

April 17, 1962

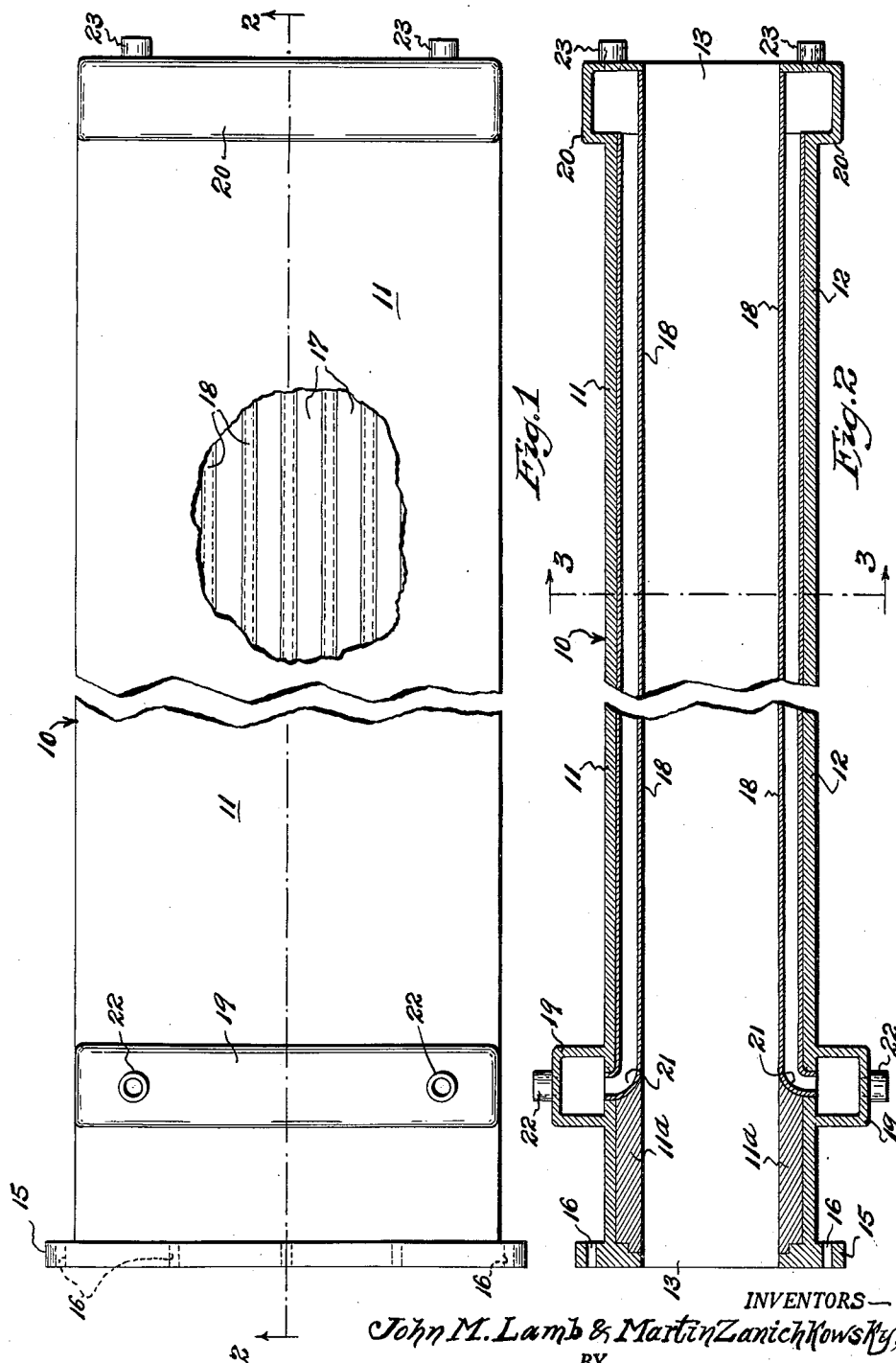
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3,030,592

