April 5, 1955 A. T. STARR ET AL 2,705,776

SWITCHES FOR HIGH FREQUENCY WAVES

Filed Feb. 4, 1952 3 Sheets-Sheet 1

FIG. 1.

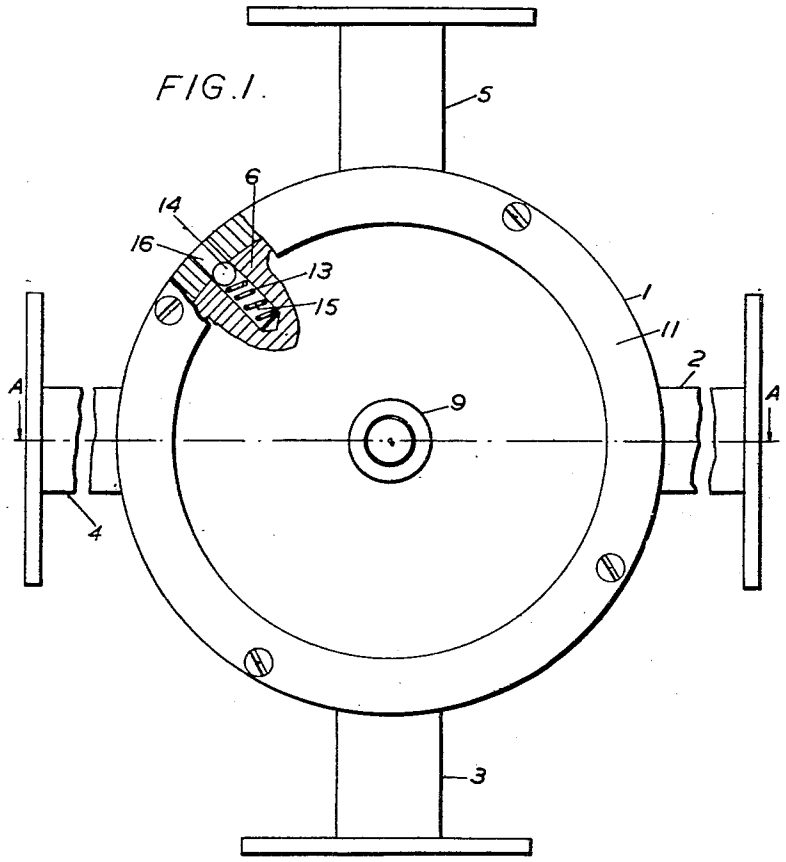
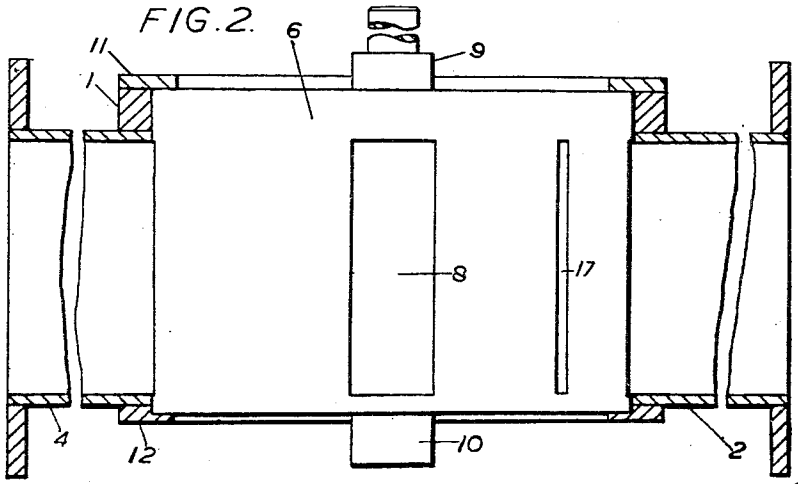


FIG. 2.



Inventors
A. T. STARR
G. KING

By R. P. Morris
Attorney

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Filed Feb. 4, 1952 3 Sheets-Sheet 2

FIG. 3.

