"Miniwatt"

DIGEST

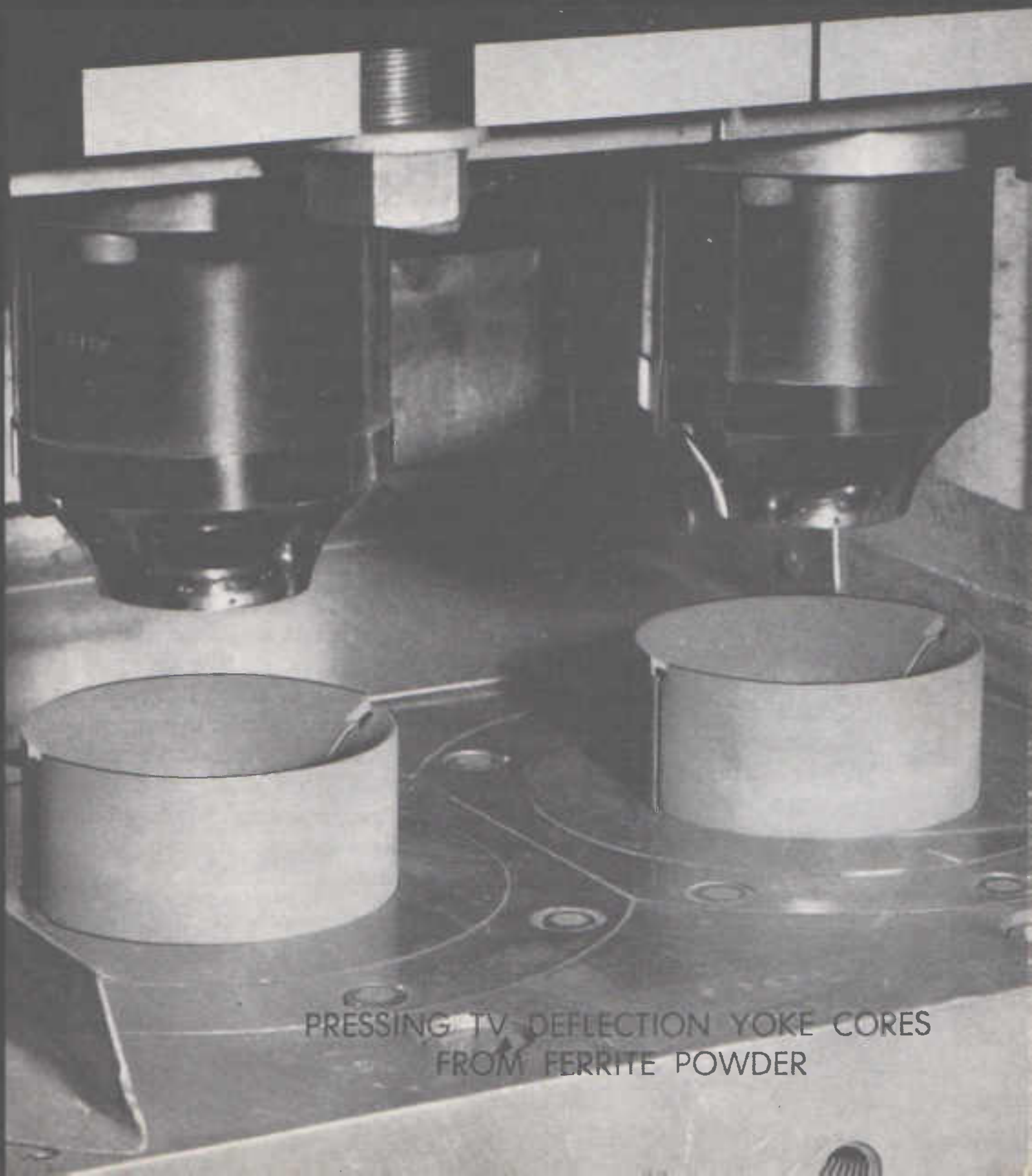
VOL. 1 No. 8
MAY 1962

TECHNICAL AND COMMERCIAL TOPICS OF CURRENT INTEREST TO THE ELECTRONICS INDUSTRY

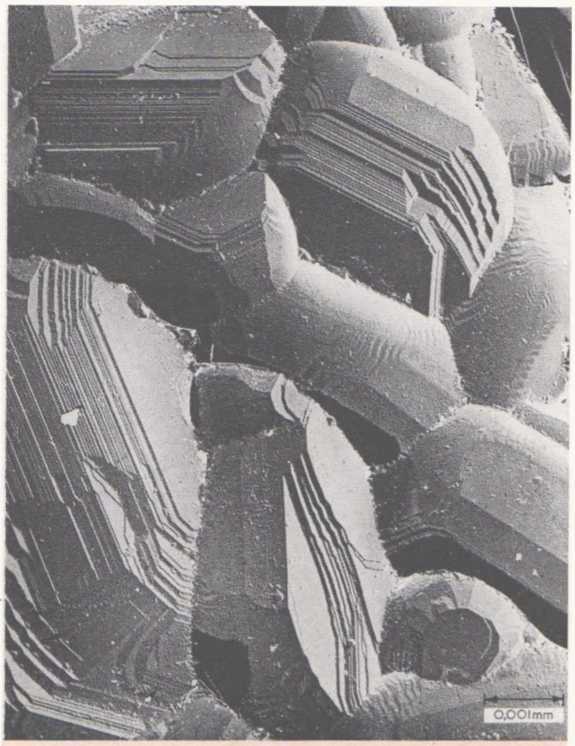
CONTENTS

Published by the "Miniwatt" Electronic Division of Philips Electrical Industries Pty. Limited, 20 Herbert Street, Artarmon, N.S.W., Australia.

PHILIPS



PRESSING TV DEFLECTION YOKE CORES FROM FERRITE POWDER



Surface of Ferroxdure ferrite showing crystal structure. Magnification 10,000 diameters.

MANUFACTURE OF

Since 1956 Philips has been manufacturing ferrite piece-parts at the Hendon, South Australia, plant. The ferrite factory is a "self-contained" unit covering a floor area of some 17,000 square feet, and produces both professional and entertainment type ferrite articles required for the many and varied applications of today.

In describing this factory as "self-contained", we mean that the ferrite manufacturing process in its entirety from raw material ores to finished articles, is carried out within its precincts. This plant is outfitted with the most modern equipment available for the purpose, and efforts are being made continually to improve working methods with an aim to producing better materials at reduced cost.

Two Groups of Ferrites

Ferrites can be divided into the same two main groupings as are used to classify other ferromagnetic materials. These groupings are:

(i) "Soft" materials for cores—manufactured by Philips in Australia under the name of Ferroxcube ferrites. Some applications are in high-quality coils, in carrier telephony, wide-band transformers, HF power transformers, IF transformers, horizontal output transformers and deflection coils in TV receivers, and in pulse transformers. They are made into a variety of shapes such as U-cores, yoke rings, antenna rods or slabs, cup or pot cores, adjusting cores or slugs, chokes, beads, memory cores, transducer cores and parts for microwave devices.

(ii) "Hard" materials for permanent magnets—manufactured by Philips in Australia under the name of Ferroxdure ferrites. Articles made from this material are mainly used either for such purposes as correction of field shapes in TV deflection units and for polarisation effects, or as simple attraction magnets as in door catches, magnetic separators, and when rubber or plastic bonded as distributed magnetic door seals. A further application growing in importance is the electro-mechanical use as in small DC and AC motors or generators.

