



# The NOTEBOOK

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## Applications of the Metal Film Gauge, Type 255-A

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In a previous issue of the Notebook,\* an article was devoted to the theoretical aspects considered in the design and development of an instrument for plating and film thickness measurement. This article is intended to show how the Metal Film Gauge, Type 255-A, is being employed in the field, in research laboratories, on production lines, and as a tool for the quality control engineer.

The instrument is useful in several different types of measurements, namely: (1) the measurement of the thickness of a non-magnetic plating such as silver, gold, cadmium, chromium, rhodium, etc., on a non-magnetic basis metal such as copper, brass, aluminum, etc., (2) the measurement of the thickness of a conductive, non-magnetic material such as copper on an insulating basis material such as glass, phenolic sheet material, ceramic, etc., (3) the measurement of the thickness of any insulating film such as an organic paint on a conductive, non-magnetic basis material such as aluminum, magnesium, etc., (4) the sorting of materials by means of their electrical conductivities, (5) the sorting or matching of materials according to their magnetic properties, (6) the determination of the degree, or effectiveness of the annealing process in metals, and finally, (7) the measurement of plating thickness of magnetic materials under certain

\*A-Piip, "Determination of Metal Film Thickness," BRC Notebook, No. 9, Spring, 1956.



Figure 1. Author Demonstrating Sample of Organic Film on Brass Basis.

conditions. Each of these types will be discussed separately in the paragraphs which follow along with a general discussion of suitable "standards" for use with the instrument. For simplicity, each type will be considered as a flat, continuous surface at least  $\frac{3}{8}$ " on each side. Treatment of geometrical configurations other than flat surfaces will be covered later in this article.

### Measurements Of Non-Magnetic Combinations

As an example of this type of plating measurement, let us consider a plating of cadmium on a basis material of copper which is to cover the thickness range of 0.00025" to 0.002". First of all, since the Metal Film Gauge, Type 255-A, is inherently a comparator, the use of a reference standard is always re-

quired in order to make absolute thickness measurements. Such a standard is shown in Figure 2.

This sample standard card is designed to slip into a holding device on the front panel of the instrument and provides the scale for the meter. In order to measure the thickness of cadmium plating for this particular combination, we proceed as follows: Place the gauge head on the sample of basis metal (in this particular case, copper) and adjust the instrument to zero reading on the meter by means of the "Set Basis" control. When approaching zero it is well to have the "Set Standard" control turned to its extreme clockwise position in order to establish a firm zero reading. Next, place the gauge head on the sample of cadmium plating which is known to be 0.0014" and turn the "Set Standard"

### YOU WILL FIND . . .

|   |   |
|---|---|
| A VHF FM-AM Signal Generator System       | 5 |
| Lubrication of Turret and Switch Contacts | 7 |
| Editor's Note                             | 8 |

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control counterclockwise until the meter needle reads 1.4 mils. The instrument has now been calibrated and is ready for use simply by placing the gauge head on any piece of cadmium plated copper of the same basis material and taking the plating thickness reading directly from the scale. Calibrated Standards, similar to that shown in Figure 2 are available as accessories for most non-magnetic metal combinations.

The manner in which a Calibrated Standard is established may be of interest. Let us assume that a Metal Film Gauge, Type 255-A is available and that we wish to measure silver plating on brass, which is a combination frequently found in such fields as waveguide, RF fittings, etc. Let us further assume that we are interested in absolute plating thickness measurements which range from 0.0001" or 0.1 mil to 0.001" or 1 mil. First, we select a sample of the basis material (in this case, brass), place the gauge head on this sample and adjust the instrument to zero by the method previously described. This establishes a point (the zero point) on a calibration curve. Next, we require three (3) different thicknesses of the plated material (let us assume 0.3 mil, 0.5 mil, and 0.75 mils) which have been accurately measured by another method; chemical, optical, or X-ray etc. Using a linear scale from 0-100 for the meter, we place the gauge head on the 0.75 mil sample and set the meter needle to an arbitrary reading approximately two-thirds full scale by means of the "Set Standard" control. Without any further adjustment of controls, we place the gauge head on each of the two remaining samples and record the meter reading. Transfer the meter readings to a piece of graph paper having plating thickness from zero to 1 mil marked off as the abscissa and the meter scale marked off from zero to 100 as the ordinate. We have now described a calibration curve having four (4) known points and a smooth curve may now be

