

No. 90652 SOLID-STATE DIPPER

CAUTION: This dipper is powered by a self-contained battery. It is essential to turn off the battery power to conserve the battery when the dipper is not in use. The ON-OFF switch is on the SET METER potentiometer knob, which shows a colored stripe in the ON condition. The switch clicks off when the battery is shut off.

I. OPERATING INSTRUCTIONS

1. General Description of the SOLID-STATE DIPPER

The Millen No. 90652 SOLID-STATE DIPPER is a calibrated radio-frequency tunable oscillator with plug-in coils, and an output voltmeter with a rugged taut-band indicating meter. The Dipper functions

(1) as a device for measuring the resonant frequency of non-energized tuned circuits, and

(2) as an absorption frequency meter with a Q-multiplier circuit to increase sensitivity and sharpen response.

A phone jack is provided for listening to beat notes. The use of semiconductor circuits enables the extension of dipper-oscillator techniques to applications which have been impractical because of the requirement for either a-c power or bulky battery packs.

The oscillator frequency calibration accuracy is $\pm 2\%$ when the DET.-OSC. control (oscillator-level control) is set for maximum output by setting full clockwise (to OSC.).

2. CONTROLS

A. ON-OFF Switch

The ON-OFF Switch is operated by the rotation of the SET METER potentiometer knob. The OFF position is indicated by the arrow on the panel, and is also indicated by a click when the switch is turned ON or OFF. A bright colored stripe on the knob is visible whenever the battery switch is in the ON condition. It is important to shut off the switch when the dipper is not in use in order to conserve battery power. The dipper requires no warm-up period when switched on.

B. SET METER Control

To operate the dipper oscillator, plug in the desired coil, and turn the SET METER control ON. After the dipper is turned ON, it is necessary to set the meter reading to a convenient value by rotating the SET METER knob to the right until a meter reading above half scale is obtained.

The SET METER control adjusts the meter reading by setting the bias on the zero-

suppression circuit of the d-c amplifier. When the SET METER knob is rotated to the right from the OFF position, the meter reading will be zero until the bias has been set to a value which will allow current to flow. With a coil plugged into the coil socket, and the DET.-OSC. control set full clockwise, the SET METER knob should be rotated to increase the meter reading to a value near full scale. Then, a trial rotation of the tuning control (see below) should be tried to see if the meter reading will stay on the scale in the frequency range desired. The SET METER control is conveniently located for adjustment as a thumb-operated knob.

The meter reading will remain constant at whatever setting is made if —

(1) no coil is in place, or

(2) the oscillator transistor is not oscillating, and

(3) the oscillator circuit is not picking up an external signal and amplifying it (as a Q-multiplier).

C. DET.-OSC. Control

The variable resistor control at the lower left corner of the panel, marked DET.-OSC., is used

(1) to adjust the oscillation level of the dipper oscillator (OSCILLATOR position), and

(2) to control the regeneration of the oscillator circuit when it is used as a Q-multiplier amplifier to feed the diode detectors (DETECTOR position).

To use the SOLID-STATE DIPPER as a dipper oscillator, it will normally be required that the control be set at maximum clockwise (OSC.→) rotation.

The SOLID-STATE DIPPER may be operated as a sensitive absorption frequency meter by adjusting the DET.-OSC. control counter-clockwise until the oscillation stops. With the control set so that the oscillator circuit is not oscillating but is regenerating, the circuit operates as a Q-multiplier amplifier which increases the sharpness of resonance and the amplitude of the response to any signal picked up by the tuned circuit. In setting the control

for DETECTOR operation, it is useful to make a check for self-oscillation by observing the meter reading as the DET.-OSC. control is rotated counter-clockwise. When the self-oscillation stops, the meter reading will remain stationary as the DET.-OSC. control is rotated below the threshold. Familiarization with the action of this control will facilitate correct settings.

It should be noted that the meter circuit remains connected even with the battery power switched off. To trace through this circuit, start with the diodes at the coil connections of the tuned circuit, proceed through the 47,000-ohm resistor, R5, to the gate of the 2N5459 JFET d-c amplifier stage, then out through the source, through the meter to the emitter of the 2N1132 zero-suppression-bias transistor, out through the base to the movable arm of the SET METER control, and through this variable resistor to ground. When the switch is OFF, the arm will be 25,000 ohms away from the ground end. Thus, the meter circuit goes from the diodes through two semi-conductor junctions and 72,000 ohms, via the meter, back to ground. The 470,000-ohm resistor, R8, from the JFET (2N5459) gate to ground is a parallel current path. If the meter reads up scale with the switch OFF, it is an indication that the dipper is in a strong r-f field and it may be strong enough to damage the oscillator FET.

D. Tuning Control

The SOLID-STATE DIPPER makes use of a Colpitts oscillator with plug-in coils and a split-stator tuning capacitor. The oscillator frequency is adjusted by rotation of the thumbwheel which rotates the drum dial and the capacitor via an anti-backlash gear. The ranges covered are indicated on the panel adjacent to the dial.

3. Adjustment of controls for operating conditions in various coil ranges.

The performance of the dipper oscillator is affected by the setting of the controls. The calibration of the oscillator frequency is correct with the DET.-OSC. control set full clockwise (to OSC.). The following notes should be helpful in the adjustment of the controls for best results.

A. DIPPER-OSCILLATOR MEASUREMENTS

Coil Ranges

- "A" (1.6-3.5 Mc/s)
- "B" (3.0-7.0 Mc/s)
- "C" (6.7-16 Mc/s)
- "D" (13-32 Mc/s)
- "E" (25-60 Mc/s)

The procedure for these ranges is approx-

imately the same for all, namely:

1. Insert the chosen coil in the coil sockets.
2. Set the DET.-OSC. control for max. OSC. amplitude (full clockwise).
3. Set the SET METER control for a meter reading in the upper quarter of the scale (between 0.8 and 1.0) with the tuning dial set for the lowest frequency (near 0 on the logging scale). This setting will generally give best sensitivity for dipping.
4. Rotate tuning control to the desired frequency, observing the meter reading. When the resonant frequency of the circuit being tested is passed, the dipper meter reading will dip if sufficient coupling is provided.

"F" (60 - 150 Mc/s)

In this coil range, the oscillation level varies somewhat as the tuning dial is rotated. The SET METER control should be used to keep the reading in the upper half of the meter scale. Generally, the meter reading will be high at the low-frequency end of the range, decreasing at the higher frequencies. The DET.-OSC. control should be set for maximum OSC. level (clockwise).

"G" (125 - 300 Mc/s)

In this range, the oscillation level is maximum at the lowest frequency, decreasing enough to require re-setting of the SET METER control at the top frequencies.

B. DETECTOR — Absorption Frequency Meter Measurements

The SOLID-STATE DIPPER incorporates provision for use of the oscillator circuit as a regenerative amplifier, or Q-multiplier amplifier, to sharpen the selectivity and increase the sensitivity of the frequency meter. To use the SOLID-STATE DIPPER as a frequency meter, a selected coil should be plugged in, and the DET.-OSC. control rotated toward the DET. marking (counter-clockwise) until oscillation stops. The frequency-meter function is then available, and rotation of the TUNING control should produce a sensitive deflection of the meter. For reduced sensitivity, the control must be set farther toward the DET. end. If the control is not set for a low enough sensitivity level, the oscillator may start up again as the circuit is tuned through an external signal, causing the meter reading to fluctuate vigorously as the dipper oscillator goes in and out of lock with the external signal.

It is, of course, possible to use the dipper oscillator circuit with the oscillator deliberately set for a low level of oscillation, observing the

meter fluctuation as an external signal is passed. Experience in the use of the SOLID-STATE DIPPER will enable the user to improve his techniques.

Although the available oscillator power output falls off as the operating frequency is increased, the sensitivity of the frequency meter is maintained up to the top of the operating frequency range. The regeneration is adjustable to provide the proper amount of gain over the entire range.