Both of the above groups can be further subdivided into many differing grades, mainly with respect to electrical or magnetic properties, but in many cases as to composition too. As a result it must be realised that there are many variations to the basic process depending on the application requirements of the end product.

Powder Preparation

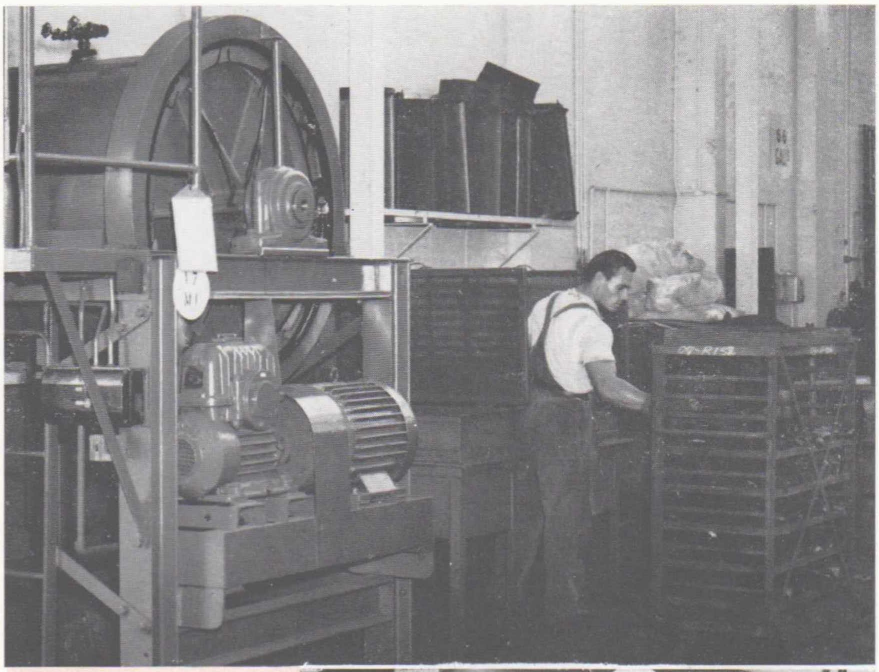
Even when the most advanced methods and equipment are used, as in Philips Australian factory, the manufacture of ferrite piece-parts remains a somewhat long process. This is especially true of the powder preparation process, wherein the various high-grade ores required are analysed, batched and chemically processed to form the various types of ferrite powders necessary for fabrication into the many and varied shapes and compositions demanded by the modern electronic market. Whenever possible, raw materials of local origin are used in this plant, although by necessity some of the high-grade ores required must originate from British or European sources.

The powder preparation process begins with the accurately controlled batching of raw materials followed by milling, filtering, presintering and disintegration as required, all steps being controlled within fine limits. This stage results in a very pure ferrite powder which may now be fabricated into its basic final shape by one of two different forming processes.

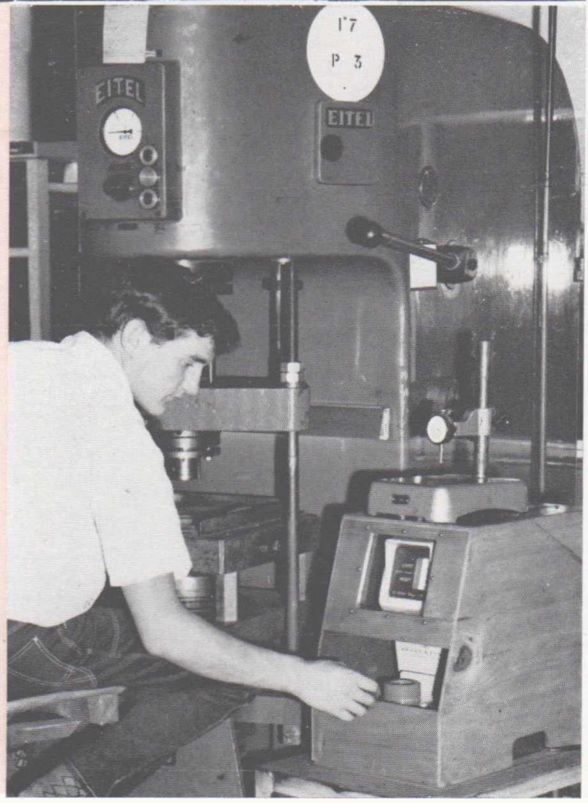
FERRITES IN AUSTRALIA

Forming Process

The forming or shaping techniques used are not unlike some other ceramic forming processes and the process of powder-metallurgy. Depending on whether the form required is of rod or tube shape basically, or of a shape other than this, then either an extrusion technique or a pressing technique is used. The extrusion technique is essentially conventional, but the pressing process is quite unusual, mainly due to the fact that ferrite powders have very little of the "flow" characteristics which play a large part, for example, when pressing a semi-liquid plastic. Thus the dies used for ferrite pressing are unique, and require a great deal of skill in design due to their unusual mode of operation and the very large shrinkage factor which must be taken into account. The factor of linear shrinkage on firing can be as high as 20%, and this factor coupled with the close dimensional tolerances required on the end product gives some idea as to how exacting the die design and fabrication process must be. Due to the abrasive nature of ferrite materials, the die movements involved, and the hundreds and thousands of pressing cycles which take place for some of the more popular shapes, it is often necessary to construct die walls from the extremely hard-wearing tungsten carbide instead of special steel. There are, in fact, certain limitations to those sizes and shapes which can be handled successfully by the pressing technique, due mainly to the lack of "flow" mentioned above. For example, designers of ferrite parts which are intended to be made by the pressing technique



"Ball Mill" and filters used in preparation of ferrite powders.



Operator checking weight of ferrite rings after pressing.

Continuous kiln for firing small ferrite products.

Surface grinding of ferrite half-cups.

should take note of the following points:

(a) Holes and recesses perpendicular to the direction of pressing should be avoided.

(b) Complicated shapes should be slightly tapered to facilitate their removal from the die.

(c) Rings with a wall thickness less than 10 mm should have a height less than three times the wall thickness.

(d) Dimensional tolerances should be as wide as possible, preferably ±3% or more, otherwise grinding is required for closer tolerances.

The limitation on size generally is due to physical limits of existing machinery, although in many instances it is possible to prefabricate large pieces by hand with quite satisfactory results. Similarly, some of the complicated shapes which cannot be extruded or pressed may be hand-turned or worked from rough pieces prior to sintering, although this practice is not encouraged due mainly to the expense of hand-working compared to machine forming. The presses used are electro-hydraulically powered and are of both the manual types and semi-automatic types, depending on the shapes involved.

