Warts and All.

"Mr. Lely, I desire you would use all your skill to paint my picture truly like me and not flatter me at all; but remark all these roughnesses, pimples, warts and everything as you see me, otherwise I will never pay a farthing for it."

(a remark attributed to Cromwell from "Walpole's Anecdotes of Paintings", Chapter 12.)

Oliver was seeking a faithful reproduction and be he telegenic, on television he would certainly show up that way.

The more faithful sound reproduction, the more critical we become of recording imperfections and incidental noises. In this issue we have something to say about low cost "warts and all" sound reproduction from small boxes. One listener claimed he could even smell the resin on the bows of the violins — such are the joys of an imaginative mind, perhaps many of us miss a little by rejecting some fantasy.

The romance of good sound at low cost is much with us and let us share it with you.

Quality Merchandise and Quality Merchandising.

Reliable performance and profitable merchandising do not necessarily demand high cost, but are factors essential to the dignity of successful business. Our contribution is high quality merchandise, continuity of supplies through the years, full technical information and from time to time a reflection on the problems of end product merchandising, ever topical, such as the warmly received "How Much Do Margins Matter?" article in the previous issue of OUTLOOK.
VIEWPOINT WITH MULLARD

SERVICE ENGINEER—AMBASSADOR EXTRAORDINARY

We still have a few of the “There is more To Service than repairing a Set” coloured posters, and the reprints “Service Engineer—Ambassador Extraordinary” and have been considering additional quantities of both.

It would assist our Technical Service Department if we could know the number of further copies required.

A small blue booklet—at least with a blue cover—is at present being distributed as complementary to the poster, being a direct link in our Mullard service engineer ambassador promotion. Something to promote the respect and dignity of the Servicing Industry by doing this from within and shining out. A booklet to be perused at a quiet and pensive moment, and when heeded, passed on to your retailer clients.

The travelling service engineer starts off with everything on his side. Unlike the door-to-door salesman, he is there by the customer’s invitation and is watched for and welcomed. In fact, there would be no end of a row if he failed to keep his date! These favourable circumstances put him in a unique position, not only to give the customer a good impression of the firm he works for, but also to do some positive “selling” on his employer’s behalf.

It is not suggested that he should become a glorified sales representative. His contribution to the overall sales effort is made in much more subtle ways, as shown in this booklet.

If you are a service engineer remember that you can play a vital part in “after-service sales”—keep this in mind when you are out on service calls!

MULLARD—AUSTRALIA

PERSONALITIES

... A BIRD IN THE HAND

"Well, it says MALLARD on the order and you know how annoyed this customer gets if we substitute!"

We believe Mullard means something in Australia—even if we say so ourselves—for that matter in Old England as well. In the Northern Hemisphere a mallard is a somewhat prolific species of indigenous duck. Be it fish or fowl, mullet is better known as a fish from these waters and Mullard is definitely not a corruption of the two.

We just thought that you would like this cartoon from one of our Mullard, U.K. journals, in that if we were preparing it locally the salesman would probably be endeavouring to shove a mullet into the carton! However, the theme is the same and we are glad that here, also, the customer specifies Mullard!

MR. JOHN D. WARD

We are happy to announce that John D. Ward has been appointed Senior Resident Representative in South Australia.

We must emphasise christian names for John Ward has Lew Ward the well-known and helpful Adelaide "valve man" as his associate and assistant; both on the same telephone number and both our members in South Australia.

Mr. John Ward has joined us after a long period of association with the guided weapon and aircraft industries: Previously with Westland Aircraft Limited at the Weapons Research Establishment at Salisbury, South Australia, he has specialised in telemetry and instrumentation and is an Associate Member of the Society of Instrument Technology, Australia.

Mr. Ward holds a Private Pilot’s Licence and is an active member of the Royal Aero Club of South Australia. He also has a special ready-made Mullard team stamp—ex R.A.F. and holds an Amateur Radio Transmitting Licence.

