Dec. 24, 1957 D. B. HAAGENSEN 2,817,739

MICROWAVE MATCHING DEVICES

Filed June 29, 1954

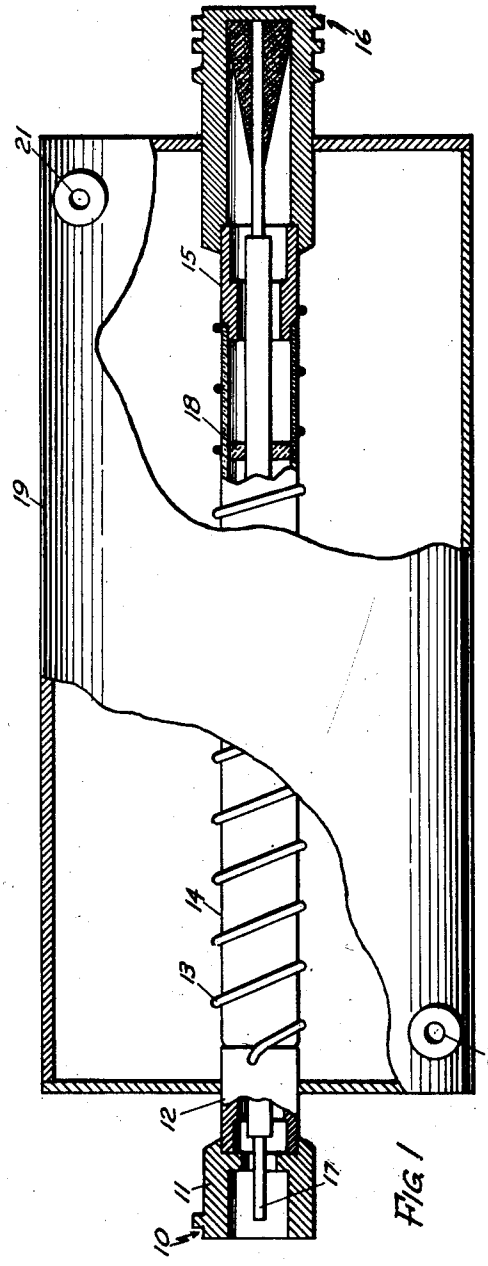


FIG 1

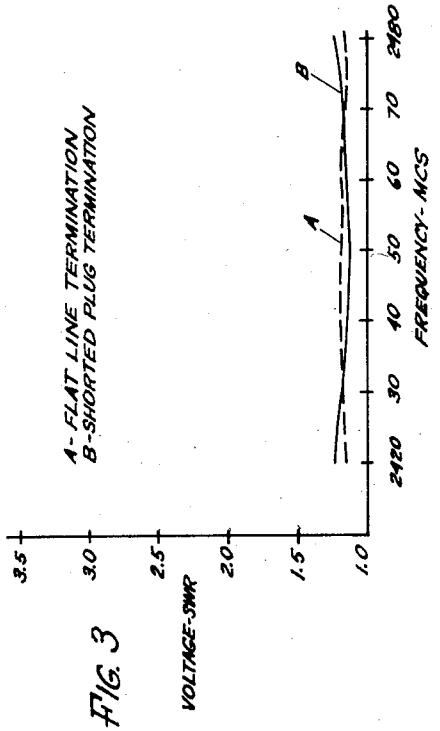


FIG 3

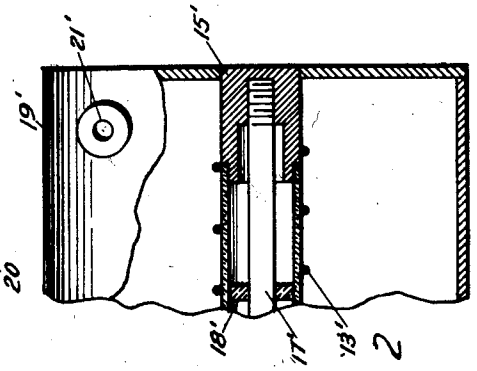


FIG 2

INVENTOR

DUANE B. HAAGENSEN

BY Elmer J. Gorn

ATTORNEY

United States Patent Office 2,817,739 Patented Dec. 24, 1957

2,817,739

MICROWAVE MATCHING DEVICES

Duane B. Haagensen, Wayland, Mass., assignor to Raytheon Manufacturing Company, Waltham, Mass., a corporation of Delaware

Application June 29, 1954, Serial No. 440,100

7 Claims. (Cl. 219—10.51)

This invention relates to a high frequency matching device and particularly to matching microwave energy to an external mass for the purpose of heating said external mass.

