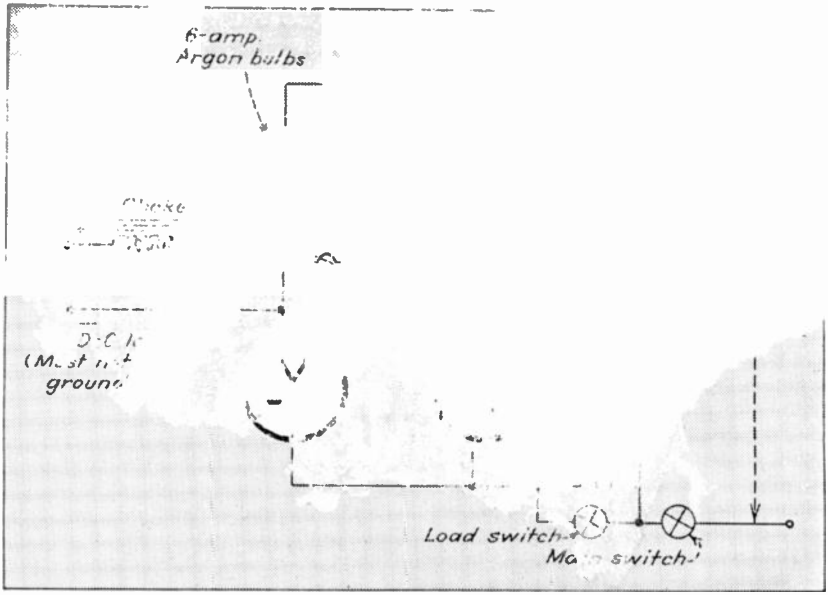

Fig. 1.—Schematic diagram of high-current rectifier circuit, using four gas-type tubes to provide d-c outputs up to 9 amp at 90 v.

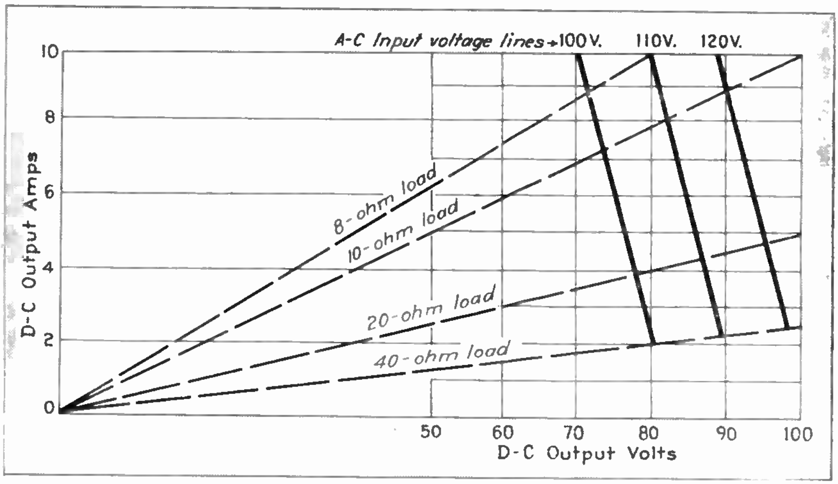

Fig. 2.—Operating characteristics of high-current rectifier circuit of Fig. 1.

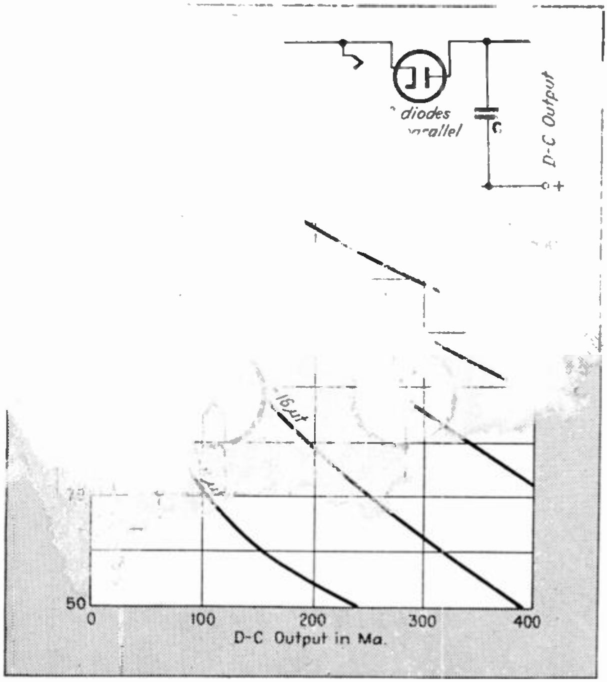

Fig. 3.—Half-wave transformerless rectifier circuit using four 25Z5 or 25Z6 tubes, with operating characteristics.

ma at 150 v; a full-wave doubler giving 200 ma at 180 v. Finally, an eight-tube bridge circuit is represented that has proved satisfactory for obtaining 2000 v d.c. at 250 ma. It uses receiver-type tubes in an unorthodox design — a simple and economical means of supplying a cathode-ray tube.

