"At Christmas play and make good cheer For Christmas comes but once a year."

THOMAS TUSSER.

The Australian Christmas scene is far removed from the traditional concept of yule log fires, frost and snow and robin redbreasts — nevertheless, the traditional roast turkey is still enjoyed *al fresco* on the beaches and picnic grounds.

How does the festive season affect you — the busy retailer who is enjoying, we hope, a steady volume of business?

You will leave others to bask in the sun while you’re out on those last-minute calls — installing TV sets, servicing radio receivers and getting family record players in trim for the festivities.

But after you have shut up shop on Christmas Eve, there will be time for rest and relaxation — you will certainly have earned it.

There is a unanimous feeling of optimism within the Industry for the year ahead — and much to justify this. Enterprise and initiative will all play their part in the months ahead — the festival of Christmas is a good time to restore your energies for 1965.

We wish you a Merry Christmas and a Prosperous New Year!

EDITOR.
"THE TELLY MAN" 

"It's the small, everyday things that count. Like wiping your shoes on the mat . . ."

Today he's handling some 3,900 calls a year. With his present resources that marks the peak. "When I'm ready to expand," he said, "I shall do it in my own way. It will mean a complete duplication of my present set-up. You see, I'm only interested in working with technicians who look at their job as I do. I'm only interested in sheer professionalism with no skimping."

A Sixth Sense

"The Telly Man's" service van is a familiar sight in the neighbourhood. It's equipped with a complete set of test gear, all the tools he's ever likely to need and, of course, Mullard valves, picture tubes and other components. ("I seldom use any other, he says. "You don't get too many call-backs with Mullard valves.")

"Through long experience," he told us, "I can usually pin down the area of a fault in about 15 minutes, employing diagnostic technique rather like the doctor's. Have you ever wondered how he asks you questions first, then studies you while you answer and finally examines you? "Of course, the doctor has an advantage over me. His patients can talk back. Mine can't!"

For all that, as we saw, our friend relies heavily on the customer's evidence for his diagnosis. When did it happen? Has it happened before? How old is the set? When was it last serviced? These are the sort of questions he poses — with the polish of a barrister — before he touches a switch.

It may sound a lengthy process, but in fact he claims to give the fastest service so far as actual execution of the work is concerned. About 95 per cent of his work is on a cash basis. "It means less accounting and fewer bad debts. My bad debt figure for last year was negligible."

12-Hour Day

With a "beat" which has a radius in excess of 12 miles, his working day is seldom shorter than twelve hours — and that doesn't include the hour spent on paper work in the morning. Like many who serve the public his phone calls are diverted from office to home out of normal business hours.

Extra Little Something

What tips our friend offer to the service man whose work frequently takes him into customers' homes?

"It's largely a matter of common sense and common politeness. But there are one or two points which might seem trivial, but are in fact important. Never turn the set upside down without making sure that the chassis bolts haven't been loosened. Always remove at least one of the legs of a set when working on the base — it will give you more room. Do insure yourself against every possible kind of accidental damage. Always finish by dusting the set and giving the screen a polish. It adds that extra little something to a good service job, well done."

Mr. J. A. Kitchen

John Kitchen has been with the Sales Division of this Company for over seven years and, during that time, he has become well-known to the purchasing officers of our customers in the TV and Radio Manufacturing Industry.

Prior to joining the Mullard organisation, John travelled for twelve months throughout England and the Continent before making Sydney his permanent home. He was born and educated in England and originally came to this country twelve years ago. John enjoys the theatre and his weekends are spent surfing and playing an occasional game of golf.

Binders for Outlook

In response to a number of enquiries from regular Outlook readers, we have prepared a plastic binder designed to contain up to three volumes of Outlook. The method of securing the copies into the binder is unique and new to Australia, and individual copies may be removed and re-inserted with ease. A self-adhesive, interchangeable strip from which appropriate portions may be detached for titling purposes, will be supplied with each order, thus making the binder suitable for past and future issues.

The anticipated charge for these binders will be approximately £1-5-0d. If you are interested in this offer, please complete and return the enclosed pre-paid postcard, which is designed to assist us in estimating the total requirement. Please do not include any remittance.
THE MULLARD PELTIER BATTERY AIDS RESEARCH

The Mullard Peltier battery PT47/5, designed for specialised cooling applications, has in this instance been adapted for use in the field of histology (the study of the minute structure of anatomical cells).

The battery has been attached to a freeze microtome which is used to prepare biological tissue for examination under a microscope, by firstly freezing the tissue and then cutting sections of desired thicknesses (5-50μ). The conventional freezing stage of this microtome was replaced by the Peltier battery. Normally, the freezing is effected by allowing liquid CO₂ to become gas under the metal stage which carries the tissue. The CO₂ freezing stage has two major disadvantages in that the temperature of the frozen tissue varies greatly and the cylinder containing CO₂ may have to be replaced during an experiment.

The Peltier battery PT47/5 contains 47 series-connected semiconductor thermo-elements*. The upper side of the unit is provided with a flat copper plate for "cold exchange" and works on the principle that, when a direct current is passed through a junction of semiconductor materials (bismuth telluride) a temperature gradient is established across the junction. Since the Peltier battery works on the cooling-gradient-principle, water is circulated through the battery so that the final temperature of the biological tissue is indirectly determined by the water temperature. The major advantage of this system is that the freezing of biological tissue can be kept at a constant temperature during sectioning.

* See also Outlook, Volume 7, Number 2, page 20.

THREE PLANAR TRANSISTORS MEET GENERAL APPLICATION REQUIREMENTS

With the introduction of three new n-p-n planar transistors—the BFY50, BFY51 and BFY52—the task of transistor-selection for a wide range of professional equipment is simplified.

These devices are truly general purpose, and may be used in many different circuit configurations in a wide range of amplifying, oscillating and switching applications.

A significant feature of the transistors is the exceptionally low saturation voltage. The values of 200mV for the BFY50 and 350mV for the BFY51 and BFY52, measured at a collector current of 150mA, are typical of germanium rather than silicon devices. The current gain is maintained over four decades of current, and the value of fτ, greater than 50Mc/s, enables most general-purpose applications to be readily met.

Instead of being faced with a multiplicity of type numbers for particular applications, the designer will be able to use a few general-purpose types for all but the most specialised applications. Limited quantities are currently available.

