DOWN TO ONE METER WITH CONVENTIONAL TUBES

RADIO WORLD

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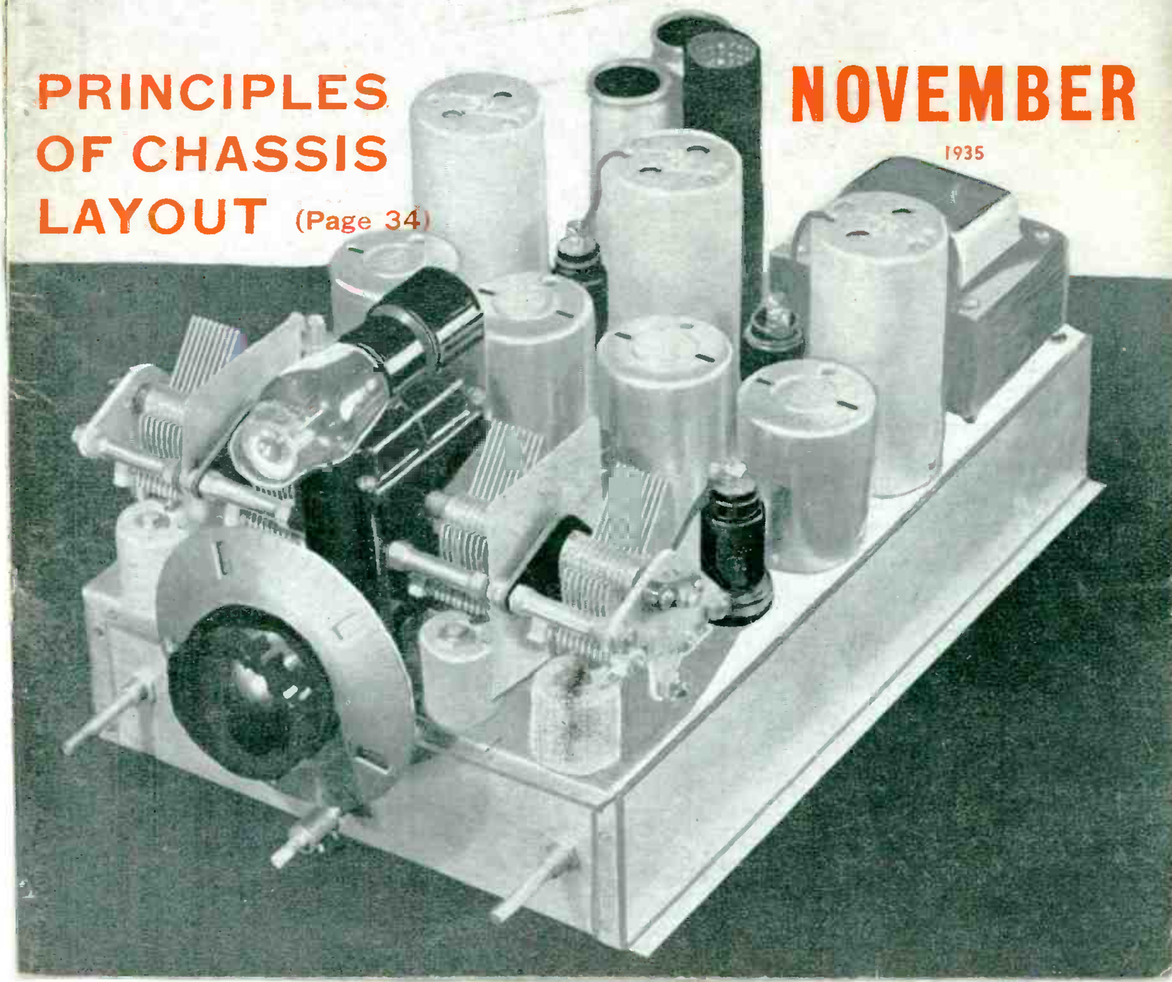
NOVEMBER

1935

PRINCIPLES OF CHASSIS LAYOUT (Page 34)



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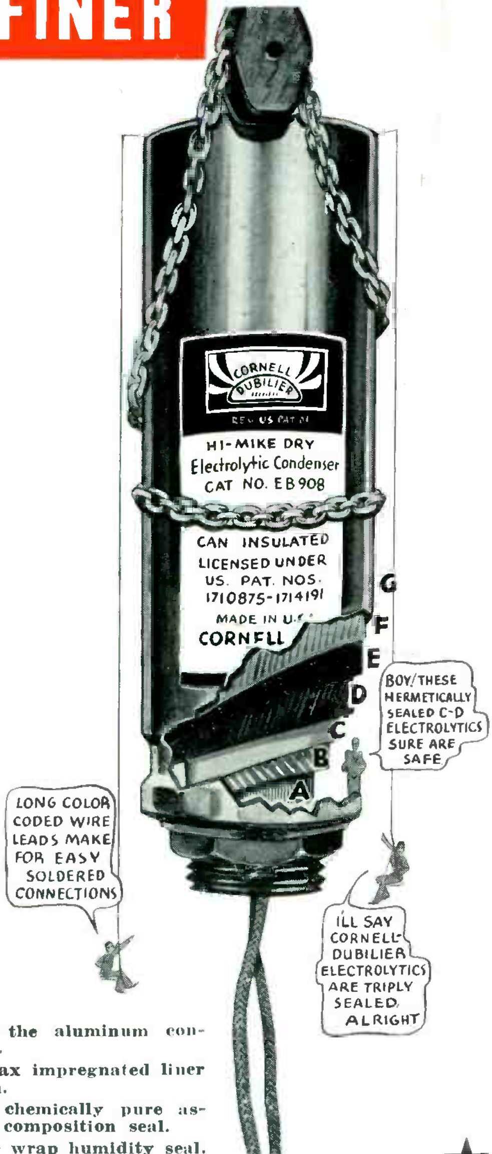

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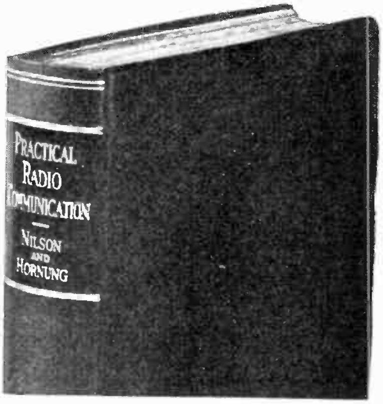

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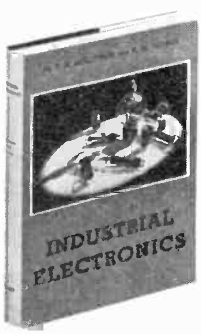

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A De Luxe Transceiver

Frequency Stability in Sending on Five Meters

By A. R. Eggensperger (W9LBI)

WHILE some commercial five meter transceivers may leave much to be desired, a device built by the author to meet rigid requirements has fulfilled all expectations and possesses that five meter rarity, frequency stability. Receivers picking up the transmission do not have to be retuned repeatedly to hold the station—in fact no retuning is required. On the receiving end this device behaves in the normal superregenerative manner.

This de luxe transceiver has the following five features:

(1)—No frequency shift when changing from "Send" to "Receive."

(2)—Can be operated from 110 volts a.c.; from 6 volt storage battery and B batteries or from regular automobile battery and suitable generators such as are now used for auto radios.

(3)—When being used with 110 volts a.c. permits 7 watts input with a conservative rating of 3 to 3.5 watts output.

(4)—Very simple switching arrangement, permitting use of two small switches on same knob, which decreases capacity in tuned circuit introduced by switches of larger design.

(5)—Gain and volume controls are operated independent of each other.

Phones Plugged Into Jack

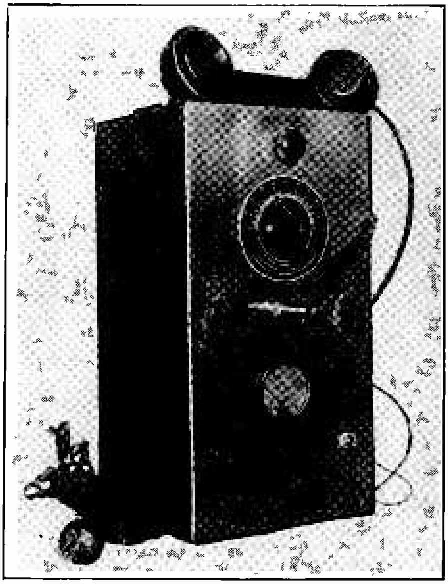
A practical 5 meter transceiver with some degree of portability, more than usual output when operated as a fixed station, and something that could be installed next to your favorite arm chair in the living room, was the ambition which prompted the writer to build the set.

The device is extremely simple to operate and if instructions are carefully followed will give no trouble when once set into operation.

The knob in the left center position on the front panel controls the volume of incoming signals, while the knob in the center right position controls the gain of the speech amplifier when the set is in the "Send" position. These controls operate independently of each other and can be left in the proper position when switching from "Send" to "Receive." This latter switch is located at the top of the panel and it is only necessary to give it a quarter of a turn, which greatly speeds up switching.

A jack (3 way) is provided on the front panel for plugging in a French type hand set.

A meter having a scale of 0 to 60 mils is also provided on the panel to facilitate antenna tuning, this being made from a meter which originally had a scale of 0 to 3 volts. It is placed in series with the plate voltage to the



The French type earphones are plugged into a front panel jack when the dual switch is at "Receive" position.

76 oscillator when the set is switched to the "Send" position, it being unnecessary to have it in the circuit when receiving.

Pilot Warns Set Is "On"

On the extreme lower right of the panel a switch turns on the power and at the same time closes one side of the microphone battery to ground. This latter feature is included to take care of the possibility of the set being left in the transmitting position while not in use, in which case it would be using microphone battery, if this precaution were not provided. Just opposite this switch and to the left is a pilot light which warns the operator that the set is "on." This no doubt justifies its place on the panel, especially when being used as a portable set with B batteries.

From the photo of the rear of the transceiver it will be noted that plugin coils are used, enabling the set to be used on the 10 meter band by merely changing coils. The small "C" battery is used for microphone current

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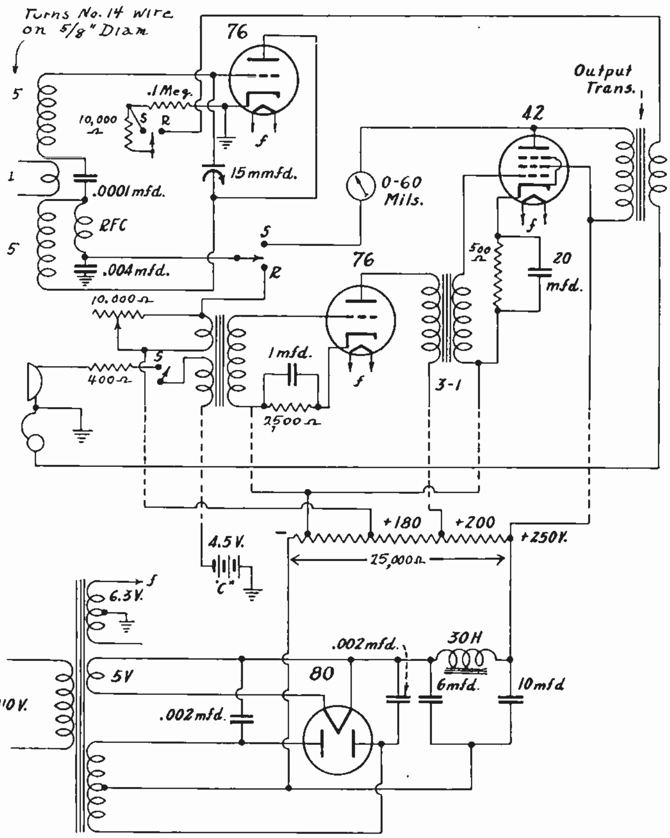


Four tubes are used in the circuit. Of these, the upper 76 is the oscillator, the lower 76 the modulator. The 42 is the modulating amplifier when the switch is at "Send" position, and is simply the audio amplifier of the rectified signal when the switch is at "Receive" position. It can be seen, therefore, that low level type modulation is used in transmission. The number of turns for the oscillation transformer winding is stated on the diagram, and some directions about fixation of inductance by separation between turns are given in the text.

(Continued from preceding page)
and there is room for two if greater capacity is desired.

The oscillator unit, part of which can be seen in the rear view of the set, is made as a removable assembly, comprising the oscillator tube, the "Send—Receive" switch, coils, choke, fixed condenser and grid leaks, all of which can easily be removed by taking out three small bolts and disconnecting a few flexible wires. This arrangement makes the oscillator readily accessible, shorter connections can be made, and it can be tested out and tried before being connected to the rest of the set.

The Switching Arrangement

At this time the switching arrangement may be described. It consists of two switches, a double pole double throw small size, and a single pole single throw toggle switch which is operated off the same shaft that operates the double pole double throw switch. The toggle switch has a forked toggle arm and is operated in the same manner as the conventional "Power—Tone Control" arrangement on many broadcast receivers. The single pole single throw switch opens and closes the microphone battery while the other switch changes grid leak values, opens and closes the receiver circuit, and makes the necessary changes to use the 42 as modulator or audio amplifier.

There is nothing unusual about the power supply. Any power supply that will supply the necessary 6.3 volts for filament and at least 250 volts d.c. with the load on, for the plate supply, may be used. A voltage divider is necessary to allow adjustment of the plate voltages on the oscillator and other tubes.

The whole unit is housed in an all metal cabinet 7 x 14 x 7½ inches deep and given a thick coat of black crystalline paint.

This transceiver has given very satisfactory results for intercity communication and will deliver the goods along with best manufactured jobs and has even outperformed one manufactured job using same number of tubes. No DX has been tried with this transceiver due to the scarcity of 56 megacycle stations in this part of the country (Fargo, N. Dak.)

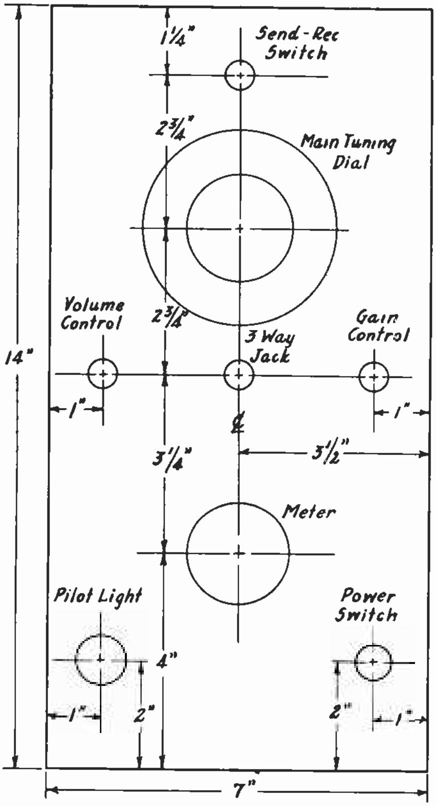
Five Precautions Set Forth

Although, with a few simple changes this set can be made to operate from a 6 volt storage battery and B batteries, no means of changing quickly from one to the other use has been incorporated in the diagram, this being left to the individual who may have his own idea about switching from one supply to the other.

No difficulty should be experienced in getting the transceiver to operate properly if the following precautions are taken:

(1)—Make all leads in the oscillator circuit as short and direct as possible.

(2)—Adjust plate voltage on oscillator until the 76 superregenerates, causing a rushing noise in the head receiver. The volume is controlled by the 10,000 ohm variable resistor shunting the primary of the audio transformer.

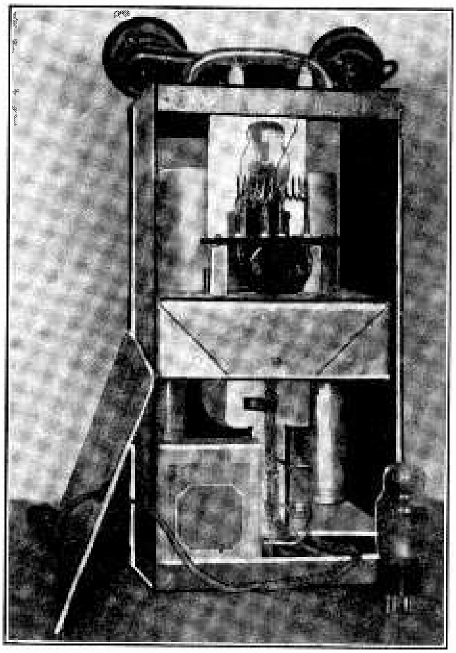


Detail for the front panel preparation. Hole sizes are not given because these will depend somewhat on the make of parts used.

(3)—If adjustment of plate voltage will not cause superregeneration try a lower value of receiving grid leak.

(4)—Adjust spacing of turns in both coils so that set covers 56 to 60 megacycles. This can be done first by roughly calibrating it against a transceiver of known coverage and then using broadcast harmonics for fine calibration.

(5)—Use an efficient antenna. A quarter wave rod adjustable for length with short 2 foot Zepp feeders makes a good portable antenna. Or two wires 48 to 53 inches in length one each attached to antenna posts will also serve for this purpose. The exact length is determined by cutting the length of both wires until the set stops superregenerating at one end of the dial, or until the plate current drops to a low value at one end of the dial when transmitting.



Rear view shows the oscillator unit at top inside the all metal cabinet. Batteries are below.

What follows has to do with the measurement of the transmitting frequencies particularly, a simplified formula being used, which relates two known fundamentals of a test oscillator with the unknown frequency. In this way the results desired may be obtained by anybody, and the formula is so simple that it is given in words, and can be worked by anybody who can read.

Taking a given example, where a test oscillator covers a relatively small range of frequencies as later proposed, suppose that there is a response due to generator's 1,500 kc. As yet we do not know the unknown frequency. Now we turn the generator dial either to higher or lower frequencies, let us say lower. The next response is 1463.4 kc. Now we may determine the unknown.

It so happens that the unknown frequency turns out to be 60,000 kc, that is, 60 mgc, because 1,500 minus 1463.4 equals 36.6, which, when divided into one read frequency equals 41 and when divided into the other equals 40, the numbers always being harmonic orders and under the recommended system consecutive, and the harmonic orders are multiplied out by the difference, 40 x 41 x 36.6, equals 60,000.

It has been stated that the inductance may be adjusted by alteration of the spacing between the turns of the coil. If the turns are put closer together the inductance will be in-

(*Continued on next page*)

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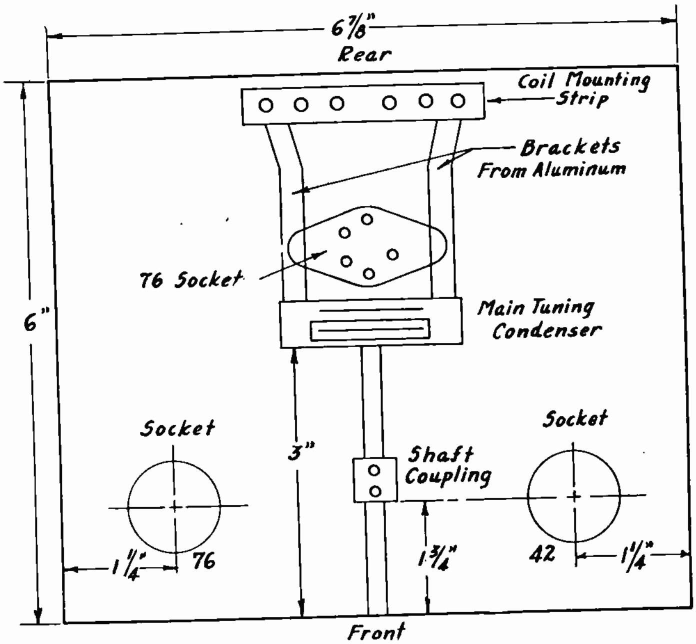
creased, and if they are separated more, the inductance will be decreased. There is supposed to be some reduction of distributed capacity, also, with increased distance between turns.

The tuning condenser capacity may be 15 mmfd., but it is customary to use somewhat more, to be surer of striking the right range, that is, including the desired frequencies. This, however, has its perils, too, as in the transmitting position there is the likelihood that one may work outside a band, which is serious.

Therefore it is vastly important that at least the terminal frequencies of tuning, and a registration of the terminal frequencies of the band, fundamental of the test generator, slowly and carefully turn to the next dial position of a test generator fundamental that repeats the response, moving in either direction, but with every precaution not to skip or miss a response, otherwise the inaccuracy would be atrocious. The second frequency is noted and the unknown is computed accurately from these two determinations. Subtract the lower read frequency from the higher one, divide this difference into one read frequency and then into the other, and then multiply the difference by the two quotients. The answer is the unknown frequency, to a percentage of accuracy equal to that of the test generator itself.



Location of oscillator parts is revealed in this detail. Since the oscillator is the heart of the circuit extreme care should be exercised in its construction. The author gives valuable pointers in the text. The locations of the sockets for the other 76 and the 42 are given also.

be realized for transmission purposes. For reception, of course, it makes no difference, as anybody is entitled to receive on any band.

Measurement of Unknowns

Since it is easy to erect a test oscillator for the broadcast band, one may calibrate it closely, and even make his own direct frequency reading dial, and, using a strong output, determine the unknown frequencies of the transceiver by the harmonic order identification method. As stated, for transmission this is vastly important, and close values are obtainable. But for reception, since the receiver is broader by far, due to superregeneration, definition of frequencies will not be so good.

The easiest way to determine the unknown high frequencies is to gain a response due to detection of the beat between the transmitter oscillator and the generating tube of the test device, then observing the frequency of the

Since easy observance of close differences of the test generator facilitates accurate and rapid results, it is preferable instead of having a generator that covers the entire broadcast band, to use the same coil as before, but with a much smaller tuning condenser, say 35 to 50 mmfd., and calibrate for the high frequency end of the broadcast band, say, from 1,300 to 1,600 kc. When this difference of 300 kc is spread over 180 degrees of a dial, naturally close readings are obtainable, and moreover the response in the beat detector is stronger, because the harmonic orders are lower.

As a check on any one measurement and computation, repeat the process, using other fundamental frequencies, since the same result must be attained at every repetition.

In conclusion I would like to state that any one building a set of this kind will be well paid for his efforts and will no doubt be surprised at the results obtained from reasonable compliance with directions.

Down to 1 Meter, Usual Tubes

All Oscillators That Work Turn into Colpitts Type

By Herman Bernard

THERE is great activity on five meters nowadays, with prospects of extended doings on still lower waves this winter. It becomes increasingly important to be able to measure these short waves, since the importance is proportionate to the number of stations using them.

The activities in these regions with which we are concerned are those of the licensed amateurs. Incidentally, however, it is necessary to pay some attention to bootleggers, who transmit without license, move from place to place with their portable apparatus, invent call letters or "borrow" legitimate call letters, and in general add to the havoc.

It was said they add to the havoc, because some licensed amateurs contribute to their own miseries by having wobbly transmitters, broadness and being outside the band.

The socalled five meter band reserved to the amateurs is useful for local service principally. In frequencies the band extends from 56 to 60 megacycles, which in meters is 5.354 to 4.997. So for a span of 4 mgc., if a band width of 20 kc were assigned to each station theoretically, then 2,000 stations could be operating at once, without interference, assuming they stayed inside their assignment. But, of course, conditions are very far removed from anything like that.

Conventional Tubes Used

Frequency stability of the oscillator is of unexceeded importance in all amplitude modulated transmitters, and the same seniority attaches to any test oscillator to be used for measurement of a transmitted wave. For instance, if the transmitter were frequency wobbly and the test oscillator likewise, the changes could be of such a serious nature, due to opposite extremes, that one could scarcely say that a measurement was being made.

In the construction of experimental circuits for generating low waves, which included the five meter band and extended even to one meter, using conventional tubes, it was found that a circuit set up as a Hartley, permitting apparent grounding the plate to radio frequencies, behaved steadily.

On any of these low waves, say 5 meters or under, the problem of grounding is not easy to solve, for everything about the system seems to have at least a small elevation of potential. A thick bus 1 inch long, which looks to the eye like a short circuit, turns out to present a sizeable impedance to the generated wave. And down on 1 meter no matter what you touched, even the ground lead itself, or any part of any conductor, including intended shield cabinet, there was a resultant click in an externally coupled detector, suggesting that grounding was still elusive.

Inductive Effects from 1 Mfd.

However, since a capacity of 1 mfd. is extremely large to these frequencies, it was connected from plate to the single point to which the ground and return leads were carried. The "ground" lead turned out to be rather an aerial. So the use of external ground may be passed up, and in mentioning grounding we will mean the reduction at some single point to the lowest r.f. potential.

One heater side of a 76 or 6C5 was selected as this point, and it was made common for all returns of radio frequencies, and of direct current. The 1 mfd. condenser was returned there, of course, so was another condenser .05 mfd.

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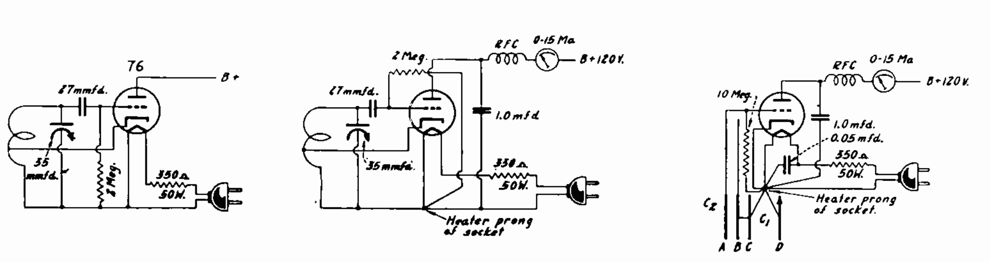


For operation on five meters the oscillator at left was used at one stage, but as a.c. was on the plate, oscillations ceased too soon, and little reduction of wavelength could be accomplished. Higher leak and inclusion of choke and by plate bypass condenser (center) improved matters. A nearly literal diagram is at right, AB, (C2), representing the grid condenser, and CD, (C1), the tuning condenser.

(*Continued from preceding page*)
capacity, the two being separated by a radio frequency choke coil.

It was found that without the choke the grounding was not nearly so effective, and also it turned out that the attempted grounding was so far from being an actual accomplishment that a decided field was present about the choke coil.

This field was strong enough to cause a response in a meter in series with the tube's plate leg when the hand was brought near the choke. Obviously it was also possible to put a coupling winding there, or a short bus for its capacity effect, and take an output in this way. The large condensers were no short circuits to these frequencies, after all, and this may have been due to their inductance, as they were of the paper type, and not specially wound noninductively. Yet at these frequencies the winding—a winding noninductive to low frequencies—would turn out to be inductive at ultra frequencies, it seems safe to prophesy.

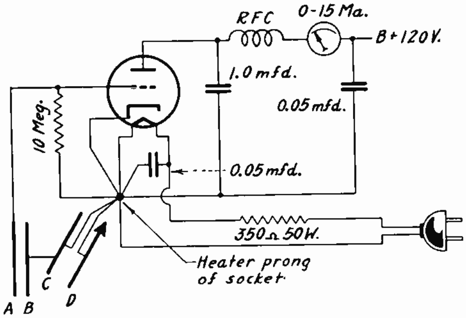
Attempts to Raise Amplitude

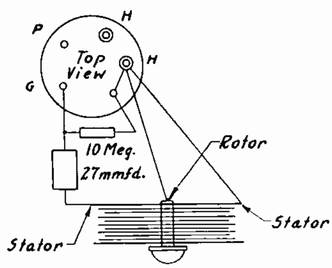
At around 1 meter, a 3¼ inch length of No. 22 copper wire turned out to be an appreciable inductance. In fact, the tuning condenser itself had almost enough inductance. The No. 22 wire strip was computed to be of 0.09 microhenry inductance. Capacity-frequency measurements confirmed this only if all other inductance was considered zero.

