

THE APPLICATION OF FIBER OPTICS TO COAL MINE PAGER TELEPHONE SYSTEMS

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ABSTRACT

This paper describes how the technology of fiber to optics can provide an intrinsically safe voice link between permissible and nonpermissible mine pager telephone systems. It further shows how an off-the-shelf fiber-optic communication system was modified to accomplish this purpose.

This fiber-optic link is undergoing final laboratory tests and will be ready for field trials later this year.

INTRODUCTION

With the increasing trend toward longwall mining, a problem has surfaced in attempting to provide communications to the longwall system's headgate area. Section 75.1002-1 in title of the Code of Federal Regulations (CFR) 30 CFR states, "Electric equipment other than trolley wires, trolley feeder wires, high-voltage feeder cables, and transformers shall be permissible, and maintained in a permissible condition when such electric equipment is located within 150 feet from pillar workings..." As a result, telephones located in the headgate area of a longwall mining system are required to be permissible.

When a telephone that is not intrinsically safe is connected to an otherwise permissible telephone system, it renders the entire system nonpermissible. Furthermore, connecting an intrinsically safe telephone to a nonpermissible system still results in a nonpermissible telephone system since the lines to the intrinsically safe telephones are not intrinsically safe. Consequently, establishing a communication link from a nonpermissible telephone system to the headgate of a longwall system requires more work than just adding another intrinsically safe telephone to the end of the existing system.

Most mines that have added a longwall section are already equipped with nonpermissible telephone systems; therefore, some method needs to be devised to communicate to the headgate area of such mines while still complying with Section 75.1002-1 of the CFR. One way to do this would be to install only permissible telephones throughout the entire mine. However, for older mines with established communication systems, an over change of this magnitude could be very costly.

Another method that looks very promising and can provide electrical isolation without the loss of communications uses fiber optics. Fiber optic phone links, unlike standard twisted-pair telephone lines, are nonmetallic, transfer only light signals, and are, therefore, incapable of transmitting unsafe voltages. The advantage of these links is that nonpermissible telephones can now communicate with permissible telephones without transferring any electrical energy; only inherently safe light signals are used.

THE FIBER-OPTIC TELEPHONE LINK

This fiber-optic link is designed to use a pair of 12Vdc Pyott-Boone permissible mine pager telephone and a 50 meter Math Associates Model 1800 analog fiber-optic telephone link.¹ The system is designed to duplicate the simultaneous voice broadcast (all page) function of standard pager telephones and to permit paging, through the fiber, to a standard permissible pager phone located beyond the link. To accomplish this, the system does two things: 1) It transfers incoming page signals (12Vdc) and reproduces them at the other end of the link, and 2) it transfers incoming voice messages and also reproduces these at the other end of the link. Both of the transfers are accomplished by transmitting only optical energy through the glass fibers.

PAGING

The fiber-optic circuit action, described below, occurs when the headgate area is paged from a nonpermissible telephone located elsewhere in the mine (see Figure 1).

