SHORT-WAVE WORLD LIST OF PROGRAM AND POLICE TRANSMITTERS

RADIO WORLD

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The First National Radio Weekly

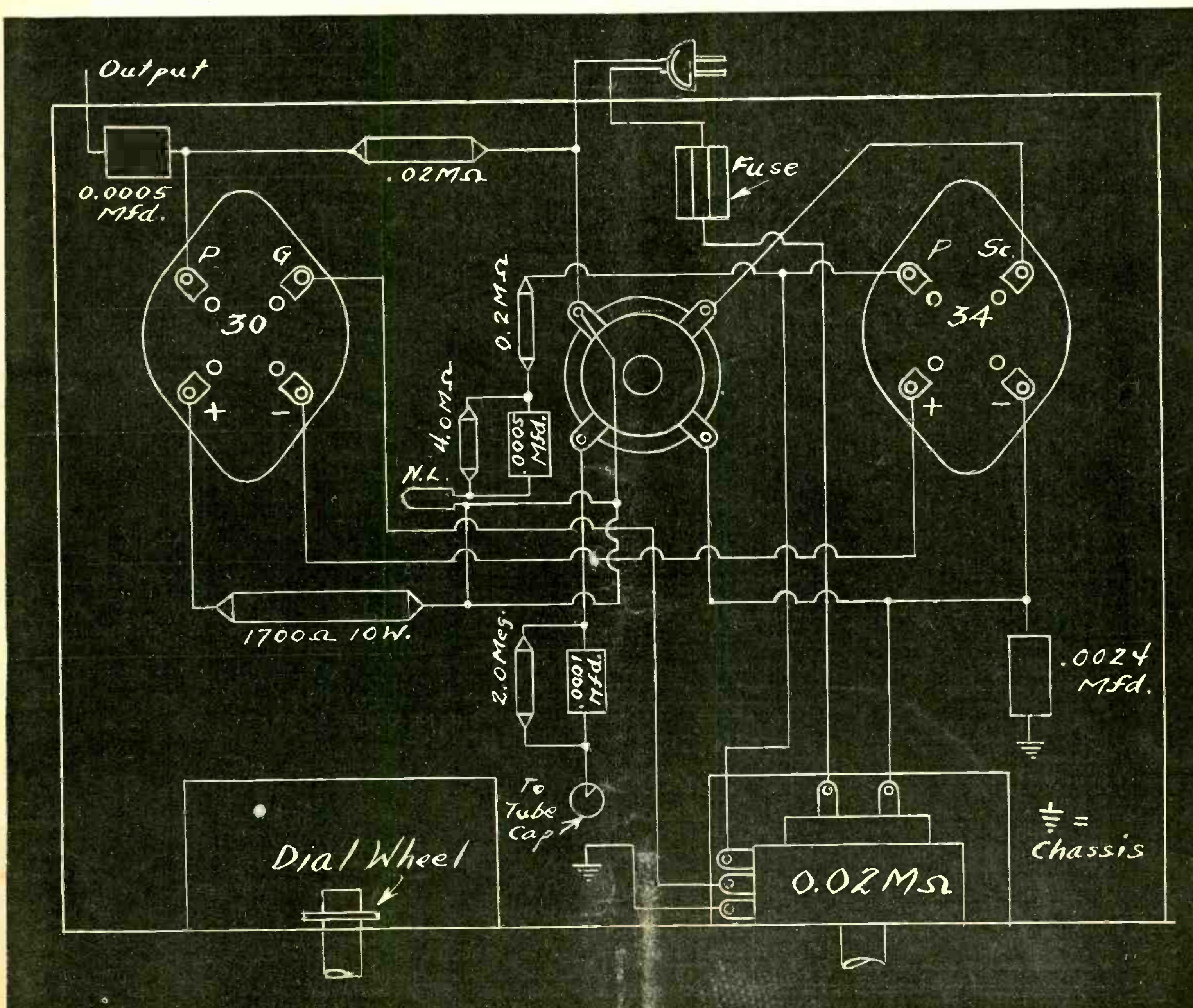
653rd Consecutive Issue—Thirteenth Year

High Frequencies Used for Killing Insects

How to Become an Harmonic Detective

Pictures Replace Morse Code in Micro-Wave Messages

Sept. 29th 1934 15c Per Copy



Architectural drawing of the circuit of the 334-A Signal Generator.

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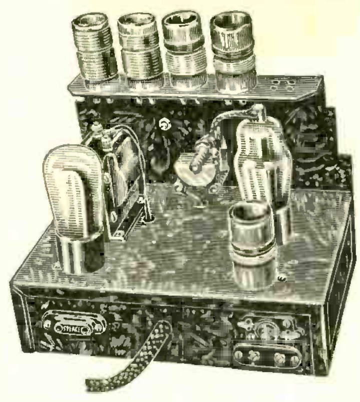

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Wired and tested .... **1.50 extra**
Set of RCA licensed tubes **1.40**

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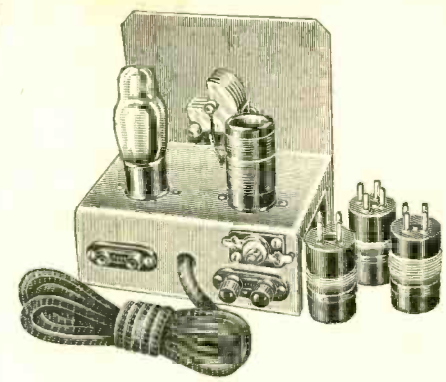

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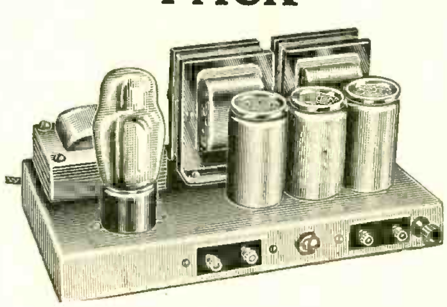

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By EDWARD M. SHIEPE, B.S., M.E.E.

THE ONLY BOOK OF ITS KIND IN THE WORLD. "The Inductance Authority" entirely dispenses with any and all computation for the construction of solenoid coils for tuning with variable or fixed condensers of any capacity, covering from ultra frequencies to the borderline of audio frequencies. All one has to do is to read the charts. Accuracy to 1 per cent. may be attained. It is the first time that any system dispensing with computation has achieved such very high accuracy and at the same time covered such a wide band of frequencies.

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From the tri-relationship chart (either one), the required inductance value is read, since frequency and capacity are known by the consultant. The size and insulation of wire, as well as the diameter of the tubing on which the coil is to be wound, are selected by the user, and by referring to turns charts for such wires the number of turns on a particular diameter for the desired inductance is ascertained.

There are thirty-eight charts, of which thirty-six cover the numbers of turns and inductive results for the various wire sizes used in commercial practice (Nos. 14 to 32), as well as the different types of covering (single silk, double silk, single cotton, double cotton and enamel) and diameters of ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½, 1¾, 2, 2¼, 2½, 2¾ and 3 inches.

EACH turns chart for a given wire has a separate curve for each of the thirteen form diameters.

The two other charts are the tri-relationship one and a frequency-ratio chart, which gives the frequency ratio of tuning with any inductance, when using any condenser the maximum and minimum capacities of which are known.

The book contains all the necessary information to give the final word on coil construction to service men engaged in replacement work, home experimenters, short-wave enthusiasts, amateurs, engineers, teachers, students, etc.

There are ten pages of textual discussion by Mr. Shiepe, graduate of the Massachusetts Institute of Technology and of the Polytechnic Institute of Brooklyn, in which the considerations for accuracy in attaining inductive values are set forth. These include original methods.

The curves are for close-wound inductances, but the text includes information on correction factors for use of spaced winding, as well as for inclusion of the coils in shields. The book therefore covers the field fully and surpasses in its accuracy any and all mechanical aids to obtaining inductance values.

The publisher considers this the most useful and practical book so far published in the radio field, in that it dispenses with the great amount of computation otherwise necessary for obtaining inductance values, and disposes of the problem with speed that sacrifices no accuracy.

The book has a flexible colored cover, the page size is 9 x 12 inches and the legibility of all curves (black lines on white field) is excellent.

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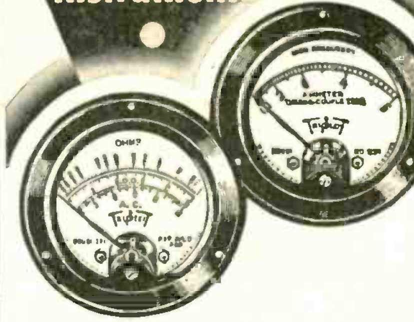

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REG.U.S.PAT.OFF
The First National Radio Weekly
THIRTEENTH YEAR

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Insects As Tuned Circuits

Their Communication System Suggests Resonance—Killing Pests with High Frequencies Adds to the Evidence

By Herman Bernard

RADIO serves not only the purposes of entertainment but it is also important in police work. By police work is not meant simply catching criminals or punishing them but all activities of the government or private agencies concerning the protection of life and property. Thus there are medical devices that are radio-operated, such as the fever machine, where high frequencies are impressed on two plates, and a locally infected part of the patient's body is subjected to the current flowing between these plates, to produce a synthetic fever, for its curative values, without resorting to the former dangerous medical practice of having the fever permeate the whole body.

With the improvement in high-frequency technique it is certain that the police services of radio will be greatly extended. Indeed, besides police work, or health work, there are activities that interest psychologists, so that machines are made to perform activities that somewhat simulate those of animals subjected to training. This type of instrument is called a thinking machine, and it is based on the constant repetition of a certain operation, whereby the machine follows that operation more closely than it did before the repetitions were tediously practised. These reactions of the machines—and they are radio devices—are called reflexes.

Consider the Dog

The word has nothing whatever to do with the reflex type circuit with which technically-minded radioists are familiar. The reflex is the reaction from stimulalation. The psychologists are most interested in the effect of such stimulations as habit and training, and the association of certain sights and smells with the time and requirement of habitual acts.

There are, of course, many natural reflexes, called unconditioned because not produced with any deliberate external intention, but then too there are reflexes that are purposely built up. These are called conditioned reflexes. As an example, consider a dog that has been in the habit of being served his food at his master's meal time. The object is to change that habit. Instead, the dog's meal is delayed each day, until after the master has finished, and has left the house unknown to the dog. Then a bell is rung and the dog is permitted to run to his filled plate. (This assumes a dude house where the dog does eat from a plate). Finally the dog is watched carefully and after months, if the bell is rung, and he is then not permitted to enter the house at once, his mouth will begin to water. He is all set to eat now and acts the part. But a few months before his mouth never watered when any bell was run. Result: a conditioned reflex.

Future in High Frequencies

Now, machines are built to behave somewhat after the same pattern, and while to call them thinking machines is to stretch the point a bit, at least the phrase is an attractive one, and it indicates what the psychologists have in mind when they construct an electrical device that enables them to show a class what they mean by a conditioned reflex, without waiting months to train a dog.

Later on, no doubt, unsuspected avenues of vital traffic for radio waves will come into common use, and may have to be turned indeed into one-way streets on account of the congestion. The high frequencies lend the attraction, for there is more in them than we know of for a certainty, and no year goes by without some almost startling discovery of the peculiarities, adaptabilities and useful purposes of high frequencies—meaning certainly frequencies above 30 mgc, far above, in most instances (much below 10 meters).

It is to be expected that the secret of insect communication will be revealed some day due to high-frequency experiments. Insects that have what children call feelers sticking out of their faces are quite familiar, and entomologists will refer to the feeler as an antenna, which is where our radio word came from. But when the borrowing was done, the significance did not fully attach, and since the borrowing we have come to suspect that these antennas of insects are indeed antennas of a radio nature! That is, they are the means of radiating the message from insect to insect. And we thought radio new, as the life of this planet goes.

Will Secret Come Soon?

That there is some form of insect communication not audible to human ears is certain. So many experiments have been performed, with proof of this assertion, such as bottling insects so they could not see one another, yet noting behavior that could be ascribed only to communication, that we must expect soon to learn the secret of this communication.

It is hard to imagine that the insects have a code of communication, but it would be hard to imagine they had a code of life, if we did not know they have one. And as soon as we start thinking about insect communication systems, and remember that communication may be limited to hundreds of yards, and when we inspect the electrical dimensions of the insect, we are bound to respect the supposition that ultra frequencies of transmission are used. The insects generate the electrical current in their own bodies —not at all surprising, when one remembers that a firefly generates heatless light that man hasn't yet duplicated—and radiate the electrical current into space, modulating it with their message.

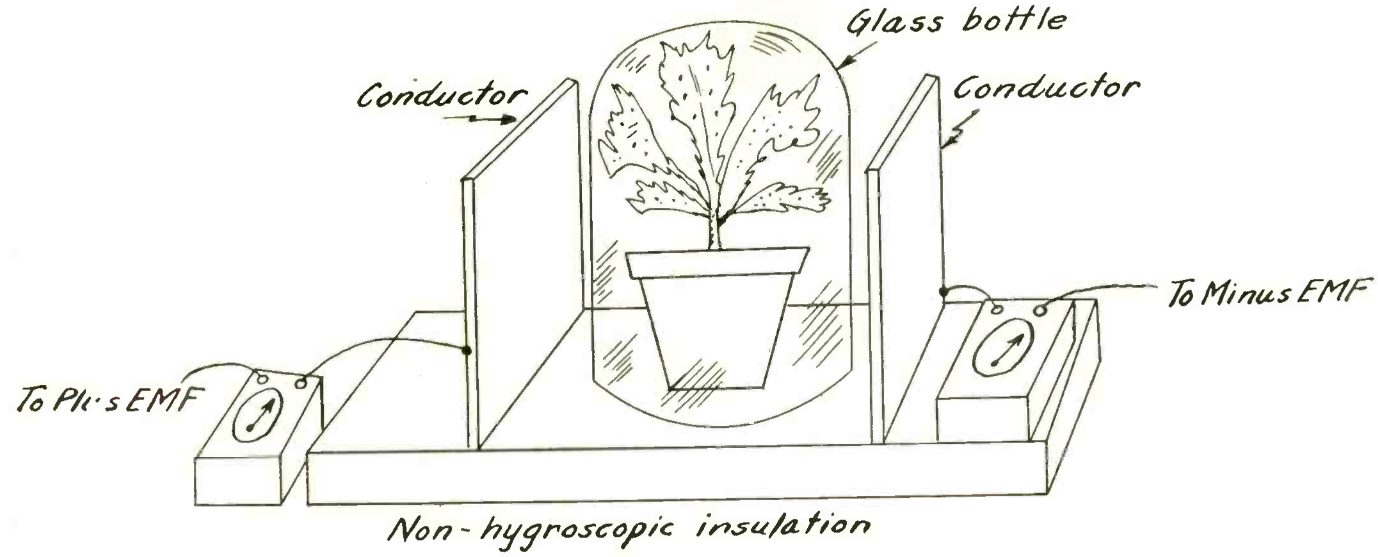
The cricket, for instance, is a direct sound radiator, and unimportant perhaps in connection with the radio-frequency insect group, yet impelling one to marvel that the chirps are so uniform that they may be used as a standard of frequency of an accuracy greater than that of the 60-cycle current of the house line. So room must be reserved for the revelation of more and greater wonders.

The Likely Answer

If it be imagined that his discussion is quite too fantastic, what should be said of the fact that high-frequency currents are used to kill insect pests, yet leaving the plants unharmed, although currents pass through the plants also?

The status of electrical dimension figures, no doubt, in this feat as well. For

Micro Waves Annihilate Parasites But Leave the Host Unharmed



Insects were killed in a high-frequency experiment, but the plant on which they lived was unharmed, and a bottle containing both stayed cool. The dead insects were warm to the touch. E.m.f. left and right represents instantaneous polarities of input to condenser plates.

instance, why should a high frequency kill an insect and leave a plant unharmed? Can you supply a good suppository reason? Why does a great deal of current circulate in a tuned circuit external to a generator, while hardly any current circulates in an object a few feet away?

Yes, it seems to be most likely that the answer is: tuned circuit. That is the most efficient method of transmission and reception, hence if we inspect an insect and determine its electrical quantity, we shall find that its dimensions correspond, say, to that of a Marconi antenna with series feed, tuned to 16 mgc. Some radio scientists should investigate the natural frequencies of insect circuits and would no doubt find much of interest and importance.

How It Was Done

The radiation that leaves unharmed a plant that has a relatively low fundamental frequency of reception or deposit, naturally would strike a small living tuned circuit, such as an insect, and destroy the circuit by incineration or electrocution. If the tuning were close the destruction would be immediate, granting high enough voltage. If the insect were somewhat out of resonance, the same voltage might take longer to do the same trick, or greater voltage would have to be applied.

The Department of Entomology of the State of New Jersey has set up an experimental station in Rutgers University. Dr. Thomas J. Headlee, director of the work, erected a high-frequency transmitter, and fed the energy to two physically large (but electrically small) condenser plates. Between these plates the high-frequency current flowed, and in the field was placed an insect-infected plant. Yes, the insects died, but the plant lived.

The entomologist appreciates, more than does the layman, that man is embattled with the insect world, and that a pitiless warfare is now going on to determine which shall survive. The insects have much in their favor. However, man probably has at least as much, and the means of gaining a great deal more. At least he has more than held his own against the horde. Experiments and findings such as those of Dr. Headlee hold forth much hope for the ultimate triumph of the topmost branch of the animal kingdom against the nether branches.

Hot Insect, Cold Bottle

Beetles, moths, flies, bees, locusts and other insects were killed by high-frequency currents, and the doctor himself was perhaps a little surprised at the immediate success of his experiment. In some experiments the plant had been put in a bottle, and the waves left the bottle cool, but the dead insects were warm to the touch, warmer than they ever were in life. Also the doctor found out that certain frequencies are more favorable to killing different insects. That is just as any radioist who contemplated the effect of the electrical dimensions of insects would expect. And the doctor seems to be quite a radio technician on his own account.

Frequencies of 3 mgc or higher were required to kill bees, thus indicating that the structure of the bee is akin to an antenna responsive to a frequency of 30 mgc or higher. For every linear inch, 4,000 volts were applied.

It is not foregone that the plant will not be injured. As the frequency is increased to 16 or 20 mgc, the voltages must be kept within excellent check, the latitude being small, for excess voltage will kill the plant as well.

A Great Advantage

"At 3 mgc the safety margin of voltage is very wide," said Dr. Headlee, "but at 16 to 20 mgc the energy level that will kill insects is very narrow."

One of the great advantages of such a system as Dr. Headlee uses is that those insects that bury themselves in plants can be killed without injuring the plant, thus opening the way to the extermination, in given cases, of pests that otherwise could not be reached without causing the remedy to be worse than the ailment.

Charleston Police Use 2,490 kc, Crystal-Held

The newly installed 50-watt police transmitter after experimental operation in Charleston, West Va., by Desk Sgt. T. A. Bird of the Charleston Police Department, has been issued a license for permanent operation by the Federal Communications Commission. The station, known as WPHI, operates on the frequency of 2,490 kilocycles and with a 50-watt output rating has been found very reliable in covering the city which has a population of 65,000. Five cruising cars with receivers operated during the test gave perfect reception.

Of particular interest is the fact that there are no "dead spots" even though the transmitter is installed in the Police Headquarters in the city surrounded by rather high hills in each direction. The installation and preliminary tests were made by W. H. Jackson and J. L. Seibert, engineers of the Gamewell and Westinghouse companies.

