137

RADIOTRONICS

Registered at the General Post Office, Sydney, for transmission by post as a periodical. Single Copy, One Shilling.

VOL. 21 NOVEMBER 1956 NO. 11

1/-

AMALGAMATED WIRELESS VALVE COMPANY PTY. LTD.

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EDITOR .... A. J. GABB, B.Sc. (Syd.), A.M.I.R.E. (Aust.)

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Radiotronics is published twelve times a year by The Wireless Press for Amalgamated Wireless Valve Company Pty. Ltd. The Annual subscription rate in Australasia is 10/-; in U.S.A. and dollar countries $1.50, and in all other countries 12/6. Price of a singe copy is 1/-.

Subscribers should promptly notify Amalgamated Wireless Valve Company Pty. Ltd., 47 York Street, Sydney, and also the local Post Office of any change in address, allowing one month for the change to become effective.

GLASS TECHNOLOGY

in valve manufacture

SUMMARY:

This brief account of some of the techniques of glass working used in valve manufacture aims at a general picture for those unfamiliar with the art. After explaining why glass is used in valves, the question of stress control and its measurement by the polariscope is examined. The problem of thermal shock is noted. Finally, there is an account of glass-to-metal sealing using Dumet.

INTRODUCTION:

Many people have, no doubt, asked themselves why it is that glass is used so extensively in the construction of electronic valves. For that matter, one might wonder why it is used so much for manufacture of articles of everyday use, such as drinking vessels and bottles, which do not have to be transparent. Everyone knows that glass is brittle, and this disadvantage limits its wider use. However, it is a cheap material, and fairly easy and therefore cheap to fabricate. This means that articles which do not need to withstand heavy blows can be made of glass at lower cost to the consumer. Besides this, glass has the great advantage over, say, plastics, of being able to hold a high vacuum and to withstand the high temperatures necessary in valve making. All these reasons make it a desirable structural material to use in valves.

GLASS AS A STRUCTURAL MATERIAL:

The basic points to consider with any structural material are firstly its strength, and, secondly the stresses it encounters in use.

(a) Strength:

A charactestisic of many brittle materials is that they are not strong in tension (pull), although they may be very strong in compression (push). (The main characteristics is that they exhibit very little "cold flow" or "creep" before breaking. That is, they do not bend much.) Concrete is a good example of a brittle material. Piers made of concrete will stand very high compressive loads, but no engineer would dare impose anything but the slightest tensile loads on them. Glass behaves similarly. It compressive strength is comparable to that of the strongest steel, but whereas the ultimate **tensile** strength of steel is about 100,000 lb. per square inch, that of glass is only about 10,000 lb. per square inch. It is an odd fact that glass is very strong in the form of fine fibres, which, if fine enough, may have a tensile strength greater than 400,000 lb. per square inch. The reasons for this are very fascinating; and a rope made of fine glass fibres can be made stronger than steel.

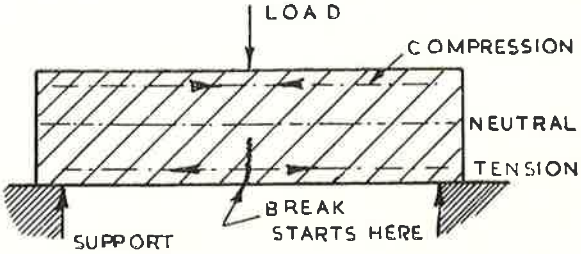


Fig. 1.

The above figure of 10,000 lb. per square inch refers to the **surface** strength of bulk glass. Oddly enough, bulk glass, unlike concrete, has a much greater tensile strength in its interior than at the surface. The interior will, in fact, withstand tensile loads about six times as great as will the surface. This fact, as we shall see, is of great practical importance.

(b) Stresses:

Consider, for example, a beam of concrete supported at both ends and with a weight in the middle, as in Fig. 1. The bottom surface is in tension. Since concrete is weak in tension, it is very likely to break, the crack beginning at the lower surface (near the middle, where the tensile stress is greatest). However, a modern building technique has overcome this. Suppose a beam of concrete with a small hole through its centre and a strong steel wire thread

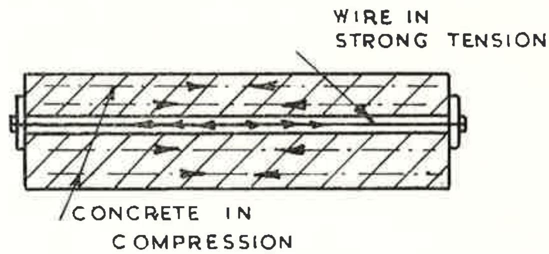


Fig. 2.

along this hole fixed to both ends of the beam and pulled very tight, as in Fig. 2. The wire is in very strong tension — which it can easily withstand — and the concrete is pushed into uniform compression all along its length. Suppose now this beam supported as in Fig. 1. The lower surface tends as before to go into tension. But it is already in compression beforehand. Thus the load must be great enough to make it go back to neutral before it can go into tension and break. It is this which enables concrete to be used in beams where heavy tensile loads are encountered: this is the "pre-stressed" concrete used so much nowadays in construction work.

It is possible to do much the same thing with glass, although it is not practicable to use wires in tension. Remembering the useful fact that the interior of glass is about six times as strong as its surface, one may arrange to have the interior of a piece of glass in tension, like the wire in the concrete. Having the interior in moderately strong tension — which it easily withstands — puts the surface into compression. See Fig. 3. Then any steady load or blow

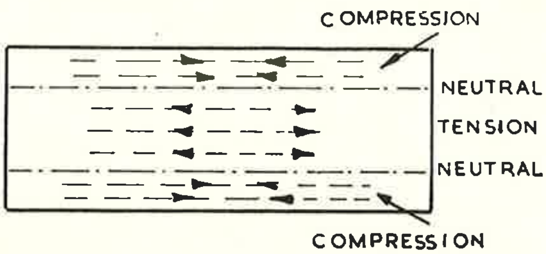


Fig. 3.

tending to put tensile stress on a surface will have to be great enough to first pull the surface back through neutral and into tension, before the glass can break. This is done with the "toughened" glass used in car windscreens. It remains to show how this is achieved.

THE PRE-STRESSING OF GLASS.

When a glass is heated it gradually becomes soft: the higher the temperature, the softer it becomes. In this respect glasses are unlike crystalline solids such as ice or metals, which have sharp melting points. In the case of ordinary glass, heating to a few hundred degress Centigrade causes it to soften appreciably. At red heat it flows like treacle, and at white heat almost like water. Most people have seen a glassblower at work, and noticed how cleverly he heats his glass to just the right temperature to make it soft enough for him to shape.