4. Replacing the Oscillator Transistor

It is possible to damage the RCA Type 3N128 oscillator transistor by subjecting the dipper to high-power-level radio-frequency fields. This accidental exposure of the MOSIGFET 3N128 to too high voltages will puncture the insulation internally in the insulated gate, ruining the electronic function of the device. If the oscillator transistor has been so damaged, it is necessary to replace it. In the design of the No. 90652 SOLID-STATE DIPPER, particular attention was directed to making it easy and inexpensive to replace this transistor. The FET used is an RCA Type 3N128, a relatively inexpensive, high-performance device, which is easily replaceable without soldering since it plugs into a socket.

The replacement is carried out as follows:

a. Remove the four screws holding the cover (bottom of the case) on the No. 90652 SOLID-STATE DIPPER and remove the cover. Set the unit down on a flat surface with the plastic insulating plate resting on the flat surface.

b. Be sure the battery switch is in the OFF position. Check to be sure.

c. The replacement RCA 3N128 FET transistor will be provided with a phosphor-bronze shorting wire wrapped around the leads next to the case of the transistor. Leave this wire in place, cut the leads to approximately $\frac{3}{8}$ " length.

d. Remove the damaged transistor and insert the replacement, being sure that the tab on the transistor can line up with the indentation in the Teflon body of the socket.

e. Pull off the phosphor bronze shorting wire to un-short the 3N128 leads. Press the transistor firmly into the socket so that it is seated against the Teflon body of the socket.

f. Replace cover of dipper case.

g. The calibration of the oscillator may be shifted slightly by this transistor replace-

ment. If it is important to know the exact frequency of operation, a calibration check would be desirable. In most cases, the shift in calibration will be negligible. See ADDENDUM for further instructions.

5. Replacement of Battery

The Millen No. 90652 SOLID-STATE DIPPER makes use of a 9-volt alkaline battery for its self-contained power source. Suitable replacements are the Mallory Type MN-1604, or RCA Type VS1323. These batteries are usually available at radio distributors, or can be ordered from drug store or other battery sales counters. The alkaline battery has a good shelf life (approx. 2 years) and will provide many months of service under normal conditions. Tests in our laboratories indicate that, when used approximately 2 hours per day, and the dipper is turned off when not actually in use in hand, the alkaline battery should last between 2 and 6 months. It is difficult to specify this figure more closely.

If the recommended alkaline battery replacement is not available, it is possible to use 8.4-volt mercury batteries as replacements. Suitable types are Mallory TR146X, RCA VS146X, Eveready E146X, or Burgess HI46X. The battery life obtained should be equal to, or slightly greater than, that obtained with the alkaline batteries recommended. The cost of the mercury batteries is somewhat greater than that of the alkaline units, and the mercury batteries are not satisfactory at low temperatures (below 50°F).

In case of non-availability of either of the above battery types, a temporary replacement could be provided by a zinc-carbon transistor radio battery, 9-volts rating, such as Mallory M1604, RCA VS323, Eveready 216, Burgess 2U6, or Ray-O-Vac 1604. The NEDA size is 1604. The zinc-carbon batteries will provide less than half of the service hours of the recommended replacements, and will show more droop in output voltage as they are used.

It is probable that a replacement battery will be required when the supplied voltage drops much below 7 volts at the battery terminals. The battery current required varies from about 3 ma. to about 7 ma., maximum, depending on the coil range in use and the adjustment of the SET METER control, and also of the DET.-OSC. control.

6. General Considerations

a. A tapped insert is provided with $\frac{1}{4}$ "-20 thread to allow attachment of a wrist strap or other safety retainer to guard against dropping

the SOLID-STATE DIPPER. This threaded socket fits most camera tripods and wrist straps. This feature is most useful in protecting the Dipper from damage when it is used in potentially dangerous locations, such as on antenna masts for tuning beams.

II. METHODS OF USE

The Millen No. 09652 SOLID-STATE DIPPER may be used in any of the following manners:

1. A Dipper Oscillator for use as an oscillating frequency meter to determine the resonant frequency of de-energized r-f circuits.

With the DET.-OSC. control set maximum clockwise to "OSC", the SOLID-STATE DIPPER becomes an r-f oscillator. (See Section I, Para. 3, above). A transistorized electronic voltmeter built into the unit measures the relative output of the oscillator.

When an external circuit, resonant at the oscillator frequency, is coupled to the "probe" inductance, power is absorbed from the oscillator and is indicated by a dip (decrease) in the voltmeter reading. The SOLID-STATE DIPPER used in this manner may then be used to check the resonant frequency of a circuit without the application of power to the circuit in question. This results in a considerable saving of time; and a definite assurance of correct frequency adjustment of a circuit is obtained without the danger of working in the presence of high voltage d-c or r-f. Circuits may be checked or pre-tuned before completion of the unit in which they are to be used. Only minor trimming is generally required under actual operating conditions. Guesswork or "cut and try" methods are eliminated, while, at the same time, possible damage to components during initial tune-up and adjustment is eliminated.

2. An Oscillating Detector for determining the fundamental or harmonic frequencies of energized r-f circuits.

With the DET.-OSC. control set clockwise to "OSC" and a pair of headphones plugged into the 'phone jack, an audible beat note may be heard when the instrument is tuned to the

b. Accessories available

The No. 46721 Probe is a coupling loop designed for use with Millen dippers. It enables coupling to circuits which are inaccessible to the SOLID-STATE DIPPER because of space or coupling limitations.

fundamental or harmonic frequency of a source of r-f. The frequency in question, or its harmonics (and sub-harmonics) may be read directly from the calibrated dial to an accuracy of $\pm 2\%$. Headphones for use in this application must carry d.c. (i.e.-magnetic or dynamic, not crystal 'phones).

3. A Signal Generator for use as a source of r-f frequencies between 1700 Kc/s and 300 Mc/s.

When the DET.-OSC. control is set to "OSC" the instrument may be employed in place of a signal generator, except in those cases where special shielding or a known r-f voltage is required. Special coils are available to extend the oscillator range to lower frequencies.

4. A Tuned R-F Diode Detector for use as an absorption-type frequency meter, using the oscillator circuit as a regenerative Q-Multiplier amplifier.

To use the SOLID-STATE DIPPER as an absorption frequency meter, set the DET.-OSC. control counter-clockwise toward DET. till oscillation stops, and advance the SET METER control so that, with no r-f being picked up, the meter reads approximately 0.2 ma. (See Sect. I, Para 2C DET.-OSC. control above). The meter reading will now increase when the probe is brought into the presence of an r-f field of the same frequency as that to which the dial is tuned. The frequency may be read directly from the dial if between 1.7 Mc/s and 300 Mc/s.

The sensitivity of the #90652 is considerably greater than conventional Grip Dip meters when used as an absorption frequency meter because of the improved indicator circuit using a Q-multiplier amplifier to drive the diode detectors, and a JFET d.c. amplifier in the indicator circuit.

III. MEASUREMENT TECHNIQUES

Correct methods of coupling the SOLID-STATE DIPPER to circuits under test are shown in Fig. 1. Because of the improved indicating circuit, the coupling need not be as close as with conventional Grid Dip Meters, particularly at the higher frequencies.

When used as a Dipper Oscillator, harmonics of lumped-constant resonant circuits will not be indicated; however, other resonant frequencies are sometimes indicated. These will be due to other resonant circuits formed by circuit wiring, stray capacitances, etc. In most cases

these will occur at a higher frequency. On the other hand, harmonics of antennas, transmission lines, etc. will be indicated, as will be explained under the heading "Antennas". It will be noted that the meter reading slowly varies as the dial is rotated; however, correct resonance of the unknown is indicated when the meter makes a sharp or pronounced "dip" or "peak". Care must be taken that the circuit under test is not coupled too tightly to the probe, for this will cause the oscillator frequency to change in proportion to the degree of coupling. The least coupling with which it is possible to obtain a recognizable indication is the proper way to use a SOLID-STATE DIPPER.