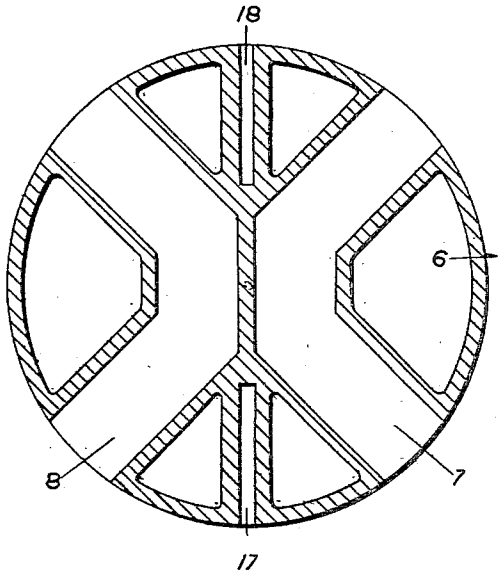
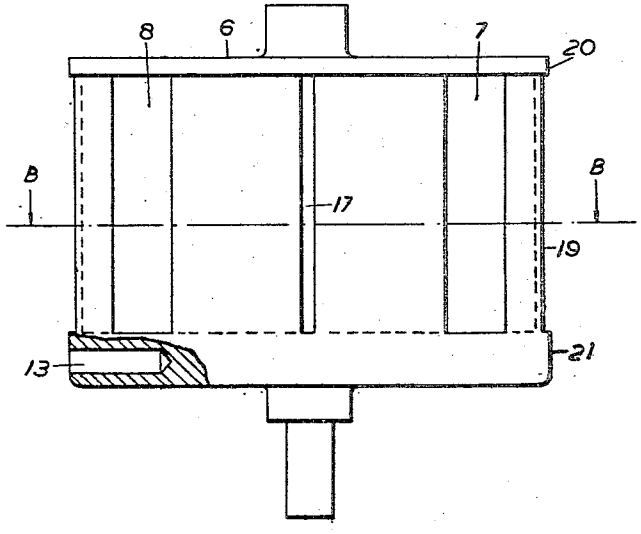


FIG. 4



Inventor
A. T. STARR
G. KING
By R. P. Morris
Attorney

April 5, 1955 A. T. STARR ET AL 2,705,776

SWITCHES FOR HIGH FREQUENCY WAVES

Filed Feb. 4, 1952 3 Sheets-Sheet 3

FIG. 5.

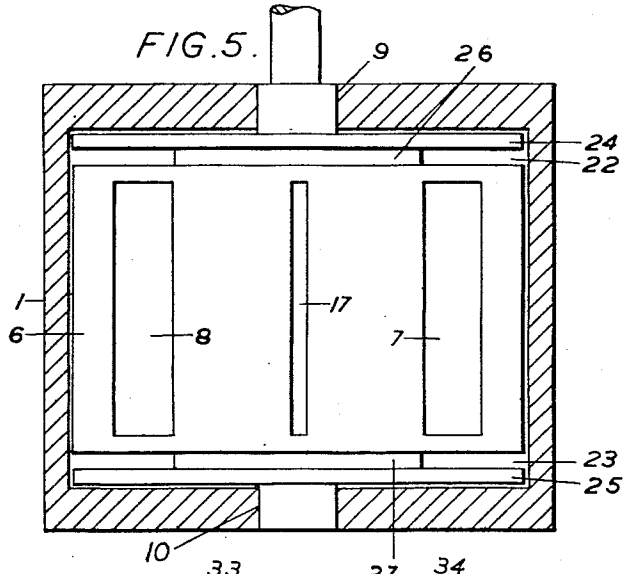
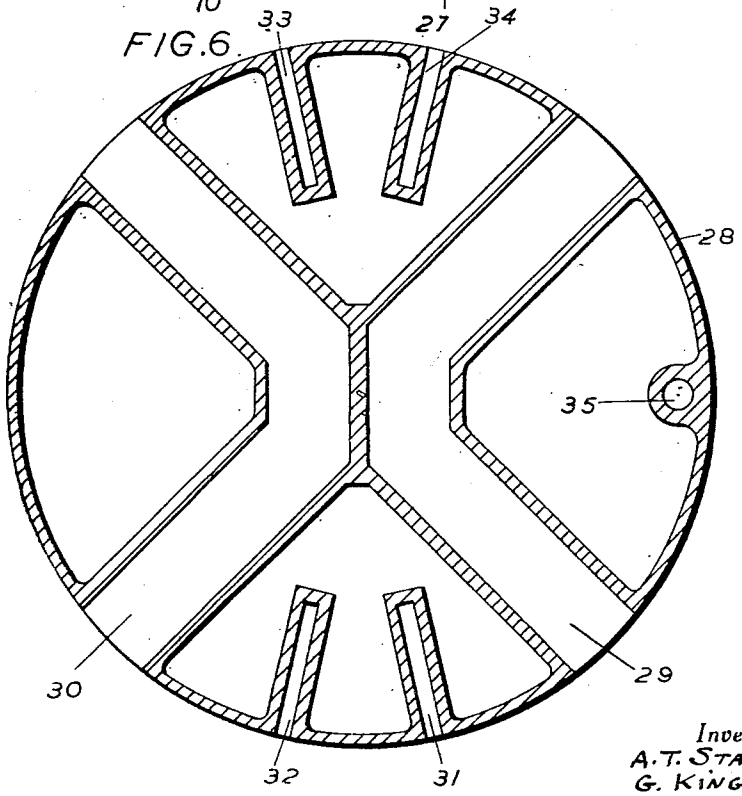