He will extend the Applications Engineering and Technical Service scope in Adelaide by projecting the facilities of our laboratory and technical-commercial engineering departments. With Messrs. John and Lew we go towards a greater Service in South Australia, with two more it would be precisely forward! We hope we have made our point and you have remembered the names, for the Wards are there to assist and extend the Mullard hand in conjunction with our good friends and South Australian distributors Telcon Australia Pty. Ltd.
MULLARD MINI SPEAKER UNITS
A DESIGN FOR SMALL LOUDSPEAKER HOUSINGS

Continuing the article in January-February, 1966, Vol. 9 No. 1 of Outlook, a small loudspeaker housing for bookshelf mounting is described. It is pointed out that the Mullard Mini Speaker Unit has been the result of a design study for a low-cost loudspeaker enclosure unit for application with solid state amplifiers. However, it is anticipated that many readers may wish to build this unit and it is understood that a number of approved kits will be available from component suppliers.*

The never ending hunt for adequate, smooth and hang-free bass reproduction has resulted in a continuous improvement in loudspeakers and loudspeaker enclosure design. Manufacturers have developed loudspeakers with lower and lower fundamental resonance, a host of enclosures, and more recently loudspeakers of much lower cone mass and substantially higher cone rigidity, for example, moulded cones of polystyrene foam; an illustration of the sensible application of entirely new materials when related to cone techniques.

It is not intended in this article to highlight physical limitations, efficiency and so on, but to accept that larger enclosures where space permits are a necessity to produce the ultimate in bass reproduction. Factors not readily accepted and more readily rejected where the real household controller has the last say! Nevertheless, where commonsense dictates, and there is adequate space and space it is relatively straightforward—the real challenge is to achieve this at low cost, with a small enclosure and perhaps a little compromise along the line.

The Specification

With a number of solid state amplifiers in mind, the introduction of new transistors enabling high quality sound amplification at low cost, it became necessary to provide the design of a complementary loudspeaker enclosure unit.

Physical Size: Whilst it has been briefly touched on in Outlook Vol. 9 No. 1 we believe that any small housing should fit into a bookshelf—not just sit on the top or on the floor! A survey of bookshelves shows that the height and depth of an enclosure must not exceed 8", and the length should not exceed 12" to 14" maximum.

Loudspeakers: From a low cost view it was considered essential that the loudspeakers be standard, locally-produced, commercial types. With an enclosure height of 8" the dimensions limit the loudspeaker size to 6" diameter or an oval type with relatively small cone area. For adequate power handling the voice coil diameter should preferably be a minimum of 1", and in view of the restricted enclosure cubic capacity the free cone resonance must be as low as practicable; also that the field flux be the highest consistent with the loudspeaker chosen. If a dual cone loudspeaker is inadequate, or for those who prefer transducers, provision was made for a tweeter. For optimum performance with the particular transformerless solid state amplifiers considered, a voice coil impedance of 7.5Ω was required.

Performance: To detail the performance specification is difficult, and perhaps better specified by something substantially flat from 50 cycles to 15,000 cycles, or at least to be practical, the best performance without exceeding the overall outside dimensions of 8" x 8" x 14".

Loudspeaker Choice

With the foregoing factors in mind the Magnavox 6WR loudspeaker came nearest the mark. It was found a tweeter was desirable and subsequently the new Magnavox Scottish Mark II tweeter was added. Messrs. Magnavox have advised that this tweeter, only recently developed, was designed as a companion for the 6WR loudspeakers where space limitations do not allow the use of their 525SIC tweeter. As the 6WR has been in use for some years there were many yardsticks on which to compare performance, although mounted in much larger enclosures.

The Design Combination

In analysing the ultra-small, totally-sealed enclosures employing high cost loudspeakers of low cone resonance, high mass and high compliance, it was evident with the 6WR that the first attempt with a sealed enclosure of 8" x 8" x 11", 490 cubic inches was inadequate, the cone resonance moved from 49 c/s in free air to 108 c/s, the enclosure being constructed of 1/8" thickness pine board. Space does not permit the reproduction of all the performance curves taken, for apart from completely sealed enclosures with various amounts of filling, figures were taken with enclosures having vented ducts of various diameters and lengths. Whilst theoretical considerations showed ducts in some cases up to 10" long, these were arranged in concentric form. The performance of the final design is shown in Fig. 1.

It must be pointed out that whilst the performance is considered more than adequate there was a strong temptation to further develop the enclosure. However, to achieve additional refinement it was considered that any improvement would be marginal, but having shown what could be achieved with low cost loudspeakers in small enclosures doubt further development will continue elsewhere—even with this particular loudspeaker and enclosure combination.

