

April 23, 1968

R. A. KEMPF
COAXIAL CABLES

3,379,824

Filed June 25, 1965

3 Sheets-Sheet 1

FIG. 1

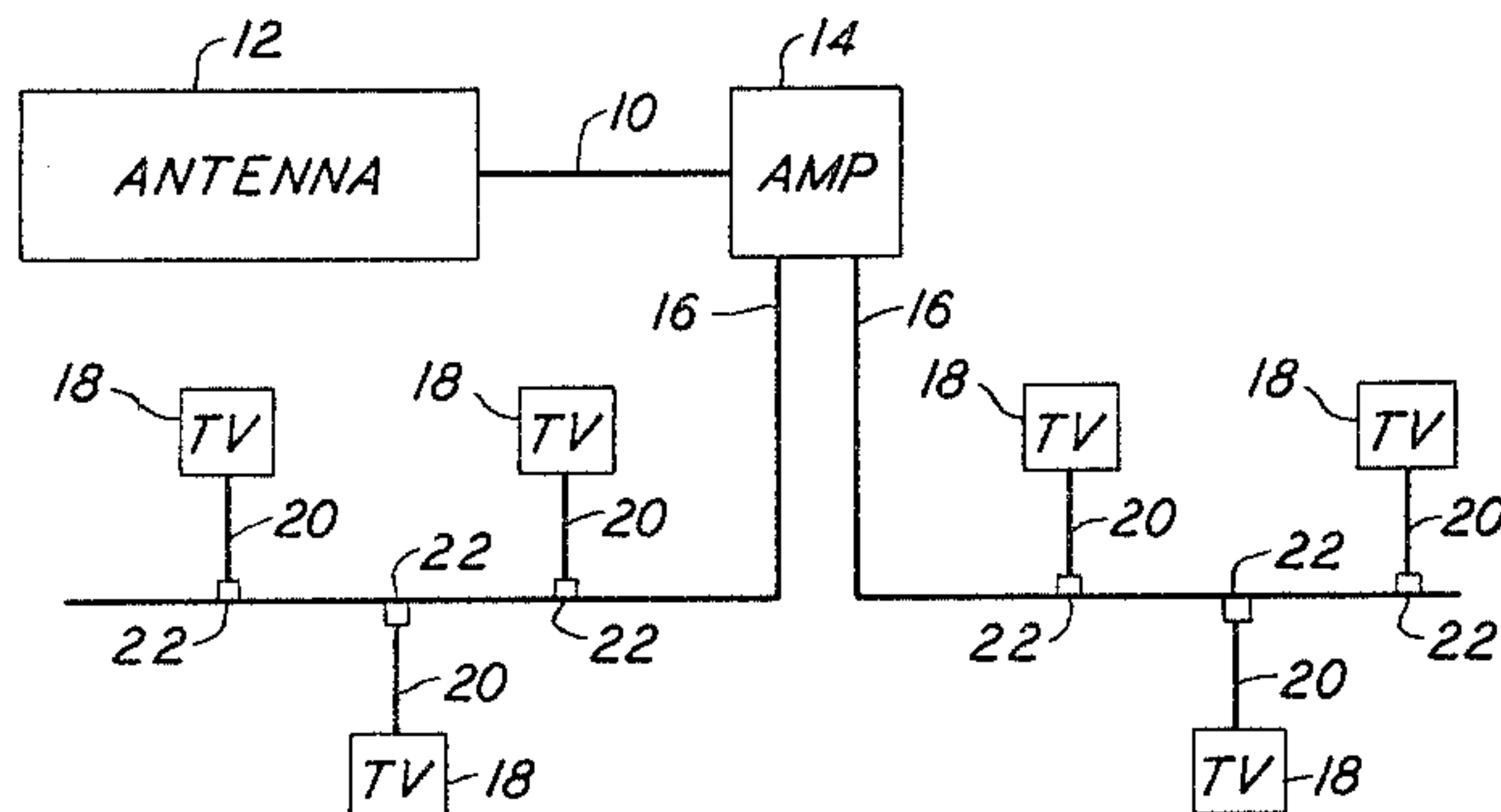


FIG. 2

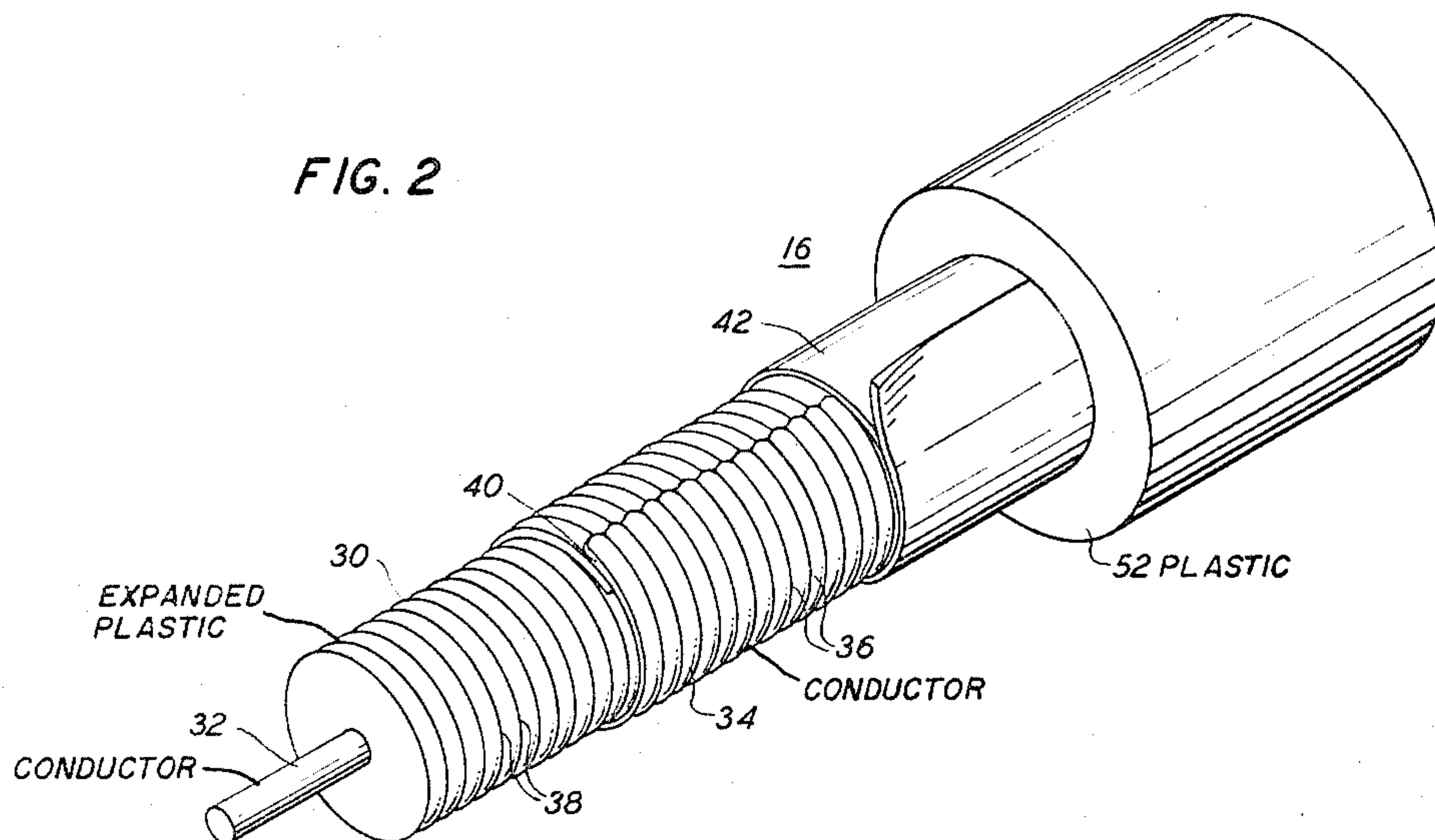
