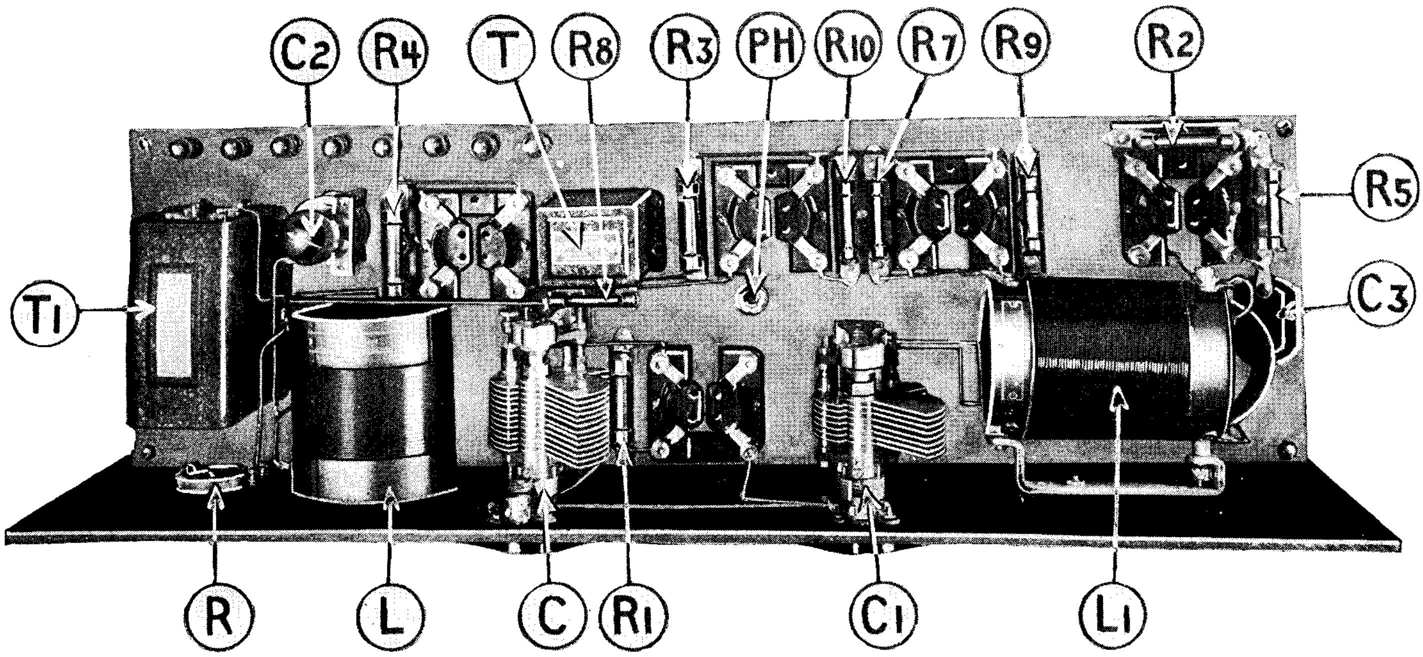


A top view of the Browning-Drake receiver designed by Mr. Lynch. The parts are: L, aerial coupler; L1, R.F. transformer; C, aerial tuning condenser; C1, R.F. tuning condenser; C2, series aerial condenser; C3, grid condenser; R, rheostat; R1, R2, R3, R4, ballast resistances; R5, grid leak; R7, R8, plate resistors; R9, R10, grid resistors; PH, Phasatrol; T, grid impedance; T1, output filter.

Modernizing the Browning-Drake Receiver*

The Use of the Phasatrol Serves to Increase the Amplification

By ARTHUR H. LYNCH

THIS article, the second of a series on the Browning-Drake circuit, describes a receiver which embodies many improvements of recent development. The complete instructions will enable the home constructor to build with little trouble an inexpensive set which is economical and easily operated; yet is both sensitive and selective, with great volume and remarkable fidelity to tone.

In June RADIO NEWS Mr. Lynch will recapitulate the previous two articles and will show how all the principles explained may be incorporated in the present model, as well as in another or similar type, in attractive cabinets, and in conjunction with devices now commercially obtainable, which make very satisfactory the operation of any receiver from the light-socket.

If you have not already done so, we recommend that you read Mr. Lynch's preceding article, in RADIO NEWS for April.

—EDITOR.

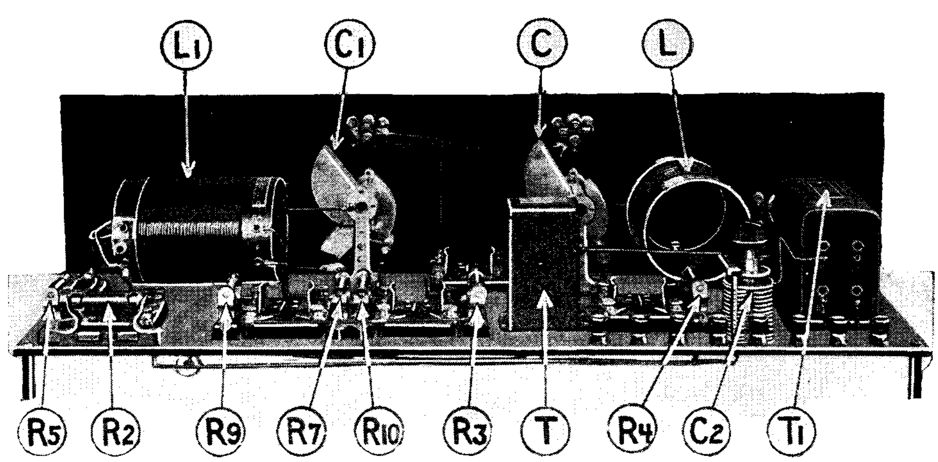
CIRCUITS have come and circuits have gone, but still that pioneer—a single stage of tuned neutralized radio-frequency amplification and regenerative detector—holds its own. Radio-frequency transformers, condensers, and methods of neutralization have been and still are being improved; but the fundamental circuit remains basically unchanged.