The experimental and comparative figures were taken with the enclosure in free air, subsequently performance curves and the final curve (see Fig. 1) was recorded with the enclosure situated against a wall.

From the final performance figures it will be seen when applying the Mullard Mini Speaker Unit, bass boost is not necessarily required, so offering a further cost advantage. It will also be noted from the performance figures that a measure of "presence" has been built in, which on listening tests provides a pleasing balance on the majority of present-day recordings.

Air Tight Housing Essential

Before describing the final cabinet design it must be stressed that it is essential the enclosure be completely airtight. To obtain this with the prototypes, and also to gain the maximum inside capacity the enclosures were constructed of 1/8" thickness pine board, the corners mitred, front and back...
ENCAPSULATED MODULE FOR THYRISTOR CONTROL

A new Mullard thyristor firing module (MY5011) recently introduced is designed for single-phase operation, but can also be directly incorporated into three-phase systems.

The module will fire four 70A thyristors connected in parallel or in series and provides continuously variable and reliable control over a range from 0.25% up to 99.9% of maximum power.

The module forms the basis of a very cheap and simple thyristor control; the only other requirements of a complete system are a feedback signal or potentiometer to control the firing angle of the thyristors, and an external AC supply of 30-0-30V (obtained from an isolating transformer).

Small size (9.14 x 6.60 x 4.82cm), rugged construction and the protection of an epoxy resin encapsulation make the module suitable for use under the most arduous conditions.

Connections to the module are by soldering tags or individual push-on connectors. A simple, single-phase module (MY5000) capable of driving two 70A thyristors is also available.
MULLARD TRAVELLING WAVE TUBES

Mullard travelling wave tubes in communications links joining New York with San Francisco and Montreal with Vancouver have completed over 100 million tube-operating hours. Many tubes are still operating at full efficiency after 20,000 hours of continuous use.

Won against fierce international competition, including bids from U.S. Firms, the contracts to build these tubes for R.C.A. companies confirmed Mullard as the leading producer of travelling wave tubes. Design, costs, the resources to mass-produce such specialised devices and the ability to make them consistently were decisive factors which have since influenced other equipment manufacturers.

While the tubes in the North American links give 10W saturated power output in the 6Gc/s band there are now in the Mullard range communications tubes of twice that power—the most advanced devices yet produced for microwave communications. These 20W tubes double the channel capacity of microwave links, or greatly extend their range, without increasing the a.m./p.m. distortion and with negligible increase in operating costs.

MULLARD TRAVELLING WAVE TUBE RANGE

<table>
<thead>
<tr>
<th>Power Output (W)</th>
<th>Frequency Gc/s</th>
<th>Forward Wave Amplifiers</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.0</td>
<td>3.8-4.2</td>
<td>LB4-8</td>
<td>Wideband communications links</td>
</tr>
<tr>
<td>12.0</td>
<td>5.9-7.125</td>
<td>LB6-12</td>
<td>Wideband communications links</td>
</tr>
<tr>
<td>250.0 (peak)</td>
<td>~ 3.0</td>
<td>LB3-25</td>
<td>Driver chain in high power radars</td>
</tr>
<tr>
<td>20.0</td>
<td>3.8-4.2</td>
<td>LB4-20</td>
<td>Communications systems of very high capacity</td>
</tr>
<tr>
<td>10.0</td>
<td>5.9-7.125</td>
<td>LB6-10</td>
<td>Wideband communications links</td>
</tr>
<tr>
<td>15.0</td>
<td>5.9-7.125</td>
<td>LB6-15</td>
<td>Wideband communications links</td>
</tr>
<tr>
<td>20.0</td>
<td>5.9-7.125</td>
<td>LB6-20</td>
<td>Communications systems of very high capacity</td>
</tr>
<tr>
<td>5.0</td>
<td>6.9-7.9</td>
<td>LB7-5</td>
<td>Point-to-point TV links, private communication systems</td>
</tr>
<tr>
<td>20.0</td>
<td>7.9-8.9</td>
<td>LB8-20</td>
<td>Communications systems of very high capacity</td>
</tr>
<tr>
<td>3.0</td>
<td>8.9-11</td>
<td>LA9-3B</td>
<td>Wideband tubes for radars</td>
</tr>
</tbody>
</table>

A typical travelling wave tube which, together with the mount, incorporating periodic permanent magnets for focussing, forms the travelling wave amplifier unit.