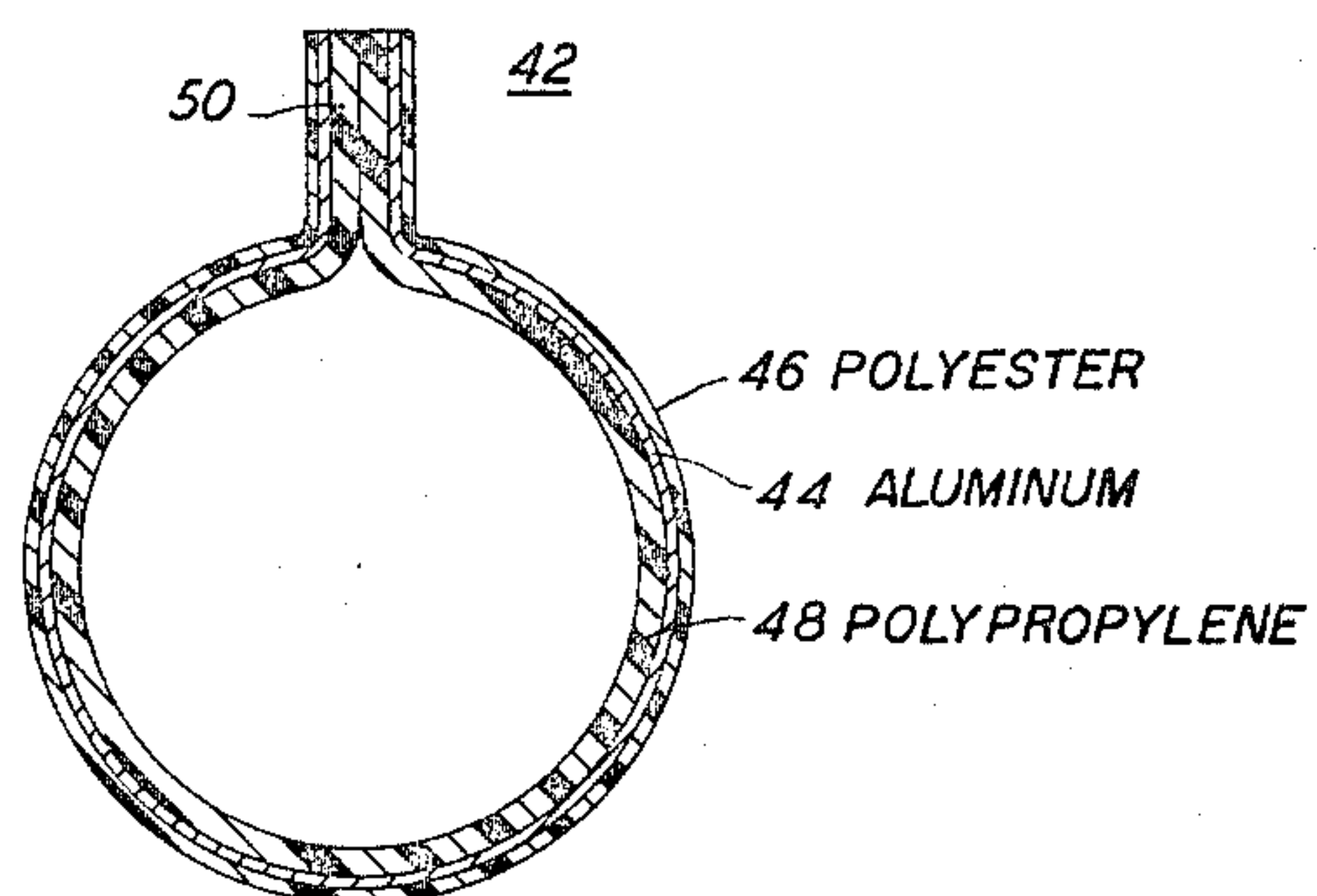


FIG. 3



INVENTOR
R. A. KEMPF
BY *Leo Stanger*
ATTORNEY

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R. A. KEMPF
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3 Sheets-Sheet 2

