

The General Radio Experimenter

VOL. IV, No. 4

SEPTEMBER, 1929

IMPROVING THE PRECISION OF SETTING IN A TUNED-CIRCUIT WAVEMETER

By JAMES K. CLAPP

THE difficulty in observing accurately the true resonance setting of the variable condenser in a tuned-circuit wavemeter is known to any one who has attempted to make precision measurements by looking for the current maximum. The peak of the resonance curve is so flat that the precision of setting the condenser is often far less than the inherent accuracy of a high-grade tuned-circuit wavemeter. These difficulties have led to the development of the incremental capacity method for indicating resonance and to its being included in the General Radio Company's TYPE 224-R Precision Wavemeter,* a special instrument to cover the high-frequency bands.

The essentials of the circuit are indicated in Figure 1, where the fixed inductance L , the variable condenser C , and the thermogalvanometer I make up the usual wavemeter circuit. The fixed air condenser (marked ΔC , for incremental capacity) and the push-button switch are the additional elements for making possible a more precise adjustment of C . The by-pass

condenser, shown in dotted lines, makes the readings of the thermogalvanometer more nearly constant over the frequency range.

When testing for resonance by the incremental capacity method, the main tuning condenser C (which is of the worm-drive precision type) is slowly adjusted, and the push-button switch is alternately opened and closed. There will be found an adjustment of C where the thermogalvanometer reading does not change when the push button is operated. This is the desired adjustment.

The principle of this procedure is shown in Figure 2, where I_1 and I_2 correspond to the two settings of C , C_1 and C_2 . Since I_1 and I_2 are equal, the thermogalvanometer shows no change in reading when the push button is operated. The scale reading of C , corresponding to C_1 , is taken as the calibration setting for the frequency in question. This is allowable, since, in a given wavemeter circuit, there is a definite relationship between C_1 , which corresponds to the scale setting observed, and C_0 , which corresponds to the true resonance condition.

Suppose the main condenser C to be set at a value of capacity slightly less

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*Although the TYPE 224 Precision Wavemeters have for some time been calibrated both in frequency and in wavelength, they are still known as *wavemeters* for catalog purposes.



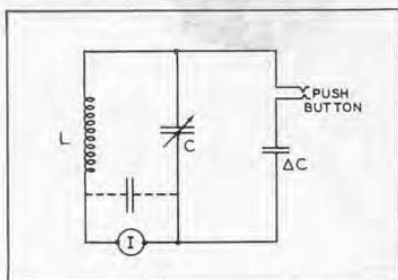


FIGURE 1. Circuit for a tuned-circuit wavemeter to be used with the incremental capacity method of indicating resonance

than C_1 (see Figure 2). The corresponding current is I'_1 which is less than I_1 . When the push button is depressed and the condenser ΔC is shunted across C , there results I'_2 , which is greater than I_2 . For this setting of C , operating the push button causes the current to change from I'_1 to I'_2 . This change, which is quite noticeable, makes possible a precise adjustment of C .

When using this method, it is only necessary to observe how the current I behaves when the push button is operated in order to tell whether the setting of C is too high or too low. If the setting of C be too low, depressing the push button will increase the reading of I ; if the setting of C be too high, depressing the push button will decrease the reading of I .

A wavemeter which has been constructed and calibrated for use with the incremental capacity method must be used with some care and caution, since it is not in resonance with the frequency being measured for either position of the push button. The ordinary wavemeter calibrated for maximum deflection of the thermogalvanometer I is intended to be in resonance.

Inasmuch as a tuned-circuit wavemeter is coupled to the circuit being measured, the coupling coils of the wavemeter and of the measured circuit are, in effect, the primary and secondary windings of a transformer. The im-

pedance of the wavemeter circuit is reflected into the oscillator circuit by "transformer action," the magnitude of the reaction depending upon the value of coupling between the two circuits. For close coupling the reflected impedance may be large enough to materially modify the effective impedance of the oscillator circuit. It should, therefore, be apparent that when a wavemeter is coupled to an uncontrolled vacuum-tube circuit,* the wavemeter may react upon the oscillator and change its frequency.

