BEGINNING

"THE SHORT-WAVE AUTHORITY"

By ANDERSON and BERNARD

Coil Winding Data For High Frequencies

A swell performer is this d-c superheterodyne, designed by Robert E. Herzog (above). See article, pages 10 and 11

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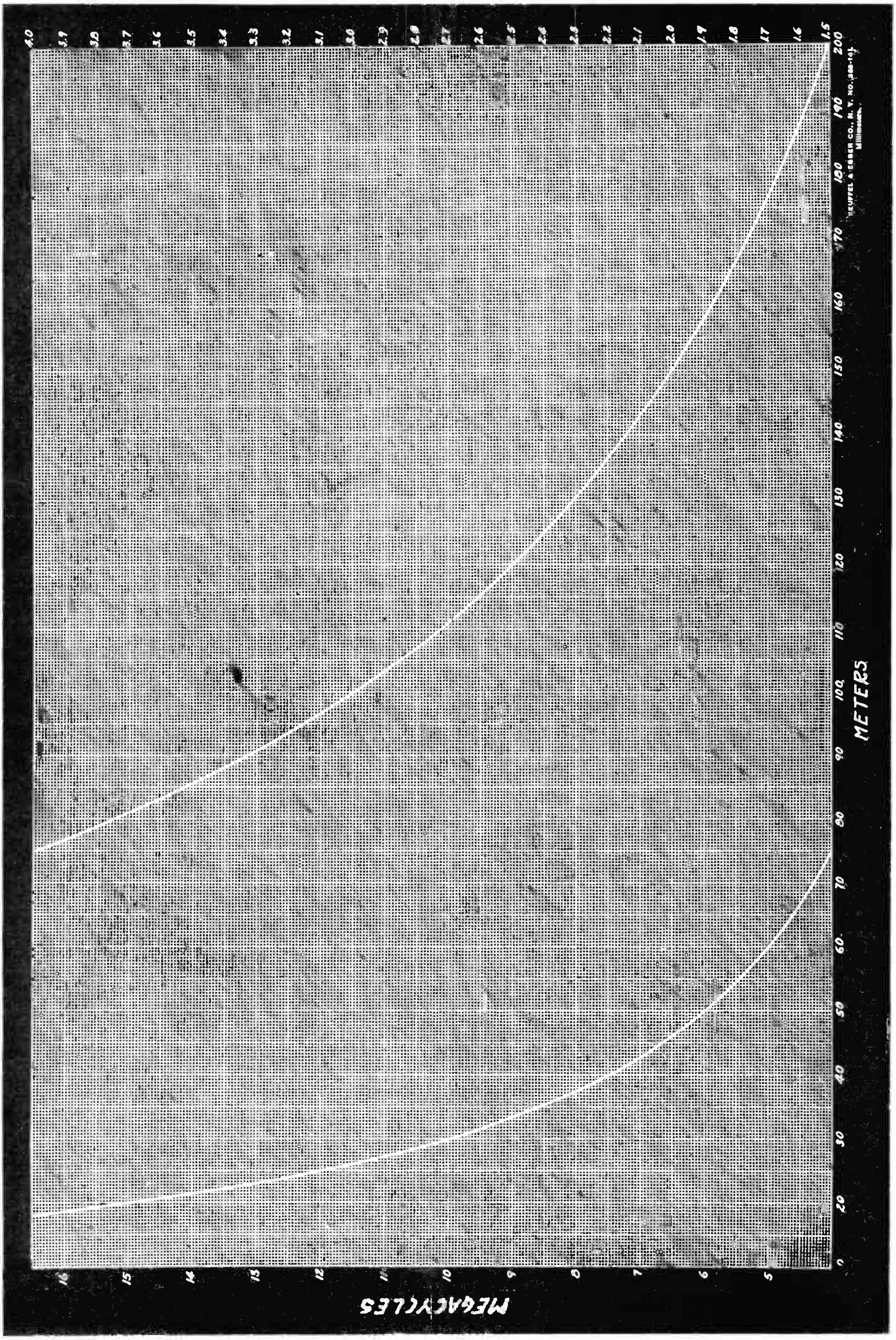

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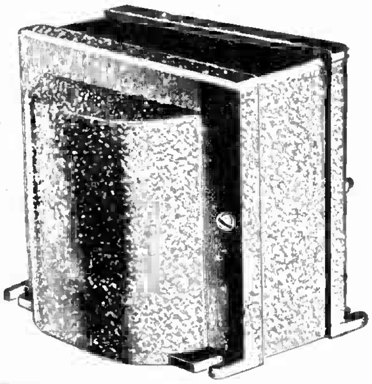

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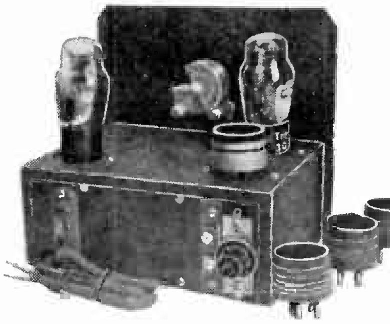

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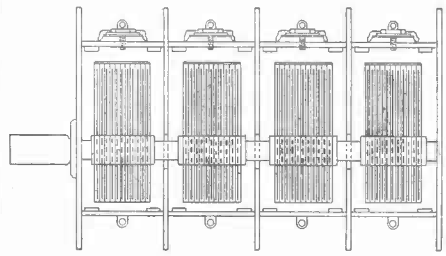

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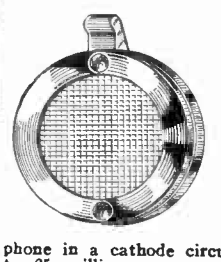

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THE SHORT-WAVE AUTHORITY

SERIAL PUBLICATION BEGUN OF A BOOK TO FAMILIARIZE USERS OF MULTI-RANGE RECEIVERS WITH THE INSTRUMENTS AND FREQUENCIES THEY USE

By J. E. Anderson and Herman Bernard

THE general public now takes a great deal of interest in the short-wave field that was once regarded as practically worthless even by the amateurs who communicate with one another by radio telegraphy and telephony, and once even so regarded by the Federal Government.

When broadcasting suddenly began to assume importance, following the successful transmission of returns of the Harding election in 1920, and more and more stations sprang up, the amateurs were assigned to higher frequencies (lower wavelengths), and assumed that they were being ditched. However, actual experiments by them proved that the lower waves had possibilities, indeed, in some respects were much more favorable than the bands from which the amateurs had been evicted. During the succeeding years assignments to include lower and lower waves followed, and instead of being regarded as their disconsolate lot, were gleefully accepted as presenting new possibilities.

Meanwhile a great deal of technical information was being amassed not only by amateurs but also by commercial radio companies that had started operations on low wavelengths. All over the world the news of such developments and their fascinating application spread with a rapidity that can be imagined and within a few years the activities on short waves became very pronounced.

In 1930 the general public got its first taste of short waves when the short-wave converter was introduced. This device was tuned to the desired short waves, and would change the frequency of each or any of them to one to which a regular broadcast receiver would respond. The results then obtained from short-wave converters were not exceptional, but the public already had its taste, and meanwhile radio technicians, including service men, students, home experimenters and the like, were busy building and rebuilding short-wave receivers.

At this time a set built for short waves did not include reception of the broadcast band, and there are certain types of exclusively short-wave receivers manufactured to-day that do not touch the broadcast band, being intended mainly for communication work; that is, reception on short waves of messages principally, and programs incidentally.

However, in 1932 receiver manufacturers catering to the general public tried the experiment of including a switching arrangement so that, besides the usual broadcast band, then established at 540 to 1,500 kilocycles (kc), the next higher span of frequencies, from about 1,500 to around 4,000 kc, could be tuned in. Thus possessors of such a dual-range receiver could bring in police calls from all over the country, airplane conversations, some ship telephony, a few

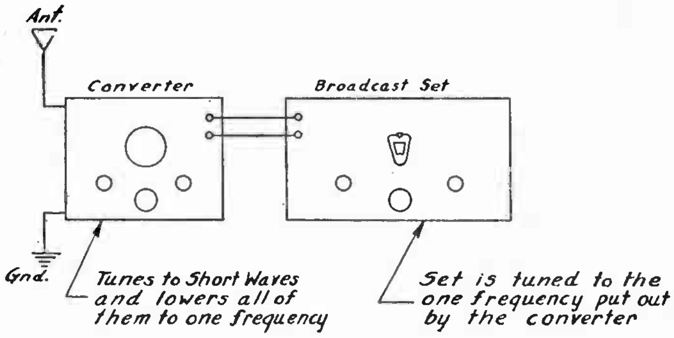


FIG. I-1

short-wave rebroadcasts of domestic chain programs, and the like, and also a few foreign stations.

This added attraction increased the sale of receivers, and it was next deemed expedient to include more short-wave bands, so that in the following year or so sets began to appear that were of the "all-wave" type. They tuned in the broadcast band and went as high as 20,000 kc, or, in wavelength, as low as 15 meters.

Just as the amateurs had experienced a new thrill because of the extremely long distances possible on short waves, particularly waves around 50 meters (m) or less, so the general public found that a new sport existed for them, that of tuning in foreign stations directly. They had had a taste of reception of foreign stations indirectly, through rebroadcasts by domestic chains, or local stations, that had tuned in the foreign program on a high-powered short-wave set, but now they were finding high pleasure in making direct connection, as it were, with the studios of stations in Rome, Madrid, Daventry, Australia, Berlin and the like.

Everybody probably has had, and still has, a desire to make a trip around the world. The multi-band radio receiver in a way helps to satisfy the longing for world travel, not by instituting travel, but by enabling one to feel that he is really in a foreign country, since by his own tuning he establishes connection with a station in that foreign country, and hears the programs that are offered. Like as not, the talk, if it be such, is in the native language, and it is surprising that so many persons listen for a long time to some one speaking in

(Continued on next page)

(*Continued from preceding page*)
a tongue not understood. There is an indescribable lure in short-wave reception, and it is exceedingly hard to define exactly the psychological reason for such anomolous behavior.

Therefore, instead of amateurs, some commercial interests, and experimenters with a desire to improve their knowledge of radio technique, a great body of short-wave listeners sprang up, until now, each day in the United States, millions of persons listen to short-wave programs, and many of them are improving their knowledge of geography, chronology and radio, so that they may obtain still better results.

The simplicity of tuning in regular broadcasting stations in the band that now is encompassed by 540 to 1,600 kc does not apply to short waves. Some skill is required for excellent results, although this skill is not difficult for anybody to attain. Besides, instead of a random tuning, or "fishing" for stations, it is practically mandatory that one seek stations of known frequency assignment, preferably particular stations on known frequencies, so that one tunes with a definite objective.

Keeping Up With Changes

This part is not so easy because, save for the exceptions in the instances of larger stations abroad, the hours on the air, or the frequency of transmission, may be changed, practically without notice. Or, if notice is given, it may be sudden, and the only medium of transmitting it may be the broadcasting thereof on the old frequency, preparatory to operation on the new frequency.

Efforts to keep up with these changes are constantly made by the technical radio press, by radio set manufacturers and others who prepare lists of foreign short-wave stations with the hours during which these stations at least transmitted when the latest word was received. Besides, listeners scattered throughout the country report to periodicals, which now include newspapers, changes that have come to their notice. The changes may even include new call letters. So it can be seen that at the present stage, and probably for a few years to come, the short-wave transmitters that send forth the programs that are so eagerly sought, are subject to a group of changes, without notice. This introduces a vestige of uncertainty, but at least it also creates an inducement to become an attentive and even an alert tuner-in of short waves, so that one may spot some of these changes for himself.

Another ameliorating circumstance is that numerous short-wave stations have several frequencies assigned to them, and may use any one of them at any time, but what these frequencies are can be ascertained from one of the lists just mentioned, or from other sources, including the technical radio press, so if a station of particular call letters is not found on one frequency of its assigned group it may be sought on another frequency in that group.

This is particularly true as some stations change their frequency of transmission each day they are on the air, that is, during certain hours of the day they send on one frequency, and during other hours at night of the same day on some other frequency. The reason is that the frequency is selected on the basis of the best transmission for that particular time.

From the foregoing one may adduce that radio waves are not uniform in their penetration, in respect to frequency, but that some travel farther by day than by night. Hence stations may have night frequencies and day frequencies. Thus, British transmission during daylight at around 20 meters, or 15,000 kilocycles, will be shifted to around 50 meters (6,000 kc), at night. As evening approaches, and night falls, the penetration of the lower waves, or higher frequencies, becomes poorer and poorer.

Behavior Analyzed

Scientific studies have been made by Government agencies and others of the behavior of waves in the short-wave category, and definite average values of penetration have been established. They depend, of course, on the frequency used by the station in transmitting its waves, on the power, on the time of the day or night, and also on the season. However, whether "night" or "day" conditions obtain is not to be judged strictly on the basis of the point of reception. For instance, suppose one desires to ascertain what the likelihood is of good reception from Australia at 5 p. m. It is not sufficient to look out the window, or at the clock, and decide on that basis, for due to the great distance, practically half the circumference of the globe, though it is evening at the point of reception, most of the route travelled by the wave in its southeast course would be in a daylight area, but the listener does not have so much choice, for he must tune for the station when it is on the air and that would be in this instance a few hours before breakfast time in New York.

Short waves are subject to special forms of interference.

For instance, the mysterious sun spots, the exact cause for which is unknown, produce effects detrimental to radio reception, and coincide with periods of magnetic storms. Naturally, any form of storm, with its possibilities of electrical aspects, since even windstorms may produce electric currents, is a possible source of radio interference.

While interference in the broadcast band is largely associated with local disturbances, such as caused by electric motors, commutators, vibrators, elevators, sign-flashers, generators, trolley cars and electric trains, and some natural static, the situation in respect to short waves is quite different. The various bands have, in general, a property of selection of interference, depending on the frequency to which the receiver is tuned. For instance, there may be a very keen sensitivity to the type of commercial electrical disturbances just numerated, when one tunes in the 50-meter band, particularly from passing automobiles, trolleys and electric trains, but in some higher band of radio frequencies these noises become less pronounced, until, when the frequencies of operation are very high indeed, there is practically no static of any kind. Both man and nature seem to be defeated in an effort to introduce interference of this type at these very high frequencies, which are higher than any that so-called all-wave sets will tune to, lying above 30,000 kc, that is, below 10 meters.

