Hi Fi YEAR BOOK

1957

QUAD II
MAIN AMPLIFIER

QUAD II
CONTROL UNIT

QUAD
ELECTROSTATIC
LOUDSPEAKER

ACOUSTICAL
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PICKUPS • AMPLIFIERS • SPEAKERS • MOTORS • TUNERS • TAPE RECORDERS

10/6

Hi-Fi Year Book

1957 Edition

Editor - - Miles Henslow

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FOREWORD

THIS second edition of Hi-Fi Year Book (1957) has been produced to take over the current story of High Fidelity sound recording and reproduction from the point at which we left it in 1956. In the main, through the medium of its articles, this book summarises the progress made during the past 12 months ; in its directory sections it lists the ranges of current equipment, together with abridged specifications, prices, and manufacturers addresses, telephone and cable addresses ; in its directory and editorial pages are over 200 illustrations of equipment.

In each chapter, available equipment has been presented alphabetically, in directory form with relevant technical data. To increase the usefulness of this book, all the advertisements are grouped in one section and indexed on page 148, and should be referred to for additional data. Prices in the editorial section are shown with Purchase Tax as an extra where it applies. While every effort has been made to ensure accuracy, no responsibility can be accepted for discrepancies.

MILES HENSLOW

Hi-Fi GUARANTEE

THE purpose of this Year Book is to take the subject of Hi-Fi to pieces, and to explain it in the most simple and understandable terms, and at the same time to provide as complete a survey as possible of all the best equipment available today on the British Market. Readers may accept, as a guarantee of quality, that no mention is made in this book of any piece of equipment that is not of really good standard, and that no advertisement is accepted from any manufacturer of components or instruments whose products are not up to the standard of " Hi-Fi ", as it is understood and accepted in its true meaning, by the Trade as a whole, by the acknowledged experts of the day, and by the editorial and publishing office of Hi-Fi Year Book.

It is, of course, important to add that no implication of unworthiness is intended towards any manufacturers whose products may have escaped mention, or whose advertisements do not appear in these pages. The above guarantee is a positive one—not a negative one, and we can only repeat that those products which *are* mentioned, or advertised, may be bought with full confidence.

THE BEHAVIOUR OF GROOVES & STYLI

By Cecil Watts

In Hi-Fi Year Book (1956), the author traced the evolution of the groove from the days of Edison to the latest l.p. (see photos on page 2). Progress has been maintained during the past 12 months. Discs are now pressed with a higher surface finish : and groove formation, which allows a larger magnification to be used (×300), exposing every detail of the recorded trace.

MANY observations and tests made during the past year have shown that quite large changes of wave form often occur on discs even when pickups of comparable specifications are used in conjunction with l.p. records. To obtain a better understanding of these changes, it is interesting to compare three different types of pickup when playing identical waveforms, and to examine the actual groove, for it would be extremely difficult to obtain accurate measurements of these peak accelerations, even with the use of a wave analyser, because they only persist for a fraction of a second.

The accompanying photomicrographs show graphically the different effects on the groove of three well-known types of pickup in the Hi-Fidelity class. For the purpose of these tests they were fitted with new and perfectly polished styli, which had approximately similar frequency responses between 40-15,000 c.p.s., vertical pressures being quoted as 3, 7 and 4 grams respectively.

Sine Waves—and Music !

There is no doubt at all that, on test, each type produced a sine wave response over this range, at these pressures, when tested with the Decca Frequency Test record LXT2695. Type 3, however, required adjustment to 10 grams before it was able to trace the piano note used for the more practical test.

Fig. 1 depicts a section of the 1,000 cycle tone from the frequency disc, the recorded velocity of which is just over 1 cm per second. **Fig. 2** is of a section from a piano note of similar fundamental frequency on Decca LK4170, which is the kind of waveform the pickups would frequently encounter in use. The magnification of the photomicrographs (×300) only allows approximately one complete cycle to be shown, but it is possible to observe every detail of the groove formation, which appears perfectly formed except for a slight roughness left by the cutting stylus along the top edge of the groove walls. Each type of pickup was used to play a new record 20 times, **Figs. 3, 4** and **5** depict the results and I venture to think these will at first be regarded with dismay ; but a closer study reveals that in **Fig. 3** (the 3-gram type) the increased rough appearance at the top of the groove wall is only produced by the stylus pushing up sufficient record material to relieve the pinch effect at this extreme velocity. It has been evenly pushed up from each wall and the original waveform has been preserved.

Change of Direction

It can also be seen that the stylus requires the most effort from the groove when changing direction to the left, as little evidence is apparent that any effort is required to change its direction for the return half cycle. In **Fig. 4** (7-gram type) the stylus indentation is naturally greater, and more disc material has been pushed up ; but the greatest difference is shown in the rate of change in direction, as indicated by the path the stylus has now made for itself. The momentum of the stylus on the steep front of the wave now has to be checked by the opposite wall in order to change its direction for the return half cycle, with the result that these indentations have altered and even increased the rate of change from that of the original waveform.

In **Fig. 5** the still further increased indentation clearly shows the resistance to lateral movement of the stylus which, together with the 10 grams required to ensure tracing the waveform, has literally ploughed out the record material, removing quite a lot of it **(Fig. 6),** providing a path which bears little resemblance to the original trace, although the reproduction from this would still be considered excellent on any speaker.

Figs. 7, 8, 9 and **10** are from a section of the same record, having again a steep wave-front similar to **Fig. 2,** but composed mainly of high frequencies (orchestral strings).

Fig. 7 again shows perfectly formed groove shape when new with evidence of frequencies of 15 Kc/s and even higher.

Fig. 8 illustrates the effect of playing this disc 20 times with the 3-gram type pickup, and except for those waveforms which are obviously too small for the radius of the stylus to follow, little deformation of the groove has occurred.

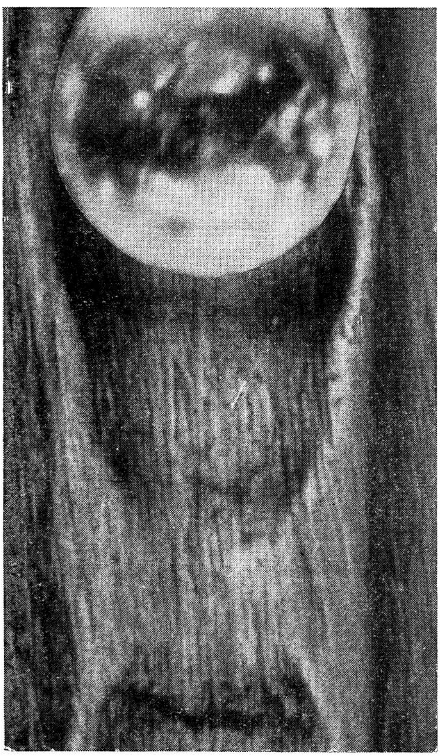
In **Fig. 9** (7-gram type) in the groove section to the left can be seen distinct signs of a change of waveform. On the right-hand wall the momentum of the stylus has produced considerable indentation at each cycle of the main frequency, and this has had the effect of increasing the amplitude and rate of change of these waveforms similar to the previous test with this pickup at the lower frequency **(Fig. 4).**

Fig. 10, in this case the increased pressure has now so attenuated the higher frequencies that only the prominent main frequency is observable. All the finer detail has been obliterated ; but may I repeat—the record still sounds very good indeed.

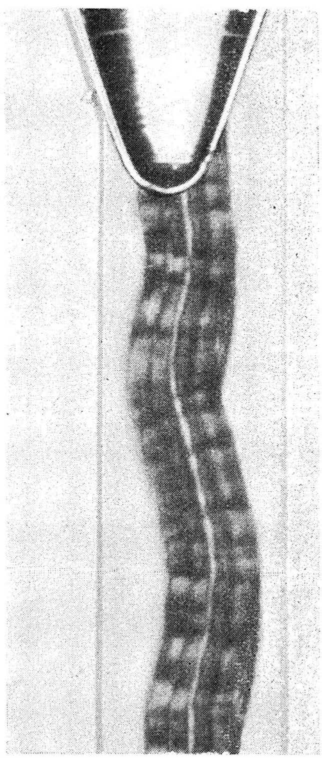
From these tests it is obvious that recording technique is still in advance of all but the most carefully constructed pickups. It also discloses the fact that there is an urgent need for more realistic specification with regard to the lateral stiffness of the armature mass before full confidence can be enjoyed by the users.

Finally, it is certain that once a record has been played with a heavier type pickup, the original waveform will rarely be regained if subsequently played with a lighter type.

FLASHBACK TO THE PICTURES OF HI-FI YEAR BOOK, 1956.



★ *The ball-point sapphire stylus and Hill-and-Dale groove of an Edison cylinder.*



★ *The sapphire stylus and lip groove of 1956. Magnification × 200. Compare this with Figs. 1 & 7.*

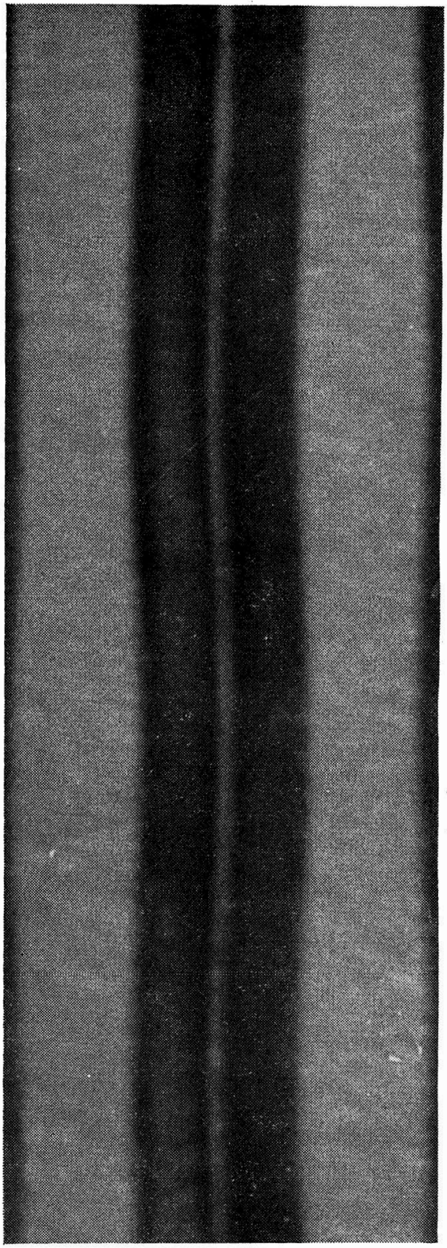


Fig. 1—*This first picture shows a section of a groove on Decca Frequency Test disc LXT*2695. *It is a recorded sine wave at a frequency of* 1,000 *c.p.s. The amplitude is* $\frac{1}{8}$ *in. As will be seen from the next picture, much greater amplitudes occur with musical notes of the same frequency.*

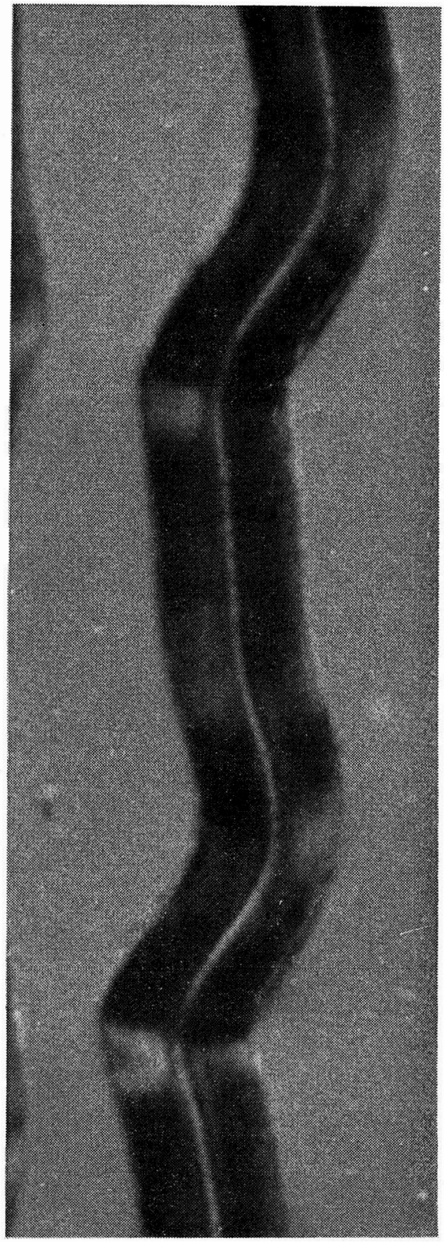


Fig. 2—*Compare this recorded trace of a piano note with the sine wave recording of the previous photomicrograph. Here we have an amplitude of approximately* $\frac{3}{4}$ *in., although the fundamental frequency is about the same* (1,000 *c.p.s.*). *The recording is from a Decca l.p., number LK*4170.

Fig. 3—*Here we see the same groove approximately* (1,000 *c.p.s. fundamental*) *of the same piano note, but the details of the scenery have changed quite considerably. The disc which was fresh from the press in Fig.* 2 *has now been played* 20 *times by a pickup with a downward pressure of* 3 *grams.*

Fig. 4—*Another copy of LK*4170 *from the same master, showing the same (approximate)* 1,000 *c.p.s. piano note. This time the disc has been played* 20 *times with another pickup with a downward stylus pressure of* 7 *grams. The alteration of the groove can be seen quite clearly.*

Fig. 5—*This disc (another copy from the same master), has been played* 20 *times by a* 4-*gram type pickup which required a downward pressure of* 10 *grams before it would track the groove correctly. Readers who are now horrified by the chaos may console themselves by the fact that this scenery is magnified* ×300 !

Fig. 6—*More chaos here ! This picture was taken before cleaning the disc for photography. It is, in fact, Fig.* 5. *The " snow " is ploughed-out disc material. The moral is clearly emphasised—keep them clean ; for whatever is in the groove is bound to colour the sound that emerges from the speaker.*

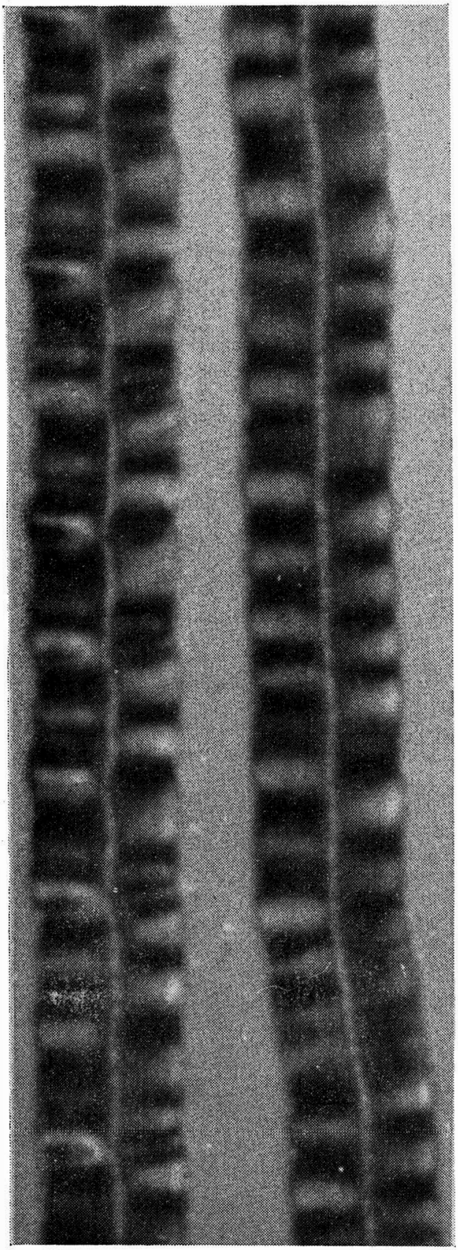


Fig. 7—*This recorded trace is also taken from Decca LK4170, but this time it is the high frequency waveform of the sound of orchestral strings. Readers may well be amazed at the patience and skill of the photographer (Cecil Watts) in producing these extremely practical comparisons from the miles of track.*

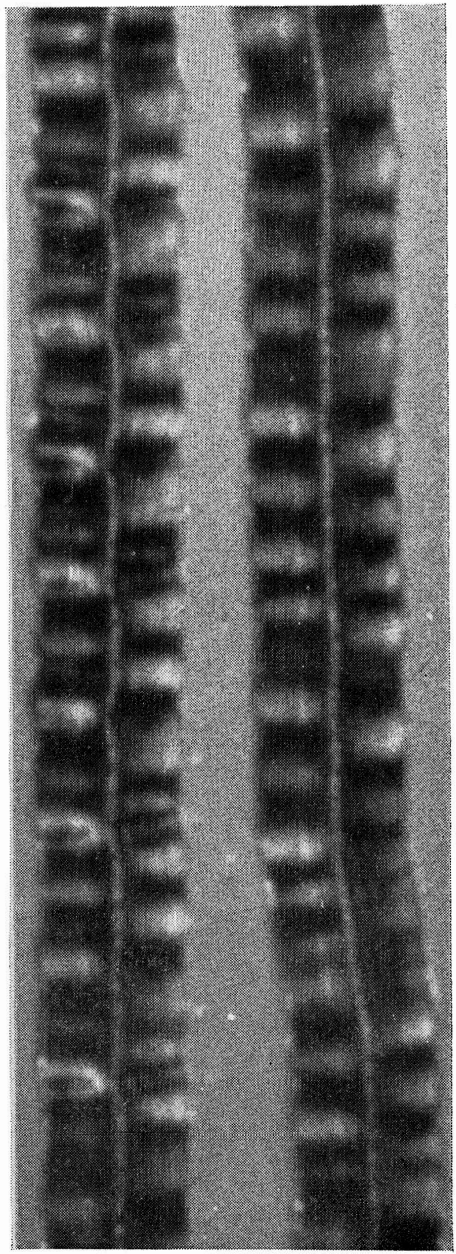


Fig. 8—*The previous photo was of a section of a groove from a factory-fresh and unplayed copy. This picture shows the same orchestral string chord after the disc had been played 20 times with a 3-gram type pickup. Very little change can be detected, even at this magnification.*

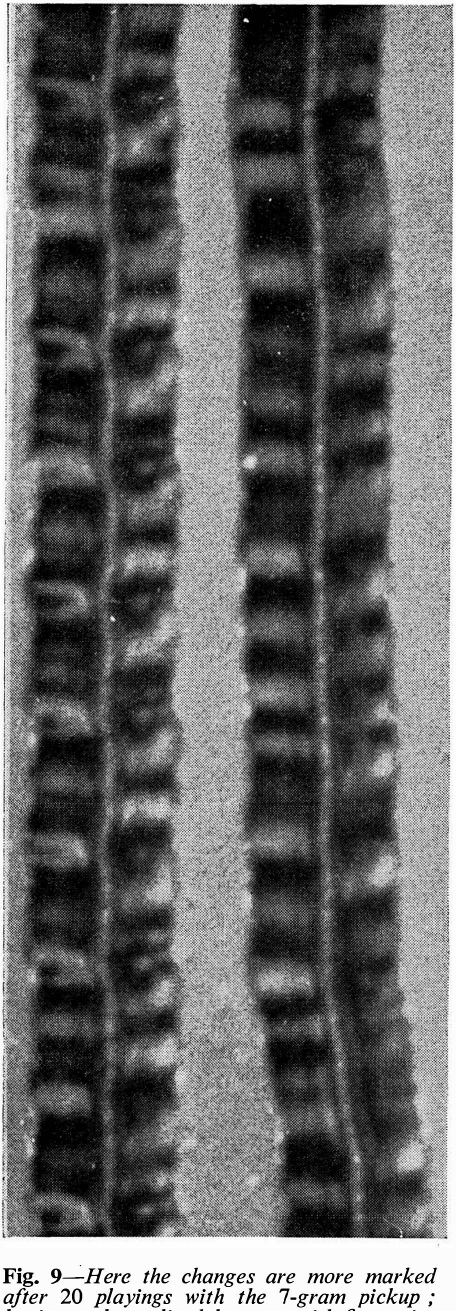


Fig. 9—*Here the changes are more marked after 20 playings with the 7-gram pickup; but it must be realised that even with fine equipment the disc will still sound perfect. These comparisons are meant to show up cause and effect, to indicate lines for future progress—and are not intended to damn good equipment.*

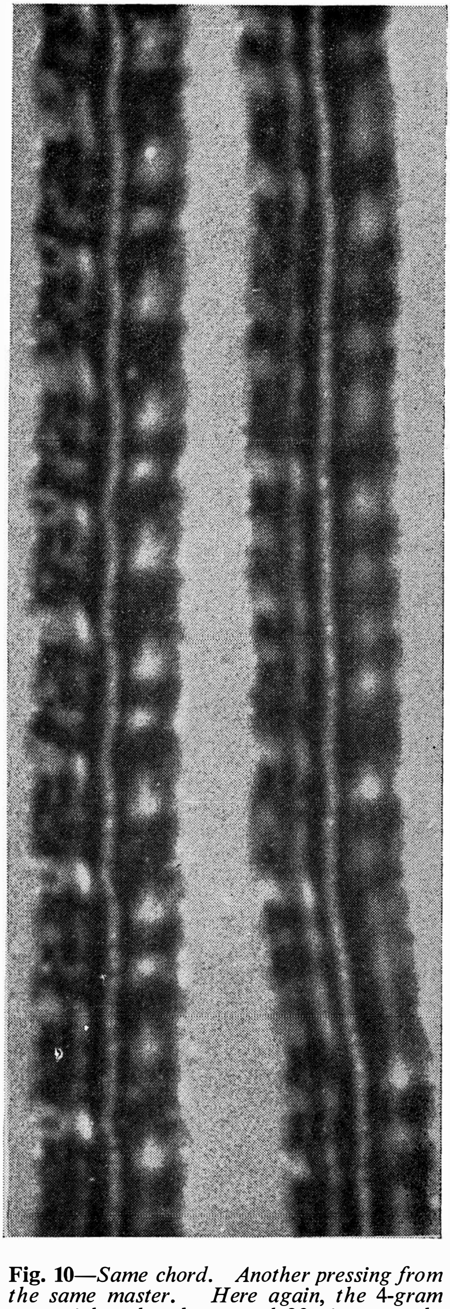


Fig. 10—*Same chord. Another pressing from the same master. Here again, the 4-gram type pickup has been used 20 times at the 10-gram pressure needed to make it track correctly. Though the disc will still sound perfect, the fact remains that the pickup has made itself felt! Disc manufacture is still ahead of pickup design.*

PICKUPS

By Stanley Kelly

THE common cliché that " progress never stops," and its paradox, that " there is nothing new under the sun " crop up almost every other day in the art of record reproduction. Viewing each season in retrospect, with gramophone pickups at least, it is difficult to see what remains to be invented and what really novel ideas have put in an appearance during the past 12 months. Rather, pickup development has been one of steady consolidation over the past 25 years instead of brilliant new stars shining in the firmament, and 1956 has been no exception.

30 Years of Development

It is over 30 years since the first magnetic pickups made their appearance ; 25 years since the first crystal pickup ; almost as long since Voigt developed his famous " long coil " moving coil pickup ; and although present-day products are identical in basic concepts they bear little superficial resemblance to these early efforts. Whilst the Telefunken pickup of 1937 used a sapphire stylus, had an effective armature mass of only 8 milligrams (the resonant frequency was about 16 Kc/s) and tracked the then standard records at 15 grams, it was, like one or two other notable exceptions, born ahead of its time. Only 10 years ago, the " super lightweight " high fidelity pickup of the day tracked at 25 grams and the frequency response extended little beyond 9 Kc/s or 10 Kc/s. Even a year ago, pickups with a genuine response to 15 Kc/s (not obtained by stylus resonance, etc.) especially on vinyl microgroove records were, whatever the advertisers claimed for them, relatively rare birds.

Hi-Fi News has had a number of pickups in for review during the past 12 months, which can claim a genuine 15 Kc/s response on microgroove and 20 Kc/s on coarse groove records. Generally, playing weights have been gradually reduced until now the majority of good hi-fi pickups will comfortably track any record (assuming a correctly designed arm is used, of course) at playing weights less than 5 grams. Stylus resonances in all cases are beyond 15 Kc/s and the compliance is never less than 3.5×10^{-6} cms per dyne.

The Requirements

The specification for a high fidelity gramophone pickup is becoming more and more definite as the months go by. It can safely be said that a maximum effective lateral and vertical dynamic mass referred to the stylus point of less than 5 milligrams is mandatory, and 2 to $2\frac{1}{2}$ milligrams should be the minimum design centre for 1957/58. The lateral compliance should be not less than 3.5×10^{-6} cms per dyne, and preferably between 5 and 6×10^{-6} cms per dyne ; whilst the vertical compliance should be greater than 5×10^{-7} cms per dyne. Stylus dimensions should be 0.0008 in. to 0.001 in. radius for microgroove, and 0.0025 in. to 0.003 in. radius for coarse groove.

The total dynamic mass of the pickup and tone arm in a horizontal direction should be about 30 grams, whilst the total effective mass in a vertical direction should not be substantially greater. The total harmonic distortion (this includes the record, of course) should be less than 2 per cent at all frequencies, and the total intermodulation content should be less than 10 per cent on the maximum modulation band of the JH138 intermodulation test record at the normal playing weight. Any friction in the back pedestal bearing results in side thrust which in turn requires additional playing weight to that required to keep the stylus in the groove, assuming a perfect arm. It goes without saying that this should be minimum, and should certainly be less than the equivalent of 1 gram playing weight, with a design centre of 0.25 gram. (It should be noted that several tone arms checked during the past year required between 2 and 3 additional grams to keep the stylus in the groove.)

From the foregoing requirements it can be shown that a maximum of two degrees of freedom in the mechanical system only can be tolerated ; one resulting in a resonance in the subaudible range, which is due to the total pickup mass and the armature compliance, and the other resonating in the superaudible range, due to the effective mass of the stylus and the record groove compliance. Any other resonances introduced which lie between these two outer frequencies will result in impaired transient response. A survey of all present pickups indicates that only very simple mechanical structures, such as the extreme lightweight needle armature, variable reluctance, or moving coil units, exhibiting only one mode of resonance which is above the upper frequency limit (say 15 Kc/s on microgroove) are suitable for use in high fidelity systems. Any system with multiple resonances, even though these are well damped mechanically, will show inferior transient response.

Rochelle Salt

Although crystal pickups are made in their millions, and rightly have an important part in the economy of the record reproducing industry, there are a number of major features which mitigate against their use in " absolute " high fidelity systems. All extended frequency range cartridges at present available use Rochelle Salt as the active piezo-electric element, and entirely apart from possible deleterious humidity effects, the very marked variation of capacity with temperature means that there can be a considerable variation in response due to this effect, especially at low frequencies, below say 250 c.p.s., unless fed into an extremely high impedance, such as a cathode follower. The majority of the crystal cartridges use as coupling members and crystal supports thermo-plastic materials based on one of the co-polymers of vinylite, these have rather marked temperature coefficient of compliance ; additionally, the crystal itself usually exhibits at least one resonance within the reproduced range ; and even though considerable damping can be and is applied to the crystal, the transient response is bound to suffer because of these relatively uncoupled vibrational modes. Also, because of cross-coupled piezo-electric axes, the crystal element is sensitive to forces in other planes than that applied by the stylus with the result that it can and does perform as an effective seismic generator and this accentuates motor rumble. At present, cartridges using Barium Titanate elements cannot be considered as serious high fidelity transducers because of their extremely low compliance and cut-off frequency.

Where Ammonium Dihydrogen Phosphate is used in place of Rochelle Salt, the anomalies due to humidity and temperature variation of capacity are absent, but against this the dielectric constant of the crystal is very low, resulting in a source capacity of the order of 50 to 100 p.f., and there is an appreciable low frequency cut-off (due to conductance of the crystal) which varies with temperature.

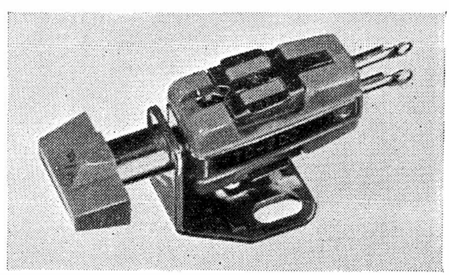
New Products in 1956

Cartridges—(Note : cartridges marked * have been fully reviewed in *Hi-Fi News*).

Four new crystal pickups have been announced, two general purpose units which while not " hi-fi " deserve mention because of their unique constructional details. These are the **EV " Power Point,"*** and Technical Ceramics' **" Sonotone "*** cartridges. Both of these are American developments which are being manufactured under licence in this country. Their main claims to fame are a ceramic element which is completely impervious to moisture (therefore these models are suitable for tropical use), together with unique stylus assemblies. They are of restricted frequency range, cutting off at approximately 9 Kc/s, have an output of the order of approximately 0.125 volts on the microgroove test record LXT 2625, a " corrected " frequency response for microgroove, and a compliance of 10^{-6} cms per dyne.

Cosmocord announce a new crystal pickup, the GP 65-1, with a claimed frequency response " pretty level up to 13 Kc/s " and an output of 0.25 volts at 1 cm. per sec. We have no other details.

Lastly, is a cartridge of Dutch origin, the **Ronette,** well known to most high fidelity fans as the cartridge fitted to the Collaro range of Transcription units. This new



The " Ronette," a cartridge which may soon appear on the British market.

cartridge is characterised with (for a crystal pickup) an extremely low effective mass, actually 1.2 milligrams, with the result that the claimed microgroove frequency response as measured on the RCA Orthophonic test record is flat within ± 3 dB to beyond 20 Kc/s ; the frequencies above 15 Kc/s being obtained by running the record (normally 33⅓ r.p.m.) at 45 r.p.m. The compliance is 3.1 × 10^{-6} cms per dyne, and the intermodulation distortion has the low figure of 4 per cent, when measured on the DDG record No. 68450. Vertical sensitivity is very good at —28 dB, reference the lateral sensitivity, and the output is approximately 160 millivolts per cm per sec. A very nice feature of this cartridge is the ease of replacement of the styli, which are simply clipped into position. This is, we believe, one of the finest crystal cartridges yet produced.

Several new magnetic cartridges have made their debut, and a number of old friends have been materially improved by attention to detail and the usual growth of experience. In the writer's opinion, unless outstandingly new developments take place with other forms of transducer the ultimate in high fidelity pickups lies with this type of cartridge (either moving coil or variable reluctance type).

Connoisseur and Expert

The frequency response of the **Connoisseur "Super Lightweight"*** pickup has been extended, due mainly to the reduction in mass of the armature, which is integral with the stylus (either sapphire or diamond) and suspended on the remote end by a nylon thread.

The **"Expert"** moving coil unit with a frequency range of 40 c/s to 18 Kc/s ± 1 dB and a phenomenally high output of 60 millivolts at 1 cm per sec. for a playing weight of 3 grams, is one of the few pickups which has held its own over a number of years.

In the same category is the **Ortofon type "C."*** This cartridge, which uses a cantilever stylus, has an equivalent stylus mass of less than 2 milligrams and a compliance of the order of 5 × 10^{-6} cms per dyne. When used with its own arm, S212, it is capable of playing all recordings at present available at 3 to 4 grams playing weight. Using the specially designed transformer with a 100,000 ohm secondary load, the output is of the order of 30 millivolts and is flat ± 2 dB 30 c.p.s. to 15 Kc/s on microgroove recordings. It is to be regretted that no British manufacturer has yet placed on the market a moving coil cartridge using a cantilever stylus.

Philips' Novosonic

The Philips laboratory at Eindhoven can always be counted upon to produce original and sometimes startling solutions (but which are always engineeringly sound) on practically every problem they tackle, and their new **"Novosonic"** pickup is no exception. The writer had opportunity of listening to this at the "Firato" in Amsterdam last year, and was extremely impressed by the workmanlike manner in which this unit performed its allotted function. From basic electro-magnetic laws going back to Faraday, a voltage will be generated in a coil if a varying magnetic flux cuts the turns of that coil, and it is fundamentally immaterial whether the coil moves (the moving coil pickup) ; part of the associated magnetic circuit moves (variable reluctance) ; or the magnet moves. In the case of the Philips' cartridge, the latter is their solution. It has one major advantage

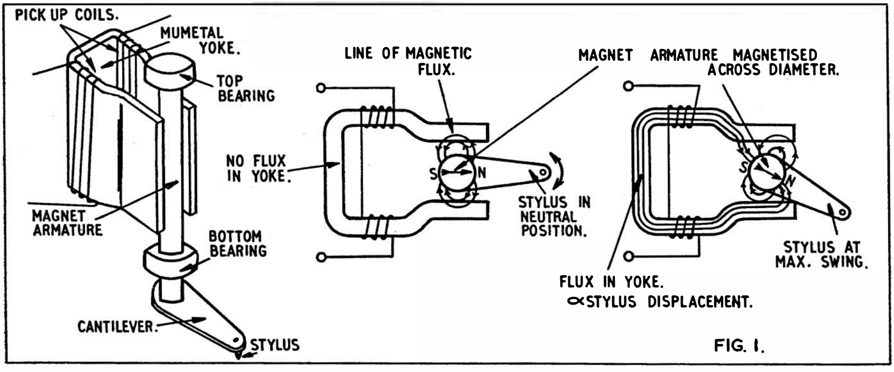


FIG. 1.

The new Philips variable reluctance pickup with the swinging cantilever movement.

over most other magnetic systems, in that the efficiency per unit weight of magnet is considerably higher, principally because a relatively massive static magnetic circuit can be built around it.

As seen from the sketch **(Fig. 1)** the pickup consists of a piece of ferrite magnet material, magnetised across its diameter, and so disposed that at its position of rest virtually no flux flows through the rest of the magnetic circuit. Swinging the cantilever will rotate the magnet, resulting in the flux flowing in either one or other direction and thus inducing an E.M.F. in the pickup coils. Very simple, very elegant, and very effective ! It comes as a plug-in unit, with a diamond stylus only for microgroove records ; frequency response flat ± 2 dB to 15 Kc/s on microgroove, and a playing weight of 3 to 4 grams.

Goldring

The foregoing cartridges are all plug-in type. **Goldring** have made improvements to their well-known type 500,* which has extended the flat frequency response very slightly to 16 Kc/s on microgroove and to beyond 20 Kc/s on coarse groove recordings, whilst the fitting of a Mumetal shield has reduced induced hum troubles to negligible proportions. A new turnover cartridge, known as the Model 600, with a frequency response to 20 Kc/s on both microgroove and coarse groove records, is achieved by using a subminiature cantilever for microgroove (about 0.1 in. long) and a rather longer one for coarse groove records. In this model, the dynamics of both systems have been approximately balanced. The stylus mass on microgroove is 2 milligrams, and 3.5 milligrams on coarse groove records. Compliance, in both cases, is 4.5 to 5×10^{-6} cms per dyne and, when used on the Goldring " Lenco " Transcription arm, the playing weight is 4 grams. Diamond stylus only is fitted for microgroove, and choice of diamond or sapphire for coarse groove.

Garrard

Another new British pickup is the **Garrard** moving coil turnover cartridge, Model GCMC5. This uses two completely separate moving coil elements with stylus rigidly coupled to the coil, the stylus and the coil being mounted on a cantilever in order to give some measure of vertical compliance **(Fig. 2).** The two coils are completely independent and are brought into circuit automatically when the cartridge is rotated for the appropriate stylus point. It is fitted in a Mumetal screening box, and the output from the secondary of the transformer is approximately 8 millivolts per cm per sec. at 0.5 megohms load resistance. The compliance is better than 6×10^{-6} cms per dyne, and the frequency response is flat ± 2 dB to well beyond 15 Kc/s. Diamond styli only are fitted for microgroove, and sapphire for coarse groove records.

The following two cartridges originate from the Continent, but are marketed in this country. The first is the **Elac " Miratwin "***

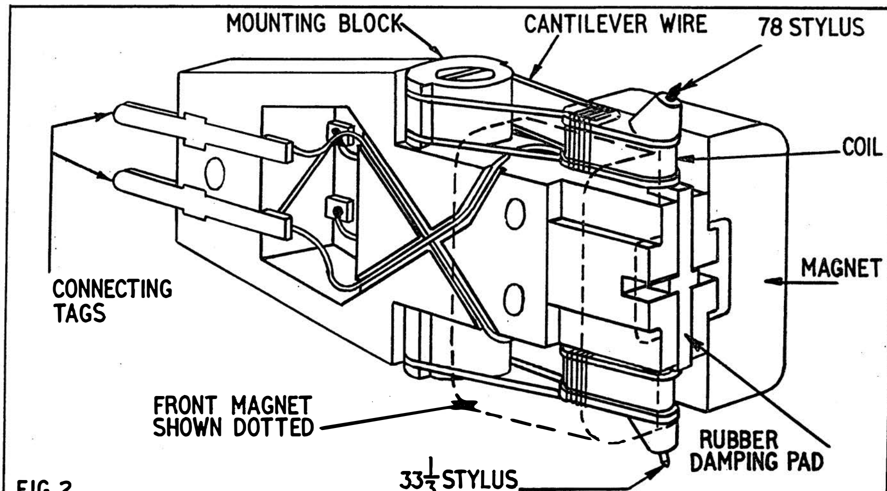
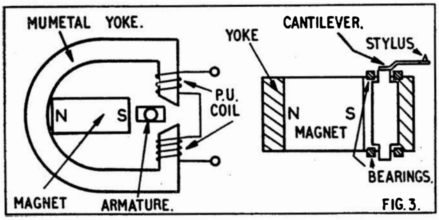


FIG. 2.

The Garrard moving coil turnover cartridge with two separate elements.

(Fig. 3) which is handled by Thermionic Products Ltd. This cartridge, as its name implies, is actually two separate cartridges, arranged back to back on a common turnover mechanism. The compliance is 5×10^{-6} cms per dyne, and the resonant frequency



The Elac Miratwin arrangement.

is of the order of 18 Kc/s to 20 Kc/s. The output is quite high for this type of cartridge, being about 5 millivolts per cm per sec. The units are completely shielded magnetically, and the stylus assembly, which is suspended in a damping medium in a small tube, is replaced as an integral whole. A switch connected to the turnover mechanism selects the appropriate cartridge.

RCA

Finally, RCA are marketing a cartridge embodying the most complex magnetic system we have yet come across **(Fig. 4)**, consisting of no less than eight poles arranged in two banks of four in which the armature, a twisted flat piece of high-permeability material, is used to couple opposing pairs of poles on the two banks. The resultant change of flux is picked up by a coil symmetrically disposed relative to the magnets. Although the system appears and is in effect somewhat complex, the mechanical arrangement is quite simple. The stylus, which is of cantilever construction, is additionally damped by means of a piece of plastic cemented between the free end of the cantilever and the armature cradle assembly, and the whole of this unit is replaced when the stylus is worn. It is available as both a single stylus and a double stylus assembly. In the case of the latter, the two styli are side by

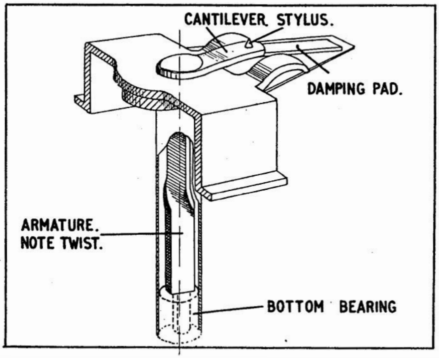


Fig. 4a—*The cantilever stylus arrangement of the RCA pickup. This forms the replaceable unit, and is withdrawn from the cartridge en bloc.*

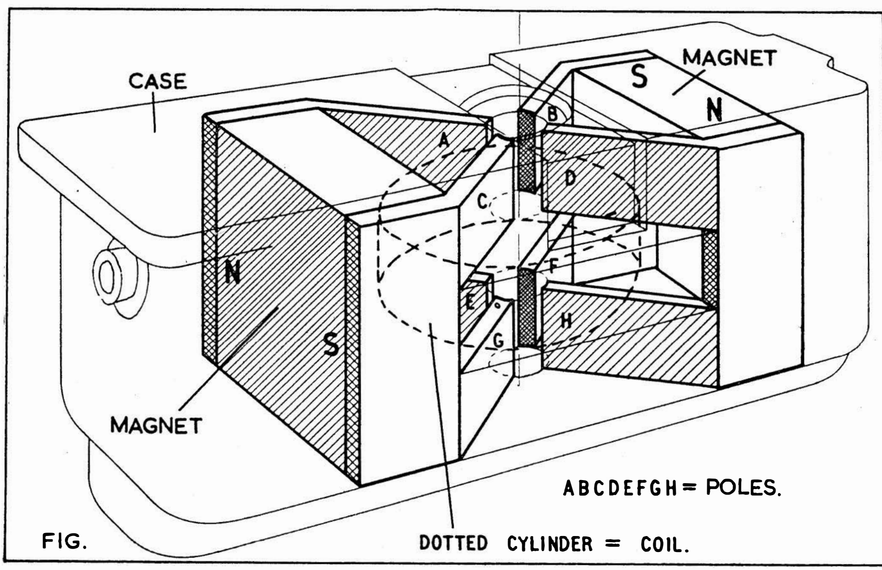


Fig. 4b—*This shows the magnetic system of the RCA cartridge, as described on this page.*

side on the same cantilever, the appropriate stylus being brought into play by rocking the whole cartridge about its main axis. It is claimed that the additional stylus only increases the stylus effective mass (3.5 milligrams for single stylus) by 1 milligram. The lateral compliance is 5×10^{-6} cms per dyne, and the claimed frequency response is 20 to 16,000 c.p.s., $\pm$ 2 dB ; the output is about 30 millivolts per cm per sec. We have not yet had an opportunity of checking this cartridge, but we note that it is the only one listed which requires different playing weights for microgroove and coarse groove recordings. In view of the extremely high compliance we think the playing weights of 5 to 7 grams for microgroove, and 9 to 12 grams for coarse groove, extremely conservative.

New Decca Design

Recent investigation by Decca into the performance of magnetic pickups has led to the introduction of an improved microgroove head. Known as the Mark II H type, the new design has a substantially flat frequency response to 15 Kc/s, coupled with a relatively high output (comparable with that of the original type H, that is 13 millivolts per cm per sec., with 1,600 ohm coil). Developments in armature design have resulted in this performance being obtained with a reduction in intermodulation distortion of some 10 dB.

The Mark II H armature assembly is directly interchangeable with the previous type and will enable users of existing type H pickups to obtain a significant improvement in overall performance. This unit is fitted with sapphire stylus only.

The ribbon pickup has probably the widest frequency response of any commercially produced transducer. It is to be regretted that the only example is no longer being produced. We refer, of course, to the Ferranti ribbon pickup.

Pickup Arms

Two new transcription arms are available for the discriminating experimenter. The **Garrard** Model PA10 transcription arm is now available for general use, and has a number of novel features. The length of the arm is variable from 7½ in. to 9½ in. and at the same time the offset angle of the head can be varied over a wide range, thus enabling optimum tracking conditions to be obtained under almost any circumstance. The height of the pedestal is readily adjustable and the pivot consists of a steel spindle lapped and ground into its bearing, the vertical thrust being by means of a single ball. The primary playing weight adjustment is by means of a watch-type hair spring which can be adjusted by the user, whilst the playing weight is kept approximately constant irrespective of tone arm length by an auxiliary spring, the tension of which is adjusted automatically according to the length of the tone arm. The package contains comprehensive information, templates, and the offset protractor developed by Mr. P. Wilson for measuring tracking error and adjusting the unit for the best conditions.

Goldring TR1

The other tone arm is the **Goldring,** available in two models : TR1 for normal 12-in. records, and the TR2 for 16-in. records. The back pedestal is supported by a pair of precision ball races and the height is adjustable over a range of about 1½ in. No springs are used for counterbalancing, the playing weight can be varied from zero to 15 grams by means of a calibrated sliding weight. The tracking angle is calculated to give minimum distortion at all points of the record, and the unit comes complete with stylus pressure gauge to measure the actual playing weight presented by the pickup point.

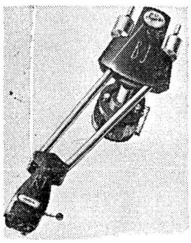
One accessory, designed to eliminate the crashes and bangs when the pickup is placed on the groove by intemperate fingers, is **Thermionic Products' "Microlift."** This is a device which gently lifts or lowers the pickup from the record. Its height is infinitely variable (within limits) and can accommodate all heights of tone arm, and covers the entire radius of a 12-in. record.

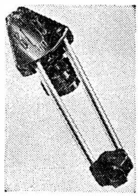
. . . and the "Dust Bug"

Finally, although it is by no means a new product, mention must be made of **Cecil Watts' "Dust Bug."** This device has probably done more to preserve the life of records and stylus points than anything we have yet come across, even including super lightweight pickups !

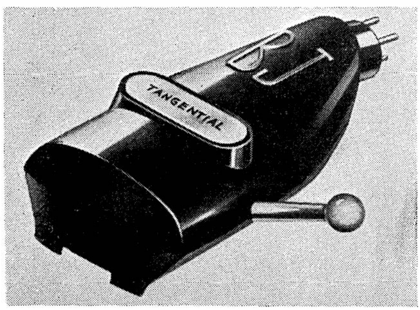
DIRECTORY OF PICKUPS AND ARMS

★ In the abridged specifications of this directory, the following abbreviations are used for economy of space : **S.r.u.**—Stylus can be replaced by user ; **D.p.**—Downward pressure of stylus ; **Cms**—centimetres per second.





B.J. " Super 90 " (left) : Standard (right)



B.J. pickup shell

Burne-Jones & Company Ltd., 62 Sunningdale Road, Cheam, Surrey. Tel. : Fairlands 8866/7.

B.J. C/12. Plug-in crystal head. Low mass cantilever stylus. S.r.u. Output voltages : l.p. $\frac{1}{3}$v ; 78 1v. Range 20, 17,000 c.p.s. D.p. 4-8 grams. High impedance. Price £1 12s. 6d. (U.K. purchase tax 13s.). Diamonds available.

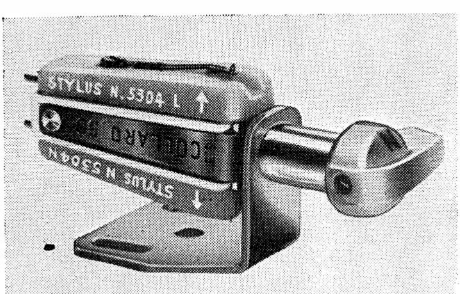
B.J. Tangential pickup arm. This arm overcomes " tracking error." Price £2 4s. 11d. (U.K. purchase tax 18s.).

B.J. Super 90 pickup arm. Two models. 12 in. and 16 in. Price (including two plug-in shells to carry standard cartridges) 90/12 in. £11 11s. (U.K. purchase tax £4 12s. 5d.) ; super 90/16 in. £12 5s. (U.K. purchase tax £4 18s.).

B.J. pickup shell for holding cartridges. Price 17s. 3d. (U.K. purchase tax 6s. 11d.).

★

Collaro transcription arm



Collaro " Studio P " cartridge

Collaro Ltd., Ripple Works, By-pass Road, Barking, Essex. Tel. : Rippleway 5533. Cables : Korllaro. Telex : Barking.

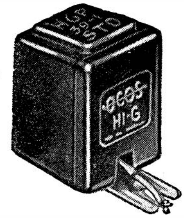
" Studio P " crystal turnover cartridge. Output voltage l.p. 50 mV. Range 50-12,000 c.p.s. D.p. 7.5 grams. Load impedance $\frac{1}{2}$ Megohm. Price, with 2 sapphire styli, £2 10s. (U.K. purchase tax 11s. 7d.).

Studio transcription arm to play up to 16-in. records, suitable for turnover type cartridges. Price complete with " Studio P " cartridge £3 17s. 6d. (U.K. purchase tax £1 9s. 11d.).

★

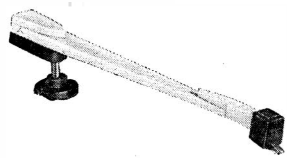
Cosmocord Ltd., Eleanor Cross Road, Waltham Cross, Herts. Tel. : Waltham Cross 5206. Cables : Cosmocord, Waltham Cross.

Acos HGP 39-1. Crystal cartridge head. Output voltage l.p. $\frac{1}{3}$v. Range 40-13,000 c.p.s. D.p. 8 grams. Load impedance 1 Megohm. Price £1 12s. (U.K. purchase tax 12s. 7d.). Diamonds available.



Acos "HGP 39" crystal head

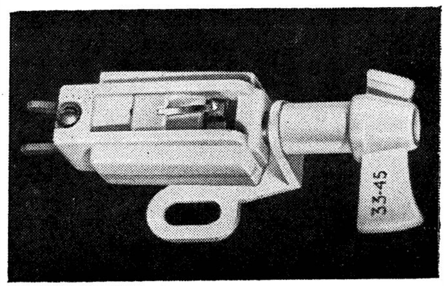
Acos GP20 pickup arm. Designed to accommodate HGP 39-1 heads. Price complete with one head, £2 12s. (U.K. purchase tax £1 0s. 1d.).



Acos "GP20" arm and head

Acos GP 65-1c turnover crystal cartridge cantilever stylus. Output voltages : l.p. 0.2v approx. ; 78 0.75v approx. Range 40-12,000 c.p.s., substantially level. D.p. 7-9 grams. Load impedance 2 Megohm. Price not yet announced. Diamonds available.

Acos transcription pickup. Turnover type. Spec. as for GP 65-1c. Price not yet announced.



Acos "GP 65-3"

★

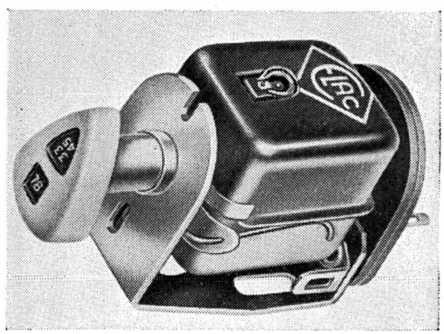
Decca Ltd., 1-3 Brixton Road, London, S.W.9.

Pickup arm, type 13024, to take 3-p.m. plug-in heads. Price on application.

★

Elac. Electroacustic GMBH, Kiel. Distributed by Thermionic Products, Ltd., Hythe, Southampton. Tel. : Hythe 3265/7. Cables : Technico.

Miratwin MST 2. Variable reluctance turnover cartridge. Output voltages at 10 cms : l.p. 55 mV ; 78 45 mV. Range 20-30,000 c.p.s. up to 19,000 c.p.s. ± 2 dB. D.p. 4-6 grams. Load impedance 100,000 ohms. Price, with 2 sapphires, £6 15s. (U.K. purchase tax £2 14s.). Diamonds available, prices on application.

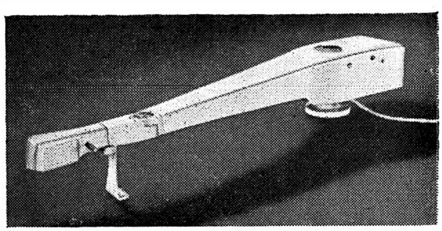


Elac Miratwin MST 2

★

EMI Sales & Service Ltd., and **EMI International Ltd.,** Hayes, Middlesex. Tel. : Southall 2468. Cables : Emiglobe, London.

Model 17 AE. Transcription arm and pickup. Oil-damped unipivot arm, moving armature pickup. Separate plug-in heads. Diamond l.p. stylus, sapphire 78 stylus, both mounted on cantilever assembly. Output voltage 50 mV (at transformer



EMI Model 17 AE

secondary). Range : l.p. 30-14,000 c.p.s. ; 78 30-16,000 c.p.s. D.p. 3-10 grams, adjustable. Load impedance 1 ohm (pickup only), matching transformer secondary impedance 15,000 ohms. Price on application.

★

Expert Gramophones Ltd., " Ingerthorpe," Great North Road, London, N.2. Tel. : Mountview 6875.

Pickup and arm. Hard steel-pointed pivots for vertical and horizontal movements. Adjustments for tracking and stylus pressure. Moving coil pickup head. Also sold as separate plug-in head. Diamond l.p. and 78 stylus, also thorn for 78. Output voltages : l.p. 60 mV ; 78 80 mV (both at transformer secondary). Range 40-18,000 c.p.s. ± 1 dB (diamond stylus). D.p. adjustable down to 3 grams. Load impedance 10 ohms (pickup only), transformer secondary impedance 250,000 ohms. Price, complete with 2 diamonds, £11 5s. (U.K. purchase tax £4 14s. 6d.) ; with diamond l.p. and thorn 78, £9 2s. (U.K. purchase tax £3 16s. 6d.). Plug-in head, diamond £9 (U.K. purchase tax £3 15s. 7d.) ; thorn £7 (U.K. purchase tax £2 18s. 10d.).

★

The Garrard Engineering & Manufacturing Co. Ltd., Newcastle Street, Swindon, Wilts. Tel. : Swindon 5381. Cables : Garrard, Swindon.

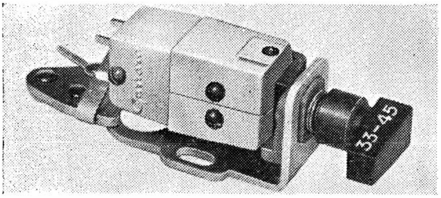
G.M.C.5 turnover moving coil cartridge. Separate coils attached to each stylus. Fitted with diamond l.p. and sapphire 78 styli. Output voltages with TP.1 transformer : l.p. 0.008v ; 78 0.03v. Range 20-16,000 c.p.s. D.p. 5 grams. Load impedance 0.5 Megohm min. across transformer. Price, including transformer, £7 7s. 6d. (U.K. purchase tax £2 17s. 7d.).

TPA 10 transcription pickup arm extendable from 7½ in. to 9½ in. Height of arm and angle of head adjustable. Price £3 15s. (U.K. purchase tax £1 9s. 3d.).

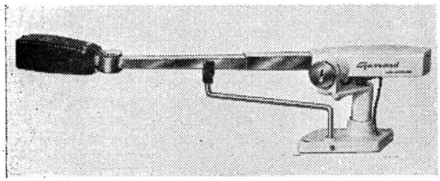
★

Goldring Manufacturing Co. (Great Britain) Ltd., 486/488 High Road, Leytonstone, E.11. Tel. : Leytonstone 8343.

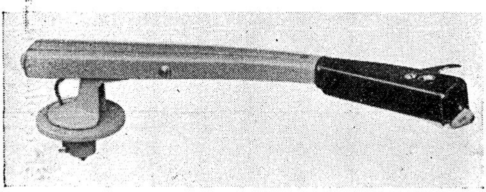
" 500 " variable reluctance turnover cartridge. Output voltages : l.p. 3.2 mV at 1 cms ; 78 10 mV at 3.16 cms. Range substantially flat up to 20,000 c.p.s. D.p. 7 grams. Load impedance 50,000 ohms.



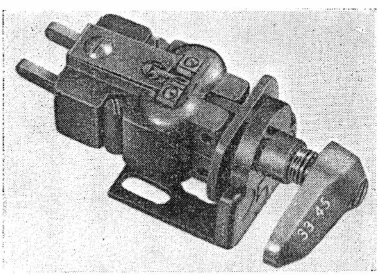
Garrard " G.M.C.5 " cartridge



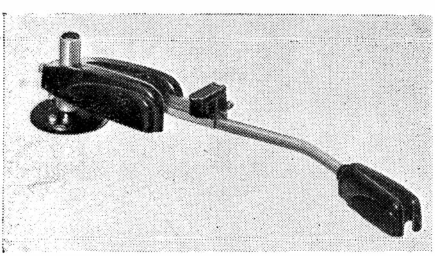
Garrard " TPA10 " pickup arm



Goldring " L.56 " pickup arm



Goldring " 500 " cartridge



Goldring TR.2 pickup arm

Price, with 2 sapphires, £2 10s. (U.K. purchase tax 19s. 6d.). Diamonds available.

L.56 pickup arm with plug-in shell. External stylus pressure control, variable from 4-20 grams, ball races throughout. Price £2 10s. (U.K. purchase tax 19s. 6d.).

TR.1 and **TR.2** transcription pickup arms. TR.1 12 in., TR.2 16 in. Counter-balance weight adjustment from 2-12 grams. Adjustable height, ball races throughout. Price, TR.1, £8 8s. (U.K. purchase tax £3 5s. 6d.) ; TR.2, £9 9s. (U.K. purchase tax £3 13s. 9d.).

★

H. J. Leak & Co. Ltd., 57/59 Brunel Road, East Acton, London, W.3. Tel. : Shepherds Bush 1173. Cables : Sinusoidal, Ealux, London.

Dynamic pickup Mk. II. Moving coil, interchangeable heads, both with diamond stylus. Output voltages : l.p. and 78 8 mV per cms (at transformer secondary). Range 40-20,000 c.p.s. ± 1 dB. D.p. l.p. 3 grams, 78 5 grams. Load impedance 50,000-100,000 ohms. Price, with 2 heads, £16. (U.K. purchase tax £5 19s. 9d.).

★

The Lowther Manufacturing Co., Lowther House, St. Mark's Road, Bromley, Kent. Tel. : Ravensbourne 5225. Cables : Lowther, Bromley.

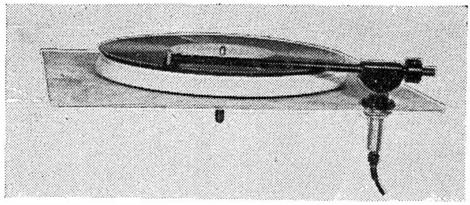
L.P. pickup. Moving coil fixed head. Output voltage 10 mV. Range 20-20,000 c.p.s. ± 2 dB. D.p. 4-6 grams. Load impedance 25 ohms. Price with sapphire stylus £5 10s. (U.K. purchase tax £2 3s. 10d.); with diamond stylus £12 10s. (U.K. purchase tax £4 19s. 9d.).

78 pickup. Moving coil fixed head. Output voltage 18 mV. Range 20-20,000 c.p.s. ± 2 dB. D.p. 6 grams. Load impedance 25 ohms. Price, same as for L.P.

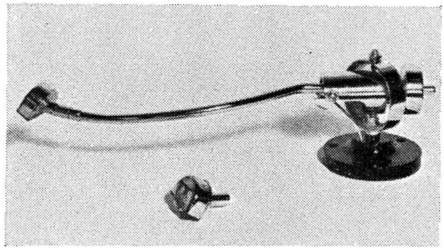
★

M.S.S. Recording Co. Ltd., Poyle Farm, Colnbrook, Bucks. Tel. : Colnbrook 430. Cables : Emessco.

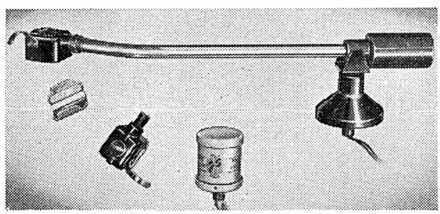
P.100 lightweight pickup. Gimble mounted arm, moving iron head. Output voltages l.p. and 78 1v. Range 50-10,000 c.p.s. (substantially flat). D.p. 5-10 grams. Load impedance, equalised 100,000 ohms. Price, with one head and sapphire stylus, £6 (U.K. purchase tax £2 14s.).



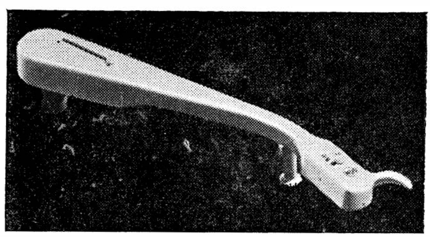
Leak Dynamic arm and head



M.S.S. " P.100 " arm and head



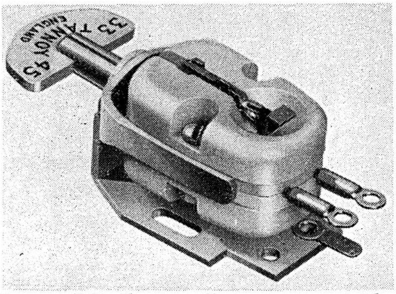
Ortofon pickup head, arm and transformer



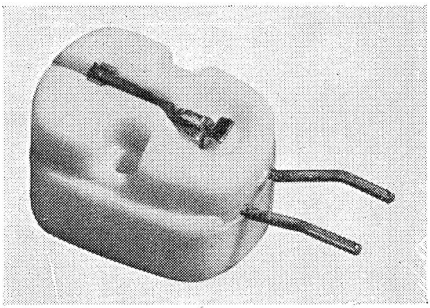
RCA Orthophonic arm

Ortofon, Fonofilm Industri A/S, Copenhagen, Distributed in the U.K. by Goodsell Ltd., 40 Gardner Street, Brighton 1, Sussex, and Rimington Van Wyck Ltd., 42 Cranbourn Street, London, W.C.2.

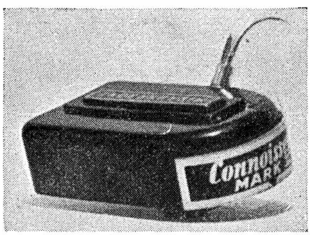
Type A. Moving coil. Exchangeable heads with vertical coils. Diamond-tipped stylus. Output voltage : l.p. 0.5 mV/am/sec. Range 20-20,000 c.p.s. ± 2 dB. D.P. 5-6 grams. Load impedance 2 ohms (transformer required). Equivalent mass at stylus point 4 m.g. Directional force at stylus point 30 m.g. Price £7 15s. (U.K. purchase tax £3 5s. 1d.).



Tannoy "Variluctance" turnover cartridge



Tannoy single stylus "Variluctance" cartridge



Connoisseur MK2 lightweight head

Type C. Moving coil as above. Diamond stylus. Output voltage l.p. 0.3 mV/cm/sec. Range linear 20-20,000 c.p.s. D.P. 305 grams. Load impedance 2 ohms (transformer required). Equivalent mass at stylus point 1.5 m.g. Directional force at stylus point 77 m.g. Price £14 (U.K. purchase tax £5 17s. 7d.).

Transformer for use with above pickups. Price £2 10s. Ortofon pickup arm price £3 15s. (U.K. purchase tax £1 11s. 6d.).

★

RCA Great Britain Ltd., Lincoln Way, Sunbury-on-Thames, Middlesex. Tel. : Sunbury-on-Thames 3101. Cables : Telex and Tex 28608.

Orthophonic 8-pole balanced variable reluctance pickup. Available in two arm lengths. Single or dual sapphire stylus, rocking cartridge. S.r.u. Output voltages : l.p. 100 mV ; 78 200 mV. Range, dual stylus, 20-16,000 c.p.s. ± 20 dB ; single stylus rises to 20,000 c.p.s. D.p. : l.p. 5-7 grams ; 78 9-12 grams. Load impedance 10-100 K/ohms. Price, long arm and dual sapphire stylus, £10 7s. (U.K. purchase tax £4 1s. 5d.) ; short arm dual sapphire stylus £9 11s. 4d. (U.K. purchase tax £3 18s. 4d.) ; short arm single stylus £9 3s. 1d. (U.K. purchase tax £3 15s.). Diamonds available.

★

A. R. Sugden & Co. (Engineering) Ltd., 36 Well Green Lane, Brighouse, Yorkshire. Tel. : Brighouse 2397. Cables : Connoiseur, Brighouse.

Connoisseur super lightweight Mk. II pickup. Interchangeable heads, moving iron. Output voltages : l.p. 15 mV ; 78 25 mV. Range 30-20,000 c.p.s. ± 2 dB. D.p. : l.p. 4 grams ; 78 8 grams. Load impedance 10 K. Price, complete with one head and diamond stylus, £8 19s. (U.K. purchase tax £3 16s. 6d.) ; with sapphire stylus £5 17s. (U.K. purchase tax £2 10s.) ; head only with diamond stylus £6 12s. (U.K. purchase tax £2 16s. 5d.) ; with sapphire stylus £3 10s. (U.K. purchase tax £1 9s. 11d.).

★

Tannoy Products Ltd., West Norwood, London, S.E.27. Tel. : Gipsy Hill 1131. Cables : Tannoy, London.

Variluctance turnover cartridge. S.r.u. Output voltages : l.p. 10-12 mV ; 78 18-20 mV. Range 20-16,000 c.p.s. ± 2 dB. D.p. 5-6 grams. Load impedance 50,000 ohms. Price, with 2 diamonds, £12 (U.K. purchase tax £4 17s.) ; with 1 diamond and 1 sapphire £9 10s. (U.K. purchase tax £3 16s.) ; with 2 sapphires £7 (U.K. purchase tax £2 16s. 2d.).

ACCESSORIES

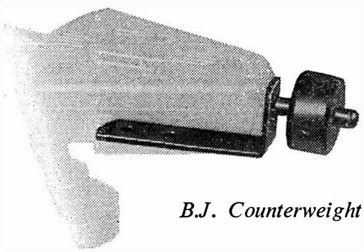
Auriol Products, 63 Shepherds Lane, Guildford, Surrey.

Auriol Pickup Control. This unit eliminates accidental damage to the record by the stylus, the control provides air cushioned lowering and positive vertical lifting and lowering of the stylus. The supporting arm is graduated and provided with three cursors which enable the stylus to be accurately positioned for lowering at pre-selected points. Price £2 3s. 6d. (U.K. purchase tax 19s. 6d.).

Burne-Jones & Co. Ltd., 62 Sunningdale Road, Cheam, Surrey. Tel. : Fairlands 8866/7.

Counterweight Unit. The addition of this weight to a B.J pickup arm permits speed and accuracy in weight compensation. The unit may be attached with or without standard weights supplied, and produces a total point pressure variation of approximately 4 grams. Price 12s. (U.K. purchase tax 4s. 10d.).

B.J/Acos Adaptor. This has been designed to accommodate Acos slide-on heads to the B.J range of arms and those arms using standard 3-pin plug-in head fixing. Price 10s. (U.K. purchase tax 4s.).



B.J. Counterweight

EMI Sales & Service Ltd. and **EMI International Ltd.,** Blyth Road, Hayes, Middx. Tel. : Southall 2468. Cables : Emiservice, Telex, Emiglobe.

Emitex Record Cleaning Cloth. For cleaning vinyl plastic microgroove records. The cloth removes dust from, and lubricates, the grooves, with claimed reduction of surface noise and record wear. It also dissipates electrostatic charges. Each cloth cleans 100 sides. Price 1s. 6d. each.

★

Goldring Manufacturing Co. (Great Britain) Ltd., 486/488 High Road, Leytonstone, E.11. Tel. : Leytonstone 8343.

Anti-static Cleaning Pad. Removes dust from records and is fitted with a detachable brush for keeping stylus clean.

★

The Garrard Engineering & Manfg. Co. Ltd., Newcastle Street, Swindon, Wilts. Tel. : Swindon 5381. Cables : Garrard, Swindon.

S.P.G.1. Stylus pressure gauge. A simple and accurate instrument which enables the stylus pressure of a pickup to be checked. Price 11s. 9d. (U.K. purchase tax 4s. 7d.).

S.P.G.2. Stylus pressure gauge, as type S.P.G.1, but also includes a spirit level for checking the level of the turntable. Price 18s. 9d. (U.K. purchase tax 7s. 4d.).

★

Sound Sales Ltd., Works & Acoustic Laboratories, West Street, Farnham, Surrey, England. Tel. : Farnham 6461-2-3. Cables : Sounsense.

Pickup Matching Unit. Types A and C. A resistor/capitance network to facilitate suitable matching of crystal pickups. Available for Collaro and Acos range. Metal screened assembly provided with terminals for connection of pickup and screened lead for output. Size $1\frac{1}{4}$ in. cube. Price 10s. 6d.

★

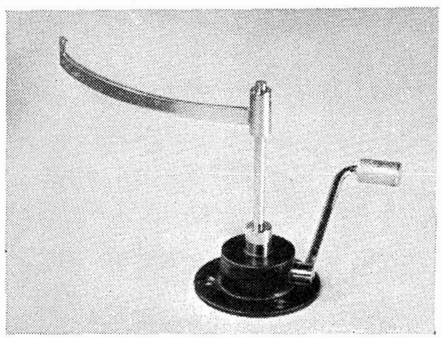
Thermionic Products Ltd., Hythe, Southampton. Tel. : Hythe 3265/7. Cables : Technico.

Microlift. A device for raising and lowering a manual pickup arm at any point on the record for minimising risk of damage either to record or stylus through handshake. Easy to fit to any back-pivoted pickup. It does not hinder record handling by overlapping the turntable. Price 21s. (U.K. purchase tax 8s. 10d.).

★

Cecil E. Watts, Darby House, Sunbury-on-Thames, Middx.

The " Dust Bug." Claimed to be the most efficient method of removing all static and dust from records as they are played. Instantly fitted, suitable for all types of records. Record quality is improved, surface noise and wear reduced. Price 17s. 6d. (U.K. purchase tax 7s.).



Thermionic " Microlift "

AMPLIFIERS
AND
PREAMPLIFIERS

By George Tillett

CONSIDERABLE thought and much ingenuity has gone into amplifier design in the last few years, and it is now generally agreed that there really is very little more that the designer can do (however ingenious he may be) to improve upon frequency response, power output with freedom from harmonic and intermodulation distortion. However, in terms of watts-output versus watts-consumed from the supply mains, the modern amplifier is still comparatively inefficient (as are even the best domestic speaker systems). Perhaps the question of stability has not always received the attention it deserves, but by and large it seems to me that much more scope for improvement lies with the pre-amplifier or control unit.

Take tone controls for instance. Are we really sure that a bass control operating from 1,000 c/s is the most satisfactory compromise ? The Baxandall circuit with its movable " hinge " is a great improvement, but it is possible that a bass control operating from 300 c/s, or even lower, might be even better—especially when listening at low volume levels. Then there is the question of pickup matching. Some otherwise excellent amplifiers leave much to be desired in this respect. If the owner decides to invest in a new pickup—always a possibility—he has to remove the control unit, take the cover off (probably losing some of the incredibly small screws in the process) and then change the load resistor with the aid of a soldering iron !

Much of the criticism levelled at British amplifiers (not all of course) regarding styling and presentation is fortunately no longer justified, but there is no doubt that although we led the world in the electronic design, we very definitely lagged behind the Americans in what may be called " eye appeal."

The trend towards higher power outputs has continued during the past year with amplifiers from Beam-Echo, Connoisseur

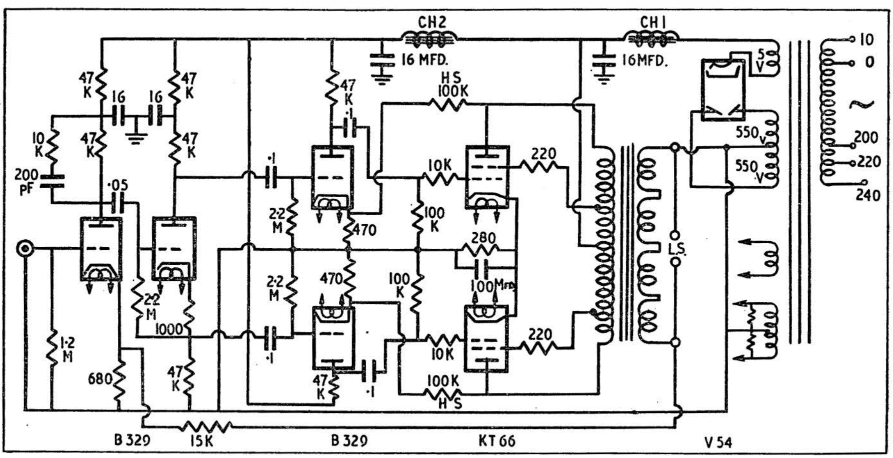


Fig. 1—*The circuit of the Cape V.L.1—basically a Williamson design, but with a difference.*

and Cape giving outputs of 25 watts or more, whilst Armstrong, Rogers and Decca are releasing larger amplifiers in the near future. There is news from Leak, too. The famous " Point One " T.L.12 has been redesigned, and now has a 25-watt Ultra-Linear output stage. A 50-watt amplifier is also planned, and this will use the new G.E.C. K.T.88 valves which are similar to the well-known American 6550 tubes.

New Circuitry

Before considering the question of power output, let us take a look at the design of some of the newer amplifiers. One of the most interesting of these reviewed during the past year was undoubtedly the Cape V.L.1, the circuit of which is given in **Fig. 1.** This is basically a Williamson design—but a Williamson with a difference. Note the Ultra-Linear output stage—the two extra feed-back loops taken from the anodes to the driver stage, and note also that C.H.1 is a " swinging " choke. That is why the mains transformer is rated at 550-O-550 volts.

Regulated H.T.

This form of regulated H.T. supply is frequently used in large amplifiers having pentode or Class " B " output stages, but as far as I know the Cape is the only amplifier using it in conjunction with an Ultra-Linear output stage. One of the advantages of an Ultra-Linear output stage is that its peak current variations are much less than triode or pentode stages, but the use of a regulated supply does in this instance contribute to the unusually smooth overload curve, shown in **Fig. 2.** (For the benefit of American

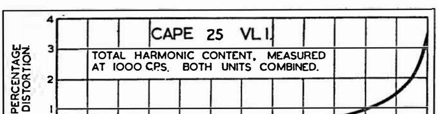


Fig. 2—*Harmonic distortion curve of the " Cape " measured at* 1,000 *c.p.s.*

readers who are accustomed to inter-modulation distortion curves, in this case 0.5 per cent. total harmonic distortion corresponds to about 1.5 per cent. I.M.). The valves used are G.E.C., types No. B329, which are equivalent to Mullard ECC82 and American 12AU7.

Both the other two newcomers mentioned —the Beam-Echo and the Connoisseur HQ 20—use similar circuitry to the Mullard

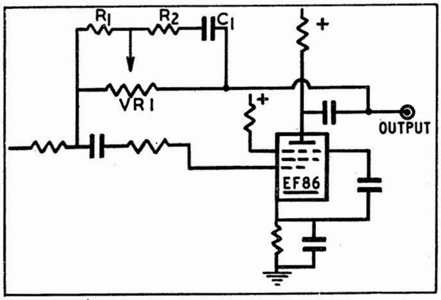


Fig. 3—*A loudness control in the Mullard circuit.* (*Beam-Echo*)

520 ; that is, an E.L34 Ultra-Linear output stage preceded by a cathode coupled phase splitter, and a directly coupled high gain pentode—although this is triode-connected in the Connoisseur. The Beam-Echo is unusual, at least as far as British amplifiers are concerned, in having a " loudness " control. This is intended to lift the bass response when listening at low volume levels.

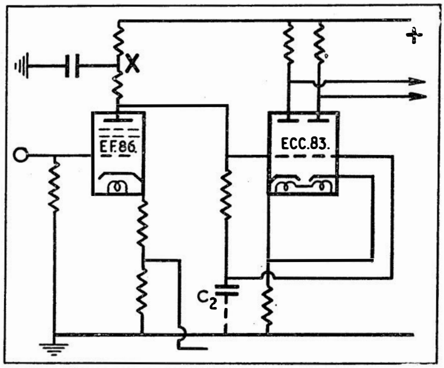


Fig. 4—*From Lowther—a novel phase splitter idea*

(See also page 24). How this feature is incorporated in the Mullard circuit is shown in **Fig. 3.** The normal resistive loop around V3 is replaced by the network R_1, R_2, C_1, and the control VRI. It is immediately apparent that if the slider of VRI is moved to the right the loop is resistive, and frequency selection occurs progressively as the slider is moved to the left. This amplifier also makes provision for crystal pickups and both high and low level magnetic types.

This brings me to the new Decca 25, an amplifier due for release later in 1957, which has a rather unusual matching arrangement. Briefly, this consists of two pre-set controls, one calibrated 0 to 10 and the other A to G, forming the matching or load resistor and the attenuator respectively. Thus any type of pickup whether high impedance or low impedance, and high output or low output, can be quickly and accurately matched.

Phase-splitting

A neat idea used in the new Lowther L.L.10 is shown in **Fig. 4.** As can be seen this is a normal cathode coupled phase splitter, as used by many amplifiers today, but here the condenser from the grid of V2 is not returned to earth as shown by the dotted line, but is taken to the H.T. line at the point X. This still leaves the grid at earth potential as regards the signal, but introduces a reverse hum voltage, tending to cancel any hum that may be present.

Stability

The new Rogers senior has a unique circuit using two ECC83 double triodes in a cascade arrangement. The main feedback loop is connected to the input grid instead of to the cathode, and its constants plus those of the output transformer (which uses grain oriented strip material) are such that the amplifier is claimed to be unconditionally stable. No coupling condensers are used, and consequently the amplifier operates down to D.C. Peak power is stated to be 28 watts with at least 15 watts r.m.s. of power output from 30 c/s to 30,000 c/s.