Brief data for the BFY50, BFY51, and BFY52 are given below.

Abridged Preliminary Data

<table>
<thead>
<tr>
<th>Transistor</th>
<th>BFY50</th>
<th>BFY51</th>
<th>BFY52</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCE (max)</td>
<td>+80</td>
<td>+60</td>
<td>+40</td>
</tr>
<tr>
<td>VCBO (sat)</td>
<td>+80</td>
<td>+60</td>
<td>—</td>
</tr>
<tr>
<td>VCEO (sat)</td>
<td>+200</td>
<td>+350</td>
<td>+350</td>
</tr>
<tr>
<td>hFE (Ice=150mA)</td>
<td>&gt;30</td>
<td>&gt;40</td>
<td>&gt;60</td>
</tr>
<tr>
<td>fτ (Vce=+6V, Ic=50mA)</td>
<td>&gt;60</td>
<td>&gt;50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>PT (max) (Tambient=25°C)</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Tj (max)</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Three Mullard silicon n-p-n transistors for industrial and professional applications. Types BFY50, BFY51 and BFY52 are manufactured to the internationally standard size in TO-5 encapsulation.
HIGH Q-FACTOR COILS

Recent advances in equipment design in the communications industry have produced more stringent requirements for inductive components. Inductors have had to be made smaller whilst retaining the same value of Q-factor, or have had to yield appreciably higher Q-factors for the same size. These requirements can be met by the Mullard range of Vinkor adjustable pot-core assemblies which enables compact inductors with high Q-factors to be manufactured for operation at frequencies from 400c/s to 15Mc/s.

Definition of Q-Factor

The Q-factor of a coil is defined by the equation:

\[ Q = \frac{\omega L}{R} \]  

(1)

where \( \omega L \) is the inductive reactance of the coil, and \( R \) is the total effective resistance, that is, the sum of all the core and coil losses. To achieve the highest Q-factor for a particular coil, \( R \) must be kept to a minimum. In other words, the losses associated with the coil and core must be as low as possible.

With the modern generation of inductors based on Ferroxcube pot-core assemblies, the loss factor is normally expressed in a form independent of frequency and inductance value. Thus:

\[ \tan \delta_{tot} = \frac{1}{\omega L} \]  

(2)

from Eq. (1) \( \tan \delta_{tot} \) is the sum of the loss factors associated with the Ferroxcube core and the winding.

Losses in the Winding

For the winding, the losses consist of the DC loss, the eddy-current loss, and the dielectric loss caused by the self-capacitance.

DC Loss

The DC loss factor for the coil, \( \tan \delta_{dc} \), is given by:

\[ \tan \delta_{dc} = \frac{R_{dc}}{\omega L} \]  

(3)

where \( R_{dc} \) is the DC resistance of the coil. This resistance can be minimised by choosing the largest possible core with the highest suitable permeability, and using the largest gauge of wire that will fill the bobbin. The DC loss predominates at the largest gauge of wire that will fill the bobbin. The DC loss factor is normally expressed in a form independent of frequency and inductance value. Thus:

\[ \tan \delta_{tot} = \frac{1}{\omega L} \]  

(2)

where \( \omega L \) is the inductive reactance of the coil, and \( R \) is the total effective resistance, that is, the sum of all the core and coil losses. To achieve the highest Q-factor for a particular coil, \( R \) must be kept to a minimum. In other words, the losses associated with the coil and core must be as low as possible.

With the modern generation of inductors based on Ferroxcube pot-core assemblies, the loss factor is normally expressed in a form independent of frequency and inductance value. Thus:

\[ \tan \delta_{tot} = \frac{1}{\omega L} \]  

(2)

from Eq. (1) \( \tan \delta_{tot} \) is the sum of the loss factors associated with the Ferroxcube core and the winding.

Losses in the Core

The losses in the core are made up from the residual and eddy-current loss, and the hysteresis loss.

The residual and eddy-current loss is controlled during the production process of Vinkors, and the value of this loss factor, \( \tan \delta_{r+e} \), is shown on the individual Vinkor data sheets. A significant reduction in this loss has been achieved with the Violet range of Vinkors.

The hysteresis loss factor, \( \tan \delta_h \), is given by:

\[ \tan \delta_h = \frac{F_i I_L}{2\pi} \]  

(7)

where \( F_i \) is the hysteresis factor shown on the individual Vinkor data sheets, \( I \) is the r.m.s. current in amperes, and \( L \) is the inductance in henrys. Normally this current is negligibly small and the hysteresis loss may be neglected.

Evaluation of Q-Factor

When all the losses have been evaluated, the Q-factor for a particular inductance and frequency can be found from the equation:

\[ Q = \frac{1}{\tan \delta_{tot}} \]  

(8)

derived from Eq. (2).

Other factors such as size and temperature coefficient influence the final design; these normally confirm the choice of a suitable Vinkor for the inductor before commencing the coil design.

Comprehensive design data and relevant information on Vinkor pot cores and Ferroxcube transformer cores may be found in Volume 6 of the Mullard Technical Handbook and in the Mullard publication "Vinkor Manual" available from Mullard offices and distributors throughout the Commonwealth, priced at 5/3d plus 8d postage.

The core assembly LA2208 is shown on the left, mounted into the conventional Vinkor housing; and on the right, assembled into the low-cost clip and base available for insertion into printed wiring.
The Mullard BZY78 is a silicon reference diode with a zener voltage of 5.1 to 5.6V. It has a voltage stability of ±1% at a zener current of 11.5mA±10%, in ambient temperatures between −50 and +100°C. The investigation discussed in this article determined how the voltage stability could be improved by stabilising the zener current and restricting the temperature range.

**Temperature Coefficient**

There are two reverse breakdown mechanisms exhibited by semiconductor diodes. Low resistance material, which has a high level of doping, gives very narrow p-n junctions which break down by internal field emission. The original theory of this form of breakdown is due to Zener, and for this reason all diodes with this characteristic are called zener diodes. In material with a lower level of doping, avalanche breakdown occurs due to ionisation by collision, which will occur at a lower voltage than that required for zener breakdown. Thus, at a specific doping level there is a transition from true zener to avalanche breakdown. This point also depends upon the current density, the junction temperature, and the presence of any impurity in the junction.