The first attempts made concerned the raising of the amplitude of the oscillation of the test device, because the excitation is feeble enough at these frequencies, using conventional tubes. The 76 was tried first, and it was hardly possible to obtain a clear definition of oscillation below three meters until the choke was put in the plate leg and the 1 mfd. condenser from plate to heater. The choke value was not critical, about 30 turns of No. 32 enamel wire on ¼ inch diameter. The small diameter was selected to keep down the distributed capacity of the choke, so that the choke would behave as a choke and not as a condenser. The end bypass condenser was not critical, as there was small gain in amplitude of oscillation when capacity of 0.05 mfd. was increased to 1 mfd. It so happened that values of capacity found in the mica condenser forms did no good as enablers, supporters or increasers of oscillation intensity.

Plate Current Measurement

The method used for measuring the oscillation intensity qualitatively was to compare the positions of the meter needle. If grid is connected to cathode, to shortcircuit the input, there will be a certain reading, which with the 76 tube, 100 volts on the plate, 10 meg. leak, 30 mmfd. grid condenser, about 7 milliamperes, when the circuit oscillation is restored the current will be less, because a negative bias is put on the grid through grid rectification. The d.c. resistance in the grid to cathode circuit is less than the grid resistor load resistor's value to an extent depending on the leakage in the tube.





The completing condenser of .05 mfd. improved the oscillation, as did bypassing the resistor in the heater circuit, which resistor was built into the line cord. Application of 120 volts d.c., replacing a.c., enabled going down to 1 meter. At right is a top view, socket above the tuning condenser, showing the V inductance used around 1 meter.

Use Small Grid Condenser

It was found that with the load grid leak omitted, and the tube leakage used, the intensity was higher than during any condition of loading the grid with an external resistor, but the stability was not acceptable. It appears therefore that the quantity referred to as the leakage resistance of the tube itself, grid to cathode, is not a constant, but changes slowly, hence for stabilization, where this would depend on the bias in any way, the load resistance introduced should be low compared to the leakage resistance, yet high as practical consistent with small *change* in the plate current as the tuning condenser is rotated throughout its full span. The highest leak value commonly obtainable therefore was introduced, 10 meg.

When it is necessary to use a high leak it becomes necessary to use a small grid condenser, otherwise there could be a modulating effect, due to the leak-condenser time constant. No modulation of this type is desired, because it is a frequency modulation system and introduces instability.

Some Oscillators "Dart"

The use of conventional tubes with uncoiled inductances is unfamiliar, because at wavelengths below a few meters it has not been acknowledged that such tubes can be made to oscillate with usual circuiting. Stoppage of oscillation at some wavelength is noted and for lower waves it is assumed that some entirely different method must be adopted. One method has been to reapportion the d.c. voltages, using preferably a tube with cylindrical electrodes, the grid being made positive, the plate negative or zero, but never positive, thus producing an untanked electron oscillator. This method was devised by Barkhausen and Kurz. It has been noted that the circuit may not always oscillate at one frequency, but may jump to some other frequency or frequencies of oscillation. The wavelength may be said to be controlled by voltage, even though with voltage constant the wavelength may dart.

The usual tank circuit is regarded as absent, although the capacity and inductance of the elements in the tube should be considered. It has been found possible to create such oscillations with an external load, the method being due to Gill and Morrell. Others have produced variations of these methods, including use of tubes with plane electrodes.

Large Tuning Capacity at First

The series Hartley circuit was used recently by the author with a 76 tube in an effort to maintain oscillation at wavelengths below the critical value at which oscillation stopped. At first a few turns of wire were used, and tap located experimentally so that the oscillation intensity was not so very much different at one extreme of the tuning than at the other. A National company straight wavelength condenser of 35 mmfd. was used, intentionally large so as to provide a considerable wavelength ratio and thus impose hardship on the circuit.

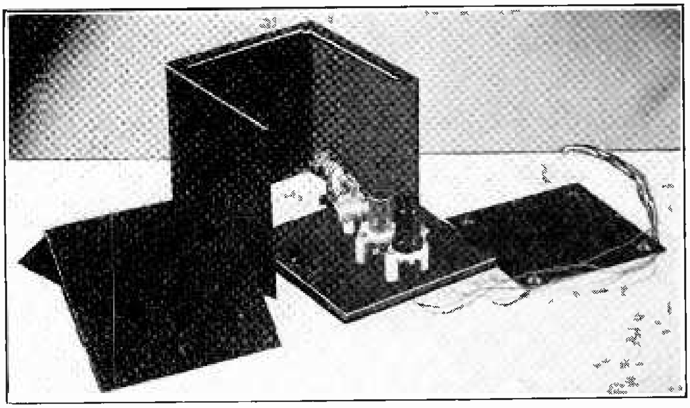
Later a 15 mmfd. straight frequency live National condenser was substituted.

Actually, the circuit consisted of a grid leak from grid to one side of the heater, grid condenser to stator of tuning condenser, total coil from stator to rotor of tuning condenser, and cathode connected to tap on the coil. As the inductance was made smaller the amount became too small and oscillation stopped. At this point means were sought to provide oscillation at lower wavelengths, as stoppage took place above 2.5 meters.

The wire used on the coil was tinned No. 20. otherwise uncovered, and the turns were spaced twice the outside diameter of the wire. Since tinning is supposed to increase the high frequency resistance, No. 18 bare copper wire was used in the same manner, but there was no improvement.

Loss Prevention Sought

Then No. 10 enamel covered wire was tried, but increase of the wire diameter did not provide a solution. The circuit losses were then so large that any comparatively small differences due to the diameter of the wire in the inductive branch provided no remedy.



Parts as shown, except for those few underneath the supporting platform, were assembled in a five meter band oscillator. The bottom piece is at right, the hinged cover and rear wall (one unit) at left.

Therefore a search was made of other branches of the circuit to ascertain whether it was possible to prevent the loss of energy assumed to be bypassed into the d.c. voltage supply. It was found that by inserting the radio frequency choke coil in the plate leg, and bypassing plate to ground, that the oscillation would continue to a somewhat lower wave. No actual measurement of wavelength was made at this time as from experience, and a look at the constants, it was obvious that the wavelength was above 1 meter, and it was intended to try to develop oscillation in the centimeter region.

Leak Value Raise

The bypass condenser was 0.0005 mfd, selected because it seemed more than amply large for the wavelength of operation. When the capacity was increased to 1 mfd. the oscillation was stronger. Also the wavelength was a little higher. The oscillation intensity did go up, as indicated by a low resistance plate circuit d.c. meter. The stronger the intensity of oscillation the less the plate current, because a grid leak and condenser were used.

The leak value at first was 2 meg., but when

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the leak was removed entirely, the oscillation could be detected at still lower wavelength. There was of course a leak present actually, because the tube had some leakage, also the socket, which at first was of the ordinary thin bakelite wafer type as used in commercial receivers. The conclusion was reached therefore that the leak resistance should be very high, and of course the tube and other leakage could be utilized for some particular circuit but would scarcely suffice for duplication, as the leakage value would be different. A value of 10 meg. was selected as this is obtainable generally. Also a value of 250 meg. was tried, this being a specially manufactured product, not found in the general market. Naturally there was a little improvement, 250 meg. compared to 10 meg. The comparison was on the basis, how low a wave can be generated, rather than on amplitude comparison by plate currents.

In all instances the plate current was nonuniform over the span of the condenser. For nonoscillation the plate current was maximum, so that by noting this maximum, and finding the current at which ratable oscillation was present, it could be determined by meter reading whether the circuit was oscillating.

Use of Plate Meter

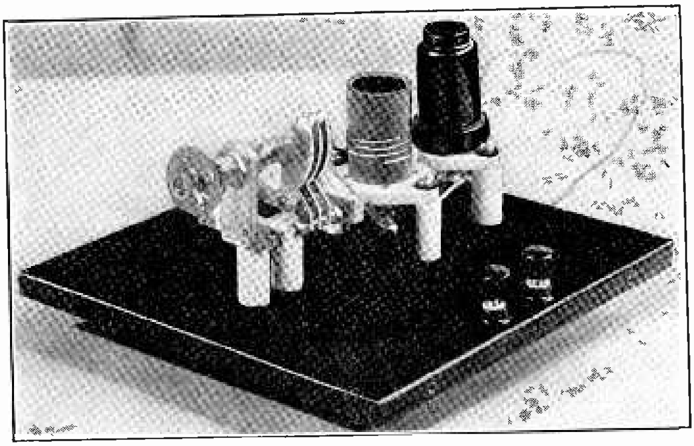
Also, of course, bringing the hand within a few inches of the inductive branch would increase the current, because of the losses to ground through body capacity, and this also is an oscillation check. The meter can be used without the hand capacity assistance to better advantage in making the full wavelength run permitted by the tuning system. The hand capacity method proved very valuable in determining whether the oscillating tube was operating on a favorable part of the characteristic curve.

The plate meter reading will change considerably if the hand is as much as 6 inches away from any part of the inductive branch, and by using outstretched forefinger it is practical to estimate where the circulating current in this inductive branch is most intense. It is very difficult to make this measurement in absolute values anyway, but the finger method at least enables one to estimate just where along the coil the inductive effect is greatest.

It is familiar in coil practice that the inductance per unit turn is not constant over the axial length of a winding, and is assumed to be greatest somewhere near the center. At least removal of end turns changes the inductance comparatively little, on large coils, until the coils come within the requirements of shape factor for approach to the "ideal."

Distributed Capacity Kept Down

The shape factor of the low wavelength coils is necessarily poor, because in the attempt to keep down the distributed capacity the winding diameter is made small. This results in the axial length of the coil not only being greater than the winding diameter but much greater.



The metal tube is the 6C5, the small triode, which performed well as an oscillator on waves to one meter, using the form of the series Hartley circuit, which, however, behaved as a Colpitts oscillator when the waves generated were low enough, say, below a couple of meters. The use of high grade sockets is of paramount importance to reduce leakage and other losses.

It was therefore decided that coiled inductances perhaps were not quite the right thing, and so it was decided to try straight wire inductances. The word coil and inductance therefore ceased to be synonymous.

Before anything was done about this, the condenser tuning was examined and the idea tried out of using the condenser's own inductance and simply connecting to the tube. However, the taking of a tap from a capacity inductance, if one may call it that, would require soldering to a stator plate, and that was not tried, so tube capacity feedback was attempted, without special inductance. It was known that the tube elements had some inductance, that any wire, however short, from condenser to any other point, had inductance, and so a rig was established, but there was no oscillation. Using special tubes, like the 955 triode and 954 pentode, some such stunt has been accomplished by others, but the present investigation had to do with conventional tubes.

The Funny Looking Diagram

The circuit was restored to its former condition, with the same sort of small *coil*, and as various wire samples were at hand, they were tried. No. 10 enamel wire and eight strand enamel covered wire equal to No. 18 were compared, with no great difference, but when No. 22 bare copper wire was used there was increased oscillation.

Of the wire sizes on hand No. 22 bare copper was selected for the test of uncoiled inductance, or straight wire. The schematic diagram of the essentials of the circuit and the pictorial representation of the essential branch under discussion are shown on page 9. C2 is the grid condenser and is drawn elongated in the schematic to emphasize the point that practically no wire is used between grid and stator of the tuning condenser C1. Also the tuning condenser is shown in an exaggerated manner in an effort to conform the schematic to the actual formation of the straight V inductance.

It can be seen that the rotor is not grounded, but that the focal point of the system is the grounded heater. With a.c. on the plate, in case the ungrounded side of the a.c. line is picked up, whereupon a little tingle is felt on touching the stator or any part of the tuning condenser, the line plug may be reversed in the wall socket. This would produce oscillation otherwise absent. The condenser across the heater is there so that grounding will prevail, as best it may be, well enough even without the reversal precaution.

Kept Up on Stilts

The rig was built on a dry wood baseboard and was elevated on stilts 1 foot high, to keep the circuit free from external effects, also tests were made more than three feet from nearest wall or ceiling or floor, the rig being elevated on a normal metallic table. Operation within six inches or so of any of these obstructing objects with an open assembly had somewhat the same effect as bringing the hand near the field of circulating current. For the same reason a 76 tube was worked without a shield around it, since it would be practically impossible actually to ground the shield, potential difference having been noted on a shield put there experimentally, though shield at top and bottom was wired to intended ground.

When the circuit was tested, with lead from stator of C1 to ground consisting of 3.25 inches and led from rotor leg at rear of C1 to ground, oscillation was present over part of the tuning, stopping near the high capacity, high wavelength end, and leaving about 30 degrees of knob rotation at the other end with oscillation absent.

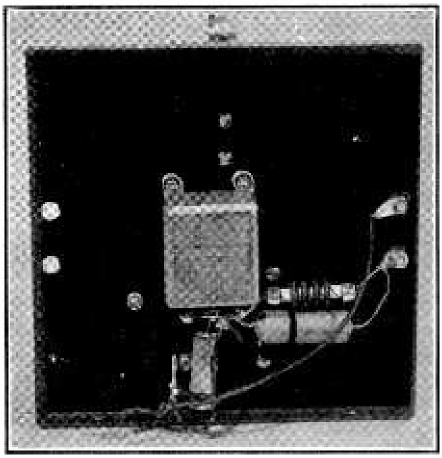
Making Some Progress

It was practical to use parallel capacity to bring about oscillation with condenser plates fully disengaged, but the oscillation stopped sooner at the other end, as the inductance to capacity ratio had become too small, considering the large losses in the functioning circuit. The inductance could not be increased without increasing the wavelength, which worked in the wrong direction, and while a smaller maximum capacity condenser could be selected to provide an apparent improvement at the high wavelength end, what was desired was not merely the establishment of a working circuit within narrow limits, but one operating satisfactorily within wide limits, so that when smaller total capacity variation was introduced later, it would be without fear that small changes in uncontrollable conditions would determine the presence or absence or extreme feebleness of oscillation. Besides, the main problem had to do with the low capacity settings, since oscillation was necessary in this region if waves below 1 meter were to be generated.

The circuit in reality had been changed from the original intention of using a Hartley, since the two branches of the V supplied by the straight wires constituted the plates of a tiny condenser.

Another Filter Condenser Added

Notice was taken of the fact that the strangely large capacity needed for bypassing from plate to ground did not have its companion at the other end of the filter system, so



Parts wired underneath the platform of the five meter oscillator, using National Company parts.

a condenser of 0.05 mfd. was put in the vacant place, and again there was some amplitude improvement, at the region of about mid capacity where the tuning condenser happened to be positioned. Then the slow but still rather exciting movement of the tuning condenser to lower and lower capacity was begun, and oscillation prevailed all the way, to the very minimum capacity. The needle had begun its movement toward higher plate current, showing that change was in the direction of lessened oscillation intensity, and at minimum capacity the amplitude was very weak indeed. When d.c. was applied to the plate of the tube, the plate current was near socalled cutoff, at zero bias the current was 15 milliamperes (no oscillation), so the oscillation intensity was good. Whenever oscillation stoppage occurred, although it followed a gradual decline, it was abrupt, in the sense that oscillation and 7 milliamperes would be followed by a reading of

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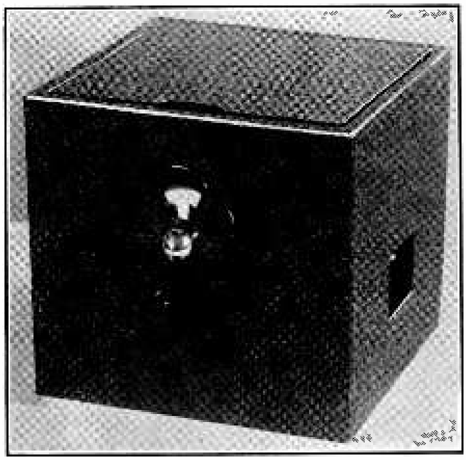
maximum 15 milliamperes for non oscillation, and in between it was not possible to obtain generation.

Operating Point Selected

The method of theoretical selection of the operating point was to halve the maximum current, for that would create operation on the steep portion of the characteristic, also the straightest portion, but control of the operating point is difficult at best, especially so when



The five meter oscillator in its metal cabinet.

preservation of oscillation is itself the outstanding objective.

Variation of grid current, hence grid bias voltage, hence plate current, in any grid leak oscillator is very considerable. This merely reflects the changes in amplitudes of the oscillation voltages at different wavelengths in the tuning. It is true on all bands and particularly is there variation on low waves, and most particularly centimeter waves. While there might be considerable variation over the tuning of a single band, as here, it is nonlinear variation.

Grid Leak Effect Incomplete

If the grid leak were completely effective in offsetting a given peak positive amplitude with an equal amplitude of negative bias, the jagged curve would not result. If there is practical uniformity of plate current, even though the tuning process is repeated time and again, there is amplitude (voltage) stability, current stability, and frequency stability, for in the light of the intended behavior of the tube as a pure resistance they are one and the same. Having established generation it would be most valuable to introduce stability of a high order, otherwise the generation is more or less an academic, since the wave becomes of value in proportion to the constancy that can be imparted to it. Stabilization at higher waves is within the known methods of the science, but stabilization at short waves, particularly centimeter waves, is as yet unknown in single sided circuits, and is only a theory even as to balanced circuits.

Small Capacity Grid Condenser

The oscillation intensity was better with the small grid condenser than with larger capacity. To attain the small value of grid condenser a compression type trimmer was used, screw removed, and plates allowed to extend their full natural displacement, yielding a capacity a bit under 10 mmfd.

Selection of grid leak and condenser values are sometimes made with the objective of improving the frequency stability, as the method, though critical, does yield such results, but the present selection was on the basis of elevating the oscillation potential, since the plate circuit treatment afforded good stability, and one of the difficulties with ultra frequency oscillators, using conventional tubes, is to get anything much out of them.

Smaller Diameter Wire Better

Some interesting sidelights were developed in the course of experiments, using both glass and metal tubes. One was that for wavelengths near one meter the large diameter wire proved to have much greater radio frequency resistance than small diameter wire. It has been common practice to increase the wire diameter to support oscillation at high frequencies, and the method has abundant verification, the theory being well understood. Since the wave travels on the outer surface of the wire, the larger diameter presents a more conductive medium. This travel on the outside is known as the skin effect.

What has not been brought out, however, is that there is a frequency at and beyond which the resistance of the wire becomes larger, the greater the diameter of the wire. Most experiments with the wire sizes were conducted by the author in the range 1 to 1.4 meters, no tests of this kind having been made on 5 meters, where the oscillation intensity was high enough, anyway, so that difference in wire diameters would not be so important, and so a commercial coil was used as found.

Some Detective Work with Amplifier

The theory behind the increased resistance for increased wire diameter requires further study. At present it is believed that the greater surface presented by the larger diameter wire to a wave travelling on the outer surface appears to the wave as a greater resistance due to phase displacement, somewhat in line with the economic analogy, the law of diminishing returns.

The wire sizes tested were No. 14, No. 18, No. 16 and No. 22, and the oscillation intensity increased each time as the diameter of the wire was reduced. The difference can not be ascribed either to capacity or inductive effects, as the improvement was marked over the entire tuning range, 1 to 1.4 meters, in all instances, when the condenser itself was 6 to 35 mmfd., and the actual lengths of the wires were changed in a direction to make the finer wire have somewhat less inductance than the next larger size wire with which it was being compared.

Another fact gleaned was that the verdict, "tube stops oscillating," rendered as the frequency is increased to the seemingly critical value, is often premature. Usual tests for presence of oscillation might disclose no indication of generation. However, an amplifier was used and then oscillation presence was observed, showing that feebleness of oscillation may be readily mistaken for absence.

Some Amplitudes Too Low

Of course when the amplitude is so low that an amplifier is necessary to denote the presence of oscillation, very little if anything can be done with the wave.

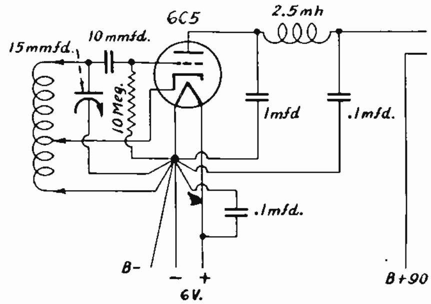
The oscillations of such a weak nature that they had to be amplified to be recognized were not included in any count. Conventional tubes, like the 6C5 and 76, yielded intensities exceeding those normally encountered with other types of oscillators, like the Barkhausen-Kurz and the Gill-Morrell. These two, and one other, the only oscillators using conventional tubes, except the circuit now under discussion, which does not depend on a positive grid, does produce a greater oscillation intensity than the others, and has good stability.

The B. K. and G. M. circuits are called electron oscillators, because the frequency is determined by the period during which the electrons are made to oscillate between grid and cathode. The method is used because it is deemed that as the frequencies become much higher than the customary high frequency limit—that is, the waves are in the centimeter region—the oscillations cannot be supported otherwise, due to the limitation imposed by the transit time of the electrons traversing their accustomed path. That is, it takes an electron longer to make the trip than the intended cycle of generation permits.

How the B.K. Is Explained

The B. K. circuit is supposedly one depending solely on the control of the electron transit by voltage application. The grid, as stated, is made highly positive, and since the grid was never intended to be a conductor of relatively large current tube life is extremely short, sometimes only several minutes. The plate is returned to a zero or negative potential. The G. M. adaptation includes a tank circuit, and this is made to control the frequency of the generator. There is some reason to suppose the two circuits are inherently the same, because the supposedly absent inductance, capacity and even resistance, that control the frequency by the B. K. method, scarcely can be absent from any circuit. The tube in the B. K. circuit is the same tube as in the G. M., and inductance and capacity are present in the tube elements and structure. Also the wiring, however short, is significant of inductance and capacity. The G. M. method is one of intentional control of frequency by external means. The B. K. method is one where practically internal constants are utilized, and the instability of the circuit is capitalized by changing the terminal voltage to control the frequency, by changing the anode resistance. This is therefore resistance variation for accomplishing tuning. The mesh normally used as the grid is the functioning anode. It should be noted that Barkhausen and Kurz maintain the frequency of their system is entirely independent of an external circuit.

All that has been done with the B. K. and G. M. circuits is to generate waves that are receivable over a distance of a few wavelengths,



Circuit used for the five meter oscillator built in the black metal cabinet. The object is to study the presence of oscillation, make the amplitude about the same for the tuning range, by noting plate current meter needle, and later on select a suitable output coupling method. The choke coil, if provided with inductive or capacitative coupling, offers one solution, since there is a pronounced field.

and the present oscillator will do at least as much, and do it with better stability.

Tests Made at 40 Feet

Because of the weak impulses from the B. K. and G. M. circuits, effort was concentrated, as already related, on building up the oscillation. The circuit was tried on 5 meters and then the wavelength was reduced without any experimental changes from a most conventional pattern, until the oscillations were deemed to have disappeared. It was discovered later that seemingly absent oscillations were really present, but unnoticed. Since the emanations were useless, the object was to build up the amplitude until it was recognizable in the tube itself and could be picked up about 40 feet away.

The radio frequency choke coil in the plate leg made oscillations instantly recognizable at a low wave where none could be detected originally, and the condensers, 1 mfd. next to the plate, and .05 mfd. or more at the other end of the choke, rounded out the improvement.

Inductance Like Safety Pin

The attempt to ground the plate was simply a random effort to find some way of making the

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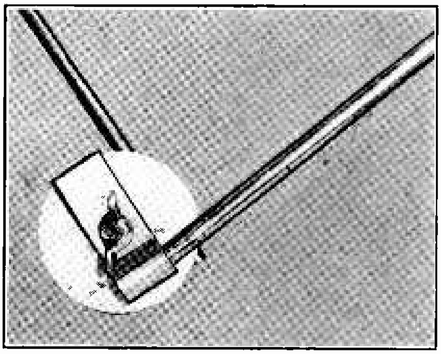
tube oscillate well at frequencies higher than common report would lead one to believe was possible. A consideration of the B. K. oscillator will disclose that in effect a grounded plate is an objective there, since plate is returned to zero d.c. potential, or to some negative potential also intended to be grounded to radio frequencies. In this respect the two circuits correspond, though the present pattern is one for external tuning, more in line therefore with the G. M. objective, but the tube is conventionally voltaged, has normal life, yields a greater output and the class of oscillator is not "electron" but regenerative.

The same circuit used for the improvement of oscillation at 1 meter and somewhat higher wavelength is useful for centimeter waves, in fact, little more need be done than to remove



Orientated antennas are effective at ultra frequencies. Single wing nut permits locking two antenna rods at any angles.

the coil from its socket, as the circuit is complete save for cathode connection, and the wiring constitutes most of the inductance. While this is feasible, the circuit nevertheless was set up separately, and merely the wiring necessary to connect tuning condenser to grid condenser, and to the common return. Straight wire was used, run V-shaped, the point of the V being at the common connection. Except for the spring and hood, the inductance (which could not be called a coil, since there was no coiling) had pretty much the dimensions and proportions of a medium sized open safety pin.

Oscillated with Tuning Condenser Out

Since the start was made at 5 meters, and the object was to keep going to lower and lower waves, 1 meter turned out to be the terminal at one end because of the capacity necessarily present, due largely to the tuning condenser. It was possible to observe the presence of oscillation when the variable condenser was detached from the circuit, but a fixed frequency oscillator was not desired, and the facts disclosed that with a condenser with smaller minimum, and with very small difference in capacity between maximum and minimum, could control ratable intensity centimeter waves. Capacity was therefore a limiting factor for the while. A condenser with a minimum of 3 mmfd. and a maximum of 4 mmfd. would permit centimeter operation.

Of course at the centimeter waves the tube's input capacity becomes important, and since the metal tubes as a rule have higher input capacity, glass type tubes might be preferred. It is fully expected that waves of 50 centimeters can be generated ratably, and the substitution of glass tubes for metal tubes has shown up the expected marked decrease in wavelengths. The difference in the input capacities of the 6C5 and 76 is only .5 mmfd., the values being 4 for the metal tube and 3.5 mmfd. for the glass tube. The grid-plate capacity is 1.8 for the metal tube, 2.8 for the glass tube, so feedback may set in for the glass tube before it does for the other, due to the higher capacity coupling.

Observations on Oscillator Types

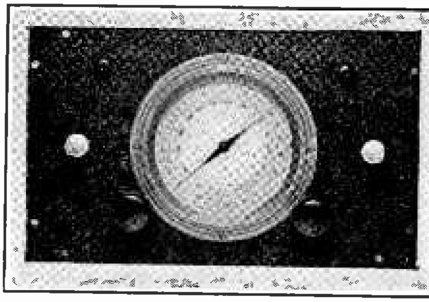
Preliminary observations of the ultra wave circuits give support to the opinion that there are only two types of oscillators in any region: Colpitts and non-Colpitts. The Colpitts is distinguished by two series condensers in the tuning arrangement, the joint of the condensers being grounded. In all other oscillators a coil is grounded, or a single terminal of a condenser (as in series tuning). Further, there is every reason to believe that all the ultra wave oscillators must be of the Colpitts type, that is, they stop oscillating when they cannot transform themselves into Colpitts circuits. Referring back to the discussion of absence of effective grounding when the frequencies became ultra high, one finds some corroboration of the presence of Colpitts oscillations, since what is supposed to be grounded turns out to be an elevated potential, and further experiments show that somewhere along the inductive branch there is a lower potential than at the common return, so that the wire intended as an inductance is substantially also a condenser. The series capacity relationship therefore is present in effect, only the branch members are not equal, indeed, due to control by the variable condenser, one capacity branch may be variable, the other fixed.

