

# Building the MULLARD 3-VALVE 3-WATT HI-FI AMPLIFIER

FOR THE READER WHO IS THINKING OF building an amplifier that must be simple to construct, which will provide an output power adequate for most homes, and which will have a distortion level low enough to warrant it being included in the highest quality class reasonably expected of such a simple design, this Mullard circuit has much to commend it.

Built to provide an output power of the order of 3 watts, with an input signal of 100mV, it would be a difficult job indeed to reduce the number of valves employed and yet retain the same high standard of performance, particularly also in regard to low hum and noise characteristics.

Much more than the usual voltage gain is demanded to be able to satisfy this requirement of input sensitivity and the provision of a negative feedback factor of 10 times (20db).

Designed round the popular Mullard nine-pin (B9A based) all-glass valves, an EF86 input pentode as the first stage voltage amplifier feeding a high-slope output pentode type EL84, and an indirectly heated full wave rectifier type EZ80, this aim has been successfully achieved by departure from the usual method of employing a pentode valve, and operating the first stage under so-called "starvation" conditions, which enables the effective stage gain to be virtually doubled.

The valve currents and voltages are much lower than is the case under normal operating conditions, due to the high value of anode load used (2.2 Megohms), and the unusual way of supplying the screen grid of the EF86 from the cathode of the EL84 output valve which provides d.c. negative feedback, and also stabilises the valve working points.

Any type of crystal pick-up can be used, and the high sensitivity of the amplifier (only 100mV for 3 watts output) will be sufficient to offset the insertion loss of any equalising networks desired between pick-up and the input stage.

As will be seen from the circuit diagram (Fig. 1) three variable controls are provided, volume (RV1), treble (RV2), and bass (RV14).

With the treble and bass controls in their minimum effective positions, the overall frequency response is substantially flat within  $\pm 1$ db from 100 c/s to 10 kc/s. This is indicated in the graph, Fig. 3, which shows the relative gains, with both tone controls in the minimum position, and also with the treble control in the maximum cut, and bass control at maximum boost, positions.

It will further be seen that it is possible to reduce the treble response at 10 kc/s by a factor of 15db, and to boost the bass response at 100 c/s by a factor of 12db, both relative to the response level at 1 kc/s.