These are entirely experimental frequencies, yet enough is known about them to enable the assurance of freedom from natural or unnatural static, and also acknowledgment of the condition of limitation to moderate distances. Unless special precautions are taken, the transmissions on these ultra frequencies do not penetrate farther than the horizon. Because of this behavior on a basis equivalent to that of light, the ultra frequencies also are called quasi-optical. Of course, the frequencies themselves are nowhere nearly so high as those of the lowest light frequency (infra-red), but it is only the somewhat similar behavior, including obstruction by opaque objects, and possibilities of reflection from bright surfaces, that gains them the appellation "quasi-optical."

There is no scientific grouping of the various bands, so that everyone would know exactly what was meant when some word or phrase was used. The broadcast band is well understood to mean the frequencies used by the regular domestic broadcasting stations, 540 to 1,600 kc. As soon as higher frequencies are concerned, the general public dismisses the problem by referring to them as "short waves." This is appropriate enough for the layman at present, although the first band of short waves thus encountered, in going from the broadcast band to higher frequencies, is not technically called "short waves," but "intermediate short waves."

Frequencies and Wavelengths

It is technically accepted that short waves are from 6,000 kc (50 m) up to 30,000 kc (10 m), and above the 30,000 kc lie the quasi-optical or ultra frequencies, where further subdivision is advisable, if a suitable and clear nomenclature is to exist. At present technical committees are attempting to codify expressions so that for each band where the behavior is strikingly different than on some other band that there will be words and phrases to identify the frequency groups succinctly.

Even the use of frequencies and wavelengths is not consistent. On very low frequencies, the quantities are expressed as wavelengths usually; for instance, 10,000 m, instead of 30 kc. At somewhat higher frequencies the preferred designation is in terms of frequencies, and this now applies also to the broadcast band. For short waves there is a division of selection, with a growing preponderance of the designation in frequencies, rather than in wavelengths, but in the ultra frequency region, or for quasi-optical wave considerations, the designations almost invariably are in wavelengths! Since the wavelengths are so short in every instance that they are measurable with an ordinary stiff ruler, or for a somewhat longer wave, by a flexible ruler, e. g. a steel tape, it is natural that the wavelength grouping be used, rather than frequencies, for ultra waves.

The wave sent out by any transmitter advances much as does any other wave, and for practically all radio frequencies passes right through buildings of all sorts, being seriously obstructed only by metals. The metal acts as a part-shield, or absorbing agency, but the other parts of the wave continue on, closing the gap, if any was made, just as a water wave closes the gap made by a giant ocean liner.

Electrical Motion

The movement of the wave is in no sense mechanical. Those who are not technically versed in electricity have difficulty in comprehending the action, but it involves alternating current, although it is much the same as that concerning a water wave. It is like a sound wave, too, for there is practically a unified condition applying to all wave motion. If a sound is struck at one corner of the room and is heard in the opposite corner, the sound has travelled across the room, though the air has not moved from one corner to the other. But the vibration has moved. As the air is made to vibrate by the sound struck, so is the conducting medium made to vibrate when a radio wave is sent out, for that wave is an electrical vibration produced by vacuum tubes, at frequencies much higher than those of sound.

The velocity of the radio wave is the same as that of light, 300,000,000 meters per second, or about 186,000 miles, the greatest velocity achieved in nature. The velocity of sound in air is only about 1,100 feet per second. Moreover, sound is rapidly dissipated, whereas radio waves have a much greater effective radius.

Sound waves, in general, especially as used in radio, range from about 25 cycles per second to about 10,000 cycles per second. This is known as the audio-frequency range. Few adults can hear well at 10,000 cycles, but sometimes children can hear well up to 20,000 cycles, and other forms of life, particularly birds and insects, may hear frequencies even higher than 20,000 cycles.

A cycle is the number of times per second that a uniformly-periodic variation takes place.

Frequencies of 10,000 cycles and higher are classed as radio frequencies, hence super-audible or supersonic. That is one reason why, if you stand beneath the antenna even of the most powerful transmitting station, you do not hear the program—all that is sent out is a radio frequency, meaning a frequency higher than one that the human ear can hear or detect.

When the frequencies are low they are identified as cycles— so, 25 cycles, 100 cycles, 9,000 cycles. When they are multiples of 1,000 cycles they are usually referred to, for convenience, as kilocycles,

An Analysis of Wavelength, Frequency and Velocity

since one kilocycle is 1,000 cycles. When the frequencies are multiples of kilocycles they are referred to as megacycles (mgc). In the calibration on dial scales of multi-wave receivers, the broadcast band is commonly designated in kilocycles, e.g., 540, 550, 560, 1,500, 1,600, etc., representing 540,000 cycles, 1,600,000 cycles, etc.; and all the higher frequencies in megacycles, e.g., 2, 3, 4, 19, 20, for 2,000,000 cycles, 20,000,000 cycles, etc. It is practical to give even the broadcast band in megacycles, as fewer numbers would have to be written, e.g., .54, .55, .56, 1.5, 1.6.

The frequency is always given in cycles, kilocycles or megacycles, and represents the number of times per second that the wave goes through a complete activity, or repetition. Starting at zero voltage, the wave, which is an alternating voltage or current, builds up to its maximum positive value, and declines to zero—this comprising half a cycle, or one alternation—and then builds up in the negative direction to maximum and returns to zero—this is the second half-cycle or alternation. Thus there are two alternations in each cycle.

The wavelength is always given in meters, and represents the distance between two equal points of the wave activity. Usually the crest, or topmost point of the wave form, is taken as the criterion, and compared to the displacement between this point and the next one of equal magnitude and direction.

The lay public finds it much easier to think in terms of wavelength, as then only a distance is stated, but technical practice favors in general the use of frequencies, and moreover frequencies lend themselves better to comparisons and interpolations.

A treadmill in a squirrel's cage may be taken as a rough example for comparison. Suppose that the squirrel always causes the mill to revolve at the same speed. This represents the constant velocity of the radio waves. Suppose a certain point is selected for focused observation of the number of always evenly-spaced wires on the drum or mill that the squirrel is turning. Wavelength represents the distance between wires. Frequency represents the number of occasions for unit of time that the treadwires pass the point of observation.

Thus longer wavelengths would be represented by removing treadwires, though leaving remaining wires equally spaced apart. Shorter wavelengths would mean adding more evenly-spaced wires. Thus, the more wires, the more that pass the eye per unit of time, or, the higher the frequency. Hence, the shorter the wavelength, the greater the frequency. The common factor that unites the two is the constant speed of the revolving drum or mill. In radio, the velocity of the wave is the uniting factor, and the unit of time is the second. Thus, if we know the wavelength we may compute the frequency, or if we know the frequency we may compute the wavelength, as they are related by the constant velocity, 300,000,000 meters per second. Thus, if the wavelength is known in meters, divide it into 300,000,000 to ascertain the frequency in cycles. If the frequency is known in cycles, divide it into 300,000,000 to obtain the wavelength in meters. The answer in wavelengths always will be in meters. The answer in frequency may be desired in cycles, for which the formula holds, or in kilocycles, whereupon the dividend becomes 300,000, or in megacycles, whereupon the dividend becomes 300.

Even if one is not able to comprehend frequency, because it is removed from what can be seen or readily assumed or realized, it is preferable to follow the practice of denoting in terms of frequency those radio frequencies which are so denoted in practice—even from 10 kc to 30 mgc.

WHEN we are talking about radio we speak glibly about wavelength, frequency, and velocity, but we do not always stop to explain what we mean by these terms, or to ask ourselves whether or not we could explain what we mean. Familiarity with the terms by constant use is not equivalent to understanding the ideas for which they stand. We may know by rote, for example, that the velocity of any wave motion is always equal to the product of the frequency and the wavelength; but if we do not know it by analysis, it is not likely that we know it at all. Yet the concept back of this relationship is fundamental in all fields where wave motion is involved, and for that reason it should be mastered by orderly thinking.

Let us begin with frequency. We know in general that if anything happens frequently it happens often. Frequency, then, means "oftenness." In physics and engineering, however, the term has a more precise meaning, and it signifies the number of times a recurrent phenomenon happens per unit of time. Unless otherwise expressly stated, the unit of time is the second. It is assumed here that the recurrence is regular so that the same time elapses between any two consecutive events.

As an illustration of the meaning of frequency let us consider the pendulum. What is its frequency if it takes one-half second for it to move from one extreme to the other? If it takes half a second to move from one extreme to the other, it takes one second to complete a cycle, and the frequency is one per second. That is,

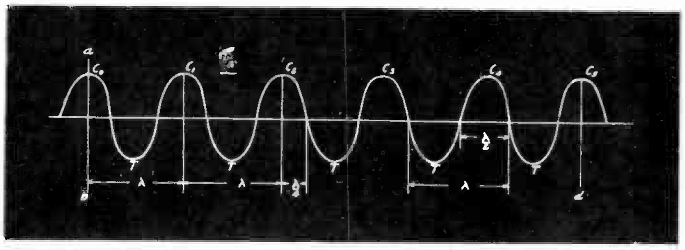


FIG. I-2
An undamped wave-train illustrating wavelength, frequency, and velocity.

it comes to any one extreme position once a second, or it passes any intermediate point in a given direction once a second. Incidentally, the seconds pendulum in a clock has a frequency of one-half cycle per second.

Wavelength introduces the idea of wave motion. Fortunately, we have a large variety of visual wave motion phenomena. The most familiar wave is that in water. We know by observation that a wave once started will travel along the surface of the water without changing its velocity or length. If we watch a fixed point and count the waves that pass that point in a given time and then divide the number counted by the number of seconds during which we counted, we get the frequency of the wave motion. If we concentrated our attention on the crests of the waves, the frequency will be the number of crests that passed per second. Since there is only one crest per wave, we also get the number of waves that passed per second. Each wave, from crest to crest, is one of the regularly recurrent events. It is also one cycle.

If the wave motion suddenly were to stop, it would be possible to measure the distance between two consecutive crests, and thus the wavelength would be obtained. Or, better still, a distance encompassing 100 wavelengths could be measured, and 1/100 of this distance would give the wavelength of each wave accurately. Of course, a wave that is radiated like a water wave will not stop accommodatingly while we measure it, but there is nothing to prevent us from imagining that it does. We can even stop the water wave by taking a snap-shop photo of the water surface and then measure the length of the wave on the photograph.

Velocity of Wave

A while ago we fixed our attention on a point and watched the waves go by. If they pass the point the wave motion must have some velocity. Let us imagine ourselves to be riding on the crest of some wave. At a certain time we pass the fixed point. After a certain time the next crest will have reached that point and we have moved away from it one wavelength. After another time we are two wavelengths away. After one second f crests have passed the fixed point and we have moved away f wavelengths, f being the number of waves that pass the fixed point per second. Now, if the length of each wave is λ units of length (λ being the Greek letter lambda) we have moved away from the fixed point a total distance of $f\lambda$. Since we moved this distance in one second, this is also the velocity of the wave motion. Hence, if v is the velocity we have the relation $v = f\lambda$, which is true for all forms of wave motion as long as the frequency and the wavelength remain constant. Stated in words the relation is, the velocity of the wave motion is equal to the product of the frequency and the wavelength. The velocity is measured in units of length (e.g., meters) per second, f is measured in cycles, or waves, per second, and λ is measured in units of length (e.g., meters).

While our decision to ride the crest of the wave was all right for the purpose of getting the velocity of the motion in terms of the wavelength and the frequency, we can ride the wave only in imagination. The particles of water constituting the wave motion do not move with the wave. Neither does a floating object, such as a cork, move along with the wave. It only moves in a small circle, coming back to its original position as soon as the wave is past. An observer attempting to ride the wave would go through the same circle, getting nowhere in the long run. For this reason we must distinguish between wave motion and the motion of the particles of the medium through which the wave progresses.

A Wave Motor

Energy is transmitted by the wave motion, although the energy carrier does not move along, the energy carrier in the case of a water wave being water particles or molecules. That energy is

(Continued on next page)

(*Continued from preceding page*)

transmitted by the wave motion is obvious, for if the wave is intercepted it performs work. For example, when the wave hits the shore it disturbs the sand and it also creates a sound. We could easily devise a wave motor by which the energy transmitted by the wave could be made to do useful work. That is essentially what a radio receiver is, a motor that is operated by the energy contained in the radiated wave. This is particularly true when the detector is a crystal, for when a tube is used the energy in the wave only operates the relay which releases local energy.

It would be possible to tune this wave motor to the frequency of the wave and thus get a great response for a small amount of energy extracted from the wave. This does not mean, of course, that by tuning we can get more energy by taking less. When the wave is electro-magnetic and the wave motor is a tuned circuit, the energy taken from the wave is extremely small, yet the effect, due to resonance, is comparatively large. The reason why the response, that is, the current in the resonant circuit or the voltage across either the condenser or the coil, is large is that there is a negligible loss of energy in the tuned circuit. The more loss there is in the tuned circuit the less will the response be, for a given rate of energy supply. A high loss in the circuit means that there is a high radio-frequency resistance in it.

In Fig. I-2 we have the cross section of a train of waves, such as water waves. Let ab be the fixed point of observation. At the instant the wave motion was "stopped" crest Co was at the fixed point. A moment before C1 was in the same position, and before that C2, and so on.

The frequency of the wave motion is the number of crests, and hence the whole number of waves, that pass the point ab per second. Now, suppose that at the beginning of the second at the end of which we "stopped," the motion crest C5 was at the fixed point ab. Then in that second five crests have passed the point, counting the first but not the last. The distance between the points ab and C5d is five wavelengths. Since the velocity is defined as change of position in unit time and since crest C5 has changed its position by five wavelengths in one second, the velocity of the wave motion is five wavelengths per second. If we know the length of each wave in meters, we know the velocity in meters per second.

