NO. OP8060-C-HB103
RETAIL .69c

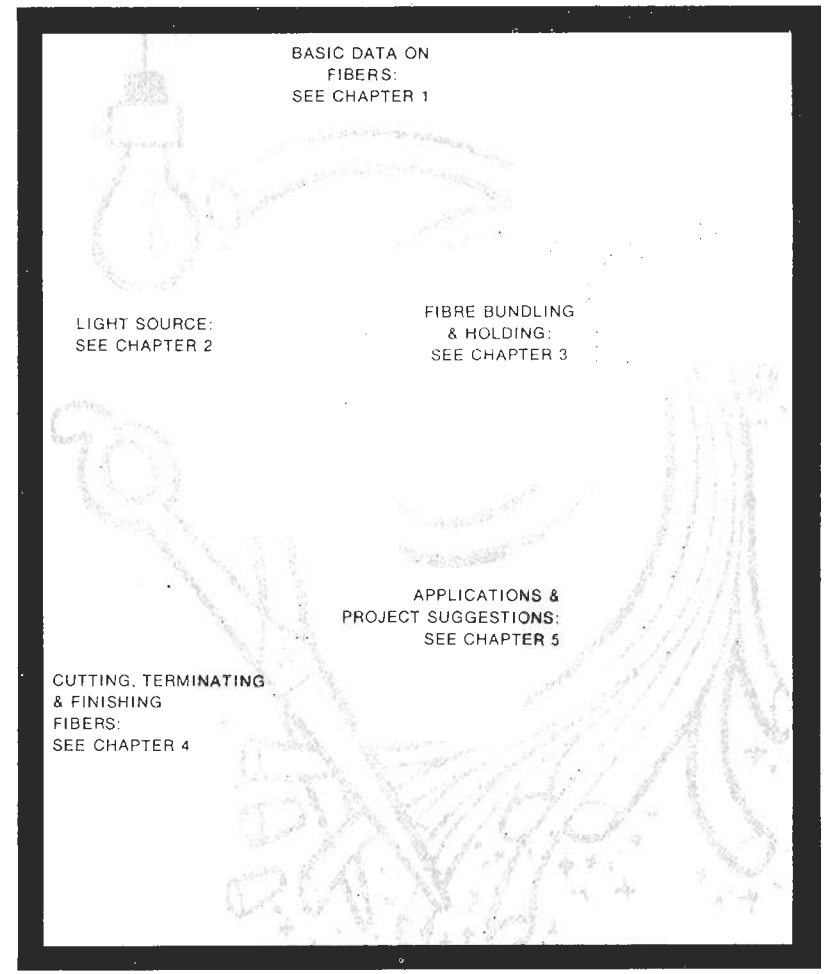
"why-how-where"

safe, cool light for everyone!

The history, principles, methods of working with, applications and project suggestions concerning plastic fiber optics. A basic handbook.

fiber Optics

INTERNATIONAL RECTIFIER IOR



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INTERNATIONAL RECTIFIER IOR

INTRODUCTION TO FIBER OPTICS

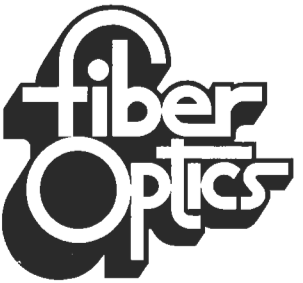
Light itself, regardless of its source, always travels in a straight line. If it strikes an object such as a mirror on its way through the air and is reflected, it will bounce off in a different direction, on another straight line. A flashlight beam, while being helpful in lighting your way through the darkness, normally will shine only straight ahead. It will not cast its light behind an object or around a corner unless you turn the flashlight itself in that particular direction.

A British physicist, Mr. John Tyndall, during the latter part of the 19th Century found that light could be conducted along a curved path. Mr. Tyndall demonstrated this phenomenon by showing that light shining into a tank of water followed a stream of water which was released from that tank.

It is now well known that a smooth and transparent cylinder such as a plastic or glass rod will transmit light by multiple internal reflections. Later it was found that even though the diameter of the rod was reduced, the same condition would exist. Experiments and research continued and as a result it was learned that bending the rod permitted the light to travel within the rod, regardless of the radius of the bend.

Through the principles of total internal reflection, International Rectifier now brings you a rare new excitement which may very well lead to new products, concepts and creations.

YOU ARE ABOUT TO DISCOVER

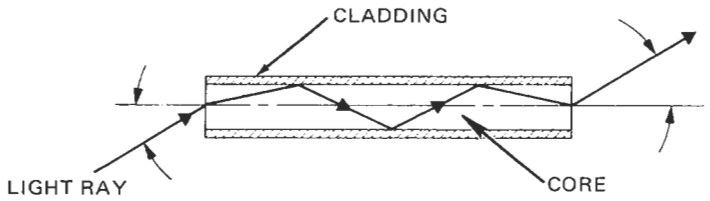


BASIC DATA ON FIBER OPTICS

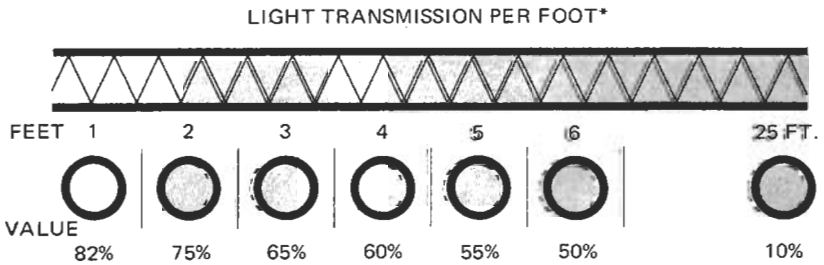
Any source of light will generate a certain amount of heat. Fiber Optics, however, will transmit only the light. Since lighted optical fibers will not carry the heat or electricity, you may be assured that it will provide safe, cool light for anyone to handle.

