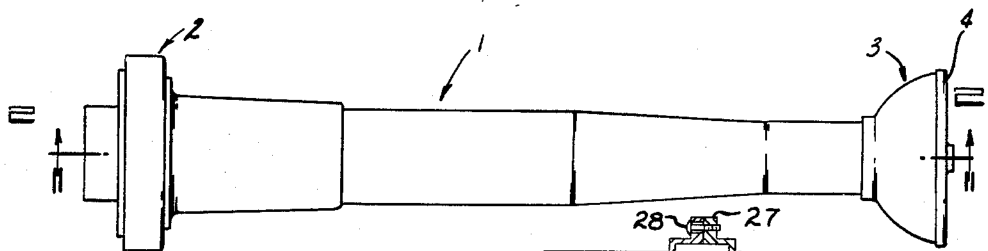
Dec. 25, 1956 L. R. BROWN ET AL 2,775,760

MICRO WAVE ANTENNA FEED

Filed July 28, 1952 2 Sheets-Sheet 1

FIG-1



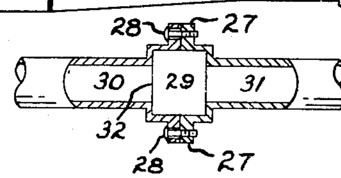


FIG-2 FIG-7

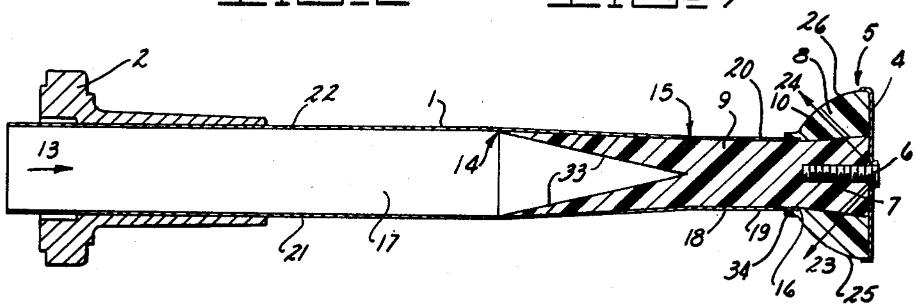


FIG-3

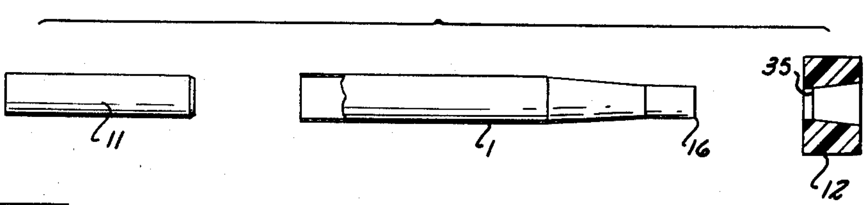


FIG-8

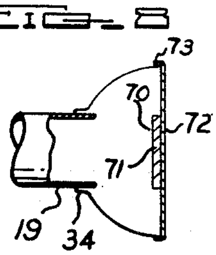


FIG-9

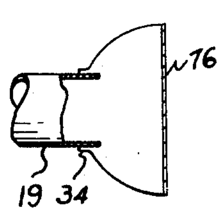


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FIG. 4

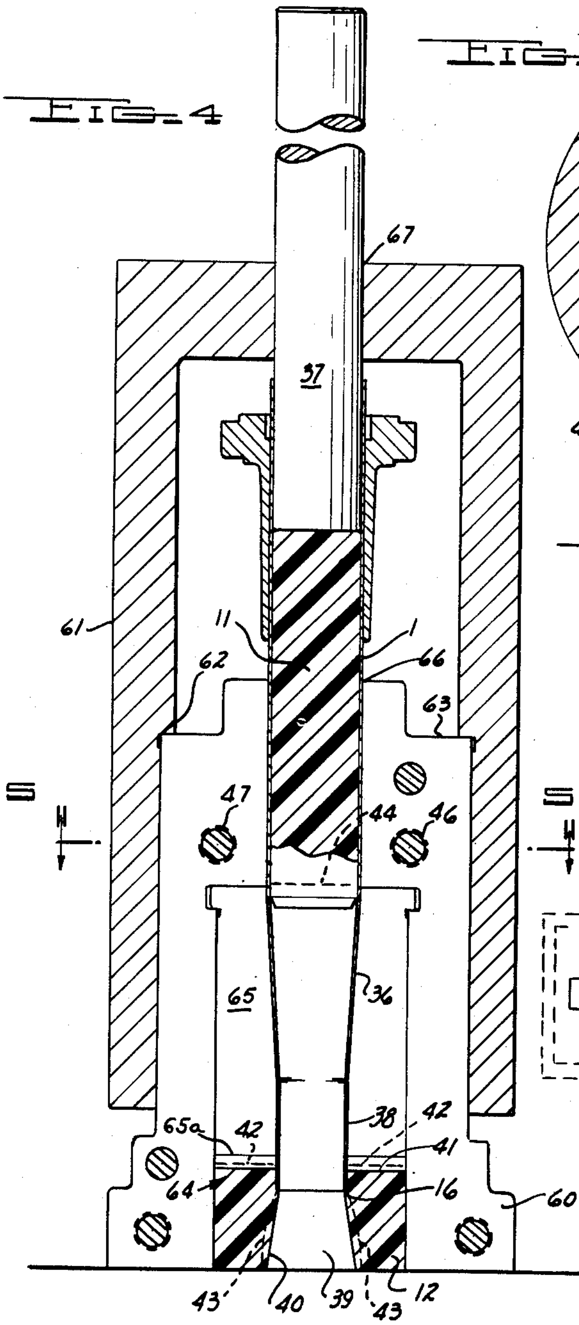


FIG. 5

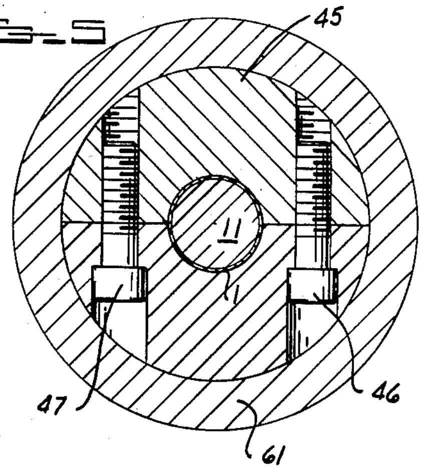


FIG. 10

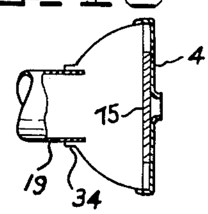
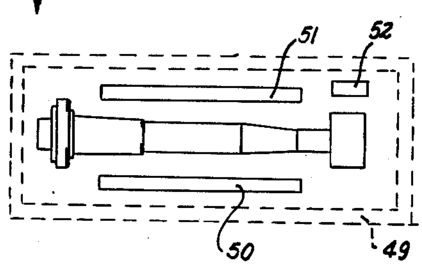


FIG. 6



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MICRO WAVE ANTENNA FEED

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Application July 28, 1952, Serial No. 301,274

4 Claims. (Cl. 343—781)

The present invention relates to a wave-guide and more particularly to a micro-wave radio frequency hollow gas filled wave-guide which, in one of its embodiments, may be utilized as a micro-wave antenna feed. Other applications of the invention will be apparent to those skilled in the art.

In the formation of such micro-wave radio frequency wave-guides, it has been common practice prior to the present invention, to provide a hollow guide body which is filled with a gas under pressure. The present invention in one of its aspects relates to improvements in the formation of the hollow guide body and in another of its aspects relates to the provision of a gas-tight barrier or plug in an open end of said body without introducing electrical anomalies in the system.

Prior to the present invention, it was a common practice to form such wave-guides as hollow bodies which were generally rectilinear in cross section. In many such instances, it was not possible to readily form or machine any tapered portions thereof without creating mechanical irregularities which created conditions which allowed electrical anomalies to be developed in the system. As distinguished from such prior wave-guides, the present invention provides a tubular hollow guide body which is generally circular in cross section and which may be readily drawn or formed to provide any desired radial reduction therein to form a tapered portion without causing structural irregularities which are conducive to the development of electrical anomalies in the system.