As a result of the improvements made in the component parts which go into a receiver employing this fundamental circuit, however, the performance is markedly superior to that of one built with the best of parts available even a year ago.

THE "BROWNING-DRAKE" CIRCUIT

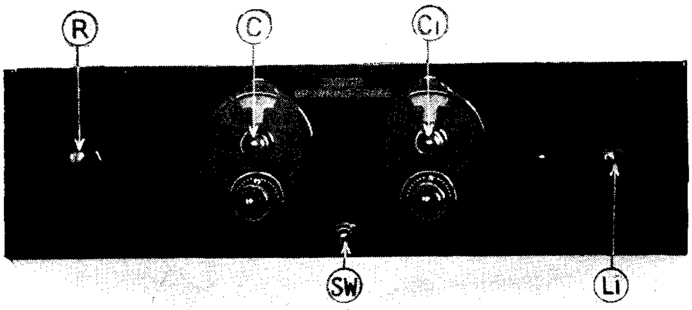
The circuit diagram of the original "Browning-Drake" receiver, described in April RADIO NEWS, which employs the radio-frequency transformer designed by Glenn H. Browning and Fred H. Drake when they were students at Harvard University, is shown in Fig. 1. While it is often referred to as the "Browning-Drake" circuit, such is not exactly the case. Browning and Drake developed a highly-efficient radio-frequency transformer and used it in this circuit, which is basically the same as that employed by Dr. Walter Van Braam Roberts in the well-known "Roberts" circuit and by the writer in his "Aristocrat" receiver, as well as in several other popular sets of the past few years. But with this diagram as a basis, let us discuss the various changes and refinements that have been developed during the past year or two and have been finally incorporated in the modernized "Browning-Drake" receiver.

To quote Mr. Browning himself on this subject: "In the set described, a tuned radio-frequency transformer is employed and the design of this transformer is the major factor in the efficiency of the receiver. The transformer was designed by Browning and Drake, from theoretical considerations; the mathematics being first worked out and the maximum possible amplification of a vacuum tube, used with a tuned-radio-frequency transformer, being computed. Investigations made at Cruft Laboratory, Harvard University, showed



A rear view of the completed receiver. The small dial lights can be seen on the panel, just above the variable condensers C and C1. It is interesting to note that the panel is supported entirely by the variable condensers, which are fastened to the sub-base.

*RADIO NEWS *Blueprint Article No.* 19.



A panel view of the completed receiver. R is the rheostat controlling the radio-frequency tube; C and C1 are the tuning condenser dials, SW the filament switch and L1 the knob controlling the tickler coil in the plate circuit of the detector tube.

that only when the capacity coupling between the primary and secondary windings was lowered to a minimum, could maximum voltage amplification be obtained.

"It is the design of the transformer rather than the particular circuit in which it is employed which is the essential feature of the Browning-Drake development. In this slot-wound transformer, capacity coupling is reduced to a minimum."

INCREASED SELECTIVITY

Now that there are so many stations on the air—more than there is actually room for—selectivity, without the loss of sensitivity or tone quality, is essential. In the original B-D receiver the antenna was connected directly to the grid coil of the radio-frequency amplifier. However, it has been found that, with the average single-wire antenna, the sensitivity of the receiver is actually increased by the use of a very small (100 micro-microfarad) variable condenser in the antenna lead. The real advantage from this arrangement is increased selectivity.

As a result of considerable research work done by the radio laboratory of the United States Bureau of Standards at Washington, it has been found that the most efficient inductance for use at broadcast frequencies is a solenoid approximately three inches in diameter, with enameled wire space-wound, so that each turn is separated from its neighbor by a distance equal to half of its diameter.

The new tuning units, which are the work of W. A. Ready, are manufactured to meet these requirements. Variable tuning condensers have been improved in many ways; first, electrically, until the losses were reduced to an entirely negligible quantity, and then mechanically. Perhaps one of the most recent developments is in the shape of the movable plates, which prevents "crowding" of stations in any one section of the tuning dial.

In the original arrangement used by Messrs. Browning and Drake, a 199-type tube was employed as a radio-frequency amplifier. The main reason for the use of this tube for the purpose was the ease with which it could be neutralized with the methods of neutralization understood at the time.

IMPROVED NEUTRALIZING METHODS

The comparatively short life and unreliability of the 199-type tube has long been the weak spot in receivers of this kind; but when attempts were made to replace it with the 201-A bulb, oscillation in the R.F. circuit could be prevented only by balancing or neutralizing schemes that were difficult to adjust for completely satisfactory operation. However, the perfection of the "Phasatrol" system by Arthur Moss and John F. Rider has made a simple and dependable expedient available. The Phasatrol makes the B-D receiver stable over the entire tuning range, even when a 201-A tube is used in the R.F. stage; it works particularly well with some of the new special tubes now on the market.

