March 3, 1959 F. RIENKS 2,876,376

MAGNETRON BEAM SWITCHING TUBE

Filed July 24, 1957

Fig. 1.

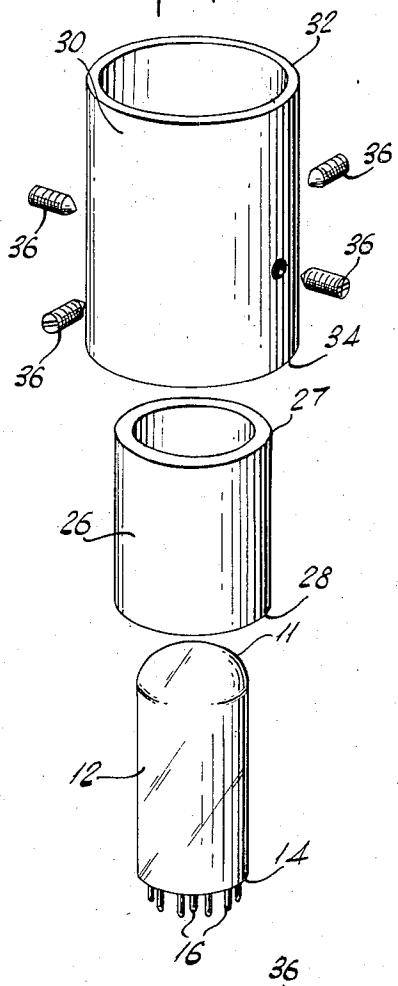


Fig. 2.

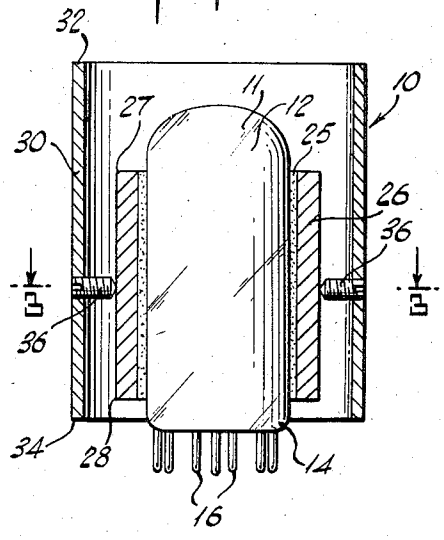


Fig. 4.

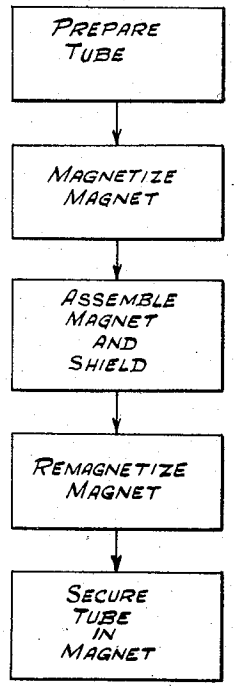
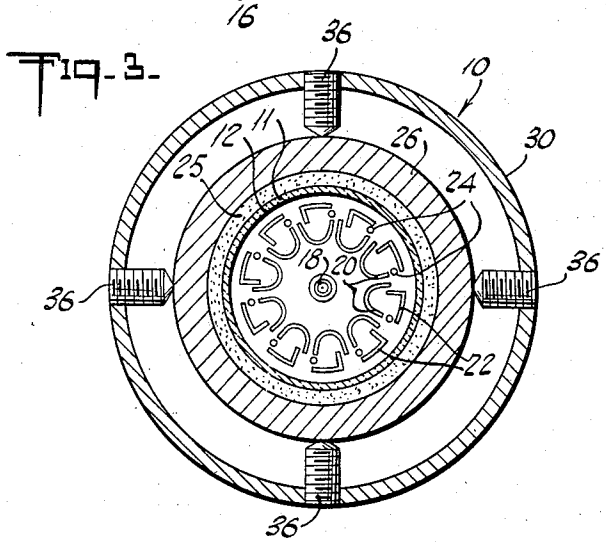


Fig. 3.