FIG. 6.



Inventor
A. T. STARR
G. KING
By R. P. Morris
Attorney

United States Patent Office

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SWITCHES FOR HIGH FREQUENCY WAVES

Arthur T. Starr and George King, London, England, assignors to International Standard Electric Corporation, New York, N. Y.

Application February 4, 1952, Serial No. 269,872

5 Claims. (Cl. 333—7)

The present invention relates to switch devices for electro-magnetic wave guides.

In high frequency radio systems employing waveguides it is frequently required to carry out switching operations whereby one waveguide can be connected to either of two or more others. The mechanical requirements of a waveguide switch are quite simple, but is found that considerable difficulties are encountered in meeting the electrical requirements.

The problem in the case of a waveguide switch is to provide paths for the high frequency energy between members of the switch having relative movement. It is well known to provide spring leaves, or similar devices, for making contact between fixed and moving members of a high frequency transmission device. In the case of a switch, this solution is difficult to realise in practice in such manner that absolutely reliable contact is obtained over a long period of operation. The solution according to the present invention depends on an alternative principle by which the elements of the switch are proportioned so that satisfactory paths for the high frequency energy are produced without mechanical contact between fixed and moving parts of the switch.

A switch of this kind must involve clearance gaps which produce undesired cross-couplings, and introduce irregularities into the waveguide which are the cause of reflections and loss. It is therefore necessary to design the mechanical details in such manner as to minimise or eliminate the irregularities and cross-couplings produced by the switch.

A large number of different forms of waveguide switch have been proposed in the past, and the form chosen for the present invention is generally similar to a well known form of "gas tap." The invention consists in the means adopted for overcoming the electrical difficulties of a switch of this kind.

The invention accordingly provides an electro-magnetic waveguide switch comprising a hollow metal body having a cylindrical cavity therein, at least three waveguide sections communicating with the cavity, a cylindrical metal drum coaxially and rotatably mounted inside the cavity, with a small cylindrical clearance gap between the inner wall of the cavity and the outer wall of the drum, the drum also carrying a waveguide passage so disposed as to connect together one pair of the said waveguide sections when the drum is switched to one given position, and to connect a different pair when the drum is rotated to a different given postiion, and a plurality of radial quarter-wave slots communicating with the said clearance gap and located in such manner as substantially to prevent electromagnetic waves which are passing through the waveguide passage from leaking through the said clearance gap.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 shows a top view of a waveguide switch according to the invention, with a small portion broken away to show a detail.

Fig. 2 shows a sectional view at A—A of Fig. 1;

Figs. 3 and 4 show details of the drum portion of the switch, Fig. 4 being a front elevation, and Fig. 3 being a section at B—B of Fig. 4;

Fig. 5 shows a diagrammatic sectional view of the switch showing a modified form of drum; and

Fig. 6 shows a section of another modification of the drum.

Referring to Fig. 1, the switch comprises a hollow cylindrical metal body **1** from which radiate four short sections **2**, **3**, **4**, **5** of rectangular waveguide terminating in flanges to which other lengths of waveguide (not shown) may be bolted. Inside the cylindrical body is located a rotatable metal drum **6**, through which run two similar bent passages **7**, **8** having the same cross-section as the waveguide sections. These passages are seen in the section of the drum shown in Fig. 3. The external openings of these passages are spaced apart by 90° round the circumference of the drum. The drum rotates in bearings **9**, **10** carried by the upper and lower cover plates **11**, **12** of the body of the switch.

