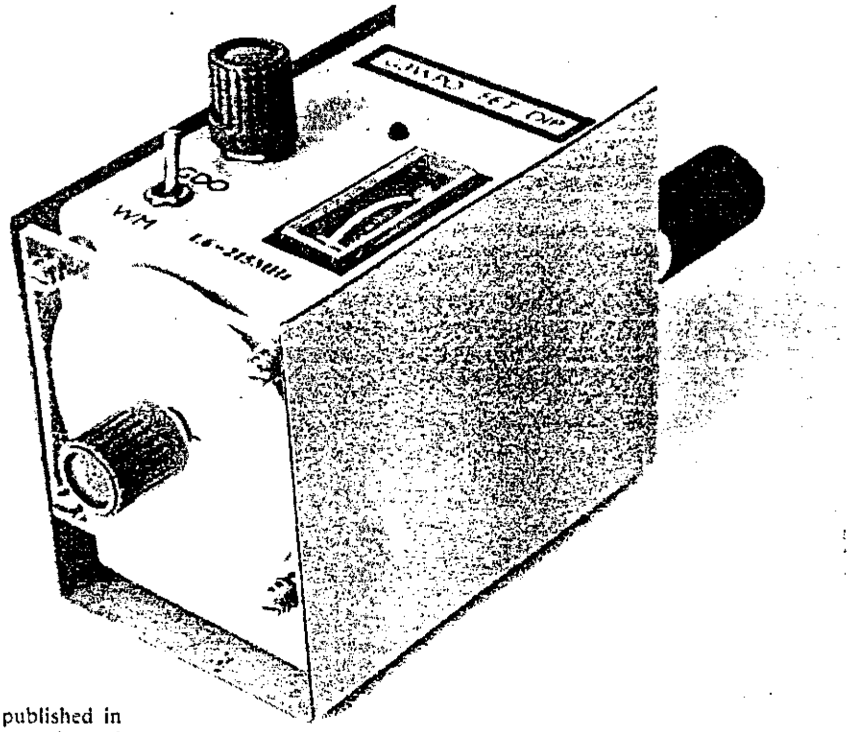
THE G3WPO FET DIP OSCILLATOR Mk2



Tony Bailey, G3WPO*

THE ORIGINAL DESIGN for a kit-form dip oscillator, published in *Radio Communication*, November 1981, has proved to be very popular and reliable, with over 4,000 of the kits built and working. In common with any design, however, a number of improvements have been suggested over the past five years by constructors and, together with some circuit improvements from the author, a revised pcb design is presented in this article which shows a very considerable enhancement in performance both in dip and in wavemeter modes.

Like the original design, full kits of parts will be available and, as the new design uses nearly all of the original parts except for a new pcb, coils and recalibration, a modification kit is to be made available for those who wish to rebuild the Mk1 version.

The new design features:

(*i*) coverage of 0·8–170MHz in six ranges;
(*ii*) enhanced dip and wavemeter functions;
(*iii*) reproducible design on one pcb;
(*iv*) new precalibrated scale; and
(*v*) audio and meter dip/wavemeter indications.

Mk1 problems

The original circuit utilized a fet kaliatron oscillator covering 1·6–215MHz. Both meter and audio indication of the dip point were provided. While the dip indication obtained was reliable at the higher frequencies, at the lower end the dip was much less pronounced and, depending on fet transconductance, sometimes difficult to detect. The main reason for this is that with such a wide (135:1) range oscillator having no inbuilt means of adjusting the gain between bands, the level of oscillation varies tremendously, and at the lower end is so high that very close coupling is often required to produce a visible or audible change in the detected output, particularly so in the 1·6-30MHz region.

The other main problem was that of insensitivity in the wavemeter mode, where the voltage supply to the oscillator is removed and the circuit simply used to detect and indicate the frequency of an rf oscillator.

Improvements

One of the concepts behind the original design was that the plug-in coils should not be complicated by needing taps, either inductive or capacitive. This eases reproducibility problems and, provided that the coil-winding details are followed to the letter, it should be possible to use the precalibrated scale provided, cutting out the tedious calibration procedure.

The original kaliatron oscillator has been retained but now uses two dual-gate mosfets rather than single-gate fets. This change in itself produces a somewhat better dip, but the presence of the second gate now provides an ideal means by which the gain of the oscillator can be preset quite easily on

Tony Bailey was born in 1945 and first licensed in 1967, after several years as an swl, and has always been interested in home-construction. After many years on top band, he moved to vhf/uhf, where he became one of the first stations on 432MHz ssb using homebrew gear. He is a founder and honorary life member of the Mid-Sussex ARS.

He is well known as a homebrew designer and author of constructional articles, and was awarded the Ostermeyer Trophy for his work in this field in 1981 and 1982. His interests in the hobby are varied, having attempted nearly all aspects, and he was the first editor of *Oscar News* for several years. Originally trained as a chemist, he is a freelance writer for both amateur and professional electronic journals, also turning his pen to novels in his spare-time.

Components list (required to convert a Mk1)

R1	10kΩ	C1	Toko polyvaricon
R2,7	39kΩ	C2,3,8,9	10nF ceramic disc
R3,5	56kΩ	C4,5	12pF ceramic disc 5%
R4,6,18,19	100kΩ	C6,7	10pF ceramic disc 5%
R8	220Ω	C10,11	10nF mylar
R9	2·2kΩ	L2,3	Toko 470µH choke type 7BS
R10,11	47Ω		
R12,21	1·5kΩ	TR1,2	3SK88
R13	3·3kΩ	TR3,4,5	BC238 or similar npn
R14	470Ω	D1	3mm red l.e.d
R15,16	33kΩ	D2,3	BA481
R17,20	4·7kΩ	ZD1	5·6V 400mW
R22	1kΩ	Extension spindle	Cirkit
All resistors are 0·25W 5% carbon film types.		Wire	Insulated copper, 0·2mm diameter
VR1	470Ω vertical mount 10mm preset		

Toko and Alps components are available from Cirkit Holdings plc, as is a Mk1 modification kit, or a complete set of components for the Mk2 together with drilled pcb, coil formers and finished case (see advert on page 294).

Members who wish to homebrew the pcb can obtain a copy of the construction details and diagrams by sending a large self-addressed envelope to the editor at RSGB headquarters.

