United States Patent

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[54] **FIBER OPTICS ILLUMINATION SYSTEM**
8 Claims, 12 Drawing Figs.

[52] **U.S. Cl.** **240/10;** 350/96

[51] **Int. Cl.** .... **A47g; 33/16** F21p 1/02.

[50] **Field of Search** .... 240/10 (T), 1 (E.I); 350/96

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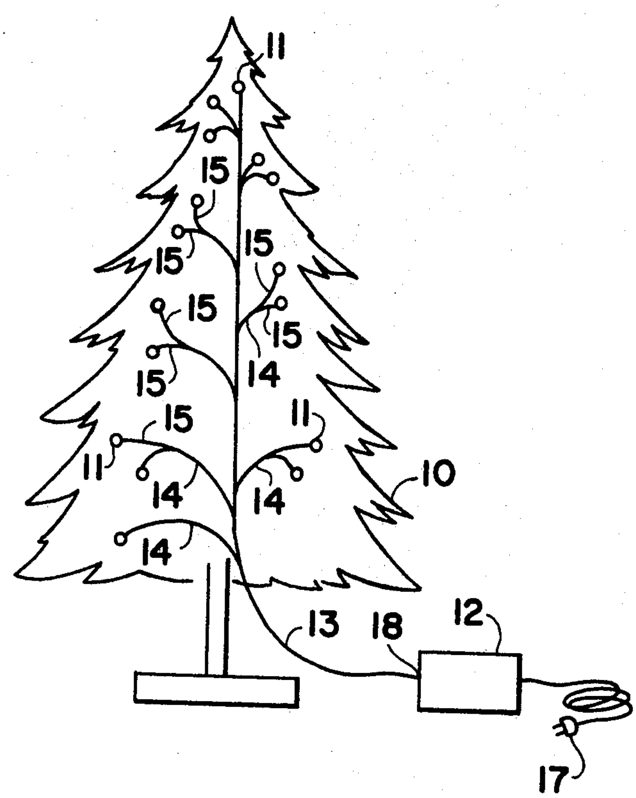
ABSTRACT: An ornamental illumination system for a Christmas tree employs a light source located at the base of the tree, which is coupled to a fiber optics harness. The harness distributes light from the source to a plurality of translucent ornamental shapes distributed decoratively about the tree. A color wheel at the light source controls the apparent colors illuminating the ornamental shapes, which shapes themselves may be made of different colors of translucent materials. The resulting displays of colors may be complex.