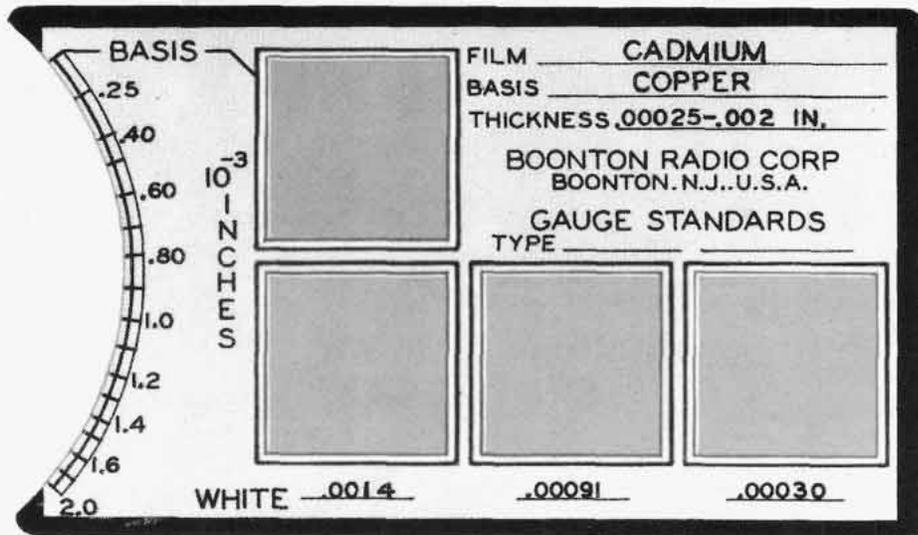


Figure 2. Cadmium Plate on Copper Basis.

drawn through the four points. All that remains is to mount the sample of basis material and the three plated samples on a standard blank card and inscribe a meter scale on the card from data taken from the calibration curve. We can now measure silver plating on brass and obtain absolute readings from the meter scale. This is the method employed by BRC in establishing reference standards that are available as accessories.

**Measurement Of A Non-Conductive Film Or Coating On A Non-Magnetic Basis Material**

In this general classification are such measurements as organic and other non-conductive paint coatings on basis materials of aluminum, brass, magnesium, titanium, etc. In fact, any insulating coating or film on a non-magnetic

basis material can be measured easily and with good sensitivity with this instrument. Again we must provide a reference standard for absolute measurements. It turns out that a reference standard may be rather easily established by using known thicknesses of mica sheets capable of resisting deformation under the gauge head. Since the instrument cannot differentiate between various kinds of insulating coatings, the mica serves as a general standard. Our field experience indicates that the range of thickness measurements between approximately 0.1 mil to several mils covers most cases. Figure 3 shows a reference standard for non-conductive coatings on a basis material of brass and covers a range from zero to three mils. This standard was established in the same manner as that ex-

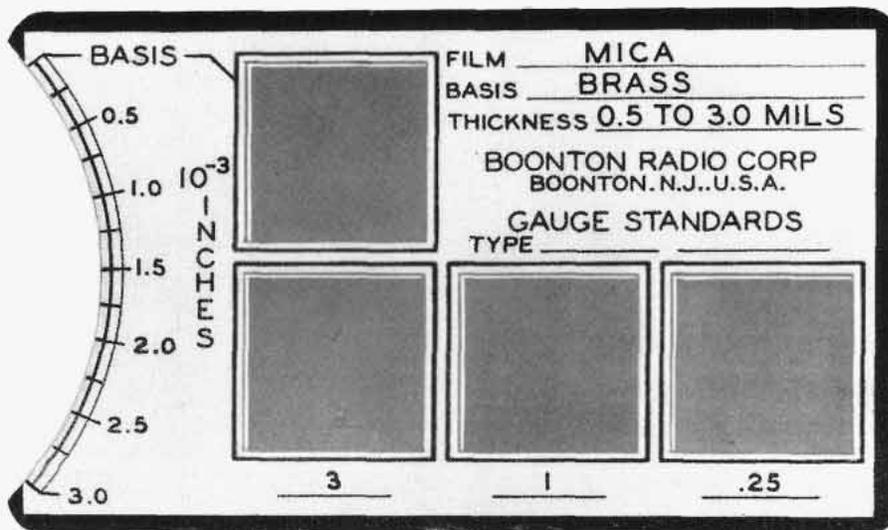


Figure 3. Non-Conductive Film on Brass Basis.

plained for silver on brass except that mica was used in place of known thicknesses of non-conductive coatings. It turns out that only one reference standard is required for many non-conductive coatings. In Figure 3 the basis material is brass. However, this same standard with its inscribed meter scale is used for non-conductive coating on basis materials of aluminum, magnesium, titanium, etc. It is only necessary to place the gauge head on the basis material and adjust the instrument to zero when changing from one basis material to another.

**Conductive Layer On An Insulating Basis Material**

In this category fall such combinations as copper flashing on a phenolic basis material, gold on quartz or glass, chrome on steatite, etc. Here the gauge head is placed on the insulating material and the meter zeroed as before. A standard is established with three known thicknesses of the conductive coating in the same manner as previously described. Limiting factors are very thin insulators coated on both sides and an extremely thin film of conductive coating which is under 1000 Angstrom units in thickness.

**Magnetic Materials**

Plating thickness on magnetic basis materials may be checked provided that the magnetic characteristics are homogeneous. This is a very broad term and is contingent upon many factors. The test for this condition is very easily made with the Metal Film Gauge, however. Simply place the gauge head on a sample of the magnetic material and adjust the meter to read zero. Now move the gauge head around on the sample (and other samples) to see if the zero point remains reasonably constant. If it does, plating thickness can be measured. If it does not remain constant, plating cannot be measured. Many of the better grades of steel, for example, exhibit this constant zero characteristic. Since the instrument is sensitive to changes in magnetic characteristics and changes in electrical conductivity, this feature leads naturally to the next application.