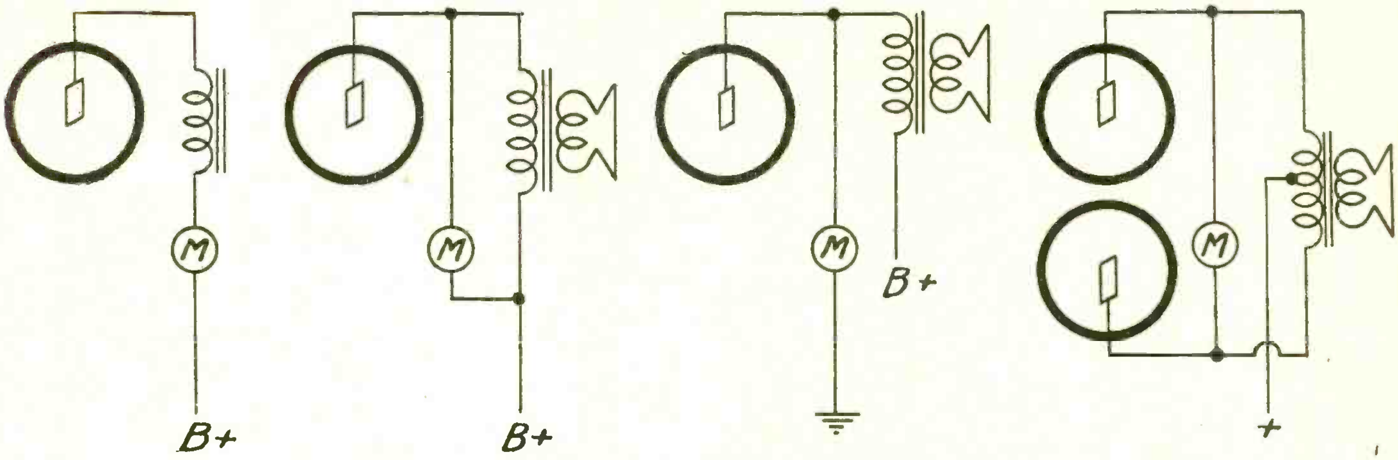
Sergeant Bird, A. W. Foster and Jules Waterloo, assisted by Fred Hammack and W. B. Ramsey, are official operators of the station. Their calls will be picked up on the very latest superheterodyne police radio receivers mounted in the five cruisings cars. Crystal control of the frequency at the transmitter insures stability of the wave so that no tuning of the receivers will be required as the cars patrol the city.

The crystal is clamped into a moisture-proof holder.

Removing Some Mysteries

From Signal-Generator Circuits

By Herman Bernard



Left to right, d-c meter in the detector circuit for unmodulated tests; an output meter at the power stage; again an output meter, returned to chassis; a push-pull stage with output meter in wrong place, for it ought to be from one plate to ground or across half the primary.

EVERY one either has a signal generator or has a desire or need for one. The instrument is of the utmost importance. It is absolutely impossible to perform satisfactory service work without a signal generator, or even to construct a receiver properly for one's own use, if it is to be a superheterodyne. All short-wave sets, for proper peaking and padding, require signal generators.

First let us find out what a signal generator is, how it is constructed, what are its capabilities and limitations, and then how it is used.

A signal generator is the same as a service oscillator or test oscillator, also sometimes called an industrial oscillator. An oscillator is a non-rotary generator of alternating current. A signal generator is then a non-rotary generator of alternating current that has a signal impressed on it. This signal is commonly called the modulation. It consists of a steady audio tone, often around 1,000 cycles, which is introduced into the radio-frequency generator, to vary the radio-frequency output at the frequency of the modulation. In battery-operated devices particularly it is usual to have means of removing the modulation at will. That comes in handy for zero-beating, which consists of setting the generator to produce a frequency exactly the same as that of some standard of frequency, as a broadcasting station, or using an harmonic of the generator for beating with the standard.

A Small Transmitter

Now we know what a signal generator is. Let us ascertain what it does.

Taking the unmodulated form first, the signal generator will emit what is practically a sinusoidal wave form, if intentionally circuited to do so, and this output is used as input to a receiver. The connection may be made to the antenna input of a set, or to the intermediate channel, or to another oscillator for beat-note reception, but in any event the instrument producing the frequency is the generator, and the other is the receiver, even if the receiver is oscillatory or regenerative. The difference between oscillation and regeneration is that oscillation consists of emitting alternating currents and regeneration consists of introducing a lesser amount of feedback, to reinforce the amplitude of the grid circuit, but not to the point where generation takes place.

Therefore the generator is a small broadcasting station, at the moment sending out only the carrier. There is no modulation. Nor is it imperative that there be modulation, for if a meter is put in series with the real detector of a receiver, meaning the detector of a t-r-f set or the second detector of a superheterodyne, then the plate current will rise or fall when the generator's output is delivered to the receiver.

At least there will be a change, and maximum change of the needle position will denote resonance of the receiver with the transmission frequency of the generator.

Thus by visual indication we can ascertain when peaking is accomplished. Even a lamp could be lit by this method. But audibility is denied, and as many prefer audibility, a sound is introduced into the radio-frequency oscillator, and when detection takes place in the receiver, so that the carrier is eliminated, the sound remains, and may be heard in any proper acoustic device or transducer. Earphones or speaker would be examples.

Wobbly Readings

Although visual indication arises when there is no modulation, and there is no acoustic response, when there is modulation visual indication may be used nevertheless. This is quite familiar in the example of the output meter. Lacking that, a neon lamp could be used at the output, and if the lamp has limiting resistor, the connection could be made even from power tube plate to chassis. However, the d-c voltage then is high enough to light the lamp, and therefore the modulation will not increase the illumination a great deal, but if the lamp is put across the primary of an output transformer, then at no signal there would be no illumination, and only the signal current or voltage would light the lamp. In the case of the neon lamp it is probably preferable to refer to the current, since the lamp is called a current-operated-device.

It is true of course that complex modulation, such as speech and music, would light the lamp, also, but then the lamp goes on and off, the illumination is erratic, and the purpose intended to be served, that of disclosing resonance, is far from satisfactorily fulfilled. But a steady tone, such as is present in the modulation of signal generators, gives a steady glow, unless the audio oscillator is very unstable, when the wobble is communicated to the lighting system, and we have about the same state of affairs as with complex modulation. Increasing the frequency of modulation then would be of assistance, if that is practical. In some special instances it can not be done.

Harmonic Situation

The signal generator is constructed as a tuned circuit associated with a vacuum tube, with a variable condenser connected across a fixed coil. Feedback is introduced from plate to grid. The frequency of generation is altered by changing the capacity of the tuning condenser. If only one band is covered fundamentally, only one coil is used. If more than one band are to be covered, then the coils must be changed, either by plugging-in or by switching.

If the signal generator is to cover only one band, and yet is to render service for frequencies higher than the fundamental, it is advisable that the frequency ratio be 2 to 1. If the fundamental is 100 to 200 kc, and if one desired to measure any higher frequency, using harmonics of the signal generator's fundamental, that could be done, for any higher number would be a whole-number multiple of 100 to 200 inclusive. But if the fundamental were 100 to 150 kc, then from above 300 kc to, say, 399 kc, no measurement could be made, because the second harmonic would be needed, and there would be no required fundamental. The fundamental range, 301/2 to 399/2 would be missing, e.g., 150.5 to 199.5 kc. Thereafter no trouble would be encountered, because the third harmonics would be sufficient for the next band, the fourth for the next, etc., and because the higher the unknown measured frequency, the less frequency ratio required of the signal generator's fundamental, because different harmonic orders then can be considered.

Hard to Measure

Harmonics are ever present in oscillators. It is practical to limit them, even unto making the second harmonic so weak that it would not be troublesome in a circuit where the second harmonic content of 5 per cent. would be undesirable. However, most generators do have strong early harmonics, at least to the fourth. The second harmonic usually has a strength equal to about 71 per cent. of the fundamental, and the reduction is sharp until a medium order harmonic is reached, say, sixth to eighth, when the difference in the intensities of the harmonics becomes very small indeed, and that between the tenth and the fiftieth harmonics might be so very small that practically nobody, unless he maintained a precision laboratory, could measure the difference. Vacuum-tube voltmeters do not measure it under the specified circumstances.

It might be imagined that, since the decline in the amplitude of the harmonics is rapid, and that soon such a low value of harmonic voltage is present that it is hard to measure, that the harmonics would be of small use. And yet they are immensely useful, and all scientific laboratories dealing with frequency measurements use harmonics, and depend on them, for in that way enormous ranges of unknown higher or lower frequencies may be determined. The Bureau of Standards has a mimeographed circular giving in closest imaginable detail the directions for using its standard frequency transmission of 5,000 kc for measurements of that frequency and of harmonics and subharmonics.

Generator Frequency

The generator itself sends out a frequency very closely equal to that of the natural period of the circuit. That is, if the frequency is computed from the inductance and capacity of the tuned circuit, the generation will be of practically that frequency. A slight modification takes place due to a phase shift in the circuit, but this is ever so slight and is neglected in practically all instances. Besides, any calibration made of the signal generator with a standard comprehends that phase shift, which is thus a part of the calibration, hence the natural period is itself not academically controlling.

The stability of the thermionic generator is exceptionally good, under conditions not difficult to satisfy, if one will avoid the unstable type, the dynatron. Stability means that when the tube is made to generate a particular frequency it continues to generate that frequency, while in use, and does not shift to other frequencies of generation.

If there is a shift it may be slow, when it is called a drift, or it may be quick, when it is called a flick. Changes that take place in circuit constants over long periods, due to meteorological conditions, vibration, etc., must not be ascribed to the tube. The generator may be stable indeed through the frequency it generates next year is not quite the same as the one it generates to-day, when the reason for the change might be, say, that some one pressed the turns of wire on the coil closer together, or moisture got into the form on which the coil is wound, or the tuning condenser plates have a smaller air-gap, because the instrument has been moved to a tropical country and the metal plates have become expanded by the heat.

The Disturbance

The test of whether the signal generator is stable is this: the tube must be made to behave like a pure resistance for establishment of stability. A pure resistance is nothing but resistance—no inductance, no capacity. In all instances the test is simply applied, if a bypassed current meter is put in the plate circuit of the generator. The meter should be of the low resistance type, not more than 50 ohms, less than 30 ohms, if possible. Then if the needle stands still as the signal generator is tuned from maximum to minimum capacity, or if the needle stands practically still, the generator is stable. This is true because all factors that disturb stability will disturb the plate current, or, the plate current is an infallible index of the behavior of the tube.

We are familiar with the curves of vacuum tubes, with grid voltage plotted against plate current, or plate current against plate voltage. Over some part of the curve the line is what is called straight. Near the extremes the bends take place. These bends are called curvatures, and the curve itself, even though it be a straight line, is called the characteristic.

Harmonic Frequencies

Now, over the straight portion the harmonic content is very low, over the curved portion the harmonic content is very high, and since it is possible to have a wide-swing oscillator, part of the cyclic operation would be over the straight portion and part over the curved portions, hence unless the amplitude is strictly limited, there will be an abundance of harmonics.

We have found that the frequency of generation is practically but not exactly the same as the natural period of the circuit. In that connection we have purposely omitted a consideration of resistance, although resistance has an effect on frequency, too. Besides, if the frequency is high, the distributed capacity of the resistance becomes a functional component of frequency. It is possible to measure the frequency effect of the resistance even at low frequencies, and of course at high ones when distributed capacity of the resistance becomes more noticeably effective.

If a series resistance is put in the plate circuit of an oscillator the frequency is lowered; if the grid leak resistance is increased, without any change in the grid-condenser capacity, the frequency is increased; if the plate circuit resistor is bypassed, the frequency is lowered still more, and the greater the bypass capacity the greater the reduction in frequency. Therefore for the establishment of any fixed ratios, as to coincide a generator with a pre-calibrated scale, resistance may be used for its effect on frequency, and resistor-trimming done at the high-frequency end.

Working Toward Accuracy

Likewise grid leak selection will serve, only the change is in the opposite direction.

Experimenters often wonder why some generator fails to establish the desired or expected frequency ratio. Coil shields, tube element capacities and the like are considered more often than the resistance factors just noted, yet a 32 tube, which normally will not track a dial calibrated for a 34 tube, was made to do so by the grid-leak resistance method. Commercial instruments advertised as having 1 per cent. accuracy actually leave laboratories under conditions of ¼ per cent. accuracy, when resistance adjustments have been made as suggested herewith.

Where harmonics are to be used it is very important that the calibration be right, because many unknowns will be determined on the basis of consideration of that calibration in more ways than one. This does not mean in any sense that the accuracy changes. If there is 1 per cent. accuracy on the fundamental there is 1 per cent. accuracy on all harmonics, for the harmonics are related to the fundamentals exactly on the basis of integral multiples, with a slight exception to be ignored unless precision to a degree better than 0.05 per cent. is required. This is never needed in servicing. An accuracy of 1 per cent., only one-twentieth as much, is quite sufficient.

Kind Word for Harmonics

Some technical writers have set forth that harmonic methods are not quite as satisfactory as fundamental methods, because of the multiplication factor. But the percentage of accuracy is not changed at all by the multiplication, and only the percentage counts. The absolute frequency divergence between the true unknown frequency and the measurement of that frequency has no meaning in an harmonic system. For any meaning to be ascribed to it a fantastic condition would have to exist whereby ascending orders of accuracy are established for ascending orders of frequency, using the harmonics of a given fundamental range.

What was meant, probably, is that operation on the fundamental alone is preferable because less confusing. That would mean band shifting. It is doubtful whether it is better. Perhaps it is true to say that one method is as good as the other. Harmonics often are condemned as confusing because their accurate use proves too much to the denouncer. Not enough information has been imparted about harmonics. Certainly it can not be maintained that high frequencies are as easily stabilized as low ones, or that the many factors introducing great losses at high frequencies produce equivalent losses at low frequencies. So, all told, the harmonics become more reliable in a sense than high-frequency fundamentals. Call it a toss-up between harmonics and fundamentals. Both systems may be used. Harmonics enable the production of less costly instruments of just as reliable and accurate service.

Identification of Harmonics

The relationship of harmonics has not been given much notice in the learned technical journals in the radio field, but rather more attention has been paid to harmonic relationships in acoustical, musical and optical fields, and in motor-generator practice. An optical harmonic counter familiar to most radioists is the stroboscope.

There are several methods of indentifying harmonics as to their order, once the fundamental frequencies used as references are accurately known. One method is that of working the signal generator into a higher-frequency receiver, establishing a response in the receiver from the generator, noting that frequency of the generator, then turning the signal generator dial in either direction and noting the frequency of the ensuing response, the receiver meanwhile unmolested. The unknown frequency is the product of the two frequencies read, divided by the difference between these two frequencies.

For any low-frequency system used for determining higher-frequency unknowns by the harmonic method, a general check may be made if the frequencies are calibrated 1 kc apart by noting when the

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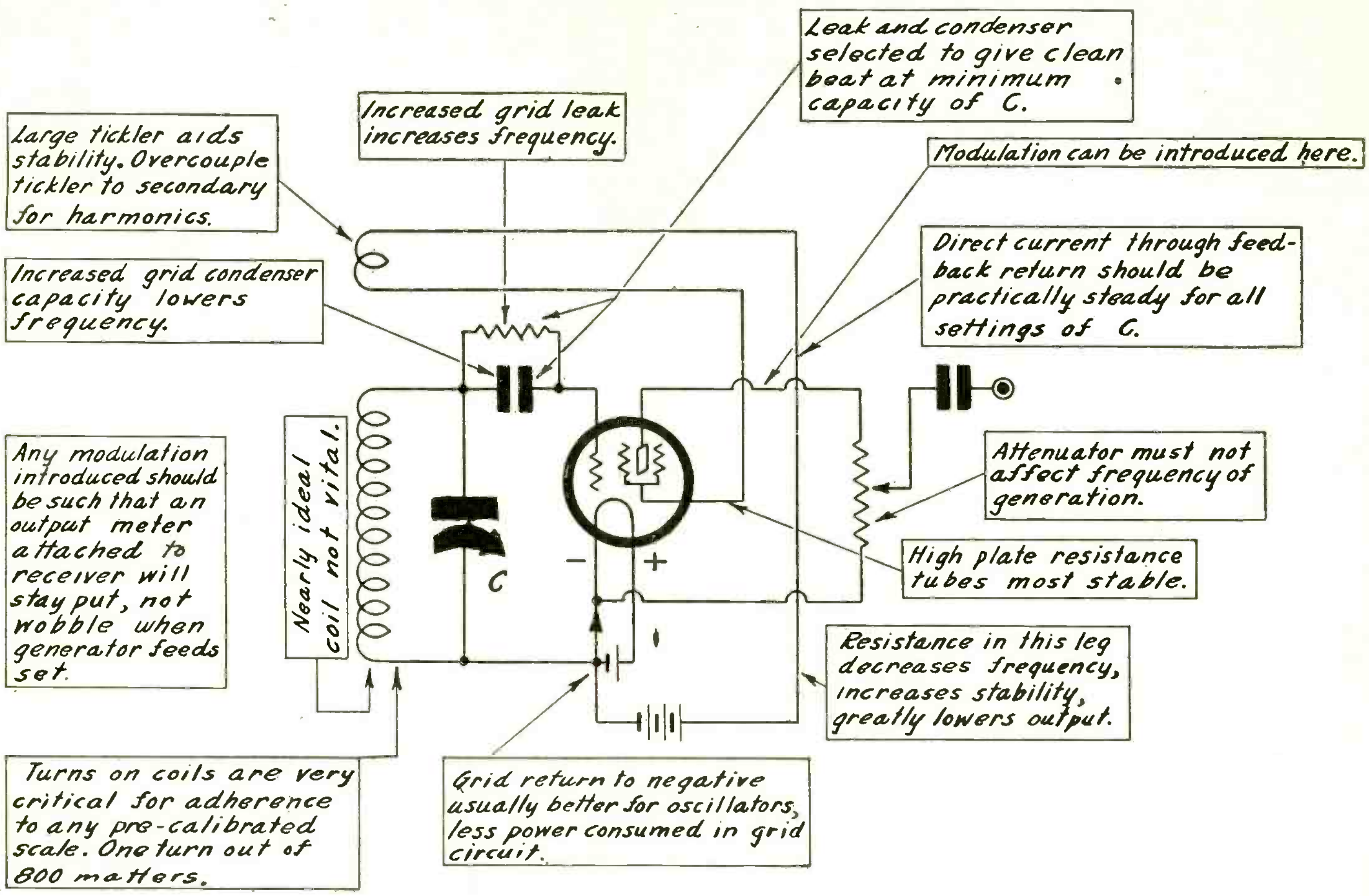

Some of the important factors concerning a signal generator. The freedom from detuning effects by the attenuator is due to electron coupling.

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responses fall exactly on consecutive bars.

Simplification of Operation

Generally the unknown frequency is known at least as to its general region, hence the approximate positions for testing are ascertained, and one need not run through the dial, checking one of 100 bars against 99 bars, but can check from the table, such as the one printed last week for 100-200 kc (page 9, September 22nd issue). For such adjacent-bar conditions, since the difference is 1 kc, instead of three processes there is only one operation, that of multiplication of the two frequencies read. The difference need not be considered, as it is 1 and does not change the result, nor need the division be made, because the divisor is 1. Any who have or will construct or buy a signal generator calibrated in 1 kc differences can obtain the frequencies for any fundamental range by such multiplication. Incidentally, the system works out very well on the basis of close differences, as between 100 and 101 kc fundamental and 101 and 102 kc fundamental the difference is 0.2 mgc in the unknowns, (10.3 — 10.1 = 0.2 mgc.) while at 20 mgc the difference is 0.25 mgc, approximately, and at nearly 40 mgc the difference is 0.4 mgc. These absolute differences refer to the steps in which the unknowns are read, and to reduce them to percentages, the jumps at the extremes are: 10 mgc region, 0.03 per cent., and 40 mgc region, 0.01 per cent. That is, the percentage difference decreases as the frequencies of the unknown increase, provided that the fundamentals used for higher frequencies of unknowns are themselves higher than the fundamentals used for lower-frequency unknowns. This is one of the few examples in harmonic technique when the ratio becomes more favorable the higher the frequency, and is the author's adaptation.

Numerous Responses

It naturally follows that for unknown frequencies substantially higher than the fundamental (order of ten times or more), that the responses become numerous when the generator is variably tuned and the receiver remains undisturbed. The higher the unknown, the closer together are the tuning points on the generator that occasion the responses, so some general idea of the frequency region of the unknown may be obtained from this test, and to some absolute approximation if the generator has a straight frequency tuning characteristic, or nearly so.

Since the closer together the tuning spots on the generator, the higher the unknown frequency, the general region, or harmonic order, may be sensed by the resultant factor when one frequency read is divided into the next higher frequency read as the generator dial is turned while the receiver is not changed any.