IMPROVED DETECTOR TUBES

At this point, it will be well to say a few words about these new tubes. Though apparently no better on local stations, so far as can be determined by the ear, these new detectors are regarded by many experimenters as giving the equivalent of another stage of R.F. amplification on distant signals. In fact, stations, which are barely audible with a 201A-type detector are often made quite clear by the substitution of a special detector.

When one of these new tubes is to be used, the detector-grid return should be made to the "A—," rather than to the "A+" as usual when using the older types. Fig. 1 shows the old positive grid return, and Fig. 2 the negative grid return for the new detector.

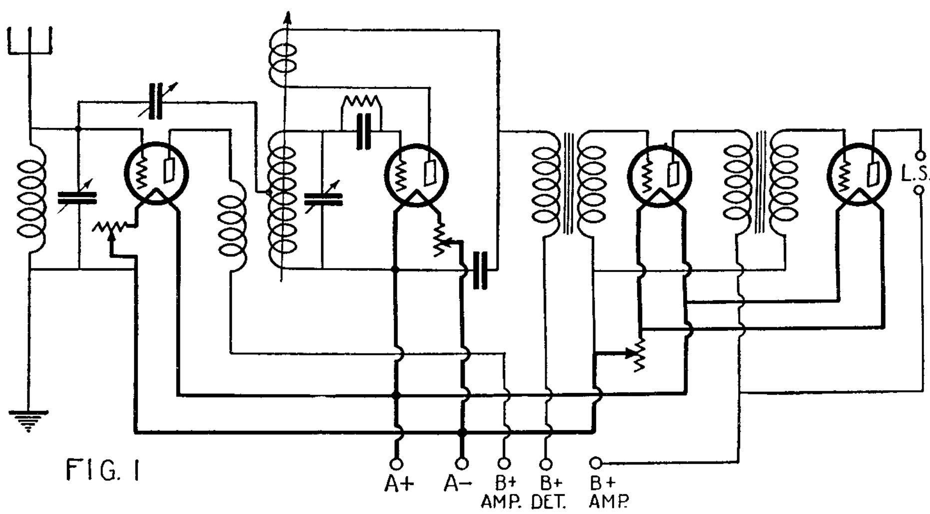


FIG. I

The original Browning-Drake circuit drawn with the addition of a two-stage transformer-coupled audio-frequency amplifier. This circuit uses a neutralizing condenser.

RESISTANCE COUPLING ADVISABLE

The plate impedance of the new detector tubes, when low plate voltages are used, is rather high, and as a result it is practically necessary to use resistance coupling, in at