Principles of Fiber Optics

The principle is called TOTAL INTERNAL REFLECTION. The conditions for total internal reflection exist at any smooth interface between two transparent materials having different refractive indices, such as between glass and air. However, the presence of contamination, such as one fiber touching another or dirt deposited on the interface, interferes with total reflection by absorbing or scattering a fraction of the light. This problem is solved by applying a transparent coating or "cladding" of low refractive index over the higher refractive index fiber core. This permits highly efficient transmission of light through tightly packed bundles of clad fibers with each fiber conducting light independently.



The light travels in a zigzag path through the transparent core of each fiber by internal reflections, as described above. The amount of transmitted light depends upon the intensity of the light source, the loss characteristics of the cladding and core structures, length of fiber or light-guide and the number of fibers per bundle.



*Transmission values are dependent on light source intensity

Fiber Characteristics and Properties

The following information has been taken from the findings of many tests made on Fiber Optics products, by either industrial or government laboratories, in an effort to derive comparative performance data under a variety of conditions. The results are intended to be more representative than conclusive, because of the wide difference in specimens and techniques employed.

Tests were made of the fibers' performance under conditions of temperature, humidity, immersion, irradiation and shelf storage.

Optical Characteristics

Acceptance angle	70 degrees F
End losses	10% average (depends on end finish)
Line losses	10% per foot exponential
Transmission range	0.4 to 0.9 microns
Bend radius	20 times fiber diameter

Physical Characteristics

Bend radius	Smaller fibers can be lightly knotted without breaking
Density	1.04 grams per cubic cm.

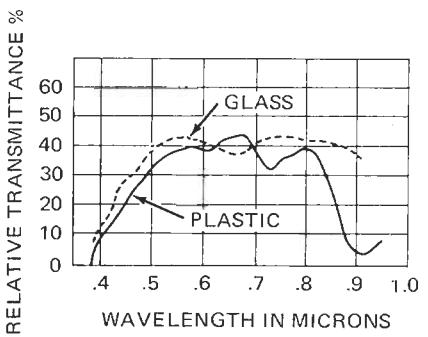
Environmental Characteristics

Temperature (Maximum continuous exposure)	180 degrees F
Minimum temperature	Operates at cryogenic levels. Remains flexible to approximately 40^{o} F.
Heat distortion temperature	212 degrees F at 264 psi
Moisture absorption	None
Chemical resistance	Unaffected by alkalies, non-oxidizing acids, salt water, photographic solutions, etc. Damaged by acetone and other strong solvents.
Aging	Three years history of dark storage reflects negligible transmission variations.

IR optical fibers have been subjected to MIL Standard Environmental tests without degradation, including shock, temperature cycling, storage at elevated temperatures, salt spray, etc.

Glass/Synthetic Transmission Comparisons

The transmission vs. wavelength plot shown here, while made under ambient conditions, reflects the nearly identical performance of glass and plastic fiber optics, especially in the ultraviolet and visible spectrum. Slight differences are shown depending on optical wavelength, but the visible spectrum values are essentially comparable. Plastic fiber optics manifest absorption in the infrared spectrum, suggesting care should be taken in the selection of solid-state emitters and sensors with peak response curves in the visible and near infrared ranges.



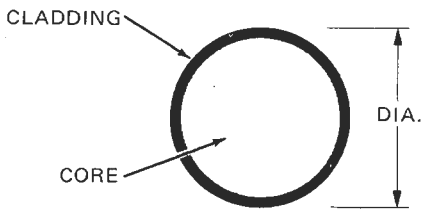
Basic Fiber Optic Products Available From IR

Bulk Fiber Specifications

The table below describes the four standard clear fiber diameters which are routinely available. The diameters listed are the most frequently used.

Part No.	Diameter (in)	Core Area	Core Diameter	Cladding Area	Cladding Thickness
OP1030/1060	0.010 (10 mil)	83%	0.0091	17%	0.00045
OP2008/2016	0.020 (20 mil)	83%	0.0182	17%	0.00090
OP3003/3006	0.030 (30 mil)	83%	0.0273	17%	0.0015
OP4503/4506	0.045 (45 mil)	83%	0.0409	17%	0.00205
Diameter control: **0.003" to 0.010 – ± 6% above 0.010" – ± 10%**					

In a monofiber, the fiber diameter is equivalent to bundle diameter.