The B. K. and G. M. oscillators for the same reason may be dissected as really Colpitts oscillators. Whether voltage, or tank circuit, is considered to control frequency does not change the nature of the oscillator. The frequency of a low frequency oscillator, even at 50 kc, can be changed by alteration of the terminal voltage, particularly the plate voltage.

Behavior Determines Oscillator Type

In regarding a circuit diagram, therefore, where centimeter waves are concerned, the appearance of the circuit is noninformative. Only the behavior tells what kind of an oscillator it is. The circuits shown herewith are of the series fed Hartley type on paper, and for 5 meters may be that, but at 1 meter are Colpitts oscillators, with no change in the diagram.

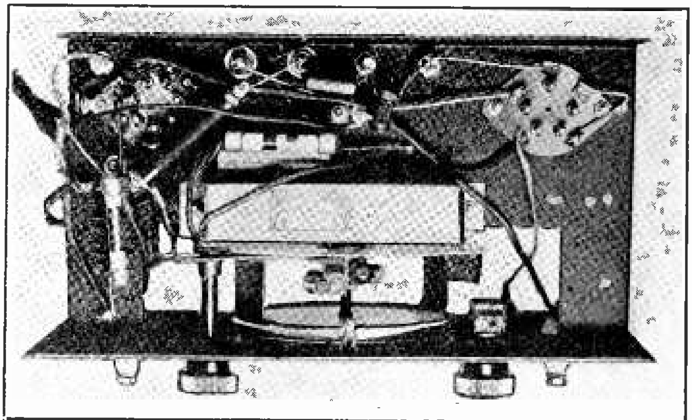
Frequency calibration of any generator consists of recording the frequencies generated at particular settings of the tuning condenser. The recording may be direct reading right on the dial, which is handier, or may be on charts or otherwise externally present. The *shape* of the curve itself, assuming that the result is communicated to graph paper, *is determined only by the rate of change of the capacity.* The inductance is a constant and need not be considered, if the capacity is measured, for the same curve shape would result were the inductance different or no inductance present. The desired ranges of frequencies are determined by selection of the proper inductance, and the frequencies resulting reflect the capacity and rate of capacity change in conjunction with the constant inductance.

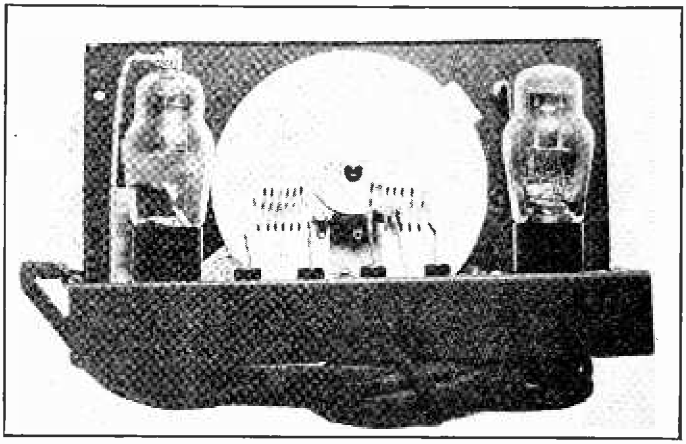


The front panel of a five meter receiver may have two high grade insulators for double antenna connections, as to a transmission line, or one may be grounded for Marconi antenna, though ground wave is weak.

The object in mind, in general, is to institute generation at 1 meter and lower, in an attempt to get low enough, in the centimeter range, with conventional tubes, operated under conditions insuring long life and satisfactory output, so that reflectors may be used, and thus paraboloids and other devices made to cause strength of wave at receiving distances of a few miles. There is a great field ahead for this type of directed transmission, although the specific purposes have not yet been explored, and experimenters are contenting themselves first with getting the systems working, the commercial or amateur applications coming along in due course as they always do.

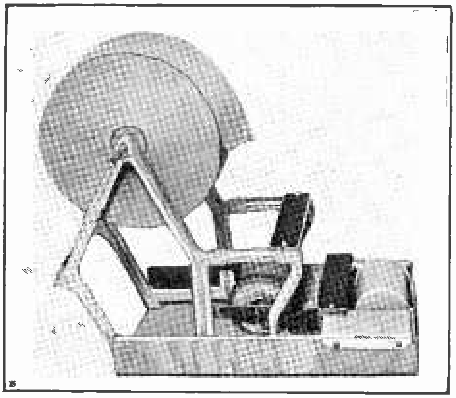
Moreover, most systems of measurements at very low waves are either extremely expensive or extremely inaccurate, and if accuracy and economy can be combined, real frequency facts can be gleaned, for application to 5 meter individual receivers (not transceivers) that are becoming so popular. The layout of one such new receiver is shown in the illustrations on this page. Knowing at just what frequencies these devices work is worth as much as the devices themselves.



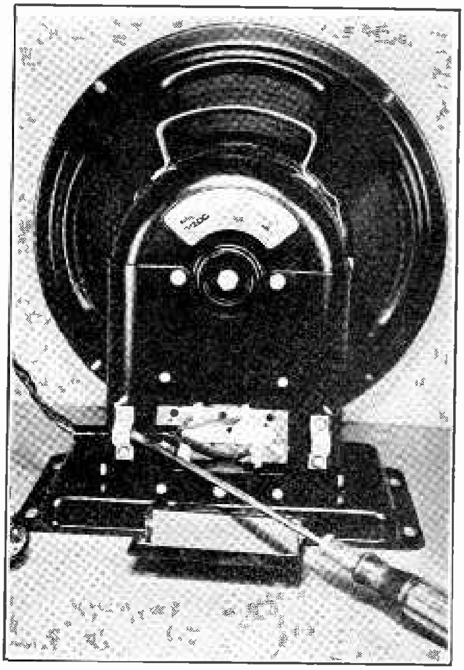


Bottom and rear views of a 5 meter receiver recently developed by Radio Constructors Laboratories, and which may have a coil system in fixed position for this band, or, by inserting a larger inductance combination, tune to the 10 meter region.

INGENUITY



PRECAUTION



ABOVE—Sealing tape machine made of radio parts exclusively, including chassis upside down as base, chassis brackets for supports, wire spool for roller and aluminum coil shield as the moistener.

AT RIGHT—Speaker cable leads protected from abrasion by wrapping with large diameter spaghetti tubing before putting the cable under the metal bracket.

NEW DIAL LIGHT IMMUNE TO VIBRATION

Radio static, the kind caused when a dial light bulb jars loose from vibration and sets up electrical interference, can now be eliminated with a new radio panel lamp that "stays put" in its socket.

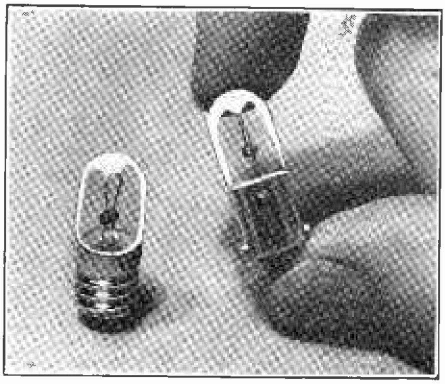
Vibration from Street Traffic

When radio dial lights were first developed they were made with a screw base just like those on our household lighting lamps, only much smaller. Recently it has been found that vibration in the set itself and sometimes from street traffic will gradually loosen the light until it sets up an electrical interference. A low, growling static is usually the result.

The new dial light eliminates this condition. It has a bayonet base as on automobile lamps. This base locks the light in a fixed position. Vibration cannot jar it loose.

Saves Awkward Job

With the translucent dial used almost universally in radios today, the panel lamp must be installed behind the dial so that the station numbers are readily visible. Everytime a new lamp is installed it means that the entire chassis must be removed first. Hence long trouble-free lamp life is important.



Two types of panel bulbs are shown, at left the screw type, which may have a tendency to work its way partly loose from the socket due to local vibration and create static-like interference by make and break contact, and at right the new bayonet type, which stays put, and gets rid of the interference. The studs at diametrically opposite positions on the bayonet base catch tightly into two keyways of a socket.

Balanced Detector Solutions

Transformerless Amplifiers Fed by Voltage Doubler

By J. E. Anderson

THE search for a push-pull detector has gone on since the beginning of broadcasting, yet so far no such circuit has yet been disclosed. The reason is that, in the strict sense, no push-pull detection is possible. However, it is not really push-pull detection that is wanted, but rather a means for coupling a detector substantially nonreactively to a push-pull amplifier, a requirement that is much less stringent. Along this line efforts have been attended with much better results.

Many circuits have been devised for dividing the output voltage of a detector between two similar tubes working in opposite phase, but scarcely any of them are strictly nonreactive. They do not have to be as long as the voltage division is symmetrical at all frequencies.

One of the popular methods of feeding a push-pull amplifier with a detector without the use of a transformer is that which employs a phase inverter tube. In this a tube, or a section of a double tube, is used for the sole purpose of inverting the phase of half the signal voltage. The voltage amplification in this inverter is unity.

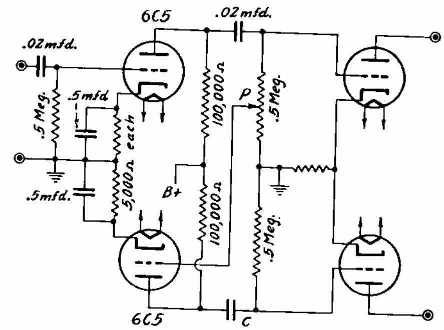
Inversion Is Reactive

The circuit is very simple, but it suffers from the defect that it is not symmetrical, and as a consequence the phase inversion is not the same for all frequencies. It deviates from the 180 degree ideal both at the low and at the high audio frequencies. Strictly, there can be only one frequency at which the phase inversion is exact. Still it is a practical circuit because the extreme frequencies at which the deviation is appreciable are of little or no interest.

A practical method of accomplishing the desired voltage division was published in the April 1, 1933, issue of RADIO WORLD at the suggestion of Orval C. LaFrance, of San Francisco. This circuit has been in constant use since that time, not only by its originator but also by others, including E. M. Hankin, of Dallas, Texas. The circuit is based on the idea of a voltage doubler rectifier, and is sound in principle. For those who do not have access to the original article, we reproduce the circuit as adapted to metal recent tubes.

Now the 6H6 May Be Used

The circuit was made possible by the introduction of the 25Z5 rectifier, which has two separate and independent rectifiers. Of course, the circuit could have been made as soon as heater tubes came out by using two tubes. No single tube other than the 25Z5 could be used until



A phase inverter circuit using two tubes. P is used for balancing the inputs to the push-pull amplifier. The larger C is, the better the balance on low notes.

the 6H6 was released. Now that this tube is available generally, the LaFrance circuit will undoubtedly gain in popularity.

The principle of the circuit is illustrated in the second drawing. It will be noted that the tuned circuit, AB, is connected in the usual manner between ground and the high voltage side of the rectifier. This is a distinct advantage of the circuit in that it obviates the need of an untuned winding, or of a tuned winding in which neither side of the circuit is grounded. The high voltage side of the circuit is connected to one anode and one cathode of the rectifier. The load on the rectifier is connected between the remaining cathode and anode.

Circuit Action Described

Let us describe briefly the action of the circuit. During that half cycle when the point A is positive with respect to ground, the upper section of the rectifier is conductive in such a direction that the upper end of R1 is positive. No current flows through R2 during this part of the cycle because the cathode is positive with respect to the anode.

During the next half cycle A is negative with respect to ground and therefore the anode of the lower section is positive. Hence current flows through R2. During this time no current flows through R1, except the discharge current from condenser C1. After the first cycle has been completed discharge current also flows through R2 from condenser C2. Thus as long as the amplitude of the signal does not vary a fairly

(*Continued on next page*)

(*Continued from preceding page*)
steady current flows through R1 and R2 all the time.

If the two sections of the rectifier are equal, and also if R1 equals R2 and C1 equals C2, the currents in the two sections are equal. Therefore the same voltages are developed across R1 and R2. This assumes further, of course, that the positive and negative half-cycles are equal in magnitude. There is no reason why they should not be.

Capacity Balance Required

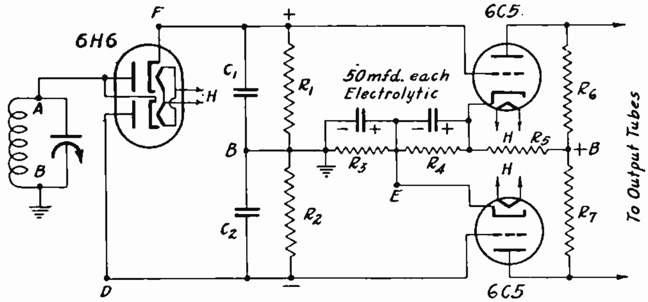
In this circuit there is a slight dissymmetry at the higher audio frequencies due to differences in capacities in the tubes, but this disappears when C1 and C2 are equal in fact. The two condensers placed in these two positions are then not necessarily exactly equal, but the capacity to ground in each leg should be equal.

The audio signal consists of the variation in the voltages developed across the two load resistances. This variation is slow compared with the frequency of the radio signal. There may be a radio frequency ripple in the output of the rectifier, but this is not likely to cause any disturbances in the audio amplifier. If it does, the ripple can be further reduced by inserting radio frequency chokes in the leads to driver grids.

When the coupling is nonreactive to audio frequencies, as in the circuit below, there is bias dissymmetry on the tubes that follow the detector. The d.c. component of the drop in R1 makes the grid of the upper amplifier tube positive and the drop in R2 makes the grid of the lower tube negative by the same amount. When the amplifier tubes are of the heater type, this bias difference can be easily compensated for.

Bias Apportionment

A voltage divider consisting of R3, R4, and R5 is connected between the positive supply voltage and ground. Both grids are returned to ground. Hence the cathodes of the two tubes are connected to different points on the voltage divider.



A nonreactive coupler between a diode detector and a push-pull amplifier, illustrating the principle of the LaFrance circuit. Nice balance is necessary. The diode is worked in a sort of voltage doubling fashion. It is intended that the two 6C5's be followed by the output (power) tubes.

If the cathode of the lower tube is connected to ground, the bias on that tube is simply the drop in R2 due to the rectification of the carrier. If that cathode is connected to the junction between R3 and R4 the bias is increased by the drop in R3. This drop may have any value required. If the grid of the upper tube is to have the same negative bias as the lower tube, the cathode of the upper tube must be connected to a point on the voltage divider which is positive with respect to point E by an amount equal to the sum of the drops in R1 and R2 due to the rectification of the carrier. That is, the drop in R4 should be equal to the sum of the steady drops in R1 and R2. This adjustment is easily effected. Since the signal current of only one tube flows through R4, this resistor should be shunted by a large condenser. Shunting of R3 is not essential if the circuit is truly balanced. Still such shunting does no harm.

This adjustment of the cathode resistors for equal bias does not entirely balance the two amplifier tubes. The effective plate voltages are different by the amount of the drop in R4.

Compensating for Difference

This difference could be compensated for by connecting the plate resistors to different points on R5, or rather by connecting the plate resistor for the lower tube to a point on R5 which is lower than B plus by the amount of drop in R4. This particular adjustment may not be necessary when the amplification factor of each tube is high, for the permissible drops in R1

Neglect of LaFrance Circuit Is Deplored

Referring to the article in the April 1, 1933 issue of RADIO WORLD in which the LaFrance circuit was first described, E. M. Hankin, of Dallas, Texas, writes:

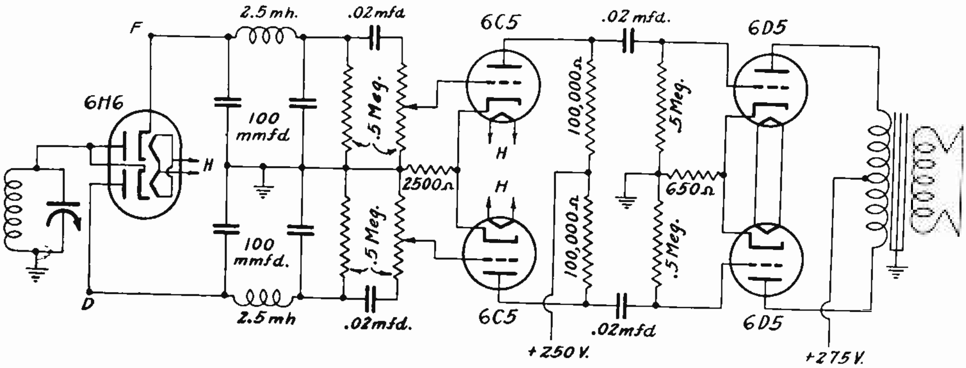
"On the strength of this article I built up the circuit, using two 56 tubes as diodes working into two 56 push-pull driver tubes with two 50's in push-pull as output tubes, and I have been using this arrangement for the past two years with entire satisfaction, especially as pertains to fidelity and overload. The disappointing feature has been all along that the circuit has, apparently, not been given its just due. Articles dealing with it and its application have been looked for in vain."

and R2 would then be small. For the tubes indicated the drop in R4 would be of the order of 16 volts.

When the adjustments have been made all around for symmetry, it is correct only for one particular amplitude of the carrier. This is a real disadvantage because it necessitates holding the carrier constant and varying the output of the amplifier after the first push-pull amplifier. The amplitude of the carrier impressed on the detector may be held nearly constant by means of automatic volume control, but not entirely stage, the stopping condensers should be increased in the same proportions as the grid leak resistances are decreased. It is not likely, however, that lower grid leaks will be needed when self bias is used on the power tubes. It is important that the stopping condensers do not leak.

It should be pointed out that if the two r.f. chokes are used to remove ripple from the input to the audio amplifier, the second pair of 0.0001 mfd. condensers should also be used, to complete the filtration.

The precautions mentioned regarding the



A complete diode detector and audio amplifier in which resistance-capacity coupling is used between the detector and the push-pull circuit. This is not strictly nonreactive, but can be made symmetrical.

so, for there must be some variation in the amplitude if the a.v.c is to function.

Grid Return Circuits for A.V.C.

If a.v.c is to be used, the grids of the controlled tubes must be connected to the point marked D, for this point is negative with respect to ground. Naturally, the returns must be made through a high resistance in order to prevent upsetting the balance of the push-pull amplifier. Even if a resistor as high as one meg. is connected between D and the grid returns, there will be some unbalancing. This, too, can be compensated for, and it is done by connecting a similar resistor between the point marked F and ground. There should be a condenser bypassing this resistor of the same value as the effective condenser on the other side of the circuit. The customary value is 0.05 mfd., for a larger value makes the a.v.c sluggish.

In view of the many adjustments necessary to make the nonreactive circuit balanced in all respects, and also as it is not necessary to have a nonreactive coupler, the circuit above is preferable. This is drawn complete from the input to the rectifier to the loudspeaker.

R.F. Chokes Optional

Stopping condensers of 0.02 mfd. are suggested in both stages, because these are large enough for the lowest notes that need be amplified, especially when taken in conjunction with .5 meg. grid leaks. If it becomes necessary to use lower grid leak resistances, as it may in the output

maintenance of balance when a.v.c is used apply equally well to the second circuit as to the first.

The output power of this amplifier will be approximately three watts, with negligible amplitude distortion and even less frequency distortion. It is assumed that the loudspeaker employed fit the two 6D5 tubes.

[Articles on balanced detectors were printed in the September and October issues, including impractical circuits, to provoke thought and discussion. The article by Mr. Anderson, and the one beginning on next page, are practical.—Editor.]

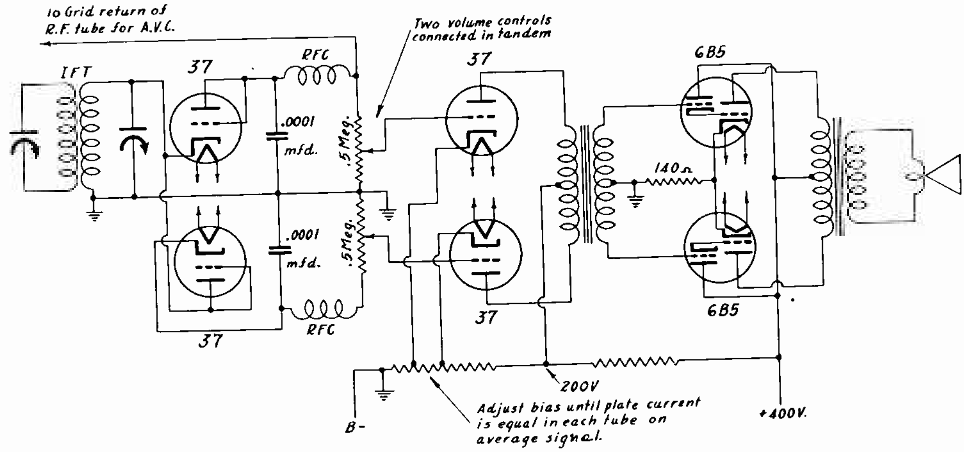
Constants Now Used by LaFrance Himself

Orval C. LaFrance submits a version of his circuit in which the rectifier is a 25Z5 and the first two audio tubes are 37's. The voltage divider resistance to which the cathodes are connected is a 25,000 ohm unit which may be tapped at any point. The two load resistances are two .5 meg, potentiometers. The cathode positions on the voltage divider are adjusted so that the bias is correct on average signal and when the potentiometers are set for maximum output. He recognizes, therefore, the fact that in the nonreactive circuit the balance depends on the setting of the potentiometers.

Stage to Stage Balance

In the La France Symmetrical Circuit

By Orval C. LaFrance



A transformer is included in this version of the LaFrance circuit. The results in the LaFrance circuit are somewhat dependent on the percentage modulation of the broadcasting stations, but the bias adjustment noted on the diagram takes care of this satisfactorily, provided the 37's are not worked near their full input voltage capability.

WHEN I first conceived of the balanced thermionic detector circuit and tested it out nearly three years ago I met with decided unbalance and thought that inequality of capacity between anode and ground and between cathode and ground might be the cause, until I discovered that unbalance was caused by leakage between the cathode and heater in the 37 tubes I was using for the detectors. In my early trials with this push-pull detector leaky tubes gave me lots of trouble, but manufacturing methods must have improved, as I haven't met with a tube which passed current from cathode to heater in quite a while. By the way, this feature will ruin even a plain diode detector, as a leakage short circuits the load resistor. In fact I discovered this fact some time before I stumbled onto the balanced diode detector idea.

Negligible Unbalance

About two years ago I tried the experiment of putting small variable compression type condensers as r.f. bypass condensers across the two load resistors in this detector to see what could be gained by adjustment. No difference could be noted either by the ear or in measured output when the condensers were opened clear out (they were 70-140 mmfd.) or closed up, or either of them opened up and the other closed. My opinion is that if there is any unbalance in this type of detector due to the capacity of the cathode-to-heater element being across one of the load resistors, it is too small to be noticed.

This seems reasonable when we realize that an r.f. bypass condenser of at least 100 mmfd. must be connected in parallel with each of the load resistors. The spurious capacity across one of the load resistors must be small in comparison with this. Possibly delicate measurement might detect some difference in output of the higher frequencies between the two sides but the ear cannot detect it.

In regard to my balanced diode detector circuit not being nonreactive, it is of course not so in a literal sense when stopping condensers or a transformer are used, but in a practical sense this is unimportant. Substantial nonreaction is attainable. I had not considered the idea of a nonreactive circuit especially. However, diagrams on pages 20 and 21 are of circuits nonreactive from diode detector to the following tubes, because of direct coupling. The drawing herewith is nonreactive at least in this respect. It could be made nonreactive all the way through if the Loftin-White principle were used to couple to the output tubes. I doubt whether the critical nature of the Loftin-White circuit would make it worth while.

Action is Independent

As for using 6B5's in the output to avoid bias complications, the 6B5 tube would no doubt be an improvement whatever coupling is used preceding it, as it would be in any other circuit, if the tube performs as well as it is rated.

One criticism that might be advanced against the circuit in its three stage form (page 21) is that while push-pull throughout from detector to output tubes, each side works independently of the other, and any unbalance that may take place in the detector or following tubes will be carried right along to the output without change and should two or more of the stages happen to be unbalanced in the same direction quite a large amount of unbalance might occur in the output. If push-pull transformer coupling were used of course any static unbalance in one stage would not be transmitted to the following stage. For this reason a high quality transformer might be used to advantage preceding the output tubes.

Case of Automatic Volume Control

Speaking of unbalance, we frequently see it stressed that balance *must* be secured between the two stages of a push-pull stage of audio amplification. One would think that should a little unbalance happen to creep in the reception would be ruined. This is ridiculous when class A amplification is used. Class B is another story. Even though one side of a push-pull amplifier goes dead, the other will continue to work as a single sided amplifier and plenty of radios work in this fashion and have done so for years. If we can get anything at all out of the weak side of an unbalanced push-pull amplifier it should be an improvement on a single sided amplifier. Of course balance is to be desired, but we don't need to give up in despair should one side be a little weak in some respect. Class B of course must be rigidly balanced or distortion will result.

The drawing herewith shows my push-pull diode detector with transformer coupling to output tubes.

Another source of unbalance is introduced when we use automatic volume control. The a.v.c. resistor-condenser circuit being connected to one side of the diode detector load resistance, bypasses some of the signal current. I used a similar dummy resistor and condenser across the other load resistor to balance it up, but could discern no difference in results.

Bias Correction

Push-pull diode detection can be achieved, the circuit direct coupled to the 6B5 output tubes after the fashion of the diagram on this page, but direct coupling should not be used without correcting the bias on the 6B5 grids in some manner, as the diode load resistors present a constant bias, one side positive, the other negative, of an amount dependent upon the strength of the carrier tuned in.

This voltage introduced across the diode load resistors has a certain value which varies with the amount of modulation taking place at the moment, but the variations are on both sides of the average so that the average value does not change, at least it isn't supposed to, if the transmitter is properly adjusted. It is this average value of the potential across the diode load resistors which has to be compensated by the batteries so that the grids of the 6B5's have their normal zero bias.

Even so, the circuit would be quite tricky. Also full output from the 6B5's will not be attained unless we tune in a station with 100% modulation. With only 50% modulation the

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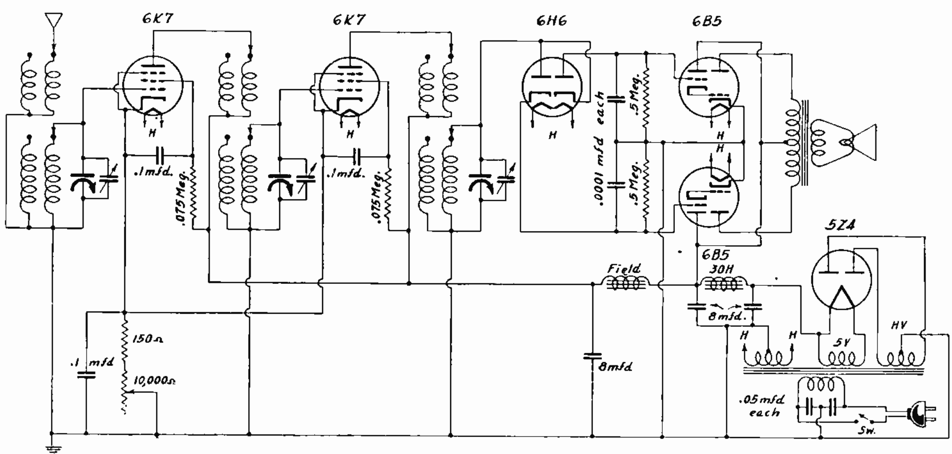


The balanced detector idea applied to a nonreactive circuit, using 6B5's in push pull output. The 6H6 detector arrangement is the one devised by Orval LaFrance, who comments, however, that oppositely polarized biasing batteries might well be included in the grid leads to the 6B5 to overcome the rectified voltage present due to the carrier when unmodulated, or due to position of a prior volume control at or near minimum value.