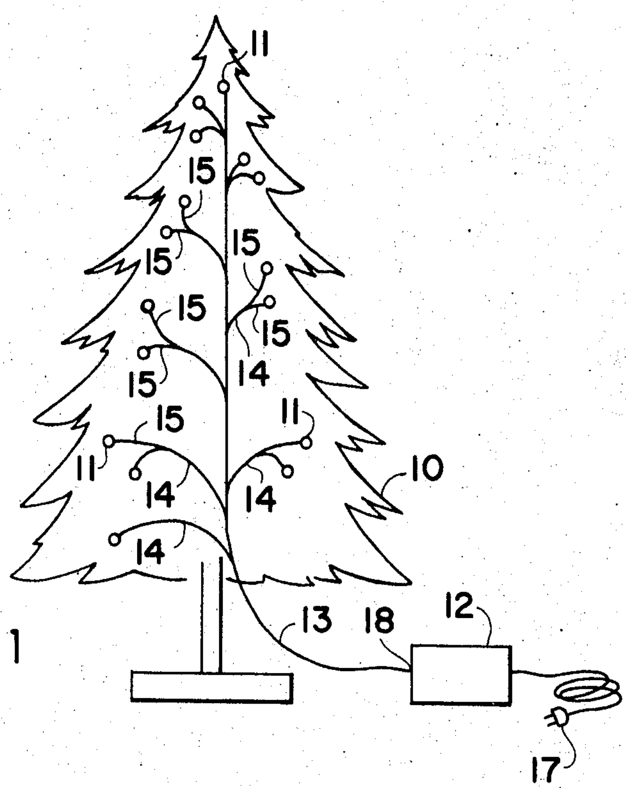


FIG. 1

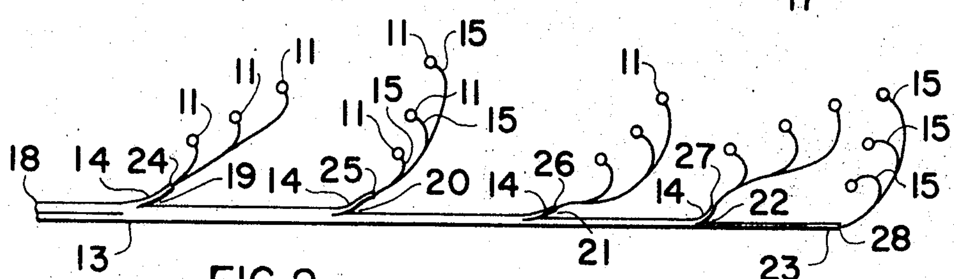


FIG. 2

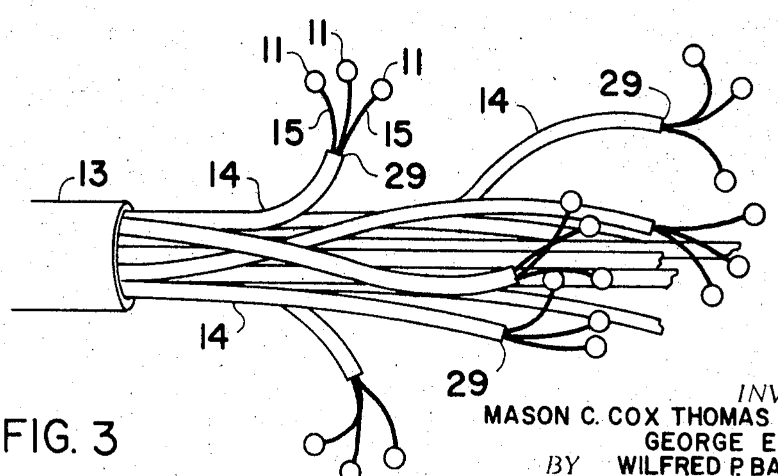


FIG. 3

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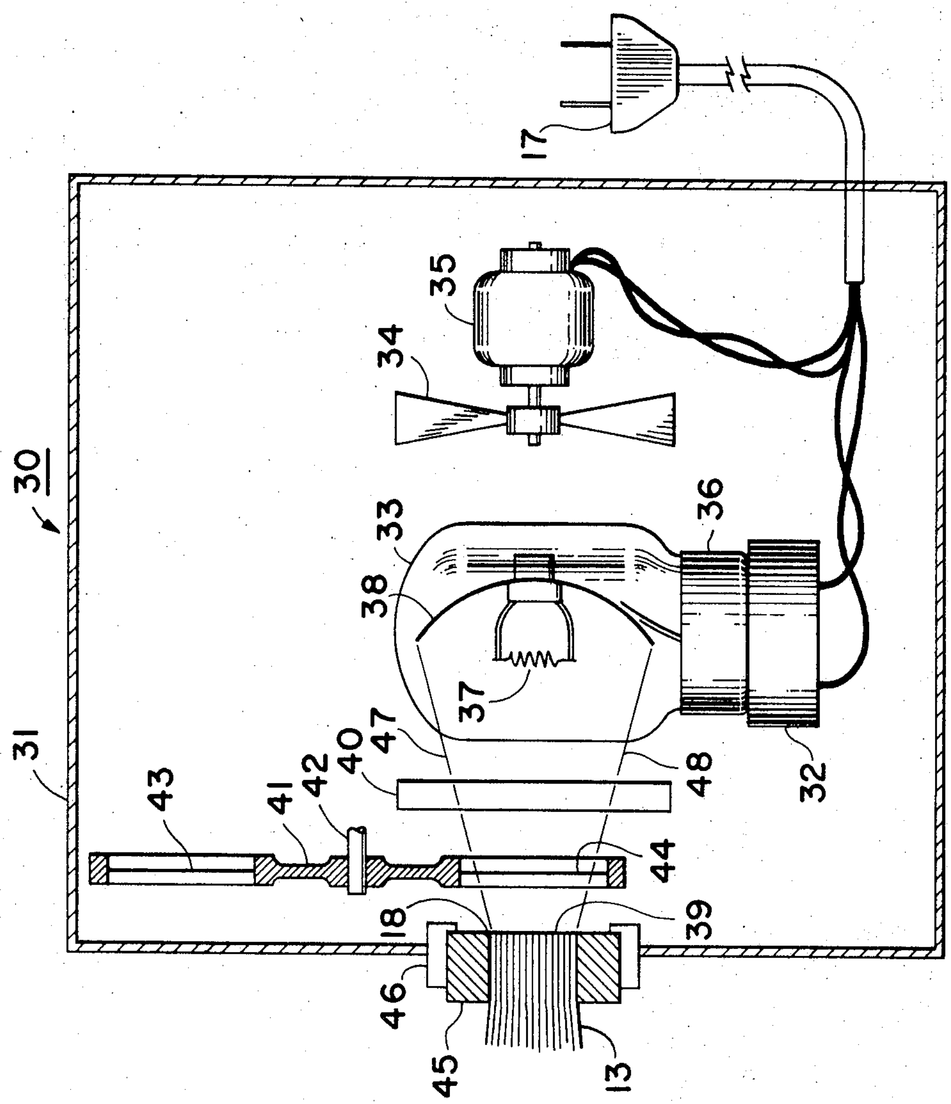

