No. 4

BERNARDS RADIO SERIES

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HAM NOTES

FOR THE HOME CONSTRUCTOR

CONTENTS

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A LOW-POWER TRANSMITTER FOR

80—40—20

WHILST low powered transmitting circuits are generally of greatest interest to the beginning amateur, who is usually expected to commence with C.W. transmissions on the lower frequencies with an input of the order of 10 watts to the final stage, a low power transmitter can prove very useful to the experienced amateur. For local and 'cross-town' contacts it is unnecessary and undesirable to use a powerful transmitter especially if 'phone operation is employed; even if the modulation level is reduced the carrier can still cause interference in distant areas, whilst a small transmitter is always of service when the main installation is being repaired or is undergoing modifications.

The transmitter shown in Fig. 1 is particularly suitable for emergency and local use since it is self contained—at least for C.W. operation, the power pack and the transmitter both being on one reasonably small chassis. The whole unit is therefore well adapted for easy storage and immediate use, the more especially since a Pierce crystal oscillator circuit and a universal output coupling tank circuit are employed. These features enable the transmitter to be put into operation in a matter of moments on practically any aerial, for the only adjustments necessary are to plug in the required crystal, switch in the correct coil with the band switching control, and a final rapid tuning to resonance.

The transmitter was tested at the G9MO laboratory with 3.5 Mcs. and 7 Mcs. crystals, the output stage acting as a doubler to 14 Mcs. with the crystal oscillator operating on 7 Mcs. With straight-through drive an output of about 10 watts is obtained, this figure dropping to an output of about 6 watts when the P.A. stage is used as a doubler, although 14 Mcs. output can be maintained by the use of a 14 Mcs. crystal in the oscillator stage, if such a crystal is available.

In order that good drive may be obtained from the oscillator through a low value capacitor a Mullard QVO4-7 beam tetrode is employed in this stage. The oscillator was tested with 'stubborn' crystals which have failed when used with other valves, but with the QVO4-7 these crystals gave immediate and steady oscillation.