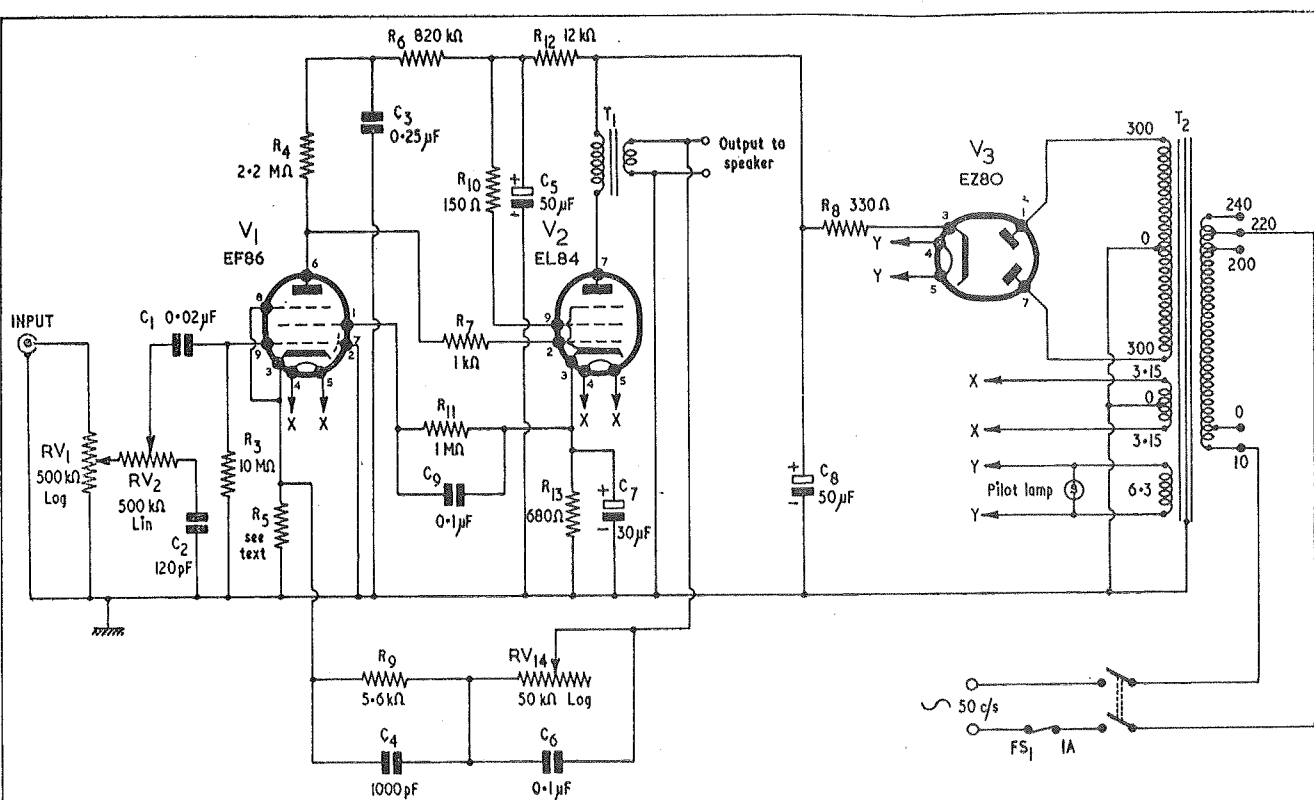


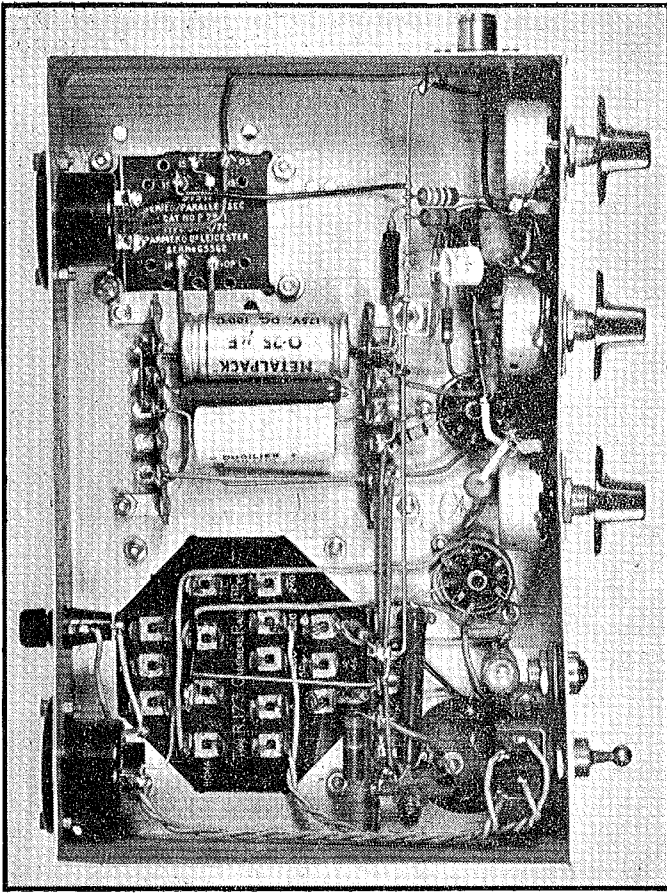
FIG.1. CIRCUIT DIAGRAM OF AMPLIFIER

running leads carrying a.c.—these obviously should be kept well clear of control grid wiring; multiple earth connections on the chassis will only result in a number of earth loops, with inevitable noisy results. The earth connection to the chassis must be made at the input socket ONLY! Use a transformer with a centre-tapped heater winding to feed the EF86 and EL84 (it is also good practice

to run the heater of the 6.3V rectifier from a separate heater winding); keep the high impedance pick-up leads as far as possible from a.c. fields; make a really clean job of the wiring-up, which should follow closely the point-to-point diagram in Fig. 2. The writer would be the first to agree that any constructor worthy of the name would not have failed to keep most if not all the points mentioned in mind, but nevertheless still feels they are worthy of mention.