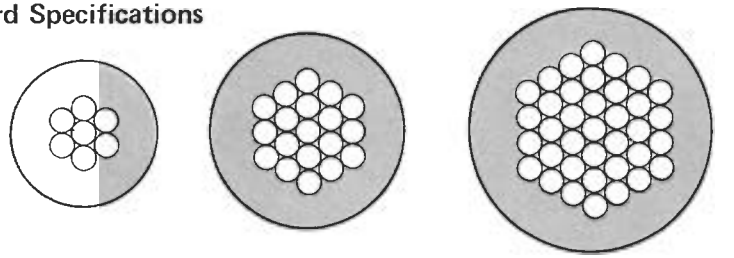


Jacketed Fiber Specifications

Chief Advantages

A jacketed light-guide can withstand all environments except elevated temperatures and toxic atmospheres. Its extended lengths and rugged construction permits in-line terminations at maximum speed, and its basic durability permits either mechanized or manual installation without resulting in breakage and processing losses.

Standard Specifications



OP7073
OP7076

OP7193
OP7196

OP7373
OP7376

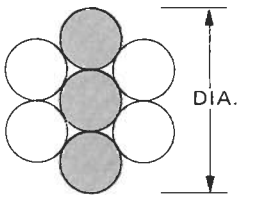
Part No.	Fiber Qty.	Fiber Size	I.D./O.D.	Fiber Optic Area (Sq. in.)
OP7073/7076	7	0.017"	0.051"/0.087"	0.00136"
OP7193/7196	19	0.017"	0.085"/0.120"	0.00431"
OP7373/7376	37	0.017"	0.119"/0.152"	0.00840"

Optical Characteristics

Jacketed light-guide transmission vs. length and transmission vs. wavelength characteristics are the same as those covered elsewhere in this brochure. In general, end losses can be as little as 8-to-10 percent and as high as 25-to-30 percent depending on method of termination, flatness, degree of polishing, etc. Line attenuation is comparable to that encountered with glass fiber optics at approximately 10% per foot. Packing density varies with the number of fibers in a given configuration for an average of 75%.

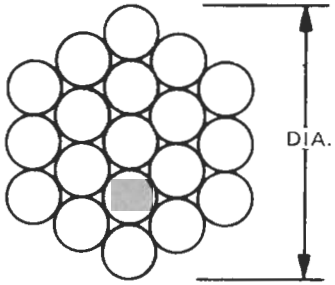
In a seven-fiber pack, the fibers equal one-third of the proposed bundle diameter.

$$F = \frac{DIA.}{3}$$



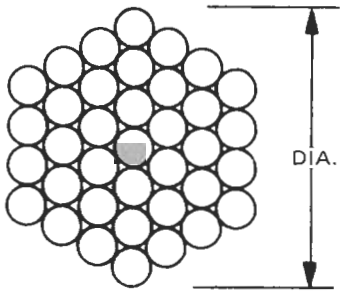
In a nineteen-fiber pack, the fiber size equals one-fifth of the proposed bundle diameter.

$$F = \frac{DIA.}{5}$$



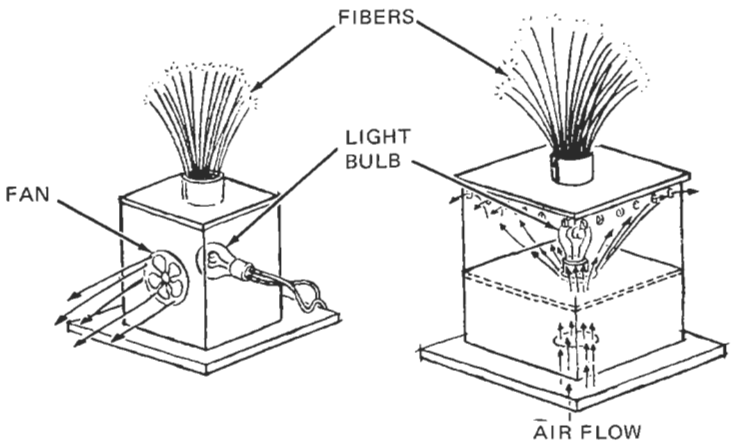
In a thirty-seven fiber pack, the fiber size equals one-seventh of the proposed bundle diameter.

$$F = \frac{DIA.}{7}$$



LIGHT SOURCES

There are a number of ways you can produce sufficient light for your fiber optic project, however, caution must be exercised simply because light sources produce heat as a major by-product. Therefore, this combination of heat and light is a major consideration in all designs. The more light the greater the heat. Shown below are two suggestions which may help to avoid the problem. Always test your idea before making the final product. This should point out any flaws which could impair the finished product.

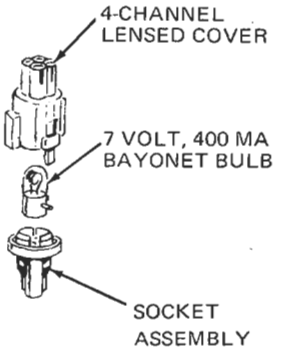


FAN COOLED CONVECTION COOLED

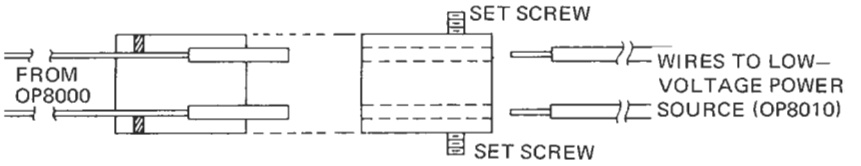
Obviously if you can produce sufficient light and reduce the heat there no longer is a problem.