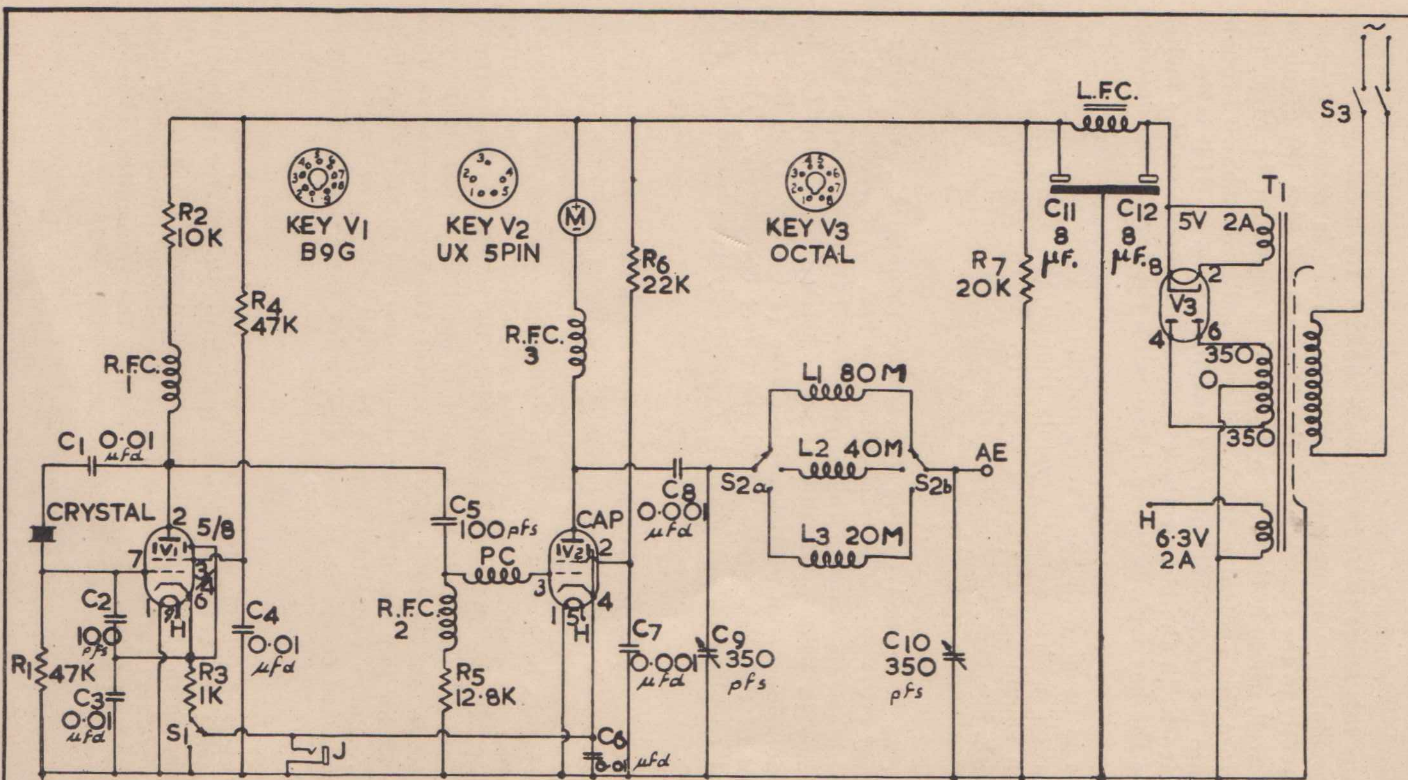

FIG. I. THE LOW - POWER TRANSMITTER FOR 80 - 40 - 20.

A switch is shown in the cathode line of the oscillator, S_1, which permits this stage to be keyed with the P.A. for break-in working, the oscillator being unkeyed when the switch is used to connect R_3 directly to the chassis or earth. On 3.5 and 7 Mcs. the oscillator keys well, though there is a trace of a chirp on 14 Mcs., and therefore this control is made optional and is not shown brought out into the front panel of the transmitter, Fig. 2. If it is desired to place S_1 in the circuit there is room for mounting the switch beside the key jack, between J and S_3 on the front panel drawing.

As is usual with the Pierce oscillator, C_2 is subject to some alteration with different crystals though the value of 100 pfs. shown should suit the great majority. If the oscillator refuses to work, however, C_2 should be reduced or increased in capacitance until oscillation is obtained.

Drive is applied to the P.A. stage through C_5, V_2 being a Mullard QVO5-25 or its equivalent, an 807. A careful check for parasitic oscillation over the bands showed that there was a slight tendency to VHF oscillation at some settings of C_9 and C_{10}, but the inclusion of an anti-parasitic-choke (P.C., Fig. 1) in the grid circuit of the P.A. stage cured the effect completely. The universal coupling output stage is capacitively coupled to the P.A. anode.

The relatively low HT line voltage allows receiving type capacitors to be employed for C_9 and C_{10} without flashover, although if the transmitter is to be speech modulated a reasonable air gap is necessary between the fixed and moving vanes of the two components. A pair of old receiving capacitors could be tried in these positions—maximum capacitance up to 500 pfs are permissible—but for telephony the capacitors specified in the components list below should be employed, unless the components to hand have an air gap slightly wider than is normal in receiving equipment. Large capacitors cannot be fitted below the chassis, and the specified components were chosen for their neat and compact form.

The transmitter can be modulated for 'phone operation from a 10 watt output amplifier. No feed-in provisions for modulation are shown in the diagrams, but these can easily be arranged, the input sockets for connection to the modulating transformer being mounted on a side or the rear wall of the transmitter chassis.

The anode meter M and the HT end of R_6 should be disconnected from the transmitter HT line and joined together, then taken to one modulation input socket, the second modulation input socket being taken to the HT line. For C.W. operation these sockets must be connected together with a shorting link, this link being removed and the secondary of the modulation transformer plugged in for speech. The load of the P.A. stage may be taken as 5,000 ohms, from which the required ratio of the modulation transformer to match the transmitter to the speech amplifier can be calculated.