Where the can of the 50+50 $\mu$ F electrolytic capacitor is used as the common negative connection, it must be isolated from the metal chassis, as otherwise the a.c. ripple current flowing may give rise to considerable hum. A bottom metal cover plate to the

*Under-chassis arrangement of prototype—compare the point-to-point diagram shown on the opposite page*



A design feature which should be noted is that maximum bass boost occurs at about 120 c/s, below which frequency the effective boost decreases at a rate of 12db per octave. This can be a very useful device for lessening possible motor rumble and hum troubles. Whilst on the subject of hum, much trouble can be avoided by attention to small things. By this is meant, for example, that a good quality valveholder should be used for the EF86, preferably of the nylon-loaded or Mykacin types; the heater leads from the mains transformer to the valveholders should be twisted; the screened pick-up lead usually provided by thoughtful manufacturers should be earthed, together with the earth tag on the motor board; care must be taken in

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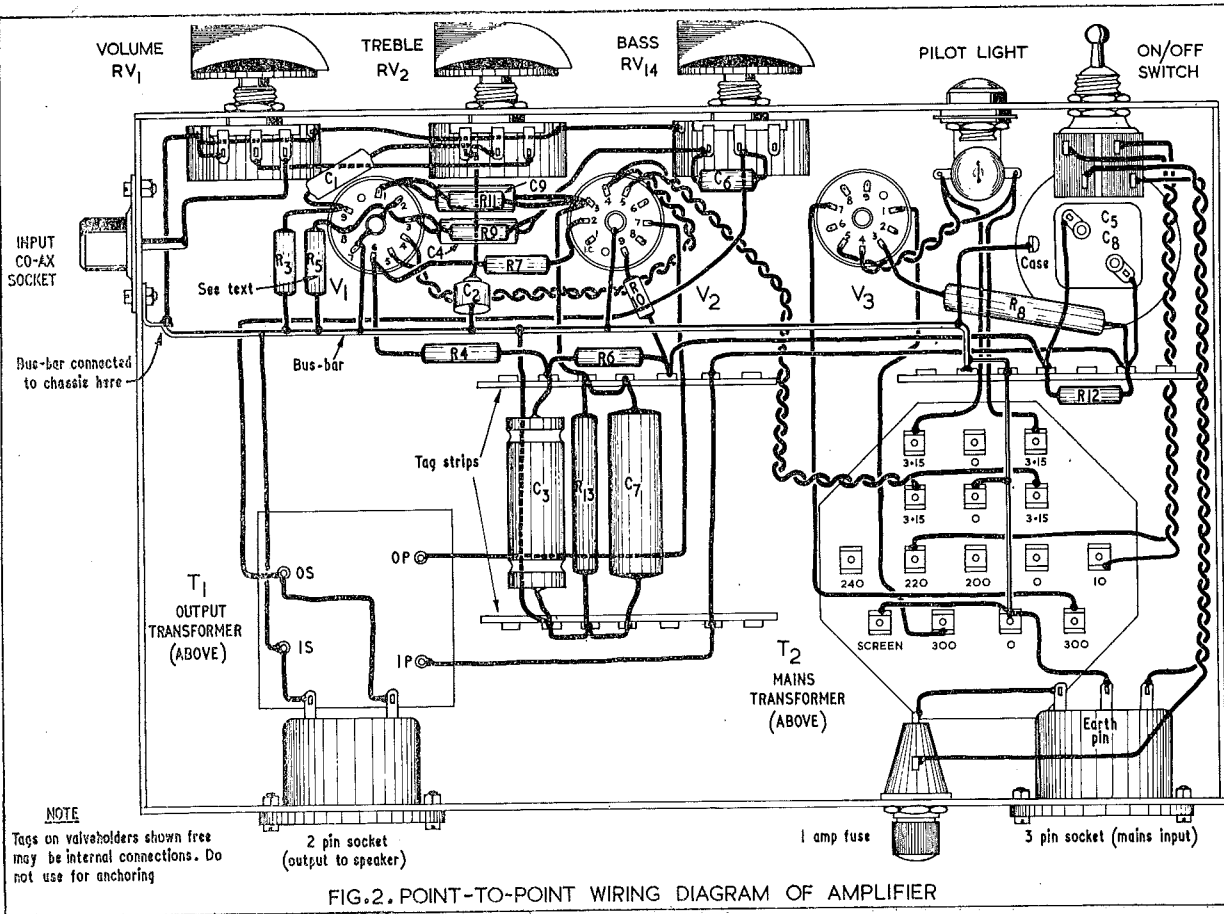


FIG.2. POINT-TO-POINT WIRING DIAGRAM OF AMPLIFIER

being indicative of the point where overloading of the amplifier is taking place.