This invention discloses a method of using microwave energy for heating purposes. The transfer of energy takes place by radiation between a coil, acting as a coaxial shield, and an external mass which is placed in close proximity to said coil. Since any two turns of said coil, when placed in a traveling wave, have a difference of potential, there is produced a voltage gradient between any two turns of said coil. The external mass being placed in close promixity to this coil is therefore affected by this voltage gradient, resulting in an internal stress in the molecular structure of the external mass. It is this stress produced by the coil that achieves the desired heating effect.

Further objects and advantages of this invention will be apparent as the description progresses, reference being made to the accompanying drawings, in which:

Fig. 1 is a cross-section view of an embodiment of the invention in the form of the microwave matching device for heating liquids;

Fig. 2 is a cross-sectional view of a microwave matching device showing a shorted plug termination; and

Fig. 3 is a graph of the standing wave ratio in a transmission line using the microwave matching device illustrated in Fig. 1 and Fig. 2.

Referring now to Fig. 1, there is shown a wave guide in the form of a coaxial cable **10** in an application for heating liquids and a method for placing said liquids in proximity to the microwave matching device.

The outer conductor **11** of coaxial cable **10** is attached to coupling **12** forming an electrical bond to the outer conductor **11**. Coil **13** is soldered to coupling **12** to continue the electrical connection and is wound on dielectric support **14** for mechanical strength and terminated by a soldered connection to coupling **15**. Dielectric support **14**, which is preferably constructed of glass, is sealed to couplings **12** and **15** for purposes of mechanical strength and also for adapting the matching device to a pressurized system. Termination takes place in a flat line termination device **16**, as shown.

An inner conductor **17** is centrally located in the glass support **14** by means of suitable locating plugs **18**. For purposes of illustration, inner conductor **17** is shown as a continuation of coaxial cable **10**. It is apparent that for wave guide applications, persons skilled in the art could construct a suitable probe and connect said probe to inner conductor **17**, terminating inner conductor **17** in the flat line termination device **16**, as shown.

Fig. 1 illustrates an application for the heating of liquids as a method of further explaining the invention. Casing **19** with a suitable intake **20** and exhause **21**, for the liquid to be heated, is placed around the microwave matching device as indicated. The coaxial cable **10** is then excited by a suitable high frequency generator, thereby causing the inner conductor **17** to conduct the microwave energy. As the microwave energy in the form of a wave moves

along the inner conductor **17**, a voltage is developed across each turn of the coil **13**. Therefore, at any particular time there is a different voltage on each turn which, in turn, develops a voltage gradient between turns. The actual heat transfer is determined by the electrical matching desired which is a function of size of wire, number of turns, and method of winding coil **13**.

Referring now to Fig. 2, there is shown a special application for the microwave matching device using a shorted plug **15¹** instead of coupling **15**. The construction shown in Fig. 2 is similar to that used in Fig. 1, with the exception that shorted plug **15¹** is threaded into inner conductor **17¹** to accomplish the termination. The shorted plug **15¹** is used to illustrate another method of terminating the matching device for special applications. To use the shorted plug **15¹** termination method, there must always be an external mass or load for coil **13¹** to radiate energy into; otherwise, reflected waves may cause damage to the high frequency generator.

Referring now to Fig. 3, there is illustrated a graph showing the absorption of energy in an external load for both a flat line termination curve A as illustrated in Fig. 1 and a shorted plug termination curve B as illustrated in Fig. 2. It will be noted that for both methods of termination there is approximately 99 percent energy absorption by the external load, the result being that, in either case, a relatively constant absorption of the microwave energy takes place. Therefore, it can be seen that regardless of the termination used, the transfer of energy to the external mass is maintained at a high level, thereby preventing high standing waves.

