3 db is 1·5:1

6 db is 2:1

10db is 3:1

20db is 10:1

30db is 30:1

Log of Ratio
To multiply ratios
add db's
as adding logs when
multiplying decimals

FRAME GRID VALVES

How They Are Made

What They Can Do

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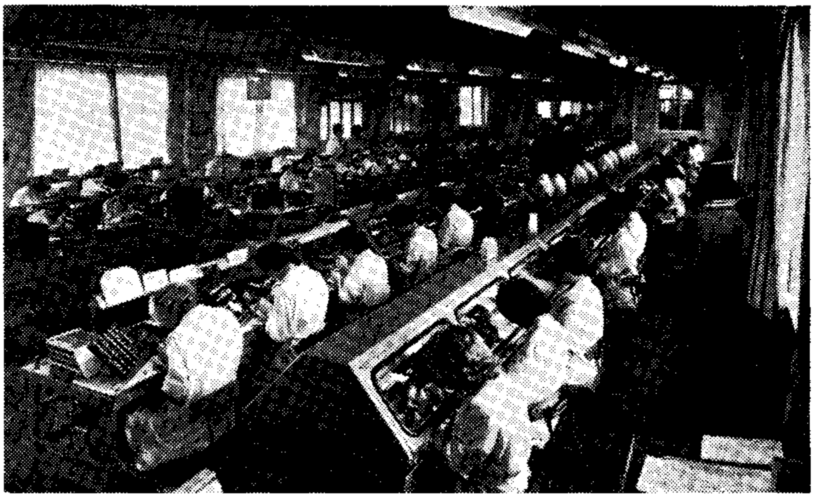


Dust-free cubicles of the kind seen in these photographs are used in several stages of the manufacture of frame grid valves at the Mullard factories in various parts of the country. On the left is seen a close-up of an operative winding the fine wire on to the grid frame, using a semi-automatic machine. On the right are seen several cubicles in line in which the valves are actually assembled by hand.

FRAME GRID VALVES

How They Are Made What They Can Do

IT is well known by radio dealers and service engineers that modern television receivers are more sensitive than their predecessors, but it may not always be realized that the reason for the considerable improvement over the last two years has been the introduction of the frame grid valve. It has always been possible to increase the gain of a receiver, if only by adding valves, but the noise factor would then increase with it and impair the picture quality, while the risk of cross-modulation would be increased.

The great advantage of the frame grid valve is that it permits an increase of gain without these two drawbacks. Each of the new Mullard frame grid valves, namely, the PCC89, PCF86, EF183 and the EF184, can provide up to twice the gain of their immediate predecessors. Twice the gain in one stage would mean four times the gain in two stages, and eight times the gain in three stages, and so on.

High-gain R.F. Amplifier

In a valve like the PCC89 this is particularly valuable as it operates in front of the frequency changer, where the maximum advantage of gain can be taken without amplifying the noise produced in other stages. Further, this valve has a signal-handling capacity about five times that of the PCC84.

Twice the gain per stage is not necessarily achieved in practice, neither is it necessary in order to obtain a worthwhile improvement in performance. Sixteen times the gain over that of a conventional receiver, with four valves, would be revolutionary, and a stage gain of one and a half times would be a lot. Sufficient gain can be achieved in practice to permit the design of a fringe receiver with only four valves in front of the vision detector, and a local station receiver with only three.

Fine Grid Structure

The increased gain in frame grid valves results from the use of finer, closely spaced grid wires and a reduction in the space between the grid wires and the cathode, which was already very small in the earlier valves. The diameter of the wire has been got down to as little as 10 microns, and the spacing between them and the cathode has been reduced to 50 microns.

A micron is one millionth of a metre, or one ten-thousandth of a centimetre, and there are about two and a half centimetres to the inch. Human hair is about 75 microns in diameter, so that you could not insert a piece of it between cathode and grid. It is necessary to realize this to appreciate the fineness of the wire and the closeness of the spacing.