Sintering

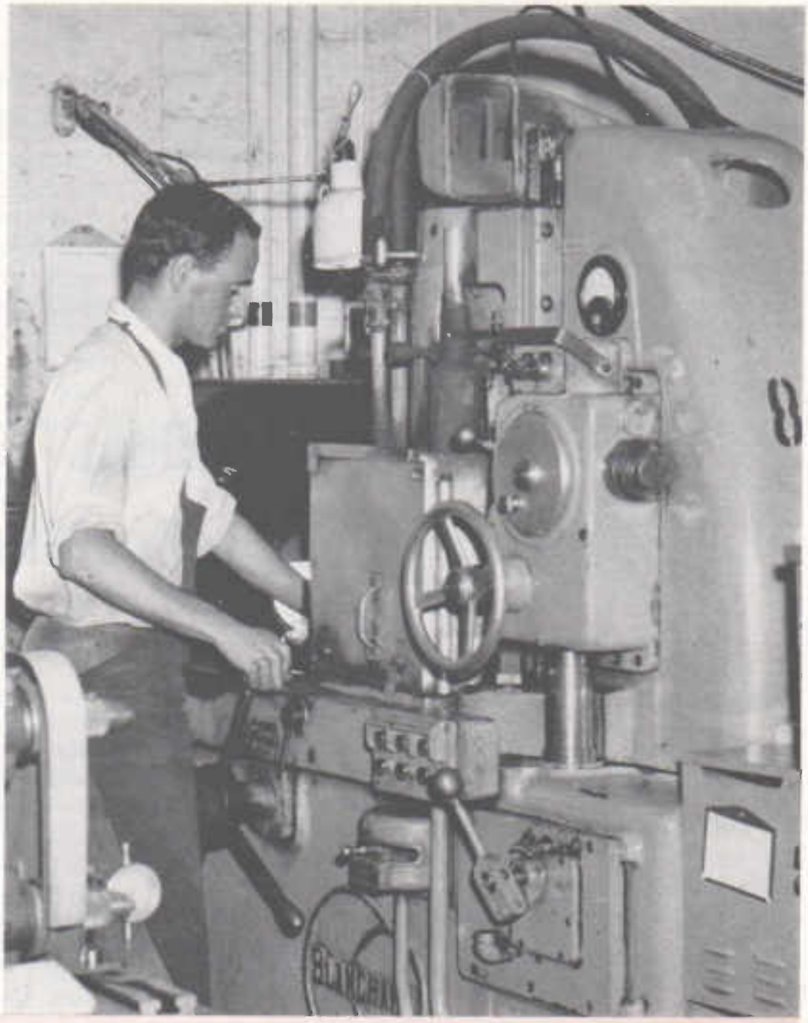
Probably the best known stage in the ceramic art is the sintering or firing stage. In the case of ferrites we are concerned not only with the physical and chemical changes which occur on sintering, but also with the electrical properties resulting from these changes, and it is in this sintering stage that great care and control of both temperature and atmosphere are required. Use is made at Hendon of both periodic kilns (stationary) and tunnel kilns (continuous), both large and small. Kilns used for ferrite manufacture generally are not as large as many of the big brick and whiteware manufacturing kilns, but the instrumentation necessary for a ferrite kiln is greater and far more complicated than that used on most kilns.

Finishing

After sintering is completed, many ferrite bodies require further treatment such as might be applied to metals, for example surface grinding, drilling, cutting or reaming. These are all part of the "finishing" operation, as it is known. Before any parts are packed ready for despatch, they are subjected to physical and electrical tests carried out as directed by the Philips Standard Sampling System and based on predetermined product specifications.

Quality Control

Quality control is under the care of a laboratory staff who have at their disposal a laboratory outfitted with all the necessary equipment to give service to the factory by way of routine batch control and statistical quality and stage quality controls. This laboratory is also working to improve existing materials and develop new materials, a task which must not be ignored if products and materials are to remain in step with the modern trends.



Surface grinding machine.

Ferrite laboratory.

This is the first of two articles describing two-stage IF amplifiers for TV receivers

FRAME GRID FROM AERIAL TO VIDEO DETECTOR

Opens the way for Two-Stage IF amplifiers

The use of two frame-grid valves in the new Miniwatt tuner NT 3009 makes a two-stage IF amplifier an attractive proposition. The higher gain of the new tuner eases the gain requirements imposed on the IF amplifier and investigation has shown that the overall performance of such a tuner/IF combination is comparable to, or better than, that of earlier three-stage strips and tuners using conventional valves.

Two IF amplifiers are to be presented, to assess the relative merits of alternative designs. This article contains a description of a design employing double-tuned bandpass transformers as interstage coupling elements, and a design with single-tuned bifilar transformers will appear in the next issue of the Digest.

GENERAL DESIGN CONSIDERATIONS

In considering a two-stage IF design, it is obvious that all signal amplifying stages between aerial terminals and video detector should contribute maximum gain to achieve a satisfactory overall performance.

For this reason a tuner with high gain frame-grid valves in both RF amplifier and mixer positions such as the Miniwatt printed coil tuner type NT 3009 is very well suited for this purpose.

The type of coupling between mixer and first valve is determined by the tuner output design and is therefore fixed for each type of tuner. In contrast to earlier Miniwatt tuners using link coupling, type NT 3009 has been designed for bottom capacity bandpass coupling[(1)].

For the IF amplifier, the obvious choice of valves is the semiremote-cutoff pentode 6EH7 for the gain-controlled first stage, and the sharp-cutoff pentode 6EJ7 for the second stage. After having decided on tuner and valve types, there remains the choice of interstage coupling circuits.

The coupling between first and second valve and between second valve and detector can be arranged either on a double-tuned bandpass or single-tuned basis. Which of the two possibilities is to be used will depend upon the performance required and upon considerations of production technique and cost.

Where highest possible gain and maximum adjacent channel rejection are not considered to be paramount, single-tuned circuits can provide adequate performance. Their construction in the form of bifilar transformers is simple and their alignment is not very critical. On the other hand, where maximum gain and selectivity are considered essential, it will be necessary to use double-tuned transformers. In theory, an increase in gain approaching 6 dB can be obtained when a staggered pair of single-tuned circuits is replaced by a double-tuned transformer. In practice, the improvement in gain is somewhat less. Double-tuned transformers are also far more selective outside their pass bands, allowing more effective adjacent channel rejection circuits to be designed. They are, however, more difficult to manufacture within close tolerances and their alignment is quite critical.

Design 1

TWO-STAGE VISION IF AMPLIFIER WITH DOUBLE-TUNED TRANSFORMERS

The design procedure adopted follows the theory for a flat stagger-tuned or Butterworth system, and has been described in the literature[2,3,4,5]. In the present case it yields data for three double-tuned transformers equivalent to six stagger-tuned circuits. Each transformer is specified in terms of bandwidth and tuning frequencies, from which information it is then possible to determine the loaded Q and coupling factor for each transformer. The positioning of the transformers in the amplifier is largely dictated by the maximum value of Q realisable in each stage. Hence the transformer requiring the largest bandwidth will be placed in the output of the second stage because of the detector loading. Similarly, the transformer with the highest value of Q must be placed between the first and second stage since the input position is limited by the primary Q in the tuner. Accordingly, the required equivalent loaded Q's of 7, 30 and 9.5 have been assigned the positions T_2, T_1 and the input transformer L_1, L_2 respectively as shown in the circuit diagram of Fig. 1. It will be noted that each transformer is loaded by a damping resistor to obtain the exact required bandwidths.