INVENTOR
FRITS RIENKS
BY Robert A. Green
ATTORNEY

United States Patent Office 2,876,376
Patented Mar. 3, 1959

2,876,376

MAGNETRON BEAM SWITCHING TUBE

Frits Rienks, North Plainfield, N. J., assignor to Burroughs Corporation, Detroit, Mich., a corporation of Michigan

Application July 24, 1957, Serial No. 673,912

7 Claims. (Cl. 313—156)

This invention relates to magnetron beam switching tubes and particularly to an improved magnetically shielded tube of this type and method of making the same.

One type of magnetron beam switching tube is shown and described in U. S. Patent 2,721,955 to Sin-Pih Fan et al. This tube includes a central longitudinal cathode and a plurality of groups of electron beam receiving electrodes arrayed about the central cathode. A cylindrical permanent magnet coaxial with the tube provides a magnetic field which operates in conjunction with controlled electrostatic fields within the tube to switch an electron beam from one group of electrodes to another in a predetermined pattern.

Many applications and systems have been devised in which tubes of the foregoing type are employed. In packaging such systems, it is desirable to mount the tubes in close physical relationship. However, when such tubes are operated in close proximity, for example closer than about four inches center-to-center, their magnetic fields interact and their operation is impaired.

An object of the present invention is to provide an improved magnetron beam switching tube and method of making the same.

Another object of the invention is to provide an improved magnetron beam switching tube which may be operated in close physical relationship with other tubes of the same type or with other magnetic devices without having its operation impaired.

In brief, a magnetron beam switching tube, according to the invention, includes a glass envelope containing a central longitudinal cathode and a plurality of electron beam receiving electrodes positioned around the cathode. A hollow cylindrical permanent magnet coaxially aligned with the tube is secured to the tube envelope and a hollow cylindrical magnetic shield is mounted coaxial with the tube and is secured to the magnet. The shield is of such size relative to the tube that an optimum magnetic field having substantially parallel lines of force is provided within the tube and promotes optimum operation of the tube.

In assembling the above-described tube, magnet, and shield according to the invention, the tube is first prepared in its entirety. Next, the magnet is magnetized to saturation and it is centered and secured within the shield in the desired physical relationship. Next, the assembly of magnet and shield is again treated to provide the desired level of magnetization of the permanent magnet. Finally, the tube is secured within the magnet in the desired physical and electrical relationship.

The invention is described in greater detail by reference to the drawing wherein:

Fig. 1 is an exploded perspective view of a magnetron beam switching tube assembly embodying the invention;

Fig. 2 is an elevational view partly in section of the tube assembly of Fig. 1;

Fig. 3 is a sectional view along the line 3—3 in Fig. 2; and

Fig. 4 is a flow chart of the method of assembling the tube of Fig. 1.

A shielded magnetron tube assembly **10** includes a magnetron beam switching tube **11** which is a multiposition beam tube of the type shown and described in U. S. Patent No. 2,721,955 to Sin-Pih Fan et al. The tube **11** includes a glass envelope **12** having a base **14** through which pins **16** extend. The tube **11** contains (Fig. 3) a central axially positioned longitudinal cathode **18** surrounded by several concentric arrays of electrodes. On a circular locus nearest to the cathode are longitudinally elongated beam-forming and holding electrodes **20**, called spade electrodes. Beyond the spade electrodes on another circular locus are similar longitudinally elongated output or target electrodes **22**, positioned so as to cover the inter-spade spaces and to collect beam current flowing into such spaces. Between one edge of each spade and the near edge of its target electrode is a longitudinal rod-like switching grid electrode **24**. These grid electrodes also are on a circular locus centered on the cathode **18**. An open-ended cylindrical permanent magnet **26** surrounds the tube **11** and is coaxial therewith and is secured thereto by a suitable insulating cement **25**. The magnet **26** is longer than the tube electrodes and has an upper end **27** and a lower end **28**.

The tube **11** employs crossed electric and magnetic fields, provided by the proper potentials applied between the cathode and the other tube electrodes and by the magnet **26**, respectively, to direct an electron beam to each of the output electrodes in succession. In operation of the tube **11**, the cathode **18** is heated to its electron-emission temperature and suitable positive potentials are applied to the spades **20** and target electrodes **22**. The magnet strength is such that the axial magnetic field provided within the tube thereby is great enough to hold the tube in magnetron cut-off so that electrons rotate about the cathode and do not flow to any of the target electrodes. However, if one of the spade electrodes is reduced in potential to about half its previous potential, the voltage gradients within the tube are distorted and a beam will form. This electron beam grazes the low potential spade and strikes the adjacent target electrode. A small portion of the electron beam also flows to this spade. With a suitable series resistor interposed in the connection of each spade to its positive voltage supply, this small portion of the beam current produces an IR voltage drop which enables the spade to hold the beam stably in place once it grazes that spade.

