

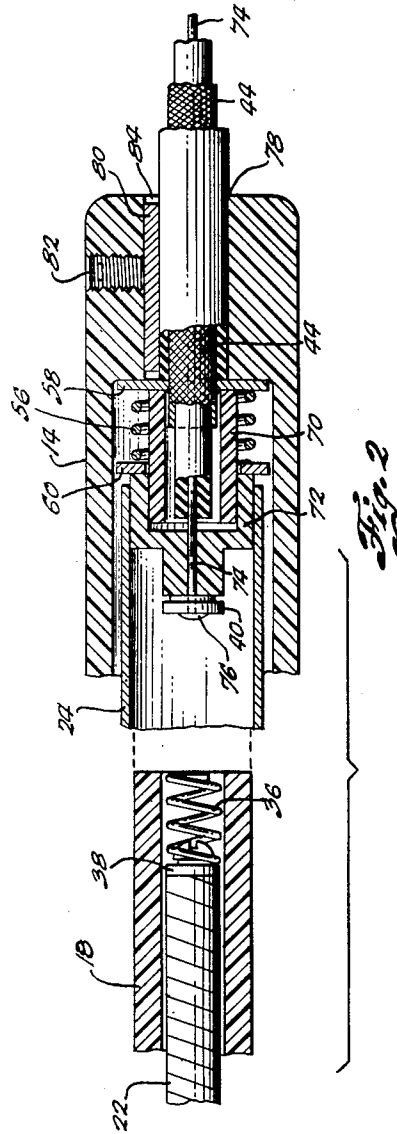
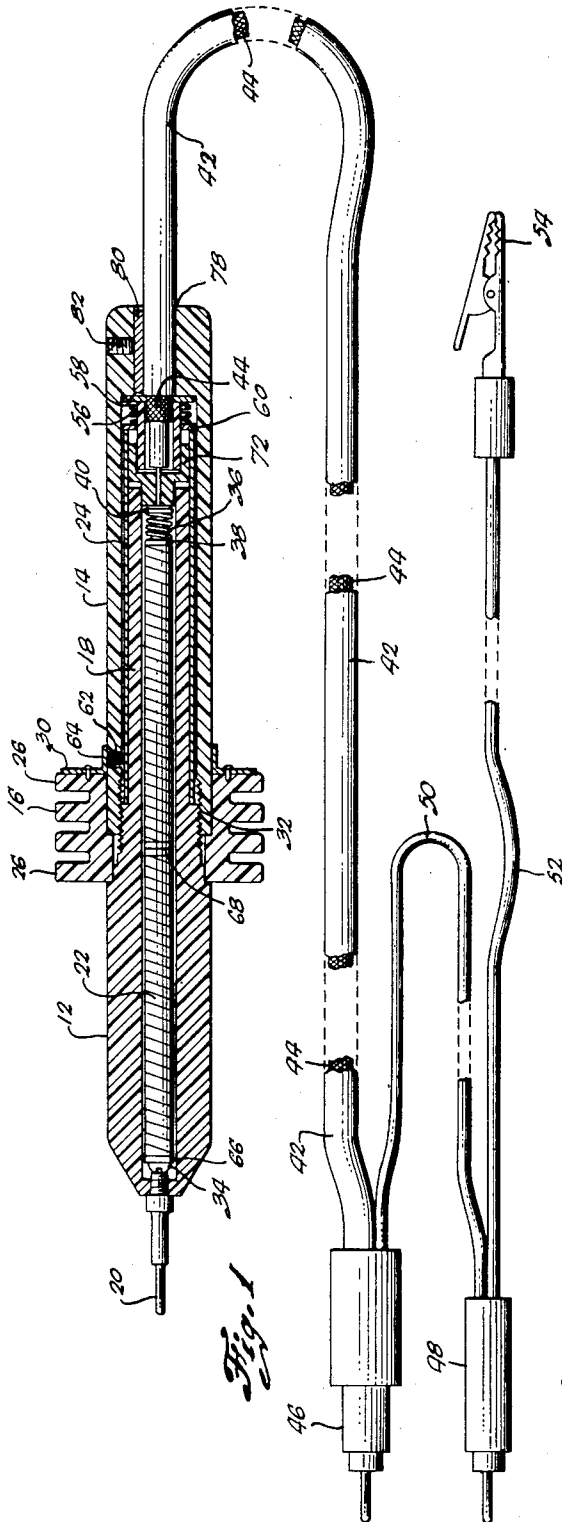
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HIGH-VOLTAGE MULTIPLIER PROBE

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HIGH-VOLTAGE MULTIPLIER PROBE

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This invention relates to probes, and more particularly to high voltage multiplier probes.