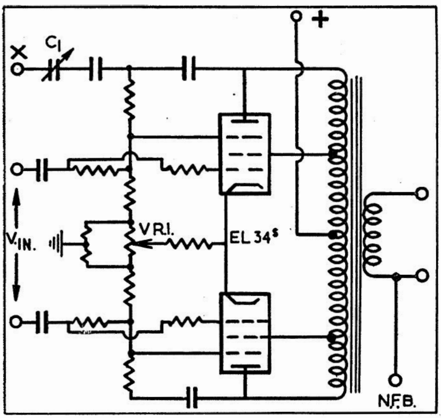


Fig. 5—*The "ultra ultra-linear" Lowther output stage.*

The Lowther L.L.16 has a number of interesting features. The output stage which might be described as beyond Ultra-Linear or Ultra Ultra-Linear is shown in **Fig. 5.** By the inclusion of the suppressor grids in a feedback network, an improvement in linearity is claimed. Note also that the cathodes are not by-passed, and that a current balancing control (VRI) is fitted. The pre-set condenser C1 is taken to the grid of the phase splitter and forms part of an ultra-sonic feed-back loop. This is adjusted at the factory for optimum square wave response which, incidentally, is stated to be maintained up to 30,000 c/s.

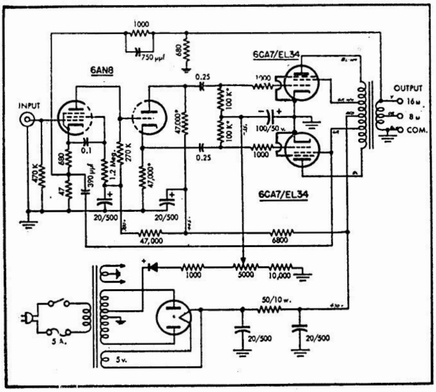


Fig. 6—*The American "Dynawatt" circuit.*

Finally, there is news of a kit amplifier —a 50-watt model at that! This is the American "Dynawatt" and it will be made and distributed in this country by the Lowther Company from about September, 1957. Designed by David Hafler of Ultra-Linear fame (will he ever live it down ?), it incorporates one or two interesting features. The valves are not operated in the conventional Ultra-Linear circuit, as it appears at first sight (see **Fig. 6**), but are operated in Class ABI with 10 per cent screen tappings and separate bias supply. A triode-pentode is used for the first stage, the triode functioning as an anode-cathode phase splitter, and being directly coupled to the pentode section. In addition to the normal feed-back loop, a second capacitive loop is taken from the screen of one of the output valves to provide some phase compensation at high frequencies. This is stated to overcome the fundamental unbalance at high frequencies inherent with this type of phase splitter, due to the unequal impedances of the anode and cathode circuits. Home construction is considerably simplified for the novice by the use of printed circuit techniques.

How Many Watts ?

The question of how much power is needed for realistic reproduction in the home is a very difficult one to answer. Hi-Fi experts differ about most things, but never more violently than about this subject. Here are some answers—graded in order of wattage !

P. Baxandall : " Five watts is sufficient for high quality reproduction in the average living room."—*Wireless World*, March, 1957.

P. Wilson : " If you have a small room, 120-180 sq. feet by 10 feet high, then a 10-watt amplifier is sufficient. If you have a room, say 20 by 15 feet, you could effectively use an amplifier of 20 watts or more."—*Gramophone Handbook*, pps. 167-168.

G. Briggs : " The indication is that a 10 to 15-watt amplifier (British rating) is adequate for home use, using a speaker of average efficiency."—*High Fidelity, the How and Why for Amateurs*, p. 57.

D. Hafler : " The required power for realistic reproduction is in excess of 30 watts, unless speakers of very high efficiency are used."—*Radio and Television News*, June, 1956, p. 61.

Audio : (Equipment report) : " . . . with 50 watts available there is a definite difference in the way the system handles music peaks, and a direct comparison between this unit and a 5-watt unit, for example, will indicate that oftentimes the distortion we attribute to pickup, record, or what-not, might better be attributed to the amplifier."—*Audio*, September, 1956, p. 54.

E. D. Nunn : (Audiophile Records Co., U.S.A.)—" 180 watts are required for a room 41 by 28 feet."

R. Greiner : (University of Wisconsin)—" 100 to 200 watts are required for a room of the above size." (41 by 28 ft.)

It should be pointed out that the room referred to is somewhat larger than the average living-room—at least in this country ; also the references may be to peak watts rather than r.m.s. watts. However, before coming to the conclusion (and I quote G. Briggs) that " The Americans like to use bigger amplifiers than we do," there are two more factors to consider. (1) speaker efficiency, and (2) amplifier ratings. It must not be forgotten that 10 watts fed into speaker A will produce the same amount of noise as 20 watts fed into speaker B, which has a sensitivity only 3 dB lower. And speaker systems vary in efficiency between 3 per cent or less to over 25 per cent for some types using horn loading.

American Watts=British Watts !

American watts are no different from British watts, as is commonly supposed, but it is true that amplifiers sold here as 25-watt models make their appearance on the American scene as 35-watt models. They do not miraculously acquire another 10 watts on their journey across the Atlantic, and the explanation lies in the different method of amplifier power rating. For instance, the Mullard 520 is called a 20-watt amplifier, yet it is capable of delivering a maximum of power in excess of 35 watts r.m.s., and it would be so described in America. This figure can be almost doubled by calling it the " Instantaneous Peak Power." The fact that this is sometimes used underlines the point that in this country we are much more conservative ; indeed, amplifiers rated at over 20 watts are looked upon with grave suspicion and have to be suitably disguised by calling them 12-watt models !

Hi-Fi Requirements

So, how much power output is really necessary ? In the Hi-Fi Year Book for 1956 I said : " Ample power must be available in order to handle peak transient power without distortion. Assuming a speaker system of average efficiency (5 per cent), the normal power used under domestic conditions would be of the order of 250 to 350 milliwatts ; but to handle peak transient power with an adequate factor of safety, an amplifier rated at 10 watts must be used. If the listener is fortunate enough to have a large room (and tolerant neighbours), or an inefficient speaker system, then it would be advisable to specify a larger reserve of power —say 20 to 25 watts." I can think of nothing to add to that statement now. Except to point out that the definition " 10 or 25-watt amplifier " means what it says. It means that these powers are available, as stated, throughout the whole audio range, and not just from a small portion of the spectrum.

The power response of an amplifier is not necessarily identical with its frequency response ; in other words, the response of an amplifier might be a beautiful straight line from 20 to 20,000 c/s at 1 watt output, but

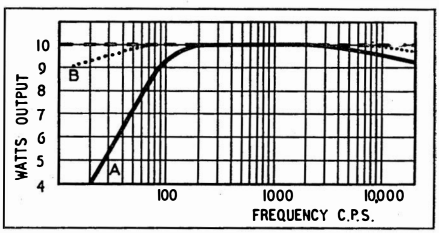


Fig. 7—*Amplifier power response curves*

at its rated power of 10 watts it may take the form shown as A in **Fig. 7.** Note that here the power available at 50 c/s is only 7 watts, and is down to 5 watts at 30 c/s. If frequencies of this order were not prevented from reaching the output stage, serious intermodulation distortion would occur although the notes themselves might be inaudible. Response curves of this nature are usually indicative of transformer core saturation, and are mostly confined to the cheaper type of amplifier. A more typical curve is represented by B, showing only a small power loss at the lower frequencies. As far as the high frequencies are concerned, some power losses can be tolerated, for apart from the cymbals, most musical instruments generate little power above about 5,000 c/s.

Another controversy, still raging among experts, concerns the use of the so-called " loudness " control, the purpose of which is to increase bass at low listening levels, and thus to restore the balance which is lost due to the fundamental non-linearity of the human ear. Most readers are no doubt familiar with the Fletcher-Munson curves illustrated in **Fig. 8.** These curves, known as equal loudness curves, demonstrate the relative intensities needed at various frequencies to produce sounds of the same *apparent* loudness as a reference note of 1,000 c/s. A number of intensity levels are given and it is quite easy to see that much greater intensities are needed for the low frequencies at low loudness levels. Note also that the curves are *relative* and that they are almost parallel above 2,000 c/s.

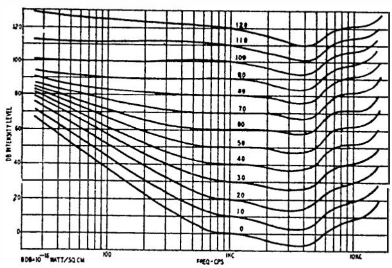


Fig. 8—*The Fletcher-Munson curves*

Wanted—a " Distance " Control

Now the advocates of a loudness control have an argument which goes something like this : assuming a symphony orchestra produces an intensity of 90 phons, and we wish to reproduce this at a level of say 70 phons, all we have to do in order to restore balance is to adjust the loudness control on our

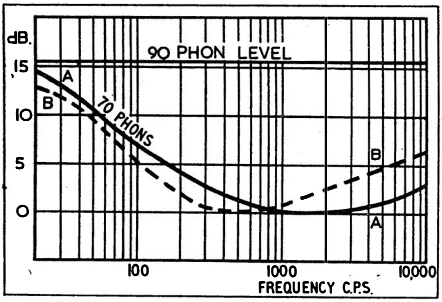


Fig. 9—*Relative level curves*

amplifier ; this will apply a compensation curve based on the difference between the 90 phon and 70 phon curves, as shown at A in **Fig. 9.** Very neat and logical. But there are in fact a number of snags :

1. The dynamic range is considerably compressed for recording purposes and varies from record to record. Compression is also used by broadcasting stations—the dynamic range of the F.M. stations being much greater than that of the A.M. transmitters in the medium and long wave bands.

2. Studio acoustics and recording characteristics are also variable factors, making it almost impossible to design a compensating control effective under all conditions.

So we see that, however carefully a control is " tailored " to the approved Fletcher-Munson specifications, the results are bound to be a compromise. Furthermore the original Fletcher-Munson experiments were carried out using pure sine waves, and since only audio engineers derive any degree of satisfaction from listening to sine waves it is pertinent to ask whether these findings can be applied to the reproduction of music. It has been stated that the ear does not judge the loudness of wide-band noises in the same way that it estimates the loudness of pure tones.[1] It is also known that the harmonic

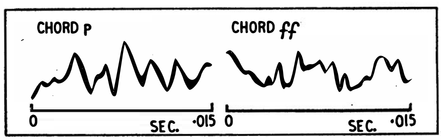


Fig. 10—*Oscillogram of piano chord struck with different degrees of loudness (C major chord at middle C). The vertical scale of the* **ff** *curve is 3½ times that of the* **p** *curve. Note increase in harmonics at* **ff** *(from " Sound Reproduction," by G. Briggs, page* 187)

1 A. J. King, An objective noise-meter calibrated in phons—*Journ. I.E.E.*, 88 part 2, 1941.

structure of most musical instruments change according to the level at which they are played **(Fig. 10).** Thus there is some justification in the charge that loudness controls employ the wrong technique ; because they try to reproduce an orchestra, as it would be heard at a distance, with the same frequency balance at which it would be heard close at hand. It is obvious that what is really required is a form of compensation that will give the effect of distance—in other words, when we are listening to music reproduced at a low loudness level we want to create the illusion that we are listening to an orchestra playing some distance away. A loudness control based on the Fletcher-Munson curves cannot do this ; but some experiments carried out by the writer at the Decca laboratories indicate that a compensation curve similar to B in **Fig. 9** gives more acceptable results, under some conditions, than either curve A or no compensation at all. Much research is needed concerning this problem, but it is considered that a single loudness control (or perhaps more logically a " quietness " control), however elaborate, can only be a supplement to the normal bass and treble controls. Most experts in this country, including Gilbert Briggs and Percy Wilson, do in fact advocate the use of the normal tone controls for compensation purposes, and in a recent letter to the *Wireless World* the latter suggested that they should be adjusted to suit the womenfolk. I prefer not to comment on this !

Electrostatics and Amplifiers, etc.

It is too early to say whether the advent of the full-range electrostatic speaker will

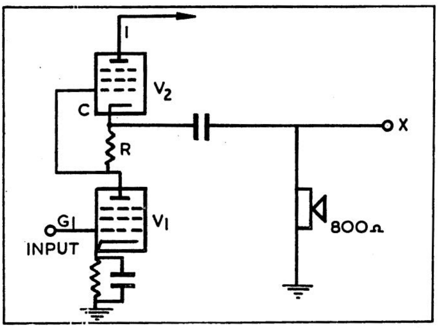


Fig. 11—*Philips' single-end push-pull circuit*

materially affect amplifier design. It is possible that more designers will be forced to adopt the tertiary feedback winding on the output transformer as being the best way of ensuring unconditional stability. This method is considered standard practice by the BBC, but at the present time very few manufacturers appear to think the extra expense justified.

On the subject of output transformers, any proposal to simplify or dispense with them altogether is likely to appeal to most designers, and it is for this reason that the single-ended push-pull output stage is now receiving considerable attention. **Fig. 11** shows a typical arrangement developed by Philips at Eindhoven, and used successfully on the Continent. The two output valves are in effect connected in series, and the current through the speaker is the sum of the current of both valves. The A.C. voltage for the control grid of V2 is obtained, without a phase inverter valve, by connecting this grid to the anode of valve V1, and thus

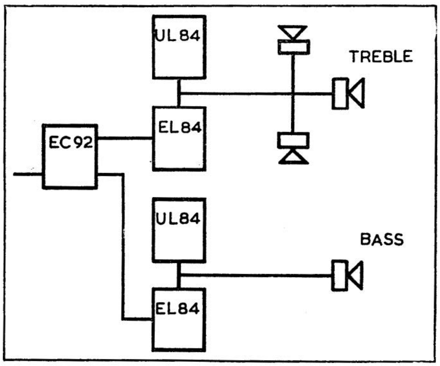


Fig. 12—*Twin channel version of single-ended push-pull output stage*

making use of the voltage drop at the resistor. Negative feedback can be taken from the point C or from the speaker side of the blocking condenser, which prevents D.C. flowing through the speech coil. This is important, because the speech coil impedance is of the order of 800 ohms necessary for correct matching with this circuit. The speaker design has indeed posed some serious problems. An American amplifier using a similar circuit was forced to use as much as 30 dB treble lift in order to compensate for the high frequency losses of the speaker !

A Solution from Philips

Philips appear to have solved these problems, and it is interesting to note that the diameter of the wire used for the speech coil of the special speakers is between 40 and 50 μ—in other words 4 to 6 times smaller than the wire used on more conventional low impedance speakers. Two such single-end stages connected in parallel are used on a 12-watt Philips High " Z " amplifier to be released shortly. **Fig. 12** shows another arrangement used in Germany, this circuit has two channels—one for bass and the other for treble. Larger valves are being developed for the single-end circuit, and even if an output transformer is used to avoid the complications of high impedance speakers, the saving on cost possible with this item might be considerable. Somewhat similar circuits are successfully used by a number of American amplifiers, including the National " Horizon."

The Electro-Voice amplifier like the, National, uses an output transformer ; but here it is used in a balanced bridge circuit, thus simplifying the design as no D.C. current flows through its windings. This configuration has the added advantage of being eminently suitable for Class AB^2 operation, for it does not give rise to the type of distortion referred to as switching transient distortion which is inherent with conventional AB^2 circuits.

Transistors

It is possible that we may see more transistors used in Hi-Fi equipment in the coming year. As readers of *Hi-Fi News* are aware, completely transistorised amplifiers have been successfully demonstrated by both Mullard and G.E.C., but initially their main application will be in pre-amplifiers for tape, microphones, or low output pickups, where their freedom from hum and microphony can be used to advantage. Due to be released shortly by the Lowther Company are three such units having gains from 45 to 100. An extremely good signal to noise ratio is claimed, and the circuit patented under the name Lowther-Murray. These units are quite small, being about 6 in. × 3 in. × 3 in., and the largest model has switched equalisation for tape and records. Incidentally, the input impedance of these preamplifiers can be as high as 50,000 ohms, which means that they can be used successfully with the Collaro tape transcriptor or with low output variable reluctance type pickups. Transistors can also be used as relaxation oscillators to generate the E.H.T. voltage necessary for cathode ray tubes, and it is possible in the future they may be used in similar circuits to provide the high polarising voltage required by electrostatic speakers. The basic requirements of a High-Fidelity amplifier were very fully dealt with in the Year Book for 1956 and can be briefly summarised as follows :

Amplifier Requirements

1. Low harmonic and intermodulation distortion. **2.** Linear frequency response. **3.** Good transient response. **4.** Adequate power output. **5.** Low output resistance. **6.** Low hum and noise level. **7.** Efficient tone controls and filter system. **8.** Reasonable versatile equalising and pickup matching facilities. **9.** Stability under all practical conditions.

Maximum Distortion—0.2%

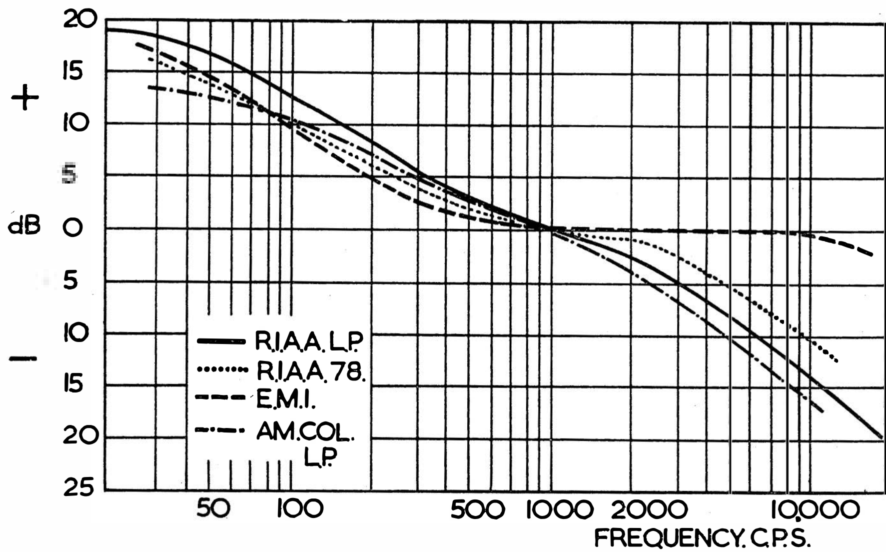
The distortion of an amplifier should not exceed 0.2 per cent. total harmonic content and intermodulation (S.M.P.T.E. standard) of more than 1 per cent at the rated output. The frequency response should be sensibly linear—say within 2 dB from 30 to 20,000 c/s, and the power output should be substantially maintained throughout that range. As mentioned before, if the power output falls appreciably at the low frequency end, a high-pass filter must be fitted. The output resistance should be not more than one fifteenth of the nominal output impedance—that is, 1 ohm for a nominal impedance of 15 ohms, thus giving a damping factor of 15. Increasing this factor to 40 or 50 will give very little noticeable improvement, and this fact has led some authorities to take the view that an adequate damping factor and low distortion can be achieved using modern valves and circuitry with a feedback loop of 14 dB or less. This would be true if the 14 dB was effectively applied throughout the whole frequency range, but in practice (mainly due to transformer deficiencies) the loop gain of an amplifier falls at each end of the scale, thus the feedback might drop to below 8 dB around 50 c/s—where in fact it is most needed.

Minimum Feedback of 20 dB

As it will be appreciated, distortion at these frequencies would not, of course, be revealed by the standard distortion measurements taken at 1,000 c/s ; that is one reason why the intermodulation figures taken with one low frequency, and one high frequency, give a truer picture of an amplifier's performance. To be on the safe side, then, a minimum feedback loop of 20 dB must be stipulated—this figure was in fact recommended recently by the author of *The Radio Designers Handbook*—F. L. Langford Smith. Very large amounts of feedback should be used with great care, especially with small amplifiers, as the overload curve may be adversely affected.

Coming to tone controls, these should have a range of from ± 10 to 15 dB at both 50 and 10,000 c/s, and preferably they should be continuously variable. The filter system should offer a choice of at least three " cut off " frequencies, and a variable slope control is a worthwhile refinement, particularly if a wide range speaker system is used. It is not only useful for dealing with record distortion, but also with poor F.M. transmissions which may result from the use of recordings or long landlines. A choice of at least four record equalising positions is desirable ; the table printed below indicates that the differences of the remaining recording characteristics are quite small, and can be compensated for by the meticulous listener by the use of the tone controls. It is as well to point out here that, because of varying studio acoustics, recording technique, etc., it may be that a more correct balance can be obtained with an occasional record by switching to an alternative position on the equaliser. The criterion should be—adjust the controls until the reproduction sounds right to you, the listener ; never mind if a certain Nixa record does sound better on the Decca ffrr setting, or vice versa.

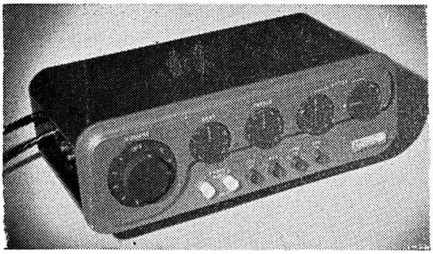
Finally, when it comes to choosing an amplifier, the best plan is to make a selection of those that meet the required specifications, including price, and then visit a Hi-Fi dealer where an instantaneous comparison can be made, using the speaker system of your choice under domestic conditions.



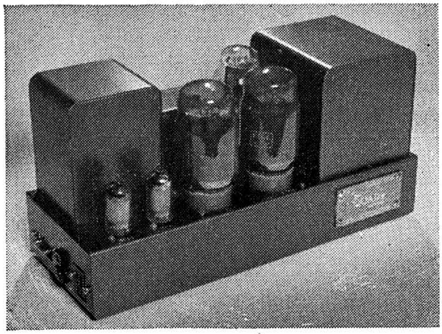
The R.I.A.A. curve sponsored by the Radio Industries Association of America was accepted as the standard by all the major recording companies in the world in 1955. It is identical with the specification B.S.S.1928/1955. The Decca ffrr 78 differs from the EMI 78 shown in the diagram by rolling off from 3,000 c/s to —5 dB at 10,000 c/s. Deviations of some other characteristics from the R.I.A.A. curve are given below. All these of course now conform to the standard curve.

Characteristics

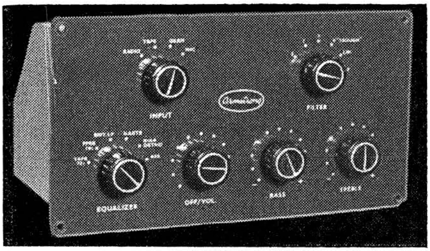
	50 c/s	10,000 c/s		50 c/s	10,000 c/s
N.A.R.T.B. ...	— 1 dB	— 1.6 dB	Nixa	— 1 dB	+ 2.4 dB
N.A.B.	— 1 dB	+ 2.4 dB	Decca	— 4.5 dB	— 3 dB
A.E.S.	+ 1 dB	— 1.6 dB	R.C.A.	— 1 dB	— 1.6 dB
E.M.I.	— 3 dB	+ 1.4 dB			



Quad II control unit

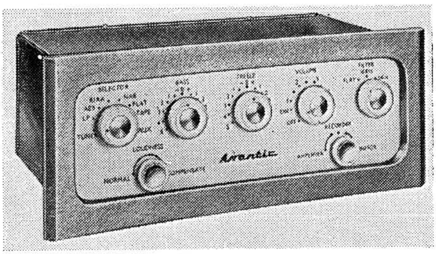


Quad II amplifier

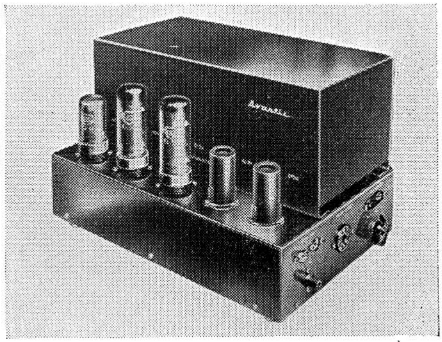


Armstrong A10 control unit

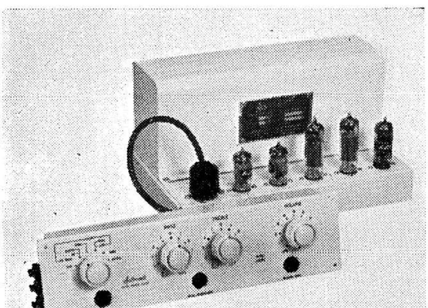
A10 amplifier



Beam-Echo "Avantic" control unit



"Avantic" amplifier



Associated Electronic Engineers "Astronic" control unit and amplifier

DIRECTORY OF AMPLIFIERS & CONTROL UNITS

★ The following abbreviations are used in this directory section : **HD**—Harmonic Distortion ; **<**—less than ; **H and N**—Hum and Noise ; **P.a.t.**—Power supplies available from tuner ; **RMS**—root mean square ; **N.L.**—Noise level ; **Sel.**—Selector switch.

Acoustical Manufacturing Co. Ltd., St. Peter's Road, Huntingdon, Hunts. Tel. : H'don 361 and 574. Cables : Acoustical.

Quad II Q.C. II Control Unit. Inputs : radio/tape 100 mV ; mic. 1.5 mV ; gram. to suit pickup. Treble, bass, vol and on/off, filter slope. Switch filter 5, 7, 10 Kc/s and " out." Tape record socket, switched playback socket. H.D. <0.1%. H and N − 70 dB. P.a.t. determined by main amp. Size 10½ in. by 3½ in. by 6½ in. Weight 7 lb. To operate with Quad II power amp or similar. Price £19 10s.

Quad II Amplifier. 15 watts. Dist. total 3rd harmonic and higher. < 0.18% at 12 watts. Input for spec. output 1.4v. RMS for 15 watts. Response 20-20,000 c.p.s. ± 0.2 dB ; 10-50,000 ± 5 dB. Feedback incorporated in original ultra-linear arrangement. N.L. − 80 dB at 15 watts. Out. imp. 7 and 15 ohms. Output KT66's. Original combined anode/screen current circuit. Size 13 in. by 4¾ in. by 6½ in. Weight 18¼ lb. To operate with QCII control unit. Price £22 10s.

★

Armstrong Wireless & Television Co., Warlters Road, Holloway, N.7. Tel. : North 3213/4.

Mk. II Control Unit. Inputs : radio 70 mV ; tape 18 mV ; mic. 18 mV ; gram. (4) 18-230 mV. 4 pos. input switch ; 6 pos. equaliser ; treble, bass, vol. and on/off ; 6 pos. switched filter. Switched tape input. H.D. 0.05% at 1,000 c.p.s. at 180 mV. H and N better than − 60 dB. Rumble filter. P.a.t. 320v at 35 mA ; 6.3 at 2A. Size 5¼ in. by 9¾ in. by 5¼ in. To operate with A10 Mk. II power amp. Price £10 10s.

A10 Mk. II. 12 watts nom., 20 watts max. Dist. 0.1%. Input for spec. output 80 mV for 12 watts. Response 15-30,000 c.p.s. ± 1 dB. Feedback 28 dB. N.L. better than − 80 dB. Out. imp. 1, 3, 7½ and 15 ohms. Output EL34's. Ultra-linear. Size 14 in. by 18¼ in. by 6½ in. Weight 25 lb. To operate with Mk. II control unit. Price £21.

Associated Electronic Engineers Ltd., 10 Dalston Gardens, Stanmore, Middx. Tel. : Wordsworth 4474/5/6. Cables : Astronic, Stanmore.

Astronic A1332 Control Unit. Inputs : mic. 20 mV ; gram. A.E.S., FFRR, NARTB 10-20 mV ; radio/tape 220 mV. 6 pos. sel., treble, bass, vol. and on/off, gram. input attenuator. Tape record and playback socket. H and N − 70 dB. P.a.t. (from main amp) 300v at 10 mA, 6.3v at 0.5 A. Size 12 in. by 3⅜ in. by 1⅞ in. Weight 3 lb. To operate with A1333 power amp. Price £9 10s. 6d.

Astronic A1333 Amplifier. 10 watts nom., 13 watts max. Dist. 0.1% at 10 watts. Input for spec. output 0.33 RMS. Response 20-20,000 c.p.s. ± 0.5 dB. Feedback 18 dB. N.L. − 72 dB. Out. imp. 3¾, 7½ and 15 ohms. Output N709's or EL84's. Ultra-linear. Size 11½ in. by 6¼ in. by 6 in. Weight 16½ lb. To operate with A1332 input unit. Price £18 19s. 6d.

★

Beam-Echo Ltd., Witham, Essex. Tel. : Witham 3184. Cables : Parion, Witham.

Avantic DL7-35 Control Unit. Inputs : P.U.1 4-6 mV ; P.U.2 40-60 mV ; P.U.3 500 mV ; tuner 1 100 mV ; tuner 2 500 mV ; aux. 1 2 mV ; aux. 2 20 mV ; tape 100 mV. 8 pos. sel, treble, bass, vol. and on/off, loudness. Switched filter 5, 10 and 20 Kc/s. 3-pos. monitor/record switch. Tape record and playback sockets. H.D. < 0.1% for 200 mV and < 0.2% for 2.0v. H and N, radio and tape − 64 dB ; pickup − 53 to − 56 dB ; aux. 1 − 45 dB. Roll-off freq. 40 c.p.s. Slope 12 dB/octave. P.a.t. 200v at 30 mA, 6.3v at 2.5 A. Size 11⅝ in. by 4⅛ in. by 7 in. Weight 6¾ lb. Sold only with DL7-35 power amp.

Avantic DL7-35 Amplifier. 20 watts nom., 45/60 watts max. Dist. < 0.05% at 20 watts, < 0.1% at 27 watts. Input for spec. output 220 mV. Response 5-30,000 c.p.s. ± 0 dB, 2-100,000 c.p.s. ± 1 dB at 1,000 c.p.s. Feedback 30 dB. N.L. − 84 dB at 20 watts.

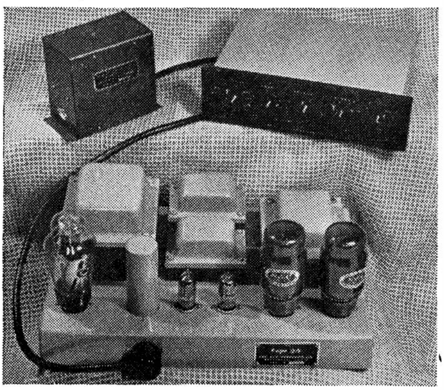
Out. imp. 4, 8, and 16 ohms, switched. Output EL34's. Ultra-linear. Size $14\frac{1}{2}$ in. by 9 in. by $8\frac{1}{2}$ in. Weight $35\frac{3}{4}$ lb. Price complete with control unit £55.

★

Cape Electrophonics Ltd., 43-45 Shirley High Street, Southampton. Tel. : Southampton 74251.

Cape VLP Control Unit. Inputs : LP1 (new AES, RIAA, etc.) 8 mV ; LP2 (old AES) 8 mV ; 78A (new AES, etc.) 7 mV ; 78B (old British) 7 mV ; amp (flat) 4 mV ; mic. (flat) 4 mV ; tape (flat) 6 mV ; tape $7\frac{1}{2}$ (100 u sec.) 14 mV ; tape 15 (35 u sec.) 16 mV. 12 pos. sel. covering 6 input points, treble, bass, vol., switched filter 5, 9 Kc/s and "out." For tape record, 1 socket from output of first stage. Tape flat for external unit, tape $7\frac{1}{2}$ (100 uS), tape 15 (35 uS), 1 socket for playback. H.D. not exceeding 0.1% for full output from Cape VL1. H and N including VL1 −60 dB average at 25 watts. Built-in rumble filter, fixed at choice of 30 or 40 c.p.s. P.a.t. 2 supply points. When used with VL1, these make available 430v at 70 mA and 6.3v at 1.5 A and 6.3v at 3 A. Size 9 in. by 6 in. by 3 in. Weight approx. 2 lb. To operate with VL1 power amp. Price £15.

Cape VL1 Amplifier. 25 watts nom., approx. 40 watts max. Dist. at 1,000 c.p.s. 0.03% at 15 watts ; 0.1% at 25 watts ; 0.2% at 33 watts ; over range 50-10,000 c.p.s. 0.1% total at 15 watts. Input for spec. output 0.8v RMS. Response 10-80,000 c.p.s. ± 0.5 dB. Feedback, external loop 20 dB. N.L. −85 dB at 25 watts. Out. imp 3.5, 7 and 15 ohms. Output KT66's. Ultra-linear.



Cape control unit, amplifier and sub-amplifier

Choke regulated power supply. Output and drive stages balanced by direct coupled feedback. Size $15\frac{3}{4}$ in. by $8\frac{1}{2}$ in. by 7 in. Weight approx. 35 lb. Price £30.

Cape VLS Sub-amplifier. Max. gain ×100. Gain and performance adjustable by feedback connection at internal tags. Can be supplied in various forms, e.g., as simple preamp with vol. control. Size $5\frac{1}{4}$ in. by $4\frac{1}{2}$ in. by 3 in. Price from £5.

★

Champion Electric Corporation (C.R.V.T.C. Ltd.), Champion Works, Newhaven, Sussex. Tel. : Newhaven 500. Cables : Champelect, Newhaven.

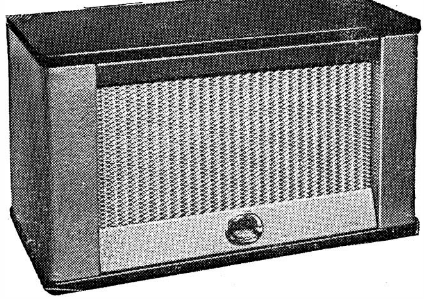
Champion 853A Control Unit. Inputs : tape/radio, replay 75 mV ; mic. 1.5 mV ; gram. 15 mV. 7 pos. sel. (5 for gram.), treble, bass, vol., low pass filter, 5, 7, 10 Kc/s level, on/off. Tape playback socket. H.D. < 0.1%. H and N − 75 dB. Size 15 in. by $4\frac{1}{2}$ in. by $4\frac{1}{4}$ in. To operate with 853 power amp. Price £18 18s.

Champion 853 Amplifier. 10 watts nom., 11 watts max. Dist. 0.1% at 4 c.p.s. at 10 watts. Input for spec. output 40 mV. Response 5-20,000 c.p.s. ± 1 dB at 1 watt ; 30-15,000 c.p.s. ± 1 dB at 10 watts. Feedback 20 dB overall. N.L. 75 dB below 10 watts. Out. imp. 3.75 and 15 ohms. Output EL84's. Ultra-linear. Size 15 in. by $8\frac{1}{2}$ in. by 9 in. To operate with 853A or tuner 854. Price £23 2s.

★

C. T. Chapman (Reproducers) Ltd., Sales Office : Riley Street, Chelsea, S.W.10. Tel. : Flaxman 4577/8.

Chapman 205CU Control Unit. 6 inputs from 1.5 mV-100 mV. 6 pos. sel., treble,



Champion 853 *amplifier*

bass, loudness. 3 pos. roll off, 5, 10 and 20 Kc/s. Tape record and playback jacks. H.D. < 0.1%. H and N radio — 64 dB, p/U — 54 dB. Rumble filter, better than 12 dB per octave below 35 c.p.s. Size 12 in. by 2 in. by 6 in. Weight 10 lb. To operate with power amp 205.

Chapman 205 Amplifier. 20 watts from 30-20,000 c.p.s. Dist. < 0.05% at 20 watts. Response 2-100,000 c.p.s. ± 1 dB. Feedback 30 dB. N.L. — 89 dB at 20 watts. Out. imp. 15 ohms. Output EL34's. Ultra-linear. To operate with 205CU.

★

Dynatron Radio Limited, Maidenhead, Berks. Tel. : Maidenhead 3811/2/3.

Dynatron TC10 Tone Control Unit. Inputs: radio 0.15v ; A.F. 0.15v ; gram 10 mV. 5 pos. sel. (3 gram.), treble, bass, vol. H.D. < 1%. H and N at least 74 dB below max output. Size 3 in. by 9 in. by 6 in. Weight $3\frac{1}{4}$ lb. To operate with L.F. 10 power amp. Price £12 12s. 6d.

Dynatron L.F. Amplifier. 10 watts nom., 12 watts max. Dist. < 1%. Input for spec. output .75v. Response 30-30,000 c.p.s. ± 1 dB. Negative feedback. N.L. at least 76 dB below max. output. Out. imp. $3\frac{3}{4}$, $7\frac{1}{2}$ and 15 ohms. Output N209's. Ultra-linear. Size $8\frac{3}{8}$ in. by $7\frac{1}{8}$ in. by $13\frac{3}{4}$ in. Weight $14\frac{1}{2}$ lb. To operate with TC10 control unit. Price £25.

EMI Sales & Service Ltd., and **EMI International Ltd.,** Blyth Road, Hayes, Middx. Tel. : Southall 2468. Cables : Emiservice, Telex, Emiglobe.

H.M.V. 3050 Control Unit. Inputs : F.M., radio and tape, all 850 mV ; aux. 3 mV ; gram. 1.5 mV. 5 pos. sel., 5 pos. equalisation switch, treble, bass, switch filter at 5, 9, 13 and 20 Kc/s. Tape playback sockets. H.D. at 1,000 c.p.s. < 0.1% at 2v. H and N including 3051, level 50 dB below 10 watts. Bridged " T " bass cut filter. Size 18 in. by $6\frac{3}{4}$ in. by $3\frac{1}{2}$ in. Weight 10 lb. To operate with 3051 power amp. or 3052 speaker comb.

H.M.V. 3051 Amplifier. (Also incorporated in 3052 speaker comb.). 10 watts nom., 18 watts max. Dist. < 0.1% at 10 watts. Input for spec. output 2.5v RMS. Response 20-20,000 c.p.s. ± 1 dB. N.L. < 75 dB below 10 watts output. Out. imp. 4, 8 or 16 ohms. Output KT66's. Ultra-linear. Size $14\frac{1}{2}$ in. by 10 in. by 11 in. Weight 50 lb. To operate with 3050 control unit. Price on application.

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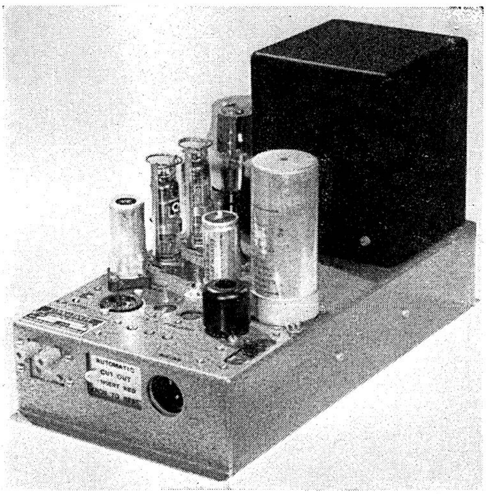
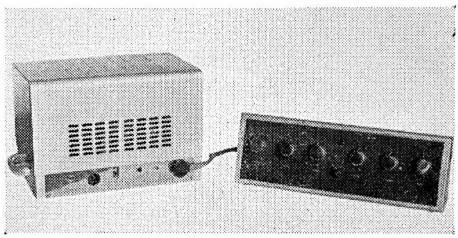
Expert Gramophones Ltd., " Ingerthorpe," Great North Road, London, N.2. Tel. : Mountview 6875.

Expert Control Unit. Input P/U : tape, radio, all 20 mV. 3 pos. sel., vol., bass, treble filter-variable slope. Tape input socket. H.D. < 0.1%. H and N — 60 dB.

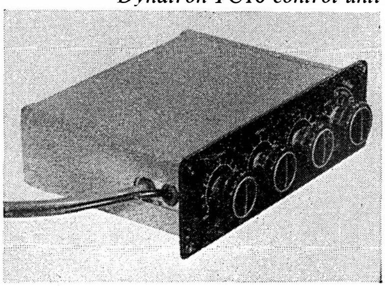


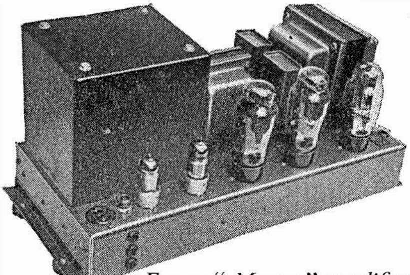
Dynatron L.F. amplifier



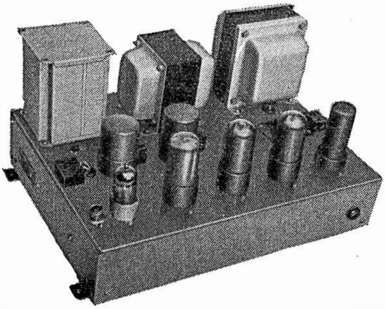
E.M.I. control unit and amplifier

Dynatron TC10 control unit

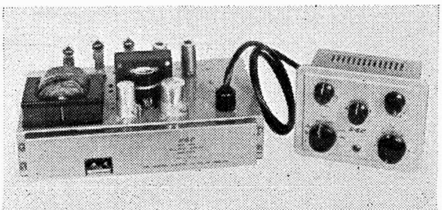




Expert " Master " amplifier



Expert " Standard " amplifier



G.E.C. control unit and amplifier

Goodsell UL/TC control unit and MA5/UL/C amplifier

Attenuation introduced below 20 c.p.s. P.a.t. from power amp. Size 12 in. by 3½ in. by 6 in. Weight 4 lb. To operate with Expert " Master " and " Standard " or any similar power amp. Price £18.

Expert " Standard " Amplifier. 8 watts nom., 10 watts max. Dist. 0.1%. Input for spec. output 200 mV. Response 20-20,000 c.p.s. ± 0.5 dB. Feedback 30 dB. N.L. – 75 dB at 8 watts. Out. imp. 15 ohms. Output 6V6's. Ultra-linear. Size 12 in. by 9 in. by 6½ in. Weight 16 lb. To operate with Expert control unit or similar. Price £23.

Expert " Master " Amplifier. 20 watts nom., 26 watts max. Dist. 0.07%. Input for spec. output 200 mV. Response 20-30,000 c.p.s. ± 0.5 dB. Feedback 30 dB. N.L. – 85 dB at 20 watts. Out. imp. 15 ohms. Output EL34's. Ultra-linear. Size 12 in. by 9 in. by 7½ in. Weight 24 lb. To operate with Expert control unit or any similar. Price £35.

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General Electric Co. Ltd., Magnet House, Kingsway, W.C.2. Tel. : Temple Bar 8000. Cables : Polyphase, London.

G.E.C. BCS2417A Control Unit. Inputs : p/U 15 mV ; radio 300 mV ; tape 7½ mV. 6 pos. sel. (4 gram.), treble, bass, presence, vol. Provision made for easy add. of tape pre-amp stage allowing direct connection to tape playback head. H and N approx. –66 dB at 12 watts. P.a.t. from BCS2418A power amp. To operate with BCS2418A power amp. and only sold in conjunction with it.

G.E.C. BCS2418A Amplifier. 12 watts nom. Dist. < 0.5% at 12 watts. Input for spec. output 120 mV. Response 15-20,000 c.p.s. ± 1 dB. Feedback 15 dB overall. Out. imp. 15 ohms (or 1, 2 or 3 3-5 ohms speakers). Output N709's. Weight 7½ lb. Price, complete with BCS2417A control unit £39 15s.

★

Goodsell Ltd., 40 Gardner Street, Brighton. Tel. : Brighton 26735.

Golden UL/TC Control Unit. Inputs : gram. 15 mV ; mic. 5 mV ; radio 60 mV. 6 pos. sel. (4 gram.), treble, bass, vol., tape/radio socket. Spec. dependent on amp used. Size 7 in. by 8 in. by 2 in. For use with MA5 or MA5 De Luxe power amp. Price £8 8s.

Golden PFA Control Unit. Inputs : gram. 5-7 mV ; mic. 5 mV ; radio 80 mV. 4 pos.

sel., treble, bass, vol. Switched filter 5, 7, 9, 13 Kc/s and " out." Spec. dependent on amp used. Size 11 in. by 9 in. by $3\frac{1}{2}$ in. Weight 4 lb. To operate with MA5 and G.W. 18 power amp. Price £20. Also low gain version available, No. ORTO/PFA. Price £17 10s.

Golden MA5 De-Luxe Amplifier. 15 watts. Dist. $<0.2\%$ at 12 watts. Input for spec. output 1.5v. Response 30-25,000 c.p.s. $\pm$ 2 dB. Feedback 20 dB. N.L. $-$ 70 dB. Out. imp. 4, 8, 15 ohms. Output KT66's. Ultra-linear. Size $8\frac{1}{2}$ in. by 7 in. by $6\frac{1}{2}$ in. Weight 16 lb. To operate with UL/TC or PFA control units. Price £17 17s.

Golden GW18 " Williamson " Amplifier. 15 watts. Dist. $<0.1\%$. Input for spec. output 1.5v. Response 20-100,000 c.p.s. $\pm$ 2 dB. Feedback 20 dB. N.L. $-$ 75 dB. Out. imp. 3 or 8 or 15 ohms. Output KT66's. Size 17 in. by $11\frac{1}{2}$ in. by $8\frac{3}{4}$ in. Weight 54 lb. This model is also available with ultra-linear connections in the output stage which raises the output to 25 watts. To operate with PFA control unit. Price £35 15s.

★

Grampian Reproducers Ltd., Hanworth Trading Estate, Feltham, Middx. Tel. : Feltham 2657/8/9. Cables : Reamp, Feltham.

Grampian 56 Control Unit. Inputs : P/U 10 mV ; radio 100 mV ; tape 50 mV. 4 pos. sel., treble, bass, vol. Tape input socket. P.a.t. from power amp. Size 10 in. by $3\frac{3}{4}$ in. by $5\frac{3}{4}$ in. Price £11 2s. 6d.

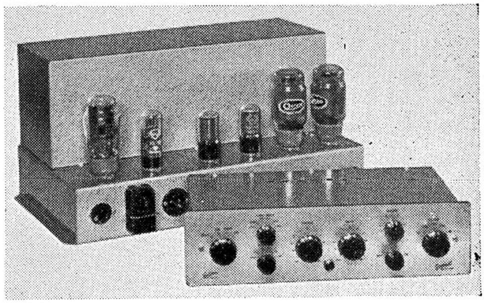
Grampian 5-10 Amplifier. 10 watts nom., 11 watts max. Dist. $<0.4\%$ at 40 c.p.s. ; $<0.2\%$ at 400 c.p.s. ; $<0.3\%$ at 2,000 c.p.s. Input for spec. output 40 mV. Response 10-20,000 c.p.s. $\pm$ 0.5 dB. Feedback 20 dB. N.L. $-$ 73 dB. Out. imp. 4, $7\frac{1}{2}$ and 15 ohms. Output EL84's. Ultra-linear. Size $10\frac{1}{2}$ in. by $7\frac{1}{4}$ in. by 6 in. Weight 13 lb. To operate with 54 or 56 control unit. Price £15 17s. 6d.

★

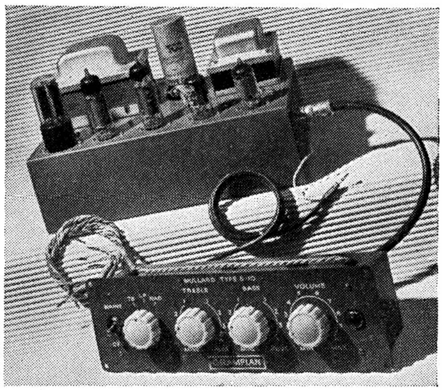
H. J. Leak & Co. Ltd., 57/59 Brunel Road, East Acton, London, W.3. Tel. : Shepherds Bush 1173. Cables : Sinusoidal, Ealux, London.

" Point One " Control Unit. Inputs : tuner 80 mV ; P/U 14 mV ; tape 80 mV. 6 pos. sel., treble, bass, vol., mains on/off. Input level controls for P/U, tuner. Tape input sockets. H.D. 0.1%. H and N $-$ 66 dB. P.a.t. Size $10\frac{3}{4}$ in. by $3\frac{1}{2}$ in. by

Goodsell PFA control unit and MA5 de luxe amplifier



Goodsell PFA control unit and GW18 amplifier



Grampian 56 control unit and 5-10 amplifier

$3\frac{3}{4}$ in. Weight $3\frac{1}{2}$ lb. To operate with TL/10, TL/12 or TL/25A power amp. Price £10 10s.

Vari-slope II Control Unit. Inputs : mic. 3 mV ; tuner 50 mV ; aux. 50 mV ; tape 50 mV ; P/U 10 mV. 10 pos. sel. 7 pos. switched, bass and treble. Switched, low pass filter, 3, 5, 7, and 9 Kc/s, plus " Vari-slope " control. Vol. Mains on/off

Input level controls for P/U, tuner, aux. Tape input sockets. H.D. < 0.1% H and N – 66 dB. P.a.t. Size $11\frac{5}{8}$ in. by $4\frac{7}{16}$ in. by $4\frac{3}{4}$ in. Weight 5 lb. To operate with TL/10, TL/12 or TL/25A power amp. Price £16 16s.

Vari-slope III Control Unit. Inputs: tape or mic. 5 mV; tuner 45 mV; pickup I 9 mV; pickup II 9 mV. 6 pos. sel. and change-over switch for pickup I/pickup II. Treble, bass, vol., mains on/off. Switched, low pass filter 5, 7, and 9 Kc/s plus Vari-slope controls. Rumble filter, cut-in. Input level controls for tuner, pickup I, pickup II. Tape input sockets on front and back panels. H.D. < 0.1%. H and N – 66 dB. P.a.t. on TL/12 plus power amp. Size $11\frac{1}{2}$ in. by $4\frac{7}{16}$ in. by 4 in. Weight $4\frac{1}{2}$ lb. To operate with TL/12 plus TL/25 plus and TL/50 power amp. Price £15 15s.

" Point One " TL/10 Amplifier. 10 watts. Dist. 0.1% input for spec. output 125 mV. Response 30-20,000 c.p.s. ± 1 dB. Feedback 26 dB main loop. N.L. – 80 dB, ± 4 dB. Out. imp. 4, 8, and 16 ohms. Output KT61's. Ultra-linear. Size $10\frac{7}{8}$ in. by $8\frac{1}{2}$ in. by 6 in. Weight $14\frac{1}{2}$ lb. To operate with " Point One " or Vari-slope II control units. Price £17 17s.

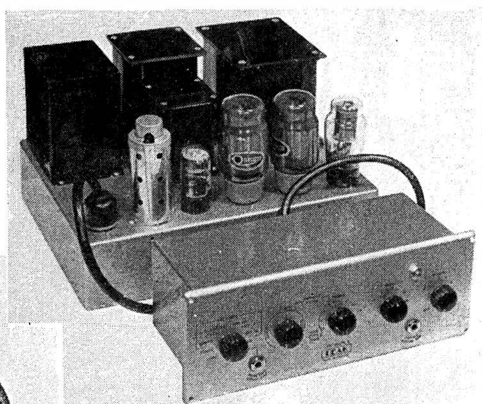
" Point One " TL/12 Amplifier. 12 watts. Dist. 0.1%. Input for spec. output 150 mV. Response 20-20,000 c.p.s. ± 0.25 dB. Feedback 26 dB. N.L. – 82 dB. Out. imp. 1-16 ohms. Output KT66's. Size $12\frac{1}{2}$ in. by 10 in. by $8\frac{1}{4}$ in. Weight $26\frac{1}{2}$ lb. To operate with " Point One " or Vari-slope II control units. Price £28 7s.

" Point One " TL/25A Amplifier. 25 watts. Dist. 0.2%. Input for spec. output 150 mV. Response 20-20,000 c.p.s. ± 1 dB. Feedback 20 dB main loop. N.L. – 76 dB. Out. imp. 2-32 ohms or as required. Output KT66's. Size $12\frac{1}{2}$ in. by 10 in. by $8\frac{3}{4}$ in. Weight $31\frac{1}{2}$ lb. To operate with " Point One " or Vari-slope II control units. Price £34 7s.

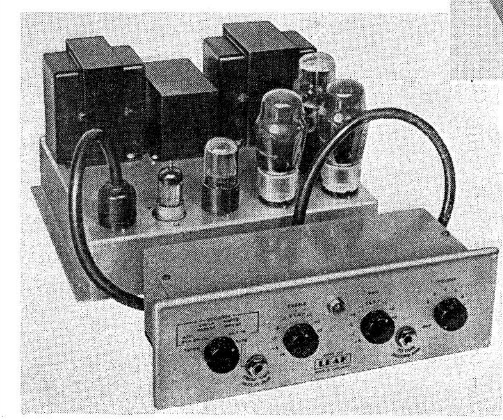
" Point One " TL/12 plus Amplifier. 12 watts. Dist. 0.1%. Input for spec. output 125 mV. Response 20-20,000 c.p.s. ± 0.25 dB. Feedback 26 dB. N.L. – 84 dB. Out. imp. 4, 8 and 16 ohms. Output EL84's. Ultra-linear. Size 10 in. by 8 in. by 6 in. Weight 16 lb. To operate with Vari-slope III control unit. Price £18 18s.

" Point One " TL/25 Plus Amplifier. 25 watts. Dist. 0.1%. Input for spec. output 125 mV. Response 20-20,000 c.p.s. ± 0.25 dB. Feedback 26 dB. N.L. – 83 dB. Out. imp. 4, 8 and 16 ohms (other imps. to order). Output EL34's. Ultra-linear. Size 10 in. by 8 in. by $6\frac{3}{4}$ in. Weight 22 lb. To operate with Vari-slope III control unit. Price £25 4s.

" Point One " TL/50 Amplifier. 50 watts. Dist. 0.1%. Input for spec. output 125 mV. Response 20-20,000 c.p.s. ± 0.25 dB. Feed-



Leak " Vari-Slope II " control unit and TL/12 amplifier



Leak " Point One " control unit and TL/10 amplifier back 26 dB. N.L. — 84 dB. Out. imp. 4, 8 and 16 ohms (other imps. to order). Output KT88's. Ultra-linear. Size 11½ in. by 9 in. by 6¾ in. Weight 26 lb. To operate with Vari-slope III control unit. Price £33 12s.

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Lowther Manufacturing Co., Lowther House, St. Mark's Road, Bromley, Kent. Tel.: Ravensbourne 5225. Cables: Lowther, Bromley.

Lowther No. 2 Control Unit. Inputs: mic. 45 mV; P/U 45 mV; radio 100 mV. 4 pos. sel., treble, bass, vol., on/off. Mic./tape input socket. H.D. 0.1% on 1v RMS. H and N — 60 dB. Size 10½ in. by 3 in. by 3½ in. Weight 2 lb. To operate with LL10, LL16 and similar power amp. Price £10 10s.

Master Control Unit Mk. I. Inputs: mic., P/U 3 mV; tape, radio 100 mV. 5 pos. sel. 5 pos. rec. equal, treble, bass, vol., on/off, low pass filter, 18 dB per octave, 35 down to 4 Kc/s. Tape input sockets. H.D. < 0.1%. H and N — 90 dB. Size 10½ in. by 5½ in. by 7½ in. Weight 6 lb. To operate with LL10, LL16 and similar power amp. Price £20.

Master Control Unit Mk. II. Inputs: mic., P/U and tape head 3 mV; radio, aux. 100 mV. 6 pos. sel. 5 pos. record equal, treble, bass, vol., on/off. Low pass filter. 18 dB per octave. 35 down to 4 Kc/s. Socket for direct connection to tape playback head. H.D. < 0.1%. H and N — 80 dB. Size 10½ in. by 5½ in. by 7½ in. Weight 6 lb. To operate with LL10, LL16 and similar power amp.

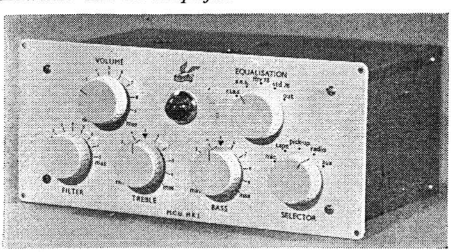
Lowther LL10 Amplifier. 10 watts. Dist. < 0.1%. Input for spec. output .75v. Response 30-30,000 c.p.s. ± 1 dB. Feedback 22 dB. N.L. — 80 dB. Out. imp. 16 ohms with adjustment. Output EL34's. "Lowther Linear" (screen and anode feedback). P.a.t. Size 12 in. by 9 in. by 6½ in. Weight 18¼ lb. To operate with MCUI, MCUII or control unit No. 2. Price £25.

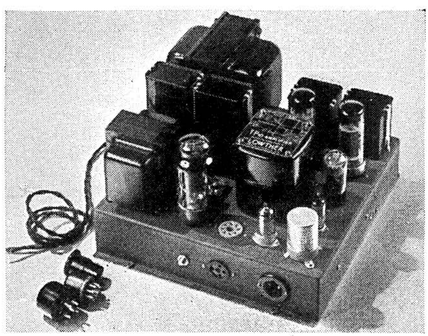
Lowther LL16 Amplifier. 16 watts. Dist. < 0.1%. Input for spec. output 0.75v. Response 20-60,000 c.p.s. ± 1 dB. Feedback 22 dB. N.L. — 90 dB. Out. imp. 16 ohms with adjustment. Output EL34's. "Lowther Linear." P.a.t. Size 12 in. by 12 in. by 8½ in. Weight 30 lb. To operate with < CUI, MCUII or control unit No. 2. Price £40.

Lowther-Murray Transistor Control Unit No. 1. Inputs: 5 mV. 5-50 ohms. On/off battery switch only. Imp. matching transistor pre-amp forward gain 100-1. Dist. not measurable at normal output. No hum/noise. Size approx. 3½ in. by 3½ in. by 6 in. Weight 1 lb. To operate with any power amp. Price (tentatively) £8 10s.

Lowther-Murray Transistor Control Unit No. 2. Spec. as for No. 1 but gain 45-1. Size 3½ in. by 3½ in. by 3½ in. Weight 8 oz. To operate with any power amp. Price (tentatively) £4 15s.

Lowther LL 10 *amplifier*





Lowther LL 16 *amplifier*

Lowther Master control unit Mk. 1 (*left*)

Lowther-Murray Transistor Control Unit No. 3. Inputs 5 mV, low imp. 5-50 ohms. Imp. matching transistor control unit with corrections for connection to normal "Radio" position. 4 pos. sel. off, R.I.A.A., ffrr 78, mic. H.D. nil. H and N no hum, less noise than record or radio background. Size approx. 3½ in. by 3½ in. by 6 in. Weight 2 lb. To operate with any power amp. Price (tentatively) £10 10s.

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Pamphonic Reproducers Ltd., 17 Stratton Street, W.1. Tel.: Grosvenor 1926.

1003 Self-contained Control Unit and Power Amp. 5 pos. sel. (3 gram.), treble, bass, vol. 10 watts. Dist. at 1,000 c.p.s., 0.5% at 8 watts. Input for spec. output 2.5 mV-100 mV according to input selected. Response substantially flat 20-50,000 c.p.s. Feedback 20 dB. N.L. mic. — 53 dB. P/U — 54 dB, radio/tape — 65 dB. Out. imp. 3.5 and 15 ohms. Output 6AQ5's. Ultra-linear. Size 15 in. by 7 in. by 9¼ in. Weight 20 lb. Price £28 7s.

1004 Self-contained Control Unit and Power Amp. Separate controls for bass, treble, volume and loudness (contour), and input selection. Plug-in gram. attenuation. 10 watts. Dist. at 1,000 c.p.s., 0.5% at 10 watts. Input voltage for spec. output mic. 2.5 mV; tape/radio 100 mV; P/U 12-15 mV. Response substantially flat 50-50,000 c.p.s. Feedback 20 dB. N.L. mic. — 53 dB, P/U — 54 dB. Out. imp. 3.5 and 15 ohms. Output 6 BW6's. Ultra-linear. Price £26 5s.

1002A Control Unit. Inputs: 3-120 mV (depending on input used). 6 pos. sel (3 gram.). Cut-off filter 4, 7, 12 Kc/s and "out." Terminals for tape input. N.L. 60 dB below 0.5v P.a.t. Size 10¾ in. by 3⅞ in. by 4 in. Weight 2 lb. To operate with 1002 power amp. Price £12 12s.

1002B Control Unit. Inputs: mic. 2-3 mV, radio/tape 60 mV; P/U 6-8 mV. Push-button sel. 9 pos. (6 gram.). Cut-off filter 4, 7, 12 Kc/s and "out." Terminals for tape input. H and N 60 dB below 0.5v. P.a.t. Size 10¼ in. by 4¼ in. by 7¼ in. To operate with 1002 power amp. Price £25 4s.

1002 Amplifier. 25 watts. Dist. at 1,000 c.p.s., 0.05% at 15 watts. Input for spec. output 0.35v for 15 watts. Response substantially flat 2-100,000 c.p.s. Feedback 28 dB. N.L. 90 dB below full output. Out. imp. 3.75, 6.6, 10, 15 ohms. Output 2 KT66's. Ultra-linear. Size 13 in. by 10 in. by 7 in. Weight 29 lb. To operate with 1002A or 1002B control units. Price £29 8s.

2001A Control Unit. Inputs: 3-120 mV depending on input. 6 pos. sel. Pre-set level control for tape/radio. Cut-off filter at 4, 7, 12 Kc/s and "out." Loudness control. Tape input sockets. H and N 60 dB below 0.5v. P.a.t. To operate with 2001 power amp. Price not yet announced.

2001 Amplifier. 25 watts. Dist. at 1,000 c.p.s., 0.05% at 15 watts. Input for spec. output 0.5v. Response substantially flat 2-100,000 c.p.s. Feedback 28 dB. N.L. 90 dB below full output. Out. imp. 3.75, 6.6, 10 and 15 ohms. Output KT66's. Ultra-linear. To operate with 2001A control unit. Price not yet announced.

★

Pilot Radio Limited, Park Royal Road, London, N.W.10. Tel.: Elgar 7353. Cables: Piloset, London.

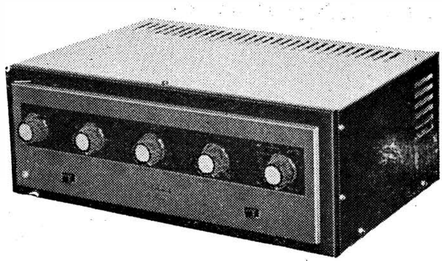
HFAII Self-contained Control Unit and Power Amp. Inputs: P/U 3 mV; tuner, tape, aux. 150 mV. 7 pos. sel. (4 gram.). Switched scratch filter. Switched rumble filter. Treble, bass, loudness and volume. Tape input socket. 10 watts output. Dist. < 1% over full frequency range at full power. < 0.1% at 4 watts. Response 20-20,000 c.p.s. ± 1 dB. Feedback 21 dB. N.L. 80 dB below full output. Out. imp. 3, 8 and 15 ohms. Output EL84's. Ultra-linear. Price not yet announced.

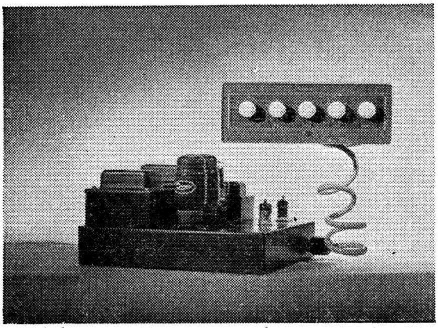
★

Pye Limited, Radio Works, Cambridge. Tel.: Cambridge 85985. Cables: Pyrad, Cambridge.

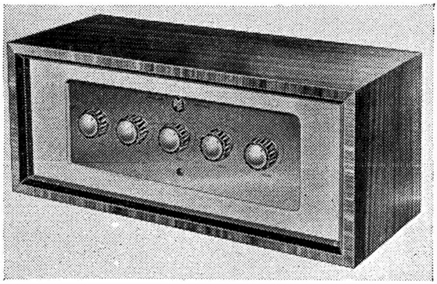
HF5/8 Self-contained Control Unit and Power Amp. HF5/8W in cabinet. Inputs: tape 100 mV; radio 100 mV; mic. 4 mV; P/U max. sens. 18 mV dependent on P/U compensator used. 7 pos. sel. (4 gram.), treble, bass, vol., loudness on/off. Tape input socket. H and N, tape/radio/mic. — 60 dB. P/U — 55 dB at 5 watts. 5 watts nom. and 8 watts max. output. Dist. 0.3% at 5 watts. Response 2-50,000 c.p.s. ± 2 dB. Feedback 24 dB. Variable pos. feedback by means of manual control. N.L. — 70 dB at 5 watts. Out. imp. 3.75 and 15 ohms. Output EL90's. Size 14½ in. by 10¼ in. by 6½ in. Weight 20 lb. Price HF5/8 £26 5s.; HF/8W £31 10s.

Pilot HFA II combined control unit and amplifier (right)

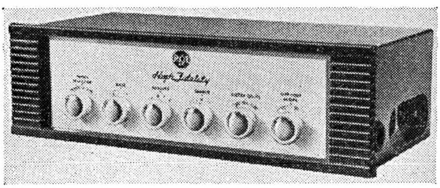




Pamphonic 2001*A control unit and* 2001 *amplifier*



Pye " Proctor " control unit



RCA control unit

RCA amplifier

Proctor HF25A Control Unit. HF25AW in cabinet. Inputs : tape 120 mV ; radio 120 mV ; mic. 3 mV ; P/U max. sens. 8 mV dependent on P/U compensator used. 7 pos. sel. (4 gram.), treble, bass, vol. and on/off. Switched filter 4, 7 and 12 Kc/s and " out." Tape input socket. H and N – 60 dB on 0.5v. Size 10¾ in. by 4 in. by 4 in. Weight 2 lb. To operate with HF25 power amp. Price HF25A £12 12s. ; HF25AW £17 6s. 6d.

Provost HF25 Amplifier. 25 watts nom., 30 watts max. Dist. 0.3% at 25 watts. 3.0% at 30 watts. Input for spec. output 0.5v. Response 2-160 Kc/s ± 3 dB. Feedback 26 dB. Variable poss. feedback by means of manual control. N.L. – 90 dB at 25 watts. Out. imp. 3.75, 6.6, 15 and 60 ohms. Output KT66's. Ultra-linear, Size 13½ in. by 10 in. by 7 in. Weight 27 lb. To operate with HF25A control unit. Price £29 8s.

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RCA Great Britain Ltd., Lincoln Way, Sunbury-on-Thames, Middx. Tel.: Sunbury-on-Thames 3101. Cables : Telex and Tex 28608.

RCA New Orthophonic Control Unit LMI.32215. Inputs : mic. 6.5 mV ; radio/tape 200 mV ; radio/tape 50 mV ; P/U (crystal) 300 mV ; P/U (magnetic) 11.5-16 mV. 6 pos. sel. (4 gram.), treble, bass, vol. Switched filter 5, 7 and 10 Kc/s. Variable slope control inc. on/off switch, variable to 35 dB per octave. Tape playback. H.D. < 0.1% at 700 c.p.s. at 10 watts. H and N 85 dB below rated output. Rumble filter built in on power amp LMI.32216.

P.a.t. 395v at 45 mA, 6.3v at 2.5 A. Size $12\frac{7}{8}$ in. by $6\frac{1}{8}$ in. by $3\frac{7}{8}$ in. Weight 7 lb. To operate with RCA power amp LMI.32216. Price £16 10s.

RCA New Orthophonic Amplifier LMI.32216. 20 watts nom., 40 watts max. Dist. at 700 c.p.s. $<0.1\%$ at 10 watts. Input for spec. output 1.2v Response 20-20,000 c.p.s. $\pm$ 0.2 dB. Feedback $-$ 40 dB total. N.L. 85 dB below rated output. Out. imp. 4, 7 and 15 ohms. Output KT66's. Improved ultra-linear. Size $16\frac{1}{8}$ in. by 8 in. by $7\frac{1}{2}$ in. Weight 32 lb. To operate with LMI.32215 control unit. Price £24 10s.

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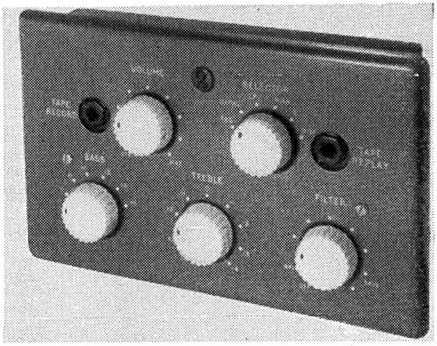
Rogers Developments (Electronics) Ltd., 4-14 Barmeston Road, Catford, S.E.6. Tel. : Hither Green 7434. Cables : Rodevco, London, S.E.6.

RD Junior Control Unit. Inputs : radio/mic. 10 mV ; radio 150 mV ; tape 200 mV ; P/U 30-50 mV. 6 pos. sel. 6 pos. bass switch, treble, vol. and on/off, low pass filter and off. Record and replay sockets. H.D. 0.1% or less at 1,000 c.p.s. P.a.t. from power amp. Size $8\frac{1}{2}$ in. by $5\frac{1}{4}$ in. by $4\frac{3}{8}$ in. To operate with RD Junior or RD Senior power amp. Price £9.

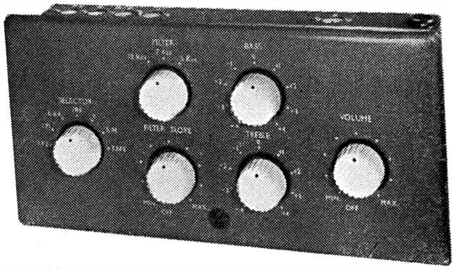
RD Senior Control Unit Mk. III. Inputs : radio/mic. 2 mV ; radio 250 mV ; tape 250 mV ; P/U 10-15 mV. 7 pos. sel., treble, bass, vol. and on/off. Switched filter 5, 7 and 10 Kc/s. Low pass filter slope control 6-36 dB per octave with switch. Tape record and replay socket. H.D. 0.1% or less at 1,000 c.p.s. 12-15 dB fall off below 25 c.p.s. Size $10\frac{1}{4}$ in. by $4\frac{7}{8}$ in. by $2\frac{5}{8}$ in. To operate with RD Junior or Senior amps. Price £12.

RD Junior Amplifier. 9-11 watts nom., 13 watts max. Dist. at 1,000 c.p.s. 0.12% at 9 watts, 0.2% at 11 watts, 0.5% at 13 watts. Input for spec. output 600 mV RMS for 9 watts. Response 20-30,000 c.p.s. $\pm$ 0.25 dB. Feedback 20 dB. N.L. $-$ 85 dB below 9 watts. Out. imp. 2-3, 6-8, 12-16 ohms. Output EL84's. Ultra-linear. Size 11 in. by 6 in. by $5\frac{1}{4}$ in. Weight 15 lb. For Junior or Senior control units. Price £17.

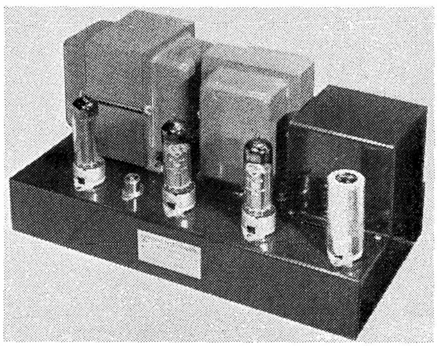
RD Senior Mk. II Amplifier. Provisional details. 15 watts nom., 25 watts max. Dist. 0.08% at 15 watts, 0.5% at 25 watts. Input for spec. output, 1v RMS for 15 watts. Response 20-50,000 c.p.s. $\pm$ 0.25 dB. Feedback 23 dB. N.L. $-$ 95 dB below 15 watts. Out. imp. 3.75, 7.5 and 15 ohms. Output EL34's. Ultra-linear. Size 13 in. by 8 in. by 8 in. Weight 22 lb. To operate with RD Senior Mk. III control unit. Price £29



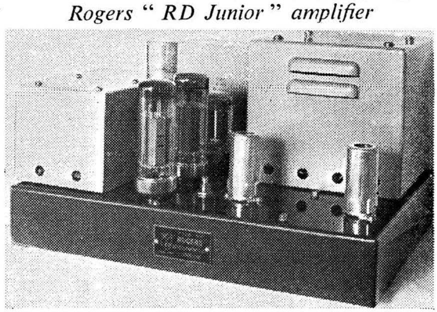
Rogers " RD Junior " control unit



Rogers " RD Senior " control unit



Rogers " RD Junior " amplifier



Rogers " RD Senior " amplifier

Sound Sales Ltd., Works and Acoustic Laboratories, West Street, Farnham, Surrey. Tel.: Farnham 6461-2-3. Cables: Sounsense.

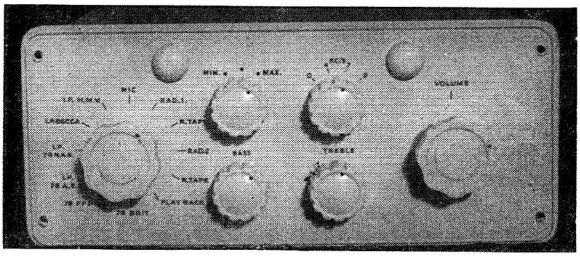
A-Z Wide Range Tone Control Unit Mk. III. Inputs : radio 150 mV ; P/U 10 or 25 mV. 5 pos. sel., treble, bass, vol. Switched filter 4, 7 Kc/s and " out." Tape input, special connection. H.D. 0.06% inc. power amp. H and N better than – 80 dB inc. power amp. P.a.t. from power amp. Size 11½ in. by 4¼ in. by 4¾ in. Weight 4½ lb. Sold only with A-Z Mk. III power amp.

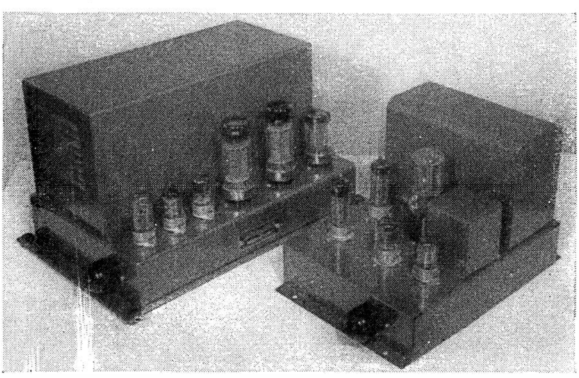
A-Z Mk. III Amplifier. 10 watts nom. 13.5 watts max. Dist. 0.06% at 8 watts. Input for spec. output, 18 dB below 1v for 10 watts. Response flat 12-17,000 c.p.s. ± 1 dB up to 27,000 c.p.s. Feedback – 22 dB. N.L. better than – 80 dB at 10 watts. Out. imp. 3, 6, 15 or 30 ohms. Output EL84's. Ultra-linear. Size 10¾ in. by 7⅛ in. by 6 in. Weight 13½ lb. Supplied only with A-Z wide range tone control unit. Price £25.

A-Z Senior Wide Range Tone Control Unit Mk. II. Inputs : mic. 5 mV ; radio 100 mV ; tape 250 mV. 12 pos. sel. : (1) radio 1 ; (2) record tape ; (3) radio 2 ; (4) record tape ; (5) tape playback ; (6) P/U, 78 Brit. ; (7) 78, FFRR ; (8) L.P. and 78 R.I.A.A. ; (9) L.P. and 78 N.A.B. ; (10) L.P. Decca ; (11) L.P. H.M.V. ; (12) mic., treble, bass, vol. Switched filter 4, 7 and 9 Kc/s. Tape input socket. H.D. 0.05%. H and N better than – 80 dB at 20 watts. Switched rumble filter. Pos. 1, cut at 40 c.p.s. down to 20 dB ; pos. 2, cut at 100 c.p.s. down to 20 dB and off. P.a.t. from power amp. Size 11¼ in. by 6 in. by 4¾ in. Weight 7 lb. Sold only with A-Z Senior power amp Mk. II.

A-Z Senior Mk. II Amplifier. 20 watts nom. 30 watts max. Dist. 0.05% at 20 watts. Response flat 10-30,000 c.p.s. Feedback 25 dB. N.L. – 80 dB at 20 watts. Out. imp. 3, 6, 15 or 30 ohms. Output EL34's. Ultra-linear. Size 14¼ in. by 8½ in. by 8½ in. Weight 35 lb. Sold only with A-Z senior control unit. Price £40.

Tri-Channel Tone-Colour Unit Mk. IV. Input : radio 100 mV ; tape 250 mV ; P/U 10, 50 and 100 mV. 12 pos. sel. (6 gram.), normal vol. (mid-channel response), treble (top-channel response), bass (bass-channel response), controlling 3 separate amplifying channels to appropriate speakers in speaker enclosure, via master volume control. Tape input, screwed sockets. H.D. 0.05% for 20 watts. H and N better than – 80 dB at 20 watts. P.a.t. from power amp. Sold only with Tri-Channel amp Mk. IV's and speaker enclosure.





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Sound Sales. Tri-Channel Control Unit, and the two Amplifiers, giving three channels. The control unit regulates the inputs to all three channels, which in turn drive their own speaker units (bass, centre, and treble). The speaker (page 120) *is included in the all-in price of* £115.