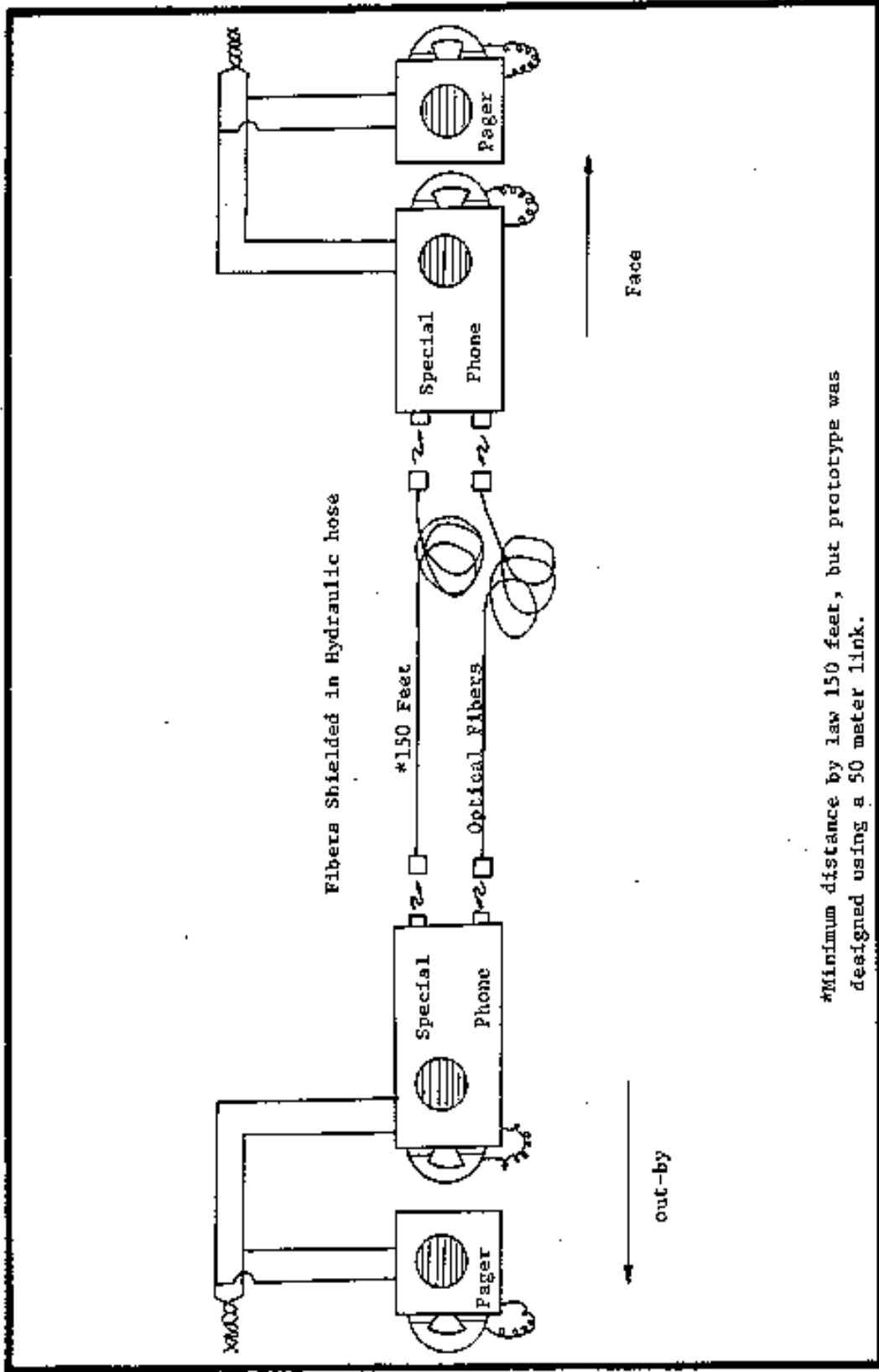
The system is bidirectional; the returning light is transmitted on a second fiber. This second fiber is needed because optical devices are unable to both transmit and receive light waves of the same frequency on a single fiber.

To extend battery life, all circuits except the optical receiver are kept deenergized until an incoming page signal is received. This is done by opening the circuit's power grounds and is particularly necessary in the fiber-optic link, since the link draws 83 ma of current when operating in the transceiver mode.

INCOMING PAGE

The incoming page (12Vdc) causes four things to happen simultaneously in the fiber-optic link. 1) It energizes the system by closing a solid-state switch in the paging relay circuit (see Figure 2), 2) it activates the telephone's paging amplifier, 3) it causes a 17 kHz paging tone to be generated, and 4) it causes the optical transducer to convert the paging tone to an analog light wave. This wave is then transmitted 50 meters through the fiber-optic cable to the headgate phone.

¹Reference to specific brands or trade names is made for identification only and does not imply endorsement by the Mine Safety and Health Administration.



*Minimum distance by law 150 feet, but prototype was designed using a 50 meter link.

Figure 1 - Typical Interface Installation.