In general, for most dipper measurements the SET METER control should be adjusted so that a meter reading of about 0.8 ma. is indicated when the SOLID-STATE DIPPER is not coupled to any external circuitry either passive or active. The SET METER control adjusts the zero-suppression of the d.c. amplifier and does not affect the level of oscillation of the oscillator circuit. In some coil ranges, it may be desirable to try reducing the oscillator level with the DET.-OSC. control. Under some conditions, this produces an apparent increase in dip sensitivity. The oscillator calibration is disturbed by this adjustment. For those cases where the

resonant frequency is not known within wide limits, it is best to set the "no coupling" meter reading, with no coupling, so that the meter stays on scale as the dial is rotated, and couple as tightly as possible to the circuit under test while varying the frequency **slowly**. Should no indication be noted on the first pass through the frequency range expected, the meter current should be increased progressively using the SET METER control with each successive pass. When an indication is obtained, the coupling should be decreased in steps while the meter sensitivity is simultaneously increased until the meter reads about 0.9 ma. No further increase of the SET METER control should be made, this being about optimum, but the coupling should be decreased until, as above, the indication is just barely recognizable. This will insure maximum accuracy of frequency calibration.

It is suggested that the user of the SOLID-STATE DIPPER at first set up test L/C combinations, short test antennas, etc. The resonant frequency of these test circuits should be measured with the SOLID-STATE DIPPER in order to become familiar with the coupling methods suggested and with the general behavior and operation of the instrument.

IV. APPLICATIONS

Receiver tuned circuits. Use the instrument as a dip oscillator. Remove power from the receiver and resonate each tuned circuit to the desired frequency as indicated by the meter dip. Gang-tuned circuits should be aligned for tracking by checking at each end of the ganged range. A check at one or two points in between will also be helpful. Methods of electrically obtaining the desired bandspread or tracking will not be explained here. Reference may be made to any good radio text book.

Following the above procedure, power may be applied to the receiver and the dip meter employed as a signal generator for checking final alignment. A very short antenna should be connected to the receiver input terminals and the SOLID-STATE DIPPER should be placed on the bench removed from nearby conductors, and where body movements are least apt to affect the r.f. signal from the instrument. Some sort of indicating device such as a "S" meter or V.T.V.M. at the receiver detector must be used. If the r.f. signal is too strong, the receiver antenna may be shortened, or the instrument may be removed to a more remote or partially shielded location.

Where a superheterodyne type of receiver is involved, if the receiver fails to function, it is quite possible that the receiver local oscillator is not working. This may be checked by employing the SOLID-STATE DIPPER as an r-f diode detector or absorption-type wavemeter. Set the controls for DET. operation. Couple the Dipper to the oscillator coil and, if the meter does not go up-scale when the instrument is tuned to the resonant frequency of the oscillator tank, the oscillator is not functioning. An alternative method having greater sensitivity and capable of more accurate frequency measurement is to use the instrument as an oscillating detector and listen for the local oscillator beat in the headphones. It is important to remember that the local oscillator will be on a frequency different from the receiver dial setting.

Transmitter tuned circuits. Use the instrument as a dip oscillator with plate power removed from transmitter and proceed to adjust tanks to desired frequency as with receiver circuits. Tubes should be in place, and where capacitive coupling is used between stages, the grid circuit associated with the following tube should be completed.

After the above procedure, plate power may be applied and final alignment made according to grid and plate meter indications. R.f. power at correct frequency in each tank may be checked by employing the SOLID-STATE DIPPER as a diode absorption frequency meter or it may be utilized as an oscillating detector. Care must be taken not to couple too closely as the dipper oscillator FET can be burned out. Due to its great sensitivity, care must be taken not to mistake pick-up from some other energized r.f. circuit. This may be checked by moving the instrument closer to the circuit under test and noting whether or not the beat increases in volume. If it does, the beat heard is from the desired circuit. Harmonics also may be heard, so it is wise to check for the beat heard at the lowest frequency.

Neutralization. Employ the instrument as a dip oscillator. Remove all plate power from the transmitter. Couple the SOLID-STATE DIPPER to grid tank of stage to be neutralized, or, in the case of capacitive coupling, to the preceding plate tank (it is assumed that the tank has already been tuned to correct frequency). Couple fairly close and leave instrument set in position with its meter deflected at bottom of the resonant dip, being sure to increase the SET METER control so that meter reads about 0.9 ma. Neutralization is then indicated when rotation of amplifier plate tank capacitor has no reaction on the deflected meter reading. Another method is to use the instrument as a diode absorption-type meter and proceed to neutralize in the manner normally employed when using absorption-type wavemeter, or as with similar indicating device, i.e.:

Remove plate power from amplifier stage to be neutralized, and apply power to stage driving the grid. Couple the SOLID-STATE DIPPER to the amplifier plate tank, tune the instrument to the driving frequency and check for the presence of r.f. in the tank as indicated by a rise in the SOLID-STATE DIPPER meter current. Adjust neutralizing capacitor until no reading is seen on the meter.

Parasitic Oscillations. Apply power to transmitter and use instrument as an oscillating detector while listening on headphones for beat of parasitic oscillation. As an alternative, the parasitic frequency may be determined by using the instrument as a tuned r-f diode or absorption-type frequency meter. When parasitic frequency has thus been determined, as read from the SOLID-STATE DIPPER scale, remove power from transmitter and use instrument as a dip oscillator to locate circuits or components, such as r.f. chokes, circuit wiring, etc., resonant at parasitic frequency.

Parallel-resonant traps. Use as a dip oscillator. Trap may be tuned or checked either before or after connecting it in desired circuit. If tuned before installation, adjustment will remain correct upon installation if its inductance is physically removed from other conductive components which may alter the inductance value. This is not usually the case, so further minor adjustment will probably be required after installation. When in the circuit, it is possible that its resonant frequency may be quite a bit off as indicated by the SOLID-STATE DIPPER. Actually, the trap itself will still be tuned to approximately correct frequency but the dip oscillator reading may be found at some other frequency (usually lower) due to circuit "strays" across the trap.

Final precise adjustment may be made by applying power to circuit and by tuning trap under actual operation for desired effect.

Series-resonant traps. Follow same general procedure as with parallel-resonant trap. To check or tune prior to installation, trap may be first connected as a parallel trap. At high frequencies or where the trap inductance is low, the lead completing the parallel circuit should be of large wire or wide copper ribbon to keep its inductance low, and care should be taken not to permit this lead to be positioned so as to add stray capacitance. Leads to be used upon final installation must also be included when external measurements are being made.

R.F. Chokes. To determine self-resonance of r-f chokes, use SOLID-STATE DIPPER as a dip oscillator. Put the coil of the r-f choke close to the dipper coil for best sensitivity.

Circuit Q. Use the SOLID-STATE DIPPER as signal generator. Connect a v.t.v.m. across the circuit to be measured. Couple instrument to circuit (Fig. 1A) and resonate for maximum, or peak reading, on v.t.v.m. Note frequency at which this occurs. Then shift the instrument each side of resonance to the frequency where the voltmeter reading drops to approximately 70.7% of that at resonance. Note the frequency of these two points and calculate the circuit Q from equation "A", Appendix 1, where F_r is the resonant frequency and Δf is the difference between the "off resonance" frequencies just found. The original coupling should be adjusted for a convenient maximum reading of the v.t.v.m. and then should be left fixed at this position for the remainder of the procedure.

Relative circuit Q at a given frequency. Use as a dip oscillator and observe character of the dip whether broad or sharp for a fixed setting of sensitivity control. The sharper the dip, the higher the Q.

Measurement of capacitance. Several methods may be employed. All involve the use of the SOLID-STATE DIPPER as an oscillator.

A small jig (Fig. 2) must be made, into which may be plugged any one of the SOLID-STATE DIPPER coils.

To check an unknown capacitor, it is then only necessary to clip the jig, with a coil inserted, across the unknown capacitance. Find the resonant frequency and refer to the calibration chart for value of capacitor with the coil employed. For over-all accuracy, it is best to employ one of the coils from the medium frequency range.

Due to the distributed capacitance of the coils, a slight error will be encountered at very low capacitance measurements. Likewise, due to self-inductance of large capacitors, a small error will be found when measuring these. Errors will be negligible for most practical purposes.

Measurements of capacity of below 50 pf are generally not obtainable because resonance at these values usually falls out of range of the coils left available for frequency checking. For measurements below 50 pf an additional calibrated coil is required.