It will be seen from Fig. 1 that the transmitter is tuned up by the indication of a fixed position meter—that is, the meter is not switched into various circuits but is retained in the P.A. anode circuit. The oscillator supply current, and the grid current due to drive in the P.A. stage, can be measured when the transmitter is first constructed, in order to check the correct operation of the circuits, but since there are no variable tuned circuits in the oscillator and P.A. grid stages constant metering is not necessary.

COMPONENTS

C_1—0.01 Mica 350 v.w. T.C.C. M3N
C_3, C_4, C_6—0.01 mfd 500 v.w. Tubular. T.C.C. 543
C_2, C_5—100 pfs 750 v.w. Mica T.C.C. M2U
C_7, C_8—0.001 mfd 750 v.w. Mica T.C.C. M3U
C_9, C_{10}—350 pfs variable Jackson Bros C604
C_{11}, C_{12}—8 plus 8 mfd 450 v.w. Electrolytic. T.C.C. CE27P with clip V3
R_1, R_4—47,000 ohms, 1 watt
R_2—10,000 ohms, 5 watt
R_3—1,000 ohms, ½ watt
R_5—12,800 ohms, ½ watt. Use 11,000 ohms plus 1,800 ohms in series
R_6—22,000 ohms. 1 watt
R_7—20,000 ohms, 10 watts
R.F.C.₁, ₂, ₃—R.F. chokes, Eddystone 1022
P.C.—Anti-parasitic-choke. 15 turns of 28 S.W.G. enam. on ¼ in. dia. former, turns spaced own dia. (A 1 meg. resistor makes a suitable former.)

T_1—200-250 volt primary 350-0-350 v. 120 m/A 6.3 v. 2 a. 5 v. 2 a. Partridge, T350/120/VDL
L.F.C.—L.F. choke, 22 henrys, 120 m/A. 350 ohms. Partridge C22/120/VDL
V_1—Mullard QVO4-7
V_2—Mullard QVO5-25 or 807
V_3—Mullard GZ32 or 504
1 B9G. 1 UX 5 pin, 1 octal holder
X—Crystal with holder
S_1—(Optional), S.P. 2-way switch
S_2a, b—2P 3-way rotary switch Wearite Ceramic
S_3—D.P. on-off mains switch
J—Key Jack, with plug
Chassis, 14 by 9 by 2½ in. aluminium
M—100 m/A moving coil meter
Aerial terminal, Belling-Lee Feed through, L1296
3 control knobs, anode clip, wire, sleeving, etc.
Coils—See text.