Amplifier Stage

The 100-200 kc fundamental coverage, with 1 kc calibration separation, also discloses the harmonic order, from the table; that is, the harmonic order of one fundamental is the frequency read for the next fundamental. So for 100 kc and 101 kc as the two frequencies read on the generator, the unknown is 10.1 mgc, and for 100 kc the harmonic order is the 101st and for 101 it is the 100th. Therefore the second response gives the harmonic order of the first response, if the adjacent responses fall evenly on adjacent kc bars.

Besides, for relatively low orders, say up to the fifth or even eighth harmonic, factors may be used mentally for getting a bearing, or even for doing better than that, by dividing the lower of adjacent frequencies read, into the higher frequency read, to ascertain the harmonic order of either. Third harmonic divided into fourth harmonic, for instance, will give a ratio of 1.33.

Probably the harmonics keep right on going, but this is a theoretical aspect, like that of radio waves, once transmitted, never ceasing to travel their way throughout eternity. Try to pick up a radio wave sent out only yesterday. So try to use a very high harmonic order on a plain receiver. For use with receivers, where high-order harmonics are to be relied on, the oscillator should be made to generate rich harmonics, usually accomplished by having a grid current type oscillator, or an overbiased oscillator operating at the negative extreme near cutoff. And as this may not be enough, an amplifier stage is now becoming very popular, especially as it also adds still another advantage: further removal of the generator itself from the effect of the load (measured) circuit.

If the receiver is oscillatory the harmonics of the calibrated generator can be detected readily, even into orders of the hundreds. The Bureau of Standards, in reference to its harmonic circular on the frequency transmissions, quite casually mentions the use of a 50th harmonic, and indeed orders well up in the hundreds are used, especially when mechanical systems serve as standards that can be counted directly, and the operation is from such a low frequency to produce radio frequencies, harmonically. To get near radio frequencies the minimum harmonic would be about the 100th, and you see mention of the 287th harmonic, 295th harmonic, etc., in special treatises on acoustical frequency multiplication for radio use.

Frequency Stability

Where harmonics are to be used, especially to a high order, the value of frequency stability becomes more pronounced, not because the percentage accuracy changes, for, as pointed out, the same percentage prevails throughout, but because the instability makes the spotting of the unknown frequency more difficult. If something that changes a little at a low frequency is multiplied, so that the change is increased exactly in the same proportion, these changes can be detected sharply at the higher frequencies being measured, though not at the original fundamental low frequencies.

The introduction of some special form of stabilization is therefore valuable in any generator of the harmonic type. Fortunately, if the tickler is made larger than for ordinary purposes, and the tickler is overcoupled to the grid circuit, the stability improves. This follows from the fact that the stability is best when the coupling is unity. It also follows from the fact that the larger the tickler, the closer does it become to being a choke that actually stops oscillation. Of course a tickler so greatly oversized would be reduced in its inductance until there was oscillation at the highest frequency intended. Just a few turns off often restores this condition of all-pervading oscillation. Then the tickler does continue to act as a damper on higher frequencies of any band, but this is the very region in which the circuit tends to be most oscillatory anyway, and therefore the amplitude-levelling effect is aided.

Amplitude Stability is Frequency Stability

That effect is the equivalent of stability. That is, if the amplitude is constant over the tuning range, the generator is stable. The constant amplitude was referred to indirectly in preceding remarks, where the plate current was read to determine really that amplitude in relative terms. The generator itself was used as a vacuum-tube voltmeter, uncalibrated, however, being merely a relatively indicator. Calibration could be introduced, but it would not serve much purpose. Measured amplitudes of fierce oscillators—Hartley type with 56 or similar tube—with tight coupling, at low frequencies showed amplitudes exceeding 100 volts. Small battery-operated generators developed amplitudes of 20 volts or so. It is quite possible in a fierce generator to have more grid current flowing than plate current.

The leak-condenser hookup is itself a stabilizing agency, particularly over the lower frequencies of tuning, that is, when much of the tuning capacity is in circuit. Near the minimum-capacity end there is a sharp rise in amplitude, usually, then after that, toward actual minimum, perhaps a drop. It is easy to explain the drop as due to insufficient capacity. Any one who has experimented much with signal generators or oscillators in general must have experienced the utter instability when the capacity across a coil becomes almost too low to support oscillation.

"Ideal Coil" Not Needed

Without capacity there can be no oscillation. With too little capacity there will be wobbly oscillation. So a ready means of introducing stability is to insert a trimming condenser of the air-dielectric type, of sufficient capacity to prevent any position of the main tuning condenser resulting in less than that minimum capacity which is consistent with stability.

In nearly all discussions of coils for oscillators in general the statement is made that stability is served when the coil is as close as possible to the so-called "ideal coil." That does not seem to agree at all with experimental findings. If we consider the oscillator as something that has a varying resistance, as revealed from the curvature of the characteristic, we can see that the thing to seek is some means of straightening out this characteristic as best we can. Even the straight line is not inconsistent with the presence of harmonics, because harmonics usually will be generated even during part of the negative cycle, due to attraction by the grid of electrons from the cathode, resulting in the flow of grid current. The heater type tubes in general will draw grid current when the negative bias is 0.4 volt or less, and battery-operated tubes behave lkewise, the grid-current flow depending a lot on the type of filament used. In general, even if the grid is half a volt negative, there will be grid current. So besides grid current during the positive cycle, there is some during part of the negative cycle, and most particularly if the plate voltage is low.

Chokes Spell Instability

The coil construction need not be given special attention on account of these grid-current facts, but at least the coil should be regarded as something that may be used as a possible basis of levelling the amplitude. It should seem reasonable to all that if there is a sharp increase in oscillation intensity or amplitude at the higher frequencies of tuning, that a corrective would be to construct a coil that has sufficient radio-frequency resistance to establish an amplitude no greater at the higher than at the lower frequencies of any one band. In the final analysis, all systems of stabilization are based on taking away something from the generator. That something is the excess amplitude. The tickler so large that it is nearly a choke is merely an example of an indirect way of introducing reflected radio-frequency resistance in the grid coil. So the secondary might be wound of fine enough wire to establish the desired end. The coil that would serve such a purpose would be far from the "ideal coil"—very far.

Radio-frequency series chokes, in general, are upsetting agencies, and therefore work against stability. They are frequently used in amateur transmitters, but the circuit is thereby made more unstable, and crystal control must be relied on to produce legally required stability. Resistors and condensers, on the other hand, are stabilizing agencies, especially resistors, and a circuit can be sensibly stabilized simply by putting the proper value of series resistance in the plate leg, although this increases the decrement and also of course reduces the output generally. That is, the output for all generated frequencies is more nearly alike, but for every frequency is less than what it would be were the resistor not there.

The "Clean" Beat

Adjustment of the grid condenser is another way of aiding stability, although a critical one, and should be used preferably with a large resistance leak.

Stability usually is best when a beat at the highest or near the highest frequency received is "clean." Rough growls denote instability.

This rough growl at the higher frequencies of any band is sometimes experienced when a very high value grid leak is used for producing modulation by the grid-blocking method. The resistance is a damper on the circuit and the condenser across the resistor is not large enough to reduce the impedance of the leak to a low enough value. Also the audio-frequency oscillation, or modulation, due to grid blocking is itself very unstable, and output meter readings follow somewhat the pattern of complex speech and musical modulation. The needle keeps wobbling about a great deal.

That is why separate modulator tubes are preferred, hence neon tubes, or regular radio tubes, are used for modulation, in the absence of the hum which suffices for modulation in a generator operated with a.c. on the plate. This type of generator is entirely satisfactory, using hum on a.c. and a neon tube on d.c. or batteries. The neon tube is in circuit all the time, but on a.c. does not oscillate, unless connected so that the r-f tube's plate current contributes sufficiently to the potential. Then the inverse rectification of the r-f oscillator supplies the neon tube with d.c. and it oscillates even on a.c., but the percentage modulation is small compared to the hum modulation, and besides the tone itself is more obscure.

So it is good practice to have a generator that has an amplifier stage, and likewise one that has a separate modulator tube, the last requirement being met of course even if the "single tube" used consists of two tubes in one envelope, such as the pentagrid tube commonly applied to conversion practice.

Why Does It Start?

In connection with signal generators, in fact all oscillators, it is interesting to note that the reason why they continue to oscillate is well known, but the reason why they start to oscillate is not known. Such a distinguished authority as E. B. Moullin, reader in engineering science in the University of Oxford, has occasion in his book, "Radio Frequency Measurements," to bring up the subject of the starting of oscillations, but ducks the explanation. For instance, dealing with a tuned-plate oscillator having grid coil coupled inductively to a plate coil, L, he says: "Now suppose that from some random cause the current through L has a small rate of decrease; this rate of decrease will cause the anode current to increase and also will induce an e.m.f. in the grid circuit."

This was the time for the mathematical expression of the cause of the starting of oscillation, and yet the author said that the current change through L was due to "some random cause." Random indeed! Daily practice all over the world, infallible starting, one of the most reliable agencies on earth, and yet "some random cause!"

John F. Rider, in his latest book, "Servicing Superheterodynes," treats of the cause of starting of oscillations, proceeding on the basis that since the oscillations are known to start, and since the emission from the cathode is the beginning of operation, the starting is due to a "flick" from the cathode electrons acting upon the grid circuit or the tuned circuit. This is undoubtedly true, although it gives a sequence and is not an explanation of why oscillations begin. It must be possible to describe the action in some mathematical manner before the reason for the starting of oscillation can be understood and appreciated. Rider's method of giving the service man some idea of what takes place, and stating the sequence, is excellent, but the sequence applies to amplification and detection as well as to generation. The mystery of the starting of oscillation is more penetrating than a sequence, and seems to have confounded everybody.

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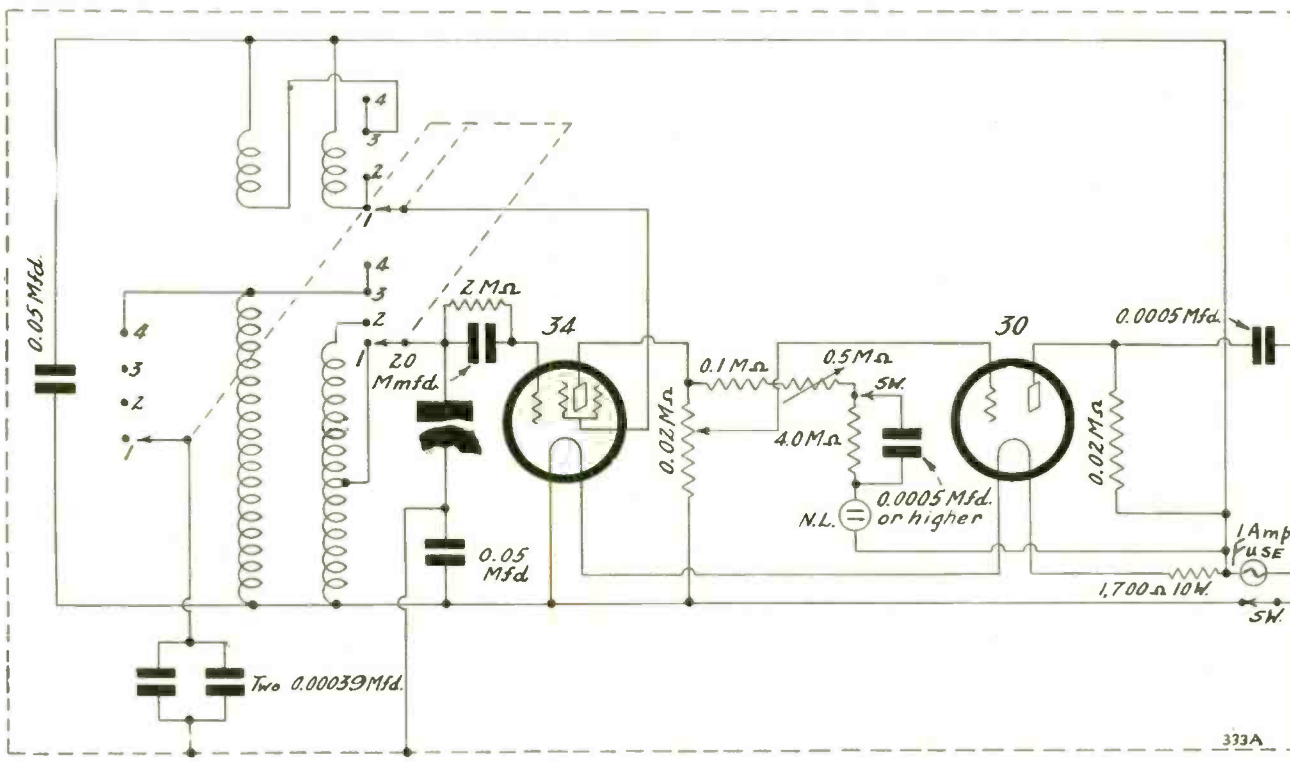
Using the Same Scale

for Two Bands and Achieving Accuracy

Theoretical and construction data on three types of signal generators were presented in the September 15th and 22nd issues. These circuits were the 333 and 333-A, switch type, using fundamentals, the A designating merely the addition of an amplifier stage; the 334 and 334-A, an harmonic type, with airplane dial; and the 335, a small harmonic type. Architectural diagrams were printed, except for the 334-A, which is shown thus on the front cover this week. With the discussion of the 333-A herewith and some data on the 334-A on another page of this issue, the series of articles on these generators is completed.—Editor.



In this service oscillator the coil at right is accurately tapped. The broadcast band is covered when the switch picks up the full inductance. Frequencies are three times as high when the condenser is switched to the tap, for the inductance between tap and line is one-ninth the total. The same scale is used for both bands.

IT will be noted that the grid leak is 2.0 meg. and the grid condenser 20 mmfd. Actually, the grid condenser is adjusted to the right value. A station is tuned in on 1,600 to 1,300 kc, whatever is conveniently obtainable, the switch set for the broadcast band, and the dial reading noted. If a small air-dielectric condenser is used for grid condenser (a midget model of, say, 25 mmfd.) should the frequency read too high the grid condenser capacity is decreased, and if the frequency reads too low the grid condenser capacity is increased. Then when the capacity is just right the coincidence of dial scale to generated frequency will be just right. Also the whole scale will track the generator, because the series condenser (0.05 mfd.) plays no part in determining the settings, being too large in respect to the capacity of the tuning condenser at maximum (about 100 times larger).

Improvised Condenser

If no air-dielectric condenser is used, the same result may be attained by using insulated hookup wire. Take an 8-inch length, bend it back on itself at the center, and twist the two 4-inch legs around each other in twisted-pair fashion. Make the twist exceedingly tight. Then snip the loop at the joined end and turn back one of these ends a bit, to avoid possibility of one bare end touching the other. The free other ends are used for connection across the leak. The two wires serve as leads of the condenser, with capacity greater than needed, so frequencies will read too high, but the wire is untwisted, just the barest bit at a time, until

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What Makes a Generator Start Oscillating?

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When the great Moullin has to gloss over the reason three or four times in one of the outstanding books in radio you can bet all you've got that the mystery is as deep as any in a baffling detective story. And yet when the answer is known it will be simple enough, in all probability.

Perhaps the explanation will run something in this line:

A circuit is established with the intention of producing oscillations, the constants, voltages, and "sense" are right. When the cathode is made to emit electrons, and the plate current starts to flow, the plate circuit is a conductive continuity and the grid circuit is sensibly open, but a tuned circuit is there located. Since the plate current is flowing through a coil there is at once created an electromagnetic field, because whenever any current, even direct current, flows through a wire, electro-magnetism results. The plate winding is inductively related to the tuned secondary, hence the tuned secondary controls the frequency of the electro-magnetism, or endows it with a frequency, and at the same time receives from this new periodic field a series of impulses. The consequent grid voltage changes are therefore in step with the plate-current changes.

Therefore the grid circuit is excited by an alternating voltage and once so excited is kept in a state of excitement by the constant recurrence of the impulses from the plate circuit. This aid from the plate circuit source is sufficient to overcome the grid circuit losses, and therefore the instant that the plate-circuit trigger first acts on the open grid circuit, the grid circuit becomes closed, a conductive continuity, usually accompanied by flow of grid current. The resistance of the grid circuit to radio frequencies becomes negative so soon as oscillation begins, or first the negative condition arises and then the oscillation starts. Negative resistance is necessary for production of oscillation.

(*Continued from preceding page*)
coincidence is perfect. In untwisting wires, flare them out, so the capacity effect of the unwound part will be practically nil. When the right capacity is established snip off the excess or untwisted wire. If this snipping reduces the capacity a bit, turn the remaining used wire back on itself just a trifle to rectify the condition.

This adjustment makes the tuning ratio just right for the broadcast band and for the intermediate band. Then for the lowest-frequency band, though the ratio is off, it may be corrected in the manner already explained.

Smaller Neon Tube

The inductance of the broadcast-band secondary is 230 microhenries and the tap is located at 25.55 microhenries from the ground end. As the capacities are the same at all positions for either broadcast or high-frequency use, the same broadcast scale multiplied by 3 serves accurately, for the frequency is inversely proportionate to the square of the capacity.

The high-frequency inductance was selected on the basis of so much of the broadcast band between 540 and 1,620 kc, a ratio of 3, and the square of three, 3 being nine, the required inductance is one-ninth as much for the higher frequencies than for the broadcast band (230/9=25.55).

It is necessary that the same capacity ratios prevail, maximum to minimum, in fact, in infinite comparison of different possible values along the scale must jibe, as well as the same absolute values prevail at all equal points, considering the repetition of the tuning. Therefore the inductance has nothing whatever to do with the ratios, except as to the difference in distributed capacity between one coil and another. The inductance shares with the capacity the establishment of the frequency, but the coincidence of scale and condenser setting for the second use, tripled frequencies, is a capacity affair. So if the coils purposely are made so that the distributed capacities are practically the same for both uses, the duplication is not difficult. Otherwise it would be necessary to have the inductances just right, and to trim each separate secondary with a separate small condenser.

The same scale is used for the Model 333 as for the Model 333A, as the addition of the amplifier tube in the second instance does not affect the generator proper. Moreover, instead of the candelabra type neon tube being used for audio oscillator, a smaller sized tube, which can be suspended on its pigtails, is used. The intensity of the audio note is just as great. In fact, a quarter-watt tube is plenty, for such is what the pigtail type is.

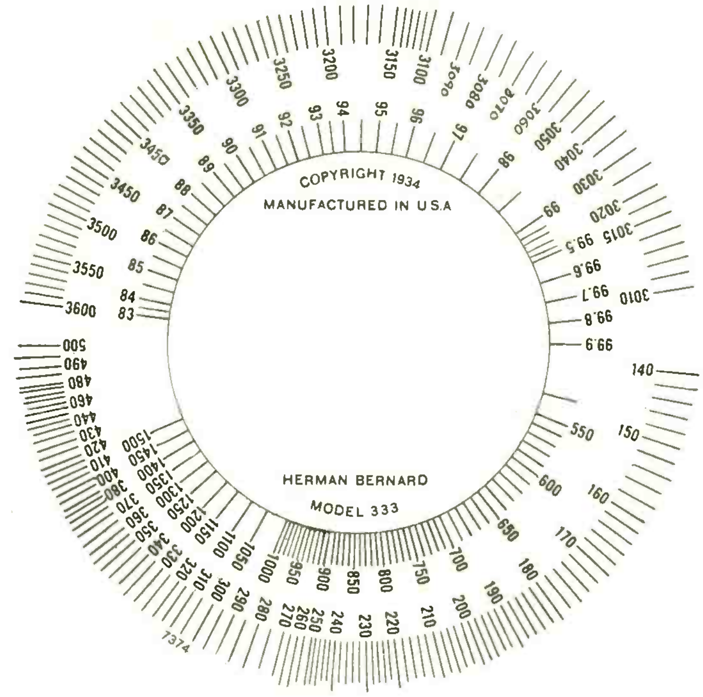
Insuring Modulation

However, there may not be any audio oscillation unless the neon bulb is of the type without limiting resistor built in. The reason is that the condenser ought to be across the resistor, and if the resistor is built in, one of the resistor terminals is inaccessible for this purpose. Hence an independent and external limiting resistor is used (4.0 meg). With 0.0005 mfd. the note is around 2,000 cycles, provided not too much current flows in the plate-to-negative filament circuit, but the note can be changed by capacity

See to Enough Tickler

In some instances there might not be any r-f oscillation in the low-frequency range. This would be due either to too small a tickler or to loose coupling. A normal sized tickler would have to be not more than one-eighth inch from secondary, measured from center of coils along the axial length. Extra tickler, without alteration of the physical position, may be supplied by connecting a 400-turn honeycomb coil in series with any present tickler, and putting it on the same form, as can be done with an 8/32 screw, as the form is threaded through the core. The commercial type coils have close enough coupling to insure oscillation.