(*Continued from preceding page*)
grid swing of the 6B5's are limited to 50% of their maximum value and we get about 25% of full output. Another difficulty is that should the set be left turned on with no carrier tuned in or the volume turned clear down, one of the 6B5's will have the maximum positive voltage applied to the grid and will draw heavy plate current to the possible ruin of the tube.

If an intermediate stage of amplification is used with sufficient amplification so that the tubes following and directly coupled to the diode detectors do not have to be worked over more than say one third or one fourth of their maximum range at full output from the 6B5's, much more leeway is allowed for stations which fall short of 100% modulation.

Percentage Modulation Meter

We can adjust our compensating bias for average percentage of modulation and average volume. Different percentage of modulation and different volume will result in the two tubes following the detector being worked a little off center on their grid voltage curves, one above and the other below, but if the maximum grid swing on these tubes is small they may still be worked on the straight portion of their grid voltage-plate current curve, without getting too far from the center.

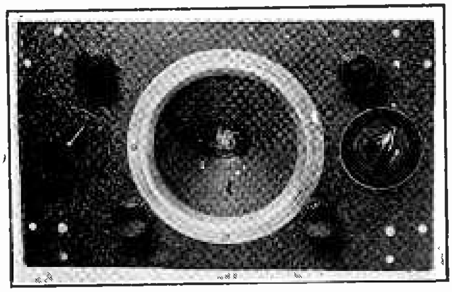
The use of a circuit such as on page 23 would give anyone a good idea of how percentage modulation varies from station to station and indeed from time to time in the same station. Such a circuit would make a good percentage modulation meter. Put a d.c. milliameter in the plate lead of one of the output tubes and an a.c. milliameter in the output of the two output tubes and a comparison of the two milliameters with proper calibration would do the trick. The d.c. milliameter could be calibrated for a certain fixed value of alternating current shown by the output meter. If the d.c. milianeter is connected in the plate of the tube that shows increased current when a carrier is tuned in, the higher the direct current for a fixed value of alternating current the lower the percentage of modulation. If connected in the plate current of the other tube a lower d.c. reading means less modulation. The best plan would be to calibrate the a.c. output meter for a fixed value of the d.c. milliameter, then an increase in the a.c. output for fixed value of direct current means increased modulation no matter which tube the d.c. milliameter is connected in.

Question of Capacity

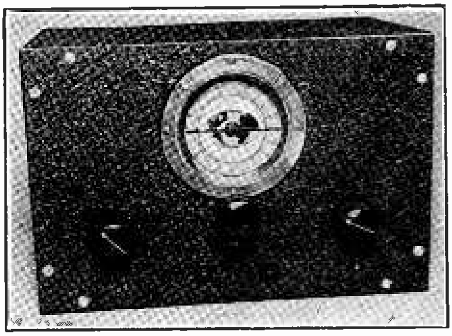
As for the capacity unbalance in opposite legs of the diode detector by reason of the high capacity between cathode and heater (or ground), this can be adjusted if necessary as it is in parallel with the bypass condenser connected across the diode load resistances. A small variable compression type condenser will do the trick. I have tried it but have not found the adjustment critical, nor even necessary.

By the way, does any one know just how much is the capacity between cathode and heater in the various tubes? I don't believe I have ever seen it printed, but it must be quite large compared to the other interelement capacities, but still quite small compared to the 100 mmfd. or more ordinarily shunted across a diode load resistor. A much more serious consideration in the use of diode detectors is to see that there is no leakage of current between diode and heater, as this shorted across a .5 meg. resistor may result in great unbalance and distortion.

Suggestions for Universal and Battery "Fronts"



A universal type small receiver usually has the speaker built in, hence one of the bar handles could actuate the tuning control.



Small battery operated receiver.

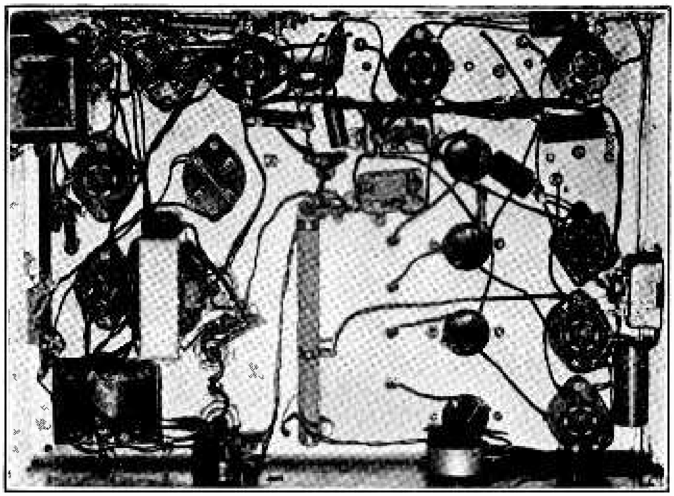
Symmetrical arrangement of the front panel is practically standard to-day. At left, above, is shown a suggested arrangement for a small universal receiver, which may be of the all wave type, the bar handle at left actuating the coil switch. With tuning control at right, the regeneration and volume control shafts would have knobs on them, as shown.

For battery operation a receiver, otherwise similar, would not normally have the speaker self-contained, but the dial would occupy the position otherwise held by the speaker, that is, centrally located. For a battery operated device it is customary also to bring out earphone leads, especially as many such receivers are for earphone use particularly.

Sensitivity, Selectivity SO High

11 Tube Superheterodyne Needs Auxiliary Volume Control

By Jack Goldstein



The voltage divider is centrally located, the separate B choke is near the power transformer, while the audio transformer is placed at left rear, in this bottom view of the supersensitive 11 tube receiver. If this choke and transformer are transposed there would be considerable resultant hum, due to the pickup by the audio transformer from the inevitable hum field about the power transformer.

EVERYBODY who has taken a more than casual interest in radio has at one time or another wished that he had a receiver of outstanding performance; and he has determined that some day in the future, when the tax collector shall become less voracious and the paymaster more munificent, he shall own one of them. Unfortunately for most of us, however, the day of fulfillment has been postponed indefinitely by economic necessity, and our own masterpiece remains in the realm of dreams.

Yet even now there are a few who are able to salvage enough of their earnings to realize his dream-set. In evidence thereof we present the circuit diagram and pictorial views of an 11 tube superheterodyne of elaborateness and excellence of parts.

The Extra Volume Control

As the circuit follows orthodox lines in its general design, let us first speak of its faults. First of all, it is too sensitive. Most persons of course, will not admit that this is a fault. Rather they will regard it as a virtue. Let us be ruled by the overwhelming majority and admit that supersensitivity in a receiver is not a fault. This admission imposes on the designer and builder the task of rendering the defect null and void without sacrificing the virtue. In this receiver it was done by the simple expedient of putting in an extra volume control.

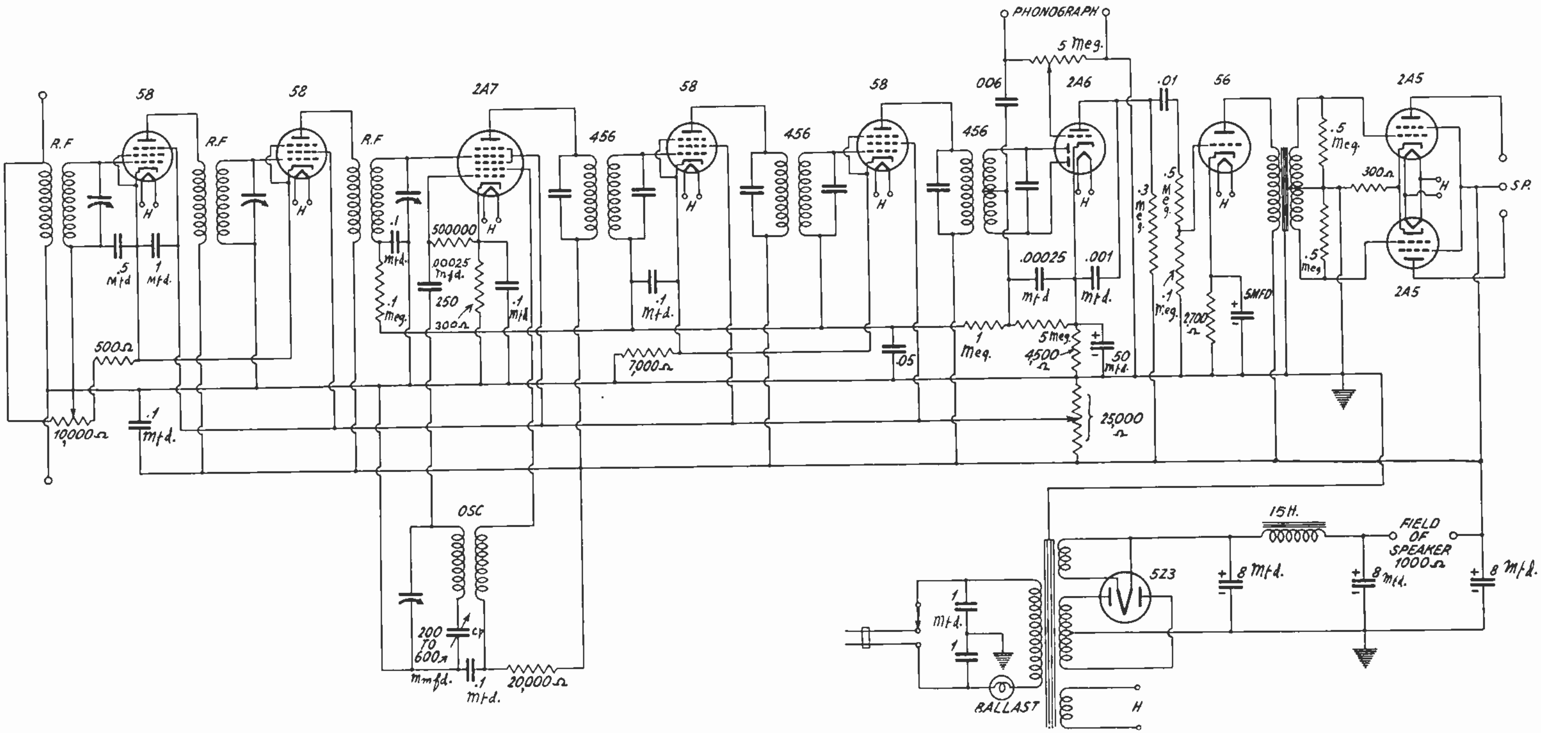
Ordinarily the first volume control would not be used in a receiver provided with automatic volume control and manual audio volume control. In this case the first manual volume control was necessary because the a. v. c. was not able to cope with the amplification, although all the tubes ahead of the second detector were put on a. v. c. The difficulty was that on strong signals the mixer tube overloaded seriously. As a remedy the first two 58 tubes were taken off the a. v. c. and put on a separate manual control as it is done in most t. r. f. receivers. This change had the desired effect in so far as overloading was concerned. But it disclosed another peculiarity.

Interchannel Noise Suppressor

Now when the first manual control is set for minimum input the receiver emits a strong hiss, which is audible even through strong local signals. The reason is obvious. When the volume control is set at minimum input all signals are extremely weak, and the intermediate it is a little refinment. The high value is used to insure that the grids of these two tubes shall be negative by several volts even on the weakest signal. Three advantages accrue.

(*Continued on page 27*)

Gain and Sharpness Pressed to Limit



For standard broadcast band coverage only, this circuit provides the practical maximum for distance reception, as well as affording quality reproduction.

(*Continued from page* 25)
When the amplifier tubes operate wide open a hiss develops.

It will be recalled that this was called a peculiarity, not a defect. There will scarcely ever be any occasion for setting the first volume control for minimum input; and if there ever should be, it will only be because the signal is extremely strong, and then it will be so strong that the a. v. c. will have plenty voltage to keep the hiss out. The first control is to be regarded as an auxiliary only, and it should only be turned toward minimum when necessary, and only as much as is necessary to avoid overloading.

This auxiliary control has a marked advantage aside from prevention of overloading of the first detector. If used judiciously it acts as splendid interchannel noise suppressor. This simply means that the receiver can be operated at less than full sensitivity. When full sensitivity is needed, a turn of the first volume control will bring it out.

Well, Selectivity is Abundant, Anyway

The second fault in this receiver is that it is too selective. Or is that a fault? Opinions vary on that point. Once again we bow to the majority. If the small minority insists that the receiver is too selective, the majority can be generous and admit that it may be. Yet it need not be. Excessive selectivity assumes that all the tuned circuits—ten of them—are all adjusted to the correct frequency. The possibility of this is more theoretical than practical. The fact is that when all the circuits are tuned as sharply as possible, and the main tuner is set so that the carrier is squarely "on the nose", there is no deficiency in the ultra-high audio frequencies. As a matter of fact, an extra large condenser had to be used across the load resistance of the second detector in order to suppress whispering sounds to a natural modesty.

Variable Coupling I.F. Transformers

In connection with excessive selectivity it is well to mention that the Hammarlund intermediate frequency transformers—which are mainly responsible for high selectivity—are also made so the coupling can be varied. Variation of coupling means variation of the effective selectivity in the circuit. Therefore if anyone should decide to build a receiver like this, and if he uses variable coupling intermediates, he can have any selectivity he desires. The writer, who is chronically one of the minority on this question, is himself convinced by this argument.

While talking about these socalled faults of the receiver some of the main advantages have to be pointed out. There is the second detector, for example. One of the three i.f. transformers has a centertapped secondary. Therefore full wave rectification is possible. Whereas this is only a little superior to half wave rectification, there is no reason why it should not be used in this set. The gain in the circuit is so enormous that the division of the signal by two in the detector is fully justified. As a matter of fact, in this case it was almost a necessity. It is that first fault of high sensitivity cropping out again.

Biasing of I.F. Tubes

Some who are conversant, more or less, with the design of superheterodynes may wonder why a limiting bias resistance as high as 700 ohms is used for the two 58 i.f. amplifiers.

First, the drain on the B supply is kept down

(*Continued on next page*)

LIST OF PARTS

Coils

Three shielded radio frequency transformers
One radio frequency oscillator coil for 456 kc i.f.
Two 456 kc, doubly tuned i.f. transformers, variable coupling
One similar i.f. transformer with centertapped secondary
One audio push pull input transformer
One 400 ohm, heavy duty filter choke
One 125 m.a. power transformer
One 8 or 10 inch dynamic speaker for pentode push pull output, with 1,000-ohm field

Condensers

One four-gang, 365 mmfd. tuning condenser, with trimmers
One 200-600 mmfd. padder
Three 8 mfd., 600 volt electrolytics
One 5 mfd., 35 volt electrolytic
One 50 mfd., low voltage electrolytic
One dual 0.1 mfd., 300 volt
One 0.5 mfd. by-pass
Six 0.1 mfd.
One .05 mfd.
One .01 mfd.
One .006 mfd.
One .001 mfd.
Two .00025 mfd.

Resistors

One 0.5 meg. potentiometer with line switch
One 10,000 ohm potentiometer
One 300 ohm
One 20,000 ohm
One 50,000 ohm
One 1 meg.
One 4,500 ohm
One 500 ohm
One 700 ohm
One 2,700 ohm
Four 0.5 meg.
One 0.3 meg.
Two .1 meg.
One 300 ohm, 3 watt, for push pull tubes
One 25,000 ohm voltage divider

Other Requirements

Two binding posts for antenna and ground
One twin phono jack
Twelve wafer type sockets (including one for ballast tube and one for speaker)
Six grid clips
Six tube shields
One cord and plug
Three control knobs
One airplane type dial
One special chassis

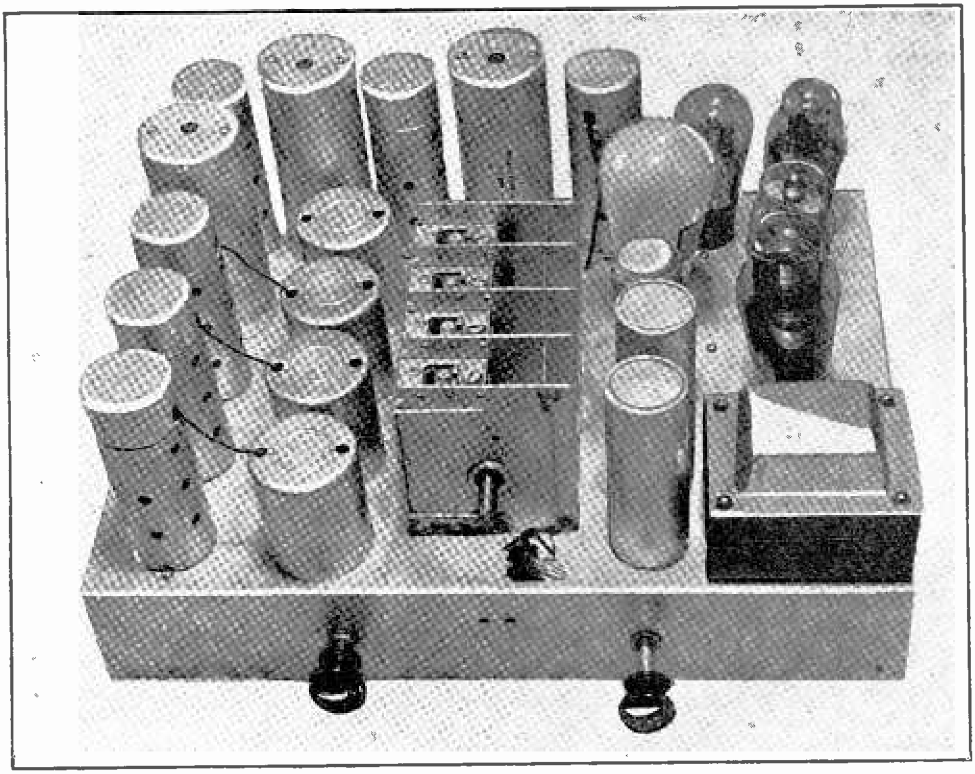
(*Continued from preceding page*)
on weak signals. Second, hiss is kept down when the signal is weak. Third, the selectivity of the i.f. transformers is not impaired by heavy grid current, which would flow if the grids were allowed to go positive.

In the grid circuit of the 56 a.f. amplifier is a voltage divider consisting of a 0.5-meg. resistor above the grid connection and a 0.1-meg. resistor below it. Just why is only one-sixth of the signal voltage impressed on the 56 tube? Because all of it was too much for the power tubes to handle. But why was the 56 stage used at all? To permit the use of a push-pull coupling transformer. Could not a 55 tube have been used in place of the 2A6 and could the coupling transformer have been connected to this tube, thus obviating the need of the 56 stage? Yes, it could. But this is a "demand" circuit, and the demand was for a 2A6.

Would it not have been just as well to use the 0.1 meg. resistor alone in the grid circuit of the 56, omitting the 0.5 meg.? It would not. That would have put a very low load on the 2A6 and the output quality would not have been as good. Moreover, the low notes would have been attenuated too much in comparison with the high.

The gain on the low notes is still further preserved by the use of a 50 mfd. electrolytic condenser across the bias resistance for the 2A6, a 5 mfd. electrolytic across the bias resistance for the 56, large filter condensers in the B supply, and high values of grid leaks in the audio amplifier. Relatively to the high frequencies, the response on the low notes is improved by the use of a 0.5 megohm resistor across each half of the secondary of the push-pull transformer.

The two 0.1 mfd. condensers across the primary of the power transformer help appreciably in reducing the effect of disturbances in the power line, such as arise when lights and various electric appliances are turned on and off.

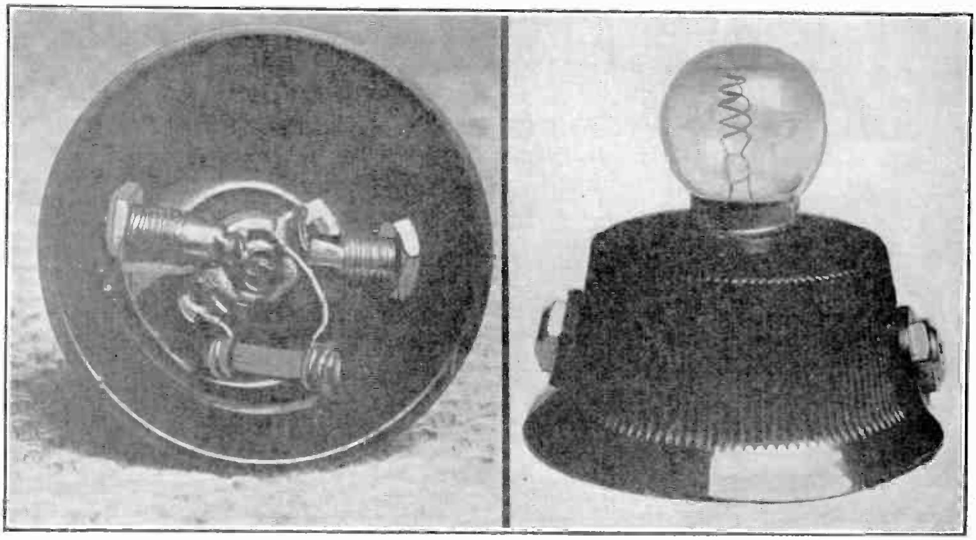


The needed auxiliary volume control is at left.

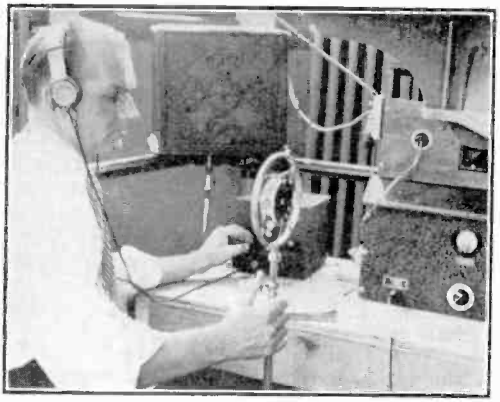
In series with one leg of the primary is a ballast tube. This was inserted only because in the locality where this receiver is to be used the line voltage fluctuates over wide limits. If the line voltage remains fairly constant, as it does in most places, this ballast is not needed.

The line switch shown in the other leg of the primary is attached to the second manual volume control.

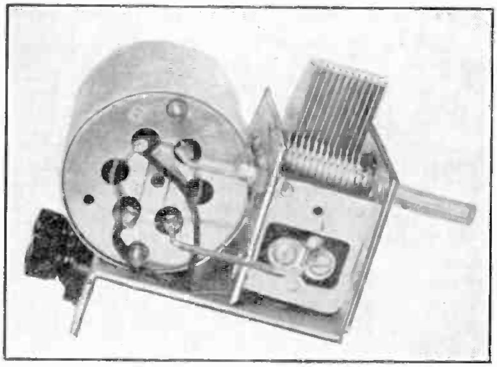
If a first rate dynamic speaker, well baffled, is used with this receiver and if the volume is turned on full, special reinforcement of the walls of the house might be essential! The neighbors of the operator of this set might regard this as a serious fault with the receiver, especially after eleven p.m.



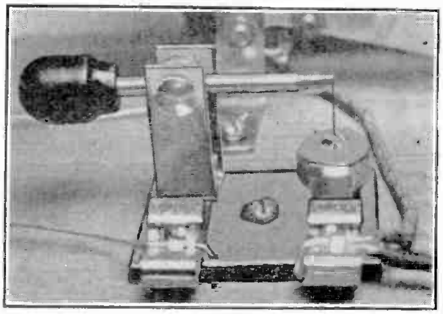
A neon lamp testing device was made in a panel knob shown slightly larger than actual size. A lamp without limiting resistor in it was used, the resistor being provided separately, .1 meg.



Harry Lawson, W2IFV, at Garden City Radio Club station, W2DKJ, almost 1,000 feet above the sidewalks of New York, in the tower of 40 Wall St.



A wave trap is very effective in cutting out an interfering station, but the coupling to the remedied circuit must be very loose.

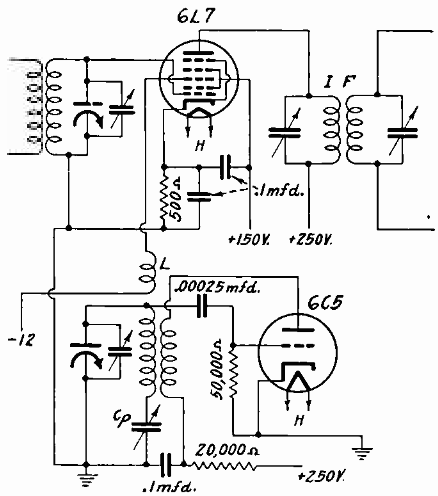


Many who now mean something entirely different than formerly when they refer to a crystal will remember, nevertheless—now that their attention is called to it—that the crystal detector had its valuable use for them more years ago than they care to recall. However, younger generation is now building crystal sets by thousands, a fact now widely known. At right is crystal with fulcrum holding catwhisker (the wire connector). At left, an assortment of crystals, mounted and unmounted.

The 6L7 Fills a Vital Need

Locking in of Proximate Frequencies Prevented

By Brunsten Brunn



A mixer circuit utilizing a 6C5 as oscillator and a 6L7 as actual mixer tube. The voltage from the oscillator is impressed on Grid No. 3 by means of coupling coil L.

THE most interesting and possibly the most important of the new metal tubes is the 6L7. Had a tube of this type been brought out many years ago, the design of superheterodynes would have taken a different trend, and many auxiliary circuits involving modulation and frequency changing would have utilized this tube. Now perhaps it will not become as popular as it would have done if pentagrid converter tubes had not been brought out first, but there is no doubt that it will be widely used.

The advantage of the new tube is that it has two independent grids, each shielded from the other and from the other elements, that are kept at a negative potential and that affect the flow of electrons from the cathode to the plate. A disadvantage is that another tube is required for the oscillator when the 6L7 is to be used in the frequency changer of a superheterodyne. The advantages, however, outweigh that disadvantage, and there is no doubt that the tube will find many applications, especially in the more pretentious superheterodynes where a tube more or less is of little importance.

Proximity of Frequencies

Just why is the extra negative grid so important? Well, there are many reasons. In the first place there is the matter of coupling between the tuned circuits in the oscillator and the radio frequency selector. The shielding of the two grids practically reduces this to zero. While this is not of great importance in a receiver designed especially for broadcast reception and in which a high intermediate frequency is used, it becomes of great importance when the circuit is intended for very high carrier frequencies. In these circuits, even though the intermediate frequency is relatively high, it becomes negligibly small in comparison with the signal frequency itself. As a result the oscillator and the radio frequency circuits are tuned to practically the same frequency. When there exists any appreciable coupling between these circuits it is difficult to make them function independently. The circuits "pull together" or interlock. The inductance and capacity in the oscillator circuit alone do not control the frequency of oscillation, which is also affected by radio frequency circuits, especially that circuit connected directly to the modulation or mixer tube.

Erratic performance of the superheterodyne is one result. With the reduced coupling in the 6L7 it is possible to operate a superheterodyne with a much lower relative intermediate frequency without any adverse effects.

Coupling Problem Prominent

The fact that both control grids in this tube operate at a negative potential is also important. Neither grid will draw any power from the circuit to which it is connected. This will increase the selectivity of the circuit connected to the grid. Of course, the control grid always or nearly always has been operated at a negative potential, but before the advent of the 6L7 there was no tube in which a negative grid for the oscillator voltage was available.

In some of the tubes were several grids but save on the control grids they were either supposed to have a zero bias or a positive voltage. In either case the grid drew power from any tuned circuit that was connected to it. While this is not serious in an oscillator, for much power is lost in the grid of the oscillator tube itself, it does add to the losses, and as a consequence it decreases the frequency stability of the circuit. High frequency stability is necessary for satisfactory performance of an ultra high frequency superheterodyne.