In radio we can count the number of waves that arrive, or pass, per second. That is what we do when we measure the frequency. If the length of the wave is short, we can also measure the length. That is usually done when the wavelength is less than 10 meters, and Lecher wires are employed. The velocity of a radio wave is not so easily measured because it is so great and also because the methods used in optics do not apply. However, theory shows that the velocity of a radio wave and a light wave, in free space, should be the same. Further, it shows that the ratio of the same quantity measured in electro-static and electro-magnetic units should be a particular function of the velocity of the radio wave in space. Precise measurements have been made of this ratio by different observers using different quantities, and in every case the resulting velocity of the electro-magnetic wave agrees closely with the measured values of the velocity of light. Hence, we may say that the velocity of a radio wave in free space is accurately known. Because of this knowledge, we know both the wavelength and the frequency as soon as we have measured either.

Accommodating Tubes to Unusual Voltages By Proportioning

Although vacuum tubes are generally operated with the "typical" electrode voltages recommended by the manufacturer, special circumstances sometimes make it necessary to use tubes at other voltages. In such cases, new operating conditions which will give the best results must be obtained. The new conditions can be readily obtained for pentodes or other types of tubes, says RCA Radiotron, Co., Inc.

If, for example, the 89 with pentode connection is to be used with a plate voltage of 200 volts, what will be the correct operating conditions? The "typical" values given by the manufacturers are for plate voltages of 250, 180, 135, and 100 volts, none of which quite fits the case. The ratio of the new plate voltage to a known voltage (250 volts) is 200 ÷ 250 = 0.8. This is called the voltage conversion factor and is identified as F_e. Multiplying all voltages by F_e gives the new voltages shown in Table I.

By means of the accompanying curves and the voltage conversion factor (F_e), the new values of the screen and the control grid voltage, the plate and the screen current, mutual conductance, power output, and load resistance can readily be determined. The factors F_i, F_p, F_r and F_{gm} are the ordinates read from the curves at the abscissa value of 0.8. The following table gives the calculated values for a plate voltage of 200 volts.

A given case was worked out and the results are shown in the following table:

	250-Volt Condition	*Factor*	*200-Volt Condition*
Plate Volts	250	F_e = 0.80	200
Screen Volts	250	F_e = 0.80	200
Control Grid Volts	—25	F_e = 0.80	—20
Plate Milliamperes	32	F_i = 0.71	22.7
Screen Milliamperes	5.5	F_i = 0.71	3.9
Mutual Conductance (Micromhos)	1800	F_{gm} = 0.90	1620
Load Resistance (Ohms)	6750	F_r = 1.12	7550
Power Output (Watts)	3.4	F_p = 0.58	1.98

In the same manner, operating conditions can be determined for other voltage ratios. This method is particularly adaptable to output pentodes where the plate and the screen current are fairly high and vary according to the 3/2 power law, and where the voltage conversion factor is not over two to three or less than one-half to one-third.

Station Sparks

By Alice Remsen

National Music Week, which began on Sunday, May 6th, is being celebrated over the National Broadcasting Company's networks with a great variety of special programs. Outstanding are two programs consisting entirely of music composed by NBC staff members, from page boy to executive. Among the compositions to be heard are Walter Damrosch's musical setting of "Danny Deever," and Frank Black's "We're On Our Way," a march dedicated to the New Deal. There is also music or songs from the pens of Ford Bond, announcer, Vincent Rugasa, page boy, Irving Miller, pianist, Dana Merriman, conductor, Jessie Deppen, Morris Hamilton and Larry Shay, all of the program department; Charles N. Grant, Louis Weinman, Adolf Schmidt and Henry Gerstle, staff arrangers; Claude MacArthur, arranger and conductor, and Robert Braine, Lee Jones and William Paisley, all of the Music Library. These two programs will be worth a twist of your dial, Thursday and Friday, May 10th and 11th, over an NBC-WJZ network from 10:30 to 11:00 p. m. EDST. . . . Grace Hayes returns to the NBC networks in a new series of song recitals, each Monday at 8:30 p. m. EDST, WEAF and red network. . . . Eddie Peabody, wizard of the bajo, and a score of other instruments, and the singing De Marco Girls, have proven so popular with a local New York audience that their sponsor has decided to make them available to network listeners. With Richard Himber's celebrated dance orchestra to assist them, Peabody and the girls have inaugurated a weekly network series under the sponsorship of the Pure Oil Company, over an NBC-WEAF hookup; each Saturday at 7:30 p. m. . . . When a bad singer tries to sing and doesn't make the grade it's terrible, but when a good singer tries to rival a cat on a back fence it's merely funny; at least so the "Cuckoo" audiences think when they listen to the diminutive Mary McCoy during her burlesque on that comedy high-spot. . . .

The Nation's Station, WLW, has begun to operate full time with their giant broadcasting unit of 500,000 watts, by permission of the Federal Broadcasting Company. . . . The "Marvelous Melodies" program, starring Jack Whiting, Jennie Lang, and Jack Denny's Orchestra, has been extended four weeks over the original contract and so will be heard over the Columbia network through the first week in June. . . . "Roses and Drums," that popular CBS dramatic series, celebrated its second anniversary on the air with a contract renewal, which will take effect after a summer vacation. . . . Little Jack Little, the dynamic composer-pianist-singer-conductor, has won a contract renewal from the Continental Baking Co. He will be heard on a new day and time commencing Friday, May 18th, and each Friday thereafter at 9:15 p. m. EDST. . . .

Birthdays of some of your favorite radio stars this month: Raymond Paige, 18th; Vet Boswell, 20th; Maybelle Ross (Do, Re, Mi, Girls) 23rd; "Skippy," 27th; "Bunny" Coughlin, 29th. . . . Vaughn de Leath, the original radio girl, is now giving her own inimitable rendition of popular and old fashioned songs over the air through WMCA, New York, in a new series of programs, each Monday, Wednesday and Friday at 9:15 a. m. Welcome back, Vaughn! Hope to hear you again where you belong—on a Coast-to-Coast chain. . . . Vera Van, blonde personality singer, has joined the Pebeco Parade on WOR. . . . Jeff Sparks, former NBC and WLW announcer, has joined the staff of WOR in a similar capacity. . . . Rae Zelda, formerly with Irving Caesar, is now with Will Von Tilzer.

A THOUGHT FOR THE WEEK

YOU'RE mistaken, Mr. J. J. T., Taunton, Mass. It is not too bad that Billie Jones and Ernie Hare have gone off the air, because they just haven't gone off. Tune in WOR on Saturdays and Mondays at 8 P.M., E. S. T., and you'll find that Billie and Ernie are telling the folks all about Tasty Bread and doing it in their old familiar jolly, clean and manly way. There's no use talking—Billie and Ernie have proven beyond any shadow of doubt that American listeners-in are, as a rule, normal minded and that you don't have to offer them the slightest taint of the cheap and suggestive in order to win their interest and hold their loyalty. A couple of comedians we have in mind would do well to remember this before it is too late.

Coils for a S-W Super

DIRECTIONS FOR WINDING THEM FOR USE WITH A TRIPLE-POLE, QUADRUPLE-THROW SWITCH FOR COVERAGE TO 10 METERS

By George C. Ingalls

THE coils for a switch type superheterodyne, using an intermediate frequency of 465 kc, may be wound as shown full-scale. There are four coils, considering each form as one coil, although there are three windings on each form, two serving the oscillator and one the modulator.

The ticklers are close-wound, the other windings are spaced, and the spacing may be judged by the eye, from the drawings. That is, to reproduce the coils, use the size and insulation wires noted, and make the spacing as shown. The eye is quite accurate in copying distances that way, within the necessity of accuracy of the present purpose.

The circuit to use is one that has a series antenna condenser that is variable, and the maximum capacity may be from 35 to 50 mmfd. The lowest winding in the drawings is the antenna coil. Antenna is connected to one side of the small variable condenser, other side of the condenser to one terminal of the winding, the other terminal of the winding grounded.

Coils Couple the Circuits

No precautions need be taken to provide coupling between modulator and oscillator, as the coil system takes care of that, by mutual inductive coupling. Again the spacing may be followed as shown, for proper coupling. The numbers of turns in the drawings of the coils are not always literal, but don't count them. Take the numerical directions from the imprinted notations at the side of the coil.

The winding form is 1 inch outside diameter, and preferably should be of a good insulating material, not cardboard. The tuning is to be done with condensers of 140 or 150 mmfd. capacity, and the frequency ratio will be slightly more than 2-to-1. An allowance of only 2-to-1 is made in meter-band notation, because at least this much is covered, and there is overlap.

The windings should be held tightly in place. In a switching arrangement, since the coil itself is not handled, unlike the situation obtaining with plug-in coils, there is little danger of shift from contact, but almost any coil has to have some binder, if the inductance is to be free from change due to mechanical shifting of windings.

Smallest Coil Oscillates

There are several preparations on the market that make excellent coil dope, as it is called by the irreverent. The transparent type of coil dope is particularly good, and has shown practically no addition of capacity or change of effective dielectric. Besides, it is moisture-proof, and thus further protects the coil, so far as its outside contact with moisture is concerned. So only a small part of the winding is hygroscopic, or subject to inductance change due to moisture in the air.

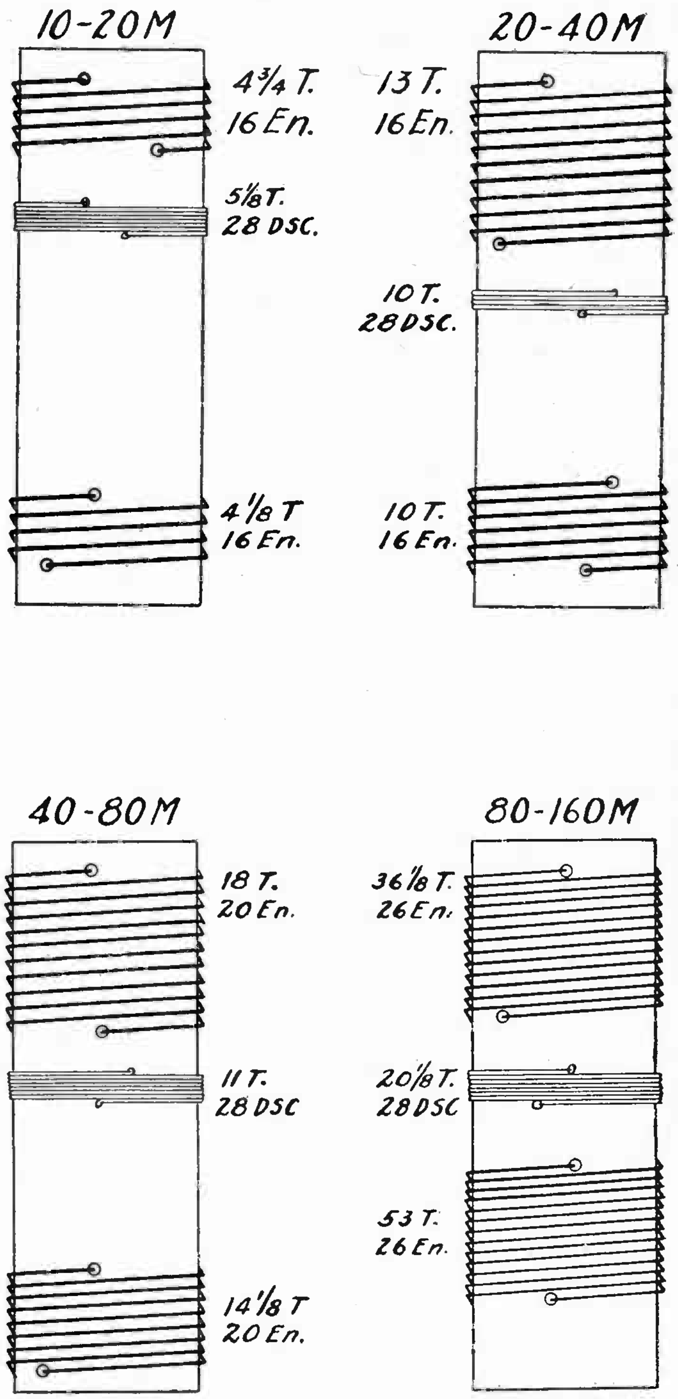
It is not intended that these coils be shielded. If shields are to be used the circuit would have to include an r-f stage ahead of the modulator, and the number of turns would be considerably greater, as shielding reduces the inductance, because it cuts the magnetic lines of force.

It will be found that the coil for the highest frequencies will oscillate, but if not much is received in this region, it will be due to the circuit, the wrong time of tuning in, and the fact generally that there isn't so much doing from 10 to 14 meters.

Series Condenser Important

While it is becoming popular practice to have a stage of tuned-radio-frequency amplification ahead of the modulator, for which the depicted coils do not provide, the series antenna condenser atones for that absence by contributing selectivity and sensitivity and enabling shift from dead-spot position.

