FIBER OPTIC LINKS FOR PTTI DISSEMINATION

by

J. F. Bryant

Mr. Bryant is with the Naval Electronics Laboratory Center, San Diego, California.

This paper is about the fiber optic development work that has been going on at the Naval Electronics Laboratory Center, particularly an application for PTTI dissemination. I really don't know how old Fiber Optics happens to be, I think the Venetians probably started it in their glass work. I have been told that it is rediscovered every generation, and I think that it's about to be discovered again. One of the advantages of using fiber optic for transmitting data is that it is secure from radiation leakage. This is of benefit not only for secure systems for communications, but also for preventing cross-talk. Being glass, they provide no grounding problems, they are free of RF interference, and they are small and lightweight. To give an idea of the weight reduction, glass is about 150 to 208 pounds per cubic foot compared to copper which is approximately 544 pounds per cubic foot. Fiber optic lines are inexpensive, comparable with coaxial cable in cost, resistant to heat, and have high tensile strength. Of course there is no copper present, except as an impurity, hopefully there is none at all, and there are no ringing problems.

NELC was asked last spring to develop a repeater system that would receive the output from a clock or from an electronic system. The specifications that it was to meet were a one volt high and a one microsecond wide pulse. Also, it was to have as high a frequency response as possible.

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Initially, a semiconductor laser system was considered, but there are restrictions in its repetition rate because of some of the components in the driving circuitry and in the laser itself. Various techniques for improving the repetition rate of pulses are being studied at our laboratory at this time. We are using an infrared emitting diode and a silicon detector.

Figure 1 is a diagram showing the mechanism of fiber optics. On the left is a schematic of a single fiber; the core is a high index refraction glass, the cladding material is a lower index refraction glass. The fibers to be used at the present time are commercially available. There are a number of companies in the United States and throughout the world that make fibers; NELC happens to be using Corning Glass Work fibers. The index of refraction of the core is 1.62 and the index of the cladding is 1.47. This gives us a numerical aperture which defines the acceptance angle of the fiber to about .6. On the right is the configuration that one might have in a fiber bundle with a large number of individual fibers and a protective covering. The protective covering that we are using at the present time is a polyvinyl chloride which seems to be able to survive extreme temperatures. At least,I know that it will go to 124° centigrade.

The diameter of the individual fibers that we are using, as shown in Figure 2,is 1.8 mils. More than 200 fibers are used in each bundle but the overall dimension of the fiber bundle is 63 mils.

Figure 3 is a representation of the transmission of the core material. As we said, we are using an infrared emitting diode so the peak radiation is about 9,000 angstroms or 0.9 micron.

Figure 4 is a schematic diagram of a light-emitting diode showing how the radiation is distributed from it. These are typical manufacturer's configurations. In Figure 5, the circuit on the left gives an indication of how one drives a diode. The graph shows the spectral response of the diode as a function of wave length which peaks at 0.9 micron. A typical mounting of a photodiode generator is shown in Figure 6. Figure 7 shows the response

