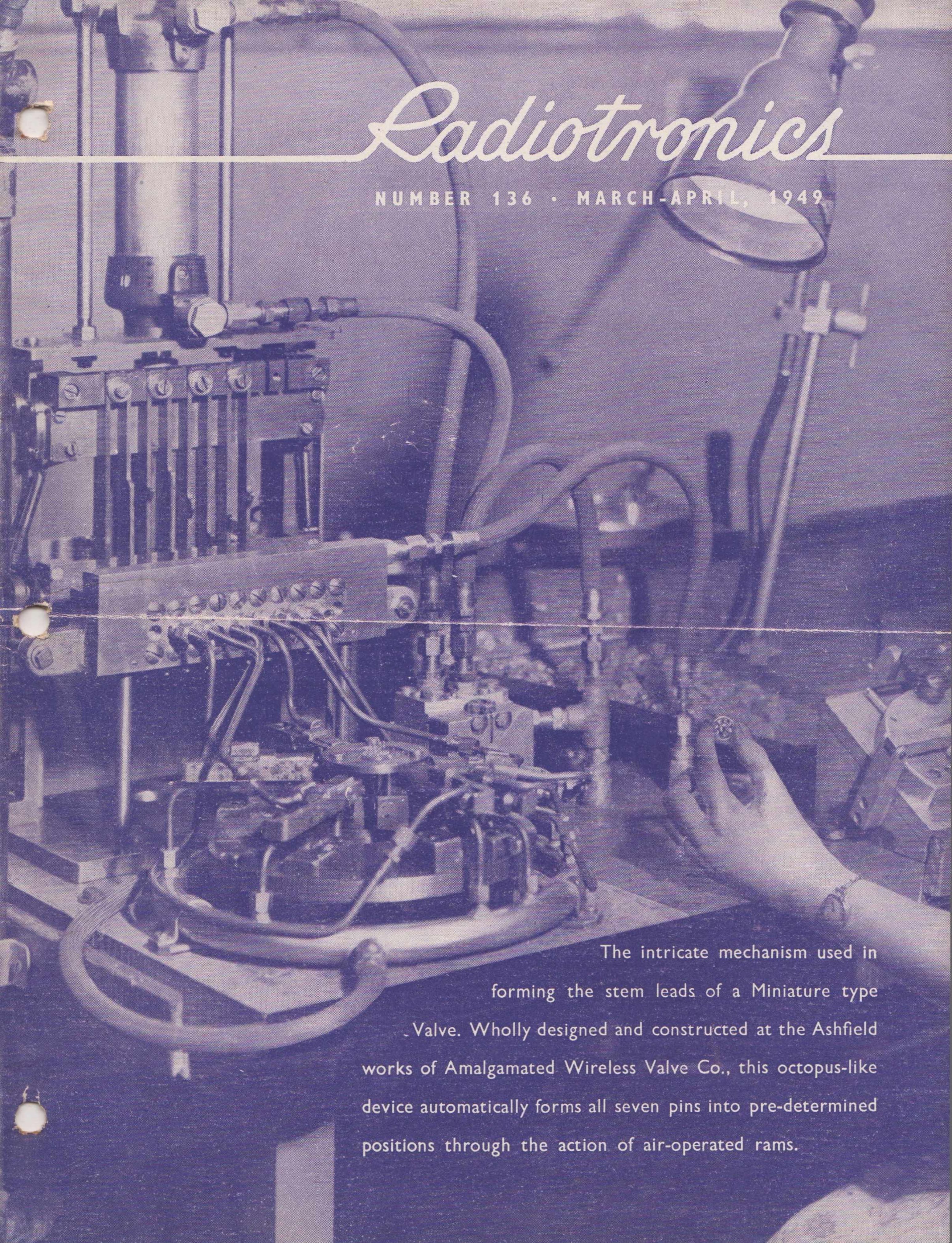
Radiotronics

NUMBER 136 · MARCH-APRIL, 1949



The intricate mechanism used in forming the stem leads of a Miniature type Valve. Wholly designed and constructed at the Ashfield works of Amalgamated Wireless Valve Co., this octopus-like device automatically forms all seven pins into pre-determined positions through the action of air-operated rams.

Forming of Miniature Valve Stem Leads

(Cover illustration)

It is necessary to look very closely at a miniature Radiotron to trace the various connections from the valve pins to their respective elements within the glass bulb.

Unfortunately the valve electrodes cannot be placed conveniently with respect to the pins, thus the lead wires have to be bent or shaped into some peculiar forms to avoid short circuits. At the same time this allows the assembly operator to weld the parts quickly.

To maintain the high standard of quality and performance required of the miniature Radiotron, all parts must be consistent. In this instance, it means when the correct shape has been found for each wire, that shape must be the same in all valves of that particular type.

The design of a tool which will do this rapidly enough to satisfy the daily quota and at the same time be simple and foolproof to operate, presents several problems. The small space available for the various supporting and forming tools and the fact that the wires frequently lie one above the other are difficulties that have to be contended with.

A costly hand operated piece of equipment was first tried but it was found in practice to give continuous trouble owing to small fragments of glass finding their way amongst the sliding tools.

These tools were operated by a series of circular internal cams which were expensive to make and the entire equipment was only suitable for one type of valve.

The present procedure is to bend the wires with small tools fixed to the ends of air operated piston rods. These are in turn operated by valves controlled by extremely simple cams which are secured in a rack and screwed to the main fixture. An entirely different type of valve stem can be formed by merely changing the cam rack and piston units.

The latter which vary in number according to the particular valve are secured to a flat steel by a screw and two dowels. The whole plate assembly is removable when it is desired to change the valve type.

The operator places the unformed stem in the correct location and presses down a foot pedal until the cams reach the bottom of the stroke when the pedal is released returning the cams into position for the next cycle.

As there is no metal supporting structure around the ends of the forming tools any pieces of wire or broken glass will fall clear. It is also possible to watch each tool perform its task by operating the unit slowly. This is of particular assistance during construction. The whole equipment was designed and built at the Ashfield works of Amalgamated Wireless Valve Company.

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Radiotron Type X61M

TRIODE HEXODE FREQUENCY CONVERTER

PRELIMINARY DATA

General: The X61M is a frequency converter of the triode hexode type, having a high conversion conductance and a comparatively low cathode current, giving a good signal to noise ratio. It is suitable for operation up to a frequency of 60 Mc/s and is supplied with a metallised bulb.

The triode hexode has been recognised as possessing advantages over other frequency converter valves, especially for ease of oscillator design and when high frequency operation is required. The X61M has the following advantages:—

1. High conversion conductance for comparatively low cathode current.

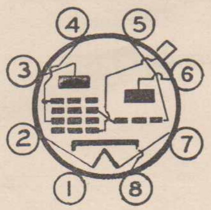
2. Large control ratio when operated with a fairly constant screen voltage.

