

No. 167

Eleven Tested Transistor Circuits using Prefabricated Circuit Units

(Transistor Circuits Manual No. 3.)

by

CLIVE SINCLAIR

CIRCUITS AND INSTRUCTIONS FOR BUILDING

1. Transistor 3 wave band Superhet Receiver.
2. Subminiature 1 Watt Transistor Hi-Fi Amplifier.
3. Transistor IF Amplifier.
4. Guitar Amplifier.
5. Stereo Amplifier.
6. Intercom.
7. Baby Alarm.
8. AF Signal Tracer
9. RF Signal Tracer.
10. Telephone Pick-up Amplifier.
11. Loudhailer.

BERNARDS RADIO MANUALS

**TRANSISTOR
CIRCUITS MANUAL**

No. 3

by

CLIVE SINCLAIR

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INTRODUCTION

The recent introduction of pre-assembled transistor units on the home constructor market has prompted me to devote this issue of the transistor circuits manual to their application in several different projects. The units are made by Görlner in Germany and achieve a level of performance and compactness which is hard, if not impossible, for the home constructor to achieve. By using them he is able to build far more advanced and complicated pieces of equipment than would otherwise be feasible and at the same time he is able to save himself money because buying these units ready made is, surprisingly enough, cheaper than building them oneself.

Home constructors are not, however, deprived of the pleasure of the construction side; they are merely given a wider dimension in which to work and satisfactory results are ensured with every project.

The main part of this manual is devoted to a receiver of very advanced design which covers the complete shortwave bands from 5.9 to 13 mc/s as well as the usual medium and longwave bands and gives a power output of one watt making it suitable for use as a car or table radio as well as a portable. This considerable increase in output power over that of the normal portable is coupled with a parallel improvement in quality of reproduction because the amplifier part of the circuit has a frequency response of 60 c/s to 16 Kc/s and is therefore suitable for use as a high quality gramophone amplifier.

The rest of the book is concerned with the many other uses to which the individual units may be put in conjunction with auxiliary circuitry built by the home constructor.

To simplify the circuit diagrams given in this book each of the units is described separately at the beginning, the circuit diagram is given and a block diagram shown which is used in the latter circuits.

The retail prices of the units are as follows :—

The transistor converter type TA 12401 (3 wave bands)	67/6 + 22/9 P.T.
The I.F. Amplifier type 322-0001 ...	92/6
The 1 watt A.F. Amplifier type GS 12005	92/6
Set of Aerial Coils for shortwave receiver	9/6
8" × 3/8" Ferrite Rod	5/-

They are all available from your local dealer now.

Transistor Converter SW, MW and LW Type TA12401

This is a very compact unit using push-button control for wave change and on/off switching. It consists of an OC170 transistor in an autodyne converter circuit together with all the coils required for conversion to the frequency of the I.F. amplifier. The frequencies covered are:—

Short Wave Band	5.9 to 13 mc/s.
Medium Wave Band	510 to 1,620 Kc/s.
Long Wave Band	150 to 275 Kc/s.

The overall size is $3.4 \times 2.1 \times 1.8$ inches which is quite small enough for it to be used in a handbag sized portable radio.

The circuit diagram is shown in Fig. 1, together with the equivalent block diagram. The diagram in Fig. 2, illustrates the top view of the converter. The unmarked push-button on the left has four contacts and may be used for switching the amplifier to the radio, in which the converter is used, from radio to gramophone and simultaneously switching the converter I.F. unit off and the gramophone motor on. It may also be used as a tone control or to connect an outside aerial to the ferrite rod when the set is used as a car radio.

The left hand button is the "push-on/push-off" type and is not mechanically coupled to any of the other three buttons. The wave-change buttons, however, are mechanically coupled and each button returns to its inoperative position as soon as either of the other two buttons is pressed in.

On the short wave band the conversion gain of the unit is about the same as that of the conventional converter operating on the medium waveband. On the medium and long wave bands the conversion gain is considerably superior to any of the converters at present in use in commercial receivers. This extra gain enables a much higher degree of A.G.C. to be used in the I.F. amplifier which prevents fading of foreign stations.

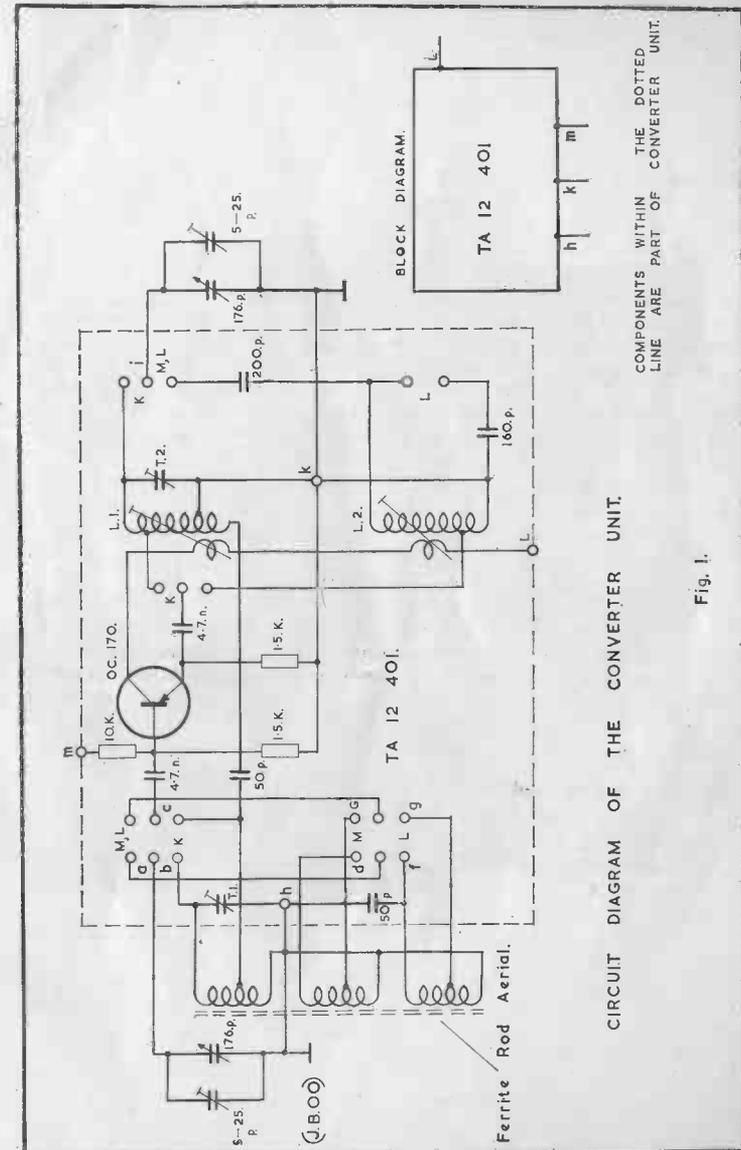
Transistor A.F.—Amplifier 1 Watt Type GS 12 005