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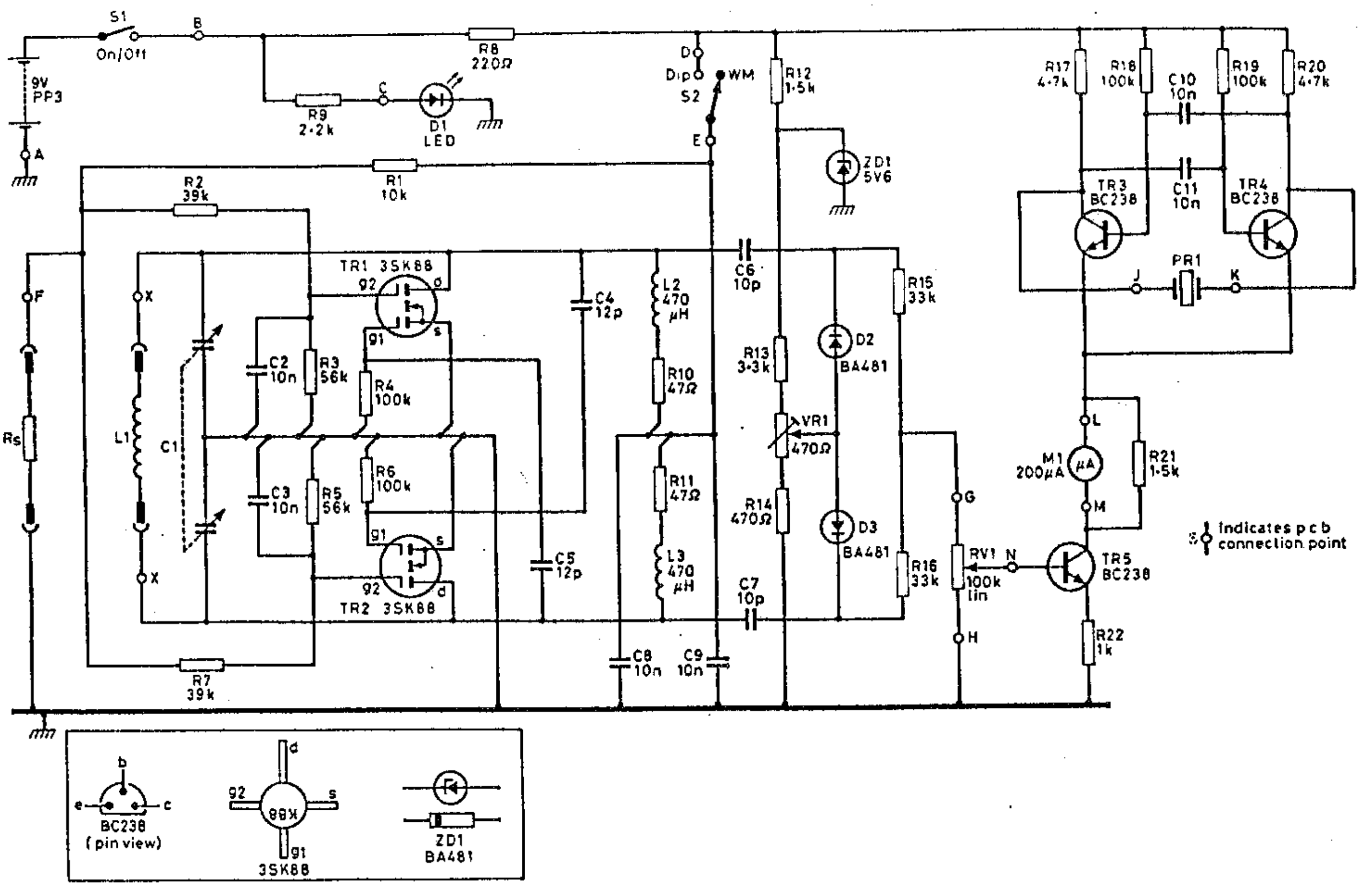


Fig 1. Circuit diagram

each range by means of a single fixed resistor. The resulting dip is now very considerably improved on all ranges.

To improve the sensitivity of the wavemeter, again by a large factor, the two detector diodes have been changed to Schottky barrier types, with these being permanently biased into conduction by a small standing current.

For those without a copy of the original article, photocopies are also available from the editor at RSGB headquarters.

Circuit

The new rf oscillator is a mosfet kaliatron design, offering wide coverage and the ability to control the overall gain by varying the Gate 2 voltage from an external fixed resistor mounted within the coil former. Inductor L1 sets the frequency coverage in conjunction with C1. The latter is a Japanese polyvaricon dual-gang type and, despite the low cost, has a very high reproducible specification.

Without Rs in place, the Gate 2 voltage is fixed at around half the drain voltage by (for TR1) R1/2/3, with the circuit running at maximum gain. On all frequency ranges, the gain is reduced by the addition of Rs as the other half of a voltage divider with R1, thus lowering the Gate 2 voltage and the overall gain. The circuit is capable of oscillating up to about 240MHz (the upper limit being fixed by circuit strays and the minimum capacitance/self-inductance of the polyvaricon) but it is difficult to optimize the performance at this high a frequency when also trying to obtain coverage below 3MHz. Consequently, the upper limit has been fixed at 170MHz for this version, thus still covering all the amateur hf and vhf bands. The self-inductance of the capacitor has been reduced by improving the stator earthing arrangement.

R10/11 damp the two rf chokes in the drain circuits, reducing to low levels inherent false dips from self-resonances. The rf is detected by D2/D3, which are Schottky barrier types biased into conduction by a stable bias voltage adjustable by preset resistor VR1—this is set so that the indicating meter reads half-scale deflection with the sensitivity control RV1 at maximum. This bias current is primarily designed to increase the sensitivity in "Wavemeter" mode, where the supply is removed from the oscillator and the circuit used as a passive indicating wavemeter, but also assists the dip slightly so has been left as a permanent feature. It also has the advantage of acting as a battery condition indicator.

The detected dc voltage is applied to the base of an npn transistor, TR5, which controls the current flowing through a simple audio multivibrator consisting of TR3/4. As the current through TR5 increases, so the audio note from the piezo resonator (PR1) increases in frequency, and the reading on meter M1 also increases. The meter and audio levels are set by the sensitivity control, RV1. This circuit has a higher audio output than the original by the addition of R21 as a meter shunt. The multivibrator commences oscillation at about mid-scale meter reading, and has a readily detectable note which drops sharply as resonance of the rf circuit is reached.

