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COAXIAL CABLE

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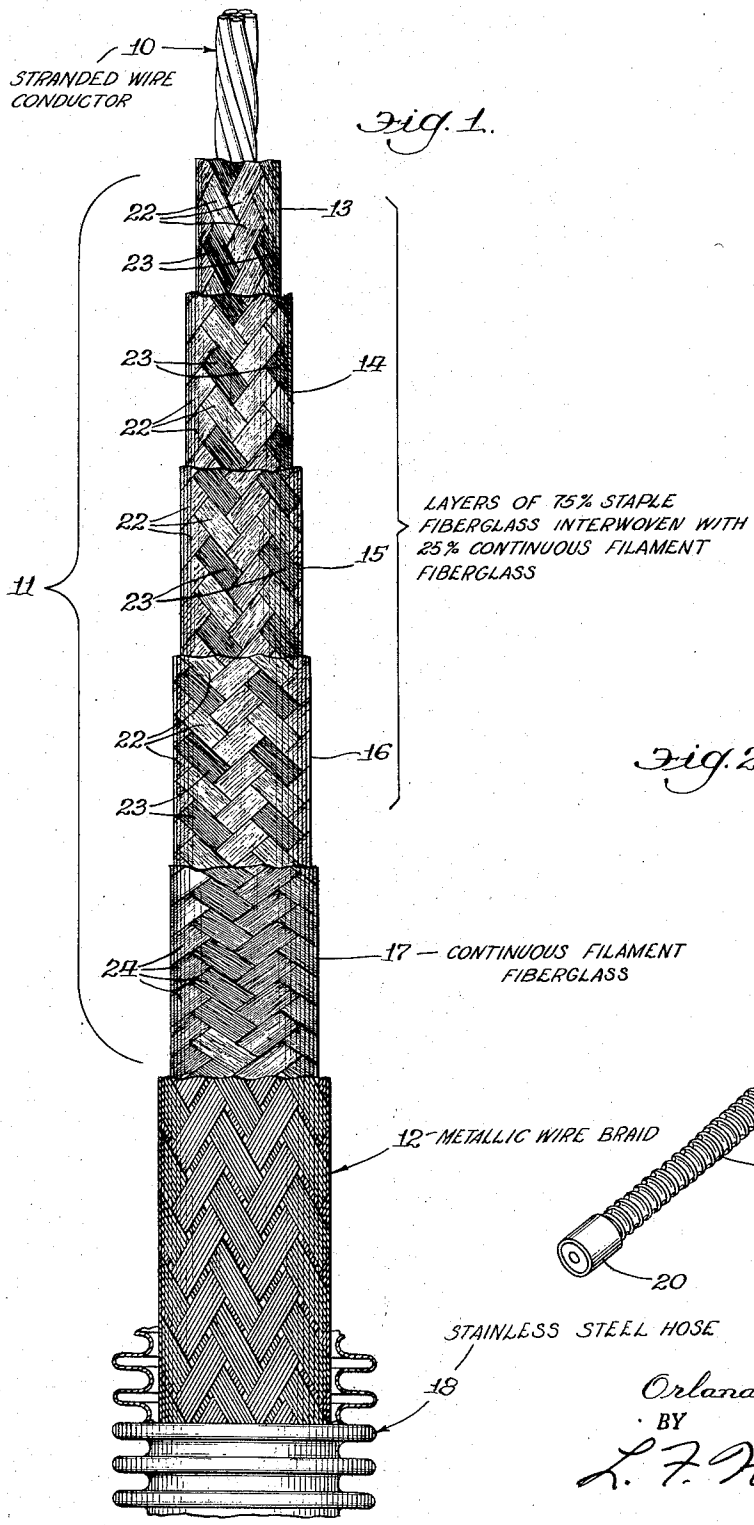


Fig. 1.

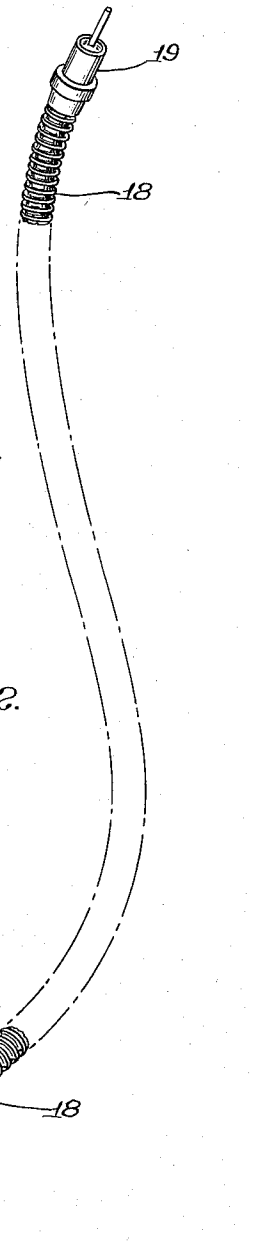


Fig. 2.