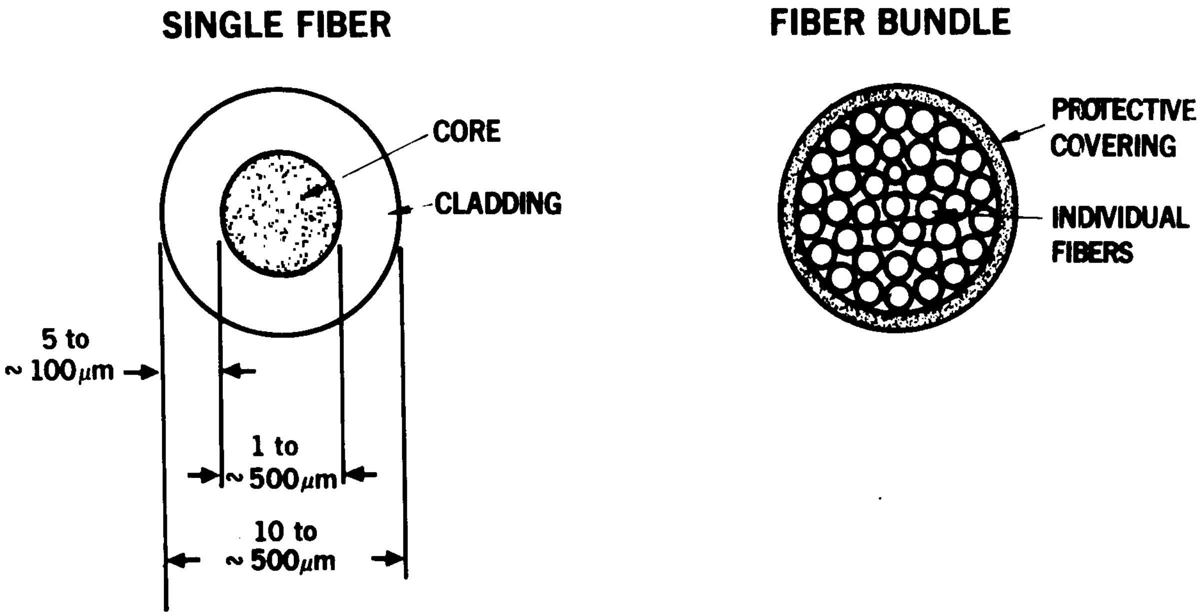

Figure 1. FIBER OPTICS MECHANISM

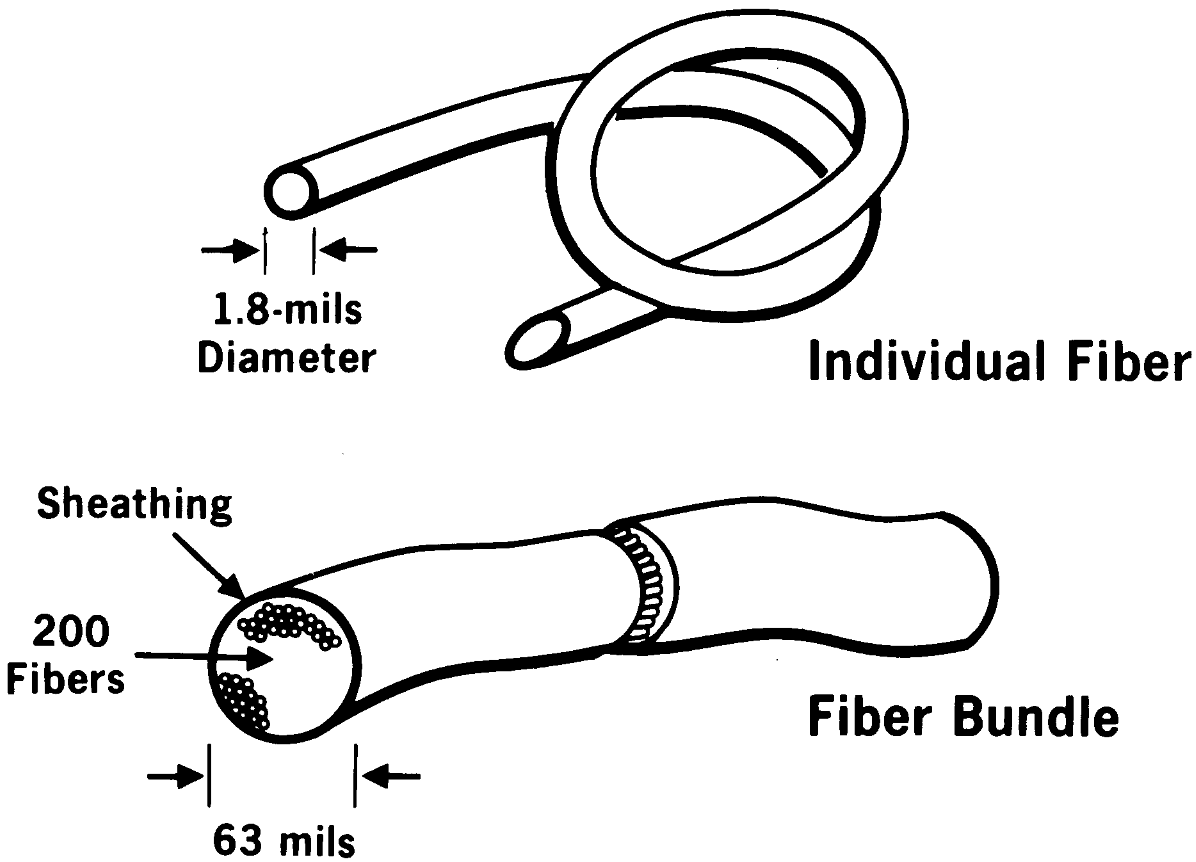

Figure 2. FIBER OPTIC DIMENSIONS

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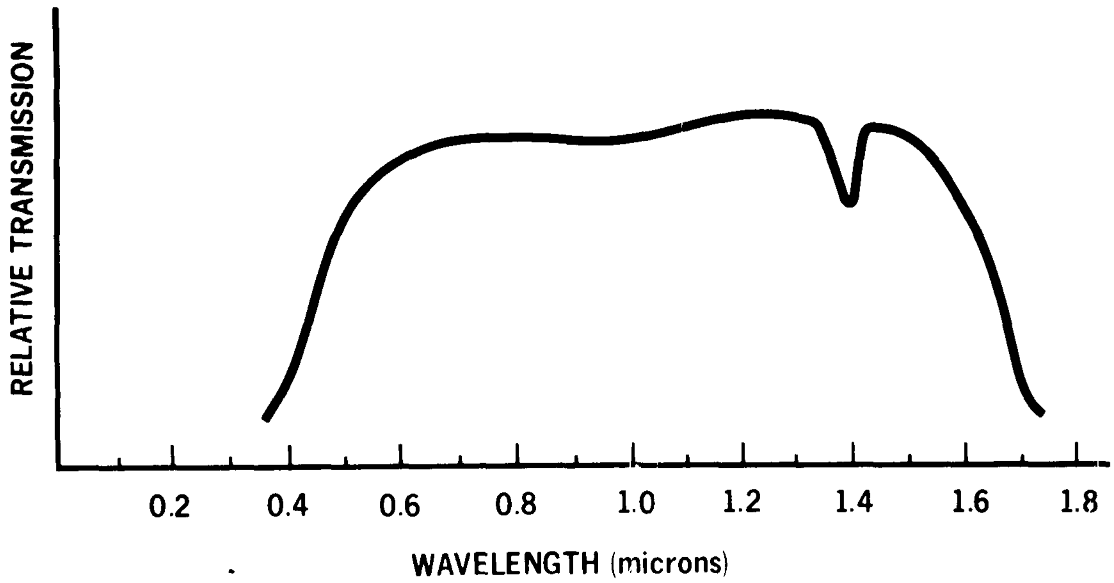