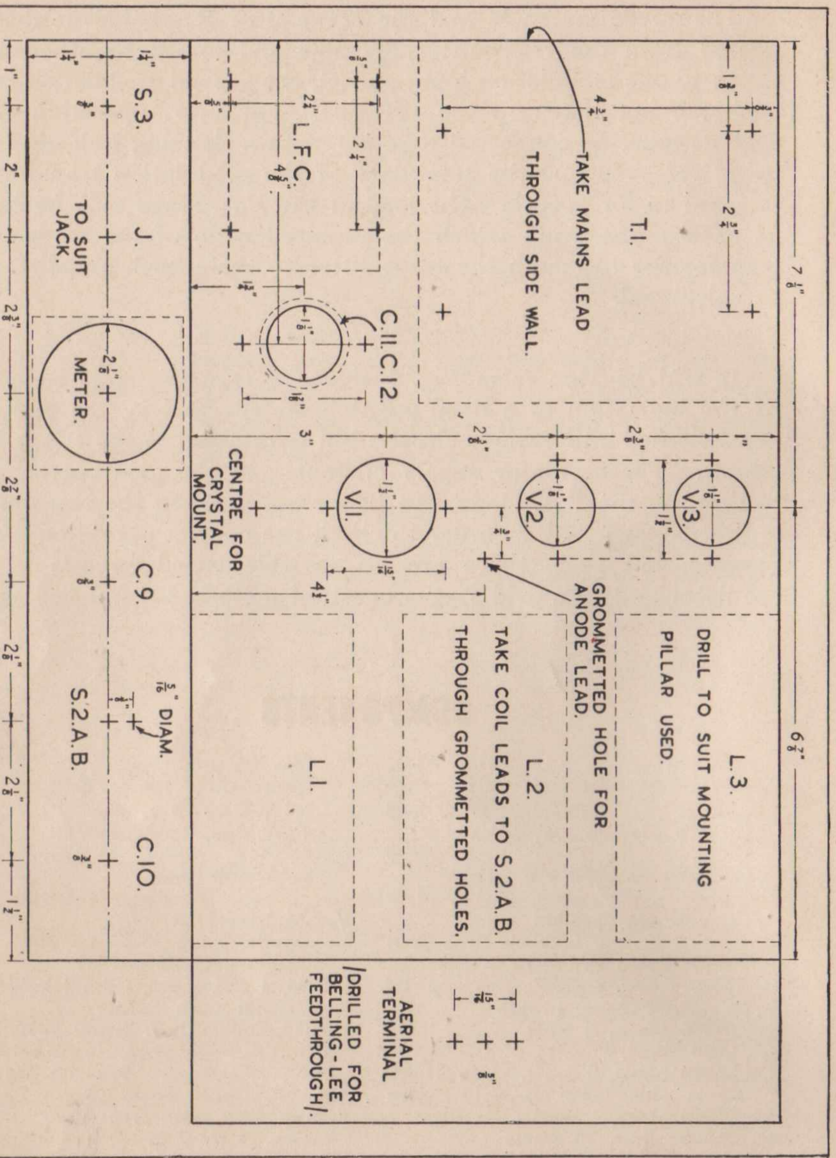

FIG. 2. CHASSIS DRILLING FOR THE LOW POWER TRANSMITTER.

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COIL DATA.

L_1—3.5 Mcs. 19 turns 16 S.W.G. in adjacent slots.
L_2—7 Mcs. 10 turns 16 S.W.G. in adjacent slots.
L_3—14 Mcs. 9 turns 16 S.W.G. in alternate slots.

All coils wound on 2½ in. diameter ceramic formers, Eddystone Type 1090, fitted with mounting pillars.

CONSTRUCTION

The transmitter chassis is drilled as shown in Fig. 2, the power pack being on the left and the output terminal on the right. The valves are arranged in line, and it will be seen that the crystal holder is placed in the same line as the valve holders, close to the front end of the chassis. No drilling dimensions are given for the crystal holder since the constructor probably has a crystal which he will wish to install in the transmitter. There is sufficient space left for the mounting of any type of crystal holder—if modern crystals are employed an octal valve holder might be used in this position.

The positions of the three coils are also indicated without drilling dimensions, in order that any type of coil mounting may be used. The specified formers are supplied with frequentite pillars by means of which they may be raised above the chassis, but small standoff insulators could also be employed.

As an alternative, and to cut down the chassis size, it is possible to employ plug-in coils. These are built by winding the coils on the 2½ in. diameter ceramic formers specified, the formers then being fitted with plug-bases, Eddystone type 1091. A base to take the plug-in coils, Eddystone 1092, is then mounted on the chassis,—the band switch 2a, 2b is of course dispensed with.

The leads from the coils to the switch, when mounted as in the original transmitter, must be as short and direct as possible.

The transmitter should be directly earthed to a good physical earth, but no earthing terminal is shown in the chassis drilling diagram as the position and type of terminal will depend on the constructor's existing arrangements. It may be possible to provide a short earth return by employing a three-core mains cable, the third lead being taken to the mains earth; on the other hand this route may be long and circuitous when a separate earth lead should be used. A small terminal or soldering tag for the earth lead can easily be mounted at any convenient point on the chassis.