FIG. 4

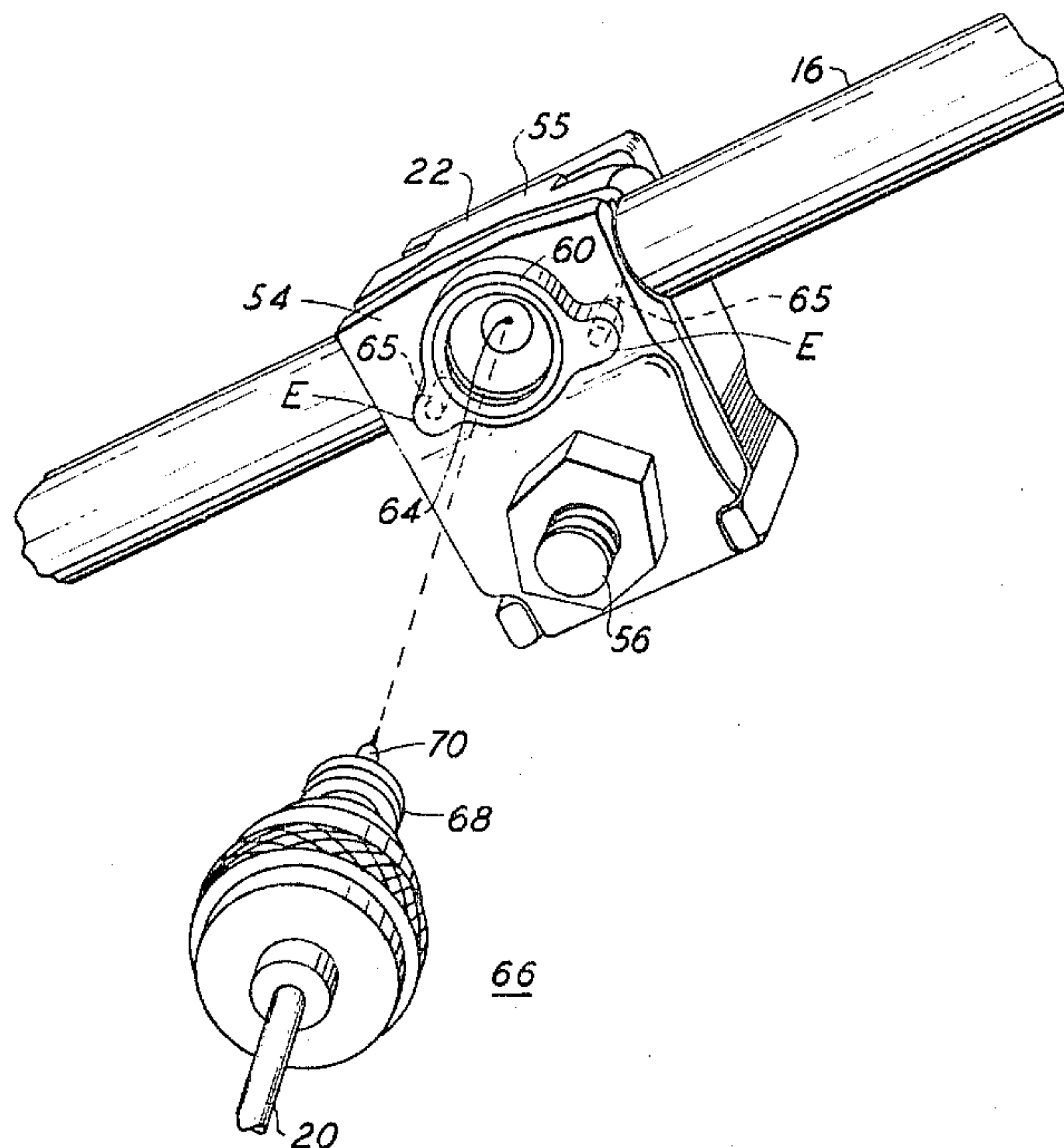
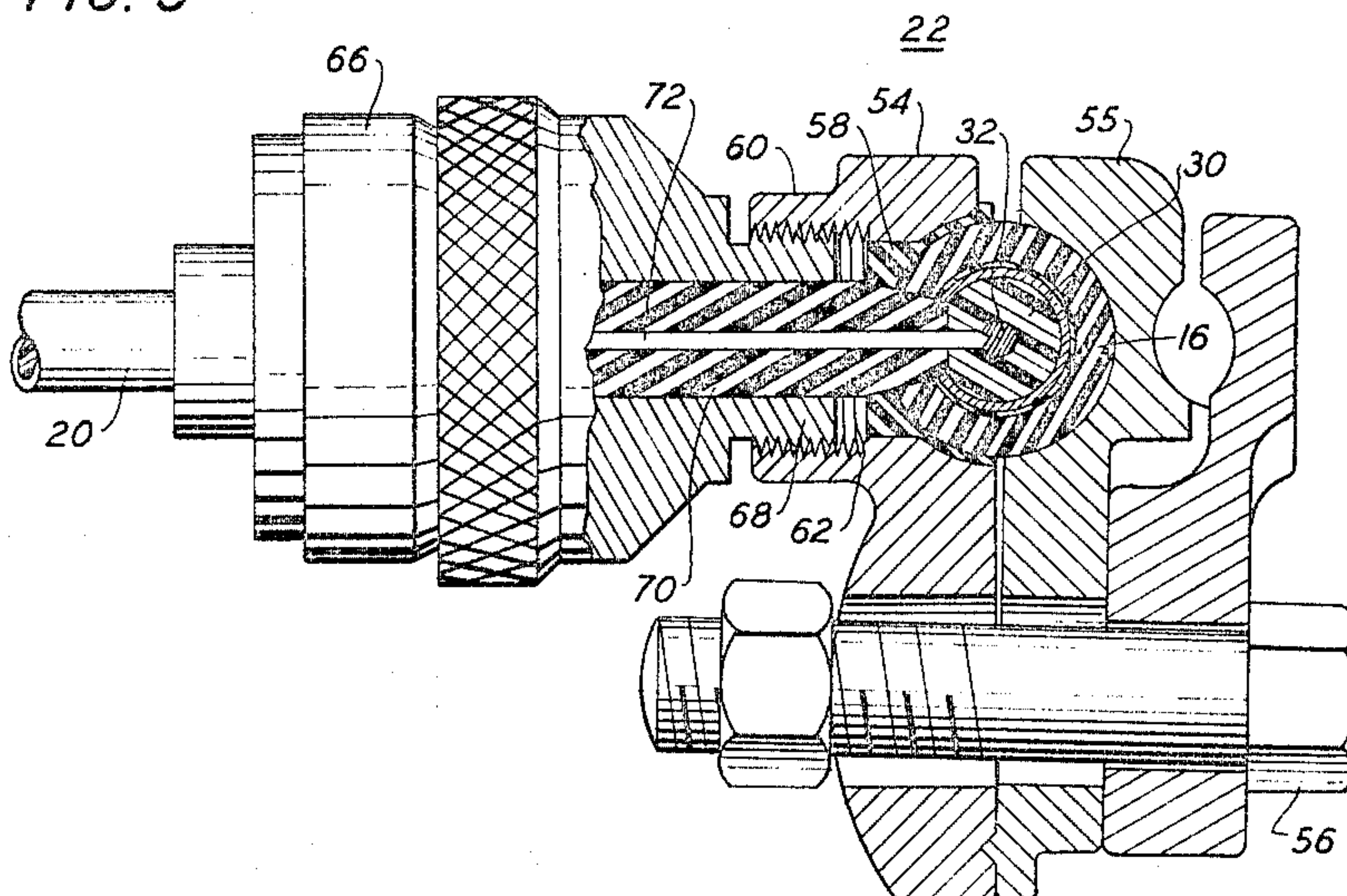