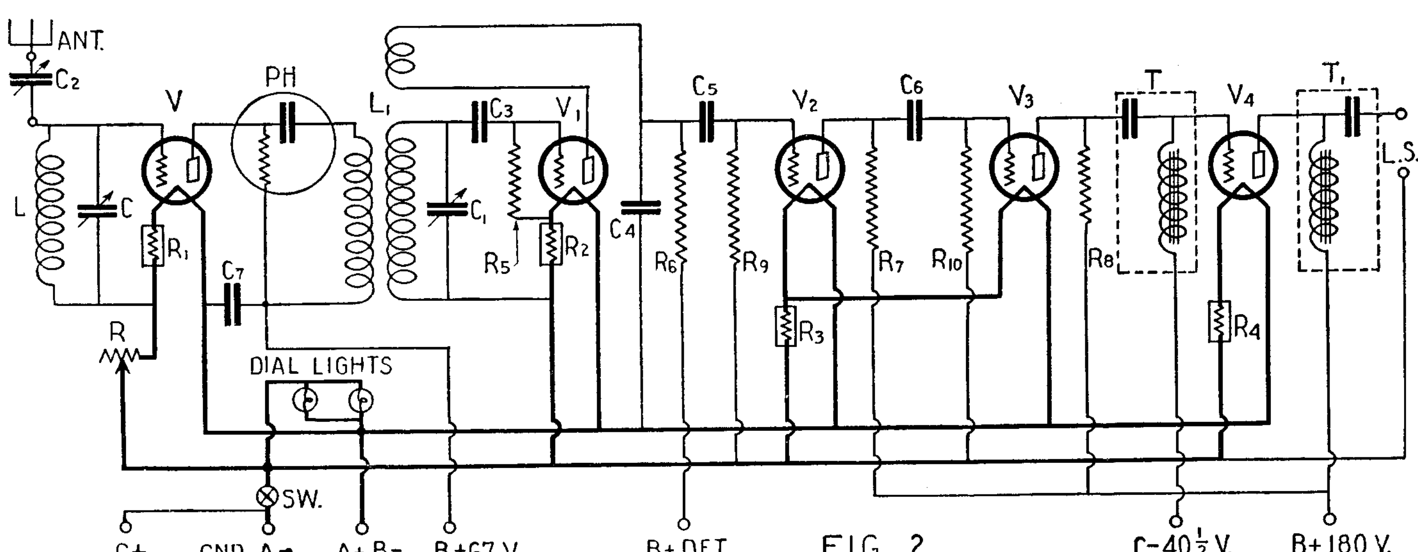
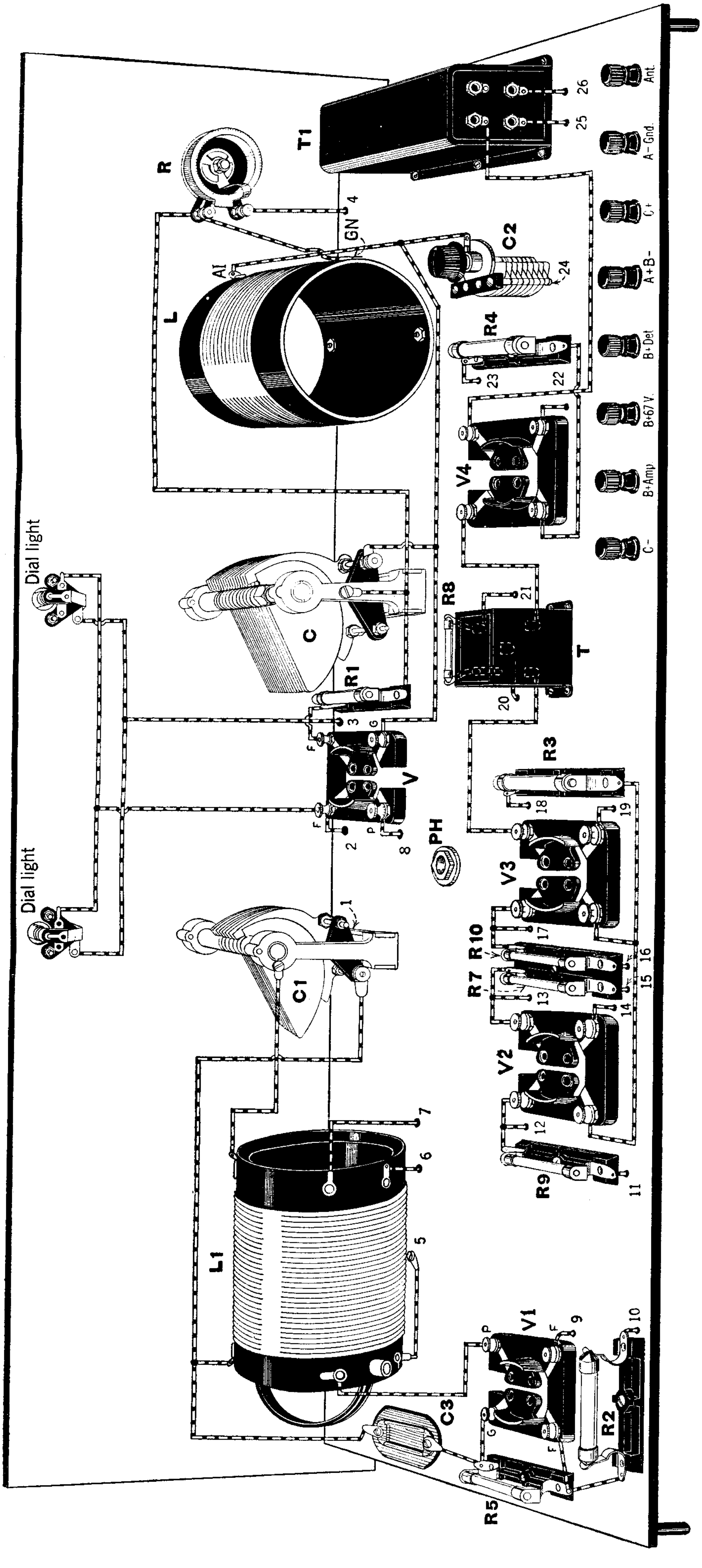
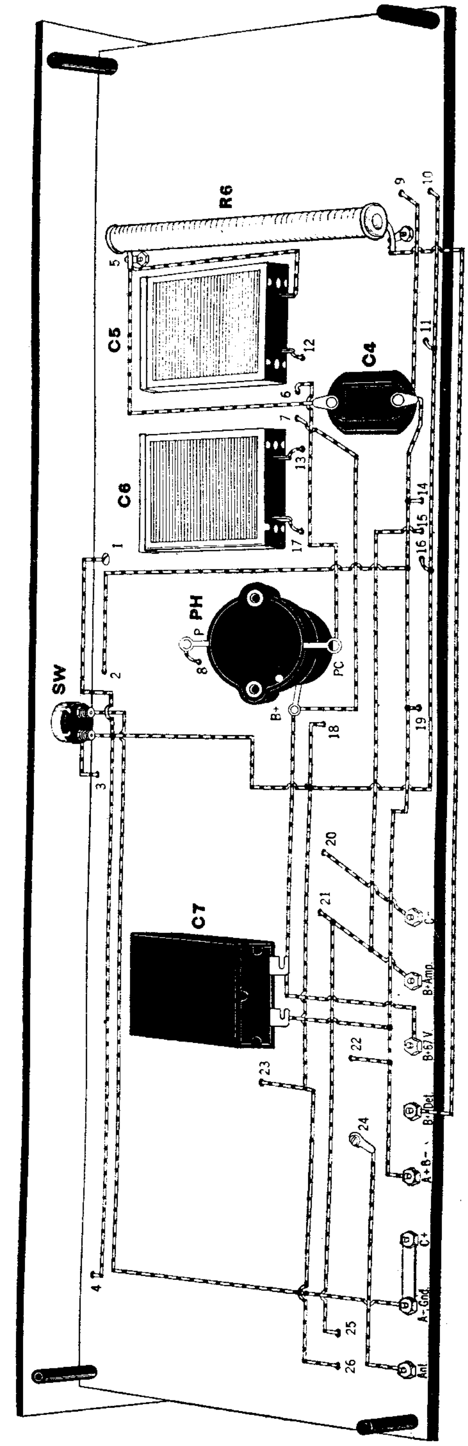


FIG. 2

The complete schematic diagram of the "Modernized Browning-Drake" receiver. PH is the Phasatrol. Note that the two high-mu tubes V2 and V3 are controlled by the same filament ballast resistance.