All resistors and capacitors can be mounted in the wiring, as can the RF chokes. The leads from the mains transformer and LF choke are taken through grommeted holes to the circuits below the chassis, and the large 10 watt resistor can be mounted between the positive lug of C_{11} and an earthed soldering tag. Remember to place soldering tags on each valveholder mounting bolt to provide a number of earthed tie-points.

The reservoir capacitor, C_{12}, may appear to have a rather low working voltage (450 v.) for a 350 v. transformer, but the bleeder, R_7, imposes sufficient load to keep the peak voltage down to a safe figure.

The transformer specified has two 6.3 volt heater windings, one supplying 2 amps. and the other 4 amps. This second heater winding can be ignored.

ADJUSTMENTS AND TUNING

With the circuit built up and the wiring checked, V_1 can be inserted and the transmitter switched on. S_1, if fitted, should be thrown to connect R_3 to earth. As the valve warms up it should go immediately into oscillation, which can be checked by touching a low power neon to the anode contact on the valve holder. If no oscillation is obtained the circuit should be checked for wiring faults, and the crystal inspected for flaws or dirt. If all seems in order, vary the capacitance of C_2. This step should not, however, be necessary, and strong oscillation should be obtained at the first trial.

To check the operation of the circuit the wiring may temporarily be broken and current measurements taken. The total current to the anode and screen of V_1 should be of the order of 25 m/A's.

V_2 can now be inserted after the anode and screen lines of this valve have temporarily been disconnected from the HT line so that these electrodes are not powered. The key is closed and R_5 is disconnected from the chassis and a low reading milliameter inserted between the earthy and of R_5 and earth; the meter should have a range of 10 m/A's full scale deflection. With the QVO5-25 unpowered the grid current indicated should be of the order of 4 or 5 m/A's and this reading should fall when the valve is powered and the output circuit tuned to resonance, to 3.5 m/A's.

The anode current to V_2 off resonance is of the order of 70 m/A's, dropping to 60 m/A's or so with the output circuit tuned and the external load correctly coupled. The wide swings of anode current associated with a more usual output tank circuit are not obtained with the universal output tank, where some load is always imposed.

To tune the tank circuit, connect in the aerial which may be practically any length of wire—for a dummy load a 15 watts lamp may be connected directly between the aerial terminal and earth. Some indicator is needed in the aerial circuit to show the conditions of maximum energy transfer; the indicator may be either a thermo-ammeter or a neon bulb, depending on the length of the aerial and the feed. The thermo-ammeter should be in series with the aerial and aerial terminal; if the indication is poor then the aerial may be taken directly to the terminal and a neon bulb touched to the terminal as an indicator.

With the correct crystal inserted and the correct coil switched, set C_{10} to about the midway position and rotate C_9 to obtain a current drop at the resonant point, as indicated by the 100 m/A meter on the transmitter panel. Inspect the aerial indicator; feed may be good or poor. In either case endeavour to increase the aerial power by further adjustments of C_{10}, each adjustment being accompanied by another adjustment of C_9 to maintain resonance. With the aerial coupling set correctly, the current dip as C_9 is rotated through the resonant point will be very slight.

As a general rule the correct coupling will be found with C_{10} at a low capacitance value.

If resonance on C_9 cannot be found with the first setting of C_{10}, readjust C_{10} to another setting and again rotate C_9, continuing until the resonant point of C_9 is discovered.

When the transmitter is correctly loaded the current indicated by M should be of the order of 55 m/A's with straight-through working on the crystal fundamental, and 65 m/A's with the P.A. doubling the crystal frequency.

Any indicator in the aerial should be disconnected before working. Such an indicator cannot show power output as a measurement, but can be used only to indicate the maximum aerial feed.