Scale for 333-A Generator



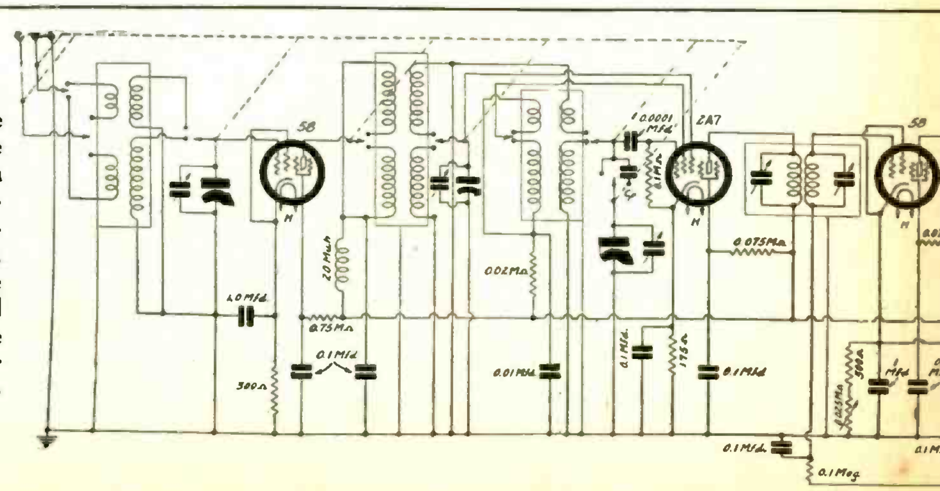
By having two escutcheons, one on each side of the knob that directly turns the condenser shaft, with two pointers on each escutcheon, four different scales may be read. The frequencies bear numbers that read on the horizontal when the above scale is used with escutcheons that have the pointers indicating to left and right. An index on the coil switch discloses which band is being used. However, for the low frequencies the same switch stop takes care of the wavelength range and also the frequency range. That is, the frequencies generated are the same, but in one instance they are calibrated in kilocycles and in the other in equivalent wavelengths in meters.

WORLD'S SHORT-WAV
AND POLICE STA

[The numbers to right of calls are frequencies in kilocycles. To
frequency in kilocycles to wavelength

Algeria		
Constantine	F8KR	6667
Argentina		
Buenos Aires	LSN	9990
Buenos Aires	LU5CZ	7080
Monte Grande	LSX	10350
Australia		
		3080, 6010, 11710 11880, 12482, 15310—Reserved
Lyndhurst	VE3LR	9580, 15230, 21540
Melbourne	VK3ME	9510
Sydney	VKZME	9590
Sydney	VLK	10525
Austria		
Vienna	OER8	6072
	OER3	11801
Belgian Congo		
Buta	OQT	6030
Basankusu	OQU	6120
Belgium		
Russylede	ORK	10330
Bolivia		
La Paz	CP5	6080, 9120
Brazil		
Marapicu	PSK	8185
Rio de Janeiro	PRA3	8186
Canada		
Bowmanville, Ont.	VE9GW	6090
Calgary	VE9CA	6030
Halifax, N. S.	VE9HX	6110
Montreal, Que.	VE9DN	6005
Montreal, Que.	VE9DR	6005
St. John, N. B.	VE9BJ	6090
Vancouver, B. C.	VE9CS	6070
Winnipeg, Man.	CJRO	
Winnipeg, Man.	VE9DR	11720
Winnipeg, Man.	VE9JR	11715
(Private experimenta ations)		1620
China		
Shanghai	XGBA	21550
Shanghai	XGBD	9579
Colombia		
Barranquilla	HJA3	6425
Barranquilla	HJ1ABB	6450
Bogota	HJ3ABD	7400
Bogota	HJ3ABF	6250
Bogota	HJ3ABI	6045
Bogota	HKE	7220
Cali	HJ5ABD	6480
Cartagena	HJ1ABD	6116
Costa Rica		
Manizales	HJ4ABB	7210
Medellin	HJ4ABE	5952
Cartago	TIRA	6080, 9590
San Jose	TITR	11790
Cuba		
Habana	CMCI	6005, 6040
	CCC	6010
Czechoslovakia		
Prague	OKIMPT	5145
Denmark		
Blaavand	OXB	1622
Lyngby	OZP	1595
Skamlebak	OXY	6060, 6070, 9520
Dominican Republic		
Santo Domingo	HI1A	6280
Santo Domingo	HIZ	6320
Santo Domingo	HIX	6000, 5953
Ecuador		
Guayaquil	BC2RL	6676
Quito	HCJB	4110
Riobamba	PRADO	6620
Federated Malay States		
Kuala Lumpur	VSZAB	6000
Kuala Lumpur	ZGE	6135
France		
Paris	Colonial Radio	0585, 11845, 11880, 11905
Paris	FLA	11710, 11720,
Paris		17765, 11905, 15243, 15295, 21490
	FYB	10578
French Indo-China		
Saigon	F3ICD	11780
Saigon	F3LCD	6116
Germany		
Konigswusterhausen	DJA	0560
Konigswusterhausen	DJB	15200
Konigswusterhausen	DJC	6020
Konigswusterhausen	DJD	11760
Konigswusterhausen	DJE	17760
Konigswusterhausen	DJL	15110
Gold Coast		
Takoradi		6080
Honduras		
Tegucigalpa	HRB	6005, 11740
Hungary		
Budapest	HAP2	4165
Szekesfehervar	HAS3	15370
Szekesfehervar	HAS5	17130
India		
		15290, 15160—Reserved
Bombay	VUB	9565
Calcutta	VUC	6110, 9575, 11870
Iraq		
Baghdad	YID	13410
Italy		
Rome	12AO	11811
Rome	12RO	3750
Japan		
Tokio	JYS	9840
		6100, 11800, 9550 —Reserved
Kenya		
Nairobi	VQ7LO	6060
Madagascar		
Tanarive	FIQA	5690
Mexico		
Mexico City	XETE	9600
Morocco (French)		
Rabat	CNR	8035, 12830
Mozambique		
Lourenco Marques	CR7AA	3543
Netherlands		
Huizen	PHI	11730, 17775
Hilversum	PCJ	9590
Kootwijk	PGD	6020, 6025, 6030
Netherland India		
Bandoeng	PKIWK	6120
Bandoeng	PLV	3190, 3186
Bandoeng	PMY	3183, 5170
Batavia		2383, 6120, 9540, 9550, 9580, 11770, --860, 15150, 15300
Cheribon		1615
Makassar	PNI	8760
Malang		1570
Semerang		4370
Soerabaya		6040
New Zealand		
Christchurch	ZL3ZC	6000
Wellington	ZL2ZX	6060
Nicaragua		
Granada	YNGRG	6664
Managua	YNA	6035, 11890
Norway		
Jeloy	LCL	6990
Jeloy	LCN	7835
Jeloy	LCO	13980
Peru		
	OA4B	7160
	OCN	6235
Philippine Islands		
Manila	KZRM	6140, 9570, 11840
Poland		
		6140, 11740—Reserved
Posen	SRI	9493, 9570
Warsaw		15275, 6115, 17780, 21480
Portugal		
Lisbon	CTIAA	9600, 15350
Lisbon	CTICT	3750, 12229
Reunion		
St. Denis		6000
Rumania		
Bucharest	YOI	6000
Russia		
Kharbarovsk	RWI5	4270, 4273
Moscow	RNE	12000
Moscow	RW59	6000
Moscow		6630
Moscow	REN	6610
Moscow	RW72	6610
Tachkent	RRRR	11740
Spain		
Madrid	EARIIO	6976
Madrid	EAQ	6045, 6110, 6070
Madrid		9545, 9860, 11810
Aranjuez		15265, 19720
Barcelona	ESJ25	6000
Straits Settlements		
Singapore	ZHI	6012

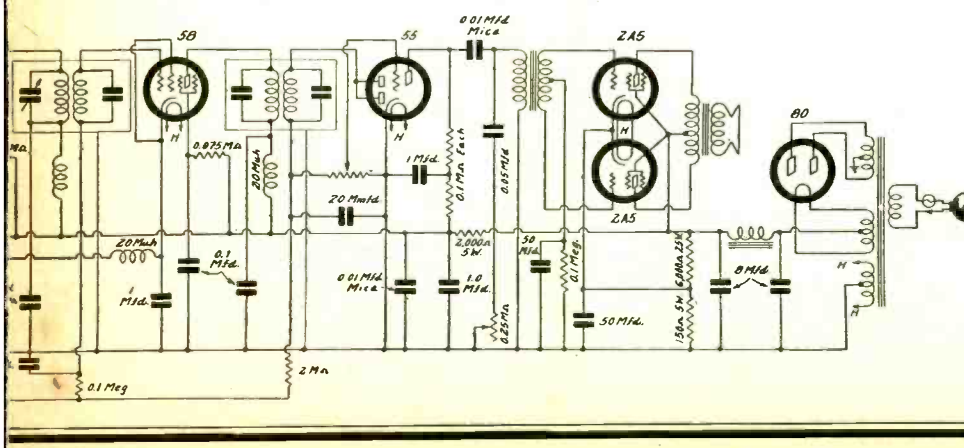
The 8-tube circuit shown herewith is one for covering the broadcast band and the principal short-wave band for program enjoyment. The theory and some practical assistance in constructing the receiver were presented last week in an article by Leonard J. Faulkner. The values of the main constants that would not be known without such disclosure are printed on the diagram. The other constants are standard, as found in commercial apparatus.



'E BROADCASTING
'TIONS BY COUNTRIES

reduce to megacycles, move point three places to left. To change in meters, consult table on Page 17.]

Sweden		
Karlskrona	SCJ	1530
Motala	SASH	6065
Switzerland		
Prangins	HBL	9595
Prangins	HBP	7797
Prangins	HBQ	7444
Union of South Africa		
Johannesburg	ZTJ	6122
United Kingdom		
Daventry	GSA	6050
Daventry	GSB	9510
Daventry	GSC	11865
Daventry		
Daventry	GSF	15140
Daventry	GSG	17790
Daventry	GSH	21470
Rugby	GBC	8860
Rugby	GBD	4270
United States		
Alabama		
Birmingham	WPFM	2414
Arizona		
Phoenix	KGZ5	2430
California		
Bakersfield	KGPS	2414
Berkeley	KVP	1712
Fresno	KGZA	2414
Pasadena	KGZB	1712
Los Angeles	KGJX	1712
San Diego	KGZD	2430
San Francisco	KGPD	2414
San Jose	KGPM	2470
Santa Barbara	KGZO	2414
Tulare	WPDA	2414
Vallejo	KGPG	2422
Colorado		
Denver	KGPZ	2442
Florida		
Jacksonville	WPFG	2442
Miami Beach	W4XB	6040
Georgia		
Atlanta	WPDY	2414
Columbus	WPFI	2414
Illinois		
Chicago	W9XA	6080, 11830, 17780
Chicago	WPDB	1712
Chicago	WPDC	1712
Chicago	WPDD	1712
Downer's Grove	W9XF	6100, 17780
Highland Park	WPFD	2430
Indiana		
Fort Wayne	WPDZ	2470
Gary	WPFL	2470
Hammond	WPFJ	1712
Indianapolis	WMDZ	2442
Kokomo	WPDT	2470
Richmond	WPDH	2442
Iowa		
Cedar Rapids	KGOZ	2470
Davenport	KGPN	2470
Des Moines	KGHO	1543
Des Moines	KGZG	2470
Sioux City	KGPK	2470
Kansas		
Chanute	KGZF	2450
Coffeyville	KGZP	2450
Topeka	KGZC	2422
Wichita	KGPZ	2450
Kentucky		
Louisville	WPDE	2442
Louisiana		
Baton Rouge	KGPY	1567
New Orleans	WPEK	2430
Shreveport	KGZQ	1712
Maryland		
Baltimore	WPFH	2414
Massachusetts		
(Portable)	WPEV	1567
Arlington	WPED	1712
Arlington	WPEP	1712
Boston	WEY	1558
Boston	WIXAL	6040, 1525, 11790, 21460
Fairhaven	WPFN	1712
Framingham	WMP	1567
Middleboro	WPET	1712
Lexington	WPEL	1567
Millis	WIXAZ	9570
Newton	WPFA	1712
Northampton	WPEW	1567
Somerville	WPEH	1712
Michigan		
Belle Island	WCK	2414
Detroit	WKDT	1558
Detroit	WPDX	2414
East Lansing	WRDS	1567
Flint	WPDF	2442
Grand Rapids	WPEB	2442
Grosse Point	WRDR	2414
Highland Park	WMO	2414
Lansing	WPDL	2442
Muskegon	WPFC	2442
Saginaw	WPES	2442
Minnesota		
Minneapolis	KGPB	2430
St. Paul	WPDS	2430
Missouri		
Kansas City	KGPE	2442
St. Louis	KGPC	1712
Nebraska		
Omaha	KGPI	2470
New Jersey		
Bound Brook	W3XAL	6100, 17780
Bound Brook	W3XL	17310
Hackensack	WPFK	2430
Toms River	WPFF	2430
Wayne	W2XE	6120, 11830, 15270
New York		
Auburn	WPDN	2458
Buffalo	WMJ	2422
Mt. Pleasant	WPFW	2414
New York	WPEE	2450
New York	WPEF	2450
New York	WPEG	2458
Rochester	WPDR	2450
Schenectady	W2XAD	15330
Schenectady	W2XAF	9530
Syracuse	WPEA	2458
North Carolina		
Asheville	WPFS	2458
Charlotte	WPDV	2458
Ohio		
Akron	WPDO	2458
Cincinnati	WKDU	1712
Cleveland	WRDH	2458
Columbus	WPDI	2430
Dayton	WPDM	2430
Mason	W8XAL	6060
Toledo	WRDQ	2470
Youngstown	WPDG	2458
Oklahoma		
Oklahoma City	KGPH	2450
Tulsa	KGPO	2450
Oregon		
Klamath Falls	KGZH	2442
Portland	KGPP	2442
Salem	KGZR	2442
Pennsylvania		
Newton Square	W3XAU	6060, 9590
Philadelphia	WPDP	2470
Pittsburgh	WPDU	1712
Pittsburgh	W8XK	21540
Reading	WPFE	2442
Saxonburg	W8XK	6140, 9570, 11870, 15210, 17780
Swarthmore	WPFQ	2470
Rhode Island		
East Providence	WPEI	1712
Pawtucket	WPFV	2470
Woonsocket	WPEM	2470
Tennessee		
Johnson	WPFR	2470
Knoxville	WPFO	2470
Memphis	WPEC	2470
Texas		
Beaumont	KGPL	1712
Dallas	WKDW	1712
El Paso	KGZM	2414
Houston	KGZI	1712
San Antonio	KGZE	2506
Waco	KSW	1712
Wichita Falls	KGZL	1712
Utah		
Salt Lake City	KGPW	2470
Washington		
Aberdeen		2414
Seattle		2414
Tacoma	KGZN	2414
Washington, D. C.		
	NAA	6120, 9550, 11730, 15130, 21500
	WPDW	2422
West Virginia		
Charleston	WPHI	2490
Clarksburg	WPFP	2414
Wisconsin		
Milwaukee	WPDK	2450
Vatican City		
	HJV	15120
Venezuela		
Caracas	YVIBC	6110
Caracas	VY3BC	6150
Maracaibo	YV2AM	7200
Maracaibo	YV5BMO	6072
Maracay	YUR	9175



The circuit is so arranged that either the Marconi type of grounded antenna or the doublet may be used. The line between the two posts to the right at the antenna position, if included as a shorting strap, as by inserting bare wire between the posts, makes the receiver of the type for a Marconi antenna. If this strap is removed the dual-high-potential connections for a doublet result, and a transmission line leadin may be included.

Be An Harmonic Detective!

Directions for Utilizing Multiples of Fundamentals for R-F and A-F Measurements

By Lester C. Lasalle

THE broadcasting stations now occupying the band, 540 to 1,600 kc, may be used as standards of frequency, particularly those stations operated on high power, and calibrations effectuated for any frequencies, audio or radio.

For instance, it would be possible to make calibrations from a low audio frequency to, say, 100 mgc, just to state limits, although there is no limit. And yet the frequency standards are broadcasting stations within 540 to 1,600 kc.

These standards are satisfactory because required by law to keep within 50 cycles of the assigned carrier frequency. Some stations, larger ones to be sure, take special pains to achieve much greater constancy or accuracy. A dozen or more stations are operating under controls assuring accuracy to 5 parts in 1,000,000.

The Bureau of Standards transmits 5,000 kc at an accuracy of 1 part in 5,000,000, if anybody needs that degree of accuracy for the type of work about to be discussed. That is a handy station to tune in—WWV, Beltsville, Md.—on the air every Tuesday, except legal holidays, continuously from noon to 2 p.m. and from 10 p.m. to midnight, EST.

Precision Requirements

The very simplest use of any standard frequency is to calibrate against it some low-frequency generator. Then harmonics of the generator or oscillator will mix with the incoming signal in a receiver tuned to the standard of frequency, and the resultant beat can be heard. The two frequencies—standard and harmonic of generator—are exactly the same when the note is reduced t o zero. If there is no modulation the zero-beating is facilitated, for if there is modulation, the note of modulation will mask the zero beat. Yet for any low frequency of modulation, say the 60 cycles of the line, the difference is immaterial between presence or absence of modulation, since zero beating in fact requires precision adjustment not possible easily without precision vernier control, and differences of 50 cycles or so pass for zero in practice. Moreover, 50 cycles out of any frequency in the broadcast band is within the legal limit of deviation, or, the constancy of the standard is not required to be greater than 50 cycles, and it therefore becomes of lesser importance to get closer to zero beat than 50 cycles. However, if one of the better-grade stations is used, that prides itself on the accuracy of its transmission to 5 parts in a million, the extra closeness may be utilized, but only if the calibration is communicated to something that will reveal the closeness. If the object is to have a frequency-calibrated dial, a very large dial would be needed. If the results are to be communicated to curve-sheets, then very large curve-sheets would be required.

How to Calibrate

Therefore the first fact to be fully understood is that a generator of relatively low frequencies will produce harmonics, and these harmonics will beat with standards that are higher in frequency.

Let us take as an example the familiar case of having a generator the frequencies of which are unknown, except in the wide sense that they are lower than the frequencies of the standards we shall use. How may we calibrate that generator?

First, we must have a receiver. Preferably it should be of the tuned-radio-frequency type, say, with four tuned stages, to support selectivity at the high-frequency end. If the set is a superheterodyne the harmonics in the local oscillator of the receiver should be suppressed as much as possible, and negative semi-fixed or fixed bias used, not grid leak and condenser.

Completely Calibrate Receiver

The frequencies tuned in on the receiver must be known. It is advisable completely to calibrate the receiver itself. This may be done by obtaining the call letters of the stations tuned in, looking up the frequencies in some reference source, or even in the local newspapers, if by chance they print even the frequencies of all the locals, and then marking the dial of the set, or running a curve, frequencies against dial settings.

Once this frequency calibration of the receiver has been made, and it may be augmented by interpolation from a curve, any fundamental of the low-frequency generator may be approximated by noting the frequency at which a response is obtained in the receiver, leaving the oscillator untouched, and tuning the receiver until the next response is obtained. The two frequencies of response in the receiver are noted, the lesser subtracted from the greater, and the difference is the fundamental frequency of the generator. Theoretically this method is flawless. In practice it is not safe to rely on it except for approximation, because the most accurate way of checking is by means of beats, and here if we encounter any beats that are accidental ones, and being accidental they might be more confusing than helpful.