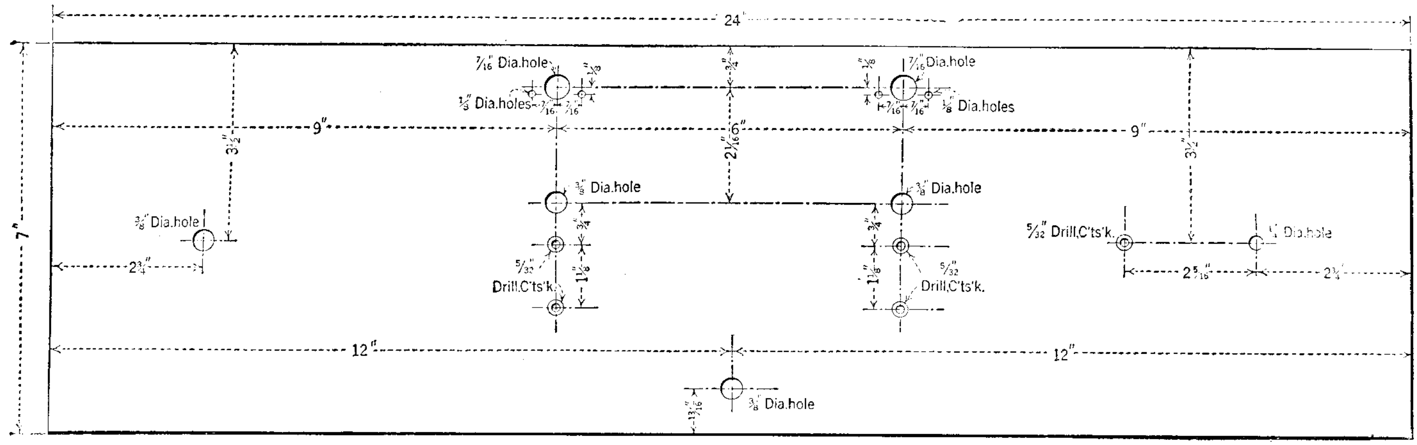




Left: Picture wiring drawing of the upper part of the receiver. The wiring under the sub-base is shown in the drawing above. The parts here are: C4, by-pass condenser; C5, C6, coupling condensers; C7, by-pass condenser; R6, wire-wound plate resistor; PH, Phasatrol; and SW, filament switch.

least the first stage of A.F., in order to secure the best of tone quality. If transformer coupling is used, the plate voltage should be raised until its value is approximately 90. This is permissible and desirable with the new "hard" type of tubes, but not with the "soft" type; the plate impedance of the former is materially reduced and better amplification of the low notes results.

In the case of resistance-coupled amplifiers, because of the constancy (regardless of frequency) of the input impedance, the detector tube may have a high-plate impedance without loss of amplification on the low notes. High voltage, however,



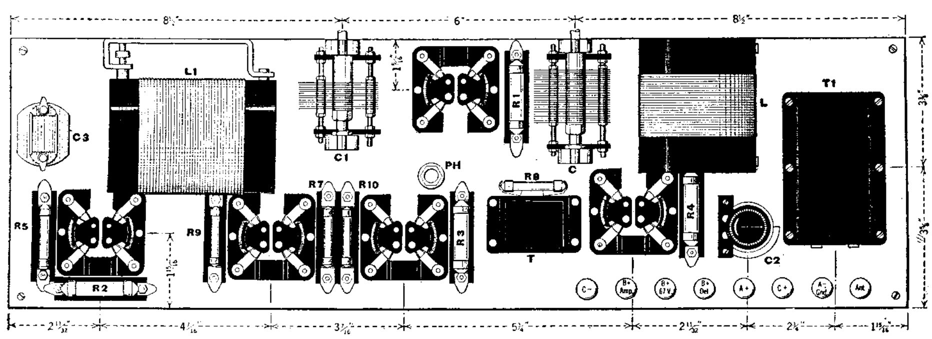
Drilling details of the front panel. All the necessary dimensions are given.

tends to increase the sensitivity of the "hard" tube and for this reason should be employed. Because of the 100,000-ohm coupling resistor in the detector-plate lead, a maximum detector-plate voltage of 135, rather than 90, should be tried.

It is also important that this resistor be of the heavy-duty type (preferably wire-wound) so that it may carry, without gradual disintegration and final failure, the rather heavy-plate current drawn by the special detector at high voltages; this runs as high as 6 milliamperes in some instances.

In sets of the past, one of the reasons for noise, distortion and short life of tubes has been the use of rheostats to control the filament voltages. Even a very slight increase of filament voltage above the rated value shortened greatly the tube's life, while a reduction of the filament voltage on the A.F. amplifier tubes resulted in distortion. Absolutely correct adjustment required the use of an expensive voltmeter.

Now, however, the perfection of filament-control devices has remedied these conditions. A voltmeter is no longer required to insure the correct voltage on the tube filaments, and needless controls are eliminated. As there are no sliding contacts, another source of noise, frequently mistaken for static, is also absent. The paper-impregnated grid leak, another noisemaker, was often far from its rated value and changed in resistance from day to day. The new metallized-filament resistors are noiseless, within 10% of their rating, and permanent in value.



Constructional drawing of the apparatus as it is mounted on the sub-base. The major dimensions are given. Note that the variable condensers also are mounted on the sub-base; they form the supports for the panel, which carries no weight to speak of.