FIG. 5



April 23, 1968

R. A. KEMPF
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3 Sheets-Sheet 3

FIG. 6

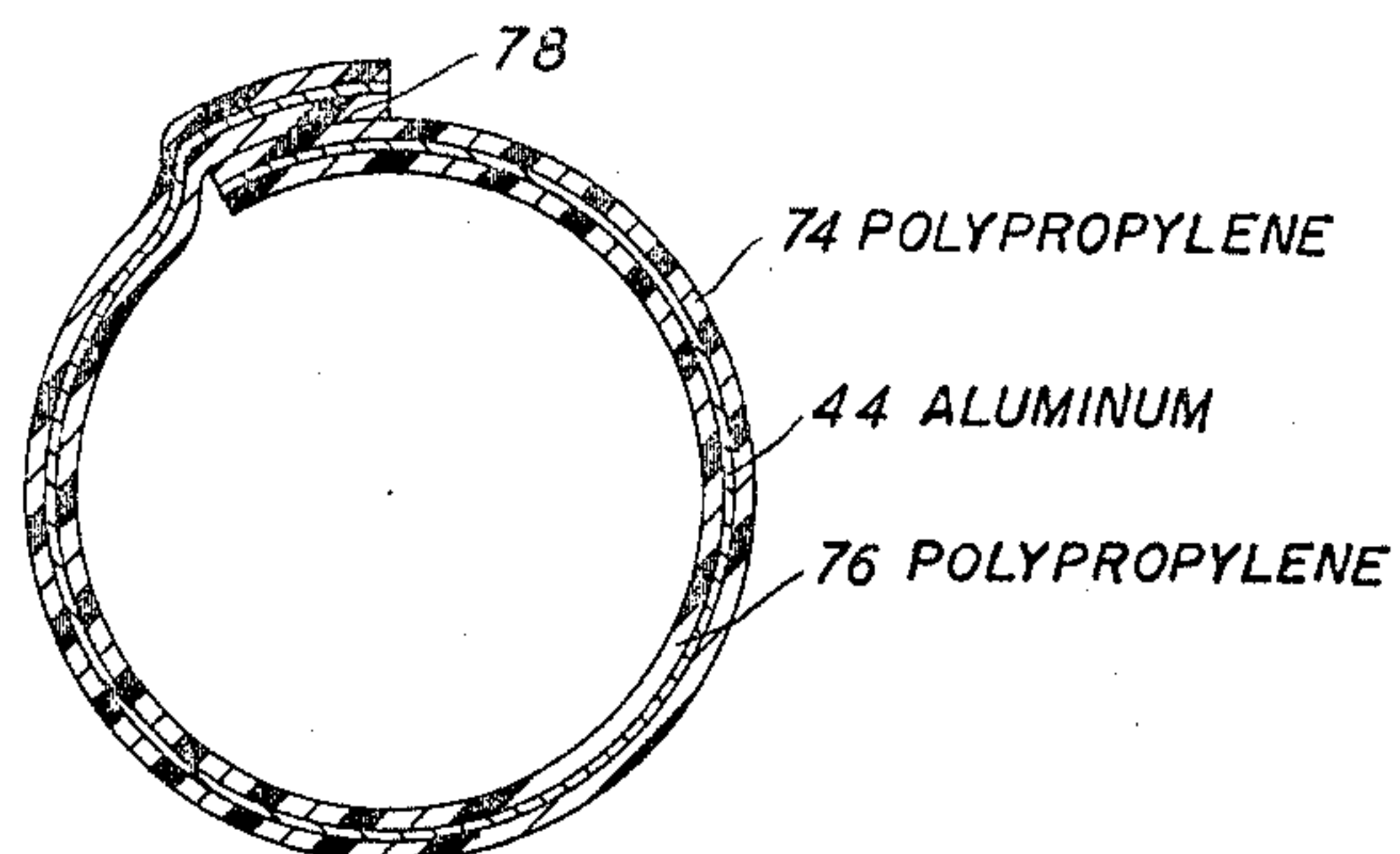


FIG. 7

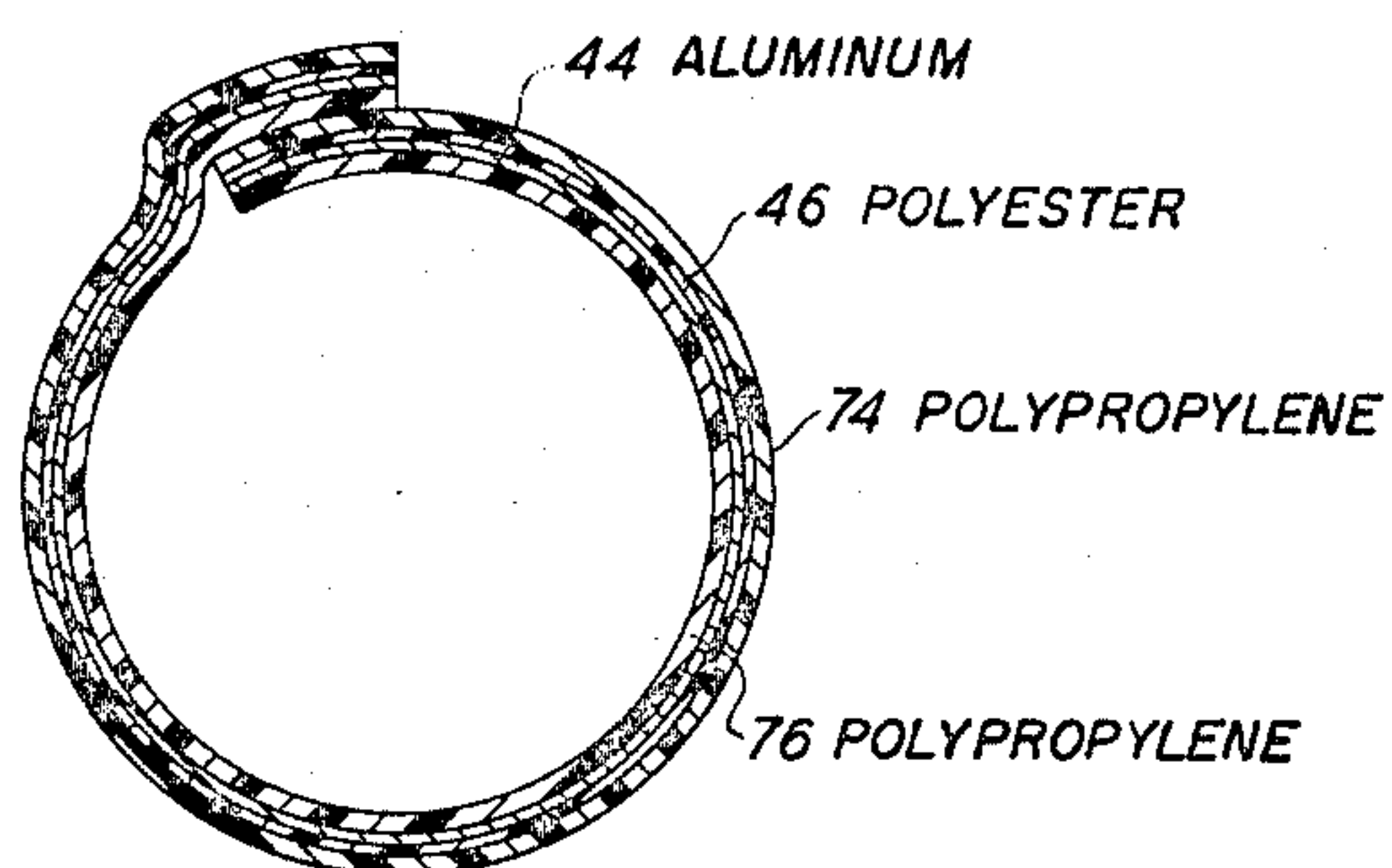
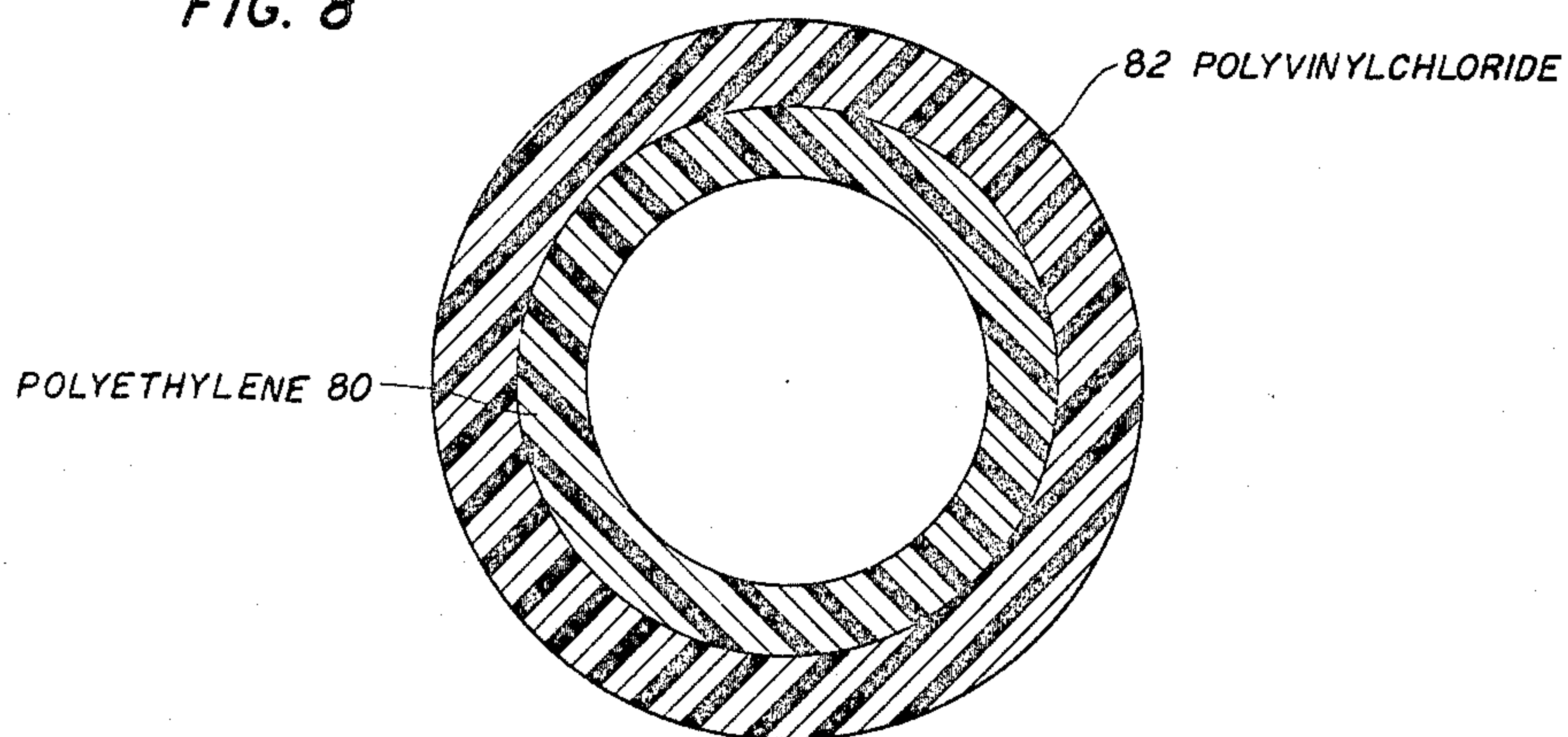


FIG. 8



1

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COAXIAL CABLES

Raymond A. Kempf, Baltimore, Md., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

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10 Claims. (Cl. 174-105)

ABSTRACT OF THE DISCLOSURE

Expanded polyethylene surrounding an inner copper conductor supports an outer corrugated conductor coaxially about the inner conductor at all points along a coaxial cable. The expanded polyethylene insulation is protected from dielectric-disturbing solder fluxes by forming a bare overlapped longitudinal seam on the outer conductor, and is protected from impregnation of ambient vapor by surrounding it with a sheet composed of aluminum foil laminated between an inner polypropylene sheet and an outer Mylar sheet. A seam is formed in the sheath by welding the longitudinal polypropylene edges together as the sheet surrounds the outer conductor.

This invention relates to high-frequency signal distribution systems, and particularly to coaxial cables for distributing high-frequency signals from a source such as a community television antenna to a number of receivers such as television receivers in subscribing homes.

A convenient and inexpensive system for distributing signals from a community antenna includes an amplifier that passes the signals from a feeder cable to a number of distribution cables. So-called "tap-off" couplings along the distribution cables pass signal energy through respective drop-off cables to local subscribers. A tap-off coupling, or tap-off, is an attenuating coupling that embraces a distribution line with a clamp that has prongs penetrating the cable outer conductor. A threaded opening in the clamp exposes a hole bored through the outer jacket and outer conductor. A signal-attenuating connector screwed into the opening of the tap-off coupling connects to a drop-off cable, and with a stud projects through the insulation spacing the outer conductor from the inner conductor and pierces the inner or central conductor. With such a tap-off coupling, drop-off cables can be easily applied and removed. The attenuation in the tap-off coupling maintains the impedance of the distribution cable and prevents excessive energy from feeding through any one drop-off cable.