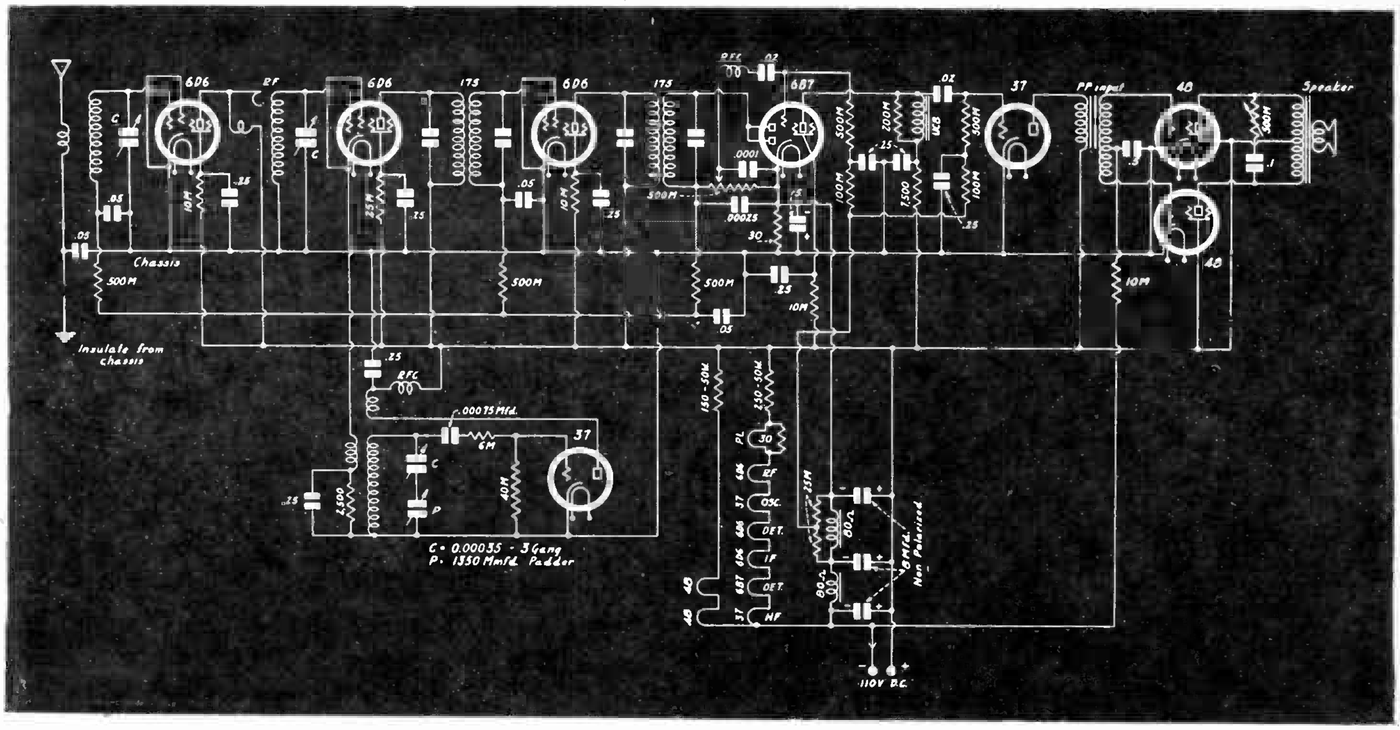
The series condenser is in no sense critical, but it proper setting enables the reception of station not otherwise heard. It is well to have a pointer knob on this condenser's shaft and a numerical plate held by the condenser bushing.



Directions for winding coils for a superheterodyne using 465 kc intermediate frequency. The upper winding is for oscillator grid, the central winding is the tickler of the oscillator, and the lower winding is for the modulator grid.

A D-C SUPER THAT B 84 OF THE 9

By Robert G. H
Thor Rad



The d-c superheterodyne designed by Robert G. Herzog, that performs on a par with a-c sets.

THE success of a particular circuit depends to a large measure on how closely the individual experimenter follows the printed data. It is for this very reason that dealers sell complete kits with drilled chassis and printed layout. These dealers usually make the purchase of kits additionally attractive by holding the complete price to from 20 to 25% less than what would be the total of the individual parts prices.

The circuit of the 8-tube d-c Super Pathfinder published herewith is the product of many hours of careful planning and accurate checking. It is our advice that the builder follow it as closely as possible. Should any changes be contemplated advice can be obtained from the author.

Grounded Cathodes

The latest type tubes are used in their most advantageous positions, each serving to its utmost to produce a d-c receiver easily comparable with similar a-c sets in tone, volume, selectivity, and to some extent sensitivity.

Whenever possible the cathodes of the tubes are grounded and bias supplied through the grid returns to line negative positions.

In the r-f and i-f circuits of this superheterodyne bias is automatic, but never less than 3 volts negative. The voltage is maintained by the d-c drop in the 30-ohm resistor in the B return. Since these 3 volts also are applied to the cathode of the 6B7 they do not affect the automatic volume control.

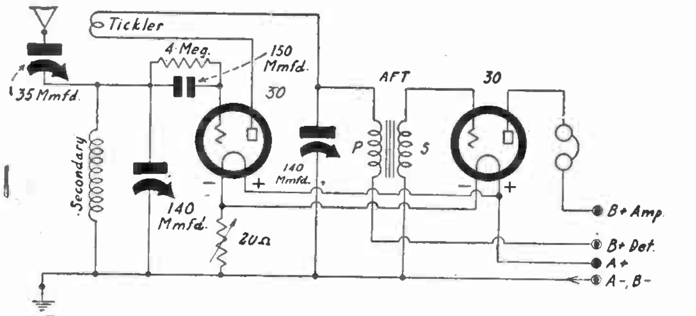
Bias for the 6B7 and 37 audio components is obtained by means of the voltage bridge arrangement across the second choke.

The voltage on the grid of the 37 first audio tube is 3 volts less than that on the grid of the 6B7, since the 37 cathode is grounded.

The plate voltage on the 6B7 is reduced by the 7,500-ohm dropping and isolating resistor to make up for the somewhat lower bias on the grid.

Power Tube Bias

The bias on the 48 is also obtained through the grid return. It is equal to the d-c drop in both chokes and the 30-ohm resistor,



New Model of Star

The reigning favorite two-tube battery-operated short-wave receiver, using plug-in coils, is used by ational Radio Distributing Company, under the trade name "World," using the diagram herewith, and yielding a product of which the other illustration gives the salient points. The circuit uses a two-winding coil for each band, and a total of only four coils, each tuned by a 0.00014 mfd. condenser. These coils take in, approximately, the 10-20, 20-40, 40-80 and 80-160 meter bands. There is some overlap, of course, to prevent missout.

The detector voltage may be 22.5 volts or 45 volts, whichever

RINGS IN
6 CHANNELS A NIGHT

erzog, B. S., E. E.
io Company

LIST OF PARTS

Coils

One antenna coil.
One R-F coil.
One No. 102 oscillator coil.
Two Litz-wound, doubly-tuned, 175 kc I-F transformers.
Two R-F chokes.
One VC-2B7 choke.
One U32B push-pull input transformer.
Two 80-ohm, 120 M.A. chokes.
One Rola dynamic speaker for PP4B, 1,800-ohm field.

Condensers

One 1,350 mmfd. padding condenser.
One 0.00035 mfd., three-gang tuning condenser.
Three 8 mfd. non-polarized electrolytic condensers.
One by-pass condenser block.
Two twin 0.05 mfd. condensers.
One 5 mfd., 35 volt electrolytic condenser.
Three 0.25 mfd. condensers.
One 0.1 mfd. condenser.
Two 0.02 mfd. condensers.
One 0.0001 mfd. condenser.
One 0.00025 mfd. condenser.
One 0.00075 mfd. condenser.

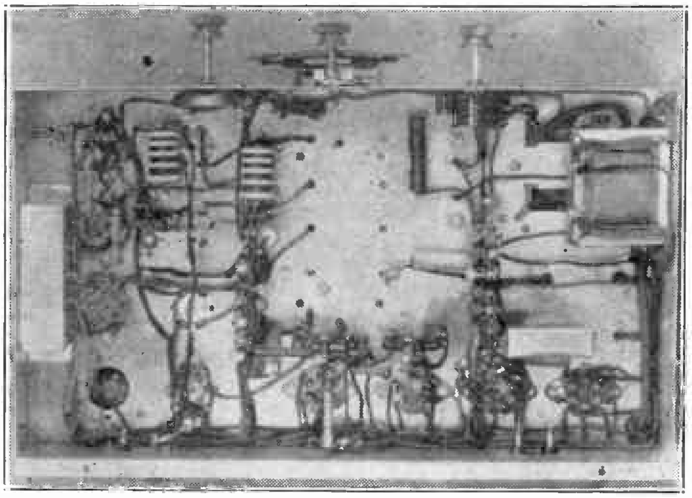
Resistors

One half-megohm volume control with switch.
One half-megohm tone control.
Five 0.5-meg., ½-watt resistors.
Four 10,000-ohm, ½-watt resistors.
Two 100,000-ohm, ½-watt resistors.
Three 25,000-ohm, ½-watt resistors.
One 200,000-ohm, ½-watt resistor.
One 7,500-ohm, ½-watt resistor.
One 6,000-ohm, ½-watt resistor.
One 40,000-ohm, ½-watt resistor.
One 2,500-ohm, ½-watt resistor.
Two 30-ohm, 3-watt resistors.
One 150-ohm, 50-watt resistor.
One 250-ohm, 50-watt resistor.

Other Requirements

Two resistance racks.
One Thor Pathfinder 10 x 18 inch chassis.
Five tube shields.
One Crowe dial and pilot light bracket.
Four grid clips.
Sockets: three 6D6, one 6B7, two 37, two 48, one speaker.
Antenna posts.
Phono posts.
Knobs.
Line cord.
Hardware and hook-up wire.

Neatness of Wiring Exhibited



Bottom view of the wired receiver.

so any changes in the circuit would change the current through these chokes and consequently change the bias on all the tubes.

The 6B7 plate is necessarily impedance-coupled to the 37 grid to prevent abnormal drop in plate supply voltage due to the plate load.

The choke used is of special design, capable of carrying 6 milliamperes and having an inductance of several hundred henries.

Neatness Seen from Bottom View

A lesson in neatness may be obtained from a glance at the bottom view pictured herewith. This view represents a completely wired model. All filament, screen, and B+ leads were wired around the edges of the chassis to make room for the parts and more important grid and plate wires.

The resistors are mounted on racks conveniently located for short and easy wiring.

After the set is completed the i-f and r-f circuits should be accurately aligned.

In a single evening the receiver in a downtown New York apartment bought in 84 of the 96 broadcasting channels with adequate volume and not too much noise.

There is no reason why every builder of this set should not have similar results.

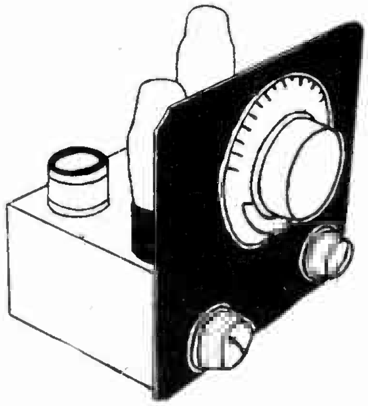
ndard S-W Circuit

works better, while B plus amplifier will be all right at 45 volts, but for considerably greater volume, if that is deemed necessary, may be raised to 90 volts. Small B batteries may be used, as the current drawn is conservative.

The throttle control of renegeration is used, following the standard hookup.

An adjustment of the series antenna condenser regeneration becomes infallible on all four coils, though the position of this condenser, that is, its capacity, may have to be different for each band.

The circuit diagram is shown at extreme left bottom of this page. The way the parts are set up is shown at right.



ANDERSON'S ALL-PURPOSE METER ASSEMBLY

Measures A-C and D-C Currents and Voltages, Also Resistance

By J. E. Anderson

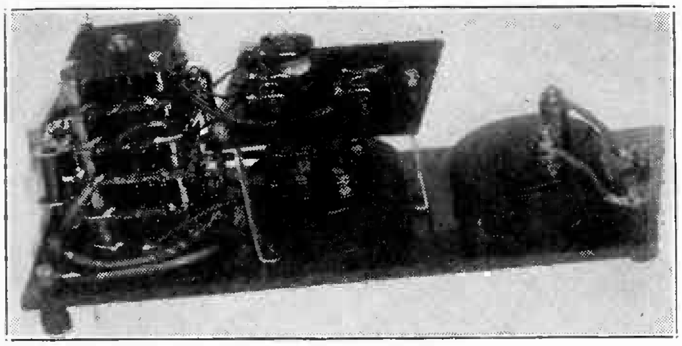


FIG. 1
Rear view of the universal meter showing thermo-galvanometer at top, the a-c, d-c meter in the middle, and the selector switch at bottom. Multipliers are placed on a platform.

THE PHOTOGRAPHS depict a very useful and handy laboratory device. At the top we have a thermo-galvanometer intended for the measurement of radio-frequency currents. The two binding posts between which is the word "GALV" serve this instrument. There is no connection between the two meters on the panel.

The middle instrument is a universal, rectifier type meter, and the switch below it shows to what uses the meter can be put. There are eleven live stops on the switch and one open. The index points to the open in the photograph. It will be noticed that as the switch is turned in either direction from the open position, it picks up high-voltage ranges, a-c on the left and d-c on the right. In either direction there is a resistance of 0.5 megohm in series with the meter and therefore the circuit is not far from open. Flanking the open by two high-voltage stops has been done for protection of the meter.

Lower Ranges

If the switch is turned one step further in either direction a 0-50 voltage range is picked up, a.c. on the left and d.c. on the right. The movement from (11) to (10) or from (1) to (2) is not done, of course, unless the deflection indicates that it is safe to do so, or unless it is necessary in order to get a closer voltage reading. The resistance in series with the meter when the switch is at either (10) or (2) is 50,000 ohms.

Stop (9) is for 0-5 volts a.c. and stop (3) is for 0-5 volts d.c. In either position there is a total 5,000-ohm resistance in series with the meter. The movement of the switch to (9) or (3) is not done unless it is necessary to get a closer voltage reading than is possible on the previous step, and it is not made if the reading on the previous step indicates danger.

Stop (8) is for the measurement of resistance. The unknown resistance is connected across the terminals labeled "OHMS" and an external battery or other source of electromotive force is connected across the two terminals at the right marked "BAT." There is a limiting resistance built into the instrument which is picked up when the switch is set on (8). In the instrument as built this has a value of 10,000 ohms and it is intended that the voltage across the "BAT" terminals is to be 10 volts. The source of this voltage is a B supply built into a unit of the same size as the present instrument and placed next to it in the carrying case. When no such voltage source is available, it is better to use a voltage of 4.5 volts, which can be supplied by three dry cells, and then use a limiting resistance of 4,500 ohms.

Second Starting Place

When the battery terminals are open, the circuit is also open when the switch is set on stop (8). Therefore this stop is used as the starting point for the current ranges. As we move the switch from (8) to (7) we convert the instrument to a 0-100 milliammeter. This is the least sensitive combination of the meter and it is picked up first after the open (8).