In use as a wavemeter, S2 removes the voltage supply to the oscillator, and the circuit becomes a passive wavemeter with an increase in meter reading and a rise in the audio frequency as resonance is reached. The circuit runs from a PP3 9V battery, with R8 acting as a current limiting resistor. Consumption varies, depending on the band, from about 5mA up to 15mA on the highest band. LED D1 is provided to act as an on/off indicator.

Table 1. Value of Rs vs band

Band	Rs	Band	Rs
A	150Ω	D	680Ω
B	470Ω	E	2·2kΩ
C	470Ω	F	10kΩ

These values can be adjusted for improved sensitivity by lowering Rs until oscillation ceases at some point, then increasing the value slightly.

Coil formers

As with the original, DIN plugs fitted into rigid plastic electrical conduit tubes are used as coil formers. These are now five-pin types, two pins used for the coil connections and two for the gain setting resistor Rs. Only the actual plug end itself is used, and is Araldited into the former after winding the coil. The conduit is widely available from electrical stockists. The lowest four range coils are wound directly onto the formers, but the two highest ranges are air wound with the former used a protective plastic shroud.

This design now uses an additional coil to extend the lf coverage down to 0·8MHz, with the highest range coil also modified against the original to suit the new circuit constants.

THE G3WPO MKII FET DIP OSCILLATOR

CONSTRUCTION

The reproducability of the design is primarily dependant on the total inductance and capacitance present, especially at VHF and hence a pcb based design will eliminate a lot of the variations that would be present in a hard-wired version. Providing the coil winding instructions are followed to the letter it will be possible to use the precalibrated dial provided, thus eliminating the tedious process of hand calibration. The whole of the electronic circuit is constructed on a single sided pcb.

Construction should be started with the actual pcb as this can be tested independantly of the mechanical part. All leads of components mounted on the board should be kept as short as possible around the RF oscillator section - the MOSFETs themselves do not present a problem as they are of stripline construction but resistors and capacitors must be inserted as close to the board as possible - failure to observe this instruction will result in poor operation and failure of calibration against the supplied scale. All components except for the tuning capacitor mount on the non-track side of the pcb.

1. Insert and solder the connection pins. The four marked 'y' are inserted from the non-track side so that the stator earthing straps can be soldered to them on the track side of board, the others go in normally from the track side. Push each hard home with a blunt nosed tool before soldering.

2. Insert and solder all fixed resistors, mounting vertically or horizontally as indicated by the layout drawing. Vertical resistors should be inserted so that the body end corresponds with the circular outline on the drawing.

3. Insert and solder all fixed capacitors, keeping the leads as short as possible for C2 - C7. Note that the board spacing for C4 and 5 is greater than the capacitor leads themselves so take care when fixing these in place.

4. Insert and solder D2/3 taking care when bending the leads not to break the fragile glass envelope - the banded ends of the diodes must face outwards to the edges of the pcb.

5. Insert and solder ZD1, mounted vertically with the banded end facing into the pcb .

6. Insert and solder L2/L3 and VR1 preset.

7. Insert and solder TR3/4/5 with the case outlines corresponding to the drawing.

8. Solder in the three link wires using insulated wire.

9. Insert the polyvaricon capacitor from the foil side of the pcb (spindle first) so that the three leads go through the appropriate holes. Ensure that it is flat against the pcb and solder the two rotor and the stator lead to the pcb, taking care not to melt the capacitor body. Cut off excess leads on the other side of the pcb.

Using two M2.5 short thread screws, fix the polyvaricon body to the pcb - DO NOT use the two 8BA x 6mm screws needed for mounting the piezo resonator as these will damage the tuning vanes beyond repair.

Prepare the two stator earthing straps from single sided pcb material or braiding and tin the surfaces with a hot soldering iron. Both straps mount with the tinned surface against the inside of the connection pins (relative to the polyvaricon) with the short stator leads from the capacitor folded over against the tinned surface. Solder the straps to the pins first, just above the pcb surface so that there are no shorts, and then the stator leads to the straps.

10. Insert and solder Tr1 and TR2 MOSFET's from the foil side of the board. Note that the bodies of these sit within the holes provided and that TR1 is mounted with the identifying legend (K88) visible on the TRACK side while TR2 has the legend on the NON-TRACK side. The longer lead on each transistor is the drain lead and faces upwards towards the centre of the board - trim the leads if necessary while soldering in place.

11. Fix the polyvaricon shaft extension spindle in place using the 20mm countersunk screw provided with the spindle.

This completes pcb construction and at this stage you should double check that all components are correctly placed, especially semiconductors. Also, using the printed pcb artwork as a reference, check that there are no solder bridges between tracks or pads.

CHECKING OPERATION

In order to verify correct operation, coil D is required and this should be built as described under 'Coil construction'.

Next, clip off and remove the center pin of the five pin DIN socket and entirely remove the lug (if any) protruding from the surrounding metal cover. Bend up the two innermost pins away from the other two pins and then solder the two outermost pins to the socket pads on the pcb (shown marked as 'X' on the layout). Then connect the two innermost pins to point F and H (earth) using short lengths of wire.

Temporarily connect the meter, sensitivity control, switch, piezo resonator and battery. Adjust the preset VR1 to mid travel. With no coil inserted, the RF assembly should self oscillate. Open S2 so that the board is in wavemeter mode, turn the sensitivity control (RV1) fully clockwise and then adjust preset VR1 so that the meter reads three-quarters fsd. The audio oscillator should be running .

Turn the sensitivity control to minimum, switch S2 to Dip mode and insert coil D. Increase the sensitivity setting until about 7/8th fsd is obtained and vary C1 over its entire travel to ensure that the oscillator is working over its whole range. The sensitivity should vary smoothly with no sudden dips although it will be necessary to adjust the sensitivity control to keep around fsd on the meter.

To check the dip, either construct coil B, which has a self resonance at approximately 37MHz, or use another coil/capacitor combination whose frequency is within coil D's range.

Once the above checks are completed the wavemeter function can be verified, turning the sensitivity control to maximum and then adjusting as required so that any rectified RF deflects the meter adequately.

COIL CONSTRUCTION

It is very important that these constructional details are followed exactly if the precalibrated scale is to be used. Primarily, the wire gauges should be the same and are given here in metric rather than swg - using the nearest equivalent swg to the nominated metric diameter will be okay on the two high range coils but will result in increasing errors on the lower ranges.