While designing superheterodynes with tubes previously available for frequency changing, the engineer has always been confronted with the question how best to couple the oscillator to the mixer. In all cases the final choice of method has been unsatisfactory, because there were only unsatisfactory methods from which to choose. With 6L7 available there will no longer be any question as to the best method. The voltage from the oscillator will be impressed on the grid especially provided for it. That will be the best way, and there will no longer be any reason for searching for any other method that cannot be as good.

Negative Bias for Grid No. 3

Naturally, there will be several ways in which this grid can be coupled to the oscillator. When the plate voltage on the tube is 250 volts and the tube is used as a mixer the extra control grid should have a negative bias of about 15 volts. This necessity must always be taken into account when the method of coupling is considered.

The first method of connecting the grid that suggests itself is to use a third winding on the oscillator coil and connect this between the grid and a point at which the potential is 15 volts negative in respect to the cathode of the 6L7. This is illustrated in the first mixer circuit, in which the pickup coil L is coupled to the oscillating circuit and is connected between the third grid of the 6L7 and a point 12 volts negative with respect to ground. Only 12 is required for the cathode if the mixer is 3 volts positive with respect to ground.

The Direct Connection

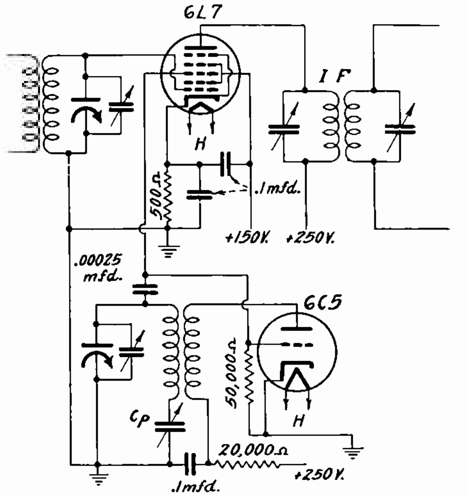
Another way of coupling is illustrated in the second mixer. In this the third grid of the 6L7 is connected directly to the grid of the oscillator tube. This does not require a pickup coil on the oscillator and it is therefore considerably simpler. The necessary negative bias on the grid is obtained in this case from the drop in the 50,000-ohm grid leak on the oscillator. The mean voltage of the oscillator grid is much negative with respect to the cathode, because of grid rectification, and since the cathode is grounded, the third grid of the 6L7 is still more negative with respect to its own cathode.

The second method is not as flexible as the first because in the second the oscillator voltage impressed on the mixer is whatever voltage appears across the grid leak, whereas in the first a wide range of voltages is available by varying the coupling between the pickup coil and the oscillator coil. In the second method more harmonics of the signal voltage will be impressed on the mixer than in the first method, and this is distinctly a point against the simple connection to the grid. A point in favor of the second method is that the question of where to obtain the negative bias for the third grid of the mixer does not arise. If the first method is employed this question must be answered.

Other Uses

The 6L7 is of the remote cutoff type and for this reason the primary control grid can be put on a.v.c. to advantage. When the bias on No. 1 grid is three volts negative the conversion conductance of the tube is 350 micromhos but it is only 5 micromhos when the grid is 45 volts negative. Thus in varying the grid bias from minus three to minus 45 volts the output is varied in the ratio of 70 to 1. This is the ratio of a.v.c. control obtainable by this tube alone.

While the 6L7 will undoubtedly be used primarily for mixing in superheterodynes it will be applied to many other uses. One obvious application is modulation of a radio frequency by an audio frequency. For this purpose the 6L7 could be the high frequency oscillator and the audio frequency signal would be impressed on grid No. 3. Coil L, as in the first mixer circuit, would then be the secondary of an audio



This mixer circuit is similar to that in the preceding figure but the oscillator voltage is obtained by connecting Grid No. 3 to the grid of the oscillator. This also provides the needed bias.

transformer. The 6L7 could also be used as a radio frequency amplifier in which the signal is modulated by an audio frequency impressed on grid No. 3.

The tube is also useful as a mixer in a beat note audio frequency generator. Again the tube could either be used as one of the essential oscillators or as an amplifier. In either case the signal voltage from the other oscillator would be impressed on Grid. No. 3. For this purpose the tube is especially desirable because of the very low coupling between the two grids. There will be practically no tendency for the two oscillators to pull together when the beat frequency is low.

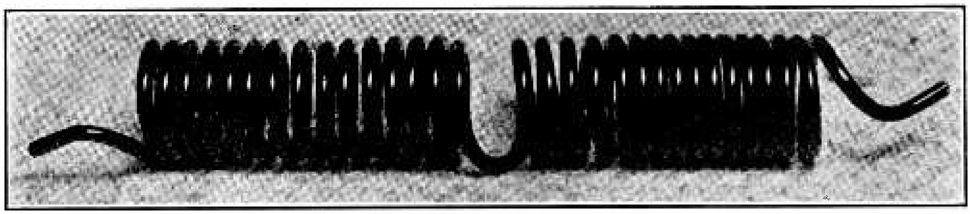
The Tube Connections

In the schematic cross section of the 6L7 (page 54) is the arrangement of elements. Grid No. 1, attached to the cap and placed next to the cathode, is the principal control grid. Grids Nos. 2 and 4, both attached to pin No. 4, form the screen. Between these two grids is grid No. 3, the second control grid. It is attached to pin No. 5 on the base. Grid No. 5 is the suppressor placed between the screen and the plate. This element is not represented by a separate pin but is tied internally to the cathode, or pin No. 8.

Line Noise Elimination

Brute Force Filter, Well Made, Does Trick

By Robert G. Herzog, E.E.
Chief Engineer, Thor Radio Company



Coils for line filters may be wound in this elongated manner, using large diameter wire, No. 8 or No. 10. Another method is to wind on dowels.

WALKING along the streets around "Radio Row in New York City," one can hear the chant of the street peddlers selling their wares. "It's the sixteen different chemicals that take out the static." cries one selling a typical panacea for all radio ills to a large audience seemingly awed by the hokus pocus of his demonstration during which by an ingenious trick he eliminates the self made noise.

"It's static that kills your tubes", he adds as another sucker shells out 35 cents for a worthless tube base filled with tar.

Noiseless Antenna System

His demonstration is a deliberate fraud. The noise is manufactured on the spot and turned off when his device is connected to the circuit. The auxiliary electrical equipment is carefully filtered only when the gadget is connected to the antenna. The foot pressing a switch often helps the deception.

The best method of eliminating noise is a noiseless antenna system. This antenna, however, must be erected away from the source of noise, in the clear.

Shielding Precautions

In some locations noise does come into the receiver through the electric light line. It is therefore advantageous to have an efficient filter connected in series with the power source.

After considerable experimentation the filter shown was devised. It is of the brute force type with double chokes and condensers in each line. The wire used should be heavy enough to carry the load. The heavier the wire, the more the number of turns required. Twenty-five turns, however, are sufficient in all cases. The coil is wound on a wooden dowel or spool. The halves of the double choke should be wound in the same direction so that magnetic field is continuous.

It is also advisable to shield the double chokes from one another with a good iron shield. The entire filter must be built in an iron shield for best results. An elongated form of winding, as illustrated, also may be used to advantage.

Good Ground Is Vital

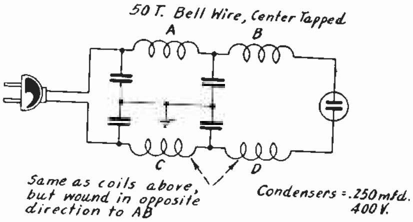
A good ground is very important to the action of the filter. Without a ground it will have no effect.

This same filter circuit can be used to filter motors, generators, rotary converters and similar electrical equipment. The connection to terminals is merely reversed.

The double choke is always more efficient than a single one. Any standard filter circuit can be improved by its use.

Tuning Light Popular

Many persons greatly enjoy visual tuning systems, both the meter and the ray indicator types. Their eyes, if not their ears, tell them reception is better.



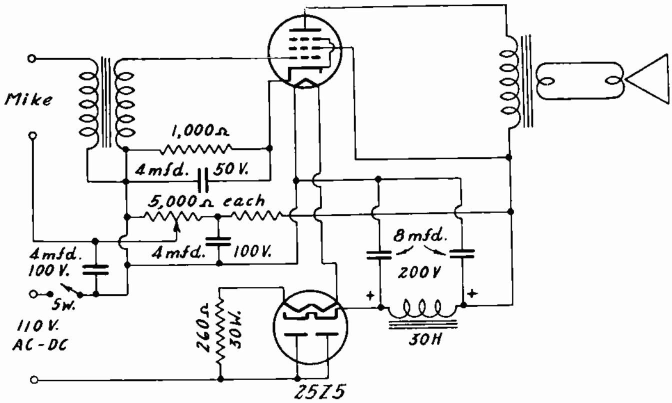
Brute force filter use in line noise eliminator. Yes, this circuit does work!

A Single Stage P. A. System

Universal Device Serves Variety of Uses

By Morris N. Beitman

A very simple audio amplifier, indeed, for use with a hand microphone. The 38 is the amplifier tube and the 25Z5 is the rectifier. Everything not vital to the operation of the circuit has been omitted. This design is suitable for universal operation — that is, on 90–125 volts a.c. or d.c. For operation on around 220 volts a much higher value limiting resistor than the 260 ohms would have to be used. This resistor is built into the line cord.



MANY times a very small public address system is needed in some special installation. This need may arise in inter-office communication or hospital sick room call system. Using a regular size amplifier would waste power, since in applications mentioned the power requirements are but a fraction of a watt. The single 38 tube amplifier described here is suitable. The amplifier is small, compact, universal in power requirement, using either 110 volt a.c. or d.c., and is made of a relatively small number of inexpensive parts.

Wiring of Theaters

The heaters of the 38 and the 25Z5 rectifier tube are wired in series together with a 260 ohm line cord resistor. The line voltage is impressed directly on the plates of the rectifier. In a.c. operation the 25Z5 serves as a half wave rectifier while in d.c. application the positive side of line must be connected to the tube's plates. Since the tube is used as a half wave rectifier on a.c., the plates are tied together, as well as the cathodes. The power filter consists of one small low d.c. resistance choke coil and two 8 mfd. electrolytic condensers.

The amplifier circuit is the 39 tube used as a pentode, self biased.

Magnetic Speaker Satisfactory

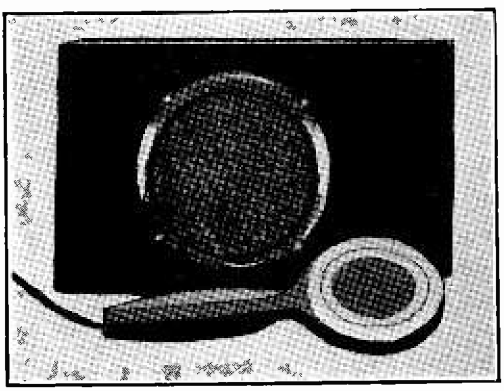
A microphone transformer is used to couple a low impedance mike to the input grid circuit. The 1,000 resistor serves as the bias and should be of one or two watts rating. It was found that because of higher sensitivity and no field current requirements, a magnetic speaker served this particular purpose better than a dynamic.

The microphone current is supplied by a bleeder circuit. The 5,000 ohm potentiometer varies the volume by increasing and decreasing the microphone voltage.

One such amplifier housed in a midget cabinet and a small hand type microphone are illustrated. The circuit has the electrical values of all the parts employed.

LONGER HOURS FOR W2XAF

W2XAF, General Electric short-wave station at Schenectady, N. Y., has added two and one-half hours to its weekday schedule of operation. The station begins its broadcasts at 4 p.m., EST, instead of 6:30 p.m. and concludes at 12 midnight. The change does not affect the Sunday schedule of the station, which is from 4:15 p.m., EST, until midnight.



The small speaker and the few parts required were put in a metal cabinet.

SCIENTIFIC LAYOUT

Best Results Increasingly Depe

as Receivers and Tuners

By Stranath

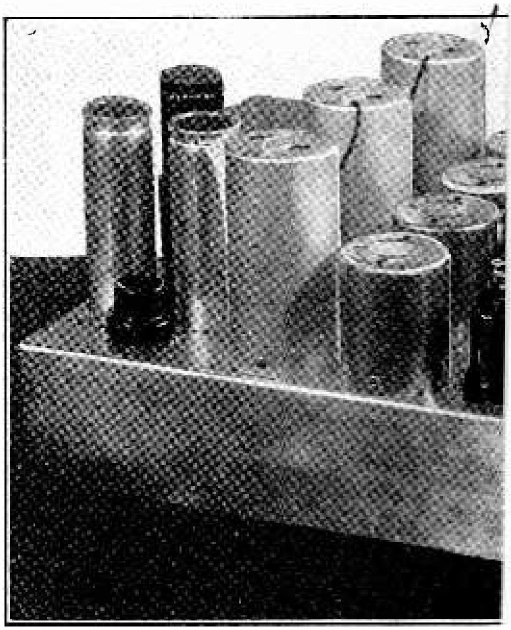
A GOOD many of the designs for circuits are not followed literally by constructors, because they have some ideas they like to embody, often associated with particular preferences for certain tubes. Also, circuits are sometimes shown in articles dealing with some interesting theory, and to try out the circuit the builder has to resort to his own chassis layout, since construction was not dealt with in the article. For such reasons a discussion of chassis layout will be presented.

The arrangement of the tuning system, as to mechanical details, will depend largely on the type of tuning drive. For the conventional airplane dial, or the disc dial of prior vogue in receivers, the condenser shaft is at right angles to the front panel, so the coils are arranged for a single band in shields atop the chassis, front to back. It is usually more convenient to have the tubes nearer the condenser, and the coils at the extreme, because most tubes for such service having caps, so the overhead leads to tubes may be run from the stator lugs of the condenser to the grid clips or other tube connectors, and the wiring to coils run from the lower stator lugs of the condensers.

Placement of Multi Coils

Where a drum dial is used the condenser shaft is parallel with the front panel, and this condition holds true also of up-to-date condenser-dial design, where a preloaded worm drive actuates straight frequency line condensers, as illustrated on the front cover, and in other reproductions of exclusive photographs herewith. With such a parallel arrangement, for a single band, the coils might be on top. The presentation illustrated shows coils in shields in that position for one band, the receiver being for coverage of four bands, so extra coils would be underneath. The circuit used is that of a tuner (no audio).

The four bands considered in the particular superheterodyne shown in the leading photographs are 500 to 1,000 kc, 1,000 to 2,000 kc, 5,000 to 10,000 kc and 10,000 to 20,000 kc. Thus



The rectifier tube, 6H6, is clearly shown at left The tube projecting horizontally at front of the eye", and is used for tuning precisely. Known as ing type. Narrowest a

the broadcast band, and more, is covered in two steps, and the foreign short wave band in two steps. The spreadout is very large, in favor of which there is an abundance of technical argument.

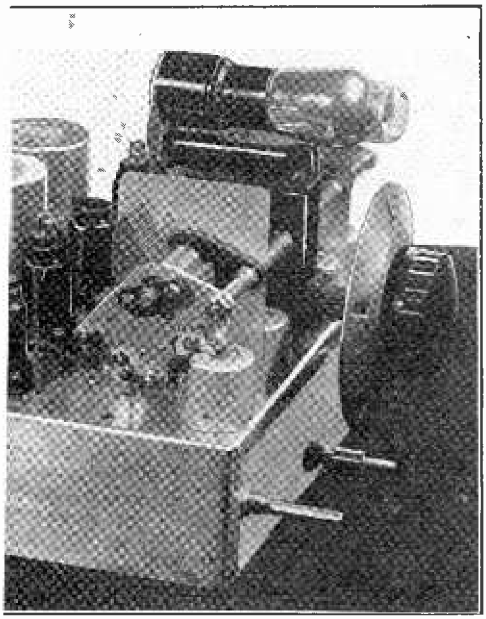
One detail with drum dial use, or the precision worm drive method just mentioned, is that if a switch is needed for changing bands, it has to be actuated also by a drum, or by a flexible coupling. Otherwise the switch shaft would have to be extended through one side of the chassis, and its knob therefore would be on a plane at right angles to the main controls.

' OF THE CHASSIS

›nd on Critical Placements

Become More Elaborate

n Edmonds



rear, close to the pair of electrolytic condensers. National PW-4 tuning unit is the so-called "magic the 6E5, this tube is of the cathode ray indicat- ıgle denotes resonance.

which introduces awkwardness. Small drums suit the purpose nicely, and notations may be written on blank scales, to denote the frequencies covered at any and all switch positions.

Avoid a Stiff Switch

The flexible drive that permits up to 90 degrees of offset, fills the bill, also, if the flexible lead is kept very short. That is, the switch should be as close as practical to the front panel, and then the flexible shaft can be cut down so that the torque is increased. If this detail is not attended to properly, there will be a considerable lag between the introduction of motion to the knob and the actual turning of the switch, and moreover the switch may not turn until several efforts are made. An unduly stiff switch should not be used with such a flexible coupling.

If the receiver is of the tuned radio frequency variety, after the detector there are only audio and rectifier stages to consider, but for a superheterodyne there must be considered the intermediate amplifier.

Even if two intermediate stages are used, and this represents the practical maximum, the three required coils, and their companion tubes, can be fitted nicely in the usual chassis width, or, in certain exceptions if it is feared there will be too much crowding, the second detector tube may be placed somewhere behind the i.f. coils, as was done at left rear in the illustrated example. The power transformer, rectifier tube and electrolytic condensers take up the remaining space atop the chassis. Underneath, of course, is the required assortment of parts to complete the performance.

None Too Much Room Underneath

Of the parts put underneath, such as resistors, fixed condensers, and some coils, also the switches, volume controls, tone controls and the like, it will be found usually with present day receivers of rather elaborate pretensions that there is not any too much room. One consideration that affects this space problem particularly is the use of radio frequency chokes and large capacity bypass condensers in the plate legs. For instance, for a four gang condenser tuner, and two i.f. stages, there would be a minimum of five such filters, and besides an r.f. choke connected to the second detector, and one will be pressed for room to accommodate so much apparatus. Fortunately, since only filtration is at stake, and since all the currents to be filtered unite in the cathode circuit of a particular stage, the choke-condenser filter may be omitted from the plate leg

(Continued on next page)

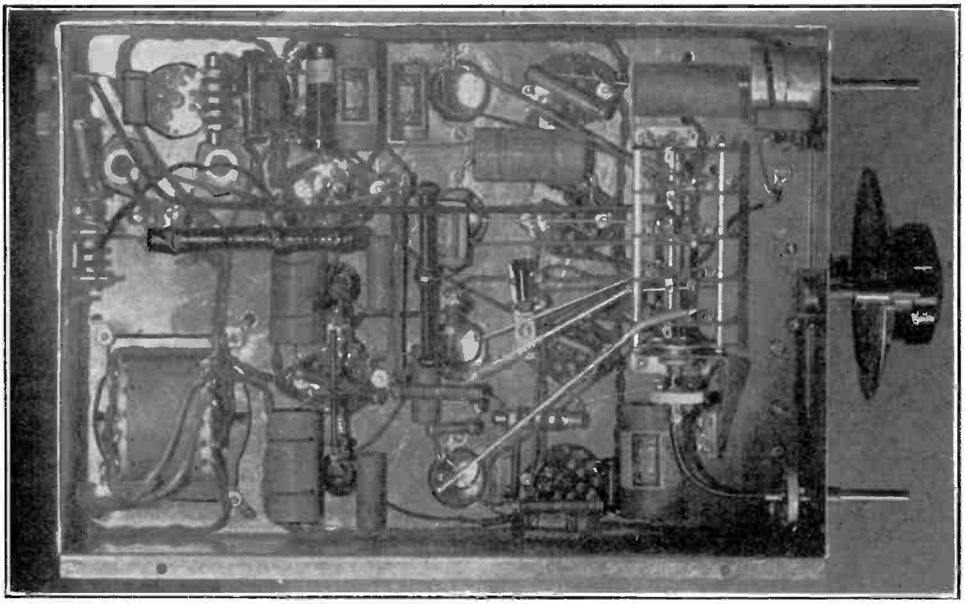
(*Continued from preceding page*)
if the condenser bypassing the cathode biasing resistor is made large enough. For the radio frequency level this would be .1 to .5 mfd. and for the i.f. level 2 mfd.

How Space Is Economized

While the 2 mfd. capacity is large, still, only one unit is used, and the total space taken up is less than that which might have to be devoted to a combination of choke and condenser, especially where the physical dimensions of the condenser are not so very much smaller than those of the 2 mfd. capacity. In chassis design, therefore, it is important to know that high capacity for cathode filtering (bypassing) is a satisfactory substitute for the choke-condenser plate filtration method.

It will be obvious from the foregoing that one does not have a completely free choice as to the location of all parts and the length of all leads, since for purposes of symmetry parts are disposed atop the chassis somewhat in the manner just described, and all chassis design starts with the dial method determining the direction of the condenser shaft and therefore the disposition of some other parts, such as tubes and coils. However, from that point on there is discretion to be exercised, and length of leads may be controlled to some extent by making certain timely selections.

Therefore the leads should be analyzed as to the frequencies of the currents they carry and the amplitudes of the a.c. voltage. The rule is that the lower frequency leads should be the longer ones, where unequal lengths between r.f. and a.f. are the option. It makes small difference, usually, if an audio lead is run from one end of a chassis to the other, except in regard to hum, which is a separate consideration. A radio frequency bypass condenser may be connected from origin to ground, to minimize or prevent pickup of radio frequencies that would be amplified perhaps in the audio channel, since some intended audio channels amplify r.f. as well as a.f. (resistance coupling). Filtration by r.f. choke and condenser at the outlet terminal for audio frequencies, from a tuner, will give adequate protection, whereas if the outfit is a receiver complete on one chassis, this extra precaution, duplicating a condition already introduced at the second detector, is unnecessary.



The fact that many parts have to be accommodated underneath, and therefore one is pressed for room, is confirmed by a glimpse of the under side of the chassis of the de luxe superheterodyne tuner. The flexible shaft is shown at lower right, enabling actuation of the switch from the usual front panel position, although the switch runs parallel to the front, instead of in the more usual right angle direction.

As between radio frequencies and intermediate frequencies, since the i.f. is lower, the same choice would be made, and as between i.f. and a.f. of course the circumstances are identical in principle to those in the other instances.

However, other things being decided on the previously stated basis, the elevation of potential of the a.c. carrier or signal has to be considered seriously. In general the plate will have a higher r.f., i.f. or a.f. potential than the grid of the same tube, about the same or less than the grid of the next tube, and much less than any "hot" leads of any subsequent tubes at an equal frequency level.

The plate and grid leads should be made the shortest possible, and the plate *return* and grid *return* leads then may be the longer ones, since the potential is lowest in the returns, which are somewhat mistakenly referred to as "cold" leads. In fact, of course, they have some potential elevation, and before reaching the coil from the terminal voltage this potential in a high gain set may be quite sizeable, especially in posterior tubes. From the foregoing reasoning, if a choice of lead length exists for a single stage the plate lead should be shorter than the grid lead.

Anomaly Explained

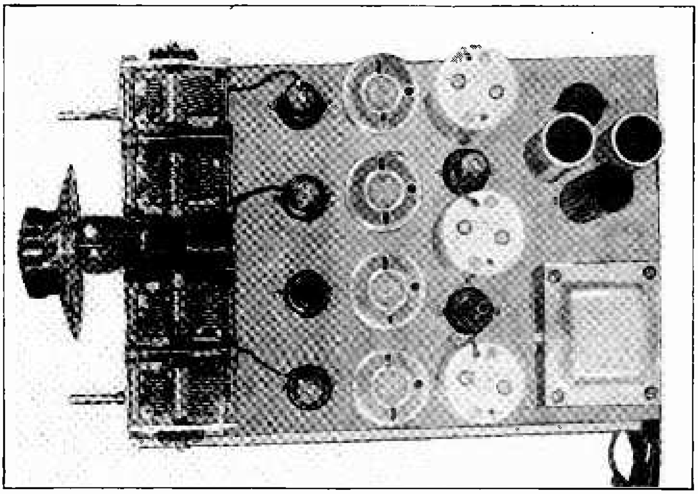
As succeeding stages of a particular level of frequency have greater amplitude, posterior stages should have the shorter, more direct leads, and the chassis layout, though restricted in some respects, leaves open the choice of where particular stages are to go, so that the leads may be kept to minimum length for the stage hardest driven, and may be longer, if need be, for earlier stages.

Independence of Returns

This seems to contradict experience, which has taught that when oscillation is present, the first stage is usually the first or worst offender, and yet this is the stage where the a.c. (carrier) potential is lowest. The current is driven from later to earlier stages, and, if the phases are right (really wrong, because we don't want the oscillation) the greatest feedback is in the first stage, where the effect is cumulative. However, with leads kept at minimum at later stages, and with full filtration, the feedback is not introduced, and besides if the design is so faulty that there is terrible feedback, the seriousness is so great that practically no solution is readily present, except to kill amplification to far below that which may be reasonably expected from the channel. Thus through faulty chassis layout what should be a splendid receiver or tuner can turn out to be very inferior.

It is especially true of all wave receivers or any receivers that dip deeply into short waves that the chassis itself can not be relied on as ground, and therefore some common point is selected, and as many as possible returns of a particular frequency level (r.f. or i.f.) are brought separately to this return, which connects to the ground post. For this special purpose of independent returns long leads are consistent with absence of trouble, for on short waves there may be a serious commingling of current in the chassis used as if it were ground.

It must not be assumed that there is any objection to grounding the chassis itself. That should be done, where practical. The only exceptions are the universal type receiver where the condenser frame is not insulated from the chassis, and all oscillators that go to ultra frequencies, where grounding can not be practically attained, everything being "hot."



The tuner representing scientific chassis layout has the tuning condenser parallel to the front panel, tubes as close behind as parts underneath permit, and four coils for one band in shields behind these tubes. The black circle at right rear discloses the second detector, a 6H6. The air dielectric type i.f. transformers are close to the i.f. tubes.

Flexibility of Coils

Fixtures providing for the mounting of coils underneath the chassis should permit of tilting the coils, as some of them may not be shielded for particular bands, or not closely shielded, and the coupling in the under and back coupling may be avoided by slight angulation.

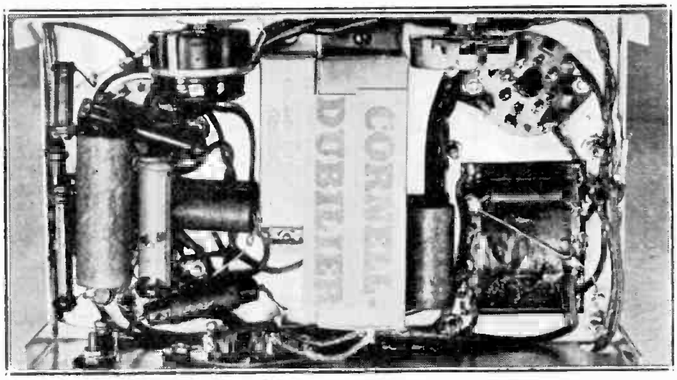
A LETTER FROM HOME

Editor, Radio World
145 West 45th St.
New York, N. Y.

You have the finest radio periodical I have yet found. Keep up the good work. Don't let it slip like others have. No one wants to buy a bunch of cheap advertisements. Lots of luck!