A low-voltage system, which provides more than adequate light yet produces a limited amount of heat, is recommended.

International Rectifier's part number OP8010 is a step down, "plug in" transformer which produces approximately three Watts when used in conjunction with IR's number OP8020 light bulb. (Any standard filament transformer of equivalent rating may also be substituted.) The four-channel light head (number OP8000) provided with IR's program may be used with or without the four-channel lensed cover, depending on your needs and the fiber optic bundle size.



One-half of the four-channel light head (number OP8000-C) connector is attached. The other half is to be attached to the wires of the IR number OP8010 low-voltage power supply as follows:

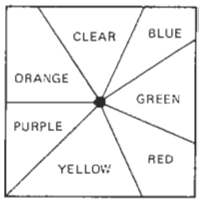


1. Loosen set screws in receptacle portion of connector (the one not attached to the light head).
2. Insert the tinned leads of the low-voltage power source (number OP8010) into the holes nearest the set screws.
3. Tighten the set screws.

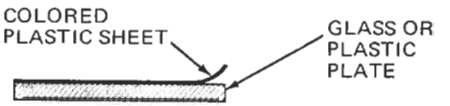
In addition, batteries, may be used as an adequate source of power for light. As an example, fiber optics is now being used for indicator lamps in automobiles, marine equipment, etc. Pencil flashlights with a Mueler number 49 insulator as a holder for fiber bundles may be used. (See Chapter V on applications and project suggestions.)

In constructing your light source housing, you may want to consider adding some form of color filters. For example, if you were constructing a large spray of fibers for a decorative lamp, you can construct a filter from a small glass or plastic plate by gluing thin sheets of colored acetate on the plate and supporting it between the lamp and the fiber.

SOLID COLOR



MULTICOLOR



When using filters, you must take into consideration that they reduce light transmission and the lamp used must be calculated accordingly. You must also keep in mind that more light will produce more heat.

You can also provide color filtering for the four-channel light head, IR part number OP8000. Simply remove the lensed cover, cut four circles of the desired colored acetate, add a drop of IR's number OP8050 end treatment and adhesive and put them in place with the end of a pencil. Allow 10 or 15 minutes to dry before using.

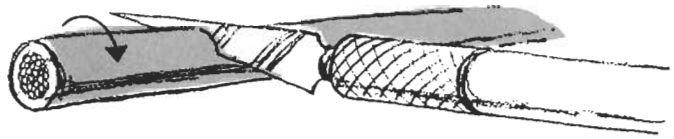
CUTTING, TERMINATING AND FINISHING

The efficiency of light transmission from optical fibers is directly proportional to the effort and results of the cutting and finishing of the ends.

Careful cutting of the ends will provide sufficient light transmission for most home applications. The effect of your completed project, however, will be greatly enhanced if finishing techniques are also utilized.

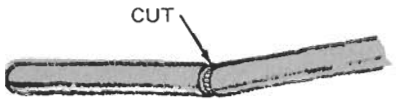
The tools required for cutting are either a single-edge razor blade or a sharp pointed knife (X-acto or equivalent).

A rolling or slicing cut is the only efficient means of cutting either the bulk optical fibers or the jacketed light guides. You may want to experiment with one end of the fiber before attempting to make your final cut. The cut should be made perpendicular to the length of the fiber and as flat as you possibly can.

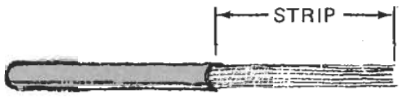


Jacketed light guides are bundles of fiber and may be cut, stripped and flared into sprays or individual light guides by following these three simple steps.

1. Carefully cut through the jacketing, being sure not to cut into the individual fibers.



2. Slice, lengthwise, from the cut to the end of the light guide and strip off the jacketing.



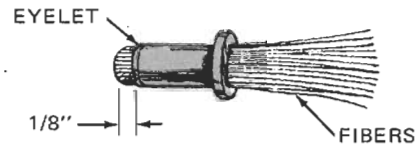
3. Flare out the fibers as desired.

The method of termination used may be determined by the size of the bundle desired. One method was described in Chapter III of this brochure.

IR's part number OP8030 contains an assortment of four different brass eyelets. Three were selected to fit the various three sizes of jacketed light guides and the fourth was selected to force fit into the four-channel light head.

The number of fibers per eyelet will be determined by the size fiber used as well as the size eyelet used. Several sizes of fibers may be put into the same eyelet if desired.

When stuffing the eyelet with as many fibers as possible, make sure they stick out the end of the eyelet by about 1/8"



There are two methods of securing the fibers within the eyelet which will produce satisfactory results.

1. Use a standard crimping tool.
2. Use IR's number OP8050 end-treat/adhesive.

When crimping, extreme caution must be exercised so that the fibers are not damaged by too much pressure. If the eyelet is filled with fibers, a slight crimp should hold them in place.

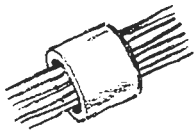
We prefer to use the end-treat/adhesive simply because you are in no danger of damaging the fibers. Simply put a few drops of the number OP8050 into the top of the eyelet and wait 10 to 15 minutes for it to cure.