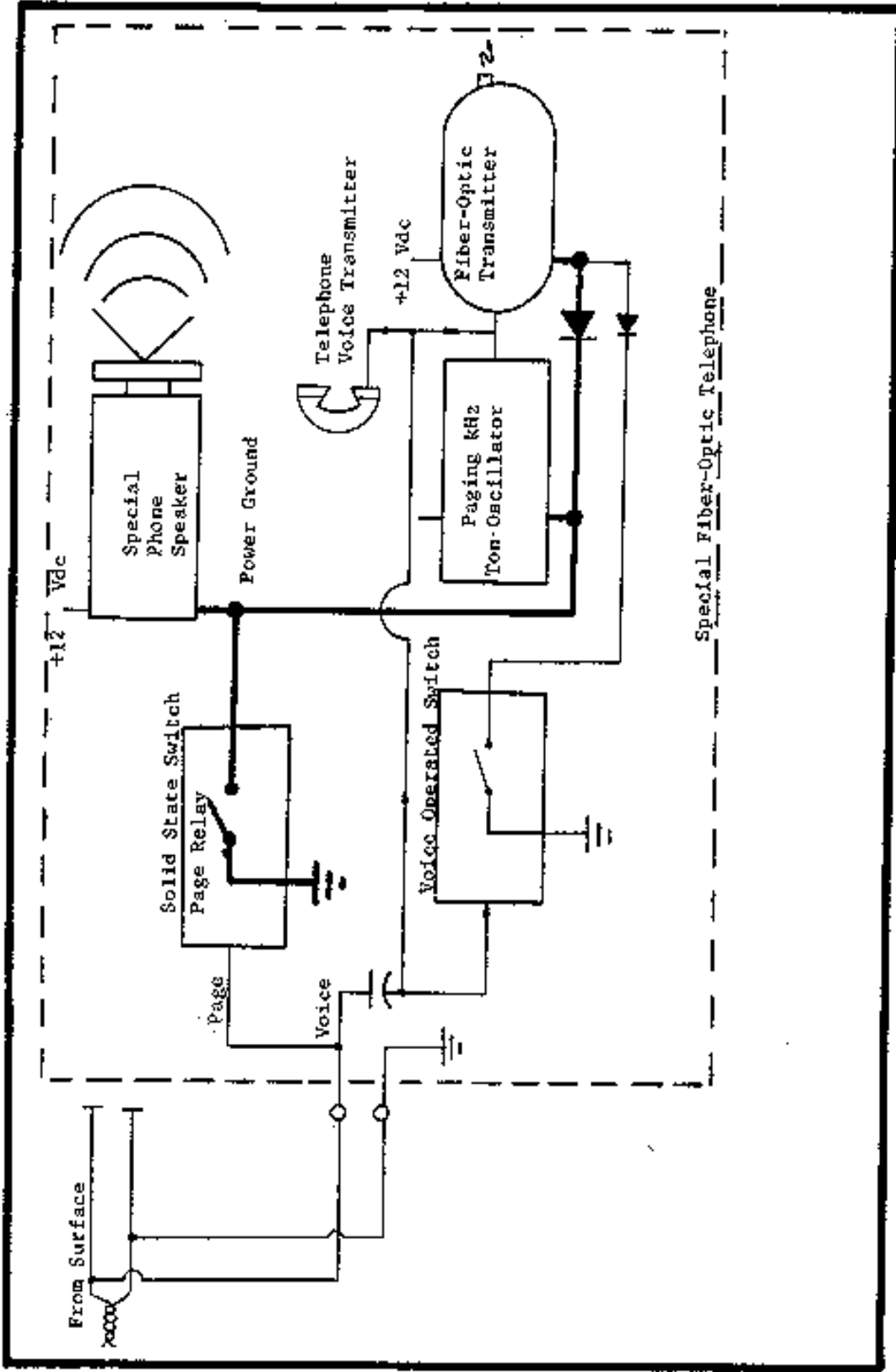


Figure 2 - Incoming Page to the Face.

OUTGOING PAGE

The optical receiver and decoder in the headgate special phone demodulate the incoming light wave (see Figure 3) and convert it to an electrical pulse. This signal then provides power for the phone by closing a grounded solid-state switch in the decoder circuit. This action closes relay k_1 , which simultaneously applies 12Vdc to the audio amplifier circuit and to the phone lines. The page therefore, continues, and all phones on the longwall machine are now ready for a voice message.

VOICE TRANSMISSION

After the page is complete, all circuits except the optical receiver are once again deenergized until the incoming voice is used to reactivate them. A voice operated solid-state switch (VOX) (see Figure 2) energizes the system again and activates all circuits except the paging circuits (loudspeaker amplifier and paging tone generator). The voice signal is simultaneously fed to the fiber-optic transmitter for transmission to the headgate phone.

When the optical transducer at the headgate receives the incoming conversation, it simultaneously transfers the voice to and initiates power for the audio amplifier circuit. The amplified voice is then placed on the phone lines and a conversation is initiated via the handsets. The system also works the same for transmissions in the reverse direction.

INSTALLATION

The fiber-optic link should be connected to the phone system about 150 ft. outby the headgate.² The permissible phone can then be located at the headgate for communication with other parts of the mine.

The fiber-optic cable should be protected by enclosing it in a spongy hydraulic hose. This limits any destructive bend-radius problems that might exist, protects it from rock falls, and provides less expensive protection than special cable casings. This approach has been used successfully in other heavy industries.

MAINTENANCE

The system requires no calibration and can be easily repaired by replacing solid-state modules and relays.

²Federal Regulations (30 CFR 75.1002-1) require all nonpermissible electric equipment to be located at least 150 ft. from pillar workings.