J. Frank Bucher, Jr.,
614 West South Street,
Angola, Indiana.

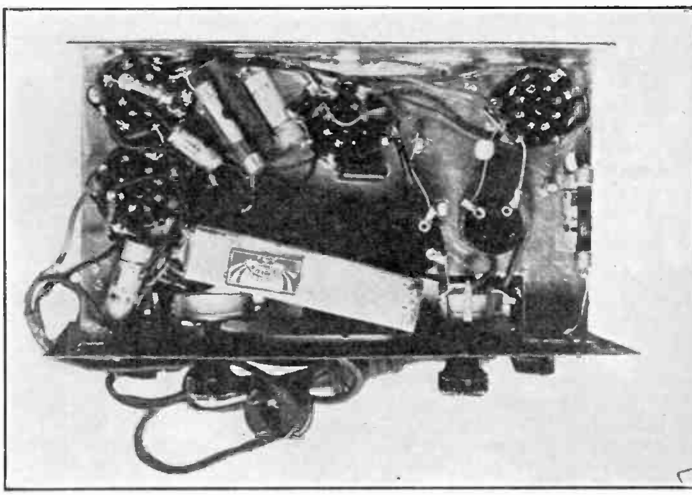
Chassis Layouts for Small Assemblies



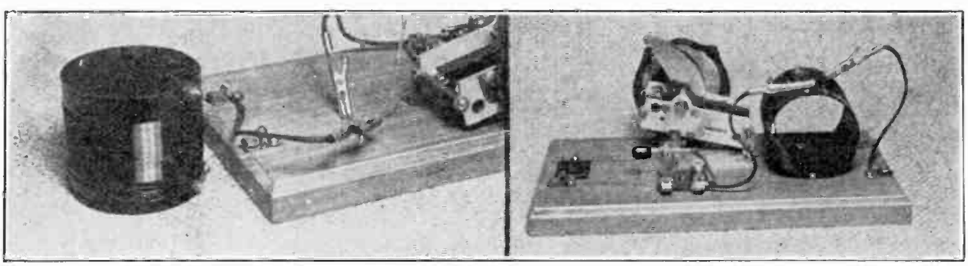
Some more information about chassis layout. A small a.c. receiver often presents problems more serious than those of a large set, from the viewpoint of scarcity of room, so it simply becomes necessary to put the parts as near as possible to the tubes or loads they serve. Many an unnecessary part has been left out because there was fortunately no room for it. The underneath view is that of a receiver stripped of all nonessentials.

Anyway, Don't Forget the Most Important Parts!

In laying out a chassis it is necessary to keep in mind at least most of the vital parts that must be included, as it becomes exceedingly embarrassing to accommodate relatively large parts that have escaped the mind and memory. The fellow who worked out this assembly seemed to have forgotten that a filter condenser was certainly to be required, otherwise the family would be singing "Hum, Sweet Hum," without apologies to anybody, and why not? However, the afterthought condenser was crowded in at a tipsy angle, as you can see for yourself.



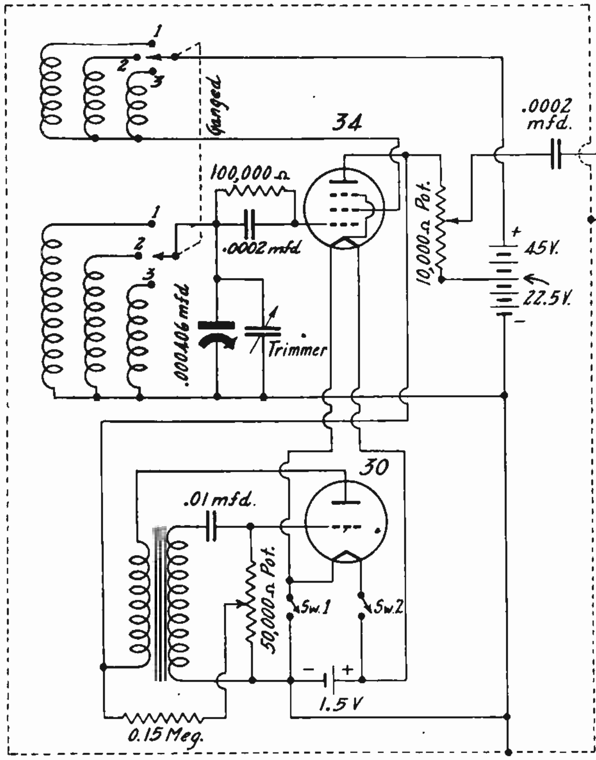
Don't Occupy Territory Like Army in Enemy Country!

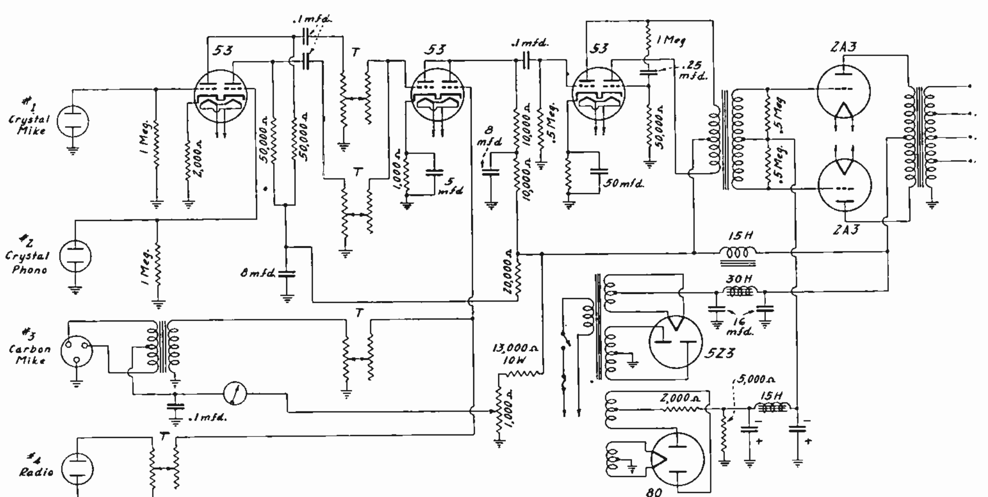


Only a crystal set, and nothing nifty about it, either. The simplest sort of receiver should be subjected to careful analysis for placement of parts, so that at least compactness and neatness will prevail, especially where the occupation of almost as much territory as an army would want in an enemy country doesn't help performance a bit.

Two Attractive Circuits: Generator and Amplifier

A three band signal generator for battery operation is shown at left. The audio frequency, or modulation, may be present or absent by switching, and if present may be controlled as to intenstiy. This control is called the percentage modulation attenuator. Then of course the radio frequency output has to be subject to attenuation, also, which it is, through use of the 10,000 ohm potentiometer. Watch the connections to the 34 tube, as the screen is used as the effective plate, while the formal plate is an output coupler, something like the third grid in the 6L7, only going out, instead of coming in, so to speak.





For those who like their audio amplifiers rather fancy, here is the diagram of a particularly good one. The parts run into money, but so do some fortunate human beings once in a while. There are four input devices, for (1), crystal microphone; (2), crystal phonograph pickup; (3), carbon microphone, and (4), audio frequencies from the detector of a radio receiver. The secondary of the output transformer is tapped for various impedances, and the one matching the voice coil impedance of the particular speaker used is the one to select, of course. Nobody would expect anything different.

Guide for Generator Selection

Uses and Performance of Different Circuits

By Percy Warren

MANY are interested in building or buying signal generators and look for advice in their selection. Really, what is needed more than advice is a statement of performance, as then the prospective buyer can make up his mind for himself.

The simplest generator is the one in battery form, without modulation, and in universal form, where on a.c. the line hum is the modulation, whereas on d.c. the modulation is absent, as in the battery example. Such a single range generator would be used for peaking intermediate channels, and the secondary inductance would be selected so that with a given capacity condenser a span of intermediate frequencies would be covered.

Uncrowding Single Range Generator

It is practical to use the tuning condenser as found, without trimmer, but with commercial condensers the higher frequencies become crowded, especially in the region where most of the measurements would be made, therefore a fixed condenser may be put permanently across the tuning condenser for bandspread. With the values cited, .0004 mfd. tuning capacity and .0001 mfd. fixed condenser across it, the range is slightly less than 2 to 1, and in a specific example is 109 to 200 kc, which is 1.83 to 1 ratio.

The lower limit, 109 kc, is sufficient, but the higher limit, 200 kc, is not, as often frequencies of 450, 456, 465 kc, etc., are desired, and these would not be covered on fundamentals. But each fundamental yields harmonics, which are whole number multiples of itself, and if only intermediate frequencies are to be peaked, then no harmonic higher than the third ever need be used, and since for harmonics there will be in this range two responses on the dial, it is practical to record just where these responses appear, and mark both positions, which of course is a harmonic confusion elimination method. That is actually done in the case of some commercial dials.

When There Is No Tone

It is nice to have audible response from the generator. However, measurement may be made without modulation, and although less convenient it has the advantage of introducing strict closeness.

The output of the generator is connected to the plate of the first detector of a superheterodyne, and a d.c. milliameter of right sensitivity is put in series with the anode (plate) of the second detector. Depending on the circuit, the introduction of the oscillation will drive the meter needle one way or the other from the steady-state condition, the direction of movement being beyond your control, and of no consequence anyway. But the intermediate frequency transformers are tuned for maximum needle deflection. Usually the generator will increase the meter reading.

The proper way is to tune the i.f condensers as nearly right as can be done rather quickly, then carefully readjust each grid circuit condenser for maximum response, then each plate circuit condenser, never molesting the grid circuit condensers after they are once set finely. Something has to be the reference point and the grid circuit condenser is it.

The second detector is used as an uncalibrated (relative value) tube voltmeter of splendid sensitivity. The net result is peaking, or establishing the sharpest resonance. In some of the latest and costly sets this "peaking" isn't proper, because the channel width is supposed to be so much, and not as narrow as circumstances permit, but the proper alignment of such a "high fidelity channel" would require a cathode ray oscilloscope.

Using Cross Section Paper

The coils for intermediate frequencies have considerably greater inductance than those for the broadcast band, and usually are made in the form of physically small sized honeycomb coils, as the result is not only compact but the honeycomb is all right for these low frequencies.

If one desires to build a signal generator he may use a single gang condenser, or one of the gangs of a multiple condenser, and obtaining a suitable coil, calibrate a 0-100 dial in terms of frequency.

Then some plotting paper (cross-section paper) has to be obtained, the frequencies written in one direction and the dial settings in the other, and curve drawn through verified points. Whenever a frequency is desired the chart must be consulted, and the generator turned to the numerical dial position that produces the desired frequency.

One objection to having charts for such purpose is that they are unhandy, a more serious objection is that unless the chart is about as large as the top of the kitchen table it would not be practical to read it to an accuracy of 1 per cent., while a 4-inch diameter frequency calibrated dial could be read to an accuracy of at least ½ per cent., and perhaps even to ¼ per cent.

Current Flows Which Way?

Considering a dry cell and a resistance connected across the terminals, current in the external circuit (that is, through the resistor) flows from negative to positive, and inside the cell from positive to negative. The direction is actually the same, and may be referred to as clockwise, to bring out the analogy to the movement of the hands of a clock, which is always in the same direction, although the hour hand from 9 to 3 travels from left to right and from 3 to 9 travels from right to left. The direction of flow through the source is seldom considered, as the flow in the external circuit is the principal subject of study and interest. The confusion that arises is really not confusion of fact but merely of viewpoints. The actual direction of current flow has been stated and is so understood by all familiar with electricity. The assumed direction of current flow is the one that was considered to represent the facts in the early days, before so much was intimately known about electricity (although probably less is known than is yet to be learned). Meters and other instruments, also formulas and processes, were described in the terminology of their day, hence by convention the wrong direction is tolerated for consistency in formulas, and otherwise popularized, and newcomers must be taught that convention in this respect is contrary to the fact. The direction of flow as stated does not apply to a. c. In that instance a generator is considered as the source of voltage (or current), and the current flows in one direction during half a cycle (one alternation) and in the opposite direction during the other half of the cycle. Although the expression "current flow" is used, this also does not mean what it says, because it is now almost universally accepted that electrical current does not flow, in the sense that water flows, but that electron activity is influenced by force or pressure (voltage), electrons are freed, only to encounter bound ones, hence are bounced back a way, and the net result is a drift of electrons, which is the result of a complex operation, probably not yet fully analyzed or understood, and which we conventionally refer to roughly as the current.

6C5 Very Attractive as an Oscillator

The 6C5, the small triode of the metal tube group, has numerous uses, principal of which perhaps is that of oscillator in a superheterodyne, to be used in conjunction with the 6L7, which requires an independent oscillator. The 6C5 has a high mutual conductance and therefore is a more ready oscillator than the general run of tubes, which is important at high frequencies, for the 6C5 is almost the last tube to stop oscillating because of circuit losses at high frequencies.

As a test such a tube was used in a five meter oscillator and attempts were made to lower the wavelength of oscillation, which was established safely at one meter, without any indication that the tube could not be made to oscillate at wavelengths below one meter, that is, in the centimeter region. Such an advantage as this is very important. Also frequency stability can be served by a limit bypassed limiting resistor, since there is plenty of pep to spare, and the reduction of the effective plate voltage does not introduce a serious counter-problem.

FINDING METAL TUBE ERRORS

A check against possible error in connecting to metal tubes is to inspect the wiring from the bottom of the socket after the tube has been inserted, since if the particular tube has any blanks for socket springs, this fact will be seen at a glance, and a wired connection to a blank would disclose an error.

LITERATURE WANTED

Readers whose name and addresses are printed herewith desire trade literature on parts and apparatus for use in radio construction. Readers desiring their names and addresses listed should send their request on postcard or in letter to Literature Editor, Radio World, 145 West Forty-fifth Street, New York, N. Y.

Jos. M. Hiznay, Jr., 132 Park Ave., Wilkes-Barre, Penna.
Edward P. York, Stonington, Conn.
Allan W. Seely, 31 Locust St., Danvers, Mass.
W8KHR—J. F. Craig, 2151 - 12th St., Troy, N. Y.
W2HUV—J. Richard Banker, Waite Dorn—Sage Ave., Troy, N. Y.
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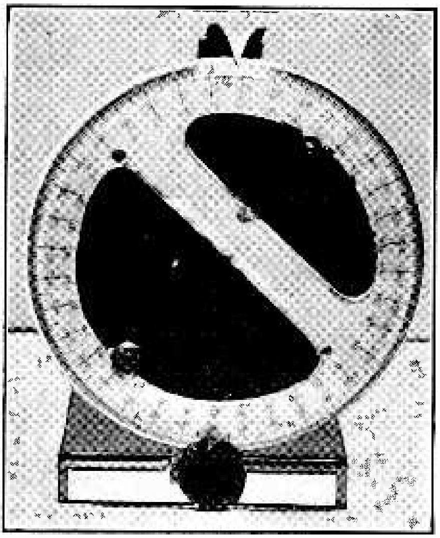
Herbert Waterman, Waterman Stock Farm, R.F.D., Greene, R. I.
William H. Franken, Amateur Radio Station W2ISZ, 216 - 44th St., Union City, N. J.
M. Wolkoff, 1010 Fairmount Ave., Philadelphia, Penna.
E. Ternovoy, P. O. Fosey, Alberta, Canada.
A. Melnik, P. O. Bellis, Alberta, Canada.
W. W. Brigham, 1595 Lincoln Ave., Lakewood, Ohio.
J. W. Jack Scott, G.P.O. Box No. 1, North Battleford, Sask., Can.
Charles Snyder, 1707 Spring St., Quincy, Ill.
Frank H. Jenkins, 2626 Northwestern, Detroit, Mich.
George L. Danforth, W1TPK, 9 Gould St., Danvers, Mass.
R. F. Brewer, Room 1056 Earle Bldg., Washington, D.C.
Melvin Shoul, 102 State St., Newburyport, Mass.
Elwood Brooks, 1412 East 27th St., Cleveland, Ohio.
Joseph Louis Babinger, Jr., Radio Technician, 191 Herkimer St., Buffalo, N. Y.
Myers Radio Service, 78 Second St., Passaic, N. J.
August L. Ferber, 1819 Van Hise Ave., Madison, Wisc.
Wm. Dowdling, 33 Grove Ave., Highland Park, Mich.
James G. Sheller, 32 W. Chestnut St., Washington, Pa.

A Precision Rotary Protractor

Scale Affixed to Metal Disc and Held to Airplane Dial

By Herbert E. Hayden



How the protractor is affixed to a metal disc, with machine screws and nuts, spacers keeping the nuts parallel with the disc, which is shown as a black background of the protractor. The bracket with two holes for anchor screws is hidden from view by the knob.

A ROTARY protractor may be made by affixing a protractor to an airplane dial and supplying a suitable pointer. Either the 180 degree or the 360 degree type protractor may be used, and either of these for one degree or half degree graduations.

The rotary protractor permits close measurements of angular displacements in terms that are conventional. In radio the method is used for obtaining the information on which a frequency calibrated scale is to be based, or may be used as a permanent installation for close reading of tuning. In radio, also capacity calibrations would be within the useful scope, and in special instances inductance measurements. In the mechanical field, apart from radio, the rotary protractor has many uses.

One of the first requirements is security. The moving member must communicate no backlash to the measured device, nor must there be lost motion between the two. In substance this requirement is that the same setting of the condenser always should cause the same reading of angular degrees. In line with this requirement the pointer must be rigid. Moreover, it should permit easy, accurate distinction between adjoining gradations of the protractor scale, and a good test of this is that one should be able to estimate the halfway mark between adjoining bars.

Pointer Is Close to Scale

Avoidance of parallax is accomplished sufficiently by having the pointer close to the scale, though not so close as to graze the scale. Sharpness of a metal point may be accomplished well by using tin and cutting away to leave a narrow angle. The cutting has to be done away from the intended point for maximum sharpness, though curling is increased. Several efforts may be necessary, before a suitable pointer results, due to lack of symmetry at the pointer, or to curling, or both. Curling cannot safely be remedied by hammering flat.

After the pointer is made from tin the remaining metal is cut to shape to suit the fixture to which it is to be attached, usually a heavy upper bracket that is part of the dial hardware, the pointer being bent over at a right angle to extend down to the calibration on the protractor. The horizontal part of the pointer should be held down at least in two places, to avoid possibility of movement.

The tin pointer will hold very well. However, if any accidental contact should displace it a bit, the protractor may be returned to the original setting and the pointer made to coincide again. This original setting is either one or the other terminal of the scale.

Sharp Result from Needles, Also

A needle may be used as a pointer. The needle is soldered to a slab of thick brass that has been bent into a right angle, so that the needle points down, and indicates the numerical readings.

The usual protractor is a little deeper than a semicircle and has gradations 0 to 180 degrees in steps of one degree. Since a protractor is normally intended to be used in conjunction with a drawing board, there are no mounting facilities. A stiff metal disc is cut to fit, and through the center of this disc is drilled a tiny hole. With this hole as guide the protractor may be centered on the disc provisionally, and points marked through which three or more holes are to be drilled in the disc, so that with the aid of spacers, nuts and bolts, the protractor can be held to the disc.

However, since it will be necessary to supply the disc with a bushing to accommodate a shaft, a fixture from a small flat type direct drive dial is used. Thus fixture has mounting holes, and their positions are registered on the disc and the fixture mounted with nuts and machine screws (No. 4). The fixture has provision for a quarter inch shaft. Into this bushing is inserted the airplane dial's quarter inch shaft, or a shaft additionally provided, and for rigidity a soldered contact to the bushing of the fixture may be provided.

Variety of Protractors

Simple transparent protractors may be purchased for a quarter or so. These may have a diameter less than that of the airplane dial, but the larger size protractors cost more. So do those that have the gradations in half degrees, instead of full degrees, and most costly are those protractors that comprehend the full 360 degrees, in half degree steps. For the double type most appropriate to airplane dials, two pointers would be necessary, preferably on either side, instead of at top and bottom, as the knob at bottom, otherwise would interfere with the intended second pointer. If the driving knob is put to one side, so that the dial bracket makes an angle with the central perpendicular line of the dial, then top and bottom of this central line are left free, and pointers may be put on a separate panel, which is cut for the airplane dial's face.

The model shown, however, is one that may be affixed to any front panel, to simply to a chassis to which a condenser to be calibrated already has been fastened. There are two holes drilled in the lower bracket, and the panel or chassis front would have to be drilled similarly, to anchor the mechanism. Some security is afforded by the connection of the mechanism to the shaft of the condenser, but the dial has to be prevented from turning as a whole, that is, the motion should turn the condenser and scale, but not turn the dial with condenser.

Ascertaining Capacities

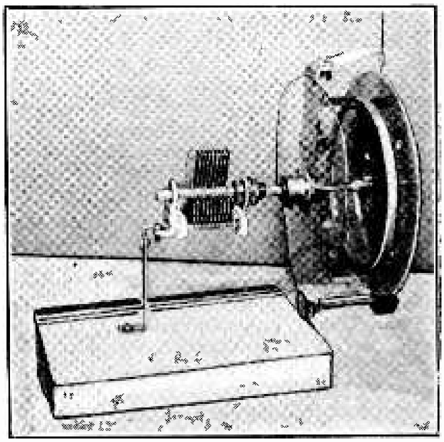
Except for variometers, which are out of style, is is virtually always a condenser that is to be calibrated in radio practice, even audio practice. For frequency values the calibration is really one of the capacities and the changes in capacities, the inductance always being a constant. Thus a frequency calibration is indirectly a calibration of capacity, although expressed in terms of frequency, because the capacities thus calibrated are in conjunction with a given inductance, hence frequencies are ascribed to the calibration.

If the actual capacity of any one setting is known, for a frequency run, the capacity of the other settings can be computed from the frequencies, as the capacity ratio is the square of the frequency ratio, or the frequency ratio is the square root of the capacity ratio. So if one frequency is twice as great as another, the capacity is four times as great at the lower than at the higher frequency.

When using the rotary protractor for determining angular positions, preferably with a scale readable in half degrees directly, with quarter degrees estimatable, the condenser plates should be at minimum setting, and the protractor fastened on that basis, reading either 0 or 180, it makes no difference which, except that a written notation should be made of the fact. For instance, 0 degrees equals maximum capacity, or 180 degrees equals maximum capacity. Of course maximum capacity will represent minimum frequency or maximum wavelength.

Getting the Displacement Straight

The setting for maximum capacity does not necessarily mean that the condenser shaft



From the condenser shaft toward the airplane dial are seen first the regular shaft hub of the dial, next the transparent disc actuated by the wedge drive (below), then the 1/4-inch shaft additionally provided, which is soldered to a flat dial fixture screwed to the supplementary disc, the one shown in black in previous illustration.

is turned as far to that extreme that it can go, as with numerous types of condensers the maximum rotation represents a condition past full mesh of plates, because the actual rotation is a bit more than 180 degrees, which is what we are testing now.

So if the shaft is put as far as possible in one direction to assumptively maximum capacity, reading one extreme in degrees, it may be found that to strike the other extreme one would have to go past zero, showing that the total displacement is more than 180 degrees.

However, the movement past full mesh of plates is one toward smaller capacity, so a knife blade or other flat device may be put on the condenser firmly, and the plates thus registered at full mesh and the setscrew tightened, with scale reading 180 or 0.

Some prefer to have the original registration at minimum capacity, and again the

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precaution must be taken not to have the setscrew fixed necessarily or the rotatable extreme of the condenser shaft, as the plates may have begun to mesh again in the reverse direction, increasing capacity this time, so the blade is used at this end to prevent excess turning of the condenser. A notation now should be written down that the scale was registered for minimum or maximum capacity, and what the dial reading was, 0 or 180.

Set Screw Must Be Very Tight

The actual method of using frequencies for test purposes to produce the calibration is beyond the scope of this article, and has been treated fully in previous issues. The present concern is the mechanical operation, though a few necessary electrical facts will be stated. The dial should be rotated now from one end to the other and especial note taken of adherence of the original terminal setting, even after one has exerted some pressure in an attempt to dislodge the setting. Sometimes the setscrew is not tight enough, and the scale will move after the condenser has come to an endstop, although modern dials often are provided with two setscrews to avoid this minimize this possibility. The dials themselves nowadays have smooth moving discs that communicate only slight pressure to the condenser after the end stop of the condenser is reached and the knob is turned as if to move the condenser some more in the direction in which it is impossible for the condenser to go further. The dial normally takes up this motion without affecting the condenser. However, as stated, if setscrew is not sufficiently tight, or dial is insecure, the scale may move, and that would spoil everything. So test this point very thoroughly. More screwdriver pressure than most persons believe necessary should be exerted on setscrews that tighten on condenser shaft—all you can put on without stripping the thread. If necessary, tighten down sufficiently to "mark the spot," and slightly drill this shaft spot, so that the screw will have an indentation for anchorage.

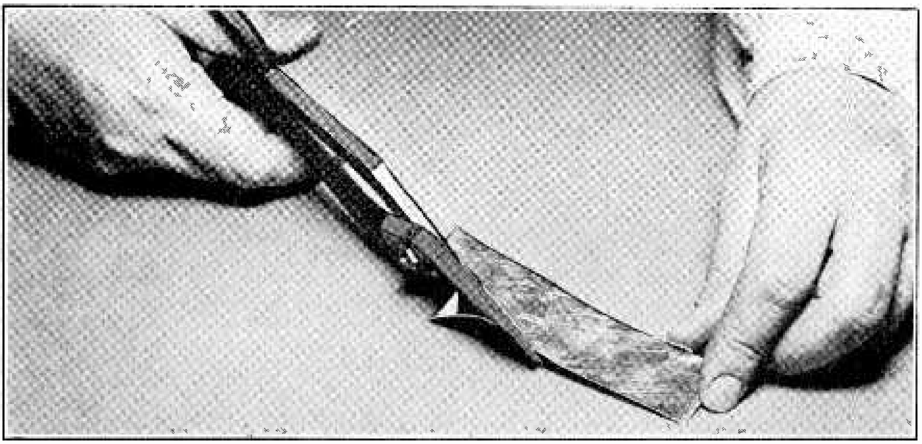
Finding End Frequencies

When points are being registered in the calibration process they should be written down, in terms of degrees, with the frequency in the next column, and the dial should be swept over half its movement and brought back to the former position to check up on whether exactly the same reading in degree prevails. This should be done for each point. As many points as possible should be obtained, the minimum being a dozen, fairly evenly spaced.

When the points have been registered the terminal frequencies may be absent, that is, the test source may not provide means of determining what are really the end frequencies. Take the broadcast band, for instance. Suppose the low terminal frequency is 520 kc in the system being calibrated, which may be a generator. Maybe 540 or 570 was the lowest frequency at hand for comparison. Then one does not know just where 520 kc comes in, if at all, although the case assumes it was reached, still the end frequency has to be found.

Troublesome End of Curve

There are two ways of doing this. One is to pick a station as close as possible to twice the end frequency, using the second harmonic of the terminal frequency for beating. That would be a station on 1040 kc in this instance. Perhaps no such station is receivable. If 1050 kc is receivable then 525 kc may be used as the lowest frequency point readily obtainable. The other method is to use a low frequency oscillator at 260 or 130 or proximate frequency, and ascertain the end frequency from this variable frequency oscilla-



The tin pointer shown in the first illustration, front view of rotary protractor, is made by using tinsmith shears, cutting away from the intended point. The index should be very sharp and several cutting attempts may be necessary to accomplish this.

tor, the accuracy of which should be known or checked.

However, with the 525 kc frequency established by the harmonic method, reading not quite at the end of the protractor scale, the general contour of the curve may be followed by extrapolation, which consists of carrying out the curve shape to the end, when the points are committed to graph paper. To permit of such extrapolation it is necessary that points very close together be obtained for this part of the tuning, say the 10 degrees or 15 degrees from the end under consideration, as this part of the curve is usually quite a departure from the shape of the rest of the curve, as especially for the last five degrees, high capacity end, where there is abrupt flattening out.