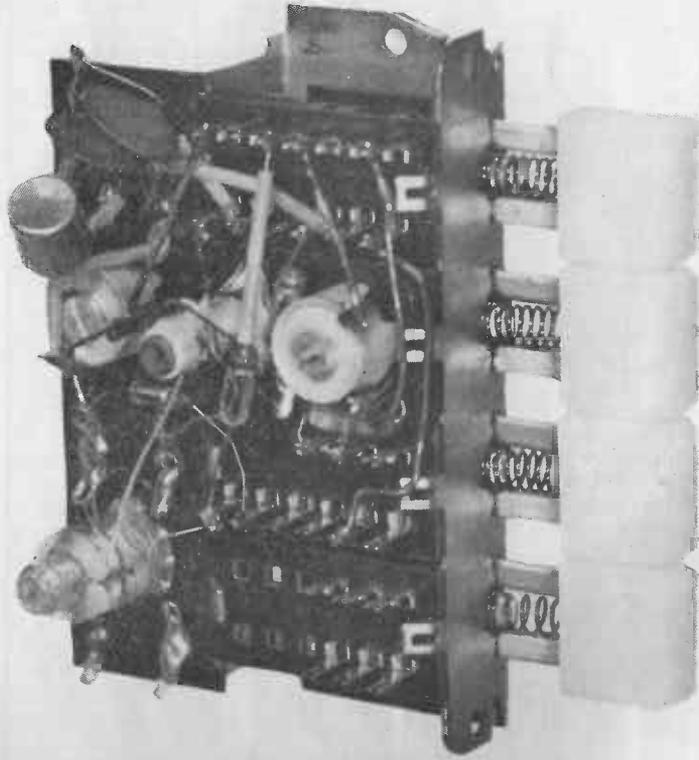
This remarkable amplifier uses two of the new OC74 transistors in push-pull to give a full watt of undistorted output power. The gain is sufficient to give an input sensitivity of only 10 mv. for full output so that it may be used in virtually any application where a quality amplifier is required.

The size of the complete unit is only $3 \times 2.2 \times 1.2$ inches high which has been made possible by the design of a special type of transformer and by using the metal part of the transformers as a heat sink for the transistors. The thermal stability is so good that full output is possible up to a temperature of 112°F.

The performance figures given for the GS12 005 are:—

Voltage	6 volts
Maximum output (3 to 5 ohms)	1 watt
Input voltage for 1 watt output	5 to 10 mv.





Top View of the Converter.

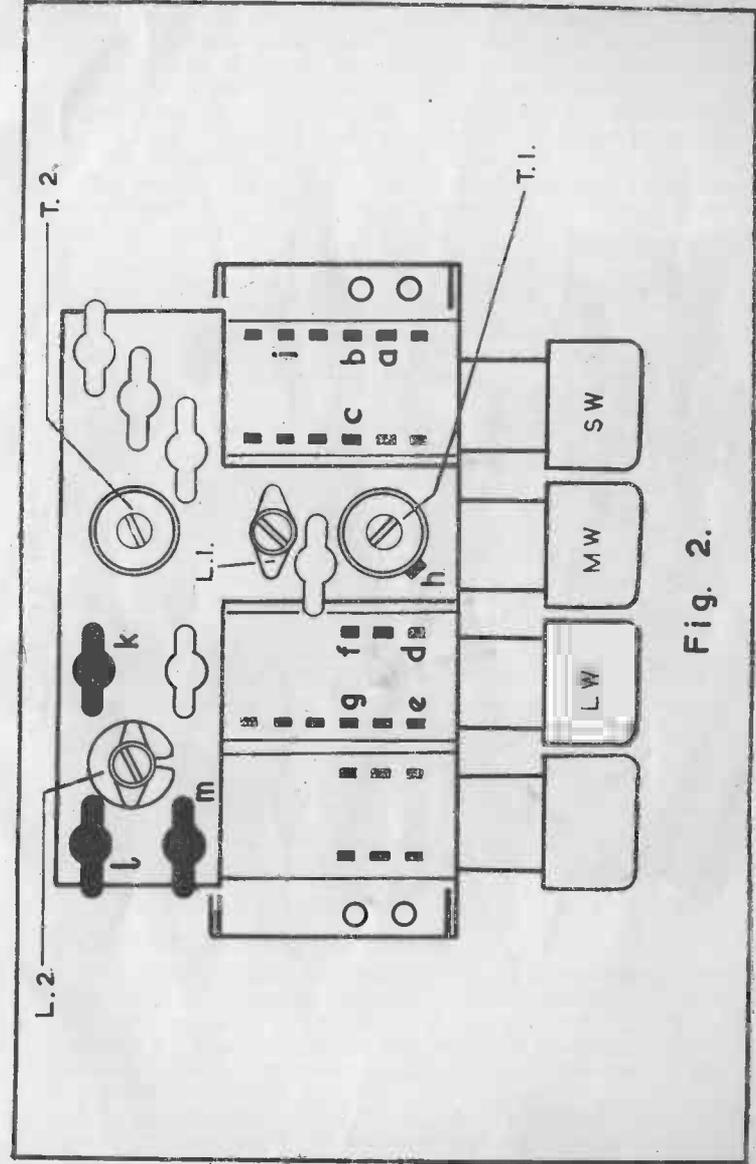
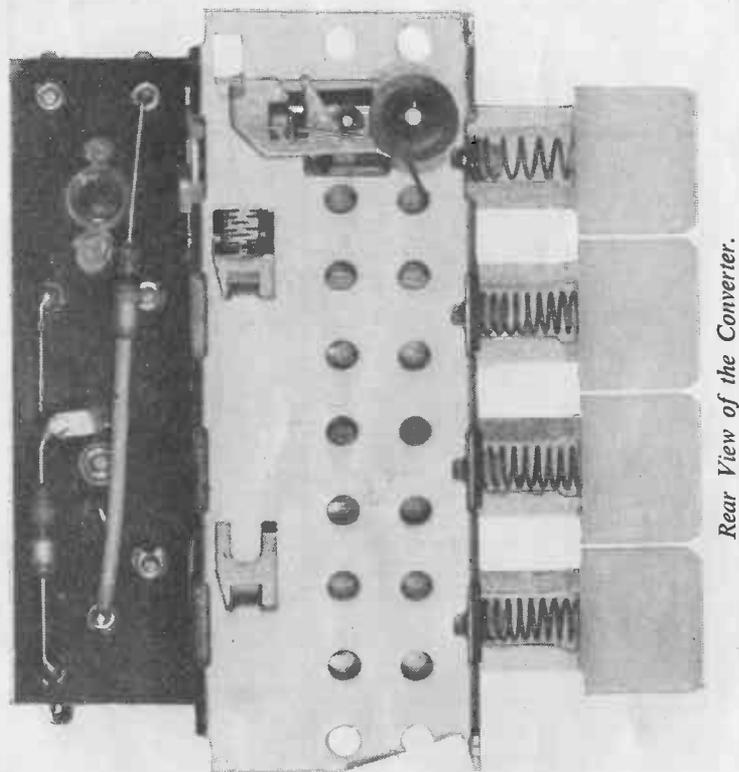


Fig. 2.



Rear View of the Converter.

Input impedance 1.5 to 2K ohms.
 Frequency Response ± 3 dB 60 to 16,000 c/s.

Fig. 3 shows the circuit and block diagrams. The circuit consists of a common emitter preamp. directly coupled to the driver which operates the Class B push-pull output stage via a phase splitting transformer. Negative feedback is applied from the secondary of the output transformer to the input of the driver.

The method of coupling used between the first and second stages is extremely interesting and leads to very good thermal stability. The collector of Tr1 is directly coupled to the base of Tr2 so that the frequency response is not degraded by the use of an electrolytic and, at the same time, several components are saved. The bias stabilisation for Tr1 is provided by Tr2 by taking the base resistor to Tr2's emitter. Because the current swing in Tr2 is far greater than that in Tr1 for any given signal, this results in excellent stability under even the most extreme conditions.

Transistor 460 Kc/s I.F. Amplifier Type 322-0001.

The usual two stage I.F. amplifier, at present in use in commercial receivers, depends for its selectivity on only three tuned circuits. The 322-0001 uses five and thus represents a considerable improvement over past designs. The size is $3.5 \times 1.5 \times 1$ inches.