Figure 3. TRANSMISSION OF CORE MATERIAL

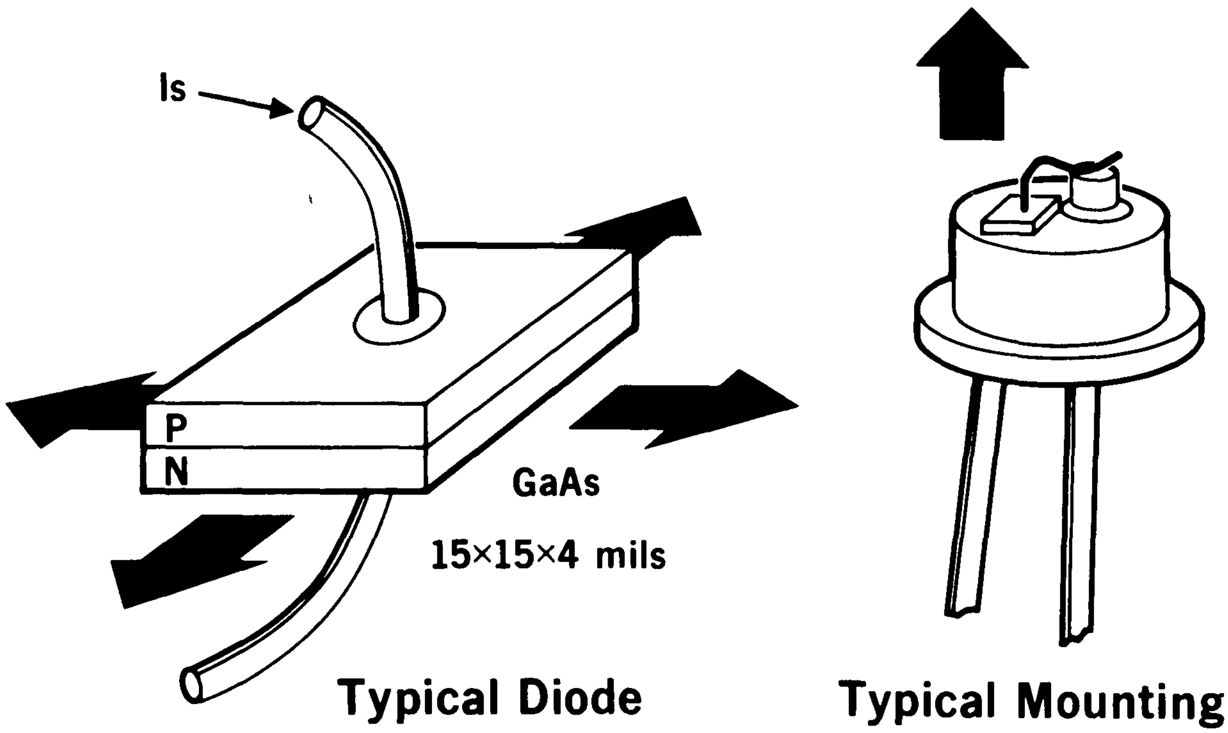

Figure 4. LIGHT-EMITTING DIODE

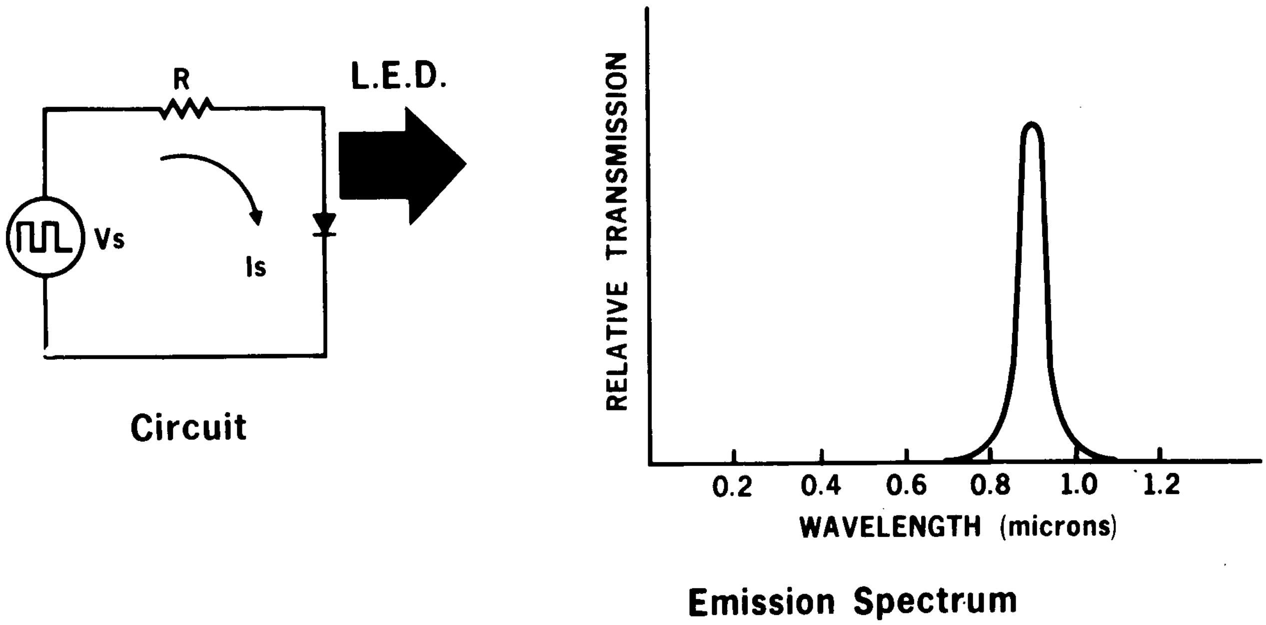

Figure 5. LIGHT-EMITTING DIODE (LED)

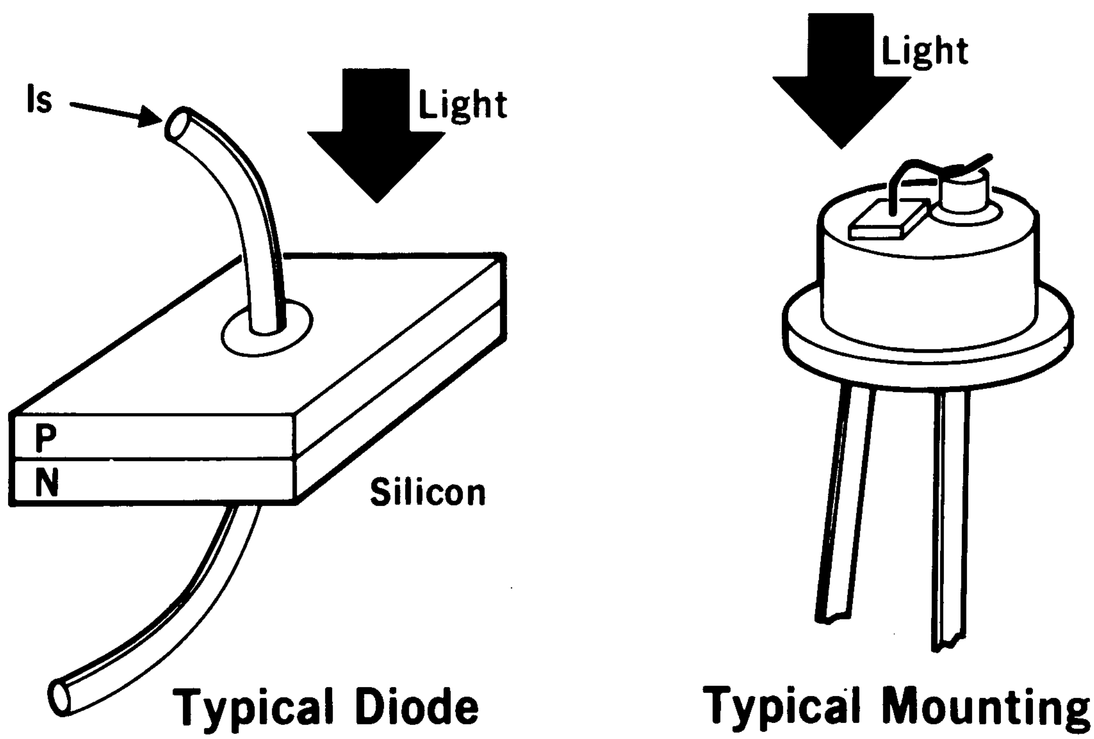

Figure 6. PHOTODIODE GENERATOR

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curve of the photo detector that we are using: a silicone photo diode which peaks at the wave length of the light-emitting diode being used.

Figure 8 is a schematic representation of the system that we have developed, which is a repeating system. An input is received, fed into the driver amplifier to excite the diode, and transmitted to some remote point through the fiber optic bundle. It is then detected by a photo detector and the pulse is reconstructed. The small PC board with the BNC connector, on the left in Figure 9, is the emitting diode section. Reading left to right we have the photo detector and the associated amplifiers, the trigger circuitry, and the pulse shaping circuitry. Figure 10 shows an experimental device; the power supply is in the base and the emitting diode is in the little box on top. The receiver, which has its own power supply, is shown in Figure 11. The circuitry is in the receiver with the power supply underneath. The power supply can be detached and, with a short cable, can be placed wherever you might like to have it.

Figure 12 shows the configuration we used with the transmitter on the left connected by the fiber optic bundle to the receiver on the right. One of the characteristics of this system is that our signal-to-noise ratio prior to entering our Schmitt trigger circuitry is 14.6 db. The radiation power out of the light-emitting diode is 3.5 microwatts and we are detecting .119 microwatts at the detector. There is a 15 db loss in the fiber optics. The measured jitter at 10 kilohertz with a 10 kilohertz with a 1 microsecond pulse is approximately 6 nanoseconds. The power consumption is 88 milliamps at 12 volts DC which is 1.03 watts. The transmitter is consuming 150 milliwatts; we have a total line power of approximately 1 watt. This system has a propagation delay time of approximately 200 nanoseconds. I would like to call your attention to a report by Dr. Taylor from our laboratory on transfer of information on Naval vessels via fiber optic transmission lines. This is available on request from the Laboratory.

