TYPE 205A FM MODULATION METER

Lampkin ENGINEERING DATA SHEETS

OPERATING INSTRUCTIONS

(1) Connect the FM Modulation Meter (MOD meter) to a source of power as specified on the nameplate. Turn the POWER switch ON, and allow the unit to warm up for three minutes or more. Turn the SPEAKER switch ON.

(2) Place the slide switch, labeled 25.0 and 12.5 KC, for the desired range on the PEAK KC meter. With the selector switch on MODULATION, and no antenna connected to the receptacle on the rear of the MOD meter, press the QUIET switch on the front panel; use the MOD. ZERO ADJ. knob to set the PEAK KC meter to zero. The zero setting may change when the slide switch is moved; therefore, be sure to recheck MOD. ZERO ADJ., if the range is changed.

(3) Change the selector to TUNE MAX. Put the 27″ whip antenna (supplied with the unit) through the hole in the top, left rear of the case, and into the coaxial receptacle. Turn the FM transmitter on, without modulation, and tune all over the MOD meter dial, noting deflections on the PEAK KC meter. Set the dial to the greatest deflection noted, which should be more than 3 KC. Turn the transmitter off, and check that the PEAK KC meter goes to zero, then turn the transmitter back on.

(4) With the selector switch on TUNE ZERO, move the polarity switch back and forth from POSITIVE to NEGATIVE; carefully adjust the vernier-tuning disc so that the PEAK KC reading is the same in either position within 1/3 KC. The loudspeaker must be quiet and the PEAK KC needle must definitely go above and below zero as the vernier tuning is moved.

(5) With the selector switch on MODULATION, modulate the transmitter with the desired voice or tone and read the FM deviation on the PEAK KC meter, at both POSITIVE and NEGATIVE positions of the polarity switch.

GENERAL NOTES

The tuning knob is two-piece; grasp both the rear knob and the front disc for rough tuning, then the front disc only for fine tuning. The control range of the vernier disc is from the 9 o'clock to 3 o'clock position of the white spot; if you run out of control near these positions, set the white spot at 12 o'clock, retune slightly with the rough knob, and then again use the vernier.

Keep TUNE MAX deflections above 3 KC, but less than 18 PEAK KC, by adjusting the position of or coupling to the antennas. See Section 3.01 inside this booklet.

Radio noise or interference around 2.5 megacycles picked up by the antenna, may affect the initial readings of the PEAK KC meter in any position of the selector switch, or may be heard in the speaker. Should interference be present, try to identify the source and eliminate the effect; see Section 3.02 in this booklet.

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RECEIVING INSPECTION

To check the Modulation Meter when received, connect it to a source of power, as specified on the nameplate. On AC there is no need to observe polarity on the attachment plug, for the AC line is insulated from the instrument case. Turn the power switch ON, and allow the meter to warm up for a few minutes. Two pilot lights, just above the meter dials, indicate when the power is on. The whip antenna is folded at the back of the case.

Normal operation of the meter (with no antenna connected at the rear receptacle) is shown by zero deflection on the PEAK KC meter with the selector switch in TUNE MAX position; put the switch in TUNE ZERO position, and rotate the MOD. ZERO ADJ. knob to see if the PEAK KC meter goes up to 10 or 15 KC and down below zero, and leave it around 3 KC. With the switch on MODULATION, the reading will be from 2 to 10 KC, on either POSITIVE or NEGATIVE polarity. This deflection is caused by set noise, which can be heard with the speaker switch ON. The noise ceases when an unmodulated carrier is tuned in or when the QUIET button on the front panel is pressed. Set the PEAK KC meter to zero while the button is down.

This completes the initial inspection, and the meter is ready for the shelf or for use as per the instructions on the front cover.

This booklet is written around the current model of the Lampkin FM Modulation Meter — the Type 205A with dual scale. However, in general details of operation it applies to all earlier models including the Type 205.

Lampkin equipment is sold direct-to-the consumer; we have no dealers or distributors. The home office and factory at Bradenton are geared to give prompt, efficient attention both to sales of new instruments and to servicing of equipment in use. Ordinarily it is advisable to communicate with us before returning instruments for any reason; sometimes the matter can be cleared without shipping the meter back; at other times, our admonition to pack well with at least two inches of cushioning material all around and to ship by express, can save further damage by transportation agencies. There are modernization or conversion procedures by which your instrument might be brought up to date or better adapted to your specific application.

We are ready and willing at all times to help you get the most satisfactory usage from our products. Please write, phone, wire, or call in person.

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ENGINEERING DATA SHEETS

TYPE 205A FM MODULATION METER

CONTENTS

SPECIFICATIONS

TYPE 205A FM MODULATION METER

FREQUENCY RANGE — 25 to 500 mc., transmitter carrier frequency. The mixer oscillator gives coverage from 25 to 50 mc. on its fundamental, and harmonics are used for transmitter frequencies above 50 mc.

ACCURACY — 10% of full scale, on voice modulation. Full scale is either 25 peak kc. or 12.5 peak kc. selected at option by a range switch. Indicating meter is 3-inch size, 1-milliampere basic movement.

RF INPUT — High impedance to grid of mixer tube, without any RF tuning. In general, a ⅜-wave-length whip plugged into the unit will suffice for RF pickup. For improved selectivity at the transmitter frequency, or for coaxial-cable feed to the meter, an external impedance-matching section of the L- or pi-type may be attached. A whip antenna, 27" long, is furnished with each instrument.

CONTROLS AND LAYOUT — Front panel, at bottom, left to right: noise-quieting push button, coarse-and-fine tuning knob, 3-position function-selector switch, 2-position modulation-polarity switch, power ON-OFF switch, fuse holder. Center panel: 0-100 tuning-dial scale, loudspeaker grille, meter zero-adjust knob, slide switch (12.5 or 25.0 KC), PEAK KC meter. At panel top: pilot light, speaker ON-OFF switch, pilot light. At rear of case: UHF coaxial antenna receptacle, oscilloscope tip jack, power cord, nameplate. Inside case: calibration adjust control, calibrate ON-OFF switch.

SIZE AND WEIGHT — 7" x 12" x 7-¼" deep, net weight not over 14 pounds, shipping weight not over 19 pounds. Panel finish is grey enamel, white lettering, and black wrinkle on the case. Construction is all metal.

POWER SUPPLY — 115 volts, 50/400 cycles, 40 watts, through a transformer.

TUBES — 6BH6 rf oscillator, 6BH6 mixer, 6BH6 limiter, 6BH6 limiter-discriminator, 6AL5 discriminator rectifier, 6AK6 audio output, 6C4 audio amplifier, 6AL5 voltmeter rectifier, 12AU7 voltmeter, VR105 regulator, and 6X4 power rectifier; all supplied with the meter.

GUARANTEE — Lampkin products are guaranteed to give complete satisfaction or your money will be refunded. We honestly want you to be satisfied, and our service just begins with the sale. Materials and workmanship are guaranteed against defects for one year from date of sale.

TYPE 205A FRONT PANEL WITH CONTROLS IDENTIFIED

1.00 DESCRIPTION

The Type 205A FM Modulation Meter (MOD meter) is an instrument for indicating the modulation deviation of a frequency-modulated transmitter. It is tunable to any transmitter frequency from 25 megacycles to 500 megacycles, and indicates instantaneous peak frequency deviations, either positive or negative, on a 0-12.5 or 0-25 PEAK KC meter scale. The working range is 10 to 2,000 feet distance from the transmitter, depending on its power and frequency. The 205A meter is especially useful for making proof-of-performance checks, as required by the Federal Communications Commission, on transmitters used in mobile-radio communication systems; and also for the proper maintenance and servicing of such transmitters.

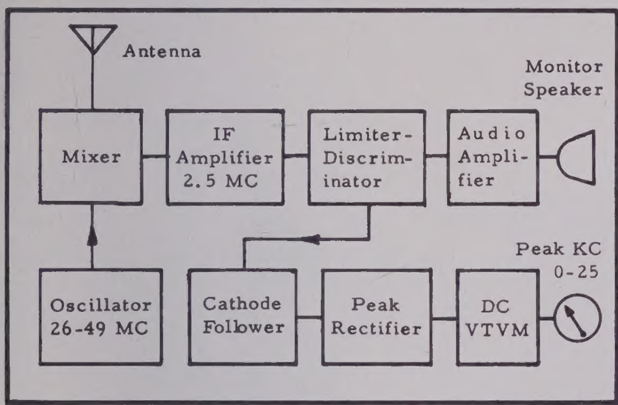


Fig. 1. Block Diagram of Type 205A FM Modulation Meter.

The salient features of the Type 205A FM Modulation Meter are:

Wide tuning range: from 25 to 500 megacycles, a 20-to-1 spread without changing coils or switching — thus accommodating an unlimited variety and number of transmitters.

Peak-reading indication on modulation: a Lampkin "first", which allows you to set up a transmitter for best modulation capability and still remain within legal limits of deviation.

Simplicity of operation: a 1-2-3 tuning procedure that takes less than 60 seconds.

Stability of calibration: the modulation-metering circuits inherently are simple and stable, and can be field calibrated, should necessity arise.

1.01 MIXER and IF CIRCUITS

A block diagram, or functional schematic, of the Type 205A meter is drawn in Figure 1. A signal from the transmitter to be measured is picked up by the antenna and impressed on the grid of a mixer tube, along with a second signal from a conversion oscillator; the conversion oscillator (VFO) is tunable over a frequency range of approximately 26 to 49 megacycles. As it is tuned, its fundamental frequency, or one of the harmonics, will come within 2.5 MC of the transmitter frequency; as any one or more of these points are passed, the difference frequency will be selected and amplified by the tuned intermediate-frequency (IF) amplifier, then fed to a pentode-type limiter; there is a moderate amount of automatic-gain-control voltage which is fed back to the mixer tube, from the limiter. The limiter cuts down the signal to a fixed level of voltage — free from amplitude modulation or variation due to input strength — which then drives the discriminator.

The discriminator consists of two tuned circuits connected in series in the plate of the limiter tube; the tuning is staggered, one circuit being higher in frequency (at approx. 2560 KC), and the other lower (at approx. 2440 KC), than the center IF frequency. The outputs of the respective tuned circuits are rectified, and connected in series with opposing polarity. Thus, at the IF center frequency, the two rectified voltages are equal and opposite, cancelling to zero. If the frequency goes higher, the voltage from the upper tuned circuit will increase while that from the lower decreases, and the net output voltage of the discriminator increases. If the frequency goes down, there is output voltage of opposite polarity. In the overall design, many details are taken into account to make the relation between frequency and discriminator-output voltage as linear as possible.

1.02 MODULATION MEASUREMENT

Directly from the discriminator load resistors, the audio voltage (corresponding to the original FM modulation) is impressed on a cathode-follower tube; the purpose of the follower is to provide a low source impedance, of the order of 300 ohms, for charging the input condenser of a shunt-fed rectifier. Since this condenser value is 0.47 microfarad, and since condenser charging time by circuit theory is R (ohms) x C (farads) = Time (seconds), it will charge in about $300 \times 0.47 \times 10^{-6} = 141 \times 10^{-6} = 141$ microseconds, or about ½ cycle at 3,000 cycles per second. On the other hand, the discharge resistor for the rectifier is 1 megohm; so the discharge time is around ½ second. The net effect is that the rectifier charges quickly and accurately to the instantaneous peaks of modulation, but the charge holds on long enough for the indicating meter to respond and be read easily.

The indicating meter is a 0-1 DC milliammeter connected in a balanced-triode DC vacuum-tube voltmeter, or VTVM. It responds to the DC voltage out of the peak rectifier, but is calibrated for PEAK KC swing out of the transmitter. Since the 205A monitor continuously displays the instantaneous peak modulation, there is no need for a peak flasher lamp as employed with some competitive monitors.

A separate audio-amplifier stage working off the discriminator drives a small loudspeaker to permit aural monitoring of the signal quality, for use as an aid in tuning, and for communication with the transmitter being monitored. There is provision for connecting a cathode-ray oscilloscope directly across the discriminator output. Thus a three-way check on the transmitter modulation is possible with the 205A meter: aural, visual inspection of waveshape, and indication of peak deviation.

1.03 INDICATING CIRCUITS

TUNE MAX: In order to tune to resonance on a transmitter, the 0-1 DC milliammeter is switched (in the TUNE MAX position of the selector switch) to indicate the grid current on the limiter tube; while in this position, the tuning control of the conversion oscillator may be varied to produce one or more resonant peaks of grid current — which of course occur whenever the difference frequency between the oscillator, or one of its harmonics, and the transmitter crosses 2.5 megacycles. The tuning control is adjusted to the maximum reading. While in TUNE MAX function, the PEAK KC milliammeter indicates relative field strength.

TUNE ZERO: In this position the milliammeter is switched back to the DC vacuum-tube voltmeter, and the VTVM is connected through a 5.6-megohm multiplier across the discriminator output. The tuning control is then touched up for center-frequency tuning as shown by balanced deflection on the VTVM.