Two OC169 transistors are used as common emitter amplifiers and a single diode provides both detection and the required A.G.C.

The amplifiers are aligned in the factory using sweep generators and oscilloscopes so that the constructor is relieved of this very tricky task. At the same time the shape of the I.F. response curve (virtually square with a bandwidth of precisely 5 Kc/s) amplification factor and stability are all controlled.

The A.G.C. voltage from the diode is applied only to the first I.F. stage leaving the second stage at optimum gain all the time. The degree of control is greater than is normally used and is sufficient to prevent fading of distant stations. The adjacent channel rejection is excellent, a signal separated from the required signal by as little as 9 Kc/s will receive only 1/900th of the amplification of the main signal which means a voltage separation of over 57dB.

7 Transistor Multi-waveband Superhet

The three units just described may be combined together with a suitable ferrite rod aerial, twin ganged tuning capacitor, loudspeaker and case to form a first class multi-waveband receiver. The completed set will have more than sufficient sensitivity and output power for use as a car radio or main radio for the home as well as a portable.

The problems that would arise in so ambitious a project, were it not for these units, do not occur because all alignment is done

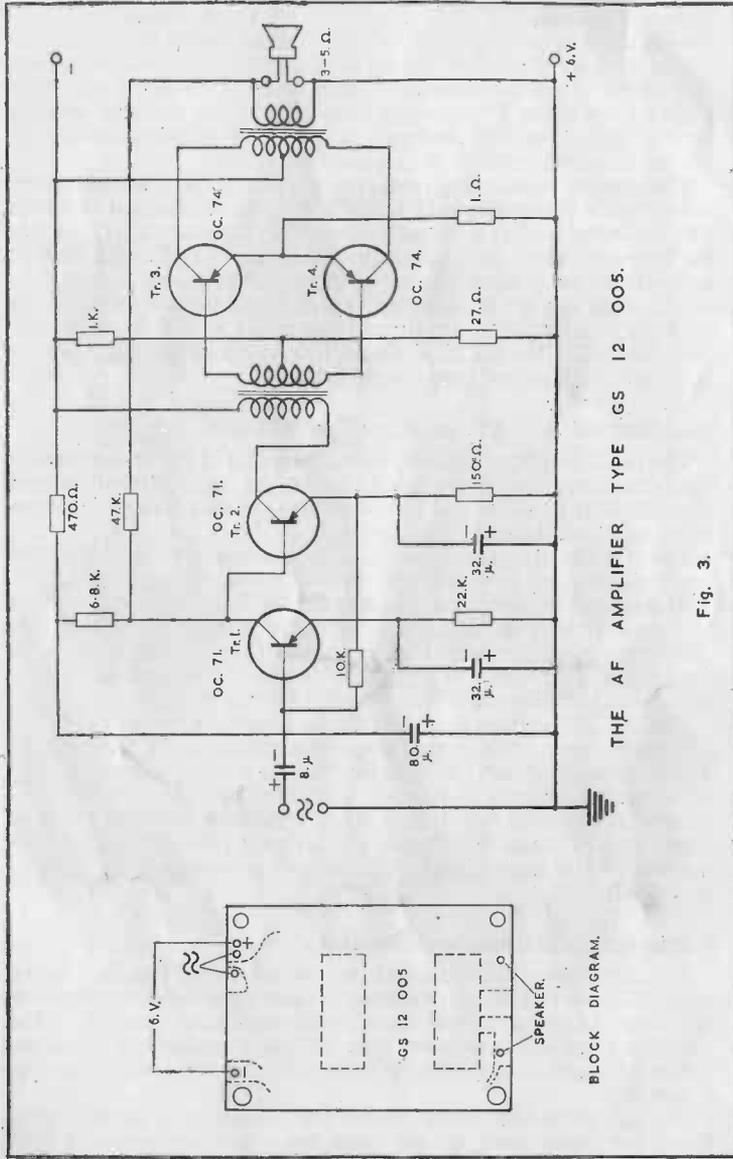
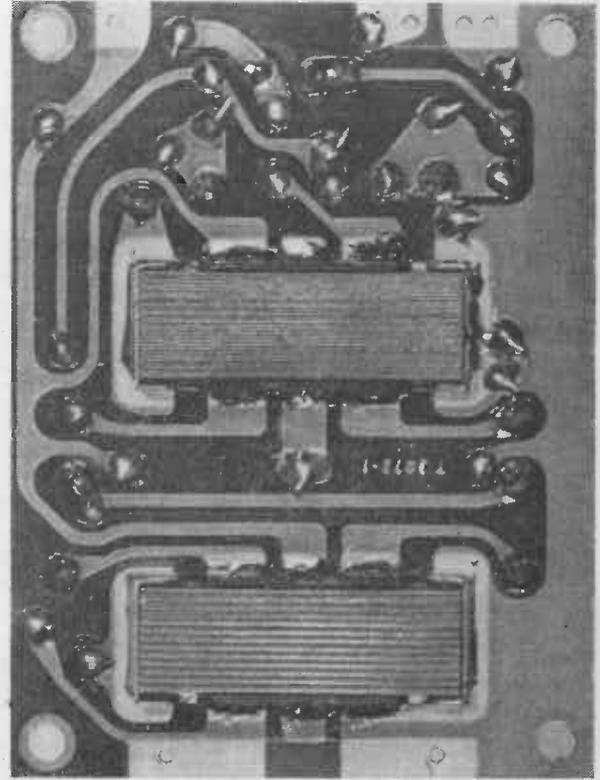
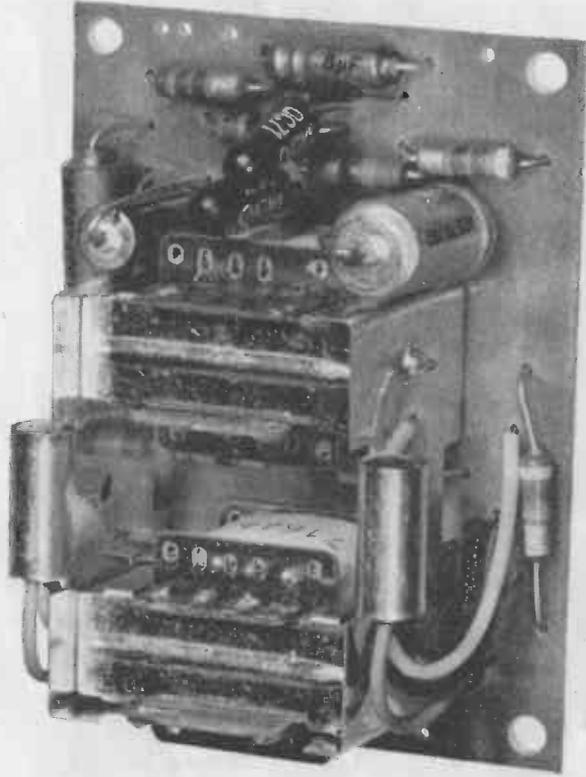


Fig. 3.



View of the A.F. Amplifier showing the Printed Circuits



Top View of the Amplifier.