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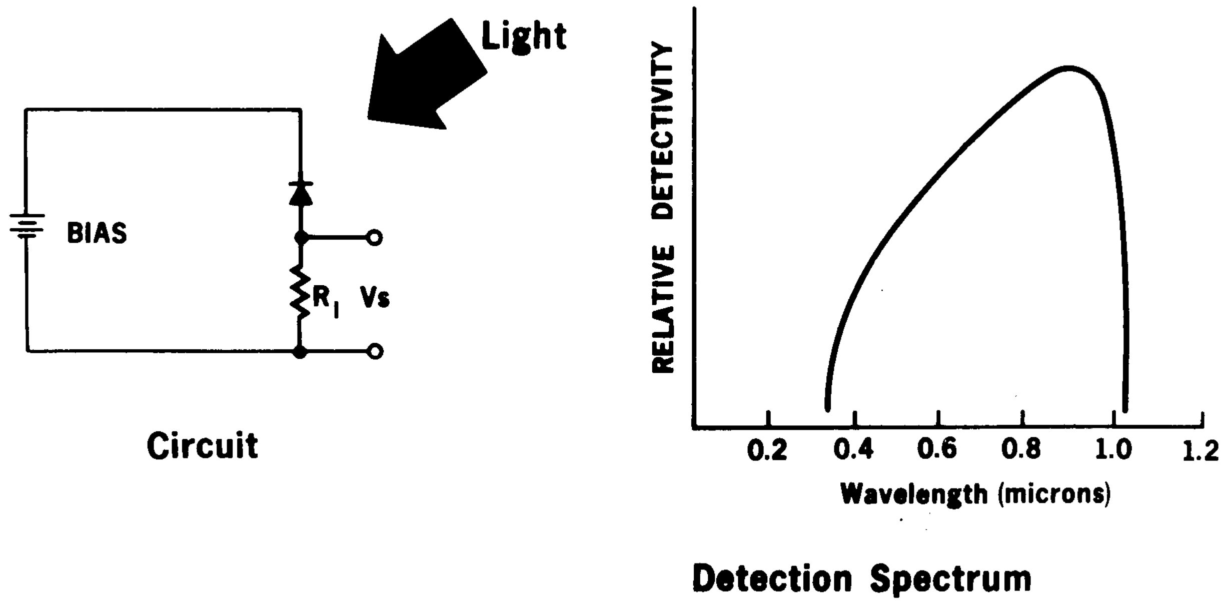