The drum carries a radial cylindrical hole **13** (Fig. 4), in which are housed a ball **14** and a spring **15** (Fig. 1) which act in conjunction with four equally spaced holes **16** (Fig. 1) in the cylindrical body **1** to form a "click" mechanism for locating the operated positions of the drum. The arrangement is such that in two diametrically opposite positions of the drum, the guide sections **2** and **4** are respectively connected to guide sections **3** and **5** through the passages **7** and **8**, while in the other two diametrically opposite positions a quarter of a turn from the former position, the guide sections **2** and **4** are respectively connected to the guide sections **5** and **3**.

It will be appreciated that a cylindrical gap of appreciable dimensions must exist in practice between the outer surface of the drum **6** and the inner surface of the body **1**. It is found that even with the smallest practicable gap, excessive leakage of the electro-magnetic waves between the two pairs of guide sections which are separately connected by the passages **7** and **8** always occurs. This not only produces unwanted cross-couplings, but also a power loss, and an impedance irregularity producing reflections.

According to the invention, the leakage is substantially prevented by cutting two radial slots **17** and **18** (Fig. 3) in the drum, bisecting the angles between the two passages **7**, **8**. One of these slots is visible in Fig. 2, and also in Fig. 4. The depth of each slot should be equal to one quarter of the wavelength corresponding to the mean frequency of the band over which the switch will be used. Also it is preferable to proportion the diameter of the drum so that the circumferential distance between each wall of the slot and the adjacent wall of the neighbouring passage is one quarter of the same wavelength.

At the same time the surface of the drum should preferably be undercut by a few thousandths of an inch over a length equal to the longer dimension of the guide, as indicated at **19** in Fig. 4, where the undercut has been exaggerated for clearness.

The rim portions **20**, **21** of the drum should be designed to fit the internal surface of the body **1** with the smallest practicable clearance, and they should be lubricated with a good electrically conducting grease containing graphite, for example. The rim portions **20** and **21** then form the real bearings of the drum, and accordingly the axial bearings **9**, **10** should be provided with sufficient clearance to permit free movement.

The conducting grease substantially seals the gaps between the rim portions **20**, **21** and the body, and it will be appreciated that the passages **7** and **8** will be connected at both ends round the circumference of the drum by a very narrow half-wave slot having a quarter wave slot tapped off the centre. The effect is substantially to short-circuit the gaps between the drum and the body along the longer internal dimensions of the waveguide, thus preventing any appreciable leakage of the electromagnetic waves.

The bend at the centre of each of the passages **7** and **8** should, of course, be proportioned according to known practice in order to obtain the best voltage standing wave ratio at the midband frequency.

Fig. 5 shows diagrammatically a modification of the switch according to the invention. In this case, a definite clearance of perhaps 0.005 inch is provided between the drum and the inside of the body **1** for the whole length of the drum, and the axial bearings **9** and **10** will then be the real bearings, and may, for example include ball or roller bearings. Leakage through the clearance in an axial direction is prevented by means of two coaxial circular slots **22** and **23** formed between the drum **6** and two coaxial metal discs **24** and **25** of the same diameter as

the drum, by means of two coaxial metal spacing discs **26** and **27** of such smaller diameter than the drum that the radial depth of the circular slots so formed is a quarter wavelength at the midband frequency.

Fig. 6 shows a modification to Fig. 3 to indicate that by increasing the external diameter of the drum, and the internal diameter of the body accordingly, two pairs of slots for suppressing the leakage of the waves may be provided.

The drum **28** is provided with two passages **29** and **30** similar to **7** and **8** of Fig. 3 except that the straight portions are longer. Between the lower open ends of these passages are provided two quarter-wave slots **31**, **32**, similar to **17** (Fig. 3), and arranged to divide the portion of the circumference of the drum between the passages into three equal parts, the diameter of the drum **28** being chosen so that the distance separating each of the slots from the other, and from the neighbouring passage, is a quarter of the midband wavelengths.