For these measurements, in a great number of cases, the capacitor need not be removed from the circuit in which it is wired unless the capacitor is heavily loaded.

Another method, similar to that above, is to employ a known inductance and find the resonant frequency with the unknown connected across it. See equation "B", Appendix 1 where f is the resonant frequency in cycles/sec. and L is the inductance in henries. C_x will be in farads.

A third method, for capacitors up to about 1000 pf, requires an inductance which is shunted by a calibrated variable capacitor. The capacitor is set at maximum and the resonant frequency of the circuit is found. The unknown capacitor is then connected across the variable and the capacitance of the latter decreased to a point where the circuit resonates at the original frequency. The difference between the first and last settings of the calibrated variable capacitor is the value of the unknown.

Measurement of inductance of R-f Coils. Connect a capacitor of known value across the coil and use the SOLID-STATE DIPPER as a dip oscillator to find the resonant frequency of the resulting L/C combination. The inductance of the coil may be calculated from equation "C", Appendix 1, where L_x is in henries, C is known capacitor in farads; or reference may

be made to an L/C-resonance chart.

In measuring small values of inductance, be sure to employ a low inductance standard condenser, connected to the unknown coil by wide ribbon, in order to obtain most accurate results. Due to the distributed capacitance, especially in large coils, some slight error will result; however, if the value of the low-inductance known capacitor is fairly high, the error will be negligible.

Relative Q of capacitors or inductances at a given frequency may be noted by observing the character of the dip, as previously described.

Antennas. Use instrument as dip oscillator. Coupling should be made at a low impedance or high current point as shown in Fig. 1E. This point, for a half-wave antenna, is at the center, and for longer wires is at points odd quarter-wavelengths measured from either end. It will be observed that a full-wave antenna will not be half-wave at exactly half its resonant frequency. This is because the end effects are found only at the antenna ends and will be absent at other points when the antenna is a full-wave or more long. It is, therefore, always necessary to measure an antenna under the conditions desired (relating to physical and electrical length). Measurement should be made with the antenna placed as near as possible to its ultimate operating position. Checks on a given antenna at different heights or positions will show an amazing difference in antenna resonance.

If it is physically impossible to reach a low impedance point, a check may be made at a high-impedance or high-voltage point. Capacitive coupling should be used as shown at Fig. 1F. If the high impedance point involved is one of the ends, the end effect will be altered due to the presence of the instrument and the resonant frequency of the antenna will slightly decrease. This must be taken into consideration when making measurement, i.e., the reading indicated will be slightly lower than true antenna resonance (with SOLID-STATE DIPPER away from end). This difference will be about 1 to 3% and will be encountered only when checking at the ends.

In all cases it is helpful to keep in mind the physical length in feet vs. electrical length (half-wave, full-wave, etc.) as calculated approximately by formula. Unlike lumped resonant circuits, antenna harmonics are detected when using the SOLID-STATE DIPPER. As previously mentioned, these harmonics will not occur at exact multiples of a half-wave.

When measurement is made, the feeders should be disconnected from the antennas. Unless the feeders happen to be perfectly matched

or terminated, true antenna resonance will not be indicated because unmatched feeders or incorrectly terminated feeders will present either a positive or negative reactance and will, therefore, alter the electrical length of the antenna.

When the antenna element is of very large diameter, such as is often found in rotating beams, sufficient coupling to the SOLID-STATE DIPPER may not be obtained and some difficulty will be encountered in finding a reading. This condition may sometimes be relieved by jumping a foot or so of the antenna at the center with a small diameter wire and coupling to this wire.

If the antenna is to be normally used with its center open, close it with the shortest possible wire during measurement. This must be done also with the folded dipole. The short may later be removed, if required, when feeders are connected.

Tuned or resonant feeders, such as used in the Zepp antenna. Use instrument as dip oscillator and check for desired resonance at the series or parallel tuned circuit on the transmitter end of the feeder. If resonance at the desired frequency is not obtainable, alterations may be made in the tuned circuit or the feeder length according to the actual resonant frequency found. Care must be exercised not to become confused by other resonance indications. It must be remembered that a Zepp is actually a long wire antenna partially doubled back on itself and resonances can therefore be noted at frequencies both higher and lower than the desired one.

Untuned or non-resonant feeders. After the antenna has been adjusted to the correct length, an untuned feed line may be connected employing some system of matching. Correct match may be obtained by making adjustment while employing an impedance bridge such as the Millen 90672 Antenna Bridge or a standing-wave-ratio bridge such as the Millen 90671 Standing Wave Ratio Bridge and using the SOLID-STATE DIPPER (set at antenna resonant frequency) as the signal generator.

The transmission bridge or the s-w-r meter should employ a meter of full scale sensitivity of 200 ua or less, for most accurate readings. Coupling to the SOLID-STATE DIPPER should be as loose as possible consistent with obtaining sufficient reading. If the coupling is too tight, the instrument frequency calibration may be slightly shifted.

The matching device should then be adjusted for as near unity standing-wave-ratio as possible. If a satisfactorily low standing-wave-ratio is unobtainable, it is due to either a fault in the matching system or due to a shift in an-

tenna resonance. The latter may be checked by slightly varying the SOLID-STATE DIPPER frequency until a lower s-w-r is found or until a better s-w-r meter null is indicated. The frequency at this point will be that of antenna resonance. If necessary, the antenna length may then be changed until the correct standing-wave-ratio is realized at the desired frequency. It may also be necessary to trim up the adjustment of the matching system.

Tuning the parasitic beam. Use the instrument as dip oscillator and adjust driven element for resonance. The feeder should be disconnected and the parasitic elements should be set at their calculated correct length. If the driven element is open at the center, close it. After this element has been properly set, connect and match feeder as described in the foregoing paragraph (open antenna center if matching system so requires). The parasitic elements may then be adjusted using the SOLID-STATE DIPPER as the signal generator coupled to the feed line and by observing readings on a receiver (with an "S" meter) connected to a short antenna some distance away. Relative field readings in actual "S" units then may be obtained after each adjustment. As when matching feeder, coupling to the SOLID-STATE DIPPER should be as loose as possible. It is a good idea to occasionally check the actual frequency of the instrument on the receiver.

Following the tuning of the parasitic elements, the standing-wave-ratio should again be checked. It will, undoubtedly, increase, because tuning of the other elements will cause a change in antenna resonance. This will have to be altered accordingly, as described under "matching of non-resonant lines". Repetition of the preceding steps is advisable for putting on the finishing touches.

If the beam is located so that surrounding objects are likely to cause detuning as the beam is rotated (this may be checked during antenna and parasitic element tuning), it may be advisable to do the final retuning with the beam positioned either towards the direction in which it will be mostly used, or where the greatest degree of rotation has the least effect.

Needless to say, the transmitter may be used as the signal generator in place of the SOLID-STATE DIPPER during the above adjustments; however, the employment of the SOLID-STATE DIPPER for this purpose is more convenient, because the entire operation may be handled right on the roof by one person, or wherever the beam is located. The use of the instrument also keeps the channel free from unnecessary QRM.

Quarter-wave shorted lines. Use as a dip oscillator and couple for open wire lines as at

Fig. 1G, and for coaxial lines as at Fig 1H. When trimming lines for correct length, fittings to be used eventually for connections should be installed on the end of the line. The approximate frequency of the line may be determined by rough calculation. Other resonant points can be found, however. These will be at three times the fundamental quarter-wave, where the line is then three-quarter waves long, or five times the fundamental quarter-wave, etc.

Quarter-wave open lines. For open-wire lines, connect a short at one end and measure as for quarter-wave shorted line. Due to the length of the short, the actual electrical length of the line (used as an open line) will be slightly in error depending on the line spacing. The closer the spacing, the smaller the error.

For coax lines, place short on line and measure as quarter-wave shorted line. The short should be as direct and short as possible from inner conductor to shield in order to avoid errors. Fittings should also be included. Remove the short after measurements are completed.

Half-wave shorted lines. For open-wire lines, couple at center as shown at Fig. II. For coax line, measure for quarter-wave shorted line at half the calculated or desired frequency. Resonant frequency thus found must be then multiplied by 2 for a resulting half-wave shorted line.

