SIGNAL GENERATOR MANUAL

LABORATORY STANDARDS

MODEL 65-B

MEASUREMENTS CORPORATION

SIGNAL GENERATOR

LABORATORY STANDARDS

MODEL 65-B

Measurements Corporation

BOONTON · NEW JERSEY

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MODEL 65-B

The Model 65-B Standard Signal Generator has been designed to provide the industry with a laboratory standard which combines attractive appearance and rapid, simple operation in an instrument small enough not to occupy excessive space on the workbench, yet complete enough to permit making all the usual tests on radio receivers.

The electrical units of the instrument are grouped into three separate mechanical assemblies, which are held in operating position on an inner sub-panel, 1/8" thick. This construction permits the working units to be removed from the case as a whole for inspection or adjustment. This arrangement also permits a convenient grouping of the panel controls; all of the modulation controls on the left-hand side of the panel, the carrier frequency controls in the center, and the output voltage controls on the right. The number of controls has been reduced to the absolute minimum consistent with satisfactory operation, and their type and location chosen to give the greatest possible ease and convenience of operation, with a symmetrical and pleasing panel appearance.

All scales and dials are direct reading so that measurements may be made with the greatest possible speed. The frequency scales and output meter scales are individually calibrated to obtain the maximum possible accuracy.

The basic circuit of this Standard Signal Generator is a master-oscillator, tuned power-amplifier, with the power-amplifier plate modulated. The design is conventional in most respects, in that it includes those features and elements which make it a source of radio frequency voltage whose carrier frequency, modulation frequency, modulation depth, and output voltage amplitude are all easily adjustable and accurately indicated. Each of these factors can be adjusted over the ranges commonly used in radio communication, so that the instrument becomes a useful source of test signals for measuring the various characteristics of radio receivers such as sensitivity, selectivity, fidelity, overload, distortion, automatic gain control, image and intermediate frequency rejection ratios, noise, stage gain, etc.


PER CENT MODULATION
STANDARD SIGNAL GENERATOR
MEASUREMENTS
MICROVOLTS
MODULATION

SPECIFICATIONS

FREQUENCY RANGE:

75 KC TO 30 MC IN SIX PUSH-BUTTON SELECTED RANGES.

MODULATION:

CONTINUOUSLY VARIABLE FROM ZERO TO 100%. EITHER 400 OR 1000 CYCLES OR EXTERNAL SOURCE. BUILT-IN LOW DISTORTION MODULATING AMPLIFIER.

OUTPUT VOLTAGE:

CONTINUOUSLY VARIABLE FROM .1 MICROVOLT TO 2.2 VOLTS.

OUTPUT IMPEDANCE:

VARIES BETWEEN 5 AND 25 OHMS.

DIMENSIONS:

11" x 20", 10¼" DEEP OVER KNOBS.

WEIGHT:

APPROXIMATELY 50 LBS.

FUSES:

TWO TYPE 3AG 2 AMPERE.

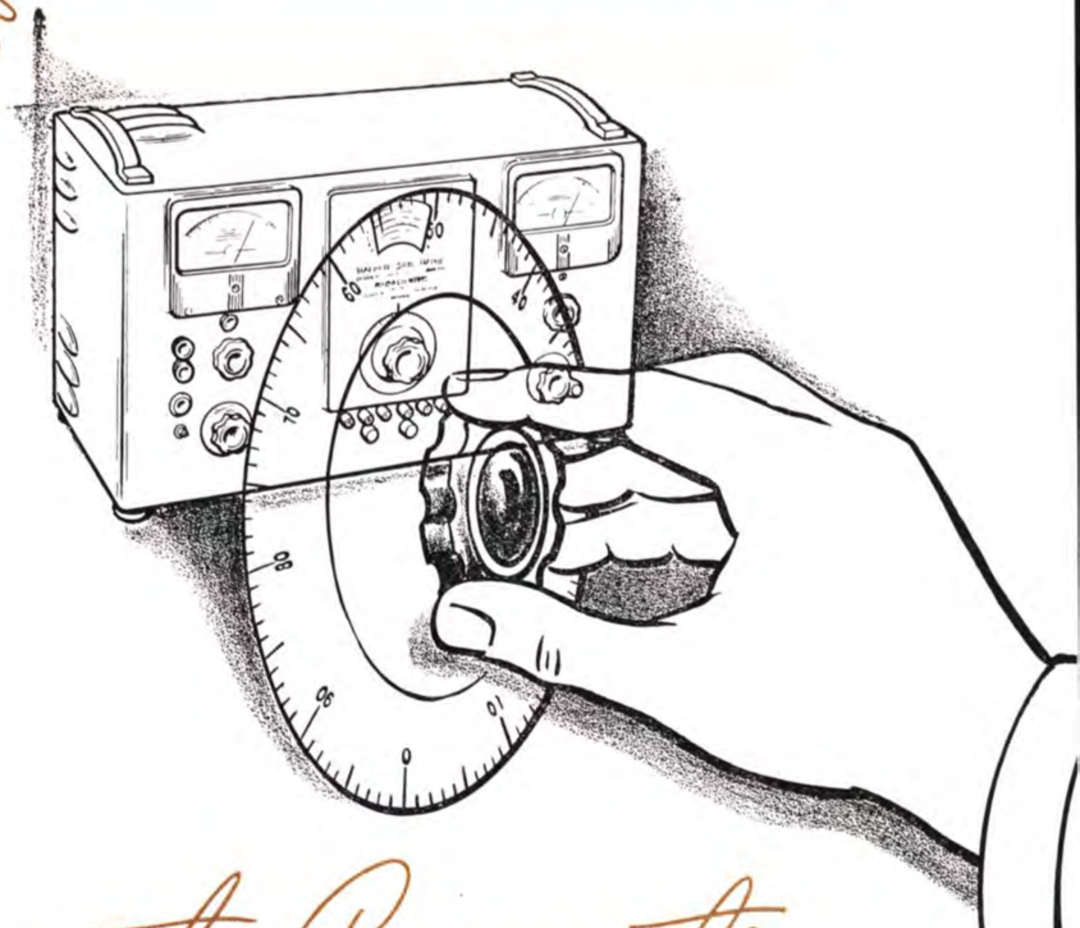
POWER SUPPLY:

117 VOLTS, 60 CYCLES.

TUBES:

TWO TYPE 6H6, TWO TYPE 6SJ7, TWO TYPE VR150-30, ONE TYPE 6SK7 (CERAMIC BASED), ONE TYPE 6AG7, ONE TYPE 6L6, ONE TYPE 5T4, ONE TYPE 6V6.

OPERATING INSTRUCTIONS



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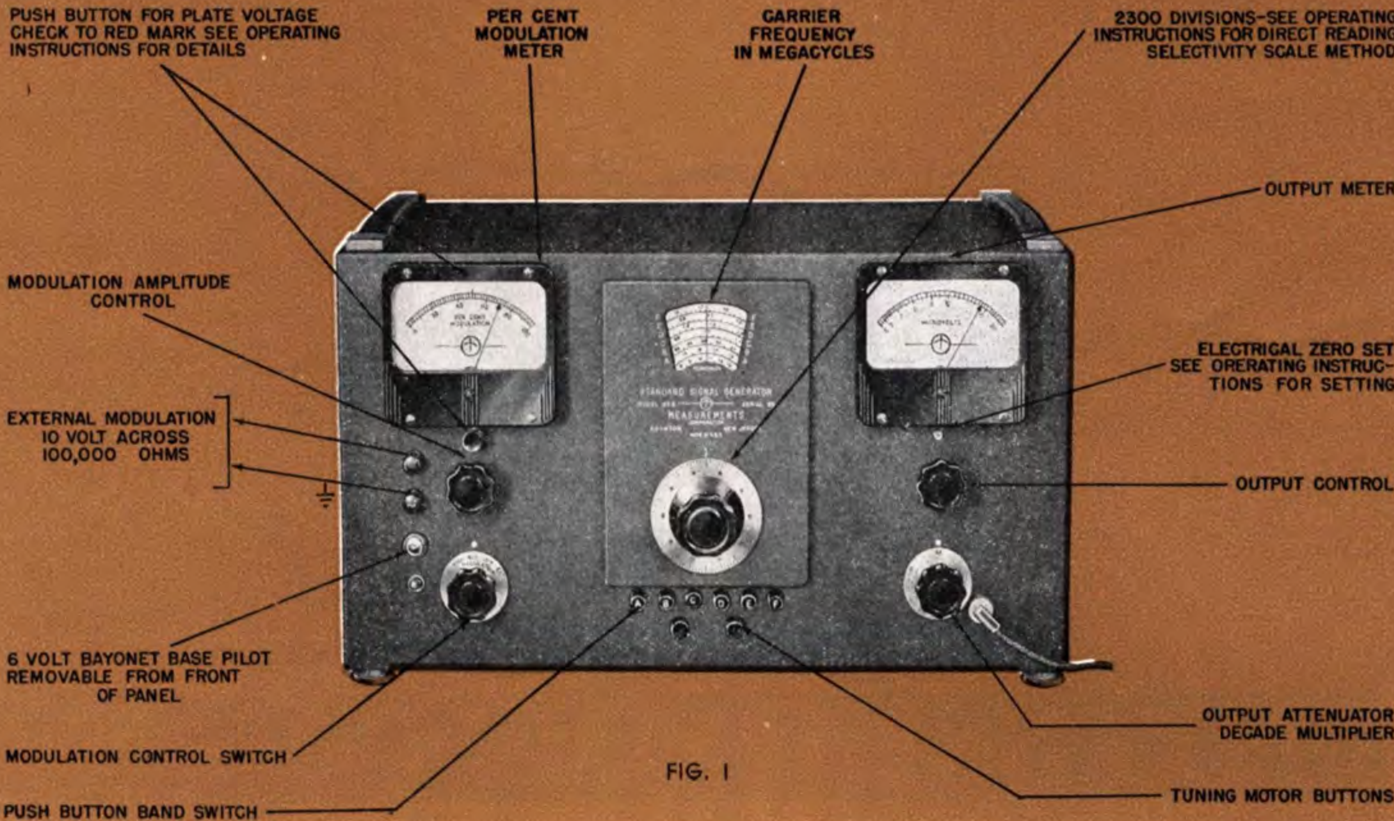


FIG. I

I. OPERATING INSTRUCTIONS:

a. SETTING UP:

Allow several inches of space all around instrument for proper ventilation. Do not tilt the case back, since this tends to restrict proper ventilation.

Check power supply voltage and frequency. All standard model 65-B's are designed for operation on 117 volt, 60 cycle power. If the supply is correct, plug in the power cord and switch on by flipping up the power switch directly under the pilot light jewel.

After 30 seconds warm-up period, the modulation meter should indicate when the modulation switch is set either to "400" or "1000" and the modulation amplitude knob (located directly under the meter) is turned to the right. The output meter should also read as the output control knob is turned to the right, if any one of the six pushbuttons below the frequency control is pushed in all the way. Indications on both meters are a sign that the instrument is operating properly.

b. ZERO ADJUSTMENT:

There are *two* adjustments of zero; electrical and mechanical, on both meters. The *electrical* zero adjustment on the per cent modulation meter is not particularly critical and is not available for external adjustment. Only the *mechanical* zero need be set on the modulation meter. This should of course be checked with the instrument *cold* or turned off for several minutes, and then rechecked after the instrument has been allowed to warm up for three or four minutes. If the warm-up setting of the modulation meter does not coincide exactly with zero, it can be reset by means of the mechanical adjustment on the meter itself. This operation is really a compensation of *electrical* zero drift by *mechanical* zero reset and is permissible only because the modulation meter is a linear scale movement. Large discrepancies in warm and cold zero should be investigated and taken care of as recommended in the Service and Maintenance section. Of course it is necessary to check the modulation meter zero with the control switch set to "off" and the amplitude knob turned all of the way to the left.

On the output meter the *electrical* zero set is located on the panel directly below the output meter. The *mechanical* zero set must *never* be used to compensate for *electrical* zero shift. *Mechanical* zero must be set first with the instrument turned off for several minutes to permit the diode cathode to cool completely. Then the screw on the face of the output meter should be adjusted until the meter reads exactly "0" on the calibration scale. Slight finger tapping is advisable to eliminate any "stickiness".

Next the instrument must be turned on for at least five minutes to permit the diode cathode to heat sufficiently. Then the output from the r.f. generating unit must be reduced by zero by pushing range buttons slightly until they all snap out, leaving none of the coils connected in the circuit. The set screw on the panel just below the output meter, marked "electrical zero set" on fig. 1, is then adjusted until the output meter again reads "0" on the calibration scale. Slight finger tapping is recommended to eliminate any "stickiness".

This last adjustment is the *electrical* zero adjustment of the diode circuit. All coils are disconnected from the circuit by the foregoing procedure to insure zero output before correcting the electrical zero adjustment. Otherwise a small residual impedance in the circuit of the output control may prevent reducing the signal output completely to zero. Due to the special shaping of the pole pieces in the output meter, no mechanical compensation for electrical zero shift should be attempted as serious errors will result.

c. CARRIER FREQUENCY SETTING:

Six carrier frequency ranges are provided to cover the range from 75 kc to 30 mc. "A" is the lowest frequency range and "F" the highest. To select any desired frequency, operate the tuning dial by depressing either the right or left motor control button until the frequency appears in the dial window; note which frequency range letter appears on the scale carrying this value, and press the button bearing this letter until it remains depressed. Any previously operated range buttons must release. The tuning dial may be turned by hand for small changes of frequency, but if several revolutions are required to reach a desired setting, time will be saved if the tuning motor is used. With practice it will be found possible to stop the dial almost exactly at a desired point, the final close adjustment being made by hand.

The six frequency scales appearing in the dial window are directly calibrated in megacycles. The seventh scale, appearing at the bottom of the window, is a counter dial for counting the revolutions of the 0 to 100 dial attached to the tuning knob. Together, these two scales constitute a long, evenly divided scale of 2300 divisions by means of which the frequency can be set much more closely than is possible with the direct reading scales. The two scales are read by considering the indication of the counter dial as hundreds and the indication of the small dial as units, and adding them. Thus if the fiducial line is in the space marked 15 on the counter dial, and the reading of the small dial is 55, the complete setting is 1555. The use of this scale will permit setting to considerably better than 0.1%, especially if tenths of divisions are used.

d. MODULATION:

An unmodulated or "CW" carrier is available when the modulation switch is turned to the "off" position. For either 400 or 1000 cycle modulation, set the modulation switch to the desired frequency and adjust the modulation to the desired depth on the meter by means of the modulation amplitude control knob located directly below the meter.

For modulation at other frequencies in the audio range from 50 to 10,000 cycles, connect an audio oscillator capable of supplying about 10 volts across 100,000 ohms impedance to the "external modulation binding posts", located at the left of the panel. (See fig. 1.) Set the modulation control switch to "external" and turn the modulation amplitude knob until the desired depth is indicated directly on the modulation meter.

Since the direct calibration of the modulation meter is based on the assumption that the applied amplifier plate voltage is constant, a check can be made by pushing the button immediately below the modulation meter and noting whether the reading is near the red mark. The reading should be between 50 and 60 for normal VR-150 regulator tubes. The red mark corresponds to 150 volts. Since it is not possible for all regulators to be exactly 150 volts, the pointer may not be exactly on the red mark. If large deviation from red mark is noted, the VR-150 is not operating, and percent modulation will not be as indicated. The Maintenance Section will show how to correct the trouble.

e. CARRIER OUTPUT:

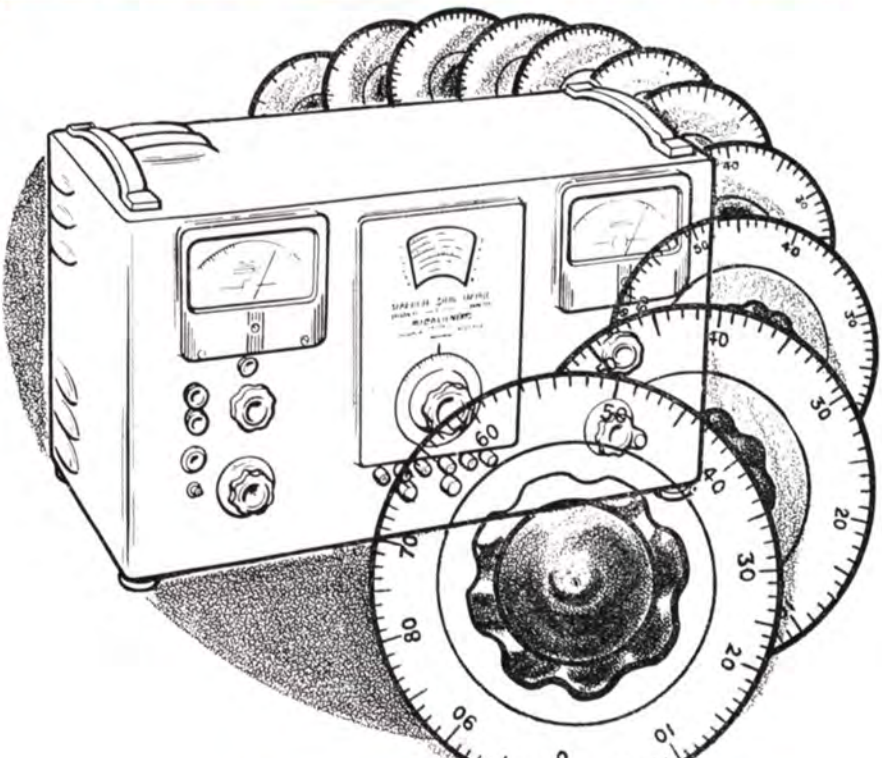
The output system is direct reading in microvolts; only two controls need be used to obtain any setting between .1 microvolt and 2 volts. Simply set the output meter to indicate the required value of output to one or two significant figures by means of the output control knob located immediately under the meter. Use the "Multiply by" knob located below the output control knob to add the correct number of zeros; for example, for 15,000 microvolts, set the meter at 15 and the "multiply by" dial at 1K (x 1000). The maximum output is obtained when the switch is set to 100K and the meter is at 22. In this switch position the output terminals are connected directly across the voltmeter which requires 2.2 volts for full scale deflection. The lowest multiplier is .1, which provides an output voltage range of .1 to 2.2 microvolts. For maximum accuracy the output meter should always be set as near to full scale as possible.

Care must always be taken regarding the choice of "dummy antenna" — particularly at the higher frequencies. See the section under "image ratio" and "antenna step-up". Disregard for the output impedance characteristic will sometimes lead to serious errors.

A terminated transmission line facilitates the use of short leads for the accurate determination of stage gains, etc., at the higher frequencies. See the section on "stage gain measurements" for precautions to be taken with regard to lead length.

For use in feeding unbalanced lines at the higher frequencies, it is possible to split the dummy antenna into two equal parts as suggested in the section on "antenna step-up". This tends to reduce the effects of resonance in the *ground-lead*.

OVERALL RECEIVER MEASUREMENT TECHNIQUE



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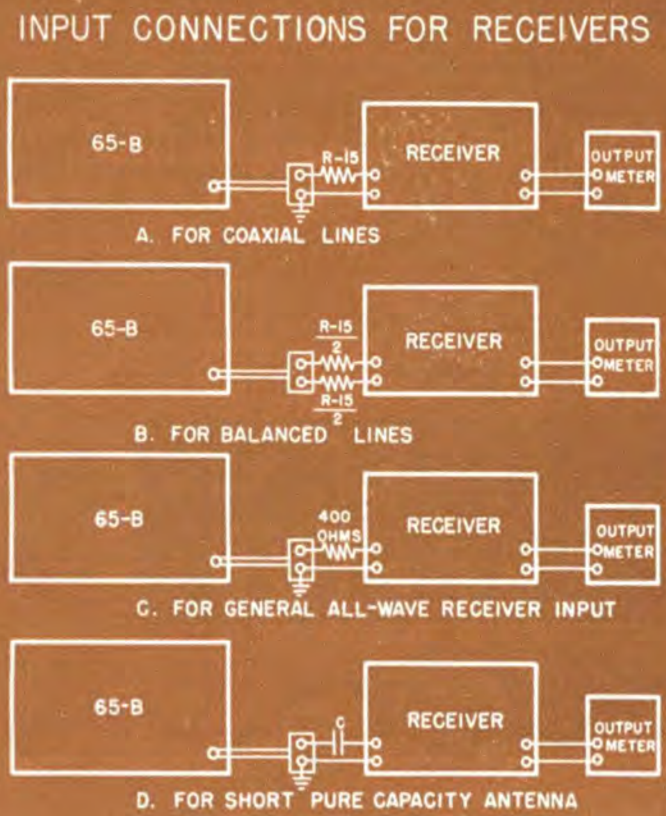
II. OVERALL RECEIVER MEASUREMENT TECHNIQUE:



NOTE:
"R" EQUALS IMPEDANCE OF TRANSMISSION LINE. THE NOMINAL VALUE OF THE 65-B OUTPUT IMPEDANCE IS 15 OHMS. "R" MUST BE FOUR OR FIVE TIMES 15 OHMS FOR ACCURATE MEASUREMENTS AT FREQUENCIES OVER 10 MEGACYCLES. CARBON RESISTORS SHOULD BE USED TO AVOID REACTANCE ERRORS.

(IF X_c IS NOT HIGH AS COMPARED TO 15 OHMS USE SPECIAL 3 OHM OUTPUT CABLE OBTAINABLE ON SPECIAL ORDER.)

FIG. 2

a. SENSITIVITY:

In measuring the overall sensitivity of a receiver it has been frequent practice to specify a certain audio power output, for so many microvolts of 30% modulated carrier input through a specified dummy antenna. This specification may be sufficient for relatively insensitive receivers, but if the sensitivity requirements are such that thermal hiss-noise, shot-noise, etc., are limiting factors, it is necessary to specify the receiver sensitivity at a *particular* signal to noise ratio. This latter type of specification is much more indicative of receiver usefulness, since it is not possible to make up loss of gain in the r.f. portion by increasing the i.f. or audio gain when input noise is to be the limiting factor in sensitivity. Many specifications define the receiver sensitivity as so many microvolts at a two to one signal to noise voltage ratio or a four to one *power* ratio as determined by an *average* type of output meter (copper oxide rectifier, for example).

It is necessary to connect the correct dummy antenna between the standard signal generator and the receiver antenna terminals. Some years ago home radio receivers were designed for broadcast band operation only, and a standard form of dummy antenna was adopted which consisted of series inductance, capacitance, and resistance. When higher frequency bands were added, it was rather general practice to use a 400 ohm carbon resistor in series with the "hot" lead of the signal generator as the dummy antenna.

Of present types of communication receivers, careful studies have been conducted to determine the antenna constants. Most dummy antenna specifications should be determined by actual antenna measurements. In some cases the receivers are designed for operation from non-resonant transmission lines of 72, 100, 150, or 500 ohm impedance levels, and the connections should be made as shown in fig. 2. Certain types of receivers have been designed specifically for operation from short, low capacity antennas in the range of 20 micromicrofarads. A brief survey of such antennas will show that at frequencies of 15 megacycles or more, the output impedance of the signal generator should be less than 5 ohms in order to avoid increased antenna losses. A special output cable can be supplied for such applications which provides a constant output impedance of 3 ohms with a fixed voltage attenuation ratio of ten to one.

It should be noted that the output impedance of the model 65-B is not constant with respect to frequency as is shown in fig. 3. This results from operating the transmission line from a 5 ohm input, or sending end impedance, and a fixed surge impedance termination at the output or receiving end. Certain *firmly* established military specifications can *only* be met with this particular type of output system, since they neglected the effects of output impedance variations with respect to carrier frequency of certain particular signal generators in writing the original specifications. The result of neglecting output impedance is most noticeable in making image ratio checks, because of the variation in antenna circuit selectivity with signal generator output impedance. (See the section on image ratio checks for further discussion on this matter.)

Of course, it should be understood that the receiver must be correctly aligned before overall sensitivity checks are made, since the band width, r.f. gain, conversion gain, etc., all affect the signal to noise ratio.

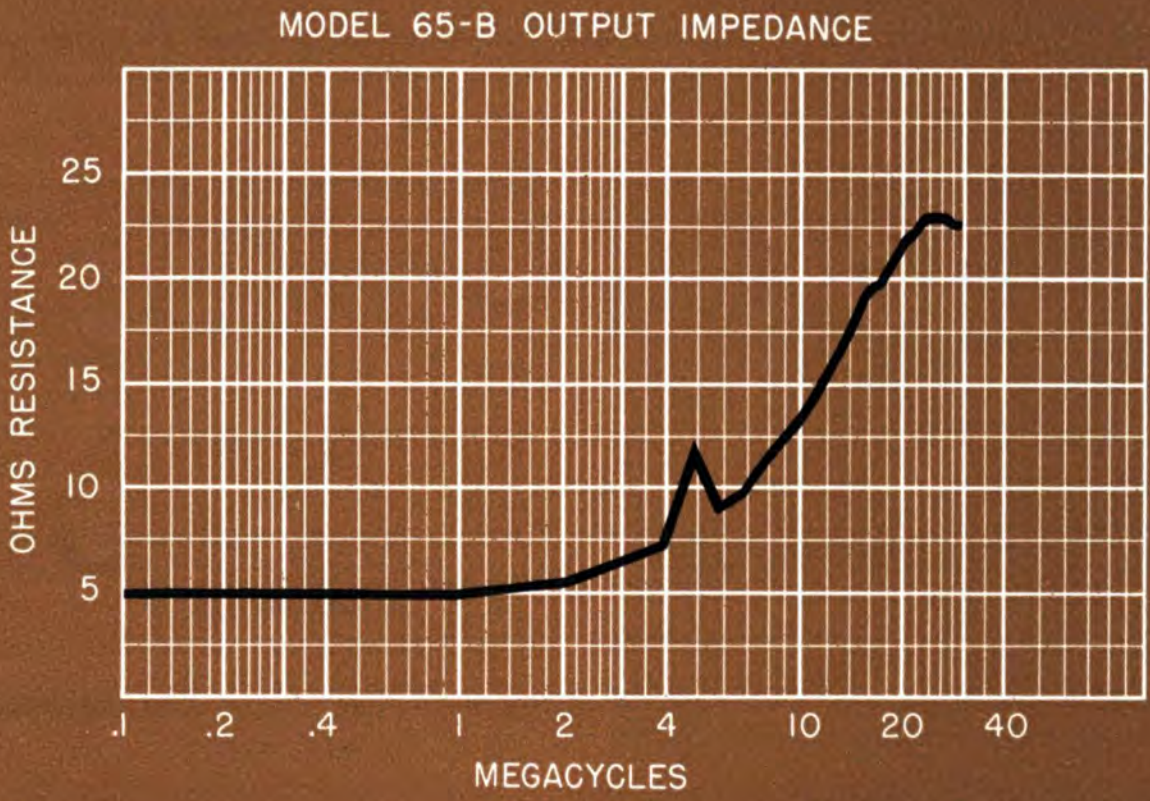


FIG. 3

b. SELECTIVITY

The linear scale provided by the 0-100 dial and revolution counter can easily be used for measuring small frequency increments by first obtaining the k.c. per division at the particular carrier or mid-band frequency to be used. Since the dial calibration is rather uniform or "straight-line-frequency", the k.c. per division will be relatively constant over a considerable portion of each tuning range. The k.c. per division can be set on the "D" scale of a slide rule, and then the k.c. deviation for each desired carrier increment can read directly.

Another method frequently used by our customers for direct reading selectivity involves the construction of special auxiliary frequency-deviation scales of white plastic which can be easily snapped over the 0-100 dial. (See fig. 12 on page 28). We can supply blank white dial rings suitable for this purpose. It has been common practice to use black letters for the deviation lower in frequency and red letters and marks for the higher side. These directly calibrated rings are used by setting the signal generator to the center frequency, and then slipping the ring over the dial with the zero directly in line with the engraved marker. They can also be used by marking the rear of each ring with the correct dial number (between 0 and 2300 divisions) corresponding to its center frequency. It should be borne in mind that signal generators are not standards of frequency, and that the exact center frequencies may not agree with dial calibrations of the receivers at all times. However, the accuracy of the model 65-B frequency scale is ±0.5% or better. For measuring overall receiver selectivity, it is not necessary to specify the center frequency very closely.

Measurements of overall selectivity are usually made by a connection indicated in fig. 2. A convenient value of output from the signal generator is employed which will reduce the noise to a negligible value. It is convenient to use some even number such as 10 microvolts, so that all calculations can be made mentally. If the output meter reads off scale, it will be necessary to reduce audio gain. A check should be made for audio non-linearity by varying the modulation above and below 30% and noting whether the audio output follows. Obviously the audio must be operated below the overload point so that there is a linear relation between % modulation and audio output. Likewise the radio frequency portions of the receiver should not be overloaded, otherwise the selectivity data will be of little value. Checks can be made for this by increasing and decreasing the carrier level slightly and noting the corresponding increase or decrease in the resulting audio output with fixed 30% modulation applied to the signal generator. It may be necessary to either operate below the a.v.c. threshhold or else disconnect the a.v.c. and use the manual r.f. gain control to avoid overloading of the r.f. tubes.

After linearity has been checked and a convenient value of audio output has been obtained for 10 microvolts input, the carrier level should be increased to 20 microvolts and the signal generator detuned slightly, either side of resonance until the output meter again reads the same value. The amount of deviation either side of the center frequency is therefore the ± k.c. deviation for 2X down response. In general, if the receiver is properly aligned, these two points should be equidistant from the center frequency. Other points at 5X, 10X, 100X, etc., can then be plotted by the same method.

It is desirable to take selectivity curves at several different input levels, such as: 10, 100, and 1,000 microvolts input. At the higher levels, r.f. gain must be reduced to prevent overloading. The checks for linearity are particularly important at the higher levels before proceeding with the selectivity measurements. If selectivity curves plotted from data taken at different carrier levels do not have similar shapes, it is an indication that regeneration may be present at lower levels where the gain is higher. Detuning of the receiver circuits by input capacity variation of the tubes will also cause some change in selectivity as the gain is varied. All of the above effects are particularly noticeable when working with broad-band, over-coupled, tuned-circuits.

The effect of incidental frequency modulation on selectivity measurements in some signal generators causes unsymmetrical curves about the center frequency. Frequency modulation has been reduced to less than .01% for 30% amplitude modulation in the 65-B. This is due to the modulated class "C" amplifier, which affords considerable isolation from the oscillator circuit. In addition some neutralization is employed to further reduce the residual f-m to a negligible value. If the band-width of the receiver under test is not comparable to .01%, very little error will be present because of frequency modulation. If appreciable f-m were present, as is common in modulated oscillator types of signal generators, the apparent selectivity curve taken on a very selective set at higher carrier frequencies will not be symmetrical with respect to mid-band frequency. This asymmetrical condition results because of the vector addition of the amplitude modulation with the frequency modulation on the two sides of the receiver selectivity curve which have opposite slopes; that is, positive and negative slopes (fig. 4). The exact location of the vector component M_{fm} of a-m resulting from the f-m of the signal generator is only an approximately linear function of frequency swing for very small deviations.

The vector M_{fm} is a complicated function. It can only be said, in general, therefore, that on the low side of resonance the vector addition will result in a somewhat greater audio output, depending on how steep the slope happens to be. Conversely, on the upper side of resonance the vector addition will always result in somewhat less audio output. The foregoing statements are based on the assumption that an increase in carrier produces an increase in frequency.

It has been general practice in the past to take selectivity curves on extremely sharp receivers containing crystal filters at i.f. frequency where f-m is negligible. If curves must be taken at high carrier frequencies, it will be difficult to read the tuning dial accurately enough, and it must always be turned in the same direction to minimize effects of backlash (about .2 division). If the band-width is less than or equal to .01%, it is necessary to remove the modulation from the signal generator and only use CW. In some receivers the "beat oscillator" can be used to provide an audio beat with the "CW" carrier from the signal generator and thus measure the selectivity. It may be advisable to readjust the beat oscillator for each setting to eliminate the audio frequency fidelity characteristic of the receiver under test.

