2/6

REVISED EDITION

F.M TUNER CONSTRUCTION

by

W. J. MAY

- Easy to Build
- Practical Point to Point Wiring
- Interference free Reception
- Super High Fidelity Response
- Equally suitable for Local and Fringe Areas

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Foreword

For some years medium-wave reception has been in difficulties due to the shortage of available wavelengths and the ever increasing interference from continental broadcasting stations. As a remedy, stations have been installed in the United Kingdom operating at considerably higher frequencies than those hitherto covered by domestic receiving sets. These broadcasts are transmitted on frequencies in the V.H.F. Band 2 (which covers 87.5 to 100 Mc/s) and employ frequency modulation (F.M.) instead of amplitude modulation as is used for existing sound and television broadcasting.

Receivers designed for these V.H.F. transmissions employ several new techniques with which most amateur constructors will be unfamiliar; particularly the design of the R.F. amplifier, frequency changer and detector stages. For this reason and due to the great scarcity of properly designed components for F.M. receivers, many would-be constructors have in the past found the construction of an efficient F.M. tuner completely beyond their scope.

Fortunately this state of affairs no longer exists. By the use of highly efficient components of unique design and not previously available to home constructors, it has been possible to design a really efficient tuner from which the difficulties and obstacles usually encountered with V.H.F. construction have been eliminated. It may be fairly stated that construction of this tuner will present less difficulty than that encountered with the average three valve T.R.F. receiver.

W.J.M.

THEORETICAL CONSIDERATIONS

V.H.F. Circuits

The following information is intended for the enthusiast who wishes to familiarise himself with the technique of V.H.F., which has now become all important in the world of Sound Radio.

In a manual of this kind it is not possible to thoroughly explore the question but the salient points will be covered so that constructors will not feel that they are building to a pattern without any idea of the reasoning behind the design.

An F.M. tuner basically follows the same form as an A.M. unit, comprising R.F., Mixer, I.F. and Detector stages. Because of the frequencies involved, the modern trend in high grade V.H.F. equipment is to use triode valves as R.F. amplifiers. Considerably less noise is generated with a triode used as a grounded grid amplifier at V.H.F. than is encountered with the more familiar R.F. pentode.

Most constructors will be conversant with the familiar triode-hexode frequency changer, almost universally adopted for ordinary A.M. designs which use this valve as a multiplicative mixer.

High grade V.H.F. designs avoid this system, firstly, because at the frequencies involved its efficiency falls to about one tenth of its normal value, secondly, critical adjustment of the oscillator voltage is necessary, even after which, the noise level is high. Finally, and most important of all, thermal frequency drift is pronounced making it necessary to retune repeatedly during the first 20 minutes of operation.

A satisfactory solution to this problem is to use an **Additive** mixer.

The additive mixer is the oldest of all frequency changer systems used in radio. It was discarded many years ago because with receiver designs current in those days it was impossible to eliminate interaction between the two tuned circuits with the result that they tended to pull into synchronisation.

This difficulty does not apply when the system is applied to the V.H.F band as the difference in frequency between signal and oscillator frequencies (10.7 Mc/s) is one hundred times as great as with the old circuits.

An additive mixer/oscillator can be formed by means of a simple triode and avoids the unpleasant drawbacks of multiplicative mixers.

From the foregoing it will be appreciated that two triodes are necessary for an effective V.H.F. "front end" that is, the stages preceding the I.F. circuits. Circuit layout has been considerably simplified by the introduction of the ECC85 a double triode valve. This valve has adequate screening between sections and enables the functions of V.H.F. grounded grid amplifier and mixer/oscillator to be carried out in one envelope.

Constructors may wonder why an R.F. stage is used to precede the mixer. The main object of the input stage is not so much to obtain the highest possible amplification as to keep the input signal as high as possible above the intrinsic noise level of the set.

In this respect the grounded grid stage with optimum noise ratio adjustment has proved itself particularly suitable. With this arrangement the grid of the first triode is earthed, and acts as a screen between the anode and input circuits; the input signal being applied to the cathode.

An additional and very important feature is that this screen isolates the aerial circuit from the local oscillator, thereby minimising the possibility of fundamental or harmonic radiation from the aerial terminals.

Radiation is a point which must be considered.

Excessive radiation is a feature of all poorly designed V.H.F. receivers and it can cause severe interference to television receivers operating on Band III. All receivers and tuner units designed to receive the new F.M. transmissions on V.H.F. radiate to some extent but with the components used for this tuner, it is exceptionally low, a certified measurement of 25 μ V. per metre. Such a low figure ensures that there will be no interference with neighbouring television receivers. It will be readily appreciated that the layout and wiring of the first stages, that is, R.F. and mixer/oscillator stages is a skilled operation not to be lightly undertaken. Any attempt at haphazard construction can only result in instability, excessive radiation and/ or, an almost complete absence of stage gain. With this tuner unit, the difficulties and problems usually expected do not exist.

A complete R.F. stage mixer/oscillator is supplied to the constructor, completely wired and tested by the manufacturer.

V.H.F. unit type UT 342/75

The position of this unique unit can be clearly seen from the photograph of the completed prototype (Fig. 1). It may be

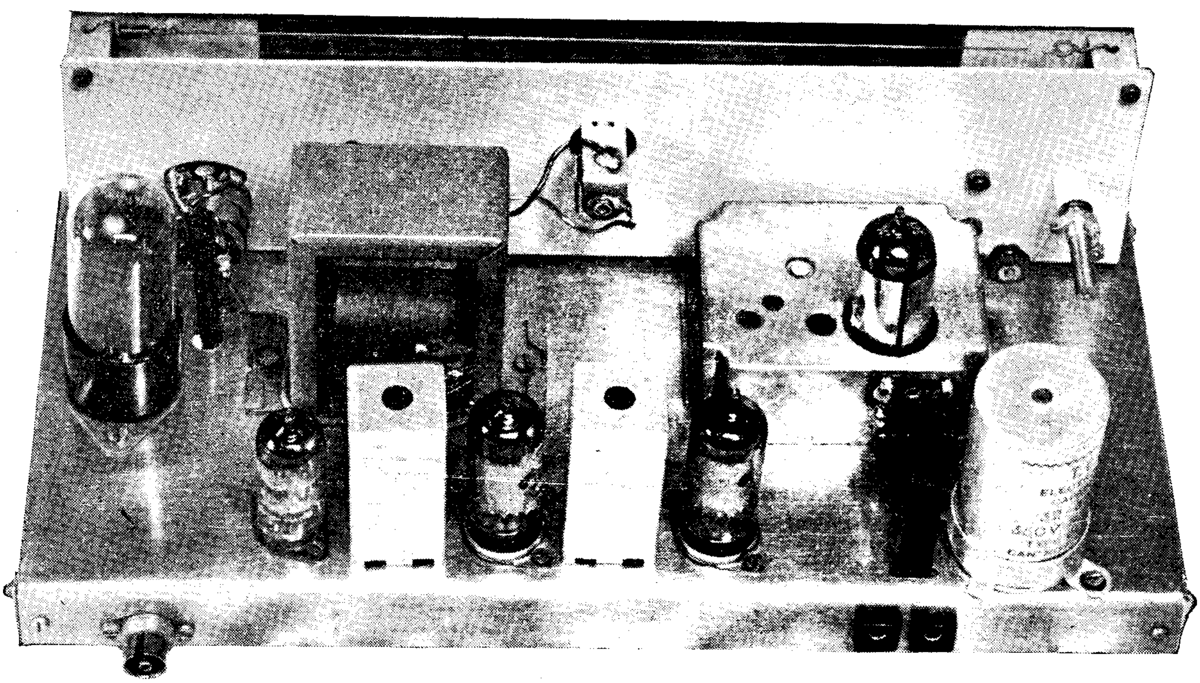


Fig. 1 Photograph of prototype tuner showing top chassis component layout.