When the index of the switch points to (6) the meter reads 25 milliamperes at full scale. At the next step the full-scale reading is 5 milliamperes, and at the next (4) it is one milliampere. The current readings are all for d-c. Only on stop (9) can alternating current be read, and then only in circuits in which a resistance of 5,000 ohms is negligible in comparison with the total resistance. On any voltage stop, a-c or d-c, the current at full scale is one milliampere.

Rear View

The instrument on the rear of the panel is illustrated. The connection of the thermo-galvanometer is clearly shown at the top. Directly over the universal meter is a platform made of thin bakelite holding the voltage multiplier spools. There is room for one more, the 10,000-ohm limiting resistor for the resistance meter. This had been removed temporarily when the photograph was taken. The platform is held up by three aluminum brackets fastened to the panel by the three screws which hold the universal meter in place.

There are three shunt resistances for the 100, 25, and 5 milliampere ranges, and these are mounted directly to the lugs on the switch. Two of them are visible in the rear-view photograph.

It is essential that the switch be mounted firmly to the panel, for if it is not, it will turn as the knob is turned. It was found that a lock washer would not hold the switch firmly enough, but the problem was solved in a very simple manner. Holding the switch assembly together are four long screws the ends of which can be seen on the bottom insulator of the switch. At the visible end are nuts and lock washers, but at the panel end are round heads. Four tiny recesses are drilled in the panel where these round heads meet it. If the holes are located accurately the screw heads will fit into the holes and when the mounting screw is drawn up, the switch is held firmly with any possibility of turning.

Wiring the Switch

Wiring the switch is not difficult, provided a suitable layout is followed. While wiring, one thing should be kept in mind, and that is not to let any rosin or other flux run into the contact surfaces of the switch. It is easier to keep rosin out than to remove it once it has got into the crevices. It is particularly important to see that three shunts make contact, for if they do not there is grave danger of burning out the universal meter.

In case rosin-core solder is used while wiring the switch, it may be that some of the rosin runs into the contact surfaces notwithstanding precautions. Therefore every contact should be tested for continuity before reliance is placed on it. It is not sufficient to make one test, for the first half dozen trials may be favorable yet the next may show an open. It only requires one open in the case of the shunts to ruin the meter. As precautions, the surfaces should be scraped clean and then wiped with alcohol-soaked cotton.

Most of the wiring is done before the switch is mounted on the panel, for then all the lugs are accessible. The wiring, as will be consists mostly of running wires from lug to lug on the switch seen on the circuit diagram printed at the top of this page, consists mostly of running wires from lug to lug on the switch assembly.

Wiring Diagrams

The pictorial diagram should be followed for making the connections of the instrument to the switch. The rows of circles represent the decks on the switch, the A-deck being the one next to the panel. The zero position, which is headed open, is repeated for simplicity. Another drawing of the same circuit is shown on the diagram above, where the decks are shown as separate switches with the points in their proper circular relationship. Either drawing may be followed in wiring up the switch.

It will be noticed that point (1) to (8), inclusive, on the A-deck are connected together and that (0) on the B-deck is also connected to these. A single bare wire can be used for making these connections. Remember that no rosin should be allowed to flow into the contact surfaces when soldering the wire to the points. Stops (9), (10), and (11) on A-deck should also be connected together.

Next a bare wire should be run around B-deck picking up (1) to (8), inclusive. The next connections are made on the C-deck, points (1), (2), and (3) being connected together. On the D-deck

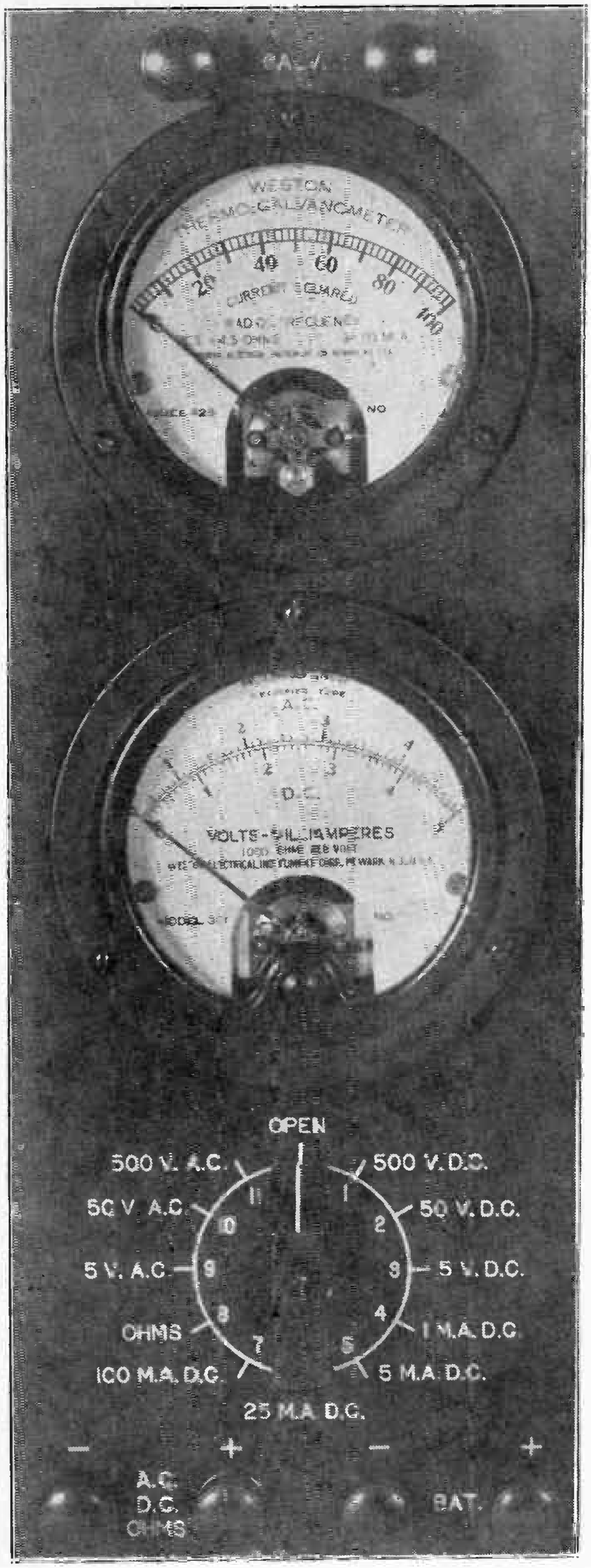


FIG. 2

Panel view.

points (3), (10), and (11) should be joined. For this an insulated wire should be used, for the lead from (3) to (10) will pass many points which should not be contacted. On the E-deck there are no connections so far.

We now proceed to join (4) on D to (4) on C, (5) on D to (5) on C, and (6) on D to (6) on C. Point (1) on D picks up (11) on E, (3) on D picks up (10) on E, and (9) on D picks up (0) on E.

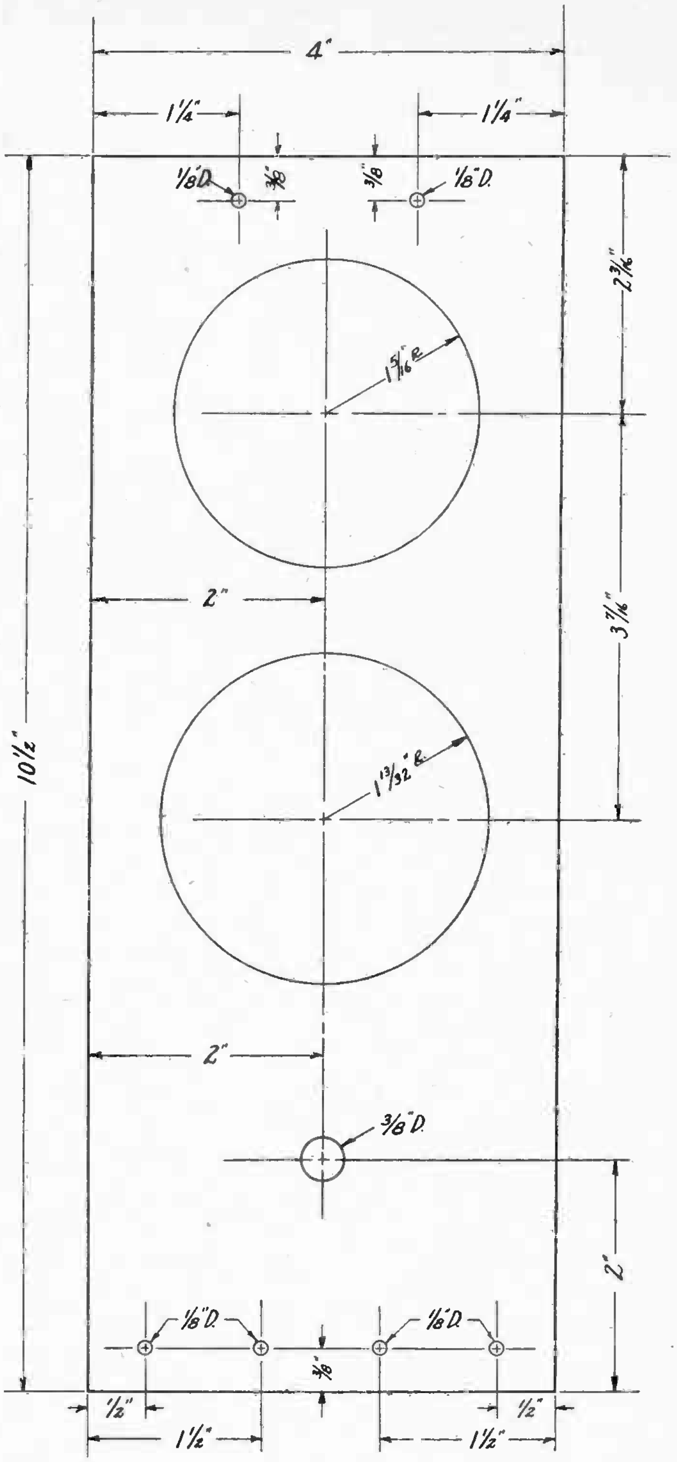


FIG. 3

Dimensional drawing of the panel of the universal meter.

Switch Mounted

We have now made all the connections on the switch that are to be made without going to the binding posts, resistors, and the meter. The shunt resistors R5, R6, and R7, however, may be mounted on the switch in the manner illustrated on the rear-view photograph. If these connections are made before the switch is mounted on the panel, subsequent wiring will be simplified.

Now is the best time to clean the contact points in case any rosin has been allowed to flow into the contact surfaces. When that has been done, the switch is mounted firmly in the manner already explained. Try it and make sure that the switch frame stays when the knob is turned.

As soon as the switch has been mounted the connections to the universal meter can be made. Note that one (AC) goes to (0) on E or to (9) on D, depending on which is the more convenient. The other (AC) goes to (9), (10), or (11) on A, depending on which one is the most convenient. The post on the universal meter marked (+) is connected to (0) on C, and the unconnected lug on the spool mounted at the back of the universal meter is connected to (8) on B, or to any one of the points on that deck to which (8) is connected. The terminal on the universal meter marked (—) is connected to (8) on A-deck, or to any one of the points connected to that point, which includes (0) on B-deck.

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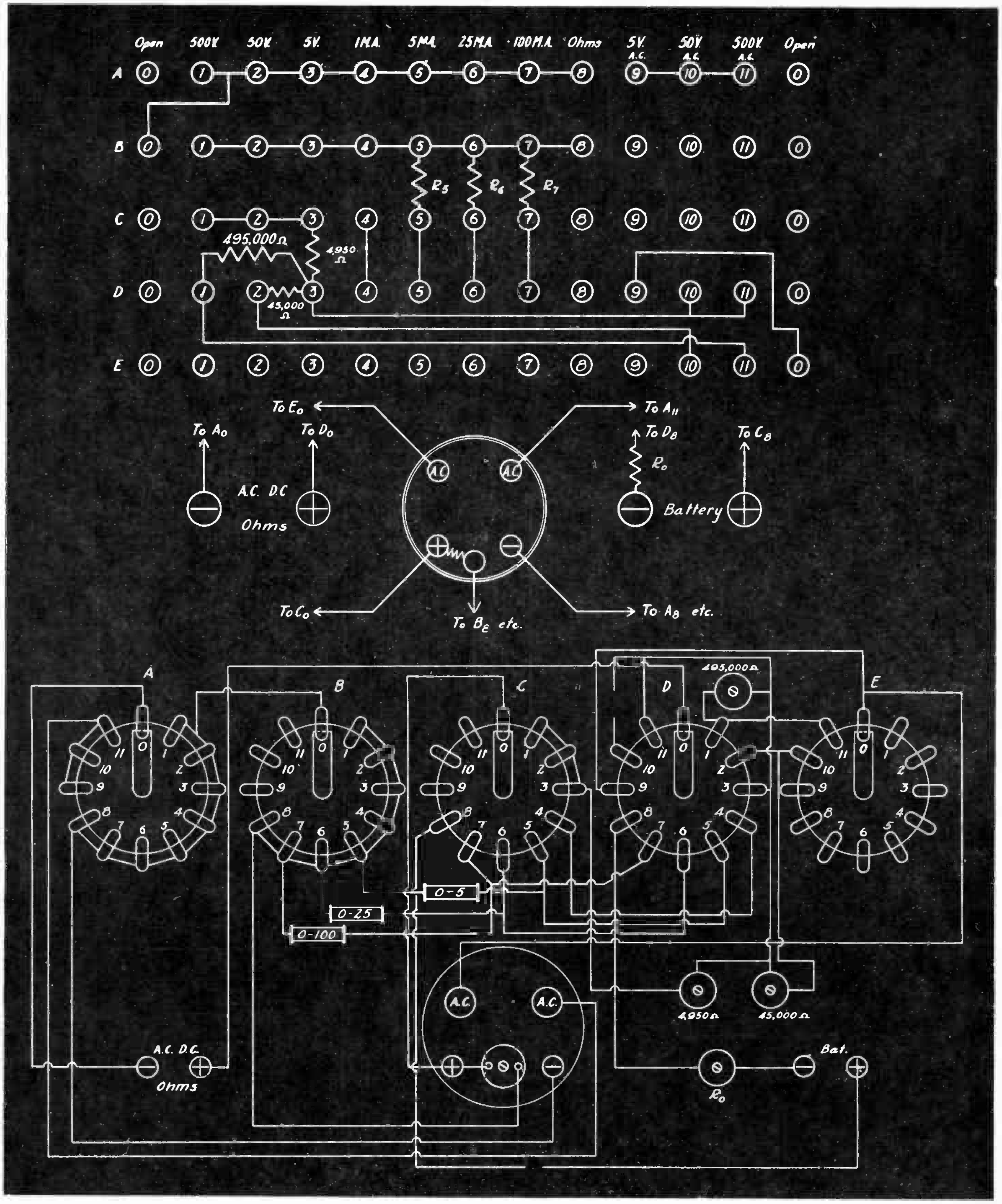

FIG. 4

A co-ordinate diagram showing the connections of a universal meter to the selector switch and the terminals for an all-purpose meter described by J. E. Anderson. Decks are shown in rows. The pictorial wiring diagram of the circuit and switch shows the same connections. Decks are shown in circles and the decks are separated.