In order to eliminate the need for modulation, a carrier output indicator can be provided, if the receiver does not have a beat oscillator. It is merely necessary to insert some sort of meter, such as a microammeter in the diode leak. In order to increase the usefulness of this arrangement, it is advisable to remove all a.v.c. from the receiver and install a temporary manual gain control for the r.f. tubes, if none is provided with the receiver. The band widths are then taken for some particular value of diode current. In general, greater accuracy of measurement will always be obtained, if it is possible to read carrier level instead of the audio output from a modulated carrier.

c. IMAGE RATIO:

A measurement of image ratio is a good indication of the amount of carrier pre-selection or r.f. selectivity. Since most superhetrodyne receivers have only one or two tuned circuits ahead of the 1st detector or mixer, care must be taken in selection of the dummy antenna constants to see that they are accurately known and reasonably near those obtained in actual practice.

In practice, actual measurements of antenna effective resistance and reactance must first be specified before sensible image ratios can be taken. Some low capacity antennas may have an effective series resistance of only 25 ohms. By reference to fig. 3, it can be seen that the output impedance characteristic of the 65-B rises to 25 ohms at the higher carrier frequencies; therefore the use of the 65-B at such frequencies will double the antenna effective resistance and greatly reduce the *measured apparent image ratios*. Special output cables can be supplied on special order which provide a fixed output impedance of 3 ohms in addition to the regular output.

The fixed output of 3 ohms is accompanied by a fixed step of 10:1 attenuation.

Corrections for variations in output impedances of signal generators of different manufacturers may account for discrepancies in image ratio measurements. If certain arbitrary dummy antennas must be employed which do not provide a resistance high compared to the signal generator output impedance, it may be well to measure the exact output characteristic of the original signal generator employed in writing the specifications. All of our 65-B signal generators have substantially identical output impedance characteristics. Certain less expensive competitive instruments have considerably different output impedance characteristics which will lead to widely divergent image ratios.

After selecting the correct dummy antenna and connecting according to fig. 2, a convenient value of input at the carrier frequency is selected and the receiver is tuned accurately to the generator. The linearity checks outlined in the section under "selectivity measurements" should be completed before proceeding. After noting the output meter reading, the generator should be tuned to the image frequency (twice the i.f. frequency higher or lower depending on whether the oscillator is tracked on the high or low side of carrier). Then the output of the signal generator should be gradually increased until the same reading is secured on the output meter of the receiver under test. It will be necessary to re-tune the generator slightly to exact resonance before noting the exact output reading. The ratio of the carrier required to produce the same audio output on the image frequency as on the correct carrier frequency is then the actual image ratio. This ratio will vary from many thousand times to only two or three to one — depending on the amount of pre-selection.

d. AUDIO FIDELITY:

Below 1 megacycle carrier frequency "side band cutting" limits the upper modulation frequency, since a single tuned circuit is employed in the final tank. At one megacycle this effect can be disregarded for modulation frequencies up to 5 k.c. As the carrier frequency is decreased below 1 megacycle, and as the L/C ratio varies over the tuning range, attention must be paid to the limitations imposed by this tuned circuit.

If measurements are confined to modulation frequencies of less than 1 k.c., no difficulty should be experienced down to the lower carrier limit of 75 k.c.

As the carrier frequency is increased above 1 or 2 megacycles, the upper limit in modulation is determined by the characteristics of the r.f. filters in the modulated

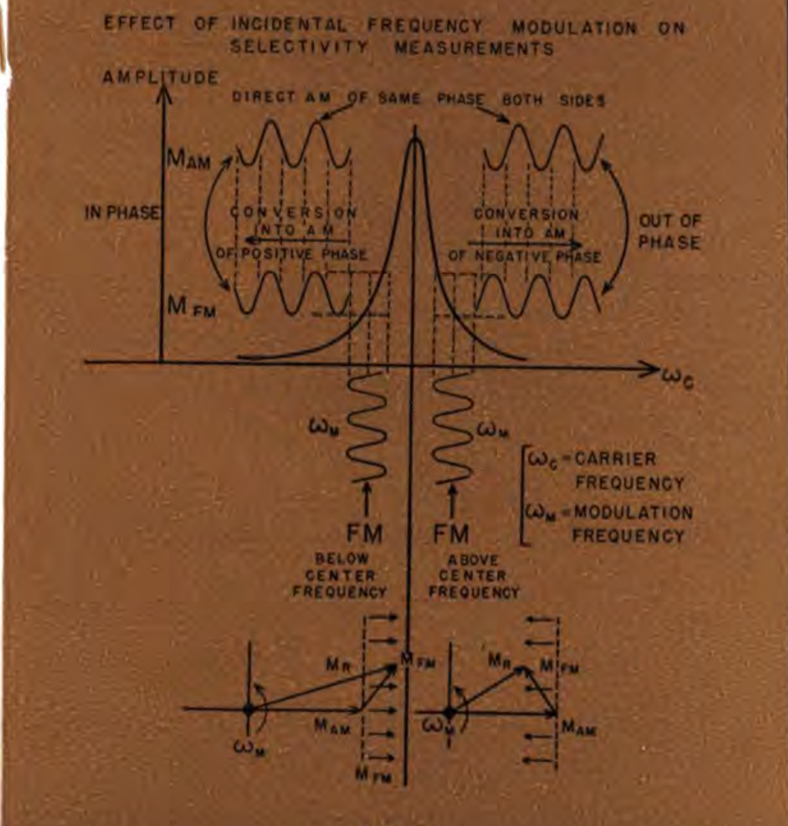


FIG. 4

B+ lead entering the r.f. generating compartment. These filters cut off at approximately 20 k.c.

In general, audio fidelity measurements will not present any special problem above 1 megacycle carrier, if the modulating frequency is kept between 100 and 5,000 cycles. If a wider audio modulation range is to be used, the actual per cent modulation should be checked for the extremes as outlined under "Service and Maintenance, Modulation and Power Unit". Because of the negative feedback, the modulation will in general be flat within 10% or 1 db from 50 to 10,000 cycles above 1 megacycle carrier frequency.

In order to make fidelity measurements some type of audio frequency voltmeter should be connected to the output terminals of the receiver under test. Thermocouple type indicators are not used for this purpose because of their susceptibility to damage by overload. Copper-oxide type output indicators are fairly satisfactory for frequencies up to 4 or 5 kc. Specially designed units can be used above this audio frequency; but in general, copper oxide type meters are subject to bad frequency errors and bad temperature errors. The most satisfactory type of output meter is the vacuum tube voltmeter, since the frequency, temperature, and overload characteristics can be made practically perfect for audio frequencies. In lieu of a vacuum tube voltmeter, a cathode ray oscilloscope can be used as an output indicator. The oscilloscope has the advantage of observing wave-form errors, detecting non-linearity or overload, and spurious oscillations.

The square wave response of the 65-B is not especially

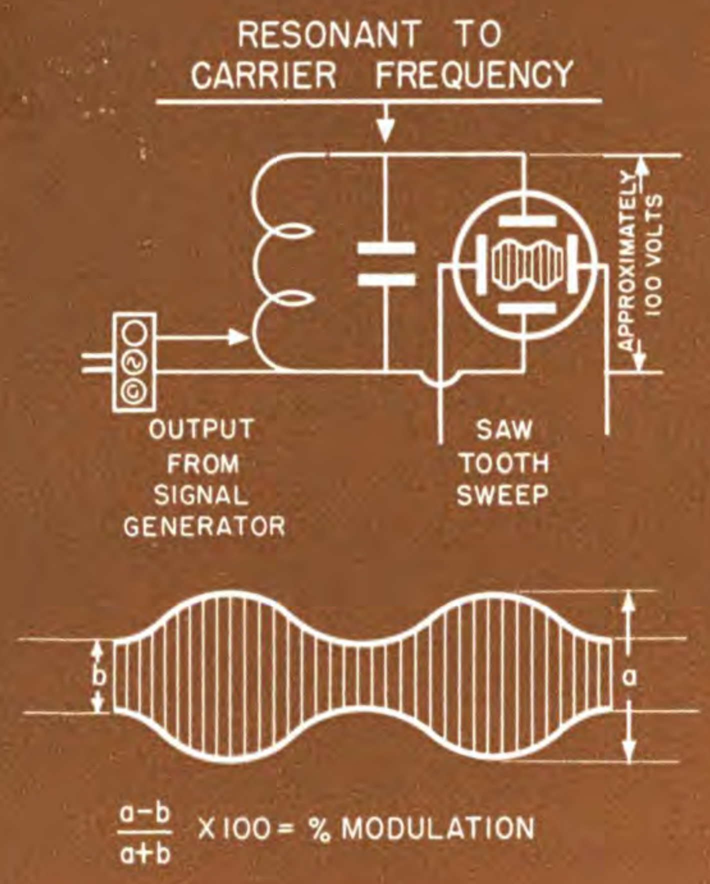


FIG. 5

good, for at the time its design was completed, the technique and equipment for square wave analysis was not well developed.* Direct observation of envelope squareness can be made on an oscillograph connected as shown in fig. 5. Our model 71 square wave generator supplies adequate voltage; however, we recommend operation with modulation amplitude control (see fig. 1) turned as near maximum as possible to avoid "rounding off" effects due to input capacity of the first amplifier tube. The output controls on the model 71 permit reasonably close setting of the modulation level.

It will be noticed that there is a transient of approximately 25 k.c. on the square wave modulation. This results from the modulation filter built into the 65-B to eliminate r.f. leakage. Such sharp amplitude response termination is accompanied by a more gradual phase or time delay cut-off, hence the 25 k.c. damped oscillation.

If very low frequency or very high frequency square wave repetition is to be used, the audio modulation system in the 65-B will not be satisfactory; however, our model 71 has a built-in modulator which will provide 100% modulation of the carrier external to the signal generator. This modulator will function well over the entire range from 5 to 100,000 square wave cycles per second. The signal level into the model 71 modulator should be kept as high as possible to avoid some small switching transients because of imperfect "d.c." balancing. The technique of square wave modulation can be utilized to check the action of "CW" keying filters, relays, transient response of broad-band or sharp band filters, etc. An application is mentioned later under "A.V.C. characteristics".

Pulse modulation can also be accomplished in a similar manner thru the use of our model 79-B Pulse Generator, which also contains a modulator stage similar in operation to our model 71 Square Wave Generator mentioned above.

e. AUDIO DISTORTION:

The total harmonic distortion of the modulated carrier envelope is less than 1% for 30%, 400 cycle modulation. This distortion rises slowly to 3 or 4% at 100% modulation except at very high frequencies, where the distortion at 100% modulation may be as high as 7%. In general the distortion up to 90% modulation is less than 2 or 3%. All of the above figures are based on the use of the built-in low-distortion oscillator. If an external source is used, care must be exercised to keep its harmonic content well below .5%.

Measurements of overall carrier envelope distortion can be made as outlined in the section under "Service and Maintenance" on "Modulation and Power Unit".

Audio distortion measurements on receivers can be made rapidly by the use of a cathode-ray oscillograph connected to the output terminals of the receiver. This method is rather good, since the presence of high order low amplitude harmonics can be seen. It is also advantageous for the detection of spurious oscillations and transient phenomena. For quantitative measurements it is best to use some type of harmonic analyser on the output of the receiver to accurately measure the amplitude of the various harmonic components.

If a harmonic analyser is not available, a simple, total harmonic measuring device can be made by using a sharp high pass filter to cut off at around 500 or 600 cycles (for 400 cycle analysis). In constructing this filter extreme care should be used in selecting the components to see that they will remain linear over the operating range of applied voltage levels. It is wise to use air-core inductances, because of the non-linear properties present in most iron core material. Dynamic speaker field coils of the 1,000 to 2,500 ohm variety can usually be used quite successfully — the only precaution is to mount them at right angles for minimum mutual inductance and remove them several feet away from power transformers to eliminate a.c. pick-up. The ratio of the total output voltage

* See References: (1), (2), and (3)

as read on an r.m.s. type meter to the voltage without the filter will give the fraction of harmonic content. (This should be multiplied by 100 to secure %). In practice an "average" type of copper oxide or vacuum tube voltmeter can be used instead of the r.m.s. type with slight differences, if the harmonic content is low.

Square wave modulation distortion has been discussed briefly in the section under "Audio Fidelity". An oscillograph is necessary for the analysis of square wave response. A careful study of references, 1, 2, 3 — at the end of this manual will be helpful in interpreting the resultant patterns.

No discussion of audio distortion would be complete without a mention of "cross-modulation" distortion.

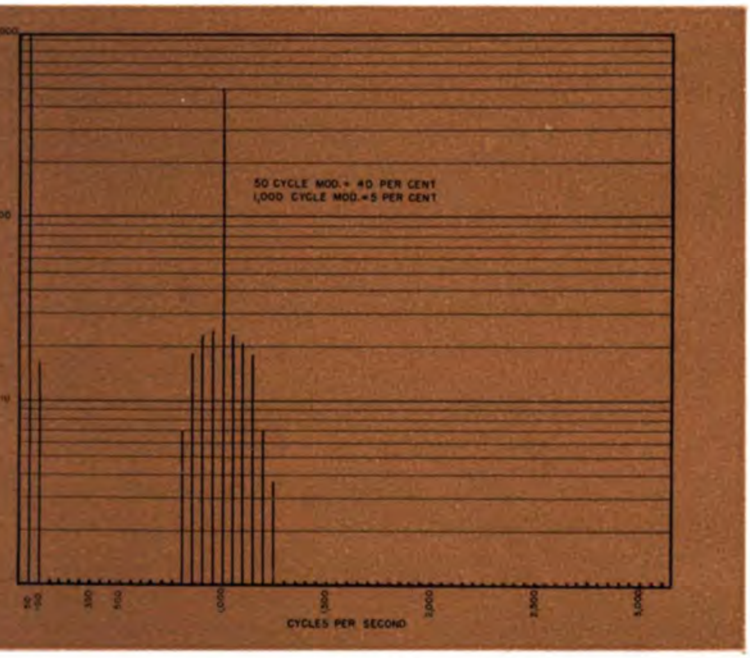


FIG. 6B

(See reference 4). The cross-modulation distortion in the 65-B was determined by applying a 50 cycle modulation and observing the sidebands created on either side of a 1000 cycle simultaneous modulating tone. Fig. 6 shows the resultant spectrum as measured on a wave analyser for different modulation levels of the 50 cycle applied modulation.

The cross-modulation distortion present in the 65-B originates mostly in the iron-cored plate choke of the "Heising" modulation system. It is doubtful whether commercial broadcast transmitters exhibit any less distortion than the 65-B. This effect should not be present in most f-m transmitters and may account for the apparent difference in bass response between the f-m and a-m broadcast transmitters carrying the same program and observed simultaneously on the same reproducing

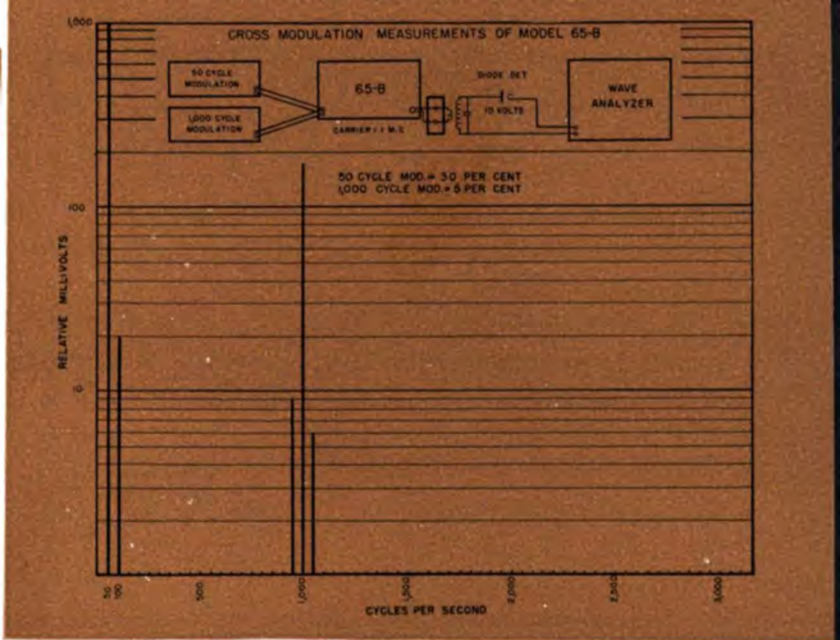
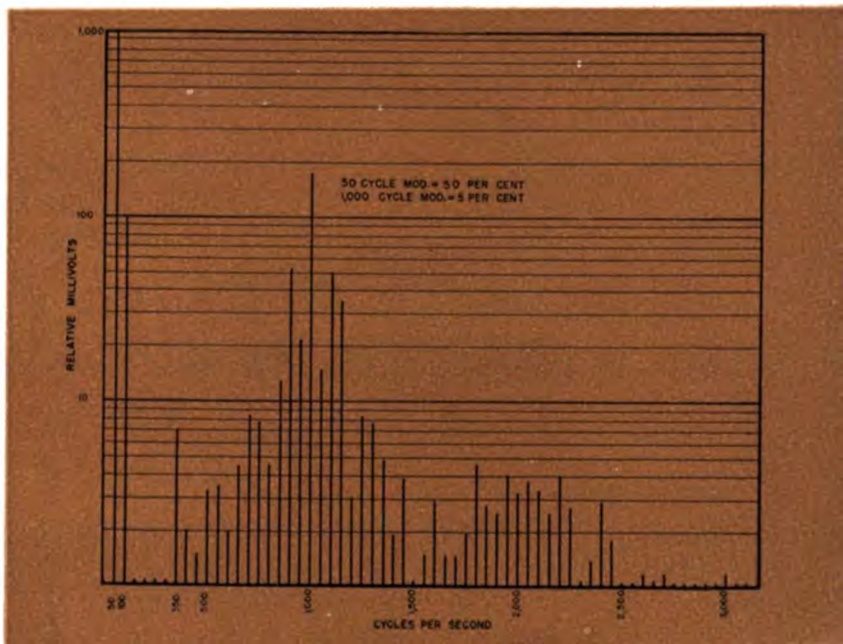


FIG. 6A

system. Invariably the a-m transmitted program seems to have more bass. Admittedly most home receivers have undersized output transformers and speakers which add many times the distortion present in the 65-B; therefore the 65-B should serve very well for the measurement and subsequent improvement with regard to this hitherto neglected matter in broadcast receiver design. More importance should be attached to non-linearities which create cross-modulation distortion, since it is relatively easy to reduce ordinary harmonic distortion to levels far below that which the ear can detect.

In order to measure cross-modulation distortion of a receiver, it is suggested that the connections be made as shown in fig. 6 except that a receiver be substituted for the step-up tuned circuit and diode shown. It is suggested that the amplitude of the 50 cycle component be kept less than 30% as read on the per cent modulation meter. The two audio modulations should be applied separately and their levels adjusted externally to produce 30%, 50 cycle and 5%, 1,000 cycle respectively; then they should be applied simultaneously. A suitable isolating arrangement should be used to prevent interaction such as is used in program mixing for broadcast

FIG. 6C



purposes. It may be more convenient to use 100 cycles for the lower tone. In this case the distortion inherent in the 65-B will be even less.

The investigation of cross-modulation effects will account for many annoying differences between the original and reproduced program. One of the most striking examples is perhaps the familiar garbling of the church choir by bass notes of the organ with the resultant difficulty in distinguishing the different voices.

f. A.V.C. CHARACTERISTICS:

It is customary to measure audio output of the receiver as a function of carrier level input. About 30% modulation can be used. The well designed a.v.c. system will usually flatten off between 10 to 100 microvolts and hold the output almost constant for higher inputs. It is possible to use a separate a.v.c. amplifier (sometimes called "shunt a.v.c.") and apply a.v.c. *after* the point at which the a.v.c. amplifier is connected to obtain very flat characteristics. The exact slope can be controlled by properly proportioning the a.v.c. between r.f., i.f., and even the audio amplifier.

Some a.v.c. characteristics are carried up as high as 2 volts input. For such high voltages, it is usually necessary to introduce an additional variable load in the antenna circuit to prevent overloading and cross-modulating of the first r.f. amplifier tube grid. This can be accomplished by connecting a pentode across the first tuned circuit in such a way that its effective shunt resistance varies from a high value down to a few hundred ohms as its grid bias is varied by the a.v.c. potential.

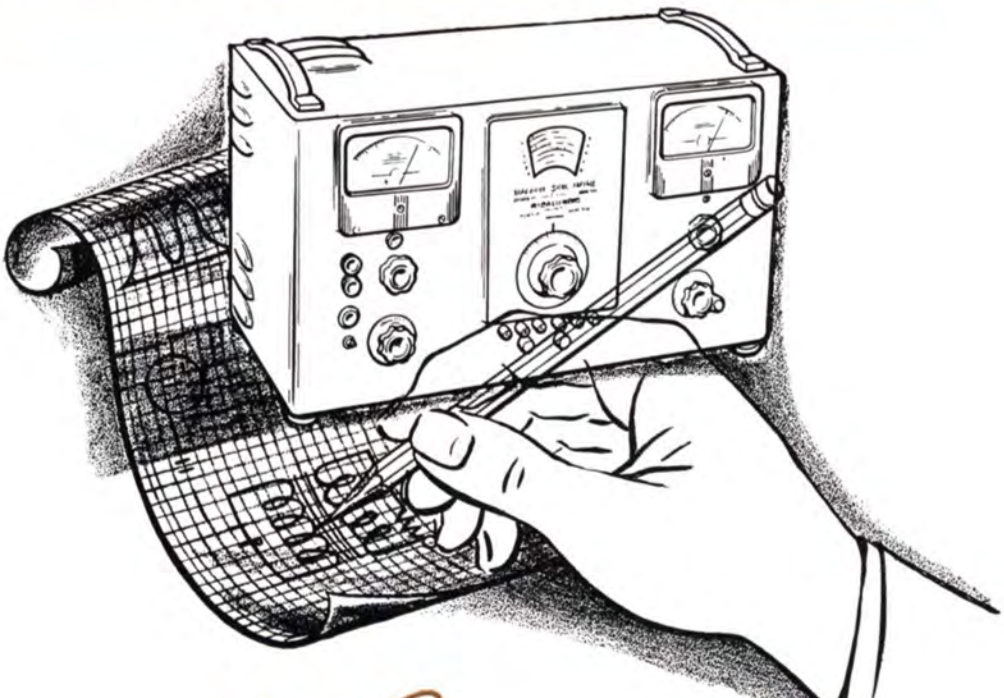
A.V.C. time constants are the subject for much argument. If a receiver is to employ a.v.c. in conjunction with "CW" reception successfully, a compromise time constant must be used. If the time constant is too fast, excessive noise and static will come up between breaks in words and sentences; on the other hand, if the time constant is too slow, rapid fading will cause rather severe fluctuations in output.

During the course of time constant specifications, it becomes desirable to make accurate measurements of the a.v.c. recovery time. These measurements can be made by the use of square wave modulation, although to the writer's knowledge this method has not been widely used. In order to measure some a.v.c. systems having rather slow recovery times, it may be necessary to use a pen and ink recorder rather than an oscilloscope, because of the severe flicker effect which accompanies the low repetition rate necessary to make the measurement. It should be noted here that our model 71 square wave generator has a built-in modulator which will produce practically 100% modulation; however, there is some transmission when the modulator tube is cut off due to stray field, coupling through the tube, etc. This may amount to 1% at the higher frequencies; therefor the modulation is only about 99%. If it is necessary to secure a variation from 2 volts down to a few microvolts, perhaps the only solution is to key the r.f. oscillator B+ lead in the 65-B. This will assure absolutely 100% "CW" modulation. A small relay can be driven from the square wave generator to accomplish this keying.

The lowest repetition rate of our standard model 71 square wave generator is 5 cycles per second; however, it can be decreased to 0.5 cycles per second by connecting two 1.0 mfd condensers on the blank terminals of the decade frequency switch and moving the mechanical stop around one more position. This position will be x 0.1 the calibration of the continuous frequency dial. This modification can be supplied by Measurements Corporation at slight additional cost.

On most aircraft beacon receivers the a.v.c. or overload characteristic must be investigated rather carefully, since an improper action may completely obscure the "cone of silence" marker directly over the station. Even though manual volume control action is usually employed on such receivers, some overloading action may take place on strong signals in the immediate vicinity of the station just before the "cone of silence" is reached and block out the receiver, thus creating a false cone of silence. With two volts carrier input, the beacon receiver must not overload with the manual gain control on full!

USE OF STANDARD SIGNAL GENERATOR IN DESIGN, DEVELOPMENT, AND RESEARCH



Measurements Corporation

BOONTON · NEW JERSEY

III. USE OF STANDARD SIGNAL GENERATOR IN DESIGN, DEVELOPMENT, AND RESEARCH:

a. STAGE GAIN MEASUREMENTS:

In measuring stage gain, the signal generator is usually connected directly to the grid of the amplifier tube, while a suitable vacuum tube voltmeter is connected in place of the succeeding tube grid. Most diode type vacuum tube voltmeters have an input capacity and effective load resistance comparable with those of the following amplifier tube which they replace for stage gain measurement purposes. See fig. 7.

Certain types of circuits employing low capacity input tubes (such as type 954, 956, etc.) exhibit very low loss, and the substitution of an ordinary diode will materially change conditions. Fortunately most of these circuits are employed at frequencies much higher than 30 megacycles, therefore there is little need for their discussion in connection with the 65-B. It is frequently possible to change the grid bias and insert a plate current milliammeter in the following tube's plate lead and thus make it into a vacuum tube voltmeter. Even this arrangement is occasionally open to question, since the reflected load into the grid circuit by such a tube will be somewhat different under these conditions than when operated as a straight r.f. amplifier.

At the higher frequencies the leads connecting the signal generator output terminals and the tube grid must be kept very short; (hence the value of the terminated transmission line.) The signal generator should be used unmodulated because of difficulties that will be experienced with peak reading voltmeters on a modulated carrier.

Some engineers prefer to make a detector out of the tube following the stage under test and insert an audio type sensitive voltmeter to read the demodulated output. In this case it will be necessary of course to use modulation on the carrier. See fig. 8.

If time permits, it is interesting to check the measured stage gain against the calculated stage gain. In order to calculate the gain it is necessary to know the "Q" of the tuned circuit as well as the mutual conductance of the r.f. amplifier tube. "Q" measurements are treated later under part "f" of this same section. The mutual conductance or g_m of the tube can be taken from curves or data published by the tube manufacturer, although it is wise to measure the actual g_m on a mutual conductance bridge. See fig. 8 for application of formula to calculation of stage gains.

After all stage gains have been measured thru a receiver, it is interesting to multiply them together to secure the *overall product* gain. This gain should be checked against the actual measured overall gain. If the measured overall gain is higher than the product gain, it is likely that there is some regeneration caused by stray coupling between various stages. Such regeneration is difficult to control and should be eliminated in any good *production* receiver. In general such coupling can be minimized by care in filtering of power supply leads including *heater* leads, and locating the output or "hot" end of the receiver as far away as possible from the input—particularly if there is no frequency conversion in the chain of amplifier stages.

b. CONVERSION GAIN MEASUREMENTS:

In measuring the conversion gain of the usual frequency convertor tube, the circuit shown in fig. 9 can be used, but checks must be made for the presence of beat oscillator voltage on the output vacuum tube voltmeter. If the signal generator output voltage is reduced to zero and a residual reading remains on the output vtvm, this reading should drop to zero when the beating oscillator is stopped (by shorting its grid to cathode). If the reading does not drop to zero, check the zero adjustment of the vtvm by shorting its input terminals. If the vtvm zero is correctly set, but a minimum reading is obtained with the beating oscillator dead, look for a parasitic or spurious oscillation in the converter stage. This may be over-

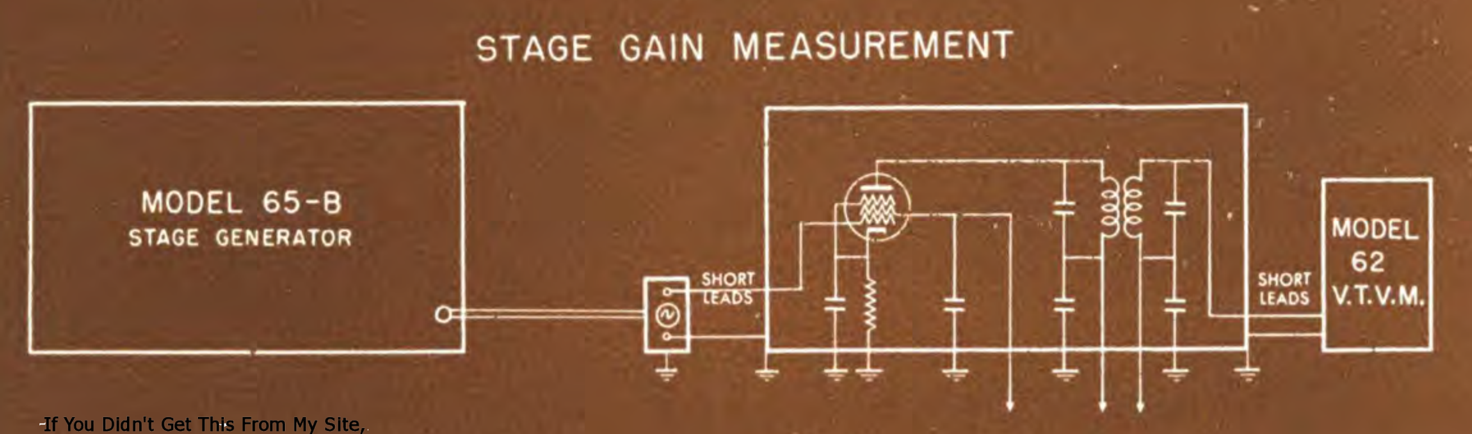


FIG. 7

STAGE GAIN MEASUREMENT WITH MODULATED CARRIER AND DETECTOR ARRANGED TO MINIMIZE EFFECTS OF R.F. OUTPUT V.T.V.M. LOADING

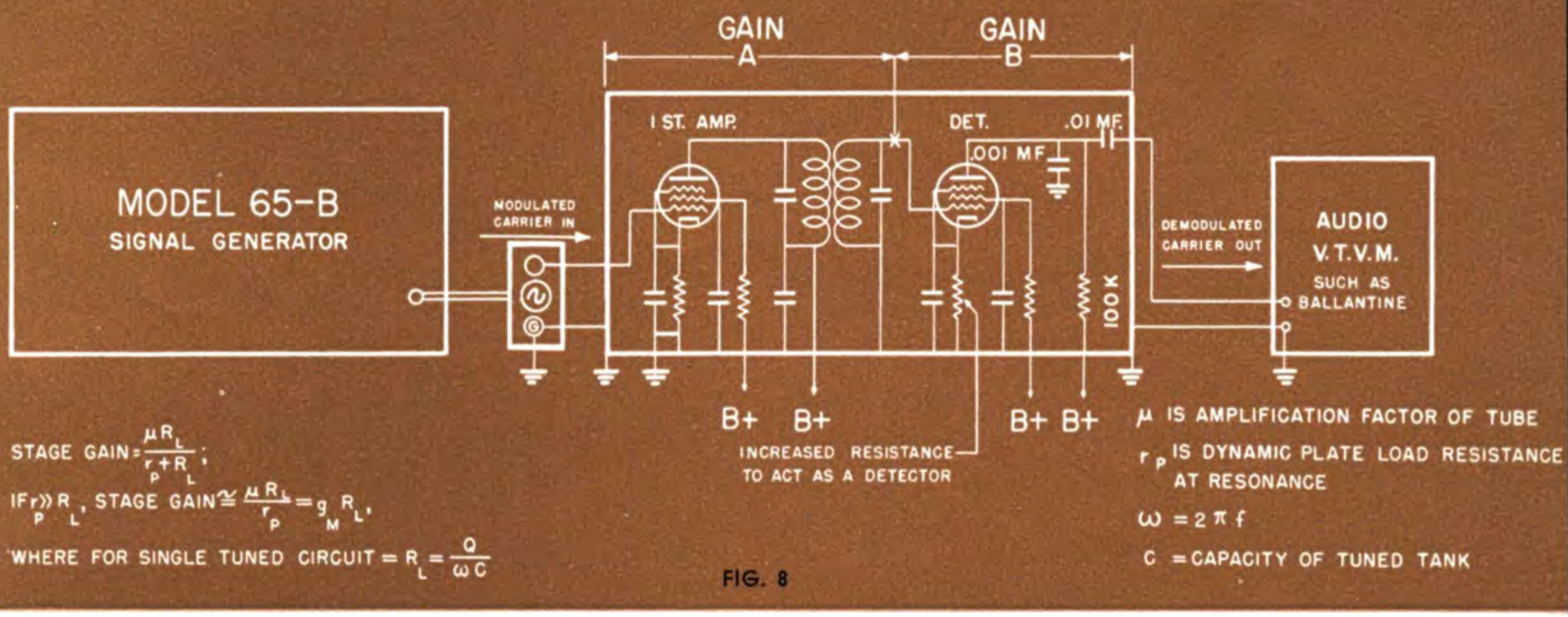


FIG. 8

all feedback which can be stopped by removing some of the i.f. amplifier tubes.