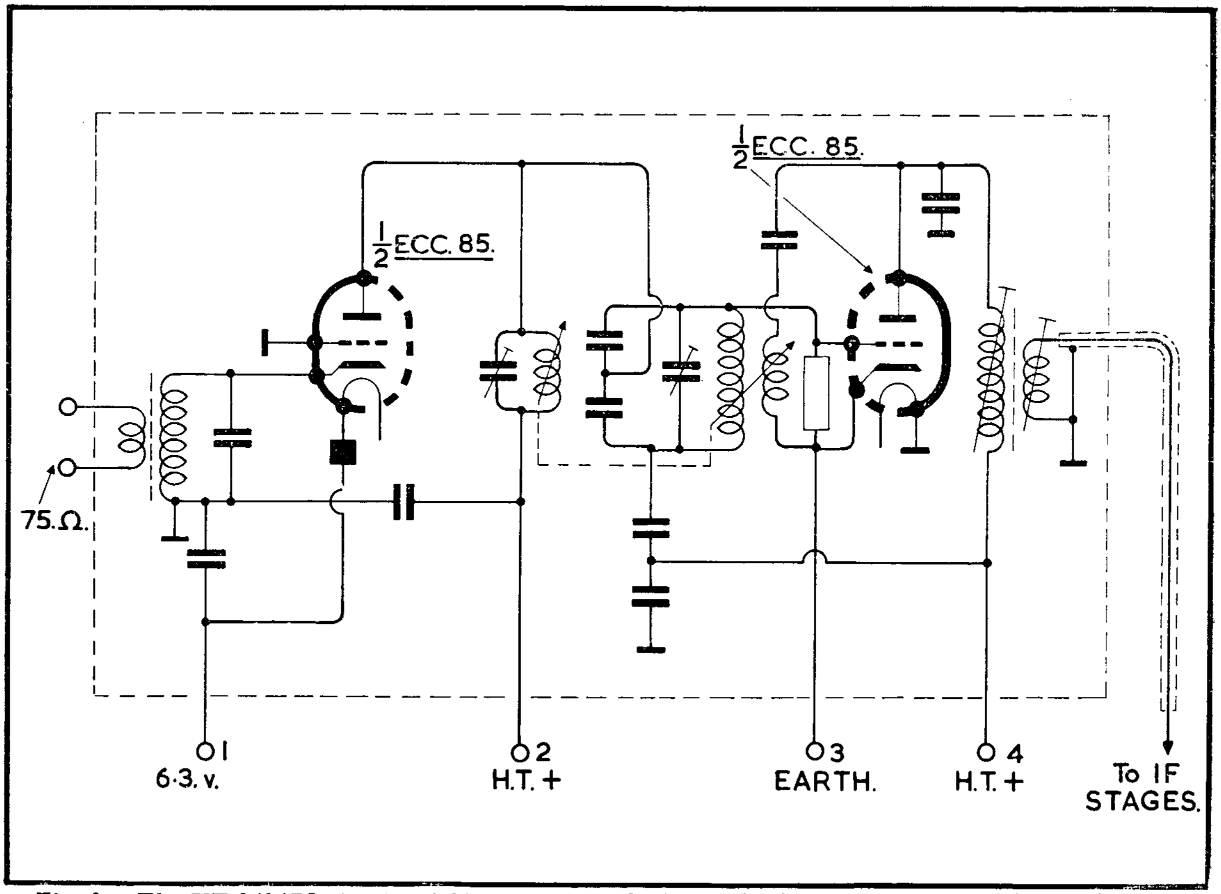


Fig 2. The UT 342/75 circuit. This unit is supplied completely wired and tested by Görler.

seen to the right of the chassis complete with valve type ECC85. A theoretical circuit diagram of this unit is given in Fig. 2.

Designed expressly for the ECC85, the unit is housed in a die-cast box together with all the necessary components for matching the input to a 75 ohm aerial system. The first I.F. transformer for 10.7 M/cs is mounted within the unit, the secondary winding being terminated in a length of screened cable about 8 inches long which facilitates connection to the rest of the I.F. chain. The self capacitance of this screened cable is used for tuning purposes, and is included in the alignment of the complete tuner. Total length is ample for most designs, and will probably be too great for the majority. If the cable is shortened so that its capacitance is reduced, a corresponding external capacitance **must** be connected across it.

Aerial matching is not arranged for maximum signal transfer, but for the best signal to noise ratio, a system which entails a slight loss in the available amplification, but this loss can be overcome quite easily in the subsequent I.F. stages. This arrangement was dictated by the more important considerations of stability, low temperature co-efficients and easy alignment.

The oscillator, for which the second triode of the ECC85 is used, works in a bridge circuit which incorporates I.F. regeneration in order to neutralise the damping of the 1st I.F. transformer by the internal resistance of the mixing triode.

Since the unit is pre-adjusted at the factory, the balancing of this circuit is accomplished by carefully chosen fixed capacitors, and only one trimmer is required for subsequent oscillator adjustments.

Fig. 3 shows the trimmer positions. Both the V.H.F. and oscillator inductors are wound with silver strip at pre-determined spacing, and tuning is by means of ganged tuning slugs which are moved on a common slide by means of a flexible nylon cord. This nylon cord is fastened to an adjustable collar attached to the tuning spindle which should be $\frac{1}{4}$ inch in diameter. The cord must be arranged to wind smoothly upon the spindle, because the two inductors have been so designed that a rotation through 180° exactly corresponds to the travel required for covering the complete V.H.F. band. Band coverage can be altered within reasonable limits, (to agree with scale markings for instance) by adjustment of the collar on the spindle. Thus, if it is desired to decrease the maximum frequency limit, it is merely necessary for the nylon cord to be drawn out a little further from the unit.

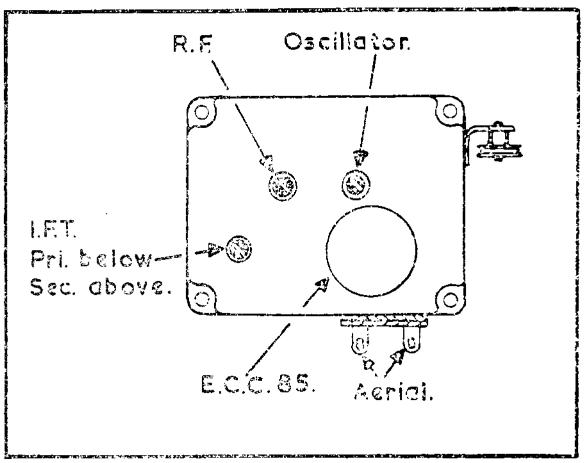


Fig. 3. Trimmer positions on UT342/75.

Where the cable comes out of the tuner it passes over an adjustable pulley. This should of course be positioned to suit the angle taken by the cord as it passes over the spindle. Connections to the UT 342 are quite straightforward and are clearly shown in both the practical and theoretical circuit diagrams.

Overall gain of the UT 342 under practical operating conditions is 450 from aerial input to secondary of the built in I.F. transformer.

I.F. Stages

These stages differ very little from the conventional arrangement used for A.M. receivers.

Perhaps the most striking difference is that of bandwidth. A.M. stations on the medium wave-band are separated by only 9 kc/s so that it is pointless to increase the bandwidth of an A.M. receiver beyond this figure. Any attempt to do so results in superimposed whistles on the programme received.

With F.M. transmissions on V.H.F. the position is quite different and in any case by its very nature an F.M. transmission demands a bandwidth of 200 kc/s.

There is no point in increasing the response beyond this figure, such practice will only lead to reduced sensitivity and can lead to unwanted interference. Maximum frequency deviation of the present B.B.C. stations is $\pm$ 75 kc/s, thus it will be noted 200 kc/s bandwidth is adequate. To ensure sufficient gain, a minimum of two I.F. stages is necessary. With this tuner the I.F. gain is ample even in extreme fringe areas. On the completed tuner, with an aerial input signal of 2μV, a signal to noise ratio of 26dB was obtained at the ratio detector. At this point it should be remarked that this happy result is due entirely to the extremely high performance of the I.F. transformers and V.H.F. unit chosen for this tuner. The author has been quite unable to find transformers of other manufacture with a comparable performance.

The 1st I.F. transformer is included in the V.H.F. unit, so that only one further inter-stage transformer and a ratio/discriminator transformer have to be added.

However carefully a receiver or tuner is designed, drift, in the I.F. stages can ruin its performance. To avoid this, I.F. transformers and valve types used in conjunction with them must be carefully selected. With the transformers chosen, powdered carbonyl iron cores are used to tune the windings and the required parallel capacitance is made up with Styroflex capacitors. This combination produces an extremely low temperature coefficient : $< -25.10^{-6/0}$ C.

Suitable valves for 10.7 Mc/s I.F. stages can also present quite a problem, mainly through thermal drift; the EF89 chosen represents the latest development in valves designed for this purpose and can be relied upon to give trouble free service.

Inter-electrode capacities are extremely low, re-alignment when changing specimens is unnecessary and perfect stability is obtained without the necessity of screen-grid neutralisation.

The advantage of using valves and transformers which do not permit drift cannot be over emphasised where V.H.F. tuners for F.M. are being considered.

Detectors for F.M.

Detectors for F.M. signals may take one of several forms each with their advantages and disadvantages, whichever form is used the requirements are the same. Briefly the detector must convert variations of frequency into amplitude variations. At the same time it is essential that the detector remains completely insensitive to amplitude modulation on the incoming signal.

Three main types of detector circuit are in use at the moment, the Foster-Seeley discriminator, the Phase discriminator and the very popular Ratio detector. Foster-Seeley discriminators are very excellent in many ways but unfortunately they respond to A.M. signals and have to be preceded by an efficient limiter stage in order to obtain satisfactory operation. Naturally this increases the cost of the receiver.

The Phase discriminator makes an excellent detector but has two disadvantages. High gain is necessary in the preceding stages which necessitates an elaborate I.F. amplifier, also, a special valve is required for the detector stage, a nonode which has seven grids.

This brings us to the third type, the Ratio detector which is the form of detector selected for this tuner. Two low impedance diodes are used for detection (these are both contained in one envelope) thus the use of an expensive multi-grid valve is avoided. Unlike the Foster-Seeley discriminator no A.M. limiting is required, because the detector is insensitive to Amplitude Modulation. To avoid any possibility of drift the bifilar wound secondary of the URF377/10 ratio detector transformer is compensated to $\pm 10^{-5/0}$C by means of a special ceramic capacitor.

The nature of frequency modulated transmissions is such, that the higher frequencies receive pre-emphasis. All receivers designed for these transmissions are fitted with a corrector to compensate for this. A simple R.C. network calculated to provide a time constant of 50 micro-seconds is all that is necessary and this is fitted at the output of the detector. Fig. 4 shows how this is accomplished. R & C can be of any combination that will provide 50μ Sec., on this tuner values of 500 pF and 100 kΩ are used. (Time constant is calculated by multiplying R in ohms by C in Farads and expressing the product in seconds).