BACKWARD WAVE TUBES

<table>
<thead>
<tr>
<th>Power Output</th>
<th>Frequency</th>
<th>Type</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>10mW</td>
<td>11-18 tunable</td>
<td>BA16-10</td>
<td>Wideband radars</td>
</tr>
<tr>
<td>50mW</td>
<td>8-12 tunable</td>
<td>YH-1100</td>
<td>Wideband radars also with Mullard spin tuned magnetron in diversity radars: signal generators</td>
</tr>
</tbody>
</table>
THE USE OF SILICON TRANSISTORS
IN THE ELECTRONIC ORGAN

This article intends to illustrate the use of silicon transistors in this application, and further elaborations such as tone filter networks, pre-amplifiers, stop tabs and keyboards will not be discussed.

Described are two oscillators suitable for use in an electronic organ. The first type is typical as used in instruments incorporating individually tuned oscillators for every half-tone of the musical scale. The second type is unusual in that the one unit covers the two octaves of bass pedal frequencies by a saturable reactor and voltage control.

Tone generation in commercial and non-commercial organs has shown quite some promising if not unusual methods in the past. Some have used master oscillators and frequency divider chains consisting of multivibrators, counter circuits, sawtooth generators, neon trigger circuits and synchronised blocking oscillators and output tuning and voicing as found in the classical human ear. Sounds that can be obtained from divider-type instruments appear quite hard and unreal.

This stems from the fact that mathematically exact ratios within octave relationships are not correct or pleasing to the human ear. Sounds that can be obtained from divider-type instruments appear quite acceptable to a good proportion of people, to others, quite 'hard' and unreal.

Square, triangular and sawtooth waveforms as obtained from frequency dividers when converted can make very realistic voices, and can, after very sophisticated filtering, make reasonable flute voices. The greater proportion of a flute (or tibia) voice is sine wave, with only a mere suggestion of upper harmonics. The main problem with sharp waveforms is that of filtering out all harmonics of the fundamental. For every key of a 61 note manual such a set of filters would prove quite cumbersome.

The easier solution would be to design a generator supplying two waveforms such that a generator would need to produce a sine wave and a waveform rich in upper harmonic content.

Increased frequency stability and efficiency is achieved by utilising the properties of the Hartley-type class C oscillator. From this type of oscillator two waveforms are available. One is a sine wave, the other an angular portion of each tip of the same fundamental wave.

The oscillator coil was designed around a standard wasteless EI lamination which is used in the smaller erase coil audio output bobbin-wound transformer. The existing clamp was modified to enable a hinging of the 'T' laminations. This, with a long 4BA steel bolt, nut and reasonably strong compression spring provides the variable gap tuning facility. When adjusted correctly, this method of tuning is comparable to any screw core coil.

The coil was scramble wound on a suitable nylon bobbin and provided with two tappings; the lower being connected to the supply and emitter drive resistor. A typical inductance value was found to be approximately 12H with the core adjusted to a 0.025" gap.

OSCILLATOR CIRCUIT
The circuit is shown in Fig. 1. The Mullard type BC108 n-p-n silicon planar transistor was chosen because of its high current gain. This allows the user to make use of a simple bias arrangement to ensure reliability of cut-off at the negative swing of each cycle. As a result of this, a proportionally small value of base coupling capacitor can be used when compared to the resonating capacitor.

Fig. 1—Circuit Diagram of the Manual Oscillators (for values of CP and CS—See table).

The high dynamic input impedance of the transistor under oscillatory conditions matches the tuned circuit by transformer action. This is a good feature as wave form distortion of the sine wave is not as great as if the circuit were loaded by mismatch conditions.

A Q of 10 was obtained by placing the emitter drive tapping at a ratio of no less than 5.5:1; with a 3760 turn coil, this would amount to 680 turns. Using this current, a 560Ω series resistor from the emitter allows a constant current drive to the tuned circuit. The conduction angle is set at approximately 60° by the 150 kΩ resistor, R2.