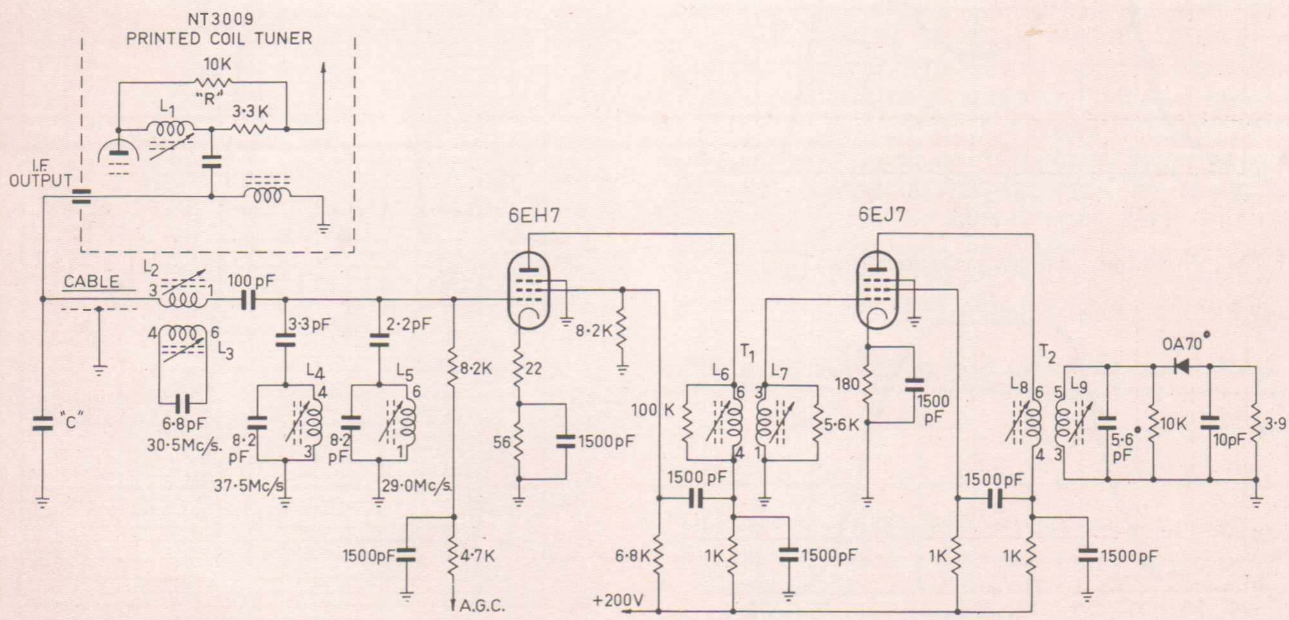
The windings of T_1 and T_2 are inductively coupled, but L_1 (in the tuner) and L_2 are bottom capacity coupled, by means of the capacitance of the coaxial cable connecting the tuner IF output to the input of the IF strip plus a fixed ceramic capacitor "C," to produce a total capacitance of 97 pF. "C" should be mounted, with short leads, at the tuner output terminal.

In this amplifier design the damping resistor R in the mixer circuit must be left intact[1].

Both the adjacent channel traps and the associated sound trap are located at the input of the first stage in order to minimise cross modulation and to cause less disturbance to the responses of the later stages. The sound trap is in the form of an absorption trap, inductively coupled to the secondary L_2 of the input transformer.

The screen grid of the 6EH7 is supplied from a voltage divider drawing heavy bleed current, which keeps the screen voltage relatively constant at approximately 90 V irrespective of AGC. This allows satisfactory gain control of the valve with relatively low AGC voltages: in the present case the mutual conductance of the valve is reduced by a factor of 100 with a change of bias from 0 to —9 V. However, the required control characteristic will depend upon the AGC amplifier and may have to be adjusted to suit the particular circumstances.

It should be pointed out that in the actual amplifier some small deviations were made from the provisional calculated response. In fact, the initial calculated design provides only a good starting point for construc-



Note: "C" + cable capacitance = 97 pF.

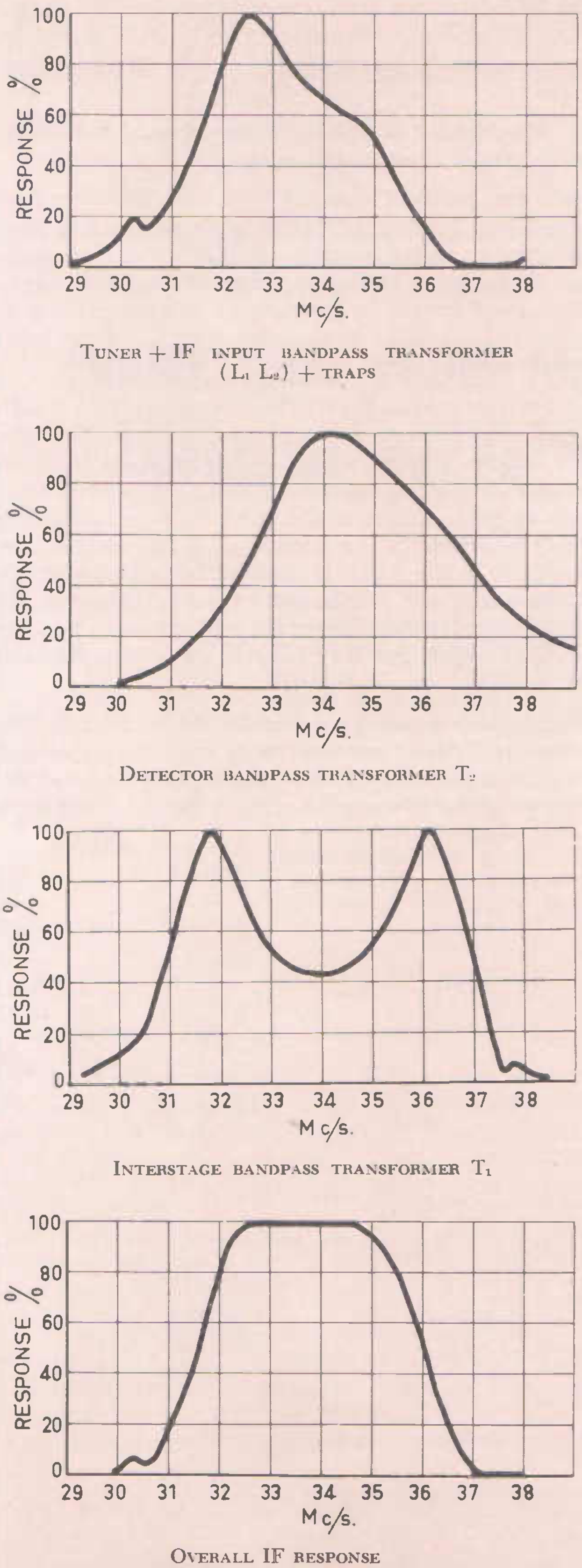
• These components are mounted inside T_2 can.

Fig. 1. Circuit diagram of two-stage vision IF amplifier with double-tuned transformers.

tion, but it will then be necessary to modify the circuit parameters slightly to take into account influences such as trap circuits, layout, and shape of the vision carrier slope. The modifications, however, should be kept to an absolute minimum since any deviations from the calculated parameters (such as tuning frequencies) will cause a reduction in maximum gain.

The swept response characteristic of each individual stage is shown in Fig. 2. The measurements were made using a low impedance detector proble. The overall response (also shown in Fig. 2, but inverted) was measured between mixer grid (tuner on blank channel position) and video detector output with a bias voltage of —5 V on the 6EH7. The output of 5 V peak-to-peak was taken through a 100 K isolating resistor.

The overall response of the IF strip is again shown in Fig. 3, this time measured by the point-by-point method with a signal generator. Adjacent channel selectivity is seen to be 50 dB (vision) and 45 dB (sound). The input to the mixer grid was adjusted to keep the vision detector output voltage constant at —1 V DC. It can be seen that due to the favourable characteristics of double-tuned transformers, high values of adjacent channel rejection can be achieved together with low amplitudes of re-entrants.



TUNER + IF INPUT BANDPASS TRANSFORMER (L_1 L_2) + TRAPS

DETECTOR BANDPASS TRANSFORMER T_2

INTERSTAGE BANDPASS TRANSFORMER T_1

OVERALL IF RESPONSE

Fig. 2. Frequency responses of individual stages and overall response.