FIG. 4

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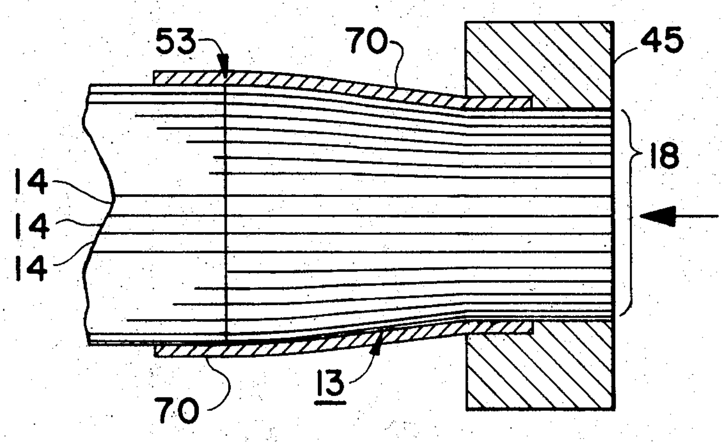

FIG. 5

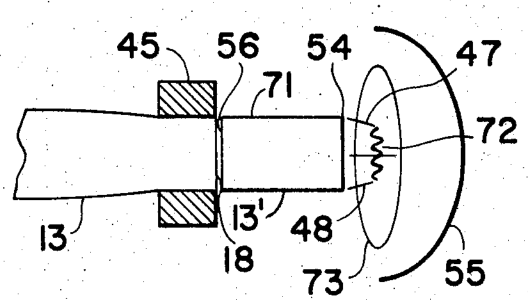

FIG. 6

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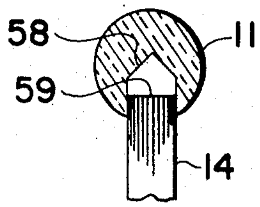