If the vtvm zero is correctly set, but a residual voltage remains when the local beating oscillator is operating, this means that some local oscillator voltage is getting thru the first tuned circuit of the i.f. amplifier to the vtvm. This will usually occur when the oscillator approaches the same frequency as the i.f. It may be possible to get rid of this difficulty by making the stage gain measurements at a higher signal level to reduce the effect of the stray oscillator voltage, or if this cannot be done without overloading the convertor tube, it will be necessary to include the first i.f. stage (for extra selectivity) and divide the total measured gain by that of the i.f. stage in order to obtain the correct convertor gain. Note that an error caused by the presence of residual local oscillator voltage will lead to values of apparent conversion gain which are too large. In general it should be possible to secure a conversion gain of about one-third the value which would result if the same tube were used as a straight amplifier with the same effective plate impedance.* This straight gain can be checked by feeding i.f. frequency voltage into the convertor grid instead of r.f. frequency, and noting the resultant gain. If this latter gain is less than three times the conversion gain, something is wrong and the measurement conditions and technique must be studied further before any reliance is placed on the results thereof.

Before making any stage gain measurement it is well to remove any possibility of a.v.c. operation by shorting out the a.v.c. supply line.

Certain types of convertor circuits popular at the higher frequencies employ grid mixing rather than electron stream injection. These must be measured by the scheme outlined in fig. 10. This system involves the measurement of the r.f. stage gain or antenna stage step-up first; then the combination or product gain from r.f. grid to i.f. grid or antenna to i.f. grid is divided by this first gain to secure the conversion gain. Again it may be necessary to use an additional i.f. stage in order to reduce the local oscillator voltage at the vtvm. It can be seen that the measurement of conversion gain when grid mixing is used is more difficult than other types of convertors.

At the higher frequencies the presence of input loading may force the use of the above scheme with electron stream mixers.

* See Reference: (5)

CONVERSION GAIN MEASUREMENTS

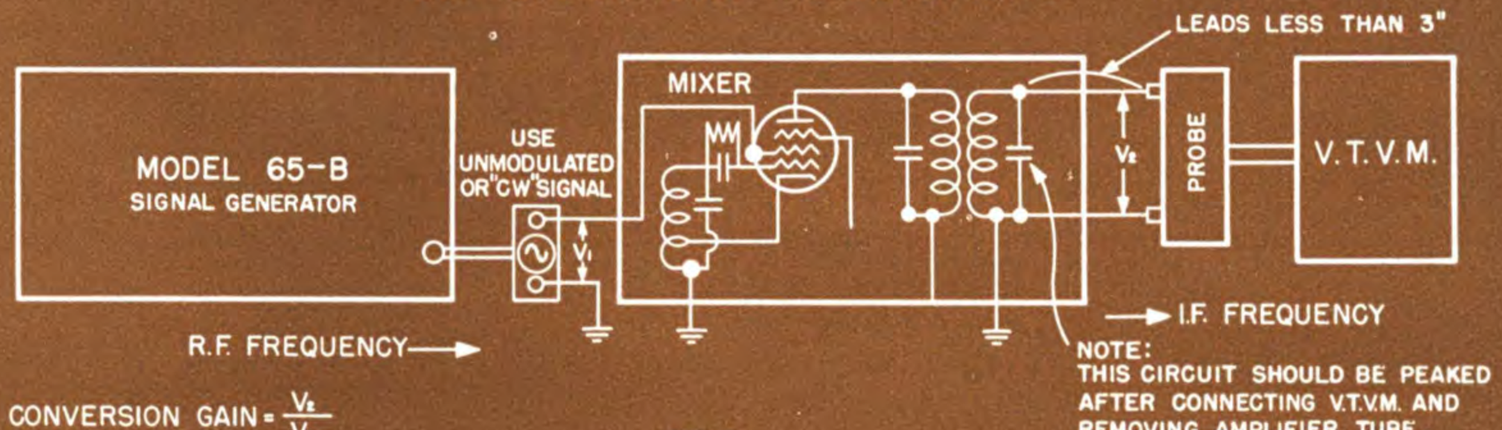


FIG. 9

c. R.F. STAGE GAIN MEASUREMENTS:

In measuring r.f. stage gain, it may be necessary to measure the combination of the r.f. plus convertor, particularly if working at the higher frequencies where input loading effects are likely to be present in the convertor grid circuit. Then the actual r.f. gain can be calculated from the measured conversion gain.

When working with grid mixing circuits it is usually customary to neglect this input loading of the convertor tube, in order to secure some sort of measurement, since the r.f. stage gain must be measured alone before the convertor gain can be determined as mentioned above under "Conversion Gain Measurements".

All leads from signal generator terminals to r.f. tube grid and from vtvm probe to tuned circuit must be kept less than three inches for accurate measurement at frequencies of 30 megacycles.

Of course the a.v.c. circuit must be blocked out in order to prevent erroneous measurements of r.f. gain.

d. ANTENNA STEP-UP MEASUREMENTS:

A correct dummy antenna should be inserted in the lead from the signal generator as shown in figure 2. Four different kinds of input circuits are shown in this figure. Altho the arrangement shown under (a.) is used by some military specifications, some difficulty will be had with signal generator output impedance in the standard model 65-B. This is true because of the rising characteristic as shown by fig. 3. If it is necessary to use a small pure capacity antenna at frequencies as high as 20 or 30 megacycles, a special output cable can be supplied on special order for our 65-B which will provide a constant output impedance of 3 ohms. This value is low enough for almost any type of antenna circuit. This special output termination adds an additional step of 10 to 1 attenuation; therefore the maximum output when using the special 3 ohm output is only .2 volt.

The neglect of the actual output impedance characteristic will cause errors not only in antenna step-up measurements, but also in any measurement wherein the actual load placed on the signal generator at that *particular* frequency becomes comparable to the output impedance. The effect of this impedance has been discussed previously under "image ratio".

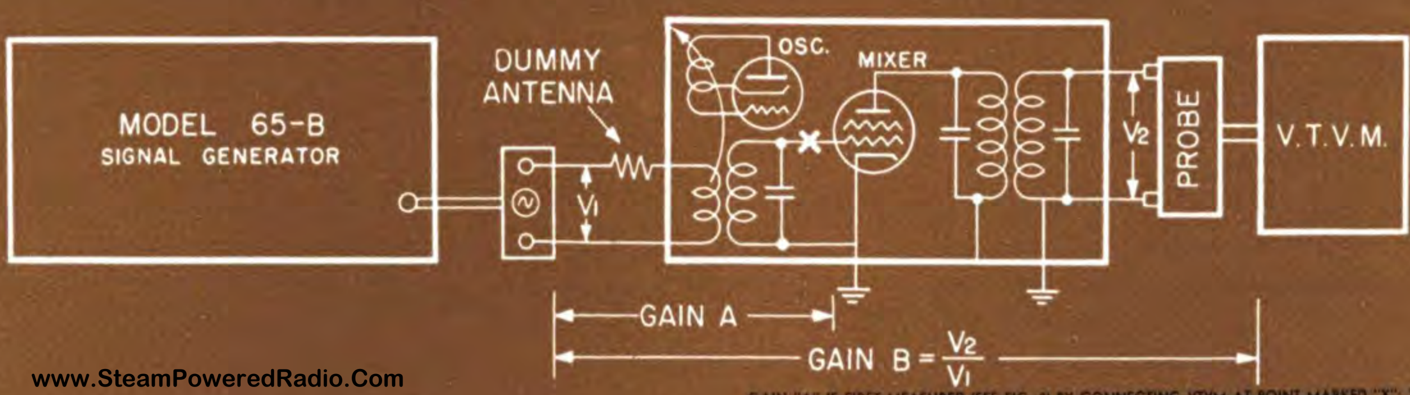
It is usually customary to design an antenna transformer to properly match the antenna or transmission line to the first amplifier tube grid. This may be done on a basis of maximum possible voltage gain, maximum signal to noise ratio, or a compromise with selectivity requirements may be necessary as dictated by image ratio checks, etc.

Under certain conditions the loading of the vtvm used to read the grid voltage may be of serious magnitude; this is easily checked by first measuring the antenna step-up with the vtvm connected across the total inductance, and then repeating the measurement by tapping down the vtvm just exactly half way on the coil and retuning. This should produce just exactly half of the voltage gain provided the vtvm loading is negligible. If the apparent gain is greater than one half, the vtvm loading is not small and the actual antenna step-up is nearer to twice the tapped value. The above procedure is, of course, based on the fact that the impedance reflected varies as the ratio of the turns squared (in this case one fourth) while the voltage varies only as the turns ratio (in this case one half). With very high "Q", low capacity circuits it may be necessary to tap down the vtvm to one quarter of the coil. This process can also be used very successfully at the higher frequencies, except that it will be necessary to either determine the voltage distribution, or else assume it for the particular case under consideration.

By the same token, the high frequency amplifier tube may load the antenna circuit so badly that much better

FIG. 10

MEASURING CONVERSION GAIN FOR GRID MIXING



NOTE:
R. F. AMPLIFIER OR PRE-SELECTOR CAN BE SUBSTITUTED FOR ABOVE ANTENNA TRANSFORMER, IF DESIGN OF RECEIVER INCLUDES R. F. STAGE. GAIN "A" THEN BECOMES THE GRID TO GRID GAIN ON THE R. F. AMPLIFIER AS MEASURED BY FIG. 7 OR FIG. 8.

GAIN "A" IS FIRST MEASURED (SEE FIG. 2) BY CONNECTING VTVM AT POINT MARKED "X"; THEN OVERALL GAIN "B" IS MEASURED.

$$\text{CONVERSION GAIN} = \frac{\text{GAIN B}}{\text{GAIN A}}$$

FREQUENCY VARIATION METHOD OF MEASURING "Q"

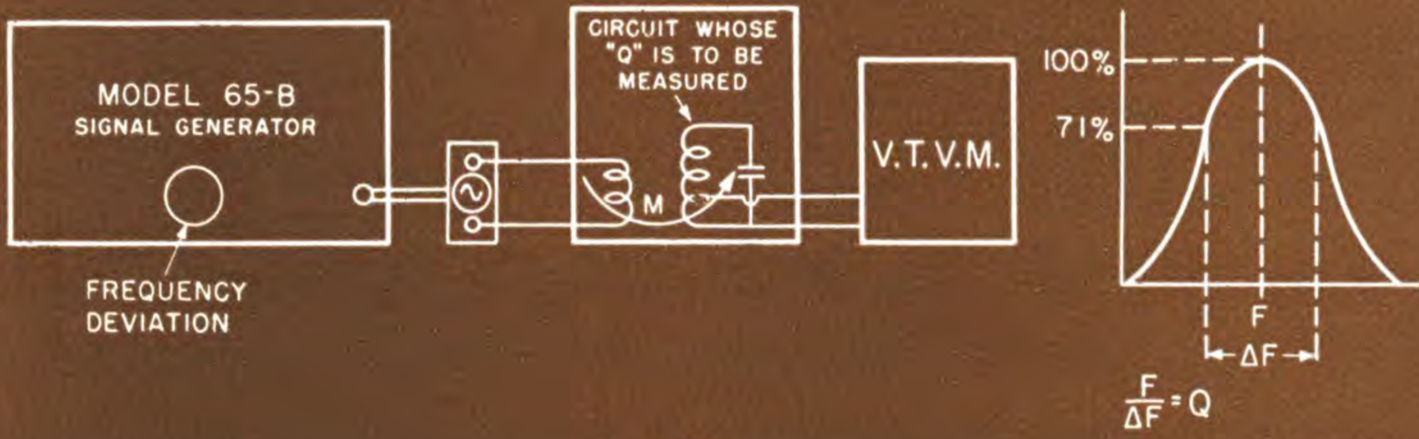


FIG. 11

selectivity can be obtained as noted by image ratio improvement without appreciable sacrifice in stage gain, if the tube is tapped down somewhat on the tuned circuit as suggested above for the vtvm. It is usually expedient to determine a compromise tap experimentally.

e. SUPERHET OSCILLATOR TRACKING:

It is usual practice to track the oscillator of a superhet by rocking the gang condenser back and forth and adjusting the oscillator padder for maximum — the series padder near the low end and the shunt near the high end of the tuning range. This process can be shortened somewhat by the following procedure:

First the r.f. pre-selector circuits are adjusted to cover the desired range. This can be done by making a connection similar to figure 8. This connection really makes a tuned r.f. set out of the r.f. pre-selector part of the receiver.

Next, the receiver is restored to normal operation and the oscillator padders and coil inductance are adjusted for noise maximums at three points; the upper, center, and lower ends of the range. This noise can be produced by any one of several methods; thermal agitation, shot noise, mechanical hash from a vibrator, etc. If the receiver is sensitive enough, thermal noise in the first tuned circuit will furnish the necessary signal for peaking of the oscillator at the three points. Usually this can be done in the commercial communication type receivers only. Most home receivers are not sensitive and will require some external noise producing device to overide the internal noise from the first convertor. A shot noise diode can be connected across the antenna circuit and the noise magnitude can be adjusted by lowering the filament temperature of the diode until the space current is limited solely by filament temperature. If the diode is connected across the grid part of the circuit, it will be necessary to block out d.c. from the grid of the first amplifier tube and trim out the extra capacity of the added diode plate. With a type 80 rectifier tube, considerable noise voltage can be developed across only 100 ohms of pure resistance — this is usually low enough to place in the antenna circuit and avoid changing of the input of the receiver being tracked. Mechanical hash is not very stable, but can be used in an emergency. Even a small annunciator type buzzer can be coupled to the antenna terminals for this purpose.

Noise alignment with wide band types of receivers is more accurate and rapid than the usual "rocking condenser" technique with a signal generator. A signal generator should first be used to set the r.f. pre-selector circuits to cover the desired range as pointed out above.

It is customary to express oscillator tracking performance by means of an oscillator tracking curve. This can be plotted to show the three intercept points of perfect tracking: for variable capacitor tuning, it is usual to plot micromicrofarads of trimmer versus frequency for perfect tracking at a number of different uniformly spaced frequency intervals in the tuning range under consideration. It is also possible to first track the set at the three points and then take a sensitivity curve versus frequency — this curve will include sensitivity variations due to imperfect tracking. Next another sensitivity curve should be taken with the oscillator tracked at each point manually by readjusting the trimmer. The difference between these two curves represents the loss of sensitivity due to imperfect tracking. In a well tracked receiver covering a three to one range, it is possible to track well enough, so that only a small per cent sensitivity loss need be tolerated.

f. MEASUREMENT OF CIRCUIT "Q" WITH STANDARD SIGNAL GENERATOR:

Long before the well known "Q" Meter was marketed by the Boonton Radio Corporation, it was customary to measure circuit "Q" with the aid of a suitable signal

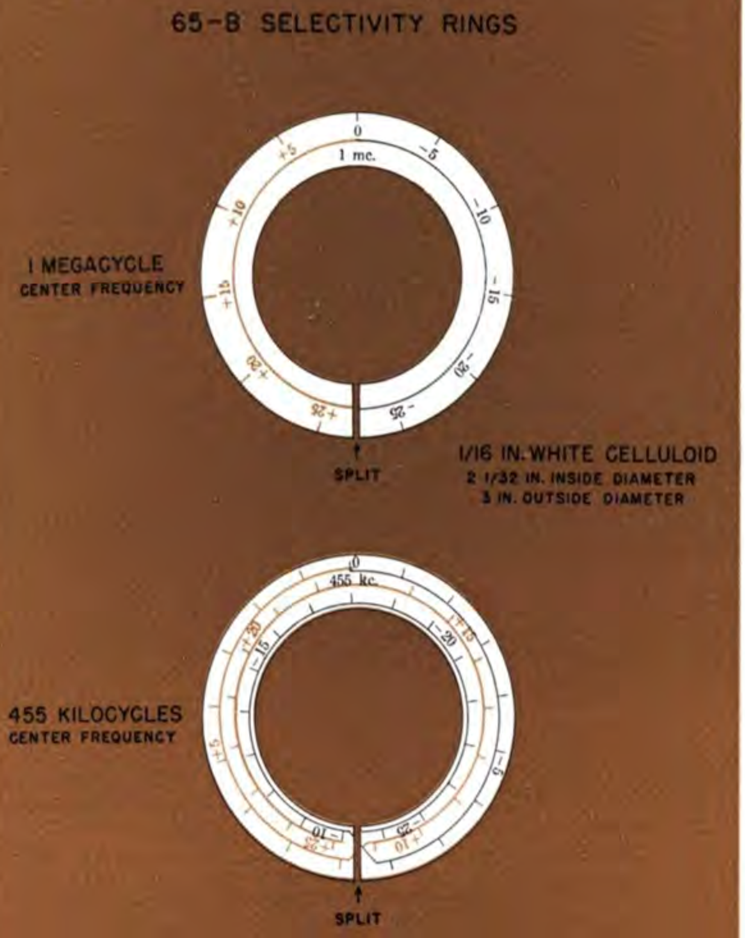


FIG. 12

source calibrated in output and frequency. This method of measurement is rather clumsy for routine production or most ordinary circuits; however, certain types of low capacity, distributed parameter circuits cannot be easily measured except by this "frequency variation" method.

The typical set-up for frequency variation method of "Q" measurement employing the 65-B is shown in fig. 11. Note that it is necessary to couple very lightly to the circuit under test both the output from the generator and the indicating voltmeter. It is not necessary to have the voltmeter calibrated, since the .707 point is determined on the signal generator attenuator. Either inductive or capacitative type coupling can be used, but it is recommended that care be taken when using inductive coupling below 5 megacycles, since the low impedance of the inductive loop may upset the termination of the attenuator output cable as well as the attenuator ratios.

After measuring the actual "Q" with the amplifier tube cold, the heater and B plus should be connected, and the decrease of "Q" due to "hot" losses determined. It is rather important to know these "hot" losses, since it may be better because of them to tap down the tube grid as mentioned previously.

Circuit "Q" can also be measured by reactance variation, but this measurement is not as accurate where distributed capacity or inductance complicate the exact measurement of either total capacity or inductance.

It may be convenient to make up a direct reading "Q" scale for the 0-100 dial on the 65-B for each particular frequency of measurement, if many measurements are contemplated. This could be constructed similar to fig. 12, by using the white celluloid rings as suggested previously for convenience in selectivity measurements.

g. MEASUREMENT OF SMALL CAPACITIES:

Frequently it is desirable to measure the internal capacity of vacuum tubes: such as plate to grid capacity, etc. The general method is outlined in figure 13. Since large signal ratios may be involved, it is necessary to test for stray or leakage around the test jig. This can be done by inserting a grounded guard ring between the "hot" signal generator connection and the receiver input lead as shown in fig. 14. There should be no stray detectible with the receiver gain at approximately maximum, and the signal output from the generator set as high as will ever be required during the course of the measurements.

If the entire set-up appears to have a bad case of "hand" capacity, the shielding should be improved by adding a large sheet of copper, brass, or aluminum under the 65-B, test circuit, and receiver. This ground plane should be connected to "ground" at the output terminal ground post of the signal generator. It may also be necessary to connect the signal generator case to the metallic sheet by a short ground braid where the output connection comes out of the signal generator case. The output cable should be kept well away from the receiver and close to the ground sheet.

It will be noted that only certain kinds of capacitors can be measured by the above method; namely, capacitors of which neither side need be grounded in order to measure them.

h. MEASUREMENTS OF ATTENUATION CHARACTERISTICS OF R.F. FILTERS:

In order to measure the attenuation of a filter some termination must be used on either end of the filter under test. Usually this is known, since the filter is designed to work into and out of certain particular impedance levels.

In certain cases, such as noise filters for automobile ignition noise and generator noise suppression, it has been expedient to establish standard test networks which standardize the test conditions rather closely. A standard test network is shown in fig. 15. The Measurements Corporation has supplied many of these networks to the industry in a form suitable for attachment not only to signal generators of own manufacture but to those of our competitors as well. It is necessary to specify the make of generator so that appropriate cable connectors can be supplied. Any good communications type receiver can be used as the output measuring device.

GRID TO PLATE CAPACITY MEASUREMENT

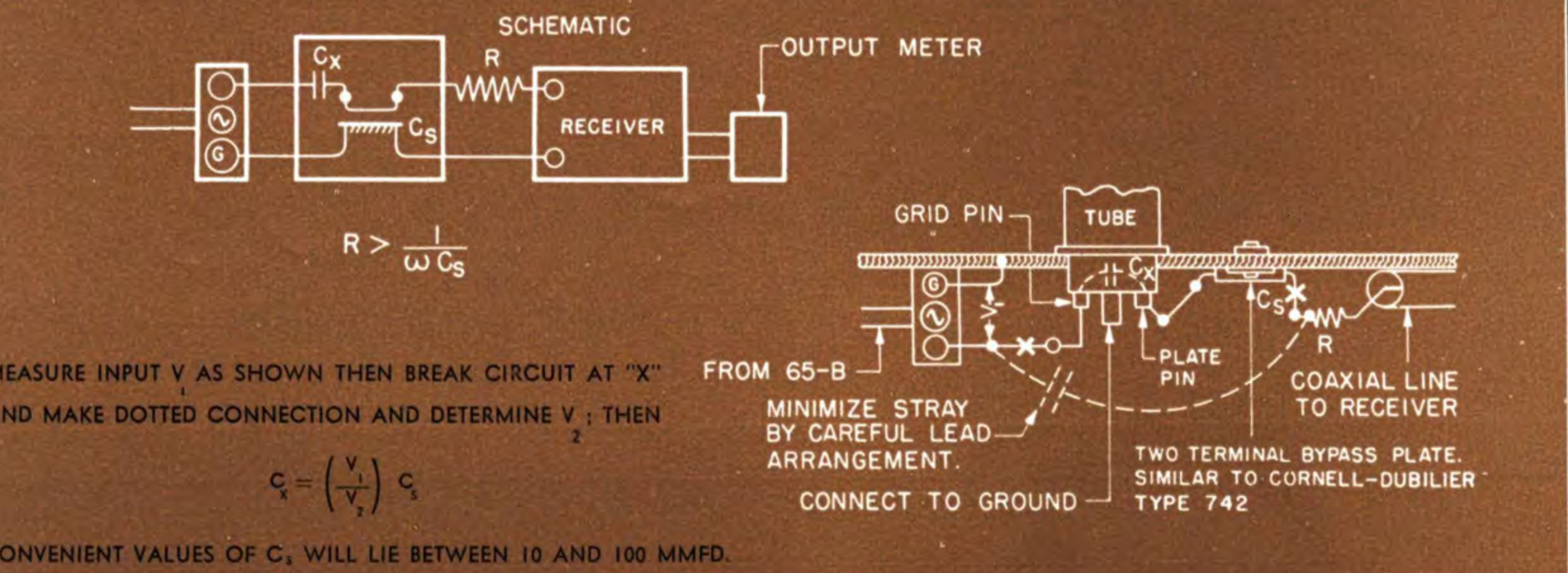


FIG. 13

The remarks under "Measurement of Small Capacities" concerning stray field or leakage apply as well to a set-up using our standard filter test networks. All stray coupling must be eliminated around the network under test at least to a level over the maximum output ever required of the generator. In general, measurements up to 80 or 90 db can be made up to 30 megacycles, provided care is taken to eliminate all strays. Usually a filter is checked over its entire operating range for any peaks or valleys in the attenuation characteristic.

I. MEASUREMENT OF SURGE IMPEDANCE AND ATTENUATION OF TRANSMISSION LINES:

It is customary to measure short circuit and open circuit impedances on a bridge or "Q" Meter and then calculate the impedance of the transmission line.

$$Z_0 = \sqrt{\frac{L}{C}}$$

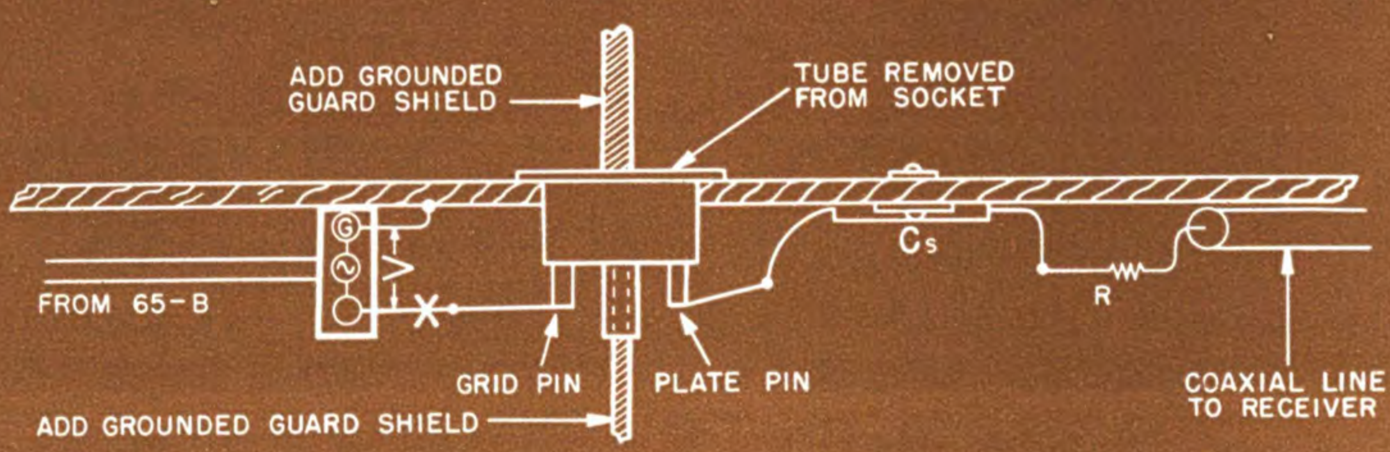
This formula neglects the effects of loss in calculating the surge inmpedance, Z_0.

As a good check on the calculated surge impedance, a frequency characteristic should be taken on the line for various values of terminating resistor. When the correct termination has been found the frequency characteristic will not exhibit any peaks or valleys, although there may be a tendency to increased attenuation at the higher frequencies because of increased line loss. Fig. 16 indicates the connections for taking a frequency run on a sample of transmission line.

It is important not to couple too closely to the signal generator, or else its own transmission line termination may be affected adversely. Note that it is not necessary to terminate the line under test correctly at the sending end, only at the receiving end.

In order to measure attenuation, the reference vtvm should be connected first to the input or sending end of the line and a frequency run taken as a check on the flat-

CHECKING FOR STRAY AROUND CAPACITY TEST JIG



IT SHOULD BE POSSIBLE TO INCREASE "V" TO MORE THAN TEN TIMES V_1 OF FIG. 13. BREAKING LINE AT "X" SHOULD PERMIT FURTHER INCREASE OF "V" FOR SAME RECEIVER OUTPUT SINCE THIS ELIMINATES CAPACITY COUPLING THROUGH SOCKET.

FIG. 14

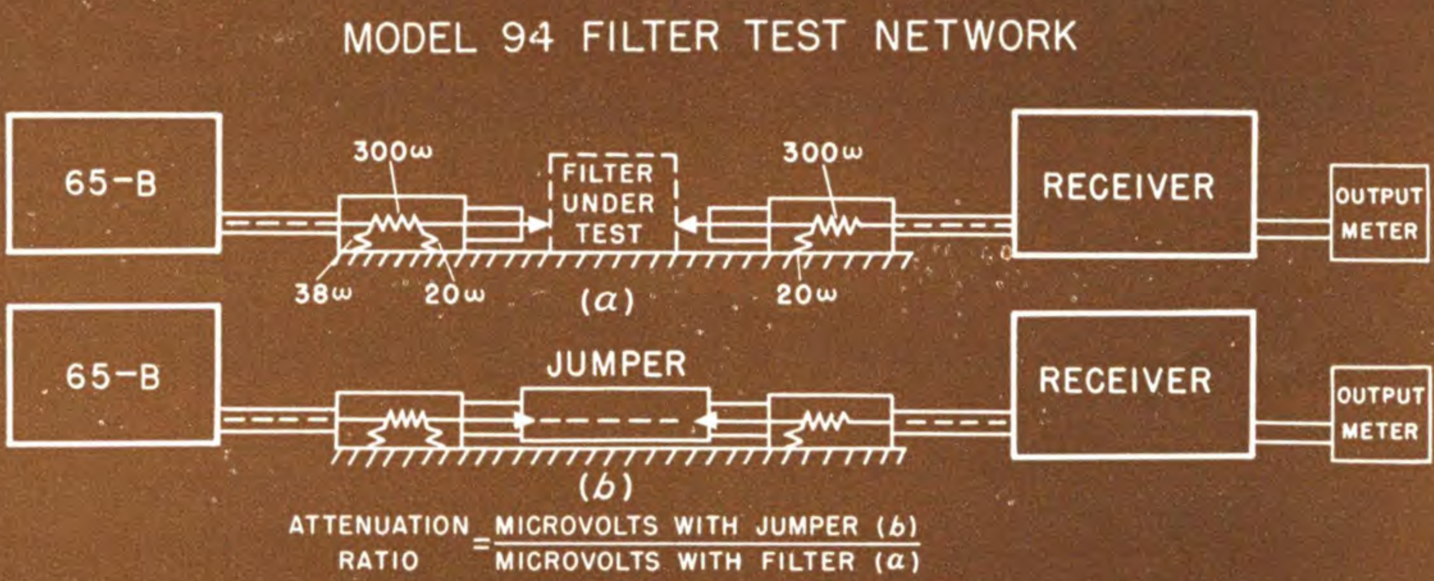


FIG. 15

ness of the 65-B. If the output is not flat to within 3% with little or no load across the output terminals of the signal generator, it may be possible that the 34 ohm terminating resistor across these terminals has changed in value. If the reference voltmeter can be transferred first from the input or sending end of the transmission line under test to the output or receiving end for each test frequency, any errors in signal generator output termination can be neglected.

Some of our customers have used the motor drive in conjunction with tests of attenuation and characteristic impedance. By pushing the motor drive with the left hand and correcting the output control knob with the right hand, the actual variation of the receiving end voltage can be continuously observed. It is convenient to place the vtvm adjacent to the 65-B output meter so that they can both be readily observed.

The method suggested in fig. 17 will permit the testing of balanced type transmission lines. Note that it is always better to secure balance with the aid of a center-tapped termination resistor, rather than a center-tapped coil or transformer. This method permits the use of an unbalanced type vtvm. In order to check balance, both sides of the receiving end should be measured. If the line is correctly balanced, the two readings should be the same.

j. USE OF A SIGNAL GENERATOR AS A BRIDGE DRIVER:

In making bridge measurements at the higher radio frequencies some care must be taken to eliminate all stray coupling between the bridge driver source and the indicating system (usually a receiver). The 65-B is well shielded and no especial difficulty should be experienced, if the precautions outlined under "Measurement of Small Capacities" are observed.

If possible a twin-T type of bridge should be used, since this will permit operation of both generator and receiver with one side grounded. If balance is necessary however, it can be better secured by the use of a balanced winding on the receiver, than by any attempt to balance the output of the 65-B. A static shield should be used with the balanced winding on the receiver to further reduce the magnitude of stray.