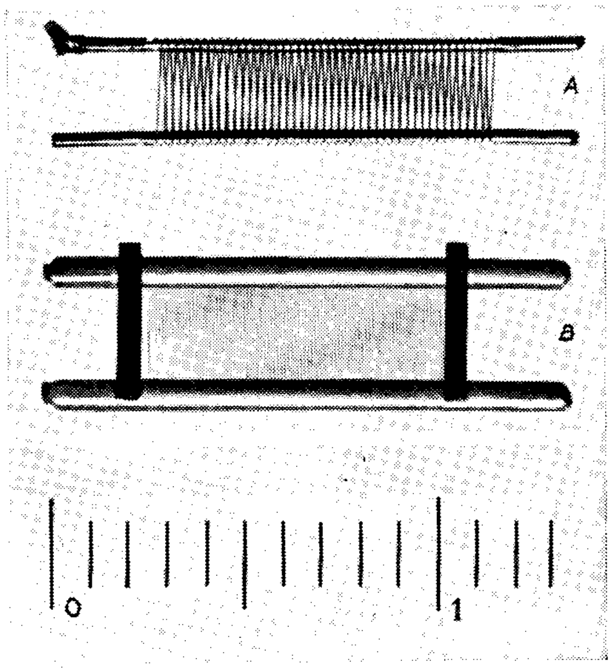
This must not be taken to mean that greatly increased gain can be achieved simply by replacing the existing valves in a receiver. Design features of the receiver must be adjusted to take advantage of opportunities offered by new valve designs, and that is one of the reasons for the change in television receiver design from year to year.

The receiver designer has the choice before him of how much extra gain he needs, and that depends on whether the set is to be of the standard type for use within the service area of a transmitter or a fringe receiver for use outside it.

Increased Sensitivity

If the sensitivity of a conventional standard receiver is taken as being about 60μV, that is to say 60μV is the lowest signal voltage at the aerial that can produce the desired output at the vision detector, with the receiver working at maximum gain, it can be reduced to, say, 15μV or 10μV, or even less, at maximum gain, by using two, three or four frame grid valves. Often two are employed in the turret, with an EF80 and an EF85 in the I.F. amplifier, but other combinations can be used.

Two triode grids compared: at A, the normal type, using (comparatively) thick self-supporting grid wire; at B, the fine (10 micron) wire wound on a rigid frame. An approximate idea of the length is given by the one-centimetre scale at the bottom. Six grids will go on an ordinary postage stamp and leave room to spare.



The manufacture of a valve assembly to these fine dimensions is possible only by using the frame grid form of construction. As can be seen from the accompanying photograph of the grid assemblies, the earlier type at A comprised two "backbone" support rods with the grid winding mounted on them, forming a ladder-shaped structure. When this is mounted in the valve assembly, of course, the top and bottom ends of the rods are firmly supported on the valve base, but until then the grid wire supports the rods.

Each turn of wire as it bends round the rod is welded to it to make a firm structure, because even in the earlier valves the grid/cathode clearance was not large, and in any case microphony must be avoided. Some of the clearances in the earlier types make interesting reading. In the EF50, for instance, it was 150 microns, and in the EF42 and EF80 it was 110 microns, against 50 microns in the EF184. The mutual conductance of the EF80 was 7·4mA/V against 15mA/V for the EF184.

Rigid Grid Support

The grid wire in a frame grid valve is very fine, and it could not be used as a support for the grid structure. Instead the grid support itself is made rigid, with straps at top and bottom to hold the side rods, or backbones, firmly in place, forming the frame-like structure from which the frame grid valve gets its name. The 10 micron grid wire is then wound over the frame and is entirely supported by the frame.

The wire is made of tungsten, which is made from raw materials and drawn to the required dimension by Mullards at their Blackburn works. Tolerance is extremely fine, actually within $\pm$0·2 microns, which as the makers point out is less than the wavelength of sodium light. The support rods are made of molybdenum, drawn to the desired dimensions within $\pm$5 microns.

The frame grid technique itself is not new. It has been used for the manufacture of "special" quality types for several years. What is new is to make frame grid valves in quantity for domestic receivers.

Some of the problems that had to be overcome before valve assemblies could be made to such close limits, and some of the methods used to meet them, were explained recently to visitors who toured one of the several Mullard factories in which frame grid valves are made.