3. High triode oscillator transconductance.

Maximum ratings and typical operating conditions are as follows:—

Heater:		
Voltage	6.3	a.c. or d.c. volts
Current	0.3	amp.
Direct Interelectrode Capacitances:		
Hexode Grid No. 1 to Cathode	5.0	μμF
Hexode Grid No. 1 to Triode Grid	0.27	μμF
Triode Grid to Cathode	11.0	μμF
Triode Plate to Cathode	7.1	μμF
Hexode Grid No. 1 to Hexode Plate	0.085	μμF
Triode Grid to Triode Plate	2.3	μμF
Hexode Plate to Cathode	14.1	μμF
Maximum Overall Length	4-1/2″	
Maximum Diameter	1-17/32″	
Base	Wafer Octal 8-pin	

Basing Diagram



Pin 1 — External Shield (Metallising)
Pin 2 — Heater
Pin 3 — Hexode Plate
Pin 4 — Hexode Grids #2 and #4
Pin 5 — Hexode Grid #3 and Triode Grid
Pin 6 — Triode Plate
Pin 7 — Heater
Pin 8 — Cathode
Cap — Hexode Grid #1

CONVERTER SERVICE

Hexode Plate Voltage		250 max. volts
Hexode Screen (Grid Nos. 2 and 4) Voltage		100 max. volts
Hexode Signal Grid (Grid No. 1) Voltage		−2 min. volts
Triode Plate Supply Voltage*		250 max. volts
Hexode Plate Dissipation		2.0 max. watts
Hexode Screen (Grid Nos. 2 and 4) Dissipation		0.5 max. watt
Triode Plate Dissipation		0.75 max. watt
Maximum Operating Frequency		60 Mc/s
Total Cathode Current		10.0 max. mA
Typical Operation:		
Heater Voltage	6.3	6.3 volts
Hexode Plate Voltage	250	250 volts
Hexode Screen Voltage	85	100 volts
Hexode Signal Grid Voltage	−2	−3 volts
Triode Plate Voltage*	250	250 volts
Triode Grid Resistor	50,000	50,000 ohms
Triode Grid Current†	300	300 μAmps
Conversion Transconductance	718	620 μmhos
Hexode Plate Resistance		0.7 megohm
Hexode Signal Grid Bias for Conversion Transconductance = 5 μmhos		−25 volts
Hexode Plate Current		3.7 mA
Hexode Screen Current		2.8 mA
Oscillator Plate Current		3.5 mA
Cathode Current		10 mA
Input Resistance at 30 Mc/s		13,000 ohms

* Applied through a 30,000 min. ohm dropping resistor.

† Triode Grid Volts — 15 Volts Peak.

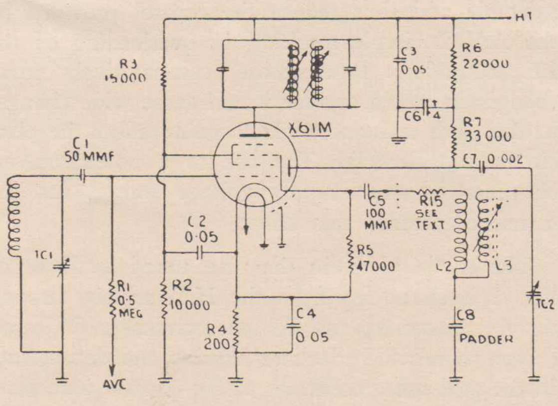


FIG 1

The normal circuit recommended for optimum performance is shown in Fig. 1 in which the triode is connected as a plate-tuned oscillator in the interests of stability, but is otherwise conventional. In Fig. 2 the triode section is shown connected in a typical grid-tuned oscillator circuit, which is more commonly used and is satisfactory for most purposes.

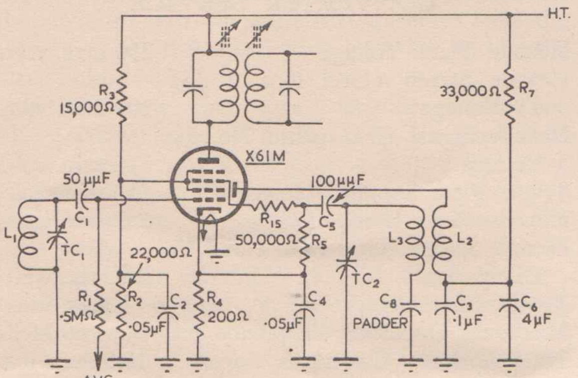
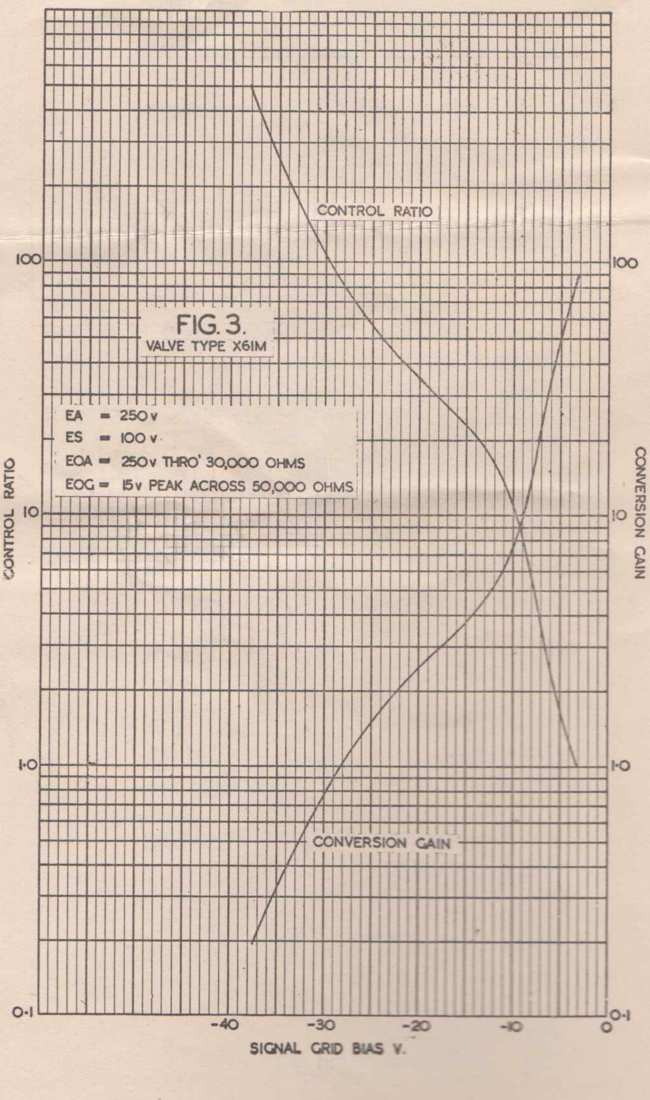


FIG. 2

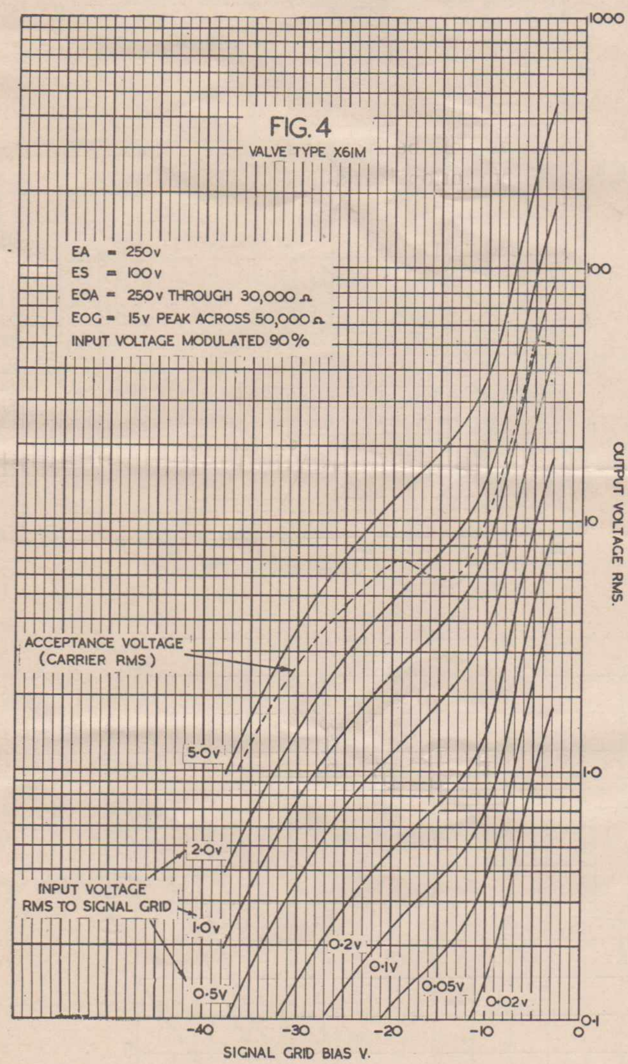
The input signal is supplied to the hexode signal grid through the condenser C1 from the circuit formed by L1 and its tuning condenser. The signal grid is returned to the A.V.C. line by the resistance R1. This method of supplying the control voltage to the grid of the X61M, instead of the more usual method of injecting it in series with the low potential end of L1, allows the degree of coupling between the signal grid and the tuned circuit to be varied by choice of the capacitance of the condenser C1, which for short-wave operation should be fairly small, in order to reduce the damping on the tuned circuit by the signal grid input resistance. Also, the bypass condenser, normally included in the tuned circuit, is no longer required.