We Get Our Bearings

Thus if we set the generator at the extreme low frequency, and get a response at 800 kc and another at 900 kc, we know that the fundamental of the generator is 100 kc, approximately. In calibration we are keenly alert for differences of 1 kc even in this range, indeed half or quarter a kilocycle, and less, and it might be hard to decide from the test now discussed if the fundamental of the generator was 100, 100.25, 100.5 etc., kc, as that much error would be expected, but at least we have gotten our bearings, and the details of exact measurement can be applied as they are ascertained.

However, it is not well to proceed far without knowing what is taking place, that is, knowing the reason as well as the result.

We know that if a generator is working on a certain frequency, F, that it will generate frequencies that are integral multiples of F, and which may be called F2, F3, F4, etc., representing the second, third and fourth harmonics, etc., of F. If F is 100 kc, then the harmonics in the noted range are F2=200, F3=300, F4=400 kc, etc. Therefore the ascending and descending order of consecutive harmonics are 100 kc apart.

When we strike the broadcast band, using the 100 kc fundamental, we shall find near the low-frequency end of the receiver a response at what is 600 kc resonant frequency in the set, the sixth harmonic of 100 kc. We could not reach the 500 kc setting for the fifth harmonic because the set does not tune that low. But the sixth harmonic is there. At first it is just a response to us, because we don't know a thing about the low-frequency generator. But when we turn the set to other frequencies (this time in only one possible direction, to higher

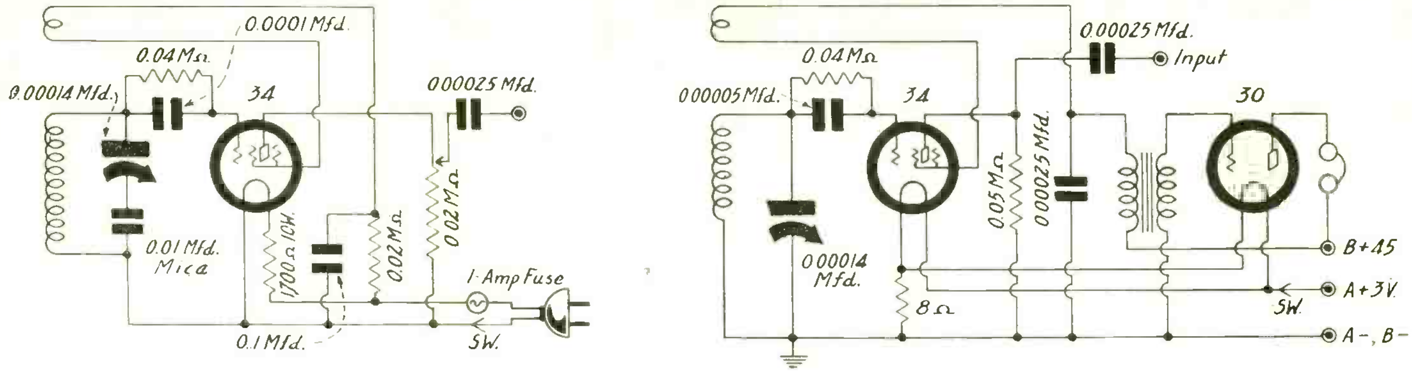
TABLE I

For Calibration of Low-Frequency Oscillator

H represents the harmonic order of the test oscillator fundamental frequency to the right of it that beats with the station frequency on top line.

H									
1	570	660	710	760	810	860	940	1180	1250
2	285	330	355	380	405	430	470	590	625
3	190	220	236.666	255	270	286.666	313.333	393.333	416.666
4	142.5	165	175.5	190	202.5	215	235	295	312.5
5	114	132	142	152	162	172	188	236	250
6	95	110	118.333	126.666	135	143.333	156.666	196.666	208.333
7	81.428	94.286	101.428	108.571	115.714	122.857	134.286	168.555	178.555
8	71.25	82.5	88.75	95	101.25	107.5	117.5	147.5	156.25
9	63.333	73.333	78.888	84.444	90	95.555	104.444	131.111	138.88
10	57	66	71	76	81	86	94	118	125

H									
11	51.818	60	64.545	69.091	73.636	78.182	85.455	107.273	113.635
12	47.5	55	59.167	63.333	67.5	71.667	78.333	98.333	104.167
13	43.869	50.769	54.615	58.462	62.308	66.154	72.308	90.762	96.154
14	42.142	47.142	50.714	54.286	57.857	61.428	67.143	84.278	89.278
15	38	44	47.333	50.667	54	57.333	62.667	78.667	83.333
16	35.625	41.25	44.375	47.5	50.63	53.75	58.75	73.75	78.75
17	33.529	38.823	41.765	44.706	47.647	50.588	55.294	69.412	73.529
18	31.667	36.667	39.444	42.222	45	47.778	52.222	65.556	69.44
19	30	34.736	37.368	40	42.632	45.263	49.474	62.105	65.789
20	28.5	33	35.5	38	40.5	43	47	59	62.5



Harmonics are generated by all vacuum-tube oscillators, particularly circuits of the leak-condenser type, when grid current flows. Oscillation results in sending out a radio-frequency and its harmonics (circuit at left), but an oscillating receiver may be used (at right) for heterodyne reception.

frequencies), we get a response at 700 kc, another at 800 kc etc.

The Rule Stated

These are due to the seventh and eighth harmonics, because so soon as we noted that the responses were 100 kc apart on the set (generator unmolested) we knew approximately the fundamental of the generator. Therefore we have the rule:

A low-frequency generator at a fixed frequency will yield in a higher-frequency receiver responses separated in frequency by the frequency of the fundamental of the generator.

Also the corollary:

The frequency span between any two consecutive response points in the receiver (generator frequency not changed) is equal to the generator fundamental frequency.

As stated, this helpful information is not controlling but merely indicative. We want something sharper, closer, more accurate. And we have it.

Since we have established the approximate frequency for one setting of the generator, why not establish other approximate frequencies? This we can do by exactly the same method. It is well to get the extreme frequencies first, for then the frequency ratio is known (by dividing the highest frequency by the lowest) and also the absolute difference in frequency between the extremes is known, which helps us when we are to apportion squares of a sheet of curve-paper (graph paper or plotting paper it is also called) if we desire to draw a curve. On one dimension frequencies are written in, on the other dial settings of numerical value. It is handy to use degrees of a circle, but dials that have such graduations are rare, and 0-100 or 100-0 will suffice.

So we have a broad view of what the frequency coverage is, and where the frequencies fall in respect to dial divisions, and we can now resort to harmonics of the generator to beat with actual stations, that is, standards. Note carefully that so far we have not used any particular standards, except that standards were used for calibrating the receiver itself, but when the approximate curve for the generator was obtained, no standards were used. That is one reason why we had accuracy of only a second order. Here goes for first-rate accuracy.

Using Harmonics

Take any stations well receivable in your locality, favoring those well distributed over the dial, meaning usually lower frequency stations. You can use harmonics now, on the indicative basis of the first approximation, without any danger of being confused. Take any broadcasting station—say, one on 710 kc. If we divide 710 by consecutive numbers, we shall obtain smaller numbers, and if these smaller numbers represent fundamentals, the divisors are the harmonic orders. For instance, divide 710 by 5. Answer, 142. Therefore at 142 kc fundamental the fifth harmonic of that fundamental will beat with 710 kc, since $5 \times 142 = 710$. Dividing by lower numbers gives us higher frequencies of fundamentals, since the reduction is less. Here we shall desire higher and lower values than 142 kc. And we shall go through the whole list of the local broadcasting stations, and divide their frequencies by numbers ranging from 2 to possibly 15 or 20, and obtain all the fundamentals which, for the stated harmonic orders, (2 to 15 or 2 to 20) would bring about the beat.

There is little help for the present to be derived from the numerous odd-frequency results that will obtain and in general practice the odd ones are ignored, and only those easy to register and locate are used. This includes frequency differences of one-half per cent., e.g. differences of 0.5 kc where the total difference over the dial is, as in the supposed case, 100 kc.

Try for 20 Spaced Points

Sometimes even or nearly even, or easy numbers, do not readily yield themselves, and one has to search for out-of-town stations perhaps, but odd numbers may be pressed into service to fill gaps.

Now we are able to get numerous points, using beats. We had a good approximation of the curve or calibration before we started to introduce real accuracy, but now with the use of harmonics and zero-beating we arrive at a very real degree of accuracy, and calibrate our low-frequency oscillator for as many points as we can find, usually desiring no fewer than 20 well spaced.

One can prepare his own list of local stations and divide their frequencies by numbers from 2 up, for a more intimate service for some localities than would be provided by the lists herewith.

An additional check is provided by using cross harmonics. For instance, some spot on the generator dial will cause beats with different local stations. Suppose one is beating an harmonic of 190 kc with 570 kc. The harmonic order of 190 is 570/190 or 5. So it's the fifth harmonic, muses the harmonic detective. But there is another station within range of the author's receiver that also produces a beat when the oscillator is left at 190 kc, and that station is 760 kc. Now, 760/190 is 4, so it's the fourth harmonic this time. This is a triple check. We found out by the receiver difference measurement that the frequency was 190, we verified this accurately by using a station that beats with an harmonic of 190, and now we verify it again by using another station that beats with another harmonic of 190. It so happens the two stations are themselves 190 kc apart, because the harmonic orders are consecutive (fifth and fourth), so we've checked up on the receiver difference measurement with beats.

Cross-Harmonics

Now, not many instances of this zero-beating with two stations will arise, but one may inspect the list he has prepared, or any list he is using, where stations' frequencies are divided by numbers from 2 up, and may look for resultant numbers that are equal, and, failing to get many of these, for numbers that are nearly equal, say, up to a difference of 0.7 kc.

The example just cited, of 190 kc contrasted with 570 and 760 kc, was one of zero beating, because 570 and 760 are divisible by integral (whole-number) numbers, to yield integers. But if the difference is not more than 0.7 kc, between harmonic and the station standard, the beat, while finite, can be heard, and zero beating need not be used for checking this way by cross-harmonics. The verification is just as good, as it is only a verification, and not the registration or calibration of any frequency for these beats of audible-tone values up to 7,000 cycles.

Removal of Modulation

Sometimes it happens that locals are so loud that their modulation—the program—causes some inconvenience. All we are interested in is the carrier. Therefore it is practical to reduce the input to the receiver so much that only the beat will be heard, and not the modulation that is supplied at the studio. This elimination is possible because the average value of the modulation is considerably below the amplitude of the carrier. The 100 per cent. modulation stations merely have capabilities of modulating up to 100 per cent. Naturally much that is sent out consists of low-amplitude tones, hence the average modulation is far less than 100 per cent.

A series antenna condenser of small value—say, 50 mmfd.—may be used for reducing the input, and at the same time the lessened capacity in circuit improves the selectivity of the receiver. Or simply the wire used as aerial may be made shorter, even only a foot or so, or a few

(Continued on next page)

(*Continued from preceding page*)
feet, until the modulation is not troublesome, and does not mask the beat you are trying to hear, or to trying to reduce to nearly zero.

Besides, there are special modulation circuits for removing the modulation but retaining the carrier. An article on one of these was read before one of the sections of the Institute of Radio Engineers and it is presumed will be printed in "Proceedings" of the Institute.

Thus far our intentions have concerned radio frequencies only, and will continue to concern them for a while, because we still have higher radio frequencies to calibrate.

Broadcast Band

From the low radio frequency to the lowest limit of the broadcast band we may use the method just outlined. For the broadcast band the calibration may be done by zero-beating the generator on its fundamental with the stations themselves that are used as standards. If confusion arises due to numerous or conflicting responses at the high-frequency end, another broadcast oscillator, set to low broadcast frequencies, may be beaten with the higher frequency stations, for second harmonics of the extra generator to beat in calibrating the instrument we have in work. Or, if it is satisfactory to have a splendid low-frequency broadcast calibration, intimately done, the higher broadcasting frequencies can be checked by putting in only important divisions, say, of 50 kc, and then using harmonics of the lower broadcast calibrated generator for closer measurements. For instance, on the dial scale herewith, which is that of the Model 333-A Signal Generator, the broadcast band is taken care of at the low-frequency end in 10 kc divisions, the high end in 50 kc divisions, but 10 kc may be applied to the higher end by setting the generator midway between any bars separated 10 kc at the low end. Otherwise 20 kc differences would result from second harmonics of 10 kc bars. In the final form of this scale the frequencies from 1,000 to 1,050 and from 1,050 to 1,100 have since been inserted, so that for from 1,100 kc up the low-frequency scale from 550 kc up may be used, say, to 1,000 kc, for coverage to 2,000 kc by second harmonics.

Change of Method

The higher frequencies may be measured by using a broadcast-band frequency-calibrated generator, and applying the formula of the product of two adjacent-response frequencies divided by the difference between those frequencies. This method has been found independently by Edward M. Shiepe and by Rex E. Lovejoy. An article about it by Mr. Lovejoy was printed last week, issue of September 22nd, page 9.

The procedure is to tune the generator to get a response in the higher-frequency set, then slowly turn the generator dial in either direction until the next response is heard in the unmolested receiver. The two frequencies are noted. Call the lower one F1 and the higher one F2. Then the unknown is

$$\frac{F2 \times F1}{F2 - F1.}$$

Note the change that has taken place. Formerly we were leaving the generator fixed and changing the receiver frequency to measure the generator. Now we are leaving the receiver fixed and getting two consecutive points on the generator that yield responses in the receiver. Also, formerly we were measuring lower frequencies by means of higher ones, utilizing harmonics of these lower frequencies. Now we are measuring higher frequencies with lower ones, still using harmonics of the low frequencies.

It is of no great importance to know what the harmonic order is, although this can be found, too. If the frequency ratio of the generator is known, as it will be since calibration has been completed, then the capacity ratio is known, for it is the square of the frequency ratio. Taking the utilized range of one generator as 2 to 1 for frequency, the capacity ratio is 4 to 1. The actual capacity may be used, or an assumed capacity will suffice, the assumption preferably being based on an estimate of the true capacity.

Case Cited

In the given instance the maximum capacity, due to everything, including condenser, tube, coil capacity, wiring, etc., was close to 102 mmfd. Using 102 mmfd., since the capacity ratio is 4-1, the minimum is 25.5 mmfd. Since the frequencies are known for these positions, the capacities for the other frequency positions may be assigned on the basis of the inductance computation. In this instance the inductance was 25.5 millihenries. The capacities for the other frequencies can be computed. For instance, 120 kc = 69.5 mmfd., 140 kc = 51 mmfd.; 170 = 35.5 mmfd. and 200 = 25.5 mmfd. If a scale is plotted on this capacity basis, then the harmonic order may be determined by taking two adjoining response points generated from the calibrated instrument, noting the capacity readings, and getting the capacity ratio.

Turner's Wavelength Counter

Several harmonic-counting systems have been shown during recent years. L. B. Turner showed one in "Wireless World" some years ago, where the low wavelengths of unknowns were determined by harmonic counting, where the counting was based on capacity differentials or ratios (not direct-reading). Thus, when the capacity at the higher frequency setting was divided by the capacity at the lower frequency setting, certain ratios were established. Consecutive responses were used, as occasioned by the manipulation of the generator.

Turner treated of wavelengths in connection with a wavemeter, therefore he established the differences in wavelengths, in terms of capacity, or capacity ratios, and identified the harmonics by the ratios. For frequency treatment, of course, the factors, 2, 3, 4 etc. would be multiplied by the frequency, though for wavelength the factors are divided into the wavelengths.

Also it may be noted the capacity for the third harmonic, compared to the second, would be $2^2/3^2$ or 4/9, that of the third compared to the fourth, $3^2/4^2$ or 9/16.

Turner started with the first response from the fundamental, but of course the same system apples no matter what harmonic is used as the starting point, and by his method there need be no preliminary identification.

If a scale is calibrated in wavelengths in meters, any so-called harmonic factors would have to be divided into the reading, instead of being multiplied by the reading, because the higher the frequency (result of multiplication by the harmonic order) the lower the wavelength (necessity for dividing by the factor instead).

A Different Way

It is also possible to completely calibrate a low-frequency oscillator, using a much higher frequency receiver, where the receiver frequency is fixed. Thus, suppose a receiver is built to bring in the 5000 kc transmission of WWV. We can get our bearings for the low-frequency instrument by the method already outlined for using a broadcast set, and if the generator's frequencies are lower than broadcast frequencies, we can note the response points in the fixed receiver due to the tuning of the generator. All positions of the generator dial represent frequencies divisible integrally into 5,000 kc, so starting with 100 kc fundamental we use the 50th harmonic, and from then on calibrate the generator for the 51st harmonic, 52nd harmonic, etc., as follows: 5,000/49 = 102.04 kc; 5,000/48 = 104.17 kc, etc., until we reach the 25th harmonic, or 5,000/25 = 200 kc. Then we do not have to depend on stations of desired frequencies being on the air, also we may make the accuracy as great as we desire, by making the measurements while WWV is on the air, using the beat principle, for the harmonics of the low-frequency generator will beat with the standard 5,000 kc frequency.

Always to gain responses in the receiver the receiver has to be of a frequency equal to or greater than that of the generator, never lower in frequency than the generator.

The product-divided-by difference method may be applied for frequencies of the unknown as high as wanted, provided of course that the generator itself should not be grossly low in frequency compared to the unknowns, if facility of manipulation and ease of correct reading are important. Yet with just the broadcast band generator, results up to 20 mgc are obtainable, though better facilities exist when the frequencies of the generator, for such service, are higher than the highest in the broadcast band.

Audio Method

In connection with low-frequency apparatus and measurements, the broadcasting stations can be used, particularly if the program modulation is removed. Then beats other than zero beats may be utilized. For instance, consulting a table of the frequencies, differences between harmonics of the generator, and fundamentals of the locals, may be noted, and tuning done to establish these beats. An extra detector tube is preferable, into which the beat is put, so that the output of the unknown uncalibrated audio-note-producing device is a part of the measurement. When the unknown is equal to the beat note the current in the detector is highest for negative-biased detection of the self-bias or fixed-bias type. For grid-leak type detector detection the current is least when the two frequencies are equal.

How to Use the Table Reversibly Converting Meters and Kilocycles

The conversion table printed on the opposite page is highly accurate, because worked out by the factor 299,820. Most tables are based on the factor 300,000, which is erroneous to 6 parts in 100,000.

The table is entirely reversible, for instance, 10 meters equal 29,982 kc, or 29,982 meters equal 10 kc. Any quantities not included in the table may be read by shifting the decimal point. If moved to the right for frequency the point is moved to the left for wavelength, and vice versa. The shift is therefore in opposite directions. The factor 299,820 is based on the velocity of a radio wave, which is equal to the velocity of light, or 299,820,000 meters per second. By dropping the three ciphers (dividing by 1,000), the factor 299,820 is used, and the answer reads in kilocycles.

Wavelength in meters is equal to velocity divided by frequency. Frequency in cycles is equal to the velocity divided by the wavelength.

That is, the numerator always is the same.