The making of the grid wire alone to a diameter of less than one-sixth of that of human hair is an achievement of considerable merit, but that we can accept as an accomplished fact. Other problems arise when attempts are made to wind it on to its supports to very tight tolerances. Such wire is difficult to handle, even difficult to see.

The wire is wound on to the support by a hand-operated machine, the frames being made in lengths containing several frames in one piece. After winding on the grid wire to all the frames in one length, the wire is sealed to the supports with a glass adhesive and then cut up into separate frames. A solution of fine glass is painted on to the edge of the assembly so as to cover the grid wire as it bends round the support rod on one side of the frame, and it is then fired in a furnace so that the glass runs and fixes the wire permanently.

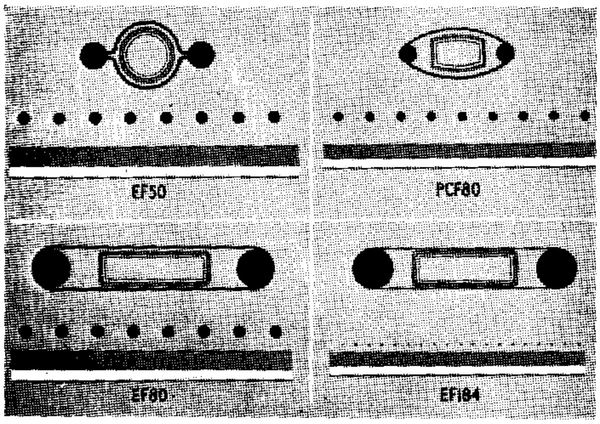
New Type of Cathode

It necessarily follows that if the small grid/cathode spacing demands microscopic tolerances of the grid, so must it do also of the cathode. Roughening of the cathode surface even to a very small degree would result in unevenness, and there would then be a risk of cathode touching the grid.

A special type of cathode is used, therefore, in the frame grid assembly. Instead of spraying the emissive solution on to the cathode cylinder, it is laid on like a ribbon round the cylinder. The result is a much smoother cathode surface that can be controlled.

The complete cathode cylinder, with its insulated heater inside it, slips inside the grid frame, which itself appears to the naked eye to have no space inside it. It might just be

Plan view of four well-known Mullard valve assemblies giving some indication of the differences between frame grid spacings and those of their predecessors.



possible to imagine how small it is from our photograph of the grid assemblies, which are accompanied by a one-centimetre scale, shown approximately to scale.

The price of increased efficiency in most fields is reduced tolerances in manufacture and more critical operation in service. Here the reduced tolerances are accompanied by reduced dimensions, and watching some of the processes in the making of frame grid valves, many of which are still done by hand, one is reminded of techniques of the jewelry and clock-making industries.

Another feature usually associated with increased efficiency is increased cost, but Mullard are proud of the fact that as a result of their success in applying mass-production techniques to the difficult subject of frame grid manufacture, which has cost them a great deal of money, these valves cost no more than those they succeed.

Upon touring transistor factories one is struck by the miniaturization of the articles and tools, the cleanliness that must be observed and the delicacy of touch needed by the operatives, and one is reminded of transistor manufacture when viewing the frame grid factory.

Manufacturing Cleanliness

Photographs accompanying this article of the Mullard works reveal features that are reminiscent of the transistor factories: the enclosed bench cubicles into which the operatives insert their hands, with glass covers which permit them to see their work; curtains in some cases to close the areas round the hands to exclude dust; in one or two cases even a constant flow of gas inside the cubicle to prevent oxidation; and a plastics-tiled floor that is most unfactory-like.

In these cubicles the operatives assemble the frame grid elements. They are all specially trained women, selected by tests for a high degree of co-ordination between hand and eye. It is surprising to see the facility with which they fit the parts together, first standing up a cathode unit in holes in a precision-made mica fitted on the valve base, then slipping over it one of these tiny frame grids. Alignment is ensured by the use of high-precision jigs which hold the electrodes (two sets in the double valves) in place while the top micas are dropped into place.

Similar cubicles to those seen in our photographs are used for several stages of manufacture, but the final stage of the frame grid itself is inspection. This is performed in these cubicles, but here the glass covers are fitted with binocular microscopes, whereas magnifying glasses are used at other stages—again reminiscent of transistor techniques.

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