The screen grid should be supplied from a low impedance potentiometer, or other substantially constant voltage source, and not through a series resistance, which would extend the control base considerably and thus reduce the control provided by the A.V.C. circuit resulting in overloading of the I.F. amplifier. Furthermore, comparatively small changes in screen current would cause wide changes in the plate resistance, which would affect the plate circuit considerably. The use of a potentiometer, or other constant supply voltage source, for the screen overcomes this effect.

The triode plate, in the plate-tuned oscillator of Fig. 1 is shunt fed from the H.T. supply through the resistances R6 and R7, the condenser C6 being chosen to provide adequate filtering and decoupling. In the grid-tuned oscillator of Fig. 2 the triode plate is normally series fed from the H.T. supply through the resistance R7, which is by-passed at the coil by the condenser C6. In both types of circuit, it may be convenient, as shown in Fig. 1, to return the earthy end of the oscillator feedback coil L2 to the junction of the padding condenser and the tuned coil L3, in order to obtain some additional capacitive feedback. This may be necessary to assist the normal inductive coupling for satisfactory oscillation, particularly at the low frequency end of short-wave bands, the frequency coverage of which is excessive. In order to use padder feedback in the grid-tuned circuit of Fig. 2, it is necessary to replace the simple R7 — C6 decoupling filter shown, by the R6, R7, C6 network used in Fig. 1 in order to avoid shunting the padder condenser by the bypass condenser C6 and to obtain adequate decoupling. For wave bands of normal frequency coverage, however, the high oscillator transconductance of type X61M makes the use of padder feedback unnecessary, as will be seen from the coil data given for the conventional grid-tuned oscillator.



The resistor R15, shown in both circuits, is used to restrict the increase in grid current which normally occurs at the high frequency end of the wave band, where the resonant impedance of the tuned circuit increases and the oscillator voltage tends to increase. If the feedback coupling is excessive, the use of the resistance R15 is desirable to avoid parasitic and over oscillation, which otherwise would occur at the high frequency end of the band. The value of the resistance normally required for satisfactory oscillation, varies from approximately 25 ohms at 30 Mc/s to 5,000 ohms at 300 kc/s. As



the conversion conductance of the X61M, however, does not vary appreciably with increase of oscillator grid voltage above the optimum value of 15 volts peak, it may be permissible to omit this resistor provided parasitic oscillations do not occur and that the increased harmonic components of the oscillator voltage do not cause interfering signals to be received.

The curves of Fig. 3 show the variation of conversion gain and control ratio with bias voltage on the signal grid. The control ratio refers to the gain at –3 volts bias.

Fig. 4 shows the acceptance curve; this curve indicates the RMS carrier voltage which the X61M will handle without giving more than 1% distortion of the modulation envelope, when the carrier is modulated to 90%.

Although the screen voltage is shown as fixed at 100 v in both Figs. 3 and 4, there is in fact some variation as signal grid bias is varied — i.e. as screen current varies. For both Figs. 3 and 4 the screen was supplied from the combination of a 15,000 ohm and 10,000 ohm resistor connected across the H.T. supply, as shown in Fig. 1. With this arrangement full A.V.C. must be applied to the X61M to give good control and also to allow the acceptance of large signals.

The input capacitance is reduced by a total of 1.5 μμf, as bias on the signal grid is increased from –3v to cut-off. This variation is unimportant in the usual application of the X61M.

The X61M may be used with its heater either in parallel or in series with other valves of suitable voltage or current rating. In AC/DC receivers, where the heaters are series connected, the X61M heater should be connected as near to the earthy end as is convenient in order to minimise modulation hum; it is usually possible to place it second in the chain, the first place being reserved for the diode-triode, or detector-audio valve.

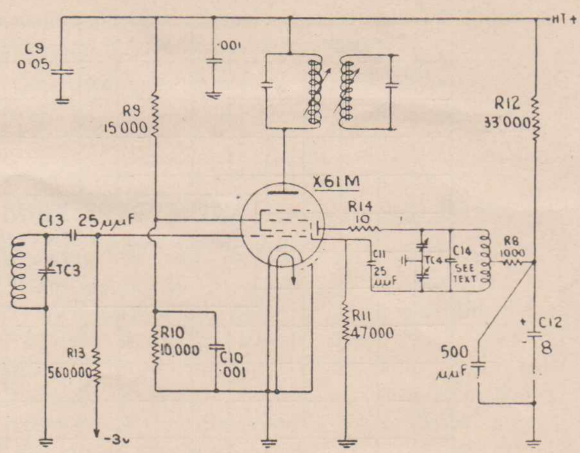
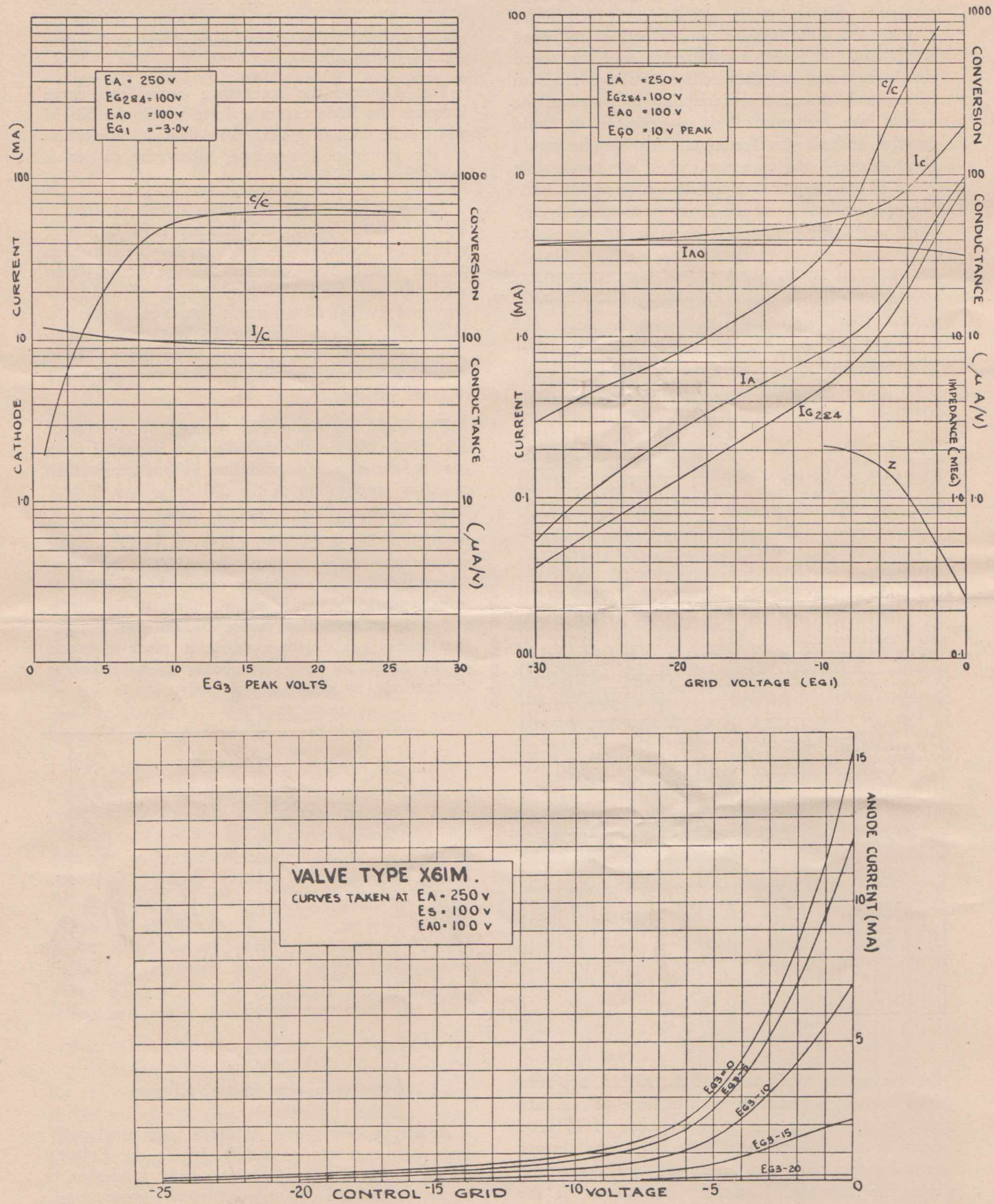


Fig 5

COLPITTS OSCILLATOR FOR UHF RECEPTION

At frequencies above 30 Mc/s., the usual oscillator circuit is not as satisfactory as the Colpitts circuit shown in Fig. 5; a two gang condenser is employed and the circuit is completely symmetrical; oscillation is easy to obtain up to 60 mcs., and operation above this frequency can be maintained.