Like other substances, glass expands when heated, and contracts when cooled. Suppose a slab of glass which is hot enough to be slightly plastic, but not so hot as to flow under the action of gravity — say like a slab of warm pitch. Consider what happens if this slab be cooled quickly on one side by a draught of cold air, while the other side is allowed to cool slowly. The top surface begins to contract as its cools, and also to "set" harder. The bottom surface has as yet hardly cooled, and so is still

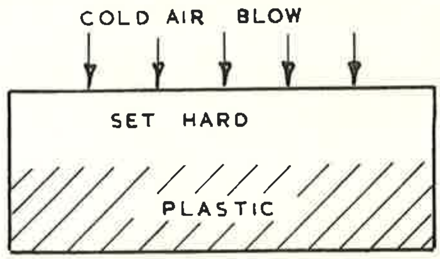


Fig. 4.

quite plastic — and able to "give" if stressed. See Fig. 4. Since the top has contracted somewhat, it tends to pull itself into tension, and therefore the bottom surface should be pushed into compression. But the bottom can "give" so the top has nothing to pull against. Hence **both remain neutral.**

One continues blowing the top with cold air. Meanwhile, the bottom is cooling slowly, and eventually it cools enough to lose its plasticity and set hard, like cold pitch. It has a good deal of contracting to do before it cools to room temperature. So has the top. However, the top has already done much of its contracting while the bottom could "give". Thus, from now on until the slab cools right out, the **bottom has more contracting to do than the top.** This means that when the slab is cold, the bottom must go into tension thus **pushing the top into compression.** The slab will now stay this way permanently. See Fig. 5.

The rule, therefore, is this: When a plastic piece of glass is cooled quickly on a surface, that surface, is in compression when room temperature is reached.

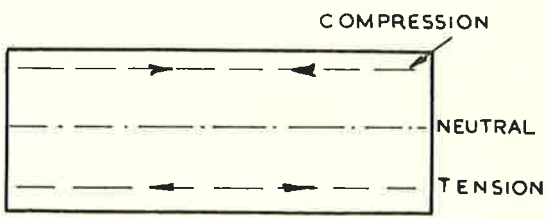


Fig. 5.

The above reasoning explains how it is possible to make toughened glass, which has **both** sides in compression. A slab of plastic glass is cooled quickly on both surfaces, causing the interior to be in tension and the desired compression to appear on each surface. This stress pattern is permanently "frozen" into the glass. Refer to Fig. 3. The process required fairly accurate control, for if the interior is given too great a tension, it will fail and defeat the purpose of toughening.

Toughened glass, made in the above fashion, is used in the button base of all miniature valves. These bases have to withstand considerable stressing when the pins are pushed (or worse, wriggled) into a tight socket. The pins act like so many crowbars embedded in the glass and a very tight socket usually transmits tensile loads to the surface of the button, via the pins it is gripping so tightly. If a glass **surface** is in moderate tension, it may not fail immediately, but may take weeks to fracture (this does not apply to the **interior**). Toughening vastly increases the durability of the button under this kind of abuse. To further safeguard the valve, *it is best to wire up the socket with a wiring jig in position.* This relieves the valve of a good deal of unnecessary stressing.

THE ANNEALING OF GLASS:

So far we have seen why, and how, the button base of a miniature is deliberately stressed or toughened. It must have occurred to the reader that an unwanted tension might well occur somewhere during valve processing which must be eliminated. An example of this is in the principal, and most critical, glass-working operation in making a valve, the making of the main seal. Main sealing is the joining of the glass "bulb" to the button base (known as the "stem"). Those who have been through the Radiotron factory will remember that all the working parts of the valve are spot-welded to the stem during assembly, resulting in what is called a "mount". The bulb is a cylinder of glass, open at one end, domed over on the other. At main sealing, the mount is pushed into the bulb, and the bottom end of the bulb is melted to the edge of the stem. In section, the finished seal looks as in Fig. 6.

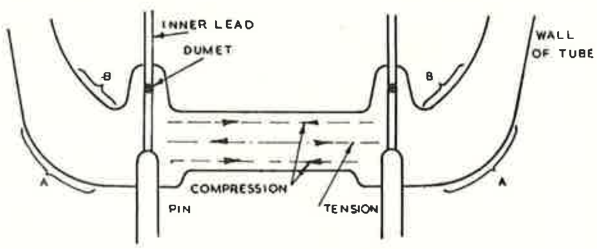


Fig. 6.

It is while cooling after main sealing that the button base is given the quick cooling treatment necessary to toughen it. However, there is a complication. Consider the area marked A on the outside surface of the seal zone, Fig. 6. Since this area is exposed to the air, it cools quickly after the seal is made. Not so with B on the inside surface. Thus, following the rule, A would be finally in compression, which is desirable, but B would cool slowly and end up in tension. A treatment is required to make A nearly neutral, so B will not be in tension. This is done by keeping A from cooling quickly — that is, to make it keep pace with B so both cool at the same rate. A warm air blow (or its equivalent, a tiny flame) directed on A achieves this. The removal of stresses from glass in this fashion is known as "annealing".

Suppose there is a piece of glass with dangerously high stresses frozen into it, which must be removed or reduced. One heats the glass until it becomes plastic to enable any stresses present to pull or push themselves away. After allowing a few minutes for this to happen, the glass is cooled slowly, taking care that every part of it cools at the same rate. The result is — a neutral piece of glass. Annealing in this way is the method used to keep stresses down to a size that can be handled.

THERMAL SHOCK:

Consider a glass rod held in both hands with pressure applied so as to almost snap it in two. The rod is certainly stressed, but the stresses are not permanent, in the sense that they are not frozen into the glass. They disappear when the rod is released. This kind of stress is called a temporary stress, in this case being due to mechanical loading. Such stresses can cause breakage every bit as much as can "frozen in" permanent ones — the rod can easily be snapped by a little more pressure. Another example of temporary stress due to mechanical load is the case of the button forced into a tight socket. Mechanical load can be administered by a blow — such as when a stone hits a car windscreen. Here, since the stress lasts only for a short moment, we refer to temporary stress due to mechanical **shock.** Now, this question of **shock loading** causing temporary stress is one to emphasise, because it leads to one of the most difficult practical problems in valve making.

Return for a moment to the slab of glass, supposing this time that it is cold. Consider

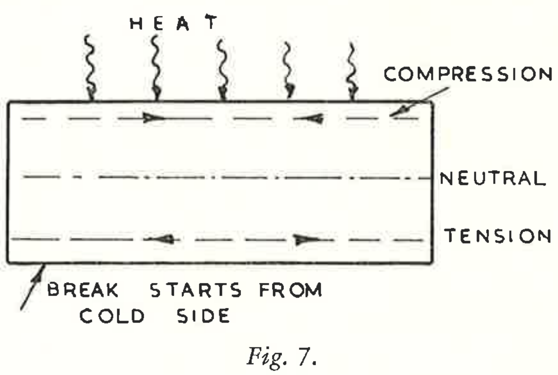


Fig. 7.

beginning to heat the top surface, as in Fig. 7. It commences to expand. But, the bottom is not being heated, and does not want to expand. Thus the top has to push against the bottom: this means the top goes into compression, the bottom into tension. *The glass has been stressed, merely by heating it lopsidedly.* This is exactly how it is that a cold milk bottle breaks when very hot water is poured inside, or a cold earthenware dish fractures when put on a hot stove. The stress is a temporary one, for it disappears as soon as top and bottom of the slab (or inside and outside of the milk bottle) reach the same temperature. This kind of loading is like a shock, and is therefore called **thermal shock** loading, because it is a temperature or thermal effect.