The switching grid electrodes **24** upset this stable beam holding condition when a suitable negative potential is applied to the grid which is in the same inter-spade space as is the beam. As this grid becomes negative, the beam fans out across the target electrode and some of it strikes the next spade electrode. This fraction of beam current produces another IR voltage drop which lowers the potential of this next spade. With a lowered potential on the next spade, the beam switches over to the next target. This switching action occurs at a very rapid rate, the time required to switch from one target to the next being in the order of one-tenth of a microsecond.

According to the invention in order to be able to operate two or more magnetron beam switching tubes in close physical relationship and, if desired, in contact with each other without having their operation adversely affected due to interacting magnetic fields, a low reluctance magnetic shield **30** is provided as part of the tube assembly **10**. The shield **30** is preferably a hollow cylindrical metal pipe open at both ends, upper end **32** and lower end **34**, and mounted coaxial with and surrounding the tube **11** and magnet **26**. The shield is

secured directly to the magnet in any suitable fashion, for example by means of a plurality of non-magnetic screws 36 of brass or the like and is preferably of low reluctance material which will not retain magnetism, for example drawn low carbon steel. The magnetic shield 30 is preferably longer than the magnet 26; however, as a practical matter, since the tube pins 16 must be accessible, the lower end of the shield should not obstruct them. For convenience, it is satisfactory for the lower end 34 of the shield to be substantially flush with the lower end 28 of the magnet while its upper end 32 extends approximately one-third of its length beyond the end of the tube and the magnet. The inner wall of the shield is spaced far enough from the magnet so that effective shielding is obtained. For the tube under consideration, this spacing may be no less than about one-quarter of an inch.

The preferred method of making the tube assembly 10 including tube 11, magnet 26, and shield 30 is set out in the flow chart of Fig. 4 and comprises, essentially, preparing two separate sub-assemblies which are put together to form the completed product. The first sub-assembly comprises the tube 11 itself which is assembled and processed to completion in accordance with standard vacuum tube techniques. The second sub-assembly comprises the magnet 26 and shield 30 and this sub-assembly is prepared in the following manner:

First, the magnet 26 is magnetically saturated and then it is inserted into the shield 30 which has previously been provided with a suitable non-magnetic centering jig (not shown). The jig holds the magnet centered within the shield and coaxial therewith. The magnet is inserted into the shield with its south pole or upper end 27 first and with its lower end 28 or north pole flush with the lower end 34 of the shield 30. With the shield and magnet thus properly coaxially positioned and aligned, the screws 36 are tightened into contact with the magnet and the second sub-assembly is thus completed. When the magnet is assembled with the shield, it loses some of its magnetism. Accordingly, the sub-assembly of magnet and shield is treated in a suitable magnetizing apparatus to provide magnetic saturation and then it is demagnetized to the desired level of magnetism.

Next, the two sub-assemblies are put together to provide the completed magnetron assembly 10. This assembly operation is accomplished by inserting the tube 11 into the magnet 30 with its base or stem adjacent to the north pole of the magnet. The tube is adjustably positioned within the magnet by means of strips of rubber or the like (not shown) which are flexible and allow the position of the magnet with respect to the tube to be adjusted to provide the desired electrical characteristics for the tube. After the desired adjustment has been made, a suitable plastic material, such as Araldite, Silastic or the like is injected into the space between the tube and the magnet. The potting material is allowed to harden and then the resilient strips are removed, whereupon, the space between the tube and the magnet is completely filled with the plastic material. The plastic material is then cured as required, for example by baking.