Characteristic curves of type X61M, triode hexode converter.

The degree of coupling to the grid is adjusted by the condenser C11. If a fairly wide frequency coverage is desired, a resistance R14 of 5 or 10 ohms may be included to suppress parasitic oscillations as the tuning capacity is reduced. It will be seen that no self-bias resistance is included; this enables the cathode lead to be kept short. The signal grid is returned to a point three volts negative with respect to the cathode. It is desirable to use a higher intermediate frequency than usual, and success has been obtained with an amplifier operating at 5 Mc/s. The response of the IF amplifier should be "flat topped" in order to minimise the effect of small shifts in frequency. Where an improved frequency stability is desired, the L/C ratio of the oscillator circuit should be reduced by the addition of a ceramic condenser, C14.

The performance of type X61M is reduced in receivers operating at low H.T. supply voltages, as it is necessary with this particular hexode to employ a plate voltage about twice that applied to the screen. The resulting low screen voltage reduces the conversion gain obtainable.

The heater supply for the X61M must not be less than six volts under any operating condition; it is permissible to use a supply as high as seven volts with safety.

For a mains voltage variation of 190-255 volts using a transformer having two taps, the heater winding should be designed to give 6.3 volts on load at 199 and 233 volts on the low and high taps respectively. The heater supply will then not exceed 7 volts at 255 volts on the high tap nor will it be lower than 6 volts at 190 volts on the low tap.

OSCILLATOR COIL DETAILS

Grid-Tuned Oscillator

Although it is generally necessary to use a plate-tuned oscillator when maximum frequency stability is required, the grid-tuned oscillator is usually sufficiently satisfactory for most broadcast receivers that it has become the common practice. For this reason, coil details covering the broadcast band of 540-1600 kc/s and the short-wave band 6.0-18.2 Mc/s have been determined, so far, only for the conventional grid-tuned oscillator shown in Fig. 2. Both coils, in conjunction with R15 as specified, give satisfactory grid current over the above bands. The resistor R5 may be omitted in cases where the wider variations of grid current obtained without its use, are not troublesome. At a later date it is hoped to give more complete design and performance data for both types of oscillator circuit.

Coil Data

Intermediate frequency	455 kc/s
Tuning condenser	12–430 $\mu\mu$F
Padding condensers	540 – 1600 kc/s : – 440 $\mu\mu$F
	6.0 – 18.2 Mc/s: –5000 $\mu\mu$F

Trimming:

Both coils are permeability tuned with iron dust cores, 3/8 inch diameter and 1/2 inch long, which provide sufficient variation to accommodate the usual stray circuit and valve capacitances.

Oscillator Grid Resistor: 50,000 ohms.

Frequency	Tuned Winding	Feedback Winding	Coil Former
540 – 1600 kc/s	80 turns of 40 SWG, D.C.C. wound in a single pie, 3/16 inch wide, inner lead earthy	60 turns of 40 SWG, D.C.C., wound in a single pie, 3/16 inch wide, spaced 1/32 inch from the tuned winding	7/16 inch diameter paxolin
6.0 – 18.2 Mc/s	10 turns of 23 SWG, ENAM., solenoid wound 16 T.P.I.	8 turns of 36 SWG, E.S.S., interwound at the earthy end of the tuned winding	3/4 inch diameter paxolin

Oscillator grid current

Coil	Value of R15	Grid Current With R8	Grid Current Without R8
540 – 1600 kc/s	1,000 ohms	260 – 310 μA	300 – 480 μA
6.0 – 18.2 Mc/s	50 ohms	270 – 380 μA	275 – 530 μA

Blower Requirements for Radiotron Forced-Air-Cooled Valves

RCA application note AN-125; reprinted by courtesy of the Radio Corporation of America.

The selection of a suitable fan or blower for cooling the external anode of an electron valve, a valve header or electrode seal, or the glass envelope of a valve having a radiation-cooled anode is a problem that often confronts an equipment designer. It is the purpose of this Application Note to assist the designer by discussing blower requirements in general and by listing representative blowers by type number and manufacturer.

General Considerations.

The selection of a fan or blower for a particular tube or application requires that three important factors be known. These factors are (A) the airflow required, (B) the static pressure at blower outlet, and (C) the amount of permissible noise. Although these factors apply generally to cooling any part of an electron valve, attention is directed in the following to the problem of selecting a blower for cooling the radiator (cooler) of an external anode valve, particularly when duct work is used. The results obtained, however, are equally applicable to the problem of selecting a blower for cooling any other part of a valve.

A. The airflow required depends upon the amount of anode dissipation and upon the maximum ambient temperature expected in a given application. This value of required airflow, usually measured in cubic feet per minute (cfm), and the corresponding value of anode temperature rise above the ambient value are given as part of the valve data. In no case should the sum of the ambient temperature and the anode temperature rise above ambient exceed the maximum rated value of anode temperature as given in the valve ratings. Because the cfm value is based on air of standard density (0.075 lbs/ft^3), a correction should be made for applications at altitudes greater than 5000 feet above sea level.

B. The static pressure (P_s) at the blower outlet depends upon the pressure-versus-airflow characteristics of the system into which the blower must deliver the required volume of air. A typical system characteristic is shown in Fig. 1. The static pressure for any system varies approximately as the square of the cfm[1] and is determined by the following factors:

1. The static pressure rating of the valve cooler when the required airflow or cfm is passing through it. This rating is given in the valve data as a function of airflow or cfm. When the outlet of a blower discharges into free air as is the case when a blower is directed at a valve header, bulb, or seal, the static pressure at the blower outlet is zero, provided no ducts, constrictions, or nozzles are used. This discharge rating in cfm of a blower at zero static pressure is sometimes called the "free delivery" rating of the blower.

2. The friction losses in connecting pipes and components such as elbows, interlock vanes, and air filters. Standard tables of duct-pressure loss may be used for estimating duct friction if the effective duct length is large.[1, 2, 3, 4]

3. The change in static pressure in a duct due to changes in cross-sectional area which increase or decrease the velocity of the air in the duct. Whenever there is any change in cross-sectional area between the blower outlet and the valve inlet, a correction for velocity changes must be added algebrically to the static pressure at the blower outlet. This correction, which is positive for a contraction in area and negative for an expansion in area, is given by the relation

$$P_s \text{ (inches of water)} = \frac{V_2^2 - V_1^2}{(4000)^2} \qquad (1)$$

where V_1 is the velocity of the air in feet per minute before the change in area and V_2 is the velocity of the air in feet per minute after the change. These velocities may be found from the expression

$$V \text{ (feet per minute)} = \frac{\text{cfm}}{A} \qquad (2)$$

where A is the cross-sectional area in square feet at the place of measurement. The factor 4000 of Equation (1) is the velocity constant for air of standard density of 0.075 lb/ft^3. Corrections should be made for different values of air density from the data given in Table I.