IMPROVING OUR A.F. AMPLIFIERS

With such improvements being made in the R.F. end of the receiver, it is little wonder that many important advances are being made in the construction of the A.F. amplifier. To improve the old designs, there have been developed new audio transformers, capable of giving an extremely high quality of amplification when used correctly with the new power tubes and a good speaker.

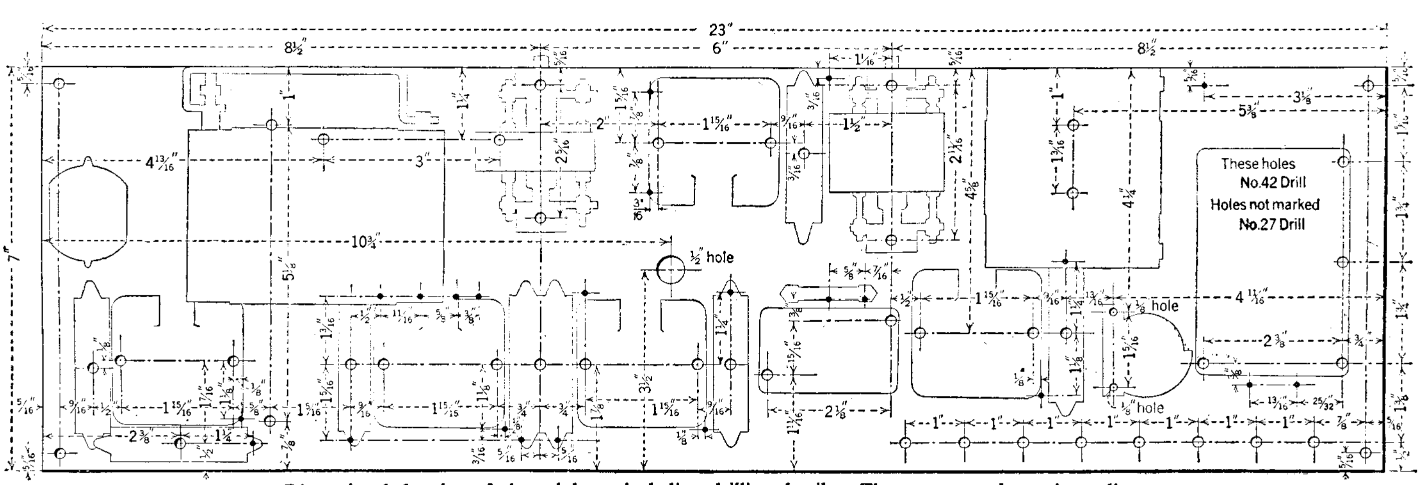
In the improved B-D model, however, a new type of audio amplification is used, in place of the former transformer-coupled audio channel. (Compare Figs. 1 and 2.) This system, which is an improvement over the old design of resistance-coupled amplifiers, embodies a practical combination of many well-known ideas and is similar to that used by James Millen in his new amplifier unit.

While resistance-coupling is one of the oldest forms of amplification, there have been many difficulties which prevented its proper use in the past. The development and perfection of metallized-filament resistors, wire-wound resistors of high ohmic value, improved coupling condensers, "high-mu" tubes, power tubes and tone-filters has done much to make the modern resistance-coupled amplifier the excellent system that it is today.

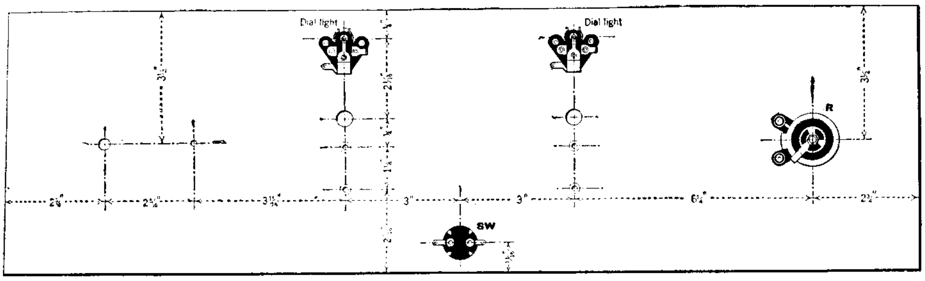
IMPROVING OLD RESISTANCE-COUPLED AMPLIFIERS

A number of resistance-coupled amplifiers have been on the market during the past few years; but while they have given fairly good results, perhaps much better than other forms of amplification available at the time they were introduced, they are no longer all that is to be desired. To modernize such a unit several easily-made changes are necessary:

(1.) Use of a heavy-duty (preferably wire-wound) input resistor for the input coupling unit, to permit satisfactory operation with special detector tubes.
(2.) Use of metallized-filament resistors in place of impregnated-paper type.
(3.) Use of proper tubes—"high-mu" tubes in the first two stages and a power tube in the last.
(4.) Use of proper "C" voltage for the particular "B" voltage employed.
(5.) Use of a suitable output device.
(6.) Substitution of an impedance leak in the last audio stage to permit use with a "B" socket unit. This impedance is



Dimensional drawing of the sub-base, including drilling details. The parts are shown in outline.



Constructional drawing of the front panel, including all the apparatus which is actually mounted on it. The tuning variable condensers are mounted on the sub-base.

connected to the two clips that formerly held the 250,000-ohm resistor, and is used to change the *phase* of the grid circuit of the power tube by approximately 90°.