The second harmonic is provided by the full-wave rectifier consisting of diodes D1 and D2. These are only used to extend the range of the instrument into the 'T' pitch, saving 12 additional oscillators to achieve this pitch at the top end of the keyboard. Lower frequencies do not necessitate this feature, as this is provided by the oscillators above them. (See dashed components in Fig. 1)

Frequency range of this oscillator extends from 64 c/s to 4186 c/s. Different values of CS and CP for different frequencies can be selected from the table entitled "Recommended values of capacitors "Cp and CS in circuit Fig. 1, for frequencies from 60 c/s to 2000 c/s."

BIAS AND TREMOLO
Fixed bias is applied to the generator system through a separate regulator transistor. Provision is made in the bias circuit for 'Chorus' and 'Tremolo'. Chorus is applied by slightly altering the bias (and therefore the pitch) in different octaves by switching the bias voltage divider so that some octaves receive more and some receive less bias than at which the generators were originally tuned.

Chorus in individually tuned generators is equivalent to the sound of an ensemble of musical instruments where at any instant no two in the group are exactly in tune with each other. This is most effective when a complex chord is played.

Tremolo is introduced simply by modulating the bias regulator with a low frequency sine wave of the order of 5-7 c/s. This in turn will result in small frequency variations in the tones produced.

Outputs from the generator as taken from points 1, 2 and 3 are fed to the keying and voicing circuits.

TEMPERATURE Vs. FREQUENCY STABILITY
One complete generator was subjected to a frequency/temperature test run. Best temperature stability was achieved by using a steel tension bolt in preference to a brass one on the transformer assembly. Stability for brass and steel tension bolts are shown in the graph Fig. 2.

Fig. 2—Temperature v. Frequency stability graph plotted for brass and steel tension bolts.

BASS GENERATOR
A basic requirement of two octaves of pedal frequencies as applied to electronic musical instruments has never been a great problem where either frequency dividers or a string of single-pitch oscillators are used. Various methods of generation are employed, but the most pleasant and deepest
sounding bass has always come from a waveform that is essentially a sine wave with very little upper harmonic content. The basic fundamental tone is sometimes slightly modified to add a character of richness to the basic tone by mixing in an upper harmonic or modifying the fundamental slightly.

The fundamental sine wave appears at the junction of D₁ and R₅. At this point a low impedance output is available; pulse output is taken across R₆ through C₆. The Q of the circuit was once again kept at an approximate figure of 10 by placing the emitter drive tapping at no less than a ratio of 5.5:1. On a 2,000 turn coil, the tap was at 365 turns. By using this ratio, a 390Ω series resistor from the emitter permitted a constant current drive to the tuned circuit, with the conduction angle set at approximately 65° by means of the 220 kΩ resistor, R₆.

**CONTROL CIRCUIT**

The base voltage of transistor TR₁ is determined by the charge across the capacitor C₁. Transistors TR₂ and TR₃ are directly coupled to TR₁, thus obtaining an amplified current change to the control windings. The contact assembly S₈ derives a bias voltage from the series string of potentiometers which form a voltage divider.

Different frequencies are chosen by S₈ selecting these potentiometers and the small vernier adjustment to tune the oscillator to the exact frequency is established by the particular potentiometer selected.

The second section of the contact assembly S₁₀ switches on a normally off keying circuit a moment after the oscillator has been tuned. When S₁₀ returns to its rest position, the keying circuit will continue to pass the signal until it is cut off. Even though the keyer is off, the oscillator will continue to oscillate with a slowly decreasing frequency depending on the time constant of C₁ and leakage of transistor TR₁.

The resistor R₇ limits the control current to a value necessary to produce a frequency slightly above the desired maximum of 132 c/s. The resistor R₈ also swamps the adverse effect on the frequency due to the leakage of C₁.

**TEMPERATURE STABILITY**

Both oscillators exhibit a temperature stability well within the acceptable limits required by musical standards. This is because a class C oscillator conducts only for a fraction of a complete cycle, and the temperature stability will mostly be dictated by the characteristics of the tuning coil and resonating capacitor. Because the BC108 silicon transistor is used in this circuit, the temperature drift due to changes in transistor parameters is kept to a minimum.
CHARACTERISTICS OF PROTOTYPES

Manual Oscillator
Output voltages:
- Pulse: 200 mV
- Second Harmonic: 125 mV
- Fundamental: 1.2 V
- Frequency stability < 0.1% for 20°C ambient temperature change.

