Equipment for testing

Radio receivers in production

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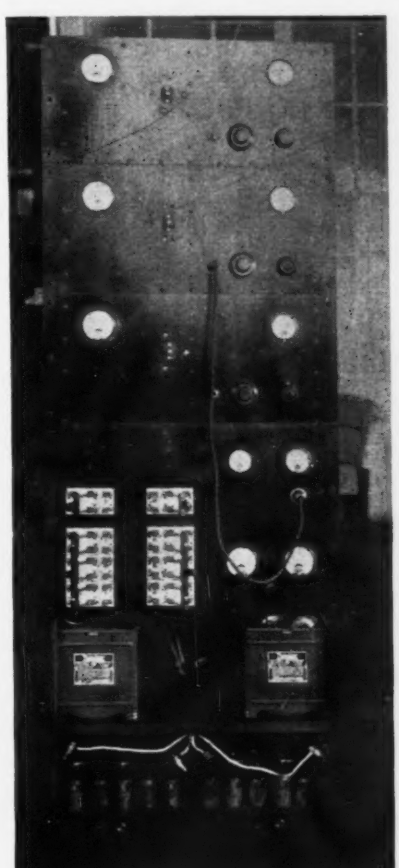
A RADIO receiver, which has been engineered through the laboratory and is then turned over to the production department to build in large quantities, represents the best efforts of the engineering staff and it is then the production department's job to reproduce it as near as possible. Without test equipment, this is an utter impossibility.

The question naturally arises as to the performance requirements of the test apparatus. These requirements may be grouped under three main heads, namely (1) accuracy, (2) ease of manipulation and (3) adaptability to varying conditions.

In discussing accuracy, we might say that the test equipment should be just as accurate as the design or laboratory equipment. In this day of high speed production and with the rapid developments made in laboratory apparatus, the question of being as accurate as laboratory apparatus and yet be able to make routine measurements and keep pace with the production schedule, becomes a well nigh impossible order. Therefore, the accuracy must be compatible with the speed of production. In the apparatus to be described this degree of accuracy is fulfilled.

Ease of manipulation goes hand in hand with high speed production schedules. This should be qualified to some extent in that the equipment should be rugged enough to withstand handling and operation by inexperienced personnel.

During the past year adaptability to varying conditions has been of major importance due to the rapid rise of the so-called "midget" or "mantel" type of receiver, which usually has characteristics that are a radical departure from the previous year's production. Since the test apparatus represents a large initial expenditure, it should not become antiquated with each new model of receiver produced.



Signal generator with power supply and modulating equipment

Receiver characteristics to be tested

In the design of a receiver there are three main features which must be engineered to completion in the laboratory: sensitivity, selectivity and fidelity. Of these, sensitivity is the most important to the production department, since the selectivity and fidelity are more constant when once produced in the laboratory. This simply means that only a small percentage of the day's production is given tests for selectivity or fidelity. These few sets may be tested in the laboratory without tying up the facilities with production receivers. Thus, we see that the major piece of test equipment must of necessity be something for measuring the sensitivity of the production receiver.

In the Howard laboratory it was determined that the receiver's performance over the broadcast spectrum could be fairly accurately determined by selecting three frequencies for testing the sensitivity: 1,400 kilocycles, 950 kilocycles and 560 kilocycles. These frequencies were selected so that none of the high power broadcast stations in the near vicinity caused interference due to heterodyning with the frequencies of the test generator.

Each of the generators for the three frequencies is of the crystal-controlled shunt-feed type. In the plate circuit of each oscillator is the tuned oscillatory circuit which also contains a current measuring meter and a one-half ohm resistor. Since a known current is passed through this resistor, there exists across its terminals a known potential difference. This voltage is fed to a single step of attenuation within the oscillator compartment and from here it feeds a radio-frequency transmission line to which are connected the test positions.

This equipment is built in the rack and panel form and is shown in Fig. 1. The first, second and third panels are the three radio frequency oscillators and modulator units. The meters are, oscillatory current meter on the left the plate voltage, filament voltage meter on the right. Directly under the filament voltmeter is the percentage modulation control knob. To the left of this knob is a small knob and dial of the filament rheostat. The jack is for plugging in the plate current meter. The oscillatory circuit condenser also protrudes through the panel and has a screw driver slotted shaft for adjusting the oscillatory current to a predetermined value.