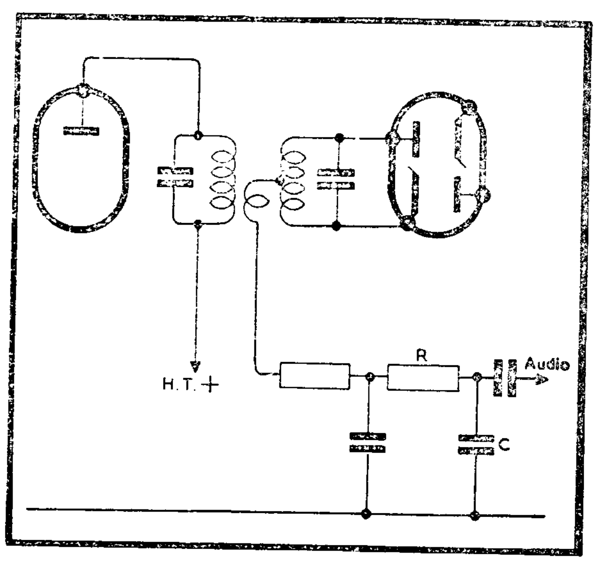


Fig. 4 The de-emphasis network.

THE PRACTICAL TUNER

Components

Construction of the tuner will not present any difficulties, but a few words on components will not be out of place. Reference to the components list will show that in the majority of cases a well-known brand of component is specified. Components shown in the list are types and makes used for the construction of the prototype and to ensure exact duplication it is suggested that the given specification should be adhered to. In a number of cases any attempt to substitute other components would lead to unsatisfactory operation, notably the IF transformers and the VHF unit.

Within limits it is possible to use other capacitors, always provided that they are of reputable manufacture, it is however, essential to use mica components, ceramic components, etc., where shown. One exception to this rule is the use of polystyrene film capacitors. These ingenious components are tubular, similar in appearance to small paper capacitors, they are encased in polystyrene and have similar characteristics to mica components, though much smaller physically.

It will be noticed that TSL resistors are used for this tuner. These resistors are quite different from ordinary carbon rod types, they are carbon track components constructed on high stability principles, thus the values do not vary with heat or age and a more stable receiver is obtained than would otherwise be possible. They are much smaller than most others, this is because they are not insulated and therefore, able to dissipate heat much more successfully than enclosed types. When wiring up, ensure that the resistors do not lay on the metal chassis, but in each and every case are suspended in the wiring.

The mains transformer is of course not critical in any way. Any component that will provide the various voltages at the required current may be used provided it is not too large physically.

A pleasant illuminated dial specially calibrated for the F.M. band has been selected for use with this tuner. It will be appreciated that in order to avoid backlash, a spring loaded gear drive is desirable and this particular dial incorporates an excellent example of this feature combined with the first sensible scale length for the F.M. band to appear on the market.

Assembling the components on the chassis calls for little comment, the drawings and photographs leave no doubt as to the location of the various parts. Most components require either 4BA or 6BA fixing bolts, and it is stressed that spring washers should be used in every case, only in this way will the nuts and bolts remain tight. It will be appreciated that slackness on any nut and bolt carrying a solder tag could cause endless trouble. Interstage wiring is best carried out in plastic covered wire which is readily available at electrical stores.

One component is not included in the components list, it is the heater choke RFC this is home made and does not call for a commercial component. It may be wound on a 5/16″ former or can be self-supporting, the latter method is recommended. Wind 20 turns 26 SWG DSC on a pencil and paint with Durafix. When the fixative has set remove the winding from the pencil and the choke is ready for use.

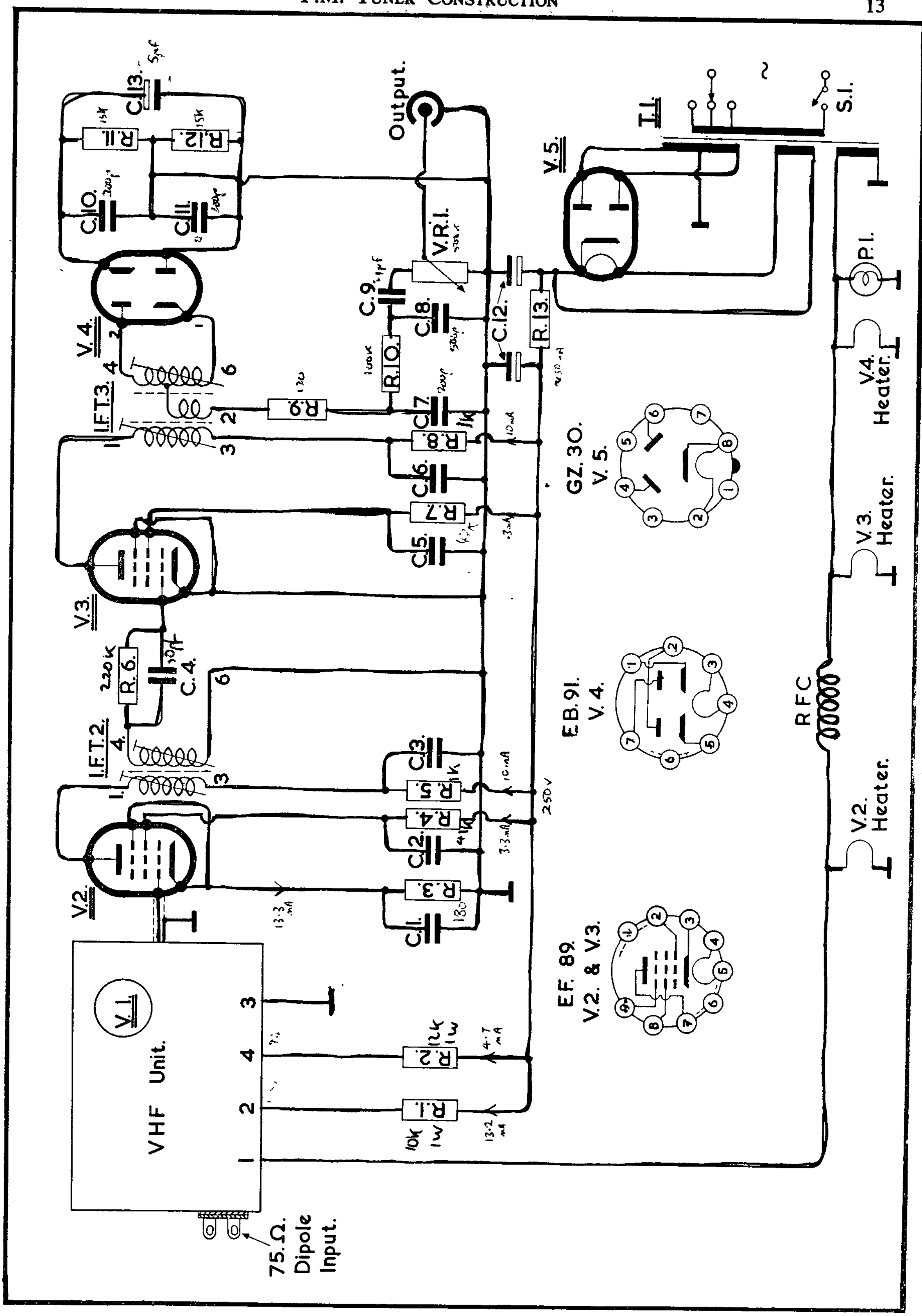


Fig. 5 Theoretical Circuit.

COMPONENTS LIST

Resistors. TSL

R1	10k ohm 1w	R6	220k ohm	R11	15k ohm
R2	12k ohm 1w	R7	47k ohm	R12	15k ohm
R3	180 ohm	R8	1k ohm	R13	330 ohm 1w
R4	47k ohm	R9	120 ohm		
R5	1k ohm	R10	100k ohm		

All resistors are TSL type R, ± 10% tolerance, and are ½ w unless otherwise stated.

Capacitors. TSL

C1	4700pF	ceramic	
C2	4700pF	ceramic	
C3	4700pF	ceramic	
C4	50pF	moulded mica	
C5	4700pF	ceramic	
C6	4700pF	ceramic	
C7	200pF	moulded mica	±2%
C8	500pF	moulded mica	±2%
C9	0.1μF	paper tubular 350v	
C10	200pF	moulded mica	±2%
C11	200pF	moulded mica	±2%

Capacitors. T.C.C.

C12	32-32μF	350v electrolytic	type CE27LE
C13	5μF	50v electrolytic	type CE30D

RF Components. TSL

VHF Unit	Görler Type UT342/75
I.F.T.2	Görler Type 11748
I.F.T.3	Görler Type URF377/10

Valve holders. McMurdo

2 B9A	Type XM9U
1 B7G	Type XM7U
1 Int. Octal.	Type B8/U

Mains Transformer. Elstone

T1. Pri. 200-250v
Sec. 250-0-250 50 mA
6.3v 1.5A Type MT/M1
5.v 2A

Valves. Mullard Ltd.

V1	ECC85
V2	EF89
V3	EF89
V4	EB91
V5	GZ30

SUNDRIES

1 Drilled Chassis	TSL.
1 11½″ horizontal dial Calibrated for Band II	TSL type FM.
2 5 way tag strips	
1 Electrolytic capacitor clip	
VR1 0.5M ohm potentiometer with SP switch (S1.)	
2 Control knobs.	TSL
P1 6.3v 0.3A pilot bulb	
1 Co-axial plug.	Belling Lee.
1 Co-axial socket.	Belling Lee.
2 Banana plugs.	Belling Lee L 378/3.
2 Insulated sockets.	Belling Lee L 316.