Another method of terminating optical fibers is to use heat shrink tubing.

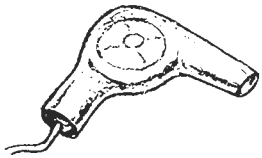
Extreme caution should be exercised when utilizing this method, however, if properly done, the end result can be as good as the manufactured jacketed light guides.

Plastic optical fibers will melt at approximately 180° F, therefore the shrink tubing as well as source of heat must be below that temperature.

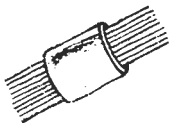
Select the tubing so that its natural state fits loosely around your bundle of fibers. Apply your heat (normally a home gun type hair dryer will produce enough heat for the low temperature shrink tubing) and watch the tubing shrink. Be sure to rotate either the bundle or heat source so the shrinking is uniform. Remove the heat as soon as the tubing stops shrinking.



HEAT SHRINKABLE TUBING
(PUT ON LOOSE)



HEAT GUN OR
HAIR DRYER



TERMINATED
BUNDLE (TIGHT)

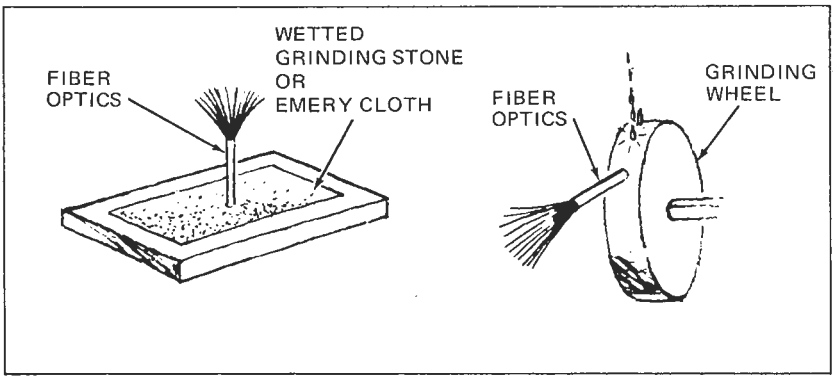
You are now ready for finishing the end of your fiber optic bundle.

Using the cutting technique described earlier, cut off the fibers sticking out of the bottom of the eyelet, shrink tubing or tape.

If your requirements are not critical and you have made a good, clean, flat cut, you may want to stop here. If so, simply add a drop or two of the number OP8050 end-treat compound which will increase the light transmission by approximately 20%.

If, on the other hand, you want greater efficiency, more light and a much more finished job, take the following steps:

1. Grind the end with a water lubricated grinding wheel (or use a wetted grinding stone) or emery paper/cloth and water.
2. Polish the end with:
   a. Wetted, cloth covered wheel
   b. Alumina abrasive powder
   c. Jewelers' rouge
   d. Lapidary powder.



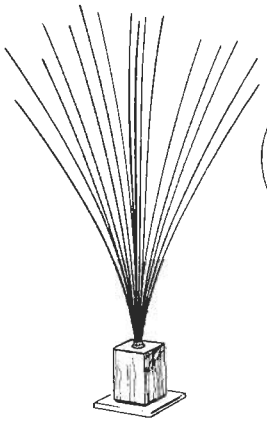
APPLICATIONS AND PROJECT SUGGESTIONS

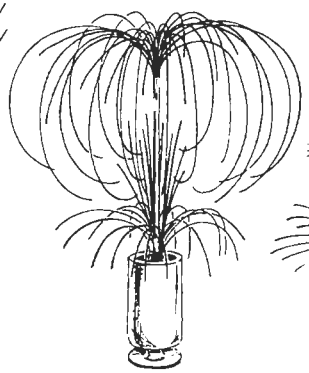
"Where there is light . . . there is an application!"

There are two limiting factors to the application of fiber optics.

1. Absence of a light source
2. The imagination of man.

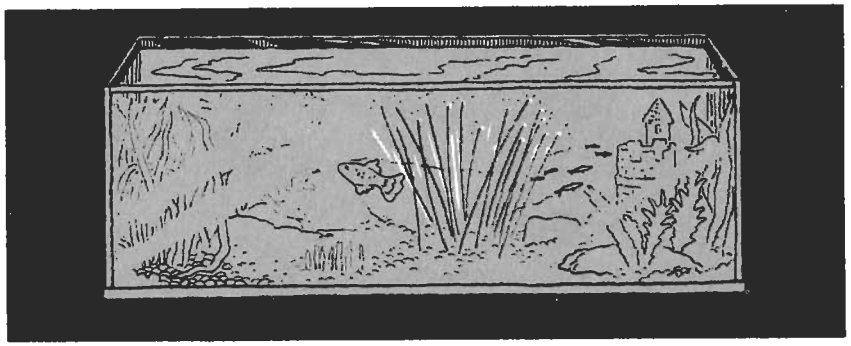
The following pages of applications and suggestions are designed to stimulate your imagination and to start you on your way to a new and exciting experience.