The zener breakdown voltage is inversely proportional to the carrier concentration in the higher resistance side of the junction. This concentration increases with junction temperature, giving a negative temperature-coefficient of voltage. Conversely, the avalanche breakdown, which is the effect of ionisation of the valence electrons in the silicon, is critically dependent upon electron mobility, which decreases with a rise in temperature. As a higher voltage must then be developed to maintain the same rate of ionisation, the avalanche mechanism has a positive temperature-coefficient.

Breakdown, which depends upon the current and the junction temperature, may therefore be zero at a lower junction temperature if the combined effect is negative. The BZY78 reference diode operates in the transition region (at about 5.3V) and exhibits high stability with temperature changes.

The coefficient of breakdown voltage with temperature is, for the BZY78, negative at high temperatures (zener) and positive at low temperatures (avalanche). The inversion point varies with current and occurs at a higher temperature as the current is increased. The operating point is selected so that the device operates in the region of high stability with change in temperature, and also has a low slope resistance.

**Slope Resistance**

The slope resistance is defined in terms of a small change in Iz and the associated change in Vz. Thus, as shown in Fig. 1, the slope resistance at any point is given by

\[ r_s = \frac{\Delta V_z}{\Delta I_z} \]

The slope resistance of low-voltage diodes is higher than that of types with breakdown voltages of between 5 and 8V, in which the maximum voltage change is less than 1V.

This article is based on a report by J. F. Miles and A. J. Tumber, Mullard Semiconductor Measurement and Application Laboratory.
are mounted in air, thus increasing the thermal resistance, the temperature difference will be greater, giving a slightly different operating temperature range. For example, if the device is mounted by its leads in free air at a certain temperature, the junction temperature may be up to 10°C higher than when the device is immersed in oil at the same temperature.

**Design**

The overall regulation improves with the number of stages, but the temperature coefficient of each stage, although subject to the regulation of succeeding stages, has an adverse effect on the stability. A three-stage reference circuit may be designed to give small advantage, therefore a two-stage circuit is considered in this article. The first stage must provide an output voltage much greater than 5-3V with a low temperature-coefficient, and it must have good regulation. A suitable output voltage with a low temperature-coefficient may be achieved by using two diodes in series, each with a breakdown voltage of approximately 5V. A very low slope resistance and a high source resistance are necessary (see Appendix) to give good regulation; and so the operating current, and hence the supply voltage, should be high. Zener diodes from the BZY88-C series were chosen for the first stage (D1, D2). The 5-1V diode type BZY88-C5V1 has a low temperature-coefficient, and two diodes in series give a typical combined voltage of 2 × 5-35 = 10-7V when run at 20mA, which is high compared with the voltage of the BZY78 (3-5V). At this current it is estimated that each BZY88-C5V1 has a worst-case temperature coefficient of +0-9mV/°C, and a slope resistance of 10-5Ω. With a 24V supply, which is high compared with 10-7V, and allowing for a zener current of 11-5mA into the BZY78, the values of R1 and R2 are 4300 and 470Ω respectively. The regulation is 0-045 in the first stage and 0-041 in the second, as calculated in the Appendix.

The stability of the reference also depends upon the resistors in the circuit. The variation in resistance value with operating conditions was studied with reference to the Welwyn C22 Panclimatic type, and it was found that the predominant factor was the temperature-coefficient. Self-heating and the voltage coefficient contribute further small variations, giving an estimated total of 0-65% for the resistors in the first stage, and 0-60% in the second.

**Calculation**

The maximum deviation in the output from each stage may be calculated as follows, using the regulation factors deduced in the Appendix.

**First stage:**

Supply ±10% × (24 × 10³) ± 0-045 = ±108mV
Resistor R1 ± 0-63% × (13-3 × 10³) ± 0-045 = ±3-8mV
Diodes D1, D2 ±25 × (2 × 0-9) = ±45mV
Total first stage deviation = ±156-8mV

The self-heating and the voltage coefficient contribute further small variations, giving an estimated total of 0-65% for the resistors in the first stage, and 0-60% in the second.

**Second stage:**

First stage drift ±156-8 × 0-041 = ±6-43mV
Resistor R2 ± 0-60% × (5-4 × 10³) × 0-041 = ±1-33mV
BZY78 drift ± 7-5mV
Total deviation in output = ±15-26mV

This total deviation represents ±0-3% of the minimum nominal reference voltage.

**Alternative Design**

With a 5-6V diode type BZY88-C5V6 substituted for each BZY88-C5V1, the same overall performance will be obtained if the values of R1 and R2 are changed to 390Ω and 530Ω respectively. This design has the advantage of better regulation at the expense of temperature stability; so if it is necessary to use the reference over a wider range of input voltage, this second design is preferable.

**Long-term Drift**

The reference voltage will be subject to the long-term stability of the resistors and diodes. The resistance values may vary as much as a further 0-15%, and the diodes are subject to a maximum drift of 200μA. These drifts may be in addition to those already calculated, giving a further possible drift of 0-012% from the initial voltage.

---

**APPENDIX TO "SIMPLE VOLTAGE REFERENCE CIRCUIT"**

The stage regulation may be calculated with reference to the equivalent circuit, Fig. 3, where

\[ V_{in} - V_1 = R_1 (i_1 + i_2) \]  \( \text{(1)} \)

and

\[ V_1 - V_2 = i_1 R_2 \]  \( \text{(2)} \)

From Eqs(1) and (2)

\[ V_{in} = V_1 + i_1 R_1 + (V_1 - V_2)(R_1/R_2) \]

or

\[ V_1[1 + (R_1/R_2)] = V_1 - i_1 R_1 + V_2 (R_1/R_2) \]

therefore

\[ \frac{dV_1}{dV_{in}} \left( \frac{1 + R_1}{R_1} \right) = 1 - \frac{R_1 d_i_1}{dV_{in}} + \frac{R_2 d_i_2}{dV_{in}} \]

\[ \frac{dV_2}{dV_{in}} = \frac{1}{1 + (R_1/R_2)} \]

\[ dV_{in} = \frac{dV_1}{1 + \left( \frac{R_1}{R_2} \right)} \]

\[ dV_{in} = \frac{dV_2}{1 + \left( \frac{R_1}{R_2} \right)} \]