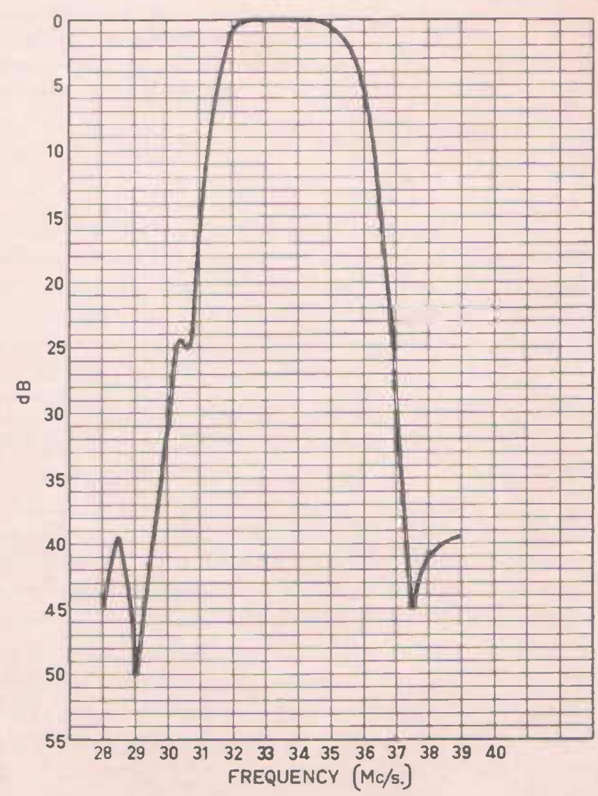


Fig. 3. Overall IF amplifier response for —1 V DC at detector and —5.0 V bias.

Gain

The gain of the IF amplifier at 33.5 Mc/s from the control grid of the 6EH7 (at zero AGC) to the detector was measured to be 60 dB, i.e., 1 mV input for 1 V DC output. The gain specification of the NT 3009 tuner states a minimum gain of 37 dB at zero bias, resulting in an overall gain from aerial terminals to video detector of 97 dB or 14 μV input for 1 V DC output. It will be appreciated that the gain specified for the tuner is conservatively rated due to measurement technique, and in practice higher gain figures may be expected.

Alignment

No spot alignment frequencies for the double-tuned transformers are given, since it is simpler to sweep each stage individually for the responses so indicated in Fig. 2. Particular care should be exercised in the alignment of the over-coupled transformer T_1, as mistuning will give rise to serious asymmetry of response. Adjustment of L_8 will control the flat top and adjustment of L_9 will control the tilt of the overall IF response. The vision carrier position may be adjusted by means of L_1. It must again be pointed out that any serious departure from the given alignment scheme will result in a loss of gain. Whereas the suggested bias during alignment is —5 V, the amplifier should afterwards be checked for stability at zero bias. There should then only be a slight change in the shape of the overall response curve.

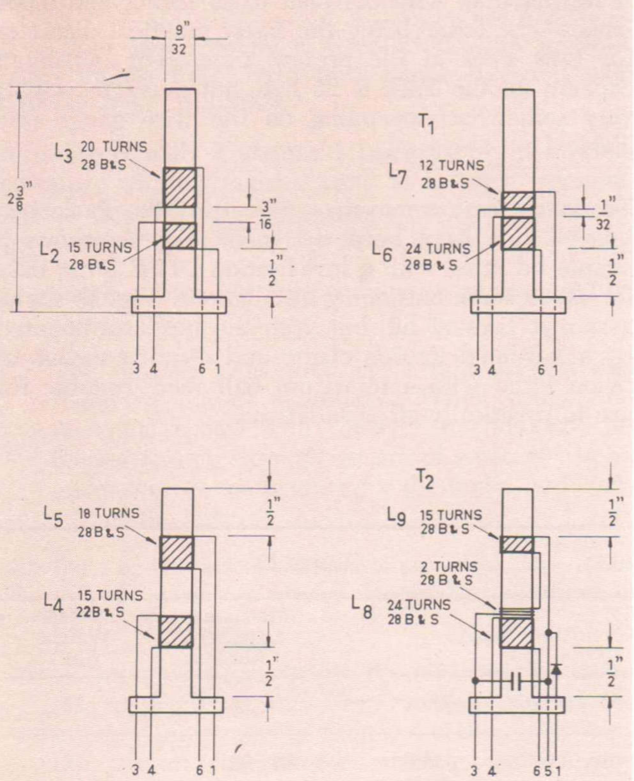


Fig. 4. Constructional details of coils.

Coil Construction

Construction of double-tuned bandpass transformers requires greater care than that of single-tuned transformers in order to produce the required bandpass characteristics. The designer may find that in a particular execution some variation in construction, spacing of windings or number of turns may be necessary to achieve correct bandpass or tuning range. Constructional details of all coils are given in Fig. 4. Note that L_9 is wound in two sections; the top section is tuned whilst the bottom section of two turns is used as a coupling winding wound hard against one end of L_8. This construction has the advantage of good control over the amount of coupling, and of maintaining this coupling irrespective of the position of the tuning cores. The coils of T_2 are wound in such a sense that the winding capacitances are aiding the coupling. T_1 is of more conventional construction, coupling being dependent upon the spacing between L_6 and L_7. The split winding technique cannot be used here, since this transformer requires a large degree of overcoupling. The winding capacitances oppose coupling in this case. It must be stressed that the construction and performance of T_1 is the most critical aspect in the performance of the amplifier, and the coil data may have to be adjusted to suit particular components and manufacturing techniques in order to give the required response as shown in Fig. 2.

General Construction

Great care must be taken in the layout of an IF amplifier. The valve socket centre shields should be earthed to the chassis with short lengths of heavy gauge wire and the two cathode connections on each valve strapped together. Cathode resistor and bypass capacitor leads should be earthed at the one point. "Single-point earthing" should be adopted for input and output connections. The heater leads and all HT supply points must be adequately bypassed using capacitors with short pigtails and all "hot" leads kept as short as possible. The detector diode and associated circuitry should be placed within the output transformer shield can to reduce the possibility of instability arising from radiation to the front end.

(This article is based on work carried out in the "Miniwatt" Electronic Applications Laboratory by P. Heins and J. Clark.)

References

1. Printed Coil Tuner, *Miniwatt Digest*, Vol. 1, No. 7.
2. A. G. W. Uitjens, TV Receiver Design, Monograph I, IF Stages, Philips Technical Library, 1953.
3. A. J. Alferink et al, IF Video Amplifiers Equipped with Frame-Grid Tubes, *Electronic Applications*, Vol. 19, No. 3, Aug. 1959, pp. 93-114.
4. J. S. Singleton, Stagger-tuned and Bandpass-coupled Circuits in Wideband IF Valve Amplifiers, *Mullard Tech. Communications*, Vol. 5, No. 42, Feb. 1960, pp. 48-59.
5. D. G. Fink (ed.), TV Engineering Handbook, McGraw-Hill, 1957, Chapters 12 and 16.

Fine Wire

Introducing

FINE WIRE BULK PACK

Philips has introduced a completely new pack design which extends the practical use of Bulk Pack into the fine wire range. Wire as fine as 0.004 inches (38 B&S) can now be supplied in Bulk Pack form.