A change in cross-sectional area also causes friction losses. Such losses are small and can be ignored when the change in cross sectional area is gradual and

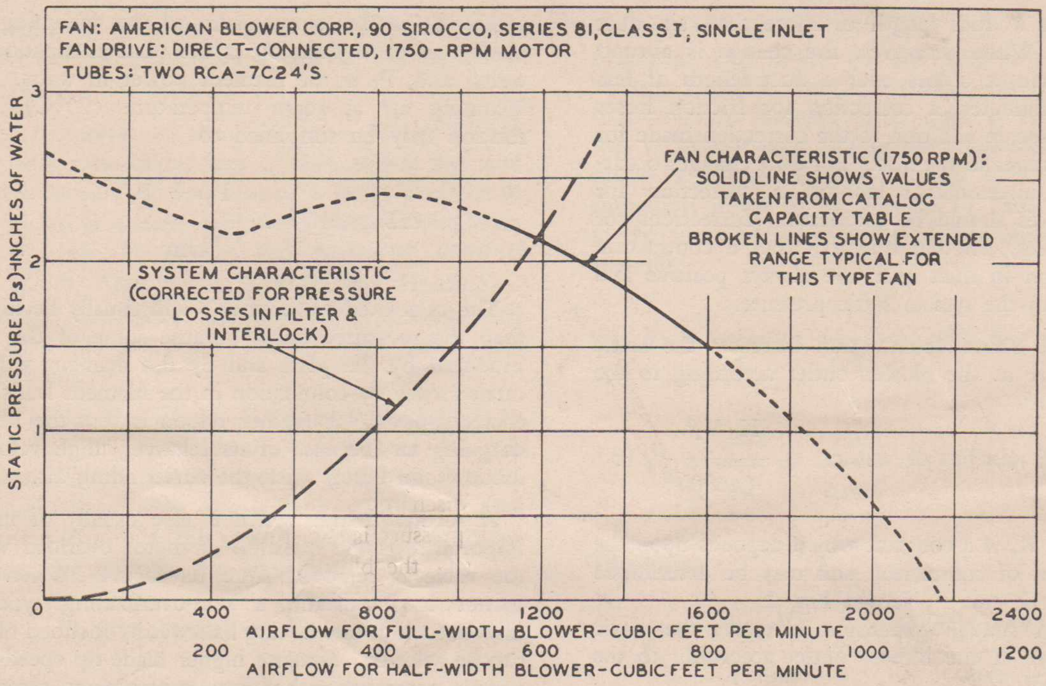


Fig. 1 - Fan Performance and System Characteristic Curves.

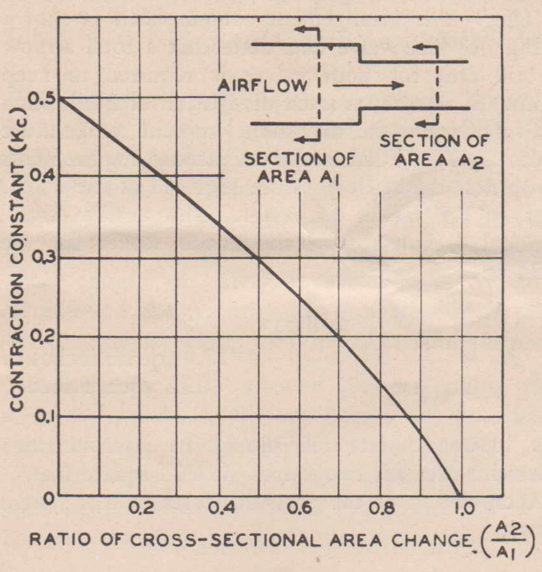


Fig. 2 - Chart for Determining Contraction Constant K_c.

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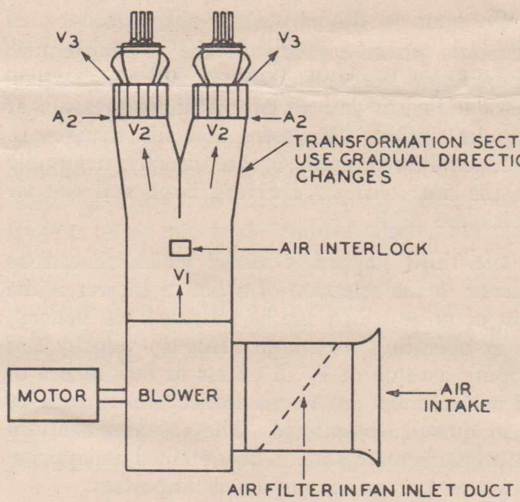


Fig. 3 - Air Duct System Used in Example.

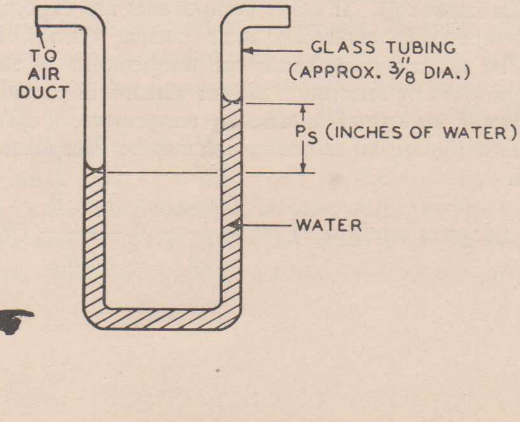


Fig. 4 - Simple "U-Tube" Manometer.

occurs over a duct length of more than six duct diameters. When, however, the change is abrupt, that is, when it occurs over a duct length of less than one diameter, a correction for friction losses must be made in addition to the correction made for velocity changes in the duct. For duct changes occurring over intermediate lengths, a correction for friction losses should be estimated. Corrections for friction losses, whether due to either a contraction or expansion in duct area, are always positive and are added to the system static pressure.

a. A sudden contraction increases the static pressure at the blower outlet according to the relation[5]

$$P_s \text{ (inches of water)} = \frac{K_c V_2^2}{(4000)^2} \quad (3)$$

where K_c is a constant which depends upon the amount of contraction and may be determined from the curve given in Fig. 2.

b. A sudden expansion increases the static pressure at the blower outlet according to the relation[5]

$$P_s \text{ (inches of water)} = \frac{[V_1 - V_2]^2}{(4000)^2} \quad (4)$$

The static pressure rating of the valve, item 1, and the friction losses in air filters and exit louvers, item 2, produce nearly all of the static pressure at the blower outlet. The correction for changes in cross-sectional area, item 3, are usually negligible unless the area changes are very large and the air velocities are high.

C. The third important factor which should be considered in the selection of a fan or blower is the amount of noise which can be tolerated. In general, a blower operating with high blade-tip velocity and developing a value of P_s in excess of two inches of water will usually produce a noticeable amount of noise in quiet surroundings. The recommendations of the manufacturer should be obtained in applications where low noise output[6] is important.

A matter of lesser importance but which may require some design consideration is the effect of the temperature of the air leaving the valve cooler on some of the circuit components such as filament bypass capacitors. If some components are exposed to temperature exceeding their normal ratings, it will be necessary to reduce the temperature of the outgoing air by selecting a blower which will provide a greater airflow. The rise in temperature (ΔT) of the outgoing air in the cooler may be determined from

$$\Delta T \text{ (degrees centigrade)} = \frac{T_1 + 273}{169} \times \frac{P_p + P_f}{\text{cfm}} \quad (5)$$

where T_1 is the temperature of the incoming air in degrees centigrade; P_p is the plate dissipation in watts; and, P_f is the filament power in watts. For incoming air at room temperature (25°C), this relation may be simplified to

$$\Delta T = 1.75 \times \frac{P_p + P_f}{\text{cfm}} \quad (6)$$

The calculated value of ΔT will usually be higher than the measured value because some of the heat produced by the plate and by the filament will be carried away by conduction in the filament leads and cooler support. A further reason is that the heated outgoing air, because of its relatively high velocity, mixes immediately with the surrounding air.