**Sorting And Matching Of Materials**

In some applications it is important that materials exhibit the same electrical and magnetic properties. The Metal Film Gauge, Type 255-A is a valuable tool in checking electrical conductivity and matching materials according to their magnetic properties. No standard other than a sample of material known

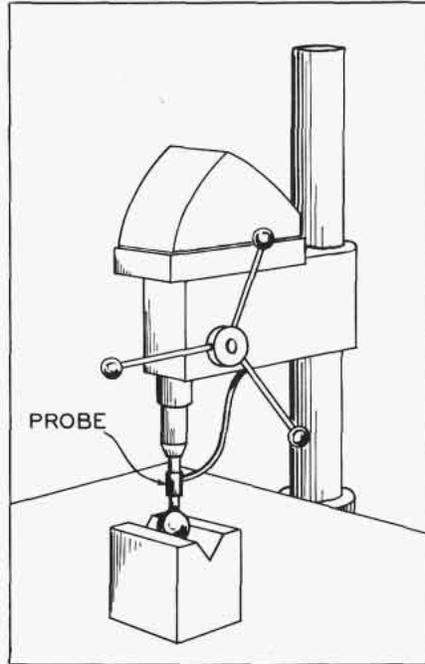


Figure 4. Jig and Fixture Combination.

to exhibit the desired characteristics is required here since we are interested only in relative readings. For sorting according to electrical conductivity, the "Set Base" control could be calibrated in conductivities in place of a linear scale from 0-100, and materials sorted accordingly. For matching magnetic properties it is only necessary to place the gauge head on a sample of the material, establish an arbitrary reading on the meter and match materials according to the deviation from the arbitrary setting on the meter scale. It is also possible to check the degree of annealing in such metals as steel, beryllium, etc. Since the annealing process electrically

"softens" the material, an arbitrary meter reading can be established with the gauge head on a sample of untreated material, and the deviation noted when the gauge head is placed on the annealed samples.

**Measuring Irregular Surfaces**

The gauge heads which are furnished with the instrument were designed for measurements on either flat or cylindrical surfaces with relatively large diameters. The instrument is not limited to this kind of surface area however, and other geometrical configurations may be handled provided there is at least 3/8" of continuous surface area available. The problem is best handled by providing a jig or fixture for holding the probe itself (which can be removed from the gauge head) and, if necessary, a holding fixture for the part to be measured. Figure 4 is a sketch of one possible way in which the jiggling problem may be handled. It is, of course, necessary to establish reference standards which have the same geometrical pattern.

**Standards For Production Line Use**

When the Metal Film Gauge, Type 255-A is used on a production line, the reference gauge standards usually take a form similar to that shown in Figure 5. Here we are interested in a "Go-No-Go" type of test rather than absolute measurements. In this case let us assume that we are concerned with measurements of a plating or coating thickness the acceptable limits of which have been specified as 0.6 to 1.2 mils. Two samples of the coated or plated material — one representing a maximum thickness and the other a minimum

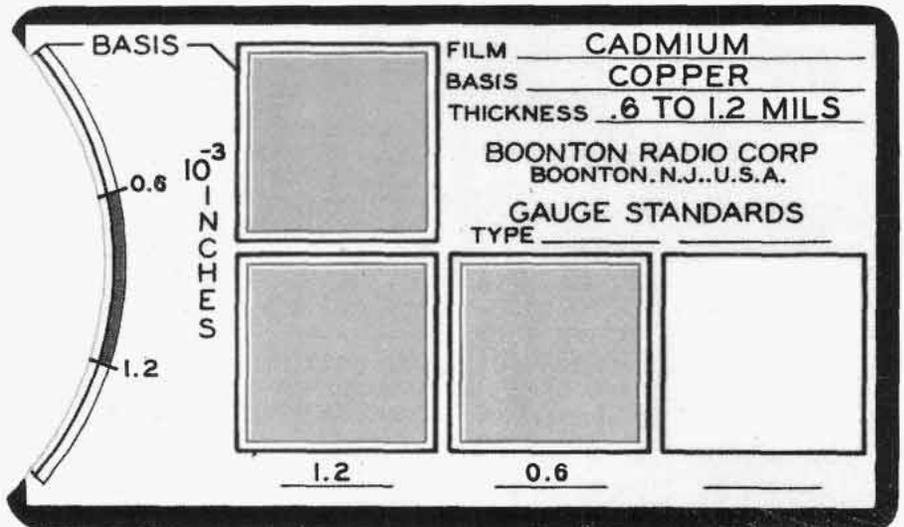


Figure 5. Production Card for "Go-No Go" Test.

thickness — are mounted on a sample card along with a sample of the basis material. The gauge head is placed on the basis material and the instrument adjusted to read "zero" on the meter scale by means of the "Set Base" control. The gauge head is now placed on the maximum thickness sample and an arbitrary meter reading of approximately  $\frac{3}{4}$  full scale is established by means of the "Set Standard" control. This spot on the meter scale should be marked on the scale since it represents the upper limit — in this case 1.2 mils. Without any further adjustment of controls, place the gauge head on the minimum thickness sample and mark the spot where the needle falls on the meter scale. We have now established the two limit points, and this portion of the meter scale can be marked off in a suitable contrasting color. This type of measurement greatly simplifies making a gauge standard and provides the production line with a tool it can use rapidly with a minimum of indoctrination.