Heretofore radio servicemen seldom encountered voltages exceeding 1,000 volts. With the advent of modern television receivers, particularly large screen receivers, the serviceman may face voltages up to 60,000 volts. To cut down the voltage supplied to the test instrument, a so-called "multiplier probe" may be employed. Such probes house a high series resistance which cuts down the voltage supplied to the cable leading from the probe, or, in effect, multiplies the voltage which may be handled by a particular test instrument.

The primary object of the present invention is to generally improve such probes, with respect to safety, convenience and range.

A more specific object is to provide a probe which will safely house a very large range multiplier, or, in practical form, a very long resistance cartridge. For this purpose the probe includes an insulation head as well as an insulation handle, and the cartridge is housed in both the head and the handle. The head is made of a particularly good high voltage insulation, preferably polystyrene, while the handle is preferably made of an ordinary synthetic resin, such as Bakelite or equivalent. In accordance with a feature of the invention, the handle is further protected against the high voltage on the cartridge by providing the insulation head with a rearwardly extending insulation sleeve which is received within the insulation handle. In accordance with a still further feature of the invention, the handle is also protected by a flashover shield, this being a grounded metal tube disposed concentrically around the insulation sleeve within the handle.

The probe has a barrier between the handle and the head. To increase the leakage path, the barrier is preferably made large in dimension both diametrically and axially, and is provided with a considerable number of deep fins or flutes. Such a large barrier might interfere with convenient use of the probe in the small space available in a modern, compact chassis, but in accordance with our invention the insulation head is made relatively long, thus bringing the barrier so far back from the tip of the probe that it does not interfere with convenient manipulation.

In accordance with still another feature and object of the invention, the probe is provided with a leakage guard to take care of the possibility of high voltage leaking along the head and around the barrier should the operator carelessly permit the probe to accumulate moisture or conductive foreign matter. The leakage guard is a metal disc disposed on the rear face of the barrier adjacent the handle, the said guard being connected to ground.

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In accordance with further features of the invention, a shielded cable is employed with the probe, and the shielding of the cable is itself used as a ground connection. The cartridge is readily removable and replaceable, no soldered connections being needed. Instead the cartridge is received between the probe tip at one end and a center contact connected to the cable at the other end, with a compression spring therebetween. The insulation head and handle are preferably assembled by means of a threaded connection, so that when separated the cartridge is readily removed and replaced. Further objects of the invention center about the provision of convenient ground connections from the shield and guard to the shielding of the cable, and for this purpose another and independent compression spring is provided for yieldable connection between the shielding of the cable and one end of the flashover shield. Still another compression spring provides a ground connection between the leakage guard and the flashover shield, and thence to the cable shield.

To accomplish the foregoing objects, and such other objects as may hereinafter appear, our invention resides in the high voltage multiplier probe elements and their relation one to another as are hereinafter more particularly described in the following specification. The specification is accompanied by a drawing in which:

Fig. 1 is a partially sectioned view showing a probe embodying features of our invention; and

Fig. 2 is a fragmentary section drawn to enlarged scale and explanatory of some of the features of the probe, the parts being shown partially separated, as when assembling the head and cartridge with the handle, or disassembling the same.

Referring to the drawing, and more particularly to Fig. 1, the probe comprises a head 12 made of a high voltage insulation, preferably polystyrene, and a handle 14 made of a standard insulation, preferably Bakelite or equivalent synthetic resin. An insulation barrier 16 is disposed between the head 12 and the handle 14. The head 12 has a sleeve 18 extending rearwardly therefrom, this sleeve preferably being reduced in diameter and received within the handle 14. The forward end of the probe terminates in a rounded metal tip 20. This is connected to a series resistor cartridge 22, the latter being received and protectively housed within the sleeve 18 and preferably also within the head 12, as here shown.