Gas-Type High-Current Rectifier

Since a d-c arc gives about four times the light output when operated on d-c as on the same current from an a-c source it is advisable to provide d-c operation.[4] A bridge circuit originally designed to supply d.c. for a carbon arc is shown in Fig. 1. Six-ampere bulbs having high crest inverse voltage and high d-c output voltage suitable for this circuit are: Westinghouse Style No. 289416 and General Electric Cat. No. 189049. (Not all 6-ampere charger bulbs have the proper operating characteristics for this circuit.)

A multiple-winding filament transformer is needed: two of the secondaries supply a single filament each (2.2 v at 18 amp), and the third feeds two filaments in parallel (2.2 v at 36 amp). The a-c line goes directly to the tubes without a transformer. Note that the d-c output cannot be grounded.

To start this circuit, the main switch is closed first. The load switch is closed after the filaments are up to operating temperature. This procedure is necessary because gas-filled tubes with oxide-coated filaments must not have plate voltage applied when cold. In the completed unit shown in the photograph, a "mark time" switch is employed; one SPST switch closes immediately, and a second SPST switch closes after a 15-sec interval.

Two fuses are shown in Fig. 1. The load fuse should be chosen to permit the desired load current to flow and no more than 12 amp [illegible] th[illegible] main fuse should be [illegible] in rating since it [illegible] rent [illegible] th[illegible] The purpose of u[illegible] tw[illegible] be sure that an [illegible] only the [illegible] still [illegible] heate[illegible] [illegible] expen[illegible] used in p[illegible]

The smo[illegible] low resistance [illegible] ance, considering [illegible] ing through it saturat[illegible] unit used has an inductance [illegible] h at 60 cps with its core (C[illegible]

[illegible] e) and a d-c resistance [illegible] 5 [illegible] obtained with a coil [illegible] 490 [illegible] No. [illegible] B & S [illegible] Coil diam[illegible] of [illegible] in. [illegible] obtained by [illegible] e core from the [illegible]

St[illegible] of operation may be obta[illegible] the use of two identical [illegible] cores. In the

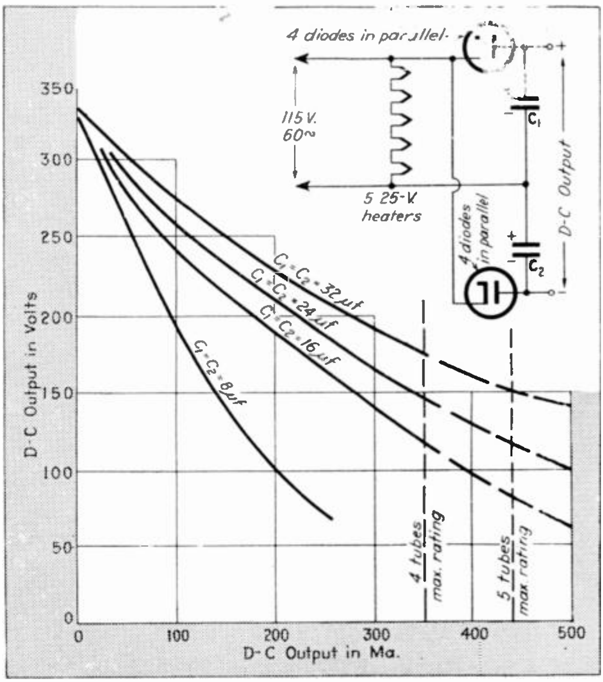

Fig. 4—Full-wave voltage-doubler rectifier circuit and performance characteristics. Output terminals cannot be grounded.