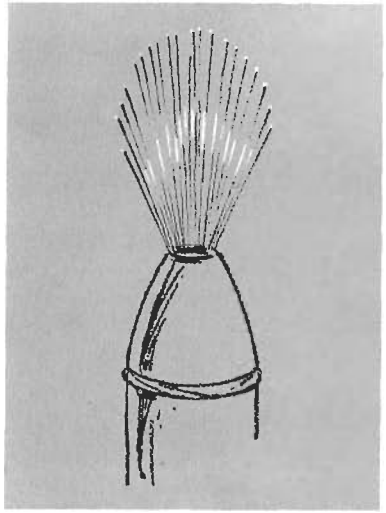


LAMP & NIGHT LIGHTS . . . using a combination of fiber sizes or single sizes

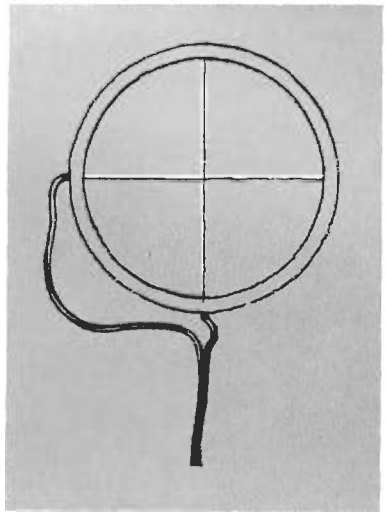
CHRISTMAS TREE STARS OR LIGHTS



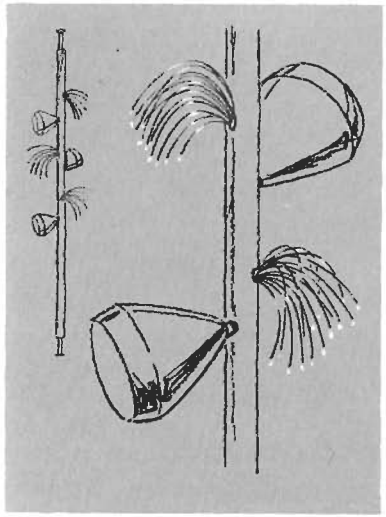
AQUARIUM LIGHTS



Magic Wand . . . Using a penlight and colored bulb or filter, arrange fibers in the shape of a "spray".

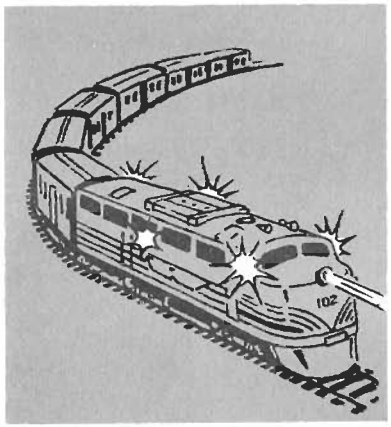


Telescope Reticle . . . Make one that has fiber crosshairs that illuminate themselves. Use battery or house current.

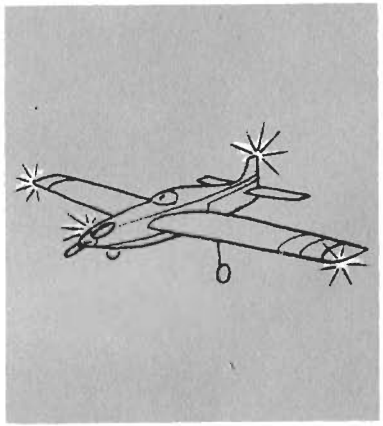


Fiber Optics Pole Lamp . . . Useful yet decorative. Requires a base for light source, IR's #OP8000 and #OP8010 and jacketed light guides.

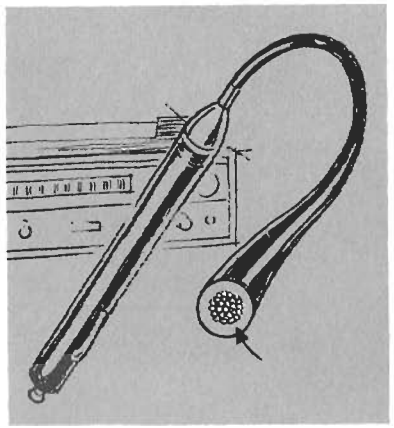
Hair Ornaments . . . Ladies are always seeking new and novel ideas. Highlight hair, hair combs, barrettes with Fiber Optics. Use penlight.



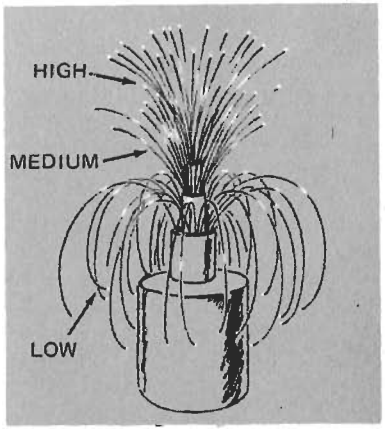
Model Railroad



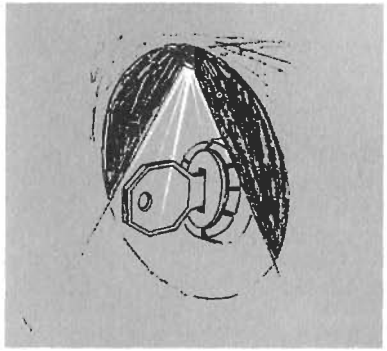
Radio Controlled Model Airplanes . . . Fly them at night . . . use #OP8000, batteries and optical fibers to light wing tips-tail and nose.