(*Continued from preceding page*)

The positive terminal for the battery is connected to (8) on C, the left input terminal (AC, DC, Ohms) is connected to (0) on A, and the right input terminal is connected to (0) on D.

Mounting Multipliers

Now is the time to mount the voltage multipliers on a platform over the universal meter (over when seen from the under side). When the multiplier resistors have been mounted, connected the 4,950-ohm resistor between points (3) on decks C and D, connect the 45,000-ohm resistor between points (2) and (3) on deck D, and connect the 495,000-ohm resistor between points (1) and (3) on deck D. The limiting resistor Ro in the negative lead to the battery is also mounted on the platform and it is connected between the battery binding post marked (—) and point (8) on the D-deck.

The connection of the thermo-galvanometer, if one is used, is obvious from the rear-view photograph.

Now when all the connections have been made, the circuits should

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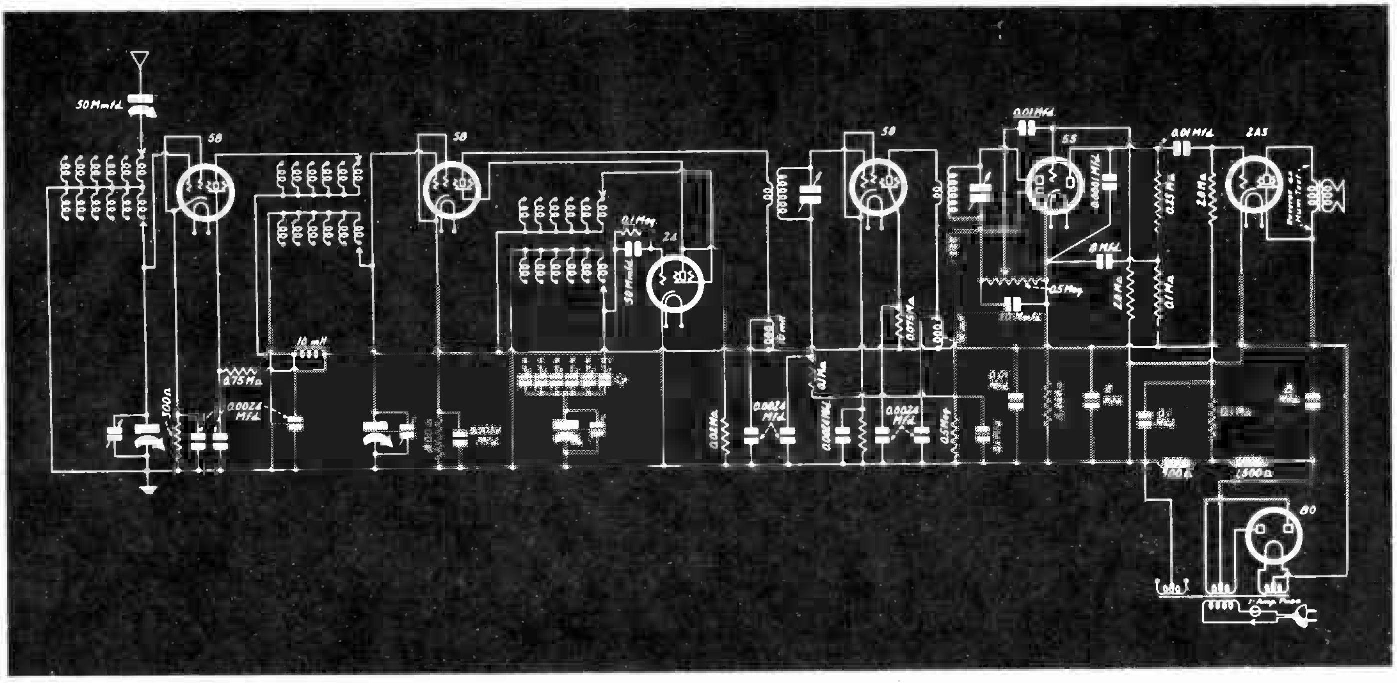
I. F. Above Broadcast Band

Is Proposed for Better Results at the Shortest Waves

By Herman Bernard



Using six coils for each of the three circuits, beginning with the low end of the broadcast band, one could tune to above 30 megacycles, on a 2-to-1 frequency ratio. For an intermediate frequency around 1,800 kc it would be advisable to pad the oscillator for each and every band, as shown at Cp 1, 2, 3, etc.

THE growing popularity of short-wave reception will lead inevitably to the use of a higher intermediate frequency, so that the shorter waves will be brought in better, due to absence of locking. When the circuits lock they become electrically one circuit, so the benefit of radio-frequency tuning is practically lost, even if there are two r-f stages.

If and when the intermediate frequency is increased, the choice will lie between using two different intermediate frequencies, say 465 kc and around 1,800 kc, or even higher, and using only one. The double channels would be more expensive, bulky and require additional switching, yet would provide an uninterrupted run from one extreme to the other of the total encompassed by the set. If only one i.f. is used, and it is a high one, then there would have to be a blanked span of, say, 40 kc, in the tuning. If the i. f. is 1,800 kc, then the blank might be from 1,780 kc to 1,820 kc. If no attention is paid to the fact that the tuner will respond to the i-f level in one instance, there would be squealing and blanked reception anyway, for about 40 kc, but if the i. f. is selected as some frequency just a bit higher than the highest of the previous band, then the lowest frequency of the next band could be so selected, by inductance determination, so the start would be some kilocycles removed from the i. f. Thus squealing would be avoided and the blanked portion probably never would be missed.

The history of the superheterodyne to date has been one of increasing intermediate frequencies. In the early days the intermediates were around 30 kc, then a burst of popularity fell upon kit-receivers that had intermediate frequencies around 90 kc, such as the Victoreen and the Magnaformer. Gradually the frequency was increased to past 100, then past 200 and past 300, until now the four hundreds provide the most popular intermediate frequencies, 465 kc being the ruling one.

That it is not the best for the shortest waves is well-known to anyone who has spent some time experimenting with superheterodynes. Particularly if close mixer coupling exists anyway, as it does in the case of the pentagrid converter tubes, while the coupling in the tube does not change much with frequency (a favorable aspect of electron coupling), nevertheless the stray capacities and the inductances outside the tube have greater carrying capabilities, hence contribute to the cumulative evil of pronounced coupling, until at somewhere above 10 megacycles the circuits may lock.

There are several reasons why the performance declines as the frequency increases, and locking is one of them. Another is the output capacity of the tubes used. To have a suitable plate impedance the inductance is made as large as practical, and since the output capacity due to the tube alone may be around 12 mmfd., a

(Continued on next page)

Anderson's All Purpose Meter

(Continued from preceding page)

be tested for continuity and absence of shorts. As a matter of precaution, use a single cell of 1.5 volts in series with a resistance of 1,500 ohms and connect across the input terminals. With this all the voltage stops and all the current stops can be tested for continuity. If there is an open anywhere in the circuit there will be no voltage indication on any of the voltage stops. If there is none, look to the contact surfaces first. Perhaps there is rosin left. On the high voltage stops the indication at best will be a mere flicker. On four current stops there will be a slight indication if there is continuity. If the limiting resistor is 1,500 ohms and the voltage applied is 1.5, the current reading should be full scale on stop (4), it should be one-fifth scale on stop (5), 0.04 full scale on (6), and 0.01 full scale on (7). There should be no indication on (8) until the battery terminals are shorted, or unless the battery is connected across the terminals and the input terminals are shorted or joined by a resistance, say 1,500 ohms.

With such an instrument precautions are in order.

(*Continued from preceding page*)

low-pass filter is unintentionally introduced. Then, of course, the inter-electrode capacities of the tube in other directions tend to require precautions which, when taken, result in lessened amplification, compared to practice on lower frequencies, although permitting reception under conditions that, without these precautions, would prevent it.

The Circuit Discussed

The circuit herewith is shown, not to be followed constructionally, but for visualization of a proposed method of meeting the problem.

A coil-switch system is used with a small capacity condenser, around 100 mmfd., to yield a tuning ratio of 2 to 1. A good plan to follow is to select the ratio on the basis of what is deemed satisfactory for the highest-frequency band to be reached, say, 30 to 15 mgc. and let the same capacity, hence frequency, ratio prevail for all the lower-frequency bands of tuning.

The modulator is the second 58 from the left, and just below it, to the right, is the 24 oscillator. For the first time a truly electron coupling system is shown whereby the conventional plate of the 24 is used only as a pickup grid, an oscillation voltage developing between this element and ground through a resistor. While this voltage normally will be low (having amounted to 2.6 volts when a B battery of 22.5 volts was used), it will be higher in the circuit shown and may be increased by increasing the value of the resistance beyond 0.02 meg. (20,000 ohms), almost without resistance limit.

Since the conventional plate of the oscillator is tied to the screen of the modulator, the oscillation voltage, or portion thereof derived from the plate-to-ground load of the oscillator, is all the screen voltage that gets on the modulator. This should be enough to be compatible with good sensitivity in the modulator, and may be checked approximately by seeing that the modulator plate current is around standard value for the 800-ohm biasing resistor, something a bit more than 5 milliamperes.

It Is Not a Dynatron

The oscillator's real plate is the element usually serving as screen, the feedback winding now being connected in that circuit in the direction of B plus. Though the conventional plate (here just a pickup element) is at a lower potential than the screen, the 24 tube will not function as a dynatron oscillator but as a triode oscillator with electron pickup. For the dynatron method to prevail the plate would have to be tuned.

The two intermediate transformers may be peaked at 1,800 kc, the second transformer having three windings, the pickup coil at lower right ahead of the 55 having about half the number of turns on the tuned secondary. The 55 diodes are used individually, one for second detection for audio communication to the output through the a-f amplifier, the other as rectifier for automatic-volume-control voltage only.

The rest of the circuit follows a familiar pattern.

Radio University

Answers to Questions of General Interest to Readers. Only Selected Questions are Answered and Only by Publication in These Columns. No Correspondence Can be Undertaken.

Key-Click Interference

AN AMATEUR operating a sending station in the same block as I live is causing a great deal of interference with broadcast reception. I have been in touch with him and he claims that he has done everything possible to eliminate interference and maintains that it is my receiver that is at fault. What can be done in a case like this? Must I get a new receiver, a new location, or can I get a new deal?—H. L. C.

If the amateur is causing general interference in your neighborhood he is required to keep quiet hours from 8:30 p.m. to 10:30 p.m., daily, and from 10:30 a.m. to 1:00 p.m. Sundays. If there are many receivers in the neighborhood and yours is the only one that picks up the interference, the presumption is that your receiver is not selective enough.

* * *

Effect of Unsteady Signals

IF A CODE transmitter is not frequency stable in what way will this fact show up in the signal?—R. E. J.

The beat note will vary. If you want to find out how the fact shows up, tune an unstable oscillator in the neighborhood of a broadcast receiver and adjust its frequency until it generates an audible beat with some station's carrier. Turn off the filament current on the oscillator. Immediately there is a chirp, indicating that the frequency of the oscillator is changing with respect to the frequency of the station's carrier. The effect can also be obtained if the plate voltage on the oscillator is changed, or if the grid bias on the oscillator is changed.

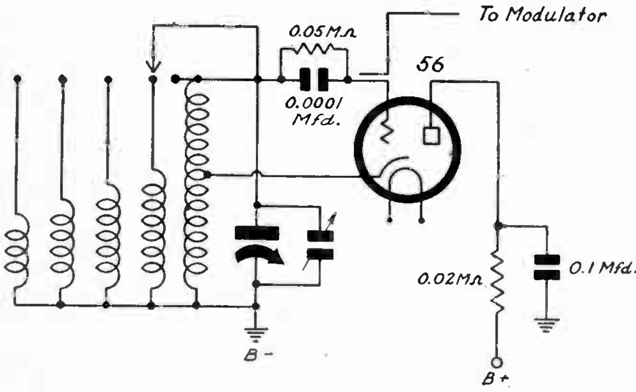
* * *

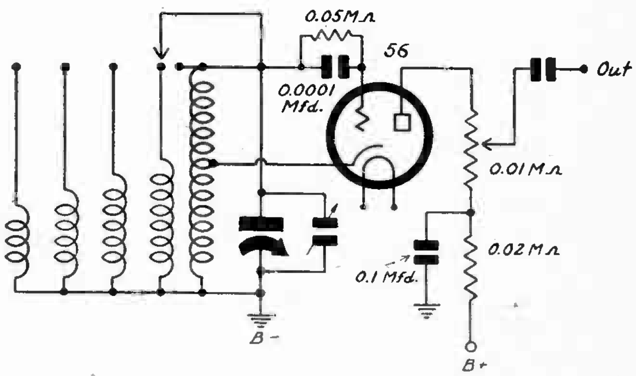
Ultraudion and Colpitts Oscillators

IT HAS BEEN ASSERTED that the Colpitts and the ultraudion oscillators are the same basically. I cannot see that this is so, for in the Colpitts there are two condensers and a coil while in the

Local Oscillator Using Paralleled Coils for Multi-Band Operation

Same Principle Used In Signal Generator, With Output Control





The method of paralleling coils in a Hartley oscillator, to simplify the coil construction for multi-band coverage. For a receiver use diagram at left, for a test oscillator the one at right, with 0.00025 mfd. output condenser (value not on diagram).