Figure 7. PHOTODIODE

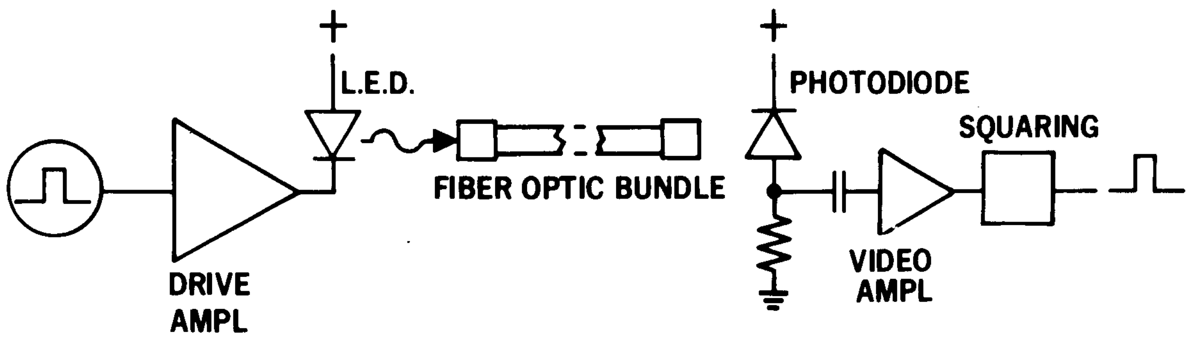

Figure 8. SCHEMATIC DIAGRAM OF A TYPICAL SYSTEM

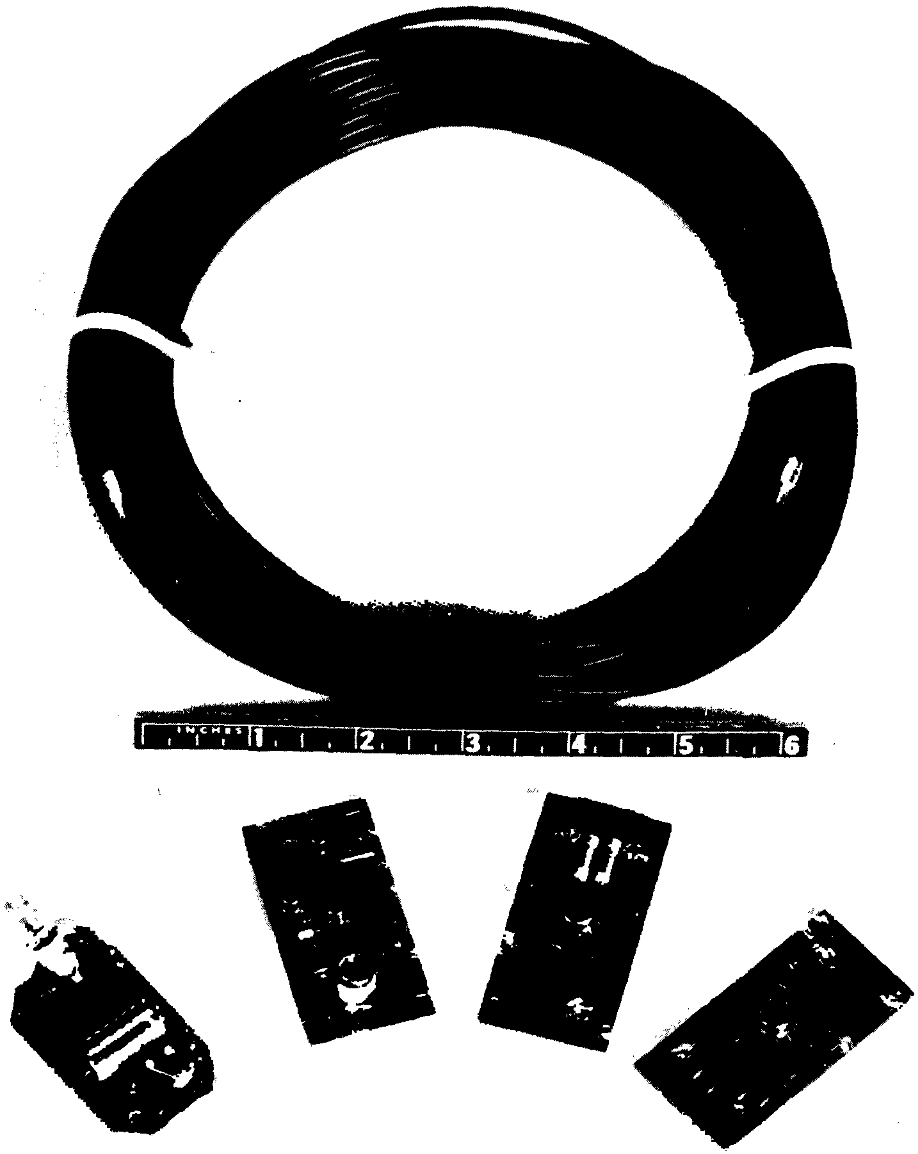

Figure 9. EMITTING DIODES

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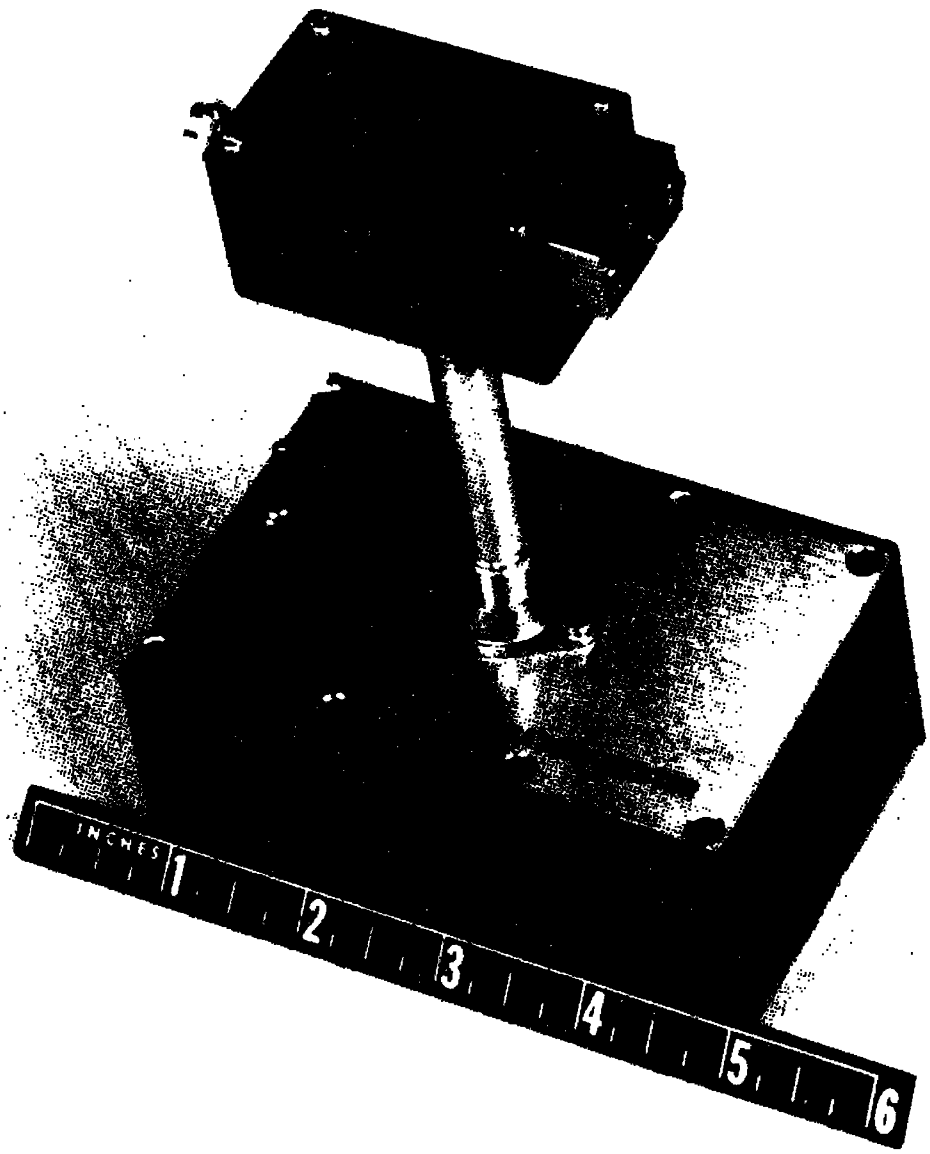