Such tap-off couplings operate especially well with distribution cables having solid insulation separating the inner from the outer conductor. Unfortunately, they fail with disk-spaced cables. There, because between the spacers the central conductor is substantially unsupported, the projecting prong will tend to displace the central conductor without proper penetration and contact. However, cables with solid insulators do not have the signal propagating properties available in disk-spaced cables, where the air provides a desirable low dielectric constant.

An object of this invention is to improve the propagating characteristics of cables susceptible to connection with tap-off couplings.

Another object of the invention is to accomplish this without subjecting the cable to other degrading effects.

According to a feature of this invention these objects are obtained by surrounding the inner conductor with so-called expanded polyethylene or other expanded plastic, then applying a coaxial outer conductor having a bare overlapped seam, and embracing the outer conductor with a high-frequency shield that comprises a layer of

2

aluminum laminated between two plastic layers which are heat sealed along a seam offset from the seam of the outer conductor. Another feature of the invention involves making the width of the heat seal transverse to the cable axis long compared to the thickness of the plastic separating the aluminum surfaces at the seal.

The expanded plastic is formed by fusing grains of plastic, in the presence of a gas-releasing agent that operates like the leavening in baking of bread. Such insulation constitutes a combination of plastic and air, exhibiting a dielectric constant lower than that of solid plastic and therefore improving the signal propagating properties of the cable which uses it.

By virtue of the invention the inner conductor is not only held securely for tap-off stud penetration by a high performance expanded plastic, but the high performance is maintained because the porous plastic is at once freed from the performance-degrading effects of flux seeping therein from the solder joint which might be used to close the seam of the outer conductor and yet is protected from entry of performance-degrading ambient water vapor by the triple laminate electric shield. All this is accomplished without a solder joint which would stiffen the cable and interfere with bending during installation.

These and other features of the invention are pointed out more particularly in the claims. Other objects and advantages of the invention will become obvious from the following detailed description when read in light of the accompanying drawings, wherein:

FIG. 1 is a schematic diagram of a system embodying features of the invention;

FIG. 2 is a perspective view of a cut-away portion of a distribution cable forming part of FIG. 1 and embodying features of the invention;

FIG. 3 is a cross section of a portion of the cable in FIG. 1;

FIG. 4 is a detailed and exploded perspective of the distribution cable and tap-off in FIG. 1;

FIG. 5 is a section transverse to the cable of FIG. 4; FIGS. 6 and 7 are sections of other embodiments of the cable sheath in FIG. 2; and

FIG. 8 is a section of another embodiment of the cable jacket of FIG. 2.

In FIG. 1 a feeder cable 10 passes signals from a community antenna 12, which may be located on a mountain top, to a central amplifier 14. Two distribution cables 16 each carrying the amplified television signals into the various streets of neighborhood subscribers. The television receivers 18 of local subscribers in the vicinity of the distribution cables 16 hook into the distribution cables through drop-off cables 20 by means of respective tap-off couplings 22. The distribution cables are preferably aerially suspended, but underground cables are not excluded.

FIG. 2 illustrates a cut-away portion of a distribution cable 16 in detail. Here an expanded-polyethylene insulator 30 coaxially surrounds a copper central or inner conductor 32 and spaces the latter from a corrugated coaxial outer conductor 34. The outer conductor 34 has corrugations 36 transverse to the longitudinal axis of the central conductor 32. It is formed from an elongated corrugated ribbon that is folded to tightly embrace the insulator 30, thereby forming some corrugations 38 in the insulation. The conductor 34 closes in a longitudinal overlapping seam 40. The seam 40 comprises the bare overlapped edges of the outer conductor 34 contacting each other.

Surrounding the corrugated unsealed outer conductor 34 is a laminated sheath 42 illustrated in more detail in FIG. 3. Here the thicknesses of the layers are somewhat exaggerated for purposes of illustration. The sheath 42

comprises a one-mil-thick aluminum layer 44 bonded between a one-half-mil-thick layer 46 of polyethylene terephthalate, available commercially as "Mylar" and a five-mil-thick polypropylene layer 48. The sleeve is formed by first producing the three-layer laminate in the shape of a long ribbon and rolling it around the copper outer conductor 34 with the polypropylene layer 48 on the inside, and bending the longitudinal edges of the ribbon upwardly to form a fin 50 about one-quarter-inch wide. The sheath is completed by heat sealing the polypropylene faces in the fin 50 to each other, and the fin 50 is bent over. The sheath 42 mechanically closes the seam on the outer conductor 34. A polyethylene or polyvinyl chloride jacket 52 is extruded about the sheath to form the completed cable 16. According to one manufacturing method the heat of the jacket 52 being extruded onto the sheath 42 seals the polypropylene faces in the fin to each other.

The laminate sheath 42 serves as a moisture barrier to prevent entrance of water vapors into the expanded polyethylene insulation. Such water vapor would eventually degrade the propagation characteristics of the cable.

FIGS. 4 and 5 are details of the distribution cable 16 where it meets one of the tap-off couplings 22. In the coupling 22 two conductive metal clamp members 54 and 55, whose interior surfaces are recessed, are squeezed onto the cable 16 by a bolt 56. An insulating gasket 58 on the clamp member 54 protects the cable 16 from deformation. A boss 60 peripherally surrounding a threaded opening 62 exposes a hole 64 bored transverse to the axis of cable 16 and through the gasket 58, the jacket 52, the sheath 42, and the outer conductor 34. Conductive prongs 65 project inwardly from the clamp member 54 from a location behind the ears E of the boss 60. The project through the gasket 58, the jacket 52, and the sheath 42 until they pierce and conductively connect to the outer conductor 34.

The tap-off coupling 22 also includes a connector 66 whose threaded protrusion 68 conductively engages the outer conductor on the drop-off cable 20 and screws into the threads in the opening 62. Insulation 70 centrally mounts a stud 72 within the protrusion 68. The stud 72 is conductively connected with the inner conductor on the cable 20. When the connector 66 is tightly screwed into the opening 62 in clamp member 54, the stud passes through the insulation 30 in the line 16 until it pierces the inner or central conductor 32. The bulk of the expanded plastic insulator 30 holds the central conductor 32 in the path of the advancing and piercing stud. This assures proper penetration and connection of the stud 72 with central conductor 32. An attenuator (not shown) in the connector 66 reduces the energy passing from the cable 16 to cable 20 and thus maintains the impedance of cable 16.

