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X-RAY MONITORING OF 230-kV CABLE POTHEADS FOR MAINTENANCE INSPECTIONS

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INTRODUCTION

The maintenance engineer of a large hydroelectric power plant should have the necessary tools to assist in the prediction of potential cable failure problems. For this purpose, Battelle, Pacific Northwest Laboratory designed a system by which pothead connections and corresponding components can be radiographically inspected for high mechanical stresses and corresponding failure potential. The system was used to inspect the potheads of cables in the high-pressure, oil-filled, pipe-type cable system at the Grand Coulee Project.

The 230 kV potheads in this radiography inspection were installed in 1968 and became operational in 1969. The 230 kV cables from the power houses were routed up the sloping face of the dam, then through a tunnel to the consolidated switchyard. Cable lengths vary from approximately 2,900 to 3,200 ft with one splice per cable between pothead terminations. The elevation change and long cable increase the possibility of high stresses on pothead connectors and the need for periodic inspection.

RADIOGRAPHY INSPECTION

A cobalt 60 radiation source with a specially designed lead collimator was used to make high-resolution radiographs of the potheads. Film cassettes

DISCLAIMER

were mounted on a special steel framework, which was attached to the top of the potheads. Vertical guide rails on the framework allowed precise positioning of the film cassette and the source collimator. Figures 1 and 2 show the equipment setup around a 230 kV pothead.

The radiographs clearly showed the mechanical condition of the pothead and cable components and could be used to identify components that deviated from their as-designed conditions. The radiographs could easily reveal signs of mechanical stress, such as longitudinal displacement of cable strands at the end of the cable and deformation of the stress cone supporting the cable. Two radiographs made at the same vertical position at two different angles around the pothead are needed to make a full-perspective inspection of a specific component.

A procedure was developed for logging all data obtained, including circuit number, phase, exposure geometry, and radiograph location (0° to 360° around the pothead with vertical position). A high-resolution radiograph can then be made later at the same location on the pothead as any previous radiograph. This referencing system provides an accurate means for producing overlaying radiographs to show changes in cable component details and to monitor the movement of cable components.

SELECTION OF EQUIPMENT AND PRELIMINARY INVESTIGATIONS

Before the radiographic techniques could be implemented, the equipment needed some refinement, and the techniques required testing to insure that there would be no damage to the organic constituents of the potheads as a result of gamma exposure. All relevant information on the effects of gamma radiation on various organic materials was obtained in previous Battelle work.[1]

Laboratory evaluation and onsite testing of the equipment and supplies were required to anticipate and prepare for possible safety problems associated with performance of the field work.

The radiation source had to have the capability to penetrate steel, ceramic, stainless steel wires, brass connectors, and copper conductors inside the potheads to produce high-resolution radiographs. These requirements were met by using a premium-fused, high-specific-activity, 130-curie cobalt 60 radiation source with a specially fabricated lead collimator.

The film had to have adequate density and the ability to withstand temperatures up to 100°F. This required the onsite testing of many types of film. Film cassettes were modified by using lead filters to give better resolution and calcium fluoride screens to reduce exposure time.

Preliminary radiographs were made to determine the best position at which to locate the radiation source. Figures 3 through 5 show some of the radiographs. This experimentation was needed to find optimum exposure times and the proper thicknesses of the lead filters to obtain the best film resolution for an accurate view of specific components inside the potheads. Exposing double film loads with films of different speeds in a single cassette provided radiographs with differing depths of field. This allows a single exposure to produce radiographs with their best definitions at different areas of interest. Figure 6 shows an example of a conductor in the crimped area of a 230 kV connector inside a pothead.

Temporary laboratory facilities were set up in the switchyard with a darkroom for loading and developing the film cassettes and viewing the radiographs. This permitted rapid evaluation of the radiographs as they were obtained.