A further matter which is also usually of minor importance is the question of motor overload when the valve is removed from its socket. When this matter is important, a non-overloading type of blower such as one having backwardly inclined blades can be selected. Because higher blade-tip speeds are usually necessary with this type of blower, the noise output may be increased.

Examples of Calculations.

By way of illustration, take the problem of choosing a suitable blower for two RCA-7C24 valves used in an air system employing some duct work and an air filter. The arrangement contemplated is shown in Fig. 3. The valve data state that a total airflow of 500 cfm for both valves is required to keep within the maximum rated dissipation of 2 kilowatts per valve when the maximum ambient temperature is 45°C. The 7C24 curve of airflow requirements shows that the static pressure required at the cooler inlet is 1.5 inches of water. The airflow cross-sectional area (A_s) of the anode socket for the 7C24 is

$$A_s = \frac{\pi D^2}{4} = \frac{\pi (4.7)^2}{4} = 17.4 \text{ square inches or } 0.12 \text{ square feet.}$$

The blower outlet area should be approximately twice this area for two valves, or 0.24 square feet.

A tabulation of the pressure losses in this system shows:

ITEM	STATIC PRESSURE
Valve cooler	1.5 inches of water
Transformation section .	0
Air interlock	0.1 inches of water
Air filter	0.25 inches of water
TOTAL	1.85 inches of water

The value of pressure loss in the air filter is an average for different types of filters. The air interlock value is an estimate.

The requirements, then, are for a blower having an approximate outlet area of 0.25 square feet and a rated delivery of 550 cfm at a static pressure of 1.85 inches of water. A blower such as an American Blower Corp., 90 Sirocco Fan, Series 81, Class I, 1/2 Width, Arrangement 4 with Steel Housing — Discharge Clockwise Upblast — Direct Connected to 1750-rpm, 1/2-hp Motor will fulfil this requirement.

The outlet area of this fan is approximately 0.25 square feet in 1/2-width size. A plot of the cfm characteristic of the fan versus static pressure as obtained from catalog data is shown in Fig. 1. Also shown in Fig. 1 is the system static-pressure curve obtained by plotting the equation

$$P_s \text{ (for system)} = K \text{ (cfm)}^2 \qquad (7)$$

Where K is a constant for a particular system and is equal to the system pressure at some specific value of airflow divided by the square of that value of airflow.

$$\text{Thus, } K = \frac{1.85}{(550)^2}$$

$$= 6.13 \times 10^{-6} \text{ inches of water/(cfm)}^2$$

The intersection of these two curves occurs at P_s = 2.15 inches of water and cfm = 590. This intersection is the operating point of the particular blower chosen for the system described. The blower choice is conservative because more air than the amount required is delivered into the system and some margin of safety is available for eventual increases in the system static pressure due to partially clogged air filters or other duct components.

Other makes and types of blowers having characteristics similar to the one chosen can be selected from catalog ratings in the same manner. The 1/2-width size chosen for this application permits operation near the maximum static efficiency of the fan and, therefore, produces minimum noise output.

It is not always possible to select a blower having the same outlet area as the air inlet area of the valve or valves being cooled. When these areas are not the same, a correction is necessary. For example, the RCA-5592 requires an airflow of 1100 cfm at a static pressure of 2.4 inches of water at the valve air inlet in order to dissipate 17.5 kilowatts at an ambient temperature of 45°C. The air inlet area of the RCA-5592 is 0.55 square feet. A blower such as the Buffalo "Limit-Load" Single-Width, Type LL, Size 2 is suitable for this application, but the blower outlet area is 0.826 square feet. Because this change in cross-sectional area causes a change in the velocity of the air, the correction given by Equation (1) must be added to the static pressure at the blower outlet. In this example,

$$V_2 = \frac{\text{cfm}}{A_2} = \frac{1100}{0.55} = 2000 \text{ feet per minute}$$

$$V_1 = \frac{\text{cfm}}{A_1} = \frac{1100}{0.826} = 1330 \text{ feet per minute}$$

Therefore,

$$P_s = \frac{V_2^2 - V_1^2}{(4000)^2} = \frac{(2000)^2 - (1330)^2}{(4000)^2}$$
$$= 0.14 \text{ inches of water}$$

If this area change is made gradually, that is if it occurs over a duct length of more than six duct diameters, no further correction for friction losses need be added and the static pressure at the blower outlet is 2.4 × 0.14 = 2.54 inches of water.

If, however, because of space limitations or other reasons the change in airflow cross-sectional area is made abruptly, an additional correction for the friction losses due to the sudden contraction must be made as given by Equation (3).

$$P_s \frac{K_c V_2^2}{(4000)^2} = \frac{(0.22)\ (2000)^2}{(4000)^2} = 0.055 \text{ inches of water}$$

The value of K_c is obtained from the curve in Fig. 2. The static pressure at the blower outlet becomes 2.4 + 0.14 + 0.055 = 2.6 inches of water.

Performance Check.

After the system has been installed, the P_s-versus-cfm curve, when given for the valve type, may be used to determine whether sufficient air is being supplied to the cooler. A simple "U-tube" manometer may be constructed as shown in Fig. 4, using water as the manometer liquid. The value of P_s may be read directly as the difference in height of the liquid levels. To make this measurement, drill a small hole (#40 drill size) in the air-supply duct at some suitable place at least three inches below the cooler. Care should be taken that the hole is free from burrs and is located in a smooth section of tubing at least 3 inches away from any joints, airflow interlock vanes, or other obstructions. Make an air-tight connection to a suitable length of rubber tubing connected to one inlet of the "U-tube" manometer. No connection is made to the outlet of the manometer which is exposed to atmospheric pressure. The value of P_s thus obtained may be directly converted into cfm from the curve of airflow versus P_s given in the tube data.

If only one value of P_s and its corresponding value of cfm is available for the valve type, a P_s-versus-cfm curve may be constructed from Equation (7) given in the 7C24 example or by drawing a straight line having a slope of 2 on loglog graph paper through the known point.

Operation at High Altitudes.

A correction for blower operation at reduced atmospheric pressure should be made when valves are to be cooled at high altitudes. If, as a first approximation, it is assumed that the same mass rate of flow in pounds of air per minute is required at high altitudes as at sea level, the blower requirements may be computed as in the following example.

It is required to cool a valve operating at an elevation of 5000 feet above sea level. Assume that the airflow requirement given in the valve data is 1000 cfm at 1.0 inches of water for air at a standard density of 0.075 lbs/ft^3. From Table I, the density of air at 5000 feet is given as 0.062 lbs/ft^3. For the same mass rate of flow, the cfm at 5000 feet altitude is

$$\overline{\text{cfm}}\Big|_{5000} = \frac{0.075}{0.062} \times \overline{\text{cfm}}\Big|_{0} = 1.21\ (1000) = 1210\ \text{cfm}$$

The static pressure against which the blower must operate is

$$\overline{P_s}\Big|_{5000} = \frac{0.075}{0.062} \times \overline{P_s}\Big|_{0}$$

$$= (1.21)\ (1.0) = 1.21 \text{ inches of water}$$

This value is the static pressure that would be measured at the valve inlet when the fan is handling 1210 cfm of air having a density of 0.062 lbs/ft^3. Since a fan or blower may be considered a constant cfm device at fixed rpm regardless of air density, the standard catalog ratings may now be consulted for a blower capable of delivering 1210 cfm against the equivalent static head of the valve for standard density air. This equivalent static head is found from the square-law relation between P_s and cfm

$$\overline{P_s}\Big|_{1210\text{ cfm}} = \frac{(1210)^2}{(1000)^2} \times \overline{P_s}\Big|_{1000\text{ cfm}}$$

$$= (1.46) \times 1.0 = 1.46 \text{ inches of water}$$

A blower such as a Buffalo "Limit-Load" Conoidal Fan, Size 2, Single Width will supply 1210 cfm at 1-1/2 inches of water, at a speed of 1880 rpm. The horsepower required for standard density air is 0.421. At 5000-feet elevation, the horsepower required will be

$$\overline{\text{hp}}\Big|_{5000} = \frac{(0.062)}{(0.075)} \times \overline{\text{hp}}\Big|_{0}$$

$$= 0.826\ (0.421) = 0.348 \text{ hp}$$

In comparison, the same blower if used at sea level would have to operate at 1527 rpm to deliver 1000 cfm at a static pressure of 1 inch of water. The horsepower rating would be 0.225.