In order to get a piece of glass hot enough to melt it and make, say, a main seal, it must first be heated to the "working temperature" at which it flows like treacle, by a flame. A glassblower, making articles by hand, is careful to warm his glass slowly to prevent its breaking from thermal shock. However, in mass producing valves one cannot waste time slowly heating the glass of each valve: it must be done fast. Something must be done to reduce the effect of thermal shock. One way to do this is to toughen the glass, as this makes it better able to withstand tensile loads. Otherwise, great attention has to be paid to temperatures of flames and glass, so that we can seal valves as fast as is possible; so that the tensions which occur are nearly — but not quite — enough to make the glass fly to pieces under thermal shock. Using special techniques developed by A.W.V. it has been found possible to measure the thermal shock and thereby obtain good process control. This can only be done by careful attention to detail.

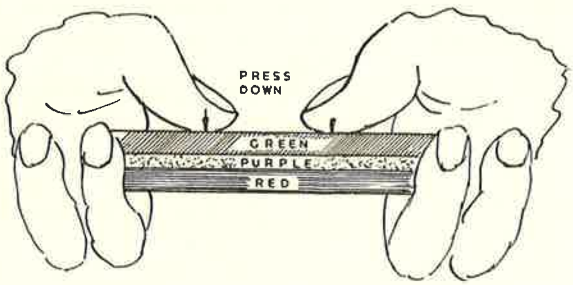


Fig. 8.

MEASUREMENT OF STRESSES IN GLASS:

The next question to consider is the measurement of the stresses present, in order to control them by annealing or toughening. The answer to this problem lies in a very ingenious device known as a polariscope. This device uses polarised light (of the same nature as the light transmitted by the better kind of sunglasses). It is a very interesting property of many transparent things that when polarised light is passed through them in a special way, they **show colours if they are stressed.** Glass behaves this way. So do perspex, celluloid, and cellulose tape. By looking at the colours produced, an idea of the stresses present can be gained.

One may even **measure** the colours, thus measuring the stresses. A very pretty demonstration of this effect is had by putting a glass rod in a polariscope and looking at it while bending with the fingers. Suppose it is grasped as in Fig. 8 and pressed. This puts the top surface in compression, the bottom in tension, and the centre neutral. (Just like the loaded beam of Fig. 1.) The colours named in Fig. 8 are seen.

If now a section be taken through a button base and under polariscope, the pattern illustrated in Fig. 9 is seen. There is here visible proof of the toughening and annealing treatment.

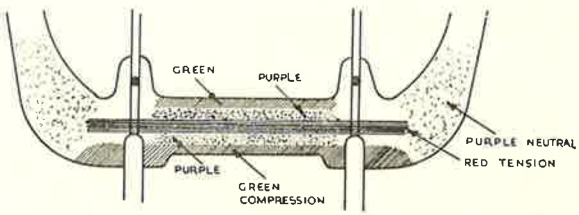


Fig. 9.

GLASS-TO-METAL SEALING:

The glass envelope of the valve must do another job besides those so far mentioned. The leads from the pins have to run through it to connect to the electrodes inside. These metal wires must make a vacuum-tight seal to the glass. The reader will realise what must be the main requirement of a glass-to-metal seal: for the metal leads must be immersed in the glass when the glass is hot enough to be soft. But they both must cool, and therefore contract, back to room temperature. In order to prevent the metal from shrinking away from the glass, the important thing is that they **must both contract the same amount.** Different substances expand and contract by different amounts. We must arrange for the *metal wire to have the same "coefficient of expansion" (and contraction) as the glass.*

It is preferable that the surface of the wire be copper in order to carry the required current as well as for an important chemical reason — copper oxide dissolves in molten glass to make a good glue to help stick the copper and glass together. However, copper will contract much more than the glass used in the button base (i.e., its coefficient is greater than that of the glass). The problem is thus to reduce the coefficient of a wire with a copper surface.

This is done in an ingenious way. Certain nickel-iron alloys can be made with a coefficient less than that of glass. The method is to make a wire consisting of a nickel-iron core with a copper sheath. A magnified cross section looks like Fig. 10. This wire is called Dumet — a

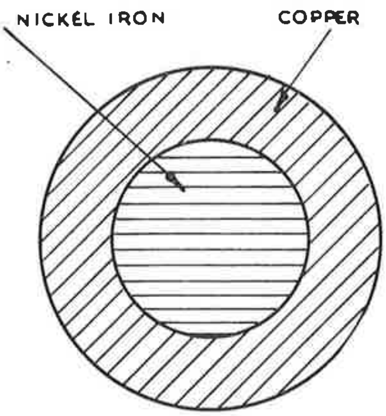


Fig. 10.

barbaric corruption of the words Dual Metal. In a miniature button, one may see the reddish or copper-coloured Dumet as the middle section of each lead, connecting the stiff outer pin to the inner lead inside the valves. See Fig. 6. It can be seen that by selecting the amount of copper and nickel-iron in the Dumet, the lead can be made to grow fatter or thinner at the same rate as the surrounding glass. This prevents the surfaces from tearing apart. However, it is impossible to make it **also** grow longer or shorter at exactly the same rate as the glass. This puts a limit on the length of Dumet one may use in a seal. This limit is of the order of an inch or two, which is no problem in ordinary valve making.

A long and fascinating story could be told about glass-to-metal seals. There would be a great deal to say about the many different kinds of seal used, particularly some of the larger ones used in power valves. Some of the techniques used in these valves are much more ingenious than the Dumet idea. The method of embedding the pin in the glass button of a miniature, would also have a place.

CONCLUSION:

This ends the present brief study of problems that crop up in the use of glass in valve making. It has been explained why glass is used to make valves and why button bases are toughened to better withstand the mechanical stresses they may encounter in use. How and why one can freeze any desired stress into glass, or leave it neutral if that happens to be the best thing to do, has been shown. The problem of thermal shock which occurs only in the factory, and the polariscope, that beautiful tool of the glass technologist, were briefly examined. Finally, something was seen of the question of glass-to metal sealing.