The DC bias for the VTVM is arranged so that, when set to zero by means of the MOD. ZERO ADJUST control in the MODULATION position of the switch, the milliammeter will read a few KC above zero in the TUNE ZERO position. This offset is called the "base reading", and is necessary so that the balance point will not fall below zero. When adjusting the tuning control for TUNE ZERO, one can set the milliammeter to base reading; alternatively, one can adjust the tuning so that base reading is the same in either the positive or negative positions of the modulation polarity switch.

MODULATION: In this position of the selector switch, the DC VTVM is connected to the output of the AF peak rectifier. With no signal input to the 205A monitor, the set noise alone will produce a modulation reading of 5 KC, more or less. Pushing the QUIET switch on the front panel shorts the mixer plate voltage, quiets the noise, and permits setting zero on the VTVM using the MOD. ZERO ADJUST knob. When a transmitter is tuned in, the set noise will be quieted, and the PEAK KC meter will read zero provided there is no residual hum or incidental FM modulation on the transmitter carrier. Another way of quieting set noise, to permit MOD ZERO adjustment, is to connect a 2.0-mfd. or larger paper condenser from the OSCILLOSCOPE jack to ground, on the rear of the chassis.

During modulation of the transmitter by voice words and syllables, the maximum excursions of the meter needle will accurately indicate PEAK KC modulation deviation. The POSITIVE-NEGATIVE switch reverses polarity of the discriminator, feeding the cathode follower, thus showing positive or negative modulation at option.

2.00 DESIGN AND CONSTRUCTION

2.01 CONVERSION OSCILLATOR

Of the blocks shown in the functional diagram of Figure 1, the two which contribute most to the performance of the 205A monitor are the conversion oscillator, and the discriminator.

The conversion oscillator has stability comparable to a crystal-controlled oscillator, although it is tunable; it makes possible converting any transmitter frequency, even at 450-megacycles, down to the measurement channel of 2.5 megacycles — without drift, without adding incidental frequency modulation, without changing coils, and without the necessity for AFC (automatic frequency control). The oscillator uses the ratio-coupled circuit*, developed by Lampkin Laboratories, Inc., in 1938.

* "An Improvement in Constant-Frequency Oscillators" G. F. Lampkin, Proc. I.R.E., March, 1939, page 199.

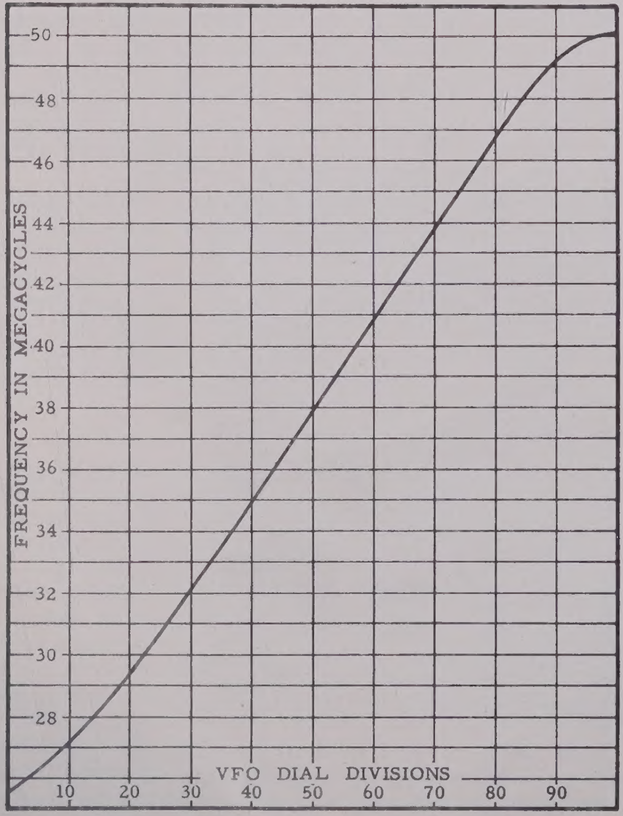


Fig. 2. Typical tuning curve for the conversion oscillator (VFO) in the 205A Meter. Transmitter coverage, using the VFO fundamental frequency, is 2.5 MC above and below the end points; VFO harmonics are employed up to 500 MC.

The total frequency drift of the oscillator during instrument warmup is of the order of 100 cycles per megacycle, in a negative direction; the drift stabilizes after 80 to 90 minutes of operation. The frequency shift caused by a 5% change in line voltage, is about 30 cycles per megacycle with the VFO dial at the high-frequency end, and about 1/5 of this at the low-frequency end. These drift figures are very small compared to those of more common oscillators, and the practical effect is that the MOD meter will stay tuned to a transmitter for long periods with little or no tuning adjustment.

The tuning dial for the conversion oscillator has a friction drive on its rim, giving a ratio of about 15 to 1 between the coarse tuning knob and the condenser shaft. The condenser is a transmitting type, Isolantite insulated, with double-spacing of plates and double end bearings for rigidity in tuning. The rotor plates are mid-line shaped to open up tuning at the low-capacity end of the dial. The oscillator tube connects across only 32% of the coil turns, in the ratio-coupled circuit; as a result, operating parameters of the tube have relatively small effect on oscillator frequency. The oscillator filament choke minimizes incidental FM, and acoustic feedback or howl from the loudspeaker.

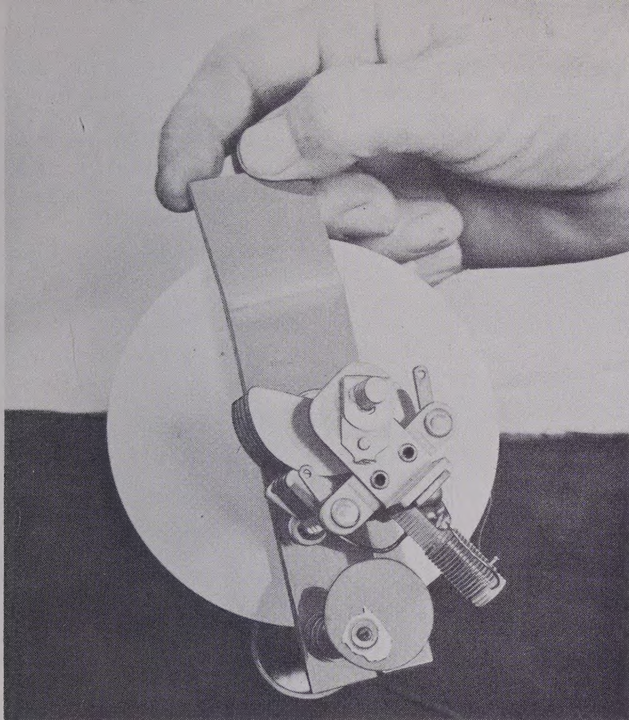
The vernier frequency control is a simple copper disc, eccentrically mounted and rotatable in the field of the oscillator coil. The total tuning range of the vernier varies from about 0.1% at the low end to 0.3% in frequency at the high end of the tuning dial — a little small to have much effect at 25 MC, but just about right at 150 MC and 450 MC. When the selector switch is on TUNE ZERO, one PEAK KC change on the milliammeter corresponds roughly to 5 KC shift in the IF.

A typical tuning curve for a 205A conversion oscillator is given in Figure 2. This tuning range will vary somewhat, depending on the manufacturer of the variable condenser which is installed.

It is possible to estimate the dial setting or settings at which a given transmitter will be tuned. An example of the procedure follows, using an assumed transmitter frequency of 152.27 MC (Xmtr MC):

Step 1a: Add 2.5 MC to Xmtr MC:
152.27 Xmtr MC
+2.50 IF MC
154.77 MC

Step 1b: Subtract 2.5 MC from Xmtr MC:
152.27 Xmtr MC
−2.50 IF MC
149.77 MC



Rear view of conversion oscillator assembly, showing tuning dial, tuning condenser, tapped inductance on solid polystyrene threaded form, and eccentric copper disc for vernier tuning.

Step 2: Divide the results above, 1a and 1b, by consecutive whole numbers which yield answers from 20 MC to 55 MC, thus:

	Harmonic		VFO MC		VFO Dial
154.77 MC	÷ 7	=	22.1	=	x
154.77 MC	÷ 6	=	25.8	=	2
154.77 MC	÷ 5	=	31.0	=	26
154.77 MC	÷ 4	=	38.7	=	52
154.77 MC	÷ 3	=	51.6	=	x

	Harmonic		VFO MC		VFO Dial
149.77 MC	÷ 7	=	21.4	=	x
149.77 MC	÷ 6	=	25.0	=	x
149.77 MC	÷ 5	=	30.0	=	22
149.77 MC	÷ 4	=	37.4	=	48
149.77 MC	÷ 3	=	49.9	=	95

The whole numbers are harmonics of the VFO, and the answers are possible VFO frequencies.

Step 3: Refer to the VFO calibration curve in Figure 2, to find the dial readings for the possible VFO frequencies. The respective dial readings are tabulated under VFO Dial. The VFO frequencies marked "x" fall outside the range of Figure 2.

From the above it can be seen that a given transmitter might be tuned at more than one place on the VFO dial. A transmitter in the 30-MC band might tune at one spot only, a 150-MC transmitter at five or six spots, and a 450-MC outfit at a dozen or more.

2.02 MIXER and IF AMPLIFIER

Referring to the circuit diagram in the back of this book, both the output of the conversion oscillator, and input from the transmitter via the antenna receptacle, are capacity coupled to the grid of the pentode mixer tube, 6BH6 MIXER. Coil L2 is tuned by means of a powdered-iron core with screw-thread adjustment; combined with the tube and circuit capacities, it tunes broadly as an anti-resonant circuit at the IF frequency. Mixing occurs in the grid of the 6BH6 MX; the resulting intermediate frequency is selected in the plate circuit by the L3-C5 combination. The 6BH6 LIMITER tube on the circuit diagram more properly is an IF amplifier (the designation could better be applied to the next tube in line) but the name is an early commitment, hard to change at the present time. Its plate circuit is tuned to 2.5 MC by L4 and C7.

In Figure 3 are given curves showing the average sensitivity of the two models, 205 and 205A. The curves were obtained by connecting a signal generator to the input of the respective models, and noting the RF millivolts required to obtain a reading of 3 PEAK KC with the selector in TUNE MAX position (limiter grid current). The curves as drawn are on the conservative side. The overall sensitivity of the 205A model is around 20 millivolts in the 30, 150, and 450-MC bands, and the upper cutoff frequency is somewhere beyond 500 MC — contrasted with about 50 millivolts and 300 MC for the older 205 unit. On the 72-MC band, tuned by the second harmonic of the VFO, the sensitivity is down for both models.

2.03 DISCRIMINATOR

As suggested in Section 2.01, the discriminator is the No. 2 heart of the MOD meter. During preliminary design a wide variety of discriminators was investigated: among others, the Foster-Seeley was discarded because it operates on phase difference — something rather hard to control at 2.5 MC.

The calibration of the stagger-tuned discriminator in the 205A meter depends primarily on the frequency separation of the resonant peaks of two tuned circuits, and on the amplitude of each peak. These two things control the slope of the frequency-voltage curve, as drawn in Figure 4. The two tuned circuits are made mechanically and electrically alike, so that each resonant frequency will be affected similarly

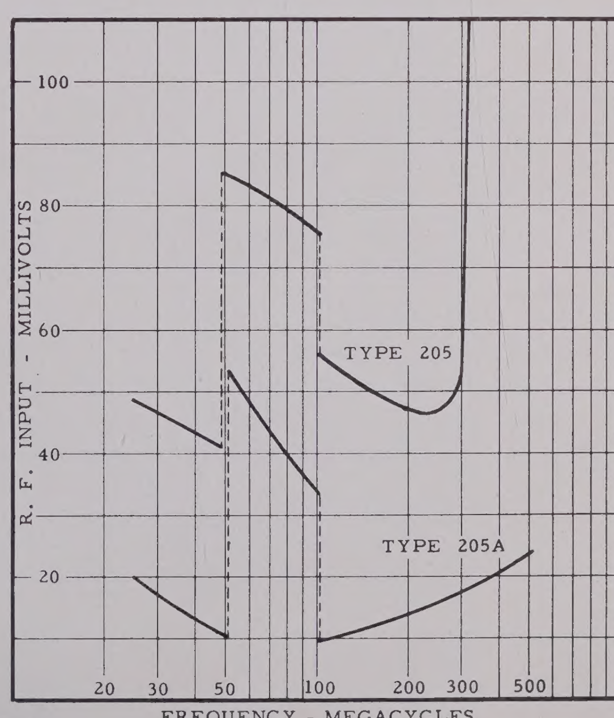


Fig. 3. Sensitivity curves for the 205 and 205A Meters, showing RF input required for 3 PEAK KC deflection in TUNE MAX position.

by outside factors — if the one frequency goes up, so does the other, and the difference or separation stays put.