ADVANTAGES OF BULK PACK OVER CONVENTIONAL SPOOLING

- Almost unlimited take-off speed
- Virtually unrestricted take-off acceleration rate
- No over-run on rapid stops
- Constant wire tension from "full" to "empty"
- Five to seven times the weight of wire as on conventional spooling
- One continuous length of wire in each Bulk Pack
- Handling costs reduced
- Number of joins or machine stops considerably reduced
- Greatly reduced short-end wire wastage
- Reduced down-time for spool changing
- Simpler tensioning devices—less adjustment
- Better winding space factor and more uniform windings
- Prolonged shelf life because of enclosed can

Basically, the Philips Fine Wire Bulk Pack consists of a metal container $9\frac{1}{4}$" high by 9" diameter (Fig. 1a). Inside is a tapered metal spool having a traverse of $8\frac{1}{2}$", a top flange of 8" and a bottom flange of 9". In conformity with Philips range of fine wires, the Pack is restricted to wire between 0.010 inches and 0.004 inches—the latter being the finest practical diameter for Bulk Pack at the present time. The maximum capacity of the Pack is 25 lbs., but average weights vary somewhat depending on the wire gauge (see Table I).

To enable easy removal of wire from the Pack, two take-off lids have been designed. Fig. 1c shows a simple lid fitted with a low friction PTFE bush, only for use in static tensioning installations. Fig. 1b shows a similar take-off lid, but with the bush surmounted by a felt-lined tension clamp and a guide sheave of nylon fitted with a miniature ball race, suitable for use in practically all installations.

TABLE I

Wire Range	Maximum Capacity (lbs.)	Average Weight (lbs.)
0.010" – 0.008"	25	20
0.0076" – 0.006"	25	18
0.0056" – 0.004"	25	15

Rotating Spool Machines

Where wire has previously been taken from a rotating spool, the Philips Bulk Pack may be used with a minimum of change to most winding machines. A suggested method of adapting the tensioning mechanism is to replace the wire spool with a Neoprene-lined Vee pulley (the Vee could also be lined with fabric-reinforced phenolic). Fed from a Bulk Pack fitted with a take-off lid with sheave and clamp, the wire is passed around the tension pulley a sufficient number of times to prevent the wire slipping, and then taken over the tension control arm. This is the system used in Figs. 2 and 3.

Back-tensioning is effected by the felt clamp fitted to the take-off lid.

Static Spool Machines

Where wire is being lapped from a stationary spool, no alteration to the winding machine should be necessary. Depending on the relative position of the Bulk Pack and the tensioning device, either a take-off lid fitted with a sheave and clamp, or with a plain bush, may be used.

A practical static-tensioning arrangement is shown in Fig. 4. It is important that the felt friction pads in static systems be kept moist with paraffin oil (or turpentine if an oil-free surface is essential).

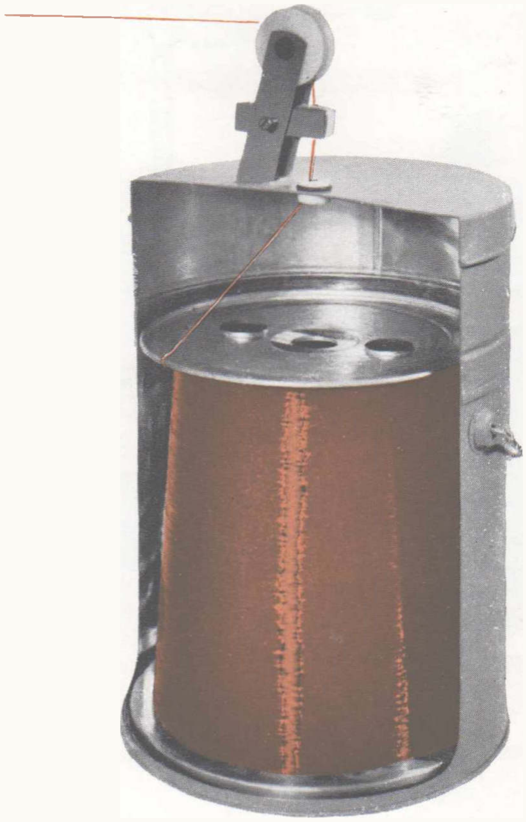
Use with Multi-winders

A marked improvement in overall efficiency is found when Philips Fine Wire Bulk Packs are used with multi-winding machines.

A test run with a standard Leesona Multi-winding machine, winding sixteen coils to a "stick", demonstrated the following advantages over past performance with conventional spools:

1. The dead time of the machines was decreased by some 7½%.
2. The tension arms took up a mid-position and remained almost stationary. When using conventional spools with "flyers", the tension arms tended to bob through an arc of some 40° in an endeavour to compensate for the under and overrun of the "flyers".
3. Due to the excellent tension control, the interleaved windings were generally smaller in diameter.
4. With conventional spools, the wide tension variation induced by the "flyer" system caused the interleaving papers to ruck and crease, increasing the overall size of the winding and causing variations in diameters of coils on the same "stick".

Fig. 1. Details of Philips Fine Wire Bulk Pack



(a) Cut-away view showing spool.

(b) Lid for use with dynamic or static tensioning.

(c) Lid for use with static tensioning only.

Fig. 2. Philips Bulk Pack used with dynamic wire tensioner which has had the spool replaced by a small Vee pulley.

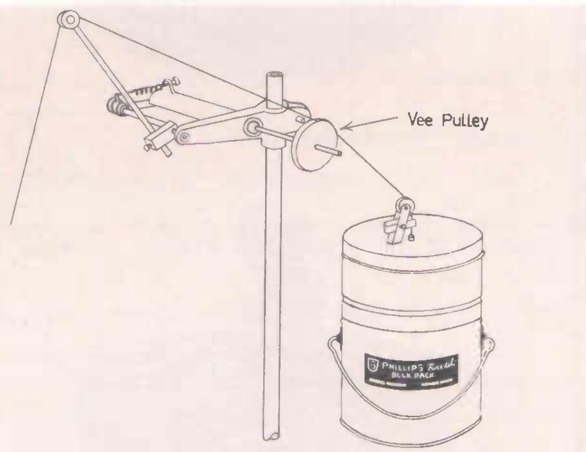


Fig. 3. Details of tensioning mechanism in Fig. 2 above.

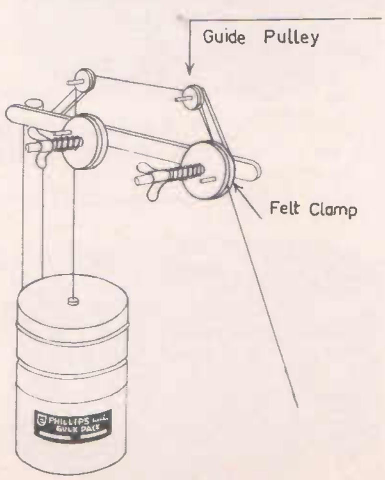


Fig. 4. Tensioning mechanism of static spool machine used with Bulk Pack.

5. The limited movement of the tension arms enabled a finer adjustment of the automatic stop for wire breakage or spool depletion. When winding from conventional spools, the jerk of the tension arm would often be enough to actuate the automatic stop so that this facility was often disconnected.
6. During the test run no wire breakage occurred.

Winding Safeguards

Because the Bulk Pack containers are of uniform size and weight, and can be arranged in any convenient position near the winding machine, a simple actuating device can be employed to provide two important safeguards in the winding operation.

These safeguards are:

(i) Warning of wire depletion (to safeguard against incomplete windings).

(ii) Automatic stopping of winding machine with sufficient wire in hand to guard against release of tension on the winding during the "coasting down" of the machine.

A suggested design for an actuating device is illustrated in Fig. 5. The Pack is mounted on a spring-supported platform which will rise as the wire supply becomes depleted. When the safe reserve limit is reached, a micro-switch is actuated, and this either energises a warning light (safeguard (i)) or initiates a "stop" signal for the machine (safeguard (ii)). The Pack can then be replaced by the winding machine operator. This device incorporates provision for calibration of the "safe reserve limit" (screw adjuster) because this quantity will vary depending on the amount of wire on the coils being wound.