Referring to the drawings, cut the coil formers to the length indicated and drill two 1mm dia holes in the positions indicated on the four longer formers. Take the length of wire indicated (see later for coil A), feed through the lower hole from the outside of the former, and out through the bottom leaving 20mm protruding from the former. Close wind the number of turns stated, finally feeding the wire through the top hole and out of the bottom of the former again. In the case of coil A, a specific number of turns is not stated (although actually about 385), it being more practical to fill the space between the two holes with wire. Secure the ends of the windings in place with a small drop of cyanoacrylate or Araldite adhesive at each hole and around the last turn at each end of the winding. Reduce the two free wire ends to 10mm in length and strip 3mm of insulation off each. Take the end of the five pin DIN plug, discarding the metal shroud and plastic cover and snip off the centre pin.

Solder resistor Rs across the innermost two pins and the two free ends of the coil to the outermost two pins. Prepare and smear a good layer of Araldite (rapid setting is best) around the lower inside edge of the former to about 3-5mm in depth and carefully insert the plug, pushing the wire back into the former. Make sure that the plug is at right angles to the former all the way round and leave to set hard.

The two upper ranges are air wound. They are both wound round a 0.375" diameter drill or other suitable former of the same diameter, the lower lead bent at right angles to the main winding and the upper lead bent into the centre of the winding and cut off at the centre. Strip a few mm of insulation from the upper lead and solder a straight piece of wire of the same gauge to this running down from the centre of the coil. Cut the two leads to 20mm in length, measuring from the lower side of the bottom turn and solder to the plug connections, with the lower ends of the wires resting against the plastic of the plug former. Prepare the shroud, slide over the coil from the plug end and then Araldite in place.

THE CASE

The case design is dictated by the physical design of the polyvaricon and requires that the tuning scale be at the opposite end to the coil if a reasonable size is to be maintained.

A slow motion drive is provided to which the tuning scale is fixed and the connection to the polyvaricon made by a special plastic extension piece fixed to its stubby shaft and then to an aluminium coupler and extension rod. The piezo resonator is fixed to the rear panel, with the rest of the controls mounted on the top panel.

A simple two part case construction is used and is supplied ready finished for use.

FINAL ASSEMBLY

It is suggested that the following order of assembly is followed if problems are to be avoided.

1. Bolt the DIN socket into place on the front panel (with leads bent as previously indicated) so that the two innermost pins used for connecting to Rs are nearest the open end of the case.

2. Fix the 4 x 25mm long 6BA bolts on to the front panel with a lockwasher and nut on each to secure. Add an additional 6BA nut to each of the four bolts and carefully slide on the pcb,

screwing down the four nuts until the rear of the polyvaricon is just touching the front of the case. Check that the pcb is parallel with the front panel on all sides and solder the DIN socket pins to the connection pads by carefully inserting a soldering iron through the gap. Then fix the pcb firmly in place using additional 6BA lockwashers and nuts.

3. Reduce the potentiometer spindle to 10mm in length and mount with the tags facing the front of the case.

4. Fix S2 in place and mount the meter in position with the tags facing the near outside edge of the chassis. Use a couple of small spots of cyanoacrylate or Araldite adhesive on the meter side flanges for a permanent fixture.

5. Mount the piezo resonator using 8BA nuts and bolts (countersunk) with an extra nut and a plain washer between each flange and the chassis to prevent the plastic flange breaking when tightened.

6. Insert two 12mm long 6BA countersunk screws through the slow motion drive mounting holes, with a shakeproof washer and two 6BA nuts on the inside of each. Reduce the shaft of the slow motion drive to 15mm in length and fix in place with further 6BA nuts and washers.

7. Cut the 1/4in extension spindle to 28mm in length, using any suitable material (a pot spindle or brass rod could be used), place the aluminium coupler over the polyvaricon extension, then the extension spindle into the other end of the coupling and the slow motion drive - it may be necessary to slightly flex out the chassis ends to achieve this. Lightly tighten up all grub screws making sure that the two chassis end plates are parallel with each other.

8. Prepare the Perspex cursor. Any light scratches can be removed with metal polish. Scribe a fine line through the centre of the Perspex to act as a cursor (this can be carefully filled with ink or graphite to enhance the line if desired).

9. Carefully cut the precalibrated scale from the paper and glue to the aluminium face plate, the exact position being unimportant at the moment. Fix the dial into place with two short 8BA screws attached to the flange on the slow motion drive.

10. Fix the cursor into place with 6BA nuts and bolts and 1/4in spacers as shown in the drawing, with the cursor line upright. Do not overtighten as this may crack the Perspex.

11. The internal wiring can now be completed following the drawing. The wiring should be placed to avoid the central shaft as it turns. The leads on the battery connector are a little short to allow easy removal of the cover with the battery in place and can usefully be extended by about 30mm (either extend the wires and insulate or remake the connector with new leads after slitting open the plastic cover).

12. The battery is fixed in place on the bottom cover using double sided adhesive tape approximately in the centre with long edge of the battery lying facing the open ends of the cover, avoiding the slow motion drive and tuning capacitor shaft.

13. The only remaining work is to orientate the dial to a known calibration marker. This can be done by first finding the fdo signal on a receiver - preferably on range E coil. Then release the grub screws holding the shaft to the slow motion drive, and while holding the shaft, turn the dial until the required calibration point lines up with the cursor. Retighten the grub screws.

The frequency ranges should be verified at the extreme ends of each coil, using a frequency counter coupled to the coil, or a general coverage receiver. As long as the coverage is correct at each end the remainder of the scale should be correct. On range F it is possible to adjust the calibration by slightly opening or squeezing together the turns. From experience of the MKI, you should find that the calibration is accurate to better than 10% on all ranges and probably within 5%. If worse than this, it is probably due to either winding errors (especially if only one coil is wildly out) or to a cumulation of capacitive errors from construction and component tolerance. If this is the case, it would be best to recalibrate a new scale from scratch.

Note that it is possible to adjust the resistor value which controls the gain on each band, either to get the maximum sensitivity out of the instrument by setting the resistor so that the circuit just oscillates over the whole band, or because there is insufficient gain in the first place (unlikely but manifested by ceasing of oscillation at one end of a band).

MODIFYING THE MKI

To convert an original model to the new version, it will be necessary to build a new pcb to this design and to provide a new calibration scale. Also new coils with their five pin DIN plugs will require to be made as it is unlikely that the originals will be easy to modify, especially if Araldite has been used in assembly.