In the "shopping list" of components will be seen several types of output transformers of different makes which have been tested

reputable dealer that the electrical characteristics are at least identical. Insistence on this point will at least ensure freedom from the poor results that could otherwise be expected were a cheap product to be used instead.

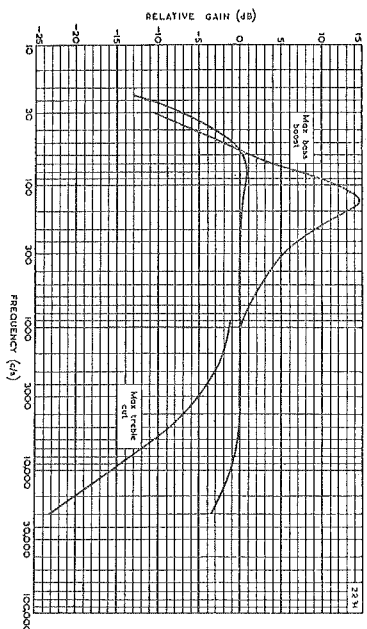


Fig. 3. Frequency response of amplifier, showing relative gain with minimum tone controls, and also with maximum treble cut and maximum bass boost

out in this circuit, and which have been found to be in every way satisfactory. This is probably the most important part of a good quality amplifier, and you are strongly advised to use one of these types which have been approved by the Mullard Application Laboratory design engineers. This is not

There must be no confusion between the terms "cheap" and "inexpensive" where output transformers are concerned. The 3.75 ohm and 15 ohm output terminations should enable the correct matchings to be made to almost any kind of moving coil loud speaker.

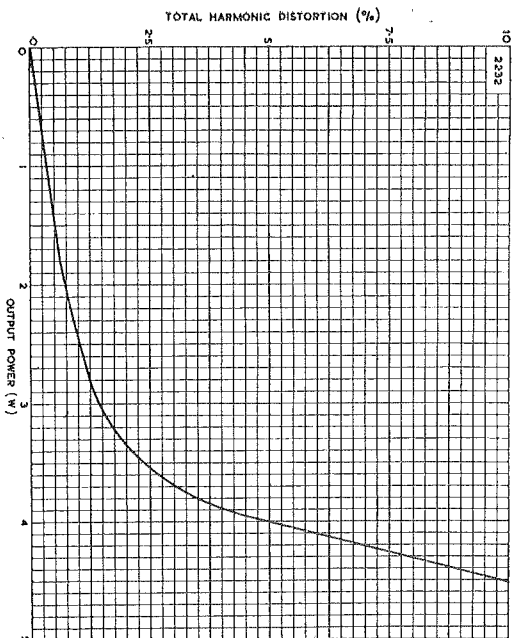


Fig. 4. Total harmonic distortion plotted against output power

intended to imply that positively no other make of transformer will be suitable, but if in your quest for a specified type you are offered a substitute, be firmly assured by a

If on testing the amplifier you hear a howling or hooting noise (gentle or otherwise depending on the position of the volume control) it is only necessary to switch off

## Component List

### Output Transformer

T<sub>1</sub> Primary: 5000Ω

Secondary: 3.75Ω or 15Ω

The following have been tested in the circuit and found to be satisfactory:

Manufacturer Type No.

Cole 35206

Gilson WO767

Parneko P2641

Partridge SVO/1

Wynall W.1452

### Mains Transformer

T<sub>2</sub> Primary: 10-0-200-220-240V

Secondaries: H.T. 300-0-300V, 60mA

L.T. 3.15-0-3.15V, 1A

(for V<sub>1</sub>, V<sub>2</sub>)

6.3V, 1A (for V<sub>3</sub>)

If only one 6.3V heater winding is available, it should have a 2A rating to supply all three valves.

### Sockets

Mains input: Bulgin, 3-way

Output: Bulgin, 2-way

Coaxial: Aerialite, 149

### Pilot Lamp

Bulb: 6.3V, 0.04A

Holder: Bulgin, D180/red

### Valveholders (three required)

Novol (EF86 skirted—see text)

### Mains Switch

230V, 2A, double pole toggle, Bulgin S300

Tag Strips  
Bulgin, T24, 5-way. Three required

Fuse  
1A, Belling-Lee, Minifuse, L575

### Class

Ready drilled, Osmor Radio Products Ltd.