FIG. 7

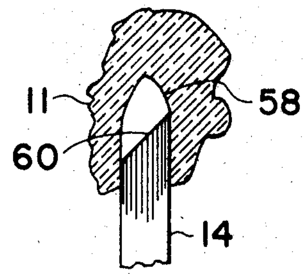

FIG. 9

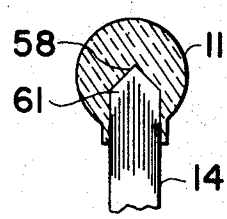

FIG. 8

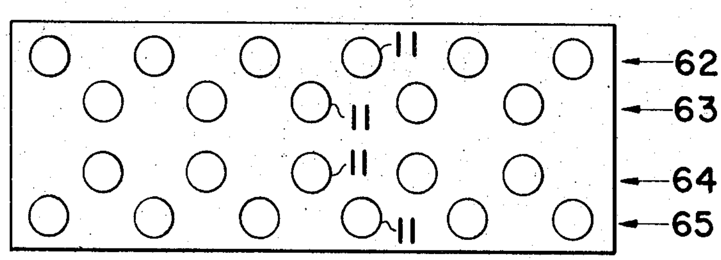

FIG. 10

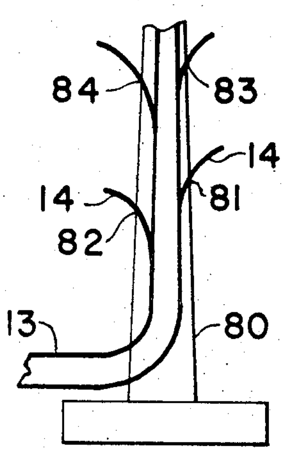

FIG. 12

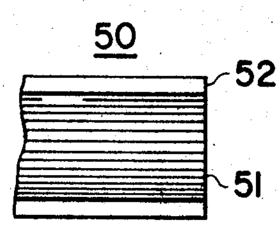

FIG. 11

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FIBER OPTICS ILLUMINATION SYSTEM

Ornamental lighting arrays customarily employed with trees, for example, utilize incandescent filaments energized electrically. While these systems have been refined over the years, they cannot be said to be absolutely safe inasmuch as they are composed os heat sources and electrical connections carrying current. Connection failure or spot overheating can initiate combustion of proximate material with consequent damage. Therefore, conventional systems are not to be left unattended indoors, if a prudent regard for safety is observed, and most particularly when the decorated item is flammable, such as the Christmas tree.

It is an object of this invention to provide for a decorative illumination system that may be safely used with flammable materials; the light source of the invention is separated from the ornamented structure, a fiber optics distribution harness being employed to transmit the light to the illuminated ornamentations.

It is another object of the invention to provide a novel Christmas tree lighting system that is intrinsically safe, and has an array of cold-light illuminated ornamentations readily adapted to a wide variety of configurations as well as appearances.

A further object of the invention is to provide novel means for varying the apparent distributed colors appearing at the ornamental terminations of the light distributing system, such means being operated solely at the light source.

Another object of the invention is to provide an efficient and economical light distributing system, wherein a maximum number of illuminated ornamentations are supplied with light from a single source by means of a fiber optical harness.

Other objects of the invention will be readily apparent from the specification herewith taken in conjunction with the several FIGS. in which:

FIG. 1 is a schematic representation generally illustrating an embodiment of the invention applied to a Christmas tree;

FIG. 2 is a diagrammatic illustration of one form of harness arrangement;

FIG. 3 shows an alternative harness arrangement;

FIG. 4 is a diagrammatic cross-sectional view of a light source;

FIG. 5 is a cross-sectional view of a harness termination at the light source end;

FIG. 6 is a diagrammatic view of an optical arrangement with a fused fiber optical heat insulator;

FIG. 7 shows one form of ornamental termination;

FIG. 8 illustrates an alternative form of ornamental termination;

FIG. 9 illustrates still another form of ornamental termination;

FIG. 10 schematically represents a set of terminations of a configuration of a multicolor array;

FIG. 11 is a longitudinal cross section view of a single glass fiber; and

FIG. 12 is a diagrammatic cross-sectioned view showing a harness with a hollow tree trunk.