CHART COVERING FROM 10 TO 29,982 METERS OR KILOCYCLES

SEE DIRECTIONS ON OPPOSITE PAGE

kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc
10	29,982	1,010	296.9	2,010	149.2	3,010	99.61	4,010	74.77	5,010	59.84	6,010	49.89	7,010	42.77	8,010	37.43	9,010	33.28
20	14,991	1,020	293.9	2,020	148.4	3,020	99.28	4,020	74.58	5,020	59.73	6,020	49.80	7,020	42.71	8,020	37.38	9,020	33.24
30	9,994	1,030	291.1	2,030	147.7	3,030	98.95	4,030	74.40	5,030	59.61	6,030	49.72	7,030	42.65	8,030	37.34	9,030	33.20
40	7,496	1,040	288.3	2,040	147.0	3,040	98.62	4,040	74.21	5,040	59.49	6,040	49.64	7,040	42.59	8,040	37.29	9,040	33.17
50	5,996	1,050	285.5	2,050	146.3	3,050	98.30	4,050	74.03	5,050	59.37	6,050	49.56	7,050	42.53	8,050	37.24	9,050	33.13
60	4,997	1,060	282.8	2,060	145.5	3,060	97.98	4,060	73.85	5,060	59.25	6,060	49.48	7,060	42.47	8,060	37.20	9,060	33.09
70	4,283	1,070	280.2	2,070	144.8	3,070	97.66	4,070	73.67	5,070	59.13	6,070	49.39	7,070	42.41	8,070	37.15	9,070	33.06
80	3,748	1,080	277.6	2,080	144.1	3,080	97.34	4,080	73.49	5,080	59.02	6,080	49.31	7,080	42.35	8,080	37.11	9,080	33.02
90	3,331	1,090	275.1	2,090	143.5	3,090	97.03	4,090	73.31	5,090	58.90	6,090	49.23	7,090	42.29	8,090	37.06	9,090	32.98
100	2,998	1,100	272.6	2,100	142.8	3,100	96.72	4,100	73.13	5,100	58.79	6,100	49.15	7,100	42.23	8,100	37.01	9,100	32.95
110	2,726	1,110	270.1	2,110	142.1	3,110	96.41	4,110	72.95	5,110	58.67	6,110	49.07	7,110	42.17	8,110	36.97	9,110	32.91
120	2,499	1,120	267.7	2,120	141.4	3,120	96.10	4,120	72.77	5,120	58.56	6,120	48.99	7,120	42.11	8,120	36.92	9,120	32.88
130	2,306	1,130	265.3	2,130	140.8	3,130	95.79	4,130	72.60	5,130	58.44	6,130	48.91	7,130	42.05	8,130	36.88	9,130	32.84
140	2,142	1,140	263.0	2,140	140.1	3,140	95.48	4,140	72.42	5,140	58.33	6,140	48.83	7,140	41.99	8,140	36.83	9,140	32.80
150	1,999	1,150	260.7	2,150	139.5	3,150	95.18	4,150	72.25	5,150	58.22	6,150	48.75	7,150	41.93	8,150	36.79	9,150	32.77
160	1,874	1,160	258.5	2,160	138.8	3,160	94.88	4,160	72.07	5,160	58.10	6,160	48.67	7,160	41.87	8,160	36.74	9,160	32.73
170	1,764	1,170	256.3	2,170	138.1	3,170	94.58	4,170	71.90	5,170	57.99	6,170	48.59	7,170	41.82	8,170	36.70	9,170	32.70
180	1,666	1,180	254.1	2,180	137.5	3,180	94.28	4,180	71.73	5,180	57.88	6,180	48.51	7,180	41.76	8,180	36.65	9,180	32.66
190	1,578	1,190	252.0	2,190	136.9	3,190	93.99	4,190	71.56	5,190	57.77	6,190	48.44	7,190	41.70	8,190	36.61	9,190	32.62
200	1,499	1,200	249.9	2,200	136.3	3,200	93.69	4,200	71.39	5,200	57.66	6,200	48.36	7,200	41.64	8,200	36.56	9,200	32.59
210	1,428	1,210	247.8	2,210	135.7	3,210	93.40	4,210	71.22	5,210	57.55	6,210	48.28	7,210	41.58	8,210	36.52	9,210	32.55
220	1,363	1,220	245.8	2,220	135.1	3,220	93.11	4,220	71.05	5,220	57.44	6,220	48.20	7,220	41.53	8,220	36.47	9,220	32.52
230	1,304	1,230	243.8	2,230	134.4	3,230	92.82	4,230	70.88	5,230	57.33	6,230	48.13	7,230	41.47	8,230	36.43	9,230	32.48
240	1,249	1,240	241.8	2,240	133.8	3,240	92.54	4,240	70.71	5,240	57.22	6,240	48.05	7,240	41.41	8,240	36.39	9,240	32.45
250	1,199	1,250	239.9	2,250	133.3	3,250	92.25	4,250	70.55	5,250	57.11	6,250	47.97	7,250	41.35	8,250	36.34	9,250	32.41
260	1,153	1,260	238.0	2,260	132.7	3,260	91.97	4,260	70.38	5,260	57.00	6,260	47.89	7,260	41.30	8,260	36.30	9,260	32.38
270	1,110	1,270	236.1	2,270	132.1	3,270	91.69	4,270	70.22	5,270	56.89	6,270	47.82	7,270	41.24	8,270	36.25	9,270	32.34
280	1,071	1,280	234.2	2,280	131.5	3,280	91.41	4,280	70.05	5,280	56.78	6,280	47.74	7,280	41.18	8,280	36.21	9,280	32.31
290	1,034	1,290	232.4	2,290	130.9	3,290	91.13	4,290	69.89	5,290	56.68	6,290	47.67	7,290	41.13	8,290	36.17	9,290	32.27
300	999.4	1,300	230.6	2,300	130.4	3,300	90.86	4,300	69.73	5,300	56.57	6,300	47.59	7,300	41.07	8,300	36.12	9,300	32.24
310	967.2	1,310	228.9	2,310	129.8	3,310	90.58	4,310	69.56	5,310	56.46	6,310	47.52	7,310	41.02	8,310	36.08	9,310	32.20
320	936.9	1,320	227.1	2,320	129.2	3,320	90.31	4,320	69.40	5,320	56.36	6,320	47.44	7,320	40.96	8,320	36.04	9,320	32.17
330	908.6	1,330	225.4	2,330	128.7	3,330	90.04	4,330	69.24	5,330	56.25	6,330	47.36	7,330	40.90	8,330	35.99	9,330	32.14
340	881.8	1,340	223.7	2,340	128.1	3,340	89.77	4,340	69.08	5,340	56.15	6,340	47.29	7,340	40.85	8,340	35.95	9,340	32.10
350	856.6	1,350	222.1	2,350	127.6	3,350	89.50	4,350	68.92	5,350	56.04	6,350	47.22	7,350	40.79	8,350	35.91	9,350	32.07
360	832.8	1,360	220.4	2,360	127.0	3,360	89.23	4,360	68.77	5,360	55.94	6,360	47.14	7,360	40.74	8,360	35.86	9,360	32.03
370	810.3	1,370	218.8	2,370	126.5	3,370	88.97	4,370	68.61	5,370	55.83	6,370	47.07	7,370	40.68	8,370	35.82	9,370	32.00
380	789.0	1,380	217.3	2,380	126.0	3,380	88.70	4,380	68.45	5,380	55.73	6,380	46.99	7,380	40.63	8,380	35.78	9,380	31.96
390	768.8	1,390	215.7	2,390	125.4	3,390	88.44	4,390	68.30	5,390	55.63	6,390	46.92	7,390	40.57	8,390	35.74	9,390	31.93
400	749.6	1,400	214.2	2,400	124.9	3,400	88.18	4,400	68.14	5,400	55.52	6,400	46.85	7,400	40.52	8,400	35.69	9,400	31.90
410	731.3	1,410	212.6	2,410	124.4	3,410	87.92	4,410	67.99	5,410	55.42	6,410	46.77	7,410	40.46	8,410	35.65	9,410	31.86
420	713.9	1,420	211.1	2,420	123.9	3,420	87.67	4,420	67.83	5,420	55.32	6,420	46.70	7,420	40.41	8,420	35.61	9,420	31.83
430	697.3	1,430	209.7	2,430	123.4	3,430	87.41	4,430	67.68	5,430	55.22	6,430	46.63	7,430	40.35	8,430	35.57	9,430	31.79
440	681.4	1,440	208.2	2,440	122.9	3,440	87.16	4,440	67.53	5,440	55.11	6,440	46.56	7,440	40.30	8,440	35.52	9,440	31.76
450	666.3	1,450	206.8	2,450	122.4	3,450	86.90	4,450	67.38	5,450	55.01	6,450	46.48	7,450	40.24	8,450	35.48	9,450	31.73
460	651.8	1,460	205.4	2,460	121.9	3,460	86.65	4,460	67.22	5,460	54.91	6,460	46.41	7,460	40.19	8,460	35.44	9,460	31.69
470	637.9	1,470	204.0	2,470	121.4	3,470	86.40	4,470	67.07	5,470	54.81	6,470	46.34	7,470	40.14	8,470	35.40	9,470	31.66
480	624.6	1,480	202.6	2,480	120.9	3,480	86.16	4,480	66.92	5,480	54.71	6,480	46.27	7,480	40.08	8,480	35.36	9,480	31.63
490	611.9	1,490	201.2	2,490	120.4	3,490	85.91	4,490	66.78	5,490	54.61	6,490	46.20	7,490	40.03	8,490	35.31	9,490	31.59
500	599.6	1,500	199.9	2,500	119.9	3,500	85.66	4,500	66.63	5,500	54.51	6,500	46.13	7,500	39.98	8,500	35.27	9,500	31.56
510	587.9	1,510	198.6	2,510	119.5	3,510	85.42	4,510	66.48	5,510	54.41	6,510	46.06	7,510	39.92	8,510	35.23	9,510	31.53
520	576.6	1,520	197.2	2,520	119.0	3,520	85.18	4,520	66.33	5,520	54.32	6,520	45.98	7,520	39.87	8,520	35.19	9,520	31.49
530	565.7	1,530	196.0	2,530	118.5	3,530	84.94	4,530	66.19	5,530	54.22	6,530	45.91	7,530	39.82	8,530	35.15	9,530	31.46
540	555.2	1,540	194.7	2,540	118.0	3,540	84.70	4,540	66.04	5,540	54.12	6,540	45.84	7,540	39.76	8,540	35.11	9,540	31.43
550	545.1	1,550	193.4	2,550	117.6	3,550	84.46	4,550	65.89	5,550	54.02	6,550	45.77	7,550	39.71	8,550	35.07	9,550	31.39
560	535.4	1,560	192.2	2,560	117.1	3,560	84.22	4,560	65.75	5,560	53.92	6,560	45.70	7,560	39.66	8,560	35.03	9,560	31.36
570	526.0	1,570	191.0	2,570	116.7	3,570	83.98	4,570	65.61	5,570	53.83	6,570	45.63	7,570	39.61	8,570	34.98	9,570	31.33
580	516.9	1,580	189.8	2,580	116.2	3,580	83.75	4,580	65.46	5,580	53.73	6,580	45.57	7,580	39.55	8,580	34.94	9,580	31.30
590	508.2	1,590	188.6	2,590	115.8	3,590	83.52	4,590	65.32	5,590	53.64	6,590	45.50	7,590	39.50	8,590	34.90	9,590	31.26
600	499.7	1,600	187.4	2,600	115.3	3,600	83.28	4,600	65.18	5,600	53.54	6,600	45.43	7,600	39.45	8,600	34.86	9,600	31.23
610	491.5	1,610	186.2	2,610	114.9	3,610	83.05	4,610	65.04	5,610	53.44	6,610	45.36	7,610	39.40	8,610	34.82	9,610	31.20
620	483.6	1,620	185.1	2,620	114.4	3,620	82.82	4,620	64.90	5,620	53.35	6,620	45.29	7,620	39.35	8,620	34.78	9,620	31.17
630	475.9	1,630	183.9	2,630	114.0	3,630	82.60	4,630	64.76	5,630	53.25	6,630	45.22	7,630	39.29	8,630	34.74	9,630	31.13
640	468.5	1,640	182.8	2,640	113.6	3,640	82.37	4,640	64.62	5,640	53.16	6,640	45.15	7,640	39.24	8,640	34.70	9,640	31.10
650	461.3	1,650	181.7	2,650	113.1	3,650	82.14	4,650	64.48	5,650	53.07	6,650	45.09	7,650	39.19	8,650	34.66	9,650	31.07
660	454.3	1,660	180.6	2,660	112.7	3,660	81.92	4,660	64.34	5,660	52.97	6,660	45.02	7,660	39.14	8,660	34.62	9,660	31.04
670	447.5	1,670	179.5	2,670	112.3	3,670	81.70	4,670	64.20	5,670	52.88	6,670	44.95	7,670	39.09	8,670	34.58	9,670	31.01
680	440.9	1,680	178.5	2,680	111.9	3,680	81.47	4,680	64.06	5,680	52.79	6,680	44.88	7,680	39.04	8,680	34.54	9,680	30.97
690	434.5	1,690	177.4	2,690	111.5	3,690	81.25	4,690	63.93	5,690	52.69	6,690	44.82	7,690	38.99	8,690	34.50	9,690	30.94
700	428.3	1,700	176.4	2,700	111.0	3,700	81.03	4,700	63.79	5,700	52.60	6,700	44.75	7,700	38.94	8,700	34.46	9,700	30.91
710	422.3	1,710	175.3	2,710	110.6	3,710	80.81	4,710	63.66	5,710	52.51	6,710	44.68	7,710	38.89	8,710	34.42	9,710	30.88
720	416.4	1,720	174.3	2,720	110.2	3,720	80.60	4,720	63.52	5,720	52.42	6,720	44.62	7,720	38.84	8,720	34.38	9,720	30.85
730	410.7	1,730	173.3	2,730	109.8	3,730	80.38	4,730	63.39	5,730	52.32	6,730	44.55	7,730	38.79	8,730	34.34	9,730	30.81
740	405.2	1,740	172.3	2,740	109.4	3,740	80.17	4,740	63.25	5,740	52.23	6,740	44.48	7,740	38.74	8,740	34.30	9,740	30.78
750	399.8	1,750	171.3	2,750	109.0	3,750	79.95	4,750	63.12	5,750	52.14	6,750	44.42	7,750	38.69	8,750	34.27	9,750	30.75
760	394.5	1,760	170.4	2,760	108.6	3,760	79.74	4,760	62.99	5,760	52.05	6,760	44.35	7,760	38.64	8,760	34.23	9,760	30.72
770	389.4	1,770	169.4	2,770	108.2	3,770	79.53	4,770	62.86	5,770	51.96	6,770	44.29	7,770	38.59	8,770	34.19	9,770	30.69
780	384.4	1,780	168.4	2,780	107.8	3,780	79.32	4,780	62.72	5,780	51.87	6,780	44.22	7,780	38.54	8,780	34.15	9,780	30.66
790	379.5	1,790	167.5	2,790	107.5	3,790	79.11	4,790	62.59	5,790	51.78	6,790	44.16	7,790	38.49	8,790	34.11	9,790	30.63
800	374.8	1,800	166.6	2,800	107.1	3,800	78.90	4,800	62.46	5,800	51.69	6,800	44.09	7,800	38.44	8,800	34.07	9,800	30.59
810	370.2	1,810	165.6	2,810	106.7	3,810	78.69	4,810	62.33	5,810	51.60	6,810	44.03	7,810	38.39	8,810	34.03	9,810	30.56
820	365.6	1,820	164.7	2,820	106.3	3,820	78.49	4,820	62.20	5,820	51.52	6,820	43.96	7,820	38.34	8,820	33.99	9,820	30.53
830	361.2	1,830	163.8	2,830	105.9	3,830	78.28	4,830	62.07	5,830	51.43	6,830	43.90	7,830	38.29	8,830	33.95	9,830	30.50
840	356.9	1,840	162.9	2,840	105.6	3,840	78.08	4,840	61.95	5,840	51.34	6,840	43.83	7,840	38.24	8,840	33.92	9,840	30.47
850	352.7	1,850	162.1	2,850	105.2	3,850	77.88	4,850	61.82	5,850	51.25	6,850	43.77	7,850	38.19	8,850	33.88	9,850	30.44
860	348.6	1,860	161.2	2,860	104.8	3,860	77.67	4,860	61.69	5,860	51.16	6,860	43.71	7,860	38.14	8,860	33.84	9,860	30.41
870	344.6	1,870	160.3	2,870	104.5	3,870	77.47	4,870	61.56	5,870	51.08	6,870	43.64	7,870	38.10	8,870	33.80	9,870	30.38
880	340.7	1,880	159.5	2,880	104.1	3,880	77.27	4,880	61.44	5,880	50.99	6,880	43.58	7,880	38.05	8,880	33.76	9,880	30.35
890	336.9	1,890	158.6	2,890	103.7	3,890	77.07	4,890	61.31	5,890	50.90	6,890	43.52	7,890	38.00	8,890	33.73	9,890	30.32
900	333.1	1,900	157.8	2,900	103.4	3,900	76.88	4,900	61.19	5,900	50.82	6,900	43.45	7,900	37.95	8,900	33.69	9,900	30.28
910	329.5	1,910	157.0	2,910	103.0	3,910	76.68	4,910	61.06	5,910	50.73	6,910	43.39	7,910	37.90	8,910	33.65	9,910	30.25
920	325.9	1,920	156.2	2,920	102.7	3,920	76.48	4,920	60.94	5,920	50.65	6,920	43.33	7,920	37.86	8,920	33.61	9,920	30.22
930	322.4	1,930	155.3	2,930	102.3	3,930	76.29	4,930	60.82	5,930	50.56	6,930	43.26	7,930	37.81	8,930	33.57	9,930	30.19
940	319.0	1,940	154.5	2,940	102.0	3,940	76.10	4,940	60.69	5,940	50.47	6,940	43.20	7,940	37.76	8,940	33.54	9,940	30.16
950	315.6	1,950	153.8	2,950	101.6	3,950	75.90	4,950	60.57	5,950	50.39	6,950	43.14	7,950	37.71	8,950	33.50	9,950	30.13
960	312.3	1,960	153.0	2,960	101.3	3,960	75.71	4,960	60.45	5,960	50.31	6,960	43.08	7,960	37.67	8,960	33.46	9,960	30.10
970	309.1	1,970	152.2	2,970	100.9	3,970	75.52	4,970	60.33	5,970	50.22	6,970	43.02	7,970	37.62	8,970	33.42	9,970	30.07
980	305.9	1,980	151.4	2,980	100.6	3,980	75.33	4,980	60.20	5,980	50.14	6,980	42.95	7,980	37.57	8,980	33.39	9,980	30.04
990	302.8	1,990	150.7	2,990	100.3	3,990	75.14	4,990	60.08	5,990	50.05	6,990	42.89	7,990	37.52	8,990	33.35	9,990	30.01
1,000	299.8	2,000	149.9	3,000	99.94	4,000	74.96	5,000	59.96	6,000	49.97	7,000	42.83	8,000	37.48	9,000	33.31	10,000	29.98

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Conflicts Mark Short Waves

Countries at Odds on Time Method To Use—Penetration Depends Much on Frequency

THE Department of Commerce, Bureau of Foreign and Domestic Commerce, which has compiled a world short-wave station list, remarks on the difficulty of obtaining reliable information on short-wave time schedules.

Reliable information regarding hours of operation has not been generally available, with a few exceptions. Certain stations offer service on fixed schedules, but for the most part scheduled operation is subject to interfering conditions in several phases of station activities, including questions of engineering, program, talent, and financial nature.

National policies regarding time standards is another source of unreliability of schedule information. Although international time zones are generally recognized, not a few countries of importance as short-wave broadcasters employ time which does not coincide with any of the neighboring international zones. In some of these countries the international zone hours are used in broadcasting; in others the national statutory or local sidereal time is followed. Transposing these schedules into the time of any one zone (eastern standard in the case of this publication) involves dependence upon private sources of information, as does the question of time schedules in most cases, which, however reliable, cannot be offered as official.

Daylight Saving Time

Daylight saving time further complicates the presentation of schedules. Few of the sources of information state whether the hours quoted are in winter or summer time in those countries. No assumption can be made safely in this respect, although where known the daylight saving schedule is given Countries using daylight saving time, according to information furnished by American communications companies and the Department of State, are: Belgium, France, Luxemburg, Netherlands, Newfoundland, Portugal, and the United Kingdom.

The so-called "24-hour clock" has been adopted in British broadcasting. This system has been in use in marine wireless for several years. The hours after noon, Greenwich time (irrespective of the actual time in the zone where the transmitter is being operated) are numbered from 13 to 24 instead of from 1 to 12, and the "a.m." and "p.m." designations are omitted. After the stroke of midnight, midnight is understood to be hour "00," so that no time is designated under the number 24 except the stroke of midnight, and that only with reference to periods closing at that time.