Bass Pedal Oscillator
- Frequency range: 30 c/s - 130 c/s
- Control Current: 0 - 40 mA
- Output voltages:
  - Pulse: 200 mV
  - Second Harmonic: 350 mV
  - Fundamental: 1 V

OSCILLATOR TRANSFORMER SPECIFICATIONS
- N1 : N2 : N3 = 1: 1: 1.5
  - Inductor winding: 3,760 turns 38 B&S D.T.E. taps at 2,600 and 3,180 turns
  - Core: ¾" wasteless medium resistance ¾" stack
  - Clamp: Standard ¾" (modified see sketch)

COMMERCIALLY AVAILABLE WOUND COMPONENTS

Special* Ferguson*

<table>
<thead>
<tr>
<th>Saturable Reactor</th>
<th>Type No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 3348</td>
<td>770</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adjustable Oscillator Transformer</th>
<th>Type No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST 3494</td>
<td>(kit set only)</td>
</tr>
</tbody>
</table>

*Special Transformers Pty. Ltd.
139 Sydenham Road,
Marwickville, N.S.W.
Tel. 56 7287.

Ferguson Transformers Pty. Ltd.
331 High Street,
Chatswood, N.S.W.
Tel. 40 0261.

RECOMMENDED VALUES OF CAPACITORS C4 & C5 IN CIRCUIT

<table>
<thead>
<tr>
<th>Generator Frequency</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 c/s to 2,000 c/s</td>
<td>(μF)</td>
<td>(μF)</td>
</tr>
<tr>
<td>1000</td>
<td>0.01</td>
<td>0.01</td>
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<tr>
<td>1500</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>2000</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>

REFERENCES:
Electronic Organ Handbook.
H. Emerson-Anderson.
The Contemporary American Organ.
William H. Barnes.
Transistor Circuit Engineering.
Service Manuals of Representative Commercial Electronic Organs.
Electronic Music is Here.
Vol. XXXIV No. 2.
Electronic Organ Tuning Made Easy.
Vol. XXXIV No. 7.

G. F. HUGHES,
Applications Laboratory—Sydney.

Reprints of the printed wiring board drawings for both oscillators are available upon receipt of a stamped addressed envelope no smaller than foolscap size endorsed "Oscillator".
A MEDIUM POWER AMPLIFIER employing two new Transistors AC187 and AC188

Two new transistors have recently been added to the Mullard range, making possible an economical 2.5W audio frequency amplifier. These transistors are the complementary output pair AC187 and AC188; preliminary abridged data is tabulated at the end of this article.

In addition to the new germanium output pair the amplifier employs n-p-n transistors, the BC108 and BC109, recently added to the preferred silicon range of entertainment transistors.

Circuit Description

The circuit diagram of one channel of a stereophonic amplifier is shown in Fig. 1. The pre-amplifier stage uses transistor types BC108 and BC109, the driver stage employs an AC125, and the output stage the complementary pair AC187 and AC188. The circuit is designed to give full output with a high impedance pick-up cartridge having an output of 60mV, i.e. 60mV via 500pF capacitor.* If a high output cartridge is used or the amplifier fed from a radio source then one of the pre-amplifier stages could be omitted.

Some degree of negative feedback is introduced in the first pre-amplifier stage by leaving the emitter resistor R1 undecoupled. Overloading is thus prevented up to and including an input of 1.1V.

If increased sensitivity is required, this can easily be achieved by decoupling the emitter resistor R1 with an electrolytic capacitor in the conventional way.

Fig. 2 shows the frequency response of the amplifier with the treble cut tone control in its extreme positions. It may be seen from the curve that 7dB of bass boost are employed at 90c/s in relation to the mid-frequencies by using a frequency dependent network in the feedback path of the amplifier between the centre point of the output pair and the emitter of TR1.

This type of amplifier is likely to be used in portable record players with small loudspeakers having relatively poor bass parameters. The additional 7dB of bass boost employed in this amplifier will compensate for this; if bass boost is not required the frequency dependent network, R11, R12, C12, and C13, could be replaced by a single 560Ω resistor.

The output transistors are attached to a heatsink of four square inches of 16 gauge aluminium to ensure thermal stability for ambient temperatures up to 45°C. This heatsink area represents the minimum requirement under normal conditions.