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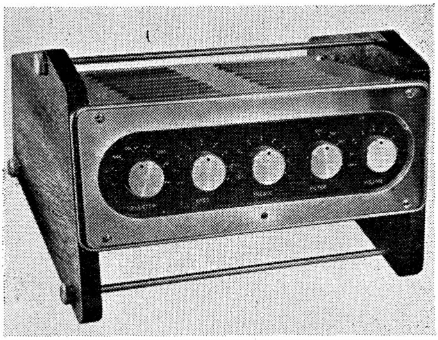
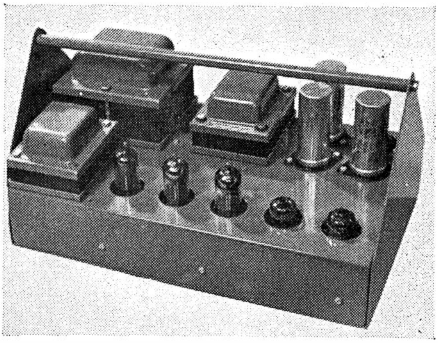
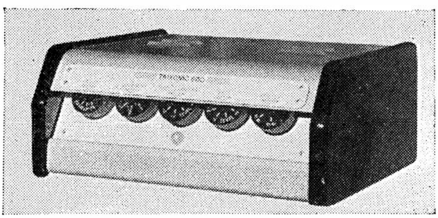


Thermionic TP100 control unit



TP100 amplifier



Trixonic T800 combined control unit and amplifier

Tri-Channel Amplifier Mk. IV. Bass 20/30 watts. Mid-channel 8-12 watts. Treble-channel 1-2 watts. Dist. 0.05%. Response infinitely variable on 3 channels. N.L. better than — 80 dB. Output EL84's, EL34's and LN309/PCL83. Ultra-linear. Price complete with control unit and Tri-Channel speaker enclosure £115.

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Specto Ltd., Vale Road, Windsor, Berks. Tel. : Windsor 1241/2. Cables : Specto, Windsor.

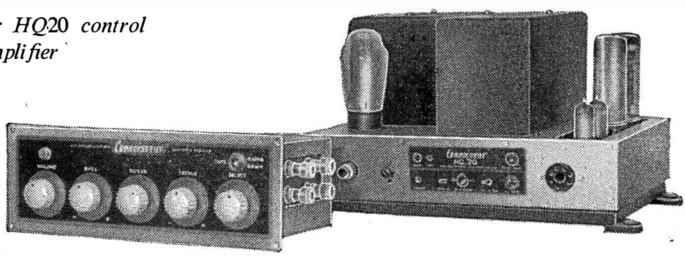
Spectone 5-15 " Eton " Combined Control Unit and Amplifier. 3 pos. sel. Plug-in equalisers for crystal P/U's. 10 watts nom. 15 watts max. Dist. better than 0.3% at 10 watts. Input for spec. output 500 mV. Response 20-20,000 c.p.s. $\pm$ 0.5 dB. Feedback — 26 dB. N.L. — 23 dB on 10 watts. Out. imp. 15 ohms. Output EL84's. Size 14 in. by 7 in. by 8¾ in. Weight 14¾ lb. Price £18 18s.

Eton Pre-amp. Available for low output P/U's, etc. Input 40 mV for 500 mV output. H.D. better than 0.1%. H and N — 73 dB. Size 6¼ in. by 3½ in. by 1⅞ in. Weight 17 oz. Price £4 4s.

Spectone 5-15 " Windsor " Control Unit. Inputs : radio 100 mV ; P/U 50 mV ; aux. 10 mV. 5 pos. sel., treble, bass, vol. and on/off. H.D. better than 0.15% on all inputs for 40 mV output. H and N — 54 dB on mic., — 73 dB others. Size 10 in. by 5 in. by 3 in. Weight 3¼ lb. Sold only with the Windsor power amp.

Spectone 5-15 " Windsor " Amplifier. 10 watts nom., 15 watts max. Dist. better than 0.3% at 10 watts. Input for spec. output 40 mV. Response 20-20,000 c.p.s. $\pm$ 0.5 dB. Feedback — 26 dB. N.L. — 23 dB on 10 watts. Out. imp. 15 ohms. Output EL84's. Size 14 in. by 7 in. by 8¾ in. Weight 14¾ lb. Price with control unit £24 17s. 6d.

Connoisseur HQ20 control unit and amplifier



A. R. Sugden & Co. (Engineers) Ltd., Well Green Lane, Brighouse, Yorks. Tel. : Brighouse 2397. Cables : Connoiseur, Brighouse.

Connoisseur HQ20 Control Unit. Inputs : radio, tape and P/U 10 mV. 5 pos. record char. switch, treble, bass, vol. Steep slope filter, 5, 7 and 9 Kc/s. Tape input sockets. H.D. at 1,000 c.p.s. better than 0.1% at 20 watts. H and N with amp 75 dB down on 20 watts. 30 c.p.s. rumble filter. Size 11½ in. by 4 in. by 4¾ in. To operate with HQ20 power amp. Price £16.

Connoisseur HQ20 Amplifier. 20 watts nom., 30 watts max. Dist. better than 0.1% at 20 watts. Input for spec. output 300 mV. Response 20-50,000 c.p.s. ± 0.5 dB. N.L. 85 dB at 20 watts. Out. imp. 15 ohms. Output EL34's. Ultra-linear. Size 12 in. by 8¼ in. by 7½ in. Sold only with control unit. Price £31 10s.

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Thermionic Products Ltd., Hythe, Southampton. Tel. : Hythe 3265/7. Cables : Technico.

TP100CU Control Unit. Inputs : mic. 50 mV ; radio 50 mV ; P/U (crystal) 100 mV; P/U (magnetic) average 20 mV. 8 pos. sel. (4 gram.), treble, bass, vol. and optional on/off. Switched filter, 5, 7 Kc/s and " out." H.D. < 0.1 %. H and N − 60 dB for 0.5 output. Rumble filter. P.a.t. 300v at 50 mA ; 6.3v at 2.5 A. Size 10⅝ in. by 7¼ in. by 5⅛ in. Weight 5 lb. 14 oz. To operate with TP100 power amp. Price £17 14s. (£1 15s. extra for special wooden " Book-End " stand.)

TP100 Amplifier. 10 watts. Dist. at 1,000 c.p.s., < 0.1% at 10 watts. Input for spec. output 0.5v. Response 25-30,000 c.p.s. ± 0.25 dB. Feedback − 20 dB. N.L. − 95 dB at 10 watts. Out. imp. 3.75 and 15 ohms. Output N709's. Size 11 in. by 7 in. by 5¼ in. Weight 14 lb. To operate with TP100CU control unit. Price £19 16s. (£1 extra for special carrying tray.)

Trix Electrical Company Limited, 1-5 Maple Place, London, W.1. Tel. : Museum 5817. Cables : Trixadio, Wesdo, London.

Trixonic T800 Combined Control Unit and Power Amp. Inputs : LP 4 mV ; 78 12 mV ; radio/tape 100 mV. 3 pos. sel., treble, bass, loudness control (additional bass and treble boost given at low vol. levels). 4 pos. pickup equalisation plug fitted. Tape input socket. H.D. at 1,000 c.p.s. < 0.5 % at 6 watts. H and N better than − 60 dB. Rumble filter 18 dB octave below 30 c.p.s. P.a.t. 270v at 20 mA, 6.3v at 1 A. 8 watts nom., 12 watts max. Response 30-15,000 c.p.s. ± 1.5 dB at 6 watts. Triple-loop feedback. Out. imp. 3, 8 and 15 ohms. Output EL84's. Size 12¼ in. by 9½ in. by 5 in. Weight 16¼ lb. Price £33 12s.

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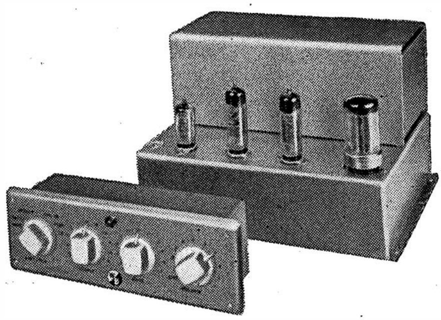
Whiteley Electrical Radio Co. Ltd., Victoria Street, Mansfield, Notts. Tel. : Mansfield 1762/3/4/5. Cables : Whitebon, Mansfield.

Stentorian WB12 Control Unit. Inputs 50 mV. 6 pos. sel. (3 gram.) treble, bass, vol. Tape/Radio input socket. H and N − 72 dB at 10 watts. P.a.t. 300v at 50 mA, 6.3v at 1.5 A. Size 9 in. by 3⅛ in. by 3¾ in. Weight 2½ lb. Sold only with WB12 power amp.

WB Amplifier. 12 watts nom., 15 watts max. Dist. at 400 c.p.s. 0.2%, at 1,000 c.p.s. 0.12%. Response 20-20,000 c.p.s. ± 0.15 dB. Feedback 25 dB. N.L. − 80 dB at 10 watts. Out. imp. 3-4 and 15 ohms. Output EL84's. Ultra-linear. Size 10⅞ in. by 7⅛in. by 9 in. Weight 13 lb. Price including control unit £25.



Whiteley Stentorian WB12 control unit and amplifier

OUTPUT TRANSFORMERS

By R. B. Gilson

— Notes on their application to audio frequency amplifiers —

WHEN considering the design requirements for A.F. transformers, it is as well first to consider the properties of an "ideal" transformer, and then to decide how nearly one may approach this "ideal" in practice. **Fig. 1** shows this ideal diagrammatically, and it will be seen to consist of two windings and a core—with no winding resistance and no leakage inductance, no stray capacitance, magnetising current or core loss. It will, therefore, have a voltage ratio equal to the turns ratio; and as the power dissipated in a pure load equals V^2/RL, it will have an impedance ratio equal to the turns ratio squared; $ZP = (NP/NS)^2 \times RL$. **(Eq. 1).**

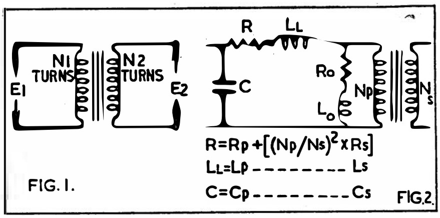


FIG. 1. FIG. 2.

Now a **practical** transformer may be represented by an equivalent diagram, as in **Fig. 2,** in which **R** = equivalent copper resistance. **LL** = equivalent leakage inductance. **Rolo** = equivalent core loss network. **C** = stray shunt capacitance.

R will be least when the copper loss is equal in primary and secondary; and as output transformers carry a d.c. component of current in the primary which cannot be induced in the secondary, this means that more space must be allocated to the primary than to the secondary winding. The relative proportions being equal to **(Eq. 2).** $\sqrt{IDC^2 + IP^2}$ /I.S. to a first approximation.

Here it may be mentioned in passing that the practice of winding several secondary sections in multi ratio output transformers is a most convenient way of complying with the constant loss requirement for various load impedances. N sections in parallel are equal to a single section, so far as turns ratio go, but are able to carry N times the current of all the sections wired in series. From this it will be seen that the term NS in Equation I refers to the number of secondary turns connected in series aiding.

Lo is mathematically equal to

$3.2 \times 10^{-8} \times N^2 \times \mu \times A/l$ Henries **(Eq. 3)**

where N = primary turns: μ = permeability of core material: A = area of core: l = length of magnetic path.

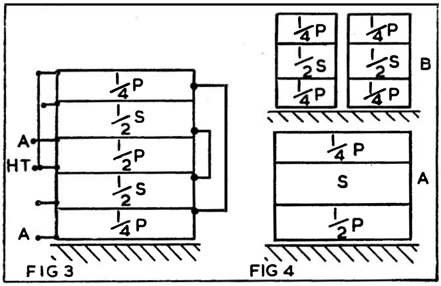
Unisil, a New Material

From this it follows that a higher value of μ can be related to a smaller value of A. In this respect a relative newcomer to the field of transformer laminations—cold rolled "Unisil" silicon steel, possessing grain orientation properties—shows a marked advantage over the older grades of hot rolled material.

This "Unisil," when in lamination form is, for economic and other reasons, mainly of interest when in the form known as "waste free." It is also widely used in the form of C cores when expense is not of first importance. For a given low frequency performance it may be stated empirically that **3lbs. of "Stalloy", or 1.6lbs. of "Unisil", or 1.25lbs. of C cores** can be wound to give the same low frequency power output in the case of push pull power output transformers, allowing about the same percentage of copper loss in each case.

LL is proportional to N^2 and $1/S^2$ where

N = the number of winding sections interleaved radially, when the first and last



sections are half subsections **(Fig. 3).** L_L is also proportional to t/l^1 when l^1=layer length, and t=radial depth of windings.

C is the sum of the stray capacities between turns, layers and winding sections. In the case of interleaved layer-wound coils, the latter two will be approximately proportional to $l^1/t \times Lmt$ where Lmt= length of mean turn. It now becomes apparent that a compromise must be affected between a small ratio of t/l^1 for low L_L, and a small ration of l^1/t for low C.

C must also increase as the number of winding sections, S, are increased, and this must of course be taken into account when S is being calculated for L_L. The calculation of C is rather difficult though Mr. N. Crowhurst[3] has produced some very useful abacs and diagrams which enable this to be done to a reasonable approximation.

Asymmetrical & Symmetrical Windings

It has been shown earlier that the ratio t/l^1 cannot be made optimum for L_L and C at the same time; it is therefore valid to adopt a rather different approach, and **Fig. 4** shows two possible arrangements of windings. Arrangement A will be seen to be asymmetrical, and B symmetrical. The asymmetrical arangement is now generally preferred, at least for small transformers up to 50 watts or so, as each half primary will have a different self-resonant frequency, resulting in heavy damping and far less tendency towards "ringing."

This automatically fixes a value of t/l^1 in the case of "Unisil" waste-free laminations, and for C cores, for each of these has a constant ratio of t/l^1 in the window proportions, and each is designed with the intention that the window space should all be filled with windings.

3 E. Eng. Nov. 1949

It is necessary that the transformer "pass band" (that is, the frequencies between LF cut-off due to iron saturation, and HF cut-off due to self-resonance, this latter being affected by stray valve and wiring, etc., capacities) should be wider than the amplifier pass band. The requirements of different "home constructors' " amplifiers vary considerably in this respect, and all the well-known circuits are published with a minimum specification laid down for the output transformer. A better transformer than that specified to meet the minimum requirements will generally result in lower levels of distortion at frequencies near the top and bottom limits of the pass bands, by improving the loop gain at those frequencies.

Tapped Screen Transformers

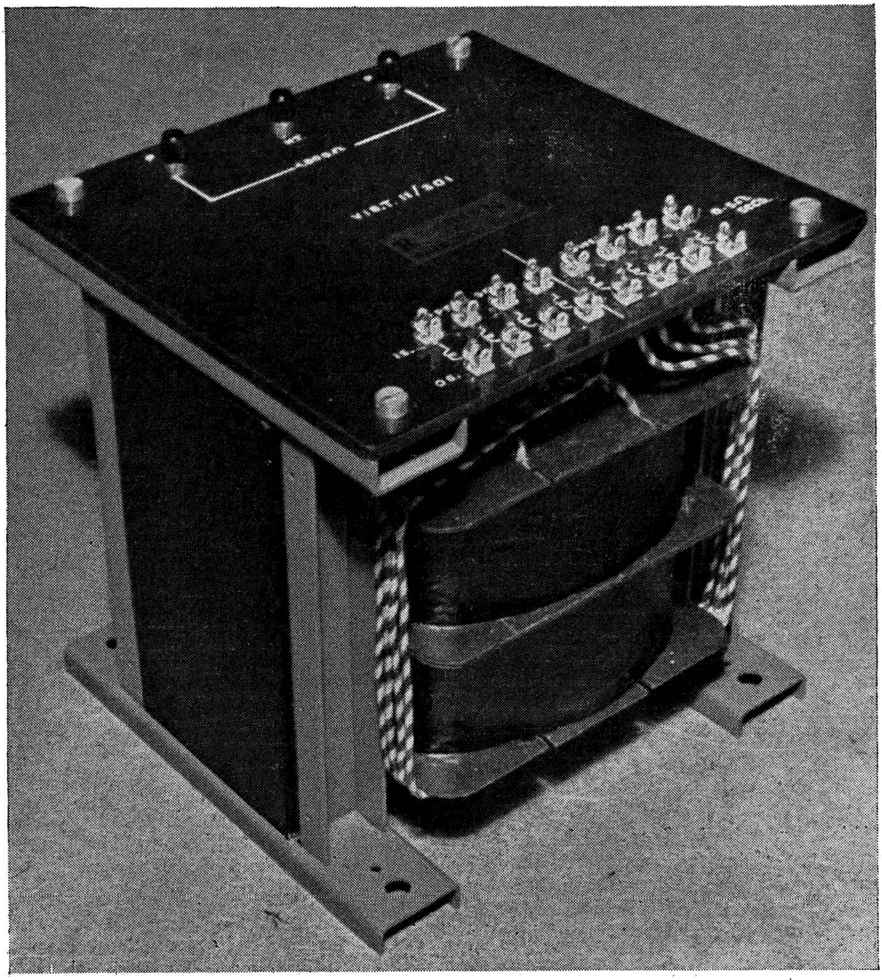
Tapped screen transformers (usually referred to as U.L. output transformers), pose a special problem, in addition to those already considered; namely, that stability in the output stage, which now contains its own feedback loop, can be conditional on certain screen and anode coupling factors being achieved in the transformer winding design. In particular, stray capacity must be so proportioned that a Colpitts mode of oscillation is not initiated at some very high frequency; this can even occur in the region of a megacycle, and can result in the loss of available power output. Leakage inductance must also be proportioned in such a way that the stage does not act as a multivibrator type of oscillator if accidentally overloaded at low frequencies.

Increases Power Output

Provided the above mentioned conditions are complied with, the U.L. method of operation results in the availability of some 2½ times the power output than can be obtained with triode connection for a given power consumption, without any loss of the advantages of low plate impedance, and low value curvature distortion. This obviously means that all the iron-cored components used in the amplifier can be smaller without loss of performance.

It is well to remember that most modern amplifiers employing large values of negative feedback will give a large output, relative to basic cost, but will exhibit a sudden onset of severe distortion if overloaded, and they should not generally be driven too close to the overload region. This latter provision is hardly important to the majority of domestic users, many of whom will in fact get as satisfactory a performance from a 6-watt or 7-watt triode connected output stage, as from a 12-watt or 15-watt U.L. stage, employing the same output valves in each case.

Summing up, it may be said that any output transformer can be regarded as a good one if it adequately meets the requirements of the amplifier it is intended to be used with ; and a completely satisfactory performance can be obtained from push-pull amplifiers equipped with transformers weighing no more than a couple of pounds. There are some basic requirements that may be regarded as common to all push-pull output transformers ; principally, the self-resonant frequency should not be lower than about 50 Kc/s, and the full rated power should be handled comfortably down to about 30 c/s without serious distortion. The other parameters can vary over quite a wide range, provided that they at least meet the minimum requirements specified for the amplifier circuit they are to be used with.



An output transformer designed and built by the author of this article for public address work. The normal working capacity of this component is five hundred watts.

NOISE IN REPRODUCERS

by H. L. York

ABSENCE of background noise is an important factor in the attainment of realism in reproduction. Hum or hiss indicates immediately that sound is reproduced and prevents any possibility of the illusion of realism being created even when other factors are favourable. A listener can mentally separate noise from signal, but some effort is involved in the process, and this undoubtedly contributes to listener fatigue. It is relevant, therefore, to consider how much noise can be tolerated and how much noise can be expected from reproducing equipment.

Room Noise Levels

A quiet living room is not free from noise due to traffic vibration, etc., which has an intensity level of about 35 dB. If the quiescent noise from a reproducer is to be inaudible, the noise level must be below that of the room, and 30 dB may be taken as satisfactory. The equivalent acoustical power for an intensity level of 30 dB for rooms of various sizes is as follows:—

Volume of room in cubic feet	1,000	2,000	3,000	4,000
Acoustical power in microwatts	0.015	0.03	0.045	0.06

Acoustical power in microwatts for an intensity level of 30dB in a quiet room having optimum reverberation time. (After Olson.)

Taking a room 16ft. × 12ft. × 10ft., having a volume of about 2,000 cubic feet, the maximum permissible acoustical power for reproducer noise is 0.03 microwatts. If the loudspeaker in use is 5% efficient, the maximum permissible electrical noise power from the amplifier is 0.6 microwatts. If the noise rating of the amplifier is 80 dB below 15 watts, it will in fact produce only 0.15 microwatts, which is well below the calculated maximum. A normal amplifier, however, will require an input of about 0.75 volts to produce 15 watts, and some preamplification is necessary.

A well designed preamplifier stage, having a band-width of 15 Kc/s and using a special low noise valve, will produce noise which may be represented by an input of about five microvolts. If the stage gain is 100, the noise output will be 500 microvolts, and with this input the main amplifier will produce 6.6 microwatts of noise, which is considerably above the calculated maximum. To limit the noise output to 0.6 microwatts, the gain of the preamplifier stage must not exceed 30.

Oscilloscope and Ears

These conclusions were checked experimentally and the noise levels obtained were judged to be very close to those predicted. An oscilloscope showed the noise to consist of hum and hiss, but due to the relative insensitivity of the ear at 50 c/s the noise output in all cases appeared to consist of hiss only.

In a practical preamplifier more than one valve will be used and some, or all, may not be of the low noise type. Additional components will add to the noise level, so that the maximum preamplifier gain for the amplifier, loudspeaker and room under consideration may be less than 30.

Volume Control Placing

To obtain the highest possible signal to noise ratio the volume control should not be placed in the input circuit. If it be placed after the input stage it will limit the signal to the following stages, which will then operate with minimum distortion.

An input stage having a gain of five, followed by a volume control and an output stage with a gain of five, is a satisfactory arrangement.

If a tone control stage having a mid-frequency gain of unity is included in the preamplifier, when boost is applied the noise level will rise. Frequency correction circuits for gramophone and tape have characteristics which give higher gain at low frequencies than at high frequencies. If the mid-frequency gain of the preamplifier with such correction is unaltered, hum will be increased whilst the high frequency components of hiss will be reduced.

Examples

Considering the case of an amplifier requiring 0.75 volts for 15 watts output, coupled to a preamplifier with a gain of 25, the input for 15 watts output is 30 millivolts. A radio tuner will normally have an output in excess of this figure, so that some reduction in gain (by negative feedback to reduce distortion) is desirable. If a gramophone pickup is used and maximum recorded velocity assumed to be 10 cm/sec, the pickup must have a sensitivity of 3 mV/cm/sec to produce 15 watts output. To have something in hand, a sensitivity of 6 to 10 mV/cm/sec would be preferred. Many pickups of the highest quality and in all price ranges are available with this sensitivity.

If a pickup of a lower sensitivity than that mentioned is to be used with the equipment, additional gain will be required and the resulting increase in noise output must be accepted. Similarly, a microphone or tape replay head will normally require additional gain. When possible this should be obtained by the use of a good input transformer, which will reduce the preamplifier gain required and will also improve the signal to noise ratio.

Preamplifier Gain

It is not good practice to make the gain of the preamplifier high and to rely upon a volume control in its output section to adjust the overall gain to the required value. Whilst this arrangement will give minimum noise output, high input signals may overload the later stages of the preamplifier, causing distortion, and the volume control will frequently be at an inconveniently low setting. The use of an additional input volume control to avoid these difficulties immediately leads to high noise output, and may also cause the signal to noise ratio to be less than desirable.

Subamplifiers

Additional gain is best obtained by switching an extra valve stage into circuit when the signal is so low as to require this. One disadvantage of this arrangement is that it increases the size, complexity and cost of the preamplifier, and a user not requiring the stage may legitimately object.

A more flexible method is to use a "sub" amplifier; i.e. a single stage amplifier unit, outside the preamplifier, connected to the input circuit in which additional gain is required. The preamplifier remains simple and will operate with a low noise output, the cost of the subamplifier being incurred only when it represents a small addition to the cost of an expensive item, such as a ribbon microphone or tape deck. The subamplifier unit is small and it may be placed out of hum fields and in a position where the input lead is short.

RADIO TUNERS

By R. S. Roberts

INTRODUCTION

RECEPTION of radio programmes has some priority with users of high quality reproducing equipment. It is probably true that there was a time when radio reproduction was capable of better quality than any other means of home entertainment. With the advancing years, and the introduction of L.P. records and tape recording, the old-established broadcasting systems have shown up their shortcomings. With the introduction of VHF broadcasting, radio reproduction now achieves the high standards of quality that are expected from tape and discs.

Tuner units for feeding a radio programme into an amplifier are available in three general types. A restricted range of tuners can be obtained for reception of AM transmissions. A range of units can be obtained for use on the relatively new FM transmissions by the BBC on the VHF band, and many manufacturers offer a comprehensive tuner for use on both AM and FM bands.

AM

AM broadcasting has, of course, been with us since the inception of broadcast home entertainment. It has many advantages and disadvantages and, on the credit side, we may list the following : **(a)** It is possible to receive European stations, and also programmes from most parts of the world by the use of short-wave bands. **(b)** A tuner for use on local stations becomes relatively simple, and technical complications in use and design are relatively few.

The disadvantages of AM are many, and most of them are factors affecting quality such as : **(a)** The band-width occupied by the station is restricted, due to the bands available for AM broadcast being very congested. It is necessary to restrict the band-width in order to avoid interference with a station occupying an adjacent channel, and such a restriction deprives the transmitter of any possibility of maintaining a good high-frequency response. **(b)** An AM receiver is extremely susceptible to any form of " noise " that may be received along with the required station, such as heterodyne whistles and electrical disturbances. Such " noise " has a twofold effect : First, its presence creates an annoyance to the listener and detracts from enjoyment of any programme, and second, the dynamic range of the programme material is restricted, due to the necessity to raise the quieter passages above any noise level that might prevail at the receiver.

FM

The FM system also has advantages and disadvantages. It is a system that requires a very much wider band-width than an AM system, hence it must be used in a part of the r.f. spectrum where wide channel spacings can be used. By international agreement, part of the VHF Band (known as Band II in this country) is used for FM broadcasting, and in Europe this band occupies 88-100 Mc/s.

Use of the VHF band means that the range of a transmitter will be short, and the user of an FM tuner can expect to receive local transmissions only. The BBC scheme for VHF transmission is intended for complete coverage of the country with a number of stations, each of which will radiate the Home, Light and Third programmes.

FM Tuner Techniques

Tuners for operation on the FM band use many techniques that are quite different from those used on AM receivers. Problems of design and use entail circuit complications that do not arise with AM, and it is in the solution of some of these problems that one finds the main differences between one make of tuner and another.

The advantages of FM are many but, to the listener, there are two main reasons why it is a superior system for local station reception : **(a)** It discriminates heavily against noise. The reason for this is that noise is mainly AM in character, and a well-designed FM receiver will not give an output from any form of AM signal input. **(b)** With no restriction on band-width, it is possible to use high modulating frequencies. A third advantage is not yet being fully utilised. In the absence of modulation, an FM signal provides a very silent background indeed when compared with AM, hence it is possible to allow the quieter modulation passages to descend to a lower level than is possible with AM. This results in a greater dynamic range with a consequent closer approach to realism in reproduction.

Amplitude Modulation

AM (or amplitude modulation) principles are fairly well known by now. The transmitter output remains at a constant level in the absence of modulation ; when modulation takes place due to speech or music, the transmitter output rises and falls at the frequency of the modulation. The amount of the rise and fall is determined by the loudness of the modulation, and the limit is determined by the fact that the transmitter output cannot fall below zero ; at this limit, the modulation level is said to be 100 per cent. The alternating current in the transmitting aerial, oscillating at the frequency of the transmitter, causes an electro-magnetic wave to be radiated with the speed of light, and any wire erected in the path of the radiated field will have an alternating current developed in it by the field. The current in the receiving aerial system will be a scaled down replica of that in the transmitter aerial, and the current will vary in a manner depicted

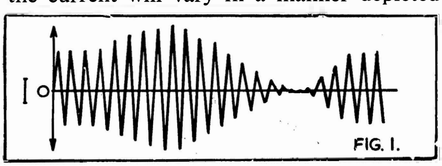


FIG. 1.

in **Fig. 1** which shows the current variation for a short period of no modulation, followed by one cycle of 100 per cent. modulation, followed by another period of no modulation. Although the receiver aerial current is a replica of the transmitter aerial current, other currents will also be flowing ; these are caused by other transmitters and noise.

Another effect of amplitude modulation (not apparent from Fig. 1) is the production of side bands. If the modulating frequency is, say, a pure tone of 1,000 c/s, two additional frequencies are produced, one above and the other below the nominal transmitter frequency ; the " side " frequencies are spaced from the centre (or " carrier ") frequency by 1,000 c/s. If the modulation is produced by speech or music which covers a wide band of audio frequencies, the side frequencies become side bands. For good quality, the a.f. modulation should extend to 10 or 15 Kc/s, resulting in a total frequency band-width of 20 or 30 Kc/s.

Station Spacing

The sound channel of a television transmitter does, in fact, occupy a wide band-width, and is capable of being reproduced with a high degree of good quality, but the much older AM stations on medium and long waves suffer from the fact that too many stations have to occupy too few channels. On the medium wave band, stations are spaced with their carriers 9 Kc/s apart and, if interference from an adjacent station is to be avoided, it is clear that one cannot expect to receive a.f. modulating frequencies higher than 4.5 Kc/s. The last remark requires a qualifying observation ; a great deal depends on the distance from the local station, and if the local signal is strong the strength of adjacent channel stations can be made insignificant with a good tuner design. It then becomes possible to use a wide band receiver and to take advantage of any high modulating frequencies that may be used at the transmitter. The side bands may be attenuated, but to receive them at all improves the quality of reproduction.

Fringe Areas

The fringe area listener is in the unfortunate position that the station he wishes to hear has a strength comparable with the stations allocated to the adjacent channels. The adjacent stations give rise to two forms of interference ; a 9 Kc/s " beat " interference exists, being produced by the two carriers 9 Kc/s apart. (More often, due to inaccurate channel spacing, the " beat " or " whistle " is produced at a lower frequency). A second form of interference is produced by the side bands of the adjacent station encroaching on the band-width occupied by the required station. The characteristic noise produced by this form of interference is often termed " monkey-chatter." Both forms of interference can be reduced by restricting the receiver band-width which, of course, degrades the quality of reproduction.

" Noise " has been mentioned as a source of interference and, again, the fringe area listener is very vulnerable in this respect. Electrical disturbances are set up by thunder storms, commutator motors, domestic electrical devices (such as vacuum cleaners or electric irons—even a light switch) and all of these can radiate a band of frequencies which are predominantly amplitude modulated and which may be picked up by the receiver along with the desired station. Very little can be done to reduce the annoyance value of these disturbances once they have developed a current in the receiver aerial and, although the band-width of the receiver may be still further reduced to afford some relief at the expense of quality, noise is an ever present companion to the programme where the fringe area listener is concerned.

Frequency Modulation

FM (or frequency modulation) is relatively new to this country, but as an alternative system of modulation to AM is very old in principle, and has been established as a broadcast system for very many years in the U.S.A. In Germany it is the only system in use for domestic broadcasting, and has been in operation in that country since the last war.

In this system, the transmitter aerial current amplitude does not change during modulation as in **Fig. 1.** The amplitude is maintained constant, and the process of modulation causes the radiate frequency to change as

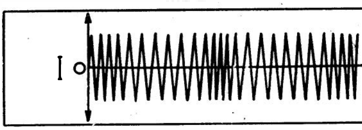


FIG. 2.

indicated in **Fig. 2.** The extent of the frequency change about the mean value is determined by the intensity of the modulating signal, and the number of times the frequency swing occurs per second is determined by the frequency of the modulating voltage. In the absence of modulation, the radiated signal frequency is steady and unvarying.

The band-width occupied by an FM transmission is very much wider than that of AM. If an FM station is modulated by a pure tone of, say, 1,000 c/s an infinite range of side frequencies are generated, spaced 1,000 c/s above and below the centre frequency, continuing down to zero frequency and up to infinity, spaced 1,000 c/s apart. This alarming picture of band-width is not quite so bad as it appears, because the amplitude of the side frequencies falls to an insignificant level after a certain point removed from the centre frequency.

If the highest modulation frequency is taken as 15 Kc/s, side frequencies are found spaced every 15 Kc/s away from the centre frequency and, as in AM, the pass band of the receiver must include the important side frequencies if the reproduced modulation is to sound anything like the original. For 15 Kc/s it is necessary to include seven or eight of the side frequencies on each side of the centre frequency, thus the pass band of the receiver should be 210-240 Kc/s wide.

Low modulation frequencies require many more side frequencies for faithful reproduction but, as they are spaced closer together, the band-width determined by the highest modulating frequency is more than adequate for the lower frequencies. The relatively wide band-width of an FM transmission precludes its use in the existing broadcast bands, hence the allocation of frequencies in the VHF band where adequate space exists.

FM Advantages

Many advantages are offered by the use of FM as a broadcasting system. On the transmission side, the fact that the range is essentially local means that one channel frequency can, with adequate geographical spacing, be used many times, if necessary, for nation-wide coverage with a number of transmitters. Even if a risk of co-channel interference was likely, another property of FM comes into operation to ensure freedom from interference. An FM receiver presented with two signals on the same frequency will reject the weaker and accept the stronger.

To the listener, the two main advantages are : firstly, the possibility of obtaining good quality and, secondly the possibility of obtaining a programme free from interference due to other stations or " noise." In some parts of the country which have been poorly served by the existing AM system, the second advantage mentioned above may, in fact, be the most important.

Signal/Noise Ratio

Whatever the type of tuner, whether AM or FM, the design should incorporate certain obvious features to ensure the best signal/noise ratio and quality. Even the superior qualities of FM will not be realised unless the tuner is given a chance, by being presented with the best possible signal.

It is a considerable temptation to operate a sensitive tuner on a convenient piece of wire that happens to be around ; but to obtain the best results from any tuner it should be fed from the best input voltage it is possible to provide—and this means the best possible aerial it is convenient to erect.

The tuner should incorporate an r.f. amplifier stage. This is a real contribution to improving signal/noise ratio, particularly when the receiver is a superhet.

The FM Tuner

Many tuner designs are now available for feeding the local station programme into a high quality amplifier. The technique of VHF receiver design is relatively new and, as a consequence, many different approaches to the problems are found.

The basic design is a superhet receiver with an r.f. amplifier stage preceding the mixer, followed by one or two i.f. stages. The demodulator is, of course, of a type that will provide an a.f. output for a frequency deviation. The a.f. output may be available directly from the demodulator or via a cathode follower. The tuning range will be 88-100 Mc/s, although some tuners (designed for European and U.S. markets) will cover 88-108 Mc/s.

The r.f. stage may be a pentode, although a triode operated as a grounded-grid amplifier is widely used. At VHF the triode has several advantages over the pentode, chief of which is the lower noise level produced in the amplifying process. The input to the stage is generally broadly tuned, and pre-set to the centre of the band.

The coupling from the r.f. stage to the mixer is conventional, but often includes a feature found in many FM tuners. One aspect of FM tuner design is that, under certain circumstances, any radiation of the superhet oscillator frequency can cause interference to other FM receivers and television receivers.

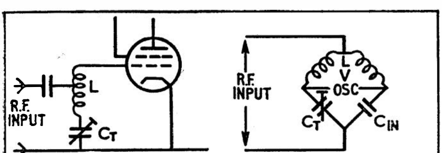


FIG. 3A. FIG. 3B

Fig. 3 (a) shows one system often used to minimise oscillator radiation. L is the input coil to the mixer across which the oscillator voltage may be developed. As shown in **Fig 3 (b)** the circuit forms, in conjunction with the mixer input capacitance C_{IN} and the pre-set capacitance C_t, a bridge circuit that may be balanced so that a minimum oscillator voltage appears across the r.f. input.

The mixer-oscillator combination generally follows conventional practice, except for the use of the so-called " self-oscillating mixer." **Fig. 4** shows the circuit principle of this system. L_1 forms the primary of the i.f. transformer. C combines the functions of providing feedback for the oscillator L_2-L_3, and forming the i.f. primary tuning capacitance. This particular system is often used in tuners where valve economy is a consideration ; a twin triode can provide a grounded-grid r.f. stage and oscillator-mixer stage.

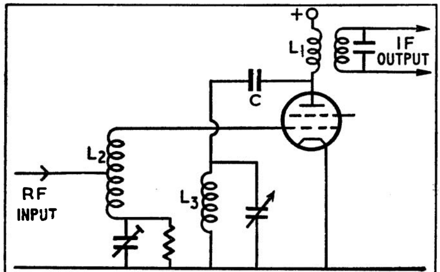


FIG. 4.

A number of tuners use a separate triode as the oscillator, feeding into a pentode or triode mixer. The main reason for this is that the oscillator circuit of an FM receiver requires rather special consideration.

Intermediate Frequencies

The i.f. used in FM receivers tends to be standardised at 10.7 Mc/s (although several manufacturers use a frequency higher or lower than this figure), and the oscillator must thus operate in the region of 100 Mc/s. The i.f. band-width is wide, but the signal must remain tuned accurately centred in the i.f. channel ; any appreciable drift of oscillator frequency will result in distortion, and this calls for a very high order of frequency stability and care in tuning.

Temperature changes in the oscillator components are one of the main causes of oscillator frequency drift, and compensation for temperature effects is often carried out by the use of special capacitors, with positive or negative temperature co-efficients. One manufacturer uses (instead of a conventional coil and capacitor oscillator) a resonant line oscillator in which the oscillator frequency is determined largely by mechanical dimensions of the line rather than the electrical characteristics of the circuit.

The quartz crystal oscillator is well known for its frequency stability, and one manufacturer uses these. Programme selection is by means of a switch that can bring any one of three crystals into circuit ; no " tuning " being necessary.

A number of tuners use Automatic Frequency Control (AFC). In this system, a valve is connected in such a manner that it behaves as a reactance. The magnitude of the reactance is determined by a control voltage derived from the demodulator, and the reactance valve is connected across the oscillator circuit. When correctly arranged, any " off-tune " in the oscillator produces a correction voltage at the demodulator, which biases the reactance valve in such a manner as to bring the oscillator back to its correct frequency. One advantage of this system is that the " tuning " operation can become less critical than it might be without AFC. When the required station is being tuned, the AFC system can take charge as the oscillator approaches correct frequency.

The i.f. stage is conventional in design, usually operating on a frequency around 10.7 Mc/s and having a flat pass-band about 200-300 Kc/s wide. The usual types of band-pass transformer couplings are used, but the circuit operation of the final i.f. stage is often that of an amplitude limiter.

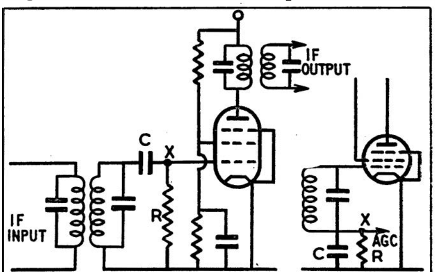


FIG. 5A. FIG.5B

The FM receiver must, of course, give no output from any signal input that is amplitude modulated, and amplitude limiting is an essential process of the receiver's operation. **Fig. 5 (a)** shows a typical limiter stage in which, by a careful choice of the CR time constant and the correct potentials for anode and screen, the signal amplitude is held substantially constant.

The grid circuit passes grid current and the capacitor C assumes a negative potential of a magnitude depending on the strength of the signal. The point X thus provides a useful source of AGC voltage, and the variation shown in **Fig. 5(b)** is often used as being more convenient in providing the AGC facility.

Where limiting is carried out elsewhere in the receiver, the last i.f. amplifier is often operated as a delayed limiter. The circuit is the same as in **Fig. 5** except that a standard cathode biasing system is used as well. This permits the valve to operate as a normal amplifier for weak signals, but as a limiter for strong signals.

The demodulator for the FM receiver is completely different from its AM counterpart. The demodulator is required to provide an a.f. output from a frequency change, but no output from an amplitude change.

Various Demodulators

FM is unique in that a large number of possible demodulator systems exist, although the two most popular today are the Foster-Seeley **(Fig. 6)** and the Ratio detector **(Fig. 8).** Both of these systems require two diodes, and both thermionic valves and Germanium

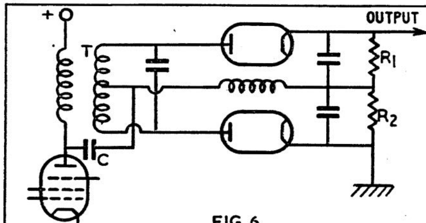


FIG. 6.

diodes are used. **Fig. 6** shows the Foster-Seeley phase discriminator and its operation is as follows : T is the final i.f. transformer and provides the two diodes each with a voltage 90° out of phase with the primary voltage, and 180° out of phase with each other. The capacitor C provides an equal primary voltage to each diode. At the centre frequency, the vector sum of the diode voltages are equal, the currents in R_1 and R_2 are equal and the output voltage is zero (R_1 and R_2 being equal in value).

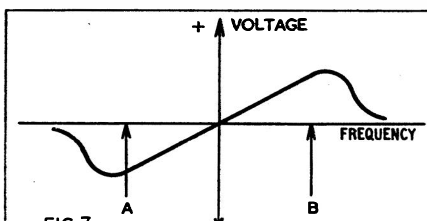


FIG. 7.

If the frequency changes, the phase of the secondary voltages will change, one diode receiving a voltage leading in phase and the other lagging. The diode currents will now be dissimilar and a D.C. voltage will appear at the output. A change in frequency in the other direction will produce an output voltage of opposite sign, and a curve relating output voltage to frequency will look somewhat like **Fig. 7.** The curve should be linear between the points marked A and B, representing the standard maximum deviation of ± 75 Kc/s.

Unfortunately, this demodulator is sensitive to AM—that is, it will provide an a.f. output if the input signal is amplitude modulated as, for instance, by noise. It *must* be preceded by a limiter, and two limiters are often used to improve the signal/noise performance.

A modification of the original Foster-Seeley detector produced by Seeley and termed a " ratio detector " is shown in

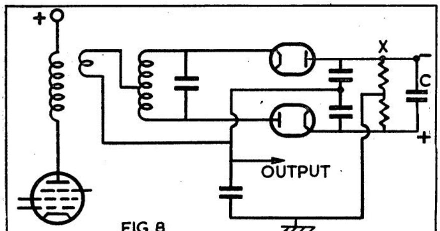


FIG. 8.

Fig. 8. The operation of the circuit is similar to the Foster-Seeley, except that the diode loads are in series and the voltages add to charge a relatively large capacitor C. The *ratio* of the voltage changes produced by a frequency swing is taken off the output point, the *sum* of the voltages being held constant by C. The ratio detector is very popular because it is inherently self-limiting, and i.f. stages can be used to provide full gain. The circuit is available in many modified forms, one of which is shown in **Fig. 9.** Another advantage of the circuit is that the point marked X in **Figs. 8** and **9** is a negative D.C. potential of a magnitude dependent on the strength of the signal, hence it can be used as a source of AGC voltage. The limiting action of the ratio detector is not perfect and at least one manufacturer uses a limiter stage ahead of the detector. The resulting AM suppression is then very good indeed.

" Counter " Type Detector

The many other possible systems of demodulation seem to be neglected, although one firm use a so-called " counter " type of detector. In this system, the signal is converted to pulses, and the pulses are caused to charge a capacitor, the voltage to which the capacitor is charged depending on the number of pulses per second. When the frequency varies during modulation, the number of pulses per second will vary and hence the charge on the capacitor will vary at the modulating frequency. The a.f. output from the demodulator is either taken direct or via an additional valve used as a cathode follower ; the advantage of the latter system being that a long screened lead can be used without detriment to h.f. response.

Whatever the output system, it must include a de-emphasis circuit. The FM transmitter uses a system, termed " pre-emphasis " whereby the a.f. output is lifted for frequencies in excess of 2-3 Kc/s. The rate of rise is standardised in terms of the circuit time constant, which is 50 μ secs. The reason for pre-emphasis is that, in FM, noise is proportional to frequency and, by raising the level of the higher audio frequencies at the transmitter, and reducing the level at the receiver, the a.f. response is restored to correct level whilst the noise is reduced.

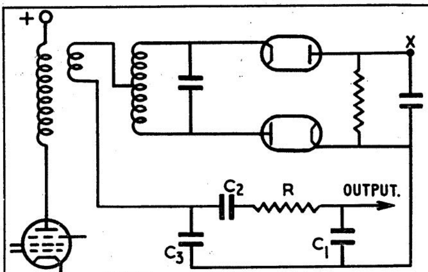


FIG. 9.

Fig. 9 shows a de-emphasis circuit in the output system, marked R and C_1. The values are chosen to provide a time constant of 50 μ secs. ; the reduction in h.f. response will then be at the same rate as the rise at the transmitter. (C_2 is a large value a.f. coupling capacitor, and C_3 is for r.f. by-pass.) In at least one tuner, the capacitance C_1 is provided by the screened output lead.

Combined AM-FM Tuners

Many firms manufacture tuners which offer the choice of the usual AM bands and, on one of the switch positions, the FM band. The design problems of such a tuner are usually concerned with using circuits that will ensure maximum economy of valves, by making the valves operate in both the AM and FM positions as far as possible. It would, of course, be easy to switch from an AM receiver to an FM receiver, but such a system mounted on one chassis would not be economical or cheap.

Considerable circuit ingenuity exists in the various makes of combined tuner, and **Fig. 10** shows, in block schematic form, one of the many possible arrangements. The tuners are usually separate, but the AM frequency changer plays a dual role by becoming an i.f. amplifier when switched to FM. The i.f. amplifier is usually combined in such a manner that each i.f. valve amplifies the AM or the FM signal presented to it. The output from the i.f. amplifier is presented to the appropriate demodulator, and the a.f. amplifier input is switched accordingly.

The i.f. transformer for AM and FM operate on different frequencies, those for AM usually being around 470 Kc/s, and the FM about 10.7 Mc/s. These are sometimes switched into circuit as required, but often the selection for correct operation is automatic, as shown in **Fig. 11.** The upper transformer is for AM, and C_1 is usually

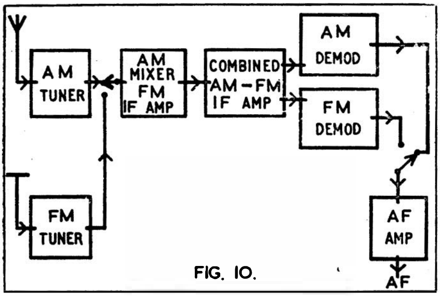


FIG. 10.

about 120 pfds ; the lower transformer is for FM, and C_2 is usually around 12 pfds. The high reactance of L_1 and the low reactance of C_1, combine to make this circuit virtually a decoupling circuit when the input signal is on 10.7 Mc/s ; but at 470 Kc/s, L_2 has such a low reactance, and C_2 such a high reactance, that the anode circuit " sees " the lower frequency to which L_1 and C_1 are tuned.

Another feature often found in combined AM-FM tuners is variable selectivity in the

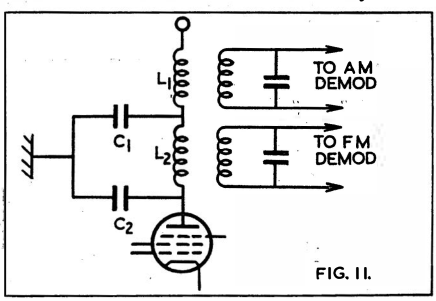


FIG. 11.

AM position. As previously mentioned, selectivity on AM is generally a compromise, and by varying it, one can obtain some enjoyment of distant programmes at the expense of quality. For semi-local station use, it is possible to open up the pass band and take advantage of some noise suppression that the stronger signal will provide by the generation of a larger AGC voltage.

Where variable selectivity is provided, the change-over from FM transformers to AM is usually complete, the AM operation often

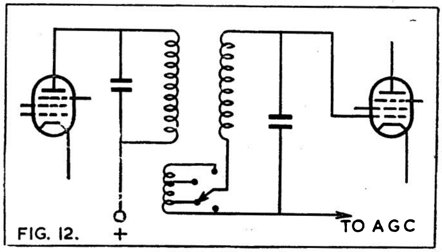


FIG. 12.

being as shown in **Fig. 12,** where a primary and secondary coupling is shown between stages. The switch S is a separate selectivity switch (usually ganged to others carrying out a similar function with other i.f. transformers), and it increases the coupling between primary and secondary as it rotates clockwise. The increase in coupling widens the band, and with enough switch positions, it is possible to establish a degree of selectivity to suit any required compromise between quality and noise.

The Aerial

The importance of the aerial system has been mentioned, but it is worth emphasising. Whatever the tuner, whether AM or FM, it should be supplied with the best input signal that can be obtained.

The AM tuner's AGC system will reduce the gain to an extent depending on the signal strength, and such gain reduction improves signal/noise ratio by reducing noise. It is true that there are some excellent Ferrite aerials for use on the Medium and Long wave band, but whilst these are better than the " bit of wire," they can never be a substitute for a good aerial erected as high as possible.

Outdoors—As High as Possible !

The FM tuner relies to a large extent on the use of a good aerial. The limiting action depends for its operation on receiving a strong signal and the stronger the signal, the better is the AM suppression, with consequent improvement in signal/noise ratio. The dimensions of a Band II aerial make it tempting to erect it indoors—on a picture rail or somewhere equally convenient ; but the guiding principle for obtaining best performance should be to mount the aerial as high as possible in the open.

TV & VHF/FM SOUND (U.K.) BROADCAST BANDS

	CHANNEL	STATIONS IN OPERATION OR PLANNED	BANDWIDTH IN Mc/s
Band I BBC TV	1	CRYSTAL PALACE • DIVIS	41-68
	2	HOLME MOSS • N. HESSARY TOR • ROSEMARKIE • LONDONDERRY	
	3	KIRK O' SHOTTS • ROWRIDGE • NORWICH • BLAEN PLWY	
	4	SUTTON COLDFIELD • MELDRUM • SANDALE • CHANNEL ISLANDS	
	5	WENVOE • PONTOP PIKE • ISLE OF MAN	
		BBC Television Transmitting Stations, designed to serve 98% of the population of the United Kingdom, are accommodated in Band 1	
		FIXED AND MOBILE COMMUNICATION SERVICES AND AERONAUTICAL RADIO-NAVIGATION	68-87·5
Band 2 Sound B'casts		BBC V.H F/F M THE BBC PLANS TO BUILD SOME 25 VHF BROADCASTING STATIONS CARRYING HOME, LIGHT, AND THIRD PROGRAMMES TO COVER 98% OF THE POPULATION OF THE UNITED KINGDOM. NON-BROADCASTING SERVICES AT PRESENT OCCUPY THAT PART ABOVE 95 MC/S The first 16 of these stations are listed below. POLICE, FIRE, AND AMBULANCE SERVICES	87·5-100
		FIXED AND MOBILE COMMUNICATION SERVICES AND AERONAUTICAL RADIO-NAVIGATION	100-174
Band 3 TV	6		174-216
	7		
	8	I.T.A. MIDLANDS	
	9	I.T.A. LONDON • LANCS.	
	10		
	11		
	12		
	13		

The BBC has made application to the P.M.G. for Channels in Band III in which to operate its Second Television Service. So far, no allocations have been announced of the remaining Channels.

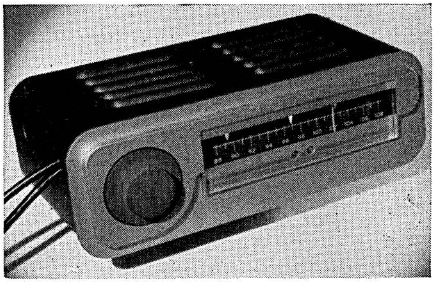
BBC FM STATION AND FREQUENCIES

Frequencies in Mc/s.

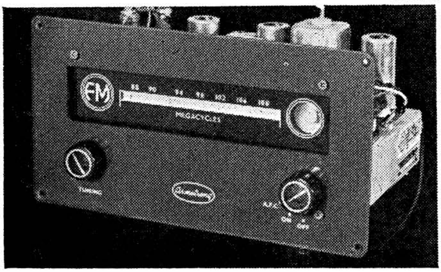
Station	Light	Third	Home
Wrotham	89.1	91.3	93.5
Pontop Pike	88.5	90.7	92.9
Divis	90.1	92.3	94.5
Meldrum	88.7	90.9	93.1
North Hessary Tor	88.1	90.3	92.5
Sutton Coldfield	88.3	90.5	92.7
Norwich	89.7	91.9	94.1
Blaen Plwy	88.7	90.9	93.1
Holme Moss	89.3	91.5	93.7
Wenvoe	89.9	—	94.3 (Welsh) 92.1 (West)
The six new stations as shown on map			
Rosemarkie	89.3	91.5	93.7
Kirk o' Shotts	89.9	92.1	94.3
Sandale	88.1	90.3	92.5 (North) 94.7 (Scottish)
Anglesey (Penmon)	89.6	91.8	94.0
N. Wales (Corwen)	88.9	91.1	93.3
Rowridge	88.5	90.7	92.9

★ *The first* 10 *FM stations in the BBC plan are marked* + *on this map. The second stage of the plan added six new stations, five of which are marked. The Anglesey station site is not yet fixed* (3/4/57). *Penmon, the present North Wales station, will shortly be changed. The shading and dotting indicate areas of good reception (field strength* 250 $\mu V/m$). *For frequencies see opposite.*

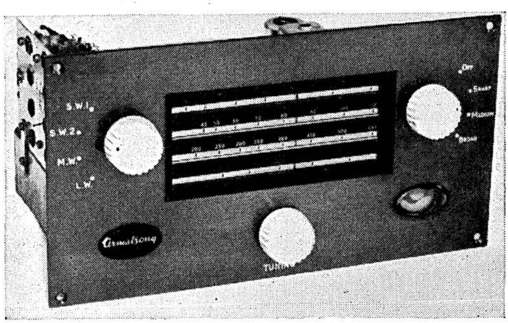
Quad A.M. Tuner



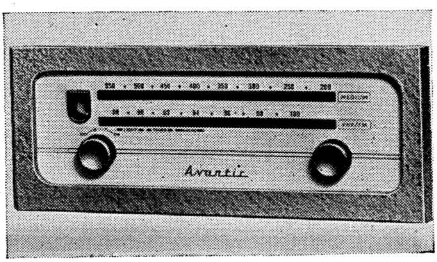
Quad F.M. Tuner



*Armstrong F.M.*61



*Armstrong A.M.*44



Beam-Echo " Avantic " Tuner

DIRECTORY OF RADIO TUNERS

★ In the abridged specifications of these directory entries the following abbreviations have been used : **P.s.n.**—Power supply needed ; **A.F.C.**—Automatic frequency control.

(Note.—The specification of the Whiteley FM tuner is correctly given in this directory without A.F.C., which the makers regret was incorrectly included in the advertisement on page 203).

Acoustical Manufacturing Co. Ltd., St. Peter's Road, Huntingdon, Hunts. Tel. : Huntingdon 361 and 574. Cables : Acoustical.

F.M. Tuner. Variable tuning. Range 87.5-108 Mc/s. Special double neon display ind. P.s.n. 330v at 27 mA ; 6.3v at 1.85 amps. Size 10½ in. by 3½ in. by 6 in. Weight 6 lb. Price £21 (U.K. purchase tax £9 9s.).

A.M. Tuner. Variable tuning, DM 70 ind. P.s.n. 330v at 20 mA ; 6.3v at 1.2 amps. Size 10½ in. by 3½ in. by 6 in. Weight 6 lb. Price £21 (U.K. purchase tax £9 9s.).

★

Armstrong Wireless & Television Co., Warlters Road, Holloway, London, N.7. Tel. : North 3213/4.

F.M. Tuner FM 61. Dial/permeability tuning. Range 88-108 Mc/s. A.F.C. Ratio disc. Magic eye ind. P.s.n. 220-410v at 30 mA ; 6.3v at 2 amps. Size 9¾ in. by 5¼ in. by 7 in. Weight 4½ lb. Price £15 15s. (U.K. purchase tax £6 6s.).

A.M. Tuner type AM 44. Range 15-50 ; 49-120 ; 190-550 ; 900-2,000 metres. P.s.n. 250/320v at 20 mA ; 6.3v at 1.4 amps. Price £14 3s. 6d. (U.K. purchase tax £5 13s. 6d.).

★

Beam-Echo Ltd., Witham, Essex. Tel. : Witham 3184. Cables : Parion, Witham.

Avantic A.M./F.M. Tuner. Continuous tuning. Range (F.M.) 88-100 Mc/s ; (A.M.) 195-565 metres. A.F.C. Foster-Seeley disc. Magic eye ind. P.s.n. 200v at 40 mA ; 6.3v at 2.5 amps. Size 12½ in. by 7 in. by 5 in. Weight 6½ lb. Price £27 10s. (U.K. purchase tax £10 14s. 3d.).

★

Champion Electrical Corporation (C.R.V.T.C. Ltd.), Champion Works, Newhaven, Sussex. Tel. : Newhaven 500. Cables : Champelect, Newhaven.

F.M. Tuner 854 with pre-amp and tone controls. Permeability tuned. Range 88-95 Mc/s. Ratio det. Magic eye ind. P.s.n. 300v at 40 mA ; 3.15—0—3.15v at 2 amps. Size 15 in. by 8½ in. by 9½ in. Price £25 0s. 4d. (U.K. purchase tax £9 12s. 8d.).

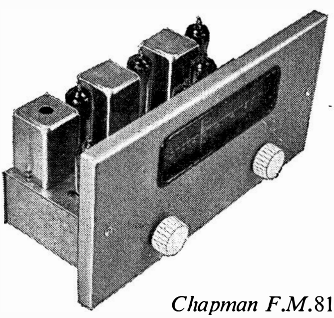
★

C.T. Chapman (Reproducers) Ltd. Sales Office : Riley Street, Chelsea, S.W.10. Tel. : Flaxman 4577/8.

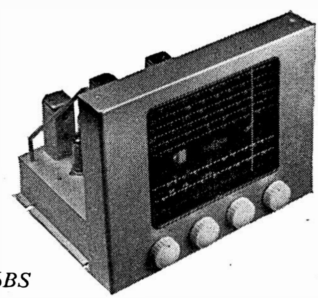
F.M. Tuner F.M.81 Mk. II. Free tuned. Range 87.5-100 Mc/s or 88-108 Mc/s. Ratio det. plus limiter. Magic eye ind. P.s.n. 250v at 40 MA. Size 10 3/16 in. by 5¼ in. by 4⅜ in. Weight 5 lb. Price £16 (U.K. purchase tax £6 8s.).

A.M. Tuner S5E. Free tuned. Range 12.5-37 m., 35-100 m., 90-250 m. Magic eye ind. fitted as extra. P.s.n. 200/250v at 20 mA; 6.3v at 1.5 amps. Size 9 in. by 7 in. by 6½ in. Weight 6 lb. Price £15 15s. (U.K. purchase tax £6 6s.).

AM/FM Tuner, S5/FM. Free tuned. Range (F.M.) 87.5-100 Mc/s or 88-108 Mc/s ; (A.M.) 16-50 m., 195-550 m., 800-2,000 m.

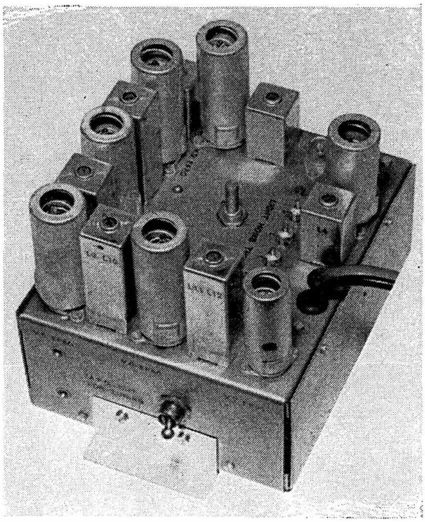


Chapman F.M.81 Mk. 2

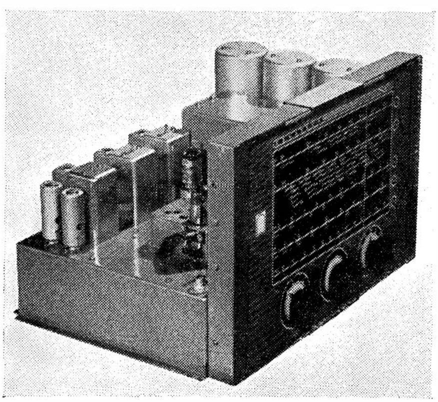


Chapman S6BS A.M. Tuner

Champion 854 *F.M. Tuner and Control Unit*



Dynatron Switched Tuner



*Dynatron T.*10 *F.M./A.M. Tuner*

Ratio det. plus limiter. Magic eye tuning ind. P.s.n. 200/250v at 40/50 mA or self-powered. Size 12 in. by $9\frac{1}{4}$ in. by $7\frac{3}{8}$ in. Weight $12\frac{1}{2}$ lb. or $15\frac{1}{2}$ lb. powered. Price £24 7s. 6d. (U.K. purchase tax £9 15s.) or £27 7s. 6d. (U.K. purchase tax £10 19s.).

AM/FM Tuner, S5E/FM. Free tuned. Range (F.M.) 87.5-100 Mc/s or 88-108 Mc/s ; (A.M.) 12.5-37m., 35-100 m., 90-250 m., 190-550 m. Ratio det. plus limiter. Magic eye tuning ind. P.s.n. 200/250v at 40/50 mA or self-powered. Size 12 in. by $9\frac{1}{4}$ in. by $7\frac{3}{8}$ in. Weight $12\frac{1}{2}$ lb. or $15\frac{1}{2}$ lb. powered. Price £24 7s. 6d. (U.K. purchase tax £9 15s.) or £27 7s. 6d. (U.K. purchase tax £10 19s.).

A.M. Tuner S6BS. Free tuned. Range—six bandspread ranges : 13, 16, 19, 25, 31 and 41 metres ; also 15-43, 43-140 ; 175-570 metres. Magic eye ind. P.s.n. 250v at 30/40 mA ; 6.3v at $1\frac{1}{2}$ amps, or self-powered. Size $13\frac{3}{4}$ in. by $12\frac{1}{4}$ in. by 11 in. Weight 14 lb. Price £33 (U.K. purchase tax £13 4s.)

A.M./F.M. Tuner. F.M.85. Free tuned. Range (F.M.) 87.5-100 Mc/s, (A.M.) 190-550 m, 800-2,000 m. Ratio det. plus limiter. Magic eye ind. P.s.n. 250v at 40 mA or self-powered. Size $10\frac{3}{16}$ in. by $6\frac{1}{8}$ in. by 7 in. Weight 7 lb. or 10 lb. Price £18 or £21 self-powered (U.K. purchase tax £7 4s. or £8 8s. self-powered.)

★

Dynatron Radio Ltd., Maidenhead, Berks. Tel. : Maidenhead 3811/2/3.

F.M. Tuner. F.M.2 LV and **F.M.2 HV.** Switched tuning. Range 87-100 Mc/s. A.F.C. control approx. ± 300 Kc/s. Foster-Seeley disc. P.s.n. 250v at 45 mA ; 6.3v at 2.5 amps. Size $5\frac{1}{4}$ in. by $6\frac{1}{2}$ in. by $5\frac{1}{2}$ in. Weight $2\frac{1}{4}$ lb. Price—F.M.2 LV £18 ; F.M.2 HV £21 (U.K. purchase tax—F.M.2 LV £7 0s. 6d. ; F.M.2 HV £8 3s. 9d.).

A.M./F.M. Tuner. Ether Pathfinder. T.10. Tuning, variable condenser (A.M.), Permeability (F.M.). Range (F.M.) 87-100 Mc/s, (A.M.) LW 800-2,200 metres. MW 190-550 metres. SW2 18-48 Mc/s. SW 148-160 Mc/s. Ratio det. Magic eye ind. P.s.n. 250v at 50 mA. 6.3v at 2.5 amps. Size $8\frac{1}{4}$ in. by 14 in. by $10\frac{5}{8}$ in. Weight $14\frac{1}{2}$ lb. Price £43 15s. (U.K. purchase tax £17 8s. 4d.).

A.M./F.M. Tuner. Ether Marshal. T.139. Range (F.M.) 87-100 Mc/s, (A.M.) 5 wavebands, 10-30, 28-80, 80-200, 200-580, 800-2,200 metres. Ratio det. Magic eye ind. Self-powered. Size $8\frac{1}{4}$ in. by 14 in. by $10\frac{5}{8}$ in. Weight 25 lb. Price not announced.

EAP (Tape Recorders) Ltd., 9 Field Place, London, E.C.1. Tel. : Terminus 0896-7.

Elizabethan F.M. Tuner. Manual tuning. Range 81-105 Mc/s. Ratio det. Magic eye ind. Self-powered. Price £18 3s. 9d. (U.K. purchase tax £7 0s. 3d.).

★

General Electric Co. Ltd., Magnet House, Kingsway, W.C.2. Tel. : Temple Bar 8000. Cables : Polyphase, London.

VHF/F.M. Tuner. BCS 1350. Switched tuning. Range 88-98 Mc/s. A.F.C. Foster-Seeley disc. P.s.n. 250v at 50 mA ; 6.3v at 2 amps. Power pack available (Cat. No. BCS 1351). Price Tuner only £19 5s. 8d. ; power unit £6 5s. (U.K. purchase tax tuner only £8 11s. 4d.).

★

Goodsell Ltd., Gardner Street, Brighton, Sussex. Tel. : Brighton 26735.

F.M. Tuner. FMT 501. Perm. tuning. Range 88-100 Mc/s. Ratio det. Magic eye ind. P.s.n. 300v at 28 mA. Size 11 in. by 8 in. by 8 in. Weight 3 lb. Price £13 17s. 6d. (U.K. purchase tax £5 16s. 6d.).

A.M./F.M. Tuner. FMT 502. Perm F.M. 2 gang A.M. tuning. Range (F.M.) 88-100 Mc/s, (A.M.) 195-550 metres. Ratio det. Magic eye ind. P.s.n. 300v at 28 mA F.M. ; 300v at 24 mA A.M. Weight approx. 5 lb. Price £16 10s. (U.K. purchase tax £6 18s. 7d.).

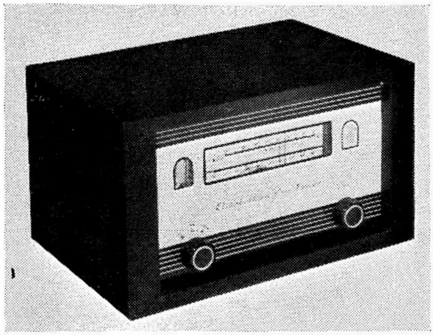
★

The Jason Motor & Electronic Co., 328 Cricklewood Lane, London, N.W.2. Tel. : Speedwell 7050.

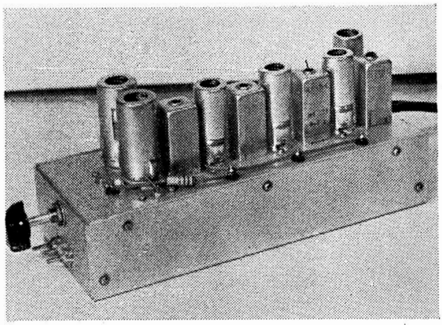
F.M. Tuner. Switched tuning. Range 89-95 Mc/s. A.F.C. Foster-Seeley disc. P.s.n. 270v at 35 mA ; 6.3v at 1.8 amps. Size 5 in. by 4½ in. by 8½ in. Price £14 5s. (U.K. purchase tax £5 11s. 2d.).

F.M. Tuner. Capacitor tuning. Range 88-108 Mc/s. A.F.C. Foster-Seeley disc. P.s.n. 270v at 35 mA ; 6.3v at 1.8 amps. Price to be announced.

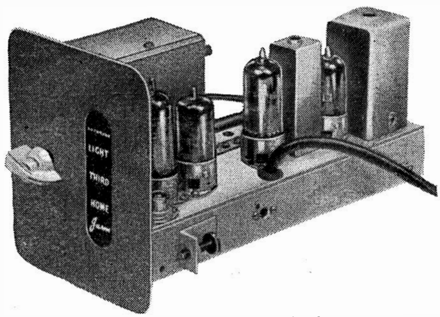
A.M./F.M. Tuner. Capacitor tuning. Range (F.M.) 88-100 Mc/s, (A.M.) 195-560 metres. Foster-Seeley disc. Magic eye ind. Price £20 12s. 6d. (U.K. purchase tax £8 1s.).



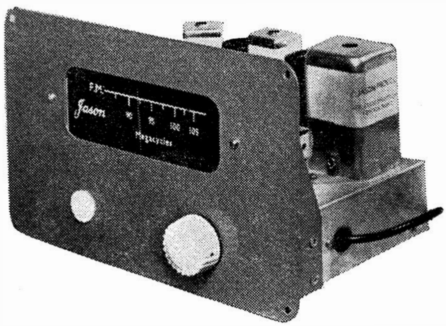
Elizabethan F.M. Tuner



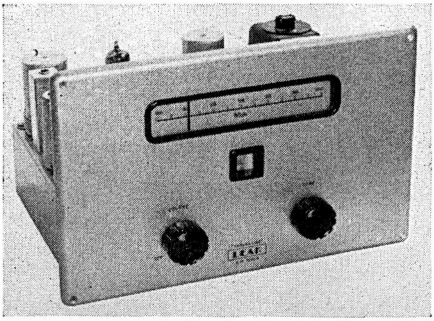
G.E.C. Switched Tuner



Jason Switched F.M. Tuner



Jason F.M. Tuner



Leak F.M. " Through-line " Tuner

H. J. Leak & Co. Ltd., 57/59 Brunel Road, East Acton, London, W.3. Tel. : Shepherds Bush 1173. Cables : Sinusoidal, Ealux, London.

F.M. Tuner, Through-Line. Variable tuning. Range 88-100 Mc/s. A.F.C. Foster-Seeley disc. Original magic eye ind., circuit accurate to 2 Kc/s. Self-powered. Size 10¾ in. by 7 in. by 7 in. Weight 10 lb. Price £25 (U.K. purchase tax £10 10s.).

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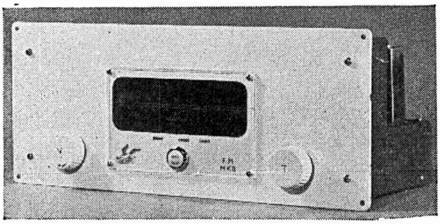


Lowther Mk. II F.M. Tuner

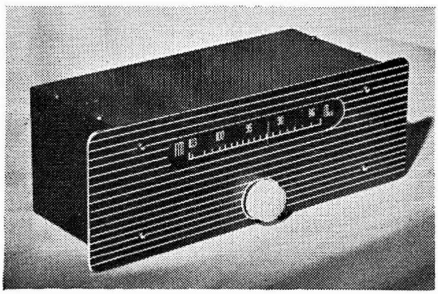
The Lowther Manufacturing Co., Lowther House, St. Mark's Road, Bromley, Kent. Tel. : Ravensbourne 5225. Cables : Lowther, Bromley.

F.M. Tuner Mk. 2. Twin gang tuning, horizontal scale. Range 87.5-100 Mc/s. A.F.C. Foster-Seeley disc. Press button ind. 50 c.p.s. injection. P.s.n. 250v at 35 mA ; 6.3v at 2 amps. Size 13¼ in. by 5½ in. by 5 in. Weight 5¼ lb. Price £22 (U.K. purchase tax £8 15s. 7d.).

F.M. Tuner Mk. III. Twin gang tuning, horizontal scale. Range 87.5-100 Mc/s. A.F.C. Foster-Seeley disc. Press button ind. 50 c.p.s. injection. Self-powered. Size 13¼ in. by 5½ in. by 5 in. Weight 5¼ lb. Price £24 10s. (U.K. purchase tax £9 15s. 6d.).

A.M. Tuner DT/5. Ganged condenser, band spread tuning. Range 12-30, 30-90, 90-200, 195-550 metres. " S " meter ind. P.s.n. 250v at 30 mA ; 6.3v at 2.75 amps. Size 12 in by 10½ in. by 12 in. Weight 10 lb. Price £33 (U.K. purchase tax £13 3s. 4d.).

★

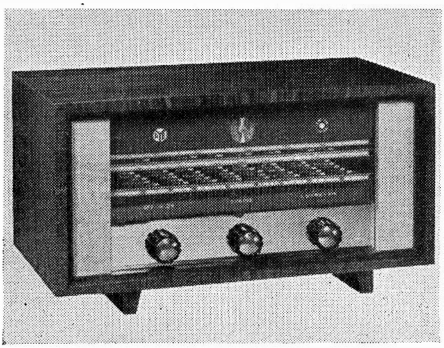


Pamphonic 630 *F.M. Tuner*

Pamphonic Reproducers Ltd., 17 Stratton Street, London, W.1. Tel. : Grosvenor 1926.

F.M. Tuner 630. Condenser tuning. Range 86-103 Mc/s. Ratio det. Magic eye ind. P.s.n. 200-250v at 30 mA ; 6.3v at 1.5 amps. Size 7 7/16 in. by 4 5/16 in. by 4¾ in. Price £12 12s. (U.K. purchase tax £4 17s.).

★



Pye F.M./A.M. Tuner

Pye Ltd., Radio Works, Cambridge, England. Tel. : Cambridge 58985. Cables : Pyrad, Cambridge.

A.M./F.M. Tuner, HFT. 111 W. 2 chassis forms. Horizontal and vertical scale. Permeability tuning. Range (F.M.) 87.1 100 Mc/s, (A.M.) 183-564 ; 956-1,910 metres.

Foster-Seeley disc. Magic eye ind. Self-powered. Size 15 in. by $8\frac{3}{4}$ in. by 9 in. Price £26 10s. 8d., chassis form £21 19s. 8d. (U.K. purchase tax £10 4s. 4d. chassis £8 9s. 4d.).

★

RCA Photophone Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex. Tel. : Sunbury 3101. Cables : Telex and Tex 8608.

F.M. Tuner LMI 32230. Continuously variable tuning. Range 87.5-108 Mc/s (full international F.M. broadcast band). A.F.C. Ratio det. 6 AL7 electron ray tuning ind. P.s.n. 230-390v at 40 mA (adjustable tappings) ; 6.3v at 2.25 amps. Size $12\frac{7}{8}$ in. by $6\frac{1}{2}$ in. by $3\frac{7}{8}$ in. Weight 7 lb. Price £24 3s. (U.K. purchase tax £9 8s. 4d.).

★

Rogers Developments (Electronics) Ltd., " Rodevco Works," 4-14 Barmeston Road, Catford, S.E.6. Tel. : Hither Green 7424. Cables : Rodevco, London.

F.M. Tuner R.D. Junior. Variable inductance tuning. Range 87-107.5 Mc/s. A.F.C. Foster-Seeley disc. Tuning ind., centre-zero meter (optional extra). P.s.n. 270v at 40 mA, L.T. built-in. Size 9 in. by $5\frac{3}{8}$ in. by $8\frac{5}{8}$ in. Price £17 10s. (U.K. purchase tax £7 7s.).

★

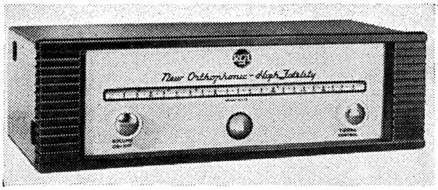
Sound Sales Ltd., Works and Acoustic Laboratories, West Street, Farnham, Surrey, England. Tel. : Farnham 6461/2/3. Cables : Sounsense, Farnham.

A-Z F.M. Tuner Mk. III. Variable tuning. Range 86-100 Mc/s. A.F.C. Magic eye ind. Price £15 (U.K. purchase tax £5 15s. 6d.).

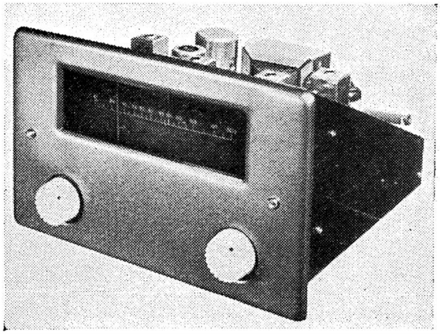
★

Stratton & Co. Ltd., Eddystone Works, Alvechurch Road, West Heath, Birmingham 31. Tel. : Priory 2231. Cables : Stratnoid, Birmingham.

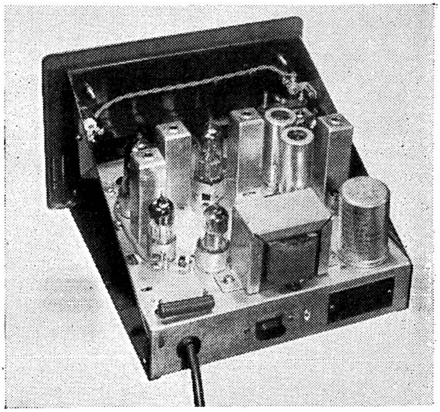
Eddystone 820 A.M./F.M. Tuner. Continuous F.M., switched A.M. tuning. Range (F.M.) 87.5-100 Mc/s, (A.M.) medium and long wave. Foster-Seeley disc. Magic eye ind. Self-powered. Size $6\frac{1}{4}$ in. by 11 in. by 10 in. Weight $11\frac{1}{2}$ lb. Price £22 (U.K. purchase tax £9 18s.).