Sealing the hollow body portions of previously known wave-guides also has been a serious problem. Gas-tight barriers or plugs previously used frequently required mechanical connections which caused electrical anomalies to develop in the system. In other instances, a barrier or plug having properties which made it satisfactory for sealing pressurized gas in the wave-guide body did not possess the required property of being transparent to the radio frequency waves to be transmitted through the wave-guide. Difficulties also were experienced in the transition areas where the path of the micro-waves through the gaseous medium was changed to a path leading through the gas barrier materials. As distinguished from these prior attempts to solve these problems, the present invention provides a gas barrier or sealing element which is fitted into the wave-guide body without introducing mechanically caused electrical anomalies in the system, the gas barrier or sealing element possessing the desired mechanical and electrical properties to permit postive sealing of the gases in the wave-guide body while being satisfactorily transparent to the radio-frequency waves.

The present invention, therefore, resides in the selection, formation and processing of the respective elements of the micro-wave radio frequency hollow wave-guide so that it possesses both the required electrical and mechanical properties, without creating conditions conducive to the development of electrical anomalies in the system.

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The principal objects of the present invention include the following:

(1) The provision of a hollow radio frequency micro-wave guide having a body conformation and cross sectional contour which permits its ready manufacture within close high precision limits on an efficient mass production basis without creating a mechanical environment conducive to the development of electrical anomalies in the system.

(2) The provision in a micro-wave guide of a gas-tight mechanical barrier or plug which is transparent to the radio frequency waves therein and which may be secured in the wave-guide body and thereafter machined or otherwise formed as determined by the electrical properties desired in the unit.

(3) To provide a micro-wave guide in which the respective elements are designed and coordinated to achieve the combination of optimum mechanical and production advantages with minimum interference with the electrical properties thereof.

(4) To provide a micro-wave guide or duct system in which the passage of high frequency radio energy through the guide and the gas barrier or plug is permitted without excessive energy loss or reflection of the micro-wave energy.

(5) To provide a micro-wave guide or duct system in which a gas pressure plug or barrier which can support a means for tuning certain elements associated with the antenna system of a micro-wave transmitting unit and which permits tuning the system to maintain the standing wave ratio in the micro-wave system within desired limits.

(6) The provision of a gas-tight barrier or plug for a micro-wave guide or duct system which has sufficient mechanical properties to permit the direct mounting thereon of tuning elements and reflector elements, thus eliminating the need for metallic supporting structures which introduce electrical anomalies in the micro-wave guide or duct system.

(7) The provision of a hollow gas-pressurized micro-wave guide or duct which has suitable mechanical and electrical properties to permit it to be employed as a micro-wave antenna feed.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Referring to the drawings:

Fig. 1 is an exterior elevation view of the present invention as embodied in a micro-wave antenna feed head.

Fig. 2 is a longitudinal cross-sectional view taken centrally of Fig. 1 substantially on the section line 2—2 in the direction of the arrows and showing the gas barrier or plug in position.

Fig. 3 is an exploded view of the micro-wave antenna feed head in the stage of construction immediately prior to assembly of the units.

Fig. 4 is a cross-sectional view of one preferred form of press machine element useful in the assembly of the gas plug or barrier in the micro-wave antenna feed head.

Fig. 5 is a cross-sectional view of Fig. 4 in the direction of the arrows and showing a method of supporting the micro-wave antenna element in position while the gas barrier or plug is inserted.

Fig. 6 is a schematic drawing of one preferred form of heat treating enclosure used for heat treating the assembled unit during its construction.

Fig. 7 is a schematic cross-sectional view of a known type of gas pressure barrier or plug in which electrical anomalies are introduced in the system and is here included to assist in visualizing the differences between such a barrier or plug and the barrier or plug of the present invention.

Figs. 8, 9 and 10 are fragmentary views, partially in section and showing modified forms of the head of the antenna feed embodying the present invention.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring to Fig. 1, the present invention is shown as applied to a micro-wave antenna feed head as one preferred embodiment. The feed head comprises a hollow tubular body element **1** constructed of any suitable materials, such as a metallic tube having high electrical conductivity. At **2** is shown a base supporting structure integrally constructed with tubular element **1** and used to support the antenna feed head and micro-wave wave-guide system with respect to the co-working portions of the micro-wave generator (not shown) and the wave-guide system (also not shown).

It is to be understood that uses other than a micro-wave antenna feed head are contemplated. Since the length of the hollow tubular body element **1** may be any practical desired length, a series of such elements may be utilized to form a duct system.