Once the new pcb is built and checked it is simply installed in the original case, with the extension rod shortened to accomodate the new spindle length, and the calibration scale changed.

USING THE INSTRUMENT

The dip oscillator is intended as a guide to the frequency of a tuned circuit rather than as an absolute frequency indication. The most accurate indication relative to the calibration scale is obtained with as loose a coupling to the tuned circuit under test as possible, and maximum coupling is obtained when the oscillator coil is at right angles to the direction of current flow. You should aim for a dip that can just be seen for best accuracy - overcoupling will initially find the resonant point and produces a spectacular dip but which is also very broad and inaccurate. Reduce the coupling to find the accurate dip point.

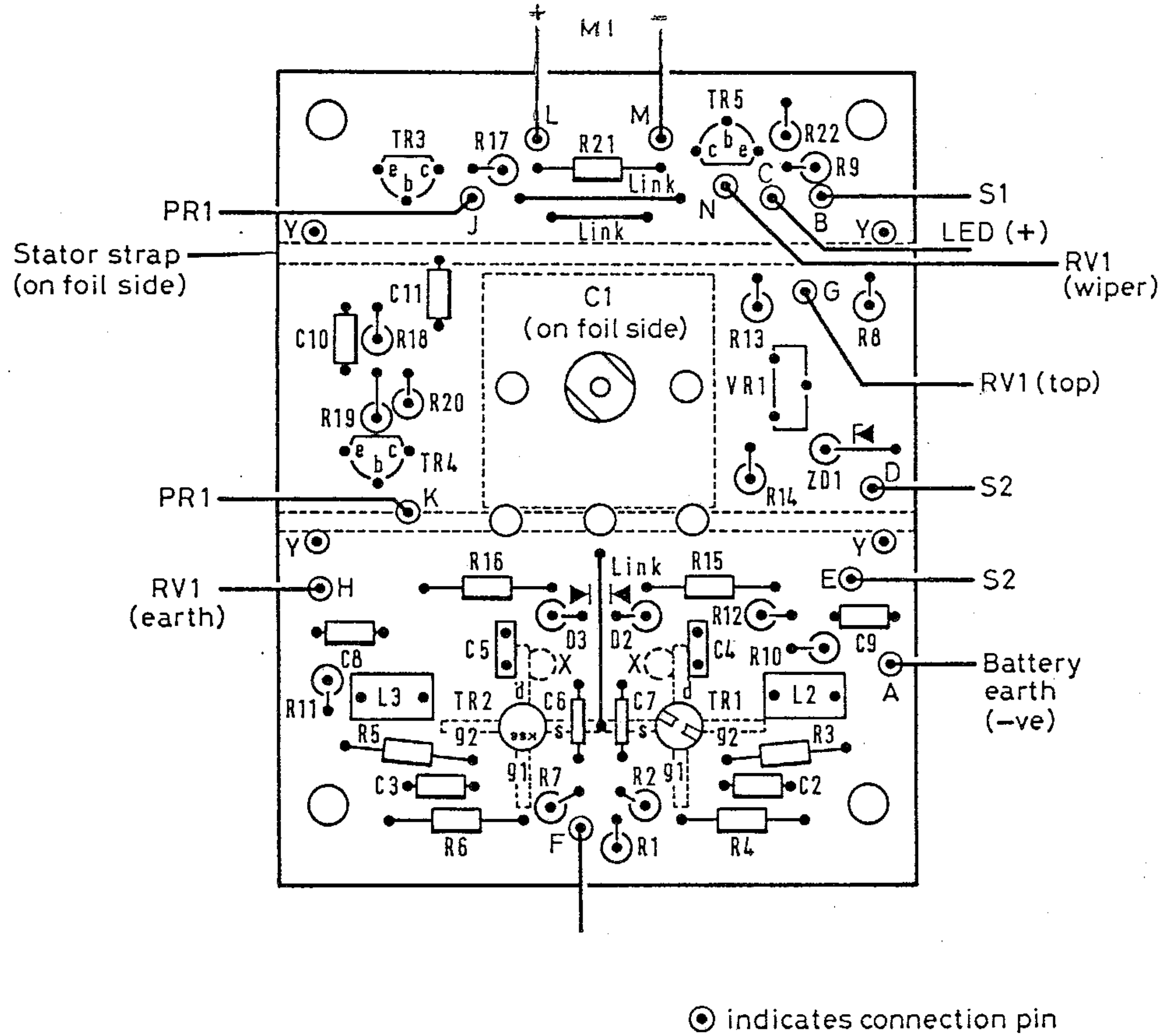
With power to the oscillator circuit removed by S2, a sensitive wavemeter is obtained which will indicate the approximate frequency of a transmitter or oscillator. It can also show the presence of harmonics. Other uses are for the measurement of inductance and capacitance (see [2] for details) and the resonant frequency of antennas since these are also tuned circuits.

The FDO will also double as a rudimentary signal generator with the advantage that the RF output is modulated by the AF oscillator, enabling easy location on a receiver.

One type of inductor/capacitor combination which cannot readily be dipped with an instrument such as this is the toroidal core, as most of the current flow is shielded within the coil winding. One method of carrying out such a measurement is to use the dip oscillator as a signal generator, loosely coupling to a detecting circuit, via a 2-4 turn link coil.

References and further reading.

[1] 'A FET Dip Oscillator for 1.6 - 215MHz with tone dip feature'. A L Bailey, G3WPO. RadCom November 1981.