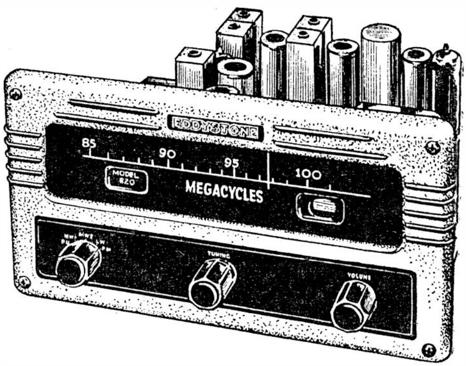
RCA F.M. Tuner



Rogers R.D. Junior F.M. Tuner



Rogers R.D. Junior F.M. Tuner (rear view)



The Eddystone 820 *A.M./F.M. Tuner*

Technical Suppliers Ltd., Hudson House, 63 Goldhawk Road, London, W.12. Tel. : Shepherds Bush 2581/4794.

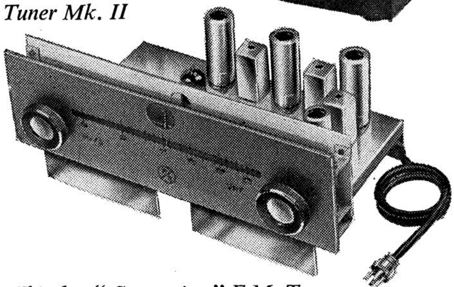
F.M. Tuner Mk. II. Variable permeability tuning. Range 85-101 Mc/s. Ratio det. EM81. Magic eye ind. Self-powered. Size $10\frac{1}{2}$ in. by $5\frac{3}{4}$ in. by $6\frac{1}{2}$ in. Weight $5\frac{3}{4}$ lb. Price £12 12s. 9d. (U.K. purchase tax £4 17s. 3d.).

T.S.L. F.M. Tuner Mk. II

★

Whiteley Electrical Radio Co. Ltd., Victoria Street, Mansfield, Nottinghamshire. Tel. : Mansfield 1762-5. Cables : Whitebon, Mansfield.

Stentorian F.M. Tuner. Permeability, continuously variable tuning. Range 88-108 Mc/s. Foster-Seeley disc. Magic eye ind. P.s.n. 200-240v at 40 mA ; 6.3v at 1.5 amps. Price £17 8s. 11d. (U.K. purchase tax £7 11s. 1d.).


Whiteley " Stentorian " F.M. Tuner

F. M. AERIALS

A properly installed aerial is essential for the best reception of FM radio programmes. The following details are of v.h.f. aerials manufactured by Antiference Ltd., Bicester Road, Aylesbury, Bucks. Tel. : Aylesbury 1467. Cables : Virility, Aylesbury.

210/1A. Single dipole with " U " bolt clamp for fixing to existing masts up to 2 in. dia. Price £1 6s. 6d.

210/2D. Single dipole with cranked mast and universal bracket for surface mounting. Price £1 15s.

221/4E. Dipole and reflector with 6-ft. mast and lashing equipment for chimney mounting. Price £3 15s.

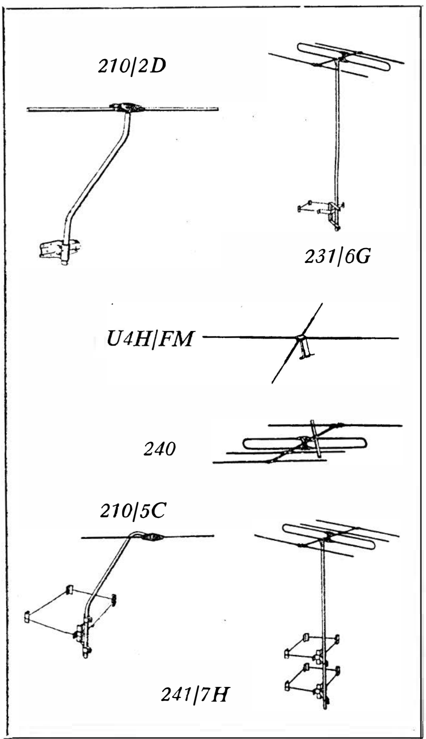
231/6G. 3-element array with 10-ft. by $1\frac{1}{2}$-in. mast and heavy duty single lashing equipment for chimney mounting. Price £7 10s.

241/7H. 4-element array with 12-ft. by 2-in. dia. mast and heavy duty double lashing equipment for chimney mounting. Price £10.

240. 4-element array with " U " bolt clamp for fixing to existing masts up to 2-in. dia. Price £4 5s.

U4H/FM. A 4-rod telescopic aerial for loft mounting, tunable for peak performance. Price £1 2s.

U2RC/FM. A 2-rod telescopic aerial in a cream plastic finish and complete with 15-ft. cream co-axial cable for room mounting. Tunable for peak performance. Price £1 15s.



DIRECTORY OF MOTOR UNITS

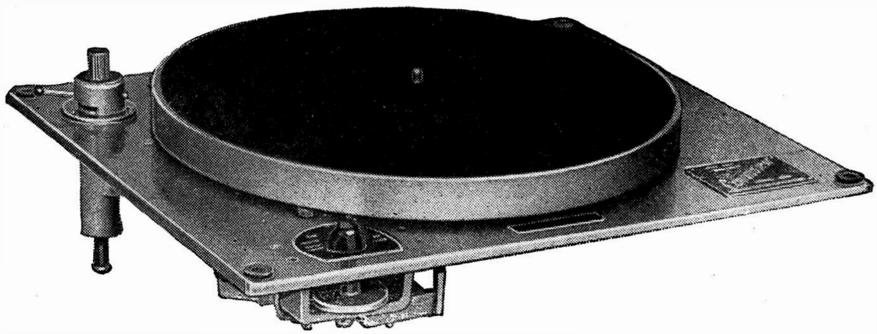
★ **Important Note**—No mention is made of record-changers in the following directory. The list is confined to motor units of transcription quality only. The products listed below can be recommended, and conform to the requirements necessary for high-quality sound reproduction.

Collaro Limited, Ripple Works, By-Pass Road, Barking, Essex. Tel. : Rippleway 5533. Cables : Korllaro Telex, Barking.

Transcription Unit, Model 4T200. Four speeds. Complete with pickup arm and " Studio P " head with turnover cartridge. Plays discs up to 16-in. diameter. Price £13 16s. 6d. (U.K. purchase tax £5 6s. 6d.). Price without pickup £10 15s. (U.K. purchase tax £4 3s.).

A. R. Sugden & Co. (Engineers) Ltd., Well Green Lane, Brighouse, Yorkshire. Tel. : Brighouse 2397. Cables : Connoiseur, Brighouse.

Connoisseur Transcription Motor. Three speeds. With variable speed adjustment. Price £20. (U.K. purchase tax £8 11s.).



Connoisseur Transcription Unit. 3-speed and variable

Collaro 4-speed Transcription Unit

Goldring Manufacturing Co. (Great Britain) Ltd., 486/488 High Road, Leytonstone, London, E.11. Tel. : Leytonstone 8343

Lenco Transcription Unit Type GL50/4. Four speeds at pre-selected points for 78, 45, 33⅓ and 16⅔ r.p.m. positions. Speed continuously variable from 29 to 86 r.p.m. Complete with pickup and Goldring " 500 " cartridge. Price £15 15s. (U.K. purchase tax £6 2s. 10d.).

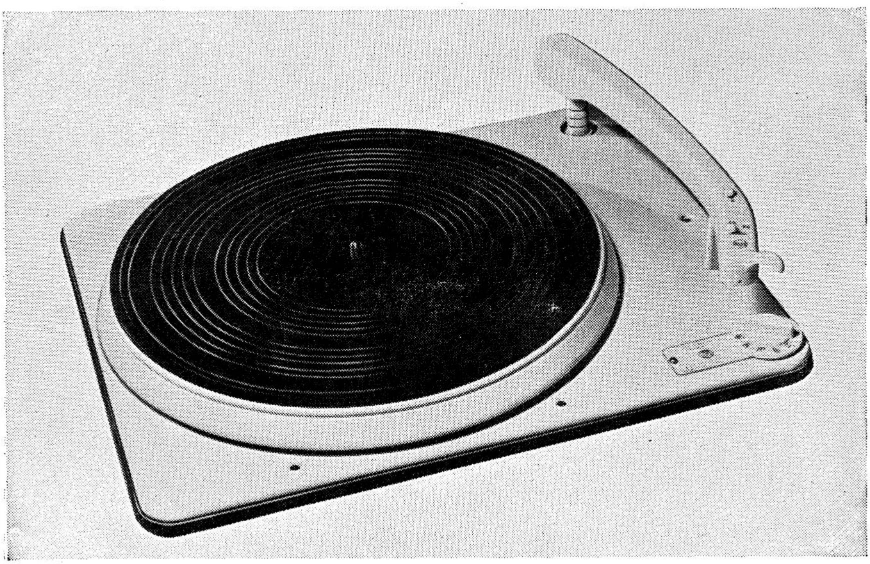
Lenco Transcription Unit Type GL56. As above, but with mechanical lift and lower device. Price £16 16s. (U.K. tax £6 11s.).

Lenco Transcription Motor Type GL55. As type GL56, but without pickup arm and head. Price £12 12s. (U.K. purchase tax £4 18s. 4d.)

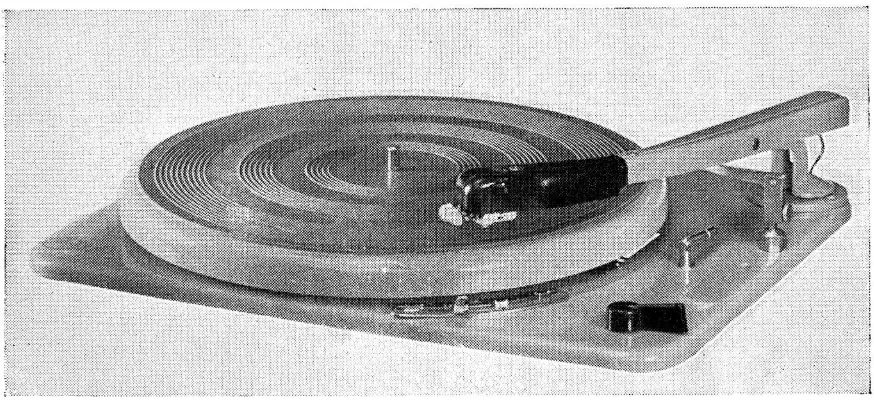
★

RCA Great Britain Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx. Tel. : Sunbury 3101. Cables : Telex and Tex 8608.

LMI-32241A Transcription Turntable Unit complete with RCA 8-pole variable reluctance pickup. Price £22 6s. (U.K. purchase tax £8 14s.).



RCA LMI 4-speed Transcription Unit



Lenco Transcription Unit. 4-speed and variable with pickup lift device

Garrard Engineering & Manufacturing Co. Ltd., Swindon, Wiltshire, England. Tel.: Swindon 5381. Cables: Garrard, Swindon.

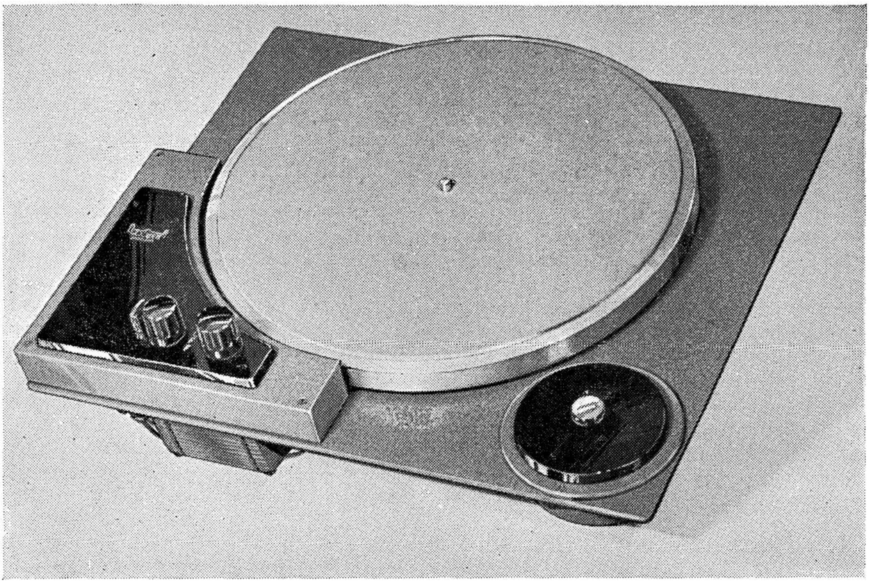
Model 301 Transcription Motor. Three speeds. Variable speed adjustment. Price £19 (U.K. purchase tax £7 8s. 3d.).

Stroboscopic Turntable for use with the 301. Price £5 5s. 6d. (U.K. purchase tax £2 1s. 2d.).

Woollett Sound and Wireless Equipment, Wells Park Road, London, S.E.26. Tel.: Forest Hill 2527.

Transcription Motor Unit. Four speed, with variable speed adjustment. Will accommodate any pickup on the base plate. Price £16 5s. 9d. (U.K. purchase tax £6 6s. 7d.).

Garrard " 301 " *Transcription Unit. 3-speed and variable*



Woollett Transcription Unit. 4-speed and variable

RECORDERS & HI-FI

THE past twelve months have seen considerable development in the realms of tape and tape recorders. On the surface, all is much as it was when we left the subject in the previous edition, except that there are a number of new instruments on the market ; but a glance at the specifications reveals a healthy move in the right direction. There is little doubt that a new and growing knowledge on the part of the buying public, in its turn fostered by an appreciation of high fidelity equipment in general, is stimulating the production of much higher standards in recorders than was previously considered necessary.

Tape Preamplifiers

The most significant move, though still in its early stages, is the development of preamplifiers for decks ; and it seems that we may soon see the tape recorder market covering two distinct demands : first, the good quality transportable recorder which can be used independently, but which will do full justice to any good equipment with which it is used : second, the deck-cum-preamplifier which will be installed as static equipment to work permanently with other hi-fi apparatus. Although tape is a comparatively new medium, such a piece of equipment is already well overdue, and it will soon be considered as necessary as the disc player.

A further development—in this case barely out of the laboratory stage—is the inclusion of stereo heads into the deck mechanism. This will make it possible for stereo tapes to be played on the same deck that is used for recording and replaying normal, monaural material. The demand for stereo sound is still small, but the writing is on the wall ; and since the additional financial outlay need not be heavy, given suitably planned basic equipment, it is reasonable to expect that the stereo facility on tape decks will be adopted by the public, as and when it becomes available. Indeed, considerable interest is already being shown in it by people who are contemplating the extension of their equipment to include tape.

However, to return to the point in paragraph two of this chapter, the most important factor to be taken into consideration, when planning for tape, is the main use to which the instrument will be put. Though the two are not strictly comparable, portable recorders and portable disc players can be regarded in the same way as tape decks and transcription motors plus pickups. Whereas it is quite possible to use both the portable units with hi-fi equipment, it is generally uneconomical, because the quality (let alone the amount) of the components required, must represent a big outlay ; and this cash has already been outlayed (in the hi-fi set-up itself) in amplifier, speaker, power pack, etc. As a general rule, tape recorders are not used, when away from the "parent equipment," for reproductions which demand exceptionally high quality ; on the other hand, when they form a part of a hi-fi chain, they must be capable of the best quality possible, otherwise they become the proverbial weak link in the chain.

Static and Portable Units

For those who require the best in both worlds, there are several recorders available in the higher price range—of professional or semi-professional standard ; and these can be used independently as transportables, or they can be hooked up to the best quality equipment to give a good account of themselves. For those who are thinking only in terms of a static unit, there are some excellent decks available, with and without the necessary preamplifier units.

It cannot be too heavily emphasised that a tape deck for the recording and reproduction of music must be of the finest workmanship —rock-steady in operation ; with "wow and flutter" content not greater than 0.1 per cent., and preferably half that figure ; with smooth, positive braking ; with foolproof guard against accidental erasure. The essential speed is, of course, 7½ in. per second, and the minimum spool diameter should be 7 in.

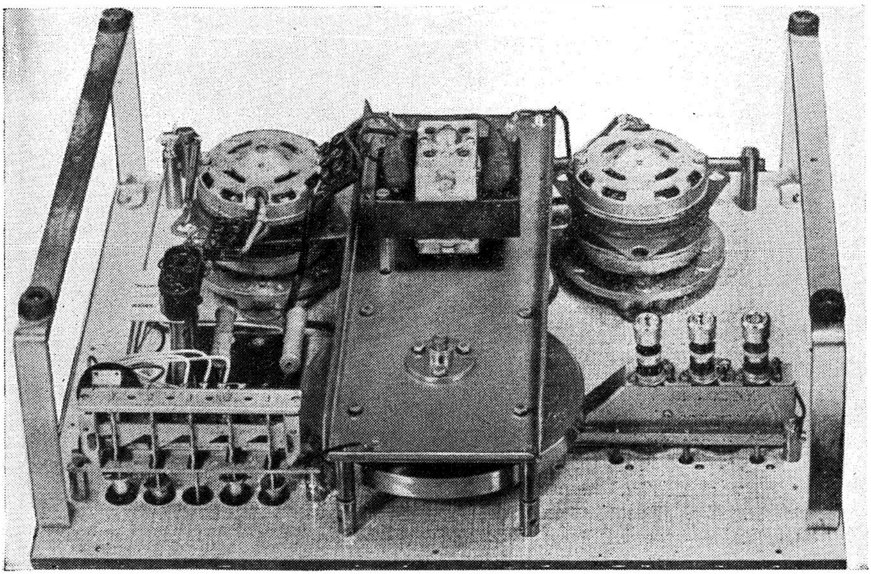
When selecting a recorder—or deck plus preamplifier—the greatest attention should be paid to the published specification. The item "to CCIR standard" is important. The frequency response should not be short of 40 to 10,000 c/s, within 3 dB, at the 7½-in. speed, and 40 to 15,000 c/s at the 15-in. speed, within the same limit. The response of the amplifier should extend beyond these figures at each end—preferably to 30 or 20 c/s in the bass, and to 20,000 c/s in the treble, and within 3 dB or better. And, most important of all, the signal to noise ratio must be good. A figure of —40 dB is a good guide ; if —50 dB is guaranteed, so much the better.

One of the most important events in the story of tape recorders was the release of Test Tape TBT1 by E.M.I. Ltd. in January, 1957. This tape, recorded to the CCIR standard, provides 13 pure tones, ranging from 40 to 10,000 c/s, and for the first time makes it possible for the man-in-the-street to test the response of a recorder, with the aid of a simple meter. It is noted that already one manufacturer has stated, as part of his specification, that his recorder will play this test tape, over the full range, within 2 dB. This is a positive guarantee, and to anyone who has played the tape on an inferior machine it means much.

Because tape is so young, and because so many recorders have been produced, for the everyday domestic market, which are totally inadequate for the high quality reproduction of music, it is necessary to exercise special care when selecting a machine for hi-fi work. No criticism is intended against the cheap recorder. It is produced for a specific market, and it does its job remarkably well. These words are written purely as a warning to the non-expert, who might otherwise buy quite the wrong type of instrument for the job it will be called upon to do.

One of the most exasperating troubles to encounter in a tape recorder is hum. And it is on this count that a recorder may well fall down, even though its other qualities are more than good. Extremely careful design is needed to keep hum from the initial parts of the circuitry, where the signal is weak, and where it is most easily picked up. In small portables, with the sound heads and their leads placed unavoidably close to two or even three motors, and a mains transformer, the problem of keeping out hum is (at this stage of knowledge and experience) almost insoluble. The fact that such a recorder does not appear to reproduce hum, when playing back through its own monitor speaker, is no guide. The bass response of such a small speaker, very simply mounted, cannot do full justice to it ! Realisation comes later.

With a tape deck and properly designed tape preamplifier, the problem is a very much simpler one to solve ; and since the reader will almost certainly be interested primarily in equipment suitable for use with other apparatus in his possession, this brief guide, followed by a careful attention to published specifications, should make it possible for him to steer clear of the inadequate, and to concentrate upon either the well constructed recorder, or the deck with its ancillary preamp.



An underside view of the Bradmatic 5B tape deck showing the well-spaced and clean layout

TAPE DECKS
AND
PREAMPLIFIERS

By D. H. W. Busby and J. C. Latham

WE are inclined to take for granted the size of the tape and the speeds at which tape decks run. In fact many years work and considerable foresight have brought us to the happy position of having a British Standard Specification on this subject. This is BS1568 of 1949 which (as revised in 1953) suggests among other things that there should be standard speeds, and which sets out the dimensions of the tape. It approves the speeds of 1⅞, 3¾, 7½ and 15 i.p.s. for domestic and semi-professional use. The width of the tape should be 0.250 in. (+ 0in. and − 0.006 in.) and the coated thickness 0.0020-0.0023 in. Since then, however, " Long Play " tape has been introduced with a thickness of about 0.0015 in. and which has proved to be perfectly satisfactory.

Speed Preference

There are two things to consider when selecting a speed. Obviously, the slower the speed, the more the recording time, but only at the expense of the high frequency response. In fact 1⅞ i.p.s. is suitable for dictation only ; 3¾ i.p.s. is convenient for good speech reproduction and for moderate quality music ; 7½ i.p.s. is quite a good standard for recording music, even live via a microphone. 15 i.p.s. should be regarded as a semi-professional speed, and should only be used with absolutely first-class equipment.

Pre-recorded Tapes

Pre-recorded tapes are now more commonly and sensibly called tape records. They are recorded at 7½ i.p.s. There is an appreciable response above 10 Kc/s on these tapes, and they are well worth playing on excellent equipment. The recordings are produced on standard 0.25-in. tape, and on two separate tracks. Recording is begun on the upper track, from left to right, and continued on the lower track in the reverse direction. A dynamic range in excess of the normal L.P. record can be obtained, so that the small amount of extra work required to thread a tape is well worth while. The tapes should be played through an amplifier with a frequency characteristic to CCIR specification.

Reproducing Characteristics

British Standard Specification 2478 of 1954 deals with the characteristics for speeds of 30, 15 and 7½ i.p.s. It accepts the recommendations of the 7th plenary session of the CCIR in London, 1953. The bass boost that should be achieved by the playback amplifier at 15 and 7½ i.p.s. is shown in **Fig. 1.** The curves are defined as those produced by a series combination of a resistor and capacitor, the product of whose values make up a true time constant of 35 μ sec. for 15 i.p.s., and 100 μ sec. for 7½ i.p.s. Unfortunately, this standard is not at present internationally accepted, so that we find different characteristics in use in both America and France.

Types of Tape

There are some four different types of tape

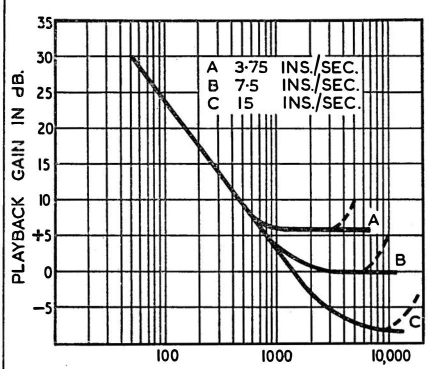


FIG. 1.

Bass boost attainable at 7½ and 15 i.p.s.

available on the market. The bases are paper, acetate, P.V.C. and Polyester. Paper-based tape is unsuitable for high-quality recording, because of the poor surface coating which results from the grain structure of the paper. This results in a considerable loss of high frequency response, since the head and the medium are not in sufficiently intimate contact. A considerable amount of modulation noise will also be noticed. Plastic-based tape, although more expensive, is considerably more satisfactory. The inherent background level of the tape no longer necessarily sets the limit to the attainable signal/noise ratio. The Polyester base is used for long-playing tape, because of its extra strength. The price difference between a spool of this and the normal plastic tape is entirely accounted for by the increased length.

Tape Transport Mechanism

Satisfactory design of the tape transport mechanism is of the utmost importance. In order to obtain the same standard of quality from tape recordings as from L.P. discs, considerably more care must be exercised. The fundamental requirement is that the tape should be moved across the heads at a constant specified speed. Even short-term variations of this speed (of the order of 0.1%) are significant, and will tend to degrade the quality of reproduction.

Efficient braking, and fast winding in either direction, from one spool to the other, are of course essentials. Counters to indicate the amount of tape used are also helpful. It has now become almost standard practice to drive the tape between a capstan and pinch wheel, one or other of which is made of rubber. Any variations of speed, occurring once at every capstan revolution, can be made to appear at a lower and less objectionable frequency by increasing the capstan diameter. Larger capstans are also easier to machine, and they require less accurate bearings. Nevertheless, since additional speed reduction is required by means of pulleys or idler wheels, their advantage may not be fully realised.

The number of motors used in the design of a tape deck is no immediate indication of excellence. The ingenious use of two—or even one—can give satisfactory results ; but it is usual, and probably simpler in the end, to provide one for each reel and another, possibly of better quality, for the capstan.

It will be found extremely difficult to prevent the playback head from picking up excessive quantities of mains hum, if thorough provision has not been made for screening it from the motors. An eighth of an inch of iron, or somewhat less of mumetal, is not an unreasonable screening thickness to expect on a good tape deck.

Magnetic Heads

Almost all magnetic heads in use are of the " ring " type, and consist of two stacks of roughly C-shaped laminations of high-grade iron. These laminations are placed face to face to form an O, with a minute air gap between faces. A coil is wound on each stack of laminations. When current is passed through the coils, flux is induced in the iron path ; and because of the coil connections and the structure of the iron path, this produces a flux which is concentrated across the gap. The gap is often as small as 0.0005 in. in recording and replaying heads.

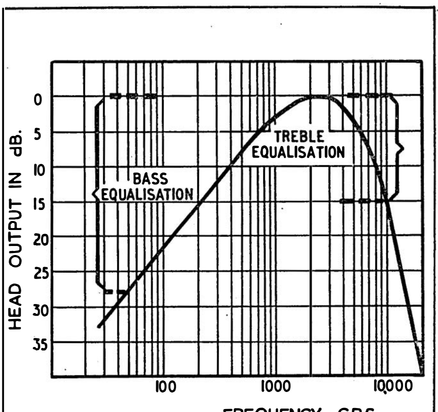


FIG. 2.

Output to be expected when head current varies with frequency.

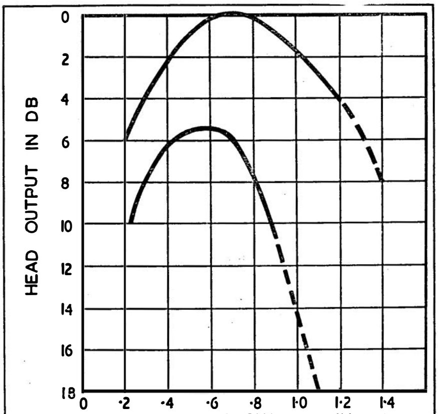


FIG. 3.

Change of level from a tape when bias is altered.

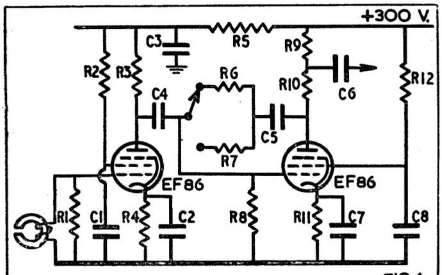


FIG. 4.

The signal is passed through a recording amplifier where a boost is applied which varies with frequency to make up for the losses which are inherent in the magnetic transfer to the tape. The amplified signal is then fed to the coils on the recording head. The fluctuations of the incoming signal vary the flux in gap, and hence the magnetic state of the coating of the tape is changed. This change is of a permanent form, and if the tape is then drawn past a similar head a corresponding voltage will be induced in the coils.

Tape Preamplifiers

The simplest design of tape preamplifier is that which is required only to provide an equalised output from a tape record. The output from the head itself (which will be of the order of 5 millivolts) will require suitable amplification, and also a correction of its frequency response by the use of the appropriate playback characteristic. In the suggested circuit shown in **Fig. 4,** which uses Mullard EF86 valves for minimum noise and hum, the equalisation is obtained by selective feedback round the second valve. An output of 200 mV (or, by tapping further down the anode load, of up to 1v) can be obtained. With the switch set to connect R6, the characteristic shown in **Fig. 1** for 7½ i.p.s. is available ; and with the switch in the other position the 15 i.p.s. characteristic is realised. Suitable circuit values are given below, and high stability components should be used for R2, R3 and R4 :

The more comprehensive playback amplifiers usually include a certain amount of treble boost to counteract undue losses in the playback heads. This is shown as a dotted line in **Fig. 1.** Without it, the output from the E.M.I. test tape **TBT1,** for example, will be found at a frequency of 10,000 c/s to be some 6 or 8 dB below the reference level. Playback amplifiers should be fully screened, and the heater supply for the valves should be centre-tapped to earth. Amplifiers which provide facilities for recording are considerably more complicated. As shown in **Fig. 2,** the output to be expected when recording at a constant head current is far from equal at all frequencies. The theoretical increase in output with increasing frequencies, turns into a rapid fall as the wavelength of the recorded signal becomes equal to the width of the gap in the head. Higher tape speeds will postpone this inevitable reduction in output until, at a higher frequency, the two are once again of similar size.

Correction of L.F. and H.F. Responses

The lower output in the bass is corrected during playback, while the high frequency response is largely equalised by an appropriate boosting of the recording current. The practicable boost is about 15 dB, so the maximum usable frequency at any tape speed is readily apparent as that at which the basic output has fallen by a similar amount. The actual value of the recording current is dependent on the type and impedance of the recording head used. About 150 μA is usually sufficient to load the tape fully, using heads with an impedance of about 20K ohms. This impedance, being largely inductive, varies considerably with frequency ; so it is usual to cover it with a high series resistance, as in **Fig. 5a,** where R4 might be 100K ohms.

Various methods of obtaining the required treble boost are employed. Two possible ones are given in **Fig. 5.** The first diagram shows the use of an inductor in the bottom arm of the attenuator R1, R2. When the impedance of the resonant circuit rises to its maximum, at the frequency determined by the tuning capacitor, then the attenuation will be reduced. R3 is included to damp the coil and to prevent excessively steep boost characteristics. Alternatively, the feedback circuit shown in **Fig. 5b** can be used, in which

R1	470K ohms	**R7**	330K ohms	**C1**	0.5 μF	**C7**	50 μF
R2	1 M ohm	**R8**	470K ohms	**C2**	50 μF	**C8**	0.5 μF
R3	220K ohms	**R9**	18K ohms	**C3**	8 μF		
R4	2.2K ohms	**R10**	82K ohms	**C4**	0.1 μF		
R5	33K ohms	**R11**	1K ohm	**C5**	180 μF		
R6	680K ohms	**R12**	390K ohms	**C6**	0.1 μF		

the required boost is obtained by use of Twin-T filter networks.

In order to reduce distortion in the magnetic process, recording amplifiers must also provide a suitable bias ; this is normally of a frequency between 40 Kc/s and 80 Kc/s. The exact bias current is of considerable importance ; it affects the distortion, also the output from the tape for a given input, and the high frequency response. **Fig. 3** shows the level to be expected from one particular type of tape as the bias is changed. On the upper curve, which is for a 1 Kc/s signal, the output reaches a maximum. This point is usually close to the optimum position, although an increase will reduce distortion. On the lower curve, increased bias results in a rapidly decreasing output at 10 Kc/s.

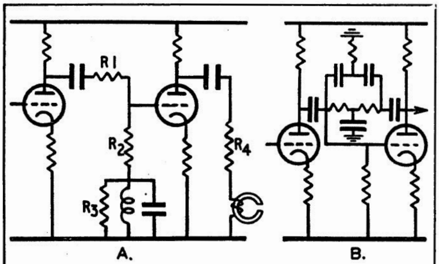


FIG. 5.

The bias oscillator also conveniently provides power for an erase head. The impedance of the erase head consists of an equivalent series loss resistance (resulting from eddy current and hysteresis losses) and an inductive component. It is in the resistance that power is dissipated, rather than in actual erasing. The harmonic distortion in the recording will nominally be set by the recording level employed, provided that the amplifier is not contributing more than 1.0%. This distortion increases rapidly as the tape begins to overload, and for this reason the recording level must be carefully controlled. It is **not** satisfactory, however, to record at very low levels, since the background noise and hum will begin to be obtrusive. The most useful recording level indicator is a meter, because it gives a more accurate reading, and it can be calibrated. However, most domestic tape recorders use " magic" eyes.

The input arrangements to a recording amplifier vary according to uses for which it is intended. Line inputs are common on professional apparatus in which the reference level is 1 milliwatt, or about 750 mV into 600 ohms. Professional microphones are also frequently of low impedance, and are fed into suitably balanced input transformers. Home recorders, on the other hand, will usually have inputs suitable for crystal microphones or radio tuners, both at impedances of up to a megohm.

Limitations on Performance

There should be little difference between the use of a tape deck and pre-amplifier, and a complete tape recorder, when applied to Hi-Fi equipment. The quality available from the tape recorder should be no different, whether it is provided with an output stage or not, because there should always be an output socket available on the instrument for feeding an adequate power amplifier and speaker (e.g., a Hi-Fi installation). The standard of this equipment is such that it will be capable of handling a recorder's output far more adequately than a built-in output stage on an average recorder.

Frequency Response

As already mentioned, the upper frequency limit occurs when it no longer becomes practicable to continue to apply treble boost. The transient response of the system will be unsatisfactory if attempts are made to use excessive amounts. Apart from increasing the tape speed, which is the best solution, a reduction in the head gap width will effect an improvement. Heads are available with gaps of 0.0002 in., but further reductions will result in an all-round decrease of output, which is undesirable. The optimum high frequency response from tape records depends upon the accurate azimuth alignment of the playback head, although this is not significant for tapes which have been recorded on the same machine. The low frequency response can be extended down to 20 c/s without experiencing difficulty in the amplifiers. Nevertheless, it is wise purposely to restrict it from about 40 c/s in order to avoid hearing low frequency noise, which is caused to a large extent by the variations of contact of tape with heads.

Noise

Factors influencing high frequency noise are numerous. It can originate in the record amplifier, in the tape (either inherently, or as a result of bad oscillator waveform) or possibly in the playback amplifier. The latter is unlikely, provided little or no treble boosting is done on playback. Oscillator waveform will also cause negligible harm if the total harmonic distortion is less than 0.5%. In the record amplifier, on the other hand, it is possible to reach noise levels comparable with the inherent tape noise if sensitivities are sufficient for microphone recording. This is mostly because of the treble boost applied. The usual precaution of using high stability resistors in the earlier stages, in conjunction with suitable valve types, should enable high frequency noise to approach within a few dB of the inherent tape noise.

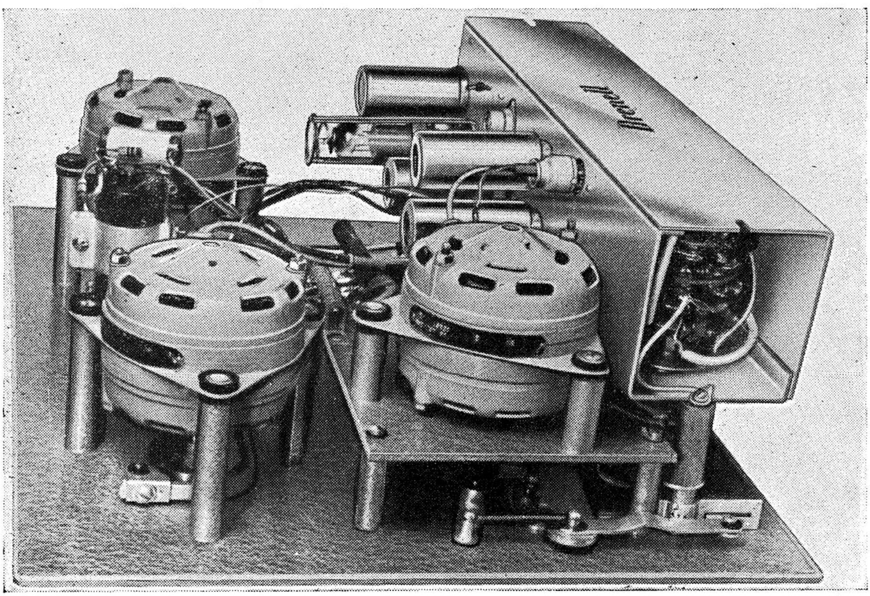
Bulk erasing is generally an advantage before making important recordings, particularly in order to reduce the low frequency noise which is less easily erased. Noise will also result from magnetisation of the heads or of other metal parts, but this can easily be cured by judicious use of the demagnetisers available.

Hum

In a carefully designed system, the hum voltage will have been reduced to about five times or so that of the background noise level ; nevertheless, as a result of the low sensitivity of the ears at those frequencies, and poor efficiency of the speaker, it will probably have about the same nuisance value. Harmonics of 100 c/s or 150 c/s are considerably more objectionable than the fundamental 50 c/s. Recording amplifiers cause little trouble, although they will of course pass on hum which originates in mixers or microphone circuits. " Playback " amplifiers on the other hand have sensitivities as high as 100 µv at 50 c/s, and they must be designed with care.

It should not be necessary to restrict frequency response to cure hum troubles. The hum level will normally be set by the hum induced in the playback head. Motors will produce relatively pure fundamentals, but harmonics can be expected from mains transformers on power packs. The best cure is thorough screening, but some improvement can be effected by hum-bucking—by inserting a few turns of wire in the earthy side of the head, so that the induced hum will cancel that existing in the head.

The best recordings can only come from the use of first-class equipment by a skilled recording engineer ; nevertheless it would be a mistake to restrict the quality of equipment to match the available skill, for skill improves with practice and careful trials, and it is not easy to improve upon the quality of the recording system. Also, given good equipment, a good recording is easier to make by magnetic recording than by any other method. Furthermore, since it is assumed that the reproducing system, including the speaker, will be capable of re-creating everything that is recorded, the best possible sound source should be used with it.



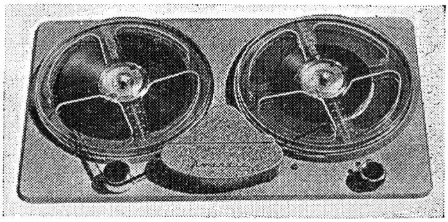
The preamplifier arrangement on the new Brenell Mk. IV deck. Note the screening of components.

DIRECTORY OF TAPE RECORDERS

★ The decks and recorders illustrated are a representative selection of those available for professional, semi-professional, and Hi-Fi work. The abbreviations used for the specifications in this directory are as follows : **Fr**—frequency response ; **i.p.s.**—inches per second ; **P.s.n.**—Power supply needed.

Beam-Echo Ltd., Witham, Essex. Tel. : Witham 3184. Cables : Parion, Witham.

Avantic Mk. III Player. G.P. $7\frac{1}{2}$ i.p.s. One motor. 7-in. spools. Fully compensated to C.C.I.R. standards by means of built-in pre-amp. Output (variable) 500 mV max. F.r. : 30-12,500 c.p.s. $\pm$ 3 dB. P.s.n., motor 115 or 230v A.C. ; pre-amp 300v at 5 mA, 6.3v at 0.4 amps. Price £40.



Beam-Echo " Avantic " Mk.3 deck

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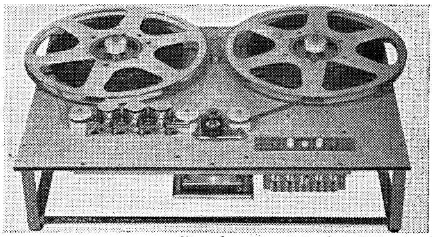
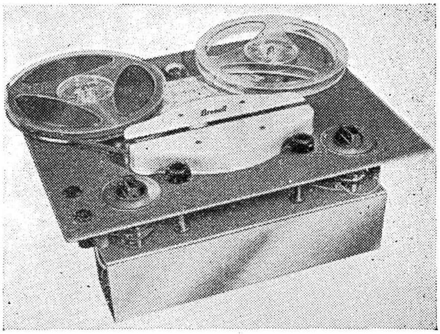
Bradmatic Ltd., Station Road, Aston, Birmingham 6. Tel. : East 2881-2. Cables : Bradmatic, Birmingham.

Bradmaster. Models 5B, 5CS, 5CD, 5D Semi-prof. tape deck. $7\frac{1}{2}$ and $3\frac{3}{4}$ i.p.s. 3 motors. Model 5B 7-in. spools ; 5CS and 5CL $9\frac{3}{8}$-in. spools ; 5D $10\frac{1}{2}$-in. N.A.B. spools. F.r. : $7\frac{1}{2}$ i.p.s., 40-15,000 c.p.s. ; $3\frac{3}{4}$ i.p.s., 40-7,500 c.p.s., both $\pm$ 4 dB (dependent on amp. used). Size and weight dependent on model. Price 5B £42 ; 5CS £45 10s. ; 5CL £47 10s. ; 5D £50.



Bradmatic Model 5D deck

Bradmatic Console. Models 25, 35, 45. Semi-prof. recorders less output stage. $7\frac{1}{2}$ and $3\frac{1}{4}$ i.p.s. 3 motors. $10\frac{1}{2}$-in. N.A.B. spools. F.r. : $7\frac{1}{2}$ i.p.s., 40-15,000 c.p.s. ; $3\frac{3}{4}$ i.p.s., 40-7,500 c.p.s., both $\pm$ 4 dB. V.U. level meter. Size, 35 in. by 27 in. by 25 in. P.s.n. 230v 50 c.p.s. or 110v 60 c.p.s. Price Model 25 (fitted with type 10/7A amp) £173 ; Model 35 (fitted with type 10/7AM amp) £175 ; Model 45 (fitted with type W/7 AS amp) £190.



Brenell deck and pre-amp Mk. IV Model 600

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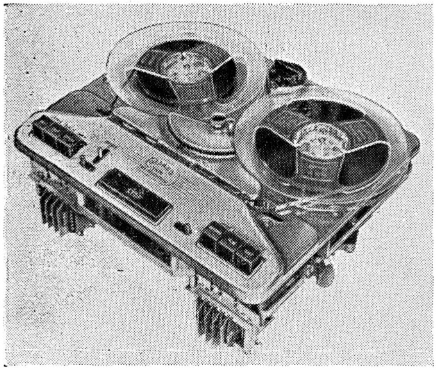
Brenell Engineering Co. Ltd., 2 Northington Street, London, W.C.1 Tel. : Holborn 7358.

Brenell Mk.IV Model 500. G.P. Tape deck. 15, $7\frac{1}{2}$ and $3\frac{3}{4}$ i.p.s. 3 motors. $8\frac{1}{4}$-in. spools. F.r. 15 i.p.s. 50-16,000 c.p.s. ; $7\frac{1}{2}$ i.p.s. 50-11,000 c.p.s. ; $3\frac{3}{4}$ i.p.s. 50-5,000 c.p.s. all $\pm$ 2 dB. Magic eye level ind. Size 15 in. by $11\frac{1}{2}$ in. P.s.n. 220/250v, 50 cycles or 110/120v, 60 cycles. Price £23 2s.

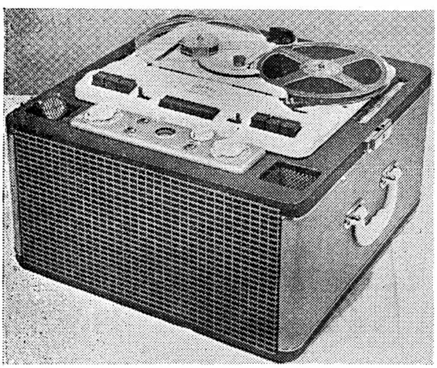
Brenell Mk.IV Model 600. G.P. tape deck and pre-amp. Spec. as for model 500, but including Brenell pre-amp. Independent headphone monitoring facilities. Inputs for mic. tuner, radio/pickup. F.r. as for Model 500. Price £40 8s. 6d.

Brenell Mark IV G.P. portable recorder



Collaro Mk. III 3-*speed deck*

E.A.P. "Elizabethan" portable recorder



*Elon J.C.*20 *portable recorder*

Brenell Mk.IV. Complete G.P. portable using standard Mk.IV deck. Spec. as for Model 500. Sold including 1,200 ft. tape. Price £55 13s.

★

Collaro Ltd., Ripple Works, By-Pass Road, Barking, Essex. Tel. : Rippleway 5533. Cables : Korlarro-Telex-Barking.

Collaro Mk. III. Prof. and G.P. tape deck. 15, $7\frac{1}{2}$ and $3\frac{3}{4}$ i.p.s. 2 motors. 7-in. spools. F.r. : up to 12,000 c.p.s. at $7\frac{1}{2}$ i.p.s. $\pm$ 3 dB with record/playback equalisation. Size 13 in. by $11\frac{3}{8}$ in. by $5\frac{9}{16}$ in. Weight $16\frac{1}{2}$ lb. P.s.n. all main voltages supplied. Price £22.

★

E.A.P. (Tape Recorders) Ltd., 9 Field Place, St. John Street, E.C.1. Tel. : Terminus 0896-7.

Elizabethan De Luxe. G.P. recorder. Collaro tape deck. F.r. : 15 i.p.s., 50-16,000 c.p.s. ; $7\frac{1}{2}$ i.p.s., 50-12,000 c.p.s. ; $3\frac{3}{4}$ i.p.s., 50-7,000 c.p.s. Magic eye level ind. Size 17 in. by 14 in. by 9 in. Weight 40 lb. Price with mic. 1,800 ft. of tape and radio connecting lead £68 5s.

★

Elon Tape Development Co. Ltd., 377 Milkwood Road, Herne Hill, London, S.E.24. Tel. : Brixton 3417.

Elon J.C. 20. G.P. recorder. Collaro tape deck. F.r. : 15 i.p.s., 40-16,000 c.p.s. ; $7\frac{1}{2}$ i.p.s., 50-10,000 c.p.s. ; $3\frac{3}{4}$ i.p.s., 50-7,000 c.p.s. ; all $\pm$ 3 dB. Magic eye level ind. Size $16\frac{1}{2}$ in. by 16 in. by $9\frac{3}{4}$ in. Weight 43 lb. Price £65 2s.

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EMI Sales & Service Ltd. & EMI International Ltd., Blyth Road, Hayes, Middx. Tel. : Southall 2468. Cables : Emiservice, Telex, Emiglobe.

H.M.V. Model 3031. G.P. tape playing deck with 2-stage pre-amp and equaliser. $7\frac{1}{2}$ i.p.s. 1 motor. 7-in. spool. F.r. : to C.C.I.R. spec., 40-10,000 c.p.s. $\pm$ 3 dB. Size $12\frac{1}{2}$ in. by $17\frac{1}{2}$ in. by $14\frac{1}{2}$ in. Weight 37 lb. P.s.n. 195-255v 50 c.p.s. Price £50 8s.

Model 3032. Similar to 3031 but mounted in a console cabinet. Size 35 in. by $20\frac{1}{2}$ in. by 16 in. Weight 60 lb. (approx.). Price £72 9s.

Model 3033. Complete G.P. tape reproducer., including amp. and loudspeaker system, using 3031 deck. Size 35 in. by 28 in. by $16\frac{1}{2}$ in. Weight 135 lb. (approx.). Price £162 15s.

E.M.I. Model L/2. Prof. battery operated portable magnetic recorder. 2 types: L/2A 3¾ i.p.s.; L/2B 7½ i.p.s. 1 motor. 5-in. spools. F.r.: 7½ i.p.s., 50-7,000 c.p.s.; 3¾ i.p.s., 50-3,000 c.p.s. Level meter. Size 14 in. by 8 in. by 7 in. Weight with batteries 14½ lb. P.s.n. 10 U2 or 2LP type 1.5v cells, and two B101 type 67.5v H.T. batteries. Price £102 18s.

E.M.I. Model TR51. Prof. transportable recorder. Four types: A, 15 and 7½ i.p.s. full track; C, 15 and 7½ i.p.s. half track; B, 7½ and 3¾ i.p.s. full track; D, 7½ and 3¾ i.p.s. half track. 1 motor 8¼-in. or 7-in. spools. F.r.: 15 i.p.s., 50-15,000 c.p.s.; 7½ i.p.s., 50-10,000 c.p.s.; 3¾ i.p.s., 50-6,000 c.p.s. V.U. level meter. Size 13¼ in. by 18 in. by 17 in. Weight 59 lb. Price £175.

★

Expert Gramophones Ltd., "Ingerthorpe," Great North Road, London, N.2. Tel.: Mountview 6875.

Everest. Complete semi-pro. recorder. 7½ and 3¾ i.p.s. 3 motors, 1 fan. 10½-in. N. A.B. spool. F.r.: 7½ i.p.s., 30-16,000 c.p.s.; 3¾ i.p.s., 30-9,000 c.p.s., both ± 2 dB. Meter level ind. Price £329 16s. 6d.

★

British Ferrograph Recorder Co. Ltd., 131 Sloane Street, S.W.1. Tel.: Sloane 1510. Cables: Britferro, Knights.

Ferrograph 2 A/N and 2 A/H. Complete semi-pro. recorders. Any two adjacent speeds from 1⅞ to 15 i.p.s. 3 motors. 8¼-in. spools. F.r.: 15 i.p.s., 40-15,000 c.p.s. ± 2 dB; 7½ i.p.s., 40-12,000 c.p.s. ± 3 dB, 50-10,000 c.p.s. ± 2 dB; 3¾ i.p.s., 50-6,000 c.p.s. ± 3 dB. Sustained peak-signal level meter. Size 18½ in. by 17½ in. by 9¾ in. Weight 49¾ lb. P.s.n. 100/130v or 200/250v A.C. Price 2 A/N (7½ and 3¾ i.p.s.) £79 16s.; 2 A/NH (15 and 7½ i.p.s.) £90 6s.

Models 66N and 66H. Complete semi-pro. recorders for console mounting. Spec. as for 2 A/N and 2 A/H. Size 17⅛ in. by 17⅛ in. by 9 in. Weight 45 lb. Price 66N (7½ and 3¾ i.p.s.) £88 4s.; 66H (15 and 7½ i.p.s.) £92 8s.

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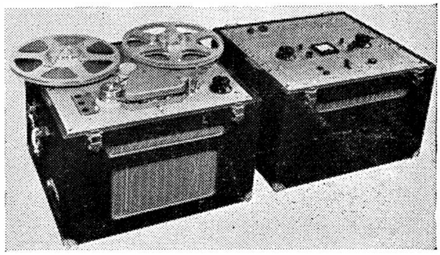
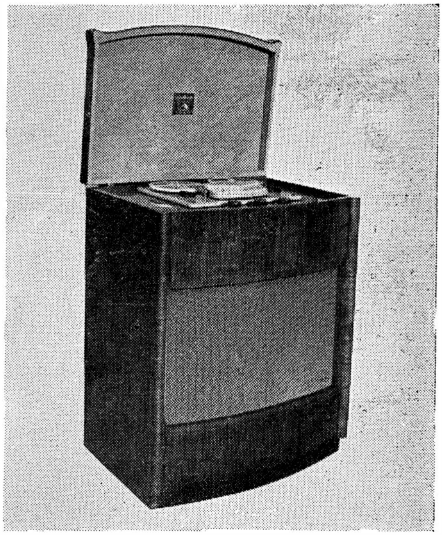
Grundig (Gt. Britain) Ltd., 6 Government Buildings, Kidbrooke Park Road, London, S.E.3. Tel.: Lee Green 8541. Showroom: 39-41 New Oxford Street, W.C.1. Cables: Grundig, London. Telex: 22054.

Reporter TK8/3D. Complete G.P. recorder. 7½ and 3¾ i.p.s. 1 motor. 7-in. spools.

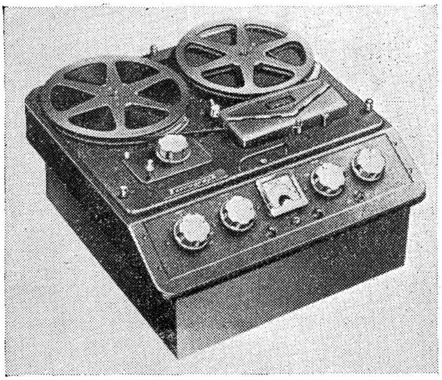


E.M.I. TR90 recorder and amplifier



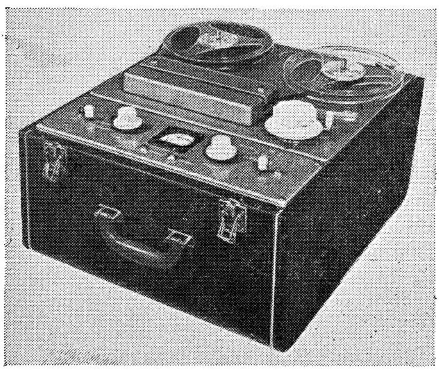
E.M.I. Model 3033 console player

E.M.I. L/2 battery driven portable



Ferrograph Model 66 *for console*

Grundig TK 820/3*D*



M.S.S. Model PMR/DE portable

F.r. : 7½ i.p.s., 50-13,000 c.p.s. ; 3¾ i.p.s., 50-9,000 c.p.s., both ± 3 dB. Magic eye level ind. Size 17 in. by 17½ in. by 9½ in. Weight 38 lb. P.s.n. 105-250v A.C. Price £75 12s.

Specialist TK 820/3D. Complete G.P. recorder. 7½ and 3¾ i.p.s. 1 motor. 7-in. spools. F.r. : 7½ i.p.s., 40-14,000 c.p.s. ; 3¾ i.p.s., 50-8,000 c.p.s., both ± 3 dB. Magic eye level ind. Size 17 in. by 17½ in. by 9½ in. Weight 48 lb. P.s.n. 105-250v A.C. Price £102 18s.

★

Leevers-Rich Equipment Ltd., 78b Hampstead Road, London, N.W.1. Tel. : Euston 1481. Cables : Leemag, London.

Model E. No. ER 111J. Prof. reproducer console. 15 and 7½ i.p.s. 3 motors. 11½-in. spools. F.r. : 15 i.p.s., 50-15,000 c.p.s. ; 7½ i.p.s., 50-10,000 c.p.s., both ± 2 dB on C.C.I.R. test tape. Size 24 in. by 22 in. by 36½ in. Weight 162 lb. Price £350.

Model E. No. E102R. Rack mounting network. Complete prof. recorder. 15 and 7½ i.p.s. 3 motors. 11½-in. spools. F.r. 15 i.p.s., 50-15,000 c p.s. ; 7½ i.p.s., 50-10,000 c.p.s., both ± 2 dB. V.U. level meter. Size 19 in. by 17½ in. by 9 in. Weight 50 lb. Price £400.

Model E. No. E121P. Prof. portable recorder. Spec. as for E102R. In two cases, 20 in. by 17 in. by 11½ in. and 15 in. by 18 in. by 10 in. Weight 79 lb. Price £450.

Model E. No. 132K. Prof. network recorder console. Spec. as for E102R. Size 30 in. by 22 in. by 36½ in. Weight 185 lb. (approx.). Price £450.

Model E. No. E121L. Prof. recorder and mixer console. Spec. as for E102R. Size 40 in. by 22 in. by 36½ in. Weight 192 lb. (approx.). Price £550.

Model C. No. C621P. Prof. portable recorder. 15 i.p.s. 3 motors. 9½-in. spools. F.r. : 50-15,000 c.p.s. ± 2 dB. V.U. level meter. Size 13 in. by 18 in. by 10 in. Weight 73 lb. P.s.n. 12v battery or auxiliary mains unit. Price £400.

Model DB. No. DB221P. Prof. portable recorder. Spec. as for C621P but in two cases 13 in. by 18 in. by 10 in. and 16 in. by 20 in. by 11¼ in. Total weight 74 lb. P.s.n. as C621P. Price £480.

Model CS. No. CS621P. Syncropulse recorder, for magnetic recording in sync. with cameras, etc. Spec. as for C621P. In two cases both 13 in. by 18 in. by 10 in. Total weight 73 lb. P.s.n. as C621P. Price £500.

★

M.S.S. Recording Co. Ltd., Poyle Farm, Colnbrook, Bucks. Tel. : Colnbrook 430. Cables : Emessco.

Model PMR/DE. G.P. recorder. 7½ and 3¾ i.p.s. 3 motors. 8¼-in. spools. F.r. : 3¾ i.p.s., 100-7,500 c.p.s. ± 3 dB ; 7½ i.p.s., 60-10,000 c.p.s. ± 5 dB, flat 100-7,000 c.p.s. Level meter. Size 16 in. by 19½ in. by 11¼ in. Weight 58 lb. Price £85, deck only £24.

Model CMR/DE. G.P. recorder. Spec. as for PMR/De. Size 36 in. by 28 in. by 18 in. Weight 110 lb. Price £140.

Model PMR/2XS. Prof. recorder. 15 and 7½ i.p.s. 3 motors. 7-in. spools. F.r. 15 i.p.s., 40-15,000 c.p.s. ; 7½ i.p.s., 50-10,000 c.p.s., both ± 3 dB. Price £140.

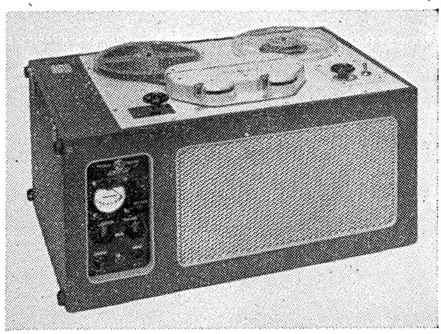
★

Rudman Darlington (Electronics) Ltd., Lichfield Road, Wednesfield, Staffs. Tel. : 31704.

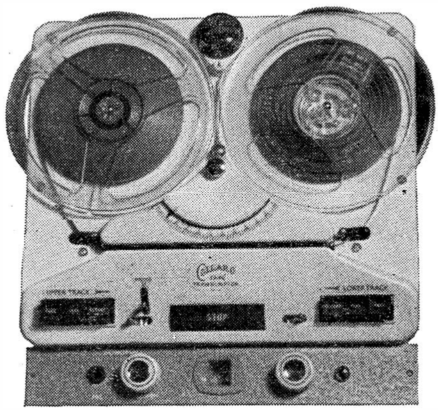
Reflectograph. Deck mechanism. Type T.D.M.1, 1 head, playback only ; type T.D.M.2, 2 heads, erase and record/playback; type T.D.M.3, 3 heads, erase, record, playback. Continuously variable speeds from 3.75 to 8 i.p.s. or up to 15 i.p.s. to special order. 3 motors. 8¼-in. spools. F.r. : 15 i.p.s., 40-15,000 c.p.s. ± 3 dB ; 7½ i.p.s., 40-10,000 c.p.s. ± 2 dB ; 3¾ i.p.s., 40-7,500 i.p.s. ± 2 dB. Panel size 17¼ in. by 13¾ in. by 7 in. Weight 24 lb. Price on application.

Reflectograph RR 101. (Record/Reproducer.) Speeds continuously variable from 3¾ to 8 i.p.s. 3 motors. 8¼-in. spools. F.r. : C.C.I.R. spec. ± 1.5 dB. Overall bandwidth 40-10,000 c.p.s. ± 2 dB (−4 dB at 13,000 c.p.s.). Level meter. Size 21½ in. by 15½ in. by 13 in. Weight 56 lb. All mains voltages and frequencies supplied to order. This model makes no provision for a built-in power stage, is intended for use with high quality power amp. Price £105.

Reflectograph RR 102. Complete recorder. This model consists of a tape record amp. and playback/reproducer, the output of which feeds into a 3 watt audio amp. which is part of the " Brick " unit. Spec. otherwise as for RR 101 above. Price £115 10s.

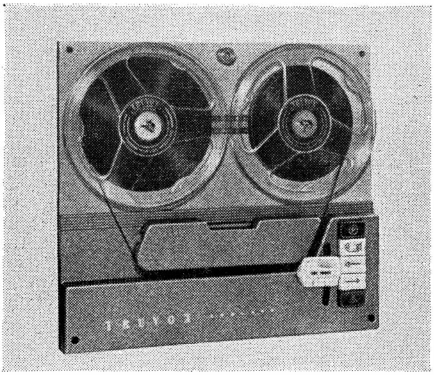


Rudman Darlington " Reflectograph " RR 102

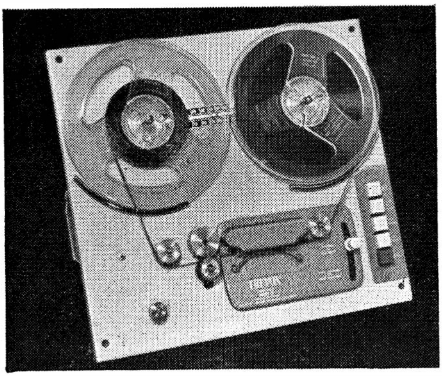


Sonomag " Adaptatape " Mk. III

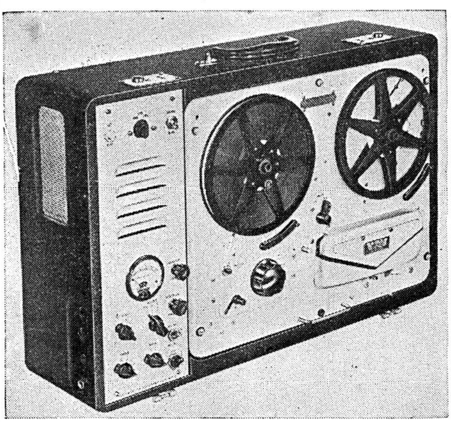
Sonomag Mk. III portable recorder



Truvox Mk. IV deck



Truvox Mk. III deck



Vortexion W.V A. semi-professional portable

Sonomag Ltd., 2 St. Michael's Road, London, S.W.9. Tel. : Brixton 5441.

Sonomag Adaptatape Mk.III. G.P. tape deck and pre-amp. Collaro tape deck. F.r. 15 i.p.s. 50-15,000 c.p.s. ; 7½ i.p.s. 50-12,000 c.p.s. ; 3¾ i.p.s. 50-8,000 c.p.s., all ± 3 dB. Magic eye level ind. Meter extra. Size 14 in. by 14 in. by 6 in. Weight 30 lb. P.s.n. 275v at 50mA ; 6.3v at 2 A. Price £35 14s. Power supply £4 4s. extra.

Sonomag Mk.III. Complete G.P. portable recorder using Collaro tape deck. Spec. as for Adaptatape. Magic eye level ind. Size 16½ in. by 14 in. by 7 in. Weight 34½ lb. Price £54 12s. incl. a mike and reel of tape.

★

Specto Ltd., Vale Road, Windsor, Berks. Tel. : Windsor 1241/2. Cables : Specto, Windsor.

Spectone 151. G.P. portable recorder. Collaro deck. F.r. : 15 i.p.s., 30-16,000 c.p.s. (to C.C.I.R. spec.) ; 7½ i.p.s., 30-12,000 c.p.s. (to C.C.I.R. spec.) ; 3¾ i.p.s., 40-6,000 c.p.s., all ± 3 dB. Level meter. Size 18½ in. by 16 in. by 11¾ in. Weight 50 lb. P.s.n. 110/250v. Price £75 12s. (inc. crystal mic.).

★

Truvox Ltd., 15 Lyon Road, Harrow, Middx. Tel. : Harrow 9282. Cables : Truvoeng, London.

Mk. III/U. G.P. tape deck. 7½ and 3¾ i.p.s. 3 motors. 7-in. spools. F.r. : 7½ i.p.s., 50-12,000 c.p.s. ; 3¾ i.p.s., 100-7,000 c.p.s., both ± 3 dB. Panel size 14¼ in. by 12 13/16 in. by 7½ in. Weight 14½ lb. Price £24 3s.

Mk. IV. G.P. tape deck. Spec. as for Mk. III/U. Weight 15½ lb. Price £27 6s. (with timing scale) ; £30 9s. (with counter).

R.1. G.P. tape recorder. Spec. as for Mk. III/U. Magic eye level ind. Size 15 in. by 14 in. by 8½ in. Weight 37 lb. Price £69 6s. (with timing scale) ; £72 9s. (with counter). Both include crystal mic. and 1,200 ft. of tape.

★

Vortexion Limited, 257/263 The Broadway, Wimbledon, London, S.W.19. Tel. : Liberty 6242. Cables : Vortexion, Wimble, London.

Model W.V.A. Semi-pro. complete recorder. 7½ and 3¾ i.p.s. or 15 and 7½ i.p.s. 3 motors. 8¼-in. spools. F.r. : 7½ i.p.s., 50-10,000 c.p.s. ± 1½ dB. Level meter.

Weight 48 lb. (approx.). Price £92 8s. (£5 extra for 15 i.p.s.).

Model WVB. Prof. recorder, extra monitor head amp. Spec. as for model WVA. Price £108 18s. (£5 extra for 15 i.p.s.).

★

Wright & Weaire Ltd., 131 Sloane Street, S.W.1. Tel. : Sloane 2214. Cables : Writwea Knights.

Wearite Tape Deck. Models 2A, 2B, 2C. Semi-pro. 15 and 7½ i.p.s. 3 motors. 8¼-in. spools. Panel size 16½ in. by 13 in. by 7 in. Weight 18 lb. P.s.n. 200/250v or 100/130v A.C. Price 2A £35 ; 2B £40 ; 2C £45.

TAPE AMPLIFIERS

Brenell Engineering Co. Ltd., 2 Northington Street, London, W.C.1. Tel. : Holborn 7358.

Brenell Pre-amplifier. Inputs : Mic., 2 meg. ohms, 1.4 mV for peak recording level. Radio 700 K/ohms, 152 mV for peak recording level. Controls : Record, playback and amplifier. Automatic guard against accidental erasure and provision for setting up any recorded signal before recording. Socket outlet for tape playback. Variable output up to 1V at source imp. of approx. 60 K/ohms. H.D. 0.5 % at peak recording level. H. & N. better than 45 dB. P.s.n. 300v at 35-40 mA, 6.3v at 1.5 A. Usually sold as part of Mk.1V Model 600 tape deck, or as second pre-amp to convert Brenell tape deck for stereophonic use. Price £17 6s. 6d.

Brenell Amplifier. 10 watts. Dist. 0.3% at 2,000 c.p.s. Input for spec. output 50 mV without tone control circuit, 600mV with tone control circuit. Response within 1 dB of 1,000 c.p.s., level 30-15,000 c.p.s. Feedback 26 dB at 1,000 c.p.s. N.L. at least 75 dB below 10 watts. Out-imp. 15 ohms. Output EL 84's. For use with Model 600 pre-amplifier. Price not announced.

★

Cape Electrophonics Ltd., 43-45 Shirley High Street, Southampton. Tel. : Southampton 74251.

Cape Tape Unit VLT. Gen. purpose professional standard tape amp. with compensation for 3¼, 7½ and 15 i.p.s. Response depending on deck used but with average deck at 15 i.p.s. 30-15,000 c.ps. ± 3 dB ; 7½ i.p.s. 40-12,000 c.p.s. ± 3 dB ; 3¾ i.p.s. 40-6,000 c.p.s. ± 3 dB. M.E. meter optional. Size 9 in. by 6 in. by 3 in. P.s.n. 300-450v at 40 mA, 6.30 at 1 A. Price to be announced.

★

C. T. Chapman (Reproducers) Ltd., Riley Street, Chelsea, London, S.W.10. Tel. : Flaxman 4577/8.

205TCU. Gen. purpose tape amp. Inputs : mic. 1.4 mV ; radio 150 mV. Record/playback switch, vol. of record channel. H.D. < 0.5% with record current of 200 mA. Size 12 in. by 3 in. by 6 in. Weight 10 lb. To operate with Chapman 205CU and 205 power amp. Price to be announced.

★

Collaro Ltd., Ripple Works, By-Pass Road, Barking, Essex. Tel. : Rippleway 5533. Cables : Korllaro-Telex-Barking.

Type M Tape Amp. and bias oscillator with power pack. Inputs : mic. 5 mV ; aux. 500 mV. 1 output and 2 input sockets. Speed equalisation switch for 3¾, 7½ and 15 i.p.s. For use with Collaro tape deck. Magic eye level ind. Size pre-amp. 9 in. by 21 in. by 51 in. ; power pack 7 in. by 41 in. by 51 in. Price to be announced.

★

The Lowther Manufacturing Co., St. Mark's Road, Bromley, Kent. Tel. : Ravensbourne 5225. Cables : Lowther, Bromley.

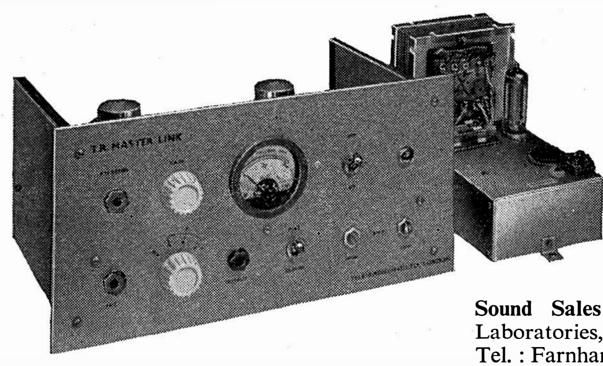
Tape B and E Unit, No. 1. Self-powered unit for bias voltage and record level metered control with playback pre-amp. or direct head connection. Switch to allow meter setting of bias voltage to suit head or tape. Price approx. £24.

Companion Supply Unit No. 2. H.T. and L.T. power supply suitable to power radio tuners. Preamp and tape bias amplifier. Output 250v at 40 mA, 6.3v at 3 A. Price £5 10s.

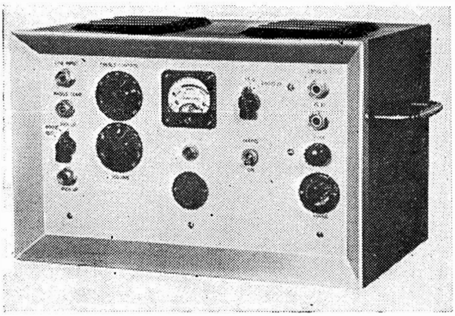
★

M.S.S. Recording Co., Ltd., Poyle Farm, Colnbrook, Bucks. Tel. : Colnbrook 430. Cables : Emessco.

4 MZ or 2 ML. Microphone mixing and control unit. Up to 4 mics. or line, P/U and 2 mics. Microphone switching and level control. Output socket for 6 ohm line and 15 ohm monitor speaker. 3 input sockets. H.D. at 1 mW 1,000 c.p.s. Tone is 0.25%.



Tele-Radio "Master Link" amplifier



M.S.S. MZ mixing and control unit

H and N at normal output level on 1 mW signal to noise ratio 60 dB. Size $14\frac{1}{2}$ in. by 12 in. by 7 in. Price £50.

RA/50. Amplifier for recording and playback. 50 watts. Dist. 2.5% at 50 watts. Input for spec. output 1v. Response 30-15,000 c.p.s. ± 2 dB. Feedback 15 dB. N.L. − 80 dB at full output. Out. imp. RA50/1 1,800 ohms ; RA50/2 200 ohms ; RA50/3 15 ohms. Output EL37's. Size 19 in. by 14 in. by 8 in. Weight 96 lb. Power available for pre-amp. Price £70.

BPA/1. Amplifier designed to enable tape recordings to be dubbed on to discs. Price £37 10s.

★

Rogers Developments (Electronics) Ltd., " Rodevco Works," 4-14 Barmeston Road, Catford, S.E.6. Tel. : Hither Green 7424. Cables : Rodevco, London.

General Purpose Power Pack. Suitable for tape units and radio tuners. Output 250v at 45 mA, 6.3v at 2.5A. Size $7\frac{1}{2}$ in. by 3 in. by 5 in. Price £4 10s.

Sound Sales Ltd., Works and Acoustic Laboratories, West Street, Farnham, Surrey. Tel. : Farnham 6461-2-3. Cables : Sounsense.

A-Z General Purpose Power Pack for supplying additional units beyond the scope of the main amplifier. Output 250v at 35 mA, 6.3v at 2 A. Size $11\frac{1}{4}$ in. by $4\frac{1}{2}$ in. by $4\frac{1}{2}$ in. Weight approx. 6 lb. Price £5 10s.

A-Z Precord Unit. Designed for use with Wearite or Collaro tape deck. Self-powered inputs : mic. or radio/pickup. Sel. switch for record and replay. Green and red ind. lights give add. visual check. Calibrated recording live indicator. Equalisation for $3\frac{3}{4}$, $7\frac{1}{2}$ and 15 i.p.s. C.C.I.R. and Ampex characteristics. Variable bias control. Record level gain control. Size $11\frac{1}{4}$ in. by $9\frac{1}{2}$ in. by $4\frac{3}{4}$ in. Weight 12 lb. Price £30.

★

Tele-Radio Ltd., 189 Edgware Road, London, W.2. Tel. : Paddington 4455.

T.R. Master Link. Tape pre-amp. primarily for Wearite tape deck. 2 units, pre-amp. and oscillator and separate power supply. Inputs : mic. 3 mV ; radio/pickup 100 mV. Meter level ind. Response 30-20,000 c.p.s. ± 1 dB. Separate high and low imp. outputs to suit head levels. Oscillator cut-out facility for deck connection. Equalisation for $3\frac{3}{4}$, $7\frac{1}{2}$ and 15 i.p.s. Separate controls for turnover and top left. Output via low imp. approx. 100 mV. Size 12 in. by 6 in. by 8 in. Price £28 7s.

★

Truvox Limited, 15 Lyon Road, Harrow, Middx. Tel. : Harrow 9282. Cables : Truvoxeng, London.

Type " C " Recording Amp. Inputs : 1 megohm at 1-2 mV ; $\frac{1}{2}$ megohm at 0.5v. Vol. and on/off. Record/replay switch. Tone control. High imp. output. H and N − 45 dB. Output 4 watts. Primarily for Truvox tape deck. Price £17 17s.

Vortexion Ltd., 257/263 The Broadway, Wimbledon. Tel. : Liberty 6242/3. Cables : Vortexion, Wimble, London.

TRG10. Complete recording amp. 10 watts nom., 15 watts max. 10 pos. sel. Equalisation for different recording speeds and playback characteristics. Dist. $< 0.1\%$ at 10 watts. Input for spec. output 0.1 mV to 3v. Response 20-50,000 c.p.s. $\pm$ 0.2%. Feedback 26 dB. N.L. — 80 dB. Out. imp. 4-16 ohms. Output EL84's. Ultra-linear. Size $4\frac{1}{2}$ in. by 5 in. by $10\frac{1}{2}$ in. Price not yet announced.

TAPE ACCESSORIES DIRECTORY

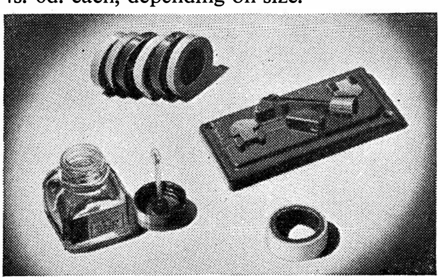
EMI Sales & Service Ltd. and **EMI International Ltd.,** Blyth Road, Hayes, Middx. Tel. : Southall 2468. Cables : Emiservice, Telex, Emiglobe.

Emitape Jointing Compound. AP35 for C.A. base tape. AP77 for P.V.C. base tape. A jointing fluid for making permanent welded joints in magnetic tape. Price 7s. 6d. per bottle.

Emitape Jointing Tape. AP103. Adhesive jointing tape for simple and quick splicing and editing of magnetic tape. Price 7s. 6d. per reel.

Emitape P.V.C. Editing and Marker Tapes. A range of six coloured tapes to enable colour code reference to be inserted in a reel of recorded tape for quick editing and indexing purposes. AP38/1 white ; AP38/2 red ; AP38/3 yellow ; AP38/4 blue ; AP38/5 orange ; AP38/6 green. Price 4s. 6d. per reel.

Emitape Plastic Tape Spools in cartons, all standard sizes available. Price approx. 4s. 6d. each, depending on size.



E.M.I. tape accessories

Emitape Jointing Block and Cutter. Type AP46. For splicing and editing tape. The tape location channel gives perfect alignment to the tape and the cutter is of non-magnetic material. Price 17s. 6d.

Emitape Non-magnetic Scissors. Type AP39. Made of non-ferrous metal, the scissors may be used for splicing magnetic tape without risk of magnetising, so ensuring a completely noiseless join. Price 16s.

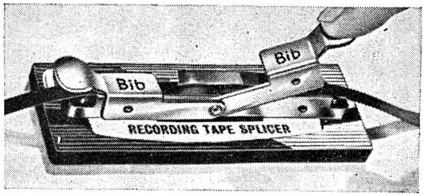
★

Leevers-Rich Equipment Ltd., 78b Hampstead Road, London, N.W.1. Tel. : Euston 1481. Cables : Leemag, London.

Lee Raser. Junior ER30A ; Standard ER31B ; Senior ER32B. Ultra rapid demagnetisers for spools of tape and accessories. Price £6 5s. ; £9 10s. ; £15.

★

Multicore Solders Ltd., Multicore Works, Hemel Hempstead, Herts. Tel. : Bosemoor 3636.