The discriminator works out of a pentode limiter tube, 6BH6 DISCRIMINATOR on the circuit diagram. This tube is driven heavily so that its plate current is cut off on the negative cycles of grid voltage, and the tops of the positive cycles are lopped off when the grid tries to go positive and draws grid current; the result is a square wave of plate current, of nearly constant amplitude at 2.5 MC, going through the discriminator tuned circuits. Some of the 6BH6 DS rectified grid voltage is fed back to the grid of the mixer tube, for automatic gain control purposes. The plate voltage of the discriminator tube is controlled by the VR105 voltage regulator tube, to protect against errors caused by line-voltage change.

Following are certain design details aimed at discriminator-calibration constancy: the resistor R10 straightens out a kink in the discriminator curve, apparently due to harmonic resonance in the IF transformer primaries. Resistor R10, discriminator load resistors R11 and R12, and the voltage-divider resistors R20 and R21 are all 1% stability, deposited-carbon type, since their values directly affect overall accuracy. The secondary tuning condensers C11 and C12 have a negative temperature coefficient of 220 parts per million per °C.; this coefficient in conjunction with that of the coils and tubes holds the resonant peaks fixed as the temperature varies. Mechanical locks are attached to the two tuning cores of the discriminator transformers, T1.

All of these steps result in a discriminator calibration curve such as Figure 4. This curve was obtained using a Lampkin Micrometer Frequency Meter (MFM) for a signal generator coupled to the input of the MOD meter; by adjusting the coupling, the limiter (TUNE MAX) deflection for 2500 KC input was set at 10 PEAK KC, then the selector switch was put on MODULATION. An external DC vacuum-tube voltmeter having 11 megohms input resistance, was connected across the outside of the discriminator load resistors, R11 and R12. The DC VTVM was calibrated against laboratory standards to 1% accuracy. As the MFM frequency was varied in 10-KC steps, the resulting DC voltage was read and plotted against frequency. This particular characteristic is linear within 1% of full scale, over a 120-KC range, and is

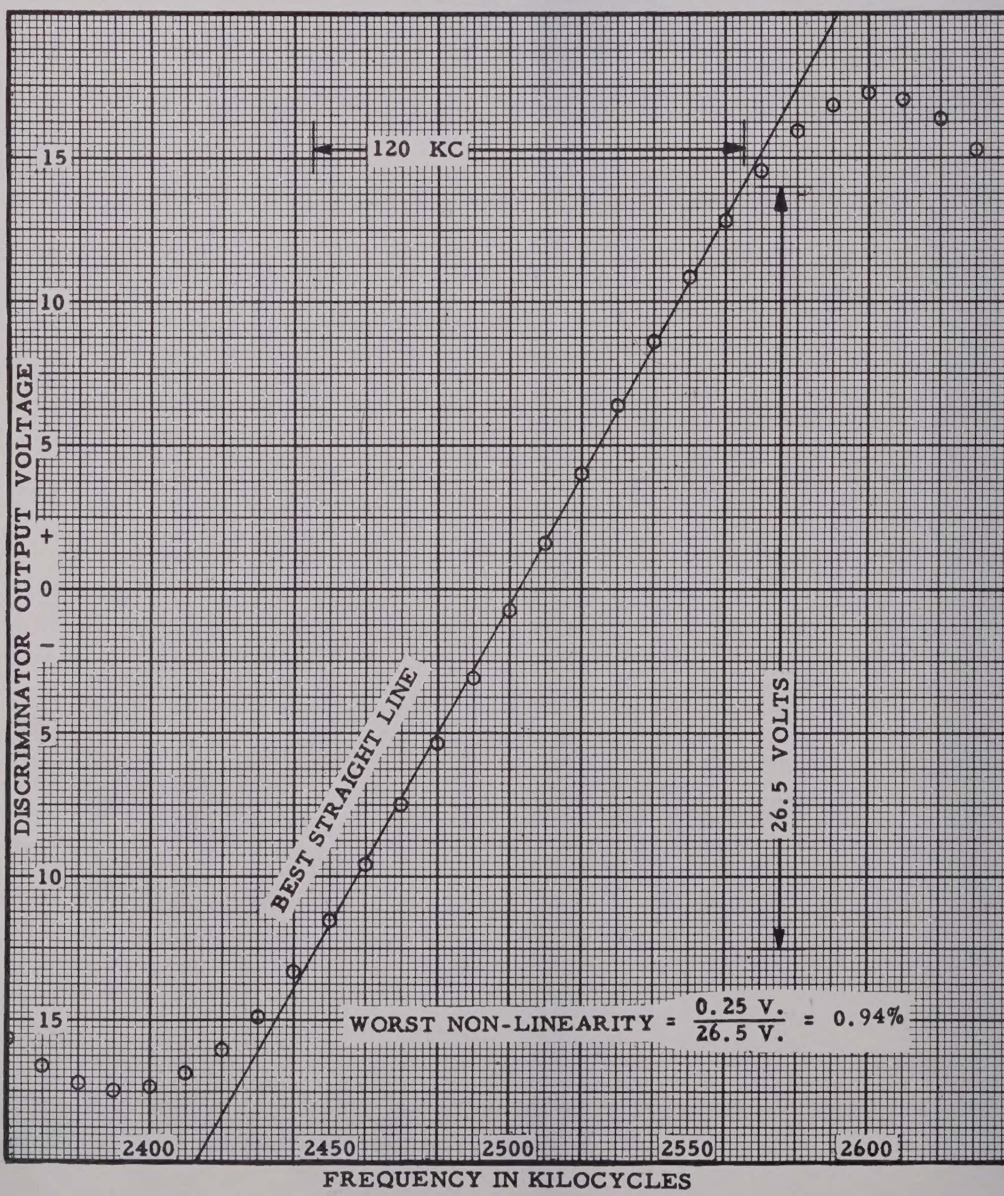


Fig. 4. Typical calibration of precision discriminator. The characteristic is linear within 1%, over a pass band of 120 KC.

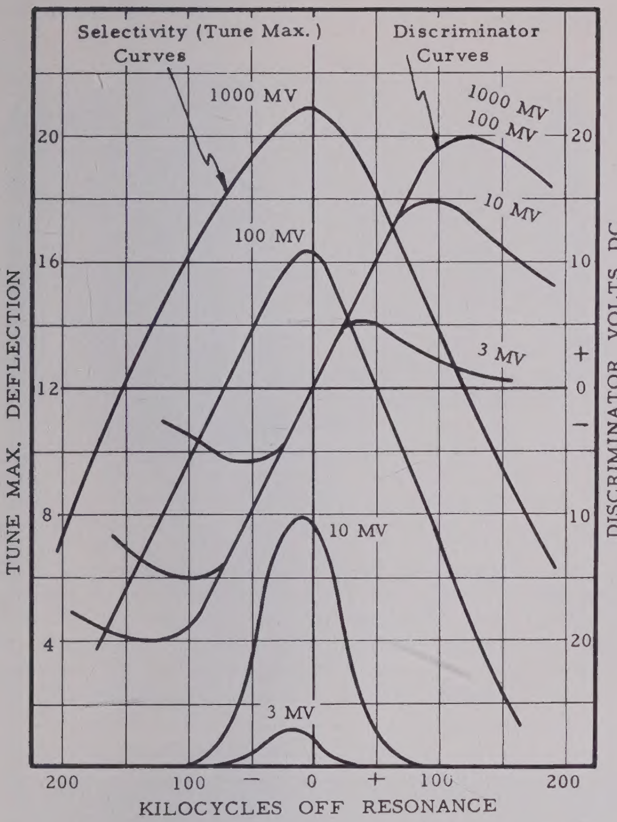


Fig. 5. Curves showing selectivity, and discriminator pass band at different levels of RF input.

typical for the 205A unit; in general, the discriminator linearity exceeds the precision of making the measurements unless laboratory standards are available.

Similar curves for the complete monitor, showing discriminator DC output voltage against frequency, are drawn in Figure 5. These were made with a Hewlett-Packard 608-A signal generator as a source, feeding the complete 205A unit at 30 MC through the antenna jack; curves were run at different RF-millivolt input levels. It is interesting to see that the discriminator pass-band decreases at very low input levels, but in each case the slope of the curve remains the same. Also interesting are the curves drawn for limiter grid current (TUNE MAX position on the selector switch); these are in effect selectivity curves for the entire unit. The limiter grid current is approximately proportional to the logarithm of the input voltage; thus the TUNE MAX scale in Figure 5 corresponds to a DB scale.

2.04 MODULATION-METERING CIRCUITS

The function of the 6C4 AF cathode follower, to provide fast rise time on voice peaks, has been described in Section 1.02; as has the peak rectifier, acting as a pulse stretcher; and likewise, the usage of the O-1 DC milliammeter in the three positions — TUNE MAX, TUNE ZERO, and MODULATION — of the function-selector switch.

In the first two selector positions, calibration accuracy is not important since the indications need to be relative only — tuning to a peak and tuning to a null. This permits concentration on the modulation-metering circuits where the overall accuracy is important.

The discriminator feeds directly into the follower, peak rectifier, and balanced-triode voltmeter. As in most AC voltmeters, the rectifier introduces a non-linearity, which results in a PEAK KC scale slightly crowded at the low end.

Range switching is inserted between the 6AL5 voltmeter rectifier and the 12AU7 DC voltmeter tube. There is a 1%-precision resistance divider at the output of the 6AL5 rectifier, consisting of R21 and R20, whose values are 0.5 megohm and 0.4 megohm, respectively. The DPDT slide switch, S7, places the 12AU7 voltmeter at the top of the divider in the more sensitive, or 12.5-KC, position, and near midpoint of the divider for the 25.0-KC scale. It may be noted that the divider ratio is $\frac{0.4}{0.5 + 0.4} = 0.444$, rather than 0.5 as might be expected. The reason is that the efficiency of the peak rectifier increases with increasing input level, so to keep the net sensitivity constant at the higher input, the potentiometer ratio must be less. Also as a result of this variation in rectifier efficiency, and in the rectifier tubes themselves, it is not possible for one set of scale markings on the meter face to be absolutely precise for both the high-scale and the low-scale figures. The graduations for the dual-scale on the 205A are a compromise, but in general the error due to this compromise will be less than 1 to 2% of full scale.

The second portion of the DPDT switch, S7, is used to preserve symmetry, on the emission voltage coming from the second half of the 6AL5 diode.

Since the 6AL5 voltmeter rectifier needs to deliver cathode currents of only a few microamperes its filament voltage can be reduced by resistor R18, for longer life and less drift with line voltage. Resistor R38 prevents accumulation of a negative charge on C17, which otherwise would cause transient kicks on the milliammeter when switching to MODULATION function. The second half of the 6AL5 VM rectifier is connected to the second half of the 12AU7 dual-triode DC voltmeter (in MODULATION function), to reduce zero drift due to line-voltage change. Plate voltage for both the discriminator and the dual-triode voltmeter is regulated by the VR 105 tube.

The net change in modulation reading, when measuring a signal with the 205A monitor, is about + 0.15% for a 1% increase in line voltage. Some error in the overall 205A calibration can arise due to changes in ambient temperature; This amounts to approximately — 0.09% for 1° F. increase in temperature. That is, if the ambient temperature rises 10 degrees, the MOD meter reading will fall 0.9%. The factory calibration temperature is 80° F.

Due to the overall polarity of IF and AF connections in the MOD meter, a downward swing of IF produces a positive indication of modulation. As noted above, and in Section 3.01 below, a transmitter usually produces a pair of response peaks; one when the conversion oscillator (or a harmonic) is tuned 2.5 MC below the transmitter, and the second when it is tuned to 2.5 MC above. When the VFO frequency is below the transmitter frequency, negative transmitter modulation corresponds to POSITIVE on the modulation meter; or, when the VFO frequency is set higher, positive transmitter FM shows POSITIVE on the modulation meter. This information may be useful when shooting trouble on a transmitter; in practice the FCC is interested only in the maximum deviation, irrespective of whether it is positive or negative.