From Eqs(3), (4), and (5)

\[ dV_1 = \frac{dV_1}{R_1} \]

\[ dV_2 = \frac{dV_2}{R_2} \]

Simplifying, we obtain

\[ dV_1 = \frac{1}{dV_{in}} \]

\[ dV_2 = \frac{1}{dV_{in}} \]

The regulation of the second stage may be calculated with this equation by substituting R1 for R1 and R2 for R2, and by making R2 infinite, giving

\[ dV_{in} = 0-045 \]

In this case the circuit values are as follows:

\[ R_1 = 430\Omega \]

\[ R_2 = 470\Omega \]

\[ R_1 = 21\Omega \]

\[ R_2 = 20\Omega \]

Then, from Eq(6),

\[ \frac{dV_1}{dV_{in}} = 0-045 \]

and, from Eq(7),

\[ \frac{dV_2}{dV_{in}} = 0-041 \]
MICROPHONY IN TAPE RECORDERS

Howlback and clang microphony are the two most common types of interference experienced with a valve tape recorder. This article defines these terms and suggests design limits in the manufacture of valve tape recorders whereby these two types of microphony can be reduced to a satisfactory level.

INTRODUCTION

Microphony is occasionally experienced in a tape recorder where high gain AF valves are used in the first stages. There are two types of microphony: howlback and clang microphony. The two types of interference are defined and discussed in detail under separate headings.

HOWLBACK

Howlback, or feedback howl, is an oscillation which occurs in the following way. Any excitation force may cause electrode vibrations in a valve resulting in an initial microphony (Ref. 1). The initial microphony of a pre-amplifier valve is then amplified and converted by the speaker into vibrations. These vibrations are fed back to the valve acoustically, mechanically, or by a combination of both, in such a manner as to sustain the original electrode oscillations which produced the initial microphony.

Requirements

As implied in the definition of howlback, this type of microphony occurs only if the valve is excited with a force of suitable phase and of sufficient amplitude. Therefore, even with a suitable phase relationship, howlback will not occur if the equivalent microphonic grid voltage of the pre-amplifier valve (resulting from a specified speaker power) is less than the signal input voltage required to produce the specified speaker power. This means that, for a speaker power of 1W and with a safety factor of two, the equivalent microphonic grid voltage \( V_{eq(ig)} \) resulting from a speaker power of 1W, should be less than half the signal input voltage \( V_{in(0.05W)} \) required for a speaker power of 1W. That is,

\[
V_{eq(ig)} \leq \frac{1}{2} V_{in(0.05W)}
\]

or, since \( V_{eq(ig)} = V_{eq(sw)} \) and the signal input voltage is proportional to the square root of the output power, the equivalent microphonic grid voltage required for a speaker power of 1W is

\[
V_{eq(sw)} \leq \sqrt{V_{in(0.05W)}}/\sqrt{0.05}
\]

where \( V_{eq(ig)} \) = equivalent microphonic grid voltage of the pre-amplifier resulting from a peak acceleration of 1g.

A typical ratio corresponds to the maximum possible values which occur in reasonably well-designed tape recorders. Normally, the valve published data give the recommended or minimum permissible value of \( V_{eq(ig)} \).

Maximum permissible average acceleration of the valve resulting from a speaker excitation of 50mW can be considered as 0.015g r.m.s. at frequencies higher than 500c/s, and 0.06g r.m.s. at frequencies lower than 500c/s. Considering that the maximum r.m.s. acceleration due to the valve is approximately three times the average r.m.s. acceleration (or \( 1/\sqrt{2} \) times the peak acceleration) and that the acceleration is proportional to the square root of the speaker power (Ref. 1), the maximum permissible grid voltage of 1g which should be used with the minimum \( V_{in(0.05W)} \) is

\[
3 \times 0.015 \sqrt{2}/\sqrt{0.05} = 0.28g
\]

for frequencies above 500c/s, and

\[
3 \times 0.06 \sqrt{2}/\sqrt{0.05} = 1.1g
\]

for frequencies lower than 500c/s.

Therefore, the maximum value of \( gsw/V_{in(0.05W)} \) is 0.28/recommended \( V_{in(0.05W)} \) for frequencies above 500c/s and 1.1/recommended \( V_{in(0.05W)} \) for frequencies lower than 500c/s. Consequently, howlback microphony can reasonably be expected to occur from the unsuitable design of the equipment if the ratio of \( gsw/V_{in} \) is greater than the above-mentioned values.

CLANG

Clang is an audible interference caused by any external forces such as speaker, motors or especially switch excitations.

General Considerations

Clang may exist even at very low values of acceleration and low electrical sensitivities, although it is not necessarily objectionable at these levels. Thus, in an amplifier incorporating a speaker, if the gain is progressively increased, clang resulting from switch excitation will be noticed first. Then, if the gain is further increased, up to a certain limit, howlback will occur.

In principle, the relative value of the interference with respect to the useful signal level determines whether the interference is negligible or not. With motor or switch excitation, the useful signal can be zero for a given interference. Therefore, ideally, the quality of motors, switches, and their mountings in the equipment should be such that the interference resulting from the excitation of these sources, with a useful signal level of zero, is not objectionable.

Generally, the clang resulting from switch excitation is more objectionable than that resulting from speaker or motor excitation. Therefore, switch excitation clang is discussed in detail and some practical requirements given.

Switch Excitation

It is important to distinguish between clanging microphony and mechanical interference. Clang is the electronic interference which is produced in the pre-amplifier valve and, after being amplified by the following stages, is audible from the loudspeaker. Mechanical interference is the sound of the switch operation as heard directly by the ear.

In the playback position the requirements for clang can be derived as follows. If the duration of the clang, \( t_c \), is less than the duration of the mechanical interference, \( t_m \), the equivalent microphonic grid voltage \( V_{eq(sw)} \) due to switch excitation, should be less than the signal input voltage \( V_{in(sw)} \) required for a speaker power of 1W, where \( P \) is the speaker output and has the same interference effect on the ear as that of the mechanical interference. That is, \( V_{eq(sw)} = V_{eq(sw)} gsw \) and the input voltage is proportional to the square root of the speaker power,

\[
V_{eq(sw)} gsw / V_{in(0.05W)} \leq P / 0.05
\]

where \( gsw \) = peak acceleration in g of the pre-amplifier valve resulting from the switching action.