Multicore " Bib " tape splicer

The " Bib " Tape Splicer. This splicer enables the tape to be jointed easily and to be edited to the accuracy of a syllable. Supplied complete with razor cutter and mounted on flock-covered panel. Price 18s. 6d.

★

Truvox Ltd., 15 Lyon Road, Harrow, Middx. Tel. : Harrow 9282. Cables : Truvoxeng, London.

Dictating Attachment. TA1. Price £4 4s. **Telephone attachment,** for recording 2-way telephone conversations. Price £2 2s. **Headphones,** for use with any recorder with low impedance output socket. Price £3 3s. and £2 15s. **A.M. Radio Jacks.** Price Standard (M.W. only) £2 10s. (U.K. purchase tax £1 2s.) ; Senior (M.W. and L.W.) £3 9s. 6d. (U.K. purchase tax £1 10s. 6d.).

★

Wright & Weaire Ltd., 131 Sloane Street, London, S.W.1. Tel. : Sloane 2214. Cables : Writewea, Knights.

Wearite Defluxer. For depolarising heads of tape recorders and players. It ensures maximum signal/noise ratio from any tape recorder and protects recorded tapes from cumulative background noise and the gradual attenuation of the higher frequencies. Price £2 10s.

STEREOPHONIC SOUND

Advantages gained by "2-eared" listening

By James Moir

STEREOPHONIC sound reproduced from magnetic tape is undoubtedly the "Highest-Fi" obtainable at the present time, and it is clear that any further major development in the sound reproducer art must be along stereophonic lines. It is therefore worth recapitulating the advantages of a stereophonic sound reproducer system, for this is a subject on which there is a great deal of misconception and distortion. The advantages can be summarised fairly briefly : A stereo system reproduces the spatial distribution of the original sound source and its environment. Description in a few words like this makes it seem unimportant, but there are far reaching implications that require further explanation if the advantages are to be appreciated.

Spatial Separation

It is now known that our hearing system uses the spatial separation of two or more sound sources to aid it in distinguishing the wanted from the unwanted sound. This it achieves because the hearing system can control the direction in which it listens with its maximum sensitivity. Sounds originating outside the zone of maximum sensitivity are not eliminated ; they are merely heard as a background to the wanted sound. This is a faculty that is used continuously in our daily life, for without it conversation in a noisy environment would be impossible. It is this faculty that permits you to understand conversation across the table in a busy restaurant, amid a perpetual clatter of crockery and the well-meant distraction of a dance band.

The value of our steerable listening system was well demonstrated by Dr. Dutton of EMI, when he presented the EMI paper on the "Stereosonic Recording and Reproducing System" to the Institution of Electrical Engineers this year. Dr. Dutton recorded the simultaneous conversations of two couples in the same studio. The recording could be replayed either through two paralleled speakers as a monaural system, or stereophonically through the same speakers to reproduce the positions of the two couples in the studio. Replayed monaurally, it proved impossible to understand anything that was being said. Replayed stereophonically, either conversation could be followed without difficulty.

Selective Listening

When we listen to an orchestra in a concert hall, or to a play in a theatre, we use our steerable hearing system to bring into prominence the instrumental group or the characters to which we wish to listen. It makes it possible to " listen away " from the brass section when it is too noisy, or to balance the different sections of the orchestra to suit our own individual tastes. The soloist can be separated from the body of the orchestra without difficulty.

Single Channel " Muddiness "

If this faculty is disabled by interposing a monaural (single channel) reproducer system between orchestra and listener, then a great deal of clarity and definition is lost. In the past this " muddiness " and loss of definition has been ascribed to intermodulation distortion in the electro-acoustic system, but it is now appreciated that it is inherent in any monaural system. Satisfactory reproduction of an orchestra cannot be obtained if all the sound emerges through a 10-in. hole. Though it would take too much space to go into detail, it can be said that merely increasing the physical size of the speaker, or using two or more speakers in parallel, does nothing to reduce this " size distortion."

There are obvious advantages in reproducing the position of the actors in a play.

They may be given their exits and their entrances ; two characters may speak a few lines simultaneously as in real life ; or the telephone bell may ring without the telephone and the actor appearing to be coincident in space.

Acoustic Scenery

The acoustic characteristics of a concert hall or theatre play an important part in our enjoyment of the performance, for they form the acoustic scenery against which the action takes place. A stereophonic reproducer system reproduces the acoustic scenery ; a monaural system almost eliminates it, and grossly distorts that fraction that it does transmit. Bass boom in a studio is much more obvious over a single channel system, and in general a satisfactory performance is only secured from a studio when very considerable care is taken to reduce the low frequency reverberation time to a relatively low value.

Though the exact reasons are not fully understood, it is well established that a non-engineering audience will not tolerate a monaural reproduction of an orchestral performance with either the same frequency or volume range as the original performance. Once again our dislike of these characteristics of an original performance has been ascribed to residual distortions in the electro-acoustic equipment—even when such distortions have been reduced to less than one tenth of the value that separate tests have shown to be " just detectable." It is now known that our dislike of the original frequency and volume ranges is due to the use of a monaural reproducing system. To a large extent, the performance of any stereo system can be judged by the frequency and volume ranges that it makes acceptable to a non-engineering audience.

In Search of " Highest-Fi "

The sound reproducer art is now well past the stage at which the reproduction of intelligible speech or recognisable music is the target. Research workers in the field are now trying to understand those elusive little distortions that differentiate the original performance from the best possible reproduction. All the available evidence goes to show that reproduction of the spatial characteristics, and the size of the original sound source, are essential if reproduction of the " Highest-Fi " is to be obtained. The cost of additional equipment is clearly a serious problem ; thus, while the performance of three- and five-channel systems can be superb, practical politics limit the domestic user to two channels. Getting three-channel performance from a two-channel system is a real challenge to the recording engineer.

DIRECTORY OF STEREO EQUIPMENT

Beam-Echo Ltd., Witham, Essex. Tel. : Witham 3184. Cables : Parion, Witham.

Avantic Mk. III. Deck and preamps. 1 motor. 7½ i.p.s. Inputs for stereophonic and ½ track recordings. 7-in. spools. Built-in preamp fully compensated to C.C.I.R. spec. Output (variable) 500 mV max. Response 30-12,500 c.p.s. ± 3 dB. Panel size 16 in. by 10⅛ in. Total depth 3¾ in. Weight 12¼ lb. P.s.n. motor 115 or 230v A.C. Preamp 300v at 10 mA, 6.3v at 0.8 amp. Price to be announced.

★

Bradmatic Ltd., Station Road, Aston, Birmingham 6. Tel. : East 2881-2. Cables : Bradmatic, Birmingham.

Bradmatic Console Model 45. Deck and preamp. Model 5D tape deck. 3 motors. 7½ and 3¾ i.p.s. 10½-in. spools. Response 40-15,000 c.p.s. ± 4 dB. Size 35 in. by 27 in. by 25 in. P.s.n. 110v, 60 c.p.s. or 230v, 50 c.p.s. Price £190.

Brenell Engineering Co. Ltd., 2 Northington Street, London, W.C.1. Tel. : Holborn 7358

Brenell Mk.IV Model 600. This G.P. tape deck and preamp can be converted to a stereophonic recorder on the " staggered " principle by the addition of one record/playback and one erase head also two pressure pads, one with mumetal screen and springs at a total cost of £4 8s. Also required is another preamp which can be mounted directly below the first one. Full spec. of tape deck and preamp given in respective directories.

★

EMI Sales & Service Ltd. and **EMI International Ltd.,** Blyth Road, Hayes, Middx. Tel. : Southall 2468. Cables : Emiservice, Telex, Emiglobe.

H.M.V. " Stereosonic " Tape Deck. Preamp. and control unit. Model 3035. 1 motor. 7½ i.p.s. Input for single channel tape records, discs, and 2 aux. inputs. 7-in. spools.

C.C.I.R. spec. Response 40-10,000 c.p.s. ± 3 dB. Deck size 17 in. by 11½ in. by 13½ in. Control unit 16 in. by 4 in. by 4 in. Bass, treble and vol. controls give combined control on both amp circuits. P.s.n. 195-255v, 50 c.p.s. Price £122 17s.

H.M.V. "Stereosonic" Reproducer. Model 3034. Complete reproducer in 2 cabinets, including 2 amps and loudspeaker system using 3035 deck. Size 35½ in. by 27½ in. by 19½ in. Weight : first cabinet with tape deck 140 lb. ; second 120 lb. Price £288 15s.

★

British Ferrograph Recorder Co. Ltd., 131 Sloane Street, S.W.1. Tel. : Sloane 1510. Cables : Britferro, Knights.

Ferrograph, Stereo "77." Complete reproducer. 3 motors. 7½ and 3¾ i.p.s. Facilities : ½-track monaural record and monitoring, playback and stereo playback, all usual inputs. 8¼-in. spools. Response at 7½ i.p.s. 50-10,000 c.p.s. ± 2 dB ; ± 3 dB at 12,000 c.p.s. Size 18½ in. by 17½ in. by 9¾ in. Weight 50 lb. (approx.). P.s.n. 100/130v or 200/250v A.C. Price £102 18s.

Ferrograph Stereo "88." A complete 2-channel recorder/reproducer. Portable. For tape speeds of 7½ and 15 i.p.s. Switched input meter enables levels of both channels to be balanced. Output of each channel on playback approx. 2 millivolts across 600 ohms. Can also be used for monaural record/replay. Price £110 5s.

The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2. Tel. : Temple Bar 8000. Cables : Polyphase, London.

Stereophonic Equipment. A complete stereophonic set-up incorporating two G.E.C. octagonal loaded-port speaker cabinets each containing a G.E.C. metal-cone drive unit and presence unit. In a separate console, two G.E.C. BCS2417/2418 amplifiers and control units and a Truvox TR2113 tape deck. Inputs for tuner and pickup. Price BCS1415 stereophonic amplifier console £163 15s. ; BCS1866 stereophonic speaker assy. complete £27 5s. 10d. (U.K. purchase tax £10 10s. 2d.).

★

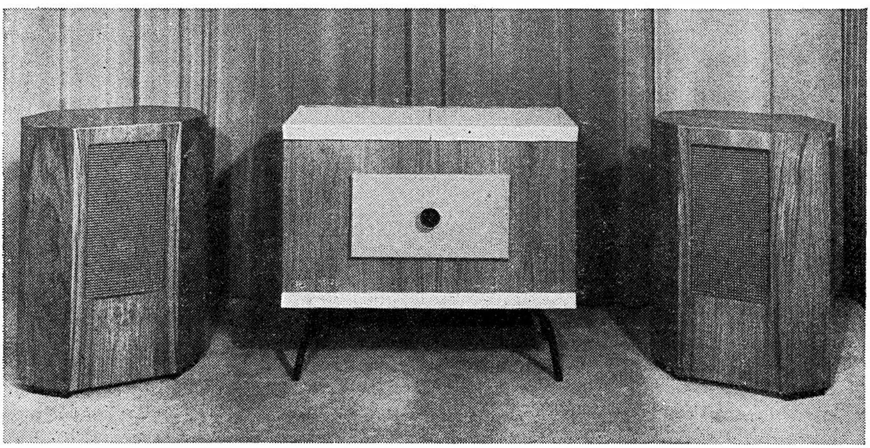
Leevers-Rich Equipment Ltd., 78b Hampstead Road, London, N.W.1. Tel. : Euston 1481. Cables : Leemag, London.

Model E. No. ED-121P. Complete portable dual channel recorder. 3 motors. 15 and 7½ i.p.s. Monitoring off tape, separate V.U. meter, unit amp. L.R. and H.R. mic. or line inputs. 11½-in. spools. Response at 15 i.p.s., 50-15,000 c.p.s. ± 2 dB. Size 2 cases 16 in. by 20 in. by 11 in. Total weight 80 lb. Price £500.

★

Rudman Darlington (Electronics) Ltd., Lichfield Road, Wednesfield, Staffs. Tel. : 31704.

Reflectograph. RR101 (S) no output stage and RR102 (S) with two 3-watt output stages. Instrument type stacked heads, C.C.I.R. spec. 3 motors. Continuously variable, 3¾-8 i.p.s. Will record monaural on top track, input



The G.E.C. stereo system, using a pair of octagonal reproducer enclosures with metal cone units sensitivity 100 mV. 8¼-in. spools. Response ± 1 dB within 50-7,500 c.p.s. range ; ± 2 dB within 40-10,000 c.p.s. range ; ± 3 dB within 40-15,000 c.p.s. range. Size of " Brick " 13½ in. by 6½ in. by 6¾ in. Weight 3 lb. (approx.). Price of " Brick " RR101 (S) £73 10s. ; " Brick " RR102 (S) £94 10s. ; tape deck T.D.M.3 for either model £65.

★

Sonomag Ltd., 2 St. Michael's Road, London, S.W.9. Tel. : Brixton 5441.

Sonomag Stereo Preamplifier. Inputs for pickup, radio, stereo and monaural tape. 6 pos. sel. L.P., 78, radio, stereo play, monaural play, record. Play tone control, bass and treble cut. Tone compensation for recording at 15, 7½ or 3¾ i.p.s. H.D. 0.5% including " record " position. To operate with Sonomag Twin channel amplifier. Price not yet announced.

Twin Channel Amplifier. 3 watts output for each channel. Dist. 1.5% total. Input for spec. output 100 mV. Response 50-15,000 c.p.s. ± 2 dB. Feedback 20 dB. N.L. 70 dB below 3 watts. Out. imp. 2.5, 4 and 15 ohms. Output EL84's. To operate with Sonomag Stereo preamp. Price not yet fixed.

Stereophonic recorder. Complete G.P. recorder, Truvox or Collaro tape deck. For spec. of decks see tape recorder directory. Magic eye level ind., meter extra. Price approx. £70. Write for further details.

Specto Ltd., Vale Road, Windsor, Berks. Tel. : Windsor 1241/2. Cables : Specto, Windsor.

Spectone 126. Complete stereophonic reproducer. 3 motors. 7½ i.p.s. Provision is made for feeding an external pickup or radio tuner unit into one or both amps. 7-in. spools. Response C.C.I.R. spec. 50-12,000 c.p.s. ± 1.5 dB. Size 32½ in. by 23¼ in. by 22½ in. P.s.n. 110/250v A.C. Price £165.

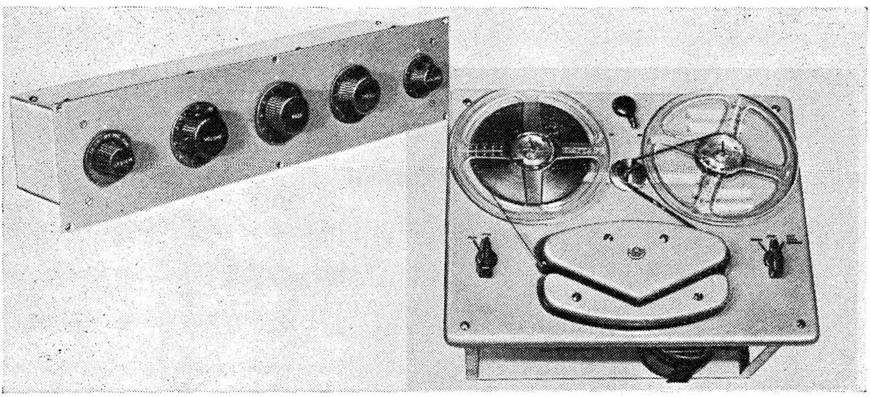
Spectone 123. Complete stereophonic reproducer. Spec. as for 126, plus provision for transcription motor, F.M. tuner, single track and stereo reproduction. Size 44 in. by 25 in. by 34½ in. Price £210.

Spectone 128. Complete stereophonic reproducer, plus ½-track recording, complete mixing of any combination of disc, radio, and mic. 3 motors. 7½ i.p.s. 7-in. spools. Size 32½ in. by 2¾ in. by 22½ in. Price and full spec. on application.

★

Truvox Limited, 15 Lyon Road, Harrow, Middx. Tel. : Harrow 9282. Cables : Truvoeng, London.

Truvox TR2049 Stereophonic Head. Stacked heads with safety gap for ¼-in. tape. Azimuth adjustment incorporated — will directly replace Truvox ½-track heads. Response 50-15,000 c.p.s. ± 3 dB with suitable amp. Impedance 50,000 ohms at 10 Kc/s. Cross talk better than 45 dB. Price £14 10s.



The E.M.I. 3035 *deck incorporates a pair of matched preamplifiers, each delivery* 1½ *volts output. The control unit, connected to the deck and preamplifiers by a length of coaxial links, provides the simultaneous control of both preamp outputs for volume, bass and treble. These three controls are in the form of stepped switches, with* 10 *stages of volume level, and five stages of lift and cut on tone. A fourth switch gives two positions for reversing left and right speakers (and their channels), also positions for full width recordings, and two auxiliary inputs (e.g., pickup and tuner). The final control is for balancing the sound from the two speakers*

MICROPHONES

By Stanley Kelly

THE introduction of domestic tape recorders has resulted in home recordings being produced by amateurs on a mass scale, and the use and misuse of microphones assumes ever increasing proportions. It is not generally possible to purchase a microphone off a shelf, just because it looks pretty, and automatically to obtain correct results from it ; but it is more than possible, with two equally good microphones having different field responses, for one to be perfectly satisfactory under domestic recording conditions and for the other to be disappointing.

Basically, all microphones can be divided into two main classes : **(a)** those with an omni-directional field response ; that is, the sensitivity of the microphone is constant irrespective of the angle from which the sound is coming, usually termed " pressure microphones " ; **(b)** microphones which are more or less selective to the direction of sound ; and these can be still further subdivided into **(b1)** " pressure gradient " microphones, which give response in the form of a " figure of eight " pattern, and **(b2)** which is a combination of **(a)** and **(b1),** usually termed " cardioid," from the shape of the polar response curve.

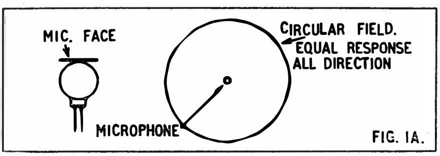


Fig. 1a—*Pressure microphone—field response.*

The idealised field response of these three types is shown in **Fig. 1.** It will be seen in the case of **(b1)** that the microphone possesses virtually no response at right angles to its face, although the sensitivity fore and aft is approximately equal ; whilst in the cardioid **(b2)** the " front to back ratio " for sound sensitivity can be anything from 4 : 1 to as high as 20 : 1.

There must be some reason for developing three different types of microphones, and this is not far to seek. If we have a sound source situated in the open air, at an altitude of a couple of miles or so, a sound emanating from it will assume the form of a spherical wave front. That is, it will proceed outwards in all directions at the same amplitude and phase. As we bring our sound source nearer to earth, more or less of the sound will be reflected from the ground, and will modify our original concept ; but under actual working conditions, especially on a flat surface, say a cricket field, the amount of reflection is not extremely great, and the sound dies away equally in all directions from its source, following what is technically termed an " inverse square law."

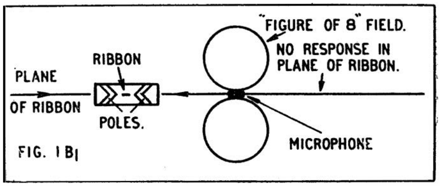


Fig. 1b1—*Ribbon microphone—field response.*

Suppose now that we move our sound source into a building. The walls, the floor, the ceiling, furniture, people, etc., will all

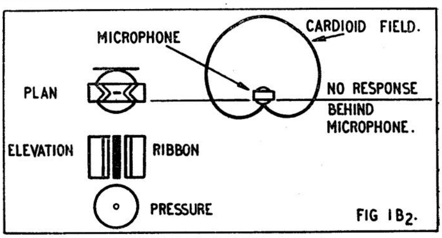


Fig. 1b2—*Cardioid microphone—field response.*

individually absorb and reflect varying amounts of sound energy. If the room is fairly small, and has hard polished reflecting surfaces, say a tiled bathroom, the absorption will be small, and the majority of the sound energy impinging upon the walls will be reflected. Because of the small losses in the system, the original sound will be reflected many times before it completely dies away. We thus have two extremes : the open air, technically termed " free field," in which there is no reflected sound ; and the small highly reflecting bathroom, in which the original sound is reflected many times and therefore persists for an appreciable time. It is possible, with specially constructed chambers, for this reverberation time, as it is termed, to last for a minute or so. Under normal conditions, however, the reverberating sound in a domestic living room is of the order of a fraction of a second. In some of our cathedrals, the reverberation time is quite long, 10 or 15 seconds or more in some cases, due to the large volume and the hard stone walls acting as reflecting surfaces.

Reverberation

It was mainly for this reason that during religious services the intoning and responses were pitched on a particular note and uttered very slowly in order that the resultant sound (the original plus the multiple reflections) would not become verbiage. Of course, the classic example of all time, at least as far as music (?) is concerned, is the Royal Albert Hall, where in favoured positions of the Hall a staccato note can be heard for a maximum of seven times, each repetition being complete and distinct in itself and dying away before the ensuing one arrives. Whilst this is an extreme example, it does illustrate what can happen under operating conditions of a domestic tape recorder.

The Ability to Focus

When we listen to sound, whether it be music from an orchestra or radio, or just another person speaking, we concentrate our effort towards the intelligence we are trying to hear and, by virtue of our two ears and the sensory perception mechanism connected to them, we can more or less " focus " our attention to a particular point in space. It is significant that if a continuous note is sounded in open air it is possible to estimate the angle from which it comes to a surprising degree of accuracy ; but if the same note is sounded in a fairly live living room, after the first second or so it is completely impossible to detect from which direction it arrives. The reason for this is that the incident and reflected waves of the same frequency add up " vectorially," so that standing wave patterns are set up in the room, and it is possible for the sound pressure (volume) at some positions to be actually greater than at the loudspeaker source. Thus if a pressure type of microphone is used under these conditions, the voltage from the microphone will be entirely dependent upon its position in the room and moving it even a few inches may alter the output by 10 : 1.

Extraneous Background Noise

If, instead of a single pure tone, normal speech or music has been transmitted, the pressure microphone will pick up equally effectively the transmitted and the reflected waves, and it is this phenomenon which results in so much extraneous background noise in home recordings where pressure microphones are used and hung in an odd corner of the room during, say, a party. If a pressure gradient microphone is used, it will respond only in the direction of the loop shown in **Fig. 1b2** and the resultant room " ambience " will be reduced. Of course, if the speakers or artists are not in the beam, their apparent volume will also be reduced.

Emphasis by Direction

Finally, the cardioid type will give a maximum signal-to-unwanted-noise ratio, provided that the source of sound is within the beam of the microphone. These various facilities are all used in professional recording studios in order to emphasise particular instruments of the orchestra ; especially in the recording of " mood " music, where as many as ten microphones may be used, each being switched in and out at the psychological moment in accordance with a specially marked score provided for the engineer. Thus, an intelligent use of the correct type microphone can improve one's recording facilities one-thousandfold.

Pressure microphones are generally of two classes : (a) crystal, and (b) dynamic. The crystal microphone depends for its action on what is known as piezo-electricity. This is the ability of certain crystals to generate an electrical charge if pressure is applied to the crystal in a particular direction. Use is made of this phenomenon by cutting slabs of suitably oriented crystal material cementing them in pairs, making what is known as a " bimorph." The bimorph is nothing more or less than a mechanical lever which, when flexed, results in the expansion of one crystal plate and the contraction of the other. The charges generated across the faces of both plates can be connected either in parallel or in series. In the case of the former, the capacity is four times the latter type, but at the same time the generated voltage is only half.

Sound Cell Construction

These crystal elements are used in microphones in two ways. As a diaphragm operated device, shown in **Fig. 2**, or in what is known as the " sound cell " construction, shown in **Fig. 3.** The diaphragm operated microphone generally has a considerably higher sensitivity than the sound cell type, but unless extreme care is taken in the acoustic damping, one or more severe peaks may be apparent in the mid-upper frequencies, between say 3,000 and 6,000 c.p.s. By correct proportioning of the acoustic resistance, it is possible to construct crystal microphones with a response flat ± 3 dB up to 9 or 10 Kc/s, with a sensitivity of about 1 millivolt (—60 dB re 1 volt) for an incident

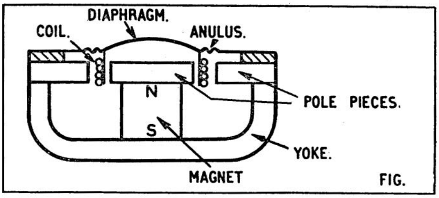
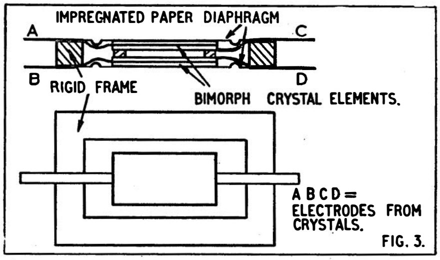


Fig. 2—*Cross section of moving coil type.*

sound pressure of 1 dyne per cm2. This value is about the loudness of a normal speaking voice at a distance of 2 feet. The open circuit low frequency response theoretically extends to less than 1 c.p.s., but because the crystal behaves as a generator in series with a condenser, the low frequency response is entirely dependent upon the input resistance of the amplifier, and because the average capacity of a crystal microphone is about 2,000 p.f., a load resistance of at least 2 and preferably 5 megohms is necessary if really good low frequence response is required.

Arrangement of Crystals

In the case of sound cell microphones, the crystals are arranged in the form of a sandwich, with a small air space between them, so that when subjected to alternating pressure they are alternatively squeezed towards or away from each other. This flexing action, results, as previously described, in a charge being developed across the crystal plates. With the larger type of sound cell, the average sensitivity is of the order of —72 dB, but because of the difficulty of applying effective acoustic damping, there is usually pronounced resonance in the 10 Kc/s region. Small sound cells are produced with resonances at 15 or even 18 Kc/s, but in



Schematic of sound cell microphone.

these cases the sensitivity and, because of the reduced capacity, signal-to-noise ratio suffer. Because of the small size and light weight, it is quite practical to use crystal inserts in the form of lapel microphones, or even to hide them under a speaker's tie, or to camouflage them as a piece of costume jewellery. This will enable close speaking (and hence very good signal-to-noise ratio) conditions to be obtained when the speaker is moving about the room or stage.

Dynamic Pressure Microphones

Dynamic pressure microphones with wide frequency response are invariably of the moving coil type. **Fig. 2** shows the cross section of one such microphone, and it will be seen that they resemble, superficially at least, a miniature moving coil loudspeaker. When sound waves impinge on the diaphragm, the coil is moved back and forth in the steady magnetic field in sympathy with the sound vibrations, and a voltage is generated which is proportional to the velocity of the coil. In order to obtain a flat and smooth frequency response over the whole audio spectrum, elaborate acoustic networks are used. With a well-designed moving coil instrument, a frequency response from 30 to 10,000 c.p.s., ± 3 dB, can be obtained. Unlike the crystal microphone, the moving coil unit has a low source impedance, usually between 15 and 50 ohms. Therefore, a matching transformer is needed if a useful output voltage is to be obtained. Ratios between 30 : 1 and 100 : 1 are common, and the output is of the order of 2 to 5 millivolts (—54 to —46 dB relative 1 dyne per cm2). In some cases, the matching transformer is wound for 200 or 600 ohms, where the microphone has to be connected into mixing units or transmission lines. But when, as in most domestic cases, it is connected directly into the grid circuit, the secondary is loaded with 50,000 to 250,000 ohms, the actual value being determined by the particular transformer design and the high frequency response required.

It will be seen that in terms of absolute efficiency, and hence signal-to-noise ratio, the moving coil instrument is superior to a crystal unit ; although in most cases, for an equal frequency response to a crystal type, they cost considerably more.

The theoretical omni-directional response of a pressure microphone is only realised in

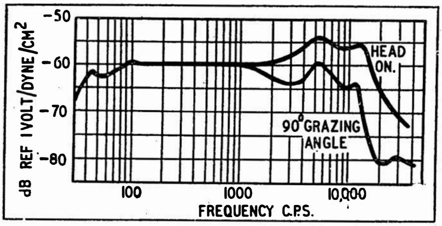


Fig. 4—*Effects of head-on and grazing sound.*

the lower frequencies. At frequencies where the wave length of sound becomes comparable to the dimensions of the microphone, considerable variations in level can take place due to obstacle effect. (*Note:* A 5,000 c.p.s. note has a wave length of approximately 2 in. in air.) Whilst at 1,000 c.p.s., the response is approximately the same for a wave coming head on to the microphone, and one at " grazing angle " **(Fig. 4)** the latter level may be —20 dB reference the " head on " sound to 10 Kc/s. The results obtained by experimenting for the optimum positioning of the microphone will repay the effort involved.

Pressure Gradient Microphones

Until now, we have spoken only of pressure microphones which, by definition, are operated by the instantaenous excess pressure of the sound wave. A second attribute to a sound wave is known as " particle velocity," i.e., " the velocity of the molecules of air which are vibrating backwards and forwards in sympathy with the disturbance," and the speed with which these molecules vibrate is directly related to the sound pressure.

The standard commercial type of pressure gradient, known colloquially as a " velocity " microphone, is the " ribbon " type, see **Fig. 1b1.** The very light aluminium foil (which is usually no more than one-fifty-thousandth of an inch thick) is suspended between the poles of a powerful magnet, and being extremely light, it vibrates in sympathy with the air molecules directly adjacent to it, because of the minute pressure difference between air molecules on each side of the ribbon. Thus, if the ribbon is facing the sound source, the pressure difference on each side will be greatest, and hence the maximum output will be obtained from the microphone. Whilst if it is at right angles to the sound source there will be no pressure difference, and thus no output. See **Fig. 1b2.**

Ribbons Best for the Home

The ribbon microphone, by virtue of its extremely simple mechanical construction has, with the exception of the condenser type, the smoothest response of any type of microphone yet available. The resistance of the ribbon is usually a few tenths of an ohm only, and thus the output of the microphone is a few microvolts, and a step-up transformer with a ratio of anything up to 400 or 500 : 1 is used. In the writer's opinion, the ribbon microphone is probably the most suitable instrument generally available for domestic sound recording.

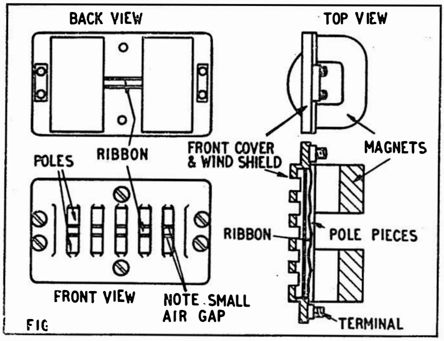


Fig. 5—*Schematic of a ribbon type.*

Cardioid Microphones

We have described the pressure microphone and the velocity microphone. By virtue of the phase relationship between the particle velocity and the pressure of a sound wave, it is possible to combine a ribbon microphone and a dynamic microphone so that the outputs are additive in the forward direction, and completely cancel in the back direction. The polar response is then the familiar heart-shaped or " cardioid " as long-haired types refer to it. Because two complete microphones, together with phase matching networks and transformers are used, it is not a cheap unit, and is beyond the pockets of most amateurs. In some circumstances, however, particularly in public address and professional recording studios, it is the only type of instrument which can be successfully used.

Other Types

We have deliberately refrained from discussing condenser microphones, principally because they are not generally available to the general public. They are usually specialist scientific instruments and their price (anything up to £175) is indicative of the precision of manufacture. In America, crystal cardioid microphones are available ; on the Continent condenser types of cardioid microphones are available. If and when these become generally available on the British market we will enter into a discussion on their relative merits.

Examples of crystal microphones are manufactured by Cosmocord and Ronette, and are illustrated elsewhere. The sound cell microphone is a high fidelity instrument, but it needs a sensitive pre-amplifier and care must be taken to avoid hum. The diaphragm operated devices allow of considerably more latitude in amplifier design, and whilst the response is not nearly so good as sound cell types, they are usually adequate for home recording, especially for speech. They are not always successful with piano recordings, and sometimes violins tend to be a little bit "stringy."

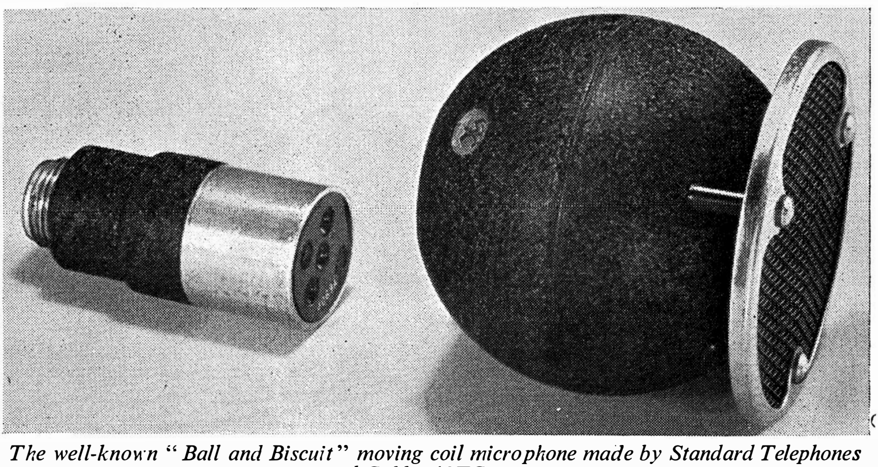
The most successful moving coil microphone yet engineered in this country is the S.T. and C. 4021 series. It is not cheap, but because of the "biscuit" fitted to the front, its omni-directional properties are better than most other types. The frequency response is approximately flat from 30 to 10,000 c.p.s. Other good moving coil microphones are illustrated in the directory.

The ribbon microphones manufactured by Messrs. Film Industries, Reslo, Simon, and Trix, are all equally good. They all have an exceptionally smooth and resonance free response, and care has been taken to reduce the "wind" noise to a minimum. The sensitivities vary slightly, but all are more than adequate for the best type of domestic tape recorders available anywhere today.

Stands Must be Firm

Whilst microphones are the "business end" of the works, they are usually affixed to a stand (with the exception of the lapel type), and a bad stand can completely negate a good microphone. Entirely apart from the obvious requirement that it should not be easily knocked over, the base must be heavy and preferably insulated from the floor by a rubber pad or feet ; the stem must be solid and rigid, without the slightest trace of shake or rattle. Remember that any vibrations in the floor (and some low frequency floor vibrations can be extremely powerful) will be transmitted to the microphone via the stand. And unless it is rigid, entirely apart from transmitting these vibrations to the microphone, it may exhibit peculiar resonances of its own.

"Anti-microphonic" co-axial cable is mandatory for crystal types, and wherever possible use an insulated outer covering. Plugs and sockets must be beyond reproach, preferably with automatic earthing devices ; and lastly, before connecting up, using, or installing, read the manufacturers' instructions carefully.



The well-known "Ball and Biscuit" moving coil microphone made by Standard Telephones and Cables (STC 4021)

DIRECTORY OF MICROPHONES

Collaro Ltd., Ripple Works, By-Pass Road. Barking, Essex. Tel. : Rippleway 5533, Cables : Korllaro, Barking.

Studio Crystal. Response 50-10,000 c.p.s. O.c.s. at 1,000 c.p.s., 1.8 mV/U.B. Source imp. 1,500 P.F. Rec. load imp. 5 megohm. 6-ft. cable. Tel. jack plug. Price £2 5s.

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Cosmocord Limited, Eleanor Cross Road, Waltham Cross, Herts. Tel. : Waltham Cross 5206. Cables : Cosmocord, Waltham Cross.

Acos Mic. 33-1 or Mic. 33-2 with Switch. Crystal. Response 30-7,000 c.p.s. O.c.s. — 55 dB, ref. 1v/dyne/cm^2. Source imp. cap. equiv. to 0.002 mfd. Rec. load imp. not less than 1 megohm. 8-ft. cable. Price £2 10s. or £2 15s. with switch.

Acos 28-2 Lapel Mic. Crystal. Response 70-5,000 c.p.s. O.c.s. — 55 dB ref. 1v/dyne/cm^2. Source imp. cap. equiv. to 0.002 mfd. Rec. load imp. not less than 1 megohm. 8-ft. cable. Table stand or adaptor for floor stand. Price £3 3s. or £3 8s. with switch.

Acos Mic. 22-1, Mic. 22-2. Crystal. Response 40-6,000 c.p.s. O.c.s. — 50 dB ref. 1v/dyne/cm^2. Source imp. cap. equiv. to 0.002 mfd. Rec. load imp. not less than 1 megohm. 8-in. table stand or floor stand adaptor. Price £4 4s.

Acos Mic. 16-1 or Mic. 16-2. Crystal. Response 30-10,000 c.p.s. O.c.s. — 65 dB ref. 1v/dyne/cm^2. Source imp. cap. equiv. 0.0015 mfd. Rec. load imp. not less than 1 megohm. 8-in. table stand or floor stand adaptor. Price £12 12s.

Acos Mic. 39-1. Crystal. Response 60-10,000 c.p.s. O.c.s. — 60 dB ref. 1v/dyne/cm^2. Price not yet available.

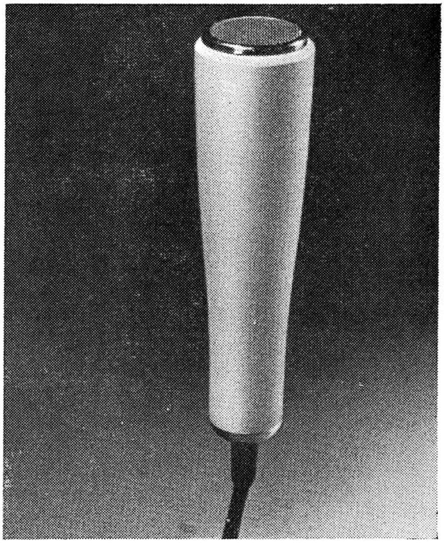
★

Film Industries Ltd., 90 Belsize Lane, N.W.9. Tel. : Hampstead 9632/3. Cables : Troosound, Haver.

M7 Moving Coil. Response 80-9,000 c.p.s. Source imp. 30 ohms or 170 K/ohms. 6-ft. cable suitable for table, desk or floor stand. Price £6 5s.

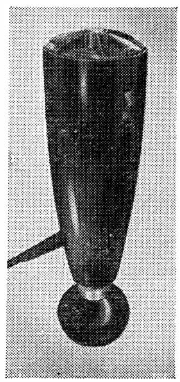
M8 Ribbon. Response 40-14,000 c.p.s. Source imp. 30 ohms or 170 ohms. Built-in transformer. 12-ft. cable suitable for table, desk or floor stand. Price £8 15s.

★ In these abridged specifications, the following abbreviations are used :
O.c.s.—open circuit sensitivity. **Source imp.**—microphone source impedance. **Rec. load imp.**—recommended load impedance.



Acos Mic 39—1

Acos Mic 16



Acos Mic 36

General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2. Tel. : Temple Bar 8000. Cables : Polyphase, London.

G.E.C. Senior Ribbon Microphone BCS2372 & BCS2373. Response 200-14,000 c.p.s. ± 1 dB, 50-200 c.p.s. ± 2.5 dB. O.c.s. BCS2372 (600 ohms) — 68 dB ref. 1v/dyne/cm^2.

BCS2373 (15 ohms) — 93 dB ref. 1v/dyne/cm^2. Built-in trans. " captive head " terminals at rear. Price both models £18 18s.

G.E.C. Studio Ribbon Microphone BCS2372S. Response 50-14,000 c.p.s. – 1 dB. O.c.s. – 79 dB, 250 ohms ref. 1v/dyne/cm^2. Built-in trans. " captive head " terminals at rear. Price £19 19s.

BCS2249A. Floor stand suitable for above mics. BCS2246A table stand. BCS2255 " Boom " studio stand.

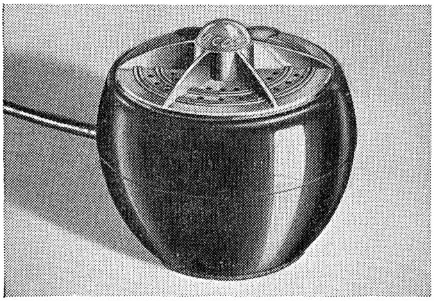
★

Lustraphone Ltd., St. Georges Works, Regents Park Road, N.W.1. Tel. : Primrose 8844. Cables : Lustraphone, London.

LX55 Crystal. Response 30-8,000 c.p.s. High source imp. 9-ft. cable. Price £2 10s.

Lustrette LD/61 Series. Moving coil. Response 70-12,000 c.p.s. Source imp. low, line and high. Built-in trans. when required. 9-ft. cable. Price £3 7s. 6d.

Master C51. Moving coil. Response 50-8,000 c.p.s. Source imp. low, line and high. Built-in trans. for line and high. 3-pin moulded mic. plug. Stand as required. Price low £5 5s. ; line and high £5 15s. 6d.



Acos Mic 33—1

Master C48 and C48/S with Switch. Moving coil. Response 50-8,000 c.p.s. Source imp. 20 ohms. 3-pin moulded mic. plug. 6-ft. cable. Price C48 £6 6s. ; C48/S £7 7s.

Hand Pencil LFV/H59. Moving coil. Response 150-14,000 c.p.s. Source imp. low, line and high. Built-in trans. for line and high. 20-ft. cable for low and line. 9-ft. for high. Price £8 8s.

Full-Vision LFV/59. Moving coil. Response 150-14,000 c.p.s. Source imp. low, line and high. Built-in trans. for line and high. 20-ft. cable with low and line. 9-ft. with high. Stand as required. Price £8 18s. 6d.

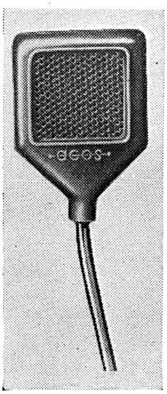
Master VR53. Ribbon velocity. Response substantially flat to 14,000 c.p.s. Source imp. low, line and high. Built-in trans. 3-pin moulded mic. plug. 6-ft. cable. Stand as required. Price £9 19s. 6d.

★

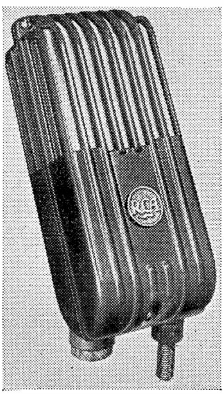
RCA Great Britain Limited, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx. Tel. : Sunbury-on-Thames 3101. Cables : RCA, London. Telex : 28608.

Varacoustic LMI. 6203C. Ribbon. Response 60-10,000 c.p.s. Source imp. 50, 250 and 600 ohms. 30-ft., 2-conductor shielded cable. Stand as required. Price £21.

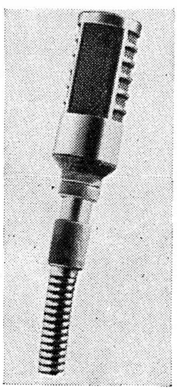
LMI 620 40C. Ribbon. Response 60-10,000 c.p.s. Source imp. 40,000 ohms. 30-ft., 1-conductor shielded cable. Stand as required. Price £21.



Acos Mic 28—2



RCA LMI 6203C



*Film Industries M*8

*Trix G*7822

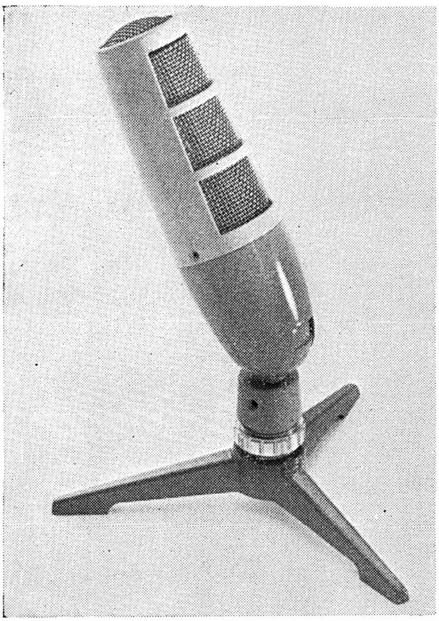
Ronette, Sole U.K. Importers : Trianon-Electric Limited, 95 Cobbold Road, London, N.W.10. Tel. : Willesden 2116 and 3696.

Ronette. 15 different crystal microphones. Response according to type from 50-10,000 c.p.s. and 20-16,000 c.p.s. Source imp. 200 ohms. Rec. load imp. 5 megohms. Supplied with or without transformers. 9-ft. cable. Price range from £2 10s. to £15 15s. Desk stand DS5 £1 7s. 6d.

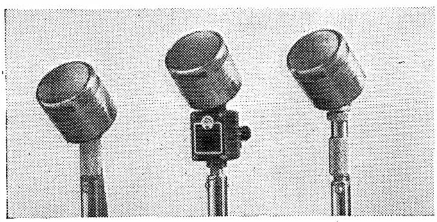
★

Distributed by Simon Sound Service Ltd., 48 George Street, Portman Square, W.1. Tel. : Welbeck 2371. Cables : Simsale, London.

Cadenza. Advance information. Twin ribbon. Response 50-12,000 c.p.s. O.c.s. approx. — 60 dB ref. 1v/dyne/cm^2. Source imp. 0.5 ohms (ribbon). High Z setting 80,000 ohms. Low Z setting 25 ohms. Rec. load imp. High imp. not less than 0.5 megohms. Low imp. not less than 100 ohms. Built-in trans. 2 output tappings. 3-pin mic. plug. 11-ft. cable (high Z) or 90-ft (low Z). Tripod base optional. Price not yet announced.



The Cadenza



Trix G7871, Models A, B and C

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Trix Electrical Company Limited, 1-5 Maple Place, London, W.1. Tel. : Museum 5817. Cables : Trixadio, Wesdo, London.

G7871. 3 models A, B, C. Moving coil. Response 50-8,000 c.p.s. Source imp. 30 ohms. G7871/A 18-ft. cable. G7871/B no cable. 2-pin plug. G7871/C 18-ft. cable. 3-pin locking type plug. Stand as required. Price A £7 10s. ; B £8 8s. ; C £9 9s.

G7822. 2 models B, C. Ribbon. Response 50-10,000 c.p.s. Source imp. 30 ohms. G7822/B 2-pin plug, no cable. G7822/C 18-ft. cable, 3-pin locking type plug. Stand as required. Price B £12 10s. ; C £11.

Various types of floor and desk stands available, also flexible stems and hand grips.

★

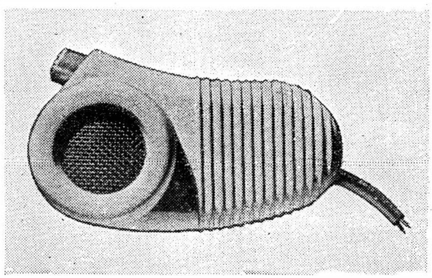
Vitavox Limited, Westmoreland Road, London, N.W.9. Tel. : Colindale 8671. Cables: Vitavox, Hyde, London.

B50. Moving coil. Response 60-8,000 c.p.s. O.c.s. — 85 dB ref. 1v/dyne/cm^2. Source imp. 25 ohms. 6-ft. cable. Price £6 10s.

B51. Crystal. Response 60-8,000 c.p.s. O.c.s. 50 dB. Source imp. 1 megohm. 6-ft. cable. Price £5 10s.

B52. Moving coil. Response 60-8,000 c.p.s. O.c.s. 85 dB ref. 1v/dyne/cm^2. source imp. 600/100,000 ohms. Built-in transformer. 6-ft. cable. Price £7 10s.

Type A. Moving coil. Response 60-8,000 c.p.s. O.c.s. — 82 dB ref. 1v/dyne/cm^2. Source imp. 25 ohms. Rec. load imp. 25 ohms. Desk, table or pedestal stands available. Price £9 9s.



Vitavox B50

SPEAKERS
AND
ENCLOSURES

By Ralph West

PART I - - - - - LOOKING BACK A YEAR

FOR several years now it has been generally realised, and widely stated, that the speaker is on the whole the weakest link in our reproducing chain. Progress during the last few years has not been spectacular, but has taken the form of steady improvement, attention to detail, a fuller and more widespread understanding of the problems and requirements a consolidation of our position as it were. It is, therefore, all the more surprising, and most certainly gratifying, that the past 12 months has seen several outstanding developments. None of these developments is so startling that it makes

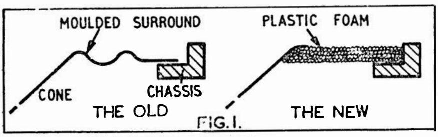


FIG. I.

everything else out of date and no longer acceptable, but all are substantial, and they represent longer jumps forward than a study of the last few years progress would have suggested.

The first of these **(Fig. 1)** is the use of plastic foam material for the cone surround (and sometimes in other parts of the cone suspension). Mr. Chave of the Lowther Manufacturing Company was the first to use it, followed quite independently by Mr. Briggs of the Wharfedale Wireless Works. Several other firms are already using it, or are about to. The damping controls (i.e., reduces) most of the multitude of cone resonances right up the limit of audibility (at least). The resulting smoother response has surprised the technician in his laboratory and equally the connoisseur who had more or less resigned himself to expecting a certain amount of harshness and colouration in the upper register. It does show that the cloth surround, as opposed to a moulded paper surround, was on the right lines. Cloth was, however, not able .o provide enough viscous damping.

The second highlight was the reintroduction of a flat baffle speaker assembly by Wharfedale **(Fig. 2).** This was indeed a bold step as it shows the moving coil speaker has developed to a point where it can produce enough bass for domestic use, right down to the deepest organ pedal notes, without the use of quasi-resonant enclosures, with all their known (and unknown) peculiarities. This calls for very large cone amplitudes since the speaker is a doublet in this range. Large cone amplitudes without distortion call for very low cone resonances, carefully designed magnetic fields and speech coils, and cone suspensions that obeys Hookes Law over a wider range of deflection we have been

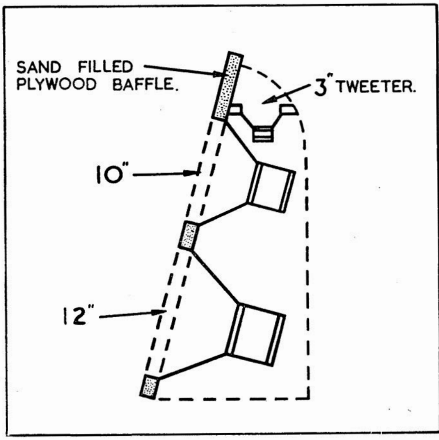


Fig. 2—*Arrangement of the three drive units in the Wharfedale flat baffle speaker SFB/3.*

used to for many years. Foam surround has eased the last problem considerably. To be precise the flat baffle has never quite died, there have always been a few protagonists active. H. F. Schwartz of the Decca Record Company has been responsible for several designs. One of them used six Axiom 80 units—very costly, but very satisfying !

Third on the list is the clever use of a fixed copper damping ring, let into the pole-piece by Philips in their new series of high fidelity speakers. This idea originated with Olsen **(Fig. 3).** Very briefly, the inductance of the speech coil is one of the main factors which limit the high frequency response of a

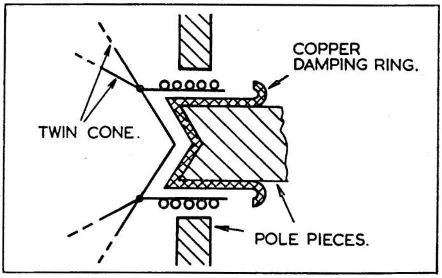


Fig. 3—*The method adopted by Philips for using a damping ring on the speaker pole-piece.*

moving coil speaker. The use of an extremely high flux density will saturate the pole tips and reduce its inductance. The use of such flux densities is very commendable on many other grounds, but the cost of providing them is very high, and only a relatively small market exists for them. This damping ring does give a long high frequency output at a much lower cost ; but of course the magnet size must not be reduced too much, or the general performance of the unit will fall below our standards. With the increased high frequency driving force available it should be possible to concentrate more on smoothness of HF response instead of quantity of HF response !

The Westrex Acoustic Lens

The fourth item is the acoustic lens introduced by Westrex. While such devices are by no means unknown, this is the first time in this country that one has been used with domestic high fidelity equipment **(Fig. 4).** A horn loaded tweeter, particularly if the driving unit is well designed, can produce really good high frequency sound, and will

REFER ALSO TO
Acoustic Lenses ... *Page* 124
Plastic Foam ... ... *Page* 126

have a particularly good transient response, without suffering from reduction in amplifier damping.

A simple horn is very directional, and for acceptable results in most circumstances arrangements must be made to dispense the sound over a wider angle. In this case a simple rectangular exponential horn is used, in which the sound wavefronts will be plane as they pass along the horn. The lens is in the mouth of the horn and is arranged to delay the sides of the wave more than the middle. This produces a curved wave-front which expands into a broad beam of sound. It is a simple and neat solution which does not in any way interfere with the horn action and definitely gives a more homogeneous beam than any other method.

The fifth surprise is the diminutive CQ speaker which produces adequate harmonic-free bass down to something below 40 c.p.s. at adequate levels for domestic use **(Fig. 5).** Coupled with this is an exceptionally smooth top response. All this from a relatively cheap 9-in. by 5-in. elliptical speaker (modified somewhat, of course). No new principles or methods are involved, just correct design, attention to tiny details and backed by a keen ear. As has been said before, this is by no means the best speaker in existence, but it exhibits no vices and it is superior to many larger speaker designs. It

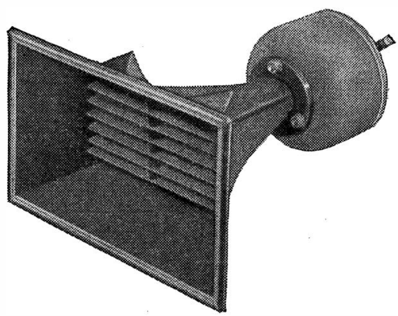


Fig. 4—*Westrex use an acoustic lens on a horn-loaded tweeter.*

does show, therefore, what improvements in performance can result when rather more design parameters than usual are correct at one and the same time !

Despite our increased mathematical knowledge of this subject, our knowledge is still far from complete. Many design problems still have to be solved by the time-honoured method of " suck it and see " ! This is where the keen and experienced ear comes in. No speaker manufacturing concern aspiring to the high fidelity market could survive long in this field without this valuable piece of equipment. Anechoic rooms, calibrated microphones, and other fabulously costly measuring equipment, while very necessary, and saving much time, will not, on their own, guarantee the production of an acceptable speaker.

It is good to see fresh blood coming into our field, and we welcome Mr. Burne-Jones with this BJ Reproducer **(Fig. 6)** ; Mr. Neve of RGA Sound Services Ltd., with the CQ speaker ; and the Westrex Company with their Acoustilens speaker system. Westrex are really old hands at the game, being amongst other things, makers of cinema equipment. Cinema equipment is built to a standard and not to a price, and it is a sobering thought to realise that the acoustic equipment fitted is so highly advanced in design and performance and generally speaking far better than the signal it is called on to handle ! It is equally good to see the older established firms working successfully to maintain their lead. Can it be that some of the moving coil speaker developments of the last year stem from the stimulus of the expected competition of the electrostatic speaker ? It's an ill wind that blows nobody any good !

Another interesting tendency has been the introduction of several successful speakers of modest size and price. Necessity is the mother of invention, undoubtedly. Money is not so plentiful as it was a few years ago ; stereophonic reproduction in some form or another is attracting attention ; without doubt, many do not feel inclined to spend their life's savings on a really expensive moving coil system if new and exciting things are just round the corner !

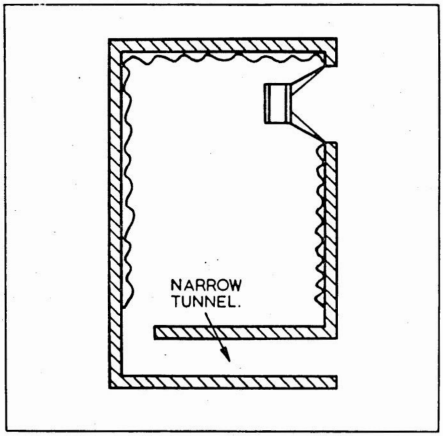


Fig. 5—*Arrangement in the CQ speaker.*

Electrostatic speakers of several shapes and sizes have been demonstrated very successfully on several occasions. Rumours have far outweighed definite knowledge, but the future augurs well. America too has caught the complaint and has also demonstrated full-range electrostatics. Whatever the outcome, we are one year nearer anyway !

The Ionophone continues to attract considerable attention. It has been in production in France for some time in tweeter form, and enough samples have reached this country to show that the dream of massless moving parts really has come true. The transient response leaves nothing to wish for. As it must be horn loaded (in its present form), it can only be made in tweeter form. More rumours, and rather more concrete news from America.

Fortunately we are no nearer the perfect speaker than we were a year ago, since our standards have risen correspondingly. There is, therefore, every chance of just as much progress next year. Long may this be the case !

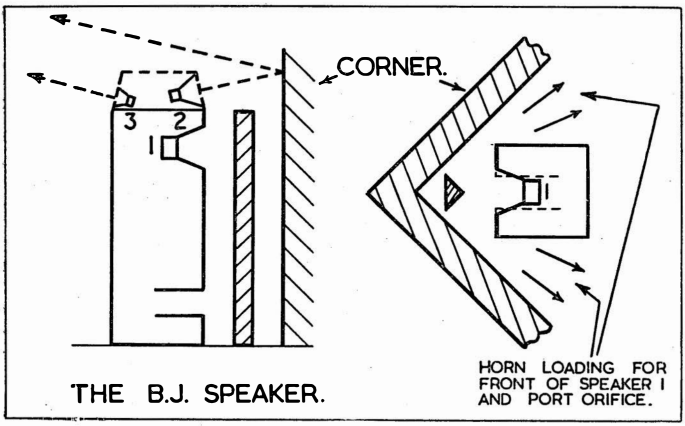


Fig. 6—*The arrangement used in the BJ speaker.*

PART 2
TAKING STOCK OF THE REQUIREMENTS

THERE is no simple yardstick by which we can judge the goodness of a speaker. Not even the well-equipped laboratory with its anechoic room, calibrated microphones, half-octave filters, B and K recorder, wave analyser, and a host of other delectable pieces of measuring equipment, can provide the complete answer. Intelligent use of this equipment can, however, answer a lot of questions truthfully. It can save considerable time by answering these questions quickly ; but only our own ears can provide the final assessment. We all have different ideas, likes and dislikes, so we shall never agree as to which is the best speaker. In fact there never will be one !

It is quite safe to say, however, that a speaker which satisfactorily passes all the scientific tests we can apply, will be a good one, and someone will think it is a very good one—maybe the best ! On the other hand, one that may score low marks in many accurate measurements, may be acclaimed by a majority of people. The present stage of the art, for art it is, then relies on both subjective and objective assessment of the progress it has made. Though there is no final answer, it is possible to list a number of basic requirements which will help to define what is a good speaker.

Frequency Response

This can be measured very accurately with a selection of the apparatus mentioned above, but the curves are seldom published. Even if they are, they tell the layman very little. Even the experienced engineer is in the dark unless response curves taken on the axis, and at several angles off the axis, are available. The high frequency response of a speaker, measured on the axis may look impressive, but there is room for only one head at a time on the axis ! A curve of total output power versus frequency would give a truer impression, but this is rather difficult to produce and anyway the bass response depends more on the enclosure than the driving unit. It would probably look shocking ! Well, what do we want ? A useful response from 60 c.p.s. to 7,000 c.p.s. could be considered the minimum for real enjoyment. The organ would have no 16-ft. pedal pipes, and the orchestral drum would sound anaemic ; but by and large, the missing lower frequencies would not often be missed.

Frequencies above 7,000 c.p.s. are not always present in the input signal, whether it be radio, record or tape. At the worst it would sound as if a thin curtain separated the listener from the music. The overall balance would be perfectly satisfactory. Another octave at each end is all the heart need desire, and only on relatively few occasions would we be using all of it. By useful response we mean the audible frequency range, when listening with *acceptable* domestic volume levels.

Frequency Range

Frequency range is by no means the most important aspect of frequency response (like the maximum speed of a car). Far more important are two other aspects. The first is balance—the balance between treble, bass and middle. The bass range contributing to overall balance is mainly the 60-100 c.p.s. region. Frequencies below 50 or 60 c.p.s. do not alter balance very much, but are nevertheless important for full realism with several musical instruments. The middle range covers very roughly the range of the human voice, i.e., in the hundreds of cycles per second. This is really the most important range, as it is the most used, and within this range the speaker should be well-nigh perfect. Far too many speakers have an uneven output curve within this range—not much to look at on a measured curve, but probably the cause of many likes and dislikes. When all is said and done, we are all most experienced in our knowledge of the human voice, whether we are consciously aware of it or not.

The treble range most affecting balance is between 1,000 and 4,000 c.p.s. ; above that, balance is not affected, but full realism is. Expressions like " clear view," " forward tone," " in the room," and " presence," are variously used to describe performance in the region above 3-4 Kc/s. While being quite important, the range 1-4 Kc/s is the more important, and it should be represented at the correct level. Progressive attenuation above 4 Kc/s can still leave a perfectly pleasant and acceptable speaker.

The Middle Range

Now many speaker designers, possibly in their enthusiasm for maintaining the response at the frequency extremes, have left the middle range a little low, relative to bass and treble. The effect is not always immediately obvious, male speech is probably very clear and free from boom, but 'cellos are rather weak. Good transmissions with lots of really deep bass and extreme top are thrilling, but continued listening on average material is rather less satisfying. Eventually the expression " lack of round tone " is used. Note that " round tone " does not mean a woolly noise, such as might be produced by using all the tone control on a cheap domestic receiver.

The general balance of music signals available varies so very much, that it is not possible to assess the balance of a speaker on any one item, except with say a known record-cum-pickup, amplifier-room combination. Most of us need to hear the speaker several times with a wide range of material. Boomy speech with male voices is usually a result of excessive output around the 150 c.p.s. mark—more often a resonance rather than lack of balance.

Smoothness of Response

The second important aspect of frequency response, already touched on, is smoothness of response. Lack of smoothness is without doubt the greatest contribution to unpleasantness in a speaker. It is one of the reasons why such drastic tone controls are fitted *and used* on ordinary domestic receivers ; why keen-eared musicians have often spurned our proudest efforts, some even preferring acoustic gramophones using fibre needles ; why our womenfolk sometimes take instant dislike to a certain speaker (it is sometimes the look or the size !). When we are young and just entering the high fidelity field, the extremes of the frequency range thrill us, and we overlook quite serious faults that we would not tolerate later on. In this matter, our womenfolk mature much faster than we men do, and therefore they can act as a useful guide to our choice. At the same time, their ears will be spared much torture and domestic opposition will be reduced !

Lack of smoothness usually stems from resonances. In the bass it is usually either the cabinet air column, or the main cone resonance. Heavy magnets, which at least stand more chance of producing more magnetic field, help considerably. Freely suspended cones—low resonant frequencies, and large cabinets place these resonances lower in the scale. The lower they are, the less troublesome they become. Below 50 c.p.s., unless sharply tuned, they are pretty well innocuous ; below 30 c.p.s. is ideal. Between 50 c.p.s. and 100 c.p.s. may give an impression of more bass, but the double bass will be noticed to play one note louder than all the others. Above 100 c.p.s. is hopeless for our purposes. Uneveness in the middle range is mainly due to sundry reflections inside the cabinet, and is minimised by strategically placed damping and irregular-shaped cabinets. The baffle-mounted speaker is singularly free from this defect, so will be the free-standing electrostatics.

Break-up Resonances

Above about 500 c.p.s. the worst region of all, cone break-up resonances take over—more or less. A truthful curve in this region is the speaker designer's nightmare. It is seldom published ! Resonances in the 1,000-4,000 c.p.s. region effectively alter the balance, and many cheaper speakers rely on this to obtain a suitable balance. This is the most difficult region to control, but there is considerable evidence that the " foam surround " offers more hope than anything hitherto. Large " holes " in the response in this region are not so easily recognised by listening tests, but the results are usually disappointing unless the speaker is played at a rather higher volume level than usual. Resonances above, say, 4 Kc/s again give a false impression of " presence," but unless very mild ones, the cone will " ring " and will emphasise surface noise from really good L.P. records, and will put continuous background hiss on good F.M. signals.

Effects of Resonances

It is a most striking effect, changing from a tweeter with resonances in the 5-7 Kc/s region, and thereafter falling rapidly, to one almost flat to say 15 Kc/s. Despite its much wider response, there is far less background noise. It usually costs more of course! In this region, too, foam surrounds and special plastic doping can make all the difference. The output in this region should not be higher than the output in the 1-4 Kc/s region, or a peculiar detachment is noticed, but this is easily corrected by the tone control.

The tone control unit we normally use cannot help us much with altering the overall balance. To alter the 1-4 Kc/s region appreciably, the 4-15 Kc/s region will be altered far too much. Again to lower, say, the 60-100 c.p.s. region a little, will depress everything below 50 c.p.s. below audibility. We could, of course, design more comprehensive tone controls, but they would be rather more complicated, bulky and difficult to use by other members of the family.

Musical Balance

Careful choice of speaker on the score of balance, is then necessary, bearing in mind that the listening room also modifies the balance and has even greater effect on the bass and top extremes. Some multi-unit speakers have attenuators fitted to the two upper units, thereby giving some control of balance. Probably the only way to do this properly is to have three tone controls feeding three separate amplifiers and speaker elements, covering roughly these suggested ranges. This does in fact exist in the Sound Sales Tri-Channel equipment.

One last word on frequency response—the extreme bass. Slight attenuation can be corrected by use of the bass boost control, but more serious attenuation cannot, without also raising the 60-100 c.p.s. region and thereby upsetting the balance. Excessive use of bass boost is to be deprecated, as it can lead to overloading of the amplifier—since the largest signal voltages usually occur in that range. If the speaker is also inefficient as a whole, due to a small magnetic field, then even more power will be needed. This may explain the American taste for amplifiers of 50 watts and upwards output for domestic use. It is unlikely they are any more "tin-eared" than we are!

Speaker Efficiency

This, then, brings us to the next aspect—efficiency. From a purely economic point of view, there is not much difference between a small amplifier and efficient speaker, and a large amplifier and less efficient speaker; and the latter has the attraction of being cheaper to replace as ideas and tastes change. The inefficient speaker almost invariably has a weak magnetic field, and this leads to three acoustic deficiencies. The main cone resonance and the main air column (cabinet) resonance are less damped and are therefore more likely to be objectionable. The damping of the aluminium former of the G.E.C. metal cone speaker and the Barker Duode are of course exceptions to this rule. The low degree of saturation of the pole tips leads to a high speech coil inductance and consequent loss of top. The Duode is again an exception, so is the more recent Philips with the fixed damping ring.

To the last point, there are no exceptions—the weak field produces a poorer transient response, and transient response covers the whole audible spectrum, not just the higher frequencies, though they do contribute more to it. It concerns the rapidity with which sounds start and stop. In terms of listening experience it means "clarity," and "hang-over" is the reverse. It will be noticed that the first of these three points, viz. bass resonance is largely bound up with this one.

Enclosure Variation

Enclosure designs are numerous and varied. In addition to housing the unit, they usually aim at improving the bass response. As already stated, the bass response usually depends more on the cabinet than on the driving unit. A small unit, say 8 in., with cone resonance as high as 75 c.p.s., will produce audible bass down to 35 c.p.s. without noticeable frequency doubling or trebling, provided that it is in a suitable enclosure. It is much easier (i.e., a simpler cabinet will suffice) if its resonance is lowered to say 50 c.p.s., and its speech coil-cum-magnet dimensions and cone suspension permit of larger movements without distortion. A larger driving unit makes life even easier, since the cone does not have to move so far to displace a certain amount of air. Cabinet sizes could be reduced slightly, but it is a pity to waste a large driving unit in a small cabinet. The large driving unit has one drawback, its high frequency response will not be so satisfactory. It will generally either be far from smooth, or will be almost non-existent (rather better); and in either case a low crossover frequency will be needed. With a larger cone, the cone breakup starts at a correspondingly lower frequency. The Westrex "20/80", a 15-in. unit, uses a 3-in. diameter voice coil which reduces the distance between the speech coil and cone edge, thereby raising the cone breakup frequency to that of a much smaller cone. It does, however, require a very large magnet to fill all that gap with a high flux density.

The cabinet must do two other things. One of these is to provide for suitable distribution of the high frequency sound energy. The lower frequencies, apart from standing waves in the listening room, normally spread widely over the room. The cabinet must either have shaped reflectors or must point the high frequency speaker(s) towards the ceiling, walls, or corner, in order to effect wide enough distribution. Not only must the high frequency sound be well distributed, but it must appear to come from a fair-sized area, otherwise the general listening effect will only suit one or two isolated items, such as a solo voice apparently *in* the room. Even this will seem unnatural unless the high and middle frequency sources are very close together. This question of location of apparent source and angle of dispersion for different frequencies has not yet received all the attention it deserves. Too many systems show considerable variation of both quantities, with change of frequency. If the early promise is fulfilled the free-standing full range electrostatic will score heavily in this direction.

Appearance

The other important thing the cabinet has to do is to look nice. The sound source does not need to be above eye level when seated, —the best seats in the theatre put the entertainment just below eye level. Too low a source does tend to be obstructed by the rest of the furniture. Remember, low furniture makes a room look and feel larger and loftier, but my lady will have the largest stake in this decision !

Mechanical rigidity of the enclosure is a complex problem, and at the present there is no general agreement. Playing for safety and making the cabinet as rigid as cost and circumstances will permit is sound policy. Making it acoustically dead by sand-filling is certainly better, though the extra weight is a problem. Several very successful speakers exist which have relatively flexible cabinet panels ; so there is obviously no hard and fast rule. It can be said with a fair degree of certainty, however, that tapped with the knuckles, no adjacent panels should emit the same tone. As final advice on choosing a speaker, *do* hear it played at a volume level you would use regularly in your own home, *do* sit down at a normal distance from it, and *do* close your eyes (the better to concentrate) and try and imagine you are listening to the real thing—through a hole, which is the speaker. Most of the good high fidelity dealers will provide suitable surroundings for judging the merits of your prospective purchases.

PART 3
ELECTROSTATIC SPEAKERS

IN 1381 Dolbear exhibited a complete electrostatic telephone system at the Paris Electrical Exhibition. So this is no new-fangled device! Between 1920 and 1930 interest was aroused in "condenser microphones" and "condenser *speakers*," and by the early 1930s several condenser speakers had appeared on the market, in the U.S.A., in Germany, and in this country. A British one, the "Primustatic", (a curved single diaphragm type about 2 ft. square) retailed for 25/-. By this time though, the moving coil speaker (Rice & Kellog 1925) was a firm favourite, and interest in electrostatic devices dwindled, except in the microphone field. Practically nothing was heard about them during and after the war years, until 1954. F. V. Hunt's book, "Electroacoustics", undoubtedly provided the key for the solution of the shortcomings that had beset all the earlier models. It now seems pretty certain that it has taken only three years to solve the major production problems.

Why this virtual disappearance and re-emergence? First let us see how they work. In its utmost simplicity, *an electrostatic speaker* (*E.S.L.*) consists of a fixed rigid plate, close to a flexible diaphragm of conducting material **(Fig. 1a)**. Any voltage applied to its plates causes attraction and consequent movement of the diaphragm. Unfortunately *both* half cycles of the (alternating) signal voltage would cause attraction, so that the diaphragm would vibrate *twice* for *one* cycle. All music would thus be heard one octave higher and, worse than that, *violently* distorted. This is because the attraction is proportional to V^2, not V. if a fixed D.C. voltage (polarising) is placed in series with the signal, and is always much larger than the peak signal voltage, much of the distortion disappears. The diaphragm is now permanently attracted, and the signal variations only increase and decrease this attraction **(Fig. 1b)**. This is quite a workable proposition provided the polarising + peak (assisting) signal voltage does not collapse the diaphragm on to the fixed plate. This is a very real risk since the force of the attraction increases with closeness of approach.

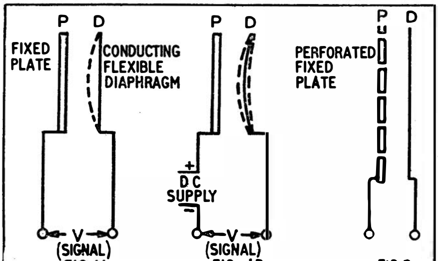


FIG. IA. FIG. IB. FIG.2

Fig. 1b has one very serious objection, as it stands. The air trapped between the two members would be compressed by (and would therefore seriously limit) any movement of the diaphragm. For this reason a perforated fixed plate is used in practically all designs **(Fig. 2)**. This will radiate in both directions. Distortion is still unacceptably high unless (a) the signal voltage is small compared with the polarising voltage—no particular difficulty, and (b) the diaphragm movement is a very small proportion of the total separation—a more serious difficulty, as reproduction of the lower frequencies usually necessitates quite large movements.

Fig. 3 shows a push-pull version of **Fig. 2**—really two single ones placed front-to-front. This is actually a very old design by Hans Vogt in Germany, on sale around 1930. This reduced distortion considerably, but still only when the diaphragm movements were small. The moving coil speaker could reproduce bass with very much less distortion, so the E.S.L. was eclipsed for quite a long time.

Despite all this, the E.S.L. had some very attractive features. Firstly its moving parts were very light—lighter than those of any other type then in existence. The high note and transient reproduction was known to be superb, though few signals available had a good high note content. Surface noise was about the only thing above 5 Kc/s. coming from our early pickups and records! Secondly, the whole of the surface is driven and, therefore, should move as one piece, provided that the mechanical design is good. Contrast that with the problem of cone breakup. A much smoother response should be possible. Thirdly, with a little cunning, shapes other than flat would be feasible, making the sound distribution a relatively simple matter. It does also seem more logical to listen to the actual bit that is being driven.

The Constant Charge E.S.L.

Though eclipsed, it was not forgotten, and when F. V. Hunt's book appeared in 1954, action was prompt and fairly widespread. He pointed out that if the diaphragm were given a constant charge (instead of a constant voltage) practically all the distortion disappeared, even for large diaphragm movements. He supported this with a rigorous mathematical analysis and experimental results confirmed it.

At the present state of the art, it is not possible to charge the diaphragm at the factory once and for all, as leakage would generally take its toll. It is not *impossible*; indeed one pre-war German model had a permanent charge, embedded in a sheet of

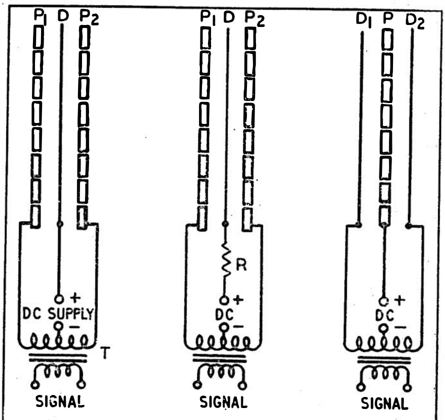


FIG.3. FIG.4. FIG.5.

insulating material—" electrets " is the word. A practical method is shown in **Fig. 4**. R is a very high resistance so that, as the diaphragm moves, though its voltage fluctuates (it falls as it approaches either plate), very little current will flow through it to upset its charge. In simple mathematical terms, R multiplied by the diaphragm capacitance (time constant) is long compared with one-half of a cycle at the lowest frequency used. Any leakage will thus be made good, and the polarising requirements are negligible after the initial charge. The force on a *constant* charge, *anywhere* between the two plates, P_1 P_2, is proportional to the difference in voltage between them. This is a linear relation, and is a prerequisite for distortion-free operation. The moving coil (and ribbon) also enjoys this basic property; i.e. force *proportional* to current (as long as the coil remains *in* the field).

The design is slightly more subtle than this. Not only must the charge be constant, or effectively so, but it must not be able to "walk about" over the surface. If it can do so, any slight irregularity of motion (due to some local difference in tension, say) would produce uneven charge distribution. This would lead to extra attraction at any part of the diaphragm moving closer than average, i.e. we need "constant charge per unit area", not merely constant charge.

Diaphragm Structure

The diaphragm material must be strong and light, and stable with time and high electrical stress. Several modern plastics show promise of providing these qualities. The conductivity can be very low; the lower the better as long as it will charge up in about the same time that it takes the amplifier to warm up. Its mass will probably be less than that of the air between the two fixed plates—a very close approach to our "massless material". High frequency response is thus assured. Low frequency response will depend on the permissible amplitude of motion and any acoustic loading that is applied. The fact that it has such light moving parts does suggest its use as a direct radiation.

Using a pair of **Fig. 2** types, back to back, produces another possible variation, shown in **Fig. 5**. Most of the foregoing remarks apply, and its performance would be much the same. It does offer some constructional advantages—it may not need external dust-sealing diaphragms.

Sound Distribution

If the width of a diaphragm is small, compared with the wavelength of sound being emitted, distribution is automatically very wide indeed. This generally applies to all speakers for frequencies below a few hundred c.p.s. I.e. bass distribution, apart from standing waves in the room, presents no difficulties. At high frequencies, though, the radiator can be well over a wavelength wide (at 2,000 c.p.s. = 6 in.). When this is so, the sound is usually radiated as a narrow beam. Simple horns and moving coil cone speakers also do this. There are two ways of overcoming this with the E.S.L. **Fig. 6a** shows the use of a curved section. The sound from the convex side is divergent and, therefore, distributed. Note also that the sound from the concave side also diverges eventually, and may prove a more convenient layout in some instances.