MODULATION MONITOR

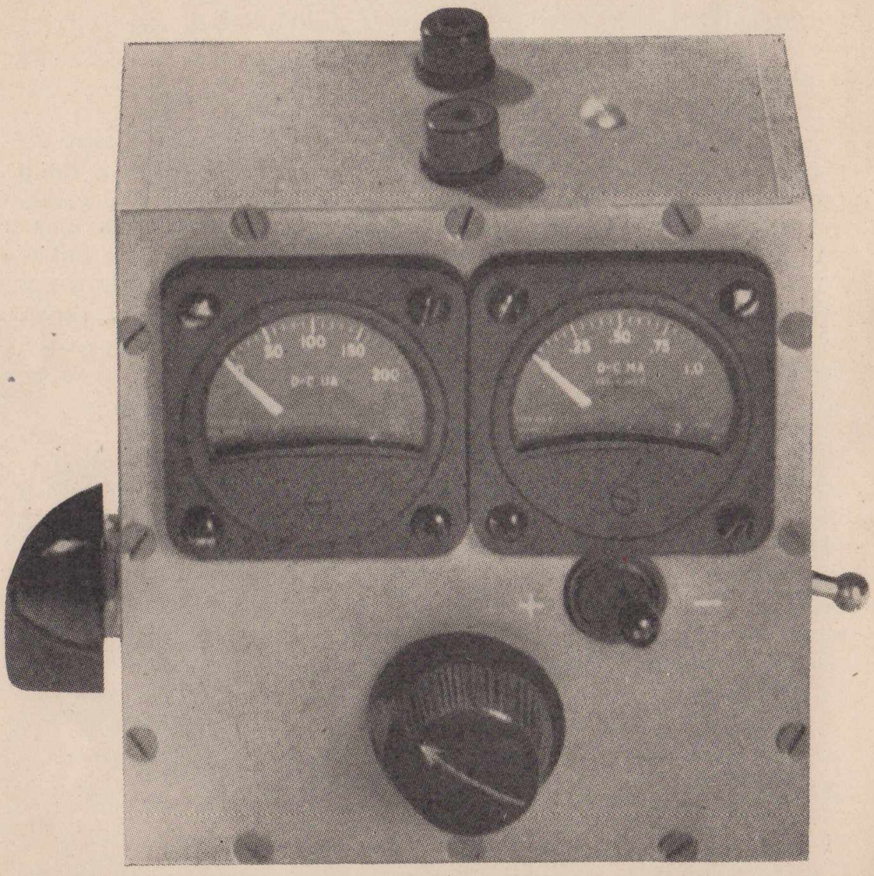

Fig. 8. Front View of Modulation Monitor

Acknowledgments

The information contained in the article(s) "*Modulation Monitor*" has been reprinted by kind permission of "General Electric Ham News" from their Vol. 3—No. 2 issue.

While serving primarily as a guide to proper modulation of a phone station, the device pictured in Fig. 8 is a valuable addition to any shack. It will serve as a carrier shift indicator, a field strength meter, a neutralization indicator, a phone monitor and a sensitive wavemeter.

Referring to the circuit diagram in Fig. 9, meter M_1, which is on the left in the photograph, is a sensitive instrument which reads the carrier level, or indicates the pressure of RF when the device is used as a field strength meter, a neutralization indicator or a wavemeter. Meter M_2 is used only to give per cent modulation readings. If the modulation monitor feature is not desired, meter M_2 and the copper-oxide meter rectifier CO may be omitted, and the device will still retain its versatility.

To use this gadget as a wavemeter, a pick-up loop is coupled to the input circuit and switch S_1 is placed on the proper position. Coil L_1 tunes to 80 and 40 meters, L_2 tunes to 20, 15 and 10 meters, L_3 tunes to 6 meters and the tap on L_3 tunes to 2 meters. With switch S_1 on the proper tap, condenser C_2 is used to peak the reading of Meter M_1. Using a calibrated dial, frequency may be read directly. Switch S_2 should be on the RF position for these readings.

For use as a phone monitor, RF should be fed into the input via a link or a pick-up wire on the positive terminal, and the LC circuit tuned to the frequency involved. Earphones inserted in jack J will allow you to monitor the signal. S_2 should be in the AF position.