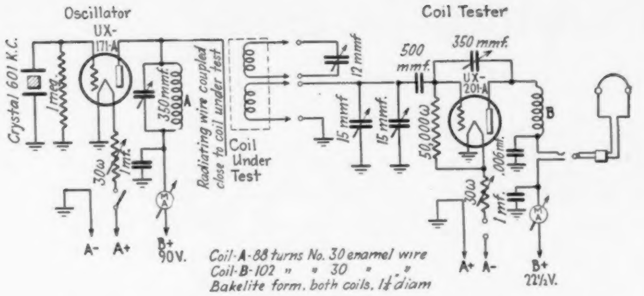
In order to determine the percentage of modulation, a vacuum tube voltmeter was placed across the oscillatory circuit and various plate voltages were applied, with the modulator disconnected, noting oscillation voltage in each case. A curve was plotted from the resulting data in order to determine over what values of plate voltage the oscillating voltage curve was linear. With this determined, an operating plate voltage in the center of this linear part of this curve was chosen. The modulator was then connected and a vacuum tube voltmeter was placed across the Heising choke. The input was adjusted until the vacuum tube voltmeter gave a deflection corresponding to 30 per cent of the operating voltage on the radio frequency oscillator.

Various special transmission lines are run from the equipment. One is used on the final factory test of all receivers to set the pointers of the escutcheon correctly. This line is taken directly from the oscillator tank circuit and is terminated by various potentiometers, for signal adjustment, whose resistances are high enough so that the oscillatory circuit is but slightly affected by them.

Another transmission line is run to another part of the factory and is terminated by another high-resistance potentiometer. Connected to the center arm of this potentiometer is a regulation receiver which has instead of a loudspeaker an audio indicating device. Into this receiver are placed various detector tubes which must give a certain specified output regardless of what other tests may show concerning their characteristics.

Other transmission lines are connected to the repair benches so that the repairmen can work without the necessity of a regular tester and thus do not break into any schedule set for the regular testers.

The maintenance of the apparatus even after a year and one-half of continuous operation is very small. About once every six months the crystals are removed, inspected and washed and the inside of the equipment blown out with compressed air. Once a month the batteries are disconnected and filled with water. This does not mean an entire shut down of the apparatus as the entire power supply is furnished in duplicate. While one set of batteries is being serviced the signal generator operates on the duplicate set. While one set of batteries is being used the other set is on charge, and since the equipment has been placed in use there has never been a complete shut down for a greater period



Crystal oscillator and resonance indicator for testing r.f. coils and transformers

than five minutes. Thus there is no loss of service.

The next most important item of test equipment is, necessarily, the equipment which tests those assemblies which go to make up the receiver itself. One of these pieces of test equipment, is the radio-frequency transformer tester.

The tester in use at the Howard Radio Company consists of two oscillators, one of which is a fixed crystal-controlled type, and the other one is built up around the coil which is under test. The accompanying schematic diagram shows the connections used. For the sake of speed and accuracy, both visual and aural methods of indication of zero beat of the two oscillators are used.

In order to make contact with the coil under test, a fixture is made equipped with plugs for insertion into the tester and connected to these plugs are phosphor-bronze contact fingers which make contact with the solder lugs at the base of the coil under test. Since various arrangements of lugs are used for the various types of receivers built, it is only necessary to change the coil holding fixture and thus the equipment is rather universal in nature.

There are four grades of coils used in our production and the greatest change in tuning capacity is hence only 2.4 micromicrofarads. In order to calibrate the testing device, a large number of coils were made up and tested in the laboratory. These coils were measured very accurately by means of an inductance bridge and then were placed in receivers. From these receivers were selected the radio frequency transformers whch were considered as the upper and lower limits of inductance variation. These coils were then placed in the coil tester and the limits were determined on the grading dial. The change in capacity of the grading condenser was then measured on a precision capacity bridge and the change found was divided by the number of grades to obtain the change in capacity per grade.