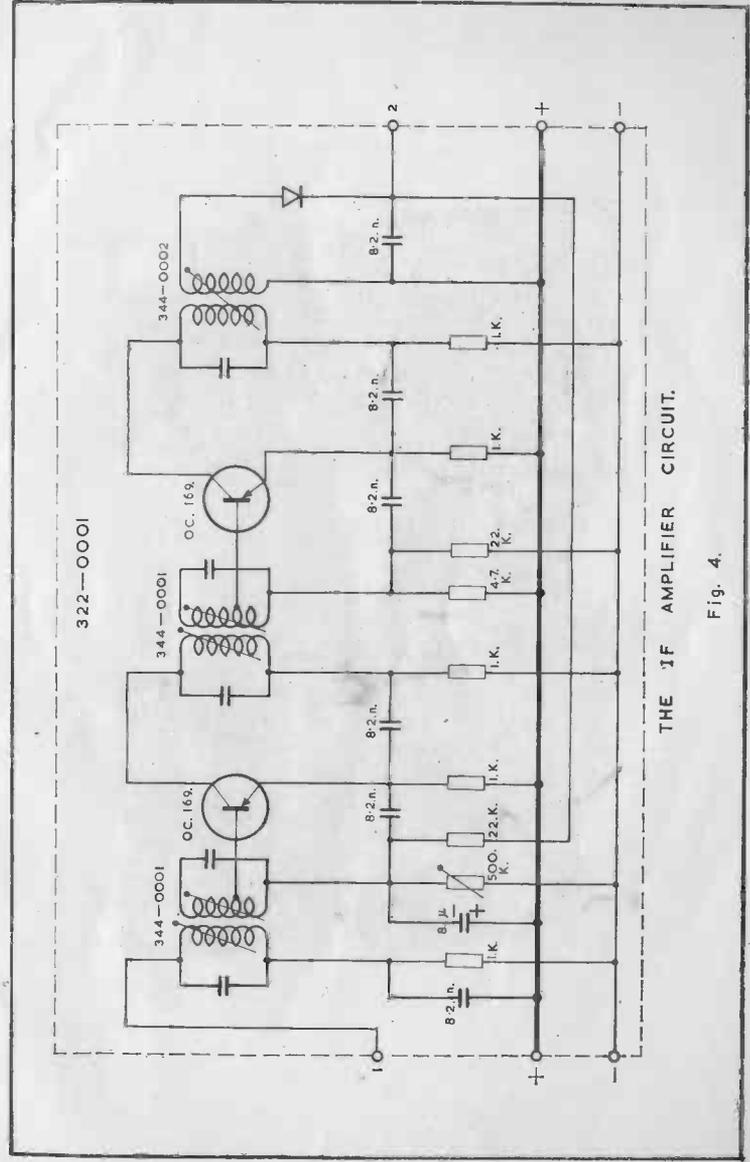
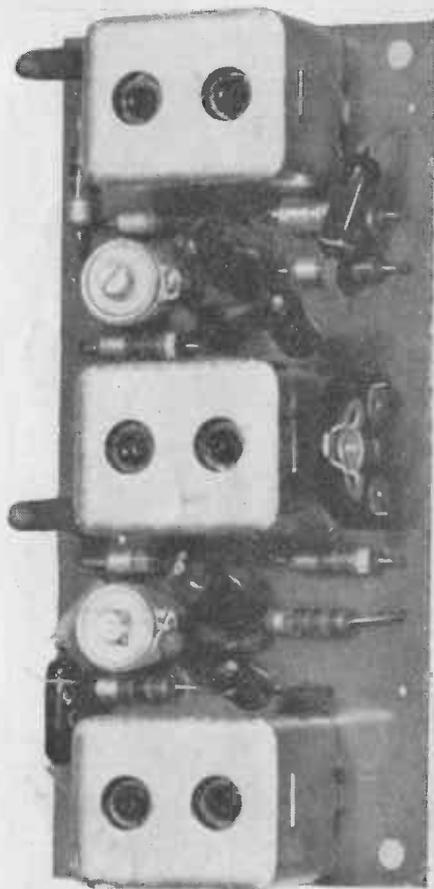
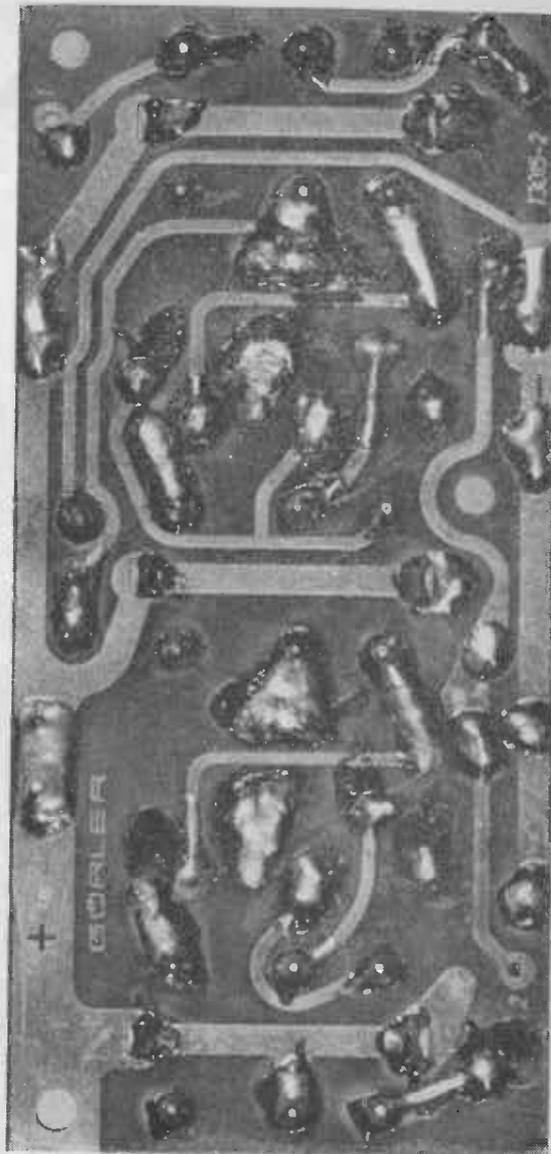


Fig. 4.



Top View of the I.F. Amplifier.



Printed Circuit Side of the I.F. Amplifier.

at the factory. However, should realignment ever become necessary proceed as follows:—start with the broadcast band by adjusting the trimmers of the tuning capacitor (Jackson Bros. type JBOO 176 + 176 pf.) and coil (L2) see Fig. 2. The aerial coil is aligned by sliding coil 1 along the ferrite rod (see Fig. 5). The long wave band is aligned simply by tuning to 200 Kc/s (Light programme) and sliding coils 4 and 5 along the rod together for maximum output. On short wave a two point oscillator alignment is obtained with L1 and T2 while the R.F. circuit is aligned with T1 and by spreading or pushing together the turns of the aerial coil.

The aerial is wound on a standard $8'' \times \frac{3}{8}''$ ferrite rod with the following wire gauges.

- L1 20 strand 47 S.W.G. Litz.
- L2 Single strand enamel covered 25 S.W.G.
- L3 10 strand 47 S.W.G. Litz.
- L4 and L5 10 strand 47 S.W.G. Litz.

All the coils are wound on single turns of paper with sufficient freedom of movement to enable them to slide up and down the rod. L1 is the medium wave coil, L2 the shortwave one and L4 and L5 form the long wave coil. L3 is designed for use with a rod or car aerial. All coils must be wound in the same direction.

If the Home Constructor does not wish to wind these coils, Technical Suppliers Limited have made available the 4 coils L1, 2, 3, 4 and 5 at a retail price of 9/6d. for the complete set. These can be ordered from your radio dealer.

The letters associated with the connections to the coils, h, e, d, b, c, etc., tie up with the letters in Fig. 2 and show how the aerial must be connected to the converter.