Identification Sounds

Although for visual purposes practically every station may be identified by its alphabetical call letters, the use of tonal characteristics and names, as well as the difference in the names of letters and numbers, interfere with a satisfactory identification of a station by ear. The following should be of some assistance in this respect:

British stations transmit the striking of Big Ben, London.

German stations play a repeated score, using bells.

Playing of the "Marseillaise," FYA, France.

Bugle call, TI4NRH, Guatemala.

Cuckoo calls, CT1AA, Portugal.

Kookaburra bird call, VK2ME, Australia.

Playing of the "Internationale," RV59, Russia.

Midnight chimes: at 5 p.m., RV59, Russia; at 6 p.m. OXY, Denmark.

"Hello, hello, here is Moscow," RV59, Russia.

"Pronto, pronto, Radio Vaticano" HVJ, Vatican City.

"Radio Roma-Napoli" I2RO, Italy.

"This is Huizen" PHI, Netherlands.

"Hello, hello, Polski, Radjo-Poznan" SRI, Poland.

"Radio Club do Brazil" PRBA, Brazil.

"Radio Rabat dans Maroc" CNR, Morocco.

"La Vox de Lago" YV11BMO, Venezuela.

"Hello, hello, ici Paris, Radio Coloniale . . " FYA, France.

"London Calling" Daventry, United Kingdom, stations.

"Estacion El Prado, Rio Bamba, Ecuador" Prado, Ecuador.

Short Waves in Broadcasting

Radio research has developed evidence that the frequency of 1,410 kc (wavelength 214 meters) has the lowest penetrability of any waves ordinarily used in broadcasting per watt of transmitting power, and that the highest is at approximately 7,500 kc or 40 meters. From 1,410 up to 7,500 kc the improvement is constant, but above 7,500 penetration again decreases, reaching the same value as at 1,410 kc well up in the range above 30,000 kc, which remains in the highly experimental stage.

Expressed in actual distance, a station of a given power operating simultaneously on 1,410 and 7,500 kc could be received on the shorter wave (higher frequency) around the world, while the range would be less than 1,000 miles on 1,410 kc. This example is, of course, based on the supposition that terrestial. weather, and climatic conditions were equal throughout the world, that the same power were used in both transmissions, and that the receivers were of equal sensitivity.

Atmospheric disturbances occur on determinate frequencies, and are more general on the lower than the higher frequencies. Short-wave reception is seemingly attended by greater disturbances, on occasion, but this effect is the result of receiving the effects of atmospheric disturbances over a far greater area than would be detected by the duller, less sensitive broadcast band receiver with its more limited range, in comparison to the strength of the signals received from the transmitting station. Reception at the same distance of medium and short waves offers a comparison highly favorable to the short waves.

Short Waves to the Rescue

In tropical countries where medium band reception has been found impossible or practically so, short waves have rendered satisfactory service, and it is interesting to note here that in Colombia and Netherlands, India, radio did not emerge from the experimental stage until short-wave equipment of popular types became available. In both countries, broadcasting is now well established, entirely on the basis of short waves.

Short-wave communication offers this greater service area per watt, but it is as rigidly limited to the factors of power, distance, and receiver sensitivity as middle band communications. The power of short-wave transmitters is therefore as important in judging the receivability of short-wave transmissions as of those in the middle band, and therefore is considered necessary to this listing of stations to the same degree.

W2XAF Begins Sending 'Mail' Toward Opposite Pole

After nine months of delivering mail to the Antartic by way of short-wave radio, the "mailman" of the General Electric short-wave station W2XAF at Schenectady, N. Y., have been rewarded by being given still another route to cover. Having previously claimed that they had the longest "air mail beat" in the world, they have now definitely cinched the title against allcomers.

Just before taking their microphone trek to the base camp of the second Byrd Expedition, they recently delivered letters and messages to Rockwell Kent, who is sojourning in the front yard of the north pole with his son. The American artist, who will be pretty much of an expedition unto himself, is spending two years writing and painting at Igdlossuit, island of Ubekjent, 600 miles within the Artic circle, and nearly as close to the north pole as Admiral Byrd and his men are to the south pole.

Establishing Ratio Values for Two Frequency Settings

IF only the relative values of capacity are correctly disposed about the scale of a frequency-calibrated dial, then the capacity ratios may be obtained when two settings are used for producing adjoining responses in a higher-frequency receiver, and by the ratio the harmonic orders may be determined. Thus, if the second and the third harmonics are the ones that cause the two response points, the ratio would be 4/9, meaning that the higher frequency of generation in the oscillator has a capacity of 4/9 that of the lower frequency of generation. It is understood that any one position of the generator scale is used, and any succeeding position that again repeats a response is the receiver.

Remember that the higher harmonic order refers to the lower frequency of the generator. That is plainly true, since the resultant response is due to first one frequency, then another, contributing successive harmonics. For instance, if F1 is the low frequency and F2 is the high frequency, some number multiplied by F1 produces FX, and some other number, multiplied by F2, also yields FX. Naturally a lower frequency has to be multiplied by a higher number to yield Fx, and a higher generator frequency multiplied by a small number to yield also Fx. The product always is the same frequency. Although this is exceedingly obvious it is a point sometimes lost to sight.

Capacities Listed

The method of capacity ratios was applied to the 334-A Signal Generator, which has fundamentals of 100 to 200 kc, and the capacities for producing the frequencies are given in the following table:

kc	mmfd	kc	mmfd	kc	mmfd
200	25	140	50	116	75
182	30	134	55	113	80
167	35	128	60	109.5	85
156	40	123.5	65	106.5	90
147	45	120	70	103	95
				100	100

From the foregoing a curve could be drawn, and the ratios of capacity determined by dividing the capacity at one response frequency into the higher capacity at the next succeeding lower response frequency. Of course, if the scale of capacities is on the dial, so much the better, for then the capacities may be read directly, the ratio quickly determined, and any harmonic order known to a certainty. Either the answer is always a whole number, or if removed from a whole number it is very minutely so removed, and the nearest whole number is used for the harmonic order without possibility of error. The insignificant descrepancies are due to the capacity calibration, but do not affect the accuracy of the result.

The dial scale of the 334-A is different from that of the 333-A, for the 334-A is an harmonic-working device, whereas the other depends almost exclusively on fundamentals, uses switching and is more expensive.

Wavelength Use

The wavelength scale enables direct reading of the fundamental wavelengths, just as the equivalent fundamental frequency scale permits direct reading on fundamentals of those frequencies. And though the harmonic system as used affords determination in frequency. these may be converted to wavelengths by turning the pointer to an easy sub-multiple of the determined frequency, noting how many times the fundamental frequency goes into the measured high frequency, and dividing the wavelength reading of the fundamental by this multiple. For example: If the unknown turns out to be 4,000 kc—because the device is useful on short waves as well as on other waves—turn the dial to read 100 kc, note that 100 enters into 4,000 just 40 times, read the wavelength on the opposite pointer as 3,000 meters, and divide 3,000 by 40, equals 75 meters.

Constructional and theoretical data on the 334-A were printed in the September 15th and 22nd issues. This week the architectural diagram of the wiring of the 334-A appears on the front cover.

The capacity comparison system is simply another form of the same problem, that of determining the harmonic order. The object is at first to have some system that will enable the identification of the harmonic. Methods requiring computation have been shown from time to time in technical books and the reports printed in magazines of learned societies.

Instead of capacity as the basis of comparison, of course frequency itself may be used. The method of utilizing the frequency ratios has been alluded to (issue of September 15th), but some further details will be given.

Use of Frequency Method

Suppose that two frequencies are to be compared. Let us select 120 and 128 kc. We know from the formula of product divided by difference that the resultant unknown frequency is 15,360/8, or 1,980 kc. We can of course divide either of the low frequencies into the sum and get the harmonic order for each, e.g., 15,360/120 = 16 and 15,360/128 = 15. Therefore the harmonic orders are 15 and 16 respectively, 15 applying of course to the higher frequency (128) and 16 to the lower (120).

It is admittedly not the predominant purpose to determine what the harmonic order is, but what the unknown frequency is, using two settings of a low-frequency generator to measure a higher frequency. But in view of the considerable adverse comment in the radio technical press on the usefulness of harmonic generators it is well to show in explicit detail that such confusion results merely from lack of comprehension of the subject, and not from a state of facts. Indeed, the harmonic method of measurement is accepted by leading scientists as being the principal one, "and not likely to be superseded," as one says, because of the wide range possible, with simplest and elementary apparatus. The only requirement is that the generator be accurately calibrated.

To return, therefore, to the example of an unknown frequency having been measured as 1,980 kc, and the identification of the harmonic order by another means, since the harmonic order is a reciprocal term, it can not be the basis of ordinary calibration. There is no means of reducing two independent variables to a single linear dimension, and computation is done.

How Ratios Work Out

If we divide the lower of the two frequencies into the higher we get a certain ratio: 128/120 = 1.0667. If we reduce 128 and 120 to the lowest terms we would get the same ratio, 1.0667. Therefore instead of using the full frequency we use the lowest terms, in this instance resulting from division of the two frequencies by 8. So 8 is the least common denominator, and when we divide the numbers by 8 what do we have? Why, we have the harmonic orders, 15 and 16. That is, 16x120 kc or 15x128 kc = 1,980 kc.

Let us take a still simpler example, that of two low frequencies of 100 and 200 kc. If we reduce the ratio to the lowest terms we have 1 and 2. Therefore the harmonic orders are 1 and 2. If we adhere to capacity ratios we have squared terms, 1 and 4. Either way, we can obtain ratio factors, or fractions, and to these ascribe harmonic orders that are infallible, though the ratios for capacities would be different than those for frequencies.

When the harmonic orders are determined, if they are ratioed the result naturally will be the same as for the frequencies; e.g., 128/120 and 16/15 yield the same result, 1.0667.

Therefore a table can be set up that enables determination of the harmonic order either from the frequency ratio or capacity ratio, and of course reciprocally would be applicable to the wavelength ratio.

The higher the unknown frequencies the smaller the differences in ratios, because the fundamentals are closer together to yield the consecutive responses.

Table of Ratios

For a fundamental frequency range of 100 to 200 kc, as established in the harmonic-type signal generator 334-A, harmonic orders up to 25 and 26 would permit frequency measurements up to 5 mgc. The table is given herewith. Any who desire to extend the range may do so by carrying out the division for values of 27/26, 28/27, up to infinity divided by infinity plus 1, if he likes:

Harmonic Order of the Higher Frequency Read Is	*Harmonic Order of the Lower Frequency Read Is*	*When the Higher/Lower F Equals This Ratio*
1	2	2
2	3	1.5
3	4	1.333
4	5	1.25
5	6	1.2
6	7	1.167
7	8	1.143
8	9	1.125
9	10	1.111
10	11	1.1
11	12	1.09
12	13	1.083
13	14	1.0761
14	15	1.071
15	16	1.0667
16	17	1.0625
17	18	1.0588
18	19	1.0555
19	20	1.053
20	21	1.05
21	22	1.048
22	23	1.0455
23	24	1.0434
24	25	1.042
25	26	1.04

When the harmonic orders are obtained they may be multiplied by the frequencies read and in each example will yield the same product, that is, confirm the unknown frequency as being that product.

Radio University

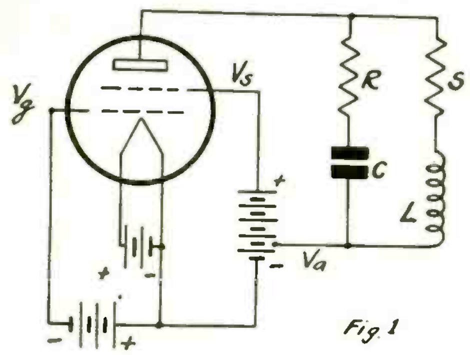

Fig. 1

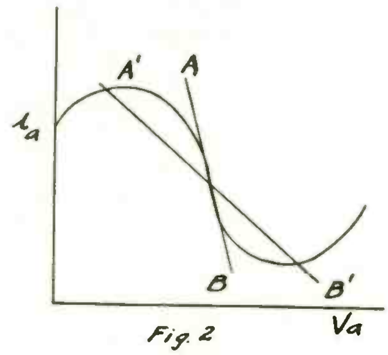

Fig. 2

A.C. and Pulsating D.C.

WILL YOU PLEASE explain your position that there is no alternating current in the plate circuit of a resistance-coupled amplifier? It is assumed a.c. is put into the grid circuit or elsewhere.—I. K. C.

That proceeds from a close adherence to the definition of what is alternating current and what is direct current. In common expression "a.c." in the plate circuit refers also to pulsating d.c., where the pulsations are of an a-c nature. However, with stricter definition of the two aspects, consider a.c. in its true form put into the grid circuit, the d-c potentials applied to the tube as usual. There is a resistor in the plate circuit, or the plate may be grounded to a positive potential and the conductive space in the tube considered, it makes no difference. The only type of power present in the load resistor or space conductor is that supplied to it, which is d.c. However, this d.c. is being acted upon by a.c. due to the grid influence. That does not change the nature of the plate circuit power at all. The grid effect modulates that d-c power, but actually no a.c. is present as such. Pulsating d.c. is the name for it. If there is a resistor load, the same pulsations are present. If a stopping condenser is between plate of that tube and grid of the next, a.c. is put into the second grid circuit. The condenser therefore acts as a sort of converter. The a.c. arises from the pulsating d.c. charging the condenser, which discharges at the same period into the leak. If there is a coil in the plate circuit, the a.c. is reincarnated due to electro-magnetism. When current flows through an inductance there is a magnetic field. When this current is modulated with pulses, that is, when the current is pulsating d.c., there takes place a reincarnation of a.c. due to the identical variations in the magnetic field. Still there is no a.c. in the plate circuit, strictly speaking, but it is present in the magnetic lines of force about the coil. Hence electro-magnetic coupling becomes feasible. In the case of leak or coil in subsequent grid circuit (following tube) the condenser simply discharges either into and delivers a.c. a coil or a leak. If there is a coil then the electro-magnetic condition exists again, and a.c. is present, but so is it present if only the leak is considered, because the load in this subsequent grid circuit receives a.c., no matter what the load is. The practice of not differentiating between a.c. and pulsating d.c. in such circuits is a handy one. Every one is presumed to know what is meant. Besides, a.c. meters will read pulsating d.c., so a general coverage by the description "a.c." is not amiss.

Television Method

WILL YOU PLEASE give a brief outline of how television is worked? I do not know anything about it. Also I am aware that a sketchy outline which aims mostly at simplicity has to sacrifice some accuracy. But at present I am all at sea about the process. So must many another be.—T. F. C.

First we have something that is to be seen. It may be a close-up of a person, it may be a group, or a scene. It has to be formed as an image, and a camera could be used, the image being cast upon something, say, a ground-glass. Or the image may be present on a movie film. Anyway, there is a picture to be scanned, one of actual or apparent motion. The movement is either natural in the actors and scenery or it is of the illusory type as in the movies, where a succession of stills, say, 24 pictures per second, create the illusion of motion due to persistence of vision. Now we have a picture but can not send it out as such to be picked up by receivers. We have to break up the picture by some method. This is called scanning. The effect of playing a spot of light horizontally across a picture, and covering the picture quickly by drawing the resultant horizontal light "line" down the length of the picture, would constitute scanning. The resultant lights and shadows, spot at a time, are introduced into a photo-sensitive device. The light values are changed into equivalent current values. This is rectification. The electric current values may be used as modulation and impressed on a radio wave. At the receiving end a set picks up the wave, modulation and all, a detector in the set removes the carrier, and the television frequencies, or picture frequencies, alone remain and are fed into a device that changes the electric current values back into light values. The light of the lamp is then scanned at the receiving end to piece together, as it were, the elements into which was originally broken up to produce the electric pulses. The result is viewing at one place the movements that took place of persons and things at a distant place, in other words, television. At the transmitting end the method of changing the light values to current values may be different from what has been explained. A photo-electric cell system may be used, so that either mechanical or electrical scanning controls the actuation of the cells by the amount of light and shade per picture element, but somehow the picture has to be broken up and the dissections turned into electric values. The electric scanning system at the sending end uses a photo-electric-sensitive device in a cathode-ray oscillograph tube (the photo-cells replacing the usual fluorescent screen) but at the receiving end the fluorescent screen is used. No moving parts intervene. This would be splendid if there were enough light. The best illumination has been demonstrated in a system using ordinary lamps the light from which is controlled by an improved Kerr cell.

* * *

The Limiting Factor

WHY IS IT TRUE that the curvature of the characteristic is the only thing that limits the amplitude of an oscillator? Why would it be possible for the amplitude to be infinite if the curvature did not exist, but the grid-voltage, plate-current curve was a straight line? Are there any oscillators that are free of harmonics?—I. H. C.

The curvature of the characteristic is an expression used to denote the fact that the tube's operating resistance is of changing value. There is very high authority for the statement that the curvature is what limits the amplitude but we were never convinced. We can conceive of the amplitude being limited under any conditions where there is resistance in the circuit, whether the curve is a straight line or not. What seems to us to be a stricter limitation on the amplitude is the law of conservation of energy. The total power in the operating circuit can not be greater than the supply. Hence infinite amplitude could not be realized. There is no such thing practically as a tube oscillator free of harmonics, although the harmonic content can be greatly reduced, and made almost negligible in fact, by operation oyer a straight portion of the characteristic. The moment grid current flows this harmonic-checking becomes impossible of full attainment. Hence nearly all systems in which the harmonic generation is suppressed a great deal are of limited amplitude, compared to the B voltage supplied.

* * *

Computing Harmonics

IS IT a fact that the harmonics can be computed from the characteristic curve of a vacuum tube, and if so will you please state in general the basis on which this is done? I would like the theory expounded, rather than the precise method, as I could develop the practice from the theory.—P. L. M.

Yes, the characteristic curve can be made the basis of harmonic computation. In the diagram Fig. 1 represents a vacuum tube circuit, with Vg the grid voltage, Vs the screen voltage, Va the anode or plate voltage. The tuning condenser C is represented by itself and also with a series resistance R shown as representing the equivalent series resistance of the condenser, likewise the series resistance S represents the equivalent series resistance of the coil. These resistance values change with frequency. Thus the current in any variably-tuned circuit with which these constants are associated changes. Likewise the tube characteristic alone is that of a changing resistance during operation, since the current is not constant. Fig. 2 shows an exaggeration of the characteristic curve, with A'B' representing a linear characteristic, and AB covering that part of the circuit's characteristic curve that is practically linear. Since harmonics are due to a multiplicity of sine waves, the departure from linearity, expressed in angular terms, can be used for computing the harmonic content. The A'B' line alone is for steady resistance, not realized. The AB line is for uniform change of resistance, with which the curve coincides only slightly. Chords taken from various points of the slopes measure the harmonic content.

VTVM

WILL YOU KINDLY state whether it is practical to have a vacuum-tube voltmeter, using a single tube, for a wide range of voltage measurements, and whether the grid-current of straight diode type is preferable? Are the calibrations independent of frequency and will they stay put? What can be done to aid the stability?—U. H.

It is not practical to have a wide range in a single instrument such as you describe, although this statement is somewhat related also to an answer to the question whether a diode or a grid-leak type circuit is preferable. The diode can be operated without any power expended, save for the normal application of d-c potentials to the tube. That is, the tube draws no current from the measured source, neither does it draw anything worth mentioning from the cathode (filament). The voltage range would be small. If any appreciable extension were to be introduced it would necessitate higher B voltage and re-biasing accordingly, and also introduce the danger of connecting a high-voltage unknown when the instrument was set to read only small voltage, and thus damage the tube. Even the diode draws a bit of current after the unknown exceeds a certain low voltage, but this may be neglected. In the grid-current type, for the usual purposes, that is, no elaborate refinements required, even the flow of grid current need not be considered. The measurements of these instruments, both types, are independent of frequency, except that at low frequencies there is a low reading unless the grid condenser is some 0.02 mfd. up for a leak of megohms. By the way, it is not practical to use a voltage divider resistor across the input for unknowns, and connect the VTVM to a small part of the resistance, to increase the range, as the potential divider draws current from the measured source, and it is to avoid this that the thermionic voltmeter is used. Usually up to 6 volts are measured. For higher voltages, say, 6 to 30 volts, the slide-back type VTVM instrument is preferred. For ranges to 6 volts the fixed-bias or grid-current-bias type may be used.