Valves  
EF86, EL84, EZ80, all Mullard

Capacitors  
C<sub>1</sub> 0.02μF paper 150V min.

C<sub>2</sub> 120pF ±10% S.M. or ceramic

C<sub>3</sub> 0.25μF paper 350V wkg

C<sub>4</sub> 1000pF ±10% S.M. or ceramic

C<sub>5</sub> 50-50μF electrolytic 350V wkg

C<sub>6</sub> 0.1μF paper 150V min.

C<sub>7</sub> 30μF electrolytic 50V wkg

C<sub>9</sub> 0.1μF paper 150V min.

and change over the two connections to the output transformer secondary. The unwanted effects of positive feedback will then be corrected to the negative feedback required.

Note that the value of the feedback resistor in the cathode circuit of the EF86 must be chosen to match the voice coil impedance of your loudspeaker, i.e. R<sub>5</sub> must be 150 ohms for a 3.75 ohms load, or 82 ohms for a 15 ohms load.

A chassis of dimensions 9in × 6in × 2½in will be required. Osmor Radio Products Ltd. have a chassis punched available.

The photograph and point-to-point wiring diagram of the underside view of the prototype amplifier provide details of the recommended layout. The designers have put a considerable amount of thought into this, and you cannot do better than copy their layout as closely as possible.

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(continued on page 579)

measure of the steepness of the line in Fig. 7. For example, if the scales of the axes of the graph are kept the same, the steepness of the line would be greater if the gm were 5mA/volt. gm is a measure of the valve's performance, but it is not the only one. However, generally the higher the gm the higher the gain obtainable from the valve.

same curve as Fig. 7 and a signal is applied to the grid. This signal (which is the waveform of a perfectly pure sound) swings half a volt either side of -1 volt. As the grid voltage is varied by this signal, the anode current varies in sympathy from 6.5mA to 3.5mA. The curve is perfectly straight over this portion (a "straight" curve is the mathe-

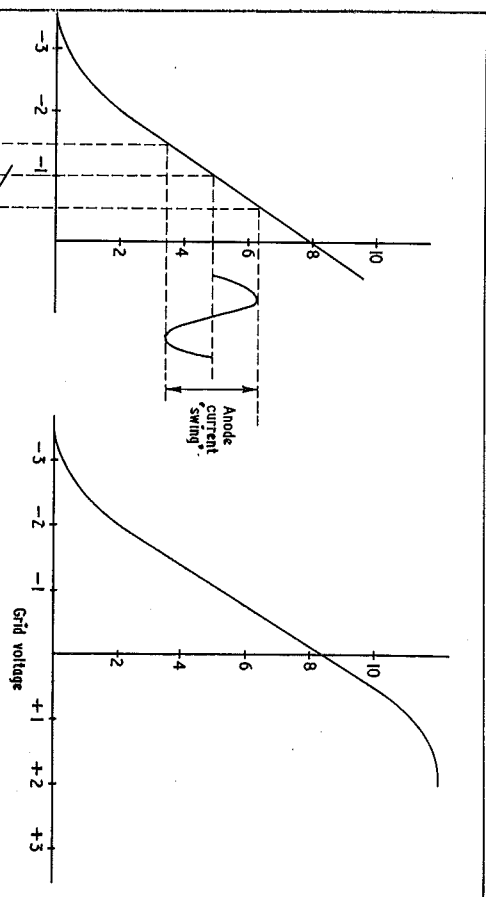


FIG. 9.

FIG. 8.

Grid voltage swing

Anode current

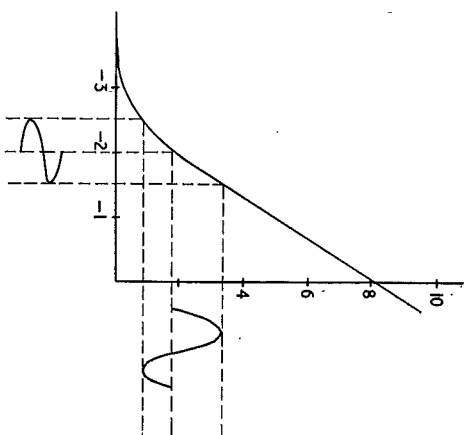


FIG. 10.