When the wavemeter is in resonance, the impedance reflected into the oscilla-

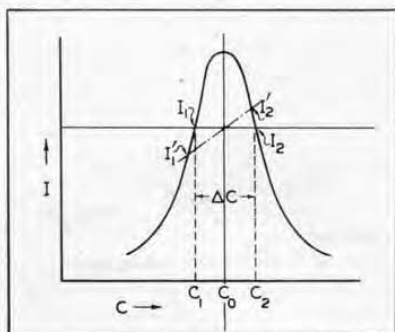


FIGURE 2. Typical resonance curve showing the operation of the incremental capacity method

tor is non-reactive and little damage is done because pure resistance introduced into an oscillator circuit causes a frequency change that is entirely negligible. If the wavemeter be out of resonance, the reflected impedance has an appreciable reactive component which alters the reactance of the oscillator circuit, and consequently alters the frequency of the oscillator.

The reactance reflected into the oscillator circuit depends upon the amount by which the wavemeter is detuned, for a given value of coupling. The de-tuning is dependent upon the ratio of the incremental condenser,

*One whose frequency is determined by the reactance of the tuned circuit, in other words.

ΔC , to the variable condenser C . As the value of C is changed in adjusting the wavemeter over its range, the reaction of the wavemeter on the oscillator also varies. By choice of the value of coupling employed with each setting of the wavemeter, the reaction may be kept at a small and practically constant value.

The precision with which readings may be taken with a wavemeter fitted with this incremental condenser is remarkably high, of the order of one part in 20,000. This means that an oscillator could be set to within 1000 cycles of a desired frequency in the vicinity of 20,000 kilocycles, or 15 meters. The absolute accuracy of the wavemeter involves such factors as the permanence of construction of the coils and variable condenser and the changes

in the constants of the circuit with temperature.

It must be borne in mind that the rating of the oscillator has nothing to do with the shift in frequency that will be caused by improper handling of the wavemeter. If the wavemeter is coupled to 5-watt and 1000-watt oscillators having identical tuning characteristics, then the wavemeter will cause the same shift in frequency in both for the same values of wavemeter-oscillator coupling.

For this reason, the push-button type of wavemeter must be used with care and the coupling kept as small as possible. Ordinarily no difficulty is encountered when measuring the frequency of a transmitter if the wavemeter be coupled to the power amplifier following any form of master-oscillator.

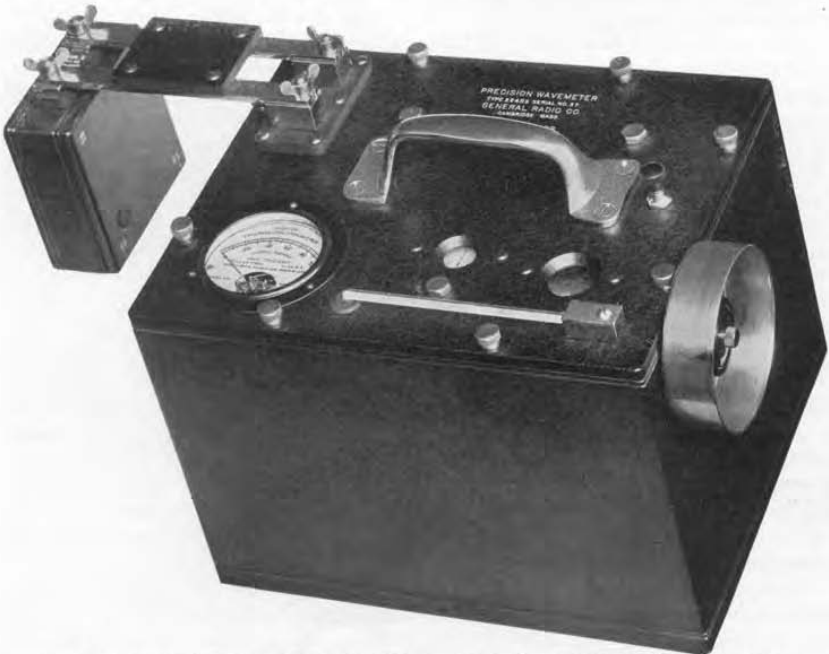


FIGURE 3. A special TYPE 224-R Precision Wavemeter equipped with a push-button switch