THE NEW RECEIVER LAYOUT

The modernized B-D receiver circuit designed by the author is shown in Fig. 2. The general layout presents several new and striking features. One is the method of mounting the coils and condensers to obtain a set with a depth of but seven inches, thus making possible the use of a standard 7x24-inch cabinet. Another feature is the simplicity of the front-panel layout; only the two tuning controls, the two volume controls and the switch are in sight.

While this set was designed primarily for use with batteries, the Millen audio system is employed, making possible the use of a "B" socket unit if desired. In such case, a relay switch should be used with the "B" supply, so that the switch on the front panel will still control the entire set.

CONSTRUCTION

The first step in the construction of the modernized B-D receiver is to prepare the front and sub-panels. Should two standard 7x24-inch panels be obtained, then it will be necessary to cut a 1-inch strip off the end of one; as the sub-panel must be at least a half-inch shorter on each end than the front panel, in order to fit in cabinets designed to carry a 7x24 front panel.

When the panels have been drilled, the various units may be mounted in place. As the coils come mounted on the condensers, it will be necessary to separate them and then, with the hardware, which came with them, they are remounted directly on the panel. When this is done, it will be found that the tickler shaft protrudes too far through the front panel. This difficulty is readily overcome by loosening the set screws that hold the tickler shaft and working it back until the knob is at the correct distance from the panel. The excess shaft may then be cut off with a hack saw.

In mounting the two coils, it is desirable to keep them at right angles to each other.

The wire-wound input resistor and the coupling condenser from the A.F. amplifier are located under the sub-panel, through which holes are drilled to receive the terminal lugs by which the resistor is mounted. By the use of separate coupling condensers and mountings (instead of the so-called "resistor-couplers" in which the condensers are located in the hollow base of the mounting) the builder is enabled to substitute condensers of different capacities, if he so desires.

The Phasatrol also is mounted under the panel, in such a way that only its adjustment screw is exposed, as shown. The two variable condensers serve also as mounting brackets to support the sub-panel.

In order to take the remainder of the strain off the sub-panel, the author has used a central support which is formed of the Phasatrol itself. The four outside corners of the sub-panel are supported by bakelite tubes 1 7/32 inches long, with a diameter of 5/16-inch and a 1/8-inch hole. This tubing is tapped with an 8-32 thread and is held in place by machine screws.

Where bakelite tubing of this character is not available, the home constructor may use a block of wood, the entire width of the sub-panel and 1 7/32-inch high, for the outside support.

SLANTING PANELS

In the model here described, a vertical panel is used and all of the units comprising the receiver are mounted directly on the sub-panel. If a slanting panel is desired it is necessary only to mount the condensers on the front panel and to run flexible leads from them to the remainder of the equipment on the sub-panel. In this instance it will be necessary to do one of two things; either slide the sub-panel back sufficiently to allow the variable condensers to fit in front of it, or mount the condenser frame in a position parallel to the front panel instead of in the vertical position shown here.

STAGES OF ASSEMBLY

When everything else has been assembled on the sub-panel, the following procedure will be helpful in placing the coils and variable condensers.

(1.) Remove the coils from the condensers by taking out the machine screws provided at the factory.

(2.) Remove the mounting brackets from the condensers by taking out the screws which hold them in place.

(3.) Mount the condensers on the sub-panel in the position indicated in the diagrams.

(4.) Mount the antenna-coil bracket on the sub-panel, by inserting machine screws from the bottom, leaving the nuts on top.

(5.) Fasten the antenna coil to its bracket.

(6.) Wire condensers and coils to the points indicated in the diagrams.

(7.) Loosen the set screws which hold the rotor on the shaft of the coil BD-2 and push the shaft back 3¼ inches. Then cut the rod which extends through the coil towards the back by means of a hack saw.

(*Continued on page* 1376)

SYMBOL	Quantity	NAME OF PART	VALUE OF PART	REMARKS	MANUFACTURER ★	
L	1	Ant. coil			1	
L1	1	R. F. trans.		With variable tickler coil	1	
C	1	Var. condenser	.0005 mf.	S L F type	1	
C1	1	Var. condenser	.00025 mf.	S L F type	1	
C2	1	Var. condenser	100 mmf.	Midget type	2	12,13
C3	1	Grid condenser	.00025 mf.		3	4,14,15,16,34
C4	1	Fixed condenser	.001 mf.	By-pass	3	4,14,15,16,34
C5,C6	2	Fixed condensers	.1 mf.	Coupling condensers	3	4,14,15,16,23,34
C7	1	Fixed condenser	1. mf.	By-pass	3	4,14,15,16,34
R	1	Rheostat	10 ohms	For R. F. tube	4	3,17,18,19,20,25
R1,R2	2	Ballast res.	5v. 1/4 amp.	With mountings	5	21,22,23
R3,R4	2	Ballast res.	5v 1/2 amp.	With mountings	5	21,22,23
R5	1	Grid leak	2 megs.		5	3,15,16,23,24,34
R6	1	Resistor	.1 meg.	Heavy duty wire wound	5	
R7,R8	2	Resistors	.1 meg.	Standard type	5	3,15,16,23,24,34
R9	1	Resistor	1 meg.	Standard type	5	3,15,16,23,24,34
R10	1	Resistor	.5 meg.	Standard type	5	3,15,16,23,24,34
PH	1	Phasatrol		Stabilizing device	3	
T1	1	Output filter		Impedance & condenser combined	1	25,35
T	1	Impedance		Grid impedance for power tube	1	
	5	Sockets		UX type	6	7,10,18,25,26,37
	2	Dials		Illuminated type	1	17
SW	1	Fil. switch			4	3,18,19
	8	Binding posts			7	18,25
	2	Single mounts		For R5 and R9	5	24
	1	Double mount		For R7 and R10	5	24
	1	Panel		7 X 24 X 3/16"	8	27,28,36
	1	Sub-panel		7 X 23 X 3/16"	8	27,28
V	1	Tube	5v. 1/4 amp.	R. F. amplifier	9	29,30,31,32
V1	1	Tube	5v. 1/4 amp.	Special detector	9	29,30
V2,V3	2	Tubes	5v. 1/4 amp.	Hi-Mu type	9	33
V4	1	Tube	5v. 1/2 amp.	Power or semi-power	9	29,30,31,32

NUMBERS IN LAST COLUMN REFER TO CODE NUMBERS BELOW.