Half-wave open lines. For open-wire lines, couple at center as shown at Fig. II. For coax line, short one end and measure for quarter-wave shorted line at half the calculated frequency. Resonant frequency thus found must be multiplied by 2 for the correct length of the line after short is removed, provided the short is made direct as mentioned above.

Check standing waves. Aside from employing the SOLID-STATE DIPPER as the signal generator in conjunction with a standing-wave-ratio meter, open-wire feed lines may be check-

ed for the existence of standing waves by using the instrument as a diode detector. A flat line is indicated when the meter reading remains constant as the "probe" coil is moved along the line. Care must be used to maintain uniform distance or coupling between coil and line. Since the SOLID-STATE DIPPER coil is protected by an insulated sleeve, the coil form may be held against the line for maintaining uniform coupling. Take care not to overload the dipper circuit and damage the 3N128 FET, or the meter.

This method is the same as that using a neon bulb, crystal detector or other similar device, but is much more sensitive because of the improved electronic voltmeter indicating circuit and Q-multiplier amplifier.

Relative field-strength meter. Use the SOLID-STATE DIPPER as diode detector. Connect a short antenna to one of the coil posts through a 5-30 mmf capacitor. In the higher frequency coil ranges, it may be useful to attach a short antenna wire to each side of the coil, keeping the circuit balanced. The instrument's frequency calibration will shift some, so the dial will have to be rotated for maximum reading of the received signal. Actual frequency calibration is unimportant for this purpose. Sensitivity of the SOLID-STATE DIPPER as a field-strength meter is not as great as that of some other devices, but it will, nevertheless, be helpful in many cases. Proper adjustment of the Q-Multiplier will enhance sensitivity over a simple tuned-circuit with diode detector.

The SOLID-STATE DIPPER may be employed for a number of other measurements, principally when utilized as a signal generator. Its use as a dip oscillator will be quite obvious and self-suggestive for measurement of many other types of equipment and circuits. The applications herein described are those which will be generally most useful.

V. MAINTENANCE

The entire unit is built on a single frame. Therefore, the cover on three sides may be removed by simply removing the four screws on the bottom.

Symptom:

1. Unit does not operate:

- check that 9-volt battery is connected properly.
- check that a coil is, in fact, plugged into the unit.

- check battery voltage. It should be between 7 and 9 volts.

2. Meter reads when SET METER control is set up-scale but DET.-OSC. control rotation does not change oscillation level:

- may require replacement of oscillator FET. (See Para. I-4).
- check tuning capacitor for shorts, and coil for continuity.

3. Spurious dips:

With the exception of the "G" range, no sharp dips should be present throughout the tuning range of the oscillator when the probe is not coupled to any external tuned circuit. Any trouble in this direction that cannot be cured by removing the dust from the variable condenser plates with a blast or two of air should result in the unit being returned to the factory for repair.

4. Calibration incorrect:

— Unit should be returned to factory

for re-calibration with complete set of original coils if possible. See ADDENDUM for further instructions.

Factory Repair Work:

No equipment will be accepted for repair if permission to return equipment and/or a proper shipping label has not been obtained from the factory prior to shipment. Care should be taken to insure proper packing of unit when shipping to factory.

VI. GENERAL SPECIFICATIONS

The Millen No. 90652 SOLID-STATE DIPPER is supplied complete, with battery, in a polypropylene case, with one set of coils. The Dipper unit is 7 1/4" lg x 3 1/2" w. x 3 3/8" high, exclusive of coils. Coils "A" through "F" extend 2 3/4" (in the direction of the length), and coil "G" extends 1 1/2". The weight of the dipper unit is 2 1/2 lbs., and shipping weight is 7 lbs.

The coils are wound on molded polystyrene

forms with insulating, formfitting covers to protect them from physical damage and to insulate them for safety. The end-plate of the oscillator unit is of molded G.E. Lexan, and the split-stator tuning capacitor is ceramic-insulated. Modern materials and techniques are applied to insure durability and excellent performance.

ADDENDUM

Dipper Oscillator Calibration Accuracy

It should be noted that the calibration of the dipper oscillator is correct (±2%) when the DET.-OSC. control is set maximum clockwise (OSC.→). The calibration of the absorption frequency meter is shifted slightly from the oscillator value, but the difference is not great and is usually of little importance.

Notes Concerning The Type 3N128 FET

(Oscillator Transistor):

Calibration Problems

It is probable that the calibration of the oscillator frequency will be disturbed if the 3N128 FET is replaced. The percentage change in frequency will probably be greatest at the top ends of the "B" and "C" coil ranges. It may be necessary to select 3N128's to get one which will duplicate the original calibration to closer than ±2%.

The 3N128 supplied with the 90652 Solid-State Dipper has been selected for proper operation (low value of input capacitance, low noise as an oscillator and adequate performance over the entire frequency range). On the basis of the data accumulated as of November, 1971, it

is probable that 20% of the 3N128's available will have unusably high input capacitances, and that most of the 3N128's which have a high value of input capacitance will have much too large a value to be used in the 90652. In other words, the 3N128's either come very close (better than ±1%) to the original calibration, or else they are completely unusable (frequency more than 2% different from dial calibration).

The gain of the 3N128 varies as 1/f, or stated differently, the gain at high frequencies is less than at lower frequencies. Hence, any Miller-effect capacitances in the oscillator will appear larger at low frequencies than at high frequencies. Thus, the reduction in tuning range at the minimum-capacitance setting of the tuning capacitor is more pronounced in the "B" and "C" coil ranges than in the "D" coil (and higher) ranges.

Caution on RF Input Power

The 3N128 FET is connected to the tuned circuit whenever a coil is plugged in, whether the battery switch (on SET METER control) is on or not. Hence, care must be used in operating the 90652 Solid-State Dipper to avoid coupling the 90652 too closely to sources of r-f power, especially transmitters.

Do not put the Solid-State Dipper next to a transmitter coil, turn on the transmitter power, and then turn on the Dipper. The preferred method is to turn on the transmitter, and then to bring the dipper closer to the coil with the Dipper turned ON. A large signal will

then be indicated on the meter if the Dipper is tuned to the proper frequency.

Observance of this precaution may prevent early demise of the 3N128 FET in the oscillator circuit.

Millen 90652 Solid-State Dipper

Parts List

Circuit Symbol No.	Description
BT 1	Battery, 9 volt, Alkaline, Transistor
C 1	Capacitor, Fixed, Button Mica, 47 pf $\pm 10\%$, 500 VDCW
C 2	Capacitor, Fixed, Button Mica, 180 pf $\pm 10\%$, 500 VDCW
C 3	Capacitor, Fixed, Ceramic, Feedthru, 1000 pf GMV, 500 VDCW
C 4	Capacitor, Fixed, Mylar, Special (Millen #90652-4-C4)
C 5 A/B	Capacitor, Variable, Air Dielectric, Special (Millen #90652-3-C5)
C 6	Capacitor, (Same as C3)
C 7	Capacitor, (Same as C3) ceramic, Feedthru, 10pf, $\pm 10\%$, 500 VDCW
C 8	Capacitor, Fixed, Ceramic Disc, .02 uf $\pm 10\%$, 1000 VDCW
C 9	Capacitor, (Same as C3)
CR 1	Diode, Silicon Planar, Type 1N3604
CR 2	Diode, (Same as CR1)
CR 3	Diode (Same as CR1)
J 1	Phone Jack, Midget, Normally Shorted
J 2	Pin Jack, for .121 in. dia. pins (Millen #90651-16)
J 3	Pin Jack, (Same as J2)
J 4	Pin Jack, (Same as J2)
J 5	Jack, Battery Clip, 2 Terminal for Transistor Radio Battery
L 1	Coil, Plug In, Special, Probe Type (set of 7 provided: #90652-A Range, 1.7-3.4 Mc. #90651/90652-B Range, 3.0-7.3 Mc. #90651/90652-C Range, 6.7-16 Mc. #90651/90652-D Range, 13-32 Mc. #90651/90652-E Range, 25-60 Mc. #90651/90652-F Range, 60-150 Mc. #90651-A/90652-G Range, 120-300 Mc.
M 1	Meter, Taut-Band, Rectangular, 0-1 milliampere
Q 1	Transistor, MOS-FET, Silicon, Type 3N128
Q 2	Transistor, N-Channel, Junction FET, Type 2N5459
Q 3	Transistor, PNP, Silicon, High Speed, Medium Current, Type 2N1132