A RADIO-FREQUENCY DRIVER FOR THE SERVICE LABORATORY

By CHARLES T. BURKE

THE service laboratory which specializes in the maintenance and repair of radio receivers finds itself in a position very much like that of the automobile garage. Present-day receivers are almost as complex as automobiles and it requires the same high type of work to service both. There was a time when anyone owning a few wrenches and a tire pump could set himself up as an automobile service station, but that day is gone. Garages equipped with many kinds of special tools are able to perform work so much cheaper that the man without equipment must often charge less than his cost in order to compete.

There was also a time when all that one needed to service a radio receiver was to possess a working knowledge of two or three popular circuits and an ability to handle a screwdriver and a soldering iron. Only the simplest of tools were required. The radio-frequency section of most receivers consisted of a relatively simple set of tuning controls which operated the detector tube; or, if there were radio-frequency amplifiers, each one had its own control. Troubles were easy to localize when one could get at all the connections.

The modern radio receiver with ganged tuning controls and chassis construction presents a much more difficult service problem. Ganged controls and concealed wiring make it troublesome in many cases to use obsolete cut-and-try methods. Besides, the cost of doing service work must now be taken into consideration. The owner of a radio set looks upon it as a finished instrument installed in his home to give him entertainment. From his point of

view, it should be as foolproof a device as the phonograph or the automobile, and he will not pay for the expense of tearing down his set whenever minor troubles develop.

There are now available on the market instruments for making service tests which not only make it possible to do more work in less time, but also to do a materially better job of it. Whether or not the service man will equip himself with good instruments or depend upon cut-and-try methods is a question that he must settle for himself, purely on a basis of cost. If one service man in a given locality makes use of the best available testing equipment and is enabled thereby to do better work at a lower cost than his competitor, the competitor will be forced to adopt similar methods or else go out of business. Many of these helps the service man may construct for himself, but here again, he must decide whether he has saved anything by building his own after allowing for the cost of his time.

II

The troubles that may arise in a modern radio receiver may be roughly classified into the following three groups: (a) those due to defective tubes, (b) those due to defects in the audio-amplifier system, and (c) those that appear in the radio-frequency amplifier and detector units. Tube troubles will be disclosed by any one of a number of testing units now on the market; many audio-amplifier troubles may be quite satisfactorily investigated by simple direct-current continuity tests. For making checks upon the radio-frequency system, however, the funda-

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mental testing device that must be used is a modulated radio-frequency oscillator, for furnishing a test signal at one or more points in the broadcast band.

When neutralizing, when adjusting trimming condensers, when aligning gang tuning controls, when making general radio-frequency continuity tests, and when making any one of a number of other investigations in the absence of a reliable signal from several different broadcasting stations, a test oscillator is an absolute necessity if an intelligent test is to be made. Since practically every one of the new receivers uses a complicated radio-frequency amplifier, the importance of a radio-frequency driving circuit for the service laboratory needs no further emphasis.

III

To meet the demand for a general-purpose driving oscillator, the General Radio Company has developed its TYPE 360 Test Oscillator shown in Figure 1. This instrument consists of a modulated radio-frequency oscillator



FIGURE 1. The TYPE 360 Test Oscillator

which will operate at any point in the broadcast band (550 to 1500 kilocycles)