#### Increasing The Sensitivity

In the case of extremely thin films the apparent, or usable, sensitivity of the instrument is sometimes greatly reduced. A technique has been developed which somewhat improves the condition. As an example, consider the measurement of a thin layer of gold, silver, etc., on a basis material such as glass or ceramic. Under certain conditions it will be found that when the gauge head is adjusted to read zero on the sample of glass or ceramic and is placed on the gold or silver coating, the meter needle will move only a short distance away from its zero point even with the "Set Standard" control tuned to its maximum clockwise position. This loss in apparent sensitivity limits our range of thickness measurements and the readable accuracy because of the small spread in meter movement. This condition can be improved by adjusting the gauge head to read zero on the coated sample instead of on the basis material. The instrument will now read any deviation from this thickness as the gauge head is placed on other samples of the coated material. However, care must be exercised in this technique. The instrument includes a rectifier which is designed to always read deviations in the same direction on the meter. Suppose we zero the meter on a coated sample which is known to be 0.02 mils in thickness. Further suppose that we next measure a coated sample which is 0.015 mils in thickness. We will read a certain deviation on the meter scale. Now,

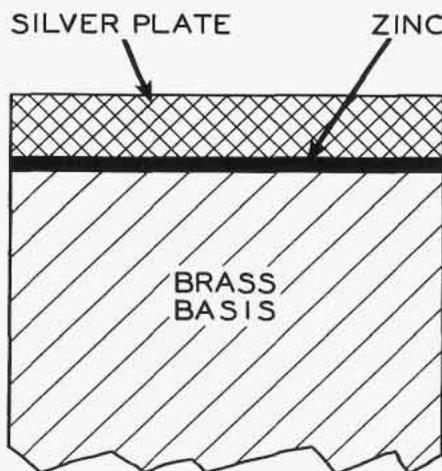


Figure 6. Cross-Section View of Multi-Layer Sample.

measure a sample which is 0.025 mils in thickness. The deviation read on the meter scale will be identical with that read on the 0.015 mil sample. If one is aware of this source of error the technique is very useful since it has the effect of "spreading out" the readings on the scale. Therefore, when the zero point is established on a plated sample, care must be taken that all subsequent measurements are made on samples which are all thinner in plating or all thicker in plating in order that an ambiguity is not introduced.

#### Multi-Layer Measurements

In instances where there is more than one layer of plating material, there are several ways in which the desired thickness measurements can be made. Sometimes a "flashing" of rhodium or silver is plated on a basis material before the final coating is applied. Figure 6 represents such a case. Here the basis metal is brass with a "flashing" of zinc and a plating of silver. If it is desired to measure the thickness of the flashing this must be accomplished in the usual manner before the silver plating is applied. If the zinc coating is reasonably constant and it is desired to measure only the silver plating the gauge head may be placed on the brass and the meter adjusted to zero. The gauge head may then be placed on the silver plated sample and the instrument will then measure the combined thickness of both the zinc and the silver. Subtracting the constant thickness of zinc yields the thickness of silver plating. Any error introduced by this method will ordinarily be small since the ratio of silver plating to the zinc "flashing" is ordinarily large. However, this error may be eliminated completely by zeroing the

gauge head on the zinc instead of on the brass. This has the effect of "washing out" any discrepancies in the zinc "flashing". All multi-layer platings may be handled by this general approach.

#### Selection Of Proper Gauge Head

The foregoing discussion applies to either of the two gauge heads which are furnished with the Metal Film Gauge, Type 255-A. One of the gauge heads operates at a frequency of 500 kc while the other operates at 8 mc. These are coded red and white respectively. The gauge head to be used should be chosen according to the thickness of the coating and composition of the film-basis combination to be measured. In general, a thin coating requires use of the white, or 8 mc, gauge head. Coatings of lower conductivity also require the white gauge head while those of higher conductivity with comparable thickness and having the same basis material require the use of the red, or 500 kc, gauge head.

#### Summary

The Metal Film Gauge, Type 255-A provides a fast, accurate, and non-destructive method for the measurement of plating thickness of non-magnetic material combinations. Of particular interest is its ability to measure the thickness of non-conductive films in the protective coating field. Other applications include the sorting of materials according to their electrical conductivities, the matching of magnetic properties, and the effect of the annealing process on metals.

#### THE AUTHOR

Douglas K. Stevens is a graduate of Catholic University, Washington, D. C. where he received a B.E.E. degree. He has had a wide range of engineering experience: Electronic Engineer with the National Bureau of Standards, Washington, D. C.; Project Engineer with the Research Division of the United Shoe Machinery Co., Beverly, Mass.; Test Equipment Engineer with the Western Electric Co., Lawrence, Mass. and a miscellaneous experience with other engineering firms. During the war, he did radar work as a member of the U. S. Air Force. Since joining the staff of Boonton Radio, Mr. Stevens has been active in field work on customer problems and special applications of Boonton Radio Corporation equipment. Mr. Stevens is married, has two young children and lives in Boonton, N. J.