Thus, it is seen that the glass envelope requires a good deal of thought and effort to manufacture successfully. Perhaps the concept of glass as a structural material, with, on a small scale, the problems faced by the structural engineer, may be novel to some readers. The concept, however, is the heart of the problem. This account has achieved its end if the reader can now think of the glass envelope of a valve as something more than a mere vacuum container for its electrodes.

Mr. J. Ziegler graduated as B.Sc. (Syd.) in 1949. He worked on the staff of A.W.V. in the Power Valve section until 1955 on the production of all types of transmitting valves (especially magnetrons). During the past year, he has been the Glass Quality engineer for the Receiving Valve division.

R.C.A. APPLICATION NOTE AN-152*

DESIGN AND ADJUSTMENT OF PICTURE TUBE CENTRING MAGNETS AND ION-TRAP MAGNETS

This note discusses some important considerations pertaining to the design and adjustment of centring magnets and ion-trap magnets used in television receivers. Particular attention is given to the use of such magnets with picture tubes utilizing electrostatic focus.

CENTRING MAGNETS.

In a picture tube utilizing electrostatic focus, the electron beam is centred by means of a small external magnet used exclusively for that purpose. This magnet, however, deflects the electron beam and may, therefore, cause defocusing. To minimize defocusing, it is important that the field of the centring magnet be uniform; to provide varying degrees of centring, it is necessary to have the field strength of the magnet adjustable to zero. Adjustment can be obtained by using two uniform fields of equal strength which can be rotated to aid or oppose each other. A magnet having a maximum field strength of 8 gausses placed directly behind the base end of the deflecting yoke will produce sufficient centring for a picture tube having a horizontal deflection angle up to 70 degrees and operating at a voltage as high as 18 kilovolts.

In the design of a centring magnet, particular attention should be given not only to uniformity of the magnetic field but also to straightness of the field lines. Non-uniform fields and curved lines produce serious defocusing, especially with electrostatic focus picture tubes designed to operate at low focusing voltages. Field uniformity can be measured with a gauss meter (such as the General Electric Gauss Meter Cat. No. 409X51) and a jig of the type shown in Fig. 1. Five holes are drilled in the top of a bakelite rod, as shown, to permit insertion of the gauss-meter probe. The probe is first inserted in the centre hole, and the magnet to be tested is slipped over the rod in the position shown in Fig. 1 and moved up and down until the point of maximum field strength is located to line up with the tip of the probe. With this arrangement, the field strength can be measured at the centre of the magnet, and at distances of $\frac{1}{4}$ and $\frac{1}{2}$ inch from the centre on either side.

Curvature of the field lines can be determined conveniently through the use of the usual iron-filings procedure. Straightness of field lines is critical only in the region through which the electron beam travels and in the plane perpendicular to the tube axis and parallel to the reference line. Field lines in this region should be straight through the entire range of the magnet from zero to full strength. A further check on line straightness can be made by placing the magnet on a picture tube in operation and observing either a resolution test pattern or a blank raster. With a well-focused test pattern or raster, the magnet should be rotated through 360° and varied from zero to full strength and the pattern or raster checked for any change in focus. When the centring magnet is well-designed, the change in focus, if observable at all is slight.

* Printed with acknowledgment to R.C.A.

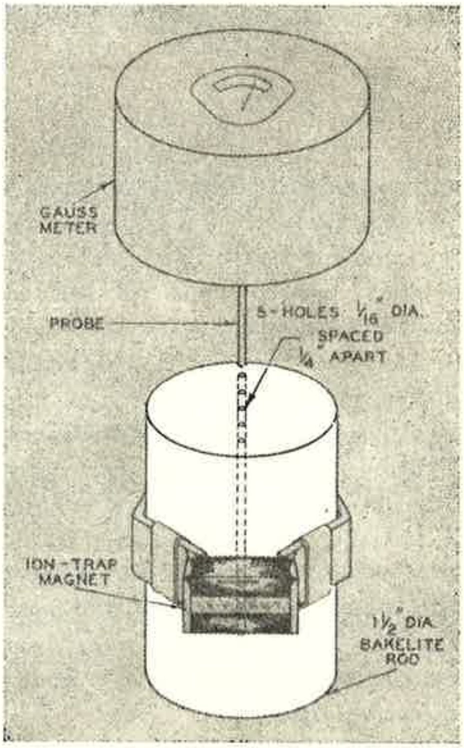


Fig. 1. Test Jig for measuring field strength of centring and ion-trap magnets with a gauss meter.

The centring magnet should be placed as close to the base end of the deflecting yoke as possible so that the field of the magnet will not extend into the field of the electron-lens portion of the gun and, therefore, cause focus distortion. Since the region between the base end of the deflecting yoke and the electron lens is limited, the pole pieces of the centring device must be comparatively narrow in order to restrict the magnetic field to this region.

ION-TRAP MAGNETS.

The effect on spot shape of the magnetic field of the ion-trap magnet is less than that of the centring magnet because the beam diameter is much smaller in the ion-trap region. Nevertheless, the effect of an improperly designed ion-trap magnet can be detected and is quite noticeable with a picture tube having low-voltage electrostatic focus.

Best performance is obtained, therefore, when the field of the ion-trap magnet is uniform and the field lines are straight throughout the region traversed by the beam. If a magnet having a non-uniform field is used, the side of the tilted gun chosen for location of the magnet influences the effective value of the field. Field uniformity can be measured with the jig and gauss meter previously described; field curvature can be studied with iron filings.

Experience with picture tubes of present design indicate that an ion-trap magnet for use with a tube having electrostatic focus generally has a field strength about 5 or 10 gausses less than that of a magnet used with a comparable tube having magnetic focus. The field strength requirement for the electrostatic-focus tube is lower because there is no external focusing device to shunt the field of the ion-trap magnet when it is moved along the neck of the picture tube toward the face-plate. The field strength requirement for a particular tube type is usually given in the published data for the tube. For a picture tube utilizing electro-static focus, it is important that the field strength be close to the given value. A field strength appreciably higher than that specified distorts the focused spot, changes the focusing voltage of the tube, and also requires a shift in the position of the magnet of the neck of the tube. A field strength appreciably lower than that specified decreases maximum brightness, makes centring of the beam difficult, and may cause neck shadow. Polarity should be indicated on the magnet in some manner to facilitate correct positioning when the picture tube is installed.

STABILITY MARGIN

In this article by F. Langford-Smith in the September issue, the section ***Minimum Stability Margin*** *should read:—*

It is usual to regard 6 decibles as the minimum safe stability margin. This is reasonably safe if the stability margin is measured on the actual amplifier in question, used on its normal loudspeaker load. However, it is possible, when copying a prototype with a stability margin of 6 db on a resistive load, to encounter trouble with instability, particularly if the output transformers are not identical or if the second amplifier is used to drive a dual loudspeaker. The writer prefers a minimum stability margin well over 6 db on a resistive load and at least 6 db on the worst likely case with a capacitance shunted across a resistance, as set out in items 1 to 5 above.