If any adjustments are made in connection with the condenser, for instance a trimmer across it is set, the sheet on which particulars are put should include some mention of the approximate setting of the trimmer, e. g., plates all the way in, half way in, etc.

Inside Facts on Adjustments

When a frequency calibrated scale is to be used later, it should be in the basis of setting the trimmer near the high frequency end, not necessarily the extreme, but fairly close to it, and if any inductance changes are to be made, these should be near the low frequency extreme, adding turns to lower the frequency, take off turns to increase the frequency. The inductance change will have practically no effect on the high frequency end, a fact not recognizable from the frequency formula, but well authenticated by years of practical application to precision adjustments of signal generators.

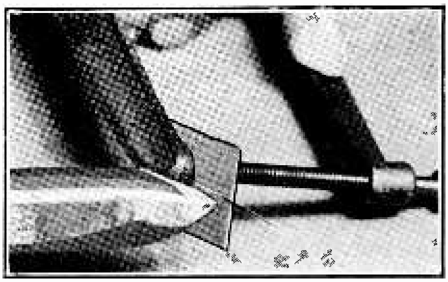
The plotting paper used should be of the type that is known as "squares of ten", and it should be as large as practical, so that at least there is a line for every degree, requiring at least 18 squares in the horizontal direction, for a protractor reading in single degrees whereas for a protractor reading in half degrees there should be 36 little squares along the horiztontal. How many of the tiers are necessary for the upward direction (perpendicular) will depend somewhat on the frequencies themselves and the closeness to where they are to read. For the broadcast band there should be at least 11, so that there will be at least 10 kc for each line measured along the upright. It is nearly always the practice to go considerably over in each instance, in the frequency direction.

A Little Difficulty Here

Even frequencies, say 500 and 1,700 kc, are written at the extremes, and 600, 700, 800, etc. kc noted even with the heavy ruled horizontal lines, the dial readings in degrees being across the bottom as usual. Then the data sheet is consulted and, using a sharp, hard pencil, the points are recorded, and are joined by a line to constitute a continuous curve.

It is difficult to create this curve, because there is no ready instrument that enables following the recorded points. French curves develop inaccuracies, as they cause their own contours to be followed, rather than the true and accurate curve desired. Occasionally French curves, over part of their parameters, fit into a small part of a frequency curve very accurately.

Some engineers use soft solder and bend it along the points to guide the pencil. However, though the solder curvature may be strictly right, it is hard to avoid moving the solder guide, and this movement or loss of place may be accompanied by a change in the shape of the solder curve, so that one is tempted in-



A needle may be used as pointer. The bracket is held in a C clamp and the needle is soldered to the bracket.

stead to put a straight edge (like the brass flange of a ruler) to join points separated one quarter to half the distance of the curve, and, guided by the departure from linearity, draw through the points lightly in pencil, by freehand, later making such corrections as are obvious to the eye, and continuing the process until the curve is complete and satisfactory, when it is closely examined for possible irregularities.

The irregularity near the high capacity end has been discussed, and this is the only one that should be tolerated. It is really not so much an irregularity as it is a departure from the general slope of the curve as found elsewhere on the plotting paper. Really irregularities are jagged and there should be no jaggedness, but a running smoothness to the curves.

If any abnormaities are encountered, off curve points, if one or two of twenty or more, may be ascribed to experimental error and ignored, or, better yet, even a single abnormality should be rechecked, and the error will be found, since the regularity of the curve over the major portion safely may be taken for granted in theory, though in practice every possible confirmation is just that much more to the good.

With the facts now in hand the use of any additional fixed protractor becomes easy for communicating the results for a frequency calibrated scale that one will prepare. The fixed protractor is fastened to the paper or other material on which the scale is to be drawn, using thumb tacks on a drawing board, the

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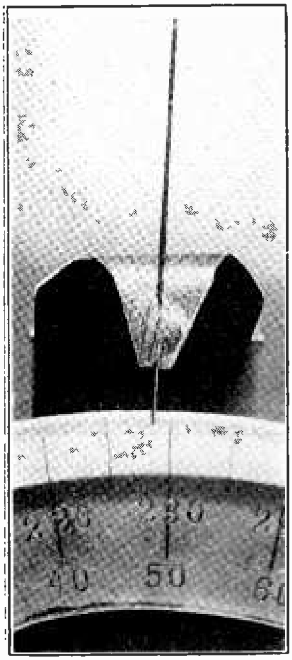
frequencies of actual test points are registered, and the other frequencies are taken from the curve. Since the curve is secondary, the known degrees for known frequencies are prime information and should be used and not taken from the curve. For the highest accuracy, all other points should be separately read from



How a needle is used as a pointer. The indicator should be just a bit higher than the top of the calibration bars. The needle or other indicator should be as close to the scale as possible, without actually grazing, to avoid parallax.

the curve for each frequency to be registered, rather than steps of 50 kc or so registered, and then prorated, since the curve is not linear.

The foregoing discussion has been literally applied to 180 degree rotation condensers, none of the straight frequency or straight wavelength line, but with obvious adaptation the method is applicable to all condensers.

Sarnoff Back from Abroad; Studied Television Tests

American radio and American radio research are still well in advance of Europe's, despite recent progress there, David Sarnoff, president of the Radio Corporation of America, said on his return to New York City after two months abroad. Mr. Sarnoff visited England, France, Belgium, Holland, Austria, Hungary and Czecho Slovakia.

"I studied the technical developments in the important radio laboratories in Europe," Mr. Sarnoff said, "and saw their latest television experiments. While interesting research work is being done along these lines in several European countries, the progress being made in our own country, is in advance of anything I saw abroad. America continues to lead the world in radio."

NEW BOOKS

Cathode Ray—*Rider*

"THE Cathode Ray Tube at Work," by John F. Rider (322 pp., 5⅜ x 8⅜ inches), published by John F. Rider, deals with the practical aspect of the tube in testing and servicing, and gives detailed applications. Numerous oscillographs are reproduced to illustrate the telling points made, and a wide variety of circuit diagrams is given for utilization of the tube in its various forms.

The subject is attacked from the viewpoint that a reader with no great familiarity with the subject considers it important, which the text proves it is.

Tests made on receivers and transmitters are reported and a detailed and comprehensive book results. The author not only had to write the book but first had to make numerous experiments, so he could report faithfully their results. The book is in no sense a review of the familiarities but rather an intense revelation of what a great amount of work will accomplish.

* * *

Servicing—*Ghirardi*

THIRTEEN hundred pages, 4¼ x 8 inches, crammed with vital material, 706 illustrations, comprise "Modern Radio Servicing," by Alfred A. Ghirardi, published by Radio & Technical Publishing Company. The publishers state that "the book is in a class by itself—nothing like is has ever been published before," which is indeed true, considering the scope and detail, which include even directions for getting and holding business. The book brings the data on servicing up to the minute, including intimate details on the use and application of the cathode ray tube. Many measuring and other testing devices are diagramed, and the book may well be considered as a course in itself.

* * *

Field Data—*Ghirardi, Freed*

AS a supplement and answer book, a 5½ x 8 inch paper covered volume of 240 pages, entitled "Radio Service Field Data," is published by the same firm. The authors are Mr. Ghirardi and B. M. Freed. The reference data consist principally of a tabulation of radio receivers by manufacturers' names and model numbers, with trouble causes stated, and remedies listed. The appeal of this type of classification is to the service man who, coming across the sets, wants the pith of their most frequent weaknesses and the cure. A section is devoted to automobile radio.

But the Cabinet Is Different!

Traditional Circuit Housed in Box Made to Look Like Finished Metal

By Erwin Collins

A small battery operated portable receiver for earphone use, wave bands changed by plugging in a single coil for each band. Note the hinged door permitting access to the coil socket for band shifting. The front panel controls may include a 35 mmfd. series antenna condenser, the one at extreme left on the panel.

HERE are some photographs of the construction of a battery type portable, with a diagram, on the next page, which does not represent the portable pictured. How come? Is it a new style to print the photographs of a particular construction, and along with it the diagram of a different receiver?

No, the style has not changed to that extent yet, though metamorphosis (look it up) is fast in radio.

The idea is simply this:

There is plenty of room in the cabinet to build either a circuit-using a single coil for each band, or for inserting another socket and plugging in two coils for each band, and you

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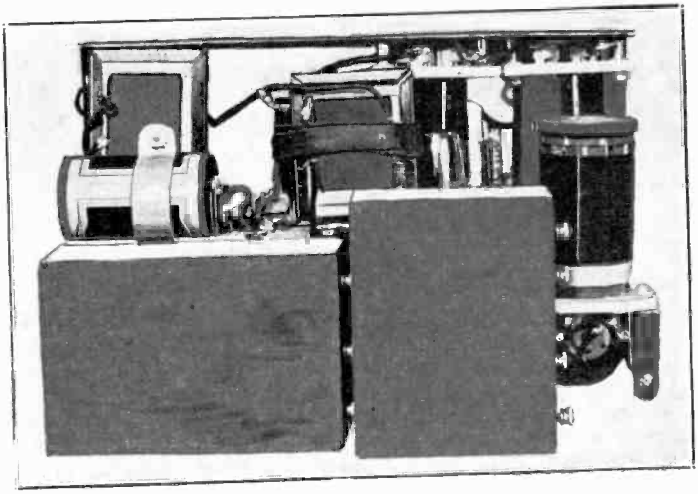


Rear view, batteries removed. A strap helps to hold the central audio transformer in place. A metal band holds the 1.5 volt biasing cell to the chassis, from which it is insulated. The object of including the biasing battery is to reduce the plate current drain and also somewhat improve the quality under conditions imposed by severely strong locals.

(*Continued from preceding page*)

can have your choice. The diagram shows the use of two coils, because then it is complete for those who like that version.

Do You Agree With Author?

And for those who, like myself, don't think that in a regenerative set that is principally made for short waves that the extra t.r.f. stage amounts to much, the same diagram suffices, with these changes:

Forget about the first tube. Connect aerial to one side of a 35 mmfd. variable series antenna condenser, the left hand member of the front panel bar handle trio, other side of this condenser to one terminal of the primary of the single coil, other side of the primary to ground, and in any event connect negative filaments of the three tubes to switch, other side of switch to grounded A minus, B minus. That's all for a three tube set.

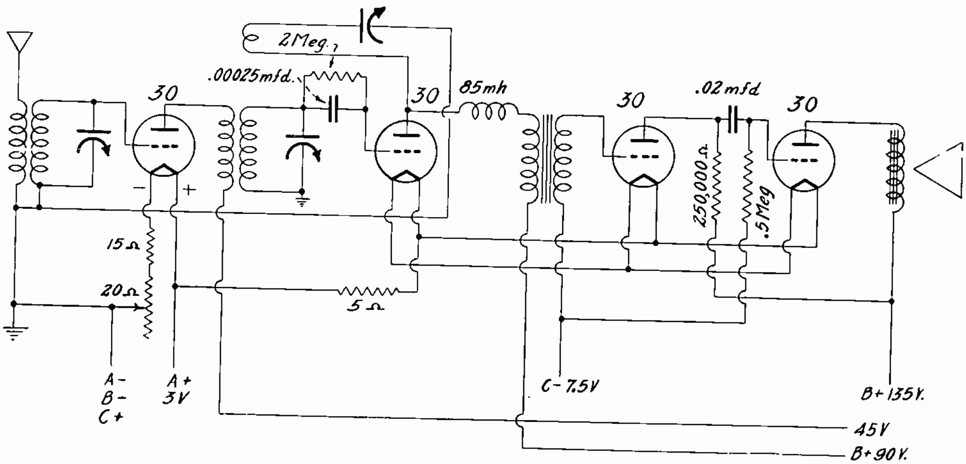
Four plugin coils then are used for covering the short wave band and there are two extra coils that will take care of the broadcast band for those who want that. Commercial coils made by Hammarlund were used, tuned by a Hammarlund Junior Midline .00014 mfd. condenser.

The Two Other Bar Handles

The lefthand control being for the series antenna condenser, the middle one is for tuning the .00014 mfd. variable connected across the secondary of the coil, while the feedback condenser, a Hammarlund Junior .00032 mfd., is the right-hand control.

With the four tube circuit used as shown, except that negative filaments of the second, third and fourth tubes grounded, the switch for the filament battery of 3 volts is in the rheostat. For the three tube model there is no switch shown in the diagram, but the switch connects as already stated, one side to negative A, other side to negative filaments. The switch is located at extreme left on the panel as illustrated. The 0-3 voltmeter may be included or omitted, as you please. If used it is connected across filaments.

The earphone jack is at extreme right on the front panel. Above the switch at left are two banana jacks, and to these aerial and ground wires are connected. The antenna I use consists of 12 feet of tinsel wire and it has proved sufficient, whereas the tip jacks are intended principally if a regulation antenna is to be connected to the set.



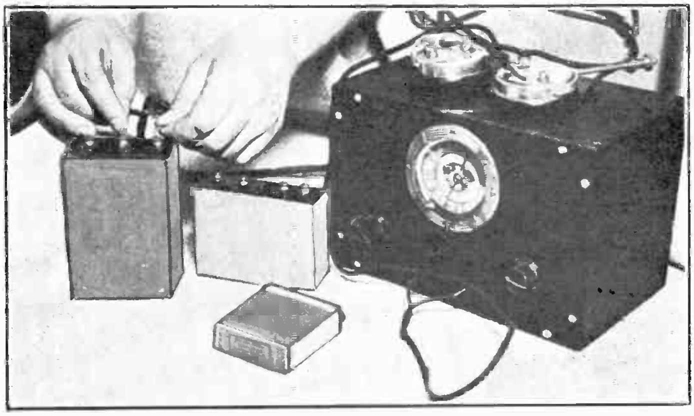
Those who like the four tube model may follow it according to the diagram, remembering to connect negative filament of the second, third and fourth tubes to one side of switch, other side of which is grounded. Those who prefer the three tube model will use only one plugin coil for each band. If one fancies the front panel meter, the inexpensive Readrite 0-3 volt meter will serve the purpose nicely, connected across filaments. On locals the set will operate a magnetic speaker, otherwise output is connected to earphones.

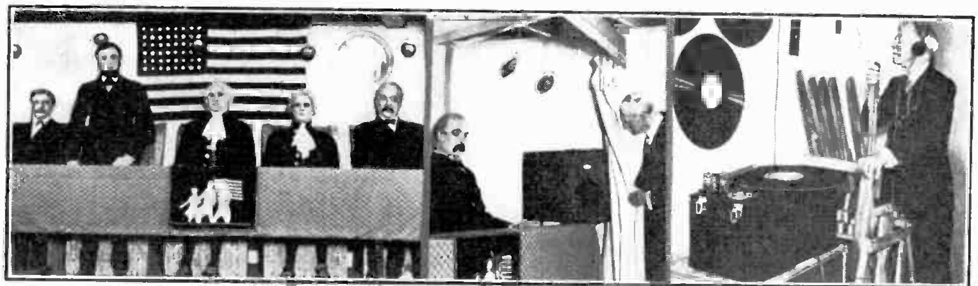
That Little Rear Door

Note the little rear door through which ready access to the coil socket is obtained. Little rear doors have served many useful purposes in bygone days, which gave the author the idea, especially when the words bar handle came to mind. The cabinet is made of wood, finished with a black crackle paint, which makes the cabnet look lke the real thing which, to tell the truth, it is.

The circuit and its uses are traditional and there is scarcely need for going over old ground in detail. All familiar with this performing circuit will be able to adapt their purposes to the constructional method used. The photographs tell more than words could. That is, the author's words.

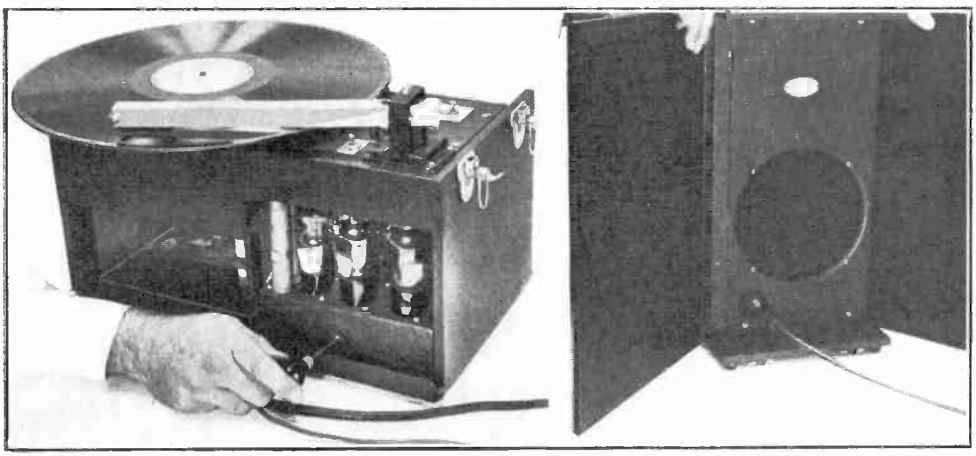
Battery sets should be carefully tested for polarities, as it is easy (oh, so easy) to incinerate the filaments by misapplication of potentials. Be sure, by continuity test, that the B plus post of the set reads as if an open to the filament, before batteries are connected.





Andrew Hallbran

Famous Presidents are made to "live again" in an exhibit consisting of lifelike figures that are caused to rise before dummy microphones when their turns come to "speak." Theodore Roosevelt, Lincoln, Washington, Jefferson and Cleveland are shown.



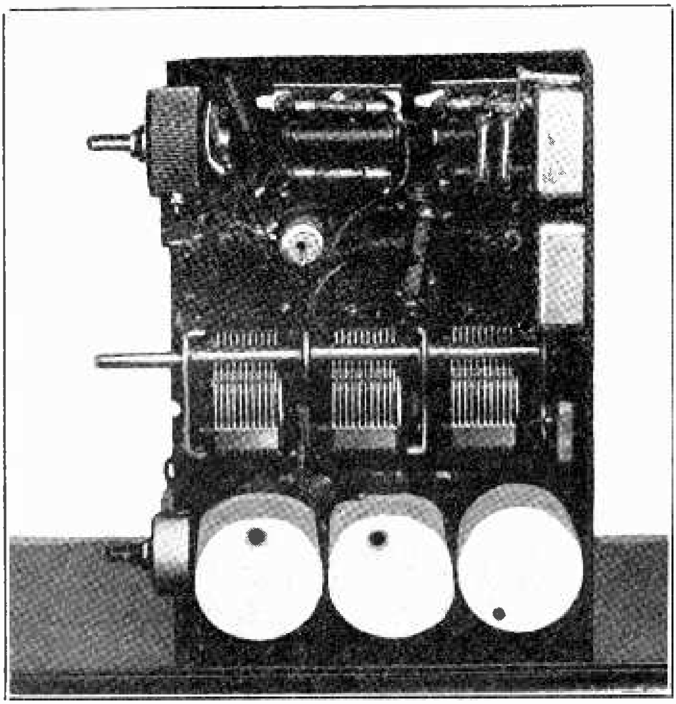
Andrew Hallbran

Extensive research was conducted to determine as nearly as possible how some of the remote Presidents spoke, the data on later ones, like Theodore Roosevelt and Cleveland, being easy to obtain. Records were made by persons who could "imitate" these Presidents, and these records are played as part of the demonstration, activities being controlled by an operator. The amplifier and housing shown are the design of Arthur C. Ansley, of Ansley Radio Corporation, and are used in the demonstration.

Anderson's Portable

Six Tube Battery Superheterodyne Has A. V. C.

By J. E. Anderson



The chassis has bracketed supports front and back. Three holes drilled in the front flap (left) are used for mounting the rheostat and switch-potentiometer, and for passing the spindle of the tuning condenser. The aluminum shields below contain the r.f. coils. The i.f. transformers are on top, hence are not visible in this underneath view.

THERE is now a complete line of special purpose tubes in the two volt series as well as in the 2.5 and 6.3 volt series. Just as versatile receivers can now be constructed with two volt tubes as with any of the other types. We have the 34 for radio frequency amplification, the 1A6 or 1C6, for oscillation and frequency changing, the 1B5 for diode detection and audio frequency amplification, and finally the 33 for power amplification. The 1B5 completed the two volt series and made possible the design of really satisfactory portable receivers with automatic volume control.

Antenna Input Untuned

The six tube portable receiver represented by the diagram incorporates all the special purpose tubes mentioned above in a manner that takes full advantage of the special characteristics of the tubes. The receiver is a superheterodyne having two r. f. stages, a mixer-oscillator, one intermediate amplifier, a diode detector and audio voltage amplifier, and a pentode power amplifier.

Since a portable receiver in most instances is operated with a loop for pickup, and since it is not practical to tune a loop with one of the sections of a gang condenser, the input in to the first tube in this case is untuned. Therefore the design of the loop used with the circuit is not at all critical. The circuit will work with a single turn of wire, or with half a turn, and it will also work with a large number of turns. The size of the turns is of little importance. However, the signal picked up by the loop is proportional to the area of each turn and to the number of turns. Therefore the larger the number of turns, and the larger each turn, the more sensitive will the receiver be.

Good I.F. Coils Help

In the radio frequency tuner a three gang condenser is used. Two sections are used for tuning the signal and the third section for controlling the frequency of the oscillator. Since there are two radio frequency tuners and since neither of these is connected to a circuit where there are any appreciable losses, the radio frequency tuner is exceptionally selective as well as sensitive. Assuming that the two r. f. circuits and the oscillator are adjusted to track reasonably well, there will be no observable image interference.

The likelihood that this trouble will occur is further reduced by the high intermediate frequency, 456 kc. The two r. f. tuners in the circuit are sufficiently selective to suppress any code signals that may be present at the intermediate frequency, and therefore no 456 kc wave trap is necessary.

If two high grade, Litz-wound, doubly tuned intermediate frequency transformers are used, the gain in the intermediate frequency level will also be very high and the selectivity may be made even more than necessary. Yet it will not be too great, as it might be if three intermediate transformers were used.

Maintaining Proper Bias

As far as the power supply is concerned, this receiver reverts to the type of receivers used a decade ago. That is, three batteries are used, a three volt battery for the filament heating, a 135 volt battery for the plate supply, and a 13.5 volt battery for the grid bias. This is the only practical power supply for a portable receiver.

Special attention is called to the arrangement of the grid circuits. Two of the 34 amplifiers and the mixer tubes are on automatic volume control. The control grids of these tubes are returned to the negative end of the load resistance on the diode.

So far the arrangement follows standard practice. There must, however, be a minimum grid bias of three volts on the grids of the controlled tubes, as well as on the triode of the 1B5. For this reason the load resistance is not connected to the negative end of the filaments, but to the minus three volt point on the grid battery. The grids of the first 34 and the triode of the 1B5 are also returned to this point. Therefore these two tubes have a fixed bias of three volts, whereas the other tubes, excluding the power tube, have a minimum bias of three volts.

Another noteworthy point is that the rotor of the three gang tuning condenser is not connected to the filament, nor to the minus three volt point on the grid battery, but rather to the common lead of the automatic bias. The rotor is grounded as usual, and this fact makes it practical to build the receiver on a metal chassis.

The rotor of the condenser used for the oscillator is, of course, grounded with the rest. Therefore the low potential side of the oscillating circuit is also connected to the a. v. c. This in no way interferes with the operation of the oscillator, because the oscillator control

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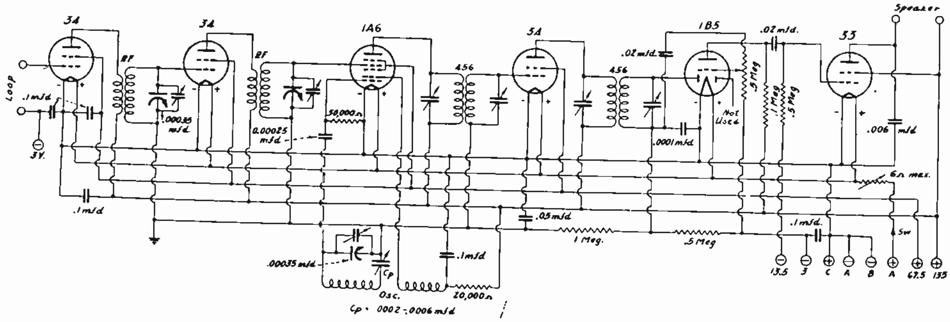


The circuit of the portable superheterodyne.

LIST OF PARTS

Coils

Two shielded rf. tuning coils for .00035 mfd. condenser.

One shielded oscillator coil for .00035 mfd. condenser and 456 kc i. f.

Two doubly tuned, 456 kc, i. f. transformers.

Condensers

One three gang .00035 mfd.
One .0002-.0006 mfd. adjustable padder.

Five 0.1 mfd.	One 0.006 mfd.
One 0.05 mfd.	One 0.0001 mfd.
Two 0.02 mfd.	One 0.00025 mfd.

Resistors

One 0.5 meg. potentiometer, with switch.

One six ohm rheostat.	
One 50,000 ohm.	Two 0.5 meg.
One 100,000 ohm.	One 1 meg.
One 20,000 ohm.	

Other Requirements

Six wafer sockets.	Four grid clips.
Four tube shields.	One small chassis.

One magnetic speaker for 33 tube.
Four binding posts (for loop and speaker).
One three volt filament battery.
One 135 volt B battery.
One 13.5 volt C battery.
One dial for tuning condenser.
Twenty to fifty feet of loop wire.
Tubes: Three 34's, one 1A6, one 1B5 and one 33.

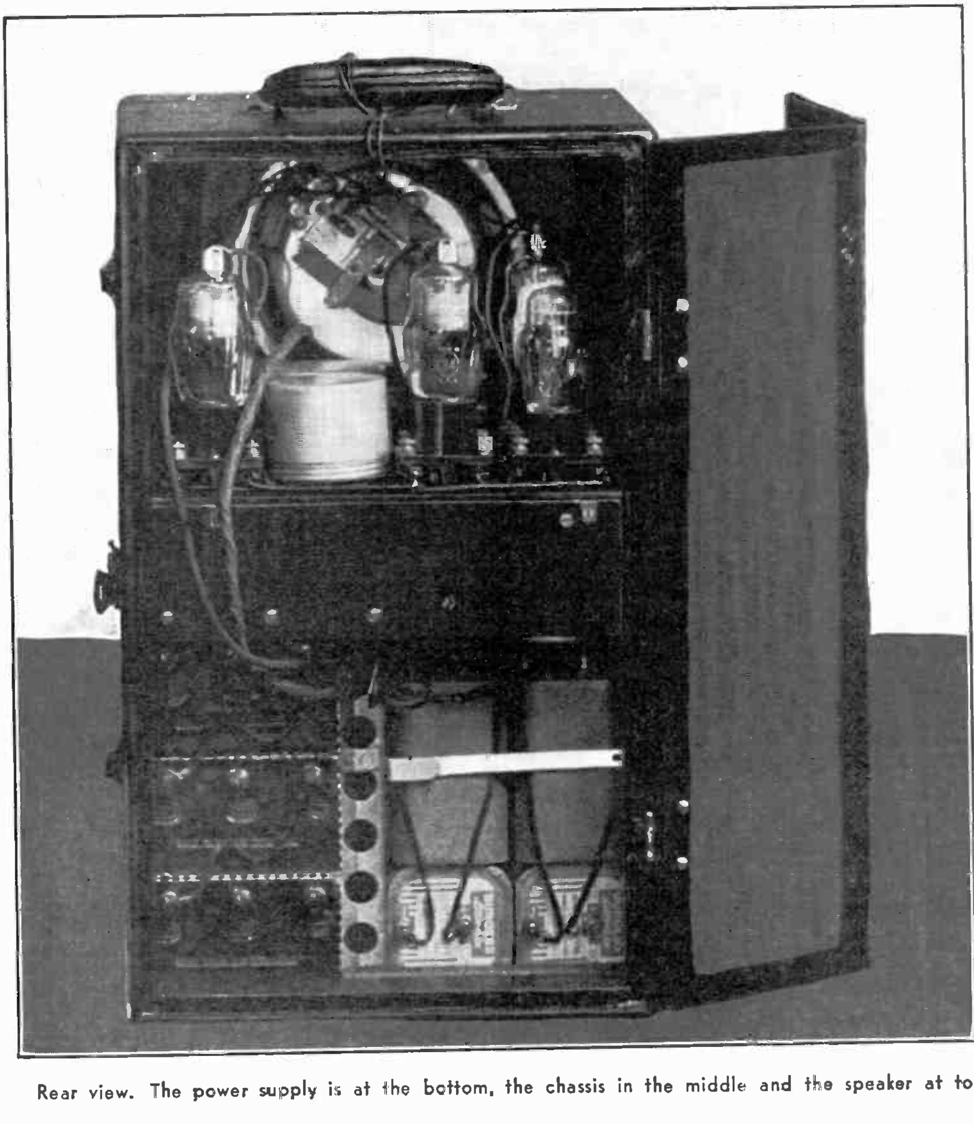
(*Continued from preceding page*)
grid is isolated from the a. v. c. voltage by the usual stopping condenser and the usual grid leak is connected directly to the negative leg of the filament.