RECENTLY YOU DISCUSSED the use of the Hartley oscillator, with the largest inductance so connected as to produce oscillation, higher frequencies being attained by coil switching, so that only one winding was necessary for the succeeding bands. This strikes me as constituting a simplifying process, comparable to that of the dynatron oscillator, except that the frequency stability should be better than that of the dynatron. What I would like to know is whether a single calibration scale can be used successfully, selecting an even ratio, say, 2-to-1, and using the factor for succeeding bands.—K. D. W.

No, this can not be done satisfactorily, because paralleling one coil after another with the low-frequency coil, for higher-frequency oscillations, of course introduces the distributed capacity of the smaller coil across the total capacity in the rest of the circuit, and the added coil will have a different distributed capacity each time, depending on various factors. For accuracy to within 5 per cent., however, not good enough, it could be done. But it would be better to have a separate scale for each band.

ultraudion there is only one coil and one condenser. If the statement is true kindly explain.—R. L. F.

The essential things in both oscillators are the condensers in shunt with the line and the coil in series. In both oscillators there is a coil between the grid and the plate, with necessary stopping condensers. In both there is a condenser from the plate to the filament and another from the grid to the filament. In both there is also a condenser across the coil. Therefore, the two oscillators are identical electrically. The difference comes in only in regard to values of the various elements. In the Colpitts we have only the coil capacity and the grid plate capacity between the grid and the plate. In the ultraudion we have in addition the tuning capacity. In the ultraudion we have only the tube capacities between the plate and ground and between grid and ground. In the Colpitts we have in addition the tuning condensers. If the two circuits differ in performance it is only because the capacities are distributed differently, not because the circuits are different.

* * *

A Magnetron Oscillator

IN WHAT WAY does a magnetron oscillator differ from the regular vacuum tube oscillators?—R. L. S.

In the magnetron the electron stream is controlled by a magnetic field instead of an electric field.

* * *

Inductance of Audio Transformers

SHOULD the inductances of the windings of an audio transformer be high or low if both the high and the low audio frequencies are to be amplified well? What should be the ratio of the transformer for best results?—W. E. T.

The inductance of the primary should be 50 henries or more, effective value when the plate current flows. The plate current will reduce the inductance of the windings and, therefore, if the transformer is used in such a manner that no d-c flows either winding, the inductance may be somewhat lower. The ratio of turns should not be larger than 3.5/1 and 3/1 is a good value. If the ratio is 3/1 and the inductance of the primary is 50 henries, the inductance of the secondary will be 450 henries. It would be better to have a primary inductance of 200 henries and a secondary of about 1,250 henries. That would make the ratio only 2.5.

* * *

Estimating Amplification

IN A RESISTANCE-COUPLED amplifier, is it possible in a practical way to estimate the amplification? If so, please outline the method of procedure.—W. E. P.

The amplification for each stage is proportional to the amplification constant for that stage. It is also proportional to the load resistance and inversely proportional to the sum of the internal resistance and the load resistance. If A is the amplification, R the load resistance, and r the internal resistance of the tube, the voltage amplification is $A=\mu R/(R+r)$, where μ is the amplification factor of the tube. If there are more stages than one the total amplification of the circuit is the product of the various stage amplifications, provided the circuit is filtered so that there is no feedback either decreasing or increasing the gain.

* * *

Use of Power Transformers

IS IT permissible to use power transformers designed for 110 volts 60 cycles on 110 volts 25 cycles? If no, why not, and what can be done about it?—L. J.

It is not permissible because the primary current will be too large. The transformer would undoubtedly burn up if it were attempted. However, if the line voltage be dropped in about the same ratio as the frequency is lowered, it will work all right. It would be best to reduce the voltage by means of a choke coil, for to do it with a resistor would be very wasteful of energy.

* * *

Crystal Harmonics

DO quartz crystals generate harmonics of their fundamental frequency? I have seen a statement in a book that was supposed to be reliable to the effect that crystals are exceptionally rich in harmonics. Yet the crystal is supposed to be super-selective. If it is, that ought to eliminate the harmonics.—E. R. H.

It is extremely doubtful that the harmonics of the crystal will be strong if it is excited at fundamental frequency. But the crystal should respond easily to any of its harmonics by proper excitation. Your question is not clear whether the statement relates to the crystal by itself or to a crystal-controlled oscillator. The harmonics in a crystal-controlled oscillator are strong, as in all oscillators utilizing vacuum tubes.

* * *

Accuracy of Oscillators

WHEN an oscillator is calibrated and the accuracy is guaranteed to be better than 3 per cent., plus or minus, what is the possible deviation at 1,500 kc? What is the greatest possible error between two oscillators both of which have been calibrated against this oscillator?—W. E. N.

Three per cent. of 1,500 is 45. Hence, the greatest possible deviation is 45 kc, and it may be either plus or minus. The probable error is smaller than that since the calibration was "better than" three per cent. The second part of the question is not clear and a definite answer is not possible. Suppose the error in the frequency is merely one of setting the dial. In that case it may be set too low by 3 per cent. in one instance and too high by the same percentage in the other. If that is the case the possible deviation would be 6 per cent., referred to the supposed correct frequency. If that is 1,500 kc, one oscillator might be 45 kc higher and the other 45 kc lower. The difference would be 90 kc. But the probability is equally good that there is no difference at all. Indeed, it is better, for nobody would set the oscillator at random.

* * *

Dynamo Flash Light

THERE are flash lights which do not require any batteries because there is a little generator in the handle, which is operated by hand like a pair of scissors. I wonder if a device like this could not be used for operating a pocket oscillator. There could be one winding on the generator for the filament of the tube and another for the plate voltage. What objections are there to such a scheme?—W. E. J.

The idea could be carried out, all right, but it would be difficult to keep the power delivered to the tube constant. The oscillator would hardly be a model of constancy. Another objection is that it requires a helper to keep the oscillator going, for in servicing a radio receiver usually both hands are required.

* * *

Parasitic Oscillations

WHAT are parasitic oscillations? How are they produced and in what respect do they differ from regular oscillations?—P. T.

Parasitic oscillations are oscillations not wanted. In other respects they do not differ from regular oscillations. As a rule, they are not wanted because their frequency is either higher or lower than the frequency desired. At any rate, they have a frequency not wanted, and for that reason they are parasitic. They take energy from the desired oscillation and that is another reason why they are parasitic. They arise from accidental circuits.

* * *

Treasure Seekers

WHAT is the principle on which treasure seekers operate? I have seen descriptions of a number of them but I don't understand them. It seems to me that they work on the principle of human credulity. I don't believe in any divining rods but there may be something to these radio devices.—T. Y.

There is a bit of science, a bit of superstition, and a bit of credulity in these radio divining rods. The principle of operation is about as follows: Two radio frequency oscillators are adjusted to the same frequency so that they zero beat. One of the oscillators is fixed in frequency and the other is variable as a result of changing in the field of its oscillating coil, which often takes the form of a loop. Suppose that a chunk of metal is placed near the loop. The inductance will change and that in turn will change the frequency of oscillation. The zero beat adjustment will be upset, and a heterodyne will be heard. Hence, the presence of metal near the loop will manifest itself by a heterodyne in the headphones. Of course, it makes no difference whether the loop is brought to the metal or the metal is brought to the loop. For testing the circuit the metal is brought to the loop while for use in the field, the loop is brought to the metal, if there is any metal.

* * *

How Spark Signals Are Heard

HOW is it possible to hear spark signals by a pair of earphones when the signals are not modulated? We cannot hear continuous wave signals without a beat oscillator yet we can hear spark without such device and without rectification.—W. L. D.

We can hear the spark signals in the earphone without a beat note oscillator but we cannot hear them without rectification. Sure the spark signals are modulated. Each spark sets off a train of waves the amplitude of which is high at first but which gradually dies down. This variation in amplitude from a high value to a vanishing value constitutes modulation.

* * *

Equivalence of Circuits

IT IS my understanding that a resistance across a condenser can be represented by an equivalent resistance in series with that condenser. Does the equivalent value depend on the frequency, on the capacity of the condenser, or on any other factor in the circuit?—R. E. T.

If R is the value of the resistance in shunt with the condenser of capacity C and if w is the radian frequency, the equivalent series resistance is equal to $Re = R/(1 + R^2C^2w^2)$. Therefore it depends on the frequency as well as on the capacity and the shunt resistance. It is clear that as the frequency increases the effective series resistance decreases very rapidly. Likewise it decreases rapidly as the capacity increases. It also decreases as the shunt resistance increases, but not as fast as when Cw increases. Suppose the frequency is 1,000 kc, that C is 350 mmfd., and that R is one megohm. Then Re is very nearly equal to 0.2 ohms. Now suppose that the shunt resistance is only 10,000 ohms. The value of Re is then 2.06 ohms, Cw remaining the same as before. It is clear from these examples that if the shunt resistance is low, the equivalent series resistance is high and will account for a great deal of loss of selectivity and sensitivity.

* * *

Reception in Steel Buildings

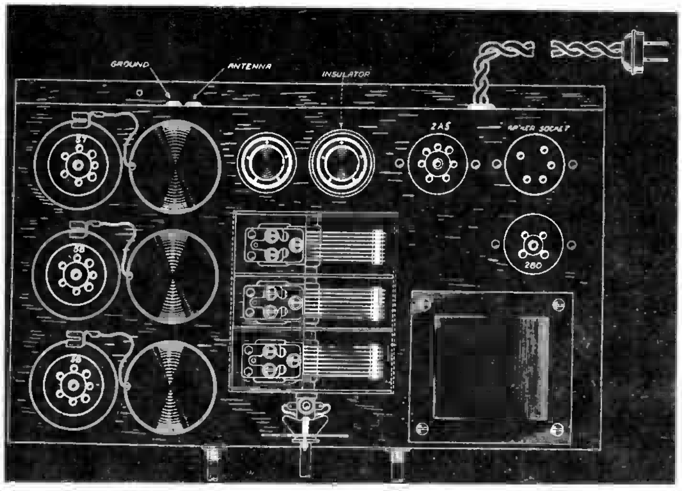
IF STEEL is a good shield for radio waves, how does a broadcast signal get inside a steel building? That it does is easily demonstrated.—R. L. J.

Possibly the waves get into the building in about the same manner as water gets through a sieve. There is no steel in the windows and the waves can get in that way. The fact is that only about one per cent of the radio wave gets inside the steel building unless it is led into it by a transmission line or an antenna wire.

A Dual-Range T-R-F Set

Five-Tube-Design Covers Broadcast and Police-Amateur-Airplane-Relay Bands

By L. Leonard Watkins



The top of the receiver chassis.

THE five-tube dual-wave set for a-c operation, announced two years ago, and sold in kit form as well as in manufactured models, has undergone some changes meanwhile, so that in general the circuit more closely follows the one diagramed herewith and published as Blueprint 632.

The circuit diagram of the wiring shows that this receiver is of the tuned-radio-frequency variety, and that it tunes in two bands. These are the broadcast band, 540 to 1,600 kc, and the next highest frequency band, about 1,500 to 4,500 kc. In meters these ranges are 555.2 to 187.4, and 199.9 to 66.63.

The Coil Switch

The wiring of the switching is shown only in the circuit diagram. A three-deck, two-position switch is used, and is connected with pointer or index or moving arm to the stator of the tuning condenser. For broadcasts the stator is connected directly to the grid. For the higher-frequency band the stator is moved to a tap on the secondary. Therefore, the full secondary winding is in circuit all the while, only the tuning is focused in one instance on the complete winding and in the other instance on one-ninth of the inductance of that complete winding. This has been found much more favorable than using the switch for shorting out the unused part of the coil, for while the voltage across the shorted part would be next to nothing, the current through that part might be exceedingly large, and constitute therefore a very appreciable loss.

All three coils are alike, and since this is a tuned-radio-frequency set there is no padding to bother about. The only adjustment is to line up the t-r-f channel at some high frequency of the broadcast band, say, 1,500 to 1,400 kc.

How the Volume Control Works

The volume control, located in the cathode leg of the first r-f tube, and also in the antenna circuit, serves a double purpose. First, as it is desired to reduce volume, the input to the first tube is reduced as the arm of the control is slid toward ground, as can be seen from the fact that when the arm is grounded the input is shorted entirely. Second, as the arm is slid in this same direction a greater resistance is interposed between cathode of the first tube and ground, whereupon the negative bias on the first tube is increased, and the amplification in the tube is reduced. Thus, by reducing the input, danger of cross-talk interference is practically eliminated, and this favorable circumstance is aided by the increase of negative bias to keep the grid sufficiently negative at any and all settings of the control, and no matter how strong the signal, so long as there is some attenuation.

Then there is a limiting resistor, to prevent zero bias on the tube, and when the control is all the way over to the right, only that limiting resistor is in the bias circuit, and across the primary of the antenna coil there is in effect a fixed resistance of 10,000 ohms. The resistance network reaches ground through the antenna winding.

If the B voltage applied to the plates of the two r-f tubes is around 250 volts, the screen voltage will be around 90 volts, if the 50,000-ohm series resistor is used, as shown, between B plus and screen.

Meter Will Read Less

On the usual voltmeter, 1,000 ohms per volt, the screen voltage will read lower, because it is lower, when the meter is in circuit, say around 75 volts, but the actual voltage, meter removed, will be around 90 volts. The difference is due to the current through the meter.

Both of the r-f amplifiers are 58 tubes, and the detector is a 57. From plate of the detector to cathode of the same tube is a bypass condenser to keep radio frequencies out of the audio channel and improve the efficiency of the detector system. The plate load consists of two resistors, one of 0.5 meg., and the other of 0.25 meg., of which only the higher value is effective, as the lower one is bypassed by a large capacity (considering audio frequencies and the high resistance). This condenser and resistor combination serves as a hum filter, preventing hum from backing into the detector, where it would be a serious nuisance, because of the high detecting efficiency and the strong subsequent audio amplification.