Likewise two other similar and similarly arranged quarter-wave slots **33** and **34** are provided between the upper mouths of the passages **29** and **30**.

Fig. 6 also indicates an alternative method of arranging the "click" mechanism. A cylindrical hole **35** parallel to the axis of the drum is provided near the edge for housing a ball and spring (not shown) arranged like **14** and **15** (Fig. 1). These will co-operate with four equally spaced depressions or holes in the top or bottom plate (not shown) of the body (also not shown).

The drum **28** in Fig. 6 can be designed as regards other features in a similar manner to the drum **6** shown in Figs. 3 and 4.

It will be noted from Fig. 3 that leakage may occur round the circumference of the drum from the input to the output end of the same passage **7** or **8**. This may not be of any importance, but it could easily be suppressed if desired, by providing two additional quarter-wave slots (not shown) similar to **17** and **18**, and spaced 90° therefrom.

It should also be pointed out that if a simple "change over" switch is required, the guide section **5** (Fig. 1) and the passage **8** (Fig. 3) might be omitted. Then the switch can be used to connect guide section **3** to section **2** or **4** according to the position of the drum. Leakage into the unconnected guide section will then be prevented by the slots **17** and **18** as already explained. In such a case the angle between the guide sections **2** and **3**, and **2** and **4**, need not be 90°, provided that the single passage **7** is designed accordingly. The slots **17** and **18** should be respectively placed one quarter wave length circumferentially from the open ends of the passages.

Various other connections could evidently be arranged on similar lines, and there could be more than four waveguide sections attached to the body, and more than two passages in the drum. The principle to be adopted is to locate a radial quarter-wave slot in the path of the leakage to be suppressed, such slot being preferably a quarter wave-length circumferentially from the nearest open end of a passage.

While the principles of the invention have been described above in connection with specific embodiments and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What we claim is:

1. An electromagnetic waveguide switch comprising a hollow metal body having a cylindrical cavity therein, at least four waveguide sections arranged symmetrically around the body and communicating with the cavity, a cylindrical metal drum coaxially and rotatably mounted inside the cavity, with a small cylindrical clearance gap between the inner wall of the cavity and the outer wall of the drum, said drum carrying a plurality of separate waveguide passages disposed so that when the drum is rotated to a given position, each passage connects together a corresponding pair of the waveguide sections, and when the drum is rotated to a different position, each passage connects together a different pair of waveguide sections and two diametrically opposite radial quarter-wave slots cut in said drum, the open end of each slot being arranged at equal circumferential distances from an adjacent open end of each passage, and the diameter of the drum being so proportioned that the said circumferential distance is substantially a quarter wavelength

2. A switch according to claim 1 in which the drum comprises two rim portions at opposite ends thereof enclosing therebetween a central portion of diameter slightly smaller than that of the rims, the diameter of the said rims being such as closely to fit the internal diameter of the cavity.

3. A switch according to claim 1 in which the drum and cavity are each of uniform diameter throughout, comprising two circular coaxial quarter-wave slots arranged respectively at each end of the drum for suppressing leakage of electromagnetic waves in an axial direction through the clearance gap.

4. An electromagnetic waveguide switch comprising a hollow metal body having a cylindrical cavity therein, four waveguide sections arranged symmetrically around the body and communicating with a cavity, a metal drum coaxially and rotatably mounted inside the cavity, with a small clearance gap between the inner wall of the cavity and the outer wall of the drum, said drum carrying two separate similar waveguide passages disposed in such manner that when the drum is rotated to a given position each passage connects together a corresponding pair of adjacent waveguide sections, and when the drum is rotated through 90° from the given position each passage connects together a different pair of adjacent waveguide sections, at least two radial quarter wave slots, diametrically opposite to one another, carried by the drum and communicating with the clearance gap, each portion of the clearance gap which directly connects two open ends of different ones of said passageways being an integral number of quarter-wavelengths long, said portions being divided circumferentially into an integral number of quarter wave-length sections by radial quarter-wave slots which open into said portions, whereby the electromagnetic waves are prevented from passing from one passage into the other through the clearance gap.

5. A switch according to claim 4 comprising two diametrically opposite pairs of slots, the open ends of each pair of slots being arranged to divide the circumferential distance between two adjacent open ends of different passages into three equal parts, each of which parts is substantially equal to a quarter wavelength.

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