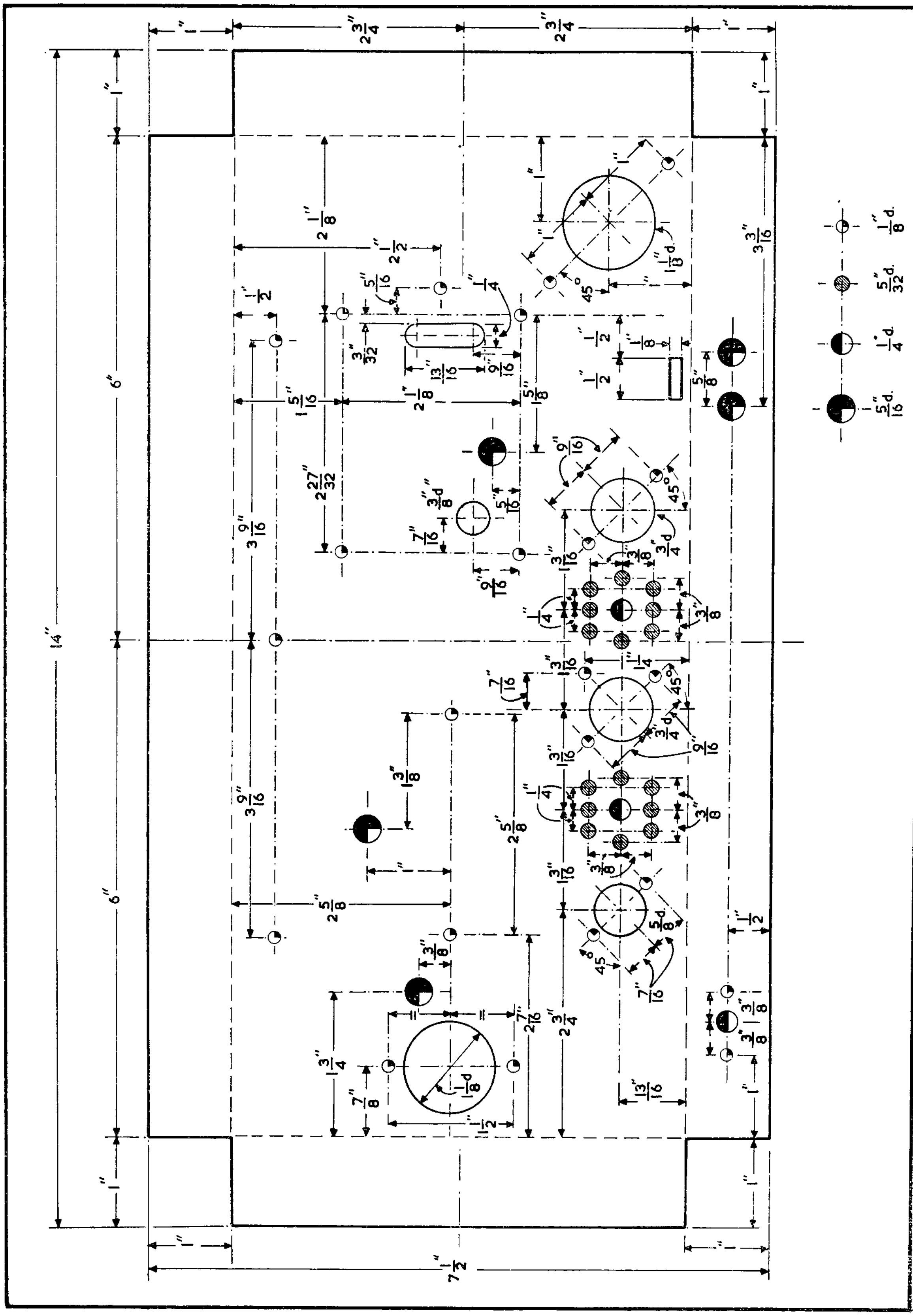


Fig. 6 Chassis drilling dimensions viewed from the top side.
Note : *A drilled chassis is available—see components list*

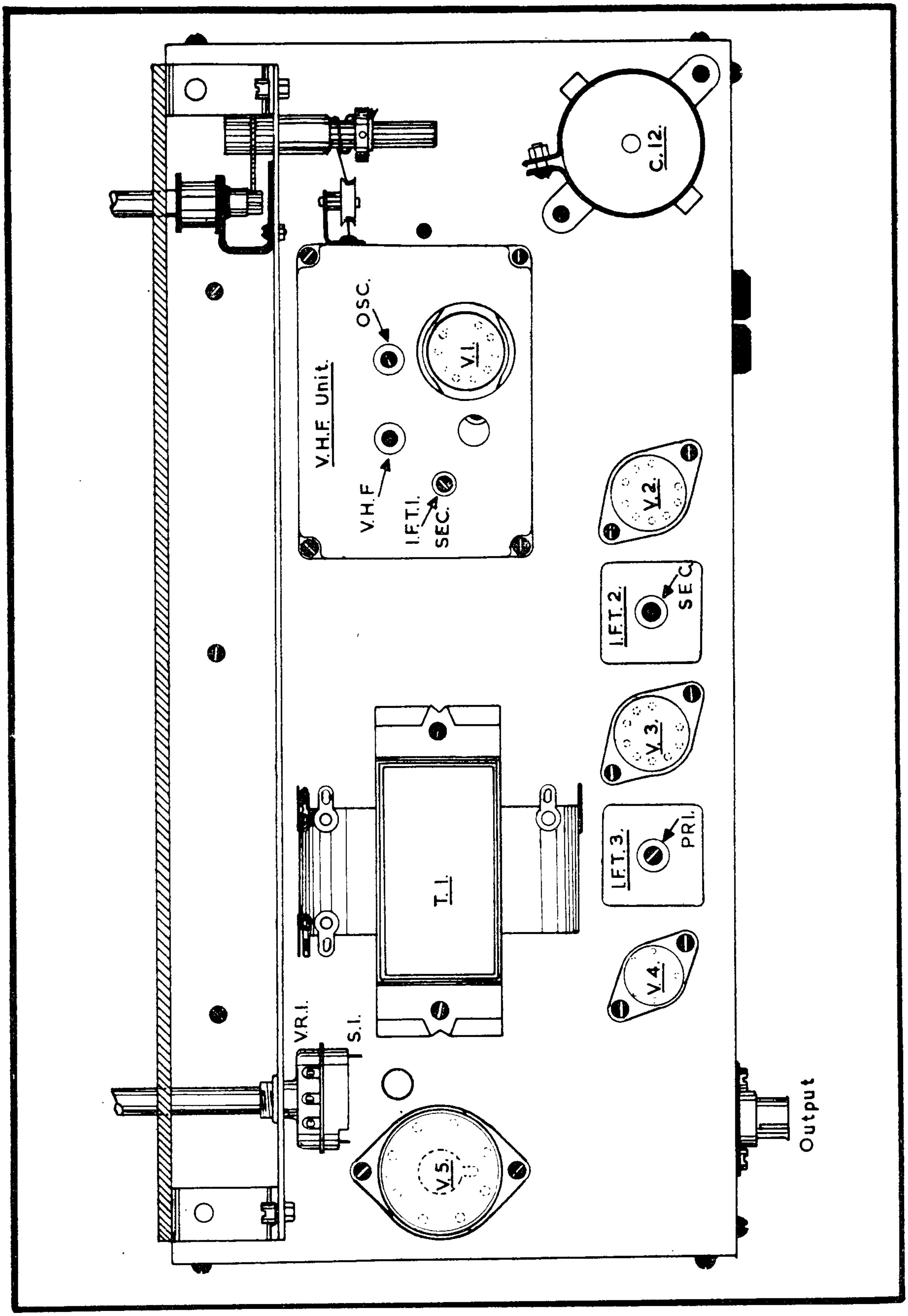


Fig. 7 Top Chassis Layout.

ASSEMBLY & WIRING

(1) Assemble all components on the chassis with exception of the dial. Make sure that valve-holders and transformers are mounted the correct way round as shown in the layout drawing. The dial is screwed into position after wiring to the **Secondary** of T1 has been completed.

(2) Cut spindle of VR1 to give an overall length of 1¾″ measured from seating base of this component. This is to ensure that the dial drive spindle and V/C spindle are of equal length when assembly is completed.

(3) Remove scale from dial assembly and fit VR1 into position. The correct position is clearly shown in the photograph and diagrams.

(4) Wire HT Secondary of **T1**, inner and outer to **V5** tags **4** and **6**., next wire H.T., C.T. to solder tag **D.**
Note these three wires are twisted together and for easy identification the C.T. lead should be in **Black** and the others in **Red.**

(5) Wire **5 volt** secondary of **T1** to **V5** tags **2** and **8**.
These two leads are also twisted.
If the rectifier heater winding is tapped at 4v. as in the case of the Elstone MT/M1., the 4v. tag is left blank, only tags marked **C** and **5v.** are used.

(6) Wire **6.3** volt secondary of **T1** to **V4**, tag **4** and to **TS-G** tag **3**. These two wires are twisted and must be in **Black** and **Red. Black** is connected to **TS-G** tag **3** and **Red** to **V4** tag **4**.

(7) Remove pilot lamp-holder from dial assembly and connect by means of 2½″ flexible leads to the **6.3 volt** secondary of **T1**. The rear tag of the lamp holder which is the insulated connection is joined to the **Red** lead of the 6.3v. winding and the frame to the **Black**. To preserve a neat appearance the flexible leads may be in red and black twisted flex.

(8) Screw the dial assembly to the main chassis. Insert 6.3v bulb in holder and replace holder in dial assembly.

(9) Wire Tag **C** on **Primary** of **T1** to one contact of **S1** (located at rear of VR1).

(10) **V4** tag **3** to **ST-C.**

(11) **V4** tag **3** to spigot.

(12) **V4** spigot to tag **6.**

(13) **V3** tag **1** to spigot.

(14) **V3** tag **3** to spigot.

(15) **V3** tag **4** to spigot.

(16) **V3** tag **6** to spigot.

(17) **V3** tag **9** to spigot.

(18) **V3** spigot to **ST-E.**

(19) **V4** tag **4** to **V3** tag **5**.