WAVE GUIDE WITH LIQUID-COOLED HIGH-POWER MATCHED LOAD

Filed Oct. 2, 1959

2 Sheets-Sheet 1



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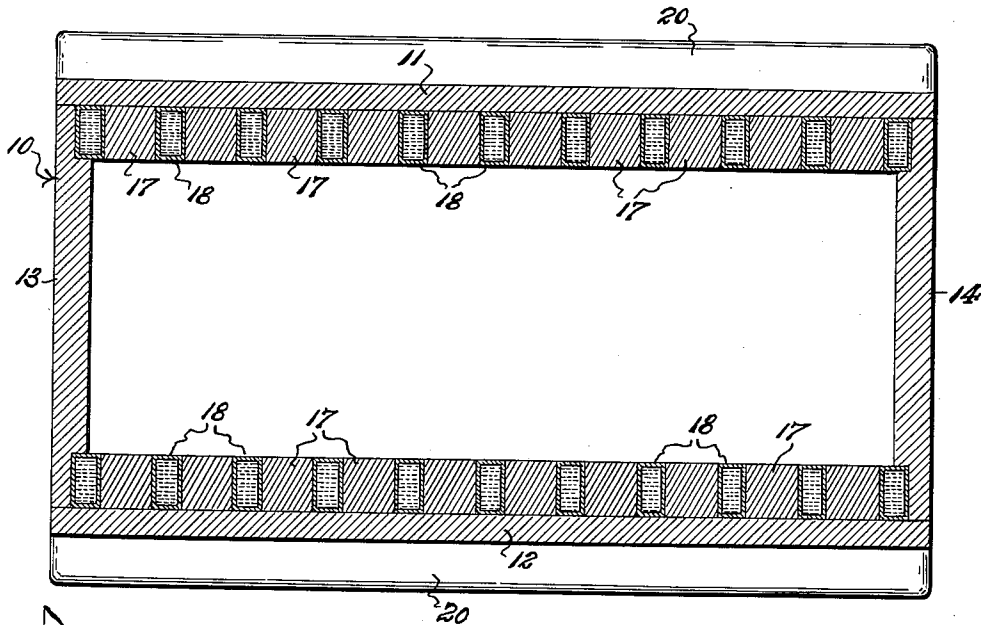


Fig. 3

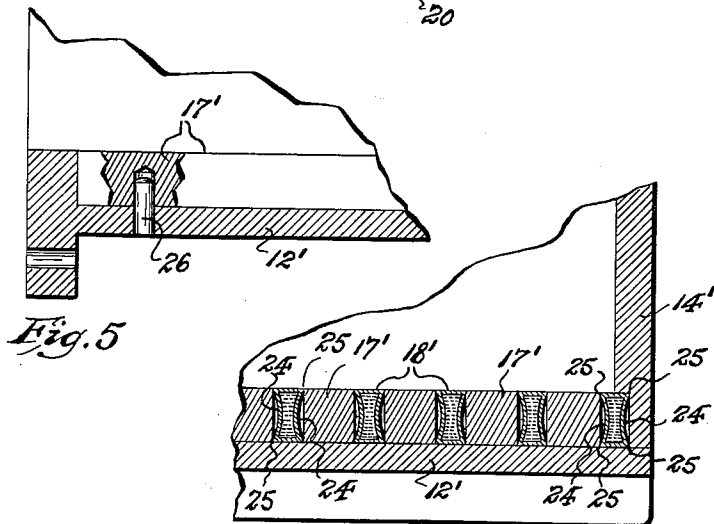


Fig. 5

Fig. 4

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1

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## WAVE GUIDE WITH LIQUID-COOLED HIGH-POWER MATCHED LOAD

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Filed Oct. 2, 1959, Ser. No. 844,098  
4 Claims. (Cl. 333-22)

The invention relates in general to wave guides that are employed to transmit microwaves between various components of radar apparatus, such as between transmitter and antenna, and has particular reference to means incorporated in the construction of a wave guide to provide a high-power matched-impedance termination, or load, to take the full output power of a transmitter tube and thereby replace the transmitting antenna under conditions where radiated power would violate secrecy or would interfere with neighboring receivers, or for testing and tuning purposes.

A serious problem imposed by the use of high-power matched loads in radar wave guides is the necessity for dissipation of the heat that results. This problem had to be met by the introduction of adequate cooling means. A typical prior art example of a means toward this end is a high-power liquid-cooled load, which is a structure designed to absorb electrical energy, specifically ultra high frequency and very high frequency, and transfer this energy to a circulating liquid.

The chronological development of loads in the prior art followed the development of increasing power sources. The first loads were water loads; i.e. the usual transmission line dielectric was replaced with a tapered or wedge-shape fill of water. The heat component of electrical energy was dissipated directly into the water and by conduction to the walls of the transmission line, and thence radiated to the surrounding air. Since this construction was limited to a fixed position, it gave way to a so-called "dry load," which was a wedge of ceramic-like material placed in the end of the transmission line to absorb energy and transfer it to the metal jacket. As the power available was increased, the load was provided with external cooling fins. Then, as the requirements for lower frequency loads increased, the problem of long loads was present. Attempts to reduce the length were made by using wedges in all four walls. However, this design was limited in maximum power handling capacity because the temperature within the guide was raised by the increased radiating surface. Raising the temperature within the guide lowered the dielectric strength of the air and flashover occurred before the thermal capabilities of the load absorbing material was reached. Moreover, the reduction in inner dimensions of the guide by the presence of the wedges compounded this problem.