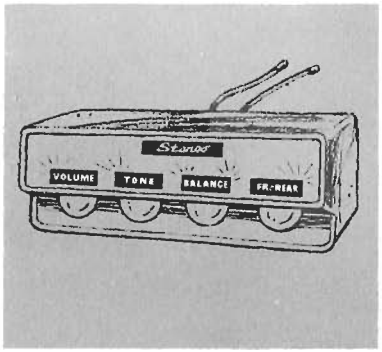
Flexible light source for those hard to see places for technicians, mechanics, and hobbyists.



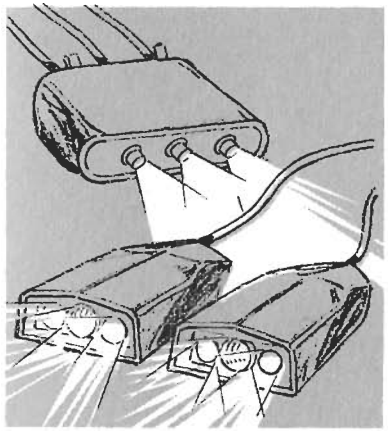
Fiber Optics Color Organ . . . High frequency . . . mid-range . . . low-frequency



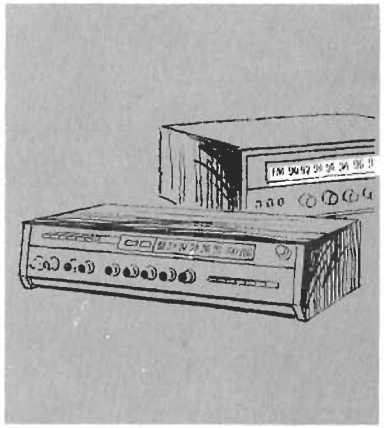
At last! Locating auto keyhole at night is easy with Fiber Optics. . .Groping blindly for automobile keyholes is a thing of the past due to recent developments with Fiber Optic light guides. The guides take little space as they carry light from an established light source within the instrument panel. All that is needed is a small light opening for the light guide to direct light onto the keyhole.



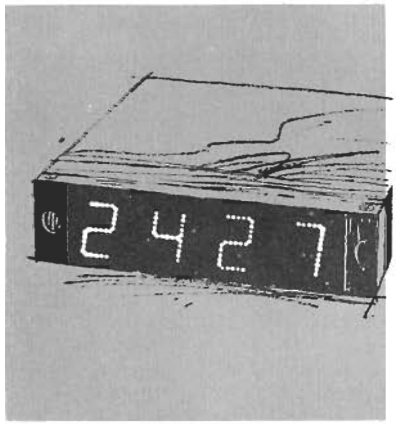
In-car stereo panel lighting from a remote lamp. . .Ideal for the automobile stereo operation panel. In order to provide light to the panel without accompanying heat, which might impair solid-state components. Fibers are used with strands leading from an already established light source in the instrument panel.
Also allows the use of the basic light source for lighting all panel instrument functions.



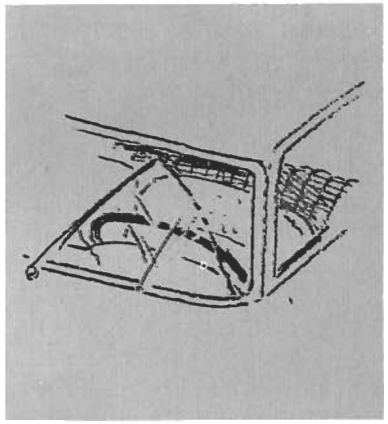
Automobile light monitoring system . . . A monitoring system that constantly informs the driver of the operating condition of his exterior lights.



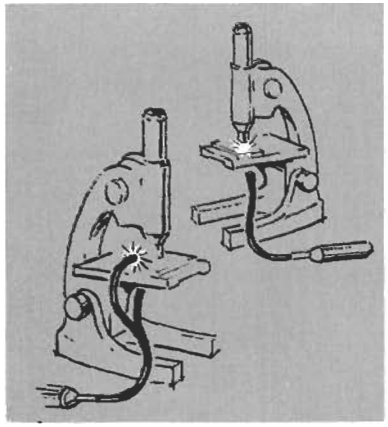
Use light guides as tuning indicators and panel illuminators for your stereo equipment. . .They help you pinpoint your channel, even in a darkened room.