Cond. copy

TECHNICAL LIBRARY

"FREQUENCY MODULATION ENGINEERING"

by C. E. Tibbs, M.I.R.E., M.Brit. I.R.E., and G. E. Johnstone, B.Sc.: published by Chapman & Hall Ltd.

Since 1947, when this book was first published, there have been such extensive additions to the literature dealing with frequency modulation engineering that a complete revision was necessary. The second edition (1956) has made free use of B.B.C. data from both published and unpublished reports.

This book is intended to provide students, engineers and all those interested, with a concise and readily digestible survey of the whole field of F-M engineering. It includes the frequency modulation of a carrier wave, interference and noise structure, F-M propagation, aerials, F-M transmitters and receivers and measurements on F-M equipment. In the latter chapters, commercial equipment is discussed at some length.

A feature of this volume are the selected references which are found at the end of each chapter.

"HIGH FIDELITY CIRCUIT DESIGN"

by N. H. Crowhurst and G. W. Cooper: published by Gernsback Library Inc.

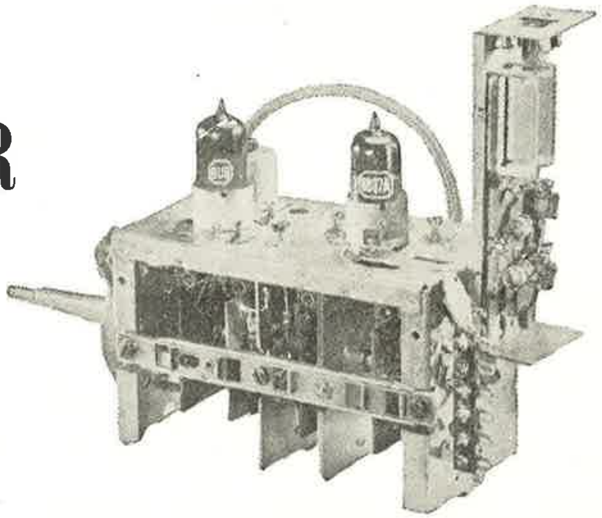
The material for this book originally appeared as a series of articles in the magazine Radio-Electronics. Additional topics have been included, where required, to make the book complete.

Starting with a discussion of negative and positive feedback, there are subsequent chapters on drivers and inverters, power supplies, attenuators, filters and equalizers, speaker systems and advanced techniques. Various testing methods and test equipment are described in later chapters. Full information is also given on how to use design data for the improvement of existing audio systems.

The book has been compiled for the audio enthusiast who wants to know the why-and-wherefor of amplifier design. At the same time it has an excellent index which makes it of great value as a reference manual.

TELEVISION TUNER

Type STT1



Tuner STT-1 has been designed to fulfil the requirements of a high performance front end for Australian television receivers. It is a high quality tuner, using the wafer switch type of construction, which is proving to be the most reliable and economical method of channel selection for T.V. receivers.

PERFORMANCE DATA:

FREQUENCY COVERAGE:

Australian television channels 1 to 10 inclusive. The fine tuning range of the local oscillator is:—

± 2 Mc/s on Channels 3-10
± 1 Mc/s on Channels 1 and 2.

BANDWIDTH:

The bandwidth measured with —3 volts on the a.g.c. line is:—

10 Mc/s on Channels 4-10
8 Mc/s on Channels 1-3.

GAIN:

The gain measured from the Aerial Terminal with the 72 ohm input termination to the grid of the first i-f valve in a receiver is approximately 100.

NOISE FIGURE:

The noise figure on Channels 4-10 is better than 8.5 db, and Channels 1-3 better than 6.5 db.

I-F REJECTION:

The i-f rejection on Channel 1 is better than 80 db. Other channels have better figures.

IMAGE REJECTION:

The Image Rejection on Channel 10 is better than 50 db. Other channels have better figures.

INPUT IMPEDANCE:

The input impedance may be selected to be either 300 ohm balanced or 72 ohm unbalanced by suitable connection to input connector.

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The standing wave ratio for the nominal impedance is less than 2 : 1 on all channels.

OSCILLATOR RADIATION -

Field intensity measurements have shown that the oscillator radiation is less than the Australian Broadcasting Control Boards recommendations by the factor of two.

OUTPUT TO I-F AMPLIFIER:

The output impedance of the link coupling winding of the converter i-f transformer is nominally 33 ohms. The i-f transformer may be tuned between 30 and 35 Mc/s.

POWER SUPPLY REQUIREMENTS:

Heaters	6.3 volts 0.85 amp.
H.T.	18 mA at 275 volts.
Bias	A.G.C. as desired.

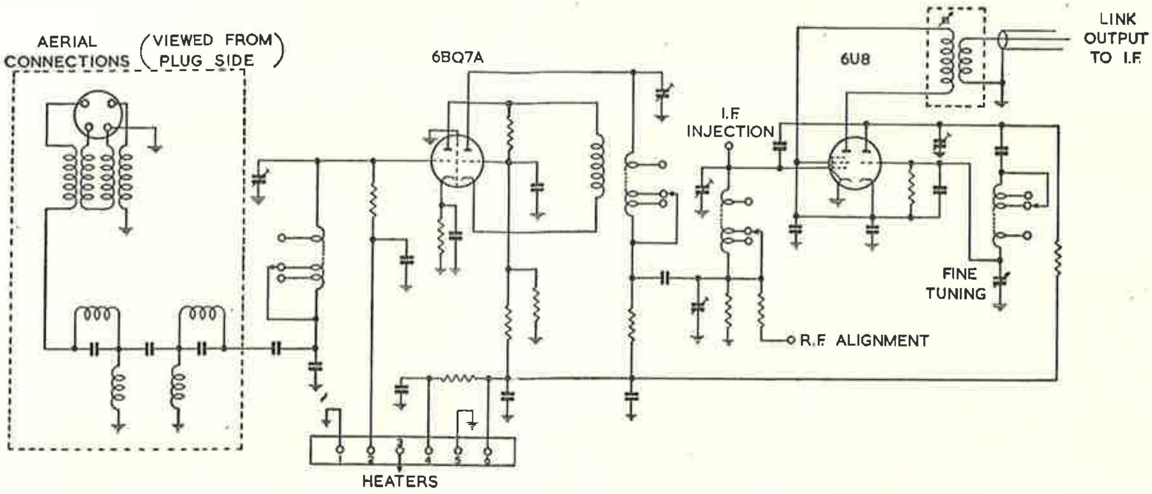
low oscillator radiation figure.