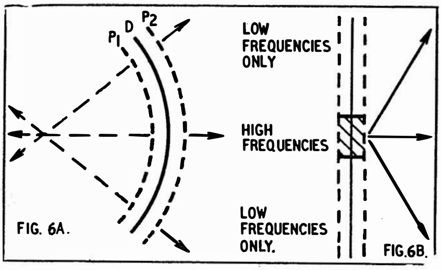
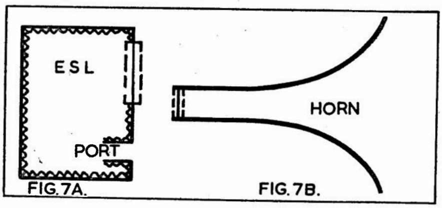


Fig. 6b shows a second method. The high frequency signals are restricted to a narrow central vertical strip. Being narrow (compared with a wavelength) it produces a broad horizontal beam. At low frequencies the whole diaphragm radiates and is again narrow compared to a wavelength. Obviously this is even better done in several progressive stages!

To achieve both horizontal (wide) and vertical (not so wide) spread, we would need double curvature using the **6a** method alone—not at all impractical if many small flat sections are used. Much better is a combination of the two methods; so that **6a** represents a side view and **6b** the plan

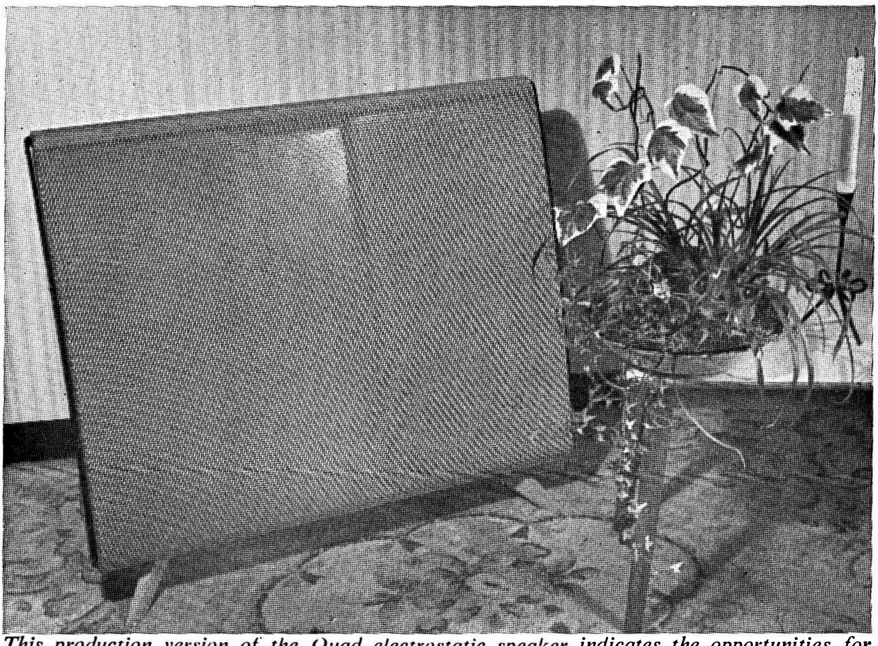


view of the same E.S.L. **Figs. 7a** and **7b** show possible alternative methods of mounting. In these two cases much smaller diaphragm amplitudes would be called for, and might prove very convenient for some applications.

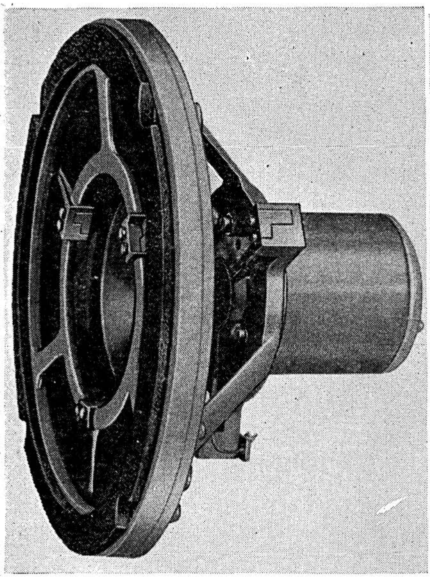
Reverting to **Fig. 6b**, this design will radiate equally from both sides, and their outputs will be opposite or antiphase. At low frequencies the diaphragm will have to move a long way to make itself heard, but not so far as a small cone on a baffle of the same overall size. This is then quite a feasible proposition, and while behaving thus it is called a " doublet radiator ". It has one very useful property, particularly useful under domestic conditions. No sound at all is emitted in the plane of the speaker, i.e. sideways, upwards or downwards. This avoids splashing sound on to so much of the surface of the room, and it thus reduces room coloration. Additionally, no room resonances (eigentones) can be excited in these directions. This leads to a much cleaner bass and clearer results generally. The general listening impression is that the speaker seems to be a wide open window through which the sound is heard. How far away it seems to be, depends on the signal supplied to it ; and that in turn largely depends upon the microphone placing in the studio and consequent extreme high and low note content.

Intrinsically the E.S.L. is very efficient, since there is practically nothing to waste energy. Resistance loss (I^2R) is negligible ; no hysteresis, eddy current or dielectric loss. Unfortunately, as its impedance is largely capacitative, it will have to be used with chokes and/or resistances ; i.e. crossover units more or less. These will waste some power. Again, being capacitative, its reactance will vary with frequency ; rising at low frequencies and consequently needing a larger driving voltage ; falling at high frequencies and needing a lower voltage. These things may well lower the apparent or effective efficiency to similar levels we enjoy with our present moving coil types. Evidence to date confirms this.

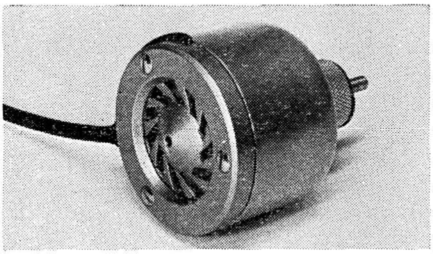
Since the E.S.L. is basically capacitative, and with its crossover networks still capacitative over some parts of the frequency range, trouble may be experienced with some amplifier designs—particularly those using considerable overall feedback and a not-too-expensive output transformer. This is no new phenomenon, since some multi-unit moving coil systems with their cross-over units have been known to provoke instability in some amplifiers. The trouble is always curable ! It is quite obvious, however, that for some time to come, E.S.L.s will be designed for use with existing amplifiers.



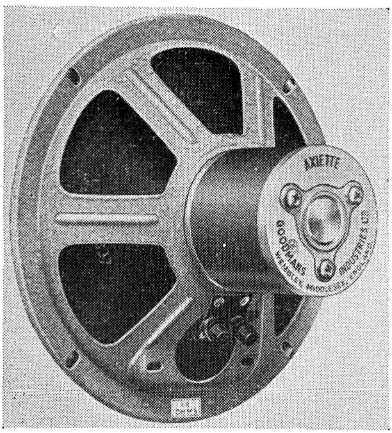
This production version of the Quad electrostatic speaker indicates the opportunities for planning room layout which will occur when such units become generally available.



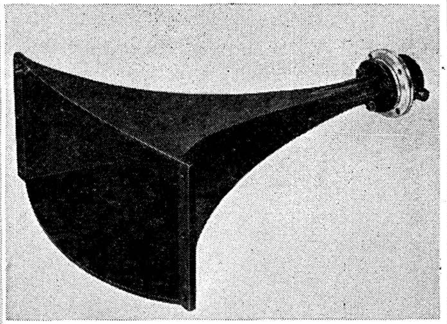
Goodmans Axiom 80



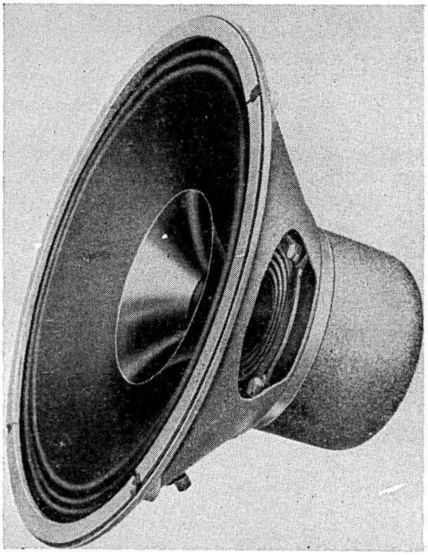
G.E.C. HF Presence Unit



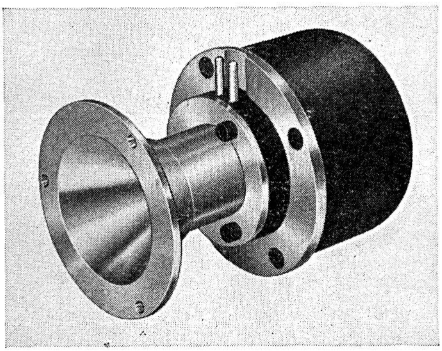
Goodmans Axiette



Goodmans Midax



Goodmans Axiom 150 *Mk.* 2



Goodmans Trebax

SPEAKERS & ENCLOSURES — Directory

● This directory is divided into two parts. **Part 1** deals with the range of drive units which, by makers' specifications, are within the Hi-Fi classification. **Part 2** deals with complete enclosures. These, as a general rule, embody the drive units of Part 1. For economy of space the following abbreviations are used : **v.c.i.**—voice coil impedance ; **r.c.f.**—recommended crossover frequency (and in Part 2) **Rec.**—recommended units; Height by Width by Depth are the order of printed dimensions.

PART 1—DRIVE UNITS

Duode Ltd., 3 Newman Yard, London, W.1.

Duode 12C. 12-in. Linen moulded cone. Cloth plastic surround. Voice coil 1.5 in. Gap flux 17,000 gauss. Total flux 190,000 lines. Handling capacity 15 watts. v.c.i. 15-8-5 ohms. Frequency range 20-16,000 c.p.s. Price £20.

Duode 12 B-C. 12-in. Linen moulded cone. Cloth plastic surround. Voice coil 1.5 in. Gap flux 14,500 gauss. Total flux 130,000 lines. Handling capacity 15 watts. v.c.i. 15-8-5 ohms. Frequency range 20-16,000 c.p.s. Price £15.

★

Goodmans Industries Ltd., Axiom Works, Wembley, Middx. Tel. : Wembley 1200. Cables : Goodaxiom, Wembley.

Axiette. 8-in. Paper cone. Plastic treated surround. Voice coil 1 in. (2.5 cms). Gap flux 15,000 gauss. Handling capacity 6 watts. v.c.i. 3 ohms or 15 ohms. Frequency range 40-15,000 c.p.s. Price £5 (U.K. purchase tax £1 18s. 6d.).

Axiom 80. 9½ in. Paper cone, free edge surround. Voice coil 1 in. (2.5 cms). Gap flux 17,000 gauss. Total flux 62,600 maxwells. Handling capacity 6 watts. v.c.i. 15 ohms. Frequency range 20-20,000 c.p.s. Price £17 10s. (U.K. purchase tax £6 14s. 9d.)

Axiom 22 MK II. 12-in. Paper cone. Paper surround. Voice coil 1¾ in. (4.4 cms). Gap flux 17,500 gauss. Total flux 195,000 maxwells. Handling capacity 20 watts. v.c.i. 15 ohms. Frequency range 30-15,000 c.p.s. Price £15 9s.

Axiom 150 MK II. 12-in. Paper cone. Paper surround. Voice coil 1¾ in. (4.4 cms). Gap flux 14,000 gauss. Total flux 158,000 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range 30-15,000 c.p.s. Price £10 15s. 9d.

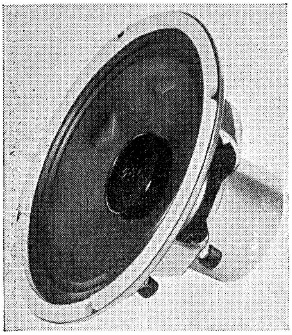
Audiom 60. 12-in. Paper cone. Paper surround. Voice coil 1¾ in. (4.4 cms). Gap flux 14,000 gauss. Total flux 158,000 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range up to 7,000 c.p.s. r.c.f. 750 c.p.s. when used as bass speaker in multi-speaker systems. Price £9 2s. 9d.

Audiom 70. 12-in. Paper cone. Paper surround. Voice coil 1¾ in. (4.4 cms). Gap flux 17,500 gauss. Total flux 195,000 maxwells. Handling capacity 20 watts. v.c.i. 15 ohms. Frequency range up to 7,000 c.p.s. r.c.f. 750 c.p.s. when used as bass speaker in multi-speaker systems. Price £14 10s.

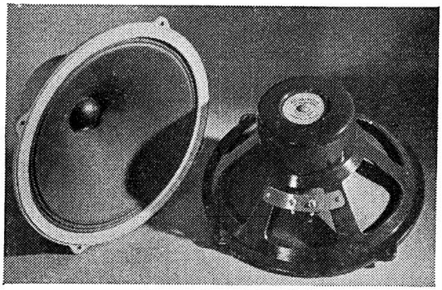
Audiom 80. 15-in. Paper cone. Paper surround. Voice coil 2 in. (5 cms). Gap flux 14,500 gauss. Total flux 215,000 maxwells. Handling capacity 25 watts. v.c.i. 15 ohms. Frequency range up to 7,000 c.p.s. r.c.f. 750 c.p.s. when used as bass speaker in multi-speaker systems. Price £22 10s.

Midax. Horn-loaded pressure mid-range unit. Resin impregnated linen diaphragm. Voice coil 1½ in. Suitable for inclusion in systems of up to 25 watts. v.c.i. 15 ohms at 400 c.p.s. Frequency range 400-8,000 c.p.s. r.c.f. 750 c.p.s. and 5 Kc/s. Price £11 16s.

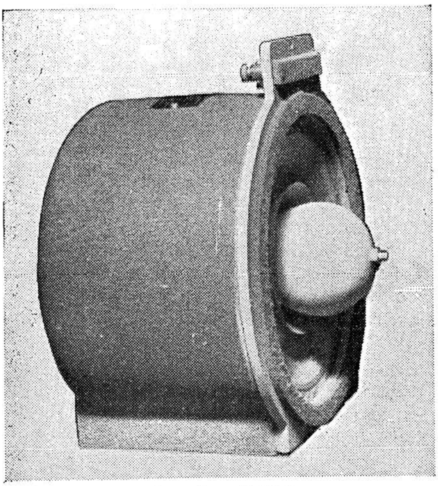
Trebax. Horn-loaded pressure Tweeter. Aluminium diaphragm. Voice coil 1 in. Handling capacity suitable for inclusion in systems of up to 25 watts. v.c.i. 15 ohms at 10 kc/s. Frequency range 2,500-16,000 c.p.s. r.c.f. 5 Kc/s. Price £6 4s.



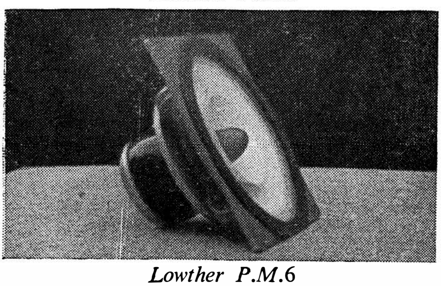
G.E.C. Metal Cone Unit



Grampian 1255/15



*Lowther P.M.*3



*Lowther P.M.*6

General Electric Co. Ltd., Magnet House, Kingsway, W.C.2. Tel. : Temple Bar 8000. Cables : Polyphase, London.

Metal Cone Speaker. BCS1851. 8-in. Duralumin cone. P.V.C. surround. Voice coil 1 in. Gap flux 13,500 gauss. Total flux 53,400 maxwells. Handling capacity 6 watts continuous, 12 watts peak. v.c.i. 4.1 ohms at 400 c.p.s. Frequency range 30-20,000 c.p.s. Price £6 13s. 7d. (U.K. purchase tax £2 11s. 5d.)

Presence Unit BCS1852. Miniature metallised pressure diaphragm. Surround integral with diaphragm. Overall dia. 1⅝ in. Voice coil ¾ in. Gap flux 10,500 gauss. Total flux 26,000 maxwells. Handling capacity 3 watts max. continuous at 5 K/cs. v.c.i. 15 ohms. Frequency range 1,000-15,000 c.p.s. Price £3 19s. 6d.

★

Grampian Reproducers Ltd., Hanworth Trading Estate, Middx. Tel. : Feltham 2657/8/9. Cables : Reamp, Feltham.

Grampian 1255/15. 12-in. Paper impregnated cone and surround. Voice coil 1¾ in. Gap flux 14,500 gauss. Total flux 130,500 maxwells. Handling capacity 10 watts. v.c.i. 15 ohms. Frequency range 20-15,000 c.p.s. Price : £9.

★

The Lowther Manufacturing Co., Lowther House, St. Mark's Road, Bromley, Kent. Tel. : Ravensbourne 5225. Cables : Lowther, Bromley.

P.M.6. 6-in. Selected paper cone. Plastic surround. Voice coil 39 mm. Gap flux 17,500 gauss. Total flux 196,000 maxwells. Handling capacity 6 watts. v.c.i. 15 ohms. Frequency range 10-18,000 c.p.s. Price £18 18s.

P.M.2. Mk.I. 6-in. Selected paper cone. Plastic surround. Voice coil 39 mm. Gap flux 21,000 lines per sq. cm. Total flux 281,000 maxwells. Handling capacity 6 watts. v.c.i. 15 ohms. Frequency range 10-20,000 c.p.s. Price £30.

P.M.3. 6-in. selected paper cone. Plastic surround. Voice coil 39 mm. Gap flux 22,000 gauss. Total flux 307,750 maxwells. Handling capacity 6 watts. v.c.i. 15 ohms. Frequency range 10-20,000 c.p.s. Not sold separately from enclosure type T.P.1.

P.M.4. 6-in. Selected paper cone. Plastic surround. Voice coil 39 mm. Gap flux 24,500 gauss. Total flux 385,000 maxwells. Handling capacity 6 watts. v.c.i. 15 ohms. Frequency range 10-20,000 c.p.s. Price £48.

★

Philips Electrical, Century House, Shaftesbury Avenue, W.C.2. Tel.: Gerrard 7777. Cables: Phillamps, London.

9710 M. 8-in. Dual cone. Paper corrugated surround. Voice coil 1 in. Gap flux 8,000 gauss. Total flux 97,000 maxwells. Handling capacity 10 watts. v.c.i. 7 ohms. Frequency range 40-18,000 c.p.s. r.c.f. 500-1,000 c.p.s. Price £4 18s. 7d. (U.K. purchase tax £1 17s. 11d.)

9762. 12-in. Paper cone. Corrugated surround. Voice coil 1¼ in. Gap flux 11,000 gauss. Total flux 134,000 maxwells. Handling capacity 20 watts. v.c.i. 7 ohms. Frequency range 40-10,000 c.p.s. r.f.c. 500-1,000 c.p.s. Price £10.

9762M. 12-in. Dual cone. Paper. Corrugated surround. Voice coil 1¼ in. Gap flux 11,000 gauss. Total flux 134,000 maxwells. Handling capacity 20 watts. v.c.i. 7 ohms. Frequency range 40-18,000 c.p.s. Price £10 10s.

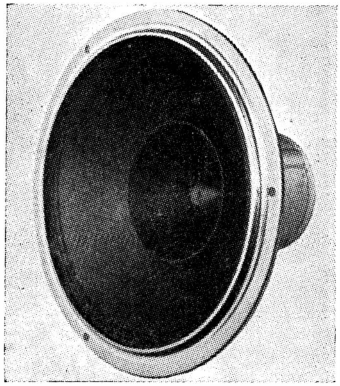
★

Plessey Co. Ltd., Vicarage Lane, Ilford, Essex. Tel.: Ilford 3040. Cables: Plessey,

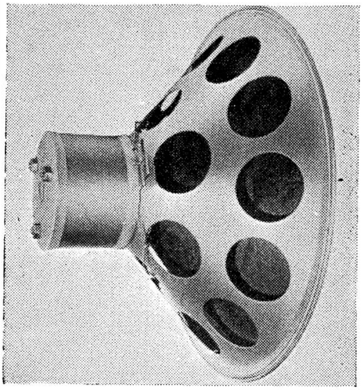
Single-twelve. CP73012/10. 12-in. Moulded fibre cone. Surround corrugations integral with cone. Voice coil 1 in. Gap flux, 10,000 gauss. Total flux 33,000 maxwells. Handling capacity 10 watts. v.c.i. 15 ohms. Frequency range 40-7,000 c.p.s. r.c.f. 2,000 c.p.s. Price £4 14s. 3d.

Dual-twelve. CP73020/12/1. 12-in. bass unit, 6 in. by 4 in. treble unit. Moulded fibre cones. Surround corrugations integral with cone. Voice coil (L.F.) 1 in. (H.F.) ¾ in. Gap flux, L.F. 12,000 and H.F. 8,500 gauss. Total flux (L.F.) 40,000 (H.F.) 17,000 maxwells. Handling capacity 10 watts. v.c.i. 15 ohms. Frequency range 40-17,000 c.p.s. Built-in crossover at 2,000 c.p.s. Price £7 2s. 3d.

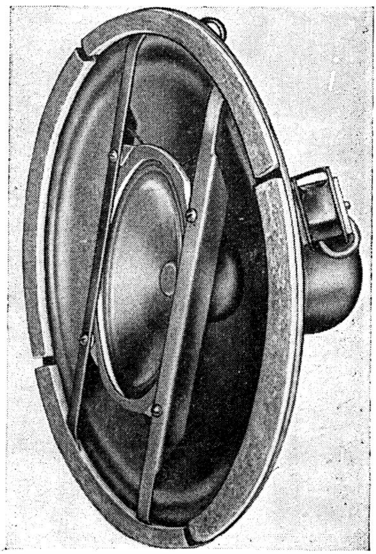
Single-fifteen/12. CP73025/12/7. 15-in. Moulded fibre cone with concentric corrugations. Velour surround. Voice coil 2 in. Gap flux 12,000 gauss. Total flux 152,500 maxwells. Handling capacity 20 watts. v.c.i. 15 ohms. Frequency range 25-3,000 c.p.s. Price £15 10s.



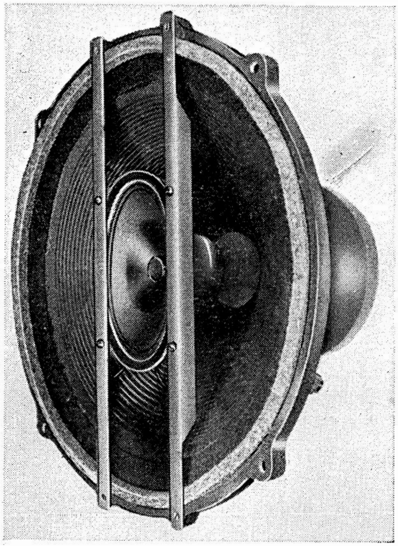
Philips 9710*M*



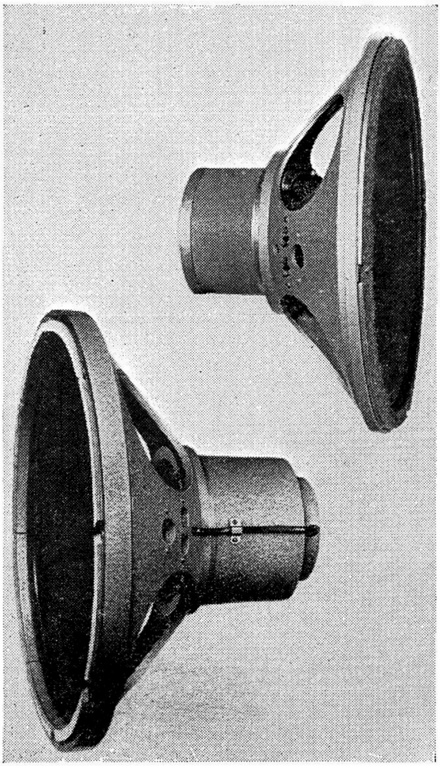
Philips 9762*M*



Plessey 12-in. Dual Concentric



Plessey 15-in. Dual Concentric



Tannoy 12-in. Low Frequency Unit (top) and 15-in. Dual Concentric

Single-fifteen/15. CP73025/15/1. 15 in. Moulded fibre cone with concentric corrugations. Velour surround. Voice coil 2 in. Gap flux 15,000 gauss. Total flux 230,000 maxwells. Handling capacity 25 watts. v.c.i. 15 ohms. Frequency range 25-3,000 c.p.s. r.c.f. 2,000 c.p.s. Price £22 10s.

Dual-fifteen. CP73021/2. 15-in. bass unit, 6 in. by 4 in. treble unit. Moulded fibre cone with concentric corrugations. Velour surround. Voice coil 2 in. Gap flux 15,000 gauss. Total flux 230,000 maxwells. Handling capacity 25 watts. v.c.i. 15 ohms. Frequency range 25-17,000 c.p.s. Built-in crossover at 2,000 c.p.s. Price £24 7s. 6d.

Six Four/H.F. Unit. CP73001/12/20. 6 in. by 4 in. elliptical curvilinear moulded fibre cone. Surround corrugations integral with cone. Voice coil ¾ in. Gap flux 12,000 gauss. Total flux 24,000 maxwells. Handling capacity 5 watts. v.c.i. 5 ohms. Frequency range 1,000-17,000 c.p.s. r.c.f. 2,000 c.p.s. Price including U.K. purchase tax £1 18s. 6d.

★

Sound Sales Ltd., Works and Acoustic Laboratories, West Street, Farnham, Surrey, England. Tel. : Farnham 6461/2/3. Cables: Sounsense.

Dual Suspension Auditorium. Models A and B. 12-in. paper cone. Very flexible velvet surround plus dual suspension spider. Voice coil working in 0.06 in. by ¼ in. deep gap, maximum effective travel ⅜ in. Gap flux 10,600 gauss. Total flux 95,000 maxwells. Handling capacity 12 watts in suitable enclosure. v.c.i. model A 15 ohms ; model B 3 ohms. Frequency range 30-13,500 c.p.s. with suitable mounting. r.c.f. about 3,000 c.p.s. Price £9 13s. 4d.

★

Tannoy Products Ltd., West Norwood, London, S.E.27. Tel. : Gipsy Hill 1131. Cables : Tannoy, London.

12-in. Low Frequency Unit. Moulded fibre cone. Plastic treated surround. Voice coil 2 in. Gap flux 10,000 gauss. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range 35-4,000 c.p.s. r.c.f. 1,700 c.p.s. Price £14.

15-in. Low Frequency Unit. Moulded fibre cone. Plastic treated surround. Voice coil 2 in. Gap flux 12,000 gauss. Handling capacity 25 watts. v.c.i. 15 ohms. Frequency range 30-3,000 c.p.s. r.c.f. 1,000 c.p.s. Price £19 10s.

Direct Radiator. 12-in. moulded fibre cone. Plastic treated surround. Voice coil 2 in. Gap flux 14,000 gauss. Handling capacity 15 watts. v.c.i. 20 ohms. Frequency range 40-16,000 c.p.s. Price £14.

Dual Concentric. 12-in. cone. (L.F.) moulded fibre (H.F.) light alloy plastic coated cones. Plastic treated surround. Voice coil both 2 in. Gap flux (L.F.) 10,000 gauss (H.F.) 15,000 gauss. Handling capacity 15 watts. v.c.i. via crossover 18 ohms. Frequency range 30-20,000 c.p.s. r.c.f. 1,700 c.p.s. Price £29 5s.

Dual Concentric. 15-in. cone. (L.F.) moulded fibre (H.F.) light alloy plastic coated cones. Plastic treated surround. Voice coil both 2 in. Gap flux (L.F.) 12,000 gauss (H.F.) 18,000 gauss. Handling capacity 25 watts. v.c.i. via crossover 15 ohms. Frequency range 25-20,000 c.p.s. r.c.f. 1,000 c.p.s. Price £35 12s.

High Frequency Speaker Unit. Horn loaded cone. Plastic coated dural surround. Voice coil 2 in. Gap flux 15,000 gauss. Handling capacity 20 watts above 1,000 c.p.s. v.c.i. 15 ohms. Frequency range 1,000-20,000 c.p.s. r.c.f. 1,000 c.p.s. Price £16 10s.

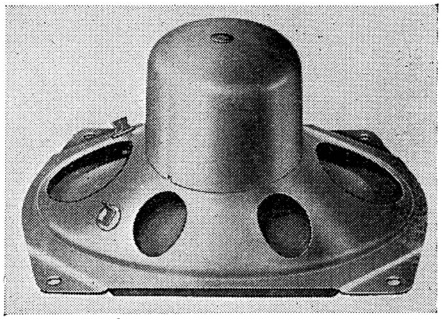
★

Technical Suppliers Ltd., Hudson House, 63 Goldhawk Road, London, W.12. Tel. : Shepherds Bush 2581/4794.

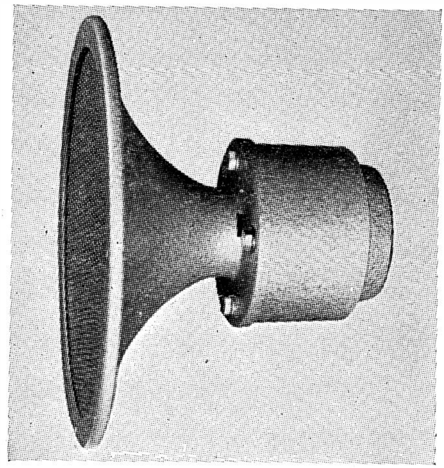
TSL-Lorenz. LP. 215. 8-in. Reinforced paper cone. Permaflex surround. Voice coil 1 in. Handling capacity 8 watts, peak load 12 watts. v.c.i. 4.5 ohms. Frequency range 35-12,000 c.p.s. Price £4 19s. 6d. (U.K. purchase tax £1 18s. 4d.)

LP. 312-2. 12-in. Reinforced ribbed paper cone. Permaflex surround. Voice coil 1½ in. Handling capacity 25 watts. (Peak rating in suitable enclosure 40 watts.) v.c.i. 15 ohms. Frequency range 20 to above 17,000 with 2 type LPH 65 treble speakers in a fitted bridge assembly. r.c.f. 3,000-5,000 c.p.s. Price £14 19s. 6d.

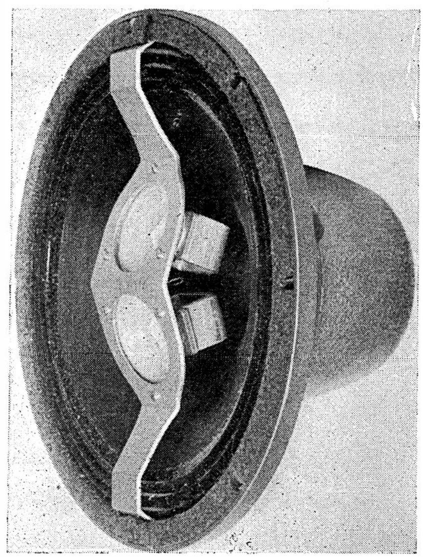
TSL-Lorenz Tweeter LPH 65. 2¾ in. Special plastic cone. Plastic surround. Voice coil ½ in. Handling capacity 2 watts (H.F. only). v.c.i. 5.5 ohms. Frequency range 2,000 to above 17,000 c.p.s. r.c.f.



Plessey Six-Four Tweeter



Tannoy H.F. Unit



TSL-Lorenz LP312-2

3,000-5,000 c.p.s. Price £1 8s. 6d. (U.K. purchase tax 11s.)

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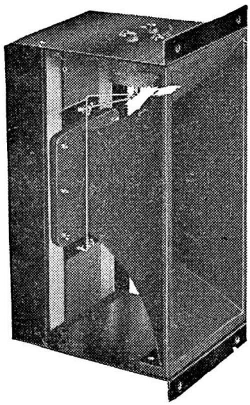
Thermionic Products Limited, Hythe, Southampton. Tel. : Hythe 3265/7. Cables : Technico.

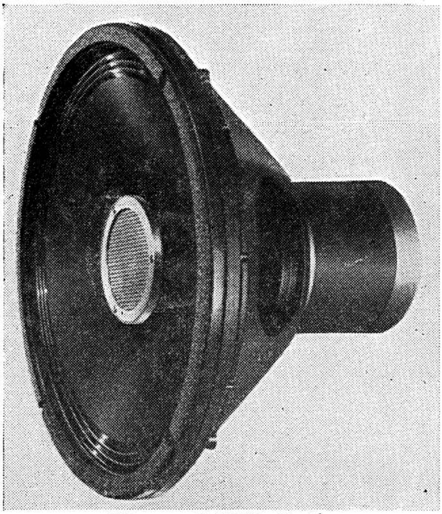


*Kelly RLS/*1 *Ribbon Tweeter*

Kelly Ribbon H.F. Speaker RLS/1. Die-cast catenoidal horn. 8 in. by 4 in. Gap flux 10,000 lines. Handling capacity 5 watts continuous, peaking to 10 watts. v.c.i. 15 ohms (3.75 ohms to special order). Frequency range 3,000-20,000 c.p.s. r.c.f. 3,000 c.p.s. in 2-speaker system ; 5,000 c.p.s. in 3-speaker system. Price £12 12s.

★

Vitavox Ltd., Westmoreland Road, London, N.W.9. Tel. : Colindale 8671. Cables : Vitavox, Hyde, London.

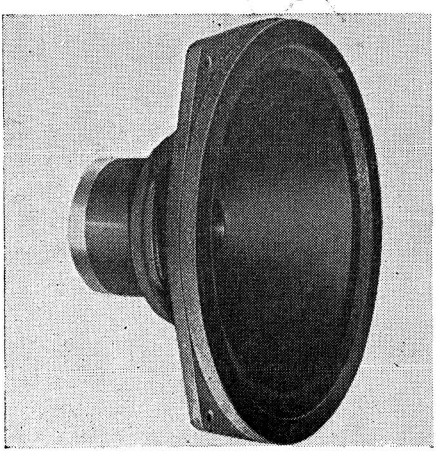


*Vitavox DU*120 *Duplex*

Duplex Coaxial DU 120. 12-in. and 3-in. Paper and polyester film cones and surround. Voice coil (L.F.) 1.75 in., (H.F.) 0.650 in. Gap flux (L.F.) 14,000, (H.F.) 12,000 gauss. Total flux (L.F.) 161,000, (H.F.) 12,520 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range 40-15,000 c.p.s. nominal. Price £19 10s.

K12/10. 12-in. Paper cone. Paper surround. Voice coil 1.75 in. Gap flux 12,000 gauss. Total flux 140,000 maxwells. Handling capacity 10 watts. v.c.i. 15 ohms. Frequency range 50-12,000 c.p.s. r.c.f. 1,000 c.p.s. Price £8 10s.

K12/20. 12-in. Paper cone. Paper surround. Voice coil 1.75 in. Gap flux 14,000 gauss. Total flux 175,000 maxwells. Handling capacity 20 watts. v.c.i. 15 ohms. Frequency range 50-14,000 c.p.s. r.c.f. 1,000 c.p.s. Price £16.



*Vitavox K*15/40

K15/40. Paper cone. Paper surround. Voice coil 2.25 in. Gap flux 14,000 gauss. Total flux 260,000 maxwells. Handling capacity 40 watts. v.c.i. 15 ohms. Frequency range 40-10,000 c.p.s. r.c.f. 500 c.p.s. Price £25.

★

Wharfedale Wireless Works Ltd., Idle, Bradford. Tel. : Idle 1235-6. Cables : Wharfdel, Idle, Bradford.

8-in. Bronze/FS/AL. Paper cone. Foam plastic surround. Voice coil 1 in. (aluminium). Gap flux 10,000 gauss. Total flux 39,500 maxwells. Handling capacity 4 watts. v.c.i. 2-3 ohms or 8-10 ohms. Frequency range 40-10,000 c.p.s. Price £3 5s. (U.K. purchase tax £1 6s.)

Super 8. 8-in. Paper cone. Surround, paper corrugations. Voice coil 1 in. Gap flux 13,000 gauss. Total flux 54,000 maxwells. Handling capacity 6 watts. v.c.i. 2-3 or 12-15 ohms. Frequency range 40-12,000 c.p.s. r.c.f. 10,000 c.p.s. Price £4 10s. (U.K. purchase tax £1 15s. 11d.)

Super 8/FS. 8-in. Paper cone. Foam plastic surround. Voice coil 1 in. Gap flux 13,000 gauss. Total flux 54,000 maxwells. Handling capacity 5 watts. v.c.i. 2-3 or 12-15 ohms. Frequency range 40-12,000 c.p.s. Price £5. (U.K. purchase tax £1 19s. 11d.)

10-in. Bronze/FSB. Paper cone with bakelised apex. Foam plastic surround. Voice coil 1 in. Gap flux 10,000 gauss. Total flux 39,500 maxwells. Handling capacity 6 watts. v.c.i. 2-3 or 12-15 ohms. Frequency range 30-10,000 c.p.s. Price £3 19s. 6d. (U.K. purchase tax £1 11s. 9d.)

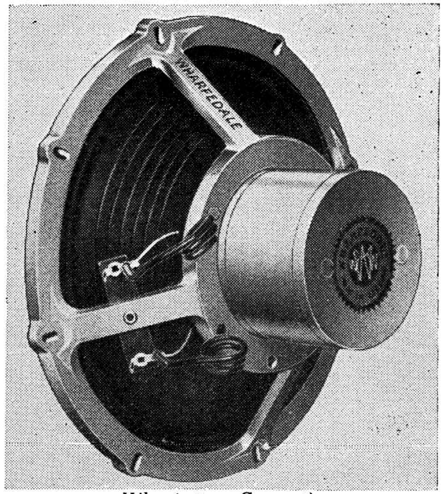
Golden/FSB. 10-in. Paper cone with bakelised apex. Foam plastic surround. Voice coil 1 in. Gap flux 13,000 gauss. Total flux 54,000 maxwells. Handling capacity 8 watts. v.c.i. 2-3 or 12-15 ohms. Frequency range 30-12,000 c.p.s. Price £6 5s. (U.K. purchase tax £2 9s. 11d.)

W10/FSB. 10-in. Paper cone with bakelised apex. Foam plastic surround. Voice coil 1 in. Gap flux 14,000 gauss. Total flux 74,000 maxwells. Handling capacity 10 watts. v.c.i. 2-3 or 12-15 ohms. Frequency range 30-14,000 c.p.s. Price £9 7s. 6d. (U.K. purchase tax £3 14s. 10d.)

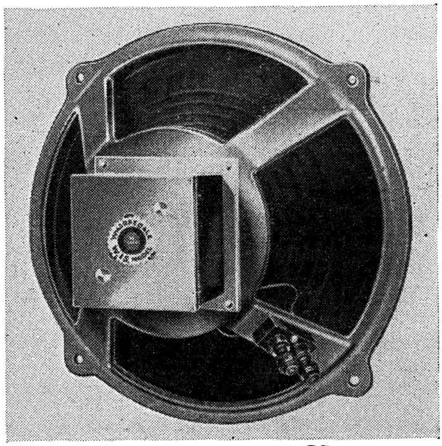
WI2/FS. 12-in. Paper cone with bakelised apex. Foam plastic surround. Voice coil 1¾ in. Gap flux 13,000 gauss. Total flux 145,000 maxwells. Handling capacity 12 watts. v.c.i. 12-15 ohms. Frequency range 30-10,000 c.p.s. Price £10 5s.

Super 12/FS/AL. 12-in. Paper cone with bakelised apex. Foam plastic surround. Voice coil 1¾ in. (aluminium). Gap flux 17,000 gauss. Total flux 190,000 maxwells. Handling capacity 12 watts. v.c.i. 12-15 ohms. Frequency range 30-14,000 c.p.s. Price £17 10s.

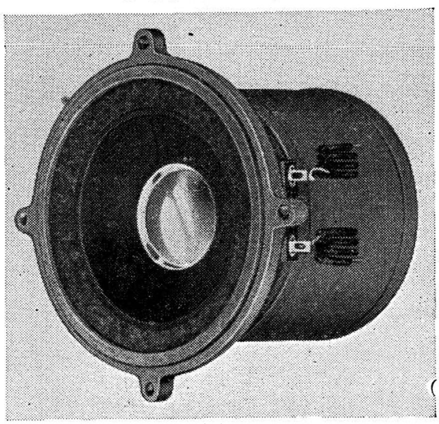
W 15/FS. 15-in. Paper cone. Foam plastic surround. Voice coil 2 in. Gap flux 13,500 gauss. Total flux 180,000 maxwells. Handling capacity 15 watts. v.c.i. 12-15 ohms. Frequency range 20-2,000 c.p.s. r.c.f. 800 c.p.s. Price £17 10s.



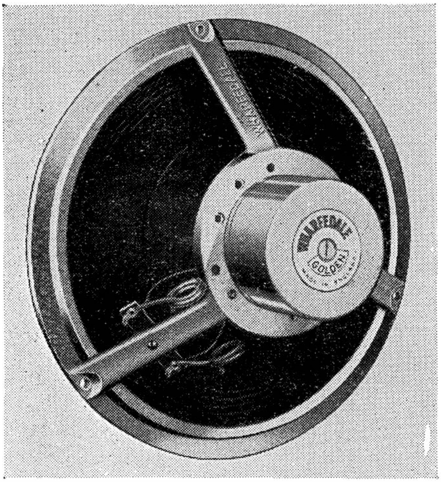
Wharfedale Super 8



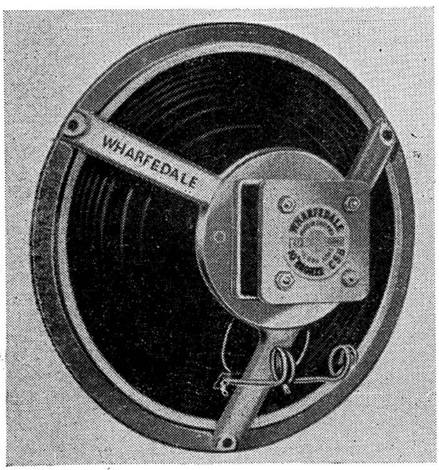
Wharfedale W15 CS



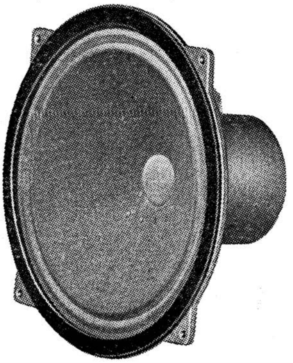
Wharfedale Super **3**



Wharfedale Golden/FSB



Wharfedale Bronze/FSB



*Whiteley H.F.*816

Super 3. 3-in. Bakelised paper cone with aluminium dome. Foam plastic surround. Voice coil 1 in. (aluminium). Gap flux 13,000 gauss. Total flux 54,000 maxwells. Handling capacity 6 watts above 1,000 c.p.s. v.c.i. 2-3 or 8-15 ohms. Frequency range 3,000-20,000 c.p.s. r.c.f. 4,000 c.p.s. Price £5. (U.K. purchase tax £1 19s. 11d.)

★

Messrs. Whiteley Electrical Radio Co. Ltd., Victoria Street, Mansfield, Notts. Tel. : Mansfield 1762-5. Cables : Whitebon, Mansfield.

Stentorian HF.812. 8-in. Composite (paper and cambric) cone. Cambric surround. Voice coil 1 in. Gap flux 12,000 gauss. Total flux 47,000 maxwells. Handling capacity 5 watts. v.c.i. universal (3, 7.5 and 15 ohms). Frequency range, 50-12,000 c.p.s. Price £2 19s. 6d. (U.K. purchase tax £1 4s.)

H.F.816. 8-in. Composite (paper and cambric) cone. Cambric surround. Voice coil 1 in. Gap flux 16,000 gauss. Total flux 63,000 maxwells. Handling capacity 6 watts. v.c.i. universal 3 ohms, 7.5 ohms and 15 ohms. Frequency range 50-14,000 c.p.s. Price £4 17s. 7d. (U.K. purchase tax £1 19s. 5d.)

T.816. 8-in. Paper cone and surround. Voice coil 1 in. Gap flux 16,000 gauss. Total flux 63,000 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range up to 17,000 c.p.s. r.c.f. 1,500 c.p.s. Price £4 12s. 7d. (U.K. purchase tax £1 17s. 5d.)

HF.912. 9-in. Composite (paper and cambric) cone. Cambric surround. Voice coil 1 in. Gap flux 12,000 gauss. Total flux 47,400 maxwells. Handling capacity 7 watts. v.c.i. universal (3, 7.5 and 15 ohms). Frequency range 40-13,000 c.p.s. Price £3 3s. (U.K. purchase tax £1 5s. 6d.)

HF. 1012. 10-in. Composite (paper and cambric) cone. Cambric surround. Voice coil 1 in. Gap flux 12,000 gauss. Total flux 47,400 maxwells. Handling capacity 10 watts. v.c.i. universal 3 ohms, 7.5 ohms and 15 ohms. Frequency range 30-14,000 c.p.s. r.c.f. 3,000 c.p.s. Price £3 11s. (U.K. purchase tax £1 8s. 9d.)

10-in. Concentric Duplex. Composite (paper and cambric) cone. Cambric surround. Voice coil 1 in. Gap flux (L.F.) 12,000 gauss, (H.F.) 13,000 gauss. Total flux 95,000 maxwells. Handling capacity 7 watts. v.c.i. 15 ohms. Frequency range 30-14,000 c.p.s. r.c.f. 3,000 c.p.s. Price £7 16s. 4d. (U.K. purchase tax £3 3s. 2d.)

HF.1214. 12-in. Composite (paper and cambric) cone. Cambric surround. Voice coil 1.5 in. Gap flux 14,000 gauss. Total flux 106,000 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range 25-14,000 c.p.s. r.c.f. 3,000 c.p.s. Price £9 15s. 6d.

HF.1514. 15-in. Composite (paper and cambric) cone. Cambric surround. Voice coil 2 in. Gap flux 14,000 gauss. Total flux 178,000 maxwells. Handling capacity 25 watts. v.c.i. 15 ohms. Frequency range 25-4,000 c.p.s. r.c.f. 1,500-3,000 c.p.s. Price £24 10s.

12-in. Concentric Duplex. Composite (paper and cambric) cone. Cambric surround. Voice coil $1\frac{1}{2}$ in. Gap flux (L.F.) 14,000 gauss, (H.F.) 17,000 gauss. Total flux 220,000 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range 25-17,000 c.p.s. r.c.f. 3,000 c.p.s. Price £25.

T.10 Tweeter. Alloy cone and surround. Voice coil 1 in. Gap flux 14,000 gauss. Total flux 44,600 maxwells. Handling capacity 5 watts. v.c.i. 15 ohms. Frequency range 2,000-14,000 c.p.s. r.c.f. 3,000 c.p.s. Price £4 4s.

T.12 Tweeter. Alloy cone and surround. Voice coil 1.5 in. Gap flux 16,000 gauss. Total flux 110,000 maxwells. Handling capacity 15 watts. v.c.i. 15 ohms. Frequency range 3,000-17,000 c.p.s. r.c.f. 3,000 c p.s. Price £12 12s.

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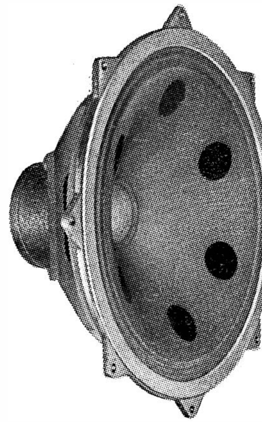
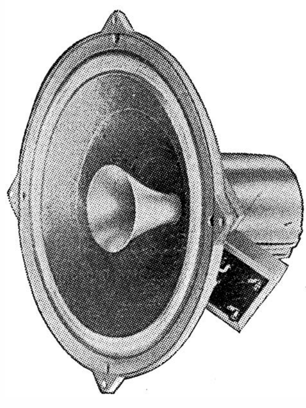
Westrex Co. Ltd., Liberty House, Regent Street, London, W.1. Tel. : Regent 1001. Cables : Westelcol, Norphone, London.

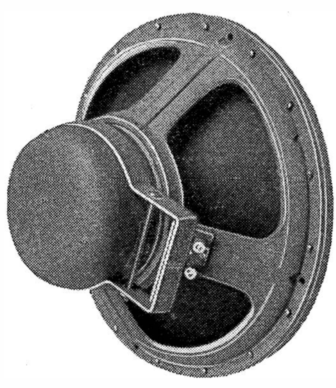
20/80 Low Frequency Unit. 15 -in paper cone with damped surround and spider. Voice coil 3 in. of edgewound copper ribbon. Gap flux 13,200 gauss. v.c.i. 16 ohms. Handling capacity 30 watts. Frequency range up to 800 c.p.s. r.c.f. 675 c.p.s. Price £33 15s.



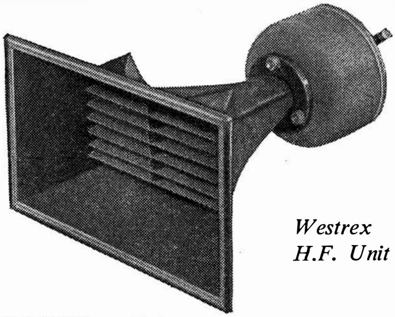
*Whiteley H.F.*1514



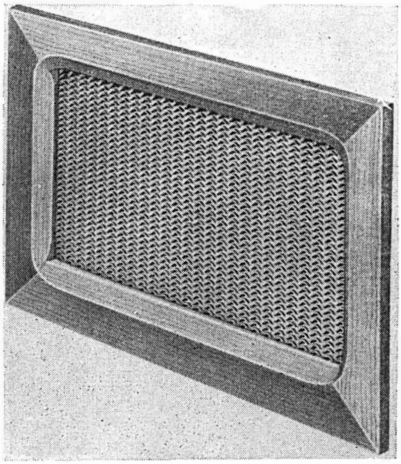
Whiteley 10-*in. Concentric Duplex*



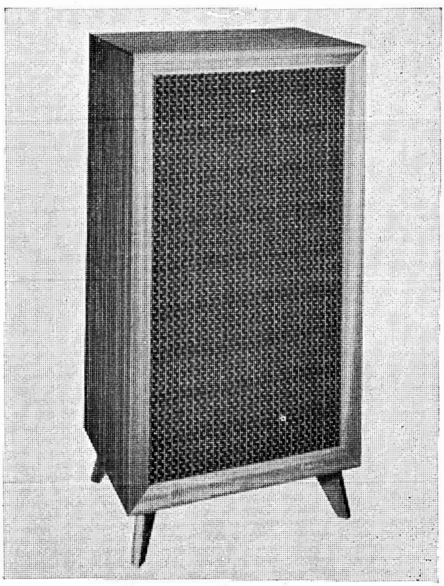
Westrex L F. Unit



Westrex H.F. Unit



Goodmans Acoustical Resistance Unit



Beam-Echo Avantic Mk. 2

High Frequency Unit, with acoustilens coupling unit. Horn loaded. Alloy dome on 3-in. voice coil of edgewound aluminium ribbon. Gap flux 17,500 gauss. Handling capacity above 500 c.p.s. up to 30 watts. Frequency range 500 c.p.s. to over 15,000 c.p.s. R.c.f. 675 c.p.s. Speaker includes horn and acoustic lens giving necessary dispersion. Price complete with horn and lens £69 17s.

★

Acoustic Resistance Units

Goodmans Industries Ltd., Axiom Works, Wembley, Middx. Tel. : Wembley 1200. Cables : Goodaxiom, Wembley.

172 ARU Unit. This unit combines both reflex port and acoustic resistance in one complete unit. The port area and resistance are calculated to suit a particular cabinet volume and speaker cone resonance, thus being usable with a variety of cabinet designs and driving units. Price £2 15s. 3d. to £3 16s. 6d.

PART 2— ENCLOSURES

Armstrong Wireless & Television Co., Warlters Road, Holloway, London, N.7. Tel. : North 3213.

Armstrong Labyrinth. Folded exponential horn, back loading. Free standing, forward facing. Two drive units. 12-in. bass ; 6-in. treble. Rec. Goodmans Audiom 60 and Plessey tweeter. Crossover 2,200 c/s. Response 20-16,000 c/s. Size 33 in. by 18 in. by 18 in. Weight 92 lb. Price (complete) £30, (without units) £21.

★

Beam-Echo Ltd., Witham, Essex, England. Tel. : Witham 3184. Cables : Parion, Witham.

Avantic Mk. 2. Friction loaded vent type. Two drive units. 12-in dual cone and horn-loaded pressure unit. Crossover 5 000 c/s. Response 30-16 000 c/s. Size 40½ in. by 20½ in by 14½ in. Weight 82 lb. Price £47 5s.

B.K. Partners Ltd., 229 Regent Street, London, W.1. Tel. : Regent 7363.

L.P.R. 103. Reflex with acoustic filter. Two drive units, with h.f. upward and l.f. direct radiation. Rec. Wharfedale Bronze 10/CSB and Wharfedale Super 3 tweeter. Crossover through 2 mfd filter condenser and level control. Response 35-18,000 c/s. Size 29½ in. by 20 in. by 11 in. (at base). Price (with rec. units) £23 13s. 6d. (U.K. purchase tax £3 11s. 8d.) ; without units, £12 8s. 6d.

H.C.12. Folded, back-coupled exponential horn. Two drive units, l.f. forward facing and h.f. upward facing with reflector. Rec. units Wharfedale W.12/CS and Goodmans Axiom 80. Crossover 800 c/s half-section. Response 40-20,000 c/s. Size 48¾ in. by 37½ in. by 27 in. (25¾ in. either side of corner). Weight 107 lb. Price with rec. units £78 15s. ; without units £41 17s. 6d.

H.C.10. Folded, back-coupled exponential horn. Two drive units with l.f. forward facing and h.f. upward facing. Rec. units Wharfedale Bronze 10/CSB or Golden/CSB, with Super 3 tweeter. Crossover 2,000 c/s quarter-section. Response 40-18,000 c/s. Size 46½ in. by 37½ in. by 26½ in. each side of corner. Weight 52 lb. Prices (complete) £32 19s. 6d. or £35 5s. (U.K. purchase tax £3 11s. 8d. or £4 9s. 10d.) with Bronze or Golden ; without units £24.

★

Burne-Jones & Co. Ltd., 62 Sunningdale Road, Cheam, Surrey. Tel. : Fairlands 8866

B.J. Reproducer Cabinet. Corner horn type, including reflex loading : a two-or three-speaker system, radiating forwards, also backwards into the corner. Rec. units, Bass units, 10-in. and 8-in. from the Wharfedale and Stentorian ranges, and tweeter if required in space provided. Response, with selected units, 30-20,000 c/s. Only supplied as an enclosure, not complete. Size 41½ in. by 35 in. by 18½ in. Price £25 4s. including side panels.

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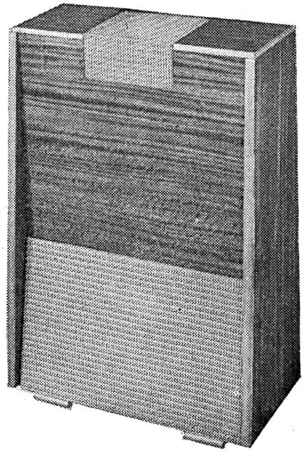
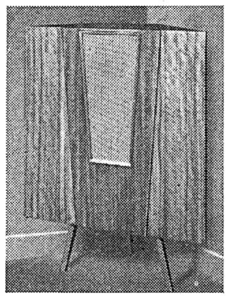
Champion Electric Corporation, Champion Works, Newhaven, Sussex. Tel. : Newhaven 500. Cables : Champelect, Newhaven.

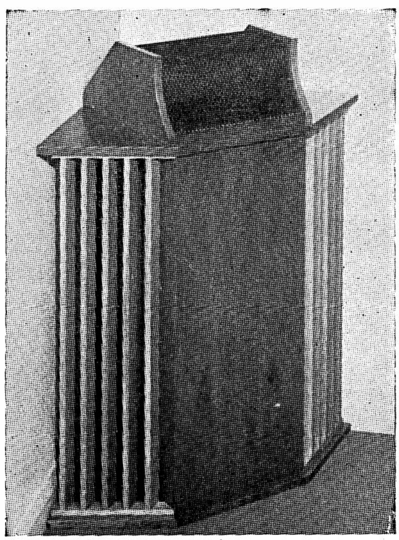
Enclosure with one 12-in. dual cone speaker and acoustical resistance unit. Response 30-15,000 c.p.s. No further details. Price not fixed.



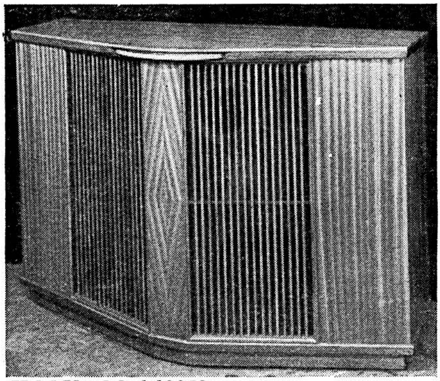
B.K. Partners L.P.R.103



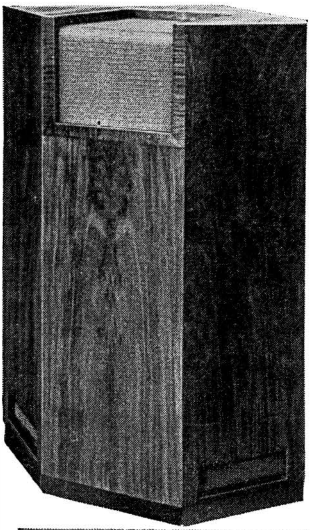
B.K. Partners H.C.10



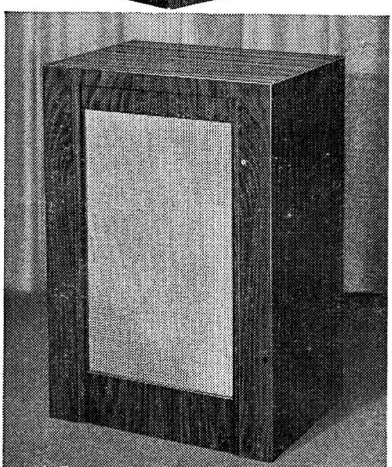
B-J Reproducer Cabinet



H.M.V. Model 3052



Expert "All Range"



Whiteley Stentorian Senior Console

E.M.I. Sales & Service Ltd., Blyth Road, Hayes, Middlesex. Tel. : Southall 2468. Cables : Emiservice. Telex : Emiglobe.

His Master's Voice Loudspeaker Combination. Model 3052 (incorporating Model 3051 power amplifier). Forward facing enclosure with non-directional H.F. dispersion, incorporating six drive units : three 12-in. m. coil (bass), two 6-in. m. coil (middle reg.), one narrow ribbon electrostatic (tweeter). Crossovers. Response 20-20,000 c/s. Size 36 in. by 48 in. by 19 in. Weight, app. 170 lb. Price £186 18s.

★

Expert Gramophones Ltd., " Ingerthorpe," Great North Road, London, N.2. Tel. : Mountview 6875.

Acoustic Column Speaker. Elongated reflex. Vertically mounted 8-in. double cone unit. Rec. Philips 9710M. Size 42 in. by 12 in. by 12 in. Price (complete) £28 16s. 6d. ; without unit £22.

All Range Speaker. Corner reflex. Vertically mounted 12-in. unit ; horizontally mounted 8-in. unit. Rec. Wharfedale W12 C/S and Philips 9710M. Size 42 in. by 30 in. by 23 in. Price (complete) £65 ; without units £40.

Master Speaker. Corner reflex. 15-in. concentric unit, vertically mounted with reflector. 90° distribution. Rec. unit 15-in. Tannoy dual concentric. Crossover 1,000 c/s. Size 60 in. by 34 in. by 24 in. Price (complete) £110 ; without unit £70.

★

General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2. Tel. : Temple Bar 8000. Cables : Polyphase, London.

Octagonal Cabinet. Model BCS1862. Loaded port type. Forward facing small enclosure. One or two metal cone-type units, 8-in. nominal, with presence unit if required. Response 30-20,000 c/s. Size 30 in. by 20 in. by 14½ in. Weight app. 30 lb. with 1 unit. Price £30 14s. 6d. with 1 unit + presence unit ; without units £17 10s.

★

Goodmans Industries Ltd., Axiom Works, Wembley, Middlesex, England. Tel. : Wembley 1200. Cables : Goodaxiom, Wembley.

Sherwood. Friction loaded, forward facing, rectangular, with sloped front, but suitable for corner. Incorporating acoustic resistance unit 172. One full-range 12-in. unit, with provision for Trebax tweeter. Rec. units, Axiom 150 Mk. 2, Axiom 22 Mk. 2, Audiom 60, or Audiom 70. Response 30-15,000 c/s, extended to 16,000 c/s. with Trebax. Prices (complete) with selected units in above order, £30 14s. 9d., £35 8s., £21 1s. 9d., £34 9s., mahogany veneer; without unit £21 9s. mahogany + £1 1s. walnut.

★

Grampian Reproducers Ltd., Hanworth Trading Estate, Feltham, Middlesex, England. Tel.: Feltham 2657. Cables: Reamp Feltham.

Grampian RB12. Forward facing reflex, shaped for corner or wall position. One 12-in. unit. Grampian unit recommended 1255/15. Size 31 in. by 22 in. by 16 in. Weight 60 lb. Price (complete) £25 10s.; without unit £16 10s.

The above cabinet also available in kit form, for user assembly. All woodwork fully machined and drilled; ready to assemble stain and polish. Complete with mesh material, screws, glue, etc., £11.

★

Lockwood & Co. (Woodworkers) Ltd., 67 Lowlands Road, Harrow, Middlesex, England. Tel.: Byron 3704.

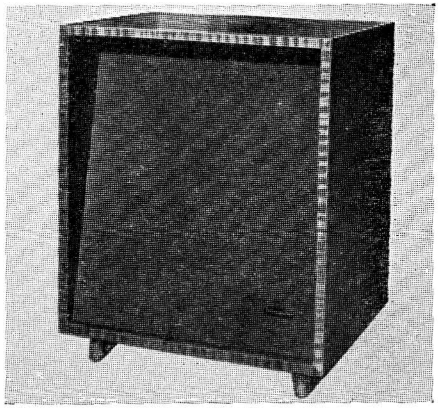
Lockwood Standard speaker cabinets, "Major" and "Minor." Free standing reflex types. Accommodating up to three units, 15-in., 8-in., 5-in. (or 15-in. with pressure units) rec. units, Wharfedale or Vitavox weights, 112 lb. and 78 lb. Prices without units £35 and £25.

★

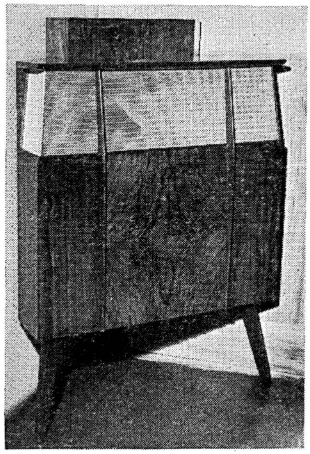
Lowther Manufacturing Co., Lowther House, St. Mark's Road, Bromley, Kent, England. Tel.: Ravensbourne 5225. Cables: Lowther, Bromley.

Corner Reproducer TP1. Folded bass horn/direct h.f. horn type. One specially designed 6-in. pressure unit, PM3. Acoustical crossover. Response 40-20,000 c/s. Size, 47 in. by 32 in. by 21 in. from corner. Weight 70 lb.

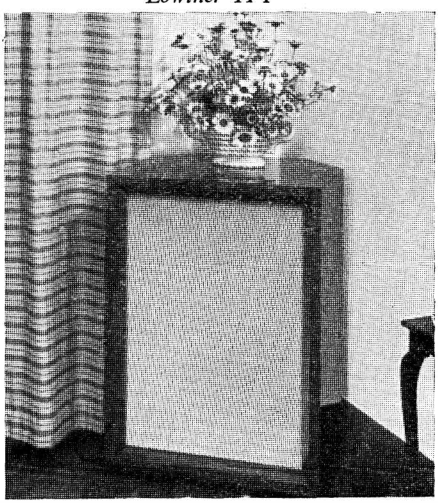
Corner Horn Model PW2. Horn and bass chamber type, with front of diaphragm horn loaded down to 250 c/s, rear bass chamber down to 40 c/s. One 6-in. or 8-in. unit. Rec. Lowther PM6 or PM2 Mk. 1. Response 40-18,000 c/s. Size 60 in. by 15 in., corner to front face. Weight 60 lb. Price £30.



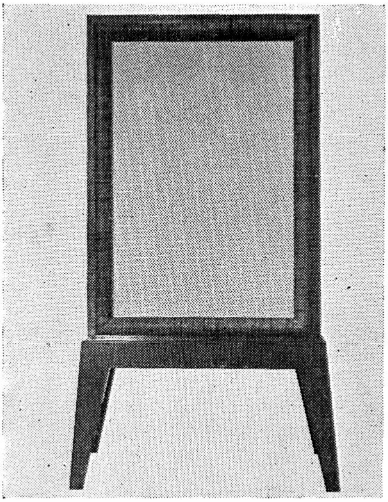
Goodmans "Sherwood"



Lowther TP1



Grampian RB12



M.S.S. LSX/1

Acousta Cabinet. Models FH/V, FH/H. Folded horn type, forward facing, with rear folded horn. Vertical on plinth, or horizontal on 12-in. legs. One unit, 6-in. or 8-in. Rec. Lowther PM6. Response 100-17,000 c/s. Size 34 in. by 18 in. by 17 in. Weight 45 lb. Price (complete) £37 18s.; without unit £18 18s., walnut, oak mahogany.

★

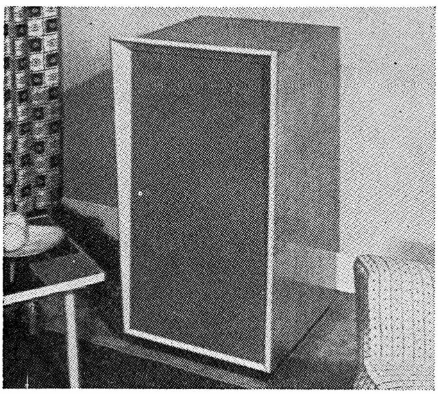
M.S.S. Recording Co. Ltd., Poyle Farm, Colnbrook, Bucks, England. Tel.: Colnbrook 430. Cables: Emessco.

Model LSX/1. Reflex forward facing. Cabinet on walnut pedestal. One 8-in. unit. Response 40-15,000 c/s. Size 34 in. by 17 in. by 10¼ in. Price £30.

★

Musicraft, 20/22 High Street, Southall, Middx., England. (Branch at 13 King Street, Richmond, Surrey.) Tels.: Southall 3828; Richmond 6798.

F.E.H. Enclosure. Folded exponential horn type, forward facing. Two units, 8-in. and 3-in. Rec. Goodmans "Axiette" and Wharfedale Super 3. Crossover 4/5,000 c/s. Response 30-17,000 c/s. Size 36 in. by 20 in. by 20 in. Price (complete) £51 1s. 7d. (U.K. purchase tax £3 18s. 5d.); without units £40 10s.



Musicraft F.E.H.

★

Pamphonic Reproducers Ltd., 17 Stratton Street, London, W.1. Tel.: Grosvenor 1926.

Victor Senior. Two units. Bass, 15-in. treble 6-in. elliptical. Response 30-15,000 c/s. Crossover 1,000 c/s. Price £57 15s.

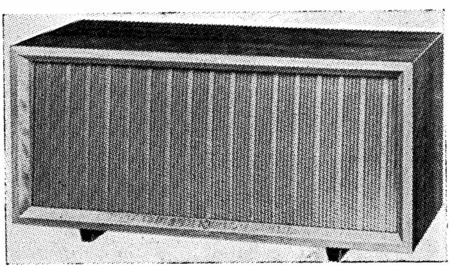
Victor Junior. Two units. Bass 12-in., treble 6-in. elliptical. Response 35-12,000 c/s. Price £36 15s.

★

Pye Limited, Radio Works, Cambridge. England. Tel.: Cambridge 58985. Cables. Pyrad, Cambridge.

Enclosure HF12BS. Reflex type, with two forward facing speakers, designed for bookshelf. 8-in. units. Response 40-13,000 c/s. Size 11¾ in. by 23½ in. by 11½ in. Weight 27¼ lb. Price £14 8s. 1d. (U.K. purchase tax £5 10s. 11d.)

Enclosure HF12SM. Reflex type, with one forward facing unit. 12-in. unit, Response 30-13,000 c/s. Size 31 in. by 20½ in. by 14½ in. Weight 79¼ lb. Price £31 10s



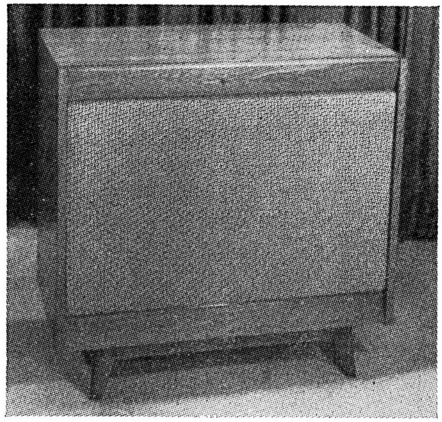
Pye HF 12BS

Enclosure HF25SC. Corner reflex. 15-in. dual concentric unit and pressure type treble unit. Response 30-20,000 c/s. Size 37 in. by (across front) 26 in. by 17 in. Weight 88 lb. Price £71 8s.

★

RCA Great Britain Ltd., Lincoln Way, Sunbury-on-Thames, Middlesex, England. Tel.: Sunbury 3101. Cables, telex and tex: 28608.

Panoramic Multiple Speaker System. Models LM1 32245B (Walnut) and LM1 32245A (Light oak). Ported bass reflex. Forward facing with plinth optional for horizontal or vertical mounting. Three m. coil units. 15-in. with cloth surround, and two 2½-in. Crossover operates at 2,000 c/s. Response 29-20,000 c/s. Price £53 18s. 6d., plus plinth £2 12s. 6d. Size 32 in. by 25 in. by 16 in. Weight 136 lb.



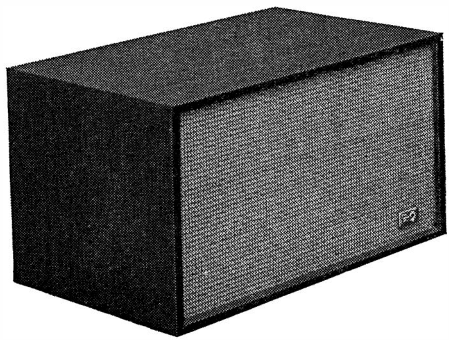
RCA "Panoramic"

★

R.G.A. Sound Services (Plymouth) Ltd., 6 Conway Gardens, Clay Hill, Enfield, Middlesex, England. Tel.: Enfield 3145.

"CQ" Enclosure. Controlled "Q" reflex. Forward facing table model with optional screw-in legs. One unit. Wide range 9 in. by 5 in. elliptical. Response 35-10,000 c/s. Size 22 in. by 12 in. by 13 in. Weight 22 lb. Price £9 (U.K. purchase tax £3 12s.).

Senior "CQ." Controlled "Q" reflex. Forward facing table model, with optional screw-in legs. Wide range 9-in. by 5-in. elliptical, and 4-in. extended range tweeter. Crossover at 7,000 c/s. Response 35-17,000 c/s. Size 22 in. by 12 in. by 13 in. Weight 23 lb. Price £12 (U.K. purchase tax £4 16s.).

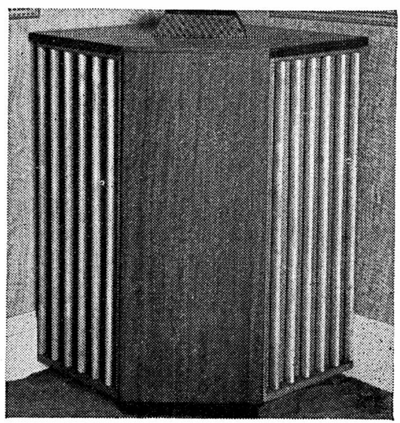


R.G.A. "C.Q."

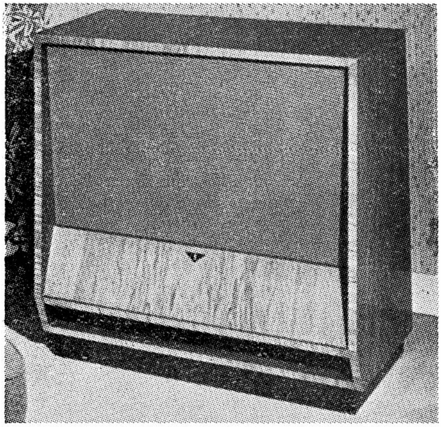
★

Rogers Developments (Electronics) Ltd., 4-14 Barmeston Road, Catford, London, S.E.6. Tel.: Hither Green 7424. Cables: Rodevco, London, S.E.6.

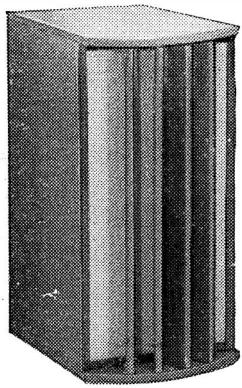
RD Junior Corner Horn. Folded exponential horn, designed to use room's corner walls as part of horn. Diffused treble. One 8-in. unit. Rec. Goodmans "Axiette," Philips 971CM, Wharfedale Super 8 AL, or Lowther PM6. Response 35-16,000/20,000 c/s (top limit dependent upon unit fitted). Size 36 in. by 32 in. by 25 in. Price without unit £18 17s. 6d., plus optional pair of side panels £3 10s. Price with PM6 unit less panels £37 15s. 6d.



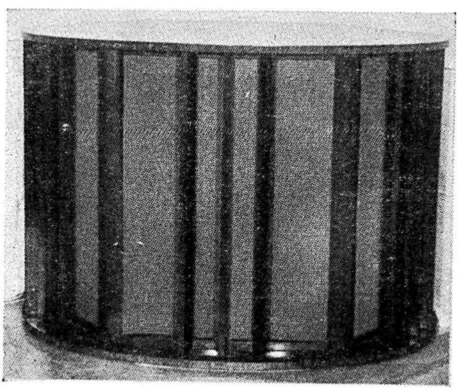
Rogers Junior Corner Horn



Simon S.E. Bass Reflex



Sound Sales " Phase Inverter "



Sound Sales Tri-Channel

RD Senior Reproducer. ARU enclosure, forward facing. Three drive units : two 8-in., one ribbon tweeter. Rec. two Goodman Axiom 80 and Kelly ribbon. Crossover 3,000 c/s. Response 20-30,000 c/s. Size 36 in. by 27 in. by 15 in. Price, units as specified £82 17s. (U.K. purchase tax £13 19s. 6d.) ; without units, £47 17s.

★

Simon Sound Service Ltd., 48 George Street, London, W.1. Tel. : Welbeck 2371. Cables : Simsale, London.

Simon S.E. Bass Reflex Enclosure. Two drive units, 12-in. with oversize magnet, and 4-in. mc. Crossover. Response 40-15,000 c/s. Size 30 in. by 30 in. by 12 in. Weight app. 80 lb. Price £31 10s.

★

Sound Sales Ltd., Works and Acoustic Laboratories, West Street, Farnham, Surrey, England. Tel. : Farnham 6461. Cables : Sounsense.

Phase Inverter Speaker. Model A, 15 ohms. Model B, 3 ohms. Reflex type. Ported cabinet for forward facing, inc. treble diffuser. 12 watt handling. 12-in. Sound Sales dual suspension auditorium unit. Response 30-13,500 c/s. Size 29 in. by 14 in. by 18½ in. Weight 44 lb. Price £18 10s.

Tri-Channel Mk.4. Special labyrinth construction, reflex. Distribution over 90° arc. Three 12-in. Sound Sales Auditorium units, and one electrostatic tweeter. Crossover infinitely variable. Response 25-27,000 c/s when used with associated amplifiers. (This equipment is sold complete. Refer to amplifier section). Size 43 in. by 31 in. by 25 in. Weight 202 lb. Price including amplifiers, complete, £115.

★

Tannoy Products Ltd., West Norwood, London, S.E.27. Tel. : Gipsy Hill 1131. Cables : Tannoy, London.

Canterbury. Reflex, with forward facing unit, dual throated ports, for corner placing. One 12-in. dual concentric unit, or direct radiator. Size 37 in. by 25 in. by 17 in. Price with dual concentric £57 10s. ; with direct radiator £39 18s.

G.R.F. Folded horn. Rear horn loaded, forward facing unit, for corner. One 15-in. dual concentric unit. Response 20-20,000 c/s. Size 48 in. by 38 in. by 29 in. Price £116 10s.