If the output transistors are used near another heat radiating component, then the heatsink area should be increased accordingly.

LIST OF COMPONENTS

<table>
<thead>
<tr>
<th>RESISTORS</th>
<th>CAPACITORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>All resistors 1/2W, 10% unless otherwise stated</td>
<td>All capacitors in μF, 10% unless otherwise stated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Circuit Ref.</th>
<th>Value</th>
<th>Description</th>
<th>Circuit Ref.</th>
<th>Value</th>
<th>Description</th>
<th>Rating</th>
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<tbody>
<tr>
<td>R1 P80</td>
<td>180 kΩ</td>
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<td>C1</td>
<td>0.0056</td>
<td>Polyester</td>
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<tr>
<td>R2 P180</td>
<td>1 MΩ</td>
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<td>C2</td>
<td>0.056</td>
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<td>0.01</td>
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<td>1/2W lin.</td>
<td>C5</td>
<td>0.22</td>
<td>Polyester</td>
<td>125V</td>
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<td>R6 P50</td>
<td>50 kΩ</td>
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<td>R7 P250</td>
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<td>0.47</td>
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<td>100 kΩ</td>
<td>1/4W lin.</td>
<td>C8</td>
<td>820μF</td>
<td>Polyester</td>
<td>125V</td>
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<td>R9 P82</td>
<td>82 kΩ</td>
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<td>10VW</td>
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<td>R10 P6.8</td>
<td>6.8 kΩ</td>
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<td>400</td>
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<td>R11 P10</td>
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<td>32</td>
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<td>R12 P270</td>
<td>270 Ω</td>
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<td>R13 P1.8</td>
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<tr>
<td>R14 P1.8</td>
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<tr>
<td>R15 P560</td>
<td>560 Ω</td>
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<tr>
<td>R16 PVA-34 N.T.C.</td>
<td>Wire wound</td>
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<td>R17</td>
<td>39</td>
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<td>R18</td>
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<td>R19</td>
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<tr>
<td>R20</td>
<td>680</td>
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<td>R21</td>
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<th>MULLARD TRANSISTORS</th>
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* The matching and equalisation of Piezo-electric Pick-ups was described in Outlook, Vol. 8, No. 5, Sept./Oct., 1965, page 79.

Ed.
A Medium Power Amplifier

It may be seen from the curve shown in Fig. 3 that the total harmonic distortion is less than 1% for a power output of 1W, 1.35% for 2W, rising to 10% at 3W, making the amplifier most suitable for medium power record players and in low cost solid state radiograms. It may be used either as a single channel amplifier or by duplicating the circuit as a transistor stereo amplifier using the small bookshelf enclosures described elsewhere in this issue.

Summary of Amplifier Performance

Power output at 10% distortion 3W
Power output before clipping 2.2W
Sensitivity for 2.5W output from 500pF source 60mV
3dB frequency response 25c/s-15kc/s
Power requirements for 3W output 15V at 350mA

It will be a month or two before the AC187 and AC188 are available through trade channels, in the meantime receivers and record players will appear equipped with these types.

R. E. BROWN
Applications Laboratory, Sydney

COMPLEMENTARY GERMANIUM MEDIUM POWER TRANSISTORS

AC187 — AC188

The AC187 and AC188 alloy junction transistors are intended for use in medium power complementary symmetry Class B output stages.

ABRIDGED PRELIMINARY DATA

| V_CBO | max. | 25 | 25 |
| V_CBO | max. | 15 | 15 |
| I_CM | max. | 2  | 2  |
| P_INT at T_case 58°C | max. | 0.8 | 0.8 |
| h-fe at I_c 0.3A | > 100 to 500 | 100 to 500 |
| | > 10 | 7 |

RATINGS (Limiting values)

Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

Thermal Resistance R_TH-jc 40 40 °C/W

Characteristics

Leakage currents

| V_CE 10V; T_j = 25°C | I_CBO | 25 | 15 |
| V_CE 10V; T_j = 90°C | I_CBO | 2  | 1  |
| V_CE 25V; T_j = 25°C | I_CBO | 0.1 | 0  |
| V_CE 25V; T_j = 90°C | I_CBO | 2.5 | 1  |
| V_CE 50mA; V_CE = 2.5V | I_RHO | 0.1 | 0 |
| V_CE 50mA; V_CE = 2.5V | I_RHO | 2.5 | 1 |