(20) **V3** tag **5** through **RFC** to **TS-H** tag **2**.

(21) **TS-H** tag **2** to **V2** tag **5**.

(22) **V2** tag **5** to **UT342** tag **1.**

(23) **V2** tag **1** to spigot.

(24) **V2** tag **4** to spigot.

(25) **V2** tag **6** to spigot.

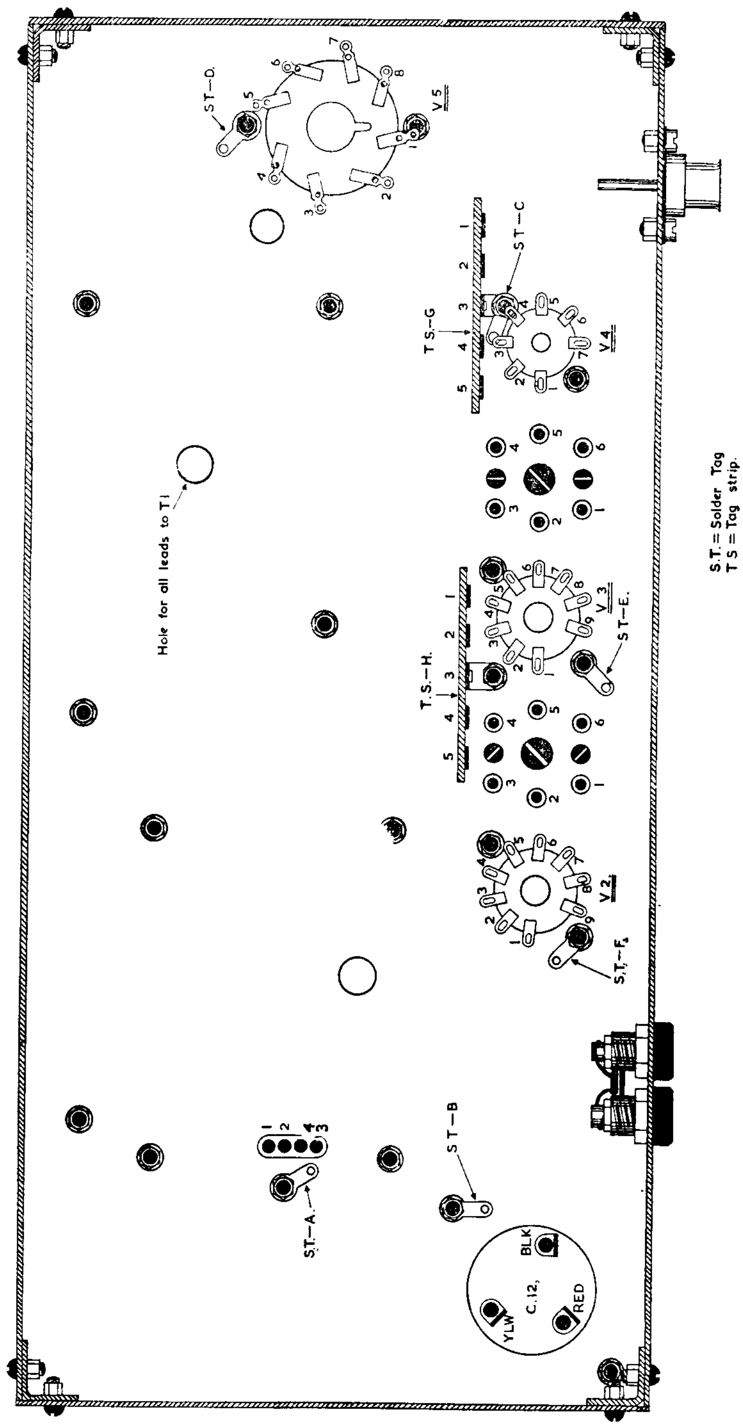
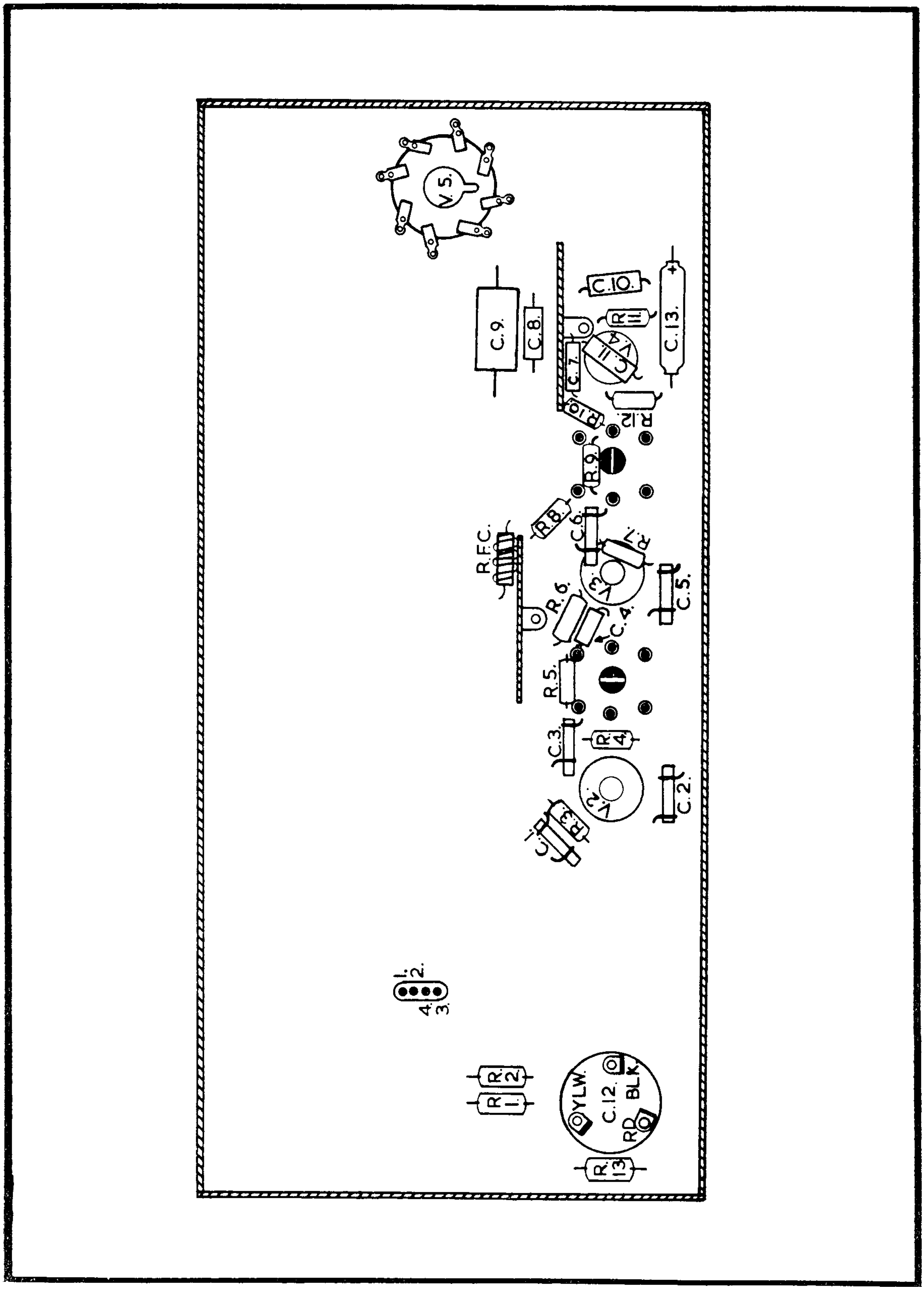


Fig. 8 Position of tag strips and solder tags.


V.5.
C.9.
C.8.
C.10.
R.11.
C.13.
C.7.
V.4.
C.11.
R.10.
R.12.
R.9.
R.8.
C.6.
R.F.C.
R.7.
V.3.
C.5.
R.6.
C.4.
R.5.
C.3.
R.4.
V.2.
C.2.
R.3.
C.1.
1.
2.
3.
4.
R.2.
R.1.
YLW.
C.12.
BLK.
RD.
R.13.

ASSEMBLY & WIRING—*Continued*

(26) **V2** tag **9** to tag **3**.

(27) **V2** spigot to **ST-F**.

(28) **UT342** tag **3** to **ST-A**.

(29) **UT342** tag **2** through **R1** to **C12 YLW**.

(30) **UT342** tag **4** through **R2** to **C12 YLW**.

(31) **V5** tag **8** to **C12 RD**.

(32) **C12 RD** through **R13** to **C12 YLW**.

(33) **C12 BLK** to **ST-B**.

(34) **V2** tag **8** through **R4** to **TS-H** tag **5**.

(35) **V2** tag **7** to **IFT2** tag **1**.

(36) **IFT2** tag **3** through **R5** to **TS-H** tag **4**.

(37) **V2** tag **3** through **R3** to **ST-F**.

(38) **V3** tag **7** to **IFT3** tag **1**.

(39) **IFT3** tag **3** through **R8** to **TS-H** tag **1**.

(40) **V3** tag **8** through **R7** to **TS-H** tag **1**.

(41) **TS-H** tag **1** to tag **4**.

(42) **TS-H** tag **4** to tag **5**.

(43) **TS-H** tag **5** to **C12 YLW**.

(44) **IFT2** tag **6** to **ST-E**.

(45) **IFT3** tag **6** to **V4** tag **1**.

(46) **IFT3** tag **4** to **V4** tag **2**.

(47) **V4** tag **7** through **R12** to **ST-C**.

(48) **V4** tag **5** through **R11** to **ST-C**.