G3WPO FET DIP OSCILLATOR PCB Component layout

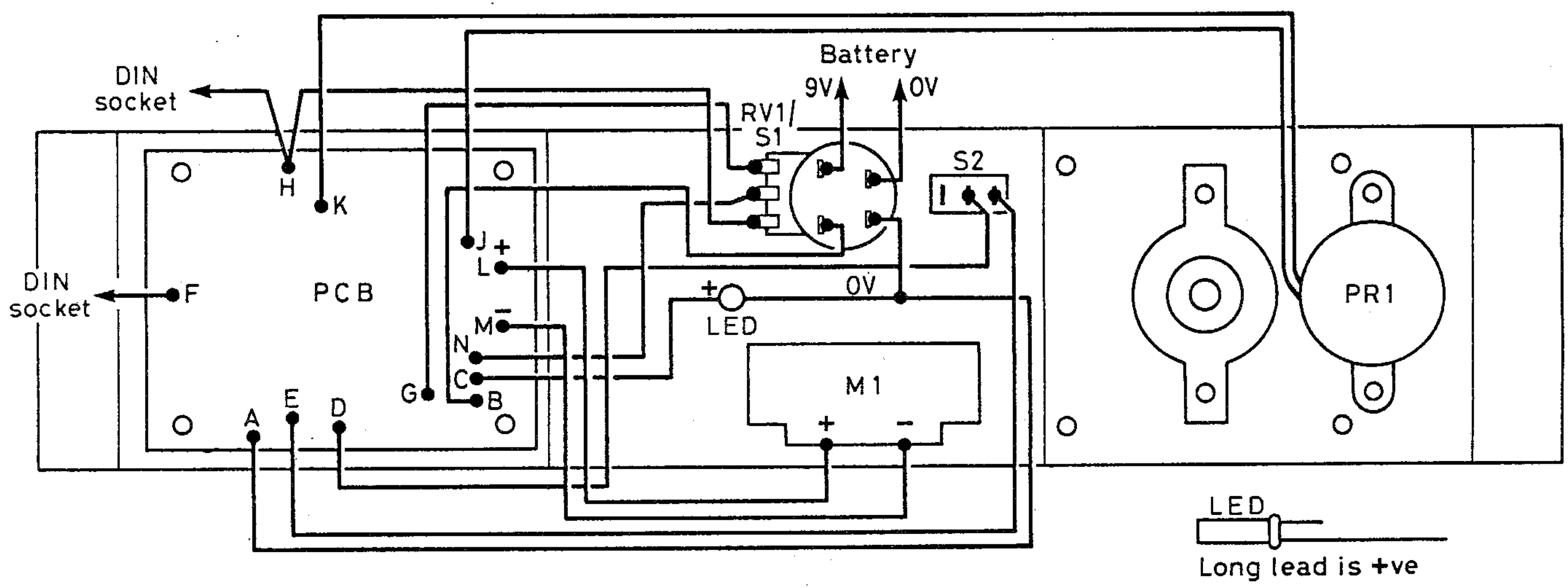
90-16216

COMPONENTS LIST FOR COMPLETE MKII FDO

R1	10k
R2,7	39k
R3,5	56k
R4,6,18,19	100k
R8	220R
R9	2k2
R10,11	47R
R12,21	1k5
R13	3k3
R14	470R
R15,16	33k
R17,20	4k7
R22	1k
Rs	1 off each 150R, 470R, 470R, 680R, 2k2, 10k.

All resistors are 0.25W 5% carbon film types.

VR1	470R Vertical mount 10mm preset
RV1	100k lin Alps pot with switch.
C1	TOKO polyvaricon
C2,3,8,9	10n ceramic disc
C4,5	12pF ceramic disc 5%
C6,7	10pF ceramic disc 5%
C10,11	10n mylar
L2,3	TOKO 470uH choke type 7BS
TR1,2	3SK88
TR3,4,5	BC238 or similar NPN
D1	3mm red LED
D2,3	BA481
ZD1	5v6 400mW
M1	Cirkit type 909 200uA
PR1	TOKO type PB2720
Slow motion drive	Jackson 4511/DAF 6:1
S2	SPCO miniature toggle
Spindle coupler	RS type 509-793
Extension spindle	Cirkit
Wire	Insulated copper: 0.20mm 2050cm 0.25mm 600cm 0.56mm 350cm 1.25mm 60cm



Wiring diagram

ALSO REQUIRED

1 off PP3 Battery connector
2 off Knobs
1 off 5 pin chassis DIN socket
6 off 5 pin DIN plugs
400mm 16mm dia conduit tube
1 off 0.25" dia plastic or brass rod
18 off 1mm dia pcb pins
1 off MKII FDO pcb
1 off Chassis
1 off Cover
1 off Dial plate
1 off Dial cover
1 off strip pcb or braiding
4 off 25mm 6BA RH bolt
2 off 12mm 6BA countersunk bolt
4 off 12mm 6BA RH bolt
6 off 6mm 6BA RH bolt
8 off 6BA plain washer
14 off 6BA Shakeproof washer
6 off 6BA Half nut
18 off 6BA Full nut
4 off 0.25" 6BA spacer
2 off 0.5" 8BA bolt
2 off 0.25" 8BA bolt
4 off 8BA plain washer
4 off 8BA nut
2 off M2.5 polyvaricon countersunk mounting screw

Notes:

The conduit may be supplied in several lengths
Braiding may replace the pcb stator straps specified.

MAY'87

FDO Mk 11 KIT.

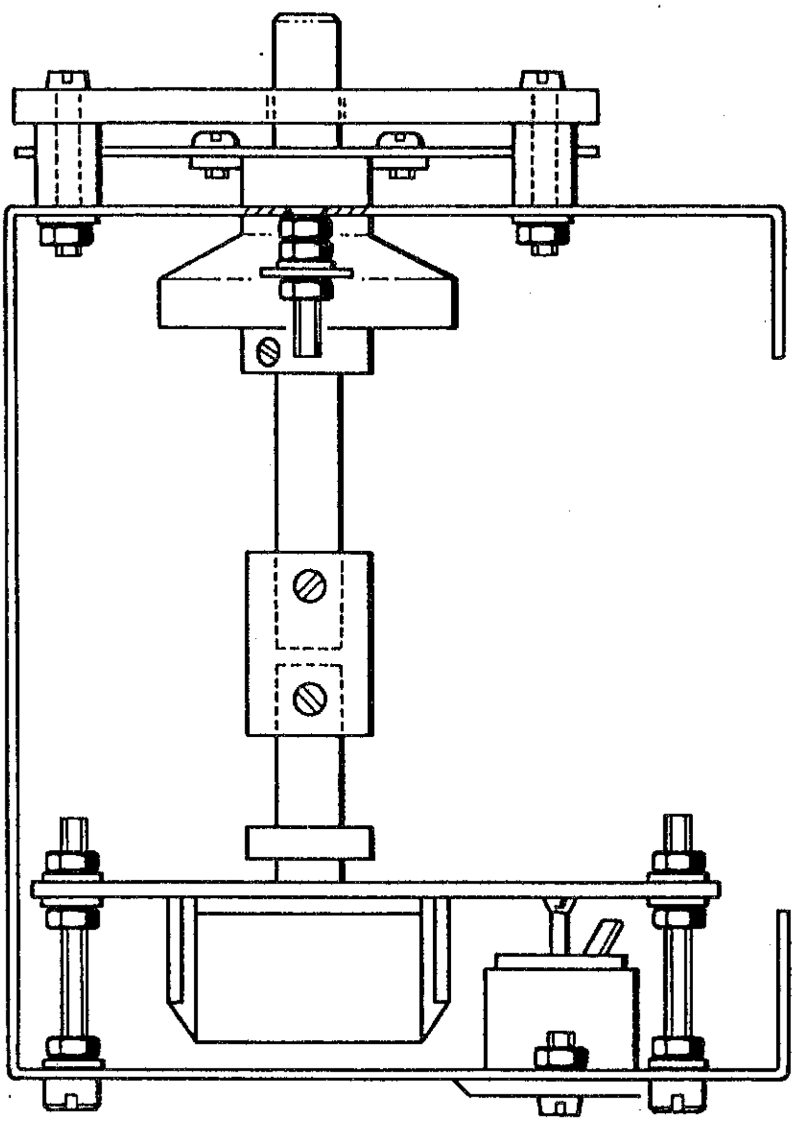
Errata.