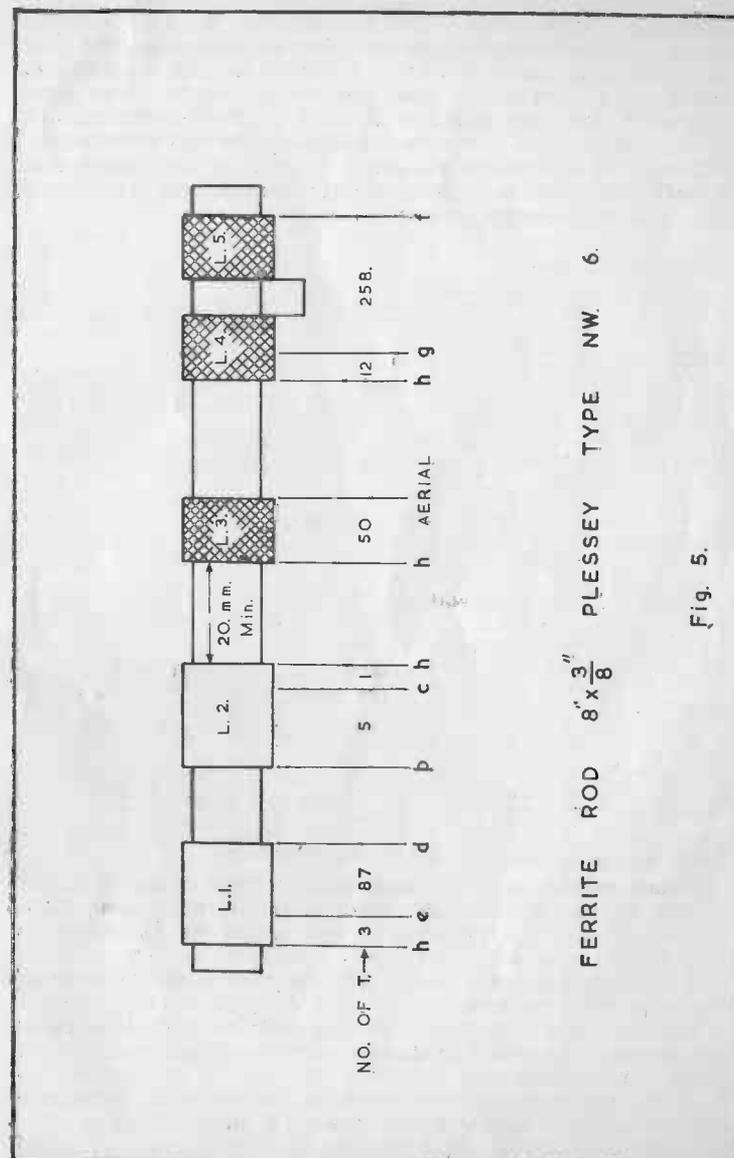
Since the sensitivity of the receiver is dependent on the signal delivered to the converter from the aerial, considerable care should be taken to ensure that the coils are wound neatly and correctly.

Fig. 6 illustrates, in block diagram form, the interconnection of the units to form a complete receiver. The points for connection on the printed circuit boards of the I.F. and A.F. amplifiers are clearly marked on the boards themselves and may be seen from the photographic illustrations in this book. The connections to the converter are illustrated in Fig. 2.

Details are given for the connection of a crystal pickup but these may be omitted if this facility is not required. When used, this is switched in and out of circuit by means of the left hand switch on the converter.

The layout of the receiver is not at all critical as each of the units is stable within itself and is therefore unaffected by its surroundings. The aerial rod should, however, be kept away from any large pieces of metal such as the speaker chassis which would damp it down and reduce the sensitivity.

To do justice to the output power available from the amplifier a loudspeaker of reasonable size should be used. For a portable



by a cathode follower, and these may be fed directly to the amplifier. As the output of this type of tuner may well be in the region of half a volt it will overload the amplifier unless some form of attenuation is provided, a volume control should, therefore, be included in the input circuitry except with tuners that have built-in controls.

Fig. 7 illustrates the circuit required for use with a crystal pick-up. The tone control is provided by a 100K ohm resistor and 0.01 microfarad capacitor in series across the input. These provide a treble cut. A full output of 1 watt will be obtained from the amplifier when the pick-up delivers an output of 1 volt. As this will only be required on absolute peaks a pick-up providing a mean output of 100 mv. should be quite adequate.

Components List

220K $\frac{1}{4}$ watt resistor
 500K volume control
 100K tone control
 0.01 microfarad paper capacitor
 Amplifier type GS12 005
 3 to 5 ohm loudspeaker
 6 volt battery

Fig. 8 illustrates the circuitry required for using the amplifier with a signal producing device of comparatively low output impedance. With very low impedance devices the 5K ohm resistor and the 0.05 microfarad capacitor is used to provide a switched tone control. In the 1 position of switch S.1. it provides a treble cut and in the 2 position a treble boost. If a three position switch is used the third contact may be left blank, and, with the switch in this position, the amplification will be linear.

Also in Fig. 8 is the circuit of a crystal set which may be coupled to the amplifier. L1 is a standard crystal set coil and D is an ordinary germanium crystal diode such as the Mullard OA70. Whilst the selectivity is not very high the quality will be as good as can be obtained on the medium wave band with any type of receiver. In the daytime the problem of selectivity is easily overcome by reducing the aerial length until the set is only sensitive enough to receive the home, light and third programmes. In most cases these are all it will receive anyway. At night, however, the circuit is less satisfactory because it becomes virtually impossible to completely separate the programmes. For daytime use, however, I personally find the set ideal. One useful way of controlling the aerial is to fit a low value trimmer, about 100 pf., between it and the receiver.

Components list for low impedance input and crystal set

10K ohm volume control with switch.
 5K ohm $\frac{1}{4}$ watt resistor.