CIRCUIT DESCRIPTION

AERIAL INPUT FILTER:

The circuit of this unit consists of two sections. The first section, an aerial matching transformer or balun, matches the impedance from either a 300 ohm balanced feeder or a 72 ohm coaxial line to a 300 ohm single-ended (or side-grounded) circuit. This is accomplished by using the equivalent of two 150 ohm transmission lines coiled up on separate coil forms. Because they are coiled, these transmission lines have high impedance for unbalanced currents. Furthermore, the use of this arrangement allows either a series or series-parallel connection to provide a match for a balanced 300 ohm input or an unbalanced input as shown on page 4, since each end of the coils may be grounded independently of the other.

The second section is a composite high-pass filter, having a constant K mid-section and terminating half sections with rejection frequencies of 36.0 Mc/s. The filter is adjusted to provide attenuation for signals below 49 Mc/s., and high attenuation to 36.0 Mc/s., the vision carrier frequency of Australian receivers.



SIMPLIFIED CIRCUIT DIAGRAM

TUNER:

Tuner STT-1 uses a Radiotron 6BQ7A twin triode as a low noise r-f amplifier and a Radiotron 6U8 triode pentode as local oscillator-converter. Both sections of each of these valves are connected in series to the B+ supply, resulting in improved stability and economy of current drain.

The output of the aerial filter unit tunes the grid of the 6BQ7A to the channel frequency desired and is a π matching network transforming the 300 ohm output impedance of the filter to the grid impedance.

The Radiotron 6BQ7A is used in a cascode circuit. The signal is injected on the grid of the first triode, amplified and direct coupled through a series inductor to the cathode of the following grounded grid amplifier. The inductor is used to give greater gain on the higher frequency channels. A.G.C. is applied to the first triode, and a resistor network to the grid of the second section is designed to give better a.g.c. characteristics to the valve as a whole. The plate of the second triode is connected to a band pass network tuned to each channel. Coupling in this circuit is obtained by the present variable capacitor on the high channels, and by this and on additional capacitors on Channels 1, 2 and 3. This circuit, together with the tuned signal grid circuit provides the necessary bandwidth and selectivity of the tuner.

The triode section of the Radiotron 6U8 is used as the local oscillator in a Colpitt's type circuit, and is operated on the high side of signal frequency. Injection from the oscillator to the grid of the pentode section is by fixed capacitive coupling. Consistent injection is achieved by the compensating effect of the series operation of the two sections of the 6U8. Tuning of the oscillator is accomplished, as in other r-f circuits by switching incremental inductance which is adjustable from the knob end of the tuner. Fine-tuning is achieved by a variable capacitor, which is driven by a cam spindle, concentric with the switch shaft.

The output voltage from the Radiotron 6U8 converter plate is transformed across a low impedance link winding in the tuner. Connection to the receiver i-f strip is made by a coaxial lead to a suitable link input transformer in the TV receiver.

This arrangement allows a great deal of flexibility in the location of the tuner to the i-f amplifier and results in low radiation of oscillator voltage present in the converter plate circuit. A suitable coupling arrangement incorporating adjacent sound and vision frequency trap circuits is shown above. A sweep voltage may be injected on the test point on top of the chassis for alignment of the i-f line circuit.

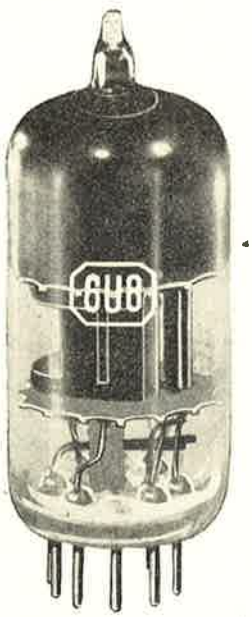
An additional test point for use during the switch alignment of the tuner is located on the side strap.

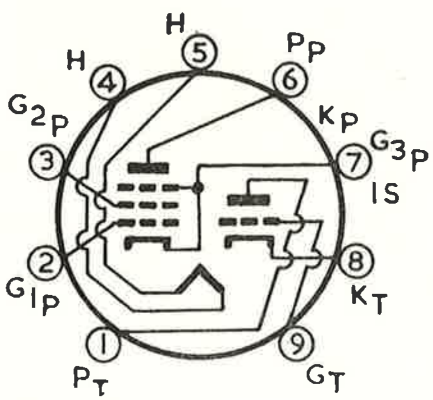
RADIOTRON 6U8

MEDIUM-MU TRIODE — SHARP CUTOFF PENTODE

(tentative data)

The Radiotron 6U8 is a 9-pin miniature valve containing a medium-mu triode and a sharp cut-off pentode in one envelope. It is designed primarily for use as a combined oscillator and mixer valve in F-M and television receivers using intermediate frequencies up to 40 Mc/s.





(bottom view)

SOCKET CONNECTIONS

Pin 1—Triode Plate
Pin 2—Pentode Grid No. 1
Pin 3—Pentode Grid No. 2
Pin 4—Heater
Pin 5—Heater
Pin 6—Pentode Plate
Pin 7—Pentode Cathode
Pentode Grid No. 3
Internal Shield
Pin 8—Triode Cathode
Pin 9—Triode Grid

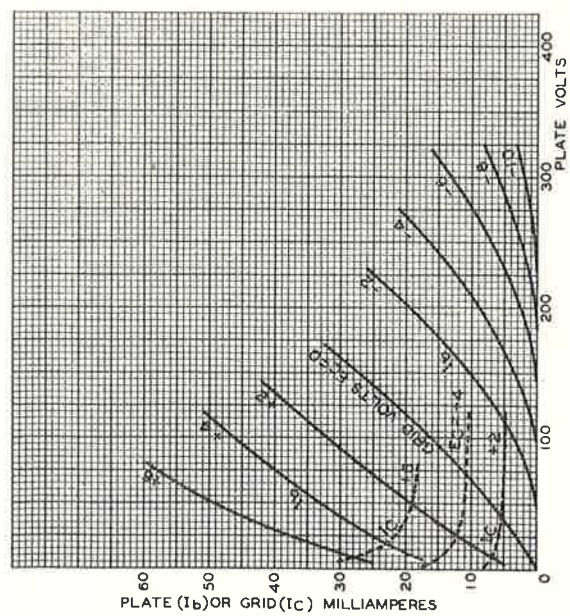
The pentode mixer unit of the 6U8 provides low grid No. 1 to plate capacitance as compared with a triode mixer and also has a low output capacitance. The low value of grid No. 1 to plate capacitance minimizes feedback problems often encountered in mixer circuits operating with I-Fs between 30 and 40 Mc/s.