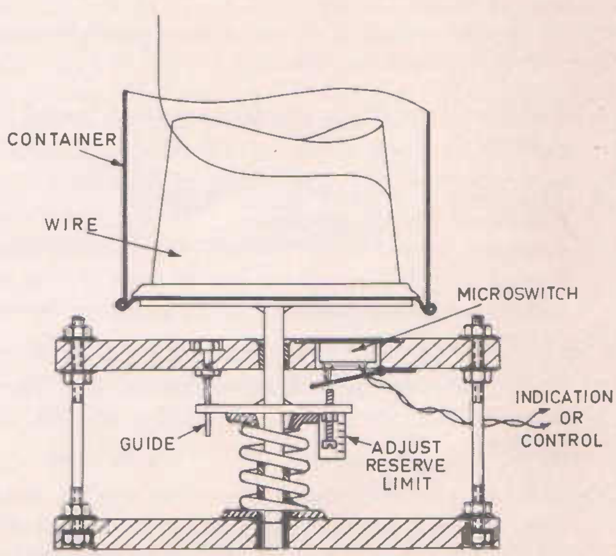


Fig. 5. Suggested actuating device to provide winding safeguards.

PHILIPS PROFESSIONAL

SILICON POWER DIODES

The Miniwatt Division presents the currently available range of 14 types of silicon diodes suitable for medium voltage and/or medium current rectification in industrial, military and other professional applications.

CUT-AWAY VIEW OF BYZ14

Listed in Table 1 are maximum ratings for the above range. As examples of the application of these rectifiers, Tables 2 and 3 show rectifier configurations with values of DC output current and voltage for a given input voltage using the BYZ14 rectifier in battery charging and resistive load circuits respectively. This rectifier is suitable for high-current applications such as resistance and arc welding, electroplating, metal finishing, battery charging and filament power for large tubes.

DC output values for other diodes in the range may be estimated by comparing their maximum ratings with those of the BYZ14. However, a complete report on selection methods to be used for specific powers, currents or voltages, will appear in a future issue of the *Digest*.

Complete individual data sheets pertaining to each diode in the range are available by writing to the Miniwatt Division at any of the addresses given on the back cover of the *Digest*.

TABLE 1
Absolute Maximum Ratings
(*Abbreviated Data*)

TYPE	$-V_{DM}$ (V)	I_D (A)	I_{DM} (A)
BYY15 BYY16	400	20	100
BYY17	50	12	
BYY18	100	12	
BYY22 BYY23	200	10	50
BYY24 BYY25	400	10	50
BYZ10	800	6	20
BYZ11	600	6	20
BYZ12	400	6	20
BYZ13	200	6	20
BYZ14 BYZ15	200	20	100

TABLE 2
Battery Charger Operation

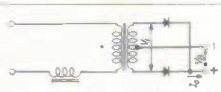
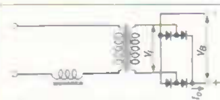
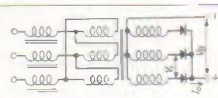
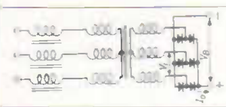
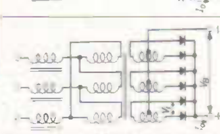
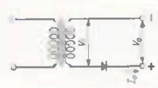
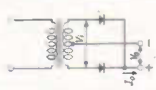
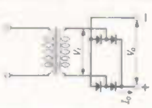
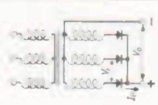
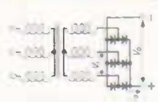
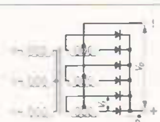
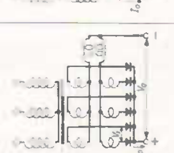
	DC Output (V_B, I_0) for V_i = 125V RMS	2 V Cells in Series
	60 V 25 A	27 max.
	120 V 25 A	54 max.
	70 V 37.5 A	32 max.
	120 V 37.5 A	54 max.
	60 V 75 A	27 max.

TABLE 3
Resistive Load Operation

	DC Output (V_0, I_0) for V_i = 140V RMS
	60 V 20 A
	60 V 40 A
	125 V 40 A
	95 V 60 A
	190 V 60 A
	95 V 96 A
	80 V 120 A

PHILIPS OMEGATRON

— for Quantitative Analysis of Residual Gases

Modern high-vacuum technique, whether it be applied to the manufacture of electron tubes, other industrial products, or to laboratory research, demands a knowledge of not only the total pressure, but also the composition of the residual gas. The Philips omegatron type 8X4AU is designed for this purpose, and is already being used at a leading research centre in Australia.

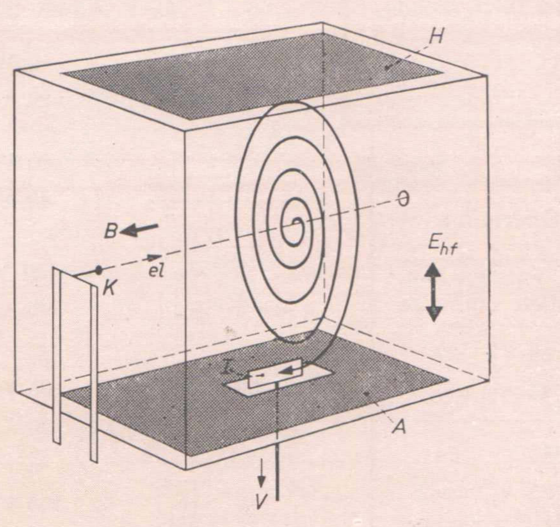
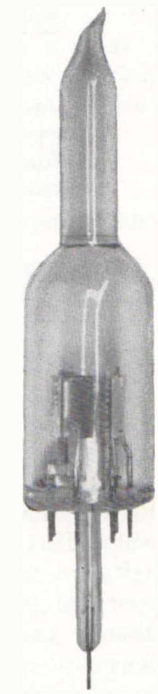


Fig. 1. The omegatron in outline—

B indicates magnetic induction,
E_{hf} indicates sinusoidal HF electrical field,
K is the cathode which emits the ionising beam of electrons,
A and H are electrodes across which the HF field is applied,
I is the ion collector,
V indicates connection to a sensitive amplifier, or other suitable measuring device.
The spiral indicates the path of an ion in resonance.

PHILIPS OMEGATRON TYPE 8X4AU



Mechanical Data

Overall length (including tubulation)	190 mm
Diameter	44 mm
Tubulation diameter	16 mm
Approx. volume	50 cm³

The 8X4AU is available with glass tubulation and with a tungsten filament. Special units can be supplied with either glass or metal tubulation, and with rhenium or lanthanum boride filament.

Max. Bake-out Temp. .... **500°C**

General Electrical Data

Filament voltage (max.) (adjusted for required emission)	1.5 V
Filament current (max.)	10 mA

Operating Conditions

Magnetic field	3000 to 3500 Gauss
RF field (for mass Nos. 1 to 100)	50 Kc/s to 5 Mc/s
Accelerating voltage	67 V
Trapping voltage	0.75 V
Emission current	10 μA
Ion collector bias	..1.5 V
RMS RF voltage	100 mV
Electron collector voltage	117 V

The omegatron is an ionic mass spectrometer based on the principle of the cyclotron. For some years, it has been used in more or less its original form[1] for qualitative gas analysis.[2] Investigations[3] carried out within Philips research and development laboratories have led to the production of the 8X4AU which, with its small dimensions and high ion collector efficiency, is suitable for accurate gas analysis in the above fields.