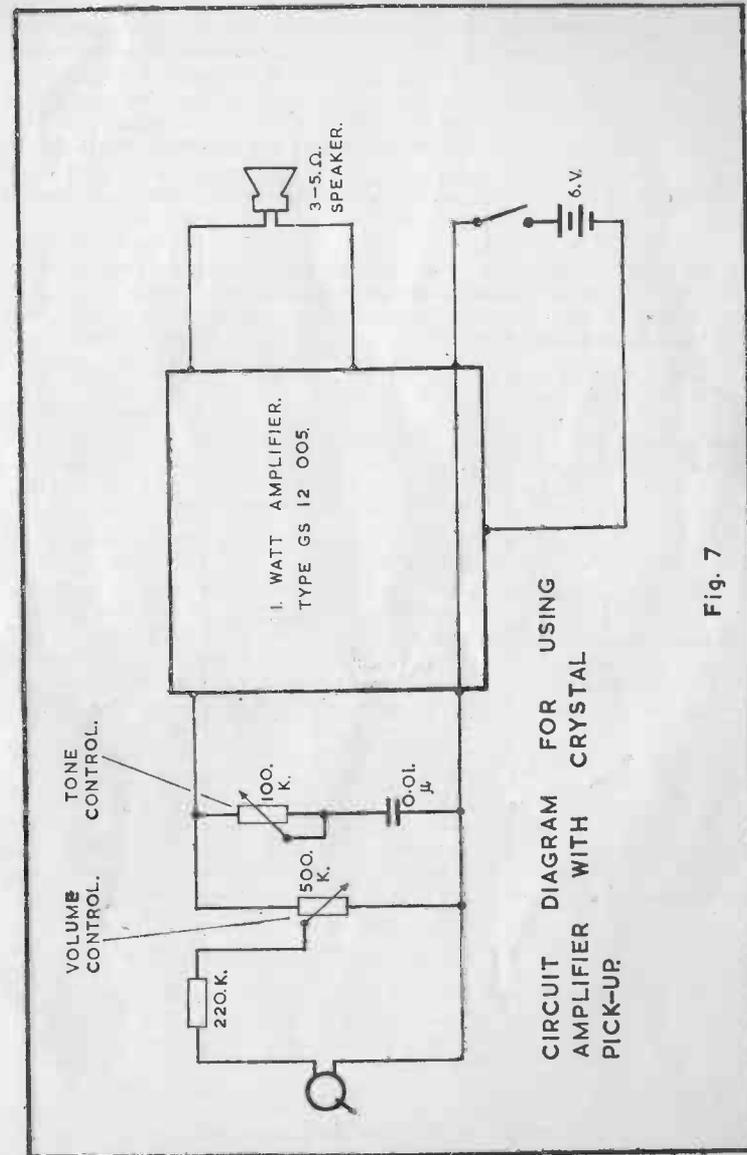


Fig. 7

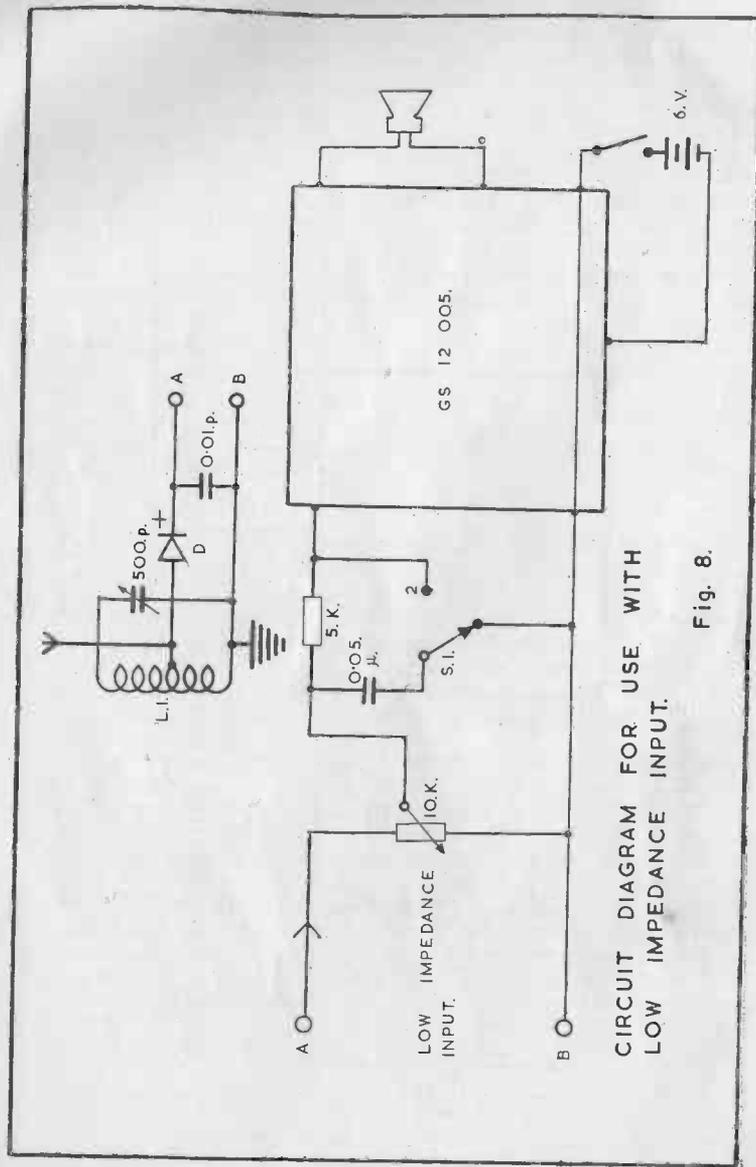


Fig. 8.

0.05 microfarad paper capacitor.
 Three position switch.
 Amplifier Type GS12 005.
 Crystal Set
 Crystal set coil.
 300 or 500 pf. tuning capacitor.
 diode (OA70 or similar).
 0.01 microfarad paper capacitor.

Guitar Amplifier

Technical Suppliers Limited are now marketing a very small guitar microphone of the contact type at 52/6d. This microphone is the crystal type and may be used with any type of guitar or musical instrument. To use it with the GS12 005 amplifier merely replace the pick-up in Fig. 7 with the mike.

Stereo Amplifier

Two GS12 005 amplifiers may be coupled to form a first class stereo unit with an output of 2 watts. The circuit shown in Fig. 7 should be used twice but only a single battery will be required.

There are several excellent crystal pick-ups now on the market which are designed for stereophonic reproduction and any of these will be suitable. The majority are compatible, that is to say, they may be used with monaural, LP records without any adjustment. A switch can be incorporated to join the two outputs from the crystal to one another so that the outputs from the amplifiers are identical on monaural.

The tone and volume controls may be ganged but in the case of the latter this will necessitate the use of a balance control unless the speakers are perfectly placed.

I now have a pair of these amplifiers in use with an Acos stereo pick-up, driving a pair of Soundcorner enclosures. The amplifiers replace two Mullard 3 watt amplifiers one of which had developed faults. There is no noticeable difference between the performance provided by the transistor units and that which I used to get with valve ones. The slightly lower output power available makes no difference because I have never found it necessary to use anything like full power.

Home or Office Intercom. and Baby Alarm

The intercom. is nowadays a familiar part of the large office equipment and has proved itself invaluable to the business man. It does, however, have many applications outside the office especially in the home where it may be used between kitchen and workshop or as a baby alarm. The main requirements of this type of equipment are clarity and ease of operation. If the cost is not to be excessive simplicity must also be a feature of the design.

As is customary, the loudspeakers in this apparatus serve as

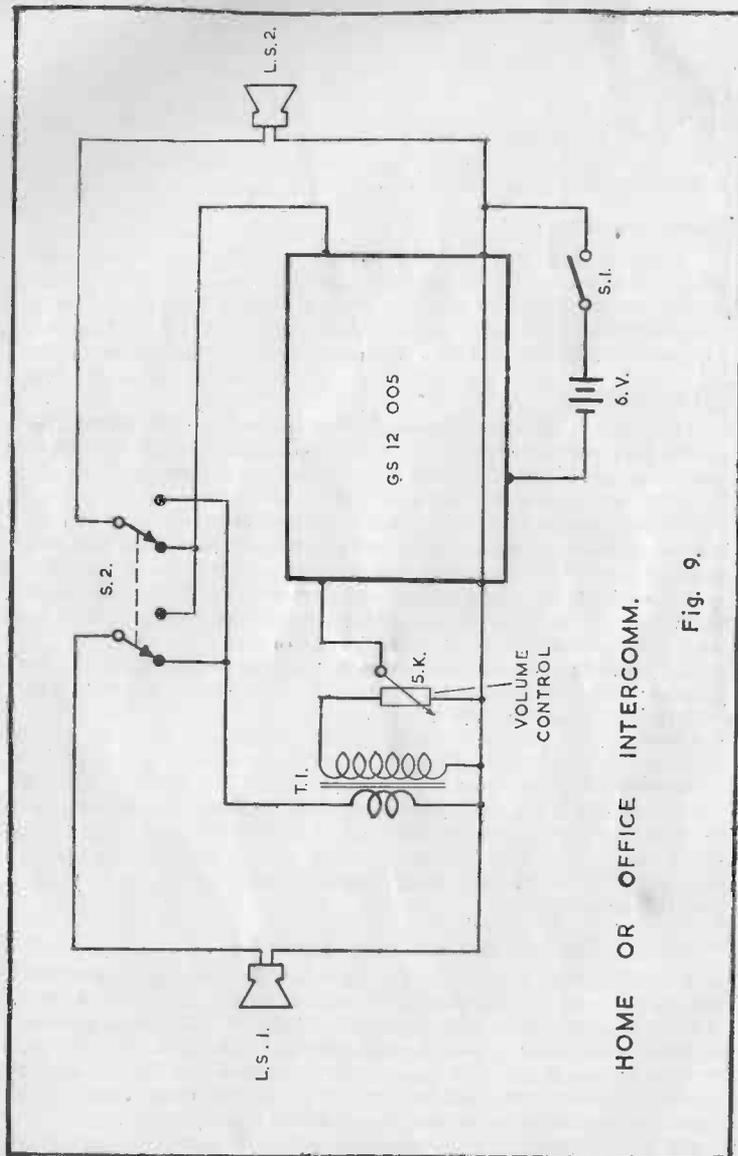


Fig. 9.

microphones as well. This reduces the cost and also means that the speaker may be some distance away from the intercom, since the large cone area means excellent sensitivity. Because the amplifier used is a high quality one, rather than the usual overstrained valve amplifier, the performance is excellent. The only controls required are the on/off switch, a talk/listen switch and a volume control which may be preset.