In general the use of radio frequency bridges becomes rather involved at frequencies higher than 5 megacycles. As the frequency is increased higher and higher, the use of resonant step-up in tuned circuits for measurement purposes becomes more practical. By substitution method the reactance and resistance of unknown impedances can be measured in a tuned circuit, using the frequency variation method to determine the circuit "Q" as outlined under "Measurement of Circuit "Q" with Standard Signal Generator".

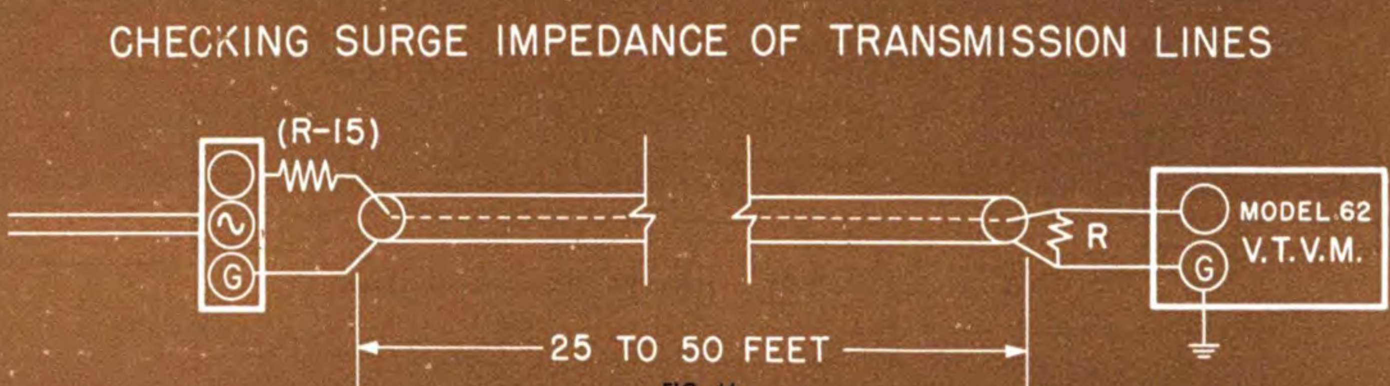


FIG. 16

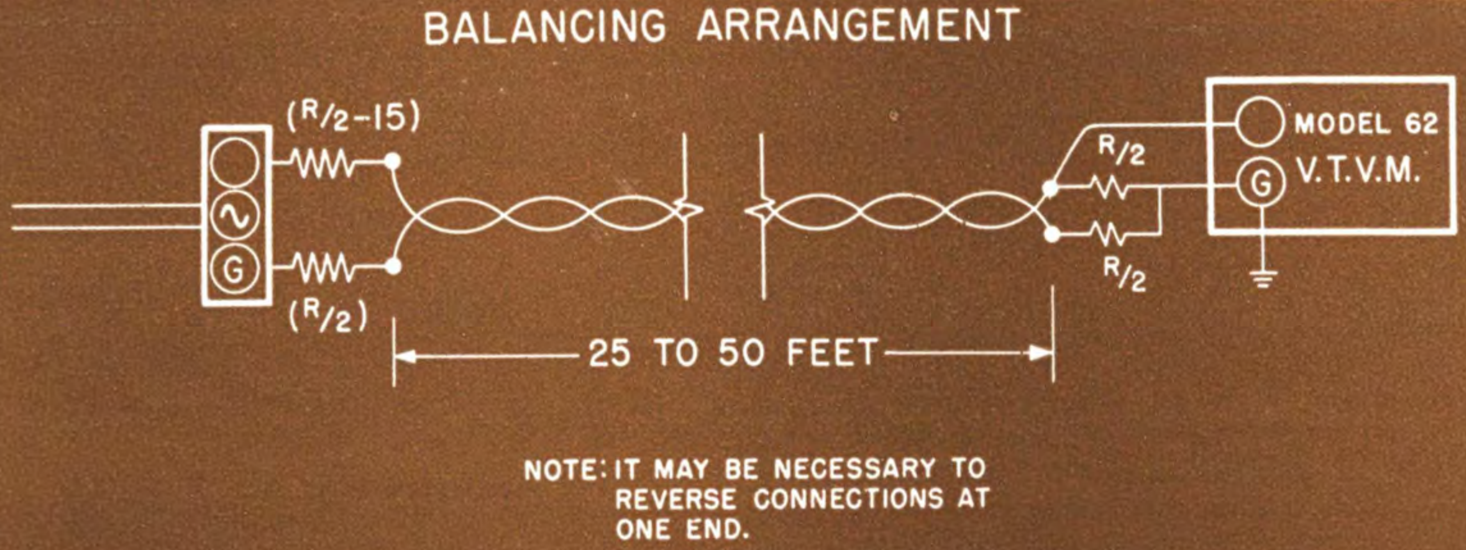


FIG. 17

k. MEASUREMENT OF RADIO NOISE OR INTERFERENCE:

Special radio noisemeters have been built both by Measurements Corporation and others; however the production demand for such instruments has exceeded the supply, and other methods for noise measurement have been used.

Generally a communication type receiver equipped with an output meter is calibrated by a signal generator at each test frequency and the noise read in terms of "microvolts of 30%, 400 cycle carrier". This method is satisfactory for steady types of noise such as generator brush ripple, voltage regulator hash, etc., but difficulties arise when efforts are made to measure ignition noise.

Ignition noise has a very high peak to average ratio. In general most communications type receivers have such selective i.f. amplifiers that very little interference voltage will pass thru them, *but* any desired carrier signal will be badly cross-modulated in the first r.f. amplifier and detector circuits by the high peak noise present there. Therefore, in the absence of any impressed carrier, little or no output will be obtained from the receiver, altho some noise may be heard in the monitor speaker. When a carrier from the signal generator is coupled to the antenna pick-up system (as shown in fig. 18), the noise output will become greater up to a certain level of carrier output, and then drop off as the level is increased. This

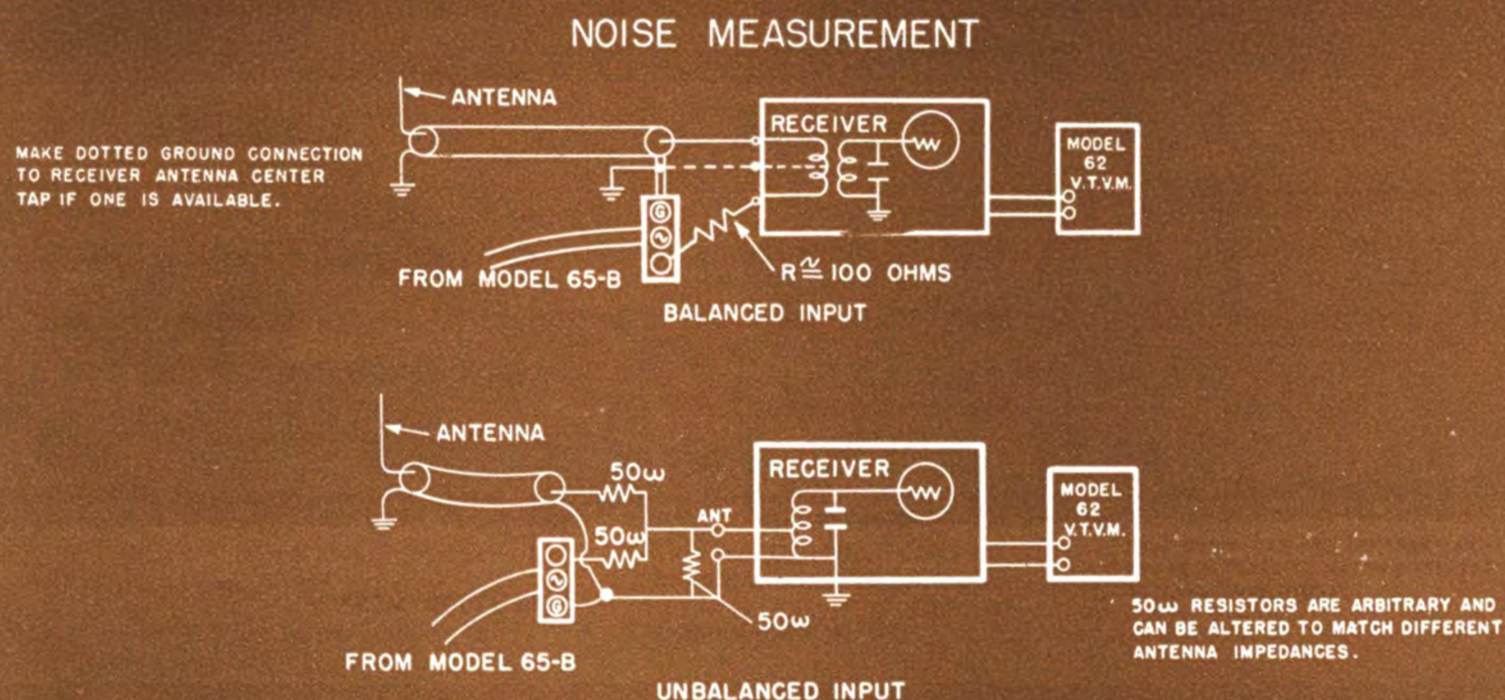


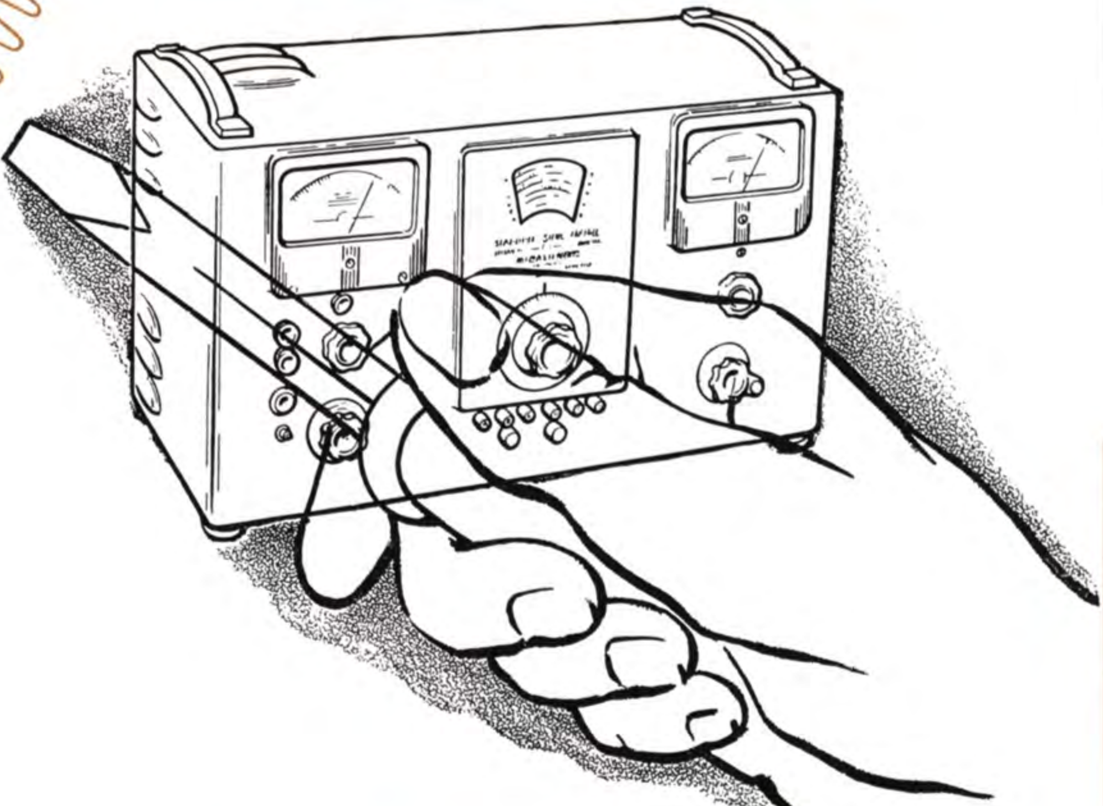
FIG. 18

drop off point is an accurate measure of the ignition interference level. As an aid to reading the drop off or submersion point more accurately, it is suggested that the receiver gain be decreased as the signal generator output is increased in order to prevent overload of the i.f. and audio.

It is suggested that a 30%, 400 cycle reference modulation be used in conjunction with a peak-type vtvm such as our Model 62 for reading the audio output from the receiver. When the noise equals only half of the 400 cycle modulation vtvm reading, the carrier level on the signal generator can be taken as a measure of the noise level at that particular frequency. The use of this submerged signal method for measuring ignition noise is somewhat analogous to the method for measuring receiver sensitivity at the two to one signal to noise ratio as described under "Sensitivity", except that a peak rather than average type audio output indicator is recommended.

Actual measurements on wide-band oscilloscopes indicate a peak value of electro-static induction field as high as 100 volts per meter as received on a broad band amplifier having a band-pass from 10 k.c. to 1000 kc within a few feet of poorly shielded vehicles. It can be assumed that the ignition noise level in the antennas of self contained radio equipment may be at least one volt peak between 1 and 10 megacycles exclusive of any resonant properties inherent in the vehicle. This is more than sufficient to shock excite the first tuned circuit and cross-modulate any low level carrier. Therefore the use of cross-modulation, as suggested above, leads to more consistent ignition noise measurements and indicates when actual reduction in noise level has been effected thru filtering and bonding.

SERVICE AND MAINTENANCE



Measurements Corporation

BOONTON · NEW JERSEY

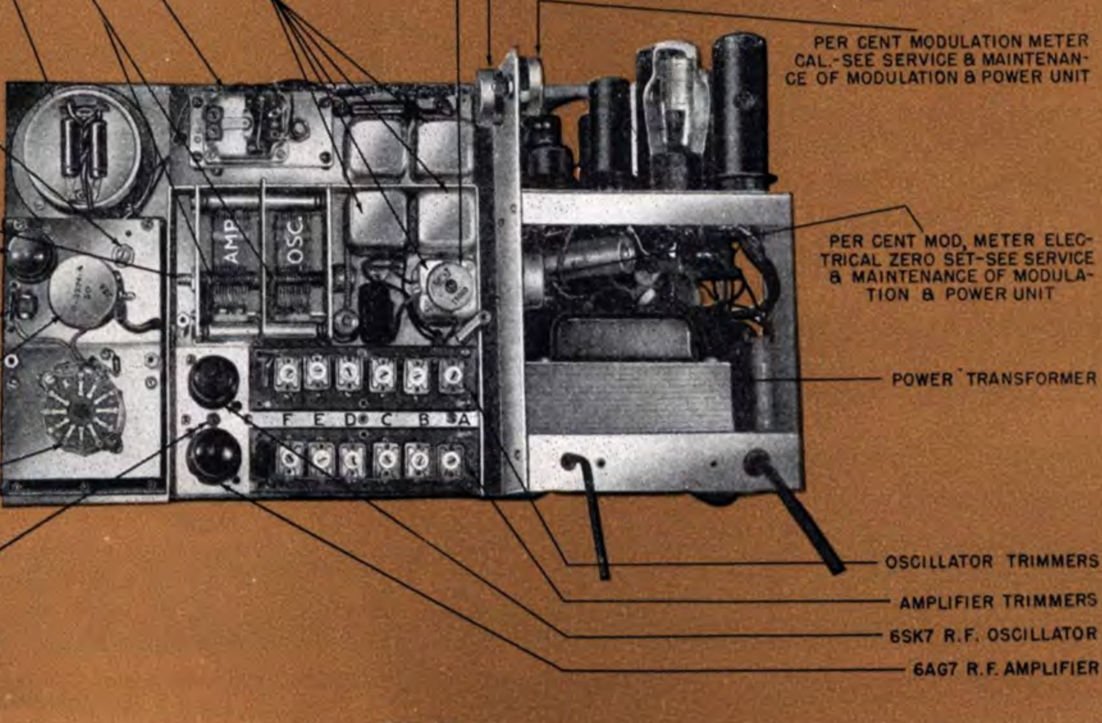


FIG. 19

IV. SERVICE AND MAINTENANCE:

a. MEASUREMENTS AND CHECK PRIOR TO REMOVAL FROM OUTER CASE

Rather complete information as to the difficulty can frequently be secured before removing the instrument from the case by making the following checks:

(1) If pilot lamp does not light and none of the indicating meters operate after a.c. switch is thrown upwards, check fuse and continuity between a.c. plug prongs. Replace fuses only with type 3 AG *two* ampere. If fuses continue to blow, remove rear cover and pull rectifier tube from its socket (this is a type 5T4, except on some early models which used type 5Z4's). If fuses continue to blow, there may be a heater short or a defective power transformer to blame. It is assumed that correct voltage and frequency are applied to the instrument. The voltage regulator for the output diode can be disconnected by removing its connecting plugs. Failure in the voltage regulator is very rare; replacements may be obtained from the Measurements Corporation. Note: on some special export models for 50 cycles, a special hot-wire type ballast was used instead of a saturated iron-core regulator. Replacement ballast should be obtained only from the factory.

(2) If pilot lights, but little or no reading can be obtained on modulation meter when modulation switch is on either "400" or "1000" and knob under modulation meter is rotated to the right or clockwise, push the button directly below modulation meter to check r.f. amplifier B+ supply voltage — this should read near the red line (between 55 and 60 or approximately 150 to 160 volts). An external audio oscillator should be connected to the external modulation binding posts and the modulation switch thrown to "ext", if no reading is obtained on the modulation meter with five or ten volts across the external posts and the knob under the modulation meter turned all the way to the right, it is likely that there is a partial short on the B+ or defective 6SJ7 or 6L6 tube. It is also possible that the 6H6 modulation diode rectifier is faulty. Rather frequent trouble with broken leads in the 6L6 and 5T4 bases, especially during shipment, necessitated the use of hold-down springs on these particular tubes.

(3) If a rather violent fluttering or "motor-boating" occurs when using the internal audio oscillator, it is likely that the .25 mfd 6SJ7 screen-to-cathode by-pass on either the audio oscillator or the modulator amplifier is defective. This condenser should be replaced with a good *mineral oil* sealed type capacitor. Meter flutter is often due to poor contact in % Mod. Zero Set Pot. This can sometimes be corrected by turning shaft back and forth

several times. Of course a loss of capacity in the power supply electrolytics can also cause a "motor-boating", or a defective VR-150 regulator may be at fault. Note: The built-in resistance tuned audio oscillator has a characteristic variation in output voltage of about 1% when properly adjusted — see section on "Modulation and Power Unit".

(4) If modulation meter reads well above zero with modulation control turned "off", the meter can be reset to zero *electrically* by the rheostat marked "% Mod Zero Set" (see fig. 19). Ordinarily this rheostat does not require resetting, and for this reason it has been placed inside the rear cover on the modulation and power supply mounting bracket. If the modulation meter electrical zero is off, the .25 mfd blocking condenser should be checked for leakage resistance. Unsoldering this capacitor should not effect the zero set of the modulation meter. Sometimes the leakage will increase as the instrument warms up for two or three hours and the modulation meter will creep up scale from zero slowly. A defective blocking condenser should be replaced with a mineral oil sealed type condenser. It may not be necessary to remove the instrument from its outer case in order to replace this condenser.

(5) If R.F. output is low on all bands, and 100% modulation causes a decrease in output, check plate voltage of R.F. oscillator tube. If voltage is well below 140 volts and one regulator tube is out, trouble may be found with the 30K ohm resistor in the attenuator. This resistor should be replaced with a *one watt* resistor.

(6) If the *output* meter does not read when the output knob is turned to the right, and yet the meter does not read below zero, remove meter and check between meter terminals for open circuit. Note: Use a very high resistance ohmmeter, for meter has a full scale sensitivity of 100 microamperes. Meter is special tapered pole construction and individually calibrated. Obtain replacement from Measurements Corporation.

(7) If output meter reads below zero and electrical zero-adjustment set-screw under output meter must be turned all of the way to the right to set output meter to zero, it is likely that either the 6H6 output diode is defective or that no heater supply is present. Note: Some trouble has been experienced from short circuiting of the diode heater lead to regulator plug against the copper shield base; this short burns out the 0.9 ohm dropping resistor in the regulator and opens up the heater supply circuit. Remedy: Place insulating sleeving or "spaghetti" over heater lead where it passes thru copper base and rewind 0.9 ohm dropping resistor inside regulator assembly.

(8) If output meter electrical zero adjustment is normal but no output can be obtained, try several different frequency bands by pushing several of the range selection buttons. Turn the tuning dial from one end to the other. If no output is obtained it is likely that the 6SK7 oscillator tube or the 6AG7 amplifier tube is defective. The B+ supply should be checked at the condenser rotor. The screen and heater supplies can be checked at their respective sockets by removing the tubes and testing the pin contacts with a high resistance dc and ac voltmeter.

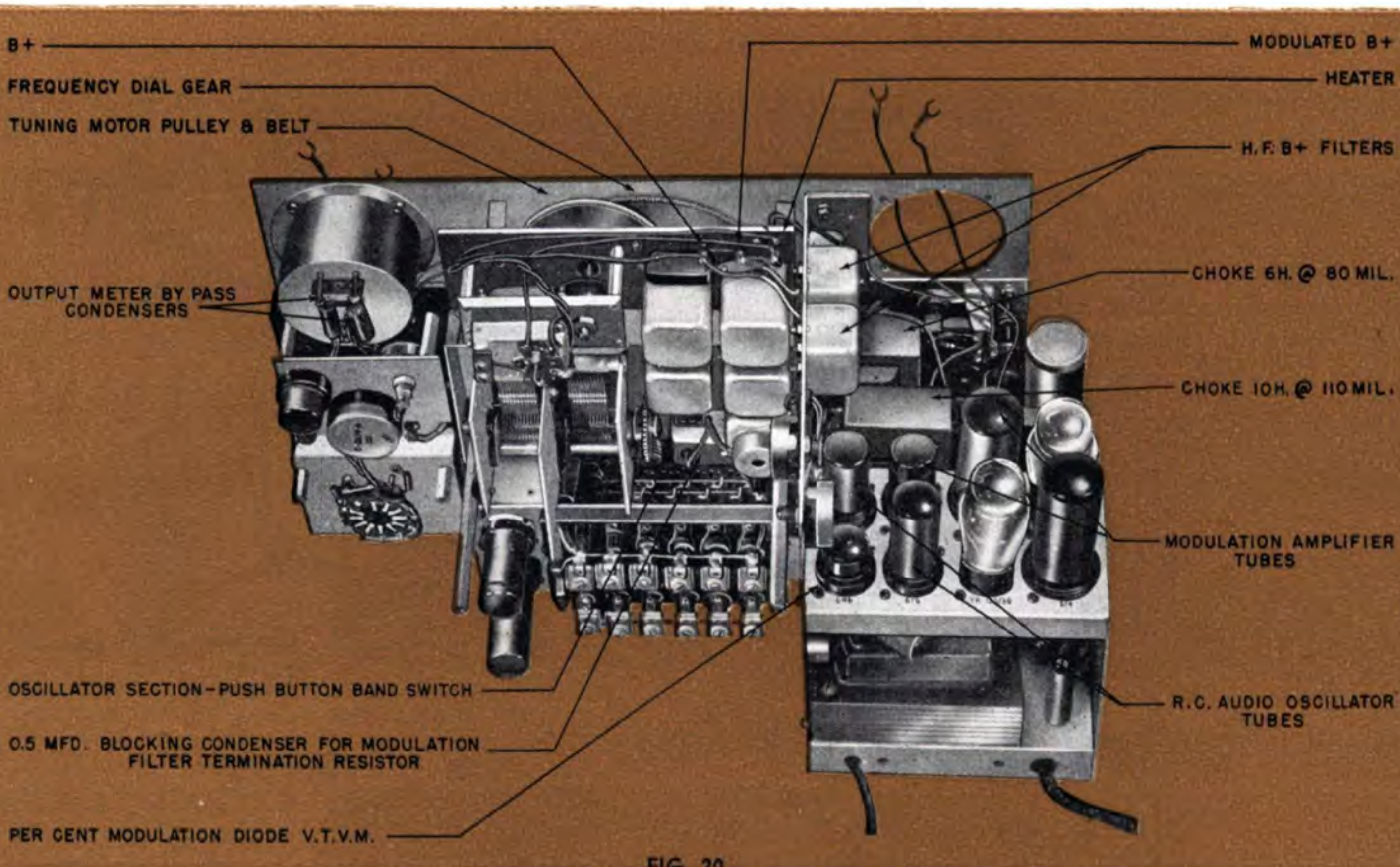


FIG. 20

Note: It is necessary to remove rear case cover and the large black r.f. shield cover for access to the r.f. unit.

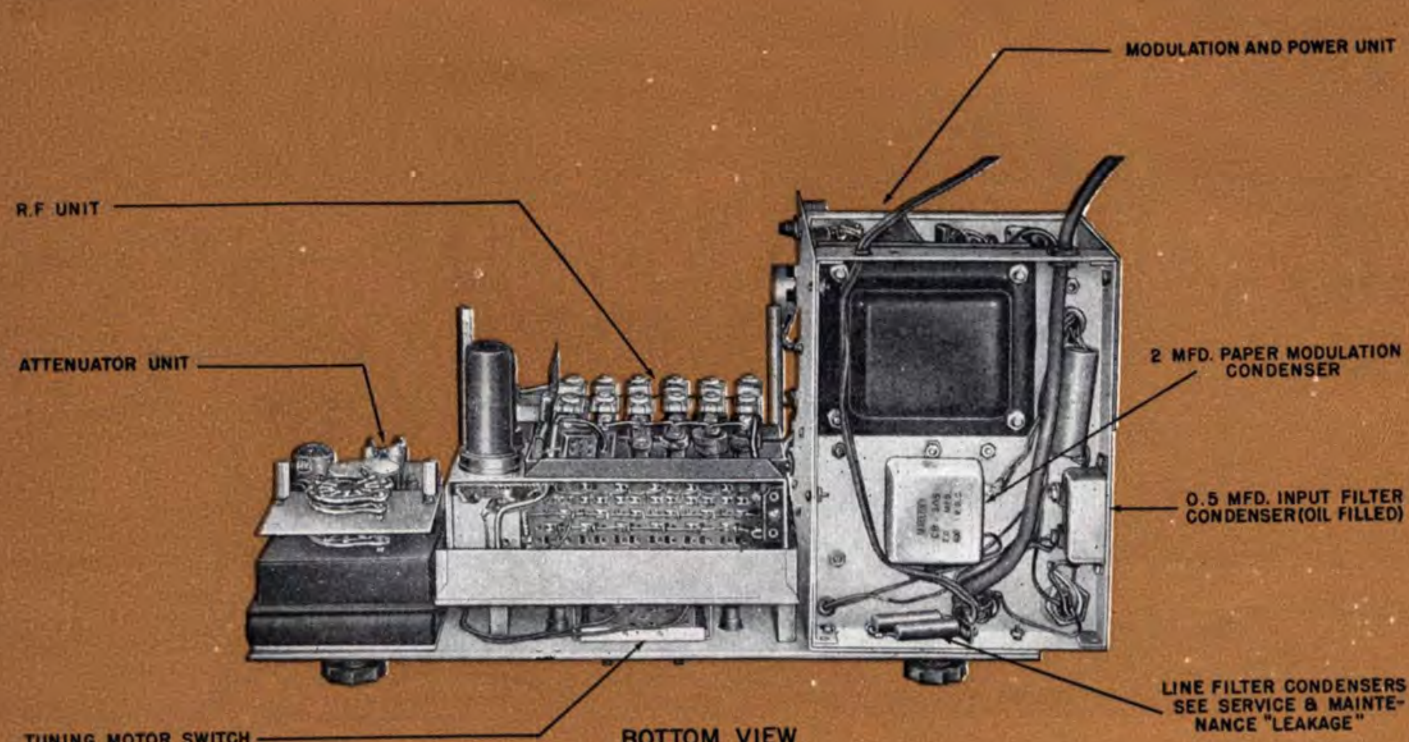
(9) If output varies erratically as the tuning dial is turned over the range, it is likely that the rotor contact wipers may need attention. Foreign matter between the condenser plates may also cause this trouble. A variation in wiper contact will usually be accompanied by a slight shift in carrier frequency at the higher frequencies. This is only true for the oscillator section — the section nearest the worm-drive end of the tuning condenser. If the contact wipers on the amplifier section are not making good contact, only the output amplitude will be affected. These difficulties can frequently be cleared without removing the instrument from its outer case by following the detailed gang-tuning condenser service instructions given under "R.F. Unit".

(10) Backlash in the tuning dial greater than 1/4 division on the 0 - 100 dial can be corrected by following the detailed instructions on the gang-tuning condenser under "R.F. Unit". In some cases the backlash can be reduced without removing the instrument from its outer case; in many cases it may be necessary to return the entire instrument to Measurements Corporation, since a new or rebuilt condenser must be installed, which will require recalibration of the carrier frequency dials. This calibration job can only be properly done with the aid of special jigs and fixtures.

(11) Errors in carrier frequency calibration not due to tuning condenser shift can be corrected without removing the instrument from its case. Errors in frequency calibration which show the same *per cent* shift on *all* six bands at the same point on the frequency dial are undoubtedly due to tuning condenser shift, which will probably mean returning the instrument to the factory for repair and recalibration. The r.f. oscillator coils are aged carefully prior to final calibration and no further aging should occur; however, the "D", "C", "B", and "A" band oscillator coils may increase slightly with time and thus shift the dial calibration a constant *per centage* over the *whole* tuning range. This can be corrected by soldering a small short-cicuited turn near the ground end and adjusting it as shown in figure 22 until the calibration is correct. Of course, it will be necessary to reset the trimmer condenser at the high frequency end after each trial adjustment of inductance at the low end. Needless to say, a source of accurately known frequency must be available. Broadcast stations can usually be employed for this purpose in the U. S. A. Some small so-called frequency standards are not very accurate — particularly the combined 100 - 1000kc crystal bars.

The inductance of the higher frequency coils ("E" and "F") can be adjusted by pushing the end turns slightly, since solenoids are used on these ranges. A good high frequency cement or lacquer such as liquid polystyrene should be used for securing the turns after adjustment. Again it will be necessary to reset the trimmer condensers at the high end of the range after the oscillator coil inductance is set at the low frequency end — these two adjustments will interlock to a certain extent.

After replacing the ceramic based 6SK7 oscillator tube, it may be necessary to readjust the trimmers on the oscillator coils on the high frequency ends of all bands. It is well to allow the instrument to warm up for an hour or so before proceeding with this adjustment.