Referring to FIG. 1, a Christmas tree generally indicated at 10 is decorated with illuminated ornaments 11, which derive their illumination from light source 12 via fiber optic harness 13 having primary branches 14 and secondary subbranches 15. Light source 12 is adapted for electrical energization via electrical plug 17, designed to be attached to conventional power outlets.

Referring to FIG. 2, harness 13 may be composed of a plurality of individual fiber optical conduits 14, each conduit 14 being a group of fibers sheathed by protective and encapsulating material, such as polyethylene. In the harness arrangement of FIG. 2, all conduits 14 are grouped together at the light pickup end 18 of the harness for convenient coupling to the light source 12; along the length of harness 13, conduits 14 periodically branch off, such as at points 19, 20, 21 and 22, thereby diminishing the harness 13 bulk towards its end 23. The encapsulation of each branch 14 retains its integrity from harness end 18 through each branch 19, 20, 21, 22 up to subbranch 15 originations 24, 25, 26 and 27. From these latter points 24, 25, 26 and 27, out to the ornamental terminations 11, the conduit 14 encapsulation is removed, permitting the division of the fiber optical material into subbranches 15 each having a particular ornamental termination 11. Suitable means are employed to encapsulate subbranches 15.

FIG. 3 shows an alternative harness arrangement, wherein harness 13 has conduits 14 branching out in an arrangement providing for the total length of conduits 14 in harness 13 to be made minimal. Briefly, the adaptation employs the most direct route practicable from light source 12 to each conduit 14 encapsulation termination 29. Each conduit 14 may be directly terminated by a single ornament 11 at point 29, rather than subbranching into a plurality of ornaments; this may be desirable if it is desired to intensity the amount of light sent to each ornament; this arrangement employs a single conduit 14 for each ornament in the array, an individual conduit 14 running from light source 12 to ornament 11 for each ornament 11 employed. In this last case, the integrity of the conduit 14 encapsulation is broken only at the light source termination and the ornamentation 11 termination.

Referring to FIG. 4, the light source, generally indicated at 30 has a housing containing a socket 32 for mounting a bulb 33. Fan 34 directs cooling airflow upon bulb 33, which operates at a high temperature. Bulb 33 may be a typical high-intensity projection lamp, having a base 36 adapted to fit to socket 32. Incandescent filament 37 is mounted to be located on a first focus of an elliptical section reflector 38. The second focus 39 of reflector 38 is suited for the location of the fiber optic harness termination 18, thereby providing for an effective concentrated mirroring of filament 37 at harness 13 termination 18, which is a condition making for maximum light transfer to harness 13.

Included with light source 30, is a heat filter 40, the conventional variety having about an 85 percent efficiency. Color wheel 41 is pivoted on axis 42 and adapted to interpose a variety of filters 43, 44 located about the body of wheel 41, between the first and second focii of reflector 38, conveniently nearest adjacent second focus 39 and termination 18 of harness 13. By means of filters 43, 44, any desired hue of light may be projected to harness 13 for transmittal to ornaments 11. Color wheel 41 may be adapted for manual rotation to the desired filter position, or conventional means for automatically advancing a sequence of filters may be conveniently employed. Alternatively, single filters 43 may be manually interposed between the focii as desired.

Mounting collar 45 of harness 13 is adapted to seat and mate with socket ring 46 integral with case 31 to thereby position termination 18 of harness 13 appropriately at the second focus of reflector 38.

For maximum efficiency of the general optical arrangement illustrated in FIG. 4, it is required that the collection angle 47—48 defined by the proportion of the ellipse provided by reflector 38, be matched to the numerical aperture of the glass fibers employed. In addition, the diameter of the harness termination 18 should be related to the filament 37 size as projected.

Typically, a filament 37 may have a size on the order of one-fourth inch. It may be effectively mirrored on second focus 39 with an apparent size of three-eighth inch. In this case termination 18 should have a diameter of three-eigth inch for best matching. Conveniently, antireflection coatings may be applied to all optical surfaces between lamp 33 and second focus 39 for highest light transmission efficiency.