3.00 OPERATING DETAILS

3.01 ANTENNA PICKUP

The antenna supplied with the 205A meter is a 27″ whip, and is shown attached to the receptacle in the rear-view photo. It resonates broadly in the 150-MC band, and gives reasonable pickup at other frequencies, from nearby transmitters. Since the input to the MOD meter is high impedance, a vertical whip connected directly to the input jack should be something between ¼ and ½-wave long. Listed below are approximate vertical antenna lengths, for four frequency bands:

Frequency Band - MC	Vertical Antenna Length - Inches
30-40	110
72-75	55
150-160	27
450-460	16

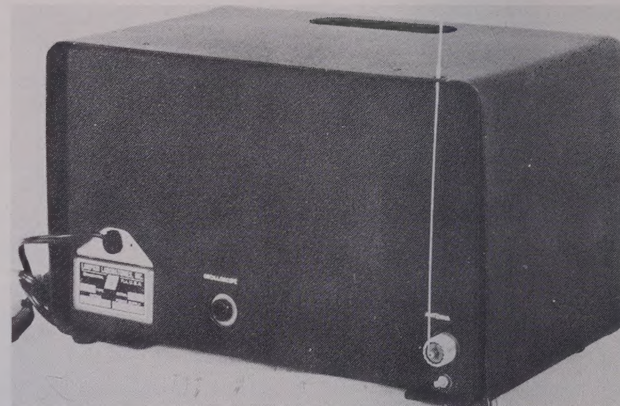
If a coaxial cable is used between the vertical antenna and the MOD meter, then the antenna length should be close to ¼-wave in order for it to match the usual 51- or 72-ohm cable. Approximately, the length will be $L = \frac{2950}{f}$, where L = antenna length in inches, and f = working frequency in megacycles. For increased pickup or directivity any of the well-known vertically polarized antenna configurations or arrays can be employed — such as ground-plane, colinear-coaxial, discone, rhombic, etc.

A length of RG-8U coaxial cable, stripped of outer braid for an antenna at one end, provides excellent FM transmitter pickup and minimizes QRM.

A simple antenna can be made from a length of RG-8U coaxial cable, by removing the outer-conductor braid from the free end, for a length of 18″ at 150 MC and a proportional length at other frequencies.

When tuning over the dial for TUNE MAX deflection, a 150-MC transmitter usually will produce a pair of response peaks, about 4 dial divisions apart, and the pair will repeat about every 30 dial divisions. This is indicated graphically in Figure 6; note that the greatest deflections do not exceed 15 to 18 KC on the meter, and any one of these is adequate for measurement.

On the other hand, if the coupling between transmitter and MOD meter is made excessive, numerous spurious peaks can appear in the tuning spectrum. Figure 7 illustrates this condition for the same setup used in Figure 6; the original response peaks are present, at the same dial settings, but there have been added many others due to harmonic interaction; note that the largest TUNE MAX deflections are still the correct tuning points, and also that the magnitude of



Rear view of Type 205A Meter, showing jack for connecting an oscilloscope across the discriminator output; also 27″ whip antenna in place.

these deflections is up to 24 KC. These two graphs illustrate the reason for keeping TUNE MAX deflections below 18 KC, and using the largest of the deflections for measurement. Modulation measurements made on a harmonic of the transmitter would be in error, since modulation frequency swing is doubled on the second harmonic, tripled on the third, etc.

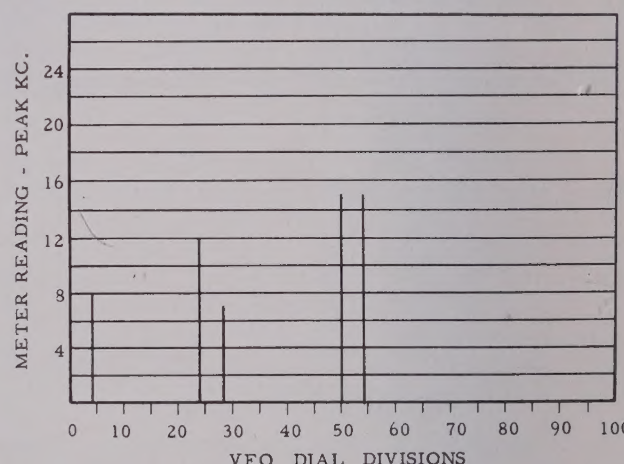


Fig. 6. Normal tuning spectrum on 150-MC transmitter, showing response peaks in TUNE MAX position. The peaks occur in pairs on the higher transmitter frequencies.

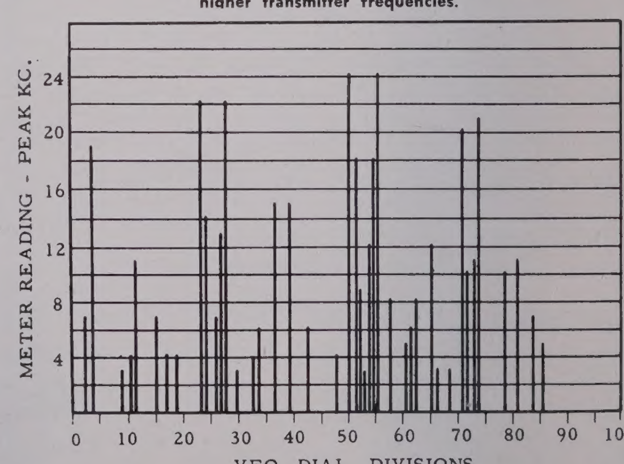


Fig. 7. Abnormal tuning spectrum on 150-MC transmitter caused by excessive input to MOD meter. Note that some deflections are greater than 20 PEAK KC, in TUNE MAX position.

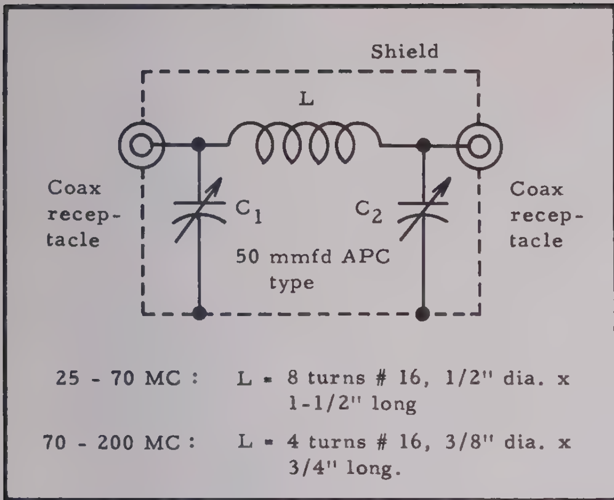


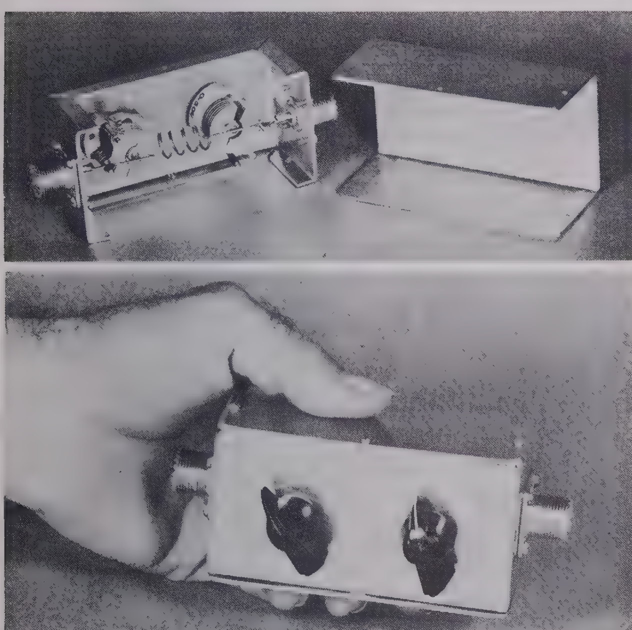
Fig. 8. Circuit diagram of pi-type matching section, for tuning coaxial-cable input to the MOD meter.

Because the input to the MOD meter is high impedance, it does not match the usual coaxial-cable impedance of 50 to 70 ohms. Some degree of matching can often occur simply because the coaxial cable is the correct electrical length overall. If desired, a lumped-constant impedance-matching section can be placed between the coaxial-cable termination and the MOD meter input; in general, such a section will increase the signal input anywhere from zero to five times, depending on the degree of original match and the efficiency of the section itself. Figure 8 gives a circuit diagram of a pi-type impedance-matching section, and values of components for two different frequency bands.

To use a matching section, connect it between the coaxial cable and the MOD meter input. Tune in a transmitter signal on the 205A, having the selector switch on TUNE MAX; adjust the coupling between the pickup antenna and transmitter for a PEAK KC deflection of 5 to 10. Then tune C1 and C2, step by step, over their respective ranges, for maximum limiter current.

When measuring mobile transmitters whose vertical antennas are at about the same elevation as the MOD meter antenna, little trouble with harmonics is experienced. On base transmitters, the antenna is often elevated well above a shielded transmitter cabinet; the radiated field directly below the antenna can be very small, while the induction field and harmonic, or subharmonic, radiation in the vicinity of the transmitter can be relatively large. In such cases, it is recommended that the MOD meter be taken out from 50 to 500 feet from the transmitter at the bottom of the antenna — at least until the characteristics of the particular installation are known.

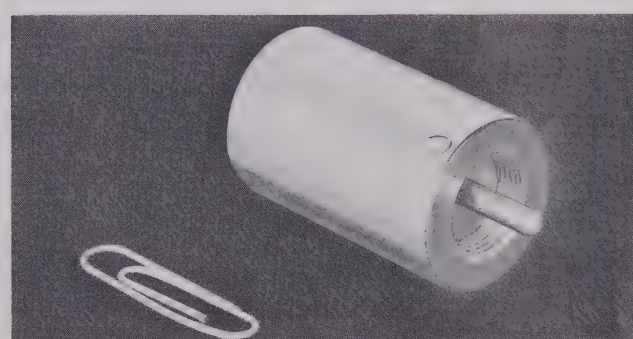
3.02 IF INTERFERENCE and NOISE



Top: Exploded view showing internal construction of pi-match section. Bottom: Completed assembly of impedance-matching section, to tune coaxial-cable input to MOD meter.

Because the input to the MOD meter is not tuned to the transmitter frequency, it is possible for it to pick up QRM or interference from signals around 2.5 MC, the intermediate frequency. Such QRM can be ship-to-shore stations, WWV, noise from sparking motors, line pops, fluorescent lights, and others. Some of it can be heard on the loudspeaker, and will kick the PEAK KC meter, in MODULATION function. Continuous-wave signals can kick the meter, in either the TUNE MAX or TUNE ZERO functions, the latter being the more sensitive indicator.

Using a pickup antenna which is cut for the transmitter frequency, and feeding it to the 205A monitor through a coaxial cable, is an excellent method of defeating QRM. The coaxial cable causes small attenuation of the desired signal, while its high capacity bypasses the interference.



A simple, series-tuned wave trap.

Wave trap attached to coaxial-cable fitting.

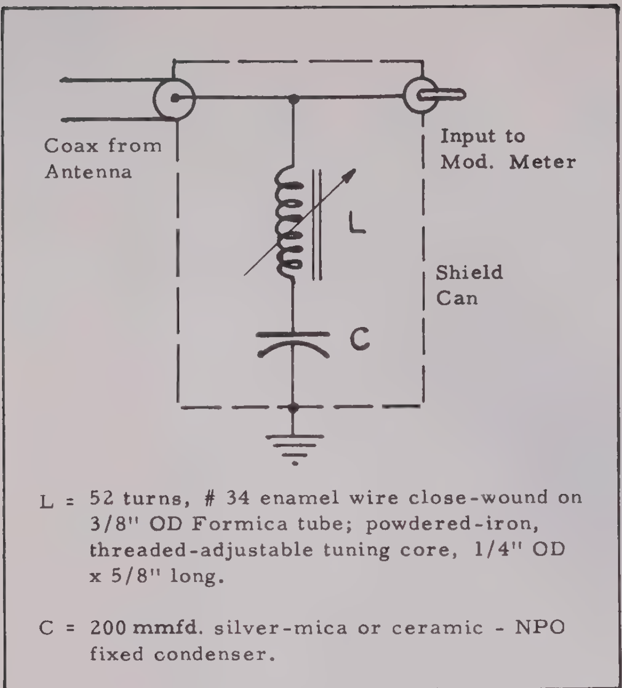


Fig. 9. Circuit details for series-tuned wave trap, to reduce interference in the MOD meter caused by sources around 2.5 MC.

For extreme cases of QRM, a combination of a wave trap, plus a pickup antenna matched to the transmitter frequency and feeding a coaxial cable, will permit operation of the MOD meter within a few hundred feet of an interfering 1-KW, 2550-KC, coastal-harbor telephone station. Figure 9 is a circuit diagram and parts list for a series-tuned trap to accomplish the job. The wave-trap unit consists simply of a coil and fixed ceramic condenser inside a shield can which screws onto a coaxial-coupling fitting; a threaded, powdered iron slug, inside the coil form is tuned through a hole in the top of the shield can, with a screwdriver, for minimum response to the interfering signal. The wave trap causes negligible loss to the desired signal.

In general, interference will have negligible effect on the MOD-meter accuracy if the following conditions are met:

(a) with antenna connected, selector on TUNE MAX, and MOD meter tuned to the transmitter as per instructions, note the PEAK KC deflection; then turn off the transmitter; any remaining PEAK KC reading should be less than 1/5 the transmitter deflection.

(b) still with antenna connected and transmitter off, check to see that the deflection on TUNE MAX is zero or the residual of (a); then put the selector switch on MODULATION; the reading due to noise or other audible interference should be less than 15 KC.