As an aid in selecting suitable blowers for RCA Forced-Air-Cooled Valves, Tables II, III, and IV have been prepared listing representative blowers for most applications. Allowance has been made for a nominal value of system static pressure over and above the normal static-pressure requirement of the valve. The blowers listed have been selected for valve operation at maximum rated plate dissipation. For a lower value of plate dissipation, a smaller blower may be used.

TABLE I. Density of Air and Velocity Constants vs. Altitudes.

Altitude above Sea Level (ft)	*Density of Air* (lbs/ft^3)*	*Velocity Constant (see text)*
0	0.0750	4000
1000	0.0722	4080
2000	0.0695	4165
3000	0.0668	4240
4000	0.0643	4320
5000	0.0619	4410
6000	0.0596	4500
7000	0.0573	4580
8000	0.0552	4670
9000	0.0532	4760
10000	0.0511	4850

** Temperature is constant at apprcximately 70°F.*

TABLE II. Blowers for Cooling Headers, Seals, and Bulbs.

Valve Type	*Part Cooled*	*cfm*	*Cooling Recommended†*
6C24	Filament Seals and Grid Connector	—	Deflect portion of main air stream used to cool anode.
7C24, 9C21, 9C22, 9C25, 9C27	Header and Filament Seals	10	Deflect portion of main air stream or use blower such as A, B, C, D, or E.
9C21, 9C27	Bulb	250	Use blower such as F.
8D21	Bulb and Electrode Seal	40	Use blower such as A, B, C, or E.
833-A	Bulb and Electrode Seal	40	Use blower such as A, B, C, or E.
880	Bulb and Electrode Seal	20	Use blower such as A, B, C, or E.
889	Bulb and Electrode Seal	15	Use blower such as A, B, C, D, or E.
806, 826, 829-B, 834, 8012-A, 8025-A, 4-125A/4D21	Bulb	—	Use ordinary small propeller fan or blower such as A, B, C, D, or E.

† For description of blowers, refer to Table IV.

TABLE III. Blowers for Cooling External-Anode Type Valves Having Integral Air Coolers.

These blower recommendations are based upon valve operation at maximum rated plate dissipation under class "C" Telegraphy conditions at an ambient temperature of 45°C and at sea level. Unless otherwise specified, the static pressure at the valve inlet has been increased by 0.25 inches of water to allow for incidental pressure losses due to air filters, interlocks, etc. Direct-connected units are specified where possible.

Valve Type	*Area* (ft^2)	*Volume* (*cfm*)	P_s (*inches of water*)	*Blower Recommended§*
6C24	0.022	135	0	Use blower such as G or H, if a gradual transition is made from 3-inch outlet diameter of blower to 2-inch nozzle diameter required by 6C24.
7C24	0.12	275	1.75	Use blower such as J, K, L, or M
9C22	0.74	1800	2.4	Use blower such as N, P, Q, or BB
9C25	0.55	1000	2.25	Use blower such as R, S, or CC
827-R	0.12	100	0.45	Use blower such as X or Y
889R-A	0.31	500	0.95	Use blower such as T or U
891-R, 892-R	0.31	450	0.5	Use blower such as V or W
5588	0.012	10	0.4**	Use blower such as A, B, or C
5592	0.55	1100	2.65	Use blower such as AA or DD

*** Without allowance for incidental pressure losses.*

§ For description of blowers, refer to Table IV.

TABLE IV.

Blower Manufacturer‡		Description
A	ILG	#6S, 70 cfm free delivery.
B	Delco	#5062369, 60 cfm free delivery.
C	F. A. Smith	#50747, 50 cfm free delivery.
D	F. A. Smith	#50745, 15 cfm free delivery.
E	Amer. Blower	#30H, 83 cfm free delivery.
F	Amer. Blower	#B Type P, 268 cfm at 2-1/2 inches of water.
G	Amer. Blower	Type P Cat. #A; 1/8-hp, 3450-rpm motor — direct connected.
H	ILG	Type P #7-1/2P; 1/8-hp, 3400-rpm motor — direct connected.
J	ILG	Type B9, 1/4h.p. 3450 r.p.m. Motor direct connected.
K	Amer. Blower	Type P Cat. #B; 1/3-hp, 3450-rpm motor — direct connected.
L	Buffalo	Type E #3E; 1/3-hp, 3450-rpm motor — direct connected.
M	Clarage	Type CI #6 ("C" wheel); 1/4-hp, 1750-rpm motor — direct connected.
N	Amer. Blower	#105 utility set direct driven at 1725-rpm from suitable 1-1/2-hp motor.
P	Clarage	Type HV #7/8 single width — single inlet belt driven at 1550 rpm by suitable 1-1/2-hp motor.
Q	ILG	Type BW—#25 single width — single inlet belt driven at 1450-rpm by suitable 1-1/2-hp motor.
R	Clarage	Type HV #3/4 single width — single inlet; 1.0-hp, 1750-rpm motor — direct connected.
S	Amer. Blower	#B18; 1-1/4-hp, 1750-rpm motor — direct connected.
T	Amer. Blower	#1-1/4-H utility set; 1/3-hp, 1725-rpm motor — direct connected.
U	Clarage	DF #1/2; 1/4-hp, 1750-rpm — direct connected.
V	Buffalo	Size D baby vent set, 1/6-hp, 1750-rpm motor — direct connected.
W	ILG	B-12: 1/6-hp, 1750-rpm motor — direct connected.
X	ILG	#B-9: 1/20-hp, 1750-rpm motor — direct connected.
Y	Buffalo	Size B baby vent set; 1/20-hp, 1750-rpm motor — direct connected.
AA	ILG	#BC-25 single width type BC — belt driven at 2250-rpm by suitable 1-hp motor.
BB	Buffalo	#2-1/4 single width type LL — belt driven at 2160-rpm by suitable 1-1/2-hp motor.
CC	Buffalo	#2 single width type LL — belt driven at 2080-rpm by suitable 3/4-hp motor.
DD	Buffalo	#2 single width type LL — belt driven at 2400-rpm by suitable 1-hp motor.
EE	Buffalo	#2-EH, 1/8-hp, 3450-rpm motor — direct connected.

‡ *For complete name and address, refer to Table V.*

TABLE V.

Abbreviation	*Name and Address*
ILG	ILG Electric Ventilating Company 2850 N. Crawford Ave. Chicago, Ill.
Delco	Delco Appliance Division General Motors Corporation Rochester, New York
F. A. Smith	F. A. Smith Mfg. Company, Inc. P. O. Box 509 Rochester 2, New York
Amer. Blower	American Blower Corporation P. O. Box 58 Roosevelt Park Annex Detroit, Michigan
Buffalo	Buffalo Forge Company Buffalo, New York
Clarage	Clarage Fan Company Kalamazoo, Michigan

REFERENCES.

1. Sturtevant Catalog #500 "What We Make", pages 124 ff.
2. American Blower Corp. Bulletin #2824 including Fan Selection Data.
3. ILG Catalog #24 including Engineering Data.
4. DESIGN OF INDUSTRIAL EXHAUST SYSTEMS, John J. Alden, The Industrial Press, New York, N. Y. 1939.
5. HEAT TRANSMISSION, Second Edition, W. H. McAdams, McGraw Hill Publishing Company, New York, N. Y. 1942.
6. "Sound Measurements Test Code for Centrifugal and Axial Fans", National Association of Fan Manufacturers Bulletin #104.
7. FAN ENGINEERING, Edited by Richard D. Madison, Buffalo Forge Company, Buffalo, N. Y. 1938.
8. "Standard Test Code for Centrifugal and Axial Fans", National Association of Fan Manufacturers Bulletin #103.