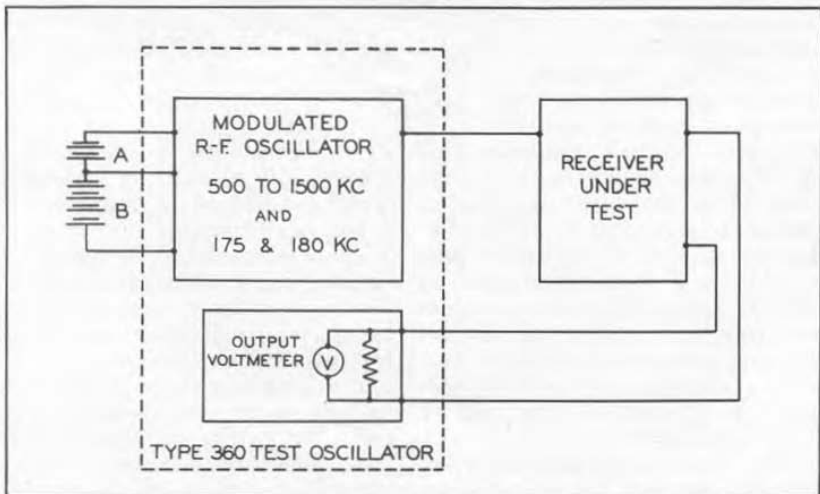


FIGURE 2. Functional schematic diagram for the TYPE 360 Test Oscillator

and in addition, it delivers a signal at 175 and 180 kilocycles for making tests upon the intermediate-frequency stages of superheterodyne receivers.

The frequency of the test oscillator in the broadcast band is adjusted by means of a variable condenser whose dial is calibrated directly in frequency (kilocycles) with an accuracy of 2 per cent. This makes it possible to know in which part of the broadcast band the test is being made. It also makes possible the approximate calibration of a receiver.

The two test frequencies at 175 and at 180 kilocycles are made available by a selector switch, which takes care of the necessary changes in the tuned circuits. A small variable condenser which permits varying the oscillator frequency over a band of about 4 kilocycles on each side of the specified channel is included in the circuit. The channel frequency is adjusted by the General Radio Company to the specified value with an accuracy of plus or minus 0.25 per cent.

The driver is modulated at a frequency of approximately 800 cycles by means of a grid leak and condenser. This is, of course, supplied so that some kind of a signal-indicating device (phones or voltmeter) may be used in the output circuit of the detector tube or of the audio-frequency amplifier to show resonance. This system provides complete (100 per cent.) modulation. It must be remembered, however, that the test oscillator is intended for general testing rather than for making quantitative measurements.

The TYPE 360 Test Oscillator is provided with an output voltmeter for showing when an adjustment on the

receiver results in a maximum output. The output voltmeter is the same one that is used in the TYPE 486 Output Meter which was described in the July-August issue of the *General Radio Experimenter*. It consists of a direct-current micro-ammeter in conjunction with a double-wave rectifier of special design. This type of instrument has considerable value in alternating-current measurements, since it permits the building of low-range instruments of high resistance.

The output device is brought to pin-jacks on the panel for connection to the output circuit of the radio receiver under test. A resistance network which offers an impedance of 4000 ohms is provided for use with the voltmeter when testing a receiver designed for use with a high-impedance (cone-type) speaker. The voltmeter is connected directly across a low-impedance (dynamic) type of speaker, and a selector switch is provided to choose between the two connections. The output voltmeter is intended only for the indication of optimum adjustment and is not designed for quantitative measurements. There is also provision for connecting a pair of telephone receivers into the output meter circuit.

The equipment provided with the TYPE 360 Test Oscillator includes the necessary leads, long- and short-handled insulated screwdrivers, and the test tool illustrated in Figure 3.

The test tool consists of a bakelite rod with a heavy closed loop at one end and a flat spade at the other. In aligning a stage of radio-frequency amplification in a receiver, the loop end is brought into the field of the coil, the



FIGURE 3. Novel test tool for use with the TYPE 360 Test Oscillator

closed loop acting as a short-circuited turn to reduce the inductance of the coil. Should this test cause an increase in signal strength, the trimming capacity in the stage should be decreased.

The flat end of the tool is intended to be brought near the tuning condenser of the stage being tested, the resulting stray capacity to the tool increasing the effective capacity of the tuning condenser. A decrease in signal strength indicates that the tuning capacity for the stage is either correct or too large; an increase in signal strength indicates that the tuning capacity is too small. This method of test, which is suitable for all receivers where the parts are sufficiently accessible, greatly facilitates the task of aligning the receiver, since it shows exactly how the trimming condenser should be adjusted.

The TYPE 360 Test Oscillator employs one 112-type tube which requires a 6-volt storage battery and 45 volts of plate battery to operate it. The necessary connection leads are provided. A hand-hole covered by a metal plate is located in the base of the cabinet so that the tube may be inserted without removing the panel. There is a small pilot light to show when the

filament of the oscillator tube is lighted.