The PCB overlay contains some errors:-

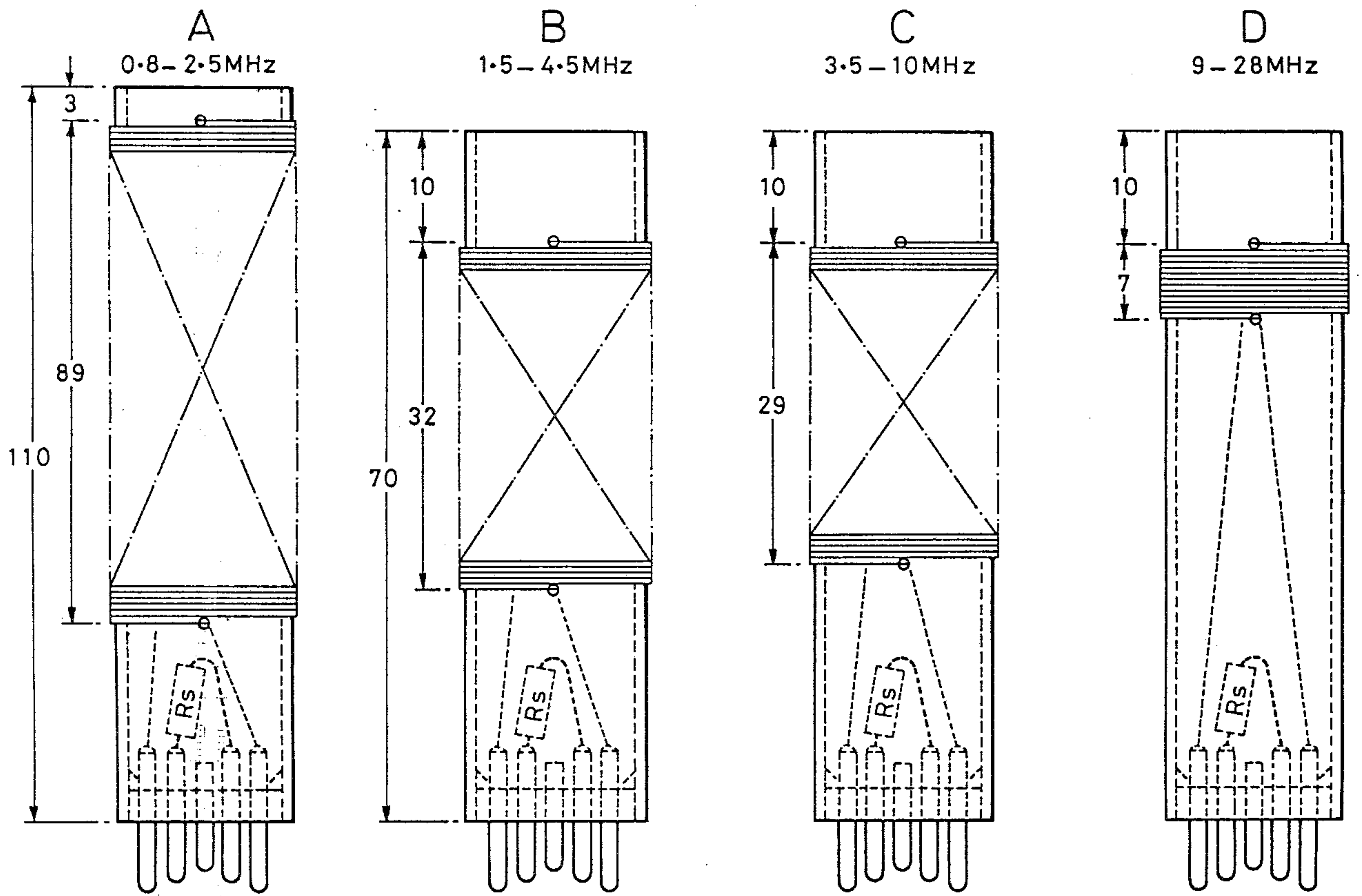
C4 and C5 are transposed with C6 and C7. ie: C4 and C5 (12pF) should be in the position of of C6 and C7, while C6 and C7 (10pF) should be in the position of C4 and C5.

The Diodes D2 and D3 are shown reversed.

The circuit diagram is correct in both respects.



