TELEVISION APPARATUS FOR BOREHOLE EXPLORATION

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Abstract.—A closed-circuit television system has been developed which operates in 8-inch-diameter and larger holes to depths of approximately 1,000 feet in either dry or water-filled holes.

A closed-circuit television system for use in water wells has been developed that can be operated in boreholes 8 inches in diameter and larger. The equipment is well adapted for locating and examining fractures and solution openings, and for identifying changes in lithology in uncased holes drilled in consolidated rock. It is useful also for examining the position and condition of screens, casing, and obstructions in cased holes. The equipment was designed to be as simple as possible and to operate at a maximum hydrostatic pressure of 1,000 feet of water.

The system uses a high-resolution Kin Tel camera and monitor modified for use in boreholes. The monitor and camera provide a full 500-line resolution, which is about twice that of home television receivers. A 14-inch aluminized picture tube with a Polaroid filter mounted in front provides a bright clear picture even in high ambient light.

The control unit was designed to provide a high degree of flexibility for both camera and monitor. The unit includes a video amplifier of 8-megacycle bandwidth to furnish the 500-line resolution. Remote camera controls including horizontal and vertical centering controls may be used to shift the field of vision electronically. Fully automatic electronic target control provides self adjustment of the image intensity over a range of 4,000 to 1. Service and operation of the unit have been simplified by placing all the control adjustments on the front panel and building the chassis so that it may be removed readily from the front of the mount.

Two cameras were used in the development of the present equipment. The first was a Kin Tel model 1990 enclosed in a metal tube 17¾ inches long by 6 inches in diameter. This camera was fitted with a lens with motor-driven focus and iris adjustments, and a mirror attached to the front of the case for viewing the side of the borehole. Several combinations of lenses and closeup attachments were used, but the results were generally unsatisfactory.

The second camera was built from a Kin Tel model 1986–C studio camera, modified to fit into an aluminum tube 36 inches long with a 4½-inch outside and a 3½-inch inside diameter. The lower end is fitted with a quartz-glass plate a quarter of an inch thick, specially cut from glass having a tensile strength of 2,000 psi. Both the viewing end and the upper end of the camera case are fitted with O-rings and sealed with silastic rubber. A high-pressure coupling with neoprene sleeves joins the conductor cable to the camera. The camera (with attached cable) has been tested successfully in a pressure chamber to simulated depths of 950 feet of water.

The camera assembly uses a very wide angle fixed-focus lens–a French-made Kinoptick "fish eye" lens with a focal length of 5.7 mm, a field of view of 117°, and an overall diameter of 3½ inches. This lens has a depth of field of from 4 inches to infinity, thus making it possible to see the lighted area of the well bore very close to the camera and eliminating the problems involved in the motor-driven iris and focus controls. The camera is shown in figure 172.1.

The most difficult problem of design has been adequate illumination in the viewed area when the camera is below water level in a well. Absorption and dispersion of the light in water reduce greatly both the contrast and intensity of the image received. The problem of lighting becomes increasingly difficult in designing lights for relatively small diameter holes. The most satisfactory lights used were 3-inch quartz iodide lamps rated at 600 watts each, wired in parallel. In larger holes, 3 lamps directed ahead at a 45° angle were placed 8 to 10 inches to the side of the camera.

In small holes the best results were obtained with 3 lights positioned 120° apart and mounted on the lower

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FIGURE 172.1.—Camera with attached lights. A reel, wound with 1,300 feet of 24-conductor cable, is mounted in the truck.

end of the camera case (fig. 172.1). With the lamps in this position, light is directed both outward and downward on the sidewall of the hole. In an 8-inch hole the lighted area of view extends from approximately 4 inches to 30 inches in front of the camera. Because of the heat generated, the quartz iodide lamp can be used for prolonged periods only when immersed in water. At present the lighting is only adequate; it is expected that future experimentation will improve this important part of the system.

A municipal well at Hampstead, Md., was used for experimental tests of the equipment. The well, which is 8 inches in diameter and was drilled by the cable-tool method, penetrates fractured gneiss and schist of the Piedmont physiographic province. It is 400 feet deep and is cased to a depth of 60 feet. Tests were limited, however, to depths of about 200 feet because the reel assembly was not equipped with a motor.

In the piedmont, ground water is produced largely from joints and fractures in the rock. Fractures, irregularities of the hole, changes from lighter to darker rock, and quartz veins were clearly distinguishable on the TV monitor. Figure 172.2 is a typical closeup photograph of the monitor showing some of the features observed in the uncased part of the borehole. Like home TV, the picture is sharper when viewed directly rather than from a photograph of the image.

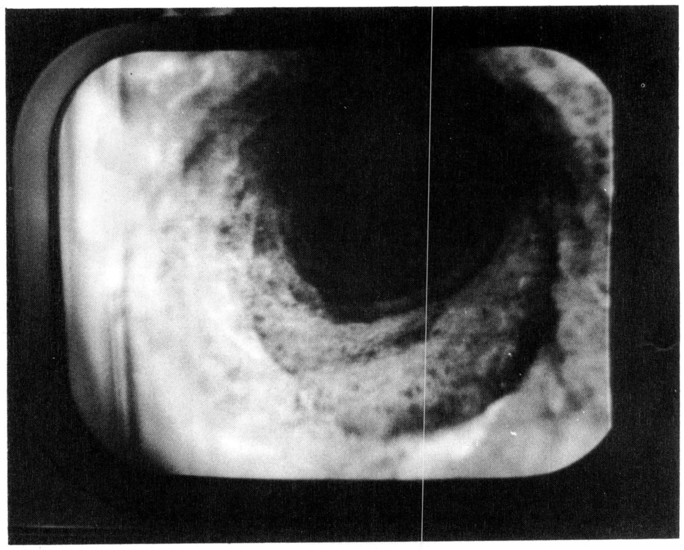

FIGURE 172.2.—Joints enlarged by drilling, in well at Hampstead.

The experiments indicate the usefulness of the TV apparatus, particularly where ground water occurs in joints or solution openings. Although the present equipment is fully operational, additional improvements are being designed; for example, except for the vidicon tube, the camera circuit can be completely transistorized. This will make it feasible to provide a part of the camera power through self-contained batteries, and will reduce the number of conductors required from 24 to perhaps 12—permitting a sizable reduction in cable weight and cable-spool size.

Transistorizing the camera also makes it feasible to reduce the diameter of the metal case containing the camera and accompanying circuit. It is expected that a modified camera assembly, without the light assembly, can be built with a 3½-inch outside diameter. Depending upon the lighting arrangement, this may make it possible to operate the equipment in 6-inch diameter holes.

A number of lighting changes are under consideration, but most of these improvements will be based on experiments in boreholes. Proper lighting appears to be a question of correctly positioning and directing the lights. Commonly, if the lights are improperly positioned, a "hot spot" or intensely lighted area saturates the picture tube. Possibly, monochromatic light with a wavelength selected to coincide with the most sensitive range of the vidicon tube may reduce light dispersion and absorption. Experiments are planned to test the feasibility of using such a lighting system.