Four grades of coils were used, which represent a plus-one-per-cent change in inductance for grade A coils, plus-one-half-per-cent change inductance for grade B, minus-one-half-per-cent inductance change for grade C and minus-one-per-cent change in inductance for grade D coils. Larger charges in the per-

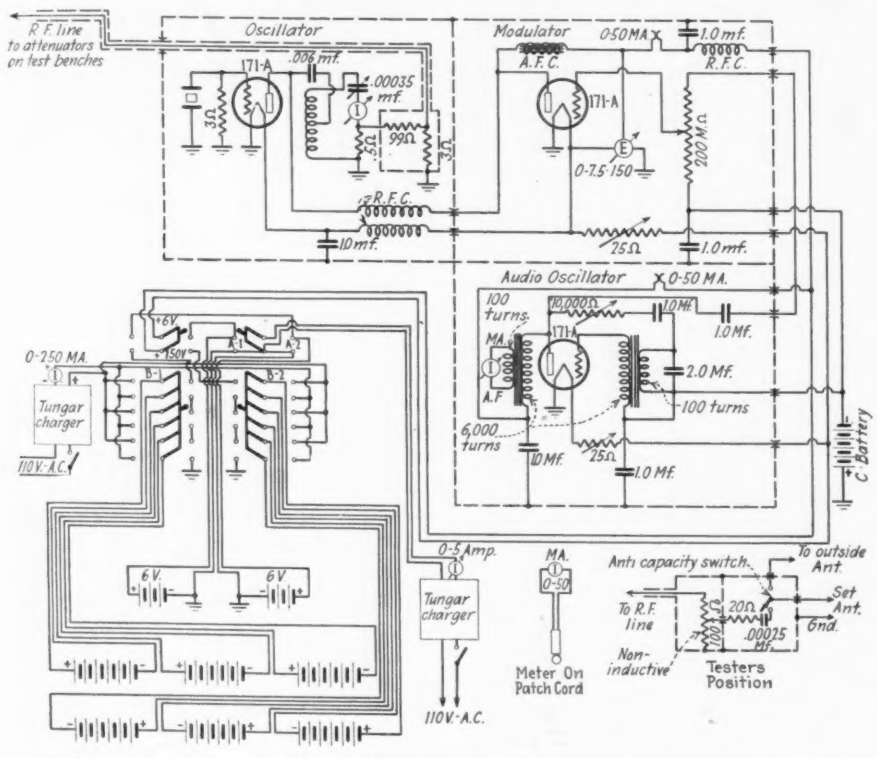
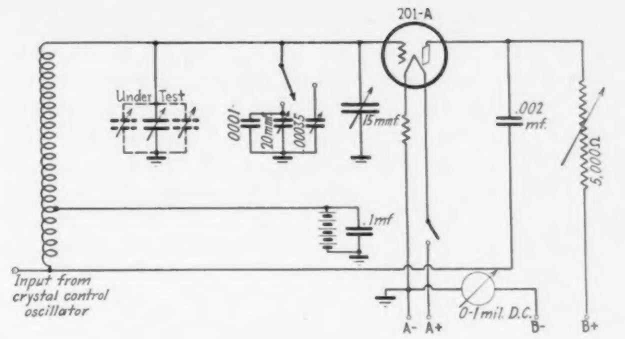


Diagram of the generator, modulator, and power supply equipment. Only one of three generators is shown here. The others are identical



Vacuum tube voltmeter circuit for testing tuning condensers

centage of standard inductance are rejected.

The calibrating method may seem laborious to the reader, but a year and one-half's operation of the equipment has proved to the writer that the labor of calibrating has adequately repaid the initial labor of calibrating.

Production tests on variable tuning condensers

Ranking in importance with the coil tester is the variable tuning condenser tester. This tester consists of an oscillator and a regenerative vacuum tube voltmeter. The oscillator is crystal controlled and the same scheme of connections was used as was used on the crystal oscillator used with the coil tester.

A schematic diagram of the vacuum tube voltmeter is also given. This voltmeter is of the conventional type with the exception that regeneration is added to increase the sensitivity. A bias battery was used instead of a grid leak and condenser so the condition of resonance would cause an increase in deflection of the resonance indicating device.