At **3** is shown the exterior surface of the gas barrier and antenna element to be more fully described hereinafter. At **4** is shown a conducting metallic plate having an overlying circumferential flange **5** as shown in Fig. 2 which is secured to the dielectric antenna head element.

In Fig. 2, the unit is shown in cross section. As there shown, a tuning screw **6** is provided which pierces the reflecting plate **4** and engages in threads cut in the gas barrier or plug of the antenna structure at **7**. The gas barrier plug is formed of two initially separate elements indicated at **8** and **9** in Fig. 2. The parts are joined along the boundary indicated at **10** when assembled.

The materials used in forming the element **8** and the element **9** are described in this application as being formed of the same dielectric materials but it is not essential that the dielectric material of **8** be the same as the dielectric material of **9**.

At Fig. 3 is shown a plug **11** of a dielectric plastic material which forms an element of the gas barrier or plug, a tubular micro-wave wave-guide body element **1** and a plastic element of suitable dielectric properties **12** which forms the antenna element **8** when machined to the desired contours as shown in Fig. 2.

For purposes of clarity in describing the present invention, the gas barrier or plug elements in combination with the other elements of the antenna feed head will be described here in two sections as follows:

(1) Functional operation for use as a device providing a gas barrier or plug which is at the same time transparent to micro-wave radio energy, and

(2) The method of constructing the gas barrier or plug to accommodate the requirements of the functional use of the barrier in a micro-wave radio frequency hollow wave-guide system.

Referring to Fig. 2, micro-wave radio energy may be considered as progressing longitudinally through the interior of the tubular element **1** in the direction indicated generally by the arrow **13**. The energy may be considered as progressing down the tube in waves having a transverse mode of vibration and will proceed down the tube **1** until it reaches a discontinuity offered to its flow by any internal change in the geometry of the tube. (The term "geometry" as herein used refers to electrical geometry and does not necessarily include the concept of physical dimensional geometry.) As the wave energy approaches the portion of the tube **14**, all of the energy would not flow uniformly down the tube because of a decreasing radius of the tube beginning at this point. The radius decrease for the tube shown in Fig. 2 extends over the tube length from the point indicated by the numeral **14** to a point indicated by the numeral **15**. During the traversal by the radio frequency energy, of this tapered section of the tube **1**, a portion of the radio energy flowing down the tube in the fashion common to hollow wave-guides will be reflected back toward its source by virtue of the change in electrical geometry. Thus the efficiency of the transmission of energy through the tube **1**, lacking the elements **8** and **9**, would be less than desirable for the reason that energy approaching the exit end of the tube shown at **16** would be reflected back toward the source and would not then radiate through the antenna head **3**. The phrase "constant electrical geometry" best describes the conditions necessary for the radio energy to progress down the tube without suffering an electrical anomaly which will in turn cause a reflection of energy.

Thus if the tube **1** is to be reduced in diameter a mechanism must be introduced in the tapered portion of the tube between the points **14** and **15**, which would re-establish the desired "electrical geometry" of the tube **1** so no reflection of energy would take place at that portion of the tube and the energy could progress forward into the reduced end portion of the tube without suffering energy loss due to reflection. A means for accomplishing this is to change the electrical space constants of the unfilled portion of the tube **1** between the points **14** and **15** so that the velocity of propagation of energy transverse to the tube **1** in the area indicated generally by the numeral **17** is altered in proportion to the radial dimensional alteration occurring between the points **14** and **15** as shown in Fig. 2.

In essence, it is required that the time required for the transverse vibration of energy to effect one complete cycle across the diameter of the tube at **17** must correspond with the time of transverse propagation across the tube in the region of reduced radial dimension between the points **14** and **15**. To accomplish this in the present invention, a material is required that reduces the velocity of propagation to the desired extent. In operation, then, as the wave energy approaches the point **14** and passes it, it is required that the time of propagation across the hollow wave-guide be held constant despite the fact that the transverse wave has a physically shorter distance to travel. This is accomplished by incorporating into the wave-guide section between the points **14** and **15** a portion of the total dielectric gas barrier or plug which is capable of decreasing the velocity of the energy wave as required to effect a constant time of transverse vibration as the wave progresses forward. It will be noted in Fig. 2 that this is accomplished by providing at the point **14** a feather edge of suitable material and increasing the thickness of the edge in proportion to the forward travel of the wave until the entire tube is filled adjacent the point **15**. Beyond the point **15** as for example in the region **18**, the entire tube is filled with the said dielectric material so that the time required for the transverse wave to effect one full cycle from point **19** to point **20** is for all practical considerations identical with the time required for one full transverse vibration from the point **21** to the point **22**. Under these conditions such a wave-guide will provide a constant "electrical geometry" and no reflection of electrical energy in the transition region between the points **14** and **15** will occur.