With the above-enumerated disadvantages of the prior art high-power matched-impedance terminations, or loads, in mind, it is the primary object of the present invention to provide an improved construction in accordance with which the absorbing material is placed in one or more side walls as a lining therefor in a manner to retain full inside dimensions, whereby the power is limited only to the rise in temperature within the guide and to the ability of the load to dissipate the heat externally. This new construction offers a novel way of reducing the inner transmission line temperature and also a way of obtaining efficient heat transfer to a circulating liquid.

Another object of the invention is to provide a cooperative construction of coolant tubes and load bars for the purpose of preventing disruption of the latter through frictional contact upon disproportionate longi-

2

tudinal thermal expansion of the coolant tubes, which have a higher coefficient of linear expansion.

Further objects, advantages and features of the invention will become apparent as the following specific description is read in connection with the accompanying drawings, in which:

FIG. 1 is a top plan view of a wave guide of improved construction, showing the same partly broken away; FIG. 2 is a longitudinal section on line 2-2 of FIG. 1; and FIG. 3 is a transverse vertical section on line 3-3 of FIG. 2 but drawn on an enlarged scale.

FIG. 4 is a fragmentary transverse vertical section similar to that of FIG. 3 showing a modified form of the device; and FIG. 5 is a fragmentary longitudinal sectional view of the same.

Referring now in detail to the drawings, wherein like reference characters designate corresponding parts in the several views, FIGS. 1 to 3, inclusive, show one embodiment of the invention, which includes as its principal structural component the rigid outer wave guide tubing or shell 10. This tubing 10 is represented as being of conventional form wherein the respective top and bottom walls 11 and 12 are substantially twice as wide as the vertical side walls 13 and 14. The respective walls 11-12-13-14 may be made of separate plates of suitable conducting metal, such as aluminum, that are united by seam welding, or the complete tubing 10 may be made in one piece by suitable process, as by extrusion.

To facilitate in the attachment of wave guide tubing 10 to a radar transmitter structure (not shown), an annular flange member 15 of rectangular form corresponding to that of said tubing is affixed in suitable manner, as by welding, to the front end of the latter. By "front end" is meant the end of tubing 10 facing the transmitter as distinguished from the end that faces the radar antenna (not shown) hereinafter termed the "rear end." Flange member 15 projects laterally outward from the respective walls 11-12-13-14 of tubing 10 and is provided with through bolt holes 16 for attachment purposes, or can have alternative means of alignment and fastening.

The high-power matched impedance termination, or load, in accordance with the present invention is constituted by plural bars 17 composed of suitable dielectric, or "lossy," material, such as graphite-cement, that are arranged in longitudinal, relatively spaced parallelism along one or more selected walls of wave guide tubing 10 as components of an interior lining thereof. As shown in the illustrative embodiment of the invention, load bars 17 preferably are applied to both opposed top and bottom walls 11 and 12, respectively, but it is to be understood that any alternative wall selection may be made within the scope of the invention, or that all four walls can also be utilized.

An alternative construction can be a three-sided covering of the cooling tubes performed by applying an additional level of the lossy dielectric material over the top of the load bars (not shown).

Each load bar 17 preferably is substantially square in cross-section with four smooth, flat side faces, but may be of generally rectangular or other shape. The cross-sectional dimensions of all load bars 17 for an interiorly lined wall of tubing 10 should be such that their inner side faces will lie perfectly flush in a longitudinal plane parallel to the inner face of that wall. This co-planar relation is essential to efficient wave transmission.

The cooling means for a wall-lining set of load bars 17 is constituted by plural coolant-conducting tubes 18, of which each is interposed between a pair of adjacent load bars in parallel relation thereto. Each coolant tube 18 is composed of suitable conducting metal, such as aluminum, and is rectangular in cross section but pref-

erably not square. As shown particularly in FIG. 3, the vertical width, or height, of each coolant tube 18 precisely equals that of the load bars 17, whereas the horizontal width of the former preferably is equal to half its vertical width, but this size relationship is arbitrary. As in the case of the load bars 17, the inner narrow faces of coolant tubes 18 should be smooth and flat and arranged in the horizontal plane of the corresponding inner faces of the related load bars so as to be perfectly flush therewith for efficient transmission functioning.