BOTTOM VIEW
FIG. 21

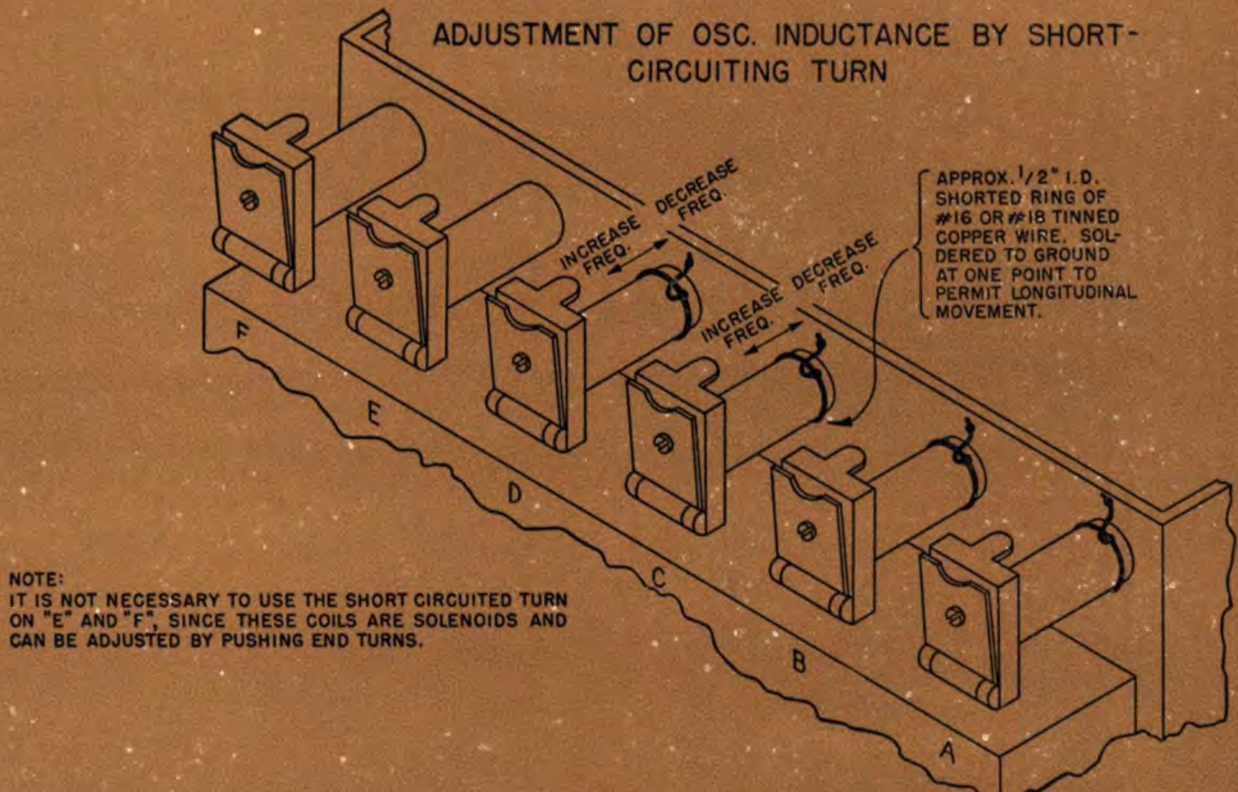


FIG. 22

(12) Microphonics or unstable carrier frequency may be due to a loose base on the ceramic 6SK7 oscillator tube. A small amount of ambroid or glyptol cement applied between the metal tube shell and the ceramic base should tighten it up and reduce the microphonics. If it is necessary to replace the 6SK7 with a new tube, the ceramic base can be removed from the old tube and installed on the new one. The use of bakelite based tubes will introduce serious frequency drift — even the mica-filled yellow bases are inferior to the ceramic base with respect to electrical stability.

(13) Failure of the pushbutton range switch is rather rare. Such failures usually are evident by a considerable shift in output and frequency when the switch is pushed out and then pushed in again several times. These effects are more noticeable at the lower ends of the higher frequency bands. The use of excess *graphite* type lubricant is never recommended on the tuning worm gear, since this may run and drip down on the band switch and partially short out the contacts. In addition, it is not well to tilt the instrument too far back in use, since this places the worm gear directly over the switch contacts so any excess lubricant is sure to fall on the contacts and lead to trouble. The use of lubricant on the pushbutton range switch contacts is not recommended. If the switch does give trouble, it is advisable to return the entire instrument to the factory for repair. We will probably install a new switch and recalibrate the instrument.

(14) On some of the earlier models (serial number less than 256), the pushbutton B+ switch directly under the modulation meter occasionally made poor contact and the modulation meter would not read. The type of switch then in use did not give sufficient wiping contact action to be self-cleaning. The remedy is to remove the modulation meter and reach in thru the meter hole with a piece of fine sand paper and wipe the contact points clean. Only a light sanding action is required. In some few cases the bakelite insulating spacers have been found to shrink, leaving the switch contacts loose and thus preventing proper operation. In order to tighten these contacts it is necessary to remove the entire instrument from the case as described later. All instruments after #256 have a different type switch which has never given any trouble, since it has wiping action silver plated contacts. These switches should not have their contact surfaces sanded, since this will ruin the silver plating.

(15) A tuning motor failure will, in general, require removing the instrument from the case for replacement. Replacement motors can be obtained from the factory. New belts can be also obtained from the factory — specially treated to prevent slippage.

(16) Defects in the output attenuator can be identi-

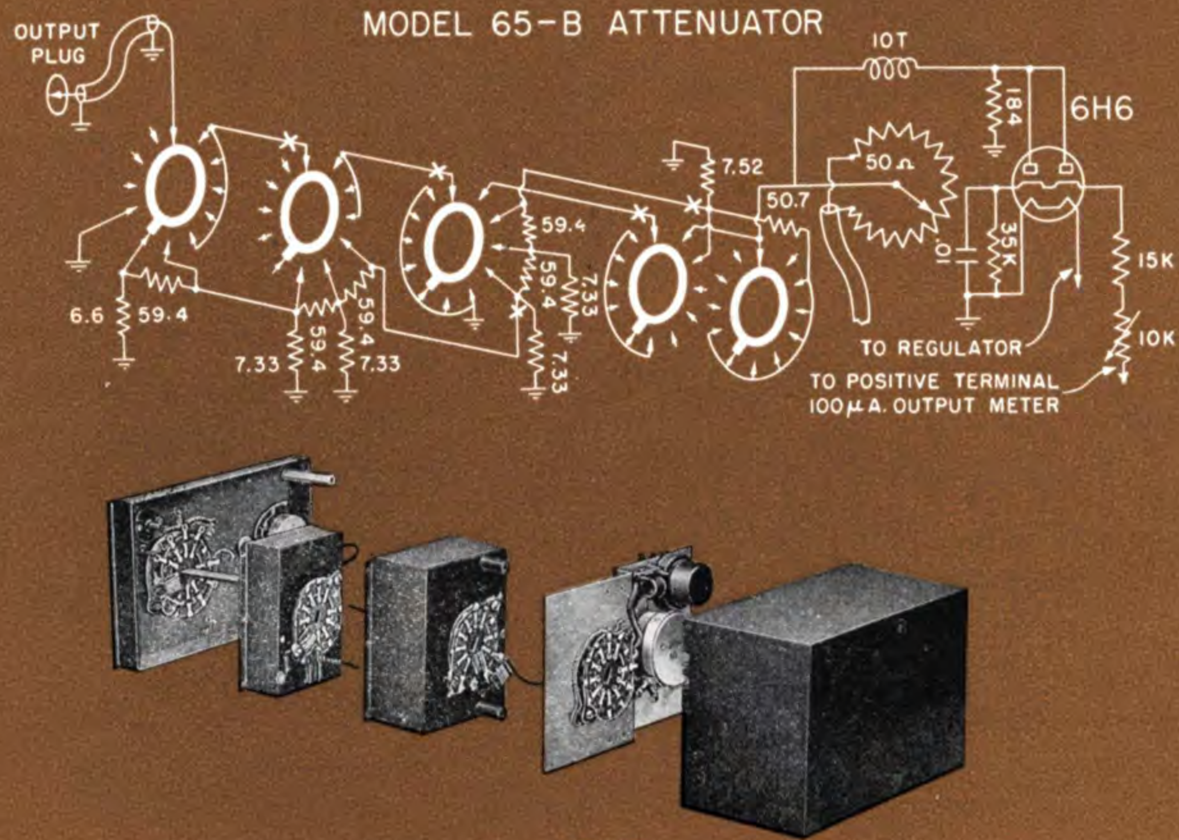


FIG. 23

fied rather definitely by connecting the output terminals across a good low resistance type ohmmeter or bridge as suggested in the section "Attenuator Unit". This check can be made without removing the instrument from the case, but the actual repair may require the removal from outer case for greater access to the parts. Figure 23 shows the attenuator assembly in considerable detail.

(17) The failure to check "overall ratios" may be due to the calibration of the meter. All output meters are individualy calibrated for three classes of 6H6 diodes. Replacing the diode or meter requires reference to the instrument serial number, or else they must *both* be supplied by Measurements Corporation. All diodes should be carefully aged and specially tested and selected. Fortunately, the life of the diodes frequently exceeds 10,000 hours of operation. Diodes and meters can be replaced without removing the instrument from the outer case. After replacing either, it is advisable to check and reset the output calibration as outlined under the section "Attenuator Unit".

(18) The application of excessive current to the output attenuator will probably either ruin or seriously shift the values of some of the resistors. This frequently results when working with ac-dc radios, etc. Generally it is better to return the instrument to the factory for repair if such an accident has occurred, since the switch contacts may be badly burned and pitted and require replacement.

(19) Leakage or stray field may be noticed by a high minimum signal or by the presence of a null at some point on the attenuator. The procedure for locating and remedying leakage is outlined under the section "Attenuator Unit", although in some cases it may concern other parts of the instrument.

(20) Since wirewound type rheostats are used for adjusting the output meter calibration, output meter zero, % Modulation meter zero, % Modulation Calibration, and audio oscillator feed back, occasionally intermittent contact may develop in one of these controls. Usually, a slight shifting of wiper arm will clear up the trouble, but severe cases may require an increase of arm tension or replacement of the control. Note: Erratic contact of the audio oscillator feedback control will cause variation in % Modulation which may sometimes appear similar to "motor-boating".

b. REMOVAL FROM CASE:

First remove the two indicating meters. Note: On some models the cover and the meter are held together by the mounting screws — care must be taken when removing them to keep the two parts together to protect the indicating movements from small particles of dust and iron or steel. Scotch tape is convenient for sealing and holding together the two parts.

Next remove the knobs and tuning dials. It is wise to turn all dials to the right before removing, by loosening set screws, in order to assist in replacing them. Reference to figure 24(a) shows all of the above mentioned parts removed. Place all screws in a small can or box to prevent their being lost. The dial cover is held in place by four screws — two of which can be reached through the rear of the instrument with a long screw driver after the rear cover is removed. The other two are under the 0-100 tuning dial which has already been removed. Save the two spacer posts under the two flat-head screws. The diode voltage regulator which is mounted on the rear cover can be disconnected from the rest of the instrument by removing the two connecting plugs. Next remove the three small flat-head screws which hold the dial. Don't attempt to use oil, carbon-tet, etc., for cleaning the dial — *just don't allow it to get dirty!* Protect it well during the time it remains out of the instrument. Do not lay it face down. Cover it with an open box to prevent

FIG. 24 - B

smearing the figures. Reference to figure 24(b) shows these items removed from instrument.

Next remove the four $1/2$ inch hex nuts on the control shafts. Then turn the instrument around and remove the power supply support bracket. This is held in place by four screws. Remove 5T4, 6L6, and VR-150 tubes. Tilt the panel assembly after removing the tubes as shown in figure 24(c) and slide out of case. It is convenient to handle the assembly during this operation by lifting inside the modulation meter clearance hole and under the attenuator cover with the left hand. It is well to mark the two VR-150 tubes and return them to their respective sockets, since their regulating voltages will vary somewhat and influence the per cent modulation calibration if they are interchanged. This error may amount to 4 or 5 volts out of 150.

FIG. 24 - A

The r.f. cover is held in place by two screws. Care must be exercised in removing and replacing it to avoid damage to the four grounding springs on the shield base. It may be necessary to work the cover sidewise slightly to loosen the grip of these grounding springs.

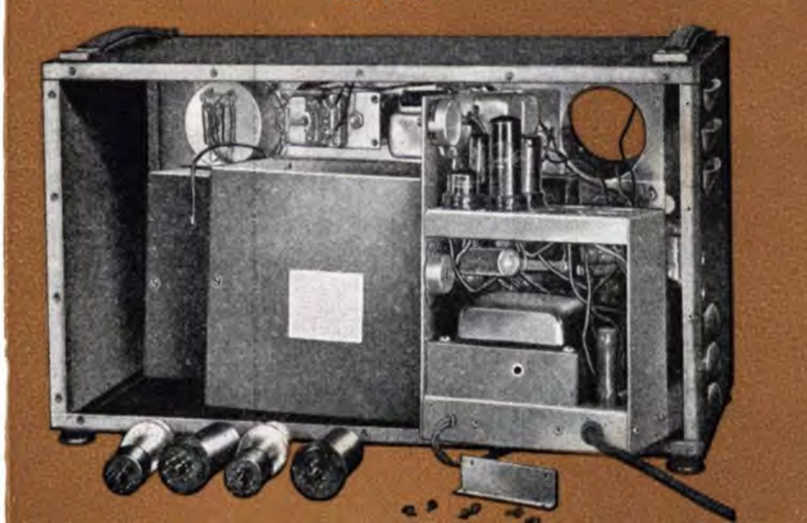
The attenuator cover is also held in place by two screws. It is unwise to leave any of the internal parts of the instrument uncovered for any length of time, for an accumulation of dust will shorten the life of the switches, etc. The two copper shield covers do much to protect these moving parts as well as provide the required and very necessary electrical shielding.

c. R. F. UNIT:

If backlash in the tuning condenser drive system seems excessive, a check should be made to find out in which portion of the tuning range the backlash is the greatest. "F" band is suggested as best for this purpose. Checks can be made by beating against harmonics of a five megacycle standard at 10, 20, and 30 megacycles.

The maximum factory limit for backlash in any one part of the range is 0.5 division, but most 65-B's are held to 0.1 division and never more than .25 division at the low frequency end. If backlash exceeds .25 division over most of the tuning range, the rear cover of the outer case should be removed and the large r.f. shield can be

FIG. 24 - C



moved. At one end of the tuning condenser shaft there is a knurled cap and lock-nut. Loosen lock-nut and turn knurled cap clockwise to tighten internal end-thrust take up spring pressure. If the backlash is not improved, it may be well to examine contact wiper lubrication and pressure, also, split worm-gear spring pressure and lubrication. Only clean petroleum jelly in moderate amounts is desirable — never use graphite grease as it may drop down on the pushbutton switch and cause difficulty when the instrument warms up by partially shorting out the switch contacts.

The silver contact wiper dimples should not be too tight — about two or three ounces drag as measured by pulling a thin (.005 to .010) silver blade between the contact points. A small letter-postage type spring scale can be used to read the friction drag. Increasing the drag beyond 4 ounces may be a contributing factor to backlash.

The end thrust ball should be lubricated with petroleum jelly and the ball race should be inspected for foreign material. If backlash occurs only at a few discreet points on the dial, the ball race may be dirty, or lack proper lubrication.

If backlash occurs only at the low frequency end of the range, the instrument should be shipped to the factory for re-centering of the plates. This will require recalibration of the frequency dial — a rather specialized operation even with proper jigs and frequency standards.

Severe backlash may be accompanied by failure to make full output voltage, particularly at the low frequency end of "F" band. This may be due to a loose rotor shaft. In all models after serial #171, a solid steel center rod was incorporated to improve the rigidity and reliability of the tuning condenser. Earlier models sometimes gave trouble when the bakelite insulating parts of the condenser rotor had shrunk and loosened up sufficiently to allow considerable sidewise deflection when the rotor shaft is pressed by the fingers. The only practical remedy is to re-build the condenser or install a new one and re-calibrate the frequency dial.

It is not likely that coil alignment errors in the field will be responsible for failure to make output; however, it may be necessary to readjust the inductance of certain coils slightly to correct the frequency dial calibration. This procedure was outlined above under section (11) of "Measurements and Checks Prior to Removal from Outer Case".

If only "F" band or "E" and "F" band operate, it is possible that there is an open connection in the grid coil jumpers on the pushbutton switch. It will be necessary to remove the instrument from the case and take off the r.f. shield cover in order to inspect these connections. (On topside of switch.)

Some cases of fluctuating r.f. output have been traced to a partial short in the 6AG7 shielded screen lead. This can be replaced by following the above outlined procedure of removing the r.f. shield cover, etc.

If the tuning motor does not operate, the set screws on the pulley shaft should be inspected to see that they are tight. Sometimes, a slipping belt can be tightened by loosening the motor mounting screws and shifting the motor slightly. Occasionally, a tight bearing in the tuning system may overload the motor. If steel chips or other foreign matter come in contact with the tuning motor gears, the gears may be badly damaged and require replacement. It is best to purchase a new motor in this event.

In serial numbers prior to #81, no special effort was made to reduce the incidental frequency modulation which accompanied the amplitude modulation. At that time careful investigation led to a reduction by approximately ten to one in the f-m. A large part of this was effected

ADJUSTMENT OF F.M. NEUTRALIZER

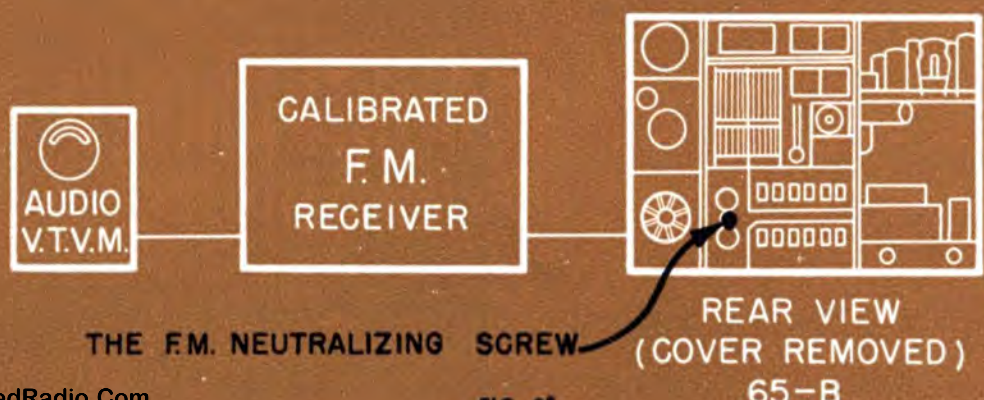


FIG. 25

by a rearrangement of leads connecting the coil switch and the gang tuning condenser to eliminate stray mutual coupling between the oscillator and output tank circuits. An additional improvement was made by installing a small neutralizing variometer in the oscillator and amplifier cathode leads. It has been found practical to reduce the f-m less than .01% for an amplitude modulation of 30%. The adjustment of this f-m neutralizer as shown in figure 25 can be made with a good f-m receiver equipped with a suitable audio output meter. Sufficient carrier should be supplied to the f-m receiver to fully saturate the limiter. If harmonics are employed, the amount of shift must be divided by the order of the harmonic. A d.c. calibration of the discriminator must first be carried out to determine the slope. Then the output meter can be calibrated directly in kc deviation. It has been found convenient to adjust the neutralizing screw at 23 megacycles for minimum f-m. Occasionally, a better compromise can be made by adjusting at 22 or 24 megacycles instead of 23. This adjustment is not critical, and it is rather unlikely that the user will ever have occasion to touch it unless rather radical changes have been made in the wiring of the r.f. leads to the pushbutton switch, etc.

d. MODULATION AND POWER UNIT:

The power supply is combined with the modulator on a common chassis assembly. The B+ rectifier and filter system are conventional in design and operation. Reference to the wiring diagram (fig. 26, see page 56) will furnish information as to resistance, voltage, current, filter capacitor size, etc.

Occasionally the VR-150 tube will exhibit unstable characteristics and cause an erratic change in regulated supply voltage. This can be remedied by replacing the tube, of course.

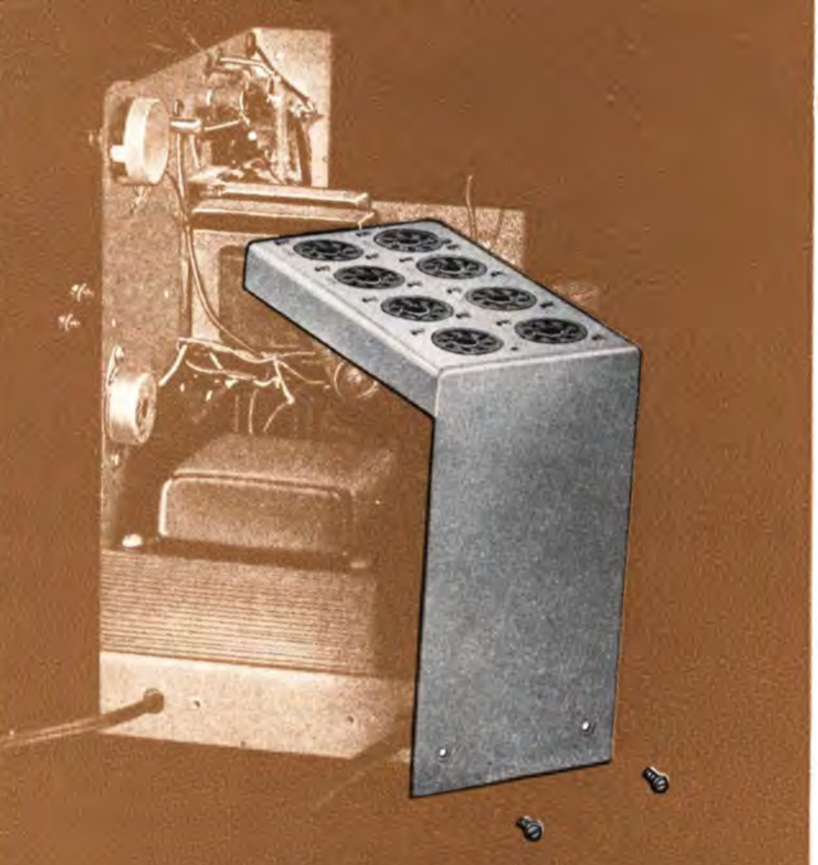
Electrolytic type filter condensers have been used and very little difficulty has resulted therefrom; however, should they fail, a standard make can be used for replacement. The use of higher capacity sections will not impair the performance.

The audio oscillator used in the modulator operates on the resistance tuned principle as described by Professor Terman in the Proceedings of the Institute of Radio Engineers for October, 1939, page 654. This oscillator has the advantage of low distortion, stable frequency, constant output, etc. The oscillator consists of a two stage resistance coupled audio amplifier which has its output tied back to its input thru a frequency selective network, such that oscillation occurs at one frequency. The amplitude of this oscillation is controlled by a degenerative network in the cathode of the first amplifier tube. This degenerative network includes a small lamp filament in such a manner, that an increase in oscillation amplitude causes an increase in the resistance of the lamp filament which increases the amount of degenerative or negative feedback, thus maintaining a constant amplitude of oscillation. In most oscillating circuits the non-linearity of a vacuum tube characteristic is utilized to limit the amplitude of oscillation and this results in some distortion. But in the resistance tuned oscillator the vacuum tubes are kept on linear or "class A" portions of their characteristics, and the control of amplitude left to the non-linear lamp characteristic, which by virtue of its thermal lag does not introduce distortion.

This resistance tuned oscillator does have a characteristic variation in output voltage of about 1% when properly adjusted. This variation takes the form of a small, slow, periodic shift in audio output amplitude. This effect results because of the fact that the lamp requires a small change in output before correction can be made, just as an a.f.c. circuit requires a small change in frequency to effect any frequency correction. The correction is a slow one because of the thermal lag characteristic of the lamp filament. If the degenerative feedback control rheostat is improperly set, so that insufficient power is applied to the lamp, it will not operate far enough up on its characteristics, and a "bouncing effect" or severe variation in audio output will result — particularly when the modulation is turned off or on. If too much voltage is fed back to the lamp by reducing the rheostat too far, the power output tube will be overloaded (the 6V6) and distortion of the waveshape will result. A dull red glow of the lamp indicates sufficient negative feedback, and under normal conditions the 6V6 tube should have no difficulty in supplying this small amount of power without distortion.

The output of the resistance tuned oscillator is applied to the input of the modulator amplifier when the modulation switch is set at either "400" or "1000". Only 7 or 8 volts are required for 100% modulation, while the audio oscillator supplies around 25 to 50 volts; therefore it should never be necessary to turn up the modulation gain control all of the way when using the internal audio source.

Stable resistance and capacity component parts in the frequency determining network are essential for maintainence of correct audio frequency. In the 65-B the resistors are held to 2% while the capacitors are held to 1%. If the audio frequency is found to be in error more than 4%, the four frequency determining components should be checked and replaced if necessary. Note: if the negative feedback network fails to keep the tubes operating on linear portions of their respective charac-



LOOSENED TUBE SHELF FOR REPLACEMENT OF SCREW BY-PASSES OR OTHER SERVICE OF MODULATOR OR POWER SUPPLY

FIG. 27

teristics, the 6SJ7 may begin to draw grid current and act as a shunt resistor on the frequency determining resistor across the grid to ground. This effect will tend to raise the frequency and make it a function of oscillation amplitude.

The exact frequency of oscillation (when both resistors have the same value and both capacitors have the same value) is that frequency at which the reactance of the capacitor just equals the resistance.

Phase shift caused by this network and not amplitude selectivity determines the frequency of oscillation. Anything which tends to affect the phase shift thru the amplifier will affect the frequency of oscillation, hence the reason for using ample negative feedback to stabilize the phase characteristic with respect to supply voltage variation, tube ageing, etc.

The modulator amplifier also employs considerable feedback to stabilize it and reduce distortion. The r.f. amplifier does not present a constant impedance load to the modulator; this necessitates a compromise in the r.f. filter termination. A rheostat is provided for the filter termination together with a suitable blocking condenser. It is worth noting that only .5 mfd is used as a d.c. blocking condenser while the value of the rheostat may be approximately 10,000 ohms. At first glance this might seem rather poor in light of the fact that the modulator must pass frequencies as low as 50 cycles; however, it is well to recall that the chief purpose of the terminating resistor on the r.f. filter is to improve the frequency response. At the higher frequencies (5 or 10 kc) the reactance of the condenser is negligible and the filter termination is satisfactory, but at the lower frequencies the insufficient size of the condenser actually has very little effect. It is true that a higher value of load impedance is made available for the modulator, and this would result in a rising low frequency response, if the use of negative feedback did not tend to obliterate effects of load impedance variation on the modulator output tube.

If troubles are experienced with the modulator amplifier, it may be necessary to eliminate the negative feedback to locate the source of trouble. This can be done by unsoldering the 190K resistor. A poor .25 mfd 6SJ7 screen to cathode by-pass condenser can cause instability — particularly with the large amount of negative feedback employed. All model 65-B instruments since serial #133 have had oil-filled, sealed type screen by-passes in them. Many instruments with serial numbers less than #133 have had new oil-filled condensers installed for the sake of permanent stability. It is advisable to remove the instrument from the outer case in order to properly install these condensers, although they have been replaced occasionally in the case. For greater accessibility, it may be desirable to loosen the tube shelf as shown in fig. 27.

There are four adjustments which can be made on the modulator: the filter termination, R-C oscillator feedback rheostat, per cent modulation zero set (electrical), and per cent modulation meter calibration. Ordinarily the feedback adjustment is made as previously described, so that the wave shape of the audio is sinusoidal (about 0.7% total harmonics), and the operation of the oscillator is stable when turned on and off. For these conditions the small lamp filament will just show a very dull red glow (visible only in darkened room).

First the mechanical zero of the modulation meter should be checked with the meter either disconnected or the instrument power supply turned off. Next the electrical zero adjustment must be made. Since this zero is not critical, the control is mounted on the rear of the mounting bracket and not accessible from the front of the instrument.

Next the filter termination should be adjusted by applying an external audio signal of 400 cycles and adjusting the per-cent modulation to exactly 100% as determined on an oscillograph at 1 megacycle. If a suitable wide-band oscillograph is not readily available, any ordinary one can be used by the arrangement shown in fig. 5. The per-cent modulation control rheostat should be set so that the meter reads below 100%, if possible. Next, 5,000 cycle modulation should be applied, and the modu-

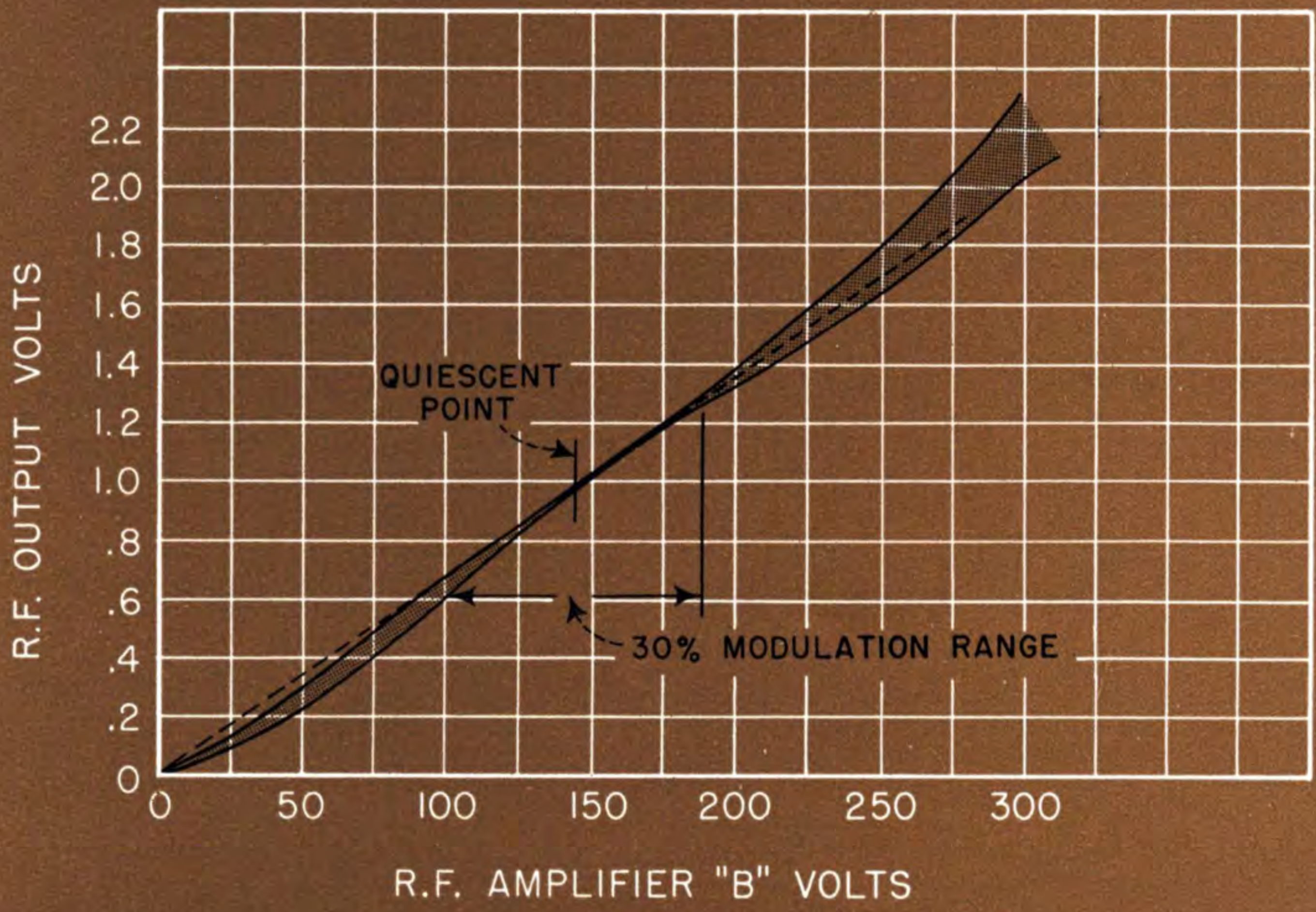


FIG. 28

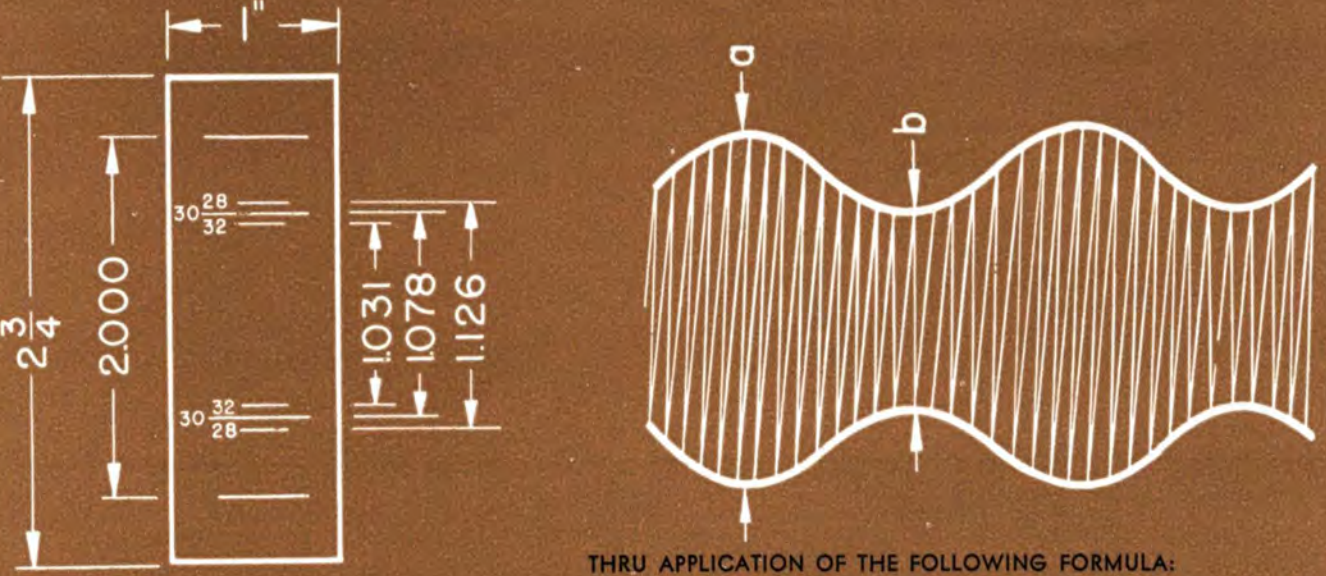
lation level adjusted until the meter reads the *same* value as for 400 cycles. Then the termination rheostat should be turned until exactly 100% modulation is obtained on the oscillograph. A recheck should be made at 400 cycles again, since there is interlocking action between the two frequencies. When the filter termination is correctly made, 100% modulation should be obtained for both 400 and 5,000 cycles for the same reading of the modulation meter (not necessarily 100%). Then check the 50 cycle and the 10,000 cycle response — they should not be down more than 10 per cent of the 400 and 5,000 cycle values. Note: the modulation meter may read exactly the same for all frequencies between 50 and 10,000 cycles, but the actual per cent modulation as read on the oscillograph will vary as much as 10% because of the 2 mfd blocking condenser at the low end and the sideband cutting action of the r.f. tank circuit at the high end. Needless to say, improper alignment of the r.f. amplifier and oscillator coils will greatly affect the performance at either 5,000 or 10,000 cycles. At lower carrier frequencies, the sideband cutting is greater and this limits the upper modulation frequency. At higher carrier frequencies the r.f. filters are the limiting factor. The design cutoff of these filters is approximately 20,000 cycles. It is necessary to cut off at this frequency in order to secure sufficient rejection of the carrier when the instrument is operated at carrier frequencies as low as 75,000 cycles.