A highly conductive cylindrical metal flashover shield 24 is disposed between the sleeve 18 and the handle 14. In the present case this is a piece of brass tubing having a diameter intermediate that of the sleeve and the handle, and disposed in concentric relation therewith. The

shield 24 is grounded, so that even in the unlikely event of an arc or flashover of high potential from the resistance cartridge through the sleeve 18, the potential will be grounded harmlessly, without endangering an operator holding the handle 14.

The barrier 16 is unusually large in dimension. It is relatively large both in diameter and in axial length, and is provided with a number of deeply cut fins 26. The polystyrene head 12 is preferably molded and highly polished, and in itself provides a long leakage path from the tip 20. The barrier 16 is also preferably molded out of Bakelite or equivalent synthetic resin, the said material taking a very high polish from the mold, and it is evident that the barrier adds greatly to the length of the leakage path from the tip 20. The insulation head 12 beyond the barrier is substantial in length, that is, the barrier is set far back from the tip 20, and it is therefore entirely feasible to use the large barrier shown without losing the necessary convenience of manipulation in close quarters.

As further insurance against leakage around the barrier, if the operator, contrary to proper practice, should permit the surface of the probe to become moist or dirty, we provide an additional leakage guard 30. The guard 30 is a disc of metal disposed on the inside face of the barrier 16 and connected to ground. Thus any potential leaking around the barrier will reach the guard 30 and be safely grounded without injury to an operator holding the handle 14.

The resistance cartridge 22 is readily removable and replaceable if damaged or if it be desired to change the multiplication ratio of the probe. The head 12 and the handle 14 are detachably assembled by means of a screw connection shown at 32. By holding the handle and barrier, the head 12 is readily unscrewed and removed. The cartridge is then exposed for removal and replacement. No soldered connections are required. The end 34 of the cartridge bears directly against the inner end of the tip 20. A compression spring 36 is disposed at one end of the cartridge, in this case at the end 38. The spring bears against a center contact 40 which is connected to the center wire or main conductor 74 (Fig. 2) of the flexible cable 42. Thus the cartridge is effectively connected in series when the parts of the insulation housing are screwed together, for at that time the compression spring 36 is placed under pressure.

The cable 42 is a shielded cable, the preferably braided flexible metallic shielding of which is indicated at 44. The usual electrical insulation is provided between the center conductor and the shielding, and additional protective insulation is preferably provided on the outside of the cable. We employ the shielding 44 as a ground connection. The jack 46 at the end of the cable is connected to the center conductor. An additional ground jack 48 is provided, this being connected to the shielding 44 by means of a flexible conductor 50. A long flexible conductor 52 extends from the ground jack 48 to a suitable clip, such as the alligator clip 54. It will be understood that the cable 42 and conductor 52 are relatively long, while the conductor 50 may be quite short, and that the jacks 46 and 48 are plugged into the test instrument, while the clip 54 is applied to a grounded part of the receiver being worked on, usually the metal chassis of the receiver.

A ground connection for the flashover shield 24 is preferably provided by means of a second

compression spring 56. A stationary metal disc 58 (Fig. 2) is connected to the shielding 44 of the cable, usually by soldering the parts together. The compression spring 56 provides a yieldable connection between the stationary disc 58 and the rear end of the shield 24. For this purpose we prefer to employ a slidable disc 60 having a diameter large enough to bear against end of shield 24. Disc 60 is slidable relative to disc 58, and is normally urged against the shield by means of the compression spring 56. The disc 60 is held against escape by the insulation fitting 72.

The leakage guard 30 is connected to ground through the grounded shield 24. For this purpose a third spring is employed, this being a small compression spring 62 (Fig. 1) received in a radial hole through handle 14. The guard 30 is formed with a cylindrical flange 64 closely surrounding the handle 14. The spring 62 is compressed between the flange 64 on the outside and the shield 24 on the inside.