Filament Current Considered

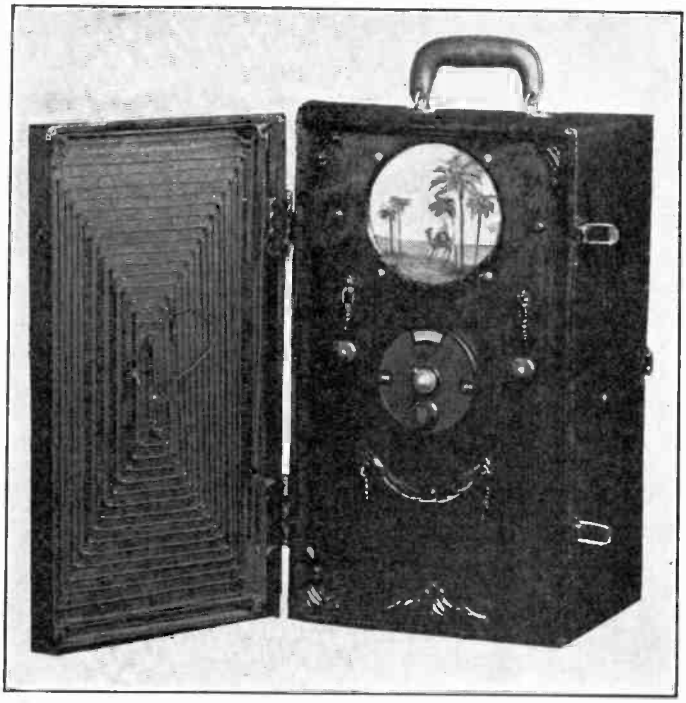
When the array of tubes shown in the circuit is used the total filament current required by this receiver is 0.56 ampere. There is no need to use the 1C6 tube for better results, in place of the 1A6, as the 1C6 requires twice as much filament current and shows to advantage principally on short waves, whereas the broadcast band alone is covered by the present receiver. The total then would be 0.62 ampere. When the receiver is to be conveniently portable it is important that the filament current be cut down as much as possible so that not too many 1.5 cells need be used. The least number that can be used is two in series, giving a voltage of 3 volts. To reduce the drain per cell, the number should be doubled.

A six ohm rheostat is put in the positive leg of the filament circuit for taking up the excess voltage of one volt. The maximum resistance that should be used when the cells are fresh is about 2 ohms. More resistance may be used when no great sensitivity is required and when the output required is small.

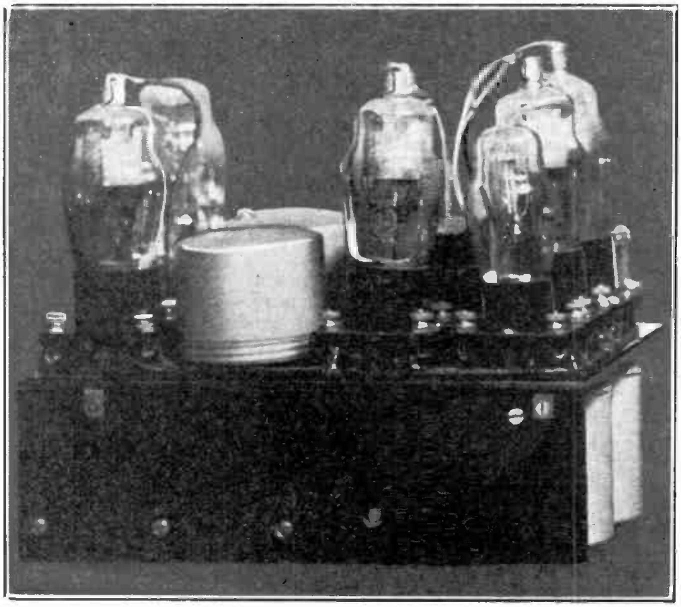
For the grid voltage supply the smallest battery that can be obtained is large enough, provided that the maximum voltage is not less than 13.5 volts, the bias required by the 33 pentode. For the plate voltage supply a medium sized battery may be used. The maximum voltage



Rear view. The power supply is at the bottom, the chassis in the middle and the speaker at top.



A desert scene painted on grille cloth was used for decorating the speaker opening. At left is shown the wire wound on pegs attached to the inside cover. This looks very much like a loop, but in fact the wire is used as an open end antenna and not as a loop, and constitutes an untuned input.



The i.f. transformers shown are of an old style and were replaced with new style transformers, whereupon results were strikingly better. Rear view of the chassis is shown. A glimpse of two r.f. coil shields is visible at lower right.

should not be less than 135 volts if good sensitivity and output are desired.

Newer Transformers Improved Results

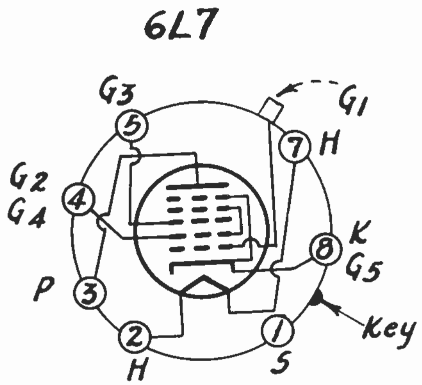
The manual volume control is put in the grid circuit of the 1B5 triode and is a 0.5-megohm potentiometer. The filament switch, Sw, may be attached either to this potentiometer or to the 6-ohm rheostat.

How one wandering radio enthusiast assembled this receiver into a portable cabinet is shown in the three photographs. One shows the bottom of the chassis and discloses the loca-

(*Continued on next page*)

RADIO CONSTRUCTION UNIVERSITY

Answers to Questions by Readers on the Building of Radio and Allied Devices. Readers Should Address Questions to Radio Construction University, Radio World, 145 West 45th Street, New York, N. Y.



The internal arrangement of the elements of the 6L7 and the connections to the pins on the base.

The 6L7 as an Oscillator

CAN not the 6L7 itself be used as an oscillator, and instead of Grid 3 being used as the injector grid (to receiver external oscillation) it may be used as the projector grid (to supply oscillation to another tube?—K. S. M.

It works, but the 6C5 is a better oscillator tube, using mutual conductance as the figure of merit, particularly as this means in practice that, other factors equal, the tube has a higher frequency limit of oscillation. The Gm (mutual conductance) comparison is 2,000 to 1,100. The 6L7 connection to independent oscillator through Grid 3 was intentionally introduced to provide the benefits of suppressor grid modulation, as found in remote cutoff tubes, without suffering sharp reduction of plate impedance, so the G3 circuit is high mu. By using the 6L7 as oscillator another 6L7 probably would have to be used as mixer, and the only object would be to provide in test oscillators some suitable means of introducing modulation, if of audio frequencies, but this can be done by conventional means in a completely satisfactory manner.

* * *

A.V.C. on T.R.F. Sets

PLEASE give diagram for inclusion of automatic volume control in the tuned radio freuency receiver described in August RADIO WORLD (page 14).—E. K.

We suggest that a. v. c. be not used in tuned radio frequency receivers, as it has some small effect in reducing selectivity, and of course operates solely on the principle of decreasing sensitivity. In a t. r. f. set you need all the selectivity you can get, as a rule, and while there may be some sensitivity to spare, this is unusual. We recommend the circuit be built as shown.

* * *

6K7 Operation Explained

PLEASE explain the action of the 6K7 as a radio frequency amplifier in connection with volume control and the maintenance of desired remote cutoff.—P. L. R.

The preferred method is to maintain the

(Continued on next page)

Disposition of Batteries in Anderson's Portable

(Continued from preceding page)

tions of the three radio frequency coils, the three-gang condensers, and various resistors. A second photograph shows the chassis from the side and it discloses clearly the locations of the tubes and of the intermediate frequency transformers. Incidentally, the intermediate transformers shown are of an old type. Better results were obtained when later models 456 kc were substituted, requiring also less mounting space, though somewhat taller.

The third photograph shows the rear of the completely assembled receiver. At the left in the bottom tier are the three 45 volt B batteries that supply the 135 volts. At the right of these are the filament batteries. It will be noticed that the latest type of A batteries is used. The chassis may be seen in the middle of this photograph. A bakelite panel hides the parts under the panel, but those above it are clearly visible. The magnetic speaker can be seen over the chassis and back of the tubes.

The pickup coil, which consists of 10 turns of loop wire, is attached to the doubly hinged back cover. The only part of the loop that is visible, however, are two binding posts. The loop extends over both halves of the cover and, as slated, is really used as an open antenna.

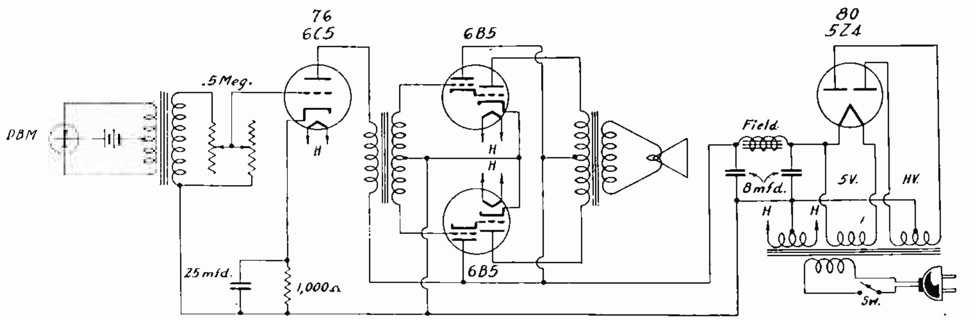
screen at a constant potential and vary the grid bias. Since the bias is the d. c. voltage that appears between cathode and grid, this is the factor to be varied. The screen voltage is maintained constant by using two resistors in series across a high B supply, say, 15,000 ohms each, across 250 volts or so, tying screen to the junction, and bypassing from screen to B minus with a capacity of 0.05 mfd. or more. The bias if from the B supply is steadiest when a resistor is between B minus of transformer and the return circuits of the receiver, usually around 1,000 ohms or so, or enough to make possible 50 volts negative bias, at least. If this resistor is in the form of a potentiometer, with a small limiting resistor built in or external to prevent going below recommended minimum bias, the arm if picking up the 6L7 Grid No. 1 return (usual bypassing with 8 mfd. or more from arm to ground) will supply the necessary bias voltage. A satisfactory substitute method, though not as good as the fundamental one previously set forth, is to use a rheostat in the cathode to B minus leg of the tube, limiting resistor of 300 or 400 ohms included to prevent bias becoming less than minimum prescribed, and varying the bias by moving the rheostat slider. Of course the screen voltage would not then be held constant, because as the bias is increased, the screen voltage is reduced as much, a circumstance that can be satisfactorily compromised by using a series resistor in the screen leg, to maximum B plus. For 250 volts this resistor may be 30,000 ohms, to maintain the screen at about 100 volts. As the screen current is reduced on account of increased negative bias the voltage drop in the series screen resistor becomes less, and the screen is therefore maintained as a sufficiently constant voltage value to make the method attractive.

* * *

When Is Shielding Necessary?

IN building a receiver is it strictly necessary to shield the coils? I notice there is a reduction of sensitivity and selectivity when shielding is used and therefore I raise the question.—W. D. S.

It is a perfectly natural question, but its answer depends on facts other than those stated. If you are to build a tuned radio frequency set, using a three gang condenser, you would get better results if you avoided shielding. Should there be oscillation at the higher frequencies this may be corrected by placing coils at right angles to each other, using 2 mfd. to bypass cathode biasing resistors, and using shielded wire on leads to overhead grids, grounding the sheath, although remember this shielded lead method increases the circuit capacity and trimmers may have to be readjusted. When a four gang condenser is used shielding becomes imperative, for the unintentional coupling among coils would be severe. With superheterodynes of the better type (that is, using more than two gang condenser for selection, as the two gang circuits are of small consequence), shielding always is imperative, not only on account of stray coupling among coils, but also because the system is very sensitive as a unit, and the antenna effect of the unshielded coils is large enough to permit stray frequencies to be picked up and amplified independent of tuning. For instance, the modulator coil may pick up enough voltage from a strong local to cause crosstalk, when the set is tuned to some other intentional frequency, the reason being that at the interfering frequency there is no benefit of selectivity in the selector. And of course the intermediate channel does not reject interference already introduced into its own carrier.



A small amplifier, using a 76 or 6C6 driver ahead of a push-pull 6B5 output, for double button microphone input.

* * *

6B5 Push Pull Amplifier

WILL you please show circuit diagram for using a double botton microphone to work into a driver tube, which in turn is to be transformer coupled to a push pull 6B5 output? Please include rectifier and filter.—I. E.

The diagram you request is printed on this page. The 76 or 6C5 driver is included, as per your suggestion, since the driving would be advisable due to the small excitation from the microphone, even though it is a carbon type and therefore comparatively sensitive. Of course there is another driver present, the input section of the 6B5.

(Continued on next page)

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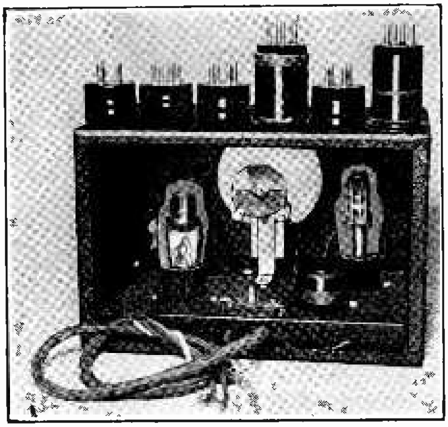
Variable I.F. Selectivity

WILL you please tell me the systems used for introducing variable selectivity at the intermediate level?—E. F.

The two methods used consist of varying the coupling between primary and secondary coils, both of which are tuned, requiring a cam system; and using three tuned windings, across each of which there is a rheostat which, when at full resistance, permits the circuits it controls to act as a load on the i. f. amplifier and thus broaden tuning, and when resistance is shorted the coil is practically out of circuit and selectivity is at its fullest. In between, various values of selectivity are obtainable. For a three coils system (two intermediate amplifier tubes) there would be a three gang rheostat, value around a few hundred thousand ohms or so. The value should not be much lower, otherwise the control is made weak and the circuit is otherwise adversely affected.



With seven plugin coils the range, 15 to 2,000 meters, can be covered with the usual short wave condenser, although the spreadout on high waves is very large, indeed—that is, bandspread with a vengeance.

* * *

Surge Impedance

IS there any difference between the surge impedance and the characteristic impedance of a line? At radio frequencies how is the impedance measured?—D. V. M.

Surge impedance and characteristic impedance are the same thing, and in ohms equal the value of terminating resistance required to prevent standing waves from appearing on the line. A standing wave is one that is not radiated, but that moves back and forth along the line, therefore represents a reflection. The surge impedance is the square root of the term, capacity divided inductance. For radio frequencies the value is computed, rather than measured, particularly at high radio frequencies, when measurements become almost impossible, in the present state of the science. One system of indirect measurement that may be tried is to use a Lecher wire rig to detect the presence of standing waves, then introduce various values of terminating resistors (must be noninductive) until the value is obtained that removes practically all trace of standing waves. The value of the terminating resistance in ohms may then be ascribed to the line as its surge impedance.

* * *

Usefulness of Micro Waves

CAN the ultra frequency oscillators, like the Barkhausen-Kurz, be put to any practical use, and if so, is much being done along these lines? What is the difference between B.-K. and G.-M., and what does G.-M. stand for? Can conventional tubes be made to oscillate at centimeter waves in conventional circuits?—J. E. J. G.

The Barkhausen-Kurz oscillator, using a conventional tube, preferably with cylindrical electrodes, puts a high positive bias on the grid, a zero or slightly negative bias on the plate, operating the tube as a triode, and establishing the frequency by the grid voltage, since the frequency depends on the velocity of acceleration of electrons. Tube life is made very short, a few hours. There is no tuning system in the sense that we commonly use that phrase. G.-M. stands for Gill-Morrell, two Englishmen who introduced a tank circuit into the Germans' device, and generated micro waves the frequency of which they could control externally. Conventional tubes have been made to oscillate in familiar circuits at centimeter waves, but with very feeble intensity. No matter how any of the circuits for ultra waves look on paper, they turn out to be Colpitts oscillators, all feeble, however. In fact, the same feebleness attends the B.-K. and G.-M. oscillations, the devices by the way being termed electron oscillators. Radiation for a few wavelengths has been demonstrated. Thus the commercial use is very limited and there is practically none now. Using special tubes, with much greater power, some commercial experiments on centimeter waves have been very successful, especially where beaming is introduced. By this method the wave is directed in a certain path, and thus the concentration of power, instead of diffuse radiation, results in laying down a stronger signal. When the wave is short enough a parabolic reflector becomes practical. Thus for 20 centimeters or so the entire reflector and stand need not be more than six or seven feet high. The parabolic reflector behaves almost optically, and, as is well known, these very short waves have characteristics that are akin to those found in optical practice, so the waves are called quasi-optical sometimes, although far removed from visible frequencies.

* * *

Wide Range Battery Set

VIEW of a layout for a battery receiver, plug-in coils used for 15 to 2,000 meters, would be appreciated. Regenerative detector and audio amplifier would be used.—L. O. C.

Rear view of such a layout is shown in opposite column.

Why I.F. Is Not Low Any More

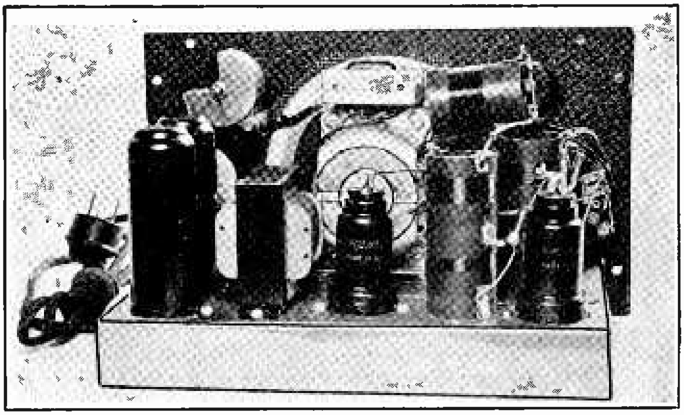
WILL you kindly inform me why a very low intermediate frequency can not be used in a superheterodyne? I have noticed the gradual increase of intermediate frequency from 30 kc to 90 kc to 125 kc to 250 kc to 350 kc to 400 kc to 450 kc to 465 kc to 480 kc, and while for short waves the image trouble may be a factor, yet for broadcast frequencies the lower intermediate frequencies are more selective and more gainful.—L. K.

Yes, both selectivity and gain are better, but the reason for using high intermediate frequencies is that the receiver has to tune to such high signal frequencies that soon the difference between the station carrier and the local oscillator frequencies becomes very small. When this is true oscillation frequency may build up on a signal grid, causing poor reception, and besides it is hard to keep the circuits independent in other directions, and the degree of independence is a measure of the success of the set. Also the image trouble you mention becomes serious, still does even for 480 kc. i. f., supposing a station carrier frequency of 20 mgc or higher. Then the difference between the oscillator and the station carrier frequencies is 2.5 per cent. or less, and since the tuner selectivity declines due to increasing circuit losses in this region the percentage is not great enough for a high degree of image suppression. The image is the other frequency signal that can be received due to it differing from the i. f. by the oscillator frequency, only in the opposite direction. The unwanted station is higher in frequency than the oscillator, whereas customarily the oscillator is intended to be the higher frequency. Hence the image frequency differs from the objective frequency by twice the intermediate frequency. Images are nuisances indeed. It is the sole object of preselection to get rid of them and crosstalk generally. Let us assume an i. f. extraordinarily low, say, 10 kc. Suppose a station of 1,000 kc is desired to be received. Then the oscillator would be at 1,010 kc. Besides the 1,000 kc station, however, one would be receivable at 10 kc higher than the oscillator frequency, or 1,020 kc. Hence the set would be limited to 20 kc selectivity, so to speak, although this phrase, apart from quantitative voltage values, has little significance. It would be impossible with the system as described to discriminate between stations 10 kc apart, and the higher the i. f. gain the greater would be the interference from an adjacent channel. The tuner might be made elaborate enough to reject a voltage 10 kc off resonance and then the system might work all right, but all-wave coverage would be out of the question. It would be hard enough to get satisfactory results in the broadcast band. Single sideband operation of the i. f. would not help, either, since the interference is present on both sidebands, and eliminating it from one does not diminish it at all in the other.

* * *

Placement of Coils

IS it practical to have a universal receiver, covering broadcast and short waves, using a single tuned circuit for regenerative selection, and yet the coils to work well, despite close quarters?—K. C. B.



Switch type coils may be used in a small tuned radio frequency receiver of the regenerative type. The trick is so to place the coils that there will be no resultant dead spots. The trick was accomplished by one constructor in this manner.

Yes, it is possible. The main consideration is avoidance of dead spots. The solution was found in a particular instance by the placement of coils in such a receiver as you discuss, as the illustration herewith shows. Each particular layout has its own special problems in this direction, and we suggest that if dead spots appear that the coils be redisposed, in an effort to get rid of this trouble. If two bands are on one form it is usually better practice to have them nonadjacent bands, in a frequency sense.

* * *

Use of Tapped Coil

AS I have coils with tap (no primary) that I desire to use in a test oscillator, would it be all right to connect the cathode to the tap for return of the circuit through part of the

(*Continued on page* 59)

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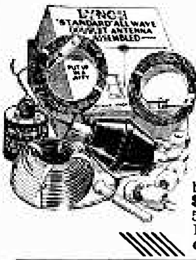

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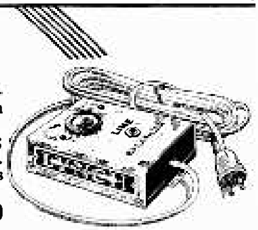

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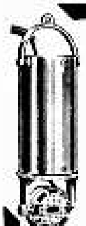

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(*Continued from preceding page*)
heater type tubes. The circuit then becomes a Hartley. Bias may be obtained through a grid leak of .05 meg. up, from grid to cathode or grid to ground, a stopping condenser of 30 mmfd. to 500 mmfd. being placed between grid and the stator of the condenser, to which one side of the coil is connected. Another way is to use semifixed bias and put the biasing resistor, say, 1,500 ohms, between cathode and tap, bypassing the resistor with .006 mfd. or greater capacity, depending on how high are the radio frequencies to be generated. Select the highest r. f. and make the bypass condenser as large as practical.

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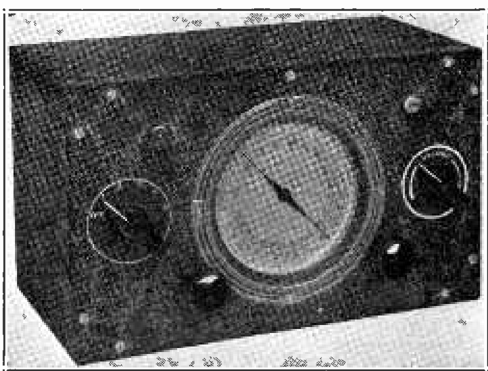

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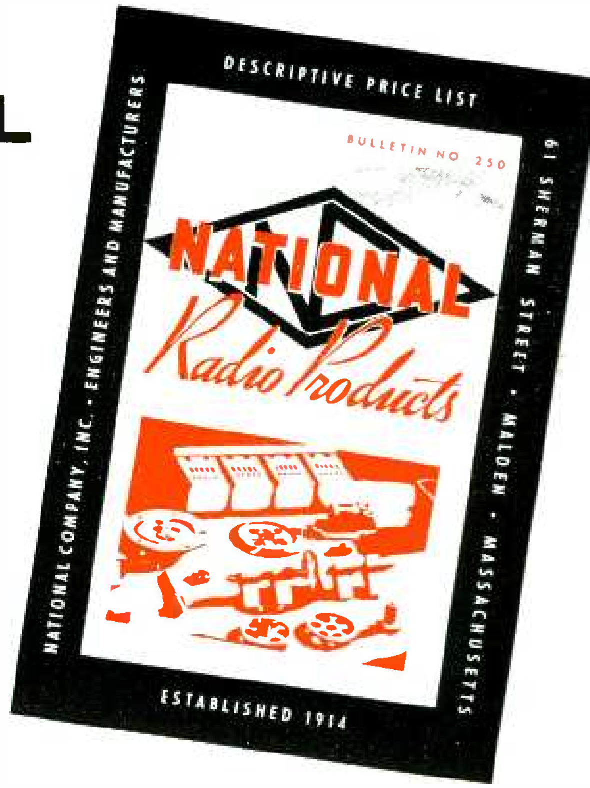

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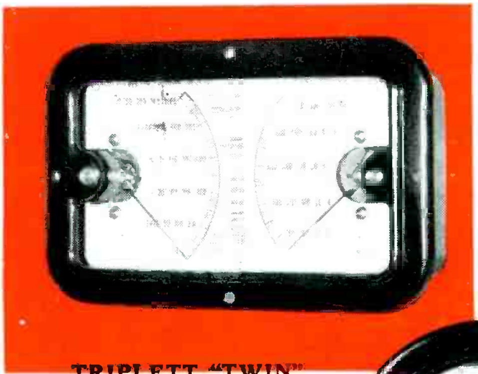

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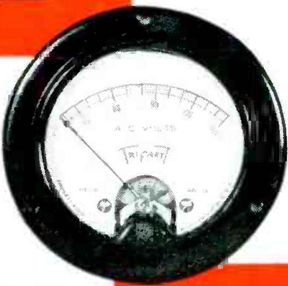

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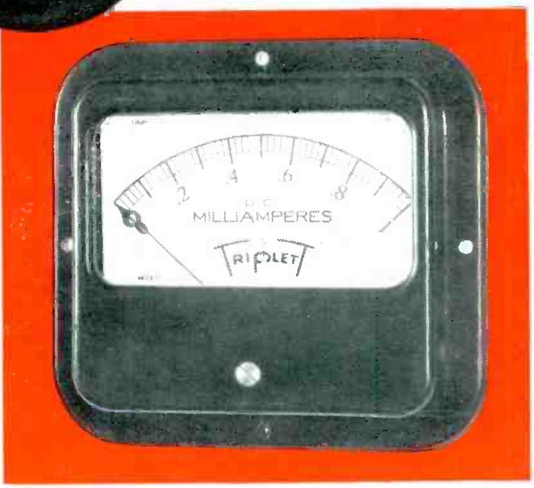

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