A residual TUNE MAX reading in (a) indicates an extraneous modulated or unmodulated CW signal; in (b) the character of the noise source usually can be determined by listening to the speaker. Should interference be present, try to locate and eliminate it.

3.03 OSCILLOSCOPE, and AUDIO CHARACTERISTICS

A jack is provided on the rear of the MOD meter for connecting an oscilloscope directly across the discriminator load resistors. The jack has a DC voltage of + 35 to ground; if the connected apparatus does not have a blocking condenser, one should be provided externally to prevent shorting the DC.

The usual oscilloscope, with input impedance of 1 megohm shunted by 20 or 30 mmfd., will have negligible effect on the MOD meter indications when connected to the SCOPE jack. The AF source impedance of the discriminator is approximately 25,000 ohms. Figure 10 illustrates a typical audio-frequency response curve for the MOD meter. It is a conservative average of several curves taken with modulated FM sources; and thus includes the overall response of the transmitter plus the RF and AF circuits of the MOD meter. The high-frequency AF response depends as much on the RF pass band of the MOD meter as it does the audio or metering circuits; it is well within catalog specifications.

3.04 TRANSIENT PEAK RESPONSE

It is important that the metering circuits in a modulation monitor be able to respond to the peaks of modulation, and to do so fast.

The regulations of the Federal Communications Commission state that the "maximum deviation" on modulation shall not exceed certain figures. The maximum deviation occurs of course on the peaks of the voice wave, so a modulation monitor must be actuated by the peaks.

The human voice, operating on a microphone, creates a wide variety of electrical wave forms, which vary in frequency and amplitude at word, syllable, and audio-frequency rates. Figure 11 is a drawing of three simulated wave shapes — a triangle, a sine, and a square shape, all of which have prototypes in voice communication. These wave shapes have been drawn to have the same average value, taken at 100; on this basis, the square wave has a peak value of 100, the sine wave has a peak of 157, and the triangle goes to 350!

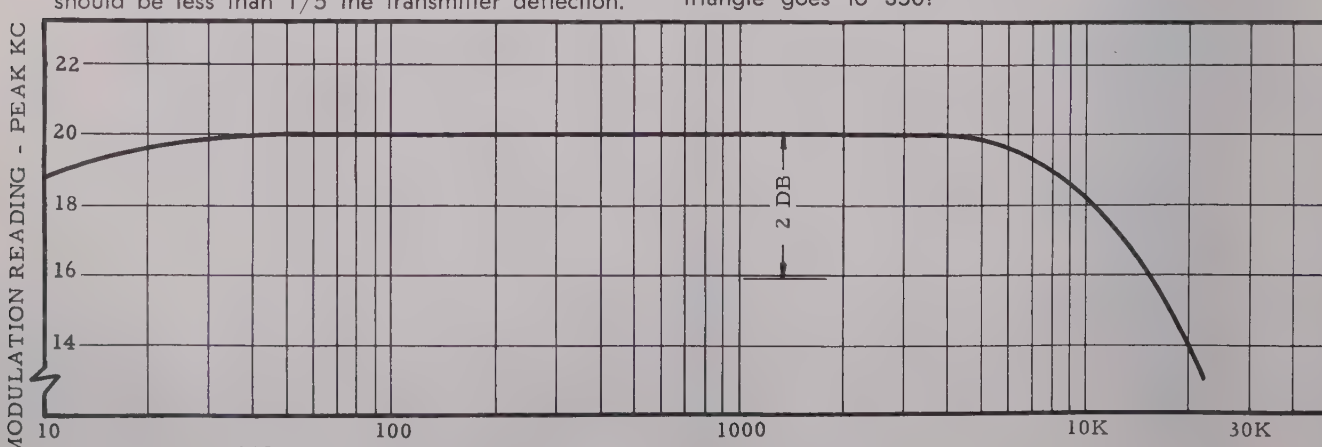


Fig. 10. Overall audio frequency response of the MOD meter, using standard FM modulated source.

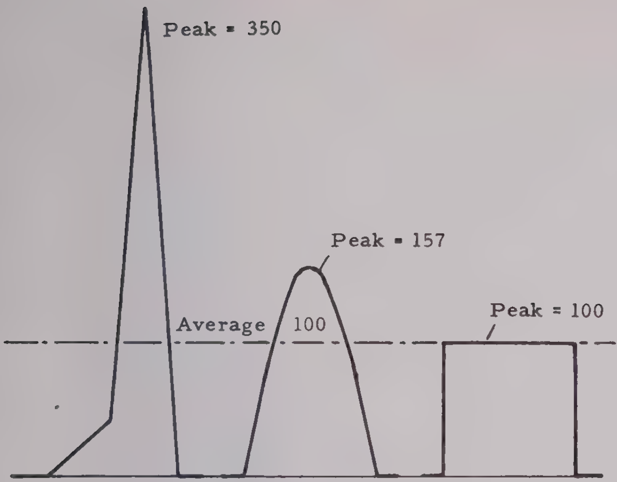


Fig. 11. Comparison of electrical wave shapes; similar waves are common in voice communication.

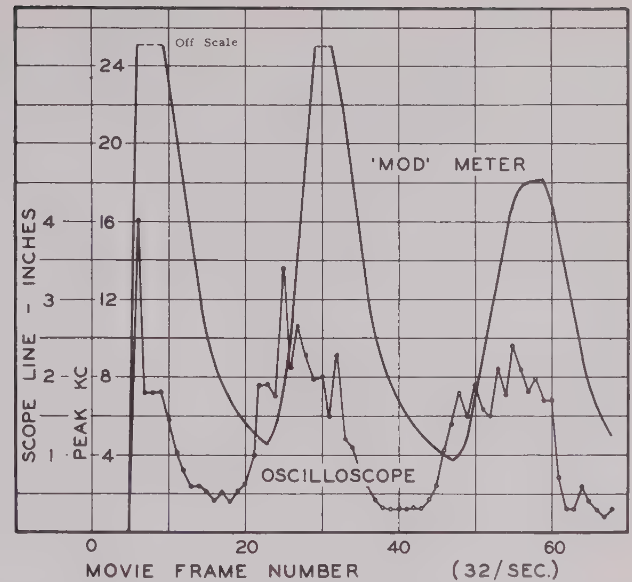


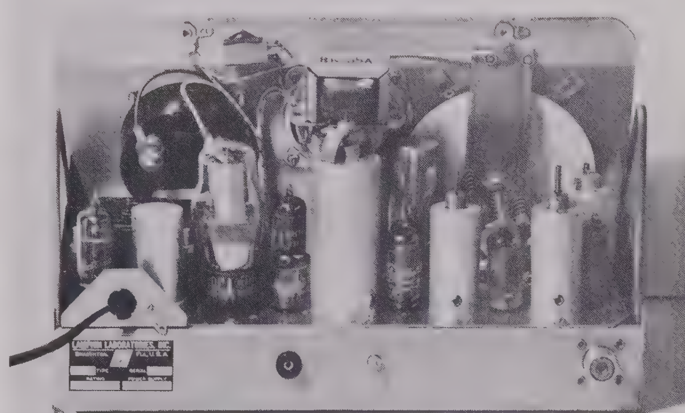
Fig. 12. Curves plotted from movie-camera film, showing simultaneous MOD-meter and oscilloscope deflections, when actuated by voice count, "One, two, three".

The male voice reproduced by a good microphone has many wave shapes tending toward the triangular in which the peak values are 4 or 5 times the average value*; on the other hand, limited or clipped speech tends toward the square-wave shape.

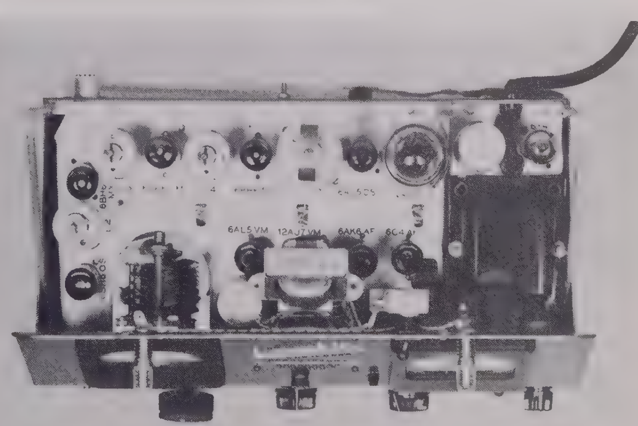
Up to the present time most mobile FM modulation monitors, other than the Type 205A, have employed an average-reading type of AC voltmeter, even though the scale might be calibrated for peak values of a sine-wave. Obviously, such an instrument would read correctly on a sine wave, but would indicate high on wave shapes of the square type, and would read low on the peaked forms. Some monitors, competitive to the Type 205A, use a peak-flasher lamp which ignites when the modulation exceeds a pre-set level. In contrast, it appears to us that a monitor should continuously and accurately display the true modulation peaks, and all models of the Lampkin FM modulation meter have been so constructed.

In order to check the peak-reading performance, an experimental setup of an FM transmitter, a MOD meter, a cathode-ray oscilloscope, and a 16-mm movie camera was made. Several hundred feet of film were run with this movie-camera setup, while investigating the dynamic response of the MOD meter to various types of modulation. The results are best illustrated by Figure 12, which is a plot of simultaneous deflections of the PEAK KC meter, and of the 'scope line, during a number count on the transmitter: i. e., "one, two, three". Because of its speed of response, the oscilloscope can be considered the final authority on instantaneous peak deflections. It can be noted that the PEAK KC meter lags behind the 'scope, but that its peak deflections are closely proportional to the 'scope peaks.

When measuring modulation on an FM transmitter, the preferred practice is to require the usual operator or dispatcher to handle the microphone in his usual manner; after setting up the MOD meter as per the instructions, observe the swings of the PEAK KC needle as he talks; take as the modulation reading the top deflections that occur about 90% of the time, disregarding the occasional higher peaks that occur about 10% of the time.



Rear view of Type 205A Meter with case removed; the overall width with case is 12", and the net weight less than 14 pounds.



Top view of 205A Meter with case removed; the RF chassis, the VFO oscillator, and the power-pack are separate assemblies.

* "Speech Power and Energy", by C. F. Sacia, Bell System Technical Journal, October, 1925. Vol. IV, No. 4.

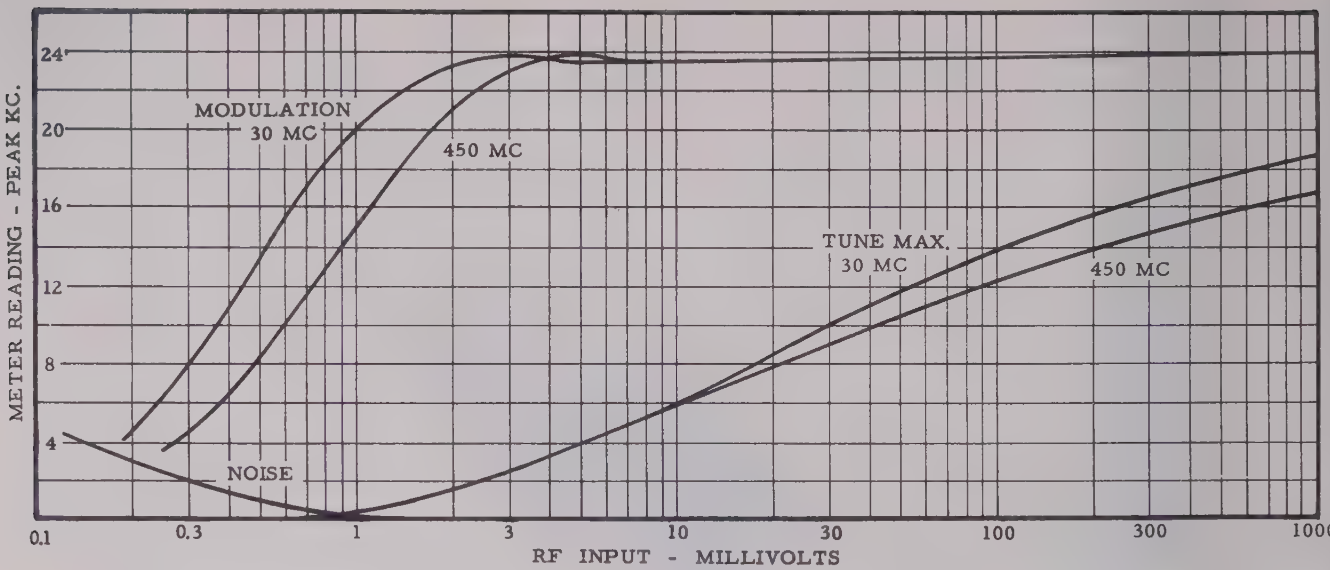


Fig. 13. Type 205A variation of modulation reading, of tuning indication and of noise quieting, all versus RF input signal level.