GENERAL DATA

Electrical:

Heater Voltage .... 6.3 volts
Heater current .... 0.45 amp
Direct Interelectrode Capacitances:

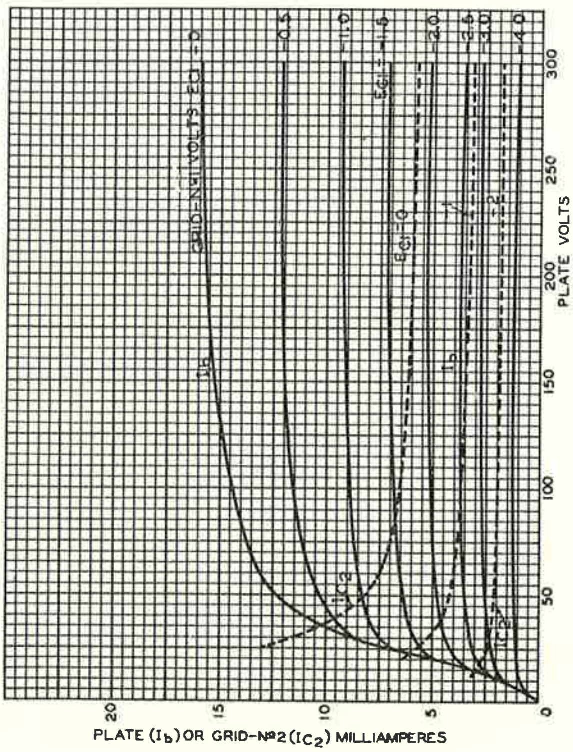
	With External Shield	Without External Shield	
Triode Unit:			
Grid to plate	1.8	1.8	μμF
Input	2.5	2.5	μμF
Output	1.0	0.4	μμF
Pentode Unit:			
Grid No. 1 to Plate	0.006 max.	0.010 max.	μμF
Input	5.0	5.0	μμF
Output	3.5	2.6	μμF
Heater to Cathode (approx. each Unit)	3.0	3.0	μμF



Average Plate Characteristics for Triode Unit of Type 6U8 or for Pentode Unit of Type 6U8 Connected as Triode.

Characteristics:

	Triode Unit	Pentode Unit	
Plate Voltage	150	250	volts
Grid No. 2 Voltage .	—	110	volts
Cathode-Bias Resistor	56	68	ohms
Amplification Factor .	40		
Plate Resistance (approx.)	5000	400000	ohms
Transconductance ..	8500	5200	μmhos
Grid No. 1 Bias (approx.) for Plate Current of 10 μamp	—12	—10	volts
Plate Current	18	10	mA
Grid No. 2 Current .	—	3.5	mA



Average Plate Characteristics for Pentode Unit of Type 6U8

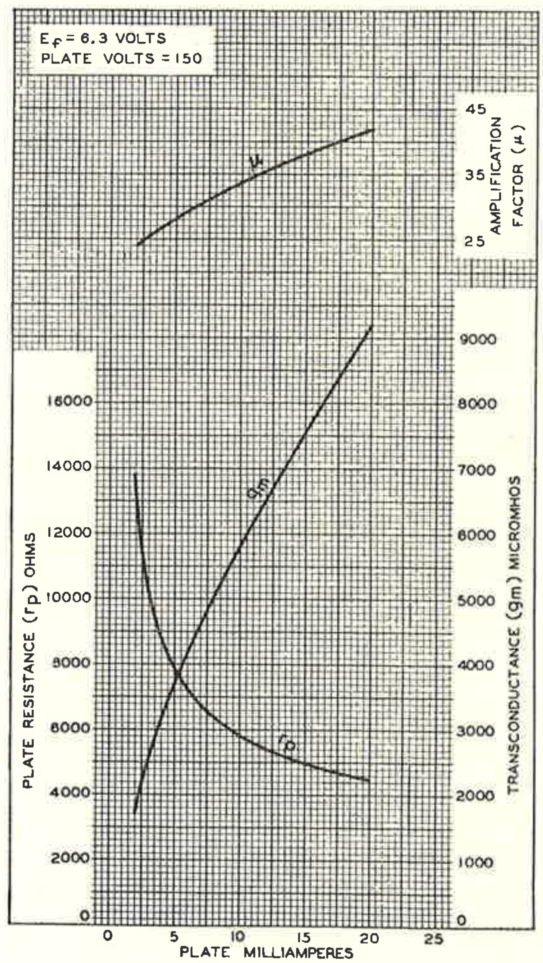
Mechanical:

Mounting Position	Any
Maximum Overall Length	$2\frac{3}{16}''$
Maximum Seated Length	$1\frac{15}{16}''$
Length from Base Seat to Bulb Top (excluding tip)	$1\frac{9}{16}'' \pm \frac{3}{32}''$
Maximum Diameter	$\frac{7}{8}''$
Bulb	T-6-½
Base	Small—Button Noval 9-Pin

CONVERTER SERVICE

Maximum Ratings (Design-Centre Values):

	Triode Unit	Pentode Unit	
Plate Voltage	300 max.	300 max.	volts
Grid No. 2 Supply Voltage	—	300 max.	volts
Grid No. 2 (Screen) Voltage			
Grid No. 1 (Control-Grid) Voltage:			
Positive Bias Value .	0 max.	0 max.	volts
Plate Dissipation	2.7 max.	2.8 max.	volts
Grid No. 2 Input	—	0.5 max.	watt
(For Grid No. 2 voltages up to 150 volts)			
Peak Heater - Cathode Voltage:			
Heater negative with respect to cathode	90 max.	90 max.	volts
Heater positive with respect to cathode	90 max.	90 max.	volts



Average Characteristics for Triode Unit of type 6U9

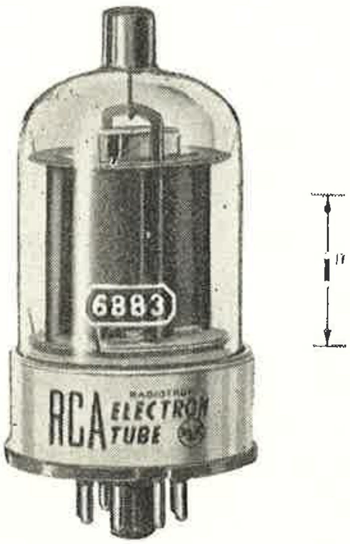
NEW RCA RELEASES

RADIOTRON 6893

BEAM POWER VALVE.

Radiotron 6893 is a small, sturdy, beam power valve for use as an r-f power amplifier and oscillator as well as an a-f amplifier and modulator in mobile equipment operating from a 12 volt storage battery. Except for its heater which is rated at 12.6 volts/0.4 amp, the 6893 is identical with the 2E26 and has the same technical data exclusive of I.M.S. conditions.

In class C telegraph service at frequencies up to 125 Mc/s the 6893 can deliver 20 watts (CCS) at a plate voltage as low as 400 volts or 27 watts (ICAS) at 600 volts, with a driving power at the value of only about 0.2 watt.



Small in size for its power-output capacity, the 6893 utilizes a rugged button-stem construction with short internal leads, a T-9 bulb, and an octal base with short metal sleeve which shields the input to the valve so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

RADIOTRON 5FP14-A

OSCILLOGRAPH TUBE.