## A VHF FM-AM Signal Generator System

JAMES E. WACHTER, *Project Engineer*

The 202-E FM-AM Signal Generator, covering the frequency range of 54 to 216 mc, incorporates many of the features most desired in a VHF signal generator; some of the more prominent of these being the high degree of stability of the r-f carrier frequency, the constant frequency deviation sensitivity with respect to the carrier frequency, the ability to deviate the carrier either plus or minus by known increments, and the continuously variable, calibrated output attenuator system.

How these features are realized is most easily explained by a discussion, in short, of how the instrument is constructed and of how it functions.

### General Features

Outwardly the instrument is composed of two units, the signal generator proper and its power supply, shown (with accessory 207-E Univerter) in figure 1. The design of the cabinets is such that the instrument may be used as conventional bench equipment or by simply removing the cabinet end-bells, it may be mounted in a standard 19 inch rack as shown. All operating controls and indicators are functionally located on the front panels and those which are calibrated are direct reading.

The heart of the 202-E Signal Generator is, of course, the RF Assembly, shown less shielding in figure 2. The rugged construction of the supporting frame and the close mechanical tolerances applied to the four section variable capacitor are in part responsible for the high degree of stability of the r-f frequency.

### Functional Description

Referring to the simplified schematic diagram of the RF assembly, figure 3, the functions of the various circuits is more readily understood. For FM, an audio voltage is applied directly to the grid of the reactance tube. The reactance modulator operates as a controllable inductance in parallel with the tuned circuit of the r-f oscillator and provides from 0 to  $\pm 240$  kc deviation of the generator output frequency. The deviation is monitored by the front panel modulation meter. To produce constant frequency deviation sensitivity

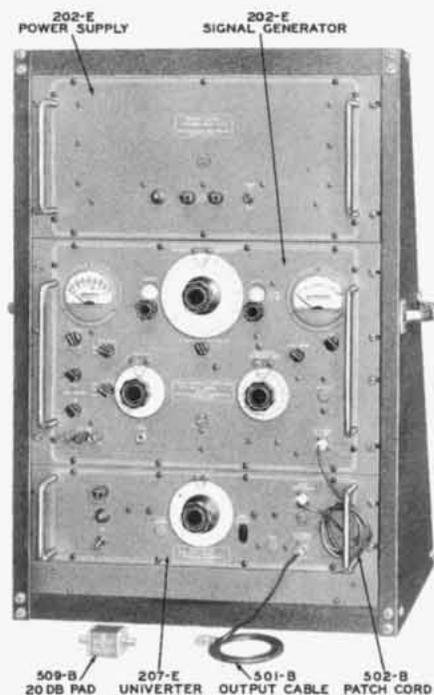


Figure 1. The RF Signal Generator, Type 202-E with Accessory Univerter, Type 207-E.

over the tuning range of the oscillator, the amount of inductance injected by the reactance tube is made to vary directly as the oscillator frequency. This is accomplished by the phase-shifter network composed of R1, R2, C1 and the reactance tube grid to cathode capacitance and grid to plate capacitance. The attenuation of this network increases as the oscillator frequency increases causing the degree of modulation

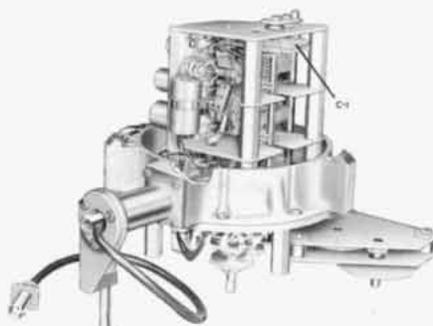


Figure 2. RF Assembly, Showing Supporting Frame and Slotted Rotor of Deviation Capacitor.

effected by the reactance tube to decrease with frequency so as to maintain constant deviation. To account for variations in components and to provide a precise deviation calibration, C1 is ganged to the oscillator tuning capacitor and is adjusted over the entire tuning range for the desired constancy of deviation.

The deviation sensitivity of the FM modulation system, as a function of frequency, is flat to within  $\pm 1$  db from 30 cps to 200 kc. and the overall FM distortion at 75 kc deviation is less than 2%.

D-C signals from a battery source (for maximum stability) may also be applied to the grid of the reactance tube to shift its operating point and thus shift the oscillator frequency by discrete amounts, either plus or minus. Control is effected by operation of a front panel switch and associated precision resistors. By this method the output carrier frequency may be shifted in steps of  $\pm 5$ , 10, 15, 20, 25, 30, 50 and 60 kc on the 108-216 mc range and half of these values on the 54-108 mc range. The relative accuracy of the steps is  $\pm 1.5\%$ . Because of the low current drain, the life of the battery is equivalent to its normal "shelf life". An uncalibrated fine tuning control, operating in conjunction with this incremental tuning circuit permits continuous tuning over a range of about 20 kc on the high frequency range and 10 kc on the low frequency range.

The r-f oscillator is a conventional tuned plate triode oscillator circuit covering the frequency range of 27 to 54 mc. The circuit is properly compensated for minimum drift and is tuned by variable capacitor C2, which is adjusted for an output frequency accuracy of  $\pm 1\%$ .

The oscillator output is applied to a self-biased class C frequency doubler, which makes possible the low oscillator frequency range and also provides the required isolation between the oscillator and the output stage necessary for the desired frequency stability of 0.01% per hour.