**Circuit
Symbol No.**

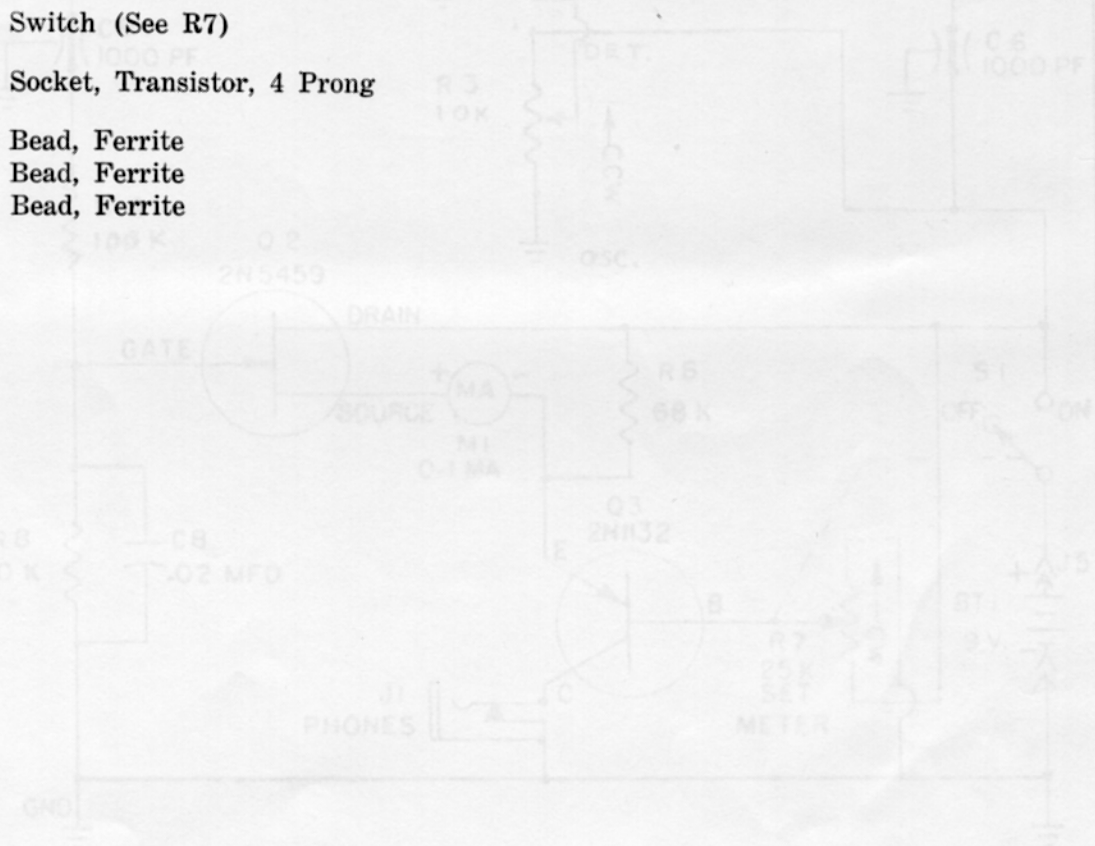
Description

- R 1 Resistor, Fixed, Composition, 470 ohms \pm 5%, 1/2 watt
- R 2 Resistor, Fixed, Composition, 200 ohms \pm 5%, 1/2 watt
- R 3 Resistor, (Potentiometer), Variable, Composition, ~~25,000~~ ^{10,000} ohms \pm 20%, 1/4 watt, Linear Taper, 15/16" dia.; Bushing: 3/8"-32 NEF.-2THD x 3/8" long; Shaft: 1/4" dia. x 3/4" long
- R 4 Resistor, Fixed, Composition, ~~10,000~~ ^{100,000} ohms \pm 5%, 1/2 watt
- R 5 Resistor, Fixed, Composition, 47,000 ohms \pm 5%, 1/2 watt
- R 6 Resistor, Fixed, Composition, 68,000 ohms \pm 5%, 1/2 watt
- R 7 Resistor, (Potentiometer), Variable, Composition, 25,000 ohms \pm 20%, 1/10 watt, bracket mounting with Knob and S.P.S.T. switch attached.
- R 8 Resistor, Fixed, Composition, 470,000 ohms \pm 5%, 1/2 watt
- R 9 Resistor, Fixed, Composition, 3600 ohms \pm 5%, 1/2 watt
- R 10 Resistor, Fixed, Composition, ~~100,000~~ ^{68,000} ohms \pm 5%, 1/2 watt
- R 11 Resistor, 56,000 ohms \pm 5%, 1/2 watt

- RFC 1 Choke, R.F., encapsulated, 36 uh \pm 5%, Iron Core (Millen #J301-36)
- RFC 2 Choke, R.F., encapsulated, 750 uh \pm 5%, Phenolic Core (Millen #34301-750)

- S 1 Switch (See R7)
- SO-1 Socket, Transistor, 4 Prong

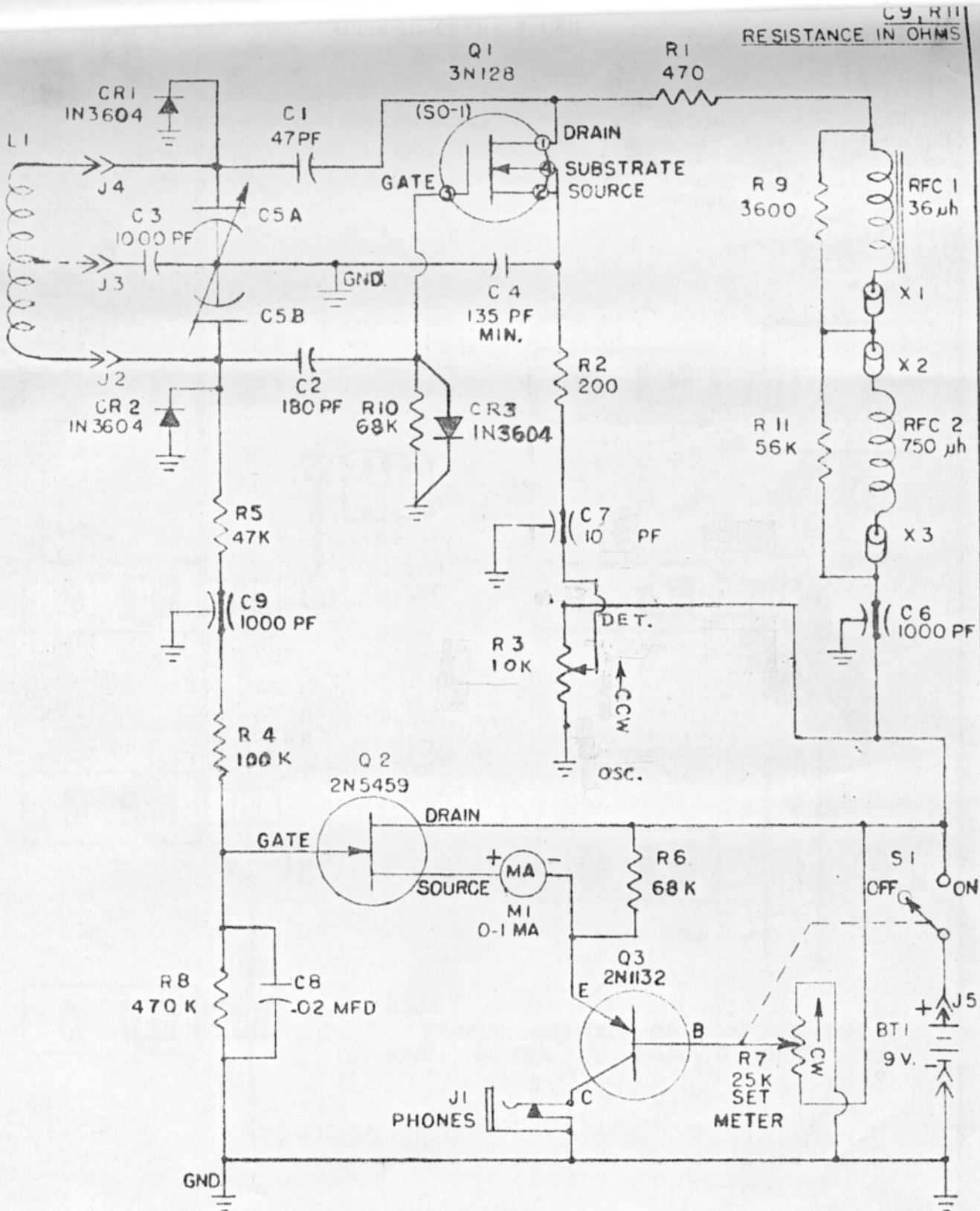
- X1 Bead, Ferrite
- X2 Bead, Ferrite
- X3 Bead, Ferrite