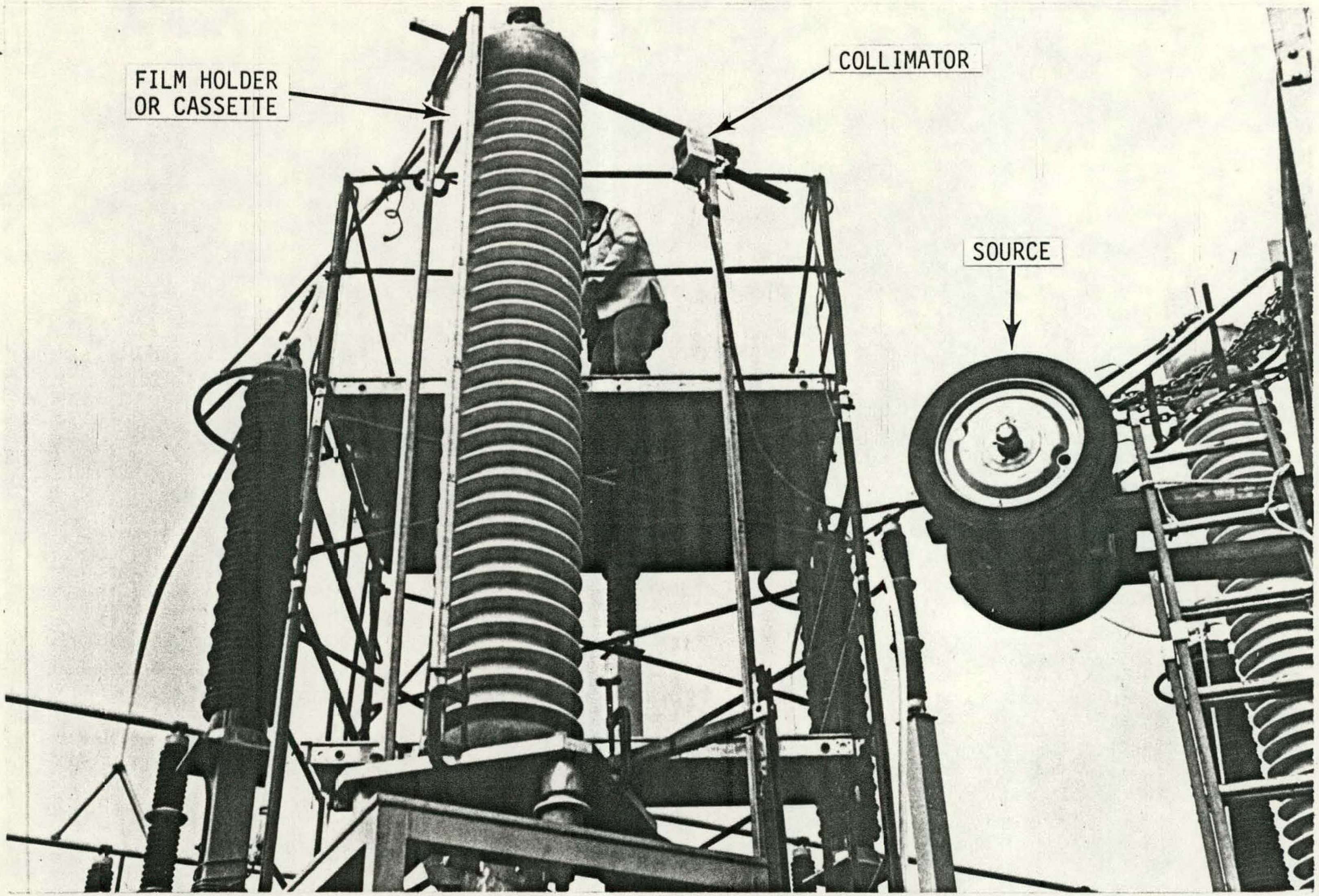
CONCLUSION

Radiography can verify conditions of cables and potheads that could result in future problems. It cannot positively identify an imminent failure. This limitation of radiography should be recognized, and care must be exercised in the interpretation of inspection radiographs. However, there is a certain amount of confidence to be realized when the cable or pothead mechanical condition appears to be normal or as-designed, and when no changes can be observed over a period of time.

With further development of radiographic techniques and special equipment, it should be possible to inspect the condition of cables inside steel-flange or ceramic potheads with a single type of cassette and a standard exposure geometry.