3.05 LIMITING, SENSITIVITY, and QUIETING

The curves of Figure 13 provide an idea of the overall performance of the 205A meter with respect to limiting, sensitivity, noise quieting, and field-strength indication. To obtain these curves, the MOD meter was fed by a Hewlett-Packard Model 608A signal generator, having calibrated attenuator output, to which a moving-coil capacity modulator was added to give frequency modulation. They are copies from graphs produced by an automatic curve tracer.

The pair of graphs marked MODULATION depict limiting action, or the variation in modulation reading shown by the PEAK KC meter, when the RF level of the standard FM signal is varied. The flat-topped portion of the curve taken at a frequency of 450 MC is essentially the same as the one for 30 MC. The total variation in modulation reading on the flat-topped portion is about 1 KC, corresponding to 5% total or +—2½%; this variation occurs while the RF input changes from 10 to 1,000 millivolts, or a 100-to-1 range.

The pair of curves marked TUNE MAX show the meter readings in the TUNE MAX function over the same range of input, at both 30 MC and 450 MC. The interesting items are that 3 PEAK KC on the limiter corresponds to a point just past the hump and onto the flat-topped portion of the modulation-reading curve; that 3 PEAK KC on the limiter requires very roughly 4 millivolts of RF input, which corresponds to better-than-average sensitivity; and that TUNE MAX deflections are approximately proportional to the logarithm of the input voltage. This means that the MOD meter gives readings similar to an S meter on a receiver, or to a DB meter, when it is employed as a relative-field-strength meter.

The remaining curve marked NOISE was taken with an unmodulated signal and shows the typical reduction of MODULATION deflection, due to set noise, as a carrier is tuned in. The set noise goes to zero before the input levels at which modulation readings might be taken.

4.00 MAINTENANCE

4.01 SOCKET VOLTAGE TABLE

A schematic diagram and a parts list are fastened inside the rear cover of this booklet. Some of the operating voltages are shown on the circuit diagram; the functions of the parts as well as the values, are listed on the second sheet as an aid in circuit analysis.

On the next page is a table giving socket voltages as measured in the MOD meter.

4.02 CIRCUIT PARAMETERS

The DC vacuum-tube voltmeter portion of the MOD meter can be quick-checked, by applying a dry cell measuring 1.5 to 1.6 volts from pin 1 of the 6AL5 VM to pin 2 of the 12AU7 VM, negative battery to the former, selector on MODULATION; starting from zero, the resulting deflection on the PEAK KC meter should be 20 to 25 KC. Do not apply the dry cell to ground — because the 12AU7 VM cathodes are +35 volts above ground. CAUTION: Do not short either terminal of the milliammeter to ground because this will blow the meter!

The AC vacuum-tube voltmeter portion of the circuit can be checked by applying an audio voltage, 200 to 2,000 cps, from ground through a 2.0-mfd-or-more paper blocking condenser to the OSCILLOSCOPE jack. For 2.0 volts RMS measured across the audio source, the PEAK KC reading should be 16 to 19, starting from zero, selector on MODULATION. The blocking condenser is necessary because the OSCILLOSCOPE jack is +35 volts with respect to ground.

The IF amplifier can be checked with a Lampkin Micrometer Frequency Meter (MFM), or other continuous-wave signal source calibrated from 2400 to 2600 KC. Set the MFM (with its selector on XMTR) to 2500 KC and couple or connect it to the input receptacle of the MOD meter; using a 103-B or 105-B MFM, the limiter reading should be 15 to 25+ PEAK KC in TUNE MAX position. Leave the back and bottom on the chassis for an IF shield. The coil L2 tunes very roughly over a range of several turns on the adjusting screw; coils L3 and L4 will peak with a fraction of a turn. L2, L3, and L4 can be touched up for resonance if desired using loose coupling to get a limiter deflection less than 5 PEAK KC, and a CW signal whose frequency is centered on TUNE ZERO.

TYPE 205A SOCKET VOLTAGE TABLE

TUBE	PIN NUMBER 1	2	3	4	5	6	7	8	9
6BH6 OS	— 3.4	0	6.0 AC	0.7 AC	+ 77	+160	0	—	—
6BH6 MX	— 1.5	0	0	5.8 AC	+123	+124	0	—	—
6BH6 LM	— 0.6	0	0	5.8 AC	+138	+139	0	—	—
6BH6 DS	— 0.9	+ 1.7	0	5.8 AC	+103	+106	0	—	—
6AL5 DS	+ 35	+ 32	0	5.8 AC	+ 35	0	+ 32	—	—
VR 105	0	0	0	0	+106	0	0	0	—
6C4 AF	+164	0	0	5.8 AC	+164	+ 35	+ 40	—	—
6AK6 AF	0	+ 11	0	5.8 AC	+160	+164	+ 11	—	—
12AU7 VM	+106	+ 34	+ 37	5.8 AC	5.8 AC	+106	+ 34	+ 37	0
6AL5 VM	+ 35	+ 34	0	4.4 AC	+ 34	0	+ 32	—	—
6X4 RECT	335 AC	0	0	5.9 AC	0	335 AC	+305	—	—

Measured with RCA Type WV77A Junior Volt Ohmyst; AC line volts = 113; VFO Dial at 50; selector on MODULATION; polarity on POSITIVE; no signal; no antenna.

Still with a continuous-wave input, and with a 2500-KC limiter current above 5 PEAK KC, check the upper half of the discriminator; set the selector on MODULATION; short a jumper from the junction of R11 and R12, to pin 1 of the 6AL5 DS, and connect a 0-50 DC vacuum-tube voltmeter from the same junction to pin 5, 6AL5 DS. The VTVM reading should peak broadly at 2600 KC +—20 KC as the input frequency is varied, at a reading of +22 volts DC +—5 volts. Similarly, the rectified output of the lower half of the discriminator can be checked by shorting from the junction of R11-R12 to pin 5, 6AL5 DS; and connecting the DC VTVM from this junction to pin 1, 6AL5 DS; the tuning should peak at 2400 KC +—20 KC, with a reading of + 22 +—5 volts DC. In no case should discriminator calibration adjustments or discriminator slug tuning be attempted at this time — these checks are suggested only for localizing trouble areas.

4.03 TUBE REPLACEMENT

The effects of tube replacement on the MOD meter calibration were investigated. Sixty different tubes of a type were obtained over the counter from radio distributors, ten each of six different manufacturers, and were inserted in turn in the respective sockets of the MOD meter, while reading a steady tone modulation from a transmitter. Except for checking in an emission-type tube tester, the tubes were not selected in any other way.

It was assumed that the oscillator and mixer tubes would have little or no effect on the calibration. The effects of changing six other tubes — the 6BH6 Limiter, 6BH6 Discriminator, 6AL5 Discriminator, 6C4 Audio frequency, 6AL5 Voltmeter, and 12AU7 Voltmeter — are shown by the curves of Figure 15 and Figure 16. For a steady modulation reading of 19.0 PEAK KC, points were plotted for the number of tubes that gave 19.0 KC, the number yielding 18.8, how many showed 20.0 KC, and so on; a smooth curve was drawn on the outside points. The more narrow the curve in width, the less effect the tube has on the calibration reading. The percentage spread marked for each curve is the error limit upward and downward, which would encompass 95% of all the tubes; it was calculated using simple statistical theory as being twice the standard deviation.

The 6BH6 LM and the 6C4 AF tubes can be replaced with negligible effect on the calibration. A new 6AL5 tube in either the discriminator or the voltmeter sockets might contribute 3% or 4% error. If necessary to change either the 6BH6 DS, or 12AU7 VM tubes, then it is a good idea to recheck the calibration, since either of these could cause errors of 10% to 20%.

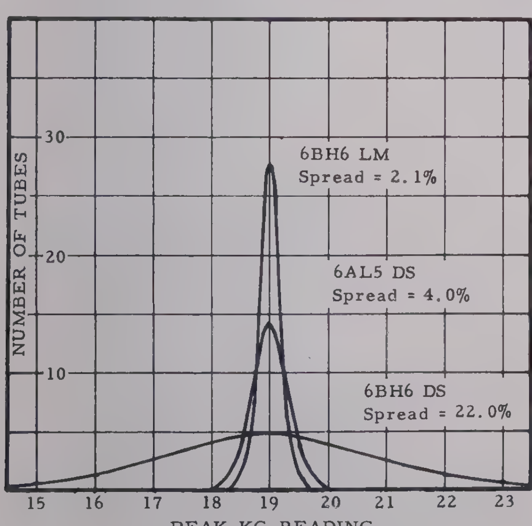


Fig. 15. Possible errors in 205A calibration resulting from tube replacement. Spread is the error limit, + and —, within which 95% of the tubes fall. The 6BH6 DS is critical.

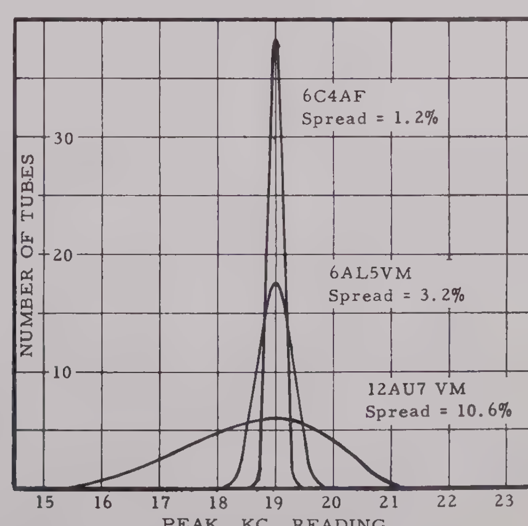


Fig. 16. Possible errors in the 205A calibration resulting from tube replacement. The 12AU7 VM tube is semi-critical.

5.00 CALIBRATION PROCEDURES

5.01 DC DEFLECTION METHOD

The Type 205A meter is designed so that the overall calibration from discriminator to meter scale reading, can be checked using only a Micrometer Frequency Meter, or other accurate CW oscillator at 2.5 MC. The idea is to generate a CW signal at the intermediate frequency of the MOD meter and set it at the center-frequency of the discriminator, as indicated by zero deflection in the TUNE ZERO position. Then the MFM is swung accurately from this point, 10 KC upward, and the resulting deflection read on the PEAK KC meter (with the 5.6 megohm multiplier shorted out).

This calibrates the discriminator and the DC VTVM for a 10-KC static frequency shift. However, when measuring FM modulation, an audio signal must pass through the follower and the rectifier, which have a net gain (loss) of 0.73 times*. Thus, the observed deflection on the PEAK KC scale must be multiplied by 0.73, and the result should equal the 10 KC frequency shift set up on the MFM.

Outlined below are the steps for DC calibration of a Type 205A meter:

(1) Remove the outer case of the Type 205A by taking out two screws at the top, and four screws holding the rubber feet. Push the chassis out the rear of the case. Leave the back and bottom on the chassis, for an RF shield.

(2) Plug both MFM and Type 205A into the power supply, and warm up for fifteen (15) minutes. Have MFM plate switch OFF, MFM selector on XMTR.

(3) Set MOD meter selector to MODULATION, and put PEAK KC meter on zero, with MOD. ZERO ADJ. knob, while pressing QUIET switch.

(4) Put coupling wires each ten inches (10") or so long, into both MFM and Type 205A tip jacks.

(5) Check with selector at TUNE MAX, to see that there are no spurious 2400 to 2600 KC signals in the vicinity which kick the meter more than 1 KC. If so, locate and eliminate them.

(6) Put selector switch at TUNE ZERO. Set MFM approximately to 2500 KC, turn MFM plate switch ON, reverse POSITIVE - NEGATIVE switch to bring MOD meter reading on scale, if necessary, and adjust MFM dial to give zero reading on PEAK KC.

(7) Throw CALIBRATE switch, located on chassis behind panel, ON — CAUTION!!!! Don't short any terminal on the 0-1 milliammeter to ground, because it will blow the meter!!!!

(8) Move selector switch to TUNE MAX, and adjust coupling between the two RF wires for a limiter reading of 10 PEAK KC. Put the selector switch back on TUNE ZERO. With polarity switch on NEGATIVE, tune the MFM and write down the dial reading which gives zero PEAK KC deflections; to this reading, add the MFM Dial Difference (the MFM dial divisions equivalent to 10 KC) at 2500 KC as taken from the MFM Standard Calibration Table; set the MFM dial to the result, then read the PEAK KC scale deflection. Repeat the process, except with the switch on POSITIVE polarity, subtract the Dial Difference from the initial MFM reading for zero PEAK KC. Set the MFM to this result, and read the PEAK KC meter. Add the two PEAK KC readings so obtained, and divide by 2 in order to obtain the average. Multiply the average by 0.73, and the result should be 10.0 KC, within a tolerance of +—1.0 KC.

(9) If the result obtained in Step 8 is out of tolerance and higher than 10 KC, turn the Rcal control, (next to the CALIBRATE Switch) clockwise from the top, say 1/16 turn. Then repeat the calibration procedure as above. DO NOT change settings of iron cores in the discriminator, unless you want to do a major job of recalibration.