The numerical aperture of a fiber may be calculated, referring to FIG. 11 generally indicating a longitudinal cross section of a fiber 50, by the formula $N.A. = \sqrt{51^2-52^2}$. The fiber core index of refraction is represented by 51, while the cladding index of refraction by 52. Employing a conventional bulb 33, the numerical aperture must be matched to a relatively small collection angle 47—48, inasmuch as the reflector 38 section of the ellipse is only a small portion thereof. Should a reflector 38 have a section more nearly onehalf an ellipse, the fibers should be selected for a matching high numerical aperture for optimum light transfer. Additionally, it is possible to employ a spherical sectioned reflector to reduce filamentary light losses otherwise escaping in the region between the ellipse section and the receiving harness termination **18**.

Referring to FIG. **5**, conduits **14** may have their protective encapsulations removed between point **53** on harness **13** and termination **18**, with the glass fibers from all the conduits **14** bound together and clamped by collar **45** at the termination **18** end. This arrangement permits collar **45** to serve as a convenient connecting means for attaching harness **13** to light source **12**, seating with ring **46** thereof. An exact seating fit is required for optimum efficiency of light transfer, inasmuch as it is desired to focus the projected filament image at termination **18**, which is the plane of the severed fibers of all the conduits **14** making up harness **13**. A suitable covering sheath **70** may conveniently be used to protect harness **13** during handling.

Alternatively, a network of fibers may be employed in making up harness **13** that have no initial encapsulation, the arrangement being dictated solely by transmission requirements, with a finish coat being applied to the assembled network to preserve the desired configuration and permit ready handling. In this case, the harness **13** connection end will not neck down from point **53**, but will exhibit a uniform diameter from termination **18** up to the first branching of the individual fibers from the basic grouping, from which point harness **13** will decrease in diameter as more branches are taken therefrom along its length.

Referring to FIG. **6**, an alternative scheme of light source is shown, in which a quartz iodide high-intensity filament **72** is employed in combination with a fused fiber bundle light guide **71**. Quartz iodide lamp **73** is located closely as possible to end **54** of light guide **71**, which serves as a heat insulator. By locating filament **72** quite close to end **54** a narrow collection angle **47—48** may be defined in which a maximum of 50 percent of the light from filament **72** may be transmitted to guide **71**, the optimum condition being that filament **72** be located in the plane of end **54** of guide **71**. A spherical reflector **55** throws back all light radiated to the rear, back upon filament **72**, thereby increasing the efficiency of transmittal to guide **71**. Alternatively, other high-intensity devices may be used, such as a xenon short arc. Light guide **71** may be in the order of one-inch long, and is matched at its cool end **56** to filament **18** of harness **13**.

Referring to FIGS. **7**, **8** and **9**, illuminated terminations **11** are shown in cross-sectional detail as fixed to the encapsulated conduits **14**. FIG. **7** shows a simple arrangement with a spherical translucent plastic sphere having a recess **58** adapted to receive the diameter of conduit **14**. Conduit **14** is severed at right angles at **59** and friction fitted within recess **58** of termination **11**. FIG. **8** shows a similar arrangement, but with the fiber ends of conduit **14** receiving a conically tapered cutting **61** prior to insertion into recess **58**. This presents a bright core appearing somewhat as an incandescent filament centered within ornamental termination **11**. FIG. **9** shows an angled cutting **60** of conduit **14**, which also appears as a bright filament. Cut **60** may be performed by simply shearing conduit **14** together with its protective encapsulation at a conveniently large angle; the cut conduit may be then inserted within recess **58** with no other operation required to achieve a high-intensity filamentlike glow. Ornament **11** in FIG. **9** illustrates that any fanciful or ornamental shape may be employed for the terminations **11**. If a permanent fitting is desired, it is found that clear epoxy glues have a desirable index of refraction for a good optical match of the fiber ends to the plastic of ornament **11**. Also, it is attractive to have larger ornaments with a frosted surface to more closely define the ornamental shape when viewed from a distance.