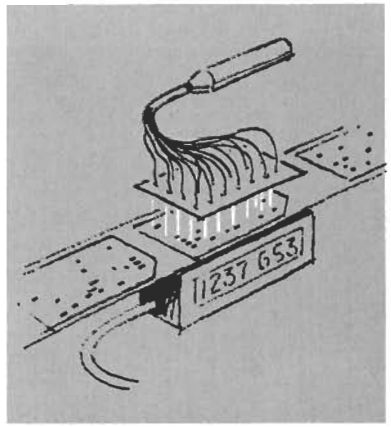
Create your own digital readouts with fiber optics



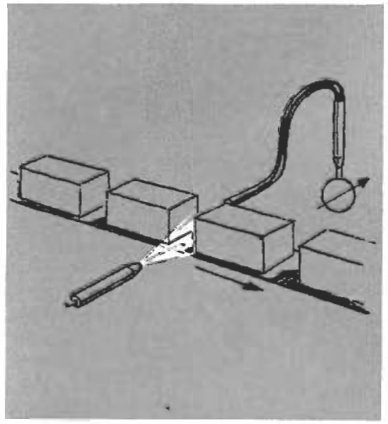
Fiber optic light guides level monitoring of automobile windshield washers



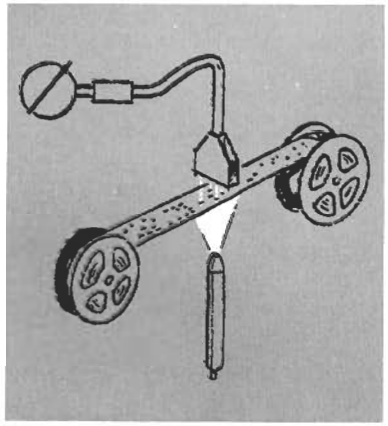
Lighting of microscopic slides . . .
(a) Lighting through microscope (from the bottom of viewing plate).
(b) Lighting from the top viewing plate.



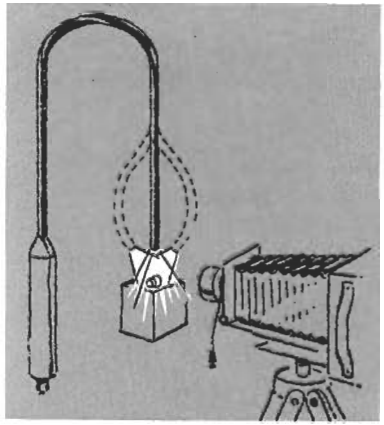
Sensing a keypunch card with a counter



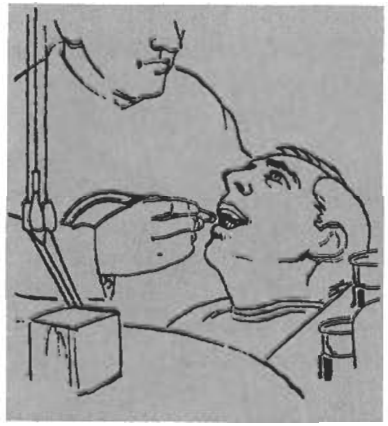
Industrial counters



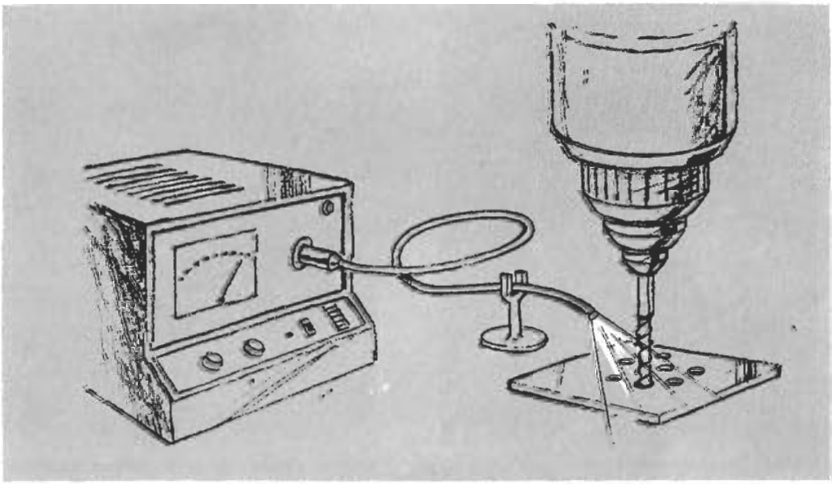
Light shines through barrier where there is no obstacle.



Lighting for photography, shadow free, glare free.



Dentists can use a Fiber Optics Light Source as supplementary lighting. Direction of the beam can be easily changed to correspond with a change in the work area within the oral cavity. The glareless, room temperature light is easily tolerated by the patient.



Many Industrial concerns have found the Fiber Optic useful as a bench illuminator. The base can be placed away from the work area, and the probe can be easily moved around to direct the beam where needed at any given time.

Fiber Optics is new, exciting and challenging . . .

We at International Rectifier would like to further the use of this phenomenal product in any way we can. It is our intent to publish more booklets concerning the use and applications of Fiber Optics.

International Rectifier will pay you $25.00 for any application of Fiber Optics which has not already been published, provided the application is submitted with complete detailed instructions on how your project was constructed, and is accompanied by a black and white or color photograph of the completed project. Your acceptance of the payment will automatically transfer all rights and privileges, legal and moral, with respect to your project and/or application.

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233 Kansas Street
El Segundo, California 90245

complete easy-to-follow details on fiber optic handling, bundling, cutting and terminations as well as project suggestions and applications included in "why-how-where of fiber optics". safe, cool light for everyone.

where there is light– there is an application! ...safe, cool light for unlimited uses.