Field strength readings can be taken with this device by using a short pick-up antenna on the positive input terminal. Again the LC circuit should be tuned to resonance. Meter M_1 will now give an indication of field strength. With S_2 in the RF position the meter is very sensitive, but if the input is too great, switch S_2 can be thrown to the AF position which will greatly reduce the sensitivity of M_1. Sensitivity can be reduced still further by using Switch S_1 connected to L_4. This is a 2.5 mh. RF choke, and tunes the input very broadly. C_2 still has some effect and may be used as a vernier adjustment.

Neutralization measurements are made by coupling the device through a pickup link to the tank coil, with S_2 in the RF position. When the LC circuit is tuned to resonance, the gadget acts as a very sensitive RF indicator. As a matter of fact, it is so sensitive that it is doubtful where any stage could be sufficiently well neutralized so that the meter could be made to indicate zero RF.

To use the device as a modulation monitor, use a pickup link to couple in RF energy. Tune the LC circuit to resonance on the proper band, and then adjust the pickup link coupling until meter M_1 reads your calibrated point value. (Calibration procedure will be discussed later.) Now, meter M_2 will respond to voice modulation and permit a constant check on the percentage of modulation. In addition, meter M_1 will give a constant check on the carrier level, which normally should stay constant.

ELECTRICAL CIRCUIT

The part of the circuit to the left of the germanium crystal X, referring to Fig. 9, is the RF pickup and tuning section. C_1 is employed as a blocking condenser and C_2 acts as a tuning condenser. The crystal acts as a half-wave rectifier, while C_3 and L_5 serve as an RF filter, so that the input to resistors R_1 and R_2 is d-c with a superimposed audio waveform.

ELECTRICAL CIRCUIT

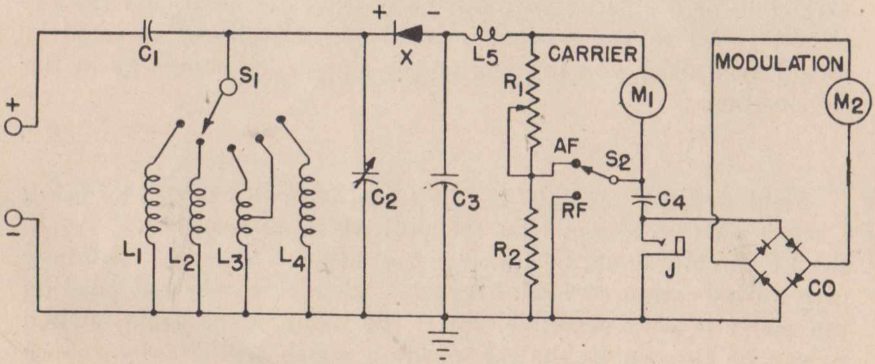

Fig. 9. Circuit of Modulation Monitor

COMPONENTS

C_1 —25 mmf mica
C_2 —75 mmf variable
C_3 —0.001 mf mica
C_4 —0.1 mf paper
J —Open circuit jack
L_1 —65T No. 33 S.W.G. enamel wire close wound on ½ inch diameter form.
L_2 —14T No. 33 S.W.G. enamel wire close wound on ½ inch diameter form.
L_3 —6½T No. 16 S.W.G. wire space wound, ¼ inch diameter, ½ inch long with tap 1½ turns from ground end

L_4, L_5—2.5 mh r-f choke
M_1 —0-200 μa. meter (G.E. 411X88)
M_2 —0-1 m/A meter (G.E. 411X92)
R_1 —50 ohm semi-adjustable
R_2 —5,000 ohm ½ watt
S_1 —Single-pole 5-position switch
S_2 —SPDT toggle switch
X —Germanium crystal (1N34 or equivalent)
CO —Full-wave copper-oxide meter rectifier

One precaution only should be observed when laying out the unit. The RF section should be separated from the meter circuits to prevent stray fields from injuring the meter movements.