* * *

Tube Gets Too Hot

THE PENTODE POWER TUBE in my set sometimes gets very hot, and even reddish inside, near the base, and I was wondering if you can suggest a cure?—J. K.

The tube itself may be defective. Another possibility is that the tube is being operated at too low a bias, or even at zero bias, due to a misconnection in the external circuit. A third possibility is that far too much signal is being put into it, and grid current flows. This tends to make the tube lose bias, in the absence of resistance and condenser to operate in leak-fashion. So interrupt the grid return for the pentode with a resistor of 0.1 meg. and put a large capacity across it, say, 1.0 mfd. up. It is also possible that nothing is wrong save that the plate voltage is much greater than the recommended value.

* * *

Constants for Resistance Audio

IN A RESISTANCE-COUPLED audio amplifier, is it necessary to select the stopping condenser and grid leak values so that the time constant will be just right?—R. E.

No. There are numerous other influences affecting the amplification, and we can't see that the time constant has much to do with the problem. There is inevitable feedback, positive or negative, sometimes one way in one stage, the other way in another stage. Negative feedback reduces amplification, especially on the low notes. Positive feedback aids amplification. The aid may be too pronounced at some particular frequency, and then there is oscillation, evidenced by slow periodic phenomena (motorboating) or fast phenomena (howl, screech or whistle). These feedback considerations, especially in high-gain audio circuits, are almost controlling. There are numerous means of correcting for any troubles that arise. Principal among them is use of enormously large filter and bypass capacities, to reduce the common impedance.

* * *

Duplicating Scale

IN A SIGNAL GENERATOR where it is desired to use the same calibration for two bands—multiplying the calibration by a factor to obtain the news and higher frequency readings—is it practical just to select the inductance accurately? Have you any suggestions?—B. C.

No, the accurate selection of the inductance, while important, is not of itself sufficient. The smaller coil may be expected to have smaller distributed capacity. Capacity differences can not be compensated by inductance. The capacity compensation may be effected by using separate trimmers, or by putting a resistance in the plate circuit, bypassing it with different switched-in capacities, as there is reflected back a small parallel capacity on the tuned circuit. Correctly different values of grid condenser also would suffice, since the effect of the grid capacity is that of a much smaller capacity. In the foregoing examples it is assumed that the grid circuit is tuned. When the circuit is perfected, any given position of the low-frequency tuning of the calibrated generator, yielding a beat with another oscillation of the same frequency, should yield the same beat when the switch-over is made, due to an harmonic, or higher harmonic, of the additional generator being then the second frequency for beating. This method of balancing, particularly using separate trimmers, is used commercially and works well.

* * *

Cardboard Tubing

IN DAYS GONE by I used to read about coils wound on cardboard. I suppose they are "out" in these days of advanced technique.—P. O'C.

If a coil is wound simply on a cardboard form, naturally it will not be much of a coil. Immerse the cardboard in water and note how fairly well it imitates blotting paper. If the form can absorb moisture readily it is not good. However, even cardboard can be treated so that the resultant coil form is acceptable. Soak the cardboard form in molten parrafin wax, with the fluid at a higher temperature than boiling water. After the winding is put on, give it a good coat of shellac and afterward bake the finished product dry. Metal pieces, metal terminals, etc., should be avoided on the coil form as much as possible. Actual measurements have been made on such a coil for broadcast frequencies. The results are quite favorable, much better than those from cheap commercial coils wound on a very low grade phenolic compound.

Speedy Messages Sent on Micro Waves as Facsimiles, Presaging End of Morse Code

The scanning principle is being applied by the Radio Corporation of America to messages and pictures sent by micro waves as the advance step in the revolutionization of commercial communication.

Due to the peculiar properties of the very high frequencies of carrier transmission, wavelengths below 5 meters, including penetration over a distance in general limited by the horizon, pictures can be sent in terms of current values corresponding to the values of light and shade in the original and can be restored to the original picture in the manner of television. In fact, some engineers believe that the first step toward practical television is the solution of the utilization of the micro waves for fac-simile reproduction. Fac-simile refers to literal reproduction of still pictures. By television is meant usually moving pictures.

May Spell End of Code

Since the horizon distance is normally 25 miles, but may be extended by transmission from altitudes, it is believed that even greater distances than 40 miles can be achieved reliably. Guglielmo Marconi transmitted centimeter waves some 160 to 170 miles.

The present plan is to perfect the methods now being used experimentally, whereby messages are treated visually, instead of being reduced to dots and dashes for code transmission. The ultimate elimination of the Morse code, because the picture of the message can be transmitted, is prophesied by some.

The Radio Corporation of America and RCA-Victor Company have been experimenting with micro waves, as has the National Broadcasting Company, the chief interest of the NBC being in television. The same principle as used in the movies and in television is to be followed, first 20 pictures a second, however, and later possibly the preferred 24.

In television it is necessary to receive these pictures as modulation impulses and gather them together again by a scanning process to reconstitute each picture and use the varieties for creating the illusion of motion. As is well known, movies consist of still pictures. The film with its succession of "stills" is moved in front of a lamp and behind a lens, the sprocket system causing each picture to stand still for a fraction of a second. Persistence of vision, a phenomenon of the eye, creates the illusion of motion.

Relays and Boosters

The plan as applied to messages, however, does not require the successive use of different poses to create the idea of motion, as no motion is wanted, only the message. Therefore each of the 20 or 24 pictures per second may be a message, and experiments already have been successful whereby several messages have been sent on the same micro wave at the same time without confusion. This is the advanced counterpart of multiplex telegraphy.

Due to the relatively short distances covered by micro waves it would be necessary to relay messages for covering considerable distance. This necessity has led to establishment of experimental booster stations, the plan being to enlarge the short-wave radio message service of RCA Communications, Inc., to enable the sending of messages in facsimile, instead of in code, and at a much greater speed. Moreover, facsimiles may be applied to anything, including photographs, drawings, contracts, etc. The capabilities comprehend anything that can be photographed.

Obey Laws of Light

The present short-wave communication system is developed by RCA Communications, Inc., on the idea of New York City as the world's message center. This idea would be carried out also in going to micro waves. Moreover, for local messages high points of radiation, as from tall buildings that abound in the metropolis, could be utilized. The buildings creating the skyline have been found not to be a disadvantage, as it is easy to attain a height that enables the waves clearing the obstructions.

Micro waves behave something like light waves and are subject to stoppage by opaque objects. Their frequencies are nowhere nearly as high as those of light waves, but the absorption, reflection and refraction follow the same laws as do light waves, and of course the micro waves can be reflected from parabolic and other mirrors, and concentrated in their paths by beam antennas, just as light is subject to beam transmission and concentration by narrowed reflections.

DO-RE-MI CODE HASN'T A THING TO DO WITH $$

One of the most revolutionary steps in the history of radio was demonstrated at 1:00 a. m. recently when WBNX, New York City, introduced a "radio" language designed to eliminate the confusion of languages in international broadcasts.

Given in cooperation with the Canadian DX Relay, a short-wave organization covering the United States, Canada, New Zealad and Europe, the program originated as a test in DX reception and was under the direction of Dr. Herbert L. Wilson, station engineer. Air channels on the 1,350 kilocycles band used by WBNX were cleared throughout the United States for the occasion.

Eight Code Words

Described by Leon Goldstein, publicity director of WBNX, the new language was defined as a "spoken code" based on the notes of the musical scale which he declared were adaptable phonetically to all civilized languages. DO, RE, MI, FA, SO, LA, SI, comprise the alphabet of the new language and it was explained that out of these seven syllables a total of 960,799 words or combinations are obtained, more than sufficient to provide for every contingency of a language.

Each of the combinations express complete thoughts instead of words, thereby eliminating the use of grammar and vocabulary. All that any person needs to understand or transmit a message is the code dictionary which is arranged in such a manner as to make every combination readily accessible to the use, it was said.

The message transmitted to short-wave listeners around the world by WBNX consisted of eight code words and three proper names, which was equivalent to 110 English words. The reason for this inconsistency, Goldstein explained, is due to the fact that the radio language requires fewer words.

The message sent by WBNX was: "RE SOFADOSI CANADIAN DX RELAY SOFADOFA LADO DOFAMISO DON LEE DOFAFADO RFALASO SUE ROYAL."

The Translation

Translated in English, the message was: "This is station WBNX operating on 1,350 kilocycles, 222 meters, located in New York City, New York. This message comes to you by means of the Spatari Radio Code, a new method of communication eliminating the problem of languages. This broadcast has been arranged in cooperation with the Canadian DX Relay and is dedicated to that organization's world-wide membership. The originator of this system of communciation asks your cooperation in making it universally known. Your commentator for this program is Don Lee. At this time we bring to you a song interlude by Sue Royal."

LITERATURE WANTED

M. C. Lake, Lake View, N. Y.
Buddenberg & Co., Lda., Merced 774, Casilla 826, Santiago, Chile, S.A.
Ernest W. Hull, Craig, Colo.
Earl Clark, Route One, Harrisburg, Ill.
Irvin R. Grant, Ola, Ark.
E. Ranzi de Angelis, Via Masone 10, Bergamo, Italy.
H. E. Howell, "Radio Service," R.R. 1, Blacklick, Ohio.

Press-Radio Bureau Failure, Dill Asserts

The enduring squabble between the broadcasting stations and the newspapers and news-gathering associations has not been satisfactorily compromised by the brief news bulletins that the news gatherers permit the stations to broadcast, according to Senator C. C. Dill of the State of Washington. Senator Dill long has been the sponsor of radio legislation originating in the Senate.

The compromise method, which followed protests by newspapers and news associations that their legal rights were being invaded by stations that used news they had no part in gathering, is applied by the Press-Radio Bureau. This bureau, said Senator Dill, is a failure.

The results, he declared, are chaotic, as the listening public does not get from the stations what it requires in the way of news.

"The stations should be permitted to furnish up-to-the-minute news, and for longer periods than the present brief bulletins," added Senator Dill. "Otherwise stations will find a way to create a means of supplying to their listeners the news that is wanted."

Dr. Andrews Joins Staff of National Union Corp.

National Union Radio Corporation of N. Y. announced that Dr. V. J. Andrews has joined the technical-sales staff.

Dr. Andrews was formerly with the Radio Engineering Section of the U. S. War Department, Fort Monmouth, N. J.

With the National Union organization Dr. Andrews is attached to the sales division and will work with radio set manufacturers in circuit development and scientific problems connected with receiver design.

Station Sparks

By Alice Remsen

RECENTLY HEARD A SONG done by the King's Guards, entitled "Nobody Loves a Riveter But His Mother"; I'm inclined to believe that is true; there's a riveter on my street, and he's making the afternoon hideous with his old riveting machine. It's almost impossible to concentrate on tapping out this column on my trusty Remington, especially when I'm also trying to listen for America's Cup race results. Oh, well, here goes for a bit or two of news, anyhow. . . . Henry A. Woodman, who for years has been traffic manager of the NBC, has been appointed general manager of Station KDKA, Pittsburgh. Mr. Woodman succeeds William S. Hedges. . . . Ann Jamison, the young Canadian coloratura soprano, now heard in the Palm-Olive Beauty Box Theatre programs, may think herself a very lucky girl. She gave but one audition, and was immediately signed for the prima-donna role in "The Fortune Teller." Miss Jamison, who has sung in concert and on the air in Canada, and whose voice was trained in Europe, came to New York less than a month ago. . . .

JIM IS TOMMY'S BROTHER

James Meighan, who is being co-starred with Rosaline Green in a new dramatic series, "Peggy's Doctor," over NBC, is a nephew of the famous screen actor, Thomas Meighan. . . . Tommy Harris, the "Little King of Song," one of the best known radio artists on the Pacific Coast, is now being featured in a regular weekly series of programs over an NBC-WEAF network, each Thursday at 4:30 p. m. . . . Another West Coast favorite is finding new fan friends in the East. He is Armand Girard, youthful and handsome Californian basso. He is heard each Thursday over an NBC-WJZ network at 7:30 p. m. . . . The NBC Music Appreciation Hour begins its seventh consecutive season on Friday, October 5th, at 11:00 a. m. over the combined coast-to-coast stations of the NBC-WEAF-WJZ networks. Doctor Walter Damrosch, dean of American conductors, assisted by Ernest LaPrade, has carefully arranged the concerts to supplement instruction in the schools by the music teachers and supervisors. . . . Albert Payson Terhune, who has returned to the air with his "Dog Dramas," every Sunday at 5:45 p. m. over WJZ, is presenting an innovation this year; it is a radio dog show open to mongrels and pedigreed pups alike. All dog owners are invited to submit photographs of their pets, and numerous prizes and blue ribbons will be awarded each week on the basis of the photographs received. . . . William Gaxton, Betty Starbuck, Thomas Meighan, Oscar Shaw and many other stage and screen celebrities were on hand to greet Charles J. Correll and his wife, when they arrived on the S.S. Aquitania after having visited England, France and Italy. Correll, as you probably know, is "Andy" of "Amos n' Andy."

MET. SINGER NEW AIR STAR

Rose Bampton, celebrated young American contralto of the Metropolitan Opera Company, will make her radio serial debut as the star of a new and elaborate musical program to be presented over the NBC networks by Smith Brothers on Saturday, October 6th, at 9:00 p. m. "Songs You Love" will be the title of the new series. . . . Harry Salter has left for the Coast, where he will conduct the Log Cabin Orchestra for Lanny Ross on the latter's new program. Each Wednesday at 8:30 p. m. over on NBC-WJZ network. . . . Danny Malone, the "fame-in-a-night" Irish tenor, who is now repeating over NBC networks the success that made him one of the most popular singers in English music halls and radio, has acquired the "swing" of American radio technique during his month on the air here. As a result, he is now on a new and augmented schedule of broadcasts over an NBC-WEAF network. He is heard on Mondays, at 11:00 p. m.; Thursdays, at 7:30 p. m., and Saturdays at 10:30 p. m. . . . Frank Buck has deserted WJZ in favor of WEAF. Since the return of Amos n' Andy to the air. Buck will have the same sponsor and the same time, however—Pepsodent and 7:45 p. m. . . . Queena Mario, famous Metropolitan Opera Company lyric soprano, is now to be heard in a new series of programs for the American Radiator Company, every Sunday at 7:30 p. m. over an NBC-WEAF network. . . . Jane Froman, the beautiful radio and stage singer, is being starred by Pontiac in its new series over NBC-WEAF, together with the Modern Choir, Don McNeill and Frank Black's Orchestra; am very glad to note also that Meyer Rappaport is receiving credit for his fine harmony arrangements used by the Modern Choir. Meyer has been one of the outstanding vocal arrangers in New York for a considerable time. . . .

MILDRED BAILEY BACK

And "Plantation Echoes" brings Mildred Bailey back on the air October 1st, with Willard Robison's fine Deep River Orchestra; don't miss this; the time set is 7:15 p. m. over an NBC-WJZ network, each Monday, Wednesday and Friday, under the sponsorship of Vick's. . . . October 1st also marks the return of Elsie Hicks and Nick Dawson in "Dangerous Paradise"—Mondays, Wednesdays and Fridays at 7:45 p. m. NBC-WJZ. Sponsored by the John Woodbury Company. . . . Jolly Coburn's Orchestra has been selected to open the new Rainbow Room Cafe, atop the RCA Building in Rockefeller Centre. Coburn will also be sponsored by the Sparks Withington Company, in a new series starting October 14th, and each Sunday thereafter at 6:15 p. m. over an NBC-WJZ network. . . .

OVER AT COLUMBIA

Over at 485 Madison Avenue, where Columbia holds sway at WABC, the big event for October 2d is the opening of the new Camel Caravan series, with Glen Gray's Casa Loma Orchestra and Walter O'Keefe, Annette Hanshaw and Ted Husing. This will be a twice weekly half-hour broadcast; Tuesdays at 10:00 p. m. and Thursdays at 9:00 p. m. . . . And then "The Shadow" returns to the Columbia network on October 1st. Frank Readick will play his old role of the Shadow under the sponsorship of D. L. and W. Coal Company, for Blue Coal; each Monday at 6:30 . . . The Booth Fisheries Corp. has turned to radio with a weekly drama called "Fish Tales," each Wednesday at 11:15 a. m.; WABC and thirteen other Columbia stations. . . . George Gershwin, supported by Louis Katzman's Orchestra, Dick Robertson, Rhoda Arnold, Lucille Peterson and a male sextet, is being sponsored by Health Products, Inc., in the interests of Feenamint; each Sunday, at 6:00 p. m. WABC and Columbia network. . . . It is good news to hear that Atwater Kent has returned to the air, this time, however, over the Columbia network. Josef Pasternack's Orchestra will be featured and world-famous artists will be presented as guests each week; Monday's at 8:30 p. m. . . . Chesterfield returns to Columbia on October 1st with an imposing array of talent, including Rosa Ponselle for the Monday programs, Nino Martini for Wednesdays and Greta Stueckfold for Saturdays. Andre Kostelanetz and his forty-piece orchestra will be featured on each program. 9:00 p. m. will be the time for each of the three-a-week broadcasts. . . . In the Columbia "Quotes of the week" Jeanie Lang says: "I've given up squeaking my songs. Although this manner of singing won me a screen role in Paul Whiteman's picture a few years ago and sent me on my way, I think it is about time I grew up. I'm going to sing right out like other people and I promise there won't be any more squeaks out of me—only a giggle now and then." Well, I guess we can stand for a giggle, providing you do keep to the now and then, Jeanie! . . .

STUDIO SHORTS

Walter Preston, NBC baritone, is writing a book on—of all things—tennis. It will be titled "Life Begins at 40-Love." . . . Leo Reisman recently insured his Guarnerius violin for $30,000. . . . Hollywood is after James Melton. They'll get him yet! . . . Howard Claney, NBC announcer, is showing a group of paintings he made of Parisian landmarks and shipboard scenes during a brief vacation to France. . . . Ralph Kirbery loves to catch fish, but always refuses to eat the fish he catches. . . . Barry McKinley was a tap dancer before coming to radio. He still taps for exercise. So do I, Barry! We'll hold a match one of these fine days. . . . Nearly a million copies of Tony Wons' Scrapbook have been sold in seven years. . . . Ray Heatherton was once employed by the New York Telephone Company to sooth ruffled customers; he is still soothing listeners—for NBC and Fels Naptha. . . . Richard Himber was a package wrapper in a department store and started his musical career as secretary to Rudy Vallee. . . . Ethel Shutta was once a chorus girl in a Chicago theatre. . . . William Daly collects road maps. . . . Vivienne Segal collects first editions. . . . Cyril Pitts collects ties, books, and automobiles. . . . It takes Dwight Weist, movie mimic, just about ten hours of listening to perfect an impersonation. . . . Frank Crumit and Julia Sanderson, although old stagers, are always nervous before a broadcast. . . .

I CAN RECOMMEND: HALL OF FAME, Sunday, 10:00 p. m. WEAF. . . . BOAKE CARTER, Mondays, WABC, 7:45 p. m. . . . LAWRENCE TIBBETT, Tuesdays, WJZ, 8:30 p. m. . . . TOWN HALL TONIGHT, Wednesdays, WEAF, 9:00 p. m. . . . VERNA OSBORNE, Thursday, WOR, 1:45 p. m. . . . KINGS GUARD QUARTET, Friday, WJZ, 8:45 p. m.,—and ROXY REVUE, Saturday, WABC, 8:00 p. m.

A THOUGHT FOR THE WEEK

THAT tragedy of the sea, the burning of the Morro Castle, brought out vividly the fact that in the final analysis the scrap between newspaper and the radio will be settled by facts rather than by argument. It is interesting to note that millions of people in all parts of the world received their first intimation of the awfulness of this catastrophe through the resources of radio.

Of course, the fact that the Morro Castle catastrophe started during the very early hours of the morning—that is, between the latest regular morning editions and early evening editions, gave radio an advantage in the matter of time. The newspaper offices were deluged with inquiries about the disaster hours before their regular editions were issued. Incidentally, here is one instance of news so great and overpowering in its significance and importance that there was very little chance for anybody to fight over the matter of precedence or copyright values.