(49) **IFT3** tag **2** through **R9** to tag **5**.

(50) **IFT3** tag **5** through **R10** to **TS-G** tag **5**.

(51) **TS-G** tag **5** through **C9** to tag **4**.

(52) **TS-G** tag **5** through **C8** to tag **3**.

(53) **IFT3** tag **5** through **C7** to **TS-G** tag **3**.

(54) **V4** tag **5** to **Positive C13**.

(55) **V4** tag **7** to **Negative C13**.

(56) **V4** tag **7** through **C11** to **TS-G** tag **3**.

(57) **V4** tag **5** through **C10** to **TS-G** tag **3**.

(58) **V3** spigot through **C6** to **IFT3** tag **3**.

(59) **V3** tag **8** through **C5** to **ST-E**.

(60) **V2 spigot** through **C3** to **IFT2** tag **3**.

(61) **V2** tag **8** through **C2** to **ST-F**.

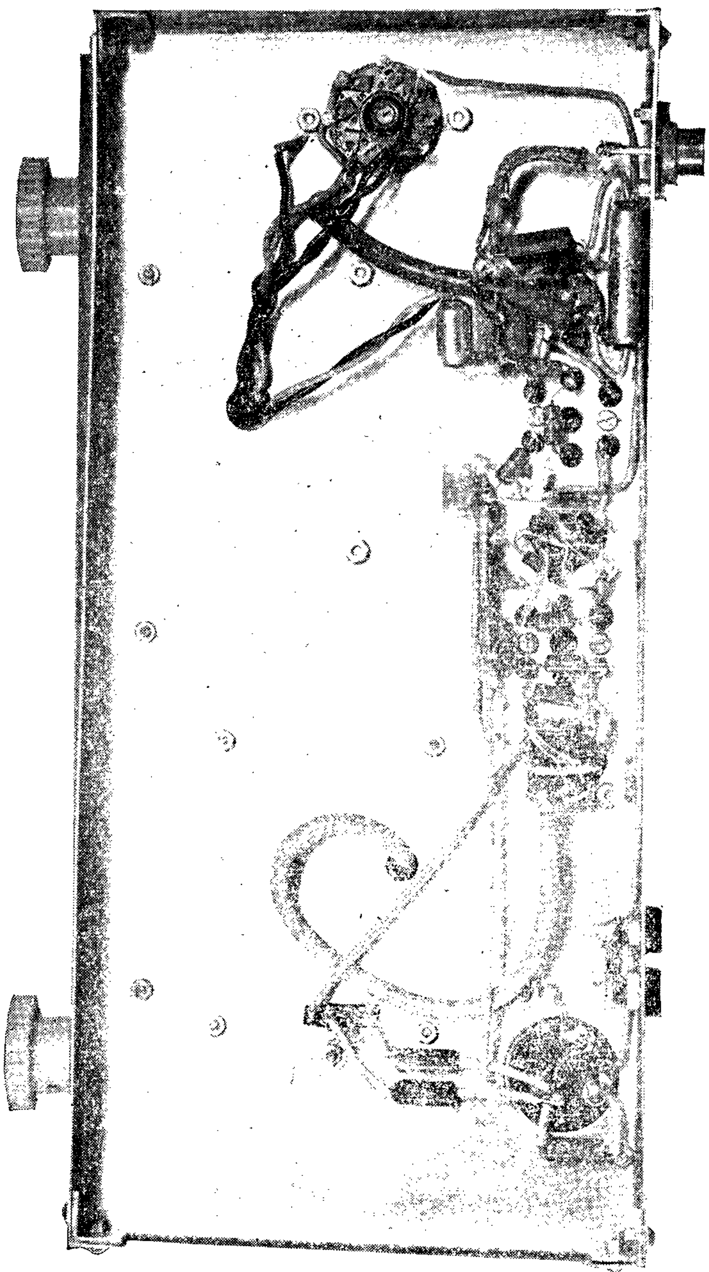


Fig. 10 Under Chassis Photograph.

ASSEMBLY & WIRING—*Continued*

(62) **V2** tag **3** through **C1** to **ST-F.**

(63) **V3** tag **3** to spigot.

(64) **IFT2** tag **4** through **C4** to **V3** tag **2.**

(65) **IFT2** tag **4** through **R6** to **V3** tag **2.**

(66) **UT342** screened output lead **INNER** to **V2** tag **2.**

(67) **UT342** screened output lead **OUTER** to **ST-F.**
Note this lead is not cut short. See under-chassis photograph.

(68) Connect aerial input terminals through a short length of twin flat plastic flex to input tags on UT342. This feeder is fed through the slot cut into the chassis for the purpose.

(69) Prepare a 6″ length of twin screened lead.
This is best made by removing the polythene covered inner conductor from a length of 75 ohm co-axial feeder, such as used for T/V aerial feed and replacing with **Red** and **Blue** covered plastic wires.

(70) Viewed from the rear of the chassis, connect the outer screening to the **Left** tag of **VR1, RED** to **Centre** tag and **Blue** to **Right** tag.

(71) Cable is fed through chassis hole provided and wired in as follows :—
Red to **TS-G** tag 2.
BLUE to **TS-G** tag 4.
Outer screening to **TS-G** tag 3.

(72) Connect inner conductor of a 2″ length of single screened cable (75 ohm co-axial feeder is suitable) between **Output Socket** and **TS-G** tag **2.**

(73) Outer screening is anchored to **TS-G** tag 1.

(74) **TS-G** tag **1** to **TS-G** tag 3.

(75) **Left-hand** tag (viewed from rear of **VR1** is connected to the metal casing of **VR1.**

(76) A length of twin mains flex is prepared with a suitable plug to fit existing mains socket fitted to one end.

(77) Connect one side to vacant tag on **S1** (located on back of VR1).

(78) Connect remaining mains flex lead to correct voltage tapping on **T1** primary.
The mains flex is anchored by means of a clip fitted under one fixing screw on **V5.**

(79) Place valves in position as follows :—

V1.	ECC85
V2.	EF89
V3.	EF89
V4.	EB91
V5.	GZ30

(80) Push shield provided over the **ECC85** and position until bottom is just below the casing of the **UT342.**
The solder tag on the **UT342** valve holder is **outside** the shield.

(81) Solder shield to solder tag.
Do **not** solder across the gap in the shield.

(82) Set dial pointer at max. high frequency setting, that is extreme left viewed from the front.

(83) View chassis from the rear and feed the cable from the **UT342** under the dial drive spindle ensuring that it is running in the pulley groove, and that the pulley bracket is turned at right angles to chassis with the wheel positioned **above** the exit hole in the **UT342.** Take a complete turn round the spindle in an anti-clockwise direction. Push collar provided over drive spindle, feed cable through hole in collar and knot to prevent it pulling out. Adjust collar on spindle to take up any slack between collar and cable, but do **not** tension sufficiently to move the tuning core inside the unit. Grub screws can now be tightened to grip the collar to the spindle. If the above adjustments are properly carried out, the tuning slug in the **UT342** is at rest with the dial pointer set to the high frequency end of the scale, as the tuning knob is turned, the pointer travels to the low frequency end and carries the slug by means of the nylon cable, thus tuning the receiver. The receiver is now complete and ready for testing and aligning.

VOLTAGE TABLE

Location	D.C. Voltage	Meter Range
C 12 Red	265v	1000v
C 12 Ylw.	250v	1000v
UT342 tag 2	118v	250v
UT342 tag 4	194v	250v
V2 tag 3	2.4v	10v
V2 tag 7	240v	1000v
V2 tag 8	100v	1000v
V3 tag 7	240v	1000v
V3 tag 8	15v	1000v

Readings taken with 1000 ohms/volt instrument.

These voltages are positive with respect to chassis.

B.B.C. V.H.F. Radio Transmitters

Station	Frequencies (Mc/s) Light	Third	Home	E.R.P. (kW) each programme	Opening Date
Wrotham	89.1	91.3	93.5	120	May 2, 1955.
North Hessary Tor	88.1	90.3	92.5	60	Summer 1956.
Sutton Coldfield ...	88.3	90.5	92.7	120	Summer 1956.
Pontop Pike	88.5	90.7	92.9	60	During 1955.
Rowridge	88.5	90.7	92.9	—	1957.
Meldrum	88.7	90.9	93.1	60	During 1955.
Blaen Plwy	88.7	90.9	93.1	60	End 1956.
Holme Moss ...	89.3	91.5	93.7	120	End 1956.
Tacolneston	89.7	91.9	94.1	120	Autumn 1956.
Wenvoe			{ 94.3 / 92.1 }	120	1956.
Divis	90.1	92.3	94.5	60	December 1955.

Alignment

For alignment purposes an **AM** signal generator covering 10.7 Mc/s is required.

If no tuning indicator is provided a DC voltmeter must be used as the indicator and should be of high resistance, at least 5000 ohms per volt, a valve voltmeter is the best instrument to use in this instance. Connect generator to **gl** V3 (that is Pin 2) and indicator meter from **C13** negative to chassis. If a tuning indicator is being used, of course the indicator meter is unnecessary.

An audio amplifier should be connected to the tuner so that the operator can hear what is going on.

Inject a modulated signal at 10.7 Mc/s and adjust the top core of IFT3 for maximum indication.

During the whole of the alignment procedure, constructors should not use a larger input signal than is necessary.

Transfer generator to **gl** V2, reduce output to avoid overloading and adjust IFT2 **Bottom** and then **Top** for maximum indication.

With generator still connected to V2, re-adjust IFT3 **Top,** connect generator to aerial input terminals.