The stopping condenser between the plate of the detector and the grid of the power tube is 0.01 mfd., which is large enough, if the grid leak is high, e.g., of the order of megohms. A value of 5.0 meg. has been found entirely suitable, if the negative bias is derived from part of the voltage drop in the B filter choke, as here. Ordinarily this value, 5.0 meg., would be too high, because for any condition of grid current flow the tube would suffer loss of bias, and the loss would be considerable if the resistance were of such a ratable magnitude. However, here as the signal increases, the negative bias also increases, and there is very little, if any, danger of grid current flowing.

The test for grid current may be made in the plate circuit, in the absence of a microammeter for the grid circuit, as the no-signal value of the plate current is measured, and should not be exceeded by 20 per cent. by any signal that is put into the tuner.

Three Hum Precautions

The grid circuit resistance is really a 5.25 meg. for direct current, as the 0.25 meg. in series with the 5.0 meg. has a condenser across it—two condensers in parallel, in fact, to constitute 0.2 mfd.—as a further precaution against hum. The third hum precaution is to try reversal of the connections to the primary of the output transformer.

The choke in the negative leg of the B supply, already mentioned, is a part of the speaker, comprising the speaker field, and the usual resistance for such a circuit is a total of 1,800 ohms, with a tap at 300 ohms from the intended ground end. This results in a negative bias of close to 20 volts under normal operating conditions, if grid return is made to the tap, and the nearer end of the choke (considered from the viewpoint of resistance) is connected to ground. Therefore B minus does not connect to ground in this circuit. Although the metal chassis is grounded, B minus goes to the opposite end of the choke than the grounded end. So, too, the electrolytic condenser next to the rectifier, that is, connected with positive side to the center-tap of the 5-volt winding, has negative going, not to chassis, which is grounded, but to B minus, which is negative in d-c voltage in respect to ground or chassis by the potential difference across the entire choke, roughly, 100 volts.

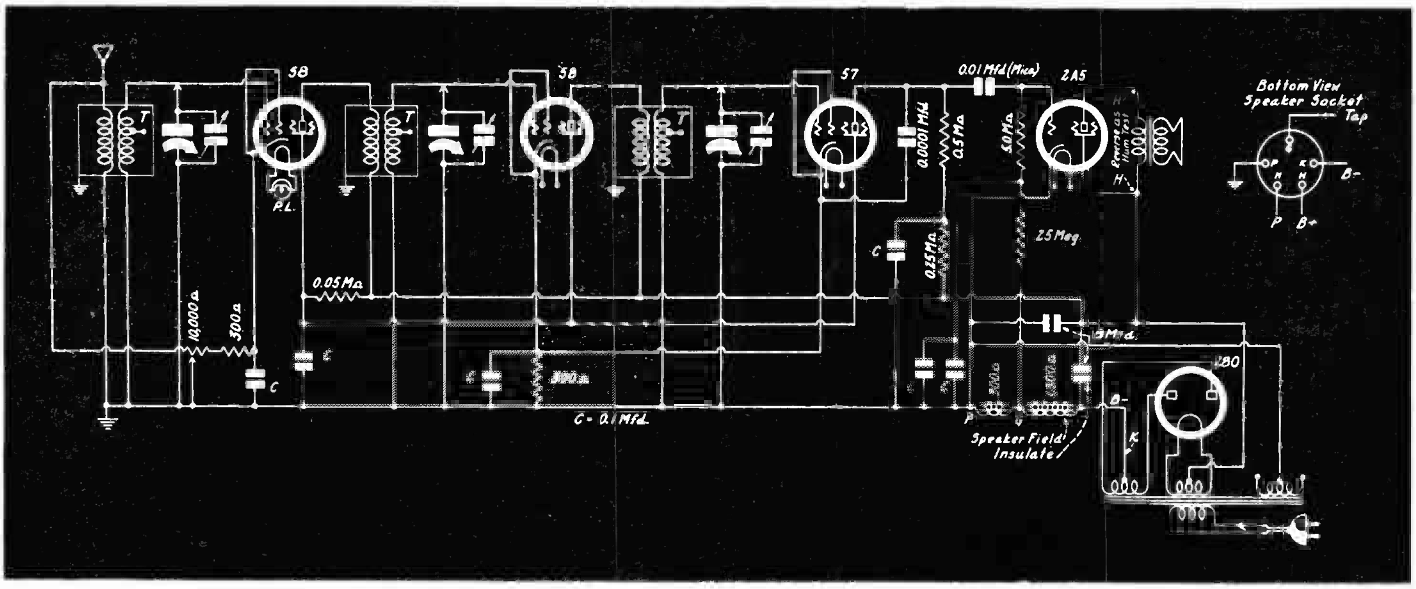
So the B voltage measured from rectifier filament to chassis or ground would be around 350 volts, and if 100 volts are dropped in the field winding, then 250 volts are left.

Full Voltage for Power Tube

This voltage is not completely available to the r-f tubes and detector, since the bias for those tubes, averaging 3 volts, say, is derived from the same source. But the power tube does get the full 250 volts, because the bias is taken from 20 volts of the 100 volts dropped in the choke. So the total direct voltage for the power tube is 270 volts, of which 20 are used for negative bias and 250 for positive plate and screen supply.

The effective plate voltage on the power tube will read around 220 volts (plate to tap), due to the drop occasioned by the d-c resist-

See Next Page for Architectural Blueprint of this Circuit



Circuit diagram of the dual-range tuned-radio frequency set, showing also the coil-switch connections, which are not included in Blueprint 632 on the next page, as the wiring would be confused in the blueprint. Connect the stators of the three sections of the tuning condenser to moving arm and the two other tabs for each switch section respectively to the extreme of the coil and the tap. Thus the condenser would be moved from across the total winding to across only a small part of the winding.

ance of the high-inductance primary winding of the output transformer.

The circuit comes in the class so simple to build that the novice may attempt it without any misgivings.

The speaker is connected, with its output transformer and field, through a plugged cable. The plug is of the five-contact type (UY) and the code for the usual run of speakers is as shown on the circuit diagram and carried out on the blueprint on the back cover of this issue. Looking at the bottom of the speaker socket in the receiver, with heaters, the thick prongs, toward you, right-hand heater is B plus and connects to center of the 5-volt winding; left-hand heater goes to plate of the power tube; the next spring, going from right to left, which would be the plate in a 56 tube, is connected to ground; the conventional grid position is for the tap, and B minus goes to a cathode.

Resistance Measurement

Any doubt as to the speaker field may be resolved by resistance measurement. Also, in connection with the power transformer, at least the high-voltage winding may be distinguished from the two low-voltage windings because the resistance is relatively high, a few hundred ohms perhaps, while the primary may be distinguished because its resistance value lies between that for the high-voltage winding and that for either of the two filaments, which usually read as a "short circuit."

The total B drain of the receiver is around 60 milliamperes. The heater voltage for the r-f and detector tubes, as well as for the power tube, is 2.5 volts, and the same winding may be used for all four tubes, as is actually done. This is because all heaters are grounded at midpoint. The 5-volt winding has a center tap, so three of the four windings, in other words all secondaries, are center-tapped. But if you have a transformer with no such tap on the 5-volt winding, simply connect to one side of the filament, a completely satisfactory method.

Such a circuit is usually built with commercially-made radio-frequency transformers, and all three transformers may be alike. They are enclosed in aluminum shields, 2 1/16 inches outside diameter, 2 1/2 inches high.

Coil-Winding Information

Those who desire to wind the coils themselves, for tuning with 0.00035 mfd. condensers, may get 1-inch diameter tubing, about 2 inches high, and put on the secondary first. This consists of 127 turns of No. 32 enamel wire, close wound. The inductance thus achieved is sufficient to strike 540 kc. and if the trimming condensers are not turned down too far, the other extreme may be 1,620 kc. as the condenser will yield a frequency ratio of 3 to 1.

However, the full 127 turns are not put on without interruption, as the tap has to be considered. This is located at 22 turns from the ground end. Therefore wind 105 turns, pierce the form, bring out the tap, and put on the remaining 22 turns.

The primary is wound over the secondary, with 0.02-inch insulation between. If nothing better is at hand, use three layers of wrapping paper. Preferably two layers of empire cloth should be used. The primary may be of any kind of wire, and is usually fine, consisting of 20 turns.

When the coil is finshed and mounted the grid terminal of the secondary winding is at top, grounded terminal at bottom, tap in between, and primary is a bit nearer the grounded end rather than centered on the secondary.

(The blueprint of the circuit is on the next page)

LIST OF PARTS

Coils

Three shielded radio-frequency transformers, with tapped secondaries.
One output transformer and one field coil, built into speaker specified later.
One power transformer with primary and following secondaries: 2.5 volts, 5 volts and 350-350 volts, all secondaries center-tapped.

Condensers

One three-gang tuning condenser, 0.00035 mfd., with trimmers built in.
Two blocks, each containing three 0.1 mfd., or any other number of blocks or individual condensers to yield six 0.1 mfd.
Two 8 mfd. electrolytic condensers. (Be careful to insulate from the chassis the 8 mfd. condenser next to the rectifier).
One 0.01 mfd. mica condenser.
One 0.0001 mfd. mica condenser.

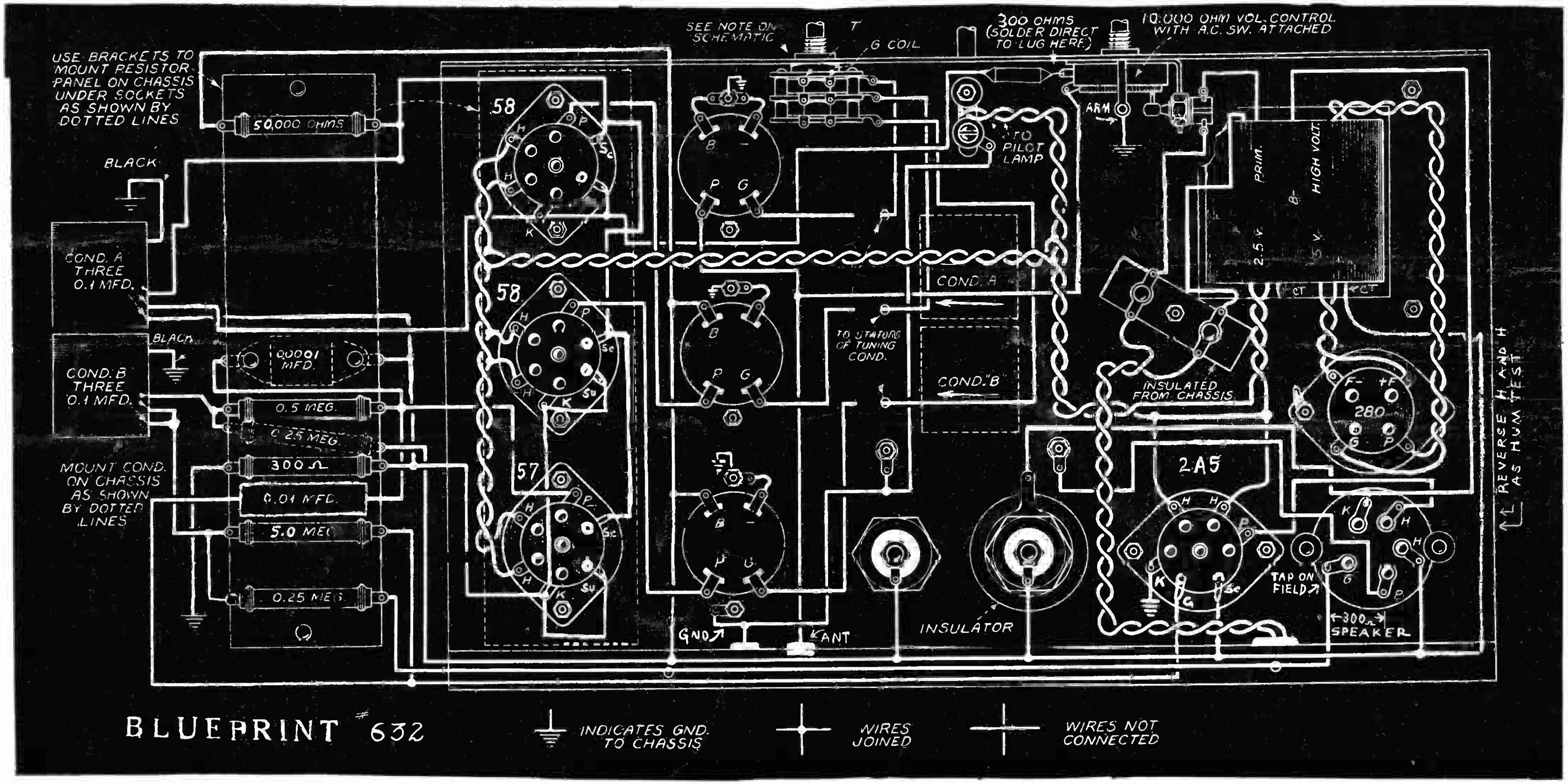
Resistors

One 20,000-ohm wire-wound potentiometer, with switch attached.
Two 300-ohm pigtail resistors.
Two 0.25-meg. pigtail resistors.
One 0.5-meg. pigtail resistor.
One 5.0-meg. pigtail resistor.
(The pigtail resistors may be of 1-watt or even ½-watt rating.)

Other Requirements

One drilled chassis, 13¾ x 9 x 2.5 inches.
One vernier dial, with escutcheon and pilot lamp and bracket.
One dynamic speaker with transformer built in for single pentode output; also field coil built in, 1,800 ohms, tapped at 300 ohms, and equipped with a five-foot five-lead cable, terminated at a UY plug.
Three grid clips.
One coil switch, three-pole, double-throw.
Three knobs (one for coil switch, one for potentiometer and one for dial).
One UX socket, one UY socket and four six-hole sockets.
Three tube shields for 58's and 57.
Tubes: two type 58, one type 57, one type 2A5 and one type 80.

Blueprint of Wiring 632 Dual-Range T-R-F Set



The wiring is complete, except for the wave-band switch, concerning which details will be found in the circuit diagram on preceding page, and in the text.