The output stage operates class C and functions as an amplifier for the low frequency range of 54 to 108 mc, and as a frequency doubler for the high

frequency range of 108 to 216 mc. This change in operation is accomplished by operating the front panel range switch, which grounds either of two taps on the output tank coil. In one position the inductance of the coil is such that the tank circuit is resonant at the fundamental frequency of the previous stage and in the other position the inductance is such that the tank is resonant at the second harmonic of the frequency of the previous stage. Damping of the output tank circuit is sufficient to reduce spurious signals to more than 30 db

microseconds, and the decay time is less than 8 microseconds.

A piston type, mutual inductance attenuator having an internal impedance of 50 ohms, is coupled to the output tank circuit to provide continuously adjustable attenuation. Because the rate of attenuation is a function of the inner diameter of the attenuator tube, this attenuator can be made to be quite accurate. With the 50 ohm terminated cable, type 501-B, (supplied with the instrument) attached to the 202-E output jack, the attenuator dial indicates,

tional audio oscillator provides the following frequencies to an accuracy of  $\pm 5\%$ : 50, 100, 400 cps, 1, 5, 7.5 and 10 kc. In addition, a 60 kc signal accurate to  $\pm 2\%$  is available specifically for use in calibrating the d-c incremental frequency circuit.

All electrical connections to the shielded RF Assembly, excepting that to the output attenuator, are made through a low-pass filter, which prevents stray r-f currents from escaping from the RF Assembly.

The voltages supplied from the power supply are all d-c and those for use in the RF assembly are regulated. The power supply operates from 105-125 volts, 50-60 cps.

**Frequency Converting Accessory**

The 207-E Univerter is a unity gain frequency converter designed to provide frequency coverage below the range of the 202-E Signal Generator. When used in conjunction with the 202-E, the Univerter covers the range of 0.1 to 55 mc; and the two instruments give complete coverage from 0.1 to 216 mc.

The 207-E matches the 202-E in appearance (figure 1) and may also be used either as bench type equipment or rack mounted. All controls and input and output connectors are located on the front panel.

To use the 207-E it is only necessary to connect the 501-B output cable to the Univerter unity gain output and connect the Univerter input to the 202-E Signal Generator output, using the 502-B patch cord supplied with the Univerter. Connected in this manner the 207-E Univerter does not appreciably alter the FM and AM character-

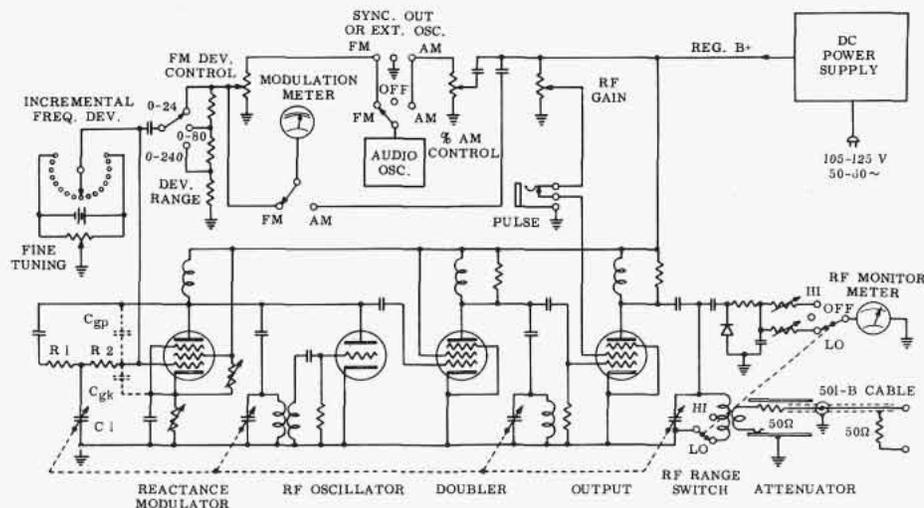


Figure 3. 202-E Simplified Schematic Diagram.

below the desired signal and to restrict, to about 2%, the amplitude modulation present at 75 kc deviation.

Up to 50% amplitude modulation is possible by modulating the screen circuit of this final r-f stage and is monitored by the front panel modulation meter. The modulating power required for this being comparable to that needed for frequency modulation, the same R-C audio oscillator is used for both types of modulation. The distortion of a 50% AM modulated signal is less than 8% and due to the buffer action of the doubler stage, the spurious frequency modulation is held to a minimum. The amplitude modulation system is flat to within  $\pm 1$  db from 30 cps to 200 kc.

**Pulse Modulation**

Square wave or pulse modulation of the 202-E is also possible by connecting an external modulation source through the front panel jack to the screen of the final stage. When this connection is made, the modulation meter and screen circuits are disconnected. Under these conditions the rise time of the modulated carrier envelope is less than 0.25

to an accuracy of about  $\pm 10\%$ , the voltage at the cable termination. (The generator open circuit output voltage is given by twice the attenuator dial reading). The attenuator dial is calibrated with two equivalent scales, 0.1 to 2000 microvolts and 140 to 14 db below 1 volt.