The method of operation is simple, with S2 in the position shown in the diagram LS.1 is acting as the microphone. The current generated is fed to T.1 which matches the 3 ohm impedance of the speaker to the 1.5K to 2K ohm impedance of the amplifier input. T.1 should have a turns ratio of about 25 : 1 but this is not very critical and virtually any small output transformer will be satisfactory. The output from T.1 goes to the amplifier via a volume control and the output of the amplifier is fed to LS.2. When S.2 is thrown to its other position the functions of the two speakers are reversed, LS.1 becomes the output or speaker end and LS.2 becomes the microphone.

The amplifier, battery transformer and all the controls should be mounted in one case with one of the speakers. Only the other speaker is mounted in the other case and only two leads are required for connection between the two units.

In many installations more than two stations will be required. This presents no problems and as many extra stations as are required may be added; each additional unit consisting only of a speaker. At the master unit a single pole switch must be added for selecting the station required. This single pole switch will need to have as many positions as there are external stations. If the equipment is required purely for use as a baby alarm the switch, S.2 may be omitted. The sensitivity will be great enough to pick-up any sounds of crying anywhere in the room in which the speaker is placed.

Components List

- 2 Loudspeakers, 3 ohm voice coils, 5 inch diameter or similar.
- T1. 25 : 1 output transformer.
- S1. On/off switch.
- S2. double pole, double throw switch.
- Vol. Control. 5K ohms.
- Görler Amplifier type GS12 005.

If the intercom. is to be built for home use the main control unit will most probably be used in the kitchen in which case the addition of a radio tuner will increase its versatility and usefulness. As the installation will probably be fixed, the crystal set type of tuner is the cheapest and, in many ways, the best type to use.

In the components list I have specified the use of 5 inch diameter speakers. This is not, however, in any way a critical size, it was chosen because this size gives a sufficiently good output to provide

clarity under very noisy conditions. Where the equipment is built for use in quiet surroundings the speaker size will be far less important but it must be remembered that the sensitivity of the speaker as a microphone depends on the strength of the magnet and the size of the cone so that whilst a low gauss unit will produce quite sufficient acoustic power when driven by a 1 watt amplifier it may not produce sufficient electrical power when used as a microphone.

Versatile Signal Tracer

A really good signal tracer is one of the most useful pieces of equipment a service engineer or radio enthusiast can have. Besides the more obvious forms of signal tracing it may be used to perform many of the functions of an oscilloscope such as oscillator testing and alignment. The fact that the former is feasible may cause a few raised eyebrows, but the trace made by an oscillator on a C.R.T. is merely an optical representation of the electrical signal which the operator has learned to interpret, in much the same way the signal tracer may be used to provide an audible representation of the signal which may also be interpreted by anyone familiar with the sounds produced by the various types of signal. It is surprising how soon one learns to differentiate aurally, between a good sine wave and a poor one and to recognise sawtooth and square waveforms. Whilst quantitative measurement is impossible (a millimeter could be fitted, in series with a diode, to the output) a direct comparison can be made between two signals of similar nature but different magnitude. For example, when testing a receiver the gain of one of the stages may be in question in which case it can be rapidly determined by listening to the signal first at the input and then at the output of the stage and mentally comparing the results.

The circuitry required for the signal tracer is shown in Fig. 10. Two probes are given one of which is designed to enable the unit to be used with modulated R.F. signals of any frequency up to about 100 mc/s. The A.F. probe is straight forward except that a 50K ohm resistor is included in the input to raise the effective input impedance of the unit thereby reducing the damping of the circuit under investigation. If the tracer is required primarily for use with valve equipment, where the impedances involved are considerably higher, the value of this resistor should be increased to between 250K ohm and 1M ohm to improve the matching.

Components List

A.F. Probe	0.1 microfarad paper capacitor. 50K ohm resistor. Co-axial cable and plug.
R.F. Probe	0.01 microfarad capacitor. Mullard OA70 crystal diode. Co-axial cable and plug.

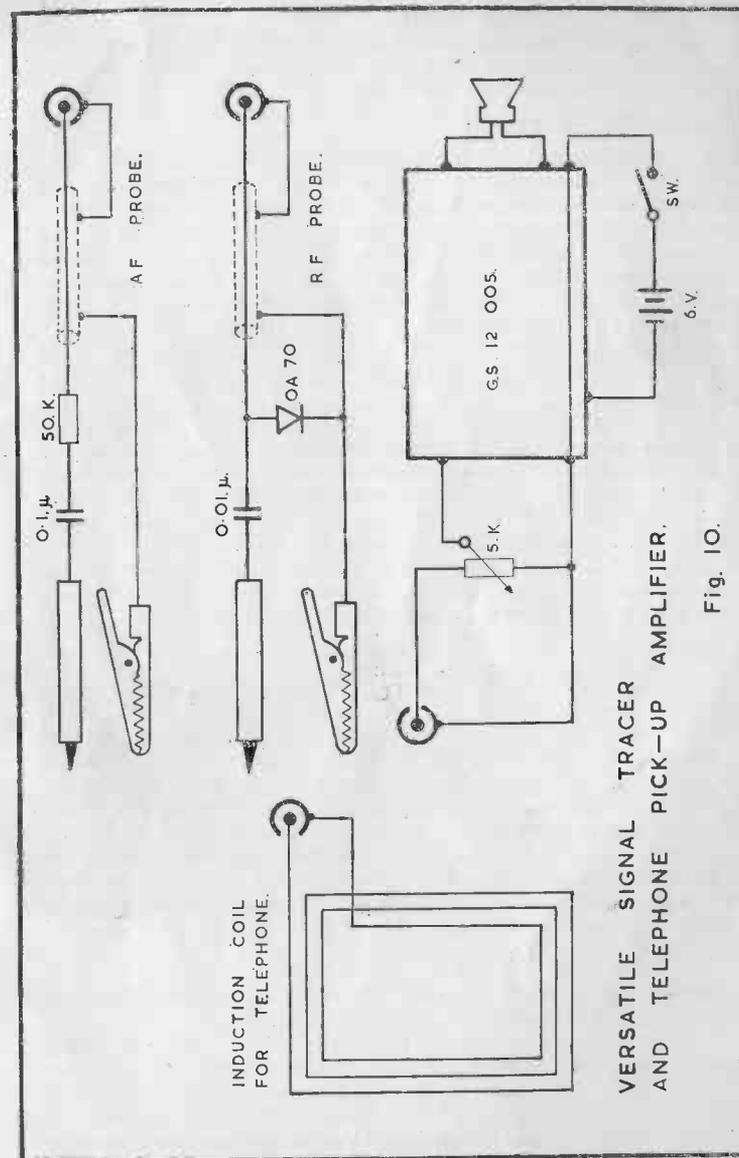


Fig. 10.