In a magnetron tube assembly of the type described above, the size and characteristics of the magnet which is employed are determined among other things by the desired magnetron cut-off, the operating voltages of the tube electrodes, the size of the tube, and the permissible size of the magnet. In one magnetron beam switching tube in which the principles of the invention are employed, the tube envelope length was about 2.5 inches and the diameter was about 1.1 inches, and the electrodes were about 1 inch long. The magnet employed had a length of about 1.75 inches and a diameter of about 1.5 inches. The shield had an outside diameter of about 2.25 inches, a wall thickness of about 0.1 inch and a length of about 2.5 inches. The tube had a magnetron cut-off of about 200 volts and a desired operating target output current of about 5.5 milliamperes. To achieve these electrical specifications, the magnet had a saturation level of about 600 gauss before it was secured within the shield and in the final shield and magnet assembly it had a magnetism level of about 400 gauss. It is to be understood that for other sizes of tubes and magnets and to obtain other electrical characteristics, the physical and electrical characteristics of the magnet might be different. In addition, the principles of the invention may be employed with other types of tubes which employ electric and magnetic fields in their operation.

One important advantage of tubes embodying the invention lies in the fact that they may be made reproducibly with substantially identical electrical characteristics and they may be operated in close proximity to each other or to other magnetic devices without having their operating characteristics changed or impaired. In addition, the shield improves the shape of the lines of magnetic flux within the tube whereby improved tube operation is achieved. A tube assembly constructed as described above is also quite rugged and may be handled freely without danger of damage.

What is claimed is:

1. A magnetron tube assembly comprising a magnetron beam switching tube including a central longitudinal cathode and a plurality of groups of electron beam receiving and controlling electrodes arrayed about said cathode, a hollow cylindrical magnet coaxial with said tube, and a low reluctance open-ended hollow cylindrical magnetic shield positioned coaxially with said tube and said magnet and completely surrounding said tube and magnet.

2. A magnetron tube assembly comprising a magnetron beam switching tube including a central longitudinal cathode and a plurality of groups of electron beam receiving and controlling electrodes arrayed about said cathode, a hollow cylindrical magnet coaxial with said tube, and a low reluctance open-ended hollow cylindrical magnetic shield positioned coaxially about said tube and said magnet and completely surrounding said tube and magnet, the upper end of said shield extending beyond the upper end of said magnet.

3. A magnetron tube assembly comprising a magnetron beam switching tube including a central longitudinal cathode and a plurality of groups of electron beam receiving and controlling electrodes arrayed about said cathode, a hollow cylindrical magnet coaxial with said tube and having a length greater than the lengths of said electrodes, and a low reluctance open-ended hollow cylindrical magnetic shield positioned about said tube and said magnet and coaxial therewith, said shield being longer than said magnet and completely enclosing said magnet.

4. A magnetron tube assembly including a magnetron beam switching tube having a central longitudinal cathode and a plurality of groups of electron beam receiving electrodes arrayed about said cathode, a hollow cylindrical magnet coaxial with said tube envelope and having a length greater than the lengths of said electrodes and a low reluctance open-ended hollow cylindrical magnetic shield positioned coaxially about and completely enclosing said tube and said magnet, the upper end of said shield extending approximately one-third of its length beyond the upper end of said magnet.

5. The method of making a magnetron tube assembly comprising the steps of preparing a magnetron beam switching tube, magnetically saturating a magnet, centering said magnet within a magnetic shield and securing said magnet in coaxial relation with said shield, again magnetically saturating the magnet, reducing the magnetism of the magnet to a desired operating level, and securing said beam switching tube within said magnet.

6. The method of making a magnetron tube assembly comprising the steps of preparing a magnetron beam switching tube, magnetically saturating a magnet, centering said magnet within a magnetic shield and securing said magnet in coaxial relation with said shield with the

ends of said shield extending beyond the ends of said magnet, again magnetically saturating the magnet, reducing the magnetism of said magnet to a desired operating level, and securing said beam switching tube within said magnet.

7. The method of making a magnetron tube assembly comprising the steps of preparing a magnetron beam switching tube, magnetically saturating a magnet to be used with said tube, centering said magnet within a cylindrical magnetic shield and securing said magnet in coaxial relation with said shield, said magnet and shield having one of their adjacent ends substantially in alignment while the other end of the shield extends about one-

third of its length beyond the other end of the magnet, again magnetically saturating the magnet, reducing the magnetism of the magnet to a desired operating level, and securing said beam switching tube within said magnet.

References Cited in the file of this patent

UNITED STATES PATENTS

2,163,589	Dallenbach et al.	June 27, 1939
2,400,770	Mouromtseff et al.	May 21, 1946
2,721,955	Fan et al.	Oct. 25, 1955
2,804,568	Kuchinsky	Aug. 27, 1957