The attenuator network in the tap-off coupling 22 bridges the distribution cable 16 without excessively disturbing its impedance and also limits radiation of the local oscillator of the television receiver 18 back into the distribution network. The attenuation is selected to provide an appropriate signal level at the television receiver related to the position of the drop along the distribution cable 16 measured from the nearest amplifier 14.

In operation the antenna 12 feeds signals from television transmitters, over a range of frequencies of 54 megacycles to 216 megacycles, through the feeder cable 10 to the amplifier 14. The amplifier 14 is a wide-band amplifier suitable for operating over this broad range of frequencies. It passes the amplified signals through the lines 16 to the tap-off couplings 22. Here connection is made between the outer conductors of cable 16 and cable 20 through the prongs 65 and the protrusion 68. Connection is made between the inner conductors through the stud 72. The drop-off cables 20 carry the broad-band signals to individual television receivers 18.

Connecting a cable 20 from television receiver 18 to

the signal-carrying distribution cable 16 is readily accomplished. It involves first securing the two clamp members 54 of the tap-off coupling 22 to the line 16, and, with a threaded corer (not shown) rotated in the threads of the boss 60, boring a hole in the jacket 52, the sheath 42, and the outer conductor 34. The connection is completed by mounting the connector portion 66 onto the cable 20, and then screwing the connector onto the clamp members 54 until the stud 72 pierces the inner conductor 32.

Assuring accurate interconductor spacing and excellent propagation characteristics, and assuring adequate support of the inner conductor during the penetrating process of the stud 72, while nevertheless preventing degradation of the dielectric constant, are the expanded plastic insulator 30, the seam 40 on the outer conductor 34, and the sheath 42. The expanded plastic of insulator 30 provides the body for centering and supporting the inner conductor 32. Its high air content is responsible for a low dielectric constant that improves the propagation characteristics of the cable. The outer conductor 34 and the sheath 42 together maintain the low dielectric constant of the insulator 30 and maximize its effect. They do this by leaving the edges of seam 40 bare and thus avoid the use of solder to close the seam 40; such a solder joint requires a flux which otherwise seeps into the expanded polyethylene and destroys its desirable characteristics. They complete the partial electrical shielding of energy in the cable with the aluminum layer 44 of the laminate sheath 42. They prevent ingress of vapor to the porous insulation 30, unprotected by a solder seam on the outer conductor 34. The sheath 42 is virtually vapor impenetrable at the aluminum layer 44. The fin 50 presents such vapor with a comparatively long ingress path along the heat seal, which ingress path is also extremely narrow due to the small spacing between the edges of the aluminum layer 44. By folding the fin 50 over along a line offset from the outer edge of seam 40 the sheath 42 forms a shield that helps the outer conductor prevent loss of electrical energy through the seam 40. On the other hand, high-intensity interference in the vicinity of the cable is effectively prevented from entering the cable.

According to another embodiment of the invention the heat seal of the sheath 42 in FIG. 2 is formed by overlapping the sheath edges rather than by folding the fin 50. Such a sheath, suitable to replace the sheath 42 in FIG. 2, is illustrated in FIG. 6. Here again the thicknesses of the layers shown are exaggerated for clarity. The aluminum layer 44 of sheath 42 is sandwiched between two 5-mil-thick polypropylene layers 74 and 76. After the sheath is folded tightly about the outer conductor 34, the longitudinal edges of the sheath are overlapped and the outer sheath 74 welded to the inner sheath 76 to form a heat seal 78. This heat sealing operation can be performed with a special heating source. On the other hand, the heat energy for the heat seal 78 may be obtained from the heat emitted when the jacket 52 is extruded about the sheath 42.

FIG. 7 illustrates another embodiment of the sheath 42 with exaggerated layer thicknesses. Here again the overlapping sheath edges form the heat seal 78 as illustrated in FIG. 6. However, here it is the aluminum layer 44 as well as the Mylar layer 46 that is sandwiched between the two 5-mil-thick polypropylene layers 74 and 76. The Mylar layer is approximately one-half-mil thick. However, it imparts considerable strength to the entire sheath. Mylar has far greater torsional, tear, and tensile strength as compared to polypropylene or similar thicknesses of aluminum. Moreover, the Mylar layer is quite flexible. Here again, the heat seal 78 is formed either by a separate step or as part of the jacket extruding process. In both FIGS. 6 and 7 the heat seal along the overlap extends one-quarter inch in the peripheral direction.

According to the invention the jacket 52 may be either

5

polyethylene or polyvinyl chloride. It may also be composed of two thick layers, that is, an interior layer of polyethylene and an exterior layer of polyvinyl chloride. The polyvinyl chloride imparts heat resistance and fire protection properties to the cable. Structures using polyvinyl chloride cable are suitable in locations where they are subject to high temperatures or fires. FIG. 8 illustrates a compound jacket 52 of polyethylene 80 and polyvinyl chloride 82.

While embodiments of the invention have been described in detail, it will be obvious to those skilled in the art that the invention may be embodied otherwise without departing from its spirit and scope.

What is claimed is:

1. A coaxial cable comprising an inner conductor expanded plastic insulation coaxially surrounding said inner conductor, a coaxial corrugated outer conductor surrounding said inner conductor and forming at its edges overlapping portions parallel to the cable axis, said overlapping portions being bare and directly contactable, a triple layer laminated sheath surrounding said outer conductor and having longitudinal edges, said sheath comprising a metal foil layer as well as an inner plastic layer and an outer plastic layer sandwiching said metal foil layer between them, said sheath forming at its edges a seal having said plastic layers at the edges heat welded together, and an outer protective jacket.

2. A coaxial cable comprising an inner conductor, fluid-susceptible high-air-content means for continuously supporting and insulating said inner conductor along its length and including expanded plastic insulation coaxially surrounding said inner conductor, dry flux-free conductive means coaxially surrounding said inner conductor and said high-air-content means for forming a coaxial electrical return free of liquid contaminants absorbable by said fluid-susceptible means, said conductive means including a coaxial corrugated outer conductor surrounding said inner conductor and forming at its edges overlapping portions parallel to the cable axis, said overlapping portions being bare and directly contactable, partly-metallic liquid-excluding means for limiting the ingress of liquid through said seam and to said fluid-susceptible means, said liquid-excluding means including a triple layer laminated sheath surrounding said outer conductor and having longitudinal edges, said sheath comprising a metal foil layer as well as an inner plastic layer and an outer plastic layer sandwiching said metal foil layer between them, said sheath forming at its edges a longitudinal fin having said inner plastic layers at the edges heat welded together, said fin being folded against the surface of said sheath and an outer insulating jacket.