VERSATILE SIGNAL TRACER
AND TELEPHONE PICK-UP AMPLIFIER.

Main Unit Co-axial socket.
5K ohm volume control with switch.
Speaker (3 to 5 ohms).
GS 12 005 amplifier.

Telephone Pick-up Amplifier

The most immediately obvious method of bringing a telephone output up to loudspeaker strength is to place a microphone feeding an amplifier near the earpiece of the telephone headset. This is unsatisfactory, however, because the distortion introduced by the earpiece will be amplified and only one side of the conversation will be fed to the speaker. It would also be difficult to prevent oscillation due to feedback from the speaker to the microphone. Fortunately there is a far more satisfactory method which is also simpler. An induction coil is placed near the main body of the phone or the earpiece and this picks up both sides of the conversation by inductive coupling.

The coil may be homewound in which case a flat coil consisting of at least 400 turns of thin wire (40 S.W.G. is suitable) and having a diameter of about 6 inches should be constructed. Alternatively a small coil consisting of a large number of turns may be wound on a ferrite rod. This second type is available as a ready made article and is manufactured by Ardenite Limited under type No. TC.1645. It is designed to match the transistor input impedance and produces an output of 100 mV. which is more than sufficient for use with the Görler amplifier. The overall size is $\frac{3}{4}$ " \times $\frac{1}{4}$ ".

Loudhailer

One application for the pre-constructed amplifier which may be of interest to readers who have an interest in outdoor events is a loudhailer. No circuit details are provided for this type of equipment as they depend so much on individual requirements and would normally not warrant it because of the simplicity of the device.

All that is normally required is a magnetic microphone of about 1000 ohms impedance and a speaker capable of handling 1 watt, preferably the re-entrant horn type which is designed for this type of application. There should be provision for a virtually air tight seal between the microphone and the mouth to prevent acoustic feedback from the speaker.

Using the I.F. Strip

The I.F. strip type 322-0001 has many possible applications beside that described in the beginning of the book.

It may be used in a conventional transistor portable in which application it will improve the performance considerably over that obtained with the usual two stage I.F. amplifier using the OC45 type of transistor. The OC169's used are drift transistors with cut-off frequencies of about 100 mc/s and they have a maximum possible

power gain of 61 dB at the I.F. frequency compared with about 40 dB obtainable from ordinary I.F. types. This considerable extra gain makes it possible to use double tuned transformers throughout the unit and still achieve considerably more gain than usual.

Since the quality of the unit is so good an excellent A.M. tuner can be made by using a normal autodyne converter before the unit. The output may then be used to drive a hi-fi amplifier or to feed a tape recorder.

TECHNICAL SUPPLIERS LIMITED are making available to the home constructor a unique range of printed circuit, pre-aligned and checked transistorized units. These enable any home constructor to build with an absolute guarantee of success, miniaturized portable receivers and amplifiers etc., more than comparable to the finest commercial standards with unrivalled performance at very low cost. Minimum of labour and technical knowledge is required. These transistorized printed circuit units are manufactured by the "Görler" Company of Germany whose experience in the field of transistor design is beyond compare. For the last ten years they have been supplying many thousands of this type of specialized pre-aligned unit both valved and transistorized to the leading set manufacturers of Europe and the United States. This in itself is a warranty of precision, workmanship of the highest class and unrivalled quality and performance.

The units are as follows :

1. "Görler" press-button, Short, Medium and Long wave coilpack and frequency changer stage using OC170 in printed circuit complete with all coils, trimmers etc., pre-aligned and checked for guaranteed maximum sensitivity.
Price 67s. 6d. plus 22s. 9d. Purchase Tax
2. "Görler" transistorized printed circuit I.F. strip for 455-465 k/cs, five pre-aligned tuned circuits complete with two transistor type OC169, pre-tested and aligned at the factory.
Price 92s. 6d. Not subject to Purchase Tax
3. "Görler" high fidelity One-watt printed circuit audio amplifier complete with two OC71 and two OC74, laboratory checked for frequency response of 70-15,000 c/s+3 dB with an output of One-watt for 5 mV input.
Price 92s. 6d. Not subject to Purchase Tax
4. Set of four special aerial coils for Medium, Long and Short wave, colour-coded and wound for highest "Q" to fit item "5" below.
Price 9s. 6d. the set of four
5. 8" \times $\frac{3}{8}$ " diameter special "Ferramic" aerial rod. Ferrite composition of this rod has been selected for maximum performance on Short wave bands thus guaranteeing best results on Medium and Long wave bands also.
Price 5s.
6. Special transistor miniaturized volume control self-contained.
Price 2s. each

The above six items may be obtained from your usual radio dealer. In case of difficulty write to : Technical Suppliers Limited, "Hudson House", 63 Goldhawk Road, Shepherds Bush, London, W.12.

TSL-LORENZ SUBMINIATURE LOUDSPEAKERS

CIRCULAR MODELS

The application of transistors to small radio receiver design brings with it the need for other equally small parts. This has been successfully achieved in all respects save one, that of the loudspeaker. It quickly became apparent that those which simply duplicated the electro-mechanical features of standard types on a small scale prevented transistor outputs from being used to full advantage. To overcome this, it became necessary to design exceedingly small loudspeakers specially with "transistor characteristics", and those presented here will be found to conform ideally with the requirements involved.

TYPE LP.70

A circular unit of extra high sensitivity, functioning well from only a quarter of the power required to obtain comparable results from larger units, yet it will comfortably handle up to 500 milliwatts loading without signs of distress. Its amazingly wide response ensures quality reproduction from the very smallest of sets, making it at least possible to compare pocket-size performance with that of top-ranking commercial portables, however powered. Model LP.70 is recommended particularly for high-quality output portable sets.

TECHNICAL DETAILS

Overall diameter—2½" x 1 1/16" depth.

Response—120-14,500 c/s.

Loading—4 milliwatts to one watt.

Impedance—10 ohms.

25/-*inc. P/Tax***T.S.L.****TYPE CMS.50**

2" diameter x ⅝" overall depth. Reponse 200 c/s to 12 Kc/s.

D.C. resistance 55 ohms. Impedance at 800 c/s—250 ohms.

Designed to be connected directly to Class A output. Sensitivity

is superior to any speaker under 4" diameter, apart from models LP.70 and LP.31.

17/6*inc. P/Tax***ELLIPTICAL MODEL****TYPE LP.31**

Of similar functional characteristics to Model LP.70, the fantastically small dimensions of this elliptical speaker with an overall face size of only 4" x 1½" makes even greater achievements in small set design possible. Using a battery-powered 45 r.p.m. turntable, a portable gramophone or radio-gram can be built only two inches in depth. High efficiency pocket receivers 4½" x 3" x 1½" become practical propositions, with outputs of ½ watt using class B drive. Yet this speaker will convert as little as 4 milliwatts into a loud, clearly audible signal. Specially made cone suspended with watchmaker's precision ensures extra sensitivity and the wide range response essential to obtain high-fidelity performance within the restricted dimensions of transistor portables. Such is their ruggedness and quality that these loudspeakers may also be used to advantage in larger size instruments.

TECHNICAL DETAILS

Size—4" x 1½" x 1" deep.

Reponse—120-14,000 c/s.

Loading—4-1000 milliwatts.

Impedance—3 ohms.

24/-*inc. P/Tax*

Obtainable from your usual radio dealer

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