It will now be necessary to increase generator output so as to push 10.7 Mc/s through the 100 Mc/s circuits of the UT342. Set dial pointer to 100 Mc/s end of scale and adjust the two IF trimmers on the UT342. Their location may be seen from the drawing Fig. 3.

First set the trimmer under the chassis which is the primary and then the secondary. With generator still connected to aerial terminals re-set IFT2 **Bottom,** IFT2 **Top**; and IFT3 **Top**; in that order. Repeat this process in the same order on all five trimmers until no further improvement is possible.

Replace generator at **gl** V2, and transfer indicator meter across **C7.** Adjust IFT3 **Bottom** (which is the secondary) for zero indication. Care must be taken over this adjustment because on either side of the zero setting there is voltage present, one side in a negative direction and on the other, positive. This means that the meter will read normally on one side of the zero setting but will go backwards on the other. By paying attention to the zero setting of the meter before making this adjustment a precise indication of zero can easily be identified. **Note** : For this measurement, a "Magic Eye" indicator is not entirely satisfactory because it does not react to voltage in a positive going direction.

During this adjustment the audio amplifier is connected, on either side of the correct zero setting there is a peak and on these peaks the modulation note from the generator will be heard but at the correct zero point as indicated by the meter, the note will be inaudible.

IF alignment is now complete and attention can be turned to the HF side. Connect an aerial at the input, set dial pointer to mid-scale and set the RF trimmer for maximum noise. The position of this trimmer can be seen from the top chassis layout drawing Fig. 7, or from Fig. 3.

Tune in the Home Service (see list on page 24).

Adjust the position of the collar on the dial drive spindle until the dial pointer registers 93.5 Mc/s when this programme is tuned in. It should not be necessary to alter the oscillator trimmer. Alignment is now complete.

Tuning Indicators.

The addition of a tuning indicator to an FM receiver is a decided asset, much more so than in the case of AM receivers.

It is very necessary that the signal be accurately tuned and because the eye is so much more discriminating than the ear, a visual tuning indicator is the ideal. Perhaps the best visual indicator is a centre zero meter arranged in a suitable network, however, this method is likely to be both expensive and cumbersome and a neater and cheaper way is to use a "Magic Eye" indicator.

Two currently available types have been used with this Tuner, the EM81 and EM34. Type EM81 is a modern valve constructed on a B9A base, the fluorescent plate is viewed on the side and the valve mounted upright in any convenient position.

As a signal is tuned, two petals will expand and tend to meet, thus diminishing the shadow area. Tuning may be considered accurate at the point of maximum petal expansion and minimum shadow area. A diagram of connections is shown in Fig. 11a, length of the leads is not critical. A convenient point for picking up the heater connections is from the pilot bulb holder. Remember that the insulated rear tag is 6.3v live and top or body connection chassis. HT+ is taken from TS–H tag 1 and the grid lead is fed to V4 tag 7 by way of the 1M. ohm resistor. It is very important that this resistor is mounted directly at **tag 7** on **V4** and **not** on the tuning indicator valve-holder.

As an alternative to the EM81, type EM34 may be used . This valve is of a larger construction mounted on an octal base. The valve is mounted horizontally and the fluorescent plate viewed on the end face of the valve.

An excellent mounting position for this type is centrally above the dial.

A useful feature of the EM34 is its dual sensitivity, thus it is suitable for local or fringe areas. Wiring for the EM34 is shown in Fig. 11b. No capacitor is included across the input, it was not found necessary. If the pattern appears fuzzy, connect a .01μF paper capacitor between grid and cathode at the valveholder, that is pins 4 & 8 on an EM34 or 1 & 2 with an EM81.

Whichever indicator is used, the HT feed resistors are mounted at the valveholder, not under the chassis.

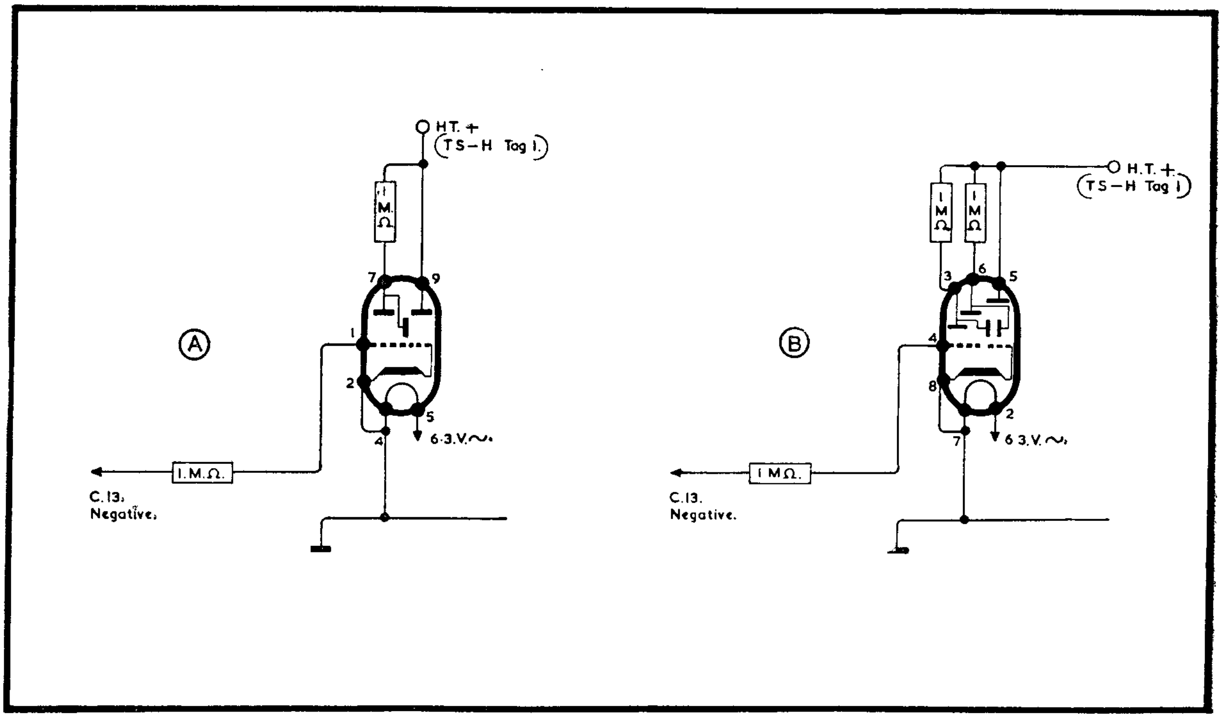


Fig. 11 *Wiring details for adding a Tuning Indicator.*
(*a*) *EM81* (*b*) *EM34*

TSL

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BERNARDS' F.M. TUNER

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Miscellaneous

The tuner will require an aerial designed to present an impedance of 75 ohms and to function in the 87.5-100 Mc/s band. A short length of wire suspended from the picture rail will **not** do. Because of its exceptional sensitivity nothing elaborate in the way of an aerial is likely to be necessary. Overall gain of the tuner is such that a signal of 2.5 μV at the input terminals will produce a signal/noise ratio of 26dB at the output. Tests have been carried out at Folkestone, Brighton, Bournemouth, Plymouth and Birmingham. In each case an ordinary home-constructed di-pole was used and the B.B.C. transmissions were received without difficulty.

Such an aerial may be constructed from ordinary lighting flex. It takes the form of a centre fed di-pole similar to those used for television installations.

Length of the down lead does not matter but the "T" crossbar arms are 3 feet each in length.

F.M. transmissions are horizontally polarised so that the aerial is also mounted horizontally. The "T" crossbar can be conveniently mounted on a picture rail, but care should be taken to ensure that it is face on to the transmitter. If there is any doubt on this point, various positions should be tried until optimum signal pickup is found. It may well be that an aerial at room level will pick up unwanted interference, and a good alternative to the picture rail is a loft or attic. In areas where signal to noise ratio is poor (and this can happen in the primary service area) an outdoor aerial should be considered.

There are a number on the market including a 4 element array consisting of folded di-pole, two directors and a reflector by Wolsey Television Ltd.

As it stands the Tuner will provide trouble-free reception in most areas. It cannot be overlooked, however, that in some areas, interference is especially severe and in such cases steps must be taken to ensure that the aerial is placed in as high a position as is practical.

Most constructors will be familiar with modulation hum. This objectionable form of interference is only apparent as a carrier is tuned in and takes the form of a low frequency hum superimposed on the received transmissions. In the event of this form of interference being present, assuming alignment has been properly carried out and the receiver is in tune, a cure may be effected by connecting a 4700pF ceramic capacitor between C12 **Red** and **Black.**

Lastly it is proposed to briefly review the audio equipment used with the Tuner.

It is not intended to present an amplifier design, such a project might well fill another manual.

Many constructors will wish to use amplifiers already in their possession or even the audio stages of ordinary AM receivers. For such equipment to prove satisfactory it is essential that it should have adequate frequency range. Any suggestion of top cut must be avoided if any benefit at all is to be derived from V.H.F. transmissions.

Unfortunately the average domestic loudspeaker will not respond to frequencies above 6 or 7 kc/s although the average small amplifier is capable of reproducing well above these frequencies.

It is not everyone who can afford a small fortune on a complex loudspeaker system but there are two very inexpensive ways of improving an ordinary system, whether it be a commercial receiver, or home-constructed apparatus. The inclusion of one or more electrostatic loudspeaker units will permit response up to 20 kc/s and impart that brilliance so characteristic of V.H.F. transmissions. Fig. 14 shows how they may be wired into circuits designed for either single ended or push-pull circuits.

They may be conveniently mounted in the centre of an existing loudspeaker suspended on four rubber bands, or where two or more are used, they should be close to the main speaker.