3. A coaxial cable comprising high-frequency propagating means including an inner conductor and a coaxial corrugated outer conductor surrounding said inner conductor, expanded plastic insulating means surrounding said inner conductor for spacing said outer conductor therefrom, said outer conductor forming a longitudinal seam with bare overlapping portions contactable with each other, high-frequency shielding means for confining high-frequency energy at the seam of said outer conductor, said shielding means including a triple layer laminate surrounding said outer conductor and having longitudinal edges, said sheath comprising a metal foil layer sandwiched between an inner plastic layer and an outer plastic layer, said sheath forming at its edges a seam having said plastic layers heat welded together, and an outer insulating jacket.

4. A coaxial cable comprising high-frequency propagating means including an inner conductor and dry flux-free conducting means coaxially surrounding said inner conductor for forming an electrical return having a fixed electrical relation with the said inner conductor and being free of materials to which expanded plastic materials are susceptible, said conducting means including a coaxial corrugated outer conductor surrounding said inner conduc-

6

tor, fluid-susceptible high-air-content means for continuously supporting and insulating said inner conductor along its length with said outer conductor, expanded plastic insulating means surrounding said inner conductor for spacing said outer conductor therefrom, said outer conductor forming a longitudinal seam with bare overlapping portions contacting each other, vapor barrier means for preventing water vapor from seeping into said expanding plastic insulating means, said barrier means including a triple layer laminate surrounding said outer conductor and forcing said overlapping portions into intimate contact, said sheath comprising a metal foil layer sandwiched between an inner plastic layer and an outer plastic layer, said sheath forming at its edges a longitudinal fin having said inner plastic layers heat welded together, said fin being folded against the surface of said sheath, and an outer insulating jacket.

5. A coaxial cable comprising high-frequency propagating means including an inner conductor and a coaxial corrugated outer conductor surrounding said inner conductor, expanded plastic insulating means surrounding said inner conductor for spacing said outer conductor therefrom, said outer conductor forming a longitudinal seam with bare overlapping portions contactable with each other, vapor barrier means for preventing water vapor from seeping into said expanding plastic insulating means, said barrier means including a triple layer laminate surrounding said outer conductor and forcing said overlapping portions into intimate contact, said sheath comprising a metal foil layer sandwiched between an inner plastic layer and an outer plastic layer, said sheath forming at its edges a seam having said plastic layers heat welded together, and an outer insulating jacket, said seam being wide compared to the thickness of its interior layers.

6. A coaxial cable comprising an inner conductor, expanded plastic insulating coaxially surrounding said inner conductor, a coaxial corrugated outer conductor surrounding said inner conductor and forming at its edges overlapping portions parallel to the cable axis, said overlapping portions being bare and directly contactable, a triple layer laminated sheath surrounding said outer conductor and having longitudinal edges, said sheath comprising a metal foil layer as well as an inner plastic layer and an outer plastic layer sandwiching said metal foil layer between them, said sheath forming at its edges a seal having said plastic layers at the edges overlapped into a seam, said seam being heat welded together, and an outer protective jacket.

7. A cable as in claim 6 wherein said sheath further comprises a fourth layer, said fourth layer being sandwiched adjacent said foil layer and between said inner plastic layer and said outer plastic layer, and wherein said outer and inner plastic layers are composed of a heated fusible plastic material and said fourth layer constitutes a high strength plastic material.

8. A coaxial cable comprising, high-frequency propagating means including an inner conductor and dry flux-free conducting means coaxially surrounding said inner conductor for forming an electrical return having a fixed electrical relation with the said inner conductor and being free of materials to which expanded plastic materials are susceptible, said conducting means including a coaxial corrugated outer conductor surrounding said inner conductor, fluid-susceptible high-air-content means for continuously supporting and insulating said inner conductor along its length with said outer conductor expanded plastic insulating means contacting and coaxially embracing said inner conductor for spacing said outer conductor therefrom, said outer conductor forming a longitudinal seam with bare overlapping portions contactable with each other, vapor barrier means for preventing water vapor from seeping into said expanding plastic insulating means, said barrier means including a triple layer laminate surrounding said outer conductor and forcing said overlapping portions into intimate contact, said sheath

comprising a metal foil layer sandwiched between an inner plastic layer and an outer plastic layer, said sheath forming at its edges a longitudinal fin having said inner plastic layers heat welded together, said fin being folded against the surface of said sheath, and an outer insulating jacket the ratio of the width of said fin to the thickness of said inner plastic layer being greater than 40 to 1.

9. A coaxial cable comprising an inner conductor, fluid-susceptible porous means for continuously supporting and insulating said inner conductor along its length and including expanded plastic insulation coaxially surrounding said inner conductor, dry flux-free conductive means coaxially surrounding said inner conductor and said high-air-content means for forming a coaxial electrical return free of liquid contaminants, absorbable by said fluid-susceptible means and for establishing with said inner conductor and said high-air-content means a coaxial electrical pair separated by a substantially uniform dielectric of only plastic and air, said conductive means including a coaxial corrugated outer conductor surrounding said inner conductor and forming at its edges overlapping portions parallel to the cable axis, said overlapping portions being bare and directly contactable, partly-metallic liquid-excluding means for limiting the ingress of liquid through said seam and to said fluid-susceptible means and for aiding the electrical sheilding properties of said outer conductor, said liquid-excluding means including a triple layer laminated sheath surrounding said outer conductor, said sheath comprising a metal foil layer as well as an inner plastic layer and an outer plastic layer sandwiching said metal foil layer between them, said sheath forming at its edges a longitudinal fin having said inner plastic layers heat welded together, said fin being folded against the surface of said sheath and an outer insulating jacket, said fin having a base where it meets said sheath, said overlapping portions having an outer edge, said base being peripherally offset from said outer edge.

10. A coaxial cable comprising high-frequency propa-

gating means including an inner conductor and a coaxial corrugated outer conductor surrounding said inner conductor, expanded plastic insulating means surrounding said inner conductor for spacing said outer conductor therefrom, said outer conductor forming a longitudinal seam with bare overlapping portions contactable with each other, vapor barrier means for preventing water vapor from seeping into said expanding plastic insulating means, said barrier means including a triple layer laminate contacting and coaxially embracing said outer conductor and forcing said overlapping portions into intimate contact, said sheath comprising a metal foil layer sandwiched between an inner plastic layer and an outer plastic layer, said sheath forming at its edges a longitudinal overlap, said plastic layers at the edges being heat welded together to form a heat seal, said seal being peripherally wide compared to the thickness of said layers, and an outer protective jacket.

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LARAMIE E. ASKIN, *Primary Examiner.*

LEWIS H. MYERS, *Examiner.*

H. HUBERFELD, A. T. GRIMLEY,
Assistant Examiners.