(10) After the calibration is in tolerance, snap the CALIBRATE switch off.

Since frequency changes in the MFM are easily read to better than 0.1%, the accuracy of the DC calibration depends chiefly on the empirical value of follower-rectifier gain. In practice, this varies up to 3 or 4% from the mean, and the overall accuracy of the method will in general be within 5%.

5.02 AC-DC CALIBRATION METHOD

This is a variation of the DC method above; it requires an accurate, high-resistance DC voltmeter, an accurate audio-frequency voltmeter, and an audio oscillator. The procedure is to measure the DC discriminator voltage produced by a 10-KC change of frequency; then substitute an audio voltage across the discriminator, having the same peak value as the measured DC, and read the resulting PEAK-KC deflection; the deflection should equal the input-frequency shift.

Detailed steps for the AC-DC calibration check are:

(1) Remove the outer case of the Type 205A by taking out two screws at the top, and four screws holding the rubber feet. Push the chassis out the rear of the case. Leave the back and bottom on the chassis for an RF shield, but bring out an insulated lead from the +35 volt bus (pin 1, 6AL5 VM).

(2) Plug both MFM and Type 205A into the power supply, and warm up for fifteen (15) minutes. Have MFM plate switch OFF, MFM selector on XMTR.

(3) Set MOD meter selector to MODULATION, and put PEAK KC meter on zero, with MOD. ZERO ADJ. knob, while pressing QUIET switch.

(4) Put coupling wires each ten inches (10") or so long, into both MFM and Type 205A tip jacks.

(5) Check with selector at TUNE MAX., to see that there are no spurious 2400 to 2600 KC signals in the vicinity which kick the meter more than 1 KC. If so, locate and eliminate them.

(6) Connect an external 0-3 or 0-5 volt DC vacuum-tube voltmeter from the +35V DC bus (pin 1, 6AL5 VM) to the OSCILLOSCOPE jack. Set the MFM to 2500 KC. Turn the MFM plate switch on, and adjust coupling between the two RF pickup wires for a limiter reading of 10 KC +—1 KC, in TUNE MAX. Put the selector on MODULATION. With the external VTVM on positive DC, adjust the MFM tuning for zero volts DC, and take the MFM dial reading. To this reading add the MFM Dial Difference at 2500 KC taken from the MFM Standard Calibration Table; set the MFM to the result and record the DC voltage. Repeat the process, except with the VTVM on negative DC; subtract the Dial Difference from the initial MFM reading for zero PEAK KC. Set the MFM dial to the result and read the DC voltage. Add the two DC voltages, and divide by 2, thus obtaining an average.

*This constant is 0.62 for some early meters, approximately serial No. 800 and lower, which have the 6C4 AF grid connected to the 6AK6 AF grid, being at ground potential, DC.

(7) Turn the plate switch off on the MFM, and remove the DC VTVM from the MOD meter. Check MOD. ZERO ADJ. setting. Connect an audio oscillator, of 500 to 1,000 cps, through a 2-mfd.-or-larger paper blocking condenser to the OSCILLOSCOPE jack and to ground on the MOD meter. Connect an accurate AF voltmeter across the audio source. Multiply the average DC voltage obtained in Step (6) by 0.707, to obtain the RMS value; set the AF voltmeter to this RMS value, and read the resulting MODULATION deflection on the PEAK KC scale. It should equal 10.0 KC +—1.0 KC.

(8) If the calibration is out of tolerance and high, rotate Rcal clockwise about 1/16 turn. Then repeat the steps (6) and (7). DO NOT change the settings of the tuning cores in the discriminator can, unless you want to do a major job of recalibration. CAUTION: DO NOT short the 0-1 DC milliammeter to ground because it is +35 volts above ground!!!!

The overall accuracy of the AC-DC check depends on the calibration accuracy of the AC and DC voltmeters, and on the purity of wave shape of the audio generator. If the AC and DC voltmeters are accurate to 1% or 2%; and the audio wave shape has less than 1% distortion, then this method will be accurate to 2 or 3%. However, since many electronic voltmeters can be 5% or more in error, on both DC and AC, they either should be calibrated against laboratory standards at the scale reading and on the audio wave employed — or, greater reliance should be placed on the DC and Bessel-calibration methods.

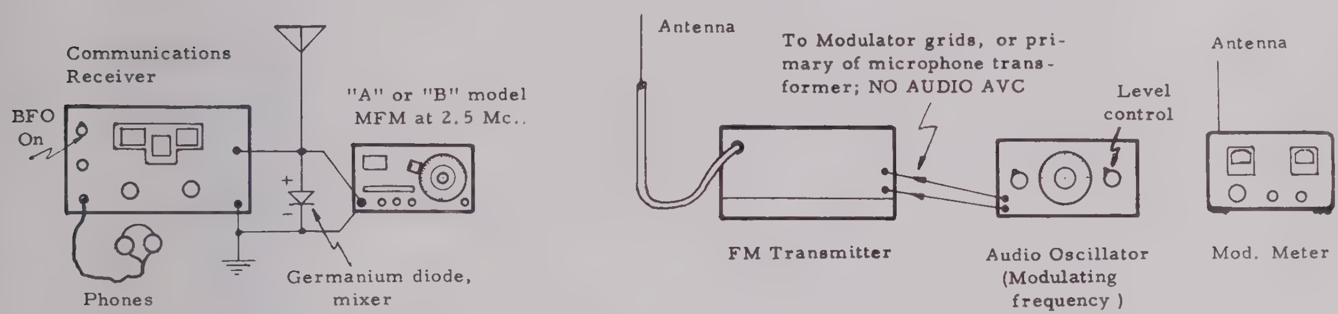


Fig. 17 Apparatus setup for Bessel-function method of calibration on MOD meter.

5.03 BESSEL FUNCTION METHOD

The basic calibration check on the Type 205A meter involves the so-called Bessel-function method. In this method, sine-wave modulation is applied to an FM transmitter; using an AM receiver equipped with a beat-frequency oscillator for continuous--wave reception, a beat note is obtained from the FM carrier. While listening to the beat note, the sine-wave level is slowly increased, starting from zero. It will be found that the strength of the beat note, and likewise the FM carrier, goes through several zero points, or nulls, as the modulation level is increased. At each of these nulls, there is a definite mathematical relation between the FM deviation and the frequency of the sine-wave used for modulation. Knowing the deviation, the MOD meter reading can be compared therewith.

Many communications receivers tune only to 20 or 30 megacycles, whereas FM transmitter frequencies of 150 to 450 megacycles are common. If an AM receiver should not be available at the transmitter frequency, the latter can readily be mixed with a CW signal from an "A" or "B" model Micrometer Frequency Meter, or other oscillator, and moved into the tuning range of the communications receiver. A typical setup is shown in Figure 17.

Tune up the MOD meter on the FM transmitter, as explained in the OPERATING INSTRUCTIONS on the front cover. With filament and plate switches ON, the MFM will produce a harmonic series spaced 2.5 MC, and some of these will mix with the transmitter output frequency. At first, have the audio-oscillator output level at zero. Tune the CW receiver (BFO on) for a likely-sounding signal, probably around 10 to 30 MC and close by an MFM harmonic. To identify the desired signal, turn off the MFM plate switch, and the FM transmitter carrier, one at a time, and see if the beat note disappears. If so, the beat arises from the transmitter carrier, mixed with the MFM. Turn both on again. Adjust antenna positions and receiver controls for loudest beat signal in the phones. Then slowly increase the audio gain from zero, listening closely to see when the selected beat note, in the headphones, goes through a null; then spot the center of the null on the audio gain control. Remove the wire from the tip jack of the MFM, (to kill the CW signal at the IF frequency) and read modulation on the MOD meter tuned to the FM transmitter.

The modulation deviation at each of the carrier nulls bears a definite relation to the sine-wave modulating frequency as follows:

FM Carrier	Bessel Factor (B)	Modulating Frequency (KC)	Modulation Deviation (B x KC)
First Null	2.40	2.00	4.8 KC
Second Null	5.52	2.00	11.0 KC
Third Null	8.65	2.00	17.3 KC
First Null	2.40	3.00	7.2 KC
Second Null	5.52	3.00	16.6 KC
First Null	2.40	4.00	9.6 KC
Second Null	5.52	4.00	22.1 KC
First Null	2.40	5.00	12.0 KC
First Null	2.40	6.00	14.4 KC
First Null	2.40	7.00	16.8 KC

It will be noted that the modulation deviation is the product of the modulating frequency multiplied by the Bessel factor.

The accuracy of any single setting, using this method, is of the order of 5%. For best results several readings should be taken in the upper part of the PEAK KC meter scale, the POSITIVE and NEGATIVE readings averaged, and the results plotted on graph paper. Use PEAK KC readings as the vertical scale and carrier modulation deviation, or Bessel KC, as the horizontal scale. After plotting five or more points, draw a straight line through zero at the lower left on the graph paper, on up through the average, by eye, of the plotted points. Theoretically, this line should pass through 25 KC on both vertical and horizontal scales. Practically, at 25 KC Bessel deviation, the line should intersect the PEAK KC scale between 22.5 and 27.5 KC, or +—10% of full scale, to be within guaranteed accuracy on the instrument. A typical Bessel-function check for a Type 205A is shown in Figure 18; the calibration is 2% high.

As in any measurement setup, several factors can influence results. The modulating sine-wave should be reasonably pure (this is determined by the AF source) and the demodulated wave should be reasonably pure (this is determined by the FM modulator in the transmitter). If these waves look good on a cathode ray oscilloscope, they are usable.

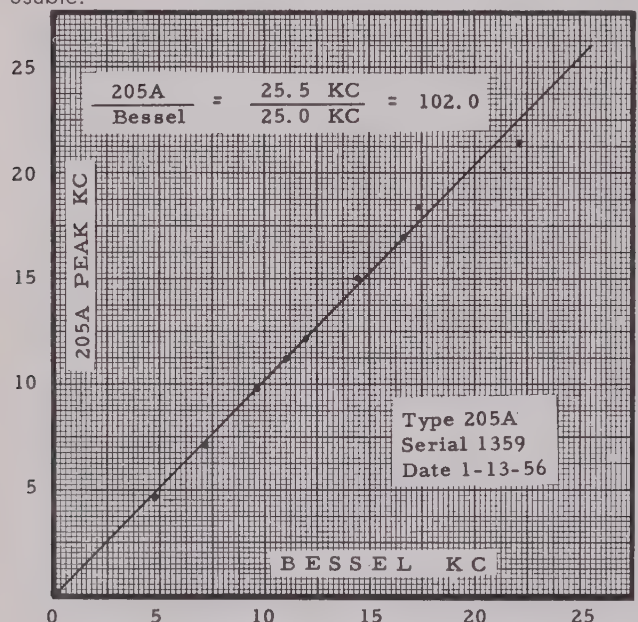


Fig. 18. Bessel-function calibration check on MOD meter. With attention to detail, the overall precision of the method is within 1% to 2%.

The value of audio frequency should be accurate to +—1%, since it directly affects the accuracy of the result. If the modulating frequency is less than some 3,000 cycles, it becomes difficult to separate the carrier beat note from the other complex tones; a good "CW Ear" developed in radio amateur work comes in handy here. The job is easier with modulation at 5,000 cycles or higher. The Type 205A limiter level has some effect on the modulation reading, and factory calibration is carried out at a limiter reading of 10 KC +—1 KC, taken with selector switch on TUNE MAX.

If the FM transmitter has any form of automatic audio volume control, or audio limiting, this must be cut out. Sometimes it is necessary to have 5 or 10-wavelengths spacing between the FM transmitter and CW receiver, in order to get a good null.