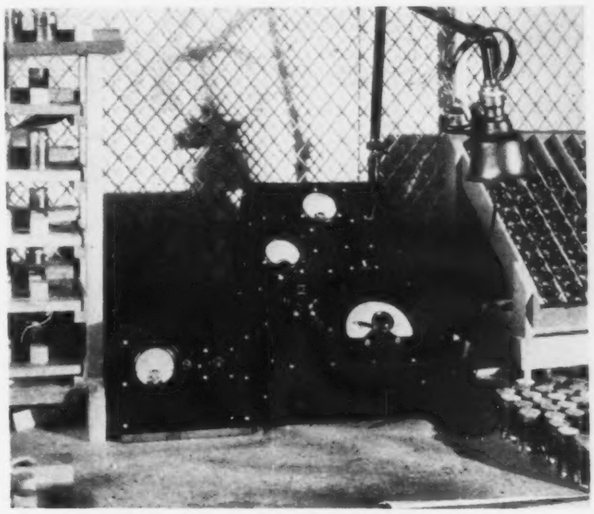
Three positions of testing the capacity of the condenser were selected as being adequate to judge the capacity variation. In the schematic diagram these three positions are shown as three separate variable condensers. Since the fundamental of the crystal only was used there were required padding capacities to bring the circuit back to resonance as the capacity of the condenser under test was decreased. These are shown connected to a second three-point switch, one contact of which is blank. With the pad condenser switch on the blank contact, the variable condenser under test is in its maximum capacity position. The third variable condenser is the grading condenser and is calibrated in the capacity limits corresponding to the particular capacity of the condenser under test.

Method of calibration

The calibration procedure is as follows: The condenser under test is connected mechanically to the tester and is rotated until the resonance indicator shows resonance, the small grading condenser having been set previously to approximately its three-fourths of full capacity position. The condenser under test is then removed and its capacity determined on a precision capacity bridge. The limits are then determined at this capacity setting ($\frac{1}{2}$ of 1 per cent = of test capacity). A precision condenser is then inserted in place of the test capacity and set at either the upper or lower determined limit. The small grading condenser is then rotated until resonance is again indicated and this position is marked. The other limit is then set on the precision condenser and the grading condenser is again rotated until resonance is indicated. The procedure is the same for the other positions of the test condenser with the exception that the small grading condenser is adjusted at approximately one-half capacity position and for the third test position it is set at one-quarter capacity position. This is done so as not to confuse the operator as to what limits correspond to each test position.

In order that the angular rotation of all condensers are alike a fixture for holding the condenser under test is rigidly mounted to the test equipment. Engaging the condenser shaft is a collet which is fastened to a shaft extending through the tester. On the shaft is a handle for rotating the condenser plates which has at its upper end a bullet-type catch which drops into depressions in a circular guide ring. These depressions correspond to the angular rotation of the rotor plates for each test position of the condenser. Any slight inaccuracies of setting on the part of the operator means a negligible change in capacity and are well with the limits of test on the condenser.

Fixtures have also been made to test gang condensers by segregating each section of the gang condenser by means of single pole multiple-point switch. Each section of the gang is treated as a single unit in making the test. One precaution must be observed in testing gang condensers and this is to see that the inductance of the leads to the various sections of the gang are compensated for. This may be done by adding inductance to the shorter leads equivalent to the inductance of the longest lead or by compensating for the inductance in the test limits. The former is by far the most successful if inexperienced personnel is to operate the equipment.



Coil tester with its crystal generator at left

After close observation over a period of a year of operation of this apparatus, we have determined that the error of setting due to mechanical inaccuracies is in the order of one-tenth of a micromicrofarad. This is well within the commercial variation limits.

In conclusion, the writer wishes to acknowledge his indebtedness for helpful suggestions to Mr. A. Crossley, chief engineer of the Howard Radio Company, under whose supervision this equipment was built, also to L. H. Hansen, mechanical engineer, who collaborated with the writer on the mechanical design and to Mr. Ralph L. Arthur, machinist, who built the apparatus.