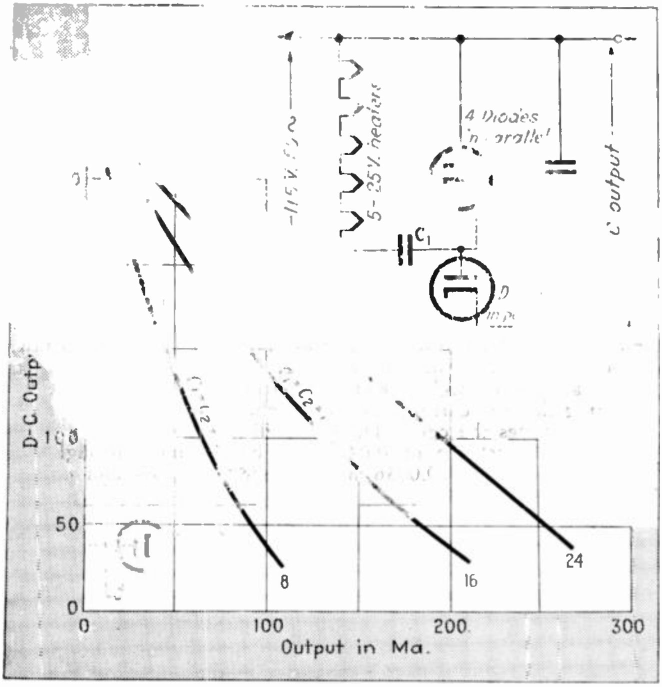

Fig. 5.—Half-wave voltage-doubler rectifier circuit and performance characteristics. One side of output can be grounded.

first coil the core is fixed for use as the d-c filter choke of Fig. 1. The second coil, arranged with a movable core, is connected in series with the load fuse as an a-c impedance. When the circuit is used to supply an arc lamp it has been found possible to put most of the reactance in the a-c side, and to use only a low resistance in the d-c part of the arc circuit.

Porcelain mogul sockets are needed for the 6-ampere bulbs. Due to the high operating temperatures of these bulbs, the use of flame-proof or asbestos-covered wire is recommended for connections.

The characteristics of this gas-type high-current rectifier are shown in Fig. 2. The dashed load lines are for 8, 10, 20, and 40 ohms, while the three solid lines are for a-c input voltages of 100, 110, and 120 v. From these curves we see that with 110 v. a-c input and a load of 8 ohms, the d-c output is 10 amp and 80 v.

The total weight of the unit, including the steel cabinet, is 39 lb.—about one-fifth the weight of a motor-generator of equal capacity.

Half-Wave Transformerless Circuit

Circuits using single 25Z5 and 25Z6 tubes are well known.[8] Often such circuits use a resistance in series with the heater for operation directly from the 115-v line. However, the circuits of Fig. 3, 4, and 5 each use five heaters in series and therefore require no additional series resistor. Only four 25Z5 or 25Z6 tubes are used as actual rectifiers, although five heaters must be used in series across a 115-volt a-c line. Of course, one heater may be replaced by an 83 ohm resistor.

A single tube—the 117Z6GT—may also be used with these circuits. This is a two-cathode, two-plate tube with a 117-v heater element requiring no series resistor on a 117 v line.

A half-wave rectifie[illegible] transformers for oper[illegible] volt a-c line is show[illegible] with its output ci[illegible] d-c side of the circ[illegible] grounded wit[illegible] example, if th[illegible] supply in Fig. 3 [illegible] tive d-c termi[illegible] Note that all [illegible] all eight of the [illegible] tube) in Fig. 3 are [illegible] allel.

Comparing the half-wave circuit of Fig. 3 with the full-wave [illegible] doubler circuit [illegible] seen [illegible] e [illegible] ge- [illegible] the [illegible] major [illegible] it is that [illegible] d when- [illegible] ued. This [illegible] amplifiers [illegible] erstage trans- [illegible] ltages must be [illegible] sed in the full-wave [illegible] cuit[1] of Fig. 4, four [illegible] ur anodes (2 tubes) [illegible] in parallel in each [illegible] nt. As in the circuit [illegible] Fig. [illegible] there are five heaters rated at 25 v each in series across the 115-v

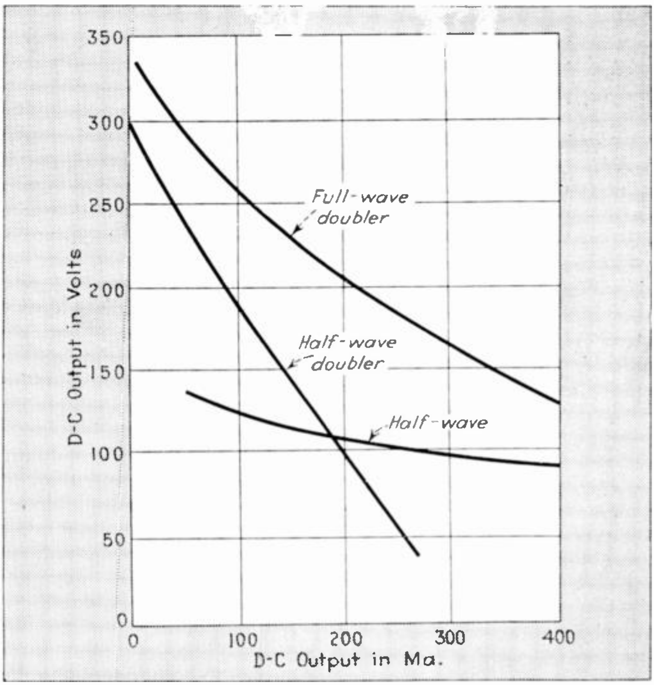

Fig. 6.—Comparison of output characteristics of rectifier circuits in Fig. 3, 4, and 5.