Radiotron 5FP14-A is a 5 inch oscillograph tube featuring high resolution capability and a medium-long persistence characteristics. It is intended particularly for pulse-modulated applications, such as radar indicator service. The 5PF14-A is unilaterally interchangeable with the 5FP14.

Employing magnetic focus and magnetic deflection, the 5FP14-A is designed with a high-resolution gun capable of providing a line whose width will not exceed 0.010 inch measured with ultor current of 200 microamperes, ultor voltage of 4000 volts, and a 49 line shrinking raster. The 5FP14-A has a deflection angle of 53° and a minimum useful screen diameter of 4¼".

RADIOTRON 6201

"PREMIUM" MINIATURE TWIN TRIODE.

R.C.A. is pleased to announce to equipment manufacturers the 6201—a "premium" high-mu twin triode of the 9-pin miniature type. Constructed to give dependable performance under conditions of shock and vibration, this "premium" version of the popular 12AT7 is especially suited for use in a wide variety of application in mobile and aircraft equipment and numerous critical industrial control devices. Such applications include: mixers, oscillators and amplifiers at frequencies up to 300 megacycles, multivibrators, and synchronizing amplifiers.

Design features of the 6201 which improve its strength for resistance to both shock and vibration include a "U" frame construction to keep the mount rigid, and the use of special valve parts which are precisely made and accurately fitted to lock the parts firmly in place and thus eliminate variations in electrical characteristics.

Other features which make this valve especially useful in critical industrial applications include grid side rods having high heat conductivity to provide cool operation and thus minimize grid emission, a pure-tungsten heater having high mechanical strength to give long life under conditions of frequent on-off switching, and a special getter shield to prevent deposit of getter flash on valve elements. Furthermore, the 6201 is controlled for cathode interface to insure dependable performance in on-off control application involving long periods of operation under cutoff conditions.

The 6201 utilizes separate terminals for each cathode to permit flexibility of circuit arrangement, and a mid-tapped heater to permit operation from either a 6.3 or 12.6 volt supply.

RADIOTRON 632-B

MERCURY VAPOUR THYRATRON

Radiotron 632-B is a four-electrode mercury-vapour thyratron of the indirectly heated cathode type. Designed for use in ignitor firing, the 632-B may also be used as a grid-controlled rectifier.

When used with an ignition for ignitor firing, the 632-B thyratron determines the instant firing. Its use prevents reverse current from flowing through the ignitron.

When used as a grid-controlled rectifier, the 632-B is operated so that its output voltage to the load is varied by varying the time of firing during the a.c. input cycle.

The grid No. 2 (the shield grid) of the 632-B can be used as a second control electrode in applications where it is desired to control the firing with two signal (triggering) voltages.

REDUCING HUM IN AMPLIFIERS

By F. LANGFORD-SMITH, B.Sc., B.E., A.M.I.E. (Aust.), S.M.I.R.E. (U.S.A.)

SOURCES OF HUM:

There are various sources of hum in amplifiers, including:

1. Hum due to leakage flux from the power transformer and, to a much less extent, from the filter choke.
2. Hum due to lack of filtering.
3. Hum due to electrostatic coupling from points carrying a.c. potentials to low level parts of the circuit.
4. Hum due to the valves in the low level stages.

PROCEDURE IN REDUCING HUM:

The procedure which we have found helpful in reducing hum to low levels is to begin by reducing hum due to leakage flux from the power transformer. This is mainly 50 and 150 c/s hum. The effects of transformer leakage flux are usually negligible except when a steel chassis is used. In the latter case a simple cure is to isolate the transformer magnetically from the steel chassis, using brass bolts and spacers to lift the transformer at least $\frac{1}{4}''$ above the chassis. This device is inexpensive, and there are good reasons for adopting it in all cases.

When the power transformer is isolated from the chassis, if the hum does not decrease to a sufficiently low level, it might sometimes be beneficial to orient the transformer with respect to the choke and other components, using the position giving least hum.

Leakage flux effects from power transformers may be reduced by placing a copper band right around the core.

In most cases it is not necessary to isolate the filter choke magnetically from the chassis, although this should be beneficial

Having reduced the hum due to leakage flux to a satisfactory low level, the next approach is to make a large improvement in the filtering by connecting a very large capacitance, say 300 μF, across the second filter choke. If this makes a substantial improvement better filtering is called for. In most cases the effect will be slight, and nothing need be done in this direction. This hum is almost entirely 100 c/s when the rectification is full-wave.

In our experience, the majority of remaining hum is usually due to electrostatic coupling, particularly with fairly low level stages on the same chassis as the power supply. The cure is to place an electrostatic screen either around the points of high a.c. potential or around the low level stages. Points which could be watched in this regard are the output mains socket, mains switch and fuse. The electrostatic screen may consist of a strip of steel or aluminium with a width of about $\frac{1}{4}''$ less than the height of the chassis. It may be mounted with a small gap between the chassis and the strip to allow the wiring to pass underneath. Rearrangement of some of the components may be necessary to make a tidy job of the screen. A good place for the screen in a conventional push-pull amplifier is immediately preceding the phase-splitter.

Measurement of the hum should be made both with and without the screen. If the improvement is worthwhile, either the screen may be retained or the components and wiring may be modified to reduce the hum due to this cause.

It is assumed that the a.c. leads to the heaters and pilot lamp are twisted and that the wiring for low level points is kept as far as possible away from them. If no centre-tap is available on the transformer, two half-watt 68 ohm resistors may be connected in series across the heater circuit, the centre point being earthed.

In many cases hum due to the heater-cathode combination may be still further reduced by biasing the heater either positively or negatively with respect to the cathode.

Of course it is necessary to observe all the rules of good wiring practice, using shielded wiring when necessary with the shield earthed to the chassis. The chassis itself and any associated equipment such as record changer or record player should be thoroughly earthed.

If a pre-amplifier is mounted on the same chassis as a main amplifier and power transformer, the problem is much the same, but intensified. No special problems requiring exceptional precautions are required if Radiotron type 6BK8/Z729 is used in both the early stages of a pre-amplifier, for input sensitivities of the order of 10 millivolts or more.

INSTRUMENTS FOR HUM INDICATION:

There are various instruments which may be used to indicate and measure hum, including:

1. Wave Analyser. This measures each component frequency separately.
2. Total Distortion Meter. This normally measures total noise including hum, but it is possible to change over from "noise" to "distortion". In the latter position the instrument indicates total noise and hum at all frequencies except the one to which it is tuned.
3. It is always helpful to have an oscilloscope connected. It may be used to separate noise and hum and to give the dominant frequency of the hum. With care, it may be used without any other instrument, to get the hum down to a low level.
4. It is also helpful to have a loudspeaker connected. If the hum sounds rough, it indicates that a considerable proportion of the hum is due to high order harmonics.

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