For the supply of coolant liquid, such as water, Prestone, etc., to the coolant tubes 18 of either or all wall linings, respective inlet and outlet manifolds 19 and 20 are located exteriorly on the corresponding wall of wave guide tubing 10 at the front and rear portions, respectively, thereof. Although it is convenient to locate outlet manifold 20 in axial prolongation of the supporting wall of wave guide tubing 10 with the rear ends of the respective coolant tubes 18 in direct axial communication with said manifold, it is necessary to locate inlet manifold 19 in radially spaced relation to the front ends of the said coolant tubes with the tubing wall intervening therebetween. Consequently, the front end portions of coolant tubes 18 are bent outwardly as at 21 and penetrate the tubing wall into communication with inlet manifold 19. In order to preserve the flush continuity of the inner faces of the wave guide tubing lining at the front end thereof, a suitably shaped filler plate 11a is fitted between flange member 15 and the front laterally bent end portions of coolant tubes 18.

For the connection of hose or other conduits leading to and from a source of supply (not shown) of coolant liquid, inlet manifold 19 and outlet manifold 20 are respectively provided with pairs of laterally spaced nipples 22 and 23. Under operating conditions, coolant liquid enters inlet manifold 19 through its substantially terminally located nipples 22—22, whence it is distributed uniformly to the several coolant tubes 18 and conducted therethrough to outlet manifold 20, from which it leaves through nipples 23—23.

Through the effects of heat transfer between load bars 17 and the coolant liquid passing through tubes 18, temperatures in the load-equipped wave guide will be kept within safe limits.

The coolant temperature can also be maintained between desired limits by varying its rate of flow through the system.

Additional advantages of the new wave guide construction may be enumerated as follows: (1) the load can be mounted in any plane; (2) assembly can withstand thermal shock between storage and use by eliminating all longitudinal seams in the water system; (3) the wave guide system can be pressurized while water cooling is in effect; (4) water manifolds can be pre-tested as sub-assemblies prior to assembly with lossy dielectric material and completion of the dummy load; and (5) there will be an increase in power handling capacity by virtue of the cooling inner walls of the wave guide system.

In FIGS. 4 and 5, there is shown a modification of the invention, intended to prevent disruption of the load bars 17' whenever the coolant tubes 18' and adjoining walls of wave guide tubing become more elongated through thermal expansion than do the load bars, due to

the difference in their coefficients of linear expansion. In this instance, the broad side walls of coolant tubes 18', which face the side walls of adjacent load bars 17' are made outwardly concave as at 24 so that only the top and bottom corners 25 of the said tubes will be in frictional contact with said bars. In cooperation with this frictional contact structure, the front ends of all load bars 17' are anchored to the contiguous wall of wave guide tubing 10 by dowel pins 26. As a result of this protective feature, when the high-expansion aluminum coolant tubes 18' expand under the influence of high temperature increases inside the wave guide, the frictional contact between these tubes and the contiguous load bars 17' of low-expansion graphite-cement will be so reduced that the tubes 18' will not stretch and disrupt load bars 17'.

While the invention has been illustrated and described with respect to only two embodiments thereof, it will be understood that it is intended to cover all changes and modifications of the embodiments shown which do not constitute departures from the spirit and scope of the invention.

We claim:

1. A wave guide comprising: an outer shell of rectangular cross section having side walls of conductive metal; an interior lining for at least one side wall of said shell including plural axially extending, laterally spaced load bars of lossy dielectric material and plural axial coolant conducting tubes interposed between respective adjacent load bars, said load bars and coolant conducting tubes being of substantially rectangular cross-section and of equal radial thickness with respect to the wave guide axis and in close lateral abutment, the corresponding inner surfaces being flat and lying in the same transverse plane in a manner to insure efficient wave reflection; an inlet manifold communicatively connected to all coolant tubes at one end of the wave guide; and an outlet manifold communicatively connected to the opposite ends of said coolant tubes.

2. A wave guide as defined in claim 1, wherein the lining is provided for a pair of diametrically opposed side walls of the shell.

3. A wave guide as defined in claim 1, wherein the coolant tubes have outwardly concave side walls for small-area corner-located friction-minimizing contact with adjoining load bars; wherein the coolant tubes are made of a metal having a linear coefficient of expansion greater than that of the load bars; and wherein the load bars are anchored to the wave guide shell at one end only thereof to permit free axial thermal extension of the coolant tubes and wave guide shell.

4. A wave guide as defined in claim 1, wherein the outer shell is open at both ends and the load bars and coolant tubes are substantially coextensive with said shell in uniform heat transfer relation throughout the length thereof.

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