Figure 10. POWER SUPPLY AND EMITTING DIODE

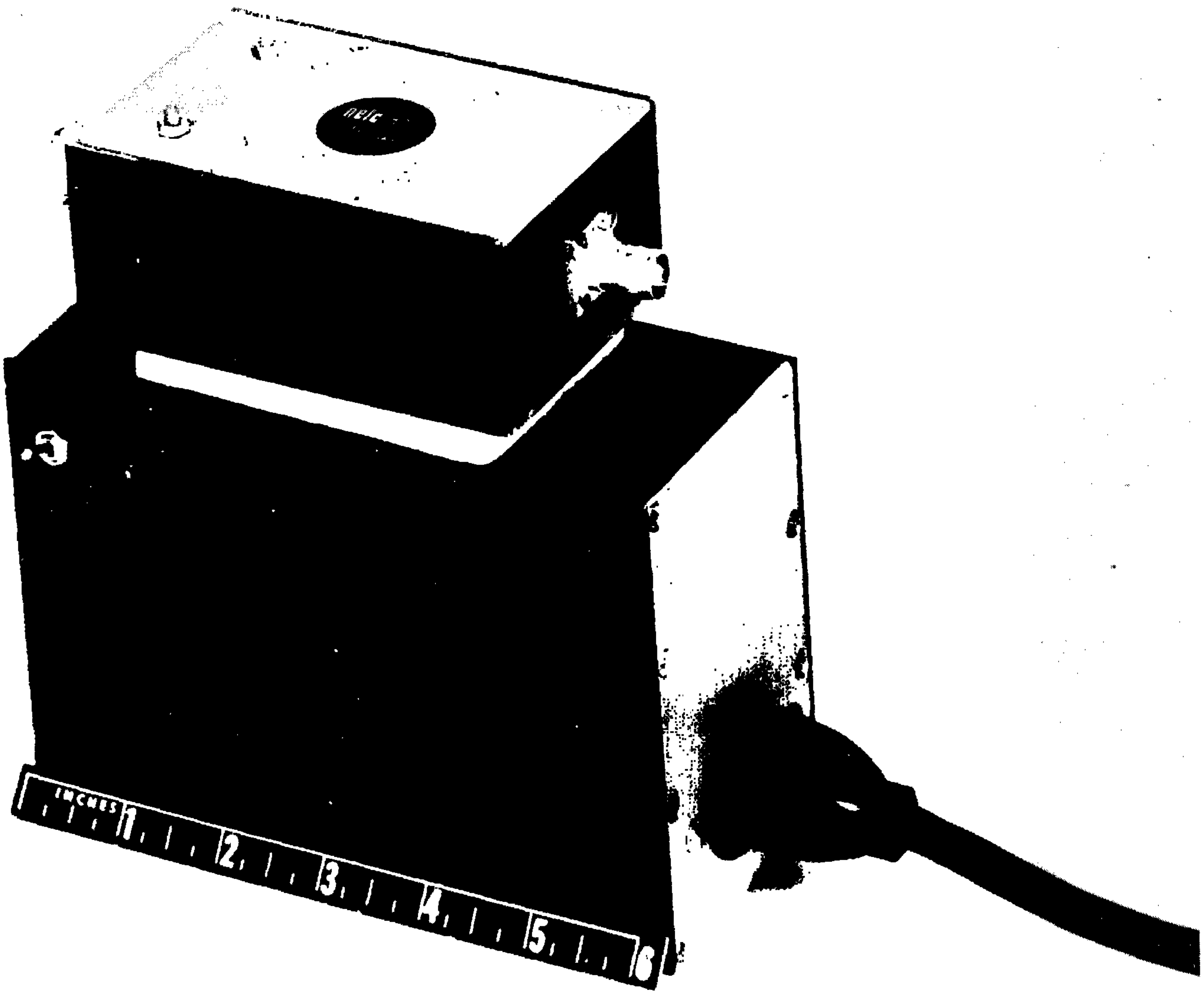

Figure 11. RECEIVER WITH POWER SUPPLY

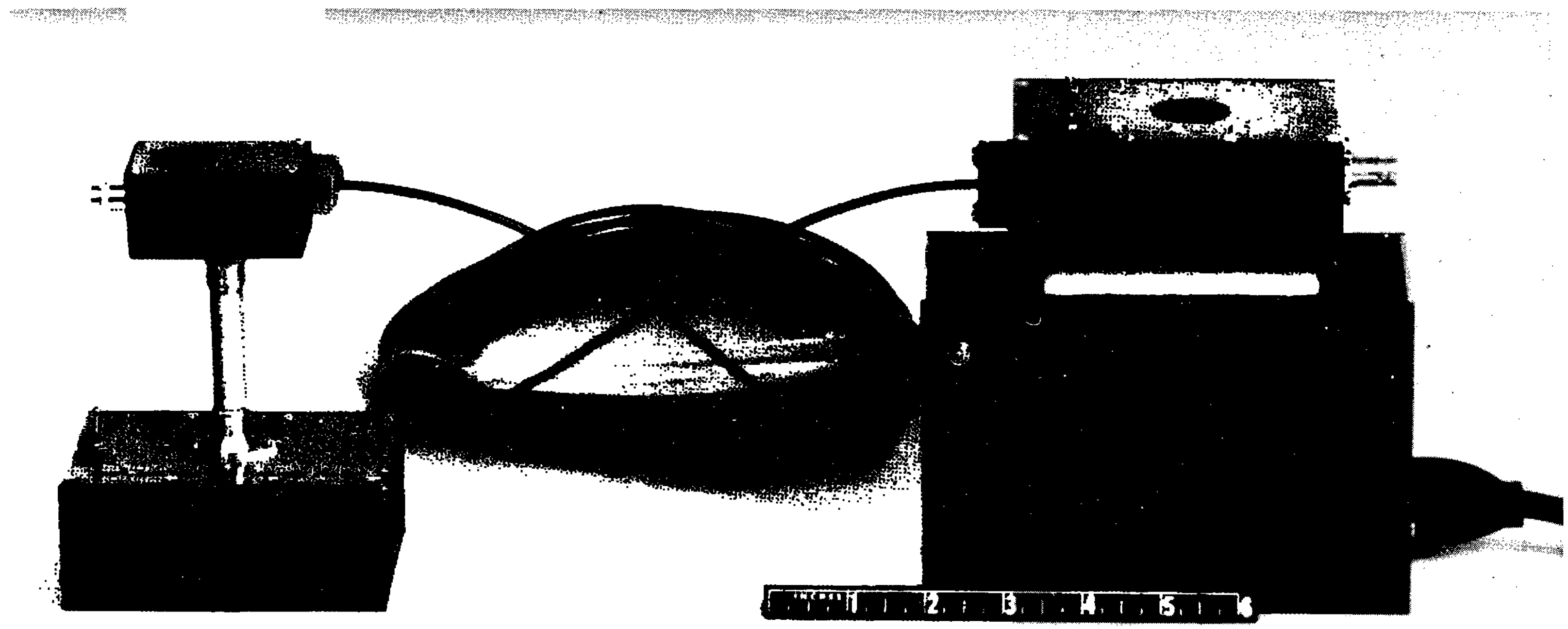

Figure 12. FIBER OPTIC CONFIGURATION

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DISCUSSION

MR. FOLTS: At the Defense Communications Engineering Office we are very interested in some of these techniques both for digital transmission and, perhaps, timing transmission. What is the general modulation frequency response over length of transmission and so on?

MR. BRYANT: Do you mean the modulation transfer function? For instance, if I were transmitting data through this, would I be able to run several miles with this at some fairly high speeds, or what? Well, at the present time, the commercially available fibers have a very high attenuation loss of approximately 1 db/ft. We are expecting delivery, within the next two months, of some specially developed fibers that have 0.1 db/ft. Next year we're hoping to have fibers that have about 0.01 db/ft so they are a little bit lossy. The loss mechanisms that are involved are absorption in the fiber optic bundle itself and also Fresnel reflection. These are very thin glass fibers, so there is some breakage. We have not as yet established specifications as to the number of broken fibers per bundle, but these are things that are to be worked on. Right now the losses are high due to coupling losses, Fresnel reflection, the packing density of the fibers in the bundle, and the number of broken fibers. I should point out that these are incoherent fibers, in that there is no correlation from one end to the other as to their spacial orientation. If you wish to use them for transmitting visual information, greater care must be taken in putting them together.

MR. FOLTS: You use a bundle as a single circuit rather than using individual fibers in a bundle for separate circuits.

MR. BRYANT: Yes, hopefully each fiber is carrying the same information and, ideally, there would be no broken fibers.

MR. PITSENBERGER: We've looked, in the past, at laser-initiated ordnance systems and this might be a variation if the power could be raised. Could you send a joule in a microsecond or a millisecond? What would be your limit?

MR. BRYANT: I'm not sure whether a joule, incident on the end of the fiber, is going to do any damage or not. It might do some pitting, it might not.

DR. HAFNER: You mentioned 200 nanoseconds delay. Is this exclusive of the propagation time through the cable or is this just your trigger and receiving circuit?

MR. BRYANT: That is the total time from the transmitter, through the fiber bundle, and through the receiver.

DR. HAFNER: What is the rise time of your pulses? How much degradation do you get?

MR. BRYANT: The rise time on the pulses from the LED is less than 10 nanoseconds.

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