The above mentioned filters are designed to operate into a 5,000 ohm load resistance. Since the 6AG7 draws approximately 15 milliamperes of screen and plate current, this represents a load of only about 10,000 ohms on the filter, hence the necessity for adding the extra termination resistance.

The adjustment of the per cent modulation calibration control is more difficult. The instrument should be either operated in its case, or else a piece of cold rolled steel (.040) having a 2¾ hole should be placed around the modulation meter to simulate the effect of the outer case. This will not be true for instruments having low serial numbers, since their cases were made of aluminum — which does not affect the meter calibration.

Because of the r.f. amplifier linearity characteristic shown in fig. 28, the modulation meter provided on the model 65-B has a slightly distorted calibration to more nearly average out modulation indication errors. Since most receiver acceptance tests are made at 30% modulation, the Measurements Corporation *always* insisted on calibrating the modulation meter at the 30% mark not at the 100% mark; this practice results in much more ac-

PER CENT MODULATION SCALE



THRU APPLICATION OF THE FOLLOWING FORMULA:

$$\% \text{ MOD} = \frac{a - b}{a + b} \times 100$$

THE ABOVE MARKS ARE CALCULATED FOR 28, 30 AND 32%.

MAKE FROM 1/16" CELLULOID, LUCITE, ETC. FILL LINES IN BLACK.

FIG. 29

curate correlation between different signal generators when other factors are in line.

It is easy to calibrate at 100% when using an oscillograph, since the modulation envelope negative peaks can be made to lightly touch the axis to accurately fix the 100% point. To calibrate at 30%, however, some care must be exercised. It is desirable to use a 3" oscillograph having a fine clean trace. Proper use of a darkened room or hood will aid in sharpening up the trace by allowing a reduction in intensity of the oscillograph with a consequent improvement in focus. It is better to use the step-up transformer arrangement shown in figure 5 rather than a wideband oscillograph for this calibration, since all oscillograph amplifiers have some non-linearity which will affect the accuracy of measurements.

It is convenient to rule fine lines on a piece of 1/16" plastic sheet as shown on fig. 29. Accurate ruling can be made with the aid of a vernier height gage possessed by most tool rooms and toolmakers. The marks for 28 and 32 per cent can be made slightly shorter for easier identification.

A synchronizing voltage lead for the horizontal sweep of the scope can be secured from the modulated B+ lead as pointed out in fig. 20. It is customary to use 400 cycle modulation at 1 megacycle carrier frequency for the initial adjustment of the modulation calibration control. The sweep and centering controls should be set for the positive peaks to occur at the center of the oscillograph tube, then the celluloid should be placed ruled side against the tube to minimize parallax. The signal generator output should be adjusted for the correct amount to just allow the envelope peak edges to split the ruled lines, then the valleys should be observed in relation to the ruled marks at 28, 30, and 32 per cent by shifting the pattern until the valley is in the center of the oscillograph screen to eliminate any possible trapezium distortion. If the meter actually reads 30% but the ruled lines show only 28% the modulation calibration control should be turned until the meter reads *28* instead of 30, then a readjustment of the per cent Modulation Meter to 30% by panel knob and signal generator output made to line up the envelope peaks again with the outer ruled lines on the celluloid sheet. Again the pattern should be shifted on the screen to reduce the possibility of trapezium distortion, and the valleys checked for the exact value of modulation. Fig. 30 shows how the lines should be covered by the edges of the envelope trace. If the above measurements are carefully made, modulation can be checked by different persons to between 29 and 31% for a meter indication of 30%.

Next the modulation should be checked at 15 megacycles. A fairly high "Q", low distributed capacity coil should be used for the step up. The frequency of the generator can be adjusted for exact resonance if the coil cannot be easily adjusted. The modulation at 15 megacycles should check not lower than 28 or greater than 32% if it has been set exactly at 30% at 1 megacycle. If the modulation does check out of the above limits at 15 megacycles, it will be necessary to replace the 6AG7 amplifier tube. Some tubes do not modulate well at the higher carrier frequencies.

It is well to check the 100% modulation at the extremes of each tuning band for lack of sufficient excitation or r.f. amplifier grid drive to fill in the positive peaks. This can be done easily by observing the action of the output meter on the 65-B as the modulation is increased up to 100% and slightly beyond. If there is plenty of excitation available, the meter will remain practically constant up to about 85 or 90% then it will start to rise slightly until 100% is reached. Being an average type meter it remains constant with varying modulation up to the point where the non-linearity of the r.f. amplifier begins to be noticeable. Beyond 100% the output should rise sharply until the positive peaks begin to flatten off because of insufficient grid drive or modulator overload. Under certain over modulation conditions a sudden change or shift in operating characteristics occurred in the early model 65-B's, which was remedied by inserting a 7 ohm non-inductive parisitic suppressor in the 6AG7 control grid lead near the tube socket.

100% modulation occurs on most 65-B's at 95 to 98% on the meter when they are adjusted at 30% correctly, however in some cases at 15 mc. the 100% point may drop as low as 92. A properly tracked oscillator and amplifier will normally provide enough excitation to drive the output up at least 50% beyond normal when over-modulated. If there is insufficient excitation at some point in the tuning range, the tracking of the amplifier should be investigated. It may be necessary to change 6SK7 oscillator tubes in order to get ample drive. If the 6SK7 is changed, the ceramic base should be transferred to the new tube. The use of a bakelite based 6SK7 will adversely affect the carrier frequency stability, particularly at the higher frequencies.

e. ATTENUATOR UNIT: (Fig. 23 on page 38)

Practically all of the resistance values in the attenuator can be checked and the defective resistor localized prior to removal of the instrument from its outer case. In order to locate errors in the steps of less than 5%, it will be necssary to measure the ratios on a specially calibrated receiver as described later.

The attenuator network was originally designed for 5 ohms impedance with 30 ohm output cable and a 30 ohm terminating resistor. Present cable is running 33.5 to 34 ohms, hence the impedance is actually 5.1 to 5.15

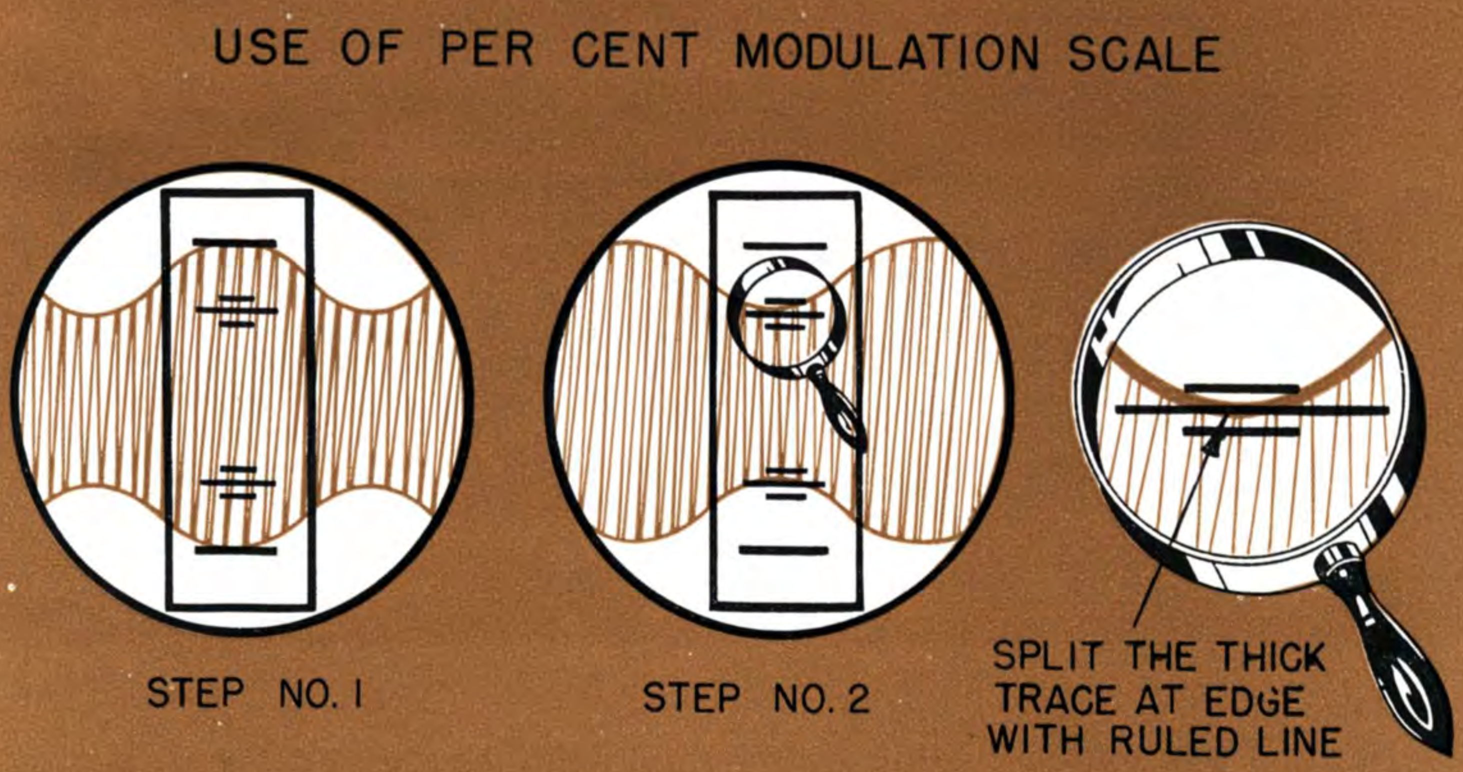


FIG. 30

ohms with cable. Without cable connected, the impedance is 6.0 ohms plus internal lead and contact resistance. All series resistors (except one on aluminum shelf) are wirewound, and the shunt resistors are composition type. If any range is overloaded (power connected to output cable), the shunt resistors on that range will probably burn out. The series resistors seldom go. If the 34 ohm terminating resistor is open, or has changed greatly, the output will be nearly normal at two or three megacycles, but measurements at higher frequencies will be in error.

The following general checks may be made with a low range ohmmeter or resistance bridge. Connect ohmmeter or bridge to end of terminated cable. With all frequency range buttons *out* (to disconnect all output coupling coils) and the attenuator in good condition, the resistance readings should be as follows:

step	resistance
x0.1	5.15 ohms
x1.0	5.15 "
x10	5.15 "
x100	5.15 "
x1K	5.15 "
x10K	5.1 to 5.4 ohms*
x100K	0 to 20.4 ohms *

* Depends on position of output potentiometer.

A more accurate check can be made with a bridge as follows:

Disconnect terminated cable and make connections from output socket directly to bridge. Open series resistors and open shunts can be determined directly by reference to the following table:

Step	Normal Reading (ohms)	Shunt open	Series open	Two Series open
x0.1	6.0 — 6.8	66.0	6.6 — 7.0	——
x1.0	6.0 — 6.75	33.0 — 33.4	66.0 — 67.5	7.33 — 7.4 *
x10	6.0 — 6.75	33.0 — 33.5	66.0 — 67.5	7.33 — 7.4
x100	6.0 — 6.75	33.0 — 33.6	66.0 — 67.5	7.33 — 7.4 *
x1K	6.0 — 6.75	33.0 — 33.6	66.0 — 67.5	7.33 — 7.4
x10K	6.2 — 6.75	29.0 — 40 **	6.8	7.51 — 7.6 *
x100K	0 — 53	——	0-53 ***	——

* Resistance of 7.33 ohms could occur only if the series resistor on two sections were open and connecting lead between sections o.k.

** Depending on position of potentiometer.

*** All other steps on attenuator will have no signal except for small capacity coupling — most noticeable at higher carrier frequencies.

If rotor lead on shelf is disconnected, all steps will show correct resistance except x100K which will read infinite. If rotor lead on next switch section is open, steps x0.1 and x1.0 will read o.k., but all steps above will show infinity.

It is recommended that replacement resistors be secured from the factory. All carbon units are brought to the low side of 1% tolerance and ground up to value *after* soldering into place. Of course, the connecting leads must be disconnected so that no other resistors are in shunt with the resistor under adjustment. If a small hand grinder is not available for adjustment, the resistors can be scraped with a knife. When using the grinder, care must be exercised not to overheat the resistor. It is always well to grind up to within 2 or 3 percent of tolerance and wait several minutes for the resistor to cool before making a final check and adjustment. Do not hold down the bridge battery circuit continuously and heat the resistor excessively while measuring — only press down the battery button on the bridge just long enough to see which way the galvanometer will deflect and then release until the bridge decade has been reset to another value, then press the battery button momentarily for another swing of the bridge galvanometer. Damaged switch sections or faulty detent mechanisms should be replaced by new ones obtained from the factory. These items contain *superior* materials to those reqularly used in home receiver production and are capable of rendering long life under severe service conditions.

When the transmission line is correctly terminated there remains another source of error at the extreme upper carrier frequency limit: the inductance of the attenuator switch leads. This is compensated by using a small 10 turn equalizing coil and resistor of approximately 184 ohms. Actually these resistors are adjusted individually to provide flat output at 1 volt as read on a probe type vacuum tube voltmeter at both 1 megacycle and 25 megacycles. The actual output calibration level is set at 1 volt at 1 megacycle by means of the 10K calibrating rheostat. The vacuum tube voltmeter is checked frequently against a dynamometer transfer standard. This in turn is checked frequently on our precision Weston Model 175 Potentiometer against a standard cell. One volt can be determined in our laboratory to approximately 1/500 of one per cent.

In calibrating any vacuum tube voltmeter extreme caution must be taken to keep the waveform as near sinusoidal as possible: for example, if a one percent accuracy is desired, the total harmonic content should be below 1%. Likewise, the signal generator should be operated at the middle or low frequency end of its range where the harmonic content is lower. No attempt should be made to check the output on a peak type vacuum tube voltmeter at frequencies as low as 100 to 200 kc, for the waveshape of most standard signal generators is not very good at such low frequencies. Resistance tuned type oscillators are more suitable in this range, if wave-shape distortion must be kept low.

Of course it is unwise to use any modulation when checking the output of signal generators. Likewise, it is impractical to attempt to check modulation percentage with a peak type vacuum tube voltmeter by noting the rise in voltmeter reading when modulation is applied. The basic reasons for not attempting to use a peak type vacuum tube voltmeter to check signal generator modulation are due to the very high impedance presented by all commercial diodes at low levels (one or two volts). This high impedance actually tends to an average reading rather than a peak reading voltmeter, with the diode at low levels.

The r.f. attenuator ratios can be accurately measured with a sensitive superhetrodyne receiver arranged as shown in figure 31. The receiver output meter indicates the carrier level and is calibrated in per cent variation of carrier at 456 kc where there is no difficulty with frequency effects in the attenuator. The independent manual adjustment of gain in the r.f. and i.f. amplifiers of the test receiver permit using the receiver over wide limits of input voltage without overloading or operating on a non-linear part of the tube characteristics, thus affecting the linear calibration of the i.f. output meter.

To check for receiver linearity, a special output cable is available. This output cable provides an accurately determined 10 to 1 step of attenuation which is independent of amplitude and frequency. Actually if the frequency is carried high enough, some error will result and a correction can be applied if necessary.

A fixed ratio of 10 to 1 in the test receiver i.f. output meter circuit permits reading directly in per cent error of the step. By this method attenuator step ratios can be read to an accuracy of 1% at any carrier frequency which the receiver is capable of converting down to the i.f. channel. The step ratio errors in the 65-B are usually less than 2% except at the higher frequencies. Here they may rise as high as 3 to 4% because of stray mutual couplings inherent in the particular attenuator design.

The ratios mentioned above are termed the "step ratios" to distinguish them from the "Overall ratios". Overall ratios are encountered every time the overlap regions between two fixed steps are checked against each other. To obtain a truly accurate report on the overall ratios, mechanical and electrical zeros must be set in the proper sequence as explained under "Operating Instructions — b. Zero Adjustment", since compensation of mechanical shift by electrical zero shift can give errors of 50% or more.

In general, if the step ratios are o.k. and the overall ratios do not even check well at 1 megacycle, it is probable that either the output meter on the signal generator is off calibration or else the 6H6 has changed its characteristics. In any event it is best to return the output meter to the factory for replacement. We will probably send along a new diode with the repaired meter, as the meter is calibrated to match the diode.

If the instrument cannot be spared long enough to secure a meter repair, then it is well to try several different 6H6 diodes until one is found which fits the meter calibration somewhat more closely as determined by the improvement of overall ratios. All 6H6 tubes should be aged at normal heater voltage for 48 hours before trying them in the output metering circuit.

On all 60 cycle models after serial #125 a saturated core type of voltage regulator is provided to eliminate zero drift of the output meter. Most saturated core regulators are rather critical as to frequency, therefore, some models which were designed for export use on 50 cycles or portable power supplies have been provided with a special ballast type regulator instead of the usual iron

CALIBRATED RECEIVER FOR MEASURING ATTENUATOR STEP RATIOS

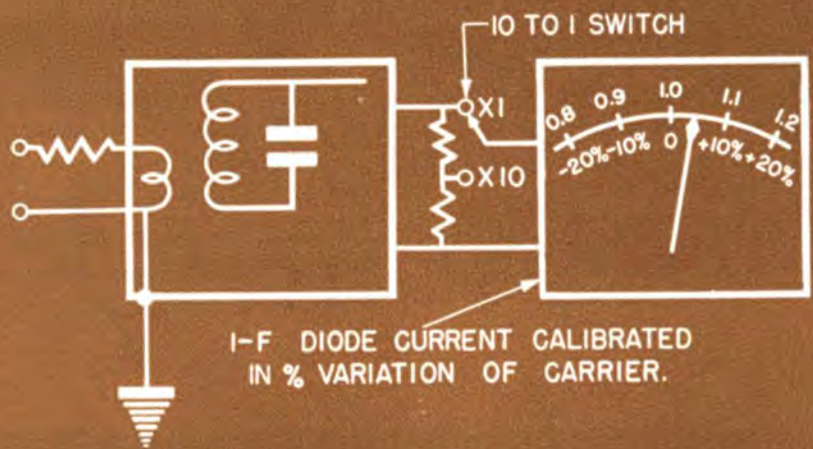


FIG. 31

core regulator. If these ballast tubes ever require replacement, new ones should be procured from the factory, since even specially selected ones do not provide quite as good regulation as the iron core type. The ballast type has the advantage of not being frequently critical, however.

With regard to stray field or leakage, there are two types; attenuator and line leakage. When both types are present at the higher frequencies there may be a null at .2 to .6 microvolts on the output. This is caused by the relative phase of the two types of leakage just exactly canceling out. Such nulls are rather uncommon in the model 65-B; the remedy is to correct both sources as suggested below.

Line leakage must be tracked down and eliminated first, as it often is mistaken for attenuator leakage. In order to locate the line leakage and measure its magnitude, a 20 megacycle sensitive receiver should be roughly calibrated, so that approximate microvolt levels can be estimated. Apply 80 to 100% modulation to the 65-B at 400 cycles and connect the *ground* terminal of the output cable to the antenna terminal of the receiver. This procedure forms a step-up loop around thru the power cord and the receiver chassis. If a signal greater than .5 microvolt is present using this connection, this can be corrected by taking off the rear cover and removing the oscillator shield cover. Clean the silver plating around the edge with benzine or carbon-tet. Then spread can sides as much as possible and still be able to replace it. Be sure each side and top edge is *between* spring and inside of shield base.

It has been found that sometimes the edges of the tapped screw holes in the back of the case are raised above the surface of the case. Filing or removing the raised edges with an oversized drill has removed line leakage from many generators.

If, after replacing r.f. shield cover and rear outer case cover, the line leakage is still high, the whole chassis will have to be taken out of the case. Check the .01 tubular line condensers under the modulation and power chassis (see figure 21), and if there is any doubt about them, replace them with others having low inductance. It is possible that a poor solder joint in these units would make them inductive and not suitable for high frequency by-passing, yet at lower frequencies the capacity and power factor would not be affected adversely. Also while the chassis is out of the case, make sure all surfaces between the front panel and modulation and power chassis are clean and bright. Be certain that the .01 line by-pass condensers make very good contact with the chassis. The above procedure should reduce the line leakage to a very low value.

Next the attenuator leakage, if any, should be cleaned up. This type of leakage results in a residual signal with the output reduced to zero. Note: the output multiplier decade should be set at its lowest point because of the minimum impedance present in the output control potentiometer. There are two principle causes of attenuator leakage. First, make sure that the shielded lead from the r.f. oscillator compartment to the attenuator is pulled tight against attenuator copper shield base, and that this lead lies close to the aluminum front panel from entrance to where it is grounded. The other reason for attenuator leakage seldom occurs in the field; it is due to imperfect contact between the copper shield cans and the attenuator front panel. Sanding of these surfaces should remove any difficulty from this source.

It is to be noted that the arrangement of leads and ground lug on the output control potentiometer is rather critical. If it is necessary to replace this potentiometer, care must be exercised to maintain the same relations in the connecting leads. The wirewound output potentiometer is of the non-inductive type employing two wires connected in parallel and wound in opposite directions around the resistance card. Occasionally one of these wires will break and the total resistance of the potentiometer will jump from 50 to 100 ohms. If the potentiometer becomes jumpy or opens up thru long use, it should be replaced by a new one. Emergency repairs have been made for temporary service by carefully soldering two wires together around the break.

f. REPLACEMENT OF TUBES:

Any standard tubes can be used for replacement in the model 65-B; however, some difficulty may be experienced with certain tubes, if the ultimate in accuracy and frequency stability is desired.

If it becomes necessary to replace the type 6H6 output diode, we suggest that several type 6H6 tubes be run at normal heater voltage for at least 48 hours to properly age their emission characteristics before selection. Then a diode should be chosen which makes the "overall ratios" check accurately at 1 megacycle. The "overall ratios" are encountered every time the overlap regions between two fixed steps are checked against each other. It is important to set the electrical and mechanical zeros before proceeding with the ratio checks with different diodes, since compensation of mechanical shift by electrical zero shift can give errors many times those of the worst diodes. Records are kept by the factory of the particular characteristics of each diode supplied; however, it is desirable after long service that the calibration of the output meter also be checked. If it is not feasible to return the meter to the factory, selection by trial of a 6H6 which makes the "overall ratios" correct is the next best solution. Of course the 1 volt point should be checked after replacing the 6H6.

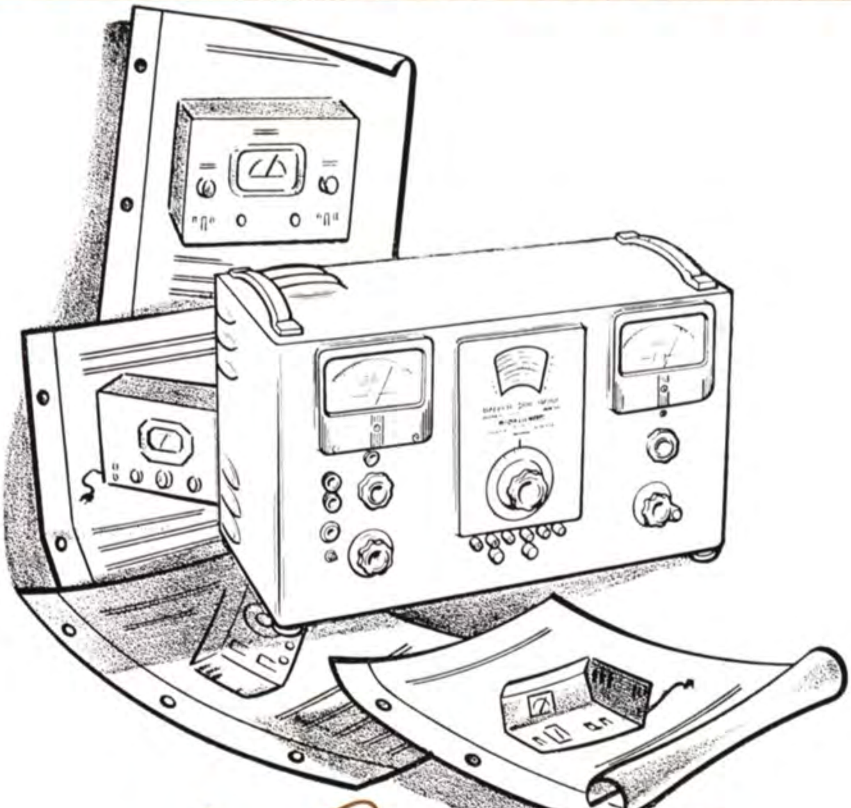
The 6SK7 r.f. oscillator tube has a ceramic base in the interest of frequency stability. This is especially important at the higher carrier frequencies. If it is necessary to replace this tube, and it is not possible to secure one having a ceramic base, we suggest the re-use of the old ceramic base again on the new tube. It is not difficult to unsolder the lead wires to the tube contact pins and remove the base from the old tube. When the ceramic base is installed on the new tube, care must be exercised not to crack the base when the four crimped ears are bent into place to secure the base. Rather than chance cracking by bending the ears too tightly, it is desirable to use a bit of some cement such as ambroid or glyptol to tighten up the tube in its base and prevent microphonics, etc. It is possible to replace a 6SK7 by a 6SK7-GT; however, it will probably be necessary to readjust the trimmer condensers on the oscillator coils to compensate for the difference in tube capacity. This trimming may even be required when substituting tubes of identical manufacture, if maximum accuracy of carrier frequency calibration is to be maintained. Care should be taken first to warm up the instrument for an hour or so.

If the instrument fails to give sufficient output, the difficulty may not be due to the oscillator tube. Usually the 6AG7 will fail to make output at the low end of "F" band when the g_m begins to drop. A failure of the oscillator to provide sufficient drive for the r.f. amplifier will affect a limiting or cut-off effect on the positive peaks of the modulated carrier envelope as observed on a cathode ray oscilloscope. Usually, a normal 6SK7 will provide sufficient over-drive to "fill in" the peaks up to two hundred per cent or more modulation. When the 6AG7 is replaced, the per cent modulation calibration should be carefully checked as outlined under "Modulation and Power Unit". A 6AG7 should be selected which yields the same modulation at 30% at both 1 and 15 megacycles.

None of the other tubes used in the instrument are particularly critical as to characteristics. Sufficient negative feedback has been employed in the audio oscillator and modulator amplifier to accommodate a wide variation of tubes. Occasionally unstable VR-150-30 tubes may be encountered. Also, some VR-150-30 tubes have been found with regulating voltage points as high as 175 volts. The use of such a tube for the r.f. amplifier supply would reduce the actual modulation per centage well below the indicated value. Normal VR-150-30 tubes range between 145 and 160 volts.

Because of our conservative design many model 65-B's have operated more than 10,000 hours with the original tubes still in use. After such long periods of operation, it is well to replace all tubes and completely recheck the calibration of the instrument. Such matters as attenuator switch sections, pushbutton switches, meters, tuning motors, worm drives, etc., may require replacements or attention in addition to the tubes. Our organization is equipped to render rapid and efficient service on our instruments at all times. We advise the return of all instruments which have passed the 10,000 hour mark to the factory for a complete service and recalibration.

CORRELATION BETWEEN DIFFERENT SIGNAL GENERATORS



Measurements Corporation

BOONTON · NEW JERSEY

V. CORRELATION BETWEEN DIFFERENT SIGNAL GENERATORS:

When divergent readings on the same receiver are obtained with several signal generators, it is always well to first check the unmodulated carrier level of all generators at 1 volt with a vtvm such as our model 62. All generators should indicate within 2 or 3 per cent at this level.

Next check all 1 volt unmodulated outputs on a *receiver* instead of the vtvm. It may be necessary to use several thousand ohms in series with the receiver antenna input lead to prevent receiver overload. Also it will be necessary to disconnect the receiver a.v.c and use some manual gain control to reduce the receiver gain to a suitable level. If the receiver is equipped with a cw beat oscillator the unmodulated outputs can be compared on an audio output meter, otherwise it will be necessary to install a diode current microammeter to read the unmodulated carrier. If a difference in signal generators is noted when measuring cw output at 1 volt with a receiver after all outputs have been checked with a vtvm, it is probable that the generators do not all have the same carrier harmonics. This will be most noticeable on "A" and "B" ranges. Examination with a wide-band oscilloscope should show up these harmonics.