When switch S_2 is in the RF position, the d-c current which flows through M_1 is a measure of the RF in the input circuit. With S_2 in the A-F position, meter M_1 is shunted with resistor R_1 and again reads a value of current which depends upon the RF input, but M_1 is now much less sensitive. The portion of d-c voltage with superimposed audio which exists across resistor R_2 is now picked up by the full-wave copper-oxide rectifier, rectified, and given as a d-c current to the percentage modulation meter M_2 Condenser C_4 acts as a d-c blocking condenser so that audio voltage only is presented to the copper-oxide rectifier. The phone jack at this point permits the insertion of earphones for monitoring purposes.

CONSTRUCTION

The unit shown in Fig. 8 was constructed in a 4 by 4 by 2 inch chassis. The particular chassis shown is not a commercial chassis but one made up of aluminium. A switch is shown on the front panel marked plus and minus. This was used in an earlier version and is not included in the present circuit.

Although a 0-200 microammeter is specified for meter M_1, a 0-1 m/A. meter will work just as well and no circuit changes need be made. The unit will be less sensitive when it is used as a field-strength meter, neutralisation indicator or wavemeter. Operation will be unaffected for modulation monitoring use, as resistor R_1 acts as a shunt and can be adjusted to accommodate either a 0-200 μ.A. meter or a 0-1 m/A meter.

With reference to Fig. 8, the band switch is placed on the left panel and the RF-AF switch is on the right panel. The front panel contains the two meters, the tuning condenser in the centre, and the phone jack is placed where the switch is shown.

WAVEMETER CALIBRATION

To check coil L_1, the unit should be coupled to a source of 3.5 megacycle energy, and meter M_1 peaked for maximum current. The condenser setting should be such that most of the capacitance is in use. If this is true, put 7 megacycle RF in and again resonate the LC circuit. The condenser should now be approaching minimum capacitance. The coil should be adjusted until both bands can be resonated with the condenser. The same procedure is followed with coil L_2. The 15 metre band should peak with the condenser approximately half-way meshed, in which case the 20 and 10 metre bands should fall on each side. In position 3 the six metre band will be found,andthe tap on L_3 can be adjusted until the 2 metre band is peaked when the switch is in position 4.

MODULATION METER CALIBRATION

To prepare for the job of calibrating the modulaton meter, it is first necessary to use an oscilloscope and set up the scope so that it is reading trapezoidal patterns. This is discussed fully in radio handbooks and will not be repeated here. Once this setup is complete, the modulation monitor should be coupled lightly to the final tank coil and the LC circuit in the modulation meter brought to resonance. S_2 should be in the AF position. The coupling should now be adjusted so that the meter M_1 reads half-scale.

The rig should now be voice modulated, and the voice level maintained so that the trapezoid pattern indicates 100% modulation on the audio peaks. Under these conditions, check the maximum deflection of meter M_2. If the maximum deflection is full scale, you may consider this as the 100% point and calibration is completed for that one point. However, if the meter does not read high enough on voice peaks, adjust the shunt R_1 on meter M_1 so that more resistance is in use.

Following this, readjust the link coupling to the final until M_1 again reads half-scale. Again check meter M_2, and repeat the above until M_2 reads full-scale, when M_1 is at half-scale and the trapezoid pattern is indicating 100% modulation voice peaks.

Inasmuch as meter M_2 will not read in a linear manner, it will be necessary to repeat the above calibration procedure for other percentages of modulation. Suggested values might be 75%, 50% and 25%. In other words, when R_1 has been adjusted so that 100% modulation is approximated by full-scale deflection of M_2, it should be kept at this value of resistance.

By changing the voice level so that the trapezoid pattern indicates 75% modulation peaks, the reading of meter M_2 can be noted which corresponds to 75% modulation. This same process may be carried out for other modulation percentages.

The unit pictured read 100% modulation at full-scale, when M_1 was adjusted to half-scale, and the value of R_1 was 42 ohms.

Inasmuch as there is a possibility that some error will be introduced if the meter is calibrated on 75 metre phone and then used on 2 metre phone, it is advisable to make the calibration on the band that will be the most widely used.

After the unit is calibrated, it will always give the same readings as a modulation indicator, whenever the LC circuit is resonated and the pickup adjusted so that M_1 reads at mid-scale.

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