Principle of the Omegatron

A simplified perspective sketch of the instrument is shown in Fig. 1. A narrow beam of electrons, emitted by the cathode, is accelerated towards a positive electrode, its direction being parallel to the magnetic field provided by external means. In its passage through the gaseous sample (contained within the omegatron) gas molecules are ionised by collision, and if the resulting ions possess a velocity component perpendicular to the direction of the static magnetic field, these ions will describe circular paths perpendicular to this field with angular velocities dependent only on their charge/mass ratios and the magnetic field intensity.

With the introduction of the HF electric field, applied perpendicular to the magnetic field, and with its frequency corresponding to a specific angular velocity of an orbiting ion, a condition of resonance results. An ion in the correct phase then absorbs equal increments of energy each revolution, and thus describes a spiral path of uniformly increasing radius. The resonating ions can then be caught on a suitably placed collector electrode, and ionic current measured with the aid of a sensitive instrument.

Not all the resonant ions produced reach the ion collector. Some are lost by collision with gas molecules, and of those that do not, a fraction reaches the collector, the remainder arriving at other electrodes. If the maximum pressure of the gaseous sample is set at 10^{-5}mm H_g, the mean free path will always be considerably greater than the total length of orbit of the resonating ions, irrespective of the composition of the gas. Also, for the 8X4AU, measurements have shown that the ion collector efficiency is high (result of special design technique) overcoming the previous fundamental limitation to the use of the omegatron in quantitative analysis.

Too high a value of electric field intensity will adversely affect the resolution of mass numbers. On the other hand, there is minimum value of RF voltage at which the ions in resonance will just reach the ion collector. A higher value of magnetic field intensity will markedly enhance the resolution. If the electron current is too high, the large numbers of ions formed will give rise to a strong space charge, with the result that the ionic current will no longer be a linear function of electron current.

Special precautions have been taken in order to ensure a uniform distribution of the HF electric field. Also the application of a weak static electric field hinders the tendency of ions to deviate from a truly planar path, due to their thermal energy.

Composition of a Gas Mixture—using 8X4AU

Prior to the introduction of a gaseous sample the whole tube can be degassed in an oven at a temperature not exceeding 500°C, but the electrodes themselves may be treated at a somewhat higher temperature by induction heating. This latter treatment would remove possible disturbing surface layers on the electrodes, but will not in general be essential.

In order to determine the composition of a gas mixture, the frequency of the applied electric field must be varied either continuously or in steps (without changing the amplitude). For a fixed value of magnetic field intensity the specific frequencies corresponding to the peaks of ionic current yield the charge /mass ratios of individual ions. As collision with electrons may produce not only singly-ionised but also multiply-ionised molecules, as well as both ionised and neutral particles, a complete ionic spectrum will result, its nature depending on the type of gas and the electron energy. For any specific gas the magnitudes of peaks are in fixed ratio, and such a "pattern"

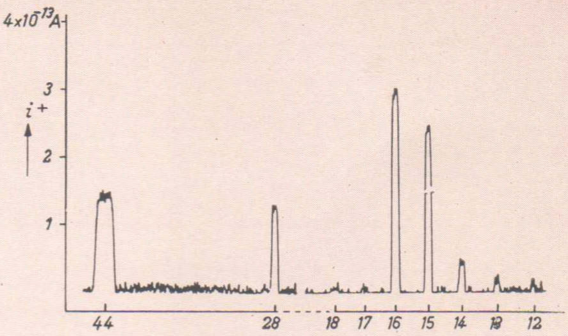


Fig. 2. Mass spectrogram obtained in studying the effectiveness of a barium getter.

The composition of the gas (expressed in partial pressures) is as follows:

CH_4	2.8×10^{-9} mm Hg	N_2	2×10^{-10} mm Hg
CO_2	1.0×10^{-9} mm Hg	C_2H_6	2×10^{-10} mm Hg
CO	8×10^{-10} mm Hg.	H_2O	1×10^{-10} mm Hg

can be used to identify this gas in a gas mixture, prior to ascertaining its partial pressure. Calibration "patterns" have been tabulated by Klopfer and Schmidt[3] for some gases commonly encountered in high vacuum work: this was the result of work carried out on a developmental omegatron.

Fig. 2 shows an ionic mass spectrogram obtained in an investigation of the residual gases in a well outgassed glass system containing a barium getter film.

Performance

The device operates satisfactorily as a spectrometer in the pressure range 10^{-5} to 10^{-9} mm Hg. Measurement of pressure is possible down to the 10^{-12} mm Hg. At pressures below 10^{-7} mm Hg, the resolution is sufficient to provide complete separation up to mass 30. From mass 30 to mass 100, the separation is less complete, but is adequate for identification of the ions present. In conjunction with helium (or other light gas), the 8X4AU is an efficient leak detector at pressures below 10^{-6} mm Hg.

References

1. H. Sommer, H. A. Thomas and J. A. Hipple, The measurement of e/M by Cyclotron Resonance, *Phys. Rev.*, Vol. 82, 1951, p. 697.
2. J. Peper, Analysis of the Gaseous Contents of Sealed Cathode-Ray Tubes with the aid of the Omegatron, *Philips Tech. Rev.*, Vol. 19, 1957/58, p. 218.
3. A. Klopfer & W. Schmidt, An Omegatron for the Quantitative Analysis of Gases, *Philips Tech. Rev.*, Vol. 22, 1960/61, p. 195.
4. J. van der Waal & J. C. Francken, Analysis of Residual Gases in Television Picture Tubes with the Aid of the Omegatron, *Philips Tech. Rev.*, Vol. 23, 1961/62, p. 122.

ERRATUM (E55L article)

In Vol. 1, No. 7, p. 114, Fig. 1, both of the grid resistors are shown as 27 K, whereas either one of these should read 2.7 K.

PHILIPS

- ELECTRONIC VALVES AND TUBES
- SEMICONDUCTOR DEVICES
- CATHODE-RAY TUBES
- LIGHT-SENSITIVE DEVICES
- TEMPERATURE-SENSITIVE DEVICES
- FERRITES
- RADIATION-SENSITIVE DEVICES
- FINE WIRES
- SPECIALIZED COMPONENTS AND DEVICES
- SPECIALIZED MATERIALS
- TECHNICAL PUBLICATIONS

For Use in the Fields of—

ENTERTAINMENT — COMMUNICATIONS — INDUSTRY
COMMERCE — MEDICINE — SCIENTIFIC RESEARCH
AND DEFENCE

PHILIPS

THE *Miniwatt* ELECTRONICS DIVISION

of

Philips Electrical Industries Pty. Limited
20 Herbert Street, Artarmon, N.S.W.
Phone 43 2171

Branches at—

ADELAIDE	11-13 West Terrace, Adelaide, S.A., phone 51 6051
BRISBANE	56-58 Cordelia Street, South Brisbane, Qld., phone 42 471
CANBERRA	C.B.C. Chambers, Petrie Street, Civic Centre, Canberra City, A.C.T., phone J 4498
HOBART	73 Brisbane Street, Hobart, Tas., phone 3 3038
MELBOURNE	590 Bourke Street, Melbourne, Vic., phone 60 1321
NEWCASTLE	194 Parry Street, Newcastle West, N.S.W., phone MA 5001
PERTH	672 Murray Street, Perth, W.A., phone 21 3131
SYDNEY	67 Mars Road, Lane Cove, N.S.W., phone 42 1261

Production Centre—

HENDON WORKS Tapley's Hill Road, Hendon, S.A., phone 4 5021

Hughin, Poole (Printers) Pty. Ltd., Sydney