1 The National Co.	17 Martin-Copeland Co. (Marco)	33 Ken-Red Corp.
2 Hammarlund Mfg. Co.	18 H. H. Frost, Inc.	34 Dubilier Condenser Corp.
3 Electrad, Inc.	19 Yaxley Mfg. Co.	35 Interstate Sales Co.
4 Carter Radio Co.	20 Central Radio Labs.	36 The Lignole Corporation
5 Arthur H. Lynch, Inc.	21 The Radiall Co. (Amperite)	37 Gray & Danielson (Remler)
6 Airgap Products Co.	22 Langbein & Kaufman (Elkay)	38
7 H. H. Eby Mfg. Co.	23 Daven Radio Corp.	
8 Bakelite Corp.	24 Int. Resistance Co. (Durham)	
9 C. E. Mfg. Co. (Ceco)	25 General Radio Co.	
10 Silver-Marshall, Inc.	26 Benjamin Electric Co.	
11 Samson Electric Co.	27 Amer. Hard Rubber Co. (Radion)	
12 Precise Mfg. Co.	28 Insulating Co. of Amer. (Insuline)	
13 X-L Radio Labs.	29 Radio Corp. of America	
14 Sangamo Electric Co.	30 E. T. Cunningham	
15 Tobe-Deutschmann Co.	31 The Van Horne Co.	
16 Aerovox Wireless Corp.	32 The Magnavox Co.	

If you use alternate parts instead of those listed in the first column of manufacturers, be careful to allow for any possible difference in size from those originally used in laying out and drilling the panel and sub-base.

★ THE FIGURES IN THE FIRST COLUMN OF MANUFACTURERS INDICATE THE MAKERS OF THE PARTS USED IN THE ORIGINAL EQUIPMENT DESCRIBED HERE.

Modernizing the Browning-Drake Receiver

(*Continued from page* 1347)

(8.) Remember, when placing the condensers, that the large one is for the antenna circuit and is mounted at the left of the R.F. socket; while the smaller is used for the tuning of the R.F. transformer.

Before fastening the sub-panel to the front panel, the two units should be as completely wired as possible. On the front panel the coils and condensers may be connected together; while on the sub-panel the audio amplifier and all filament wiring may be completed. The two units are then brought together and the work finished. Well-tinned flexible insulated wire should be used. All the filament and "B" leads should be so arranged that they may be gathered together and bound into a single cable when all the connections have been completed.

USING THE RECEIVER

With the wiring completed the receiver is ready to be connected to its accessories. Most economical operation will be obtained if the large, heavy-duty "B" batteries are used.

The antenna should not be very long; generally about forty feet, including the lead-in, is enough. A good ground connection to a cold-water pipe, especially if a "B" socket unit is used, is essential.

There is little to be gained in constructing a set capable of well-nigh perfect tone quality, if it is to be used with any speaker other than the best. It is advisable to place the speaker in some other part of the room, preferably in an opposite corner from the set.

NEUTRALIZING

With everything hooked up, insert the different tubes, resistors and equalizers in their proper places. Then, before attempting to tune in a local station, gently turn the adjusting screw in the Phastrol as far as it will go in a clockwise direction. Then tune in a local station and slowly turn the adjustment screw on the Phasatrol backwards in a counter-clockwise direction until maximum signal strength, without oscillation, is obtained.

The antenna series condenser should next be adjusted until the two tuning dials read approximately the same. The station call letters may then be recorded directly on the dials.

In tuning for local stations the use of the coarse vernier control will generally be found most desirable, as it permits rapid changing from station to station. For distant reception, however, a finer adjustment will as a rule be more desirable. By means of the small levers at the bottom of the dials any ratio from 6:1 to 20:1 is instantly available.

The regeneration control will be found most useful in the reception of distant stations, as its use increases both the sensitivity and selectivity of the receiver. For local reception best quality is obtained when very little regeneration is employed. When reduction of the regeneration to a minimum fails to reduce sufficiently the volume of a local station, then the R.F. amplifier may be gradually cut out by means of the "volume" control rheostat at the left-hand end of the panel.

Because of the use of resistance coupling, it may be necessary to try as much as 135 volts for the detector tube before best results are obtained. It also frequently happens that the use of a higher-resistance grid leak (even as high as six megohms) will prove more satisfactory with some tubes than the 2-meg. unit generally recommended.

THE POWER TUBE

There are two types of output tubes available at present for home use; the 112 semi-power and the 171 power tube. The 171 permits of much greater volume, without distortion due to overloading or "blasting," than the 112 type. Where batteries are used as a source of "B" power, however, the 112, with limited undistorted power output, is preferable to the 171 for economic reasons. The 171 draws a plate current of 20 milliamperes at 180 volts. When a "B" power unit is to be used, however, the power consumed need not be considered and of course the 171 is then to be recommended.