Doc. No. 119-464-AP

DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

Rev. 5 11/72	(4)	Add CR3	SOLID-STATE DIPPER SCHEMATIC	
Jan 7 1973	(3)	Change R5, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83, R84, R85, R86, R87, R88, R89, R90, R91, R92, R93, R94, R95, R96, R97, R98, R99, R100, R101, R102, R103, R104, R105, R106, R107, R108, R109, R110, R111, R112, R113, R114, R115, R116, R117, R118, R119, R120, R121, R122, R123, R124, R125, R126, R127, R128, R129, R130, R131, R132, R133, R134, R135, R136, R137, R138, R139, R140, R141, R142, R143, R144, R145, R146, R147, R148, R149, R150, R151, R152, R153, R154, R155, R156, R157, R158, R159, R160, R161, R162, R163, R164, R165, R166, R167, R168, R169, R170, R171, R172, R173, R174, R175, R176, R177, R178, R179, R180, R181, R182, R183, R184, 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Ser. Nos. 119 and up.

DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

Feb. 9, 1972	4	Add CR3
Jan. 7, 1972	3	Change R3 to 10K; R4 to 100K; R10 to 68K; C7 to 10PF; Ckt. chg.
Oct. 8, 1971	2	Changed R4 to 10K
MAY 18 1971	1	Change J R5, R8, R11, C8, Q3, Re-labelled R3, C4
MAR. 15 1971	-	Brought Schematic up to date

SOLID-STATE DIPPER SCHEMATIC

DESIGNED BY F.D.L.

CHECKED BY *F.D.L.*

SCALE

DRAWN BY R.I.F.

APPROVED *R.I.F.*

JAMES MILLEN MFG. CO., INC.

DATE

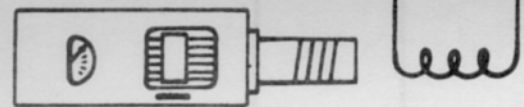
MALDEN MASS., U.S.A.

JAN. 22, 1971

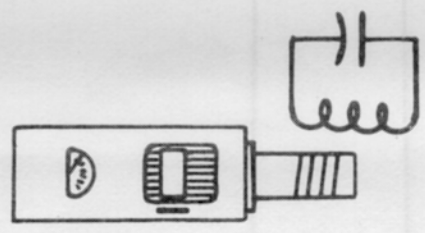
K90652-1

HIGH FREQUENCY
HAIRPIN COIL COUPLED
AT SIDE.

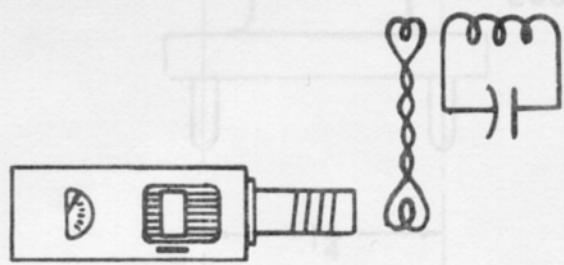
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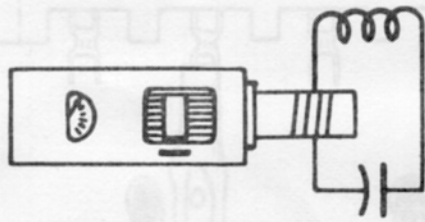
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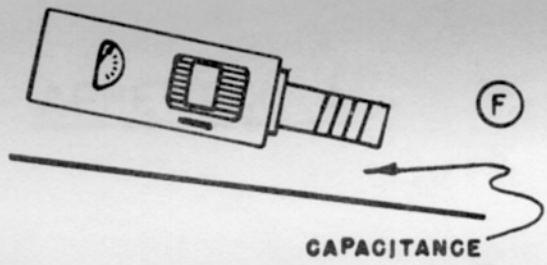
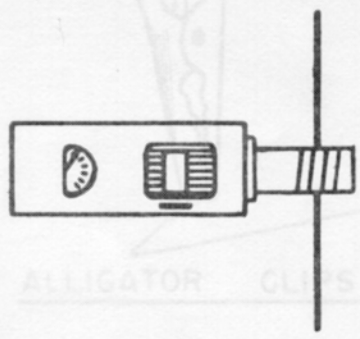
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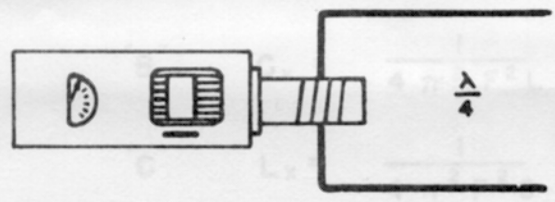
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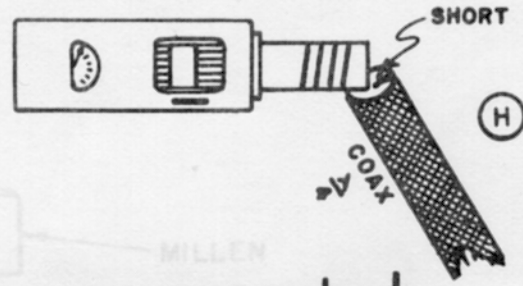
(E)



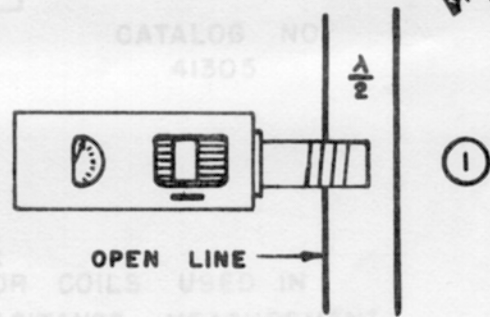
(F)



(G)



(H)



(I)

NOTE :
PROPER METHODS OF COUPLING THE
GRID - DIPPER TO CIRCUITS UNDER TEST.

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (1)

FIRST MADE FOR

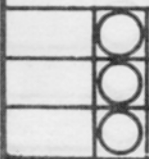
DESIGNED BY _____
DRAWN BY H. GOTTERLY

CHECKED BY R.W.G.
APPROVED _____

JAMES MILLEN MFG. CO., INC.
MALDEN, MASS., U.S.A.