With the wave proceeding forward, i. e., from left to right as shown in Fig. 2, in the region **18** it is approaching the end of the wave-guide system and is fed into the "head" section of the antenna. The radio energy leaves the wave-guide at the end of the tube shown at **16** and would normally proceed in a forward direction and propagate into free space. Under the circumstance of the present embodiment of the invention it is desired that the radiant energy be reversed in the direction of its travel to the directions generally indicated by the arrows **23** and **24**. It is apparent that the emission of the radio energy from the solid material into free space which occurs at the faces **25** and **26** would introduce an electrical anomaly into the circuit and cause the reflection of energy back down the tubular system. To prevent this action, a metallic tuning element is inserted into the antenna head at **6** and by adjusting the amount of the tuning element that is inserted into the head to an optimum value determined experimentally, it has been found that the energy reflected back into the system may be reduced to an acceptable minimum.

To effect the reflection of the energy which has heretofore proceeded axially down the tubular element **1** and been emitted in the directions indicated by the arrows **23** and **24** it is necessary to incorporate into the antenna head proper a plate **4** formed of a suitable reflecting material. The reflecting material comprises a high conductivity metal against which the radio energy impinges and by reflection mechanisms common to the art is reversed in its direction of travel. Since the wave shape outside of the tube end **16** is degenerating from a flat plane to a spherical configuration, the direction of travel is not directly re-entrant into the tubular wave guide **1** but is in keeping with the normal laws of incidence and reflection which occur for any reflection occuring at a plane surface.

The selection of materials for use as the gas barrier or plug in applications such as has been described is complicated by the requirements that must be met from both the electrical and physical standpoint. Since the velocity propagation constant dicates the extent of physical dimensional change that the designer may incorporate in the wave-guide design, the matter of the velocity of propagation of radio energy through the material is of prime consideration. From the standpoint of the velocity of propagation, the selection of materials is limited to a relatively few dielectric materials such as certain of the silicones or polymers of gaseous tetra-fluoroethylene known commercially as "Teflon."

A second prime consideration is the matter of energy loss as the high frequency radio energy traverses the plastic material. Usually, although not necessarily, the requirement for a proper material in this regard is that it possess an extremely low ohmic conductance and also that its power factor at very high frequencies be low. Usual desirable power factor values are 0.0005 or less. In addition the material must be incapable of absorbing water since experience has shown that the presence of water either in liquid or dissolved form in the dielectric material will produce prohibitively high power factors at these frequencies.

Taking into consideration the foregoing limitations on the selection of a proper material the so called "Silastic" silcone plastics and the polymers of gaseous tetra-fluoroethylene known as "Teflon" plastics satisfy all of the requirements with two exceptions. In the case of the "Silastics," it is difficult to obtain a homogeneous material that is easily machined and which also possesses high physical strength. With regard to the "Teflon" materials, all of the requirements are satisfied with the one exception that "Teflon" has thus far not been made so that it can be made to adhere to a metallic surface. Thus its use in all phases of the problem, both electrical and mechanical, are satisfied with the exception that no adhering connection can be made between the "Teflon" and the inner wall of the wave-guide as shown in Fig. 2.

The necessity for gas barriers of the type that have been described from an electrical standpoint as heretofore described, arises from the usual practice in the art of micro-wave radio wave-guide construction of providing a positive gas pressure in the hollow wave-guide system in order to exclude the entry of moist air or other corrosive atmospheres which are capable of corroding the inner surface of the wave-guide and thereby reducing its conductivity to electrical energy. Usually, the gas is nitrogen under a pressure of the order of 20 pounds per square inch absolute, which, at sea level, provides approximately a five pound per square inch pressure difference between the interior and exterior of the wave-guide system. At extreme altitudes, as when the system is used in aircraft, a theoretical maximum of 20 pounds per square inch difference in pressure exists. This gas pressure thus provides a positive means of excluding unwanted vapors from the wave-guide system. In order to maintain such gas pressures, it is necessary to provide gas barriers or plugs in the wave-guide system which are capable of retaining the gas pressure and which at the same time are relatively transparent to the passage of the radio frequency energy.