Landsdown. Reflex. Forward facing unit, dual throated ports. For side wall placing. One 12-in. dual concentric unit. Response 30-20,000 c/s. Size 32 in. by 36 in. by 17 in. Price £68 5s.

York. Reflex. Forward facing unit, dual throated ports, for corner placing. 12-in. or 15-in. dual concentric unit. Response 35-20,000 c/s. Size 45½ in. by 32 in. by 22½ in. Price, with 12-in. unit, £63 ; with 15-in. unit £71 8s.

Guy R. Fountain Autograph. Folded horn. Front and rear horn-loaded unit, forward facing for corner placing. 15-in. dual concentric unit. Response 20-20,000 c/s. Size 58½ in. by 43 in. by 26½ in. Price £150 3s.

★

Trix Electrical Co. Ltd., 1-5 Maple Place, London, W.1. Tel. : Museum 5817. Cables : Trixadio, Wesdo, London.

Unicorn 908. Ported bass chamber and ellipsoid reflector giving 90° diffusion of higher frequencies. 1 8-in. unit. Response 50-12,000 c.p.s. Size 22 in. by 17 in. by 37 in. Price without units £49 7s.

★

Vitavox Ltd., Westmoreland Road, London, N.W.9. Tel. : Colindale 8671. Cables : Vitavox, Hyde, London.

Klipschorn. Double channel horn. Folded L.F. horn, forward facing H.F. horn. 2 drive units : 15-in. L.F., pressure type H.F. Crossover at 500 c/s. Response 30-15,000 c/s. Size 50 in. by 30 in. by 27 in. Weight 210 lb. Price with specified units £145.

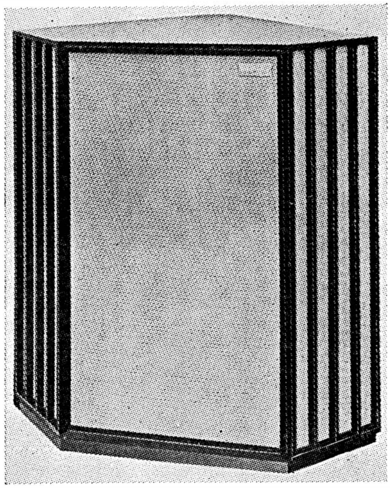
★

Wharfedale Wireless Works Ltd., Idle, Bradford. Tel. : Idle 1235-6. Cables : Wharfdel, Idle, Bradford.

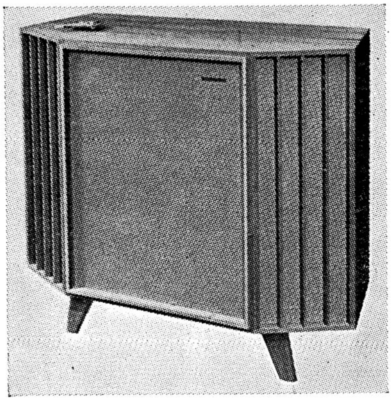
R.J. Damped reflex, forward facing. 1 8-in. drive unit. Rec. Super 8/FS/AL, 8-in. Bronze/FS/AL. Response 60-14,000 c/s. Size 23½ in. by 11 in. by 10¼ in. Weight 15¼ lb. Price without units, in polished whitewood £7 ; in polished walnut veneer £9 10s.

R.J.-2. Damped reflex. Spec. as for R.J. but with entire front covered with anodised aluminium mesh. Price without units £10 10s.

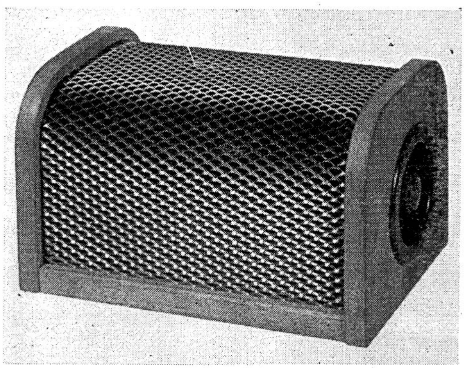
AF/10. Forward facing reflex with acoustic filter. 1 10-in. unit. Rec. 10-in. Bronze/FSB, Golden/FSB, W10/FSB. Response 40-10,000 or 14,000 c/s depending on unit fitted. Size 30 in. by 17 in. by 10½ in. Weight 35 lb. Price without units £15.



Tannoy " G.R.F."



Tannoy " Landsdown "



Wharfedale Super 3 Cabinet

SFB/3. Sandfilled baffle. 3 drive units. 12 and 10-in. units facing forwards. 3-in. H.F. unit facing upwards for omni-directional treble distribution. Response 30-20,000 c/s. Size 34 in. by 31 in. by 12 in. Weight 64 lb. Price with units £39 10s. (not sold separately).

Omni-directional 3-speaker system. Sandfilled reflex enclosure, bass units facing forward, separate mid range and treble units facing upward. 15-in., 8-in., and 3-in. units. Rec. W15/FS, Super 8/FS, Super 3. Response 20-20,000 c/s. Size 48 in. by 34 in. Weight 160 lb. Price with specified units £73 10s.; sandfilled panel only £31; twin treble cabinet £8 15s.

Super 3 Cabinet. Open baffle, facing upward to house 1 Super 3. Crossover 5,000 c/s. Response 5,000-20,000 c/s. Size 8 in. by 6 in. by 5 in. Weight 1¾ lb. less unit. Price £3 10s. (for 8/15 ohm speakers); £4 (for 2/3 ohm speakers).

★

Westrex Company Ltd., Liberty House, Regent Street, London, W.1. Tel.: Regent 1001. Cables: Westelcol, Norphone, London.

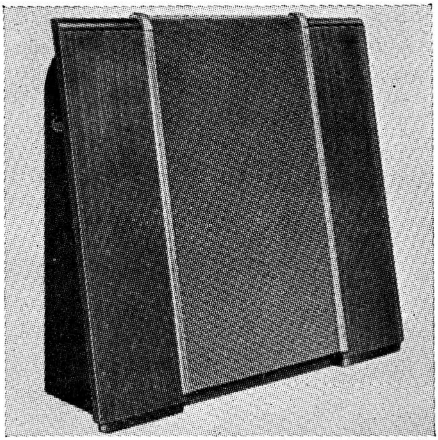
Acoustilens 20/80 High Fidelity System. Large reinforced 1-in. ply reflex housing own (15 in.) 20/80 low frequency unit and horn loaded high frequency unit with acoustic lens. Crossover 675 c.p.s. Response below 30 c.p.s.—above 15,000 c.p.s. Size 44 in. by 33 in. by 19½ in. Weight approx. 160 lb. Price complete with units and crossover £169.

Note.—The two drive units incorporated in this enclosure will be found in an earlier part of this directory, as will the dividing network. For information on the acoustic lens, as fitted to the high frequency unit, refer to the article on page 124.

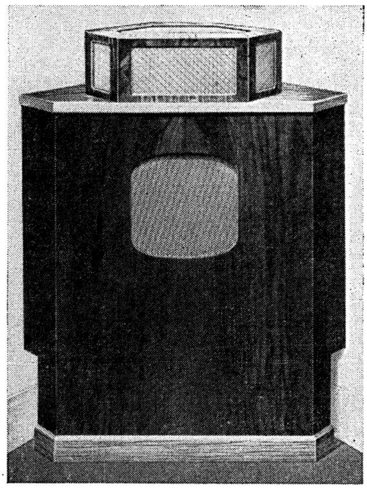
★

Whiteley Electrical Radio Co., Ltd., Victoria Street, Mansfield, Notts. Tel.: Mansfield 1762/3/4/5. Cables: Whitebon, Mansfield.

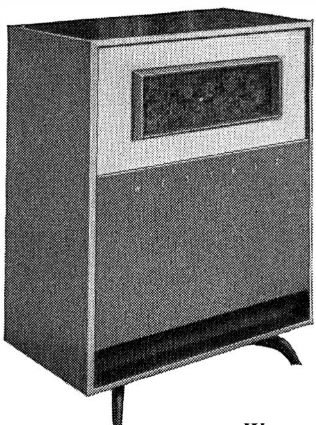
Stentorian Corner Console. Infinite baffle. 1 8-in. unit. Rec. HF812. Response 50-12,000 c/s. Size 26 in. by 17 in. by 7½ in. Price with specified unit £8 9s. 6d. (U.K. purchase tax £1 4s.); without unit £5 10s.



Wharfedale SFB/3



Wharfedale Omni-directional



Westrex 20/80

Stentorian Junior Console. Bass reflex for corner position. 1 or 2 drive units. Rec. HF816 or HF1012 with T10 tweeter, if required. Crossover 3,000 c.p.s. Response HF816, 50-14,000 c/s ; HF1012 & T10 30-14,000 c/s. Size 33 in. by 22½ in. by 18½ in. Price with HF816 £14 6s. 7d. (U.K. purchase tax £1 19s. 5d.) ; with HF1012 and T10 £18 14s. (U.K. purchase tax £1 8s. 9d.) ; without units £9 9s.

Stentorian Standard Console. Forward facing bass reflex. 1 or 2 drive units. Rec. HF1012 or HF1214 with T10 or T12, if required. Crossover 3,000 c/s. Response with HF1012 and T10 30-14,000 c/s ; with HF1214 and T12 25-17,000 c/s. Size 32 in. by 22 in. by 16 in. Price with HF1012 and T10 £19 15s. (U.K. purchase tax £1 8s. 9d.) ; with HF 1214 and T12 £34 7s. 6d. ; without units £10 10s.

Stentorian Senior Corner Console. Bass reflex for corner position. 10-in. or 12-in. drive unit with tweeter, if required. Crossover 3,000 c/s. Response with HF1012 and T10 30-14,000 c/s ; with HF1214 and T12 25-17,000 c/s. Size 35 in. by 30 in. by 19 in. Price with HF1012 and T10 £20 16s. (U.K. purchase tax £1 8s. 9d.) ; with HF1214 and T12 £35 8s. 6d. ; without units £11 11s.

Stentorian Sloping Dual Front. Tweeter housing, reversible, either forward or rear facing. 1 8-in. unit. Rec. T816. Response 1,000-17,000 c/s. Size 13 in. by 10½ in. by 7½ in. Price with unit £8 10s. 1d. (U.K. purchase tax £1 17s. 5d.) ; without unit £3 17s. 6d.

Crossovers, etc.

Goodmans Industries Ltd., Axiom Works, Wembley, Middx. Tel. : Wembley 1200. Cables : Goodaxiom, Wembley.

X0/5000 Crossover Unit. A 2-way half-section crossover network, operating at 5,000 c.p.s. All terminations 15 ohms. Price £1 19s.

X0/750 Crossover Unit. A 2-way, half-section, crossover network, operating at 750 c.p.s. All terminations 15 ohms. Price £5 10s. 9d.

★

Technical Suppliers Ltd., Hudson House, 63 Goldhawk Road, London, W.12. Tel. : Shepherds Bush 2581/4794.

HP1 Crossover Unit. A ¾-section crossover specially designed for use with T.S.L. Lorenz LP312-2 speaker system, crossover at 5,000 c.p.s. Price £2 2s.

★

Westrex : Dividing Network. Constant impedance parallel network, using two L-type filter sections, low and high pass, crossover at 675 c.p.s. For any impedance 16-24 ohms. Price £13 10s. 6d.

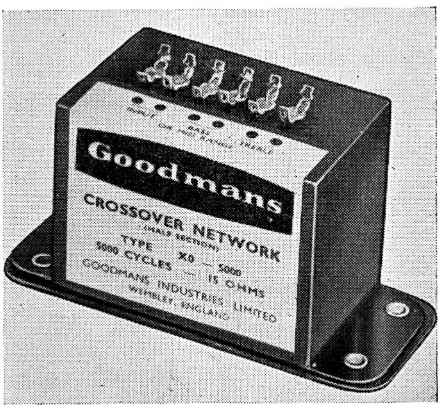
★

Wharfedale Wireless Works Ltd., Idle, Bradford, Yorks. Tel. : Idle 1235-6. Cables : Wharfdel, Idle, Bradford.

Loudspeaker Separators. ½-section type. Operating at 1,000 or 3,000 c.p.s. 8 units available to cover from 2-16 ohms impedance. Slope 6 dB/octave. Size 7 in. by 4 in. by 3¾ in. Weight 2-2½ lb. Max input 30 watts. Price from £2 11s. to £4 17s. 6d. depending on type.

HS/CR3/2. ½-section 3-way separator unit with crossover at 800 and 5,000 c.p.s. Max input 30 watts. Slope 12 dB/octave. Size 9 in. by 6 in. by 5 in. Weight 6½ lb. 2 models. 2-6 ohms, Price £11 ; 7-16 ohms, Price £8 10s. Also available with crossover at 400 and 5,000 c.p.s. 7-16 ohms only, Price £12 10s.

WMT1 Matching Transformer. Auto transformer for matching 10-16 ohms or 7-9 ohms speakers to sets with 2-5 ohms output or vice versa. Response 20-15,000 c.p.s. ± 1 dB. Handling capacity 15 watts. Can also match speakers of different imps. to crossover unit in 2 or 3 speaker systems. Size 2⅞ in. by 2¾ in. by 2¾ in. Weight 12½ oz. Price 13s. 6d.



Goodmans X0-5000 *Crossover*

ACOUSTIC LENSES

By R. A. Bull

THE simple optical lens that brings light to a focus has been known for many centuries ; science, however, did not propose a completely satisfactory explanation of the phenomenon till more recent times. The physicist Max Born showed that Maxwell's famous equations for wave motion were equally applicable to a medium composed of particles, provided that the particles are small compared to a wave length. In glass the particles are sufficiently small compared to the wave length of light to fulfil this requirement and are so much denser than the air, that light waves take longer to pass through the thicker centre of a simple lens than through the thinner edges. Thus a wave front is bent towards a focus point. Light waves and radio waves are both electro-magnetic in character, and only differ in the magnitude of their wave length ; this led to the concept of lenses for radio waves.

Max Born's Theory

According to Max Born's theory, an aggregate of particles, in this case they would have to be metal particles, arranged in an appropriate pattern, should act as a lens to radio waves, always provided that the particles are relatively small compared with the wave length. At a frequency of 10,000 Mc/s the wave length is about 3 cms, and an array of metal spheres, each about 0.5 cms diameter arranged in a pattern reminiscent of a lens as shown in **Fig. 1,** does in fact act as a lens, and brings an incident wave to an approximate focus.

Koch's Array

A few years ago, W. E. Koch of the Bell Laboratories, who was working on radio lenses, suggested that an array of particles as shown in **Fig. 1** should produce precisely the same focusing effect if exposed to an acoustic wave having the same wave length as the radio wave. The frequencies of course are vastly different, 10,000 Mc/s in one case and 11.5 Kc/s in the other. Koch's prediction was confirmed. The array acted equally well as a radio or as an acoustic lens.

For success, however, there was one difference. With radio, the spheres had to be metallic, and could be shells very light in weight ; while in the acoustic case the

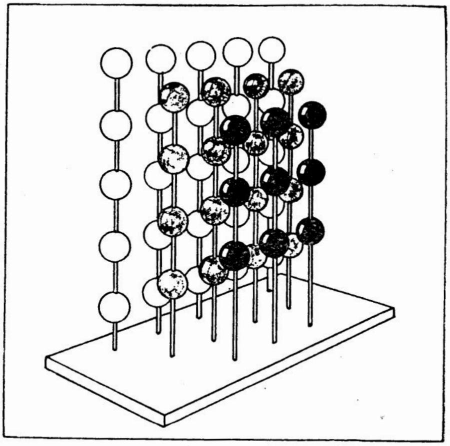


Fig. 1—*The particle array of Koch's experiments.*

spheres had to be solid, heavy and rigid. This difference gives rise to an approach which permits computation and prediction of the performance of an array. The radio lens is regarded as composed of nearly perfectly conducting spheres, in which electric currents are set up, and which re-radiate their energy with negligible loss. That is, they are near perfect reflectors. In the acoustic case the spheres are so rigid that they are immovable with respect to the air, and are again near perfect reflectors.

In both cases the re-radiated wave from each particle combines with the original wave to produce a new wave having a lower velocity while inside the array. The idea of the near perfect conducting sphere, and the near perfect rigid sphere, can be used to arrive at a mean density inside the array. In the radio case the relative dielectric constant is unity for free space, and infinite at the surface of the conducting sphere. An array thus appears to have a dielectric constant greater than unity. Similarly, the rigid sphere in the acoustic case has an almost infinite density compared to air and thus the array appears to have a density greater than unity. In both cases, one where the dielectric constant inside the array is greater than unity, and the other where the density is greater than unity, the concept of an index of refraction which itself is greater than unity can now be introduced. There is, therefore, a complete parallel between the optical lens and the acoustic lens, the radio lens being a close variant of the optical lens.

Micro-wave Lenses

The radio micro-wave lens is designed for a given wave length, but in the acoustic case we have to deal with wave lengths of several metres down to a few centimetres ; in fact a ratio of the longest to shortest wave length of over 300. It is logical to ask, therefore, if the acoustic lens can be designed to cover such a range and where, if at all, does it fail ? Failure occurs at the shorter wave lengths or the higher frequencies if the particle dimensions are not small compared with a wave length. The failure takes the form of a miniature, half-wave organ pipe type of resonance between particles. When this occurs, the medium becomes in effect infinitely dense and acoustic transmission stops.

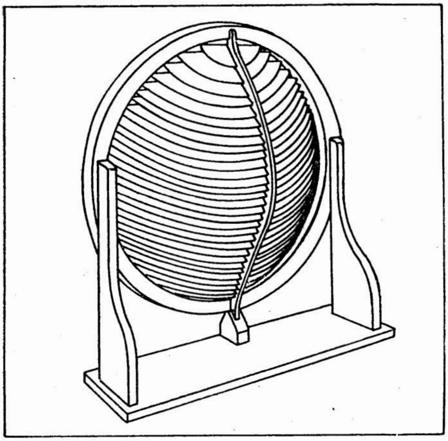


Fig. 2—*An array of* 30-*in. diameter slant plates.*

There is an alternative and more practicable design approach for both the electromagnetic and acoustic lens ; this is to adopt a path delay principle. **Fig. 2** shows an array of slant plates 30 in. in diameter arranged as a lens. In a lens of this type the delay action is obtained by guiding the incident wave through a longer path between parallel plates, slanted at some desired angle with respect to the original wave direction. The index of refraction is simply the reciprocal of the cosine of this angle. This lens operates equally well for acoustic and radio waves, the limiting frequency being reached when the plate separation is half a wave length. This particular lens is of the convergent type and can either focus a plane wave to an approximate point, or with a small radiator at the focus, can produce a near parallel beam.

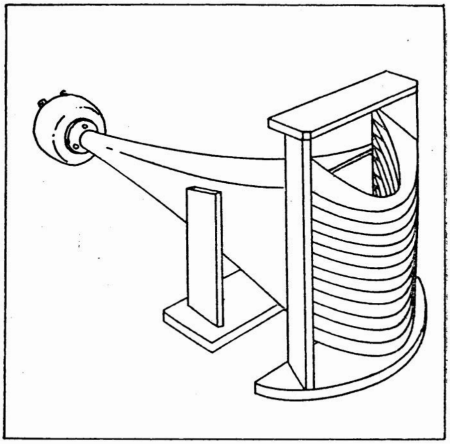


Fig. 3—*Sketch to illustrate the divergent lens principle.*

Lenses for Hi-Fi Work

In Hi-Fi work we are particularly interested in the divergent type of acoustic lens. In all direct radiating loudspeakers, the diaphragm diameter is small compared to a wave length at low frequencies, and large compared with a wave length at high frequencies. The speaker is, therefore, a spherical radiator at low frequencies and a beam radiator at high frequencies.

It is well known that paper diaphragms cannot be persuaded to function as pistons when working direct into free air, and thus most diaphragms only radiate at high frequencies from the area adjacent to the driving coil. This is to our advantage, since it tends to raise the frequency at which beam radiation takes place. It is, however, incongruous to expect ideal quality if the desired response characteristic is only obtained when listening directly on the axis of the speaker. The combination of a radiator and an appropriately designed divergent acoustic lens can largely overcome this fundamental characteristic of the loudspeaker, and produce a substantially constant broad polar characteristic over the audible frequency scale.

An example of the divergent lens principle is shown in **Fig. 3.** It will be seen that it is associated with a horn and not a direct radiator ; there is a basic reason for this. A horn, properly designed, produces a close approximation to a plane wave at its mouth ; and a lens can only be designed to give an approximately constant divergent radiation at all frequencies if the curvature of the incident wave is known and is constant. If a divergent lens is associated with a direct radiating diaphragm, the divergent radiation from the lens varies with frequency, because of the variable curvature of the radiation from the diaphragm.

An example of the embodiment of these principles occurs in the case of the Westrex " Acoustilens." This is a device consisting of a highly developed loudspeaker driving unit, having an electro-acoustic efficiency in the region of 20 to 25 per cent, associated with an acoustic coupling device in which the principle of a horn and a cylindrical horizontal divergent lens have been incorporated in a single design.

PLASTIC FOAM

By Ralph West

THE plastic foam material rapidly coming into fashion amongst speaker manufacturers is generally a specially prepared sample of the same foam material to be seen in many of our shops at the present time. It is known chemically as Poly-urethane, and was developed in Germany during the war years as a synthetic fibre. It has a similar elasticity to nylon, and fabrics spun from it exhibited similar properties to nylon. Unfortunately its melting point is almost 180°C, whilst that of nylon was about 215°C, which is less easily damaged when being ironed. Thus its rival, nylon, has replaced it as a synthetic fibre. In expanded foam form it has, however, some very useful properties. It is chemically stable ; i.e., it does not harden or go sticky with the passing of time, as does rubber ; it is unaffected by most liquids and vapours and it possesses excellent damping properties. This latter property is the one that interests us most. It may not be the only material having these properties, but it came along first and it does the job.

Application to the Cone Edge

The cone is driven at point A and some energy is radiated between A and B, some reaches B so that B also moves. The amplitude of B's motion is (generally) less than A's and its phase is variable, depending on the distance AB, the velocity of sound in the cone (more or less transverse vibration), and the frequency concerned. Between A and B there may be several zones with opposite motions. This is our old foe, cone breakup, and it leads to an irregular response above, say, 500 c.p.s. for a 12-in. cone ; rather higher for a smaller cone. As the operating frequency is raised, first comes a dip in the response **(Fig. 2a),** then a peak **(Fig. 2b),** next another dip **(Fig. 2c),** and so on. This is still further complicated by the fact that the pattern can also vary round the cone. These dips and peaks would not be very

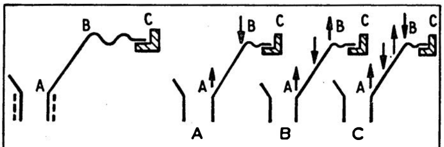
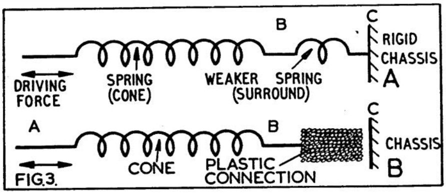


FIG. 1. FIG. 2.

marked since, say, in the **Fig. 2a** case, there would not be anywhere nearly complete cancellation, since the amplitude of B should be less than that of A. Dips in the response cannot be heard, though they can be noticed if deep enough ; but peaks can, unfortunately.

In practice more happens, because the unradiated energy reaching B must go somewhere. B is attached to the heavy, rigid chassis by the springy surround, and the cone itself is springy, so the surplus energy is reflected back again towards A.

Now, depending on the distance AB, and frequency (as before), this energy will sometimes boost up the cone motion and sometimes reduce the cone motion. The boosting or reduction will be greatest near the outside of the cone. This will increase some of the peaks and increase some of the dips—which is serious ; some peaks and dips will be evened out somewhat, but the damage



is already done. **Fig 3** shows a simple mechanical analogy. At certain frequencies the longer spring will surge to and fro with considerable amplitude. Such behaviour in the cone is simply resonance, no more, no less ! Now interpose a block of some viscous or spongy material between the spring and the rigid mounting, and it will be impossible to excite such large vibrations any more. This will hold for all frequencies if the mass elasticity, and viscosity of the block is chosen to match the spring. The same applies to our speaker. The surround is the most obvious place in which to use it, but its possible use in other parts of the moving system is not unlikely. It does not make the response flat, but it does reduce the worst peaks, the true resonances, which have resulted from reflection of unused energy.

A very soft paper cone *could* absorb so much energy by friction between its own fibres, that little or none ever reached B. However, it would be extremely difficult to get enough of the cone to move at high frequencies to produce any useful sound at all ! That may be all right for a very large " woofer," indeed it is good practice.

The usefulness of the foam surround is not limited to the high frequencies, however. If used in the right proportions, it can materially help to damp the main (bass) cone resonance. This is the one where the cone and speech coil behave as one solid member, and swing to and fro against the springiness (compliance) of the surround and centring device. If at least one of these springs has viscous or damping properties, then the resonance must be reduced. One further benefit accrues—this material will stretch (in a springy manner), while a paper or cloth surround cannot (appreciably). Paper and cloth bend very nicely and behave perfectly for small cone movements, but they both tighten up *suddenly* when anything more than a certain displacement is attempted. So foam can give better bass as well !

NEW EQUIPMENT ON THE WAY

Part I—Speakers

Acoustical Manufacturing Co. Ltd., St. Peter's Road, Huntingdon, Hunts. Tel. : Huntingdon 361 and 574. Cables : Acoustical.

Wide-range Constant-charge Electrostatic Speaker. Direct radiating full range electrostatic doublet. Moving elements 7 by 10^4 grams per square centimetre. Being of constant-charge-per-unit-area type, it is distortionless. Distribution is figure of eight, practically independent of frequency. Designed to operate with standard quad amplifier or equivalent. No bass lift needed. Price complete with polarising and matching units £35-£40.

★

Cape Electronics Ltd., 43-45 Shirley High St., Southampton. Tel. : Southampton 74251.

Cape Reflex Enclosure. A free standing bass reflex enclosure to accommodate one speaker up to 15 in. with enclosed type of treble unit if required. This enclosure is constructed upon a new principle (provisional patent) which reduces colouration from resonance, interval standing waves and external defraction.

Flat parallel sides are avoided and the enclosure is formed from concentric skins, sand filled. Expected delivery about October, 1957. Prices from £18 depending on size.

★

Philips Electrical, Century House, Shaftesbury Avenue, W.C.2.

High Impedance Speakers for use with the Hi-Z amplifier. 400 ohms impedance, otherwise same specifications to models 9762, 9762M, and 9710 (see speaker directory).

DIRECTORY OF EQUIPMENT ON THE WAY
Part 2—MISCELLANEOUS

Tape Decks, Tape, etc.

Bradmatic Limited, Station Road, Witton Lane, Aston, Birmingham 6. Tel. : East 2881-2. Cables : " Bradmatic," Birmingham.

Shortly available, a miniature version of their standard magnetic sound heads. Only 15 mm. in diameter.

Also, a modified version of the model 5 range of tape deck with speeds of 7½ and 15 c.p.s.

★

E.M.I. Ltd. & E.M.I. International Ltd., Blythe Road, Hayes, Middx. Tel. : Southall 2468. Cables : Emiservice, Telex, Emiglobe.

" Emifilm." The latest type of sprocketed magnetic recording film. There will be five different types 35 mm. fully coated (type 351); centre coated (type 352); striped 260 mils. and 50 mils. (type 353); 17.5 mm. fully coated (type 171); and 16 mm. fully coated (type 161).

★

Leevers-Rich Equipment Ltd., 78b Hampstead Road, London, N.W.1. Tel. : Euston 1481. Cables : Leemag London.

Magnetic Film Recorder, Series F. A versatile sprocket-driven magnetic recorder suitable for film production and similar applications using 16 mm. or 17.5 mm. perforated film.

★

Philips Electrical, Century House, Shaftesbury Avenue, W.C.2.

Twin-track Tape Recorder Type Ag8108. Three speeds, 7½, 3¾ and 1⅞ i.p.s. Magic eye indicator. Inputs for mic., P/U and radio. Output for external speaker. Treble and bass controls. Revolution counter built in. Size 15¾ in. by 13¼ in. by 8 1/16 in.

★

Rogers Developments (Electronics) Ltd., " Rodevco Works," 4-14 Barmeston Road, Catford, S.E.6. Tel. : Hither Green 7424. Cables : Rodevco, London, S.E.6.

RD Junior Tape Unit. Low-level record and replay amplifier with bias oscillator, designed for use between tape deck and RD Junior or RD Senior Mk. III Control Units. Suitable for Collaro and Wearite tape decks. Approx. price £15, less power pack. Initial deliveries, Autumn, 1957.

Motors, Amplifiers, Tuners, etc.

Philips Electrical Limited., Century House, Shaftesbury Avenue, W.C.2. Tel. : Gerrard 7777. Cables : Phillamps.

Transcription Motor with Philips magnetodynamic pickup. Four speeds, sold only complete. Diamond stylus.

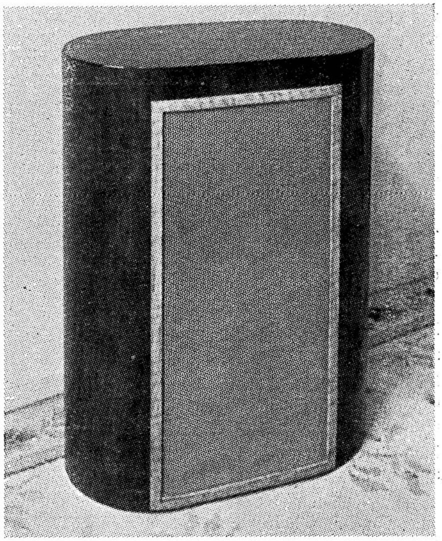
Hi-Z Amplifier and Control Unit. 12 watts. This amplifier uses a new type of output stage without an output transformer. Output impedance 400 ohms. Negligible phase shift and intermodulation. Total harmonics distortion $< 0.1\%$.

★

Grampian Reproducers Ltd., 19 Hanworth Trading Estate, Feltham, Middx. Tel. : Feltham 2657/8. Cables : Reamp, Feltham.

In the course of preparation an F.M. tuner unit and 24 watt amplifier.

★



Prototype model of the sandfilled " Cape " speaker enclosure listed on page 127 under " New Equipment on the Way." Features include stressed skin construction and all sides of unequal dimensions.

ROOM ACOUSTICS

By James Moir

THE quality of the sound from a speaker is modified to a greater degree by the room in which the speaker is placed than by any other link in the long chain between the studio and the listener's ear. In spite of this, the acoustic characteristics of the listening room are rarely given a thought, presumably because no one has yet produced a saleable " black box " that will correct the multitude of faults that seem inherent in the average living room. Let us examine the problem.

In 1895 Wallace Clement Sabine, a physicist at Harvard University, discovered that the " acoustic goodness " of a room was determined by the rate at which the room boundaries and furnishings absorbed the sound energy emitted by a singer or instrumentalist. If the sound energy was absorbed too slowly, the room was too live and reverberent, and there was confusion between successive phrases in singing or playing. Room colouration was excessive.

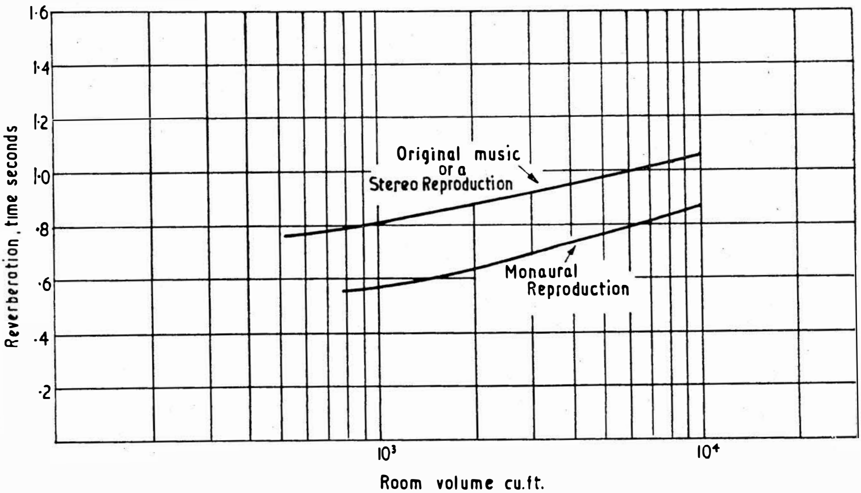
If the sound energy was absorbed too quickly the resultant musical tone was hard and dry and musicians found difficulty in playing together. Though unsatisfactory for music this condition was more favoured for speech.

Optimum Reverberation Time

Between these two limits Sabine established that there was an optimum rate of absorption that musicians considered gave the best musical tone to the room. As an indication of the rate of absorption, Sabine introduced the term " reverberation time," defining this as " the time required for the sound energy to decay to one millionth (60 dB) of its initial value." It should be noted that, in these terms, a low rate of sound energy absorption implies a long reverberation time, and vice versa.

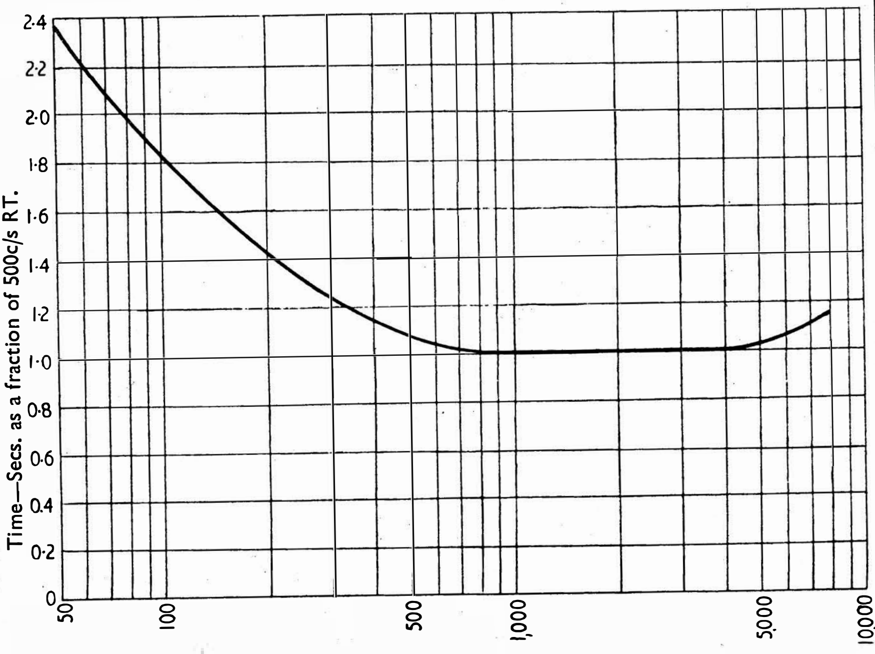
A listening room used by the author for stereophonic reproduction.

Fig. 1



SUGGESTED OPTIMUM REVERBERATION TIMES FOR SMALL ROOMS.

Fig. 2



OPTIMUM REVERBERATION TIME/FREQUENCY. Mc.Nair.

The next logical step was to establish the optimum reverberation time, and this Sabine did by the simple but tedious process of taking a small group of musicians and a panel of judges into a series of music rooms in the University. In each room Sabine adjusted the reverberation time to the preferred value by introducing seat cushions until the acoustic characteristics met the judges wishes. From the data he collected, Sabine was able to produce curves relating room value and optimum reverberation time. This procedure has been repeated by later workers using more modern equipment and from their results the curves shown in **Fig. 1** have been produced.

Typical small rooms vary between 1,000 and 3,000 cubic feet, and should have a reverberation time between about 0.55 and 0.7 second if the room is to be used for single channel reproduction, but appreciably higher values may be allowed if the room is to be used as a music room or for the stereophonic reproduction of music.

Sound Absorption

The sound energy emitted by a source is radiated as an air pressure wave, and ultimately strikes one of the room boundaries or some of the room furnishings. On impact, some of the incident energy is dissipated as heat in the pores of the surface material, some is transmitted through the material to the outside world, and the remainder is reflected from the surface and strikes another surface where the process is repeated. The fraction of the incident sound energy that is absorbed is a function of the surface material, and soft porous materials such as cushions and felts absorb a higher percentage of the incident sound than the hard impervious materials such as wood or glass.

Absorption a Function of Frequency

The fraction of the incident sound that is absorbed by a material is a characteristic property of that material (or approximately so), and it has been tabulated by Sabine and later research workers. Typical values for the usual range of building and furnishing materials are given in **Table 1.** It will be seen that the amount of sound that is absorbed is a function of frequency ; few materials absorb an appreciable fraction of the incident sound in the low frequency range, while all the fibrous materials, such as curtains and carpets, absorb a high percentage of the incident sound at frequencies above 1 Kc/s. The implications of this will be discussed later.

TABLE 1

		Sound Absorption Coefs at Frequencies					
		120	250	500	1,000	2,000	4,000
Acoustic Materials							
Acoustic Celotex—							
C1	½ in. thick	.36	.58	.51	.52	.62	—
C3	13/16 in. thick	.25	.27	.76	.88	.60	—
C4	1¼ in. thick	.37	.43	.98	.79	.57	—
Asbestos Paxfelt Tiles	1 in. thick	.47	.5	.8	.6	.8	.6
Sprayed Asbestos ...	1 in. thick	.6	.8	.75	.55	.7	.85
Glass Wool	1 in. thick	.3	.6	.85	.9	.9	.95
Slag Wool	2 in. thick	.25	.7	.9	.95	.9	.9
Lithalun	... ...	—	.3	.45	.7	.55	—
Hair Felt	1 in. thick	.11	.26	.62	.73	.66	.45
Building Materials							
Painted Brick	...	.012	.013	.017	.02	.023	.025
Concrete unpainted	...	.01	.012	.016	.019	.023	.035
Plaster	...	.03	—	.04	—	.04	—
Hard Plaster	...	.02	—	.03	—	.03	.03
Wood Polished	...	.09	—	.08	—	.11	.12
Furnishings							
Carpet ⅜ in. thick on felt ...	...	.11	.14	.37	.43	.27	.25
Velour drapes in folds ...	...	.14	.35	.55	.72	.7	.65
Light cotton hangings ...	...	.07	.31	.49	.81	.66	.54
Theatre type seats, per seat	...	2.9	3.3	3.55	3.65	3.7	3.7
Audience standing with coats	...	3.6	4.2	4.6	4.6	4.9	5.0

Sabine rounded off his investigations by deducing an equation relating the dimensions of a room, the acoustic properties of the boundary surfaces, and the resultant reverberation time. This is :

$$T = \frac{.05V}{S\alpha} \text{ seconds}$$

where V = room volume in cubic feet, S = total interior surface area of the room in square feet, α = average absorption coefficient of the surface material.

After some further discussion this equation will be applied to calculate the reverberation time of a typical room, and the result will be compared with the measured values.

Table 1 indicates that the absorption coefficient α (or percentage of incident sound absorbed) varies with frequency, and thus it is to be expected that the reverberation time will also vary with frequency. It seems probable that the shape of the curve which relates reverberation time and frequency is more important in determining sound quality than the absolute values of reverberation time at 500 c/s, as read off **Fig. 1.** There have been several attempts to predict the optimum shape of the reverberation time/frequency curve, for good sound quality, but our knowledge of the underlying factors is so incomplete that any such prediction must be well supported by practice if it is to have any validity. Knudsen and McNair have deduced " optimum curves " on the assumption that all frequency components in the reverberant sound should reach inaudibility together, and on this basis have produced the relation shown in **Fig. 2.** (Page 130) It may be a coincidence, but this is the shape of the reverberation time/frequency relation that found favour until quite recently. However, in the last ten years there has been a steady trend towards a reverberation time/frequency relation that does not exhibit the rise at the low frequency end of the range, as shown in **Fig. 2.** In the writer's opinion, a flat reverberation time/frequency relation may be satisfactory for broadcast studios intended to originate monuaral speech transmissions, but it results in a musical tone that is too hard and dry. Some rise at the bass end seems preferable, though it may not need to be as great as shown in the Knudsen/McNair curve.

Calculation of Reverberation Time

The reverberation time can be calculated from the data contained in **Table 1** and Sabine's equation. Such calculations are most conveniently set out in tabular form, and as an illustration of the procedure the reverberation time of a typical domestic living room will be calculated for a frequency of 500 c/s. Calculation of the reverberation time at higher frequencies is necessary, but at frequencies below 500 c/s the discrepancies are so large that calculation is hardly worth while.

Low Frequency Absorption

Measurements of the reverberation time of the average living room are in fair agreement with calculation above 500 c/s, but rather inaccurate below this frequency. Examination of the data in **Table 1** suggests

TYPICAL REVERBERATION TIME CALCULATION 500 c/s

Room—21 ft. × 13 ft. × 8 ft. Volume 2,180 ft.^{3}

Surface	Area	Material	Coefficient	Absorption units
Floor	165	Wood blocks	.06	10
Floor	108	Carpet	.3	32.4
Walls	460	Plaster	.02	9
Window	85	Glass	.1	8.5
Ceiling	273	Plaster	.1	27
Doors	32	Wood	.1	3
Total area = 1,123 sq. ft.				
Settee				6.5
Easy Chairs				9
Curtains	150	Heavy	.4	60
Books, etc.				5
2 people				8
			Total absorption (Sabines) = 178.4	

$$\text{Reverberation Time (Sabine)} = \frac{.05 \times 2{,}180}{178.4} = .61 \text{ secs.}$$

that the reverberation time should continue to rise as the frequency is decreased, but in fact it is generally found to stay roughly constant, or to fall away at frequencies below 500 c/s. This discrepancy between simple theory and practice is due to the presence of an unsuspected absorbent. The basic materials of which floors, doors and ceilings are constructed are all rather poor absorbents, but when assembled in panel form, rather than in bulk, there is a very considerable increase in the amount of energy they absorb from the air. This extra absorption is due to mechanical resonance of the panels, the sound energy being dissipated as frictional losses in the vibrating material.

Calculation of the effective absorption coefficient of a vibrating panel, such as a hollow door, is possible but difficult, and will not be pursued at this point. The effect of panel vibration on low frequency reverberation time in domestic rooms is well shown in **Fig. 3** which gives some typical measured reverberation times obtained in average domestic rooms. Methods of avoiding the fall-off at low frequencies will be considered in the section dealing with building practice.

Room Resonance

Small rooms of domestic proportions are limited in performance by other factors that require consideration. At the frequency at which the room length is exactly one half wave length, standing waves will be set up by multiple reflection between the opposite walls, and at that frequency the sound pressure will be increased by a factor of five to fifteen times. Thus, while the amplifier designer finds comfort in the fact that his frequency response is flat to within 0.1 dB over the whole frequency range, the room itself may introduce a peak of 15-25 dB. Such peaks are not limited to the frequency at which the room length is exactly one half wavelength, for similar peaks will appear at the frequencies at which the room width and room height are exactly one half wavelength. Further peaks will appear at all the harmonics of these basic frequencies, and there will be others at frequencies determined by the dimensions of the diagonals.

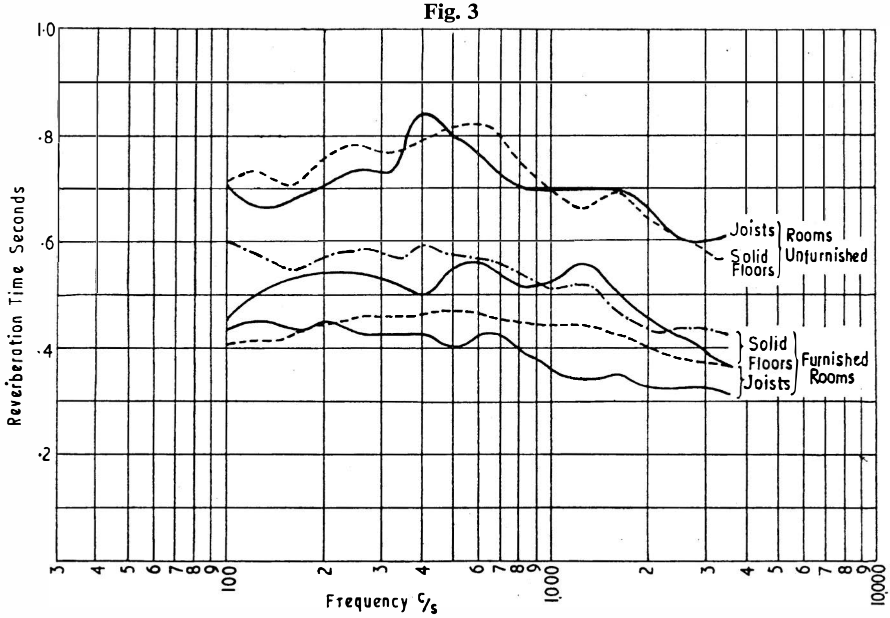
Rayleigh predicted the existence of these peaks and deduced a formula that enables the resonant frequencies to be calculated. This is

$$f = \frac{c}{2}\left[\left(\frac{A}{L}\right)^2 + \left(\frac{B}{W}\right)^2 + \left(\frac{C}{H}\right)^2\right]^{\frac{1}{2}}$$

where A, B, C are the intergers 1, 2, 3, etc., substituted in turn. L = Room length. W = Room width. H = Room height. c = velocity of sound.

Applying Rayleigh's formula to a typical room (15 ft. × 11 ft. × 8 ft.) gives the frequencies listed in **Table 2** as the first ten room resonances. It is significant that all of

Fig. 3



TYPICAL REVERBERATION TIMES FOR DOMESTIC LIVING ROOMS these resonances appear in the lower audio frequency range, though it should be noted that the peaks get closer together as we move up the frequency range. Under domestic conditions little can be done to reduce the height of these peaks, but in studio designs it is possible to minimise their effect by adding absorbents which have peak efficiency at the room resonant frequencies. Though the height of these room resonance peaks cannot be easily reduced, it is possible to choose the room dimensions to spread them uniformly over the lower audio frequency range, and thus smooth out the overall room response. This procedure will be considered more closely when the details of the room design are being considered.

Prominent room resonances have other deleterious effects on sound quality, for the sound energy contained in the generally reverberant sound rapidly concentrates into these resonant modes during the decay process. Thus, the direct sound emitted by the speaker may be uniformly distributed over the frequency band, but the reverberant sound energy is concentrated in the lower frequency room resonances during the decay.

Room Design and Construction

After this rather general discussion on principles, it is perhaps of value to consider what the future builder of a house might do to ensure that at least one room has a good acoustic performance. It might be assumed that, since they cannot be eliminated, the room resonances should be distributed as uniformly as possible over the lower audio frequency range. On this assumption, the room dimensions should be so chosen that the resonant frequencies due to length, width and height are not coincident. This can be achieved by a suitable choice of the ratio of the room dimensions. Volkman has suggested the following dimension ratios for this purpose :

Note for Architects !

	L	W	H
Small Room ...	1	1.25	1.6
Average Room	1	1.6	2.5
Large Room ...	1	1.25	3.3

Applied to rooms having the standard height of 8 ft. we get :

	L	W	H
Small Room ...	8ft.	10ft.	12ft. 9in.
Average Room	8ft.	12ft. 9in.	20ft.
Large Room ...	8ft.	10ft.	25ft. 6in.

Personal experience supports these shape ratios as having some considerable merit, though a length in the vicinity of 21 ft. tends to make mains hum unduly prominent.

Perturbations of shape, such as prominent chimney pieces, are of considerable value in producing some scattering of the sound waves. Rooms with a volume of less than about 2,000 cubic feet rarely give good results, for too many of the room resonances appear in the lower audio frequency range.

Constructural practices that lead to a reduction in structural resonance are the use of a proprietary cinder block, rather than brick, for the inner leaf of a cavity wall, and the use of a wood block floor on solid concrete, rather than a floor of wood boards on joists. Ceilings should be of lath and plaster, or preferably of plaster on insulation board. Solid doors are better than doors built of plywood or hardboard on a frame, and the additional cost might be considered justifiable in one room.

Room Furnishing

With construction completed, some thought needs to be given to the furnishings. A floor covered from wall to wall with carpet on a thick underfelt, confines too great a proportion of the total absorption to the floor ; so from this point of view a wood block floor furnished with a few thick scatter rugs has advantages.

TABLE 2

The First 10 Resonance Frequencies in a Typical Small Room.

Dimensions : 15.3 ft. × 11 ft. × 8.2 ft.

1	36.77	**6**	77.85
2	51.14	**7**	85.57
3	63	**8**	89.7
4	68.63	**9**	93.15
5	73.9	**10**	100.7

Wallpaper appears to have some advantage over a paint or distemper finish, and it is advantageous to include about as much absorption in the form of curtains on walls and windows as is supplied in the form of carpets to the floor. This ensures that the decay of the reverberant sound energy flowing between opposite walls occurs at about the same rate as the decay of sound energy flowing between floor and ceiling.

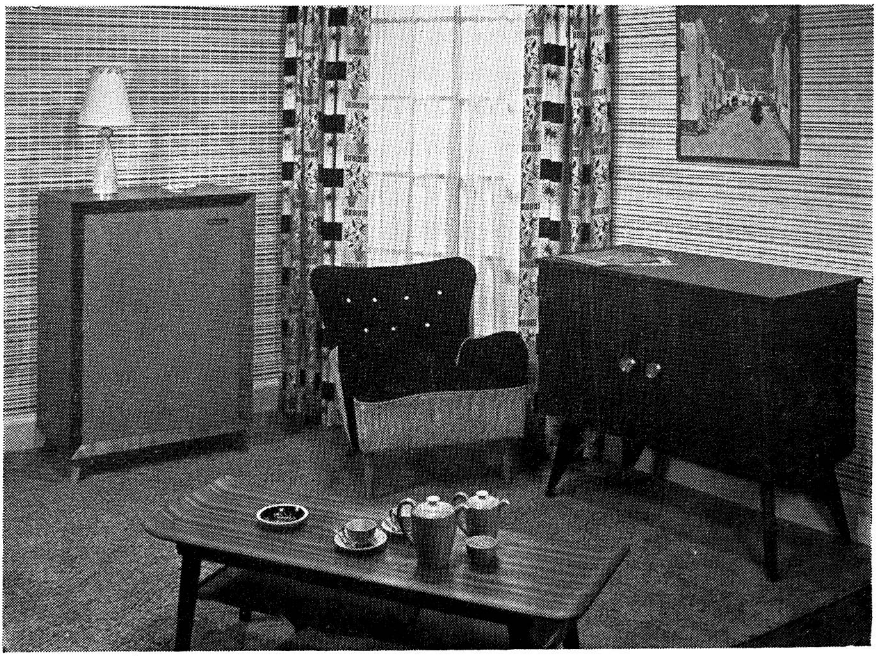
Furnishings such as easy chairs and settees are more effective as absorbents when placed away from the wall and towards the centre of the room. In this position they also serve to scatter sound energy into all the room resonance modes, and thus help to smooth out the overall response curve. Furniture, radiators, pictures and ornaments all contribute their quota of resonance colouration, but the results can generally be detected by careful listening near suspected objects.

Loudspeaker Position

The speaker position can have an important effect on the overall response and some experimental work is advisable. Corner mounting for the speaker results in an improvement in the bass response, and at the same time it provides the best acoustic coupling to all the modes of room resonance. However, if the room dimensions are such that there is a prominent and comparatively isolated resonance, it may be advantageous to choose a speaker position that minimises acoustic coupling into that particular mode. Thus, mounting the speaker in the middle of the long wall will reduce the height of the first low frequency peak by as much as 10 dB, and it may produce an improvement in the overall response. This is a point that can only be settled by experiment. Where two or more identical speakers are available it is advisable to mount one unit in a corner as a reference, moving the second speaker into each of the alternative positions that are acceptable to the wife. A rapid changeover between speakers then allows an accurate comparison of the results.

Rooms and speakers are now the weakest links in a sound reproducer system, but time given to the design of the room can undoubtedly produce a greater improvement in sound quality than any attention given to other parts of the system.

My thanks are due to Messrs. Chapman and Hall for permission to use the diagrams from my book *High Quality Sound Reproduction.*—J.M.



As a tailpiece to " Room Acoustics," this picture of Hi-Fi equipment styling is interesting. It is a selection of Avantic units, by Beam-Echo, in matching cabinets.

DIRECTORY *for* HOME CONSTRUCTORS

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Sydney S. Bird and Sons Ltd., Cambridge Arterial Road, Enfield, Middx.

Mica dielectric and air dielectric trimmers.

A. H. Hunt (Capacitors) Ltd.

Electrolytics, foil and paper, metalised paper, and ceramics. Special attention to requirements of home constructors.

Telegraph Condenser Co. Ltd., Wales Farm Road, London, W.3.

All types of capacitors. Printed circuits.

Resistors

Erie Resistor Ltd., Carlisle Road, Hendon, London, N.W.9.

Carbon and wire-wound resistors.

Erg Industrial Corporation Ltd., 10 Portman Square, London, W.1.

Carbon and wire-wound resistors.

Potentiometers

Colvern Ltd., Mawneys Road, Romford, Essex.

Sealed wire-wound potentiometers and variable resistors.

Coils

Weymouth Radio Manufacturing Co. Ltd., 16 Crescent Street, Weymouth, Dorset.

R.F. coils, I.F. transformers, chokes and tuned coils, discriminator transformers, etc.

Transformers

Associated Electronic Engrs. Ltd., Dalston Gardens, Stanmore, Middx.

All types of audio transformers.

Partridge Transformers Ltd., Roebuck Road, Tolworth, Surrey.

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RGA Sound Services (Plymouth) Ltd. (London Office) 6 Conway Gardens, Clay Hill, Enfield, Middx.

Transformer range specifically designed for Mullard and other published circuits. Range includes mains, output transformers and chokes.

Sound Sales Ltd., West Street, Farnham, Surrey.

Output transformers, grain oriented or C-core, single ended or push/pull ultra-linear. up to 50 watts, mains transformers and chokes

Woden Transformer Co. Ltd., Moxley Road, Bilston, Staffs.

Chokes, relays and transformers, C-cored, etc.

Transistors

The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.

Transistors and valves, etc.

Standard Telephones and Cables Ltd., Brimar Valve Works, Footscray, Kent.

Transistors, germanium rectifiers, quartz crystals, valves, etc.

Circuits

Mullard Ltd. (Valve Division), Century House, Shaftesbury Avenue, London, W.C.2.

Booklets of Mullard 5-10 and 20-watt amplifiers, and F.M. tuner on request, price 3/6.

G.E.C. Ltd., Magnet House, Kingsway, London, W.C.2.

Osram "912 Plus" amplifier booklet on request, price 4/-.

Test Gear

The Automatic Coil Winder Co. Ltd., 92-96 Vauxhall Bridge Road, London, S.W.1.

The Jason Motor & Electronic Co., 328 Cricklewood Lane, London, N.W.2.

British Physical Laboratories, Houseboat Works, Radlett, Herts.

Taylor Electrical Instruments Ltd., Montrose Avenue, Slough, Bucks.

Advance Components Ltd., Marlowe Road, Walthamstow, London, E.17.

General Home Construction Components

The Jason Motor & Electronic Co., 328 Cricklewood Lane, London, N.W.2.

Coils for F.M. tuners, intermediate frequency transformers, ratio detectors, Foster-Seeley discriminators, twin I.F.s for A.M./F.M. tuners, medium wave aerial and oscillator coils, chassis and dial assemblies for F.M. tuners, A.M./F.M. tuners, switch controlled tuners.

Stratton & Co. Ltd., Eddystone Works, Alvechurch Road, West Heath, Birmingham 31.

Variable tuning capacitors, tuning coils, coil joiners, insulated couplers, slow-motion dials, control knobs, I.F. and discriminator transformers.

Technical Suppliers Ltd., Hudson House, 63 Goldhawk Road, London, W.12.

Capacitors, I.F. transformers, control knobs, resistors, VHF units, permeability tuned comprising R.F. and mixer stages with 1st I.F. transformer completely wired and tested.

Wharfedale Wireless Works Ltd., Idle, Bradford, Yorkshire.

Inductors for crossover networks, anodised aluminium mesh, low impedance speaker, switch, output transformers, "Truqual" speaker volume control.

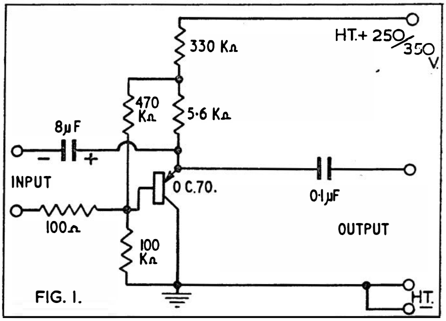
TRANSISTORS

By Stanley Kelly

IT is now almost ten years since Dr. Schockley, then of the Bell Telephone Laboratories, announced the transistor. This was the culmination of the effort of literally hundreds of physicists and kindred scientists engaged on semi-conductor development for over a decade. During the ten years since the announcement of the transistor very considerable development of the basic premise has ensued. The early transistors were fragile " cat's whisker and crystal " affairs with low efficiency and signal to noise ratio, *but were at least capable of amplification of electrical signals without recourse to a heated cathode or other electronic emissive element.* It is not proposed to deal in this article with basic semi-conductor theory. The reader is referred to " Principles of Transistor Circuits," by R. F. Shea, or " Transistors, Theory and Application," by Coblenz and Owens, as authoritative sources of information.

Advantages of a Transistor

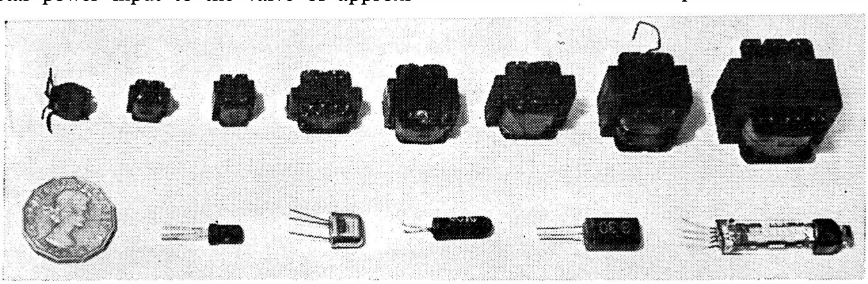
The greatest virtue of the transistor is its inherently high efficiency. As an example, let us take a representative voltage amplifying triode, say the EBC41 (we will disregard the diodes). With a 100,000 ohm anode load, and 250 volts anode potential, the anode current is 0.85 milliamps, which is equal to approximately 0.21 watt high tension consumption ; whilst the heater power is 1.45 watts (6.3 volts at 0.23 amp.) ; giving a total power input to the valve of approximately 1.6 watts ; the stage gain is about 42. In the case of a pentode, such as the EF86, the stage gain of approximately 112 would be obtained with an anode load of 100,000 ohms, a total power input of approximately



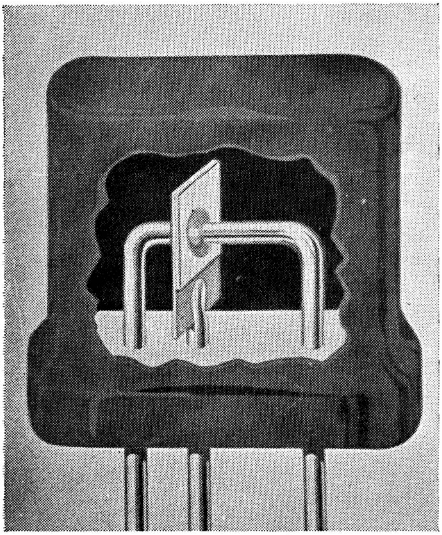
Transistor pre-amplifier circuit.

1.75 watts. Using a normal transistor, say an OC70, with a 250 volt line supply, a voltage gain of 330 can be obtained for a current drain of 0.7 to 1 milliamp., or a total power consumption of less than 0.25 watt. In other words, entirely apart from the very high amplification obtained with this circuit configuration **(Fig. 1)** a power efficiency ratio of times 6 over thermionic valves is obtained.

At the other end of the scale, an amplification of 20 dB (power gain of times 100) can be obtained from a power source of a



Compared with a threepenny piece for size, are five transistors and, above, eight fully screened transformers, miniature and sub-miniature, as used by Fortiphone for deaf aids.



This cutaway drawing shows the construction of a transistor of the type marked by the British Crystal Co. The enlargement is about ten times.

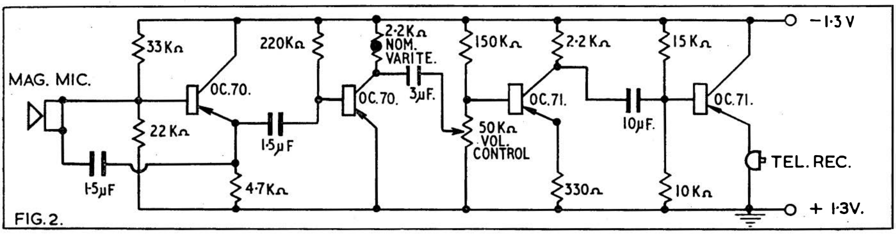
shilling piece and a halfpenny, separated by a piece of moistened blotting paper. The actual voltage of this power source is approximately 0.25, and the current about 25 microamps. Whilst this is admittedly interesting as a scientific experiment, it is not basically as outlandish as it seems at first sight, because it indicates that "wrist watch" small amplifiers and/or radio receivers powered from sunlight (via a photo-electric cell), body heat (by a thermo-couple), or from a tiny radioactive capsule, become a positive possibility. The writer has constructed a transistor amplifier for a crystal receiver in which the actual power supply was obtained from the rectified signal obtained from the crystal detector. This has also been successfully applied as a voltage pre-amplifier for pickups.

By far the largest use of transistors today is in the hearing aid industry, and **Fig. 2** shows the representative circuit schematic of such an aid. Here, four transistors consuming only 2 milliamps at 1.3 volts give a power amplification of 95 dB, and an overall acoustic gain in this particular instance of 60 dB at 1,000 c.p.s. As a corollary of this, the absolute efficiency (that is the ratio of acoustical power output from the telephone receiver to total electrical input) is of the order of 4 per cent, and this includes the losses in the telephone receiver, compared with about one/ten-thousandth of 1 per cent for modern high fidelity reproducing equipment.

A Little Theory

The point contact transistor has been considerably developed, but it is principally used nowadays in switching circuits, and in some cases as an oscillator. The junction transistor has almost completely supplanted it for general purposes, and that only will be discussed here. The transistor can be considered as a "Black Box" with three terminals ; the base, the emitter, and the collector. Very approximately this corresponds to the grid, cathode, and anode of a thermionic valve. Because of the coupling between the collector and the base, this analogy is not rigorous, but it is a most useful idea to get the feel of transistors at first acquaintance. **Fig. 3** shows the three basic configurations of a transistor, and their approximate valve equivalents. The grounded emitter configuration is probably used in 90 per cent of all applications.

In the case of valve circuits, we normally think in terms of voltage amplification. This is because the grid impedance is sufficiently high that the power input to it can be neglected. In the case of a transistor the input impedance is quite small, of the order of a few thousand ohms, and is almost always less than the output impedance. In a perfect transistor, the input impedance would be zero and the output impedance would be infinity. From this it can be inferred that the transistor is inherently a



A typical circuit using four transistors for a miniaturised hearing aid.

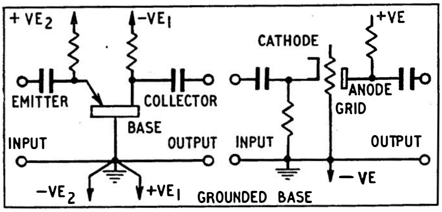


Fig. 3a—*Transistor (base grounded) and equivalent valve circuit.*

current amplifying device, as against the thermionic valve being approximately a voltage amplifying device.

All currently available transistors are what are known as P-N-P devices. Whilst in the thermionic valve the electronic stream is actually a discreet flow of individual electrons, emitted by a heated cathode, in the case of semi-conductors, the current flow can be by " negative carriers " (electrons) from the positive to the negative terminals of the battery, or by " positive carriers " (" holes ") in the reverse direction. The theory dealing with electrons and " holes " is complicated

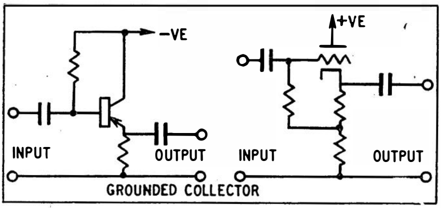


Fig. 3b—*Transistor (collector grounded) and valve equivalent.*

and need not bother us here. Suffice it to say that in P-N-P type transistors, which are the majority of commercially produced units, the current is carried by holes and therefore the collector, which roughly corresponds to the anode of a thermionic valve, is negative to the emitter. The letters P-N-P signify that the transistor is a triode, having three layers of semi-conductive material which are fused together, see **Fig. 4.** The outer layers are usually Indium or other

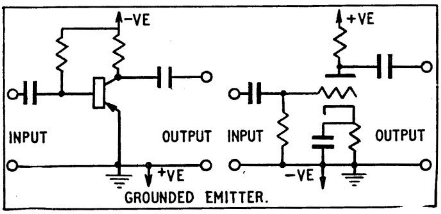
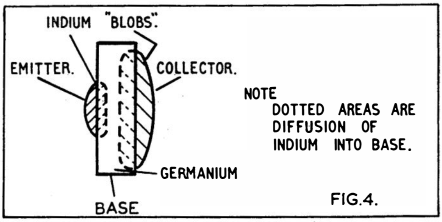


Fig. 3c—*Transistor (emitter grounded) and valve equivalent.*

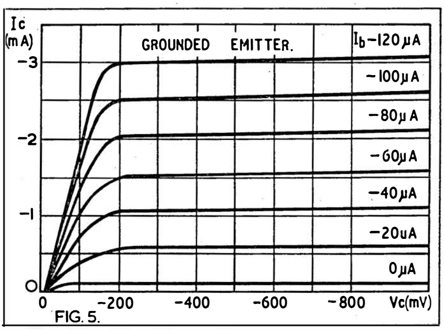
P type semi-conductor, whilst the centre is Germanium. Under operating conditions, the holes from the emitter diffuse through the base and arrive at the collector, thus, as before stated, the emitter corresponds to cathode, the base to grid, and the collector to anode. Graph, **Fig. 5,** shows a typical set of curves in which collector current is plotted against collector voltage, but using *base current* rather than grid voltage, as in the case of a thermionic valve.

In a perfect transistor, connected as grounded base, as in **Fig. 3,** the emitter will be sending a continuous flow of positive holes into the base, and all of these will



Schematic construction of a P.N.P. transistor.

diffuse through to the collector. Thus, the current ratio of emitter to collector would be unity. In practical transistors, some of these holes will combine with electrons in the base material, and the actual ratio of collector to emitter current will be of the order of 0.96 to 0.98, and is given the symbol " α ". But, because the ratio of output impedance to input impedance is very great, a useful voltage gain is obtained and is approximately equal to the ratio of these two impedances.



Collector current/collector voltage characteristic.

It should be noted at this juncture that we are not dealing with the static values of current but with the actual dynamic values ; that is, the ratio of AC voltages and currents. The static values are very temperature dependent and will be dealt with later. The above illustration is the equivalent of a grounded grid in valve parlance and is characterised by a low input impedance, high output impedance, and unity current gain. With a grounded emitter, the input current is applied to the base, and this current restores to the base the electrons which recombine with a small proportion of the holes flowing from the emitter to the collector. Therefore, the quantity of holes which can flow from the emitter to the collector will be dependent upon the number of available electrons for the holes to recombine with, and will be a function of the electrons available from the current supply to the base. That is, with an α of 0.98, 2 per cent of the holes will combine with electrons supplied into the base, and this ratio of 2 per cent (or its reciprocal times 50), will be a constant for a particular transistor. This is approximately equivalent to the amplification factor of a valve and numerically is equal to :

$$\alpha 1 = \frac{\alpha}{(1-\alpha)}$$

We have discussed this at some length because the grounded emitter is the most generally useful of all circuit configurations.

The grounded collector corresponds to the cathode follower of a valve circuit and is usually only used as an input stage when fed from a high impedance source, such as a crystal microphone or pickup. It has a high input impedance and low output impedance, the voltage gain is always slightly less than unity, but the current gain is approximately equal to that of the grounded emitter circuit. The Table below gives a comparison between the three circuit configurations.

Points to Watch

Transistors are by no means perfect. They require special care in the design and they suffer from several limitations which can be serious if not controlled by correct design. A first limitation is absolute temperature rating, which with present Germanium based transistors is 75°C (this refers to the temperature of the element). Because of the inevitable resistive losses in the transistor, the temperature will rise above ambient, and the greater the power dissipation the greater the temperature rise. Whilst this is not serious in the case of low powered units (dissipations of less than 10 milliwatts), in the case of power transistors it is the major control on power rating. A representative power transistor is the Mullard OC16. One of these units operated at 7 volts and a collector current of 500 milliamps, will deliver a power output of 1.3 watts. Under these conditions, the junction temperature will be approximating 75°C. The actual power dissipated by these large transistors is

TABLE 1 - - - - - - - - Comparisons

Grounded Base	Grounded Emitter	Grounded Collector
Current gain α less than unity	High current gain $\alpha' = \alpha/(1-\alpha)$	High current gain α'' approximately equal to α'
Low input impedance	Medium input impedance	Input impedance = α''x load impedance
High output impedance	Medium output impedance	Output impedance = (source impedance)/α''
Highest maximum operating frequency	Max. operating frequency considerably less than that for grounded base	Max. operating frequency varies with source impedance
Small collector leakage current $I_{c(o)}$	Collector leakage current between $I_{c(o)}$ and $I'_{c(o)}$ depending on resistance in base circuit	Collector leakage current between $I_{c(o)}$ and $I'_{c(o)}$ depending on resistance in base circuit
Zero phase shift between input and output voltages	180° phase shift between input and output voltages	Zero phase shift between input and output voltages

very much a function of the " heat sink " to which they are connected. The more efficient the heat sink, the greater the power output.

A second limitation is the variation of characteristics with temperature. The collector current consists of two components, the first known as the " collector leakage current " $I^{1}_{c(o)}$ is a prime function of temperature and varies as shown in Graph, **Fig. 6 ;** the other component " I_c " is a function of the " base " bias and varies only as a second order of temperature. Some means of stabilising the collector current with temperature is therefore necessary, otherwise at very low temperatures the collector current will be extremely small and the gain of the stage be limited. At high temperatures, because of the high collector current, the transistor collector will " bottom " and again the gain will fall.

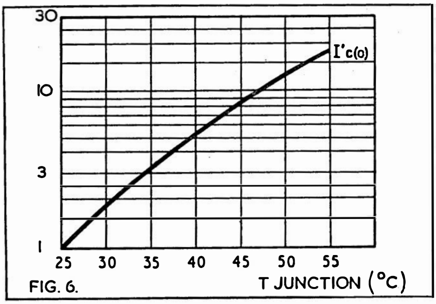
The last major disadvantage is frequency limitation. Most junction transistors have an upper frequency limit of a few tens of Kilocycles only. Recently, however, transistors have been developed with an upper frequency limit of 1.5 to 2 megacycles, and this has rendered possible the development of a true pocket radio or a car radio, working directly from the storage battery without the recourse to vibrating convertors and the like. Unlike thermionic valves, there is appreciable internal feedback in the transistor, and the circuit design must be so arranged as to neutralise this feed back. This, although not identical to, is analogous to the old neutralised triode amplifiers which were common some thirty years ago.

Audio Circuits

In the grounded emitter circuit, the input impedance is usually about 1,000 ohms, whilst the output impedance is between 10,000 and 20,000 ohms. For optimum power gain, these impedances should be matched ; and this can best be achieved by a transformer of suitable turns ratio, usually of the order of 3 : 1 or 4 : 1. Under these circumstances, a power gain of about 40 dB can be obtained. Unfortunately, subminiature transformers with sufficient primary inductance for adequate low frequency amplification are costly, and it is often cheaper to use more stages of R-C coupling. For instance, two stages of transformer coupling can give 80 dB of gain, whilst three stages of R-C coupling, using 3.3K collector resistance, will give a gain of 26 dB per stage, or approximately the same gain as for the transformer amplifier. The actual production cost of this latter amplifier and its volume and weight will be slightly less than the former.

R-C Coupling

A gain of about 20 dB per stage is fairly typical. A high value collector resistor brings higher gain but also (1) reduces the permissible collector current swing (that is, clipping occurs at lower levels) and (2) permits a low collector current which may vary appreciably with temperature. The rise in leakage current with temperature will



This curve shows the variation of collector leakage current with junction temperature.

" bottom " the transistor at some current depending on the D.C. resistance $R_{D.C.}$ in the emitter and collector circuits. The bottoming current I_{bott} is given by :

$$I_{bott} = (V_{cc} - V_{knee})/R_{D.C.}$$

For example, suppose the collector resistor is 3.3 Kohm and the emitter resistance zero, then $R_{D.C.}$ is 3.3 Kohm. For the OC70 and OC71 the knee voltage is about 0.2 volts, so for a battery supply of -4.5 volts :

$$I_{bott} = (4.5 - 0.2)/3.3 \times 10^3 = 1.3 \text{ milliamps.}$$

If the OC70 has a leakage current of about 100 microamps at 25°C, in this circuit leakage current alone will bottom the stage when it has increased by a factor of $1.3/0.1 = 13$, that is, at a junction temperature of 50°C from Figure 6.

It will be noticed that bottoming will not occur until higher temperatures if a lower D.C. resistance is used. A transistor with a high leakage current (because of production spreads) bottoms at a lower temperature.

Coupling Capacitors

The coupling capacitors are usually electrolytic, owing to the comparatively low input impedance of transistor stages, values of 8 or 10 μF being the most typical. Their value is chosen according to the bass response required. The approximate value of the coupling capacitors required in transistor circuits can be established from a current generator equivalent circuit. The A.C. output is shunted by the collector load resistor of the first transistor, and flows into the next stage through the coupling capacitor. A 3 dB reduction in current will occur when the reactance of the coupling capacitor becomes equal to the input resistance of the next stage plus the load resistance of the first transistor, its output impedance being sufficiently high to be neglected.

The positive pole of the electrolytic coupling capacitor is normally connected to the base of the transistor, as the voltage from base to emitter is perhaps only—100 millivolts, whereas −1 volt or −2 volt, etc., is present on the preceding collector. For the input stage there may be some difficulty in determining the polarity, and often the negative side must be connected to the base.

Calculations can be made on small-signal R-C stages using the small-signal parameters given in transistor data :

Power Gain = current gain A_1 × voltage gain A_V

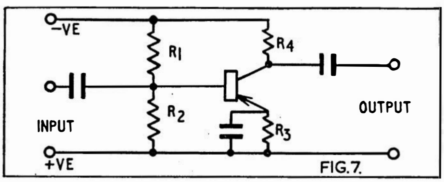
= $A_1 \times A_1 \times$ load resistance ÷ input resistance

= (current gain)$^2 \times R_L/R'_{1n}$.

For an R-C coupled amplifier, the collector resistance is usually larger than the input resistance of the next stage, so that the effective load resistance is approximately equal to R'_{1n}. Thus if two R-C coupled stages have the same working point, the power gain of the first is approximately equal to (current gain)^2.

D.C. Stabilisation

The most effective method of stabilising the working point is by the use of D.C. negative feedback, as shown in **Fig. 7.**



D.C. stabilisation circuit for transistors.

Here, the base potential is stabilised by means of the potentiometer R_1 and R_2, and because the voltage drop between the base and the emitter is of the order of a few millivolts only, to a first approximation, the emitter potential will be that of the base. The current through R_3 will thus be equal to the base potential divided by R_3, and by correct proportioning of these three resistors (R_1 R_2 R_3) relative to the transistor characteristics and the load resistance, a stability factor (that is, the ratio of the unstabilised collector current to stabilised collector current) of any reasonable value can be obtained. Power is dissipated in R_1, R_2, and R_3 which, for the prime purpose of the transistor (that is, developing power for the load resistance) is wasted, and it is unfortunate that the greater the degree of stabilisation required the greater must be this unwanted dissipation of power.

Power Output Stages

Because of the rather restricted maximum permissible collector dissipation of transistors at present available, it is usually necessary to drive the transistor to its maximum limits in the attempt to obtain sufficient output power. A push-pull output stage can therefore be used to advantage. A Class A push-pull stage can be designed in principle at least with a collector to collector load which is twice that for one transistor. High power consumption in Class A push-pull however, occurs even under quiescent conditions, and the maximum efficiency of the stage is 50 per cent. These two limitations are particularly important in transistorised equipment operated from batteries.

In practice therefore, Class B push-pull is most suitable for a transistor output stage. The quiescent power consumption is very small, and the available output power for sine wave drive is about five times the maximum permissible collector dissipation of a single transistor. The maximum theoretical efficiency of the Class B stage is 78.5 per cent ; in practice a figure of 75 per cent can often be achieved.

Thermal Runaway

The effect known as thermal runaway is not apparent in low voltage, low power a.f. circuits. However, with the introduction of transistors of higher power dissipation (the OC72 and OC16) and of higher voltage rating, the prevention of thermal runaway may set a further limit to the working point, in addition to those set by the limiting values.