If the duration of the clang is longer than that of the mechanical interference, experiment indicates that the ratio of the signal input voltage required for the maximum available speaker power \( V_{in(0.05W)} \) to the equivalent microphonic grid voltage \( V_{eq(sw)} \) should be greater than 24dB (16 times). That is,

\[
V_{eq(sw)} / V_{in(0.05W)} < 1/16
\]

or

\[
V_{eq(sw)} gsw / V_{in(0.05W)} < 0.3 \quad (3)
\]

Poor mechanical design of the equipment can produce a ringing effect and make the duration of the clang longer than that of the mechanical interference. Therefore, the problem of ringing effects should be taken into account at the design stage of the tape recorder. Thus the duration of clang would not exceed the duration of the mechanical interference and consequently, the rather rigid requirements of Eq (3) need not be considered.

Design limits for clang microphony can be derived simply, as discussed in the results given for howlback by using Eq (2) and (3) with the following typical values.

PERFORMANCE OF THREE TYPICAL TAPE RECORDERS

Measurements have been made on three different types of commercially available tape recorder.

Vibration

The acceleration of the pre-amplifier valve resulting from a speaker power of 50mW was measured, in three mutually...
TWO NEW LOW-COST SILICON P-N-P TRANSISTORS

Mullard have introduced two new high-voltage, medium-gain silicon transistors, the BCY54 and OC207, which have been developed from the highly successful BCY38 and OC204 series. They are particularly suitable for pulse and audio applications, compact DC converters, servo process control, power switching and relay drivers.

Having a typical gain of 50 and a collector voltage of 50V, the BCY54 and OC207 will find special application in equipment where the higher voltage rating of the OC205 and BCY39 is not required, yet where a higher gain would be an advantage.

Upated BCY38 Series

The BCY54, in TO-5 encapsulation, joins the recently uprated BCY38 series which now has a power dissipation of 400mW in free air at 25°C and 500mW at a case temperature of 88°C. Sample quantities will shortly be available.

Abridged Data

for BCY54 and OC207

\[ V_{CE} \text{ (max)} \text{ (Ic=0mA)} \] = −50V
\[ V_{CE} \text{ (max)} \text{ (cut-off)} \] = −50V
\[ h_{FE} \text{ (Ic=30mA)} \text{, } V_{CE}=-2V \] = 50 typical
\[ h_{FE} \text{ (Ic=150mA)} \text{, } V_{CE}=-1V \] = 25 typical
\[ f_T \text{ (V_{CE}=-6V)} \text{, } I_C=1mA \] = 2.0M/s typical

NEW TYPE NUMBERING SYSTEM FOR THYRISTORS

A new type numbering system has been adopted for the Mullard high-voltage thyristor range and will gradually be introduced for the remaining ranges.

Thyristors with the same current rating are given a type number consisting of the letters B (denoting silicon), T (denoting thyristor), and a letter and two figures as a serial number. Individual types within the series are identified by a group of figures which represent the maximum repetitive peak reverse voltage of the device. A final letter R indicates a "reverse-polarity" device, that is, the anode is connected to the stud, e.g. "BTY87-400R".

ZENER DIODES FOR SHUNT STABILISER CIRCUITS

The BZY91 series of zener diodes has been introduced for use in shunt stabiliser circuits, and is particularly useful in applications where equipment must be protected from surges. The diodes in this series will dissipate 75W at a stud temperature of 65°C and the surge ratings are 4kW for 100µsec and 170W for 100msec.

The range of zener voltages is from 10 to 75V with nominal zener voltage tolerance of ±5%. The diodes use stud mounting and are in DO-5 encapsulation. Reverse polarity versions will be available later.

Continued from page 72

perpendicular directions, by a Brüel and Kjaer accelerometer, type 4329, mounted on the valve socket. The peak accelerations caused by a 0-05W speaker power in the frequency spectra above 500c/s and below 500c/s were less than 0-05g and 0-1g respectively. The peak accelerations g_{max} corresponding to a speaker power of 1W in the same frequency spectra were less than 0-2 and 0-7g respectively. The peak-to-peak acceleration (that is g_{pp}) resulting from the operation of switches was between 0.5 and 2g, with durations of 15 to 60ms and frequencies up to 500c/s.

Electrical Sensitivity

In the playback position, the value of the input voltage \( V_{in} \text{ (max)} \) in the frequency range 50 to 10 000c/s, varied with frequency and the individual equipment from 0.01 to 0.03mV. The maximum available speaker power \( P_{(max)} \) varied between 1 and 3W.

Howlback, Clang and Mechanical Interference

Howlback and clang tests were carried out in the playback position with the volume control at maximum. No interference could be detected by ear.

Mechanical interference and clang resulting from switch operations were measured with a Peekel Sound Spectrometer, type GR3, and an oscilloscope. The two sources of interference were isolated with a sound-proof box, and the following results obtained:

Duration of mechanical interference \( t_{on} = 50 \text{ to } 200\text{ms} \).

Duration of clang \( t \). 20 to 30ms. The relative amplitude of clang with respect to the amplitude of the mechanical interference, as sensed by the spectrometer — 0.2 to 0.7.

The speaker power required to produce the same interference effect on the spectrometer as that of the mechanical interference of the switching action 0.9 to 2.5W.

Thus, in the three tape recorders examined, it was found that clang and howlback microphonic were within the limits given in this article.

REFERENCES

2. S. S. Dagpunar, Mullard (U.K.) Applications Research Laboratory.

THYRISTOR FOR COMPUTER PRINT-OUT EQUIPMENT

The BTX18 has been specially introduced for fast-speed applications. It is designed for use in fast line-and-time print-out devices for computers.

Fast Print-out Thyristor

A device with a very high gain and fast operating time is required between the logic circuits of a computer and the print-out equipment. The BTX18 can provide sufficient current to operate the print-hammer solenoid directly from the gating pulse produced by a transistor or defluxing core. The maximum value of gate current required to fire the thyristor is 15mA with a pulse length of 6µs.

The BTX18 is in TO-5 encapsulation for ease and economy of mounting. Because of the short duty cycle encountered in this application (about 5%) the device will handle peak currents of 0.3-5A without exceeding the dissipation limit. The rapid rise in current necessary to operate the print-hammer solenoid quickly requires a high driving voltage and the BTX18 has a 150V rating to enable it to be used with wide voltage margins.