**Simultaneous FM and AM Modulation**

Simultaneous FM and AM modulation may be obtained from the 202-E by using an externally connected, low distortion, audio oscillator to provide the FM modulating signal and the internal audio oscillator for the AM modulating signal. The only requirement is that the external oscillator be capable of providing about 5 volts across 1500 ohms, the FM requisite for 240 kc deviation. In use the external oscillator is connected to the front panel FM binding posts and the 202-E modulation selector set to AM; the modulation meter can be switched from AM to FM and the levels of each type of modulation independently set.

It might be noted here that the in-

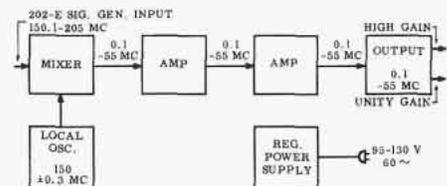


Figure 4. 207-E Block Diagram.

istics of the 202-E Signal Generator.

A 20 db attenuation pad, Type 509-B, is supplied with the Univerter for use where the signal level required is low compared to the constant noise level of the Univerter. Used at the output of the 207-E, the pad attenuates both signal level and constant noise level, thus permitting the use of a higher input signal and improving the signal to noise ratio.

# Lubrication Of Turret And Switch Contacts

LAWRENCE O. COOK, *Quality Control Engineer*

When frequency ranges must be changed, as in an RF oscillator, a means of switching the circuits is needed. This is usually accomplished by means of movable metallic contacts. Such contacts normally introduce an element of unreliability, i.e., contact resistance uncertainty results in fluctuating oscillator voltage, and sometimes fluctuating frequency, which, in turn, results in unstable meter readings. These effects can usually be minimized by the use of a lubricant on the contact surfaces.

## Contact Types and Service Conditions

In this article we wish to discuss the effects of various lubricants on electrical measuring instrument, low-power rf oscillator contacts of the wiping type. A turret containing coils connected to brass pin contacts for the individual frequency ranges is rotated until the contacts for the range to be selected engage stationary clip contacts of beryllium copper. The clip tips wipe or rub opposite sides of the pin during the additional slight rotation of the turret required to reach the indexed position. The contacts then remain stationary during use until another frequency range is selected, i.e., for a period ranging from a fraction of a minute to one week or longer.

The circuit resistance in the instrument stability may be as low as 0.3 ohm, hence the contact resistance stability becomes important.

Contact resistance stability may worsen when the instrument reaches an age of about one year. Improvement of a temporary nature may sometimes be effected by repeated operation of the faulty range switch (this "wipes" the contacts).

## Test Method

For test purposes, two turret contact pins were connected together and meshed with two stationary contact clips. The clips were connected by short wire leads to a Wheatstone Bridge to allow measurement of the dc resistance of the resulting "short-circuit" (designated as a "pair" in the Figures 1 and 2). Remeshing and re-measurement were repeated several times, the extremes of the resistance values being plotted. Four con-

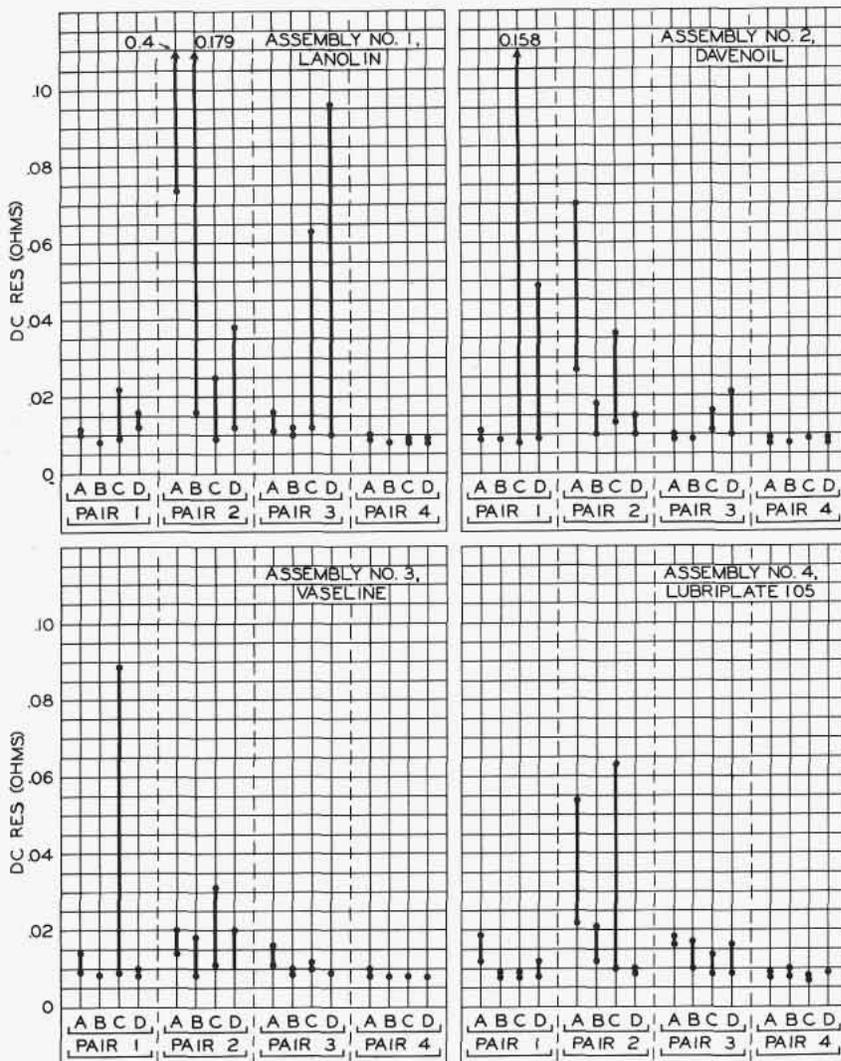


Figure 1. A—Un-Lubricated, B—Following Lubrication, C—Following Three Months Storage, D—Following Eight Months Additional Storage.