The method of providing these gas plugs heretofore has been considerably complicated by the necessity of changing the electrical characteristics of the wave-guide to accommodate the presence of the gas plug.

For example, as shown in Fig. 7, a prior device proposed the use of a flanged coupling as here shown to connect two adjoining wave-guides. The flanges **27** are held compressibly together by clamping screws **28** and form a collar-like cavity in the wave-guide proper. Within the collar-like cavity within the wave-guide proper may be placed a barrier **29** which acts as a stop for gas at **30** under pressure and thereby prevents the loss of gas pressure into the section of the wave-guide shown at **31**. It can be seen that such a gas barrier provides an electrical anomaly which causes serious reflection of the micro-wave radio energy at the joint. Another disadvantage of a gas barrier of the type shown in Fig. 7 is the difficulty encountered with high voltage gradients occurring at the face of the gas barrier at **32**. Since the voltage relationships present in wave-guides of this nature are transverse to the axis of the tube any dielectric boundary occurring in the wave-guide has voltages induced across it commensurate with the amount of power being transmitted down the wave guide and the dimensions of the wave-guide. Consequently, arcing will occur if the voltage gradient is sufficient to ionize the gas within the wave-guide and if the dimensions of the wave-guide dielectric boundary are such to induce high voltage gradients. It can be seen, referring to Fig. 2, that the dielectric boundary occurring at **33** is greatly elongated over that of a common type gas barrier shown in Fig. 7 and the voltage gradient transverse the dielectric boundary is therefore considerably less.

Referring to Fig. 2, it will be noticed that a small projection of the antenna head projects backward along the outside of the wave-guide as shown at **34**. This projection provides a material of high dielectric strength to reduce the voltage gradient present at the exit of the wave-guide at **16**. The small backward projecting collar **34** also effectively insulates the end of the tube against voltage breakdown or ionization of such gases that exist exterior to the wave-guide.

In our experience, we have found that the most desirable plastic material to use for the gas barrier or plug is a polymer of gaseous tetra-fluoroethylene which is commercially known as "Teflon," which term will be used hereinafter to designate said materials. In its raw state, "Teflon" is produced as a solid granular polymer. Under heat and pressure this granular polymer may be press molded into intricate shapes of considerable physical strength and extraordinary chemical resistance. Once the granular polymer has been compressed and cured it may be distorted by the application of pressure and will flow into the confines of a mold but will tend to return to its former shape when the confining action of the mold is removed. We have observed that the rate at which the material returns to its undistorted shape and the magnitude of the restoring forces are a function of temperature. In the present application this characteristic of "Teflon" has been used to adapt it to the particular requirements of the problem of micro-wave wave-guide systems.

Referring to Fig. 3, at **1** is shown the metallic tubular wave-guide prior to fixing to it the mounting bracket **2**. At **11** is shown a cylindrical slug of "Teflon" in position to be forced into the hollow interior of the wave-guide **1**. At **12** is shown in cross section the unmachined shape of the antenna head into which the end **16** of the wave-guide section **1** is forced into the corresponding cavity **35**.

The assembly of the "Teflon" elements and the tube **1** is accomplished preferably as shown in Fig. 4. As here shown, an assembly fixture is provided which consists of a base **60** which extends upwardly into the sleeve **61** which is provided with an internal circumferential shoulder **62** which engages the top edge **63** of the base **60**. The base **60** is provided with a bottom chamber **64** to receive the unmachined "Teflon" antenna head **12**. Directly above the bottom chamber **64**, the internal portion of the base **60** is provided with a supporting die **65** which is internally machined to provide an external support for the end of the tube **1**. The lower boundary of the support die **65** is shown at **65***a*. The internal opening of the supporting die **65** aligns with the cylindrical opening **66** provided in the top portion of the base **60**. The opening **66** is formed to provide an external support for the walls of the tube **1**. The punch **37** is guided through the sleeve **61** and reciprocates through the punch guide opening **67** to enter and be withdrawn from the open end of the tube **1**.