The resistance cartridge 22 may be of standard construction. That here shown is made up of a carbon resistance stripe or film applied helically along an insulation rod, preferably a non-hygroscopic steatite rod. The ends of the rod are coated with a conductor such as silver paint, indicated at 66, into or beneath which the helical resistance film runs. In practice the cartridge is preferably made up of two half cartridges connected in series, as is indicated by the bands of silver paint at 68. The steatite rod has threaded holes at the ends, and the two rods are secured together by screwing the same in opposite directions on a short headless screw. This brings the silver films on the contacting ends of the rods into tight, face-to-face connection. Small headed screws are preferably provided at the outer ends to improve the contact at those points. One of the end screws may be used to hold the compression spring 36 in assembled relation to the cartridge. The reason it is preferred to make the cartridge of two sections is that it greatly increases the tolerance in manufacture, for the manufacturer may join together half cartridges having such resistance values as provide the desired total resistance. In other words, half cartridges having a resistance somewhat too high may be used with half cartridges having a resistant somewhat too low.

The polystyrene head 12 and sleeve 18 are shown in one piece. They may be molded as one piece, or the sleeve 18 may be cut from tubing and then welded or cemented to the rear end of the head 12, the latter being molded. Also, the sleeve 18 may be tubing, one end of which slides into a suitably undercut section at the rear end of head 12.

To assemble the complete probe the following procedure is followed: One end of the flexible cable 42 is first provided with a compression contact assembly best shown to enlarged scale in Fig. 2. For this purpose metal disc 58 is soldered to metal shielding 44. An insulation sleeve 70 and compression spring 56 are added, followed by slidable disc 60 and insulation collar 72. The latter is stepped, and its small end is slid over the center conductor 74 of the cable and is held in place by soldering a small metal disc or center contact 40 in position, as indicated at 76.

The other or then free end of the cable is slid through the handle and thru the hole 78 in its end. When the stationary disc 58 has reached the end of the handle, the cable may be locked to prevent strain on the concentric compression

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contact assembly by using a metal strip or block 80 and a set screw 82. The block 80 is received in a keyway 84. The set screw 82 is preferably of the headless or Allen type.

The tubular metal flashover shield 24 is then slid into the handle and around the concentric compression contact assembly as shown. The small compression spring 62 is placed in the hole receiving the same, and the barrier assembly 16 is then slid over the end of the handle and over the compression spring 62. The barrier assembly includes the leakage guard 30, held by small drive pins. The cartridge 22 is then placed in either the handle or the head 12, and the latter is screwed into the handle, thus automatically compressing the contact springs 36 and 56. The tip 20 has, of course, been previously screwed into the head. The jacks are added at the other end of the cable.

To examine or to change the cartridge the procedure is, of course, far simpler. It is merely necessary to hold the handle 14 and barrier 16 in one hand, and to grasp and unscrew the head 12 with the other.

It is believed that the construction and method of assembly, as well as the advantages of our improved high voltage multiplier probe, will be apparent from the foregoing detailed description thereof. The particular probe shown is intended for use with voltages up to 60,000 volts. The polystyrene has a dielectric strength of approximately 25,000 volts per millimeter, and the probe has a substantial safety factor, it being good for voltages over 120,000 volts. It will be noted that there is a substantial thickness of polystyrene dielectric at the high voltage end of the cartridge. At the opposite end of the cartridge there is less thickness of polystyrene, but at that end the voltage has already been substantially reduced by the action of the resistor itself. Moreover, the operator is protected by the insulation handle and by the grounded flashover shield.

Various other features of the invention belong advantageously together. For example, a high reduction in voltage is obtained by using a long resistance cartridge. The long cartridge is accommodated by housing the same within a long insulation head, as well as within a long handle. The long head in turn increases the leakage path and makes it possible to use a large dimension barrier which further increases the leakage path. The location of more than half the cartridge ahead of the handle makes it possible to reduce the thickness of dielectric inside the handle, and thus to keep the overall diameter of the handle within convenient dimension, in this case about $1\frac{1}{8}$ ".

The safety of the probe is enhanced by the flashover shield and by the leakage guard, both of which are safely and dependably grounded through the shielding of the cable. This is in addition to the dielectric strength of the insulation itself, and the long leakage path provided. The ground plug arrangement has the advantage that the operator is less likely to forget to complete the necessary ground connections, for in completing the ground connection for voltage measurement, he automatically completes the ground connection for safety, this resulting from the wire 50 inseparably connecting the jacks 46 and 48.

It will be understood that while we have shown and described our invention in a preferred form, changes may be made in the structure disclosed,

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without departing from the spirit of the invention, as sought to be defined in the following claims.