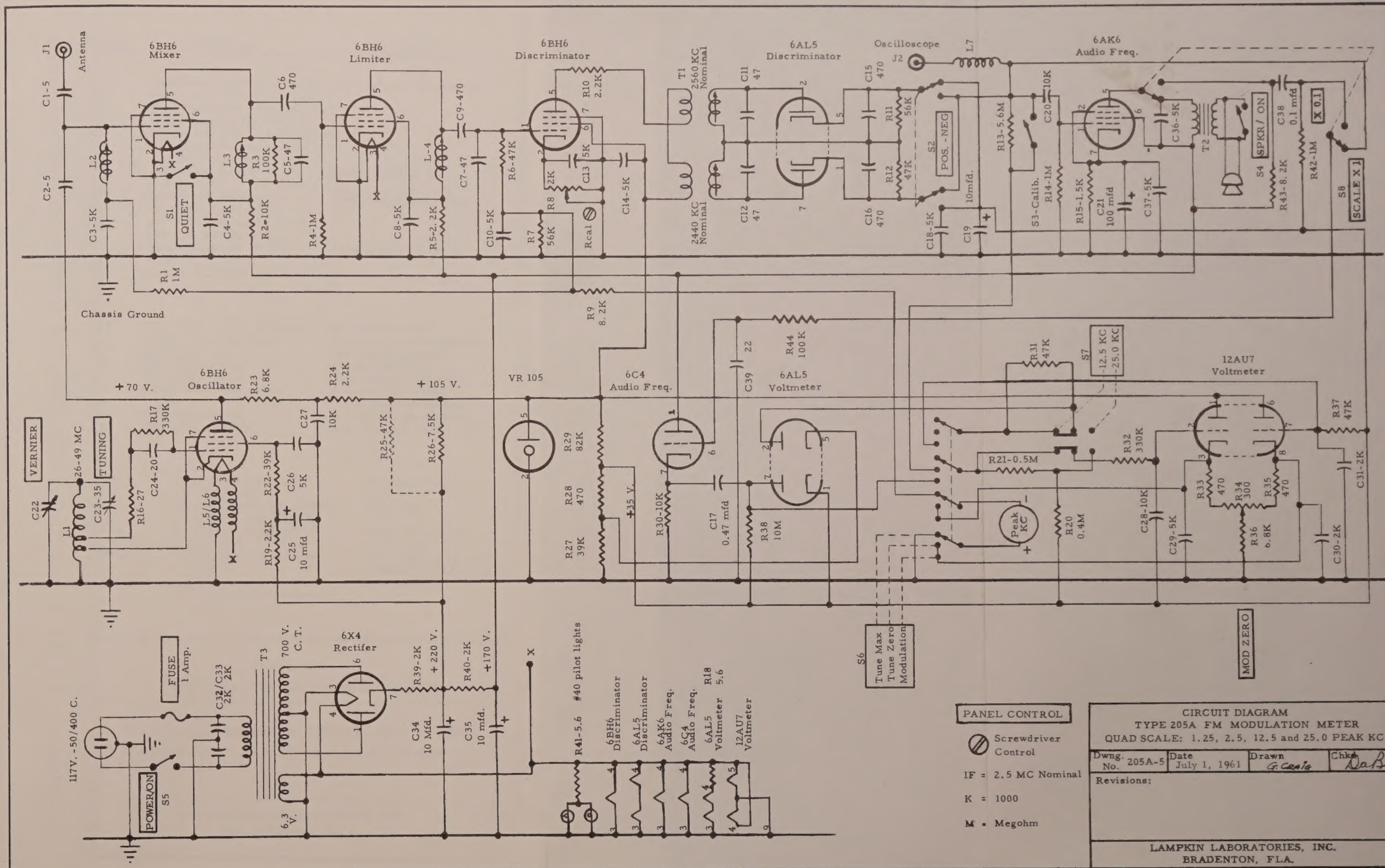
5.04 CHECKING 12.5-KC SCALE

The procedures outlined in the three sections above are for the 25-KC scale.

One check on the 12.5-KC scale is to measure the values of the divider resistors, R21 and R20, using test instruments which are known to be accurate to better than 1%.

A second method is to compare the 12.5-KC calibration against the 25-KC range, using an audio voltage source and an accurate AC voltmeter. Set up a standard AC voltmeter with accuracy at the working frequency better than 1%, and an audio oscillator with 2 to 3 volts output at 500 to 1,000 cycles with less than 1% distortion. Remove the 6BH6 LM tube from its socket, to kill the set noise; with the range switch on 25.0 KC, check the MOD. ZERO adjustment; apply the audio voltage through a 2-mfd. condenser to the OSCILLOSCOPE jack and ground. With the precision AC voltmeter connected across the oscillator terminals, increase the audio output level until the PEAK KC meter reads exactly 25.0 KC; then read the input voltage, E_{IN}. For any other KC scale reading, the required AC input voltage will be in proportion: thus, 1/5 E_{IN}. should give a 5-KC scale reading ($\frac{5\ KC}{25\ KC} = 1/5$).

Be sure to recheck the MOD. ZERO ADJ. when changing the range switch on the front panel.



CIRCUIT DIAGRAM
TYPE 205A FM MODULATION METER
QUAD SCALE: 1.25, 2.5, 12.5 and 25.0 PEAK KC

Dwng. No. 205A-5	Date July 1, 1961	Drawn G. Craig	Chkd DaB.

Revisions:

LAMPKIN LABORATORIES, INC.
BRADENTON, FLA.

PART	DESCRIPTION	FUNCTION
C1	5 mmfd ceramic	Antenna coupling
C2	5 mmfd ceramic	Oscillator-mixer coupling
C3	5000 mmfd ceramic	Mixer grid bypass
C4	5000 mmfd ceramic	Mixer plate bypass
C5	47 mmfd ceramic N080, 10%	Mixer plate tuning
C6	470 mmfd ceramic	Limiter grid coupling
C7	47 mmfd ceramic N080, 10%	Limiter plate tuning
C8	5000 mmfd ceramic	Limiter plate bypass
C9	470 mmfd ceramic	Discriminator grid coupling
C10	5000 mmfd ceramic	Discriminator grid bypass
C11	47 mmfd ceramic N-220, 10%	Discriminator tuning
C12	47 mmfd ceramic N-220, 10%	Discriminator tuning
C13	5000 mmfd ceramic	Discriminator cathode bypass
C14	5000 mmfd ceramic	Discriminator plate bypass
C15	470 mmfd ceramic	RF bypass
C16	470 mmfd ceramic	RF bypass
C17	0.47 mfd 200v Mylar-paper	Peak rectifier input
C18	5000 mmfd ceramic	Discriminator RF ground
C19	10 mfd 450v electrolytic, triple with C21, C25	Discriminator AF ground
C20	10,000 mmfd ceramic	Audio amplifier coupling
C21	100 mfd 50v electrolytic, triple with C19, C25	Cathode audio bypass
C22	Eccentric copper disc	Oscillator tuning vernier
C23	35 mmfd max., variable air	Oscillator tuning
C24	20 mmfd ceramic	Oscillator grid coupling
C25	10 mfd 450v electrolytic, triple with C19, C21	Oscillator hum filter
C26	5000 mmfd ceramic	Oscillator screen bypass
C27	10,000 mmfd ceramic	Oscillator plate bypass
C28	10,000 mmfd ceramic	Voltmeter RF/AF bypass
C29	5000 mmfd ceramic	Voltmeter RF bypass
C30	2000 mmfd ceramic, dual with C31	RF bypass
C31	2000 mmfd ceramic, dual with C30	RF bypass
C32	2000 mmfd ceramic, dual with C33	RF bypass
C33	2000 mmfd ceramic, dual with C32	RF bypass
C34	10 mfd 450v electrolytic, dual with C35	Plate supply filter
C35	10 mfd 450v electrolytic, dual with C34	Plate supply filter
C36	5000 mmfd ceramic	Audio plate bypass
C37	5000 mmfd ceramic	RF cathode bypass
C38	0.1 mfd, 400v Mylar-paper	AF coupling
C39	22 mmfd ceramic	2.5-Mc. filter

NOTE: All ceramic condensers are general-purpose (GP), 500 WVDC, 20% tolerance or guaranteed-minimum-value, except as noted.

PART	DESCRIPTION	FUNCTION
R1	1 megohm	Mixer grid leak
R2	10 K ohm 1-watt	Mixer plate dropping
R3	100 K ohm	Mixer RF loading
R4	1 megohm	Limiter grid leak
R5	2.2 K ohm 1-watt	Limiter plate dropping
R6	47 K ohm	Discriminator grid leak
R7	56 K ohm	Grid leak/AGC divider
R8	2 K ohm 2-watt ww variable	Discriminator bias, "Rcal"
R9	8.2 K ohm	"Tune Max." dropping
R10	2.2 K, 5%, deposited-carbon	Parasitic suppressor
R11	56 K ohm 5% deposited-carbon	Discriminator load
R12	47 K ohm 5% deposited-carbon	Discriminator load
R13	5.6 megohm	"Tune Zero" dropping
R14	1 megohm	Audio amplifier grid leak
R15	1.5 K ohm 1-watt ww	Audio amplifier cathode bias
R16	27 ohm ww	Parasitic suppressor
R17	330 K ohm	Oscillator grid leak
R18	5.6 ohm 1-watt ww	Diode heater dropping
R19	2.2 K ohm 1-watt	Oscillator hum filter
R20	0.4 megohm dep. carbon 1%	Voltmeter voltage divider
R21	0.5 megohm dep. carbon 1%	Voltmeter voltage divider
R22	39 K ohm 1-watt	Oscillator screen dropping
R23	6.8 K ohm 2-watt ww	Oscillator plate load
R24	2.2 K ohm 1-watt	Oscillator RF filter
R25	47 K ohm 1-watt (factory option)	Adjustment for R26
R26	7.5 K ohm 5-watt ww	Voltage-regulator dropping
R27	39 K ohm 1-watt	Regulated-voltage divider
R28	470 ohm ww	Regulated-voltage divider
R29	82 K ohm 5% dep. carbon	Regulated-voltage divider
R30	10 K ohm 1-watt	Cathode-follower bias
R31	47 K ohm	Voltmeter grid balancing
R32	330 K ohm	Voltmeter grid filter
R33	470 ohm ww	Voltmeter cathode bias
R34	300 ohm 2-watt ww variable	"Mod. Zero Adj."
R35	470 ohm ww	Voltmeter cathode bias
R36	6.8 K ohm 2-watt ww	Common cathode bias
R37	47 K ohm	Voltmeter grid balancing
R38	10 megohm	Peak rectifier bleeder
R39	2 K ohm 10-watt ww	Power supply filter
R40	2 K ohm 10-watt ww	Power supply filter
R41	5.6 ohm 1-watt ww	Pilot lamp dropping
R42	1 megohm	Grid leak
R43	8.2 K ohm ww or dep. carbon, 1-watt	Audio load value selected for stage gain of 10.0 ± 5%
R44	100 K ohm	2.5-Mc. filter

NOTE: All resistors are carbon composition, 1/2-watt, and 10% tolerance, except as noted. K= 1,000 ww = wire-wound.

PART	DESCRIPTION	FUNCTION
L1	14.5 turns #22 Formex wire, 3/8" dia. 21/32" long, on threaded polystyrene rod, cathode tap 2.6 turns and grid tap 4.8 turns above ground.	Oscillator coil
L2	205 turns #34 Formex wire, 1/2" dia. 1-3/8" long; powdered-iron core 3/8" dia. x 3/4" long.	Input IF tuning
L3	108 turns #34 Formex wire, 3/8" dia. 7/8" long; powdered-iron core 1/4" dia. x 3/4" long.	Mixer IF output tuning
L4	Same as L3	Limiter IF output tuning
L5- L6-	93 turns each #32 Formex wire, bifilar, 1/4" dia. x 1-9/16" long on polystyrene rod.	Oscillator filament chokes
L7	2.5 mh, 4-pie, ceramic core, RF choke.	RF filter for oscilloscope jack

PART	DESCRIPTION	FUNCTION
T1	Top and bottom halves are identical. Each primary 40 turns #34 Formex wire, 5/8" dia. 1/4" long; each secondary 81 turns #34 Formex wire, 1/2" dia. 5/8" long; each powdered-iron core 3/8" dia. x 3/4" long.	Discriminator transformer
T2	Audio output, 5-watt, 10,000 to 4 ohms	Speaker transformer
T3	Primary 115v 50/400c; sec. 700v. CT 50 ma DC; sec. 6.3v 2.5 amp AC. core size 7/8" x 2-1/2" x 3".	Power supply transformer
J1	Coaxial receptacle SO-239, or 83-1R	Antenna input, rear
J2	Tip jack, for .083" phone tip	Oscilloscope jack
S1	Push-button switch, miniature	RF noise Quieting
S2	2-pole 2-throw tap switch	Modulation polarity selector
S3	SPST toggle switch	Modulation calibration
S4	SPST toggle switch	Speaker "ON-OFF"
S5	SPST toggle switch	Power supply "ON-OFF"
S6	4-pole 3-throw tap switch	Selector, "Tune Max., Tune Zero, Modulation"
S7	DPDT slide switch	12.5/25.0 Peak-KC Scale
S8	DPDT toggle switch	Scale selector, x 1.0 or x0.1
Fuse	3AG 1a 250v 1/4" dia. x 1-7/32" long	AC power-supply fuse
Antenna	Stainless-steel whip, .045" dia. x 28" high, .156" dia. tip	RF pickup
Pilot Lamps	6v 150 ma brown-bead, G4-1/2 bulb	Mazda #40 miniature screw base
Peak-KC	0-1 ma. DC milliammeter, 3" square	"Tune Max, Tune Zero, Modulation" indicator.
Speaker	2" dia. 4-ohm voice coil, 0.68-oz. permanent magnet	Aural monitor

PARTS LIST
TYPE 205 A FM MODULATION METER

For Circuit Diagram No. 205A-5, July 1, 1961

QUAD SCALE: 1.25, 2.5, 12.5 and 25.0 PEAK KC

LAMPKIN LABORATORIES, INC.
BRADENTON, FLA.

76192-1K