Mechanical detail of case and drive



0·2mm closewound to fill space between holes. Start length 2050cm

109 turns closewound
33swg (0·25mm)
Starting length 580cm

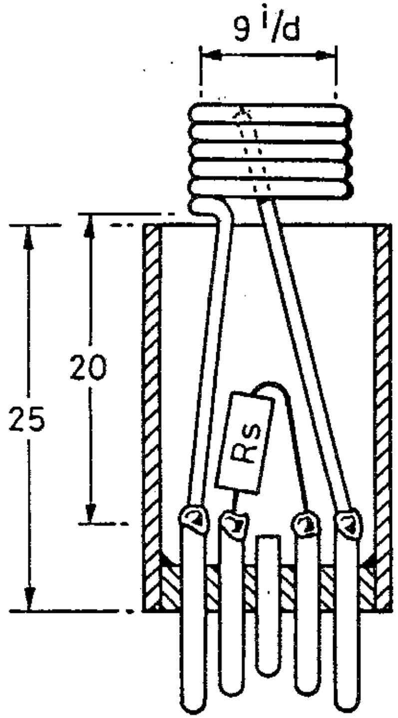
45 turns closewound
24swg (0·56mm)
Starting length 255cm

11 turns closewound
24swg (0·56mm)
Starting length 65cm

Coil winding data (Sheet 1 of 2)

E

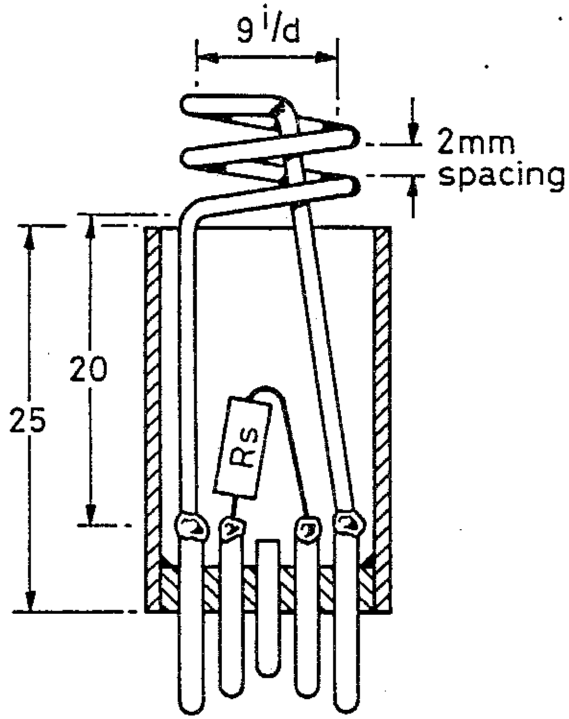
25–90MHz



$5^1/2$ turns closewound
18swg (1·25mm)
Starting length 27cm

F

40–170MHz



2 turns spaced 2mm
18swg (1·25mm)

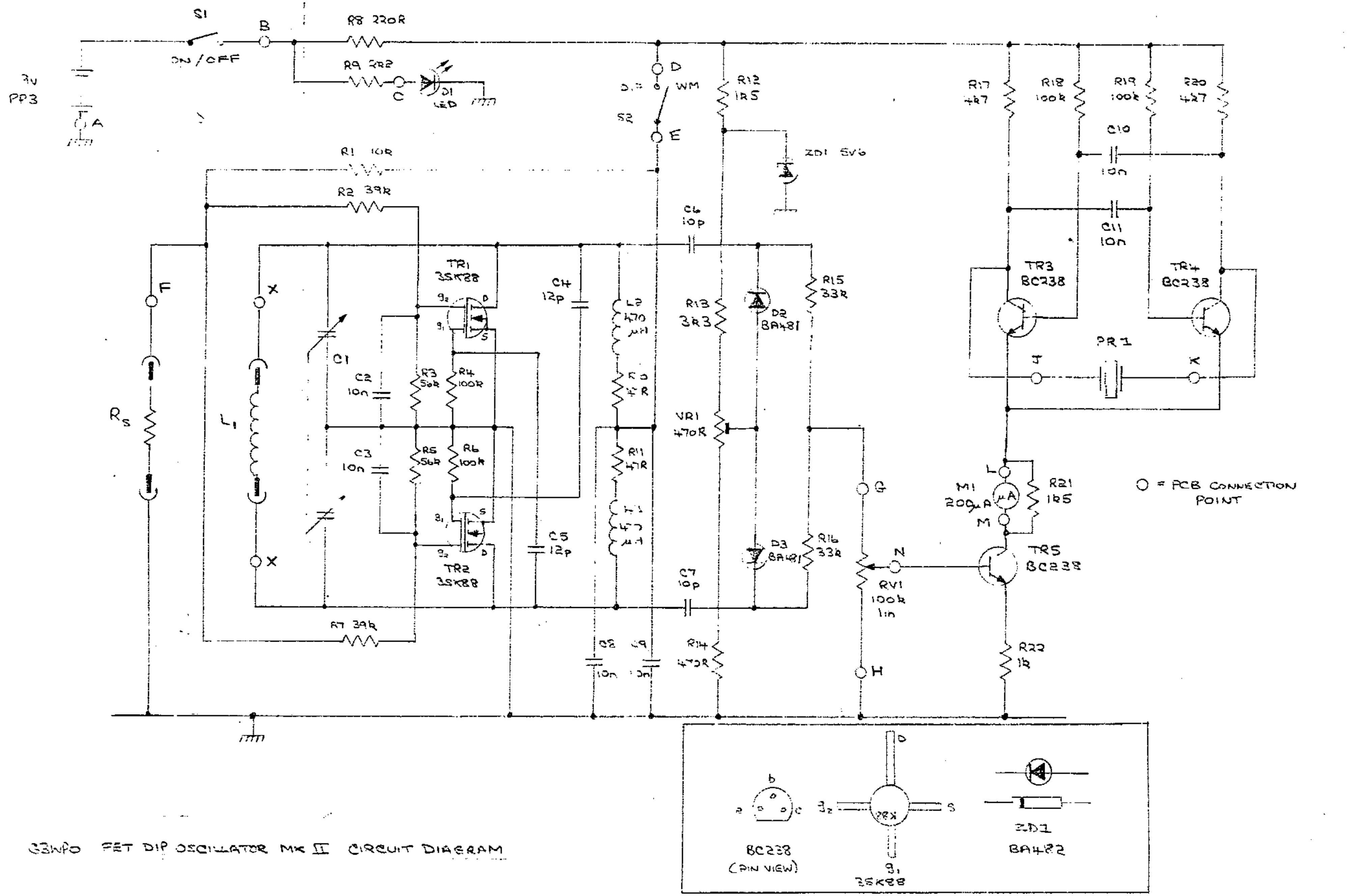
All formers are 16mm o/d
EGA rigid conduit tube
HLG/1M
1·1mm wall thickness

Dimensions in millimetres

Table 1. Value of Rs

Band	Rs	Band	Rs
A	150Ω	D	680Ω
B	470Ω	E	2·2kΩ
C	470Ω	F	10kΩ

Coil winding data (Sheet 2 of 2)



G3WPO FET DIP OSCILLATOR MK II CIRCUIT DIAGRAM