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COAXIAL CABLE

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This invention relates to radio frequency transmission lines. More specifically, it relates to an improved type of coaxial cable capable of continuous dependable service at extreme temperatures or under conditions of intense nuclear radiation, yet quite flexible and with a high degree of flexing endurance.

The specific form of cable here disclosed has been demonstrated, by actual test, to be capable of continuous operation at 1000° F. ambient temperature with satisfactory attenuation and VSWR characteristics; with no perceptible deterioration or change in insulation resistance even after 20,000 cycles of bending over a mandrel ten times the diameter of the cable under test. No other cable presently available to the industry accomplishes comparable performance.

It is thus the primary object of the present invention to provide a unique and improved coaxial line capable of continuous operation under ambient temperatures in the 1000° F. range and also cabable of withstanding thousands of cycles of bending without undue deterioration, particularly as to the breakdown voltage or insulation resistance of the cable dielectric. The manner in which the foregoing objects are accomplished will be described in greater detail in connection with the drawing attached to and forming a part of the present specification wherein:

FIGURE 1 is a detail side elevational view of a portion of the transmission system described hereinafter, with the outer jacket and the successive layers of which the line is formed shown cut back to illustrate the details of construction thereof; and

FIGURE 2 is a sketch of a sealed radio frequency transmission system consisting of a length of the unique line shown in FIGURE 1, extending between a pair of connector fittings.

As will be observed from FIGURE 1, the basic parts of the line are the central conductor **10**, which is surrounded by a semi-solid silica dielectric **11** and a tubular outer conductor **12**. The dielectric **11** preferably consists of plural layers **13**, **14**, **15**, **16** and **17** of fiberglass, each in the form of a continuous coaxial sheath around the central conductor. The parts **10** and **11** thus comprise a core closely encased in the outer conductor **12** of braided wire and surrounded by a jacket **18** consisting of a flexible hose of stainless steel. The opposite ends of the stainless steel jacket **18** are brazed to terminal connector fittings **19** and **20**, each of which have dielectric inserts hermetically sealed in the connector shells so that the entire unit functions as a sealed radio frequency transmission system.

In the present preferred commercial embodiment of the cable, which is designed to have a characteristic impedance of 50 ohms, the central conductor **10** consists of seven strands of American wire gauge size **21**, silver covered copper wire. The nominal diameter of each strand of this wire is .0285 inch, whereby the inside conductor has a nominal diameter of .085 inch with a lay of .7 to 1.3 inches. The fiberglass core is made up of a major portion (substantially 55% of the strands) of yarn formed of fiberglass bonded staple sliver **22** (identified in the industry as ESD–E–10), with a minor portion (45%) of continuous filament fiberglass yarn. In the preferred construction, this includes about 18% of the strands **23** of filament identified as ECG–150–4/4 and about 27% of the strands **24** identified as ECG–150 1/10, 8 ends. For

optimum results, the inside layers **13**, **14**, **15** and **16** of the dielectric are each woven with twelve strands **22** of the staple fiberglass, interwoven with four strands **23** of the continuous filament fiberglass to give a major portion of 75% staple fiberglass and 25% continuous filament fiberglass in the innermost layers, while the outer layer **17** is formed of twenty-four strands **24** of continuous filament fiber. This results in five coaxial sheaths of progressively thinner layers of braided dielectric, with the wall thickness of the inside sheath **13** being greatest and the sheaths **14**, **15**, **16** and **17** progressively less.

After the sheaths **13–17** are braided, the line is subjected to high temperature baking, preferably for a period of at least an hour, and at a sustained temperature of at least 900° F. The outer tubular conductor **12** of the line is then applied.

As illustrated, the outer conductor consists of a layer of metallic braid formed of 168 strands of No. 32 American wire gauge silver-plated copper wire, in 24 carriers of seven strands each. The wire of both the inner and outer conductors should preferably be of oxygen-free, high conductivity copper and free of oil or other foreign matter. The line is then drawn through a sizing die and dried overnight at a temperature of 300° or 400° F., after which indivdual lengths of the cable are mechanically pulled through corresponding lengths of stainless steel hose **18**. End connector fittings **19** and **20** are brazed to the hose to close the ends of the sealed system.