REFERENCE

1. Lawrence, R. C., Preliminary Evaluation of Irradiation Levels for Materials Used in Cables, Potheads and Splices. BNW-564. Battelle, Pacific Northwest Laboratory, Richland, Washington 99352.



<u>FIGURE 1.</u> Equipment Setup around 230 kV Pothead

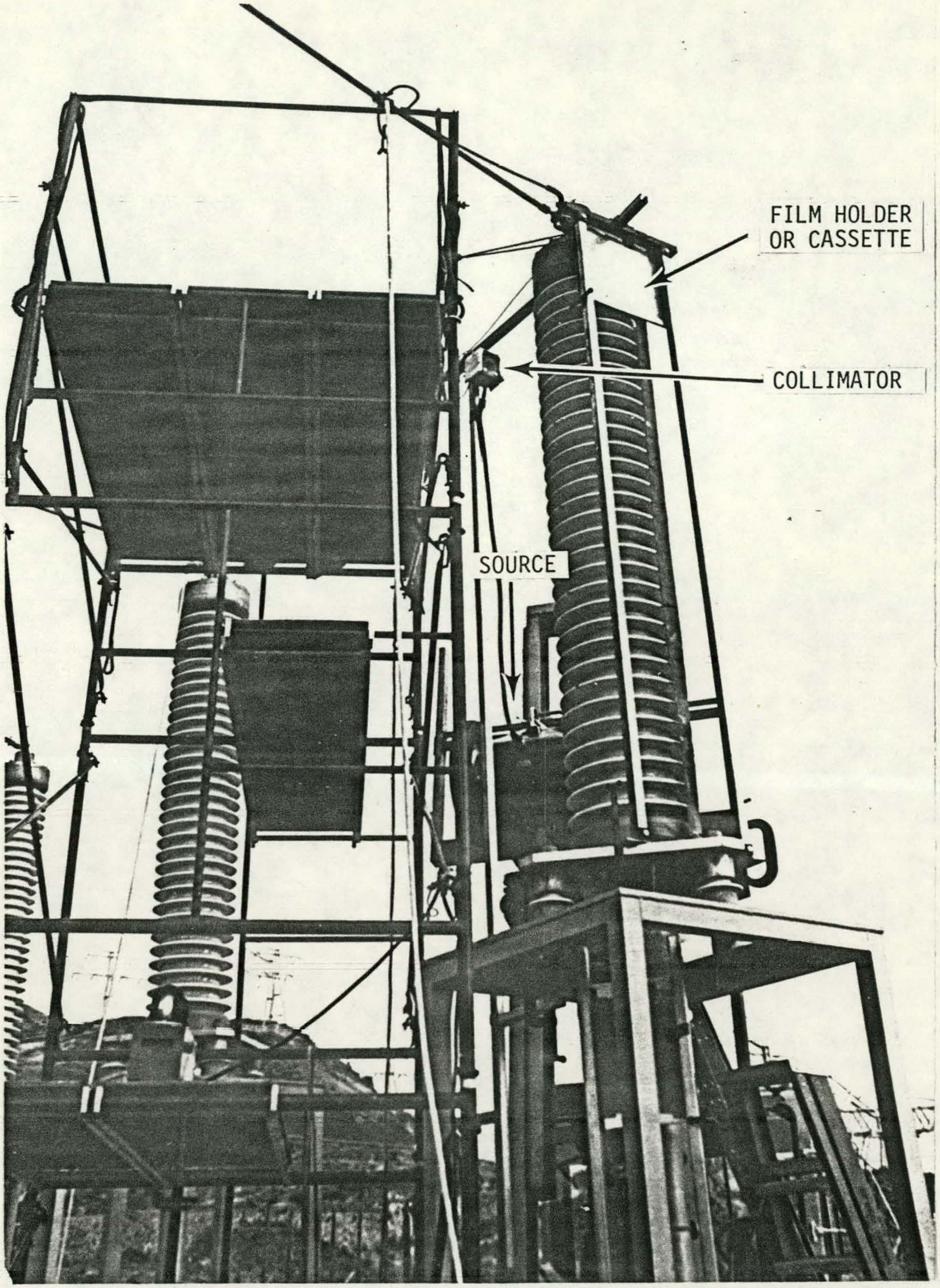


FIGURE 2. Equipment Setup around 230 kV Pothead

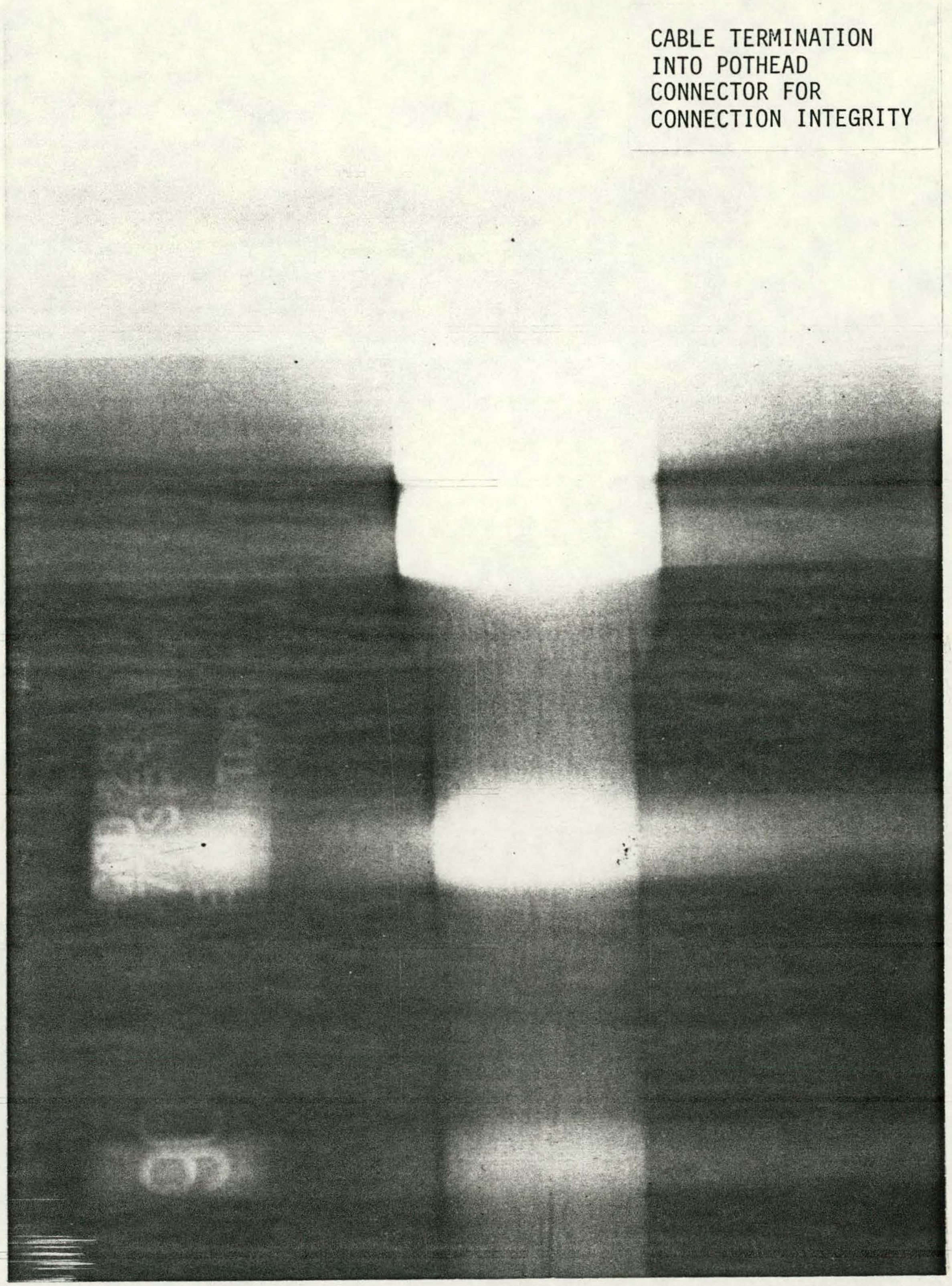
