

Aug. 1, 1944.

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2,354,809

TRANSMISSION LINE LOAD FOR HIGH FREQUENCIES

Filed Sept. 18, 1942

Fig. 1.

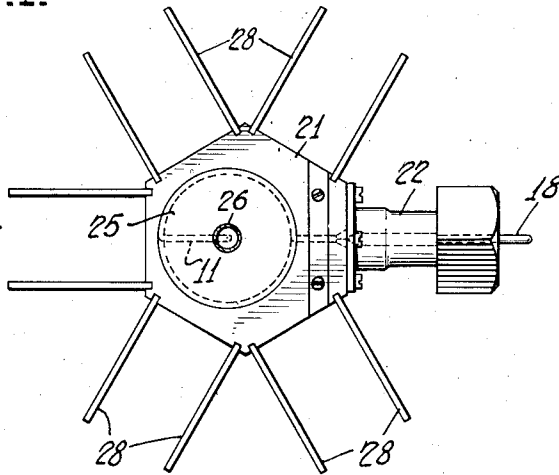


Fig. 2.

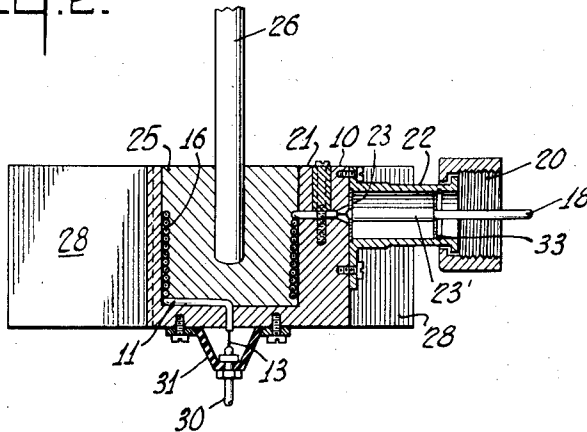
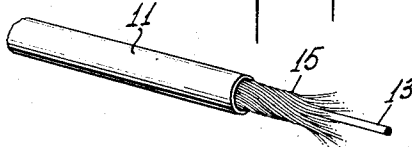


Fig. 3.



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2,354,809

TRANSMISSION LINE LOAD FOR HIGH FREQUENCIES

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Application September 18, 1942, Serial No. 458,801

10 Claims. (Cl. 201-64)

The present invention relates to dummy loads for high frequencies and, particularly, for loads designed to match coaxial transmission lines over a wide band of frequencies.

An object of the present invention is the provision of a high frequency load which is compact in size.

Another object of the present invention is the provision of a high frequency load in which the power dissipated may be readily determined.

A further object of the present invention is to provide a high frequency load which is aperiodic in its characteristics.

Still a further object of the present invention is the provision of a high frequency load which is capable of working over a wide band of frequencies without the necessity of returning the apparatus for each frequency.

A further object of the present invention is the provision of a high frequency load in which a considerable amount of power can be dissipated without materially changing the electrical characteristics.

It is desirable when adjusting transmitters to determine the characteristics of the transmitter when working into a resistive load. A load having the proper resistance will absorb all of the energy applied thereto through a transmission line connected to the transmitter. If the load is so designed as to have an impedance equal to the surge impedance of the transmission line there will be no reflected wave and the transmission line is said to be matched to the load. For high frequencies the surge impedance of low loss transmission lines is substantially resistive. For adjusting the loading of a transmitter, its modulation characteristics, etc., it is essential that the transmitter operate into a transmission line which is properly terminated.

Therefore, in accordance with the principles of the present invention the load which is used may be constructed in the form of a concentric line having a resistance equal to the surge impedance of the transmission line to which it is connected and having the further properties that its input impedance is purely resistive and does not change with frequency. A small concentric line, the inner conductor having a high resistance per unit length, may be used for the load.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which Figure 1 shows one view of a dummy load constructed with the principles of the inven-

tion, while Figure 2 shows a sectional view of the embodiment shown in Figure 1, while Figure 3 is an enlarged view of a part of the embodiment shown in Figures 1 and 2.

Referring, now, to the drawing, reference numeral 10 indicates a coaxial transmission line having an outer sheath 11 and an inner conductor 13. The inner conductor 13 has a high resistance per unit length. In a particular example which was actually used, nichrome wire having a diameter of .004 inch was used for the inner conductor 13. The outer conductor 11 was a copper tube having an inner diameter of .023 inch and an outer diameter of .028 inch. The inner and outer conductors were maintained in their proper coaxial relationship by spun glass insulation 15 which was wrapped around the inner conductor 13 in the form of a close helix of several layers. The surge impedance Z_0 of such a transmission line is given by the following relationship:

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \quad (1)$$

where R is the resistance and L and C the inductance and capacity per unit length and G is the conductance per foot.

The capacity per foot of a transmission line having the dimensions as given above is of the order of 26 $\mu\text{f.}$ per foot while the inductance is about .106 $\mu\text{h.}$ per foot. The resistance per foot is approximately 43 ohms. The above given value of inductance is determined from the relationship

$$\mu\text{h./ft.} = 61 \log \frac{23}{4} \times 10^{-3}$$

At 150 megacycles, neglecting the term G of Equation 1, since its effect is small, the surge impedance

$$Z_0 = \sqrt{\frac{43 + j99.2}{G + j.0255}} = \sqrt{4240 / -23.4} \quad (2)$$

$$= 65 / -11.7 \text{ ohms} \quad (3)$$

The conductance G may be so determined by using proper insulation that the surge impedance is real and substantially constant with a variation in frequency. If desired, the resistance per unit length of the wire 13 may be made smaller so that the surge impedance has a smaller phase angle. At higher frequencies, say 500 mc., the resistive term of the equation for the surge impedance (Equation 1) has less effect and the

phase angle is smaller, as shown by the following example:

$$Z_0 = \sqrt{\frac{43 + j297}{G + j.082}} - \sqrt{3660 / -8.25} \\ = 60.5 / -4.12 \text{ ohms} \quad (4)$$