We claim:

1. A high voltage multiplier probe comprising a hollow insulation body having a metal tip at one end and a shielded cable extending from the opposite end, a resistor housed in said insulation body and connected between the metal tip and the wire of the cable, a metal leakage guard forming a part of said probe body, said guard being connected to the flexible metal shield of the cable acting as a ground wire, the remote or free end of said cable being connected to a jack, said probe assembly including also a separate ground jack having two flexible conductors leading therefrom, one of said conductors extending to the main jack and being connected to the cable shield, and the other of said conductors terminating in a spring clip.

2. A high voltage multiplier probe comprising a hollow insulation body having a metal tip at one end and a shielded cable extending from the opposite end, a resistor housed in said insulation body and connected between the metal tip and the wire of the cable, a tubular metal flashover shield forming a part of said probe body, said shield being connected to the flexible metal shield of the cable acting as a ground wire, the remote or free end of said cable being connected to a jack, said probe assembly including also a separate ground jack having two flexible conductors leading therefrom, one of said conductors extending to the main jack and being connected to the cable shield, and the other of said conductors terminating in a spring clip.

3. A high voltage multiplier probe comprising a hollow insulation body having a metal tip at one end and a shielded cable extending from the opposite end, a resistor housed in said insulation body and connected between the metal tip and the wire of the cable, a tubular metal flashover shield and a metal leakage guard forming a part of said probe body, said shield and guard being connected to the flexible metal shield of the cable acting as a ground wire, the remote or free end of said cable being connected to a jack, said probe assembly including also a separate ground jack having two flexible conductors leading therefrom, one of said conductors extending to the main jack and being connected to the cable shield, and the other of said conductors terminating in a spring clip.

4. A high voltage multiplier probe comprising a head made of insulation, a hollow handle made of insulation, said head having a tubular sleeve of reduced diameter extending rearwardly therefrom and received within said handle, a grounded flashover shield made of tubular metal disposed between the sleeve and the handle, a metal tip on said head, and a resistor cartridge received and protectively housed within said sleeve, the rear end of the handle receiving a shielded cable, the inner end of the cable being connected to a center contact, the metal sheath or shield of said cable being connected to a stationary metal ring electrically connected by means of a compression spring to the rear end of the flashover shield, said cartridge bearing against a second compression spring at one end, the arrangement being such that when the head is assembled with the handle the cartridge is yieldably connected to the center contact of the cable, and the shield is independently yieldably connected to the shield of the cable.

5. A high voltage multiplier probe comprising a head made of high voltage insulation, a hollow handle made of synthetic resin, an insulation barrier between said head and said handle, said head having a tubular sleeve of reduced diameter extending rearwardly therefrom and received within said handle, a grounded flashover shield made of tubular metal disposed between the sleeve and the handle, a metal tip on said head, and a resistor cartridge received and protectively housed within said head and sleeve, the rear end of the handle receiving a shielded cable, the inner end of the cable being connected to a center contact, the metal sheath or shield of said cable being connected to a stationary metal ring electrically connected by means of a compression spring to an axially slidable metal ring having a diameter such as to bear against the rear end of the flashover shield, said cartridge bearing against a second compression spring at one end, the arrangement being such that when the head is assembled with the handle the cartridge is yieldably connected to the center contact of the cable, and the shield is independently yieldably connected to the shield of the cable.

6. A high voltage multiplier probe comprising a head and sleeve made of the same high voltage insulation and contiguous in end to end relation, a hollow handle made of synthetic resin, said sleeve being a tubular sleeve of reduced diameter extending rearwardly directly from the head for approximately the length of the handle and being received within said handle, a metal tip on said head, and a resistor cartridge received and protectively housed within said sleeve and electrically connected to said tip, whereby a hand holding the probe is protected from the cartridge by both the sleeve and the handle.

7. A high voltage multiplier probe comprising a hollow head made of high voltage insulation, a hollow handle made of synthetic resin, a barrier between said head and said handle, said head having a high voltage insulation sleeve of reduced diameter extending rearwardly directly and contiguously therefrom for approximately the length of the handle and received within said handle, a metal tip on said head, and a resistor cartridge received and protectively housed within said head and sleeve and electrically connected to said tip, whereby a hand holding the probe is protected from the cartridge by both the sleeve and the handle.