The test oscillator is coupled to the receiver under test by a single lead-wire provided with the instrument. It is intended that it shall be placed far enough away from the receiver to minimize spurious couplings, even though the receiver be poorly shielded.

IV

Last year, it will be remembered, the General Radio Company built a test oscillator particularly for use in making adjustments upon the Radiola super-heterodyne receivers. There was a test signal at 180 kilocycles and one at either end of the broadcast band. This instrument is now obsolete, its place having been taken by the TYPE 360 Test Oscillator. Although it is similar in many ways to the old one, the new test oscillator is distinctly a general-purpose testing device for use with any kind of receiver whose radio-frequency amplifiers are tuned to frequencies within the oscillator's working range.

The price of the TYPE 360 Test Oscillator is \$110.00, its size is $10\frac{3}{4}$ inches by $10\frac{3}{4}$ inches by 7 inches, its weight is $11\frac{1}{2}$ pounds, and the code word is OVATE.

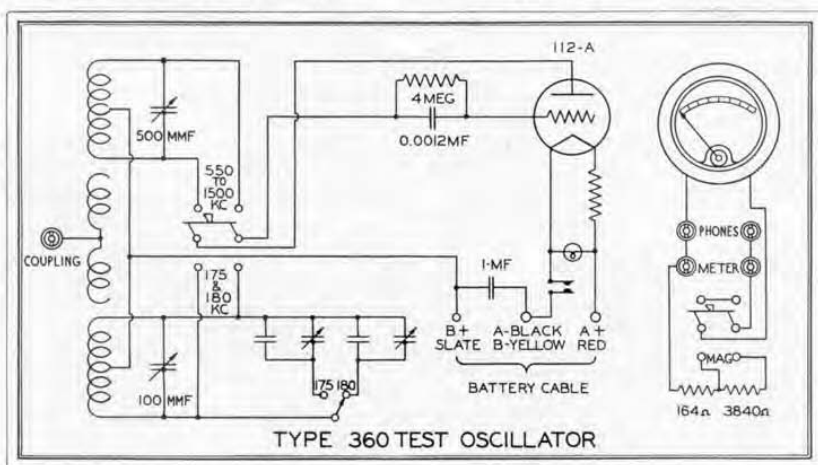


FIGURE 4. Diagram showing the wiring details for the TYPE 360 Test Oscillator

MISCELLANY

By THE EDITOR

ENCLOSED with this issue of the *Experimenter* is a postal card upon which you are asked to report to us whether or not your name and address appear correctly on our stencils. The card will also give you an opportunity to indicate whether you wish to continue on the mailing list.

Please print or typewrite your entries on the card and return it promptly in order to insure your receiving the October issue. Our new mailing list will be made up from the returned cards.

* * * *

This year's superheterodyne receivers have intermediate-frequency amplifiers tuned to 175 kilocycles; last year's models operated at 180 kilocycles. The General Radio TYPE 320 Test Oscillator (no longer manufactured) may be modified to supply the new test frequency. There is a charge of \$8.50 net for this service, which may be performed only at our factory.

Instruments returned for modification should be carefully packed, shipped express *prepaid*, and bear the name and address of the sender. They should be accompanied by a letter stating exactly what changes are to be made.

This repair work will not convert a TYPE 320 Oscillator into a TYPE 360 Test Oscillator; the latter is an entirely different instrument.

The General Radio Company takes pleasure in announcing that on September 3 Arthur G. Bousquet joined its Engineering Department. Since his graduation from the course in electrical engineering at Tufts College with the Class of 1928, he has been with the Bell Telephone Laboratories, Inc., in the Apparatus Development Department.

CONTRIBUTORS

Both contributors to this issue of the *Experimenter* are members of the General Radio Company's Engineering Department:

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Readers of the *Experimenter* will recognize CHARLES T. BURKE as a previous contributor to the magazine.

The General Radio *Experimenter* is published each month to furnish descriptions of the latest developments in General Radio apparatus and to distribute useful engineering information. It is sent without charge to interested persons. Address requests to the

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CAMBRIDGE A, MASSACHUSETTS

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