Although specifically designed for print-out applications, the BTX18 can also be used for other applications such as DC inverters and for firing other thyristors where a high current is required for a short time.

The BTX18 is available in sample quantities.

MULLARD PUBLICATIONS

A revised, up-to-date edition of the Mullard Film and Filmstrip Catalogue is available from Mullard offices on receipt of a stamped, self-addressed, foolscape envelope endorsed "Films".

Also available from Mullard offices and distributors throughout the Commonwealth are reprints of the two popular Mullard publications "Stereo Sound Systems" and "Vinkor Manual" priced as follows:—

Stereo Sound System": 6/3 plus 8d. postage
Vinkor Manual": 5/3 plus 8d. postage
Since electronic controls first became practicable, reliability has been a major factor in determining how readily — or even whether — industry has accepted them as aids to productivity. It is evident by the number of industrial applications utilising electronics, that designers of components and systems are attaining the required standards.

Insistent demands for greater reliability have forced designers away from relays and other devices with moving parts. Instead they have turned to the inherently reliable solid state devices as a means of performing switching and logical operations in control systems. In doing so they have gained an additional advantage, for with solid state or static switching, it is easier to design systems that 'fail-safe' — an essential requirement in applications like nuclear power stations and railway signalling installations.

In 1958 a new type of solid state device was added to the system designer's armoury by the Bell Laboratories. Known as Laddie, it makes use of the square-loop magnetic properties of ferric materials (such as Ferroxcube) to provide, in an almost indestructible form, a logic element of great intrinsic reliability able to operate in systems with fail-safe characteristics.

Laddie is pressed from Ferroxcube into the shape of a ladder (hence LADDer-logIC). Its only other parts are simple, often single-turn windings round certain rungs and parts of the side rails.

It is extremely small and light in weight a general-purpose ladder core with eleven rungs may measure only 0.8 in x 0.13 in x 0.08 in thick. The type number of the Mullard ladder core is FX2717.

In the Mullard laboratories development of ladder has been carried on since 1959, and for some time the company has manufactured cores so that designers might experiment with the new device. During this period when practical manufacturing techniques were being worked out, applications research was begun to discover the best ways of applying ladder to the solution of practical control problems. Its use in reactor safety systems was the subject of one study, undertaken recently.

A ladder core may be wound in many different configurations according to the job it is to do. One of the simplest arrangements, that to perform the logic function of AND, is also the simplest by which to explain how ladder works.

As Fig. 1 shows the ladder core has a 'set' winding round rung A, a 'reset' winding, which threads every alternate aperture, 'hold' winding round rungs B, D, F and H, and an output winding round rung K.

A pulse of current through the reset winding magnetically saturates the whole core, setting up a flux pattern as shown by the arrows in Fig. 2. A second pulse, of opposite polarity to the reset pulse, is then applied to the set winding on rung A. The set pulse tries to reverse the flux through the shortest possible path, which is down rung A, along the side, up rung K, and along the other side back to rung A (see Fig. 3). The remainder of the ladder is unaffected — there is no reversal at the right-hand end and therefore no voltage is developed in the output winding.

But if the hold winding on rung B (Fig. 4) is energised by a control or hold circuit in a direction that opposes the flux change on that rung, the flux reversal must seek the next shortest path. Rung C has already been saturated in the 'reverse' direction by the initial reset pulse, so the flux reversal must occur in rung D. If this, too, has been energised by its hold winding that path is also closed. Rung E, like rung C, is already saturated in the direction of the change, so that path too is impassable.

Now assume that the hold winding on rung F is not energised, so leaving an open path for the flux reversal along the opposite sides of the ladder and back to rung A. Obviously, rung K and the output winding on it are unaffected and there can be no output signal.
Thus only if all the hold windings are energised will a current pulse applied to the drive winding produce an output signal (Fig. 5), and the laddie is therefore able to perform the logic function of AND. In practice the set and reset pulses are applied alternately so that the core is saturated, ready for operation, after each drive pulse.

Other logical functions can of course be produced. For example, a hold rung may be energised by any of several windings placed on it, in which case the laddie can be made to operate as an OR gate.

The set and reset pulses may be repeated at whatever frequency the system requires—they are equivalent to the clock pulses of a computer. The laddie core itself can be switched in about three microseconds, but the maximum operating speed of a laddie system is at present limited by the associated circuitry to about 10 kc/s. There is no lower limit to the operating frequency and it is practicable, and economical, to use the supply mains frequency to control the clock.

Designs for pulse generators covering most frequencies likely to be needed are being developed in the Mullard Applications Laboratories. Provided they are maintained long enough to switch the core, the hold and set pulses need not be accurately defined. Laddie's toleration in this respect would be useful in industrial control systems, enabling the hold windings to be energised by transducers at some distance from the laddie.

At its present stage of development it seems certain that laddie's first appeal will be for systems that must be, above all else, reliable. An example is the safety system of a nuclear reactor. Here, the position of the neutron-absorbing control rods would govern the hold circuits. As soon as a rod occupied a wrong position the hold circuit would be broken and the laddie would decline to pass the set pulses to the output. The absence of a signal which could, of course, be caused by a failure in any part of the safety circuit, would indicate trouble and be made to initiate the necessary alarm action.

In railway signalling systems the hold circuits could be operated by the signals, by the points, or by electrical impulses representing traffic conditions. Here again, a no-signal condition would immediately cause the system to fail-safe.

Those are obvious situations; there are many others where laddie systems could increase safety or reduce operating costs. The chemical industry has many dangerous processes which must be precisely controlled such as the manufacture of nitroglycerine, in which the reaction, if too fast, produces excessive heat and becomes uncontrollable unless the temperature is lowered immediately the danger point is reached.

In all but the most rudimentary systems a number of laddies would have to be connected in cascade, and methods of coupling them using various transistor and thyristor circuits are being devised. Magnetic coupling elements, although they introduce a complication, are a possible alternative and one now under development is expected to give satisfactory results.

This article has described only the bare bones of laddie. There are, as already stated, many elaborations by which the device could be called-on to provide almost any mode of logic control. By variations in the winding configuration, by a multiplicity of windings, and by different methods of interconnecting a number of laddies, an extremely wide field of operation can be covered.