R.C.A. VALVE RELEASES

Radiotron type 5762 — is a forced-air cooled grounded-grid power triode, with a thoriated-tungsten filament, for F.M., broadcast and industrial services. The type 5762 has a maximum plate dissipation of 2.5 Kw. and can be operated with full ratings at frequencies up to 110 Mc/s, and is an improved version of the 7C24.

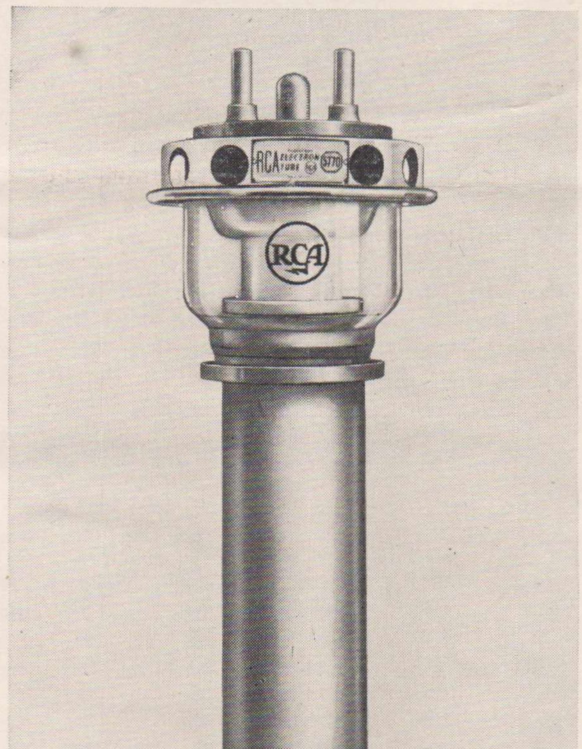
Radiotron type 5WP11 — is a 5″ short-persistence cathode-ray tube for photographically recording television programmes on motion-picture film. The type 5WP11 is identical to the 5WP15, except for the screen.

Radiotron type 16AP4 — is a 16″ directly-viewed kinescope, employing a high-efficiency, white fluorescent screen. The type 16AP4 has a metal-cone envelope and a relatively flat face.

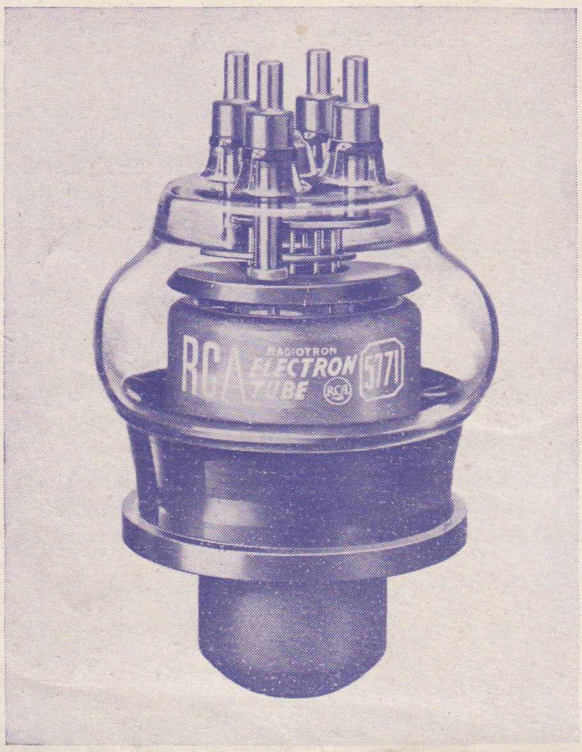
Radiotron type 5769 — is an image orthicon for outdoor or studio pickup use. The type 5769 may be used as a substitute for type 2P23 in any applications where the intensity of the illumination is not excessively low. For studio use type 5769 may be substituted for type 5655.

Radiotron type 3KP4 — is a 3″ directly-viewed kinescope, similar to the 3KP1, except that it has a high-efficiency, white fluorescent screen. It is intended primarily for use in small, low-cost television receivers.

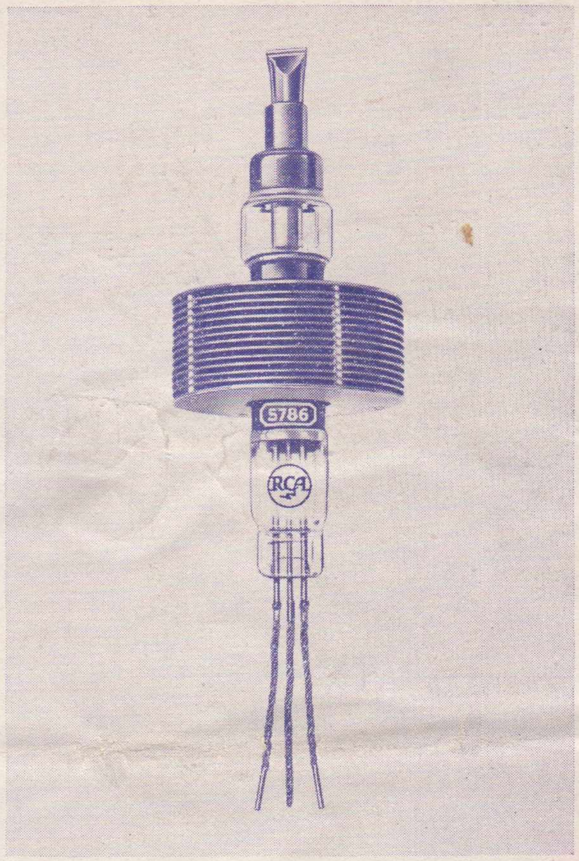
Radiotron type 5770 — is a water and forced-air cooled power triode, with a thoriated-tungsten filament, designed for high power industrial and broadcast applications. In unmodulated class C telegraph service it has a maximum plate dissipation of 50 Kw. The type 5770 can be used with full ratings at frequencies up to 20 Mc/s and with reduced ratings up to 35 Mc/s. The type 5770 may be used as a replacement for type 9C21.



Radiotron type 5771 — is a water and forced-air cooled power triode, with a thoriated-tungsten filament, designed for industrial and communication service. In unmodulated class C telegraph service it has a maximum plate dissipation of 22.5 Kw. The type 5771 can be used with full ratings at frequencies up to 25 Mc/s and with reduced ratings up to 50 Mc/s. The type 5771 may be used as a replacement for type 880.



Radiotron type 5786 — is a compact, forced-air cooled power triode, intended primarily for industrial application but useful for broadcast service. In unmodulated class C service it has a maximum plate dissipation of 600 watts, and full ratings may be used at frequencies up to 160 Mc/s.



C.W. RATINGS FOR SEVERAL RADIOTRON RECEIVING VALVES.

Valve Type	Max. Plate volts	Max. Screen volts	Max. Grid volts	Max. Plate Ma.	Max. Screen Ma.	Max. Grid Ma. (Note 1)	Max. Plate Dissipation (watts)	Max. Screen Dissipation (watts)	Power Output (watts) (Note 2)	Max. Freq. in Mc (Note 3)	Grid-Screen Amp. Factor (approx.)
6AG7	375	250	–75	30	9	5	9	1.5	7.5	30	22
6AK6	375	250	–100	15	4	3	3.5	1	4	60	9.5
6C4	300	—	–100	25	—	8	5	—	5.5	60	18
6F6	400	275	–100	50	11	5	12.5	3	14	30	7
6L6	400	300	–125	100	12	5	21	3.5	28	30	8
6N7	350	—	–100	30 (per plate)	—	5 (per grid)	5.5 (per plate)	—	14.5 (total)	30	35
6V6GT	350	250	–100	47	7	5	8	2	11	30	9

Note 1: 100,000 ohms maximum grid resistor.
2: Based on 70% plate efficiency.
Note 3: Maximum frequency for full power output and input.

Publication of this data should not be taken as an indication that all types mentioned are available from stock. Amateurs possessing any of these types will find the above chart a useful guide to maximum operating conditions. It should be noted that metal tube ratings given above do not necessarily apply to G and GT equivalents.