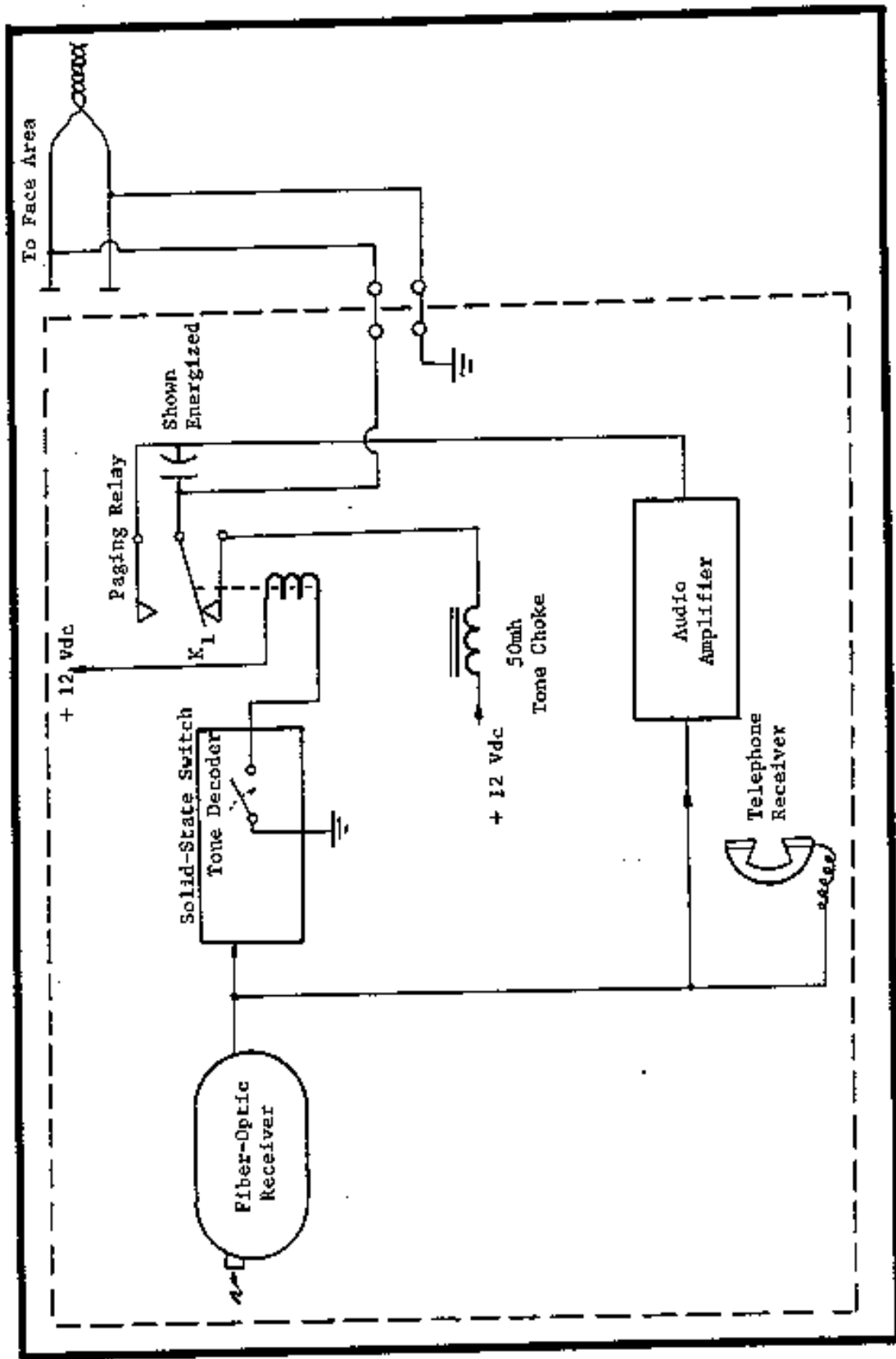


Figure 3 Outgoing Page

If the fiber should be damaged, which is unlikely if it is permanently mounted in a hydraulic hose, it can be replaced for about \$250. This is much cheaper and less time consuming than attempting to locate and repair damage to optical cables. Splicing techniques for optical cables are somewhat tedious and should be carried out in a clean environment.

SYSTEM COST

Based on an estimated cost of \$2,500 for parts, a manufactured system should sell for about \$4,000. While this may seem expensive, the costs are negligible when the price of a longwall machine, the additional safety benefits, and the reductions in downtime are all considered.

CONCLUSIONS

A fiber-optic system appears to be a safe, moderately priced method for providing a permissible telephone link to a nonpermissible mine communication system.

The fiber-optic link has demonstrated its capability to function during laboratory tests. Mine demonstrations of the unit are scheduled for the near future.