In critical control situations—for instance, in nuclear engineering—it is usual to use three transducers to monitor the same parameter, and the decision to 'go' or 'no-go' is a majority verdict. Thus, the failure of one transducer need not mean the unnecessary, and expensive, shut-down of a large plant. Provided two of the transducers show that conditions are normal the laddie elements, to which all three are connected, can be arranged to pass the set pulses to the output.

Reliable magnetic logic systems could be designed for air traffic control and for aircraft blind-landing aids. Where high operating speeds are not essential laddie can also take its place in industry, and many concerned with its future development believe that it will eventually be used extensively in railway signalling.

The Mullard contribution to this highly reliable approach to electronic control is to help plot the future for a control device that, in its sphere, may yet rank in usefulness with the transistor.

Far left: Laddie Ferroxcube logic elements in an experimental model of a safety control system for nuclear reactors.

Centre: An experimental 50 c/s industrial logic system using a laddie. The output from the laddie triggers silicon controlled rectifiers which in their turn switch large amounts of 50c/s power.

Left: Examples of laddie Ferroxcube elements.
SIMPLE TRANSISTOR MEASUREMENTS

This article is the second in a series being published in Outlook and containing suggestions and instructions on a number of experiments in which the properties and behaviour of alloy junction transistors are examined. They are intended to give the student a better understanding of the basic operation of the transistor and to illustrate its practical application.

MODES OF OPERATION

There are three basic methods of connecting the transistor in any circuit—in grounded or common base, in common emitter or in common collector configuration. These are indicated conventionally in Figs. 5, 6 and 7.

Common Base

Because junction transistors have a slight current loss between emitter and collector (represented by the base current) the whole of the power gain in this arrangement is obtained as a result of the low input impedance and high output impedance.

A transistor in common base connection is shown in Fig. 5. If $I_e$ is the emitter current, $I_c$ the collector current and $I_b$ the base current then

$$I_b = I_e - I_c$$

For small signal inputs the current gain ($a$) may be taken as

$$a = \frac{I_c}{I_e}$$

Taking into account the leakage current ($I_{col}$) which flows from collector to base

$$I_b = (1-a)I_e - I_{col}$$

and

$$I_e = aI_b + I_{col}$$

Thus the collector current depends upon the leakage current and the current gain. If the base is disconnected $I_c = I_e$ and

$$I_c = \frac{I}{1-a} = I_{col}$$

An input change of 1mA through 25Ω in the emitter circuit produces a change of 0-98mA through 100,000Ω in the collector circuit. The current gain ($a$) is thus 0-98 and the theoretical power gain is calculated as follows:

- **Total Power in Collector Circuit**
  $$\text{FR} = \frac{(0-98)^2}{1000} \times 100,000Ω = 96\text{mW}$$

- **Input Power**
  $$\text{FR} = \frac{1}{1000} \times 25Ω = 25\text{mW}$$

- **Power Gain**
  $$= \frac{\text{Power in Collector Circuit}}{\text{Input Power}}$$
  $$= \frac{96 \times 10^{-3}}{25 \times 10^{-3}} = 3.840$$

- **This power will be divided between the collector diode and the load, and the useful output power will depend upon load matching.**

Common Emitter

In the common emitter arrangement it is the base current and not the emitter current which is the controlling element. If the base current is increased or reduced by an external circuit, the output current is also increased or reduced.

A transistor in common emitter connection is shown in Fig. 6. For small signals the current gain denoted by $a'$ is taken as

$$a' = \frac{I_c}{I_b}$$

It can also be shown that

$$I_c = a'I_b + I_{col}$$

The characteristic of the common emitter circuit is high current gain, medium input impedance and medium output impedance. A higher leakage current is also apparent.

In this example, using the same transistor as employed in Fig. 5, a change of 0-02mA in base current produces a change of 0-98mA in collector current, so that the current gain is 49.

In this case the power gain depends upon two components. There is in the first place the current gain and there is also a power gain due to the ratio between the output and input impedances. This power gain is of the order of:

$$\frac{25,000}{600} = 41.7$$

Common Collector

The arrangement shown in Fig. 7 is similar to the common emitter circuit but now the input is effectively between base and collector and the output is effectively taken between emitter and collector. The general characteristics are similar to those of a cathode follower. With a load in the emitter circuit, the input impedance is approximately equal to the product of the load resistance and the current gain $a'$ which, as previously indicated, is in this case 49. The voltage gain of the circuit is less than unity.

(Continued in Next Issue)
TABLE OF CONTENTS—VOL. 7, 1964

A
Abridged Technical Data for 35D Heatsink Extrusion
ABTQ3 Up 1 Mc/s
AFY19 in VHF Transmitters, Performance of the Amplifier, Increased Power Output from Complementary Symmetry
An Electronic Thermometer
A59-11W, Picture Tube

B
Battery Life, Temperature Compensation Prolongs Effective
BAY66, New Semiconductor for Telecommunications
Biscuits, Special Channel 3
BLY17 Transistor
BSY11 Silicon Mesa N-P-N Transistor

C
Ceramic Pick-Up Cartridges, Valve Pre-amplifiers, Input Facilities for
Channel 0 in Melbourne
Channel 3 Biscuits, Special
Circuits, Mullard Thin Film
Coils, High-Q Factor
Compact Cold Sources for Specialised Cooling Applications
Complementary Symmetry Amplifier, Increased Power Output from
Computer Print-Out Equipment, Thyristor for
Cooling Applications, Compact Cold Sources for Specialised

D
Digitube TG 121 A
Diode, Gallium Arsenide
Diodes for Entertainment Applications in Australia, Mullard Preferred Range of
Diode Rectifier Stacks, Thyristor and
Double Pentode 6Y9
Double Pentode 6Y9/EFL200
Double Triode for TV Distribution Systems

E
EHT Rectifier Modules
EHT Supply, Variable
Elements, List of the
Electronic Thermometer, An
Electronics in Industry
Exhibition, Mullard at the A.S.E.E.
Experiment with Norbit Static Switching Elements

F
Film News
Four Element Photoconductive Relay RPY13, A

G
Gallium Arsenide Diode
G.M. Overseas

H
Heatsink Extrusion, Abridged Technical Data for 35D Heatsinks for Transistors, Diodes, Thyristors, Mullard High Q-Factor Coils