The "Teflon" cylindrical plug **11** is here shown in cross section as it enters the wave-guide element **1** and as it is being forced into the restricted or reduced diameter section of the wave-guide at **36**. The "Teflon" cylindrical plug **11** is forced under great pressure into the reduced diameter section of the wave-guide at **36** by the punch ram shown at **37**. Under the compulsion of the punch ram **37** the "Teflon" cylindrical slug **11** is forced to flow through the reduced diameter portion of the wave-guide at **36**, the cylindrical reduced diameter section of the wave-guide shown at **38**, and into the cavity **39** of the previously prepared somewhat cylindrical section of the unmachined antenna head **12**. It will be noted that the angle of the hole drilled previously through antenna element **12** is not truly cylindrical but is shaped as a truncated cone as shown at **40**. We have found that the desirability of perforating antenna element **12** with a hole whose diameter was not constant increased the retentive forces tending to hold the two pieces of "Teflon" **11** and **12** together after they had been forced into close physical contact under the actuating pressure of the punch ram **37**.

As the punch ram **37** forces the cylindrical "Teflon" plug **11** into the reduced portion of the wave-guide shown at **36** and **38** and out of the end of the wave-guide at **16** into the hollow portion **39** of the unmachined antenna head **12**, it distorts the antenna head **12** so that the boundary **41** rises slightly as shown by the dotted line **42** and also distorts the shape of the truncated cone **40** into a shape approximating those shown by the dotted lines **42** and **43**. When the "Teflon" has been thus forced into the wave-guide as described in the previous paragraphs, and distorted necessarily in order to be forced through the wave-guide and a portion of the slug extending into the hollow portion **39**, the top portion of the "Teflon" slug is at approximately the location shown by the dotted line **44**. The punch ram may then be retracted and the wave-guide with the "Teflon" within it may be removed from the press.

Referring to Fig. 5, the "Teflon" material is forced into the wave-guide as shown at **11**. The wave-guide at **1** in Fig. 5 is surrounded by the die section **45**. The die section is constructed in such a fashion that it may be opened by removing the die bolts **46** and **47** after the encircling case **61** is slipped from around the die **45**.

Because of the persistence of "memory" in the "Teflon" there is a constant tendency for the slugs to return to the initial forms they possessed before the pressure was applied thereto. Therefore, the assembled but unmachined wave-guide and antenna element is then placed in a heating chamber **49** as shown schematically in Fig. 6. The chamber is equipped with heating elements **50** and **51** with a temperature sensitive element **52** for controlling the energy available to heat the chamber. We have found that a curing temperature of approximately 225° F. is satisfactory to erase the "memory" of the materials and hold them in their assembled positions. The temperature is held at this value for approximately one hour, at the end of which time the wave-guide element is removed and allowed to return to room temperature.

When the assembled wave-guide has returned to room temperature, it may be machined into any desired shape. Referring to Fig. 2, the specific embodiment described in this disclosure shows that the "Teflon" insert in the end of the wave-guide has been provided by any suitable means such as a gun drill, with a conical cavity as shown at **33** to facilitate the transmission of energy from the entrant to the exit portion of the wave-guide section described, and the antenna head has been shown machined in a somewhat hemispherical shape as shown at **25**. In addition the machining of the antenna head described in this disclosure provides a threaded hole at **6** into which a threaded tuning slug may be inserted and held in position by the excellent machining abilities of "Teflon." The reflector disc **4** is held in position by the flange **5** rolled over the edge of the hemisphere and by the tuning slug **6**. It may, however, be accomplished in any other suitable manner.

Three modified forms of antenna heads embodying the present invention are shown in Figs. 8, 9 and 10, respectively. They differ from the head previously described in the particular mounting of the reflector cap and the tuning arrangements provided therefor. In Fig. 8, the end surface of the head is machined as indicated by the numeral **70** to provide a shallow recess into which a metallic spacer **71** is mounted. The reflector cap **72** is seated against the end surface of the head and in intimate contact with the metallic spacer **71**. A circumferential flange **73** is crimped over the circumferential edge portion of the head and holds the assembly in position.

In place of machining the head as in Fig. 8, the head shown in Fig. 10 is similar to that shown and described in Figs. 1 and 2 except the reflector cap **4** is spaced from the end of the antenna head by a metallic spacer **75** whose thickness is selected to provide the desired spacing of the reflector cap **4** relative to the end of the antenna head.