As indicated in the introduction to the present disclosure, there are many and varied instances in which extremely high temperature coaxial cables are needed in connection with jet aircraft, guided missiles, rockets and many variations of nuclear installations, yet there has not heretofore been developed a transmission line capable of satisfactorily withstanding such temperatures and still possessing the degree of flexibility and mechanical endurance necessary to withstand repeated cycles of flexing or extreme vibration. It has been learned, however, that coaxial transmission line constructed as described above is superior in high temperature performance to any flexible line heretofore available to the industry and that, when constructed according to the specifications here given, it is quite practical to achieve a high degree of flexibility and flexing endurance greatly exceeding normal requirements, yet to also maintain satisfactory insulation resistance and breakdown voltage characteristics even after continued flexing at these elevated temperatures. This is accomplished, moreover, with a cable construction having very satisfactory characteristics as to voltage standing wave ratio and attenuation. Further, it has been discovered that while neither staple filament fiberglass nor continuous filament fiberglass have shown themselves to be capable of forming a cable dielectric achieving the desired results, yet the combination of these two types of glass fibers, in the proportions and placement here disclosed, succeeds in achieving the desired temperature characteristics without a compromise of electrical, physical or mechanical requirements, and thus results in a cable having properties not obtainable with either fiber alone.

Having thus described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. A high temperature radio frequency transmission system comprising an airtight flexible metallic jacket of corrugated stainless steel hose extending between a pair of terminal connectors and hermetically sealed thereto, together with a flexible coaxial transmission line interconnecting said connectors and housed within said jacket; the coaxial line consisting of a central conductor of stranded flexible wire, an outer tubular conductor of high conductivity woven metallic wire braid, with the central

and outer conductors held in coaxial spaced relation to each other by a semi-solid silica dielectric resistant to temperatures of 1000° F. and resistant to repeated bending; said dielectric consisting of a plurality of continuous sheaths of braided fiberglass yarn surrounding each other and affording plural dielectric layers between the central and outer conductors; with each of the interior sheaths composed substantially 75% of yarn consisting of bonded staple sliver fiberglass and 25% of yarn consisting of continuous filament fiberglass, and the outer sheath consisting of continuous filament fiberglass.

2. A high temperature radio frequency transmission system comprising an airtight flexible jacket extending between a pair of terminal connectors and hermetically sealed thereto; together with a flexible coaxial transmission line interconnecting said connectors and housed within said jacket; the coaxial line consisting of a central conductor of flexible wire and an outer tubular conductor held in coaxial spaced relation to each other by a semi-solid silica dielectric resistant to temperatures of 1000° F. and resistant to repeated bending; said dielectric consisting of braided fiberglass yarn composed substantially 55% of yarn consisting of staple fiberglass and 45% of yarn consisting of filament fiberglass.

3. A flexible high temperature coaxial radio frequency transmission line consisting of a central conductor of stranded flexible wire and an outer tubular conductor of high conductivity woven metallic wire braid, with the central and outer conductors held in coaxial spaced relation to each other by a semi-solid silica dielectric resistant to temperatures of 1000° F. and resistant to repeated bending; said dielectric consisting of a plurality of

continuous sheaths of braided fiberglass yarn surrounding each other and affording plural dielectric layers between the central and outer conductors; with each of the interior sheaths composed substantially 75% of yarn consisting of bonded staple sliver fiberglass and 25% of yarn consisting of continuous filament fiberglass, and the outer sheath consisting of continuous filament fiberglass.

4. A flexible high temperature coaxial radio frequency transmission line consisting of a central conductor of flexible wire and an outer tubular conductor held in coaxial spaced relation to each other by a semi-solid silica dielectric resistant to temperatures of 1000° F. and resistant to repeated bending; said dielectric consisting of a plurality of sheaths of fiberglass yarn surrounding each other and affording plural dielectric layers between the central and outer conductors; with each of the interior sheaths composed substantially 75% of yarn consisting of staple fiberglass and 25% of yarn consisting of filament fiberglass, and the outer sheath consisting of filament fiberglass.

References Cited in the file of this patent

UNITED STATES PATENTS

2,234,560	Keyes	Mar. 11, 1941
2,669,695	Bird	Feb. 16, 1954

FOREIGN PATENTS

34,302	Netherlands	Dec. 15, 1934

OTHER REFERENCES

Wire and Wire Products (publication), November 1946, pages 885–888 and 910.