8. A high voltage multiplier probe comprising a hollow head made of a styrene molding compound, a hollow handle made of a phenol formaldehyde molding compound, a finned barrier made of a phenol formaldehyde molding compound and located between said head and said handle, said head having a styrene tubular sleeve of reduced diameter extending rearwardly directly or contiguously therefrom for approximately the length of the handle and received within said handle, a metal tip on said head, and a resistor cartridge received and protectively housed within said head and sleeve and electrically connected to said tip, whereby a hand holding the probe is protected from the cartridge by both the sleeve and the handle.

9. A high voltage multiplier probe comprising a head made of insulation, a hollow handle made of insulation, said head having an insulation sleeve of reduced diameter extending rearwardly therefrom for approximately the length of the handle and received within said handle, a tubular flashover shield made of metal disposed be-

tween the sleeve and the handle, means to facilitate grounding the flashover shield, a metal tip on said head, and a resistor cartridge received and protectively housed within said sleeve, and electrically connected to said tip, whereby a hand holding the probe is protected from the cartridge by the sleeve, the shield, and the handle.

10. A high voltage multiplier probe comprising a head made of high voltage insulation, a hollow handle made of synthetic resin, a barrier between said head and said handle, said head having a high voltage insulation sleeve of reduced diameter extending rearwardly therefrom for approximately the length of the handle and received within said handle, a tubular flashover shield made of metal disposed between the sleeve and the handle, means to facilitate grounding the flashover shield, a metal tip on said head, and a resistor cartridge received and protectively housed within said head and sleeve and electrically connected to said tip, whereby a hand holding the probe is protected from the cartridge by the sleeve, the shield, and the handle.

11. A high voltage multiplier probe comprising a head made of a styrene molding compound, a handle made of a phenol formaldehyde molding compound, a finned barrier made of a phenol formaldehyde molding compound between said head and said handle, said head having a tubular sleeve of reduced diameter extending rearwardly directly and contiguously therefrom and received within said handle, a tubular flashover shield made of a highly conductive metal disposed concentrically between the sleeve and the handle, means to facilitate grounding the flashover shield, a metal tip on said head, and a resistor cartridge received and protectively housed within said head and sleeve and electrically connected to said tip, whereby a hand holding the probe is protected from the cartridge by the sleeve, the shield, and the handle.

12. A hand-held high voltage probe comprising a head with a metal tip, a handle made of insulation, a barrier made of insulation and located between said head and said handle, and a grounded leakage guard, said guard being a metal disc disposed on the rear face of said insulation barrier and having means connecting said metal disc to ground.

13. A hand-held high voltage multiplier probe comprising a head made of a high voltage insulation, a handle made of insulation, a multiple finned barrier made of insulation and located between said head and said handle, a metal tip on said head, a resistor cartridge within said head, and a grounded leakage guard, said guard being a metal disc disposed on the rear face of said insulation barrier and having means connecting said metal disc to ground.

14. A high voltage multiplier probe comprising a head made of high voltage insulation, a handle made of synthetic resin, a barrier between said head and said handle, said head having a tubular sleeve of reduced diameter extending rearwardly therefrom and received within said handle, a flashover shield made of metal disposed between the sleeve and the handle, means to facilitate grounding the flashover shield, a metal tip on said head, a resistor cartridge received and protectively housed within said head and sleeve and electrically connected to said tip, a leakage guard, said guard being a metal disc disposed on the rear face of said barrier, and conductive means disposed in a passage through the wall of the handle between the aforesaid guard and the

aforesaid shield for grounding the leakage barrier.

15. A high voltage multiplier probe comprising a head made of insulation, a handle made of insulation, a finned barrier made of insulation and located between said head and said handle, said head having a tubular sleeve of reduced diameter extending rearwardly directly and contiguously therefrom and received within said handle, a tubular flashover shield made of a highly conductive metal disposed concentrically between the sleeve and the handle, means to facilitate grounding the flashover shield, a metal tip on said head, a resistor cartridge received and protectively housed within said head and sleeve and electrically connected to said tip, a leakage guard, said guard being a metal disc disposed on the rear face of said barrier and having a cylindrical flange at the center dimensioned to fit around the aforesaid handle, and a small compression spring disposed in a passage through the wall of the handle between the aforesaid flange and the aforesaid shield for grounding the leakage barrier.