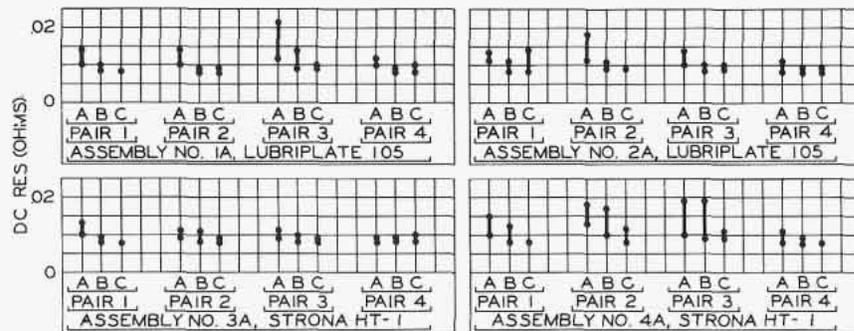


Figure 2. A—Un-Lubricated, B—Following Lubrication, C—Following Six Months Storage.

RF Oscillator Contact Assemblies — Contact Resistance Measurements Versus Lubricants. Plots Show Range of Resistance Measured for Repeated Meshing of Contacts.

tact pairs were tested on each assembly.

To determine the effect of lubricants, the contact resistance measurements were made first on dry contacts. The contacts were then lubricated and re-measured. Following a prolonged period of inactive storage, the measurements were repeated.

### Test Results

Giving preference to the lubricants showing consistently lower contact resistance we have summarized the test results on the five materials as follows.

| CONTACT RESISTANCE PREFERENCE | LUBRICANT                     |
|-------------------------------|-------------------------------|
| 1st                           | Lubriplate 105<br>Strona HT-1 |
| 2nd                           | Vaseline                      |
| 3rd                           | Lanolin*<br>Davenoil          |

Lubriplate 105 and Strona HT-1 are considered equal on the basis of contact resistance and both are manufactured for lubricant use. Strona HT-1 showed a slight disadvantage of "stringiness" during application. Vaseline showed somewhat higher contact resistance and is not manufactured for use as a lubricant.

As a result of these tests made on a particular type of contact, our choice favors Lubriplate 105 and Strona HT-1, these materials tying for first place.

\* Anhydrous lanolin dissolved in carbon tetrachloride for ease of application.

### EDITOR'S NOTE

The prevalent attitude towards instruction manuals may be neatly wrapped up in the cynical saw, "If all other methods fail, recourse to an instruction manual may be mandatory." Entirely justified viewpoint in our opinion, for this reason: the role and character of the instrument the manual is supposed to describe is seldom self-consciously considered in the preparation of the manual. In many cases the instrument in question is a piece of test equipment of which the engineer may have a dozen or more types. He simply hasn't the time to digest the information in the form in which it is presented. This is the decisive fact that should determine the kind of material, its quantity and arrangement, and the general format of the manual.

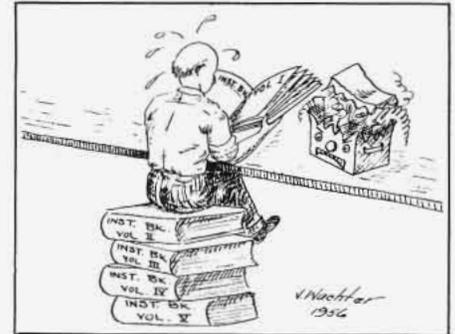
Judging by the tome-like and overblown appearance of many manuals, one can make better use of them as equipment props, (in many cases their only useful function). With such manuals, engineers usually wait for the moment just before the instrument is about to disappear in a cloud of smoke. In other cases the manual is resorted to only after the instrument has been completely disassembled and lays strewn about in impossible confusion.

### Organization of the Material

With the specific function of the instrument held firmly in mind, the preparation of the manual can be approached in a more confident manner. In general a manual of instruction for a

piece of test equipment (which is simply an electronic tool) should be prepared along these general guide lines:

Instruction Manual should be divided into two main sections. Section one (in our estimation the more important of the two) should be as compact and abbreviated as possible and subdivided into four general categories: (1) *Essential* operating information, (2) Special applications, (3) Tabulation and location



of components *most likely* to need attention, (4) Annotations copiously sprinkled throughout text with *specific* references to material found in the second half of the manual where a full and conventional treatment of the instrument is given.

Such an approach separates the immediate, practical knowledge from the generally useful but otherwise frustrating information. This will be greatly appreciated by an engineer who, for example, wants to find the location of a blown fuse in a hurry but must waste precious time wallowing through pages of extraneous material to find it.

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