Fig. 13 shows a polar diagram which illustrates the response, with the listener situated at different positions with relation to the unit itself. It will be noticed that at 15 kc/s it is necessary to be almost directly in front of the unit.

By using two units, one on either side of the existing magnetic speaker, the listening angle is greatly increased.

Now the electrostatic speaker does not function like an ordinary speaker, its main function is to respond to transients. Much of the time it appears to do little, but on transient peaks it is very much in evidence. It will be very noticeable when triangles, cymbals, or castanets are in use, if a bell is sounded the effect is startling in its realism.

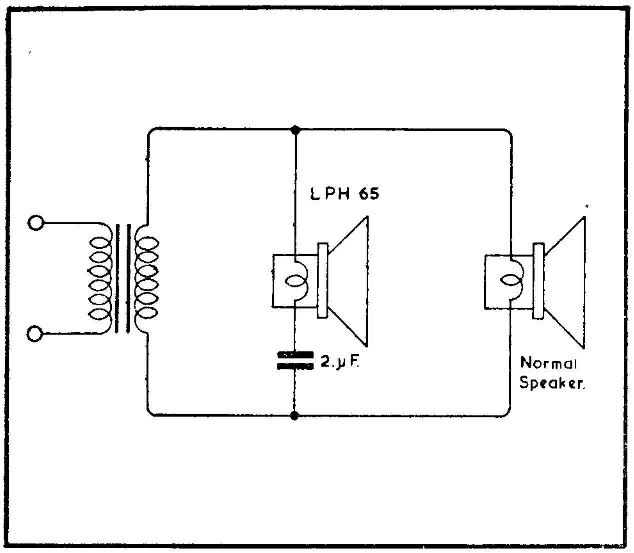

Fig. 12 Method of connecting electro-dynamic tweeter across speech coil of existing speaker. Because of the capacitor in series with the tweeter, matching is not affected.

One drawback with this class of speaker is that they require feeding from a high impedance source which limits their sphere of usefulness because unless amplifier and loudspeaker are located in the same cabinet installation is impracticable. They are most useful with table receivers and radiograms. Many installations suffer from poor middle and upper register and where this is the case electrostatic units cannot on their own, effect correction. In cases such as this and for equipment where the loudspeaker is remote from the amplifier an electro-dynamic tweeter will effect remarkable improvement. T S L market a suitable unit, type LPH65, as used by the B.B.C. with certain of their equipment. This little unit has a 2½" plastic cone and has a wide sound dispersion characteristic. An impression of its appearance can be gathered from the illustration on page 32. Referring to Fig. 12 note that the unit is wired in parallel with the existing loudspeaker through a 2mfd capacitor. This capacitor forms a high-pass filter which permits the speaker to take over at about 5 kc/s. If it is required to take over at 3 kc/s the value should be increased to 4 mfd. The capacity must not be increased beyond this value and under no circumstances may the capacitor be omitted. Because they have a solid back, these units can be mounted in bass reflex and similar enclosures without interaction with the main speaker. The power rating is only 2 watts which is more than sufficient since powerful amplifiers do not develop this power at the frequencies involved.

It is hoped that these few observations will enable the constructor to modernise his existing loudspeaker installation and thus be enabled to take full advantage of the remarkable quality provided by the V.H.F. transmissions and this Tuner.

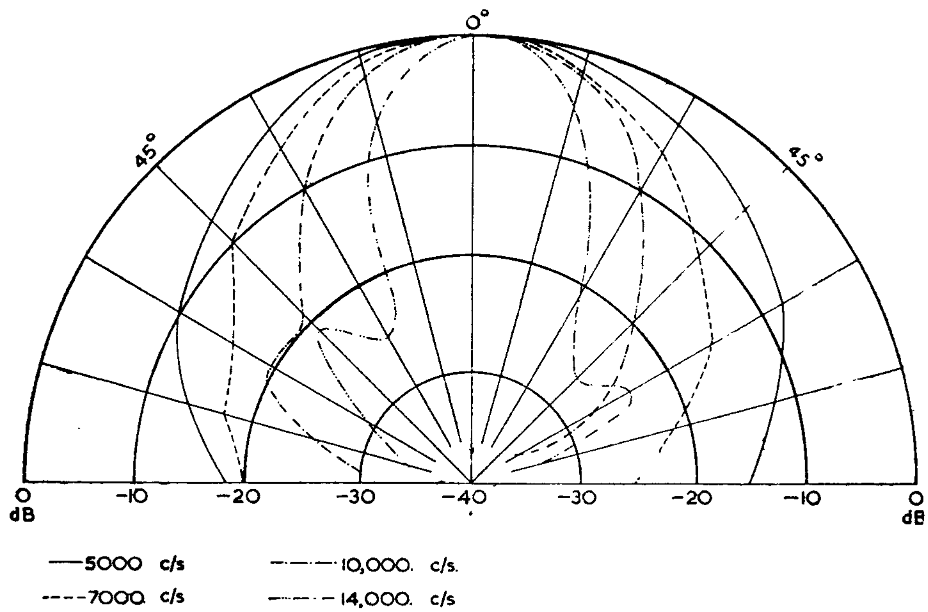

FIG. 13 POLAR DIAGRAM

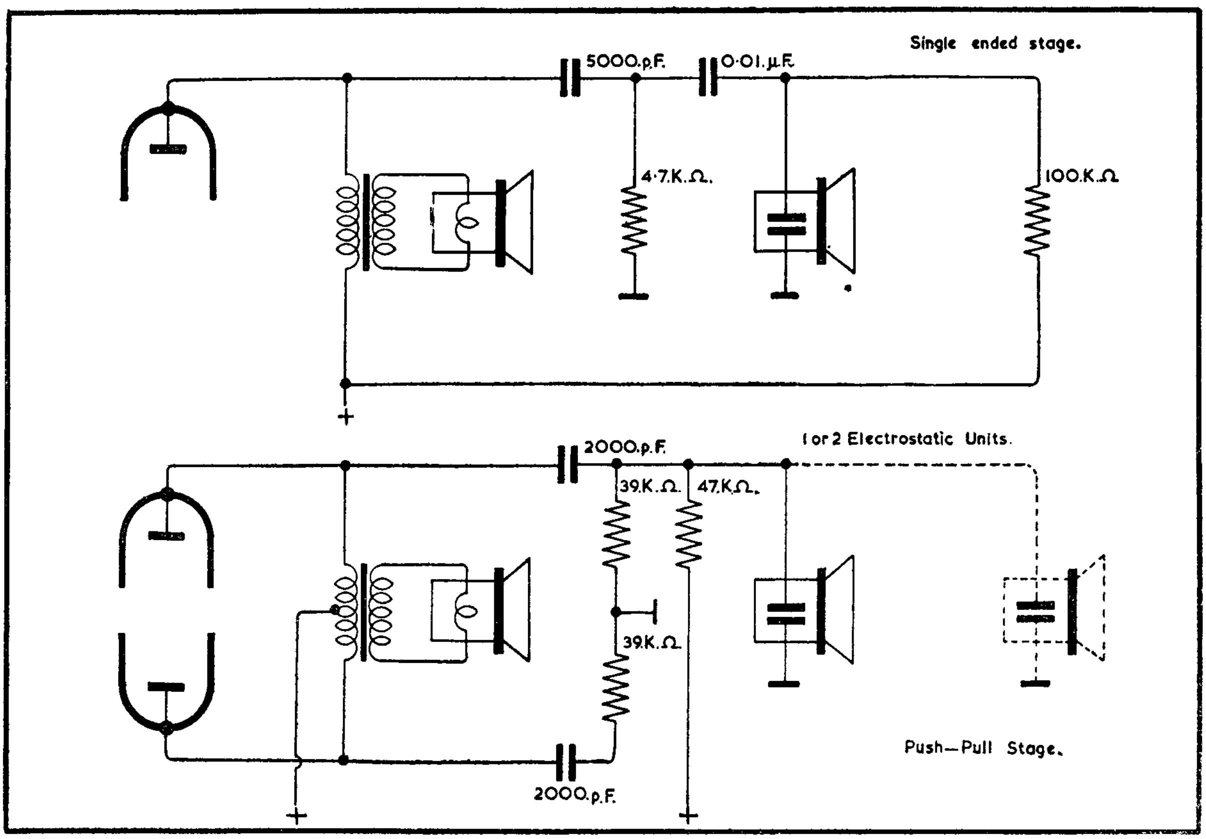

Fig. 14 Connections for adding TSL Electrostatic Speakers to existing Amplifiers. On small single ended Amplifiers the 4.7k ohm filter resistor can often be increased up to 12k ohms with advantage.

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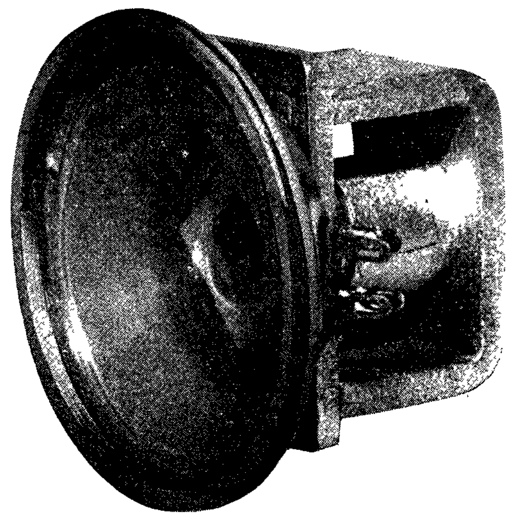
TSL LORENZ PERMANENT MAGNET ELECTRO-DYNAMIC

HIGH FREQUENCY LOUDSPEAKER TYPE LPH 65



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SPECIFICATION :—

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