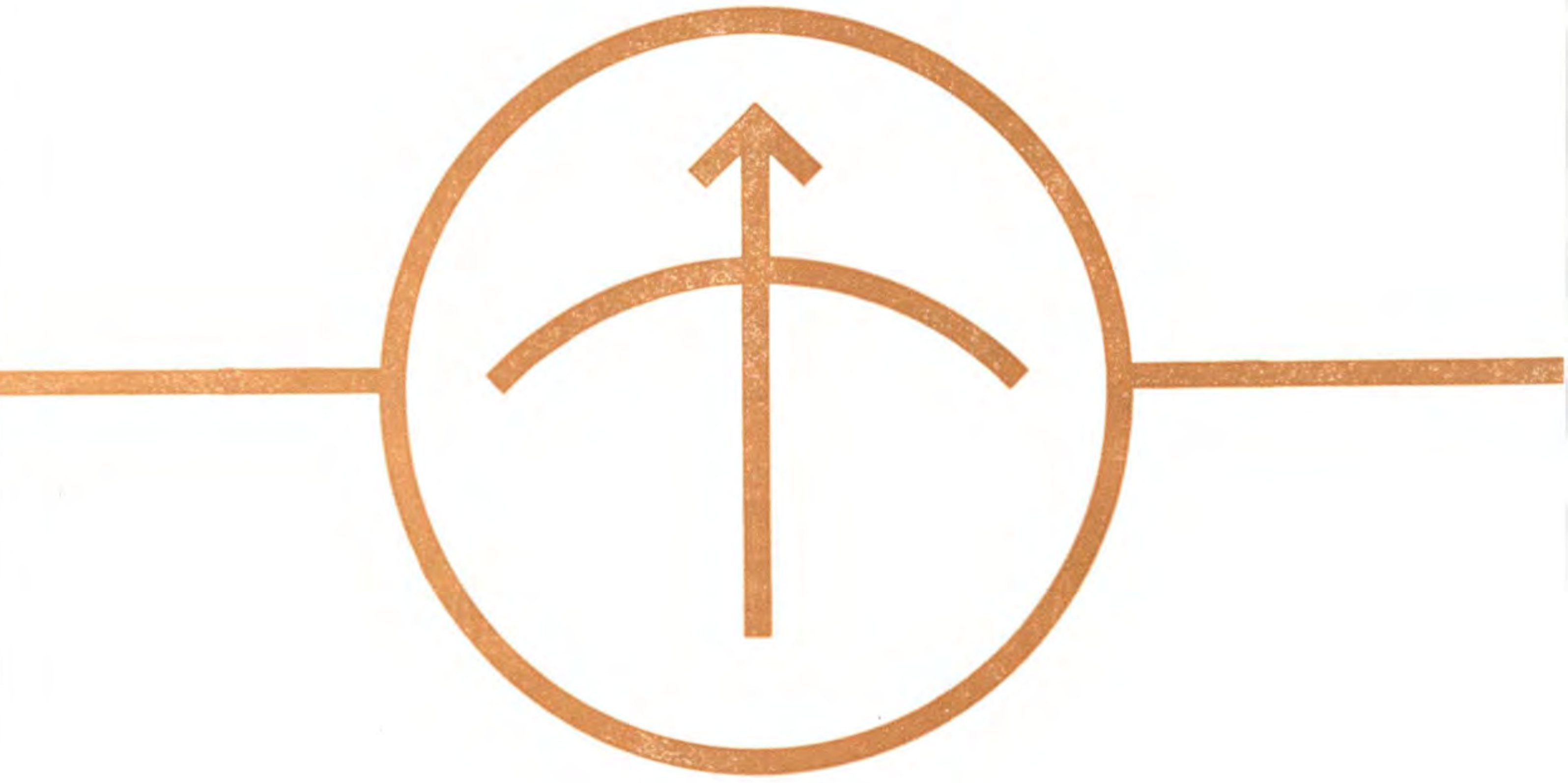
Next check the cw outputs from the various generators on each respective attenuator step. This will tend to show up cumulative step errors. Checks should be taken at the carrier frequencies in use. In general, checks at 1, 5, 10, and 20 megacycles should show up any step errors. It will be noted that all signal generators will tend to diverge somewhat as the output level is reduced, particularly at the higher frequencies. The maximum cumulative cw output error should not exceed $\pm 15\%$.

After the cw outputs have been compared, apply 30% modulation at 400 cycles and compare all of the generators. (This can be done at any one of the carrier levels.) Any error of modulation indication will be superimposed on top of the cw output errors. In general the maximum error of modulated output should not exceed $\pm 20\%$ for 30% modulation. This means that the absolute value of the modulated microvolt should lie between 0.8 and 1.2 microvolts, which is ± 2 db out of a range of 120 db. The error will generally be less than the above figures.

The presence of excessive frequency modulation will affect the accuracy of output measurement, if the frequency deviation is greater than the receiver band width at two or three times down. The generator having frequency modulation can be easily detected, for it will not yield symmetrical selectivity curves. This is treated in detail under "Selectivity".

A difference in output impedance between generators of different manufacture may cause errors in output indication, especially if too small a dummy antenna is employed. A discussion of output impedance and dummy antennas has been given under "Sensitivity".

In the actual use of signal generators for inspection of radio receivers to close limits, it may be necessary to carefully standardize all signal generators. It is usual to select some one instrument which is not operated as continuously as the rest and call it the standard against which all of the others are checked from time to time. It is well to check them at the actual operating carrier output level and per cent modulation normally used.



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WIRING DIAGRAM SECTION

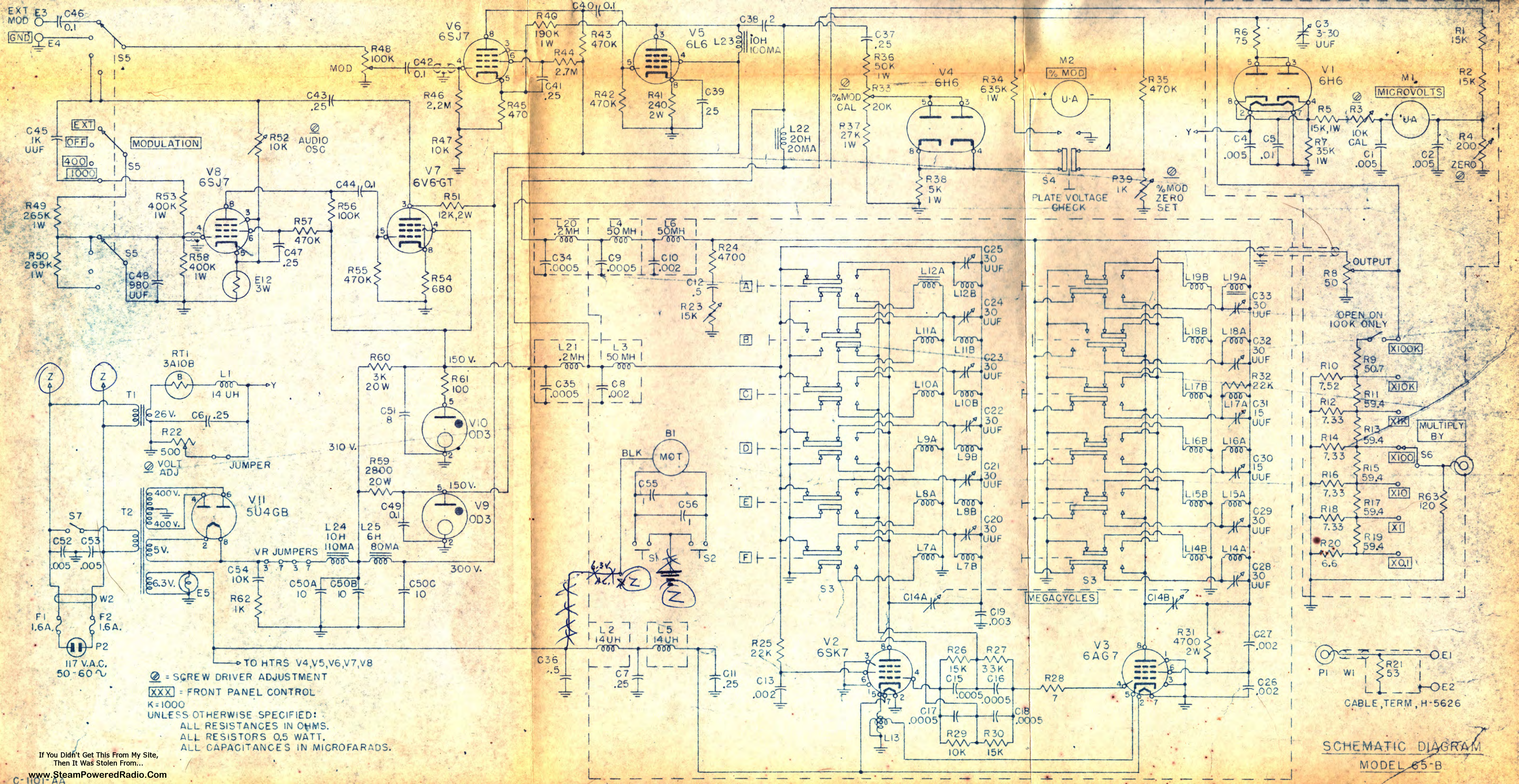

EXT MOD
GND
MODULATION
EXT
OFF
400
1000
AUDIO OSC
MOD
%MOD CAL
PLATE VOLTAGE CHECK
%MOD ZERO SET
% MOD
MICROVOLTS
CAL
ZERO
OUTPUT
OPEN ON 100K ONLY
X100K
X10K
X1K
X100
X10
X1
X0.1
MULTIPLY BY
MEGACYCLES
VOLT ADJ
JUMPER
VR JUMPERS
TO HTRS V4,V5,V6,V7,V8
117 V.A.C. 50-60 ~
CABLE TERM. H-5626
= SCREW DRIVER ADJUSTMENT
XXX = FRONT PANEL CONTROL
K=1000
UNLESS OTHERWISE SPECIFIED:
ALL RESISTANCES IN OHMS.
ALL RESISTORS 0.5 WATT.
ALL CAPACITANCES IN MICROFARADS.
SCHEMATIC DIAGRAM
MODEL 65-B
C-1101-AA

TABLE OF REPLACEABLE PARTS

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
B1	MOTOR: Capacitor type; reversible; operates on 115 volts 60 cycles; approximately 2-1/8 x 2-1/8 x 1-7/16 deep excluding shaft; 13/16 shaft with pulley. Measurements Corp. Part H-4994.	Drives tuning capacitor.
C1	CAPACITOR: fixed; ceramic; 5000 mmf. min.; 500 VDCW; 19/32" dia x 3/16" thick. Measurements Corp. Part H-4122.	By-pass, meter M1.
C2	CAPACITOR: same as C1.	Same as C1.
C3	CAPACITOR: variable; mica dielectric; 3-30 mmf; 300 VDCW; 5/8" wd x 13/16" high x 1/2" deep, excluding adjustment screw; 2 solder lug terminals; Measurements Corp. Part H-2774-1.	High frequency compensator for output meter M1.
C4	CAPACITOR: same as C1.	R-f by-pass, heater of tube V1.
C5	CAPACITOR: fixed; mica dielectric; 10,000 mmf ± 20%; 300 VDCW; body dim. 53/64" lg x 53/64" wd x 11/32" thk; molded bakelite case; 2 axial wire leads. Measurements Corp. Part H-5168	By-pass, cathode tube V1.
C6	CAPACITOR: fixed; paper dielectric; 250,000 mmf ±20%; 200 VDCW; 1-1/8" lg x 3/8" dia; molded plastic case; 2 axial wire leads. Measurements Corp. Part H-5325	R-f filter, heater of tube V1.
C7	CAPACITOR: same as C6.	R-f filter, heaters tubes V2, V3.
C8	CAPACITOR: fixed; mica dielectric; 2,000 mmf ± 10%; 500 VDCW; body dim. 53/64" lg x 53/64" wd x 9/32" thk; molded bakelite case; 2 axial wire leads; Measurements Corp. Part H-5326.	R-f filter, B+ supply, tube V2.
C9	CAPACITOR: fixed; mica dielectric; 500 mmf ± 10%; 500 VDCW; body dim. 23/32" lg x 15/32"wd x .20" thk; 2 axial wire leads; Measurements Corp. Part H-5179.	R-f filter B+ supply, tube V3.
C10	CAPACITOR: same as C8.	Same as C9.
C11	CAPACITOR: same as C6.	R-f filter, heater tubes V2, V3.
C12	CAPACITOR: fixed; paper dielectric; oil filled; 500,000 mmf.±20%; 600 VDCW; body dim. 1-13/16" lg x 1" wd x 1" h; 2 solder lug terminals on top. Measurements Corp. Part H-5327.	P/o termination for modulation filter.

SYMBOL	DESCRIPTION	FUNCTION
C13	CAPACITOR: same as C8.	R-f by-pass, screen of tube V2.
C14	CAPACITOR: variable; air dielectric; plate meshing type; 2 sections; 10-415 mmf per section; essentially SLF characteristic; 23 plates per section; dim, excluding shaft, 3-3/16" lg x 3-9/16" wd x 2-23/32" h; 180 deg. clockwise rotation; 3 mtg studs; ceramic insulation. Measurements Corp. Part H-1087.	Tuning capacitor, r-f osc, and amp.ccts.
C15	CAPACITOR: same as C9.	Grid coupling, r-f osc. (Bands A to E) tube V2.
C16	CAPACITOR: same as C9.	Grid coupling, r-f amp. (Bands A to E) tube V3
C17	CAPACITOR: same as C9.	Grid coupling, r-f osc. tube V2 (Band F).
C18	CAPACITOR: same as C9.	Grid coupling, r-f amp. tube V3 (Band F).
C19	CAPACITOR: fixed; mica; 3000 mmf ±20%; 500 VDCW; 13/16" x 25/32" x 1/4"; 2 axial leads. Measurements Corp. Part H-5328.	R-f by-pass, +B supply to osc.
C20	CAPACITOR: same as C3.	Trimmer, F band osc.
C21	CAPACITOR: same as C3.	Trimmer, E band osc.
C22	CAPACITOR: same as C3.	Trimmer, D band osc.
C23	CAPACITOR: same as C3.	Trimmer, C band osc.
C24	CAPACITOR: same as C3.	Trimmer, B band osc.
C25	CAPACITOR: same as C3.	Trimmer, A band osc.
C26	CAPACITOR: same as C8.	R-f by-pass, screen of tube V3.

TABLE OF REPLACEABLE PARTS

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
C27	CAPACITOR: same as C8.	R-f by pass, B+ supply to osc.
C28	CAPACITOR: same as C3.	Trimmer, F band amp.
C29	CAPACITOR: same as C3.	Trimmer, E band amp.
C30	CAPACITOR: variable; mica dielectric; 1.5-15 mmf; 300 VDCW; 5/8" wd x 13/16" high x 1/2" deep, excluding adjustment screw; 2 solder lug terminals; Measurements Corp. Part H-2774-2.	Trimmer, D band amp.
C31	CAPACITOR: same as C30.	Trimmer, C band amp.
C32	CAPACITOR: same as C3.	Trimmer, B band amp.
C33	CAPACITOR: same as C3.	Trimmer, A band amp.
C34	CAPACITOR: same as C9.	R-f filter capacitor, B+ supply, tube V3.
C35	CAPACITOR: same as C9.	R-f filter, B+ supply, V2.
C36	CAPACITOR: fixed; paper dielectric; oil filled; 500,000 mmf, ± 20%; 200 VDCW; body dim. 1-13/16" lg x 1" wd x 1" h; 2 solder lug terminals on top. Measurements Corp. Part H-5553.	R-f filter, Heater cct.
C37	CAPACITOR: fixed; paper; .25 mfd, 600 VDCW. Measurements Corp. Part H-5596.	A-f coupling, plate V4.
C38	CAPACITOR: fixed; paper dielectric; 2 mf ±20%; 400 VDCW; body dim. 2" lg x 2" wd x 1-1/8" high; 2 solder lug terminals on side. Measurements Corp. Part H-5175.	Modulation coupling capacitor.
C39	CAPACITOR: fixed; electrolytic; 25 mf +150%, -10%; 25 VDCW; 1-1/16" lg x 5/8" dia; 2 axial wire leads. Measurements Corp. Part H-5182.	Cathode by-pass, tube V5.
C40	CAPACITOR: fixed; paper; .1 mf ± 20%; 400 VDCW; Measurements Corp. Part H-5589.	Grid coupling, tube V5.

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
C41	CAPACITOR: same as C37.	Screen by-pass, tube V6.
C42	CAPACITOR: same as C40.	Grid coupling, tube V6.
C43	CAPACITOR: same as C37.	A-f feedback coupling, plate tube V7.
C44	CAPACITOR: same as C40.	Grid coupling, tube V7.
C45	CAPACITOR: fixed; mica; 1,000 mmf. ± 1%; 500 VDCW; 25/32" x 25/32" x 1/4"; molded bakelite case; 2 axial wire leads. Measurements Corp. Part H-5128.	Series Cap. in freq. determining network, a-f osc.
C46	CAPACITOR: same as C40.	Couples external modulator to selector switch.
C47	CAPACITOR: same as C37.	Screen by-pass, tube V8.
C48	CAPACITOR: fixed; mica; 980 mmf ± 1%; 500 VDCW; 25/32" x 25/32" x 1/4"; molded bakelite case; 2 axial wire leads. Measurements Corp. Part H-5129.	Shunt cap. in freq. determining network, a-f osc.
C49	CAPACITOR: same as C40.	+B filter cap., plate tube V9.
C50	CAPACITOR: fixed, electrolytic; 3 section; 10-10-10 MFD; 450 VDCW. Measurements Part H-5061	+B filter cap.
C51	CAPACITOR: fixed; electrolytic; 8 mf +150%; 450 VDCW; 1-7/16" lg x 3/4" dia.; 2 axial wire leads. Measurements Corp. Part H-5002.	+B filter cap.
C52	CAPACITOR: same as C1.	Power line filter.
C53	CAPACITOR: same as C1.	Same as C52.
C54	CAPACITOR: fixed; paper 10,000 mmf, ± 10%; 2,000 VDCW; metal case; hermetically sealed; 7/8" dia. x 1-5/8" lg; mineral oil filled; radial wire leads. Measurements Corp. Part H-3752.	P/o damping network, choke L24.
C55	CAPACITOR: fixed; paper; 1 mfd, ± 20%; 600 VDCW; molded bakelite; 2 axial wire leads. Measurements Corp. Part H-5554.	Phase shift capacitor.
C56	CAPACITOR: same as C55.	Phase shift capacitor.

TABLE OF REPLACEABLE PARTS

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
E1	POST, BINDING: brass; nickel plated; consists of body and screw cap; post extends 37/64" above mtg. surface; screw cap extends 3/16" beyond top of stationary post; mounts by male thread shank #8-32 x 3/8" lg. Measurements Corp. Part HS-18-1 and HS-18-5	R-f output connector on cable assembly W1.
E2	POST, BINDING: same as E1.	Ground connector on cable assembly W1.
E3	POST, BINDING: screw type; no engraving; cap and base dim. 1/2" dia x 11/16" high; stem #6-32 x 9/16 lg; molded bakelite insulation; knurled cap; shouldered insulating base. Measurements Corp. H-5329-1	Input connector for external modulation.
E4	POST, BINDING: screw type; engraved "GND"; cap and base dim. 1/2" dia x 11/16" high; stem #6-32 x 9/16" lg; molded bakelite insulation; knurled cap; shouldered insulating base. Measurement Corp. H-5329-2.	Ground connector for external modulator.
E5	LAMP: incandescent; 6-8 V., 0.20 amp.; bulb G-3-1/2 clear; 15/16" lg. o/a ; miniature bayonet base; burn any position. Measurements Corp. Part H-4136.	Pilot light.
E6	KNOB: round; fluted; black phenolic resin; 1-3/8" dia x 11/16" h; fits 1/4" dia shaft; two #8-32 set screws 90 deg apart; brass insert. Measurements Corp. Part H-2788	Modulation control.
E7	KNOB: same as E6.	R-f output control.
E8	BUTTON, PUSH: round; 5/8" dia x 1/2" lg. Measurements Corp. Part H-5343	Push button for motor switch.
E9	BUTTON, PUSH: same as E8.	same as E8.
E10	BUTTON, PUSH: set consists of 6 push buttons; each button 1-3/8" lg x 7/16" dia; engraved with letters A through F. Measurements Corp. Part H-1060.	Push buttons for r-f range switch.
E11	BUTTON, PUSH: round; black; phenolic; 15/32" lg x 1/2 dia; fits on .052"x 3/16" flat shaft. Measurements Corp. Part H-5330	Push button for +B check switch.
E12	LAMP: incandescent; 120 volt, 3 w; S6 bulb; 1-7/8" lg o/a; candelabra screw base. Measurements Corp. Part H-5052	Automatic feedback control, a-f osc.

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
F1	FUSE: cartridge; 1.6 amp; rated continuous for 110% load; opens in one hour at 135% load; 125 V; one time; glass body; metal ferrules; 1-1/4" lg x 1/4" dia. Measurements Corp. Part H-5018-11.	Power line fuse.
F2	FUSE: same as F1.	same as F1.
H1	HANDLE: leather; black; 6-3/8" lg with hardware. Measurements Corp. Part H-2790.	Carrying handle.
H2	HANDLE: same as H1.	same as H1.
I1	LIGHT, INDICATOR: with lens for miniature bayonet base lamp; o/a dim. 1-23/32" lg x 7/8" wd x 1-1/16" h; mounts in single hole 11/16" dia; red lens; smooth face; frosted back. Measurements Corp. Part H-5019.	Pilot light socket assembly.
I2	DIAL: scale; blank uncalibrated main tuning dial; round; 5-3/8" OD x 1/2" ID x 1/16" thk; 3 mtg holes spaced 120° apart on 3/8" rad white finish. Measurements Corp. Part H-290.	Frequency scale, uncalibrated (for replacement only).
I3	DIAL: control; moveable scale type; MODULATION; four indications marked 1000, 400, OFF, EXT; flat disc with fluted knob for 1/4" dia shaft; 1-7/8" dia x 3/4" h; two #8-32 set screws. Measurements Corp. Part H-5134.	Modulation selector control.
I4	DIAL: control; disc type; 100 equal divisions over 360 degrees; for 1/4" dia shaft; o/a dim. 2-3/4" dia x 1" h; two #10-32 set screws at 90 deg. apart. Measurements Corp. Part H-2956.	Vernier tuning r-f frequency.
I5	DIAL: control; moveable scale type; MULTIPLY BY; seven indications marked 100K, 10K, 1K, 100, 10, 1.0, 0.1; flat disc with fluted knob for 1/4" dia shaft; 1-7/8" dia x 3/4" h; two #8-32 set screws. Measurements Corp. Part H-4827.	R-f output voltage step selector control.
J1	CONNECTOR: receptacle; JAN type UG-290/U modified per Measurements Corp. Part H-4577.	R-f output connector.
L1	COIL: R.F.; choke; single winding; 7/8" dia. x 1-1/16" lg overall; 2 radial wire leads; inductance 8-20 uh; D.C. resistance less than 0.04 ohm; distributed capacity less than 4 mmf. Measurements Corp. Part H-2316.	R-f filter choke, heater, tube V1

SYMBOL	DESCRIPTION	FUNCTION
L2	COIL: R.F. same as L1.	R-f filter choke, heater, tubes V2, V3.
L3	COIL SUB-ASSY, R.F.: choke; 2 pie windings; unshielded; 50 mh ±5%; 75 ohms d.c. resistance, ±10%; 2-1/16" lg x 3/4" dia o/a; paper coil form; powdered iron core; mounts on self-contained #6-32 screw. Measurements Corp. Part H-2325.	R-f filter choke, +B supply, tube V2.
L4	COIL SUB-ASSY, R.F.: same as L3.	R-f filter choke, +B supply, tube V3.
L5	COIL, R.F.: same as L1.	same as L2.
L6	COIL SUB-ASSY, R.F.: same as L3.	same as L4.
L7	COIL SUB-ASSY, R.F.: oscillator; for 11.0 to 30.0 mcs range; comprises sections 7A and 7B, capacitor C20. Measurements Corp. Part H-1055-1.	F band oscillator.
L8	COIL SUB-ASSY, R.F.: oscillator; for 3.9 to 12.2 mcs range; comprises sections 8A and 8B, capacitor C21. Measurements Corp. Part H-1054-1.	E band oscillator.
L9	COIL SUB-ASSY, R.F.: oscillator; for 1.45 to 4.2 mcs range; comprises sections 9A and 9B; capacitor C22. Measurements Corp. Part H-1053-1.	D band oscillator.
L10	COIL SUB-ASSY, R.F.: oscillator; for 0.52 to 1.56 mcs range; comprises sections 10A and 10B, capacitor C23. Measurements Corp. Part H-1052-1.	C band oscillator.
L11	COIL SUB-ASSY, R.F.: oscillator; for 0.2 to 0.56 mcs range; comprises sections 11A and 11B, capacitor C24. Measurements Corp. Part H-2097.	B band oscillator.
L12	COIL SUB-ASSY, R.F.: oscillator; for 0.075 to 0.21 mcs range; comprises sections 12A and 12B, capacitor C25. Measurements Corp. Part H-2095.	A band oscillator.
L13	COIL SUB-ASSY, R.F.: This coil is listed for reference only. Not separately replaceable.	Minimizes incidental f-m.
L14	COIL SUB-ASSY, R.F.: amplifier; for 11.0 to 30.0 mcs range; comprises sections 14A and 14B, capacitor C28. Measurements Corp. Part H-1055-2,	F band amplifier.
L15	COIL SUB-ASSY, R.F.: amplifier; for 3.9 to 12.2 mcs range; comprises sections 15A and 15B, capacitor C29. Measurements Corp. Part H-1054-2.	E band amplifier.
L16	COIL SUB-ASSY, R.F.: amplifier;for 1.45 to 4.2 mcs range; comprises sections 16A and 16B, capacitor C30. Measurements Corp. Part H-1053-2.	D band amplifier.

TABLE OF REPLACEABLE PARTS

SYMBOL	DESCRIPTION	FUNCTION
L17	COIL SUB-ASSY, R.F.: amplifier; for 0.52 to 1.56 mcs range; comprises sections 17A and 17B, capacitor C31. Measurements Corp. Part H-1052-2.	C band amplifier.
L18	COIL SUB-ASSY, R.F.; amplifier; for 0.2 to 0.56 mcs range; comprises sections 18A and 18B, capacitor C32. Measurements Corp. Part H-2096.	B band amplifier.
L19	COIL SUB-ASSY, R.F.; amplifier; for 0.075 to 0.21 mcs range; comprises sections 19A and 19B, capacitor C33. Measurements Corp. Part H-2094.	A band amplifier.
L20	COIL. R.F: choke: single winding; 15/16" dia x 3/4" lg overall; unshielded; inductance 0.2 mh ±20%; approximately 8 ohms DC resistance. Measurements Corp. Part H-2321.	R-f filter choke, +B supply, Tube V3.
L21	COIL,R.F: same as L20.	R-f filter choke, +B supply, tube V2.
L22	REACTOR: modulation; inductance 20 h @ 20 ma; 300 ohms DC max resistance; 2-3/4" lg x 2-5/8" wd x 3-1/16" h. Measurements Corp. Part H-5331.	Modulation choke.
L23	REACTOR: modulation; inductance 10 hy @ 100 ma; approx 300 ohms DC resistance; 2-3/4" lg x 2-5/8" wd x 3-1/16" h. Measurements Corp. Part H-5332.	Modulation choke.
L24	REACTOR: power; inductance 10 hy @ 110 ma; 4" lg x 1-7/8" wd x 2-5/8" h. Measurements Corp. Part H-3561.	+B filter choke.
L25	REACTOR: power; inductance 6 hy @ 80 ma; 2-3/4" lg x 1-3/4" wd x 2-5/16" h. Measurements Corp. Part H-5333.	same as L24.
M1	VOLTMETER: DC type; single scale, MICROVOLTS: 0 to 20; hand calibrated; numbered at 0,2,4,6,8,10,15,20; black marking on white background; rectangular bakelite case; flange 4-17/64" w x 3-31/32" h x 45/64" deep; resistance 1280 ohms ±10%; end scale accuracy ±2%; calibrated on vertical steel panel; four mtg holes 5/32" dia at 3-5/8" horiz x 3-5/16" vert centers; Measurements Corp. Part H-718. NOTE: Each meter is calibrated with its associated diode (V1). Meter replacement requires replacement of matching diode. Order H-4888 for meter with matching diode.	Indicates r-f output voltage.
M2	METER, Modulation; DC Type; single scale, PER CENT MODULATION; 0 to 100; 50 divisions, numbered at 0,20,40,60,80,100; black marking on white background; rectangular bakelite case; flange 4-17/64" W x 3-31/32" h x 45/64" deep; resistance 230 ohms ±10%; accuracy ±2% of full scale value; calibrated on vertical steel panel; four mtg holes 5/32" dia at 3-5/8" horiz x 3-5/16" vert centers. Measurements Corp. Part H-717.	Indicates percent modulation.

SYMBOL	DESCRIPTION	FUNCTION
01	BELT: tuning. Measurements Part H-6469.	Couples drive motor to tuning capacitor.
03	DETENT: consists of detent mechanism and first section of switch S6. Measurements Corp. Part H-1171.	Detent for switch S6.
P1	CONNECTOR: plug; JAN type UG-88C/U.	Terminates one end of output cable W1.
P2	CONNECTOR: plug; 2 contacts; not polarized; straight type; 1-7/8" lg x 1-1/2" wd x 1"thk, excluding terminals; includes receptacles for two cartridge fuses 1-1/4" lg x 1/4 dia. Measurements Corp. Part H-5059.	Terminates one end of power cable W2.
R1	RESISTOR, fixed; composition 15,000 ohms ± 10%; 1/2 watt; 3/8" lg x 9/64" dia.; two axial wire leads. Measurements Corp. Part H-3728-153.	P/o d-c voltage divider for meter M1.
R2	Same as R1.	Same as R1.
R3	RESISTOR: variable; wire wound; one section; 10,000 ohms ± 10%; 2 watts rating; linear taper; three solder lug terminals; round metal shaft, screw driver slotted, 1/4" dia x 1/2" lg from mtg surface; contact arm insulated; case 1-3/8" dia max x 9/16" deep; mounts by 3/8"-32 x 3/8" lg bushing. Measurements Corp. Part H-5211.	Calibrating control for meter M1.
R4	RESISTOR: variable; wire wound; one section; 200 ohms ± 10%; 2 watts rating; linear taper; three solder lug terminals; round metal shaft, screw driver slotted, 1/4" dia x 3/8 " lg from mtg surface; contact arm insulated; case 1-1/4" dia x 9/16" deep; mounts by 3/8"-32 x 1/4" long bushing. Measurements Corp. Part H-5335.	Zero adjust control for meter M1.
R5	RESISTOR: fixed; metal film; 15,000 ohms ±2%; 1 w. Measurements Corp. Part H-5592-10.	P/o diode load, tube V1.
R6	RESISTOR: fixed; composition; 75 ohms ± 5%; 1/2 w; 3/8" lg x 9/64" dia.; two axial wire leads. Measurements Corp. Part H-3727-750.	Plate resistor, tube V1.
R7	RESISTOR: fixed; metal film; 35,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-13.	P/o diode load, tube V1.
R8	RESISTOR, variable: wire wound; 50 ohms ± 10%; non-inductive winding; special taper; three solder lug terminals; round metal shaft 1/4" dia x 5/8" lg from mtg surface; case 1-11/16" dia max x 11/16" deep max; mounts by 3/8"-32 x 3/8" lg bushing. Measurements Corp. Part H-1085.	R-f output voltage control.
R9	RESISTOR: fixed; deposited film; 50.7 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-16.	P/o r-f ladder attenuator.

TABLE OF REPLACEABLE PARTS

SYMBOL	DESCRIPTION	FUNCTION
R10	RESISTOR: fixed; deposited film; 7.52 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-15.	Same as R9.
R11	RESISTOR: fixed; wire wound; bifilar; 59.4 ohms ± 1/2%; body 5/8" lg x 3/8" dia; two radial wire leads. Measurements Corp. Part HQ-24-2.	Same as R9.
R12	RESISTOR: fixed; deposited film; 7.33 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-14.	Same as R9.
R13	RESISTOR: same as R11.	Same as R9.
R14	RESISTOR: fixed; deposited film; 7.33 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-14.	Same as R9.
R15	RESISTOR: same as R11.	Same as R9.
R16	RESISTOR: fixed; deposited film; 7.33 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-14.	Same as R9.
R17	RESISTOR: Same as R11.	Same as R9.
R18	RESISTOR: fixed; deposited film; 7.33 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-14.	Same as R9.
R19	RESISTOR: Same as R11.	Same as R9.
R20	RESISTOR: fixed; deposited film; 6.6 ohms, ± 1%; 1/2 watt. Measurements Corp. Part H-4882-13.	Same as R9.
R21	RESISTOR: fixed, deposited film 53 ohms ± 1%; 1/2 watt. Measurements Part H-4882-21.	Output cable termination.
R22	RESISTOR: variable; wire wound; 500 ohms ± 10%; 4 w; linear taper; three solder lug terminals; round metal shaft, screw driver slotted, 1/4" dia x 1/2" lg from mtg surface; contact arm insulated; case 1-13/16" dia x 15/16" deep; mounts by 3/8"-32 x 3/8" lg bushing. Measurements Corp. Part HT-3-3.	Voltage adjust for Diode Heater.
R23	RESISTOR: variable; wire wound; 15,000 ohms ± 15%; 2 w; linear taper; one solder lug terminal; screw driver adjust; case 1-5/8" lg x 1-1/8" w x 1/2" h; two mtg holes 3/32" dia spaced at 1-7/16" ctrs. Measurements Corp. Part H-4846.	P/o termination for Modulation filter.