SUMMARY OF RECTIFIER CHARACTERISTICS

		[illegible]	Circuit in Fig.	Typical D-C Output	Notes
High-[illegible] gas-type full-wave bridge			1	90 v, 9 amp	Neither side of d-c output can be grounded
Half-wave		[illegible]			One side of d-c output is grounded by grounding a-c line
Full-wave doubler	Four 25Z5 [illegible] 25Z6			[illegible]	Neither side of d-c output can be grounded
Half-wave doubler	Four 25Z5 or 25Z6	None		150 v, 0.13 amp	One side of d-c output is grounded by grounding a-c line
High-voltage bridge rectifier	Eight 80	8 Fil. 1 Plate	7	2500 v, 0.25 amp	Either side of d-c output can be grounded. For 5Z3 tubes, output current is 0.45 amp

a-c line, although only four tubes are connected in the rectifier-doubler.

Full-Wave Rectifier-Doubler Circuit

The capacitance marked on each curve in Fig. 4 is half the total capacitance required. For example, the 24-μf value at 100 and 500 ma means that two 24-μf capacitors are needed. Also note that the maximum output rating for 4 tubes is 350 ma.

If electrolytic capacitors are used in the circuit of Fig. 4, they must be polarized as shown. It is impossible to use a dual electrolytic of the 16-16-μf type if the negative leads are common. Such a dual capacitor can of course be used as a single 32-μf unit, in series with a similar one correctly connected.

Half-Wave Doubler Circuit

A half-wave doubler circuit[2, 7] in which one side of the a-c input is connected to one side of the d-c output is shown in Fig. 5. Capacitor C_1 is rated 150 v d.c., and preferably has a paper dielectric, but C_2 may be either a paper or electrolytic 300-v unit. For light d-c loads C_1 may be a polarized electrolytic capacitor with the negative lead connected to the a-c line. For heavy d-c loads (above about 190 ma at 110 v), the voltage on C_2 reverses, and an electrolytic is not suitable.

Comparison of Circuits

The three curves in Fig. 6 permit direct comparison of the three circuits, each of which uses a total capacitance of 48 μf, and four 25Z5 or 25Z6 tubes as rectifiers. In all cases the full-wave rectifier-doubler gives the highest output voltage and current. Of the three circuits, the half-wave doubler has the poorest regulation and the half-wave rectifier has the best regulation.

The choice between the half-wave doubler and the half-wave rectifier may be based either on the required d-c output or the regulation, considering that both have one d-c terminal at the same potential as one a-c terminal. The d-c outputs of these two circuits are equal at 190 ma, 110 v. For lower current values, the half-wave doubler permits higher voltages; for higher output currents, the better regulation of the half-wave rectifier appears advantageous in giving higher output voltage.

In general the vacuum-tube rectifiers are self-protecting to a great extent and require no preliminary heating of their cathodes, so that the circuits of Figs. 3 . and 5 may be connected simultaneously to the d-c loads and the a-c lines.

(To be continued)

Square-Wave Testing of Amplifiers

(Continued from page)

producing the square waves on the screen. Most three-inch scopes on the market will not give good response when the repetition frequency of the square wave is lowered to 60 cycles. Even the high-frequency end is not as good as expected, although the range usually extends beyond 30 kc. and will do for ordinary audio amplifiers. The best method of obtaining satisfactory results is accomplished by connecting the output of the amplifier to be tested directly to the vertical plates of the oscilloscope, although at times this may not be feasible due to the small magnitude of the output voltage.

In closing, it is important to mention that amplitudes of square waves are seldom measured. The shapes seen on the oscilloscopes are generally independent of amplitude providing no overloading takes place. Here again is a simplification of the ordinary point-to-point method.

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2. Freeman and Shantz, "Video Amplifier Design," Electronics, August, 1937.

3. Donald G. Fink, "Television Engineering" McGraw Hill Publishing Co., 1940.

4. Bukstein, "Wide Band Amplifier Design" Radio News, August, 1943.

THE RADIO TRADING POST

(Continued from page 6)

FOR SALE—One complete set new parts for 300 watt short-wave diathermy machine, all mechanical work completed, ready to be wired, GE tubes Triplett meter, etc., $125.00 F.O.B. Los Angeles. Frank M. Kelly, 949½ West Jefferson St., Los Angeles 7, Calif.

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WANT—Weston 772 or similar VOM or combination, oscilloscope, Rider's 11, 12 and 13 and other books. Any test equipment. Send lists. Have Hammarlund Pro standard model, sell, trade. Glenn Watt, Chanute, Kansas.

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