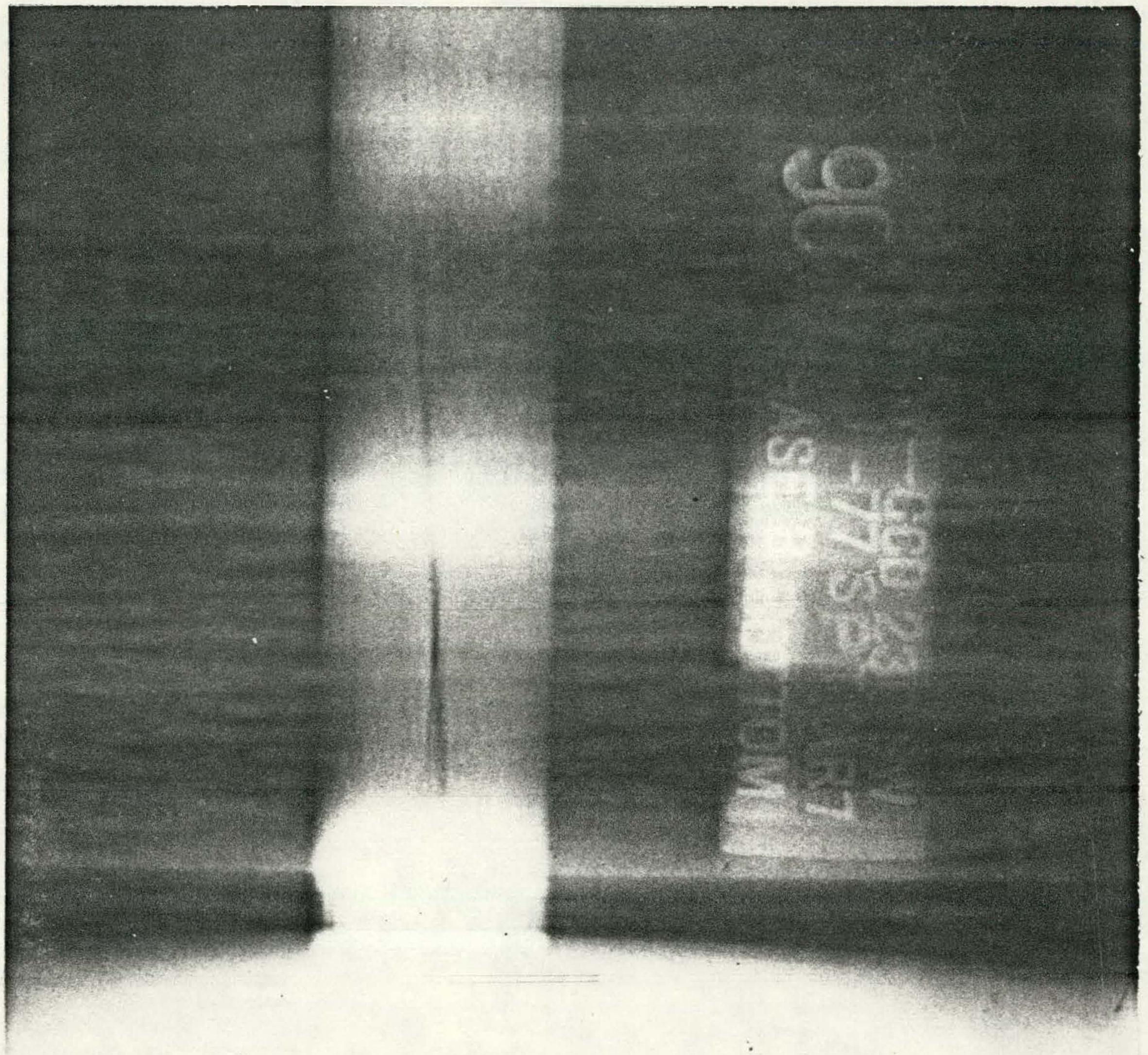


FIGURE 3. Radiograph



SWITCHYARD POTHEAD - "B" PHASE.
POSITION - PORCELAIN INSULATOR -
BOTTOM FLANGE
AXIS - 90^{o}

EXPOSED FOR CABLE STRANDING "GAP"