16. A hand-held high voltage multiplier probe comprising an insulation head with a metal tip, a hollow insulation handle, said head having an insulation sleeve extending rearwardly directly and contiguously therefrom for approximately the length of the handle and being received in said handle, and an insulation barrier between said head and said handle, said insulation barrier being large in diameter and axial length and having a number of deeply cut fins to substantially increase the length of the barrier leakage path, the aforesaid insulation head being substantial in length so that the barrier will not interfere with convenient use of the probe despite the large dimension of the barrier.

17. A hand-held high voltage multiplier probe comprising a hollow insulation head and a hollow insulation handle, said head having an insulation sleeve extending rearwardly directly and contiguously therefrom for approximately the length of the handle and being received in said handle, a threaded connection between said parts affording ready separation thereof, a resistance cartridge received and housed within said head and sleeve, a metal tip at the forward end of said head, a metal connection at the rear end of said handle, and a compression spring disposed at one end of said cartridge whereby said cartridge is electrically connected in circuit without the use of soldered connections or the like, and is readily removable and replaceable by unscrewing said parts.

18. A hand-held high voltage multiplier probe comprising a hollow insulation head made of high voltage insulation, a hollow insulation handle, said head having an insulation sleeve extending rearwardly directly and contiguously therefrom for approximately the length of the handle and being received in said handle, a threaded connection between said head and handle affording ready separation thereof, an insulation barrier located and held between said head and said handle by said threaded connection, a resistance cartridge received and housed within said head and handle, a metal tip at the forward end of said head, a metal connection at the rear end of said handle, and a compression spring disposed at one end of said cartridge whereby said cartridge is electrically connected in circuit without the use of soldered connections or the like and is readily removable and replaceable by unscrewing the head from the handle.

19. A high voltage multiplier probe comprising a hollow insulation head open at its rear end, a hollow insulation handle open at its forward end, said head being closed at its forward end and provided with a metal tip which projects through the head to the inside, said handle being closed at its rear end except for an opening through which a flexible insulated cable passes, an insulation barrier disposed between the head and the handle, said head and handle being provided with mating threads at the open ends for screwing the same together with the insulation barrier gripped therebetween to hold it in position, and a resistor cartridge disposed within the hollow head and hollow handle, the forward end of said cartridge contacting the inner end of the metal tip within the head, a compression spring at the rear end of said cartridge which spring bears against the end of the flexible cable within the handle, whereby the screw connection of the head and handle provides good electrical contact for the cartridge and holds the barrier and facilitates changing the cartridge.

20. A hand-held high voltage multiplier probe comprising a hollow head made of polystyrene insulation, a hollow handle made of synthetic resin insulation, said head being closed at its forward end and provided with a metal tip which projects through the head to the inside, said handle being closed at its rear end except for an opening through which a flexible insulated cable passes, said cable being provided with a metal cap at its inner end, and insulation barrier including multiple fins of insulation disposed between the polystyrene head and the insulation handle, said head and handle being provided with mating threads for screwing the same together with the insulation barrier gripped therebetween, said barrier being held in position by screwing the head and handle together, and a long resistor cartridge disposed within the hollow head and hollow handle, the forward end of said cartridge contacting the inner end of the metal tip within the head, the rear end of said cartridge being provided with a compression spring which bears against the metal cap of the flexible cable within the handle, whereby the screw connection of the head and handle provides good electrical contact for the cartridge and holds the barrier and facilitates changing the cartridge.

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References Cited in the file of this patent UNITED STATES PATENTS

Number	Name	Date
988,192	Hetherington	Mar. 28, 1911
1,043,150	Schweitzer	Nov. 5, 1912
1,615,788	Feldkamp	Jan. 25, 1927
1,724,014	Garau	Aug. 13, 1929
2,020,402	Edwards et al.	Nov. 12, 1935
2,135,353	Rorden	Nov. 1, 1938
2,261,675	Edler	Nov. 4, 1941
2,413,484	Berger	Dec. 31, 1946
2,466,211	Crockett	Apr. 5, 1949

FOREIGN PATENTS

Number	Country	Date
236,437	Great Britain	July 9, 1925
587,343	Great Britain	Apr. 22, 1947
323,375	Germany	July 21, 1920