SYMBOL	DESCRIPTION	FUNCTION
R24	RESISTOR: fixed; composition; 4,700 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-472.	P/o termination for Modulation filter.
R25	RESISTOR: fixed; composition; 22,000 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-223.	Screen resistor tube V2.
R26	RESISTOR: same as R1.	Grid resistor, tube V2 (Bands A to E).
R27	RESISTOR: fixed; composition; 33,000 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-333.	Grid resistor, tube V3 (Bands A to E).
R28	RESISTOR: fixed; composition; 7 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-5338.	Parasitic suppressor, grid, tube V3.
R29	RESISTOR: fixed; composition; 10,000 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-103.	Grid resistor, tube V2 (Band F).
R30	RESISTOR: fixed; composition, 15,000 ohms ± 10%; 1/2 watt. Measurements Part H-3728-153	Grid resistor, tube V3 (Band F).
R31	RESISTOR: fixed; composition; 4,700 ohms ± 10%; 2 w; 11/16" lg x 5/16" dia; two axial wire leads. Measurements Corp. Part H-3734-472.	Screen resistor, tube V3.
R32	RESISTOR: same as R25.	Load resistor for plate section, coil L17.
R33	RESISTOR: variable; wire wound; one section 20,000 ohms ± 10%; 4 w. rating; linear taper; three solder lug terminals; round metal shaft, screw driver slotted, 1/4" dia x 1/2" lg from mtg surface; case 1-17/32" dia x 11/16" deep; mounts by 3/8"-32 x 3/8" lg bushing. Measurements Corp. Part H-5339.	% Mod Cal.
R34	RESISTOR: fixed; metal film; 635,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-37.	Series multiplier, meter M2.
R35	RESISTOR: fixed; composition; 470,000 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-474.	P/o Zero set bucking network for Mter M2.
R36	RESISTOR: fixed; metal film; 50,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-16.	P/o % MOD CAL network.
R37	RESISTOR: fixed; metal film; 27,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-12.	Same as R36.

SYMBOL	DESCRIPTION	FUNCTION
R38	RESISTOR: fixed; metal film; 5,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-6.	Diode load resistor, tube V4.
R39	RESISTOR: variable; wire wound; one section; 1,000 ohms ± 10%; 2 watt rating; linear taper; three solder lug terminals; round metal shaft, screw driver slotted, 1/4" dia x 3/8" lg from mtg surface; contact arm insulated; case 1-1/4" dia x 9/16" deep; mounts by 3/8"-32 x 1/4" lg bushing. Measurements Corp. Part H-5556.	% Mod Zero set.
R40	RESISTOR: fixed; metal film; 190,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-28.	P/o negative feedback network tube V5 to V6.
R41	RESISTOR: fixed; composition; 240 ohms ± 5%; 2 w; 11/16" lg x 5/16" dia; two axial wire leads. Measurements Corp. Part H-3733-241.	Cathode resistor tube V5.
R42	RESISTOR: same as R35.	Grid resistor, tube V5.
R43	RESISTOR: same as R35.	Plate resistor, tube V6.
R44	RESISTOR: fixed; composition; 2.7 megohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-275.	Screen resistor, tube V6.
R45	RESISTOR: fixed; composition; 470 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia two axial wire leads. Measurements Corp. Part H-3728-471.	P/o cathode resistor tube V6.
R46	RESISTOR: fixed; composition; 2.2 megohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-225.	Grid resistor, tube V6.
R47	RESISTOR: same as R29.	P/o cathode resistor tube V6.
R48	RESISTOR: variable; composition; one section; 100.000 ohms ± 20%; 3 w; audio taper; 3 solder lug terminals; case 1-3/8" dia x 9/16" deep; round metal shaft 1/4" dia x 7/8" lg from mtg surface; flat on shaft 7/16" lg; contact arm insulated; mounts by 3/8"-32 x 3/8" lg bushing. Measurements Corp. Part HT-2.	Modulation control.
R49	RESISTOR: fixed; metal film 265,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-30.	P/o frequency determining cct. for 1000-cycle osc.
R50	RESISTOR: same as R49.	Same as R49.

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
R51	RESISTOR: fixed; composition; 12,000 ohms ± 10%; 2 w; 11/16" lg x 5/16" dia; two axial wire leads. Measurements Corp. Part H-3734-123.	Plate resistor, tube V7.
R52	RESISTOR: same as R3.	Feedback control, plate V7 to cathode V8.
R53	RESISTOR: fixed; metal film; 400,000 ohms ± 2%; 1 w. Measurements Corp. Part H-5592-32.	P/o frequency determining cct. for 400-cycle osc.
R54	RESISTOR: fixed; composition; 680 ohms ± 5%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3727-681.	Cathode resistor, tube V7.
R55	RESISTOR: same as R35.	Grid resistor, tube V7.
R56	RESISTOR: fixed; composition; 100,000 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-104.	Plate resistor, tube V8.
R57	RESISTOR: same as R35.	Screen resistor, tube V8.
R58	RESISTOR: same as R53.	P/o frequency determining cct. for 400-cycle osc.
R59	RESISTOR: fixed; wire wound; 2,800 ohms + 10%; 20 w rating; body dim. approx 2" lg x 1/2" dia; vitreous enamel coated; two solder lug terminals; panel mounted by axial screw. Measurements Corp. Part H-5340.	Voltage dropping resistor, +B supply.
R60	RESISTOR: fixed; wire wound; 3,000 ohms ± 10%; 20 w rating; body dim. approx 2" lg x 1/2" dia; vitreous enamel coated; two solder lug terminals; panel mounted by axial screw. Measurements Corp. Part H-5249.	Voltage dropping resistor, +B supply.
R61	RESISTOR: fixed; composition; 100 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-101.	Plate series resistor tube V10.
R62	RESISTOR: fixed; composition; 1,000 ohms ± 10%; 1/2 w; 3/8" lg x 9/64" dia; two axial wire leads. Measurements Corp. Part H-3728-102.	P/o damping network, choke L24.
R63	RESISTOR: fixed; deposited film; 120 ohms ± 1%; 1/2 watt. Measurements Part H-4882-22	Attenuator compensator resistor.

SYMBOL	DESCRIPTION	FUNCTION
RT1	RESISTOR: thermal; 70 ohms nominal at 72 deg F; nominal operating current 0.3 amp; for AC/DC use; ballast tube type; ST-14 bulb, 4-11/16" lg. overall max.; mounts in octal socket. Measurements Corp. Part H-833.	Ballast resistor, heater circuit of tube V1.
S1	SWITCH: push button; momentary contact; normally open; SPST; 7/8" lg x 1/2" wd x 1-1/2" h overall. Measurements Corp. Part H-5341.	Actuates tuning drive motor.
S2	SWITCH: same as S1.	Actuates tuning drive motor.
S3	SWITCH: push button; 6 push rods; 2 sections each; silver contacts; solder lug terminals; 5-5/8" lg x 2-1/4" wd (excluding rod extension) x 1-19/32" h o/a; push rod extends 15/16"; two mounting holes on 5-3/8" ctrs Measurements Corp. Part H-1035.	R-f range switch.
S4	SWITCH: push button; 1 push rod; DPDT; single wafer; solder lug terminals; 1-3/8" lg x 1" wd x 1/2" h; push rod extends 3/4"; two mounting holes on 3/4" ctrs. Measurements Corp. Part H-1099.	+B voltage check.
S5	SWITCH: rotary; 3 pole; 4 positions; single section; silver plated brass contacts; 3/4" lg x 1-9/16" wd 1-7/8" h; 3/8-32 threaded bushing 3/8" lg; 1/2" shaft extension; round shaft; single hole mtg; Measurements Corp. Part H-1100.	Modulation selector.
S6	SWITCH: rotary; 5 sections; each section single pole; 8 positions; NOTE: This switch is not available as an assembly and field replacement is not recommended. Part of Attenuator assembly M-229.	Output voltage range selector.
S7	SWITCH: toggle; SPST; 1-1/4" lg x 11/16" wd x 21/32" deep excluding terminals; 13/32" lg. bushing 15/32-32 thread; single hole mounting; Measurements Corp. Part H-383-1.	Power switch.

MODEL 65-B STANDARD SIGNAL GENERATOR

SYMBOL	DESCRIPTION	FUNCTION
T1	TRANSFORMER: power; input 115 volts; 50 cycles; single phase; one output winding; secondary 26 bolts at .315 amp; shell type metal case 3" lgx 2-1/2" wd x 2-1/4" h; 4 leads brought on through 2 holes in one half of shell; 4 mounting screws # 8-32 on 2-1/2 x 2" ctrs. Measurements Corp. Part H-2047	Heater supply for diode V1.
T2	TRANSFORMER: power; plate and filament type; input 117 volts; 50-60 cycles; single phase; 3 output windings; Sec # 1, 400-0-400 volts at 200 ma; red, red-yellow leads; Sec # 2, 5 volts at 4 amp; yellow leads; Sec # 3, 6.3 volts at 5.14 amp; green, green-yellow leads; shell type metal case; 4-1/2" lg x 3-3/4" wd x 4-1/4" h; leads brought out through 2 holes in side of one shell; 4 mtg screws on 3-3/4" x 3" ctrs. Measurements Corp. Part H-1073.	Supplies power for all tubes.
V1	TUBE: electron; RTMA # 6H6. NOTE: Replacement of tube requires recalibration of meter. Order H-4888 for meter with matching diode.	R-f output Voltmeter diode.
V2	TUBE: electron; similar to RTMA # 6SK7 but equipped with ceramic base. Measurements Corp. Part H-4845.	R-f oscillator.
V3	TUBE: electron; RTMA # 6AG7.	R-f amplifier.
V4	TUBE: same as V1.	% Modulation diode.
V5	TUBE: electron; RTMA # 6L6.	Modulator.
V6	TUBE: electron; RTMA # 6SJ7.	Modulation amplifier.
V7	TUBE: electron; RTMA # 6V6GT.	P/o a-f oscillator.
V8	TUBE: same as V6.	P/o a-f oscillator.
V9	TUBE: electron; RTMA # 0D3/VR150.	Voltage regulator.

TABLE OF REPLACEABLE PARTS

SYMBOL	DESCRIPTION	FUNCTION
V10	TUBE: same as V9.	Voltage regulator.
V11	TUBE: electron; RTMA # 5U4GB	Power rectifier.
W1	CABLE: terminated; includes P1 connector, 4 ft. long cable, binding posts E1 and E2 and 50-ohm terminating resistor. Measurements Corp. Part H-5626	R-f output cable.
W2	CABLE ASSEMBLY: power; electrical; 2-cond. #18 AWG; type SJ; approximately 6 feet lg; stripped both ends. Measurements Corp. Part H-714.	Power cable.
XE12	LAMPHOLDER: single holder; for candelabra screw base lamp; rated 125V, 75 watts; brass body 1-1/4" lg x 1/2" w x 3/4" h; two solder lug terminals; angle bracket mounted one hole. Measurements Corp. Part H-5342	Mounts E12
XRT1	SOCKET: electron tube; octal; eight spring brass cadmium plated contacts; round plastic body; 1-7/64" dia x 1/2" h excluding terminals; one piece saddle mtg; two mtg holes 5/32" dia on 1-1/2" ctrs. Measurements Corp. Part H-5313.	Socket for RT1.
XV1, XV4 thru XV11	SOCKET: electron tube; octal, eight spring brass solder coated contacts; plastic body; 1-3/16" dia x 1/2" h excluding terminals; one piece saddle mtg; two 9/64" dia holes on 1-1/2" ctrs. Measurements Corp. Part H-5056.	Sockets for tubes V1, V4 thru V11.
XV2, XV3	SOCKET: electron tube; octal; eight spring brass contacts; ceramic body; 1-3/32" dia x 1/2" h excluding terminals; one piece saddle mtg; two mtg holes .140" dia on 1-1/2" ctrs. Measurements Corp. Part H-5228.	Sockets for tubes V2, V3.

LIST OF COMPONENTS FOR MODEL 65-B
MOTOR CONVERSION (M-525)

Quantity	Description
1	Motor Assy. complete with Pulley and Mounting Hardware.
1	Switch Assy. with Connecting Leads, and 2 push buttons.
1	Pulley with Stop Pin.
1	Terminal Strip, 8 Lug.
1	Bracket with 2 - 1 mfd capacitors.
6	Screws, 6-32 x 3/8, RHBM, N. P.
6	Lockwashers, #6.
6	Nuts, 6-32 x 1/4, Hex.
2	Screws, 6-32 x 1/2, FHBM, N. P.
1	Belt (Spring)
1	Capacitor, .25 mfd, Molded Plastid.
12"	Wire, #22 AWG, Hook-Up, White/Red Tr.
1	Instruction Sheet, HM-525
1	Schematic Diagram.

Done 6/19/67

INSTRUCTIONS FOR REPLACEMENT OF MOTOR IN MODEL 65-B

1. Remove Model 65-B from its case (see Instruction Manual).
2. Remove R.F. Unit from Main Panel by removing 8 MTG screws. Unsolder necessary wires.
3. Remove tuning motor switch and cut leads.
4. Assemble new switch assembly to Main Panel using 2 Flat Head Screws, 2 Lockwashers and 2 Nuts, as shown on Sheet 3.
5. Rotate tuning shaft full counter-clockwise against stops. Remove large gear with insulating hub by removing screw in end of shaft.
6. Remove parts as shown on Sheet 4.
7. Splice 12" length of hook-up wire to Red Lead from Attenuator Shield Can.
8. Drill holes in R.F. Unit sub-panel to mount capacitor bracket assembly and motor. (See Sheet 5 for dimensions).
9. Assemble capacitor bracket assembly (See Sheet 6) to R.F. Unit sub-panel using 2 round Head Screws, 2 Lockwashers and 2 Nuts.
10. Assemble motor to R.F. Unit sub-panel (See Sheet 6 and 7).
11. Assemble terminal strip (See Sheet 6) to R.F. Unit sub-panel using 2 Round Head Screws, 2 Lockwashers and 2 Nuts.
12. Wire per Sheet 6.
13. Remove large shield cover from rear of R.F. Unit, exposing tuning capacitor.

<u>Note:</u> Tuning capacitor rotor is fully engaged.

14. Remove worm gear on tuning capacitor taking care not to lose springs in split gear.

15. Remove tuning shaft assembly.

16. Replace pulley with one supplied in kit taking care that relationship between flat for worm gear and stop pin is the same.

<u>Note</u>: The two shafts on the pulley should be concentric within .005 T.I.R. over their entire length.

17. Re-assemble tuning shaft assembly and worm gear. (Split gear should be spring-loaded approximately 1 tooth). Rotor should be fully engaged and worm set screw should be in same location as in Step 14.

18. Re-assemble large gear with stop on gear against stop on pulley.

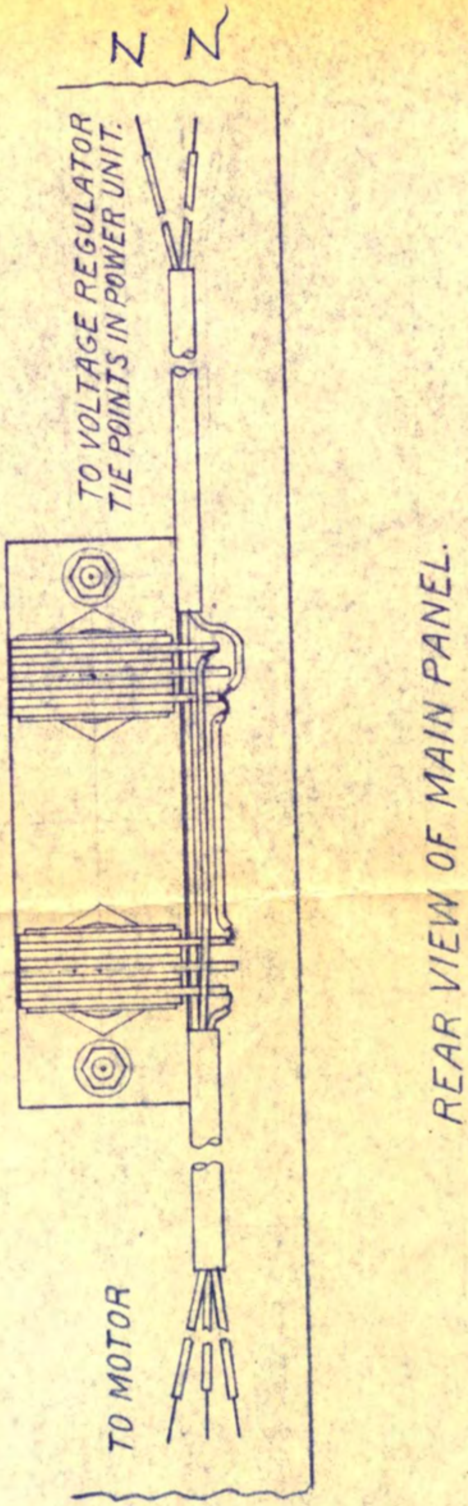
19. If the rotor is not fully engaged, it may be adjusted by loosening the set screws in the split gear and slipping the rotor shaft until rotor is .010 from being fully engaged. Tighten set screws in split gear.

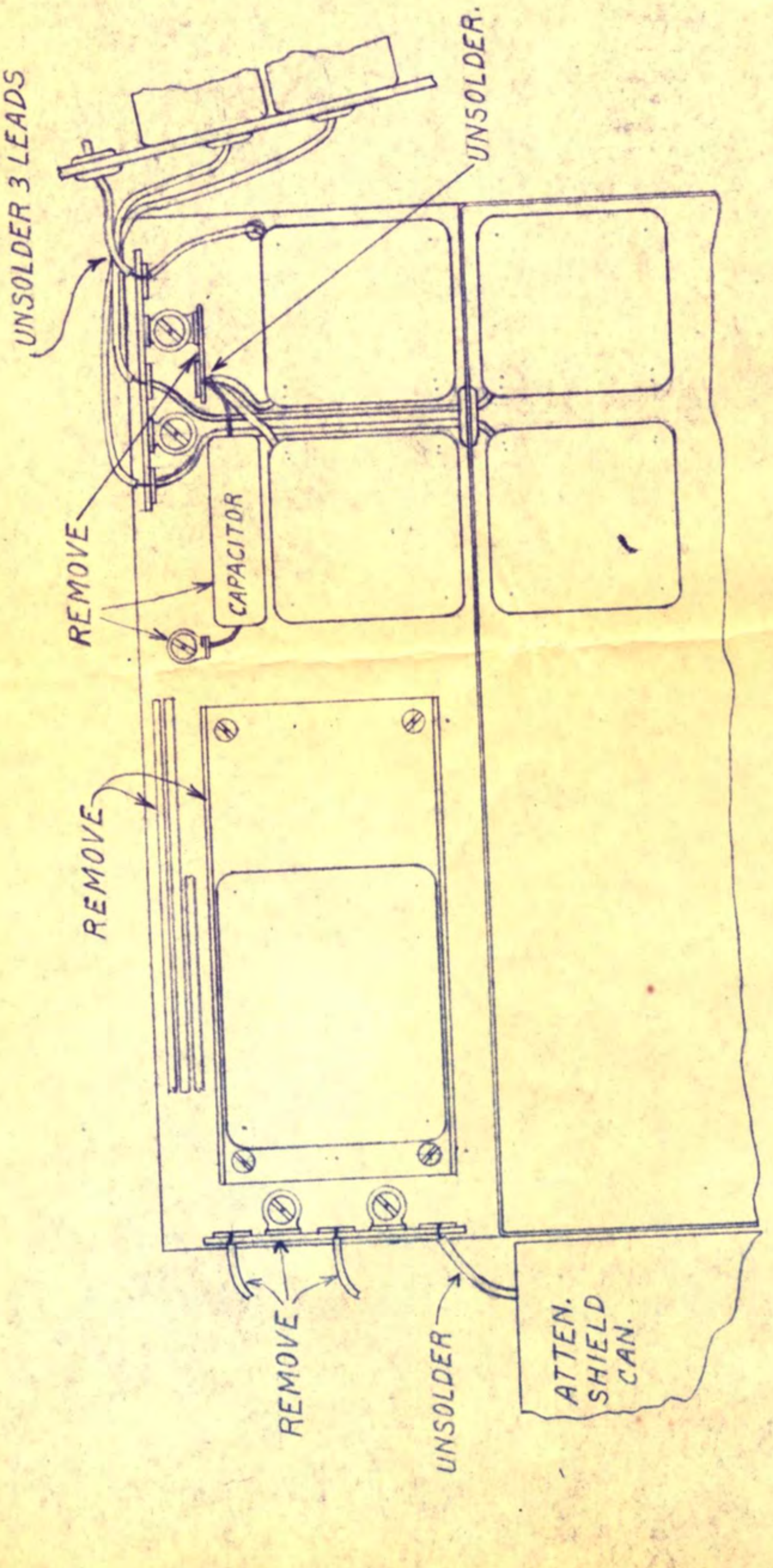
20. Assemble belt over large pulley and motor pulley.

21. Re-assemble R.F. Unit to Main Panel.

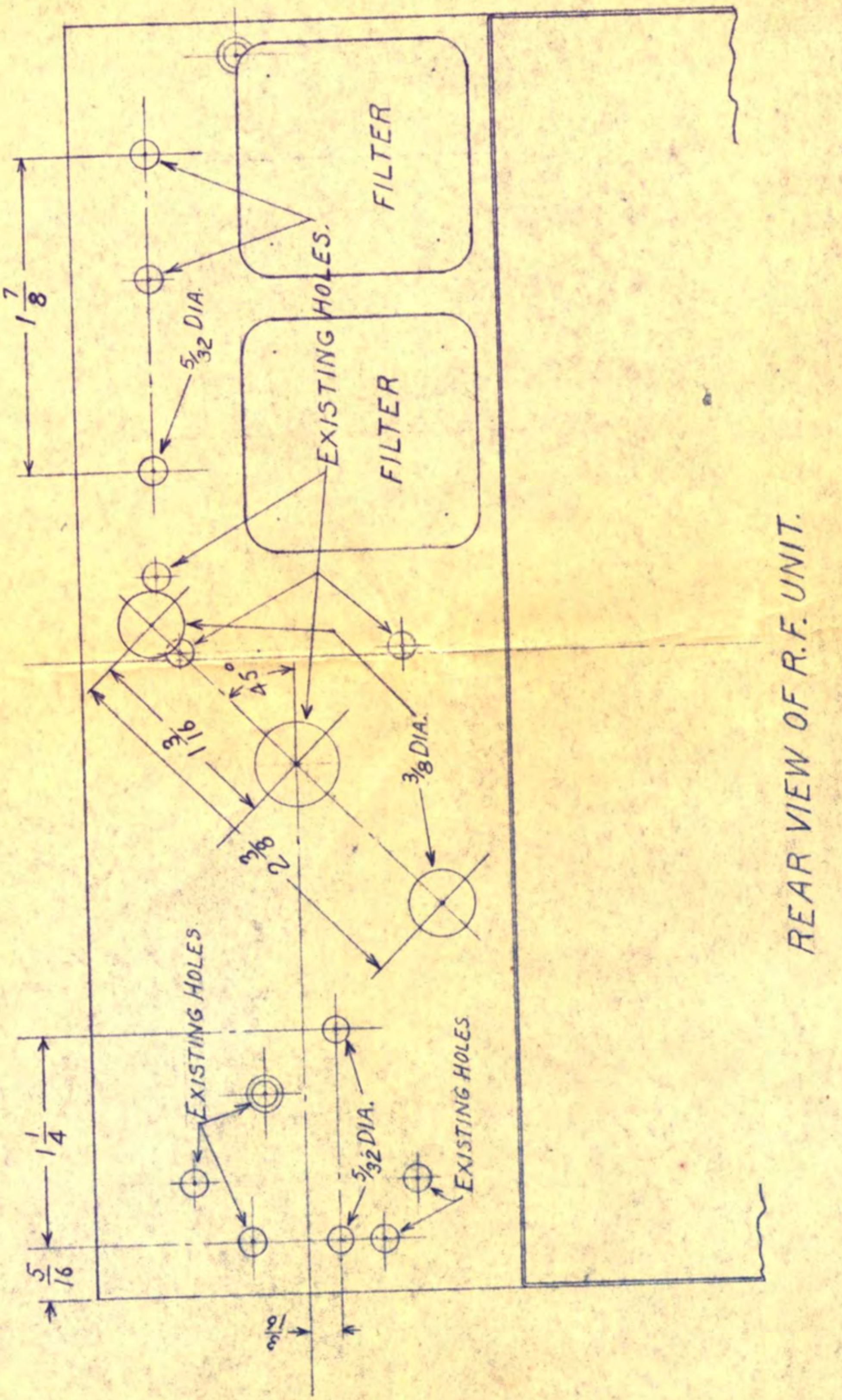
22. Replace Model 65-B in case.

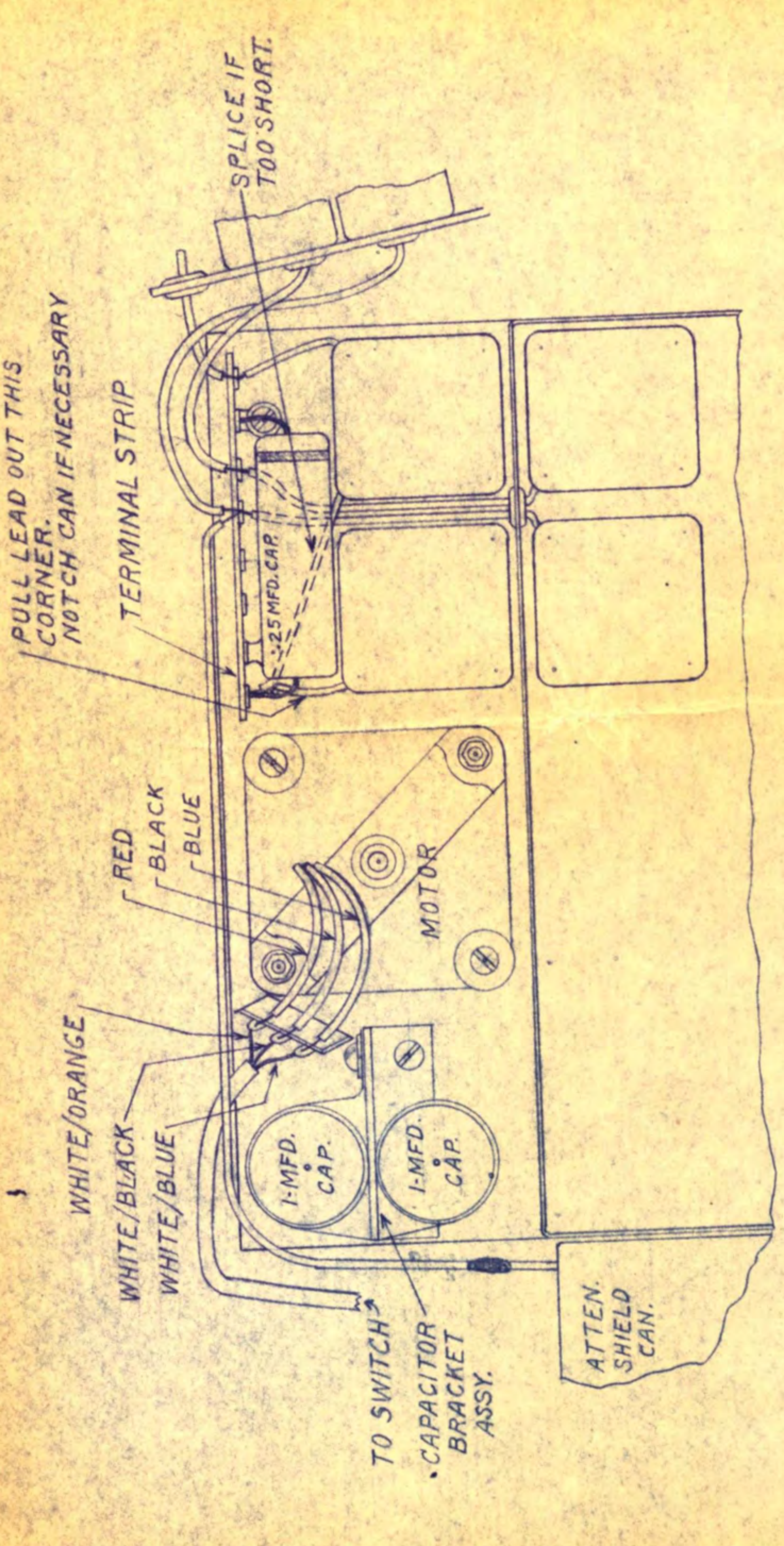
23. Re-calibrate Model 65-B if necessary.


N N
TO VOLTAGE REGULATOR
TIE POINTS IN POWER UNIT.
TO MOTOR
REAR VIEW OF MAIN PANEL.

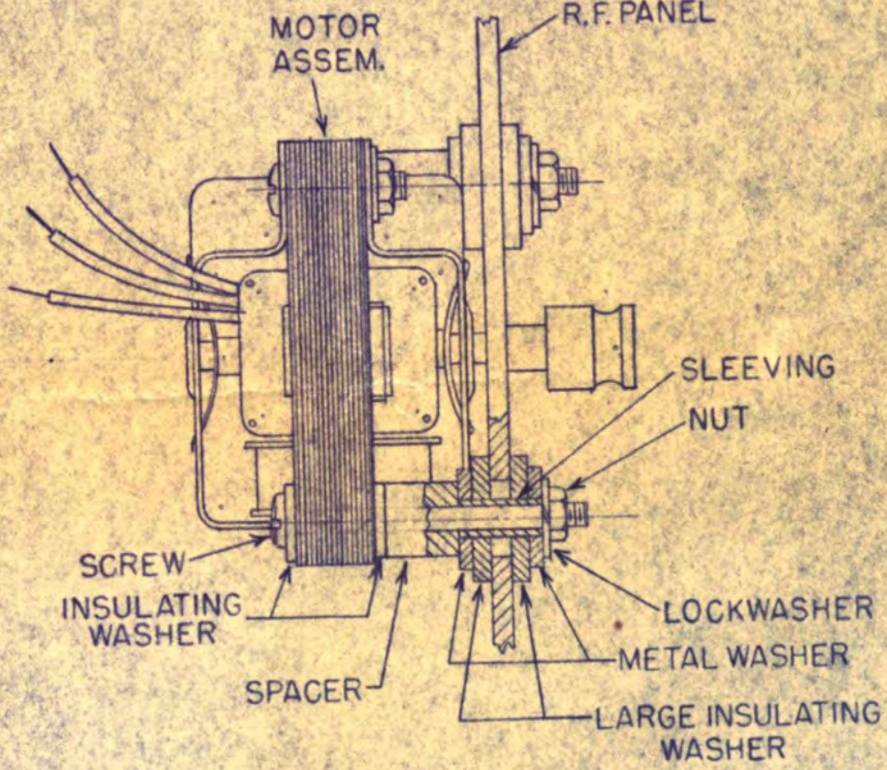


REAR VIEW OF R.F. UNIT.


FILTER
FILTER
EXISTING HOLES.
5/32 DIA.
1 7/8
1 3/16
45°
3/8 DIA.
2 3/8
EXISTING HOLES
1 1/4
5/32 DIA.
EXISTING HOLES
5/16
3/16
REAR VIEW OF R.F. UNIT.



REAR VIEW OF R.F. UNIT.


MOTOR
ASSEM.
R.F. PANEL
SLEEVING
NUT
SCREW
INSULATING
WASHER
LOCKWASHER
METAL WASHER
SPACER
LARGE INSULATING
WASHER

Model 65-B 10/18/60

Part numbers of the following reference symbols should be changed as noted:

R9	change	part	number	to	H-6485-4
R10	"	"	"	"	H-6485-3
R12	"	"	"	"	H-6485-2
R14	"	"	"	"	H-6485-2
R16	"	"	"	"	H-6485-2
R18	"	"	"	"	H-6485-2
R20	"	"	"	"	H-6485-1
R21	"	"	"	"	H-6485-7
R63	"	"	"	"	H-6485-8