FIGURE 4. Radiograph

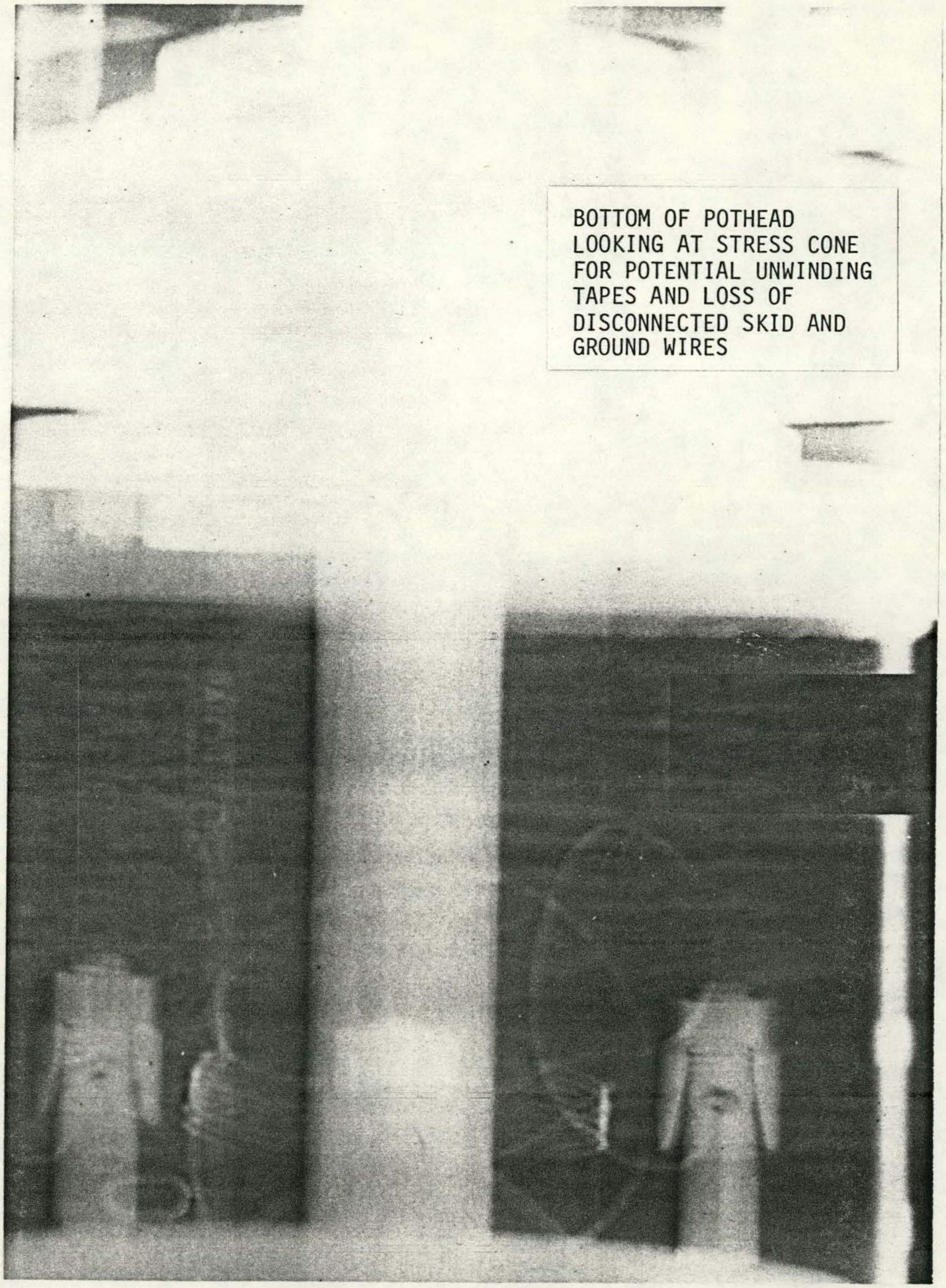


FIGURE 5. Radiograph