I
Increased Power Output from Complementary Symmetry Amplifier
Industrial Triode TY6-5000
Iso-Q Curves

L
Laddic LADDeR LogIC
Lectures on Transistor Radio Servicing
List of the Elements
Low Voltage Silicon Power Rectifiers

M
Magnetron for Civil Radar Band
Melbourne Manager, New
Microphony in Tape Recorders
Mullard at the A.S.E.E. Exhibition
Multivibrator for Educational Purposes, A Low Frequency

N
Norbite Static Switching Elements, Experiments with N-P-N Transistor, BSY11 Silicon Mesa

O
OT4020 and PT1932

P
Peltier Battery Aids Research, Mullard
Pentode, 6Y9/EFL200, Double
Performance of the AFY18 in VHF Transmitters
Personalities, Mullard-Australia:
Mr. Arthur F. Felton
Mr. M. F. Jessop
Mr. L. Ronalds
Mr. John G. Alexander
Mr. J. A. Kitchen
Photoconductive Relay RPY13, A Four Element
Picture Tube, A59-11W
Planar Transistors Meet General Application Requirements, Three
P-N-P Transistors, Two New Low-Cost Silicon Power Transistors, Mullard Introduce Four New Pre-amplifiers, Input Facilities for Ceramic Pick-Up Cartridges, Valve
Preferred Range of Diodes for Entertainment Applications in Australia, Mullard
Preferred Range of Transistors for Entertainment Applications in Australia, Mullard
Preferred Range Thyristors, Mullard
PT1932, OT4020 and

Q
Q-Factor Coils, High

R
Radar Band, Magnetron for Civil
Rectifier BYZ14, An Interesting Application Silicon Power
Rectifier Modules, EHT
Rectifiers, Low Voltage Silicon Power

When locating products and their type numbers, readers should also refer to the Product Type Number Index shown overleaf.


**MULLARD PRODUCT TYPE NUMBER INDEX**

The tabulation below, in alphabetical and numerical order, is of Mullard product type numbers which are frequently referred to and which have appeared in Outlook, Volume 7.

**A**

- A3.178.70 .......................... 22
- A59-11W ............................. 53, 60
- AA119 .................................. 24
- 2-2AA119 ............................ 51, 62
- AC125 .................................. 24
- AC126 .................................. 24
- AC127 .................................. 24
- AC128 .................................. 24
- AC129 .................................. 24
- AD139 .................................. 24, 62
- AD140 .................................. 24
- AD141 .................................. 24
- ADY26 .................................. 70
- ADZ11 .................................. 70
- ADZ12 .................................. 70
- AF114N .................................. 23
- AF115N .................................. 23
- AF117N .................................. 23
- AFY19 .................................. 48
- AT7580 .................................. 22

**B**

- BA100 .................................. 24
- BA114 .................................. 24
- BA122 .................................. 24
- BA66 .................................. 56
- BCS38 .................................. 73
- BC54 .................................. 70
- BRY10 .................................. 70
- BDY11 .................................. 70
- BF50 .................................. 68
- BFY51 .................................. 68
- BFY52 .................................. 68
- BLY17 .................................. 57
- BSY11 .................................. 57
- BTX12 .................................. 17
- BTX13 .................................. 17
- BTX18 .................................. 17
- BTY0 .................................. 16
- BTY51 .................................. 16
- BTY87 .................................. 17
- BTY91 .................................. 17

**C**

- CZ.319.800 .......................... 45
- CZ.320.084 .......................... 45
- CZ.321.057 .......................... 22
- CZ.321.097 .......................... 22
- CZ.320.104 .......................... 22
- CZ.320.078 .......................... 22
- CZ.320.199 .......................... 45
- CZ.320.031 .......................... 22
- CZ.320.034 .......................... 22

**D**

- BY100 .................................. 24
- BY13 .................................. 16
- BY14 .................................. 16
- BY15 .................................. 16
- BY15 .................................. 16
- BY21 .................................. 12
- BY22 .................................. 12
- BY24 .................................. 16
- BY26 .................................. 12
- BY27 .................................. 12
- BY28 .................................. 16
- BY39 .................................. 16
- BY41 .................................. 16
- BY81 .................................. 16
- BY91 .................................. 16

**E**

- ECC2000 .............................. 12
- ECF200/6X9 ......................... 29, 30
- ECF300/6X9 .......................... 29, 30
- ECF802/6W8 .......................... 29, 31
- EDF300/6X9 .......................... 29, 32
- EFS6 .................................. 62
- EFL200/6Y9 .......................... 29, 31
- EY51/6X2 .............................. 11
- EY51-20069 .......................... 29, 31

**F**

- FX2380 .............................. 65, 74
- FX2717 .............................. 65, 74

**G**

- G50-25 .................................. 48

**J**

- JY1020 .................................. 12
- JY1090 .................................. 12
- JY1091 .................................. 12
- JY20 .................................. 20
- JY21 .................................. 20
- JY22 .................................. 20
- JY23 .................................. 20
- JY24 .................................. 20
- JY25 .................................. 20
- JY26 .................................. 20
- JY27 .................................. 20
- JY28 .................................. 20
- JY29 .................................. 20
- JY30 .................................. 20
- JY31 .................................. 20
- JY32 .................................. 20
- JY33 .................................. 20
- JY34 .................................. 20
- JY35 .................................. 20
- JY36 .................................. 20

**L**

- LA208 .................................. 69
- LA211 .................................. 69
- LA212 .................................. 69
- LA213 .................................. 69
- LA214 .................................. 69
- LA215 .................................. 69
- LA216 .................................. 69
- LA217 .................................. 69
- LA218 .................................. 69
- LA219 .................................. 69
- LA220 .................................. 69

**M**

- M540-100 .............................. 31

**N**

- NT3001 .................................. 22
- NT3005 .................................. 22
- NT3006 .................................. 22
- NT3007 .................................. 22

**Q**

- QV06-20 .............................. 47
- QV09-100 ............................. 47
- QV13-72 .............................. 47
- QV14-250 ............................ 47
- QV15-500 ............................. 47
- QV16-3000A ......................... 47
- QV17-3000W ......................... 47

**T**

- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67
- TG121 .................................. 67

**Z**

- ZC.320.084 .......................... 45
- ZC.320.097 .......................... 22