In Fig. 9 the "mutual characteristic," as the curve is called, is used to show how grid voltage. Here we have the

mancian's idea, not mine!) so the anode current is directly related to any change in grid voltage. If we were to move the signal

to the left and swing it about -2 volts, the curve has become "curved" in the true sense, and the anode current would no longer be a faithful reproduction of the grid voltage, as shown in Fig. 10.

It is clearly important to choose the

## MULLARD 3-VALVE AMPLIFIER, continued from page 569

It pays to become the possessor of the best possible loudspeaker your pocket will allow. A large range of loudspeakers is now being offered by a number of reliable manufacturers, at prices to suit most purses. Having a speaker, the next most important job is to see that it is properly housed in a suitable enclosure, usually in some form of cabinet of air-tight construction. The improvement in results obtainable by using a properly designed and made enclosure to suit the particular speaker is such that it amply repays the time and trouble taken in enquiring for details of suitable cabinets. Quite often a good dealer can make recommendations, and perhaps obtain constructional details for those who are interested. It is important to realise that the furnishings of a room (also its size) have considerable

correct voltage about which to let the signal swing if distortion is to be avoided. This voltage is called "grid bias" voltage. We shall see next month how the bias voltage may be applied to a practical amplifier, and how valves may be coupled together.

influence on the quality of sound reproduction. The echo effect in an empty, bare room is well known, and only little less so, perhaps, the deadening, muffling effect of heavy curtains on music, due to undue absorption of the higher frequency tones.

Sometimes it is possible to bring about an improvement in sound quality by moving the loudspeaker to another part of the room—in a corner, for example. It is certainly worth experimenting to achieve the best possible results under any given conditions.

Finally, an inexpensive amplifier such as the one described above, with a good loudspeaker, is an infinitely better proposition than an expensive amplifier with a poor speaker!

## CLUB NEWS

Details for insertion in this section should reach us not later than 7th of the month of publication. Insertions are subject to space being available.

### CHESTER AND DISTRICT A.R.S.

Meetings are held regularly at the Tarran Hut, Y.M.C.A. Hon. Secretary, D. J. Rickers, GW3HEU, 97 Ruabon Road, Wrexham, Denbighshire.

### CAMBRIDGE AND DISTRICT A.R.C.

Meetings are held at the Jolly Waterman, Chesterton Road, Cambridge. Hon. Secretary, F. A. E. Porter, 38 Montague Road, Cambridge.

### LEICESTER RADIO SOCIETY

Meetings are held on Mondays at the Holly Bush Hotel, Belgrave Gate, Leicester at 7.30 p.m. Hon. Secretary, J. Trammer, 4 Grocot Road, Evington, Leicester.

### CLIFTON AMATEUR RADIO SOCIETY

Meetings are held every Friday at 7.30 p.m. at the clubrooms at 225 New Cross Road, London S.E.14. Details may be obtained from the Hon. Secretary, C. H. Bullivant, G3DIC, 25 St. Fillans Road, Catford, S.E.6.

### BRITISH A.T.C. (Midlands Group)

Details of membership and meetings may be obtained from the Hon. Secretary, F. J. Rawley, G3FHZ, 16 Kings Road, New Oscott, Sutton Coldfield, Birmingham, 23.

### EAST KENT RADIO SOCIETY

Particulars of meetings and membership may be obtained from the Hon. Secretary, D. Williams, Llandovery Bridge, Canterbury.

### RAVENSBOROUGH AMATEUR R.C.

Club stations will be on the air on all bands during the exhibition held at the Downham Mens Evening Institute, evenings only, April 9-14th. Meetings of the club are held every Wednesday evening at Dur-ham Hill School, Downham. Hon. Secretary, J. H. F. Wilson, 4 Station Road, Bromley, Kent.

### HASTINGS AND DISTRICT A.R.C.

Meetings are held every Tuesday at 7.30 p.m. and Friday is an additional night for free activity. When the workshop is fully organised, the premises at 22 Middle Street, Hastings will be available at any time to members. Further details from the Hon. Secretary, W. E. Thompson, 8 Coventry Road, St. Leonards-on-Sea, Sussex.

### ROMFORD AND DISTRICT A.R.S.

Meetings are held every Tuesday evening at 8.15 p.m. at R.A.F.A. House, 18 Carlton Road, Romford. Hon. Secretary, N. Miller, 55 Kingston Road, Romford.