K

DATE
5 - 3 - 49



APPENDIX I

EQUATION

"A"

$$Q = \frac{Fr}{\Delta F}$$

EQUATION

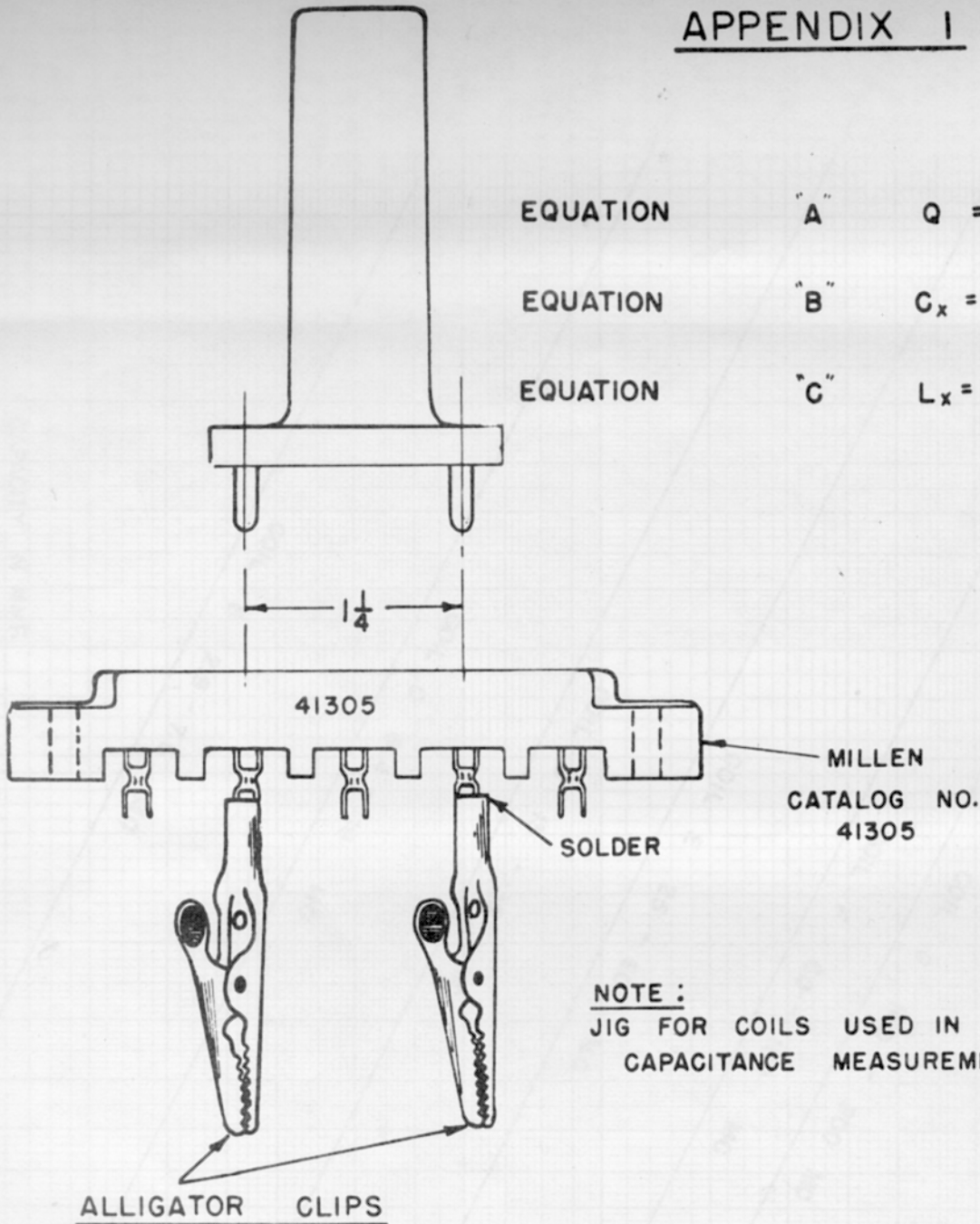
"B"

$$C_x = \frac{1}{4 \pi^2 F^2 L}$$

EQUATION

"C"

$$L_x = \frac{1}{4 \pi^2 F^2 C}$$



NOTE :
 JIG FOR COILS USED IN
 CAPACITANCE MEASUREMENTS

ALL DIMENSIONS UNLESS OTHERWISE NOTED MUST BE HELD TO A TOLERANCE OF

FIG. (2)

FIRST MADE FOR

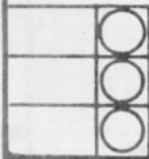
DESIGNED BY _____
 DRAWN BY H. GOTTERLY

CHECKED BY R.W.G.
 APPROVED _____

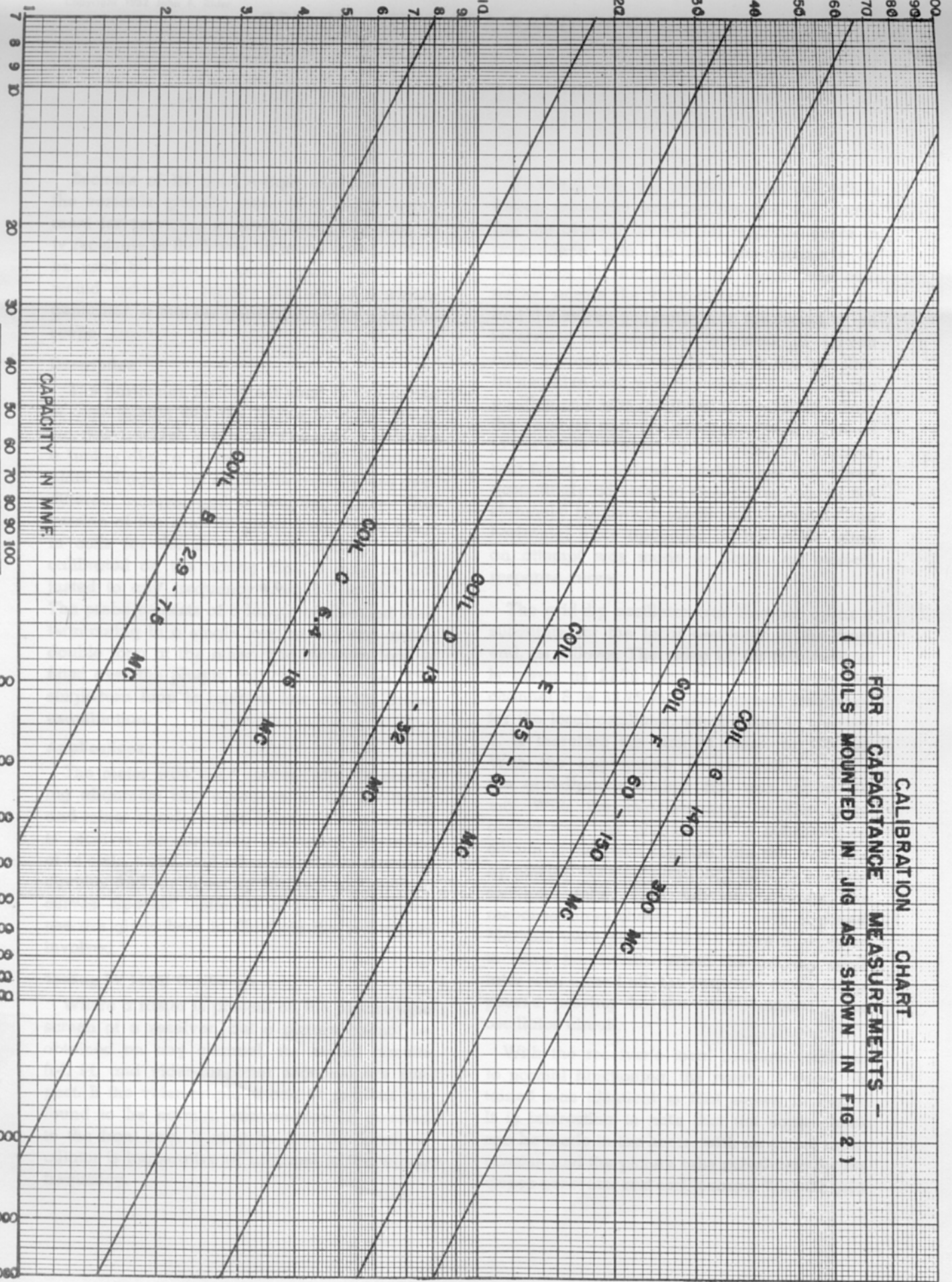
JAMES MILLEN MFG. CO., INC.
 MALDEN, MASS., U.S.A.

K

DATE
 5 - 3 - 49



FREQUENCY IN MC



CALIBRATION CHART
FOR CAPACITANCE MEASUREMENTS -
(COILS MOUNTED IN JIG AS SHOWN IN FIG 2)