By the correct selection of wire size and insulation thickness the surge impedance may be made to match any transmitter transmission line. The attenuation is so high on the load line that a short piece of line represents an input impedance that will not vary greatly with a change in frequencies. If the section of coaxial line which constitutes the dummy load is open circuited on the far end of the line the input impedance Z_{in} is given by the following:

$$Z_{in} = Z_0 \left(\frac{\sinh 2\alpha L - j \sin 2\beta L}{\cosh 2\alpha L - \cos 2\beta L} \right) \quad (5)$$

where α is the attenuation constant in nepers per unit length and β is the wavelength constant in radians per unit length. If $Z = R + j\omega L$ and $Y = G + j\omega C$, γ (propagation constant) $= \sqrt{YZ}$, the real part of which is equal to α and the imaginary part equal β ,

$$Z_0 = \sqrt{\frac{Z}{Y}}$$

With the constants given above for the small nichrome concentric line the input impedance varies about $\pm 4\%$, if the line has a length about 6 feet for an operating frequency of 150 mc.

A convenient mechanical arrangement of the load is to wind the coaxial line 10 into a small diameter helix 16, as shown in section in Figure 2. With the successive turns touching, and using such small line dimensions a very compact coil results. For example, the 6 feet of line mentioned above may be wound into a 1 inch diameter helix having about 23 turns. The total height of the coil is then approximately .64 inch. The coiled coaxial line has one end of inner conductor 13 connected to a plug 18 of a coaxial line connector 20, while the casing 21 into which the helix is inserted is connected to the outer shell 22 of the coaxial line connector 20. The conductive portions of connector 20 are maintained in coaxial relationship by means of insulators 23 which, preferably, are little affected by heat. Plug 18 has a portion 23' between insulators 23 of greater diameter than the central holes in the insulators to maintain the insulator spacing and to hold the plug in position against end thrust. One insulator rests against a shoulder in casing 21 while the other is held in place by a split ring 33 in a groove in connector 22. The concentric line 10, coiled within the cavity in casing 21 is embedded in a slug 25 of some metal of high heat conductivity such as tin or zinc. A thermometer 26 is inserted in the metal slug for measuring the temperature rise under load. Casing 21 may further be provided with radiating fins 28 for dissipating the heat developed. In some cases it may be desirable to employ forced air cooling or fluid circulation cooling. The open end of conductor 13 is connected to a terminal 30 which is supported in position on casing 21 by an insulator 31. The calibrating power, which may be direct current or low frequency alternating current, may be applied to the conductor 13 by means of terminal 35 and plug 16.

In use, the temperature rise is measured by means of thermometer 26 and recorded as a func-

tion of time. Then calibrating power is applied to the conductor 13 and the amount of power required to give the same amount of temperature rise is noted. Thus the power dissipation at radio frequencies may be determined.

Due to the attenuation of the radio frequency power along the length of line 10, the power dissipation will not be equally distributed over the length of the line. The first foot of the transmission line will have more power dissipated than the second foot, etc. Therefore, the line must be so arranged that the insulation 15 is not excessively heated nor is the inner conductor 13 burned out due to local overloads. This may be assured by using a lower specific resistance wire for the part nearest the input end; or the length of the line may be made longer and the resistance of the wire lower if it is permissible to make the power dissipation per unit of line length lower.

While I have particularly shown and described several modifications of the present invention, it should be clearly understood that the invention is not limited to these forms alone, but that modifications may be made.

I claim:

1. A high frequency load including a two-conductor line having at least one conductor with a high resistance per unit length for dissipating the energy applied to said line there being no electrically conducting path between said conductors.

2. A high frequency load including a two-conductor line having at least one conductor with a high resistance per unit length for dissipating the energy applied to said line and means for coupling a source of high frequency energy to one end of said line, said line being open at the other end, the resistance of said conductor increasing along the length thereof from said one end.

3. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line there being no electrically conducting path between said conductors.

4. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line and means for coupling a source of high frequency energy to one end of said line, said line being open at the other end, the resistance of said conductor increasing along the length thereof from said one end.

5. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line, said line being coiled into a helix and immersed in a substance of high heat conductivity.

6. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line, said line being coiled into a helix and immersed in a substance of high heat conductivity and means for measuring the heat developed in said load.

7. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line and means for coupling a

source of high frequency energy to one end of said line, the resistance of said conductor increasing along the length thereof from said one end, said line being coiled into a helix and immersed in a substance of high heat conductivity.

8. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line and means for coupling a source of high frequency energy to one end of said line, the resistance of said conductor increasing along the length thereof from said one end, said line being coiled into a helix and immersed in a substance of high heat conductivity and means for measuring the heat developed in said load.

9. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high re-

sistance per unit length for dissipating the energy applied to said line, said line being coiled into a helix and arranged within a casing, said coiled helix being immersed in a substance of high heat conductivity and means associated with said casing for removing therefrom the heat developed in said line.

10. A high frequency load including a coaxial line having an outer sheath and an inner conductor, said inner conductor having a high resistance per unit length for dissipating the energy applied to said line, said line being coiled into a helix and arranged within a casing, said coiled helix being immersed in a substance of high heat conductivity and means associated with said casing for removing therefrom the heat developed in said line, said last mentioned means including cooling fins on said casing.

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