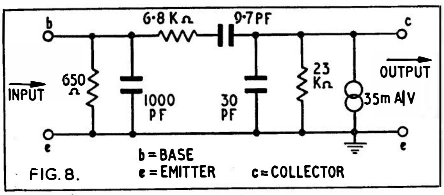
On switching on the power supply, the collector dissipation at the working point increases the junction temperature above that of the surroundings. This rise of junction temperature in turn increases the collector current, because of the temperature dependance of the leakage currents. The rise in collector current increases the dissipation, and this increase will obviously be greater at higher collector voltages. This is a form of " positive feedback," when the loop gain exceeds unity the transistor " runs away " ; great care must therefore be taken to ensure adequate stabilisation.

Two Transistors in Class B Push-Pull

The similarity of the output characteristics of a junction transistor to those of a pentode valve is of considerable assistance in circuit design, and the use of a load line follows valve practice. However, the input characteristics of transistors differ widely from those of valves, and particular attention has to be given to these differences when designing an output stage.

As is the case with valve circuits, the supply voltages should come from a low impedance source because of the variation of currents in the output stage with drive. The grounded emitter stage has high power sensitivity and is generally most suitable.

Grounded collector and grounded base stages have a lower gain but there is also less distortion, and they can be used to advantage for transistor types having a poor $\alpha' - I_c$ characteristic. A grounded base stage gives a rather high effective output impedance, but that for grounded collector is low and may be of the same order as the load impedance. The grounded collector stage should thus give a better speaker damping and transient response than either the grounded emitter or grounded base stage. The load in series with the emitter provides both A.C. and D.C. feedback, and performance as regards temperature stability and distortion is better than in the grounded emitter stage. Its big drawback, however, as compared with the grounded emitter configuration, is that the lower power sensitivity often makes an extra transistor necessary in the input stages.



Equivalent circuit at R.F. (470 *Kc/s*).

Output Transformer

Because the transistors conduct only on alternate half cycles, the presence of one transistor has no effect on the load seen by the other. For an output transformer ratio of N+N : 1 the effective load per collector is equal to the resistance of the primary winding plus N^2 times the secondary load resistance.

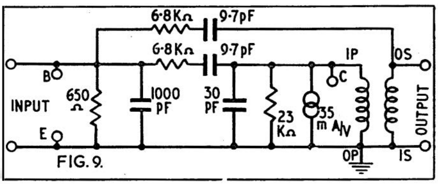
In Class B stages there is no cancellation of flux, since the transistors only conduct alternately, and therefore the transformer primary winding must be capable of carrying the full peak primary current without saturation. Also, because of the comparatively high peak currents and the low battery voltage available the winding primary resistance R_P should be as small as possible.

Driver Stage Requirements

In valve circuits the chief requirement to be met by the driver stage is that it should provide sufficient voltage swing to the grids of the output valves. Transistor driver stages must meet three requirements. Firstly and secondly, sufficient drive current and sufficient drive voltage are required to cope with the production spreads of the output transistors. Lastly, the effective drive impedance must be sufficiently high to give a substantial current drive.

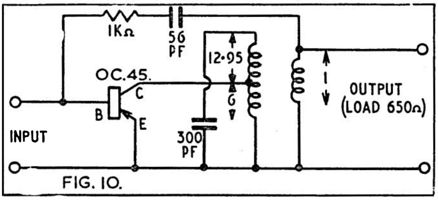
R.F. Transistors

The equivalent circuit of an R.F. transistor is shown in **Fig. 8,** in which BE are the base and emitter input connections and CE are the collector emitter output connections ; it will be seen that the coupling



Equivalent circuit of Fig. 8 with neutralising components added.

R_2C_2 from the base to the collector is appreciable. **Fig. 9** shows the neutralising components necessary to operate the transistor successfully. The secondary of the transformer is wound antiphase to the primary, so that the current fed to point B will be identical in value, but 180° out of phase, to that due to R_2C_2. It can be shown also that the output impedance of the transistor is considerably higher than the input impedance, therefore for optimum gain the transformer turns ratio must be adjusted to give optimum power transfer. **Fig. 10** shows how this is achieved, by using tuned transformer in which the numbers refer to the turns ratio. Using this system, an optimum Q (and hence selectivity) and power transfer is obtained. It will be seen that the feedback components are now of different value to those required for unity coupling, but the modus vivandi is to obtain the correct phase relationship and amplitude of feedback voltage.



Complete A.C. circuit with transistor O.C. 45.

The foregoing notes have dealt in a general way with junction transistors commonly available. They are all of P-N-P type, using a Germanium base, and whilst the art is not nearly so far advanced as electronic tube technique, it must be remembered that the development of transistors has taken place over only ten years as against approximately fifty years with the vacuum tubes. The general policy of transistor manufacturers in this country is not to make transistors available until they have been fully type approved in production, and because of this, silicon transistors which will employ an ever increasingly important part in industrial and service applications have been specifically excluded, as also have N-P-N type transistors. By the definition N-P-N it will be seen that these are complementary to the P-N-P types described except that all the polarities are reversed.

Summary

The major manufacturers of transistors in this country are Messrs. Mullard Ltd., Pye Industrial Electronics, Hivac Ltd., Standard Telephones and Cables Ltd., and the Brush Crystal Co. Ltd. All of these concerns manufacture transistors covering the audio supersonic and R.F. fields, and have produced comprehensive information regarding the transistors ; and the experimenter would do well to peruse them carefully before spending hard-earned cash in equipment for abortive experiments.

Specialised Components

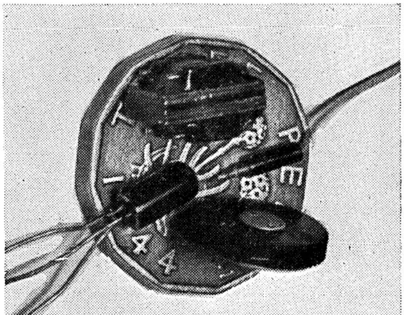
As with thermionic valves, transistors cannot be used by themselves alone and, in view of their small size and particular circuit requirements, specialist manufacturers have produced components specifically for use with transistors. The photographs in this Chapter show groups of components specially designed for use with transistors. It can safely be said that transistors have now passed the laboratory and experimental stage ; they are used in their tens of thousands in hearing aids today, and in the near future will revolutionise the engineering concept of portable equipment.

Equipment is Available

Already available on the market are transistorised record players (e.g., Philco) ; several manufacturers have placed on the market all transistor portable radio receivers (e.g., Pye) ; and one firm (Lustraphone) have announced a completely transistorised portable public address system ! There are doubtless many other firms who are either actively developing or producing similar units, but we may rest assured that all the time, effort, and money that has been invested in transistors during the last decade is going to make its impact felt on the general public in the very near future.

Acknowledgments

Acknowledgment is made to Messrs. Mullard Ltd. for specific information on circuitry, and to the other manufacturers mentioned in this article for their help and information on their products.



Again, using a threepenny piece for size comparison, here are a sub-miniature volume control (bottom), sub-miniature jack plug and transistor (centre) and transformer (top). These components, used by Fortiphone, show the size of things to come.

THE FUTURE

LAST year, venturing a peep into the future, we queried the coming of the longer-playing l.p., stereophonic broadcasts, twin-track discs, recorded T.V., and the replacement of valves by transistors. Taking these items in the same order, let us see what has happened—and what has not.

Longer playing discs, it seemed, were on their way during 1956. A 7-inch version had been developed in America, and a 12-inch version on the continent of Europe. At the 1956 Radio Show, new 4-speed playing units were introduced. But in spite of everything, the extra slow speed of $16\frac{2}{3}$ r.p.m. remains a facility for the future, and a tantalising ornament on the motor boards of those who bought them. No discs of that speed have appeared on the British market ; and unless some manufacturer is very good at keeping secrets, none is even in the offing.

What are the possible advantages of such discs ? And what are their limitations ? The slower speed would, of course, double the amount of playing time on a disc. The views of best informed authorities are that this speed could be adopted at any time—such is the advanced state of recording techniques—and that there need be no loss of quality in the recorded sound. However, in order to make it possible to reproduce high quality sound at that speed, playing units would have to be produced to a consistently high standard, and only the very best of the motors on the market today could provide the rock-like steadiness that would be necessary ; for wow and flutter would be far more noticeable, if present, than they are at $33\frac{1}{3}$ r.p.m. There would also be a need for very carefully polished diamond styli to track the grooves, and pickups would have to be made to operate at much lower playing weights — possibly 1 or 2 grams. In other words, although the record makers could easily deliver the $16\frac{2}{3}$ goods if they wished ; the motor and pickup makers would have to be on their toes to bring their products into line ; and many users would also have to re-adjust their ideas again—just

★

This is the console of the Ampex " Videotape " recorder which records and reproduces complete television sound and vision programmes. The deck can be seen immediately below and in front of the monitor screen. 14-in. tape spools are used, and this provides capacity for recordings of over 1-hour duration. The tape is of 2-in. width, and the tape speed is 15 in. per second. As the tape passes the heads it is mechanically scanned, and this process effectively raises the tape/head speed to several hundred i.p.s.

★

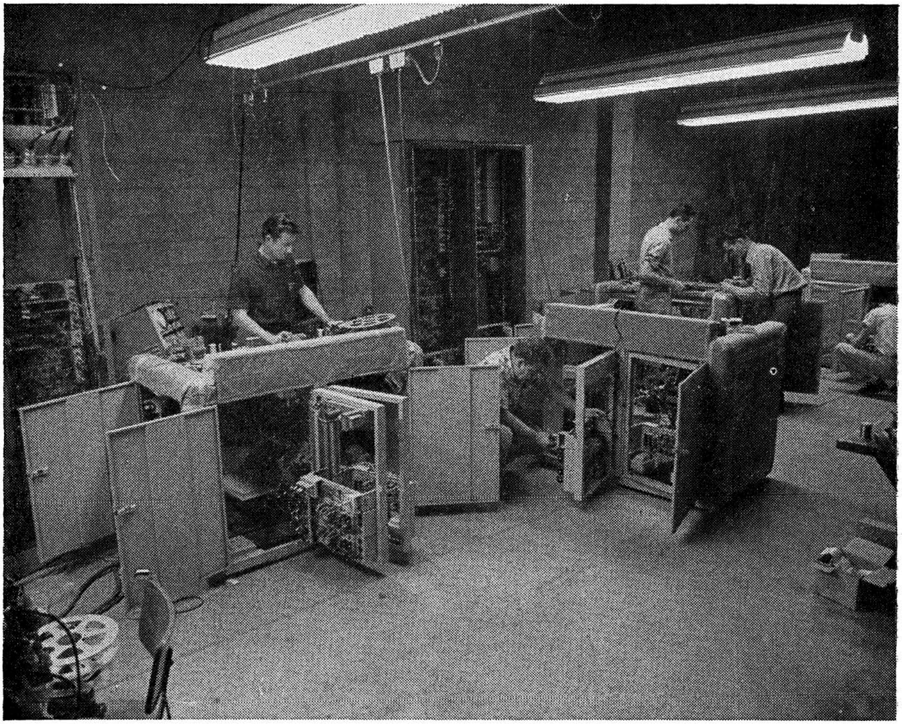
as they did when speeds dropped from the whirligig days of 1948 and back.

Stereophonic broadcasts are seemingly as far away today as they were 12 months ago. Methods of transmitting two stereophonic components of a programme simultaneously, by the one transmission, are quite possible. The B.B.C. engineers could handle that side of things quite easily. But until such time as many more thousands of homes are equipped with twin-channel reproducers, which could be adapted to make use of such a facility, it is very obvious that the financial resources of the B.B.C. will be used for things far more urgently needed by the public as a whole.

Twin-track, or stereophonic discs, still remain with another " question mark " as these words are written. It is now fairly common knowledge that more than one record manufacturer has been experimenting with them during the past two years ; and Mr. (Connoisseur) Sugden demonstrated stereo discs at the 1956 B.S.R.A. Show. Anything might well happen at any moment in this field, for stereo discs are now a practicable proposition, but are also one of the most closely guarded secrets of those who are able to launch them—or withhold them. They might well be with us tomorrow : they might equally well be a thing of the future in another year's time.

Recorded T.V. has arrived, and is by all accounts a great success—in America. The honours due for this achievement go to the engineers of the Ampex Corporation. On November 30th, 1956, a tape recording of both vision and sound was used by the Columbia Broadcasting Service to re-broadcast a T.V. programme ; and since then the Ampex " Videotape " system has gone into regular use with both C.B.S. and N.B.C.

The system is based upon the use of a 2-inch wide tape, at a tape speed of only 15 inches per second. But as the tape moves, it is mechanically scanned at high speed by the recording or reproducing heads ; and the result is the equivalent of a tape speed of several hundreds of inches per second. This,



A true peep into the future is provided by this picture of the first " Videotape " recorders being assembled at the Ampex laboratories. Two racks of equipment go with each console to form a complete vision-plus-sound record/playback unit, capable of working at frequencies up to 4 Mc/s. Videotape recorders are already in regular service with U.S.A. television networks.

in turn, makes it possible to record and reproduce frequencies over a range as great as 4 Megacycles per second. The picture detail achieved is excellent—better, it is said, than that obtained by film recording ; and a 14-inch spool of tape is thus able to handle a complete sound-and-vision programme of over 1-hour duration.

Looking between the scanned lines of this remarkable achievement, we may reasonably expect the effects to be heard, as improved sound, from our tape recordings of the future. Four million c.p.s. is a big jump from the 16 Kc/s that we are able to enjoy from our sound recorded tapes today. We have far more to expect from tape, in the future, than we have experienced so far, despite the good progress which has been made. Tape is definitely the medium to watch.

Transistors. In this field there has been far more progress behind the scenes than has been apparent on the surface, which we see as the domestic market. Because of the very nature of sound reproducers, the size of valves does not yet enter into account to any appreciable degree (though the imaginative may well be thinking in terms of pickups, etc.). Nevertheless, the transistor has a definite place in the scheme of things which govern the needs of our pre-amplifiers and amplifiers, and particularly in tape recorders—but for reasons other than size. Mullard Limited exhibited a remarkably neat experimental transistorised amplifier at the 1956 Radio Show, and several manufacturers are now at work with transistors for tape recorders. The years 1957/58 will probably bring with them some interesting developments in this field.

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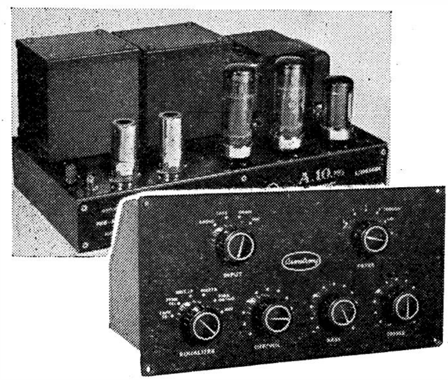

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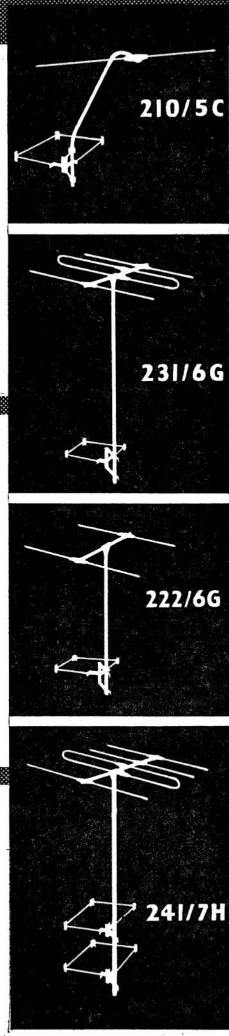

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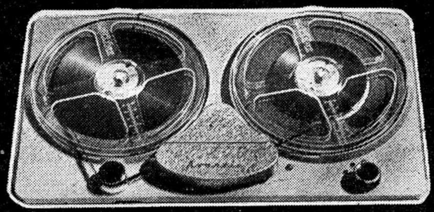

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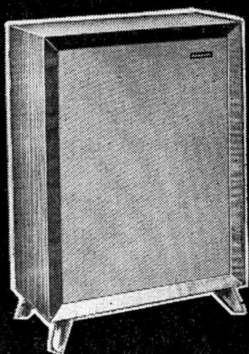

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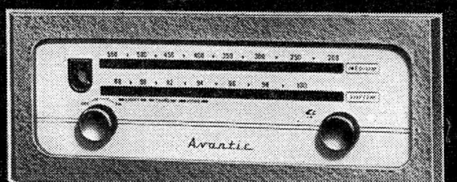

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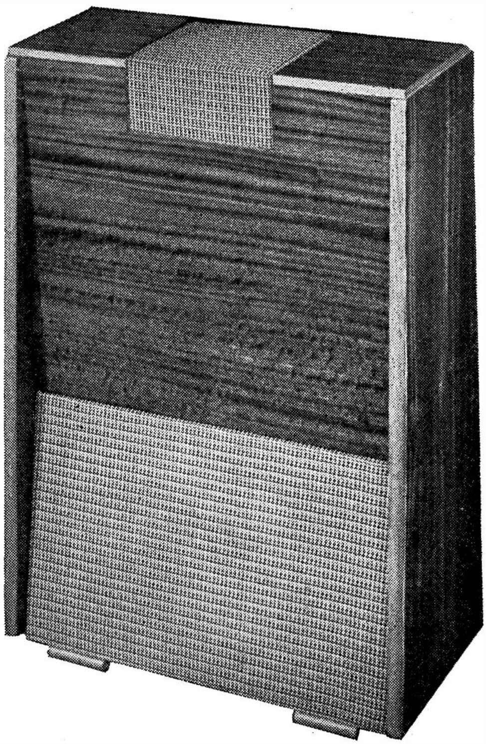

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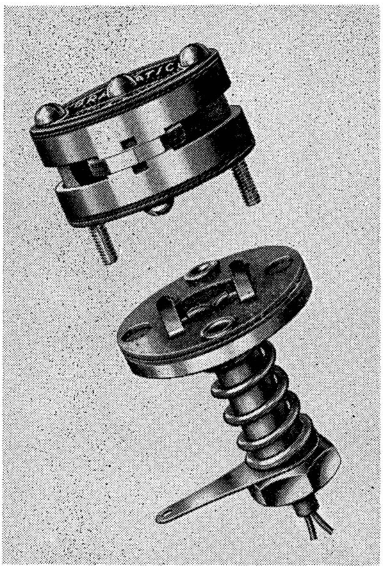

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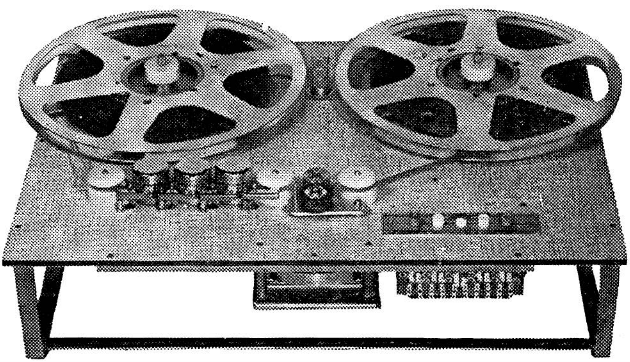

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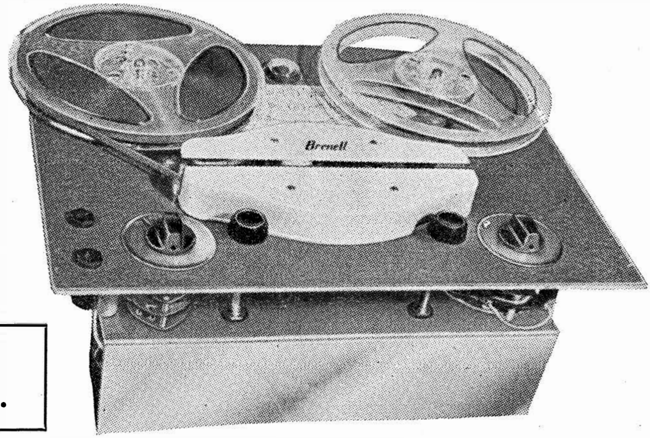


Price :
38½ gns.

Entirely re-designed to permit conversion to stereophonic sound when required, the new Brenell Mark IV Deck represents outstanding value for money. Among its many advanced features are : three independent high performance motors, 3 speeds (3¾, 7½ and 15 i.p.s.), interlocked switching to prevent accidental erasure, instant stop without tape spill, 8¼in. spools, digital rev. counter, azimuth head adjustment, etc.

Note : New Brenell Portable Tape Recorder now incorporates Mark IV Deck. 53 gns.

Available as Tape Deck only or (as illustrated above) with Pre-Amp Unit and Magic Eye Level Indicator ready for use with any standard Amplifier. Note that all Mark IV Decks can be fitted with four heads for dual-channel operation when required. Full details available on request.

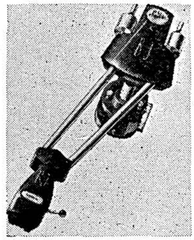
From your Wireless Dealer or in case of difficulty write to sole manufacturers

BRENELL ENGINEERING Co., Ltd.
2, NORTHINGTON STREET, LONDON, W.C.1.
Telephone : HOLborn 7358

BJ

TANGENTIAL

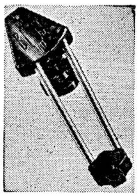
The Most Famous Name In Pick-up Arms



The "Super 90"

Complete versatility and adaptability make this the most advanced arm in the world. Friction-free tangential tracking goes with finger-touch pedestal adjustments and counter balances.

An effortless optimum is achieved with any choice of head or cartridge. **£11.11.0** P.T. **£4.12.5**

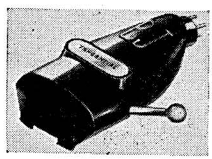


BJ Standard Arm

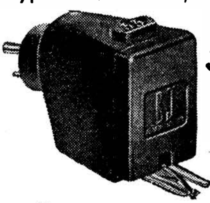
By overcoming tracking error BJ sets a new standard in high fidelity reproduction. Its addition to any gramophone immediately reveals the advantages of reduced distortion and longer record life.

£2.4.11 P.T. **18/-**

The Plug-in Shell



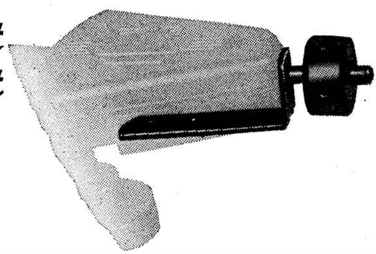
Designed to adapt all popular cartridges to the BJ arms, the shell's attractive lines and versatility are combined with finger lift control. Cartridges include Tannoy, Goldring, Collaro, Acos and most American types. **17/3** P.T. **6/11**



The BJ C12 Head

The advantages of high sensitivity and cantilever stylus action are united in a head of extremely low mass. The total weight is only 11 grammes. **£1.12.6** P.T. **13/-**

Counterweight Unit



The addition of this weight unit to the standard arm permits speed and accuracy in weight compensation. The total point pressure range is 4 grammes.

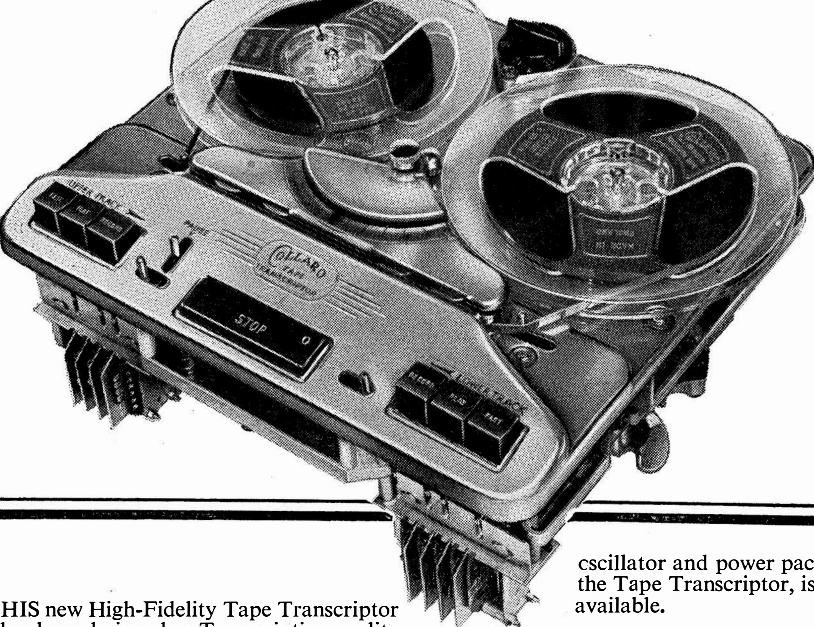
12/- P.T. **4/10**

ASK YOUR LOCAL DEALER FOR FULL DETAILS

BURNE-JONES

SUNNINGDALE ROAD · CHEAM · SURREY · ENGLAND

THE COLLARO TAPE TRANSCRIPTOR
Mark III



THIS new High-Fidelity Tape Transcriptor has been designed on Transcription quality principles for live recording, recording from FM Broadcasts, etc., and for reproducing pre-recorded tapes. A twin-track model fitted with four heads, it runs at speeds of $3\frac{3}{4}$, $7\frac{1}{2}$ and 15 inches per second. It has low wattage input motors, and the tape tensioning is automatic.

The operation and the braking are mechanical and performed without the aid of rubber belts or solenoids. The 3-speed mechanism effects the final drive through the periphery of a heavy-weight flywheel and is instantaneously reversible. The drive pulleys retract automatically when the machine is switched off.

Several new modifications are incorporated in the Mark III, including the Pause control and removable switches. Pre-amplifier, incorporating bias cscillator and power pack for the Tape Transcriptor, is now available.

4-SPEED GRAMOPHONE TRANSCRIPTION UNIT (MODEL 4T200) for truly faithful reproduction

Entirely new type 4-speed mechanism ensures absolutely uniform speed, with reproduction free from frequency modulation. A very heavy turntable is fitted with a ground and lapped spindle running on to a ball which takes the total thrust of the turntable, and results in correct speed with no detectable " wow " or " rumble."

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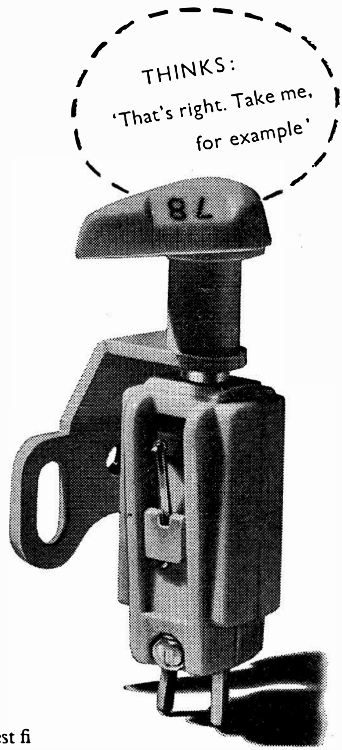
Telephone: Rippleway 5533 - Telex 8748 *Telegrams: Korllaro-Telex-Barking*

Makers of Record Changers, Gramophone Units, Studio Pickups, Electric Motors, etc.



With a new factory and enlarged technical staff, Acos are creating a new, consolidated range of cartridges and styli. Each unit in the series is made specifically for a particular kind of record player: highest output for popular instruments, medium output and highest fi for the exceedingly exacting. Every cartridge will have the right characteristics for its job; a stylus individually inspected at 500 times magnification and easily exchanged in the new slip-in fitting; and very low weight. We should like to demonstrate.

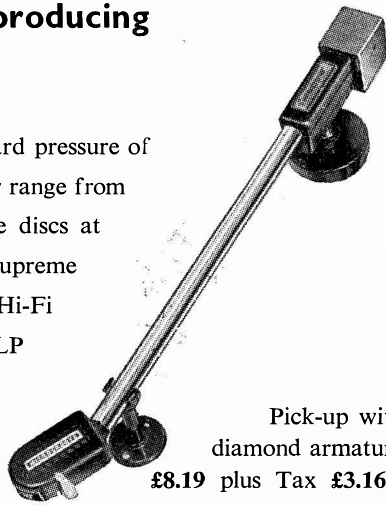
acos ARE DOING THINGS IN STYLI

COSMOCORD LTD. WALTHAM CROSS HERTS. TEL: WALTHAM CROSS 5206 (London telephone subscribers please dial WA4 5206)

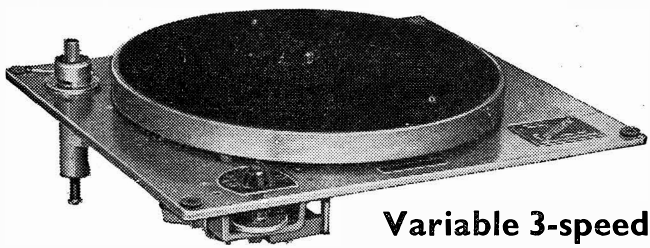
Connoisseur

Fine equipment for reproducing sound from disc

Pick-up (Mark II) has a downward pressure of only 4 grams and has a frequency range from 20 c/s to 20 Kc/s on soft vinolite discs at $33\frac{1}{3}$ r.p.m. This is the unit of supreme quality and high-class finish for the Hi-Fi enthusiast. 15 mV obtained off LP disc, 100 per cent. screening of coil by magnet system. Easily replaced armature system.



Pick-up with diamond armature
£8.19 plus Tax **£3.16.6**



Variable 3-speed motor

A hand-built product which meets with the most stringent requirements.

Three speeds with 4 per cent. variation by mechanical means. No braking action applied to motor.

The motor is a synchronous hysteresis type, running in substantial phosphor-bronze bearings.

The motor will remain in synchronisation with 25 per cent. variation of line voltage. Heavy full-sized die-cast platform, $15\frac{3}{4}$ in. × $13\frac{1}{2}$ in.

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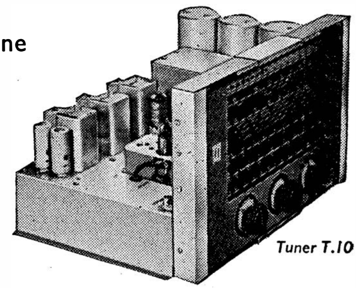
DYNATRON SOUND PERFECTION

ETHER PATHFINDER CHASSIS

The superb Ether Pathfinder series provide the listener with a set of high fidelity radiogramophone chassis which give exceptional performance from radio and records without complicated controls.

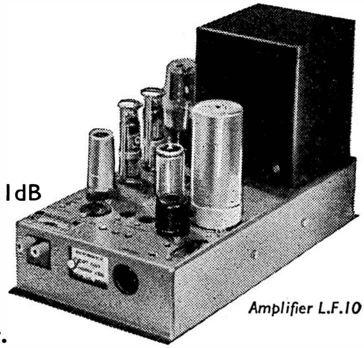


Tuner T.10

AM/FM TUNER:

8 Valves.
5 Wave bands.
Variable selectivity tuning.
Separate tuner head.

Price: £66
(*Tax Paid*)



Amplifier L.F.10

POWER AMPLIFIER:

4 Valves.
Push-pull output.
12 watts output.
Frequency response better than ±1dB

Price: £34 . 15 . 0
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TONE CONTROL UNIT:

2 Valve high gain pre-amplifier.
Provision for various inputs.
Bass/Treble/Selector switch/Volume Controls.

Price: £17 . 18 . 0
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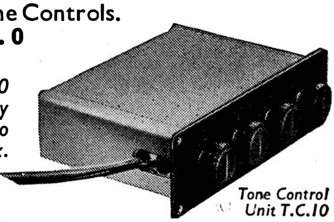
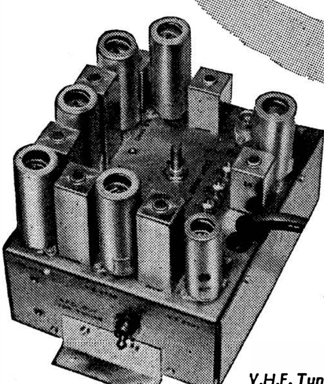
If the L.F.10 and T.C.10 are ordered separately they are not subject to purchase tax.



Tone Control Unit T.C.10



V.H.F. Tuner F.M.2

V.H.F. RADIO TUNER

7/8 valve tuner · Pre-tuned 4 fixed frequencies Automatic frequency corrector · Single Switch operation · Two versions, one with extra L.F. valve, giving 2 volt output.

Separate Power Unit available if required.

7 valve F.M.2(LV)	...	**Price: £25 . 0 . 6**
8 valve F.M.2(HV)	...	**Price: £29 . 3 . 9**
Power Unit, type P.1	...	**Price: £9 . 7 . 8**

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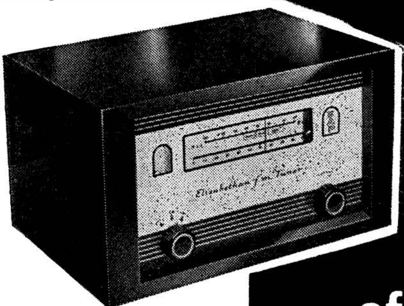
a leading name in the world of sound

ELIZABETHAN F.M. TUNER
Range 85–101 Mc/s
Self-powered.



ELIZABETHAN 56
2 speed, 3½ watts output.
Complete with microphone and L.P. Tape.

ELIZABETHAN DE LUXE
3 speed, 6 watts output.
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TAPE RECORDERS

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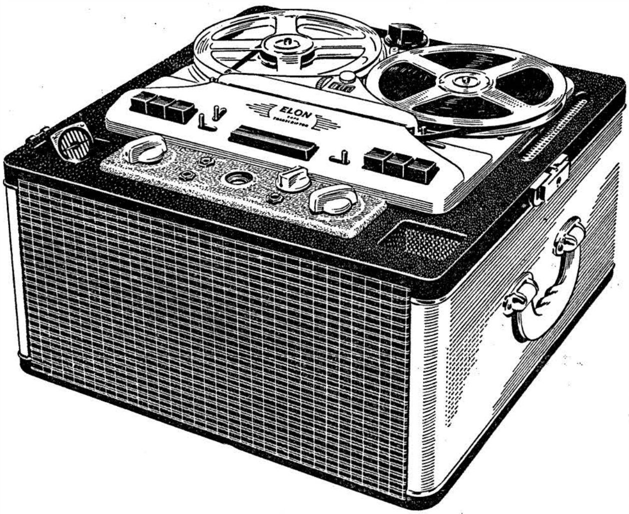
DHB/3005

ELON JC 20



WE KNOW our Recorder is superior to most other makes, even those in a higher price range, but we do not expect a potential customer to accept such a statement at its face value. Fortunately the solution is simple : a demonstration of various models, including the JC 20, and your ear will convince you that our claim is fully justified.

The chief feature of the JC 20 is its time tested Amplifier with a wide frequency range, at less than 2% total harmonic distortion on playback, which has been obtained only after years of specialised development, and is now a worthy supplement to the Collaro Tape Transcriptor.

Our object is to manufacture a Recorder that will give the best possible reproduction, avoiding innovations that will impair the ultimate performance, but utilising all worthwhile developments, thereby setting a new high standard for medium priced Recorders. For further technical information, and leaflets, please contact our Sales Office at the following address :

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LENCO TRANSCRIPTION UNIT MODEL G.L. 55
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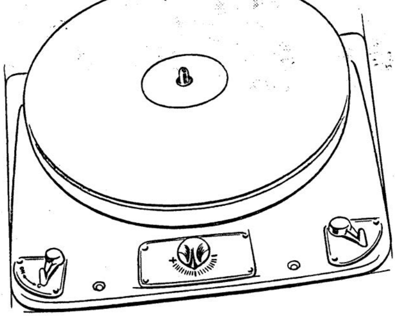


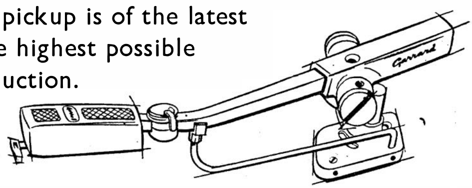
Model 301
Transcription Motor

Recognised as the world's finest transcription motor. The connoisseur of High Fidelity reproduction will appreciate its superb quality and reliability. As used by the B.B.C. and many other Broadcasting stations throughout the world. A turntable stroboscopically marked on its rim is available at extra cost.

High Fidelity...

T.P.A. 10
Transcription Pickup Arm

The Garrard Model T.P.A. 10 Transcription Pickup Arm is supplied complete with the Garrard GMC 5 moving coil pickup and transformer. The pickup arm is designed for the critical expert who desires the best. Its styling is ultra-modern and the arm is fully adjustable. The Garrard moving coil pickup is of the latest design giving the highest possible quality reproduction.



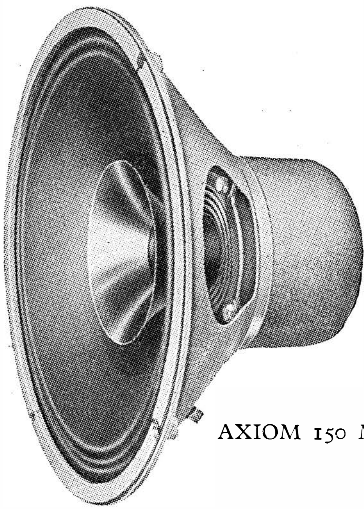
Send for descriptive leaflet of complete range of Garrard Gramophone Equipment

Garrard AUDIO PERFECTION

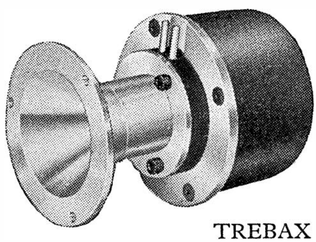
THE GARRARD ENGINEERING & MANUFACTURING CO. LTD., SWINDON, WILTSHIRE

From Goodmans High Fidelity range

AXIOM 150 Mk. II, a full Range Loudspeaker and the **TREBAX PRESSURE TWEETER** are but two of the comprehensive range of Goodmans High Fidelity Sound Reproducers. Goodmans Products are precision-built to the closest engineering tolerances. Rigid quality control at every stage of manufacture maintains the tradition of excellence enjoyed by Goodmans products in all parts of the world.



AXIOM 150 Mk. II



TREBAX

Goodmans

Full details of these Units and other Loudspeakers, Cabinets, Crossovers and Acoustical Resistance Units, available on request

GOODMANS INDUSTRIES, LTD., AXIOM WORKS, WEMBLEY, MIDDX.

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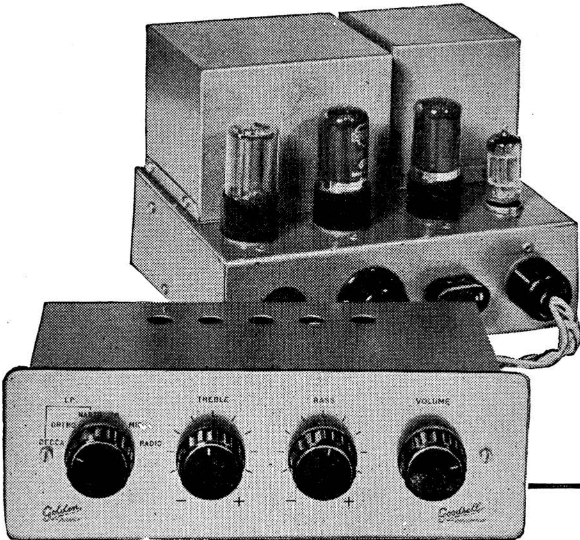
more pleasure...



MA5 Amplifier and TC/UL Tone Control.

Also available : Williamson Amplifiers and FM Tuners.

from GOODSELL

• authentic •

HIGH FIDELITY EQUIPMENT

... because you control the balance of reproduction: you decide the value of treble and bass boost for the particular recording, to suit your taste and preference. In appreciating the quality of the recording you will appreciate too the perfection of GOODSELL "Golden Range" Equipment.

Details from **Goodsell Ltd.,**

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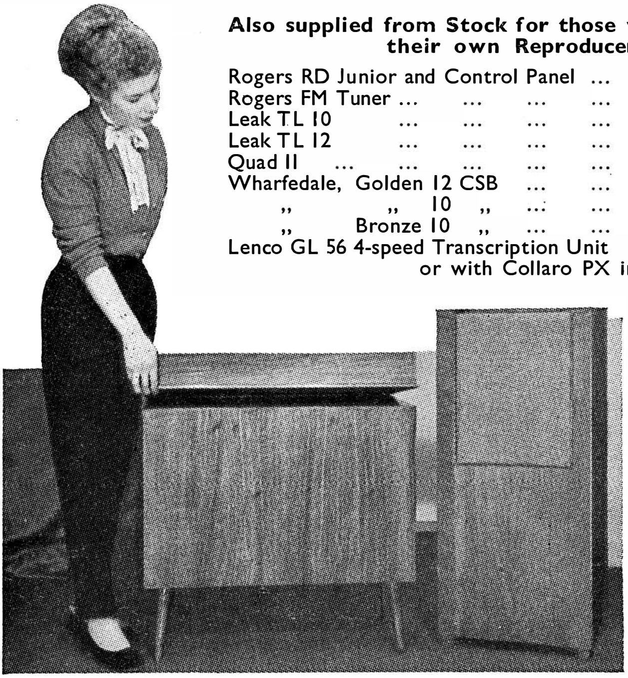
SUPPLIED COMPLETE

Also supplied from Stock for those wishing to build their own Reproducer.

Rogers RD Junior and Control Panel	**£26**	**0**	**0**
Rogers FM Tuner	**£24**	**17**	**0**
Leak TL 10	**£28**	**7**	**0**
Leak TL 12	**£45**	**0**	**0**
Quad II	**£42**	**0**	**0**
Wharfedale, Golden 12 CSB	**£9**	**15**	**0**
,, ,, 10 ,, ...	**£8**	**14**	**11**
,, Bronze 10 ,, ...	**£5**	**11**	**3**
Lenco GL 56 4-speed Transcription Unit ...	**£23**	**7**	**0**
or with Collaro PX insert	**£22**	**6**	**0**



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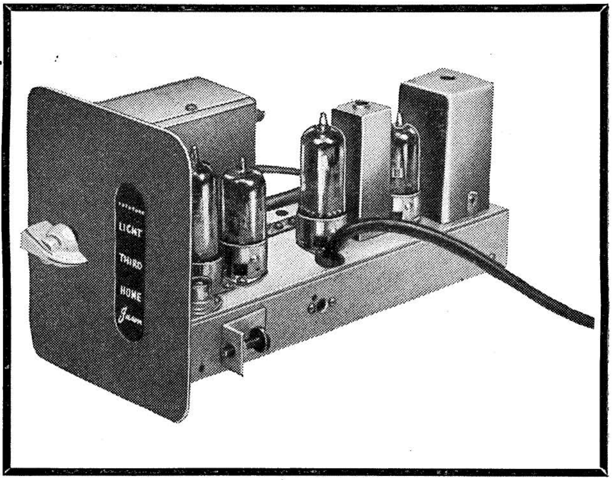


JASON

SWITCH-TUNED QUALITY F.M. TUNER

Of the many successful designs for F.M. Tuners produced by Jason, this is the one most likely to appeal to the discerning listener whose interests are more with quality than technicalities. This unit is for feeding into high quality amplifying equipment. It is very easy to install. Programme selection is by turning the pointer switch to the desired B.B.C. station named on the front panel, which presents a neat old gold finish in keeping with modern trends. Other finishes to match existing equipment can be supplied. The Jason Switch-Tuned quality F.M. Tuner is completely stable and free from drift, and once installed needs no further adjustment. It has an effective range of 60 miles from the transmitter dependent on local conditions and will, on the average, operate up to 30 miles away, on an indoor aerial. An external source of power is required for which a Jason Power Pack Unit is available if necessary.

Jason F.M. Tuning Units are sold by high-fidelity stockists. In cases of difficulty, we will be pleased to send you leaflets and name and address of your nearest supplier.

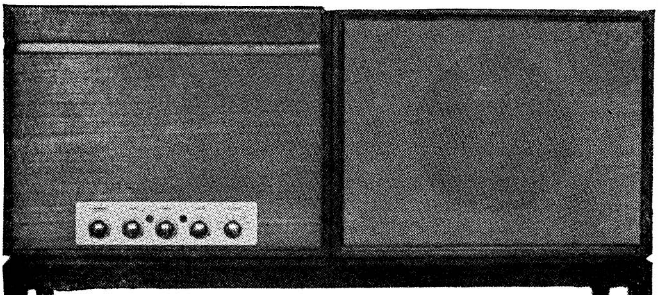
£19. 16. 2 *inc. P/Tax*

Power Pack, if required, £3. 10. 0

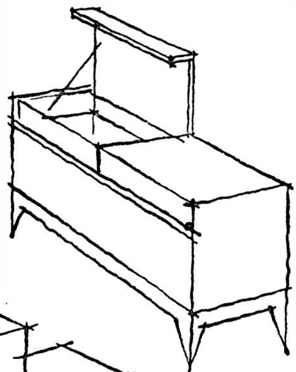
JASON MOTOR & ELECTRONIC CO.,

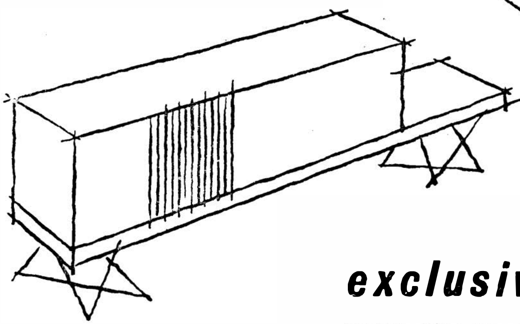
328, CRICKLEWOOD LANE, LONDON, N.W.2 *Phone: SPE. 7050*

Imhofs bring the unit furniture idea to Hi Fi...



These new functional, versatile cabinets bring the unit idea to Hi Fi furniture. Distinctively styled, they are exclusive to Imhofs. Flexibility is the keynote of the system which comprises loud-speakers, amplifier and record storage cabinets in either double or single units. Different sizes and types of legs, or special bases, are available. Come and see the range for yourself at our New Oxford Street showrooms. And remember, Imhofs are Europe's Hi Fi Centre . . . selling the finest amplifiers, tuner units and other sound reproducing equipment.





exclusive to IMHOFS

ALFRED IMHOF LIMITED

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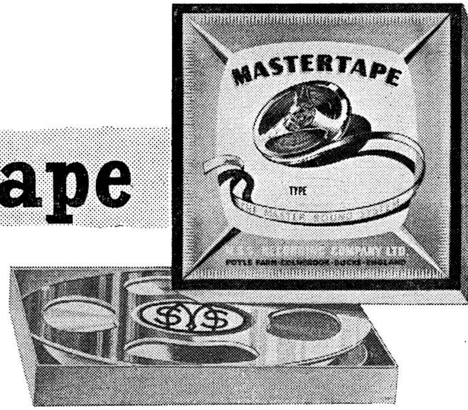
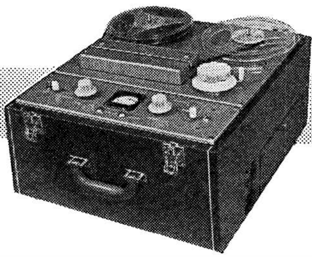
Mastertape



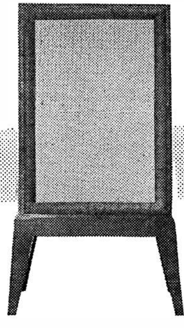
For all
Tape recording
Equipment

Here is the new and still further improved magnetic tape incorporating the advances in design to meet the most exacting professional requirements. Owing to the high output level at high frequencies Mastertape is the ideal tape for you to use.



Tape Recorder PMR/DE £85

Perfection in design
Perfection in listening
Ask for a demonstration



Extension Speaker LSX/I £30

Frequency Response :
Flat from 40 c/s to 15,000 c/s
An F.M. Tuner unit is also available

M.S.S. RECORDING CO. LTD.

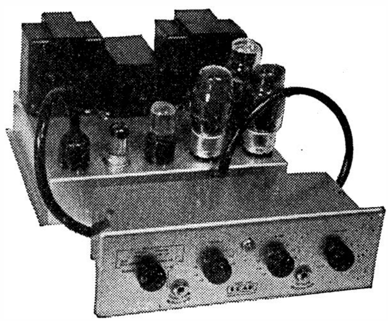
COLNBROOK . BUCKS . Telephone : COLNBROOK 430

Britain's finest Hi-Fi Equipment

We have devoted over 22 years entirely to the design and manufacture of audio equipment and we are proud of our position of being leaders in this field. We were the first firm in the world to design and market Amplifiers *having a total distortion content as low as* 0.1% ; a claim which was received with incredulity in 1945 but which was subsequently confirmed by the National Physical Laboratory and has become an accepted world-wide standard.

High engineering ideals have guided our efforts, and Leak Amplifiers have been the choice of the *B.B.C., Commonwealth and foreign Broadcasting Authorities and Recording Studios.* This acceptance by professional audio engineers has led to a demand for Leak equipment from music lovers throughout the world.

On the important question of prices it is appropriate to mention one of the basic principals of Leak design. From long experience and by extreme attention to design details during development work on the production models, we enabled our labour forces to achieve a high output per man hour. The labour costs thus saved offset the increased cost incurred for high grade materials, components and finishes, and this, together with quantity production (made possible only by a world-wide market) explains how quality products may be sold at reasonable prices.



LEAK TL/10

10-watt Amplifier, 17 gns. and "Point One" Pre-amplifier, 10 gns.

(Prices made possible only by world-wide sales)

Harmonic Distortion 0·1% 1,000 c/s, 7·5 watts output.

FREL is the trade name of the LEAK Full-range Electrostatic Loudspeaker which will be available to the public in 1957. The design is original and has great theoretical and practical advantages over previously described electrostatic loudspeaker systems. It is the result of intensive research work carried out by H. J. Leak, M.Brit.I.R.E., and A. B. Sarkar, M.Sc., who are the authors of a paper, describing the basic design principles of this loudspeaker, which was published in the *Wireless World*, October, 1956. A reprint of this paper will be supplied on request.

The first name in High Fidelity . . .

LEAK

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Bib RECORDING TAPE SPLICER

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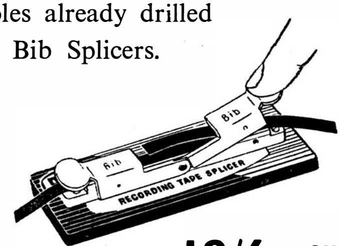

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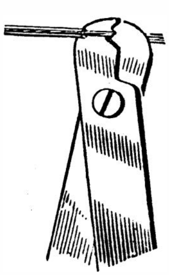

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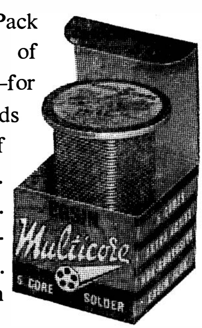

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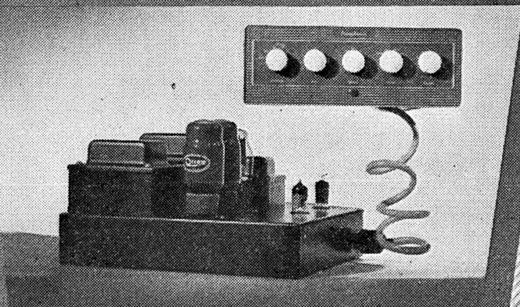

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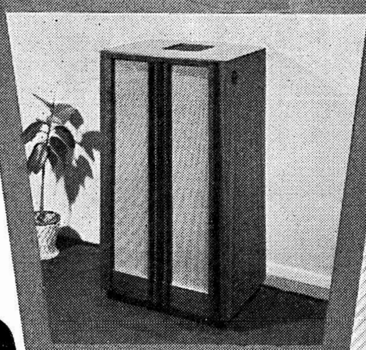

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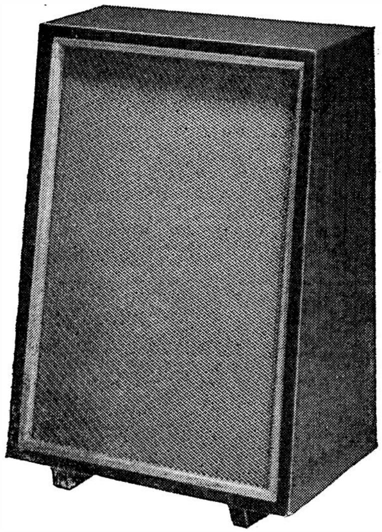

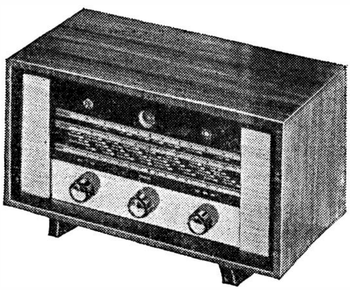

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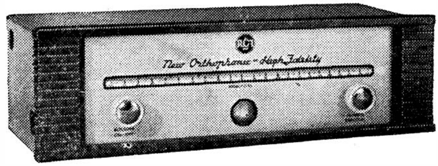

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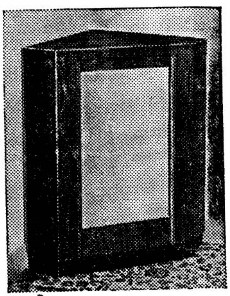

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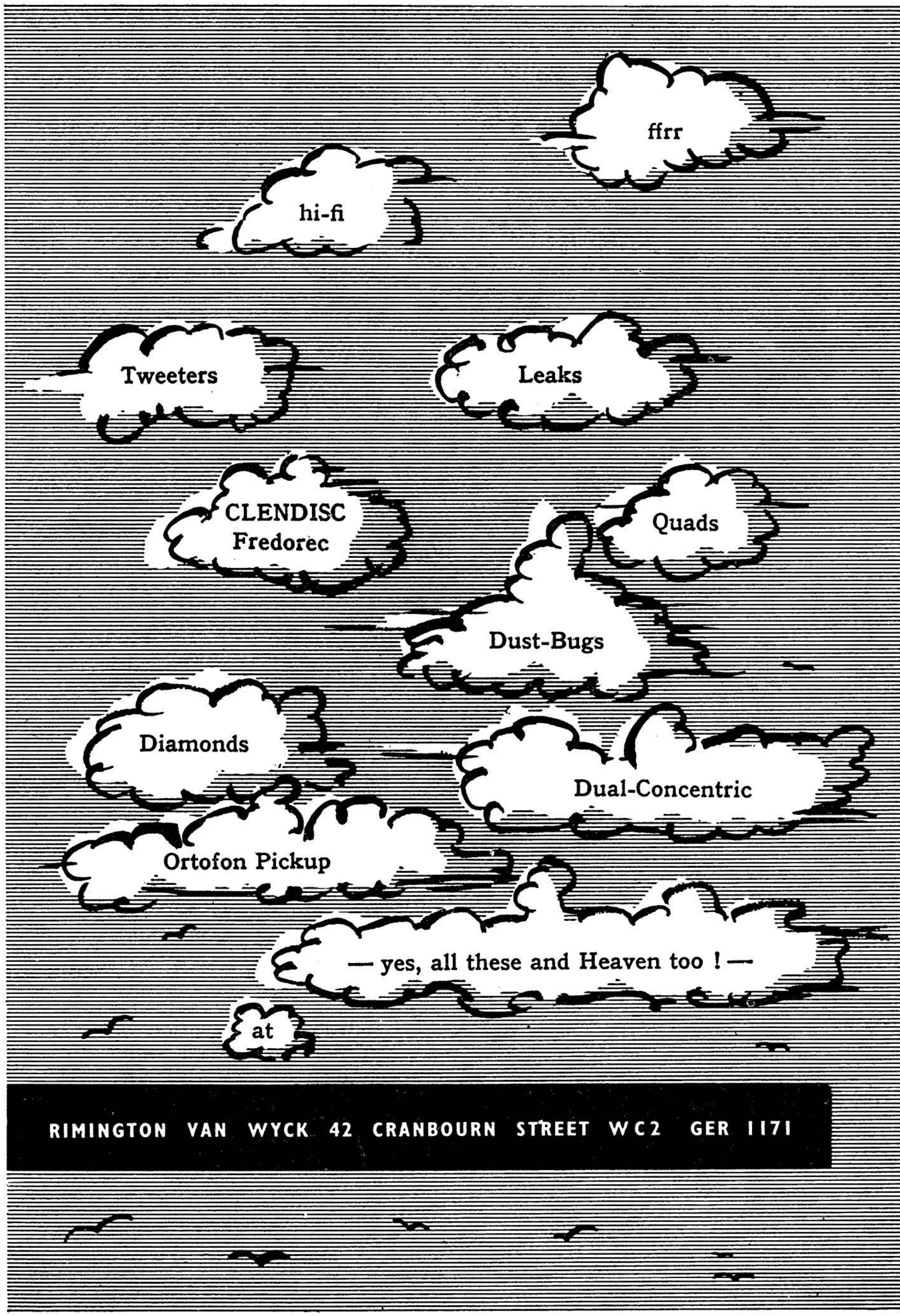
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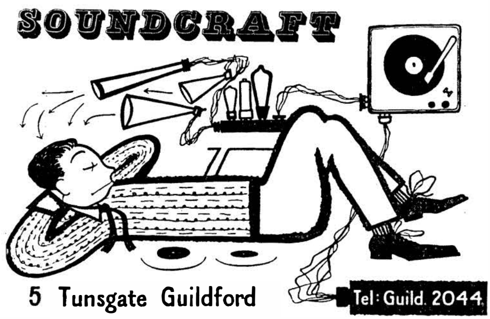

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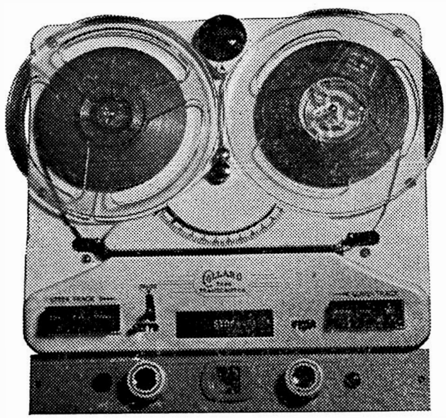

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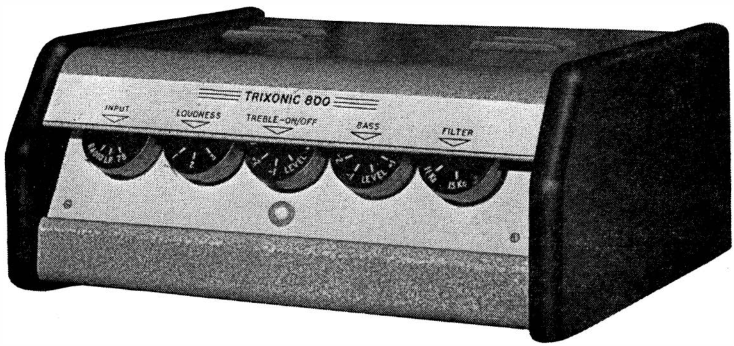

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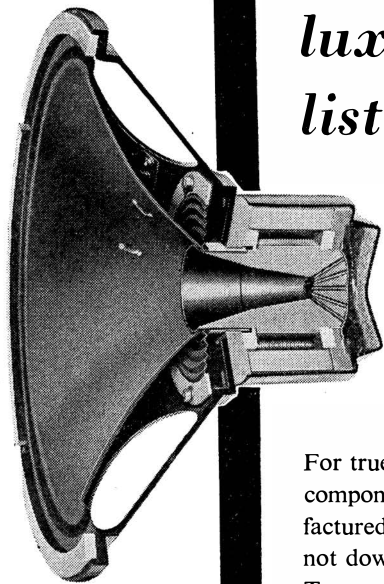

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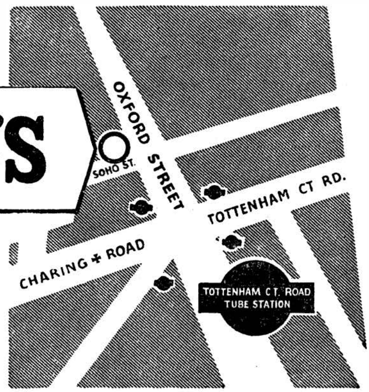

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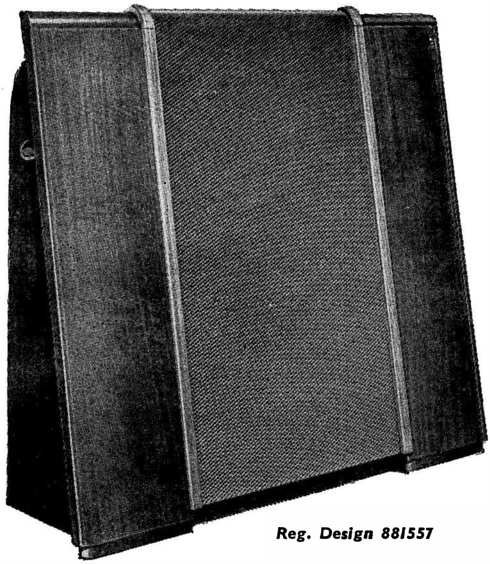

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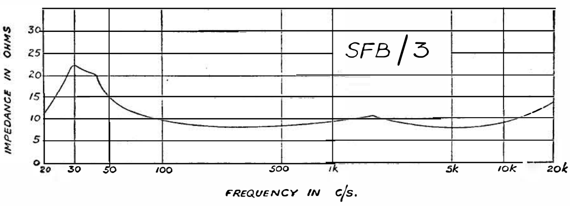

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Miniature Pressure Microphones

by

Gunnar Rasmussen)*

ABSTRACT
Methods of making a given microphone "look acoustically smaller" in a sound field are briefly outlined and some measurements described. Choice of optimum diaphragm thickness for ¼" microphones is discussed and various design problems facing the development of small microphones reported. Finally the influence of severe environmental conditions upon the operation of the microphone is mentioned. Some methods used during the manufacture of precision microphones to control their various characteristics are also indicated.

SOMMAIRE
Les conditions nécessaires à la réduction des «dimensions acoustiques» d'un microphone sont brièvement analysées ainsi que les principes des méthodes de mesure.
Les différents problèmes relatifs à la miniaturisation des microphones à condensateurs sont ensuite présentés, en particulier les effets de l'inertie de l'air sur le mouvement de la «membrane equivalente».
Enfin l'influence de conditions d'environnements sévères et les problèmes de contrôle des caractéristiques en cours de fabrication sont considérés.

ZUSAMMENFASSUNG
Meßmikrophone geben aufgrund ihrer endlichen Abmessungen Anlaß zu Schallfeldverzerrungen. Durch geeignete konstruktive Meßnahmen kann man die Abmessungen eines Mikrophons im akustischen Sinne verkleinern. Die grundsätzlichen Probleme, welche mit der Entwicklung eines kleinen Kondensatormikrophons zusammenhängen, werden eingehend beschrieben.

In his textbook "Electroacoustics, the analysis of transduction and its historical background" F. V. Hunt writes about Wente's "uniformly sensitive instrument" of 1917: It ushered in a new and thrilling era for the quantitative measurement of acoustical phenomena. The principal changes introduced in the condenser microphone itself during the next three decades consisted of the virtual elimination of the cavity in front of the diaphragm and a drastic reduction in the size of the instrument.
The removal of any cavity in front of the diaphragm, and also an increase in the effective sensitive area of a condenser microphone will make the transducer appear smaller in an acoustic sound field. This effect is best illustrated in Fig. 1 where the free field correction for 0° incidence are shown for two microphones. The front cavity is only 2 mm deep with an internal diameter of 18.6 mm, but it will make the microphone look more than 10 % larger in diameter and increase the free field correction by more than 1.5 db between 7 and 12 kc/s. It is possible, however, to utilize the

*) This paper was presented by the author at the 4th International Congress on Acoustics, Copenhagen 21.—28. August 1962.

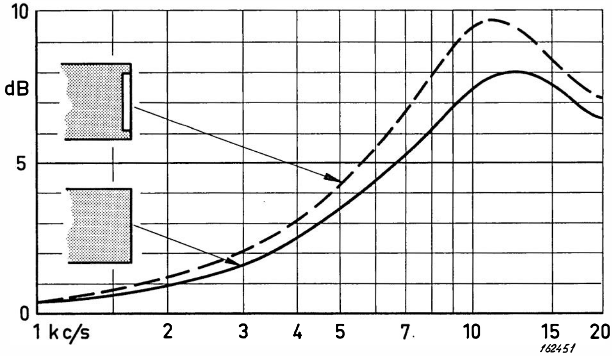

Fig. 1. Typical free-field correction curves (0° sound incidence) for a condenser microphone with and without a small cavity in the front of the diaphragm.

effect of cavities and obstacles in front of a microphone diaphragm, to increase the linear frequency range and the omnidirectional properties far beyond the frequency range given by the conventional considerations regarding diaphragm resonance, wavelength and diameters. In Fig. 2 are shown the frequency response curves obtained by optimizing the properties of a front cover in order to obtain the best possible uniformity of sensitivity for a 1″ microphone at any angle of incidence. In fact this 1″ type 4131 microphone with random incidence corrector UA 0055 is more omnidirectional up to 15 kc/s than a conventional microphone, only ½″ in diameter. Some of the experimental steps leading to this design are shown in

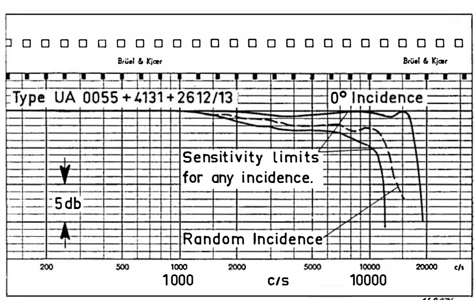

Fig. 2. Frequency Response curves obtained by "optimizing" the properties of a front cover.

Fig. 3.—It is thus possible to optimize some of the properties of a given cartridge size, one could say make it look acoustically smaller in some respects than it really is.
Now for acoustical—and for fluctuating air pressure measurements in general—properties other than omnidirectivity may be called for, and we have investigated the possibilities of miniaturization of both the microphone cartridge itself and the succeeding preamplifier.
It should be kept in mind that the miniature microphones must still be stable with time, temperature and ambient pressure. They must have reasonable dynamic range, a high resonant frequency, and a flat frequency response. They should be unaffected by severe environments, including high vibration levels. The condenser microphone seems at the moment to be the only which is able to fulfil all these requirements. In particular it must be a stretched metal diaphragm type in order to ensure the stability.

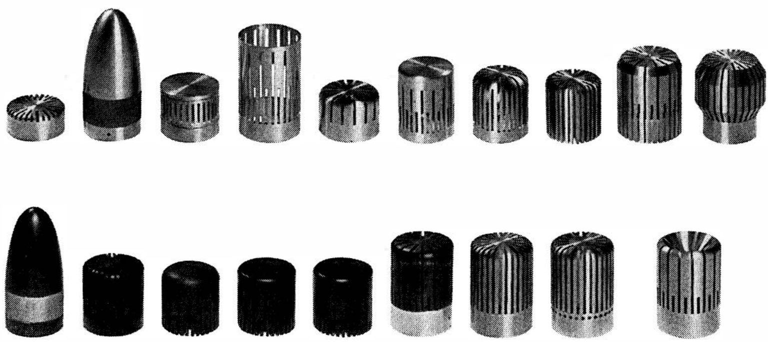

Fig. 3. Some experimental front cover designs which have been investigated at Brüel & Kjær.

The resonant frequency is given by the root of the compliance and the mass of the diaphragm. The sensitivity is controlled by the compliance below and by the mass above resonance. The effective mass is determined by the mass of the diaphragm material itself plus the mass of the moving air loading the diaphragm. The mass of the diaphragm itself should thus be less than the mass of the moving air in order to obtain the maximum sensitivity and highest resonant frequency. The mass of moving air near a diaphragm 4.5 mm in diameter is given by: $0_1 \frac{8 \times \alpha \times \varrho}{3\,\pi} \pi\,\alpha^2 = 0.43 \frac{8}{3} \times 1.29 \times 10^{-3} \times 0.45^3$ $= 1.7 \times 10^{-4}$ gr. 0_1 is a reduction factor for the diaphragm movement below the first resonance, $\frac{8\,\alpha}{3\,\pi}$ is the air columne as given by Lord Rayleigh,*) and ϱ the density of air and "α" the diaphragm radius.**) This mass will equal that of a 5 μ nickel diaphragm if we calculate the effective moving diaphragm mass using a reduction factor of 0.27 (see **).

Fig. 4 shows the relationship between the frequency responses and sensitivities for 1″, ½″ and ¼″ microphones. It is possible by the technique used to make microphones of similar design of still smaller diameters. A ⅛″ type has been made for laboratory use.

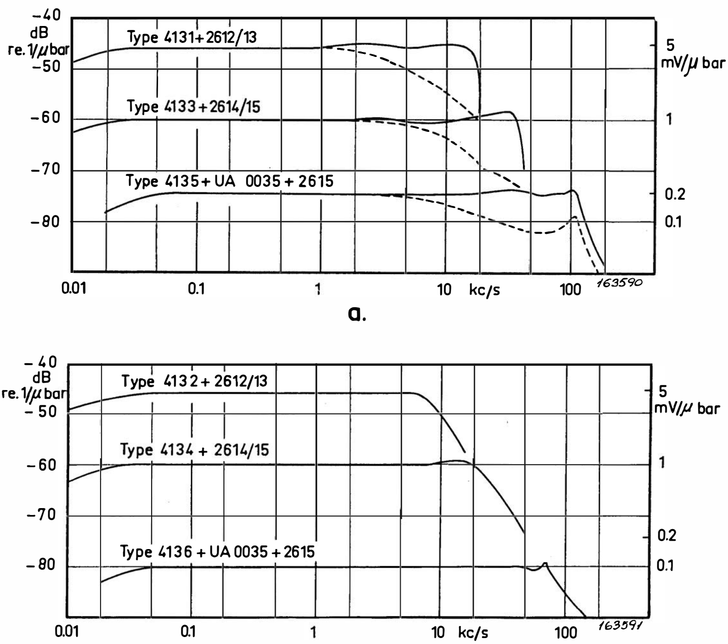

Fig. 4. Relationships between the frequency response and the sensitivity of three different "sizes" of condenser microphones (1″, ½″, and ¼″).
a) Free-field type cartridges
b) Pressure type cartridges

*) Theory of Sound, Vol. II, Chapter XVI, 2nd Ed.
**) Die Grundlagen der Akustik von E. Skudrzyk, page 430.

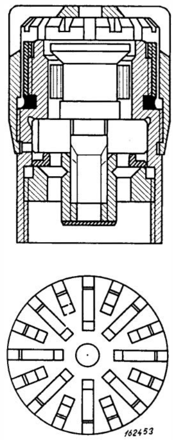

Fig. 5. Sketch of a ¼″ microphone cartridge.

In Fig. 5 is shown a ¼″ type. This microphone has only recently come on the market and I should like to mention some of the design problems faced during its development. The diaphragm is made up in a way which will give a maximum free moving area. The diaphragm tension is adjusted by tighting up the diaphragm on the housing from the front. The diaphragm thickness is 6 μ for one type and 2 μ for another. The material is nickel. The diaphragm thickness is choosen in order to give a flat and uniform pressure response for the one type and a flat free field response at 0° incidence for the other type. The frequency response for the pressure type is linear up to 70 kc/s within $\pm$ 2 db. It is interesting that the natural frequency of the diaphragm with no air loading and no air cushion between the diaphragm and the back plate is 50 kc/s. It is possible to increase the frequency range to 70 kc/s by choosing the correct size of back plate and using maximum damping of the diaphragm center around resonance, thereby virtually blocking the diaphragm center and increasing the resonance. In this way the maximum sensitivity will be located at the edge of the back plate. This will make the microphone more sensitive to wave motions in the space between the diaphragm and the insulator. A special shaped Teflon damping ring is introduced in order to overcome this. How this works is shown in Fig. 6. This standing wave effect is incidentally also present in ½″ and 1″ microphones but normally does not manifest itself within the working frequency range. In 1949 Isadore Rudnick proposed the effect as a reason for resonances in the W.E. 640 A.A. at 36 kc/s.*) The sensitivity and thus the com-

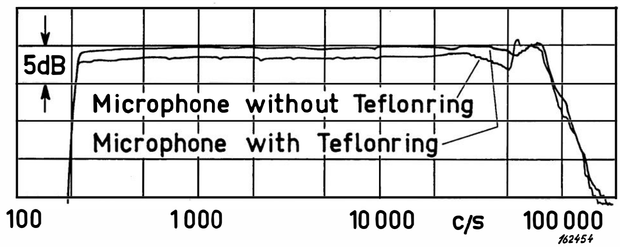

Fig. 6. Response curves illustrating the effect of using a specially shaped Teflon ring upon wave-motion in the space between the diaphragm and the insulator.

pliance of the type with 2 μ diaphragm is around 2—3 times that of the type with 6 μ. The resonance of the free moving diaphragms are the same. However, it is possible to damp the 2 μ diaphragm in order to compensate for the pressure increase in front of the diaphragm for 0° incidence and obtain a flat response above 120 kc/s still with good sensitivity.

The stiffness of the back space is kept very low in order to maintain the sensitivity stable at low ambient pressures as encountered at high altitudes. The stiffness is less than 8 % of the diaphragm stiffness as seen from the curves in Fig. 7. This again gives the equivalent volume of the microphone as less than o.0005 cm^3. The back space volume is o.005 cm^3. The resonance damping will of course decrease at low ambient pressure and it is interesting to see that Q values of the order of 500 are obtained for the diaphragm resonance at 14 mm of mercury. The equalization of the pressure from the back space takes place through a small slot to the front of the cartridge and it is adjusted to a lower limiting frequency of 1—5 c/s. The rate of climb allowed for less than 1 db change in sensitivity is greater than 20ooo m/sec.

The microphones are aged at 150°C for several days and exposed to controlled temperature variations for at least two weeks, during which period it is checked for stability. They are tested in a humidity chamber overnight and must work properly under normal conditions within 15 min. after they have been taken out from the humidity chamber.

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*) JASA Vol. 20, No. 6, 1948, I. Rudnick et M. N. Stein.

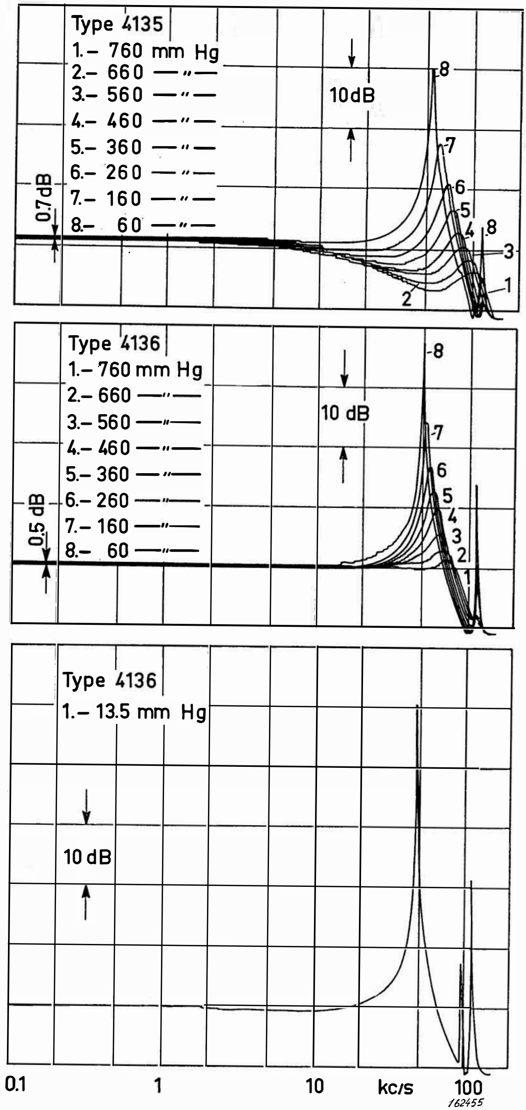

Fig. 7. Measurement of diaphragm stiffness and air damping.

Having produced condenser microphone cartridges for several years we have found it possible to avoid most of the troubles with moisture sensitivity normally believed to be an inherent failure in microphones of that type. This requires trained personnel and good working conditions, but once established it seems possible to prove that condenser microphones can be made to withstand even one of the most severe environments—the dessicator. People sometimes still store their condenser microphones in dessicators—an old practice maybe. But if there are any disturbing particles in the microphone they will dry out, maybe become loose and drop in between the diaphragm and back plate, or be attracted by the polarizing voltage when taken into use again. After 7—15 min. the microphone will sometimes get noisy when the dried-out particles absorb moisture again. Therefore we do not recommend the use of dessicators, although we try to make microphones which can stand this treatment.

By further miniaturization, employing the technique from which I have mentioned a few examples and peculiarities, it should be possible to extend acoustical measurements into fields hitherto not well investigated. Careful design may offer stability and accuracy comparable to that of the associated electronic instrumentation.