Cut-off frequency

I_C = 1mA (I_CBO value for which I_C = 1mA at V_CE = 1V) V_CE < 0.8 0.6 V

Base-emitter voltage and DC current gain

| V_BSE (mV) | AC187 | AC187 | AC188 | AC188 |
| V_HFE | 100 to 130 | 70 | 115 to 145 | 70 |
| V_HFE (mV) | 100 to 130 | 70 | 115 to 145 | 70 |
| V_BSE | < 350 | 90 to 450 | < 280 | 90 to 450 |
| V_BSE | < 660 | 95 to 500 | < 550 | 95 to 500 |
| V_BSE | < 900 | > 50 | < 700 | > 80 |

Outline and Dimensions

Conforming to J.E.D.E.C. TO-1
SILICON DIODE BY100 — 750mA

The BY100 was added some years ago to the preferred range of Mullard Silicon Diodes. It is one of the most widely used rectifiers in the comprehensive range of Mullard High Efficiency Silicon Double Diffused Junction Diodes.

Whilst this diode provides excellent performance technically, development proceeded and has resulted in an improved heat transfer from junction to case thereby making possible a current uprating \( I_{fa} \) from 550mA to 750mA. The graph depicts the current derating for elevated ambient temperatures as well as for inductive and capacitive load when used in conventional rectifying circuits.

Maximum transient peak rating of 1250V makes the BY100 suitable for rectifier applications where 800V repetitive peak reverse voltages are normally encountered together with switching transient voltage spikes in 240V mains.

MAP OF THE WORLD CENTRED ON PERTH

Readers may be interested to know that the wide acceptance of the recently released Mullard Great Circle Map has already necessitated a second printing.

Whilst this chart has been centred on Sydney as a compromise for N.S.W., Southern Queensland, Victoria and South Australia, a separate chart has been compiled centred on Perth.

The map for our friends in Perth is printed in one colour only and identical to the original Great Circle Map of the World in multicoloured print. It also measures 2' x 3' and is an azimuthal equidistant projection of the World. A complete 1966 listing is provided tabulating approximately 400 countries together with their prefixes.

It is suggested that the Great Circle Map is mounted on to strawboard approximately \( \frac{1}{4} \)" thick. With certain types of strawboard, particularly the lighter variety, there is a tendency to warp and in order to counteract this, it is suggested that a sheet of neutral paper is applied to the other side.

PLEASE NOTE

The map centred on Perth is available only from the Mullard Distributors in Western Australia

Tedco Pty. Ltd.
579 Murray Street,
PERTH, W.A.
for $1.00 each plus $0.11 for packing in a cardboard mailing tube to avoid damage and $0.09 postage.

Cheques, money orders and postal notes should be made payable to "Mullard-Australia Pty. Ltd."

The current uprating is also applicable for OA650, OA660 and OA670 Silicon Diodes which are identical to the BY100 except for peak reverse voltages of 500, 600 and 700V respectively.

CHIEF ENGINEER OVERSEAS

Mr. H. S. Watson, Mullard - Australia Chief Engineer, will leave Sydney on the 17th of May, 1966 for overseas. He will visit our parent company in the U.K., also visit the Continent, United States and Canada. Mr. Watson expects to return mid-July. During his absence Mr. R. Donohoe will be acting on his behalf.

FOUR-STAGE PHOTOMULTIPLIER

TYPE XP1114

The XP1114 has an overall gain of 4mA/1m and a cathode sensitivity of 40µA/1m. Because of its small size and rugged construction it is particularly suitable for missile and space-vehicle instrumentation.

CURRENT LIMITING MODULE

The MY5051 current-limiting module has been designed to be used in conjunction with existing thyristor firing modules and stacks.

The MY5051 enables single-phase or three-phase control systems to provide automatic correction for load current variations or short circuit conditions as well as start facilities for motor controls.

When the module is connected in a feedback circuit between a current transformer (or another current sensing device) and a thyristor module, the onset of the current limit occurs when the input to the MY5051 is 2.6V r.m.s. At lower inputs the MY5051 has little effect on the control circuit, but at higher inputs the trigger angle of the thyristor is rapidly increased.