This completes the description of the embodiment of the invention illustrated herein. However, many modifications thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. For example, coaxial cable **10** can be replaced with a wave guide and coil **13** can be constructed of various shapes, sizes and materials, depending on the heating effect desired. For a system having a constantly present load, the flat line terminating device 16 may be substituted by a shorting plug **15¹** as shown in Fig. 2. Accordingly, it is desired that this invention not be limited to the particular details of the embodiment disclosed herein, except as defined by the appended claims.

What is claimed is:

1. A system using microwave energy for heating a liquid mass comprising an energy radiating means, coupling means for connecting a source of microwave energy to said energy radiating means, terminating means for artifically terminating said energy radiating means, and means for maintaining said liquid mass in close proximity to said energy radiating means, said microwave energy directly heating said liquid mass.

2. A system using microwave energy for heating a liquid mass comprising a coil surrounding an energy carrying conductor for radiating said microwave energy into said liquid mass, coupling means for connecting a source of microwave energy to said energy radiating means, terminating means for artificially terminating said energy radiating means, and means for maintaining said liquid mass in close promixity to said energy radiating means, said microwave energy directly heating said liquid mass.

3. A system using microwave energy for heating a liquid mass comprising a coil surrounding an energy carrying conductor for radiating said microwave energy into said liquid mass, a wave guide coupling means for connecting a source of microwave energy to said radiating means, terminating means for artificially terminating said energy radiating means, and means for maintaining said liquid mass in close proximity to said energy radiating means, said microwave energy directly heating said liquid mass.

4. A system using microwave energy for heating a liquid mass comprising a coil surrounding an energy carrying conductor for radiating said microwave energy into said liquid mass, a coaxial cable coupling means comprising a means for connecting the center conductor of said coaxial cable to said energy carrying conductor and the outer conductor of said coaxial cable to said coil, terminating means for artificially terminating said energy radiating means, and means for maintaining said liquid mass in close proximity to said energy radiating means, said microwave energy directly heating said liquid mass.

5. A system using microwave energy for heating a liquid mass comprising a coil mounted on a dielectric support surrounding an energy carrying conductor, said coil being adapted to radiate energy to said external liquid mass, wave guide coupling means for connecting a source of microwave energy to said coil, said coil electrically connected to said wave-guide coupling means, terminating means for artificially terminating said coil, and means for maintaining said liquid mass in close proximity to said energy radiating means, said microwave energy directly heating said liquid mass.

6. A system using microwave energy for heating a liquid mass comprising a coil mounted on a dielectric support surrounding an energy carrying conductor, said coil being adapted to radiate energy to said external mass, wave guide coupling means for connecting a source of microwave energy to said coil, said coil electrically connected to said wave-guide coupling means, terminating means for artificially terminating said coil, and a casing

surrounding said energy radiating means, said casing having openings to receive and exhaust said liquid mass held in close proximity to said energy radiating means, said microwave energy directly heating said liquid mass.

7. A system using microwave energy for heating a liquid mass comprising a coil mounted on a dielectric support surrounding an energy carrying conductor, said coil being adapted to radiate energy to said external liquid mass, wave guide coupling means for connecting a source of microwave energy to said coil, said coil electrically connected to said wave guide coupling means, flat line terminating means for artifically terminating said coil, and a casing surrounding said energy radiating means, said casing having openings to receive and exhaust said liquid mass held in close proximity to said energy radiating means, said microwave energy directly heating said liquid mass.

References Cited in the file of this patent

UNITED STATES PATENTS

2,294,881	Alford	Sept. 8, 1942
2,399,930	Keister	May 7, 1946
2,448,044	Ovrebo	Aug. 31, 1948
2,556,642	Bird	June 12, 1951
2,633,532	Sichak	Mar. 31, 1953
2,718,580	Shirley	Sept. 20, 1955
2,738,406	Zaleski	Mar. 13, 1956
2,752,572	Bird et al.	June 26, 1956