Referring to FIG. **10**, a set of ornaments **11** is shown arranged in four rows, **62**, **63**, **64** and **65**, each row being a particular shade such as clear, red, green, yellow. The entire combination array of FIG. **10** thus represents a possible arrangement of terminations **11** provided with a particular harness **13**. In connection with varying colors being transmitted by harness **13**, the apparent effects will be determined by the instantaneous hue provided for by color wheel **41** and the particular filter **43** interposed with the light source. If the light transmitted by harness **13** is white, then the apparent illumination will match that of the hues of terminations **11**. Should the transmitted light be green, clear row **62** will also be green, red row **63** will be black, green row **64** will be a different shade of green, and yellow row **65** will appear blue. As the color wheel **41** selects other colors, the appearance will continue to vary, the effects being determined by the nature of the two sequential filters in effect with every termination **11**, the first light filter being that provided by color wheel **41**, and the second by the hue of ornamental termination **11** itself.

It may be considered an advantage, in view of the relative thickness of harness **13** near its termination **18**, principally owing to the encapsulation material of conduit **14**, to employ the ornamental system with an artificial tree permitting use of a fabricated hollow trunk **80**, shown in FIG. **12**. The bulk of the harness **13** may then be contained within the vertical hollow of the trunk, with conduits **14** being brought out from the trunk **80** interior at points **81**, **82**, **83**, **84**, as desired. In this manner, the maximum thickness of harness **13** that may be present on the outside of trunk **80** is limited to that of one single conduit **14**.

While there has been shown what is considered to be a preferred embodiment of the invention, it will be manifest that many changes and modifications may be made therein without departing from the essential spirit of the invention. It is intended, therefore, in the annexed claims to cover all such changes and modifications as fall within the true scope of the invention.

We claim:

1. An ornamental illumination system for a Christmas tree display comprising:
   - an assemblage of separately encapsulated fiber optic conduits having first ends of each conduit closely positioned one another to form a light receiving termination for said assemblage and with said light receiving termination placed in a location proximate to the base of the trunk of a Christmas tree and with said assemblage of separately encapsulated fiber optics leading generally upwards from the base region of said tree along the trunk thereof and each conduit of said assemblage individually branching out to tree locations to be illuminated and with each conduit being separately terminated at second ends thereof at said locations to be illuminated;
   - a light source positioned at said location proximate to the base of the trunk of a Christmas tree and coupled to said light receiving termination of said assemblage and with said source adapted to project illumination in concentration upon said light receiving termination and with an actuatable color filter having a plurality of differing colors interposed between said light source and said light receiving termination; and
   - a plurality of translucent ornamental shapes each having a recess therein and each being fitted thereby in a close fit over the encapsulation of a respective conduit at said second end thereof to thereby display light originating from said light source.

2. The ornamental illumination system of claim **1**, wherein said tree is artificial and having a hollow trunk for containing the vertically disposed bulk of said harness.

3. The ornamental illumination system of claim **1**, wherein each individual branching is separately encapsulated up to a point prior to its ornamental termination end and from that point subdivided into subgroups each subgroup having its own particular ornamental termination.

4. The ornamental illumination system of claim **1** employing a rigid light guide as a heat insulator between said light source and said source termination of said harness.

5. The ornamental system of claim 1 employing a light source having a lamp in combination with an elliptical section reflector with the diameter of said reflector defining a collection angle substantially matched to the numerical aperture of the optical pickup located at one focus thereof, the radiating portion of said lamp being located at the other focus.

6. The ornamental display system of claim 1 with said second end of each conduit being cut at an angle to exhibit a fiber optic section within said recess of said translucent ornamental shape to thereby display a bright core in each said recess from the light originating from said light source.

7. The ornamental display system of claim 1 with said plurality of translucent ornamental shapes comprising a plurality of differing colors.

8. The ornamental display system of claim 1 with said light source employing a high-intensity lamp and a reflector therewith to project illumination upon said light receiving termination wherein the collection angle defined by the size and shape of said reflector is matched to the numerical aperture of the fibers in said fiber optic conduits.