The antenna heads of Figs. 8 and 10 are designed primarily to provide a wide band preturned antenna. The head as shown in Figs. 1 and 2 is primarily designed where a narrow band variable tuned antenna is desired. Thus the present invention will provide a reflector cap mounting with either a fixed or variable tuning as may be desired.

In the modification shown in Fig. 9, the antenna head portion is provided with a thin metallic skin or layer **76** which acts as the reflector cap and is adhered to the end surface of the antenna head. When using "Teflon" as the dielectric material, the metallic skin or layer **76** is applied thereto by causing the vapors of boiling metal to condense thereon the process being effected at reduced atmospheric pressures common to the art. This provides a means for effecting a tightly adhering metal skin or layer without mechanical attachments such as the circumferental flanges previously described.

It is to be understood that if desired, the head may have a reflector cap such as shown in Figs. 8 and 10 secured directly to the metallic skin or layer **76** as here shown.

Experience gained in the operation of micro-wave antenna heads and micro-wave gas barriers constructed in this fashion revealed that they satisfactorily and completely sealed the inner gas pressure against escape at the end of the micro-wave wave-guide and also by their physical characteristics serve in every other desirable way for the transmission of radio frequency energy at these frequencies.

The process as described effects a high unit area pressure between the "Teflon" and metallic wave-guide thus effectively providing a seal not requiring the adherence of the "Teflon" to the inner portion of the wave-guide but obtaining a seal by simple pressure action. We have determined by experiment that if an extraordinarily high pressure is to be maintained in the hollow portion of the wave-guide system the inner surface of the wave-guide may be slightly roughened to provide additional shearing forces necessary to force the "Teflon" plug out of its position. Another method of increasing the retentive force involves plating of a suitable metal on the external periphery of the plug by evaporative means. Soldering or similar processes may then be used to effect a firm fastening of the device in place. Under normal operating conditions, however, these precautions are not necessary. Additionally, the conical shape of the "Teflon" slug at **33** in Fig. 2 transmits, by virtue of its shape, the additional pressure of the gas pressure within the wave-guide element in a radial direction thus increasing the unit pressure of the "Teflon" against the inside surface of the wave-guide element. This further decreases the chance of gas seepage in the boundary between the "Teflon" and the metallic wave-guide.

From the foregoing, it is apparent that we have been successful in overcoming the mechanical limitations of "Teflon" by a unique method of construction and processing, thereby making available for the art the excellent electrical and chemical characteristics of "Teflon" for use in the construction of gas barriers, antenna and tuning elements and similar appurtenances for radio micro-wave hollow wave-guides.

Having thus described our invention, we claim:

1. In the process of forming a gas barrier in a hollow micro-wave antenna feed, the novel steps of deforming a fused homogeneous blank of polymerized gaseous tetrafluoroethylene under pressures sufficient to effect its flow into the restricted end of a confining body portion of said feed and thereafter curing it at a temperature of approximately 225° F. for approximately one hour to induce the stable retention of said blank in its constrained shape.

2. In a micro-wave guide having a hollow electrically conductive body, a gas-tight dielectric barrier disposed in the end of said hollow body and projecting therefrom and a dielectric antenna head disposed on the projecting end of said barrier, the improvement consisting of the provision of a portion on said antenna head projecting backwardly along the outside of said hollow electrically conductive body in the region of the high voltage gradient existent at the metallic terminus of the hollow body.

3. In a micro-wave guide having a hollow, electrically conductive body and a dielectric antenna head affixed on one end of said body, the improvement consisting of the provision of a portion on said antenna head projecting backwardly along the outside of said hollow electrically conductive body in the region of the high voltage gradient existent at the metallic terminus of the hollow body.

4. In the process of forming a gas barrier and an antenna head on a hollow micro-wave antenna feed wherein said gas barrier is formed from one blank of dielectric material and said antenna head is formed from a separate blank of dielectric material, the novel steps of supporting a fused homogeneous antenna head blank of polymerized gaseous tetrafluoroethylene adjacent one end of said hollow antenna feed, deforming a fused, homogeneous, gas barrier blank of polymerized gaseous tetra-fluoro-ethylene under pressure sufficient to effect its flow into said hollow wave guide from the opposite end thereof and into mechanical locking engagement with said antenna head blank, curing said blanks at a temperature of approximately 225° F. for approximately one hour to induce the stable retention of said blanks in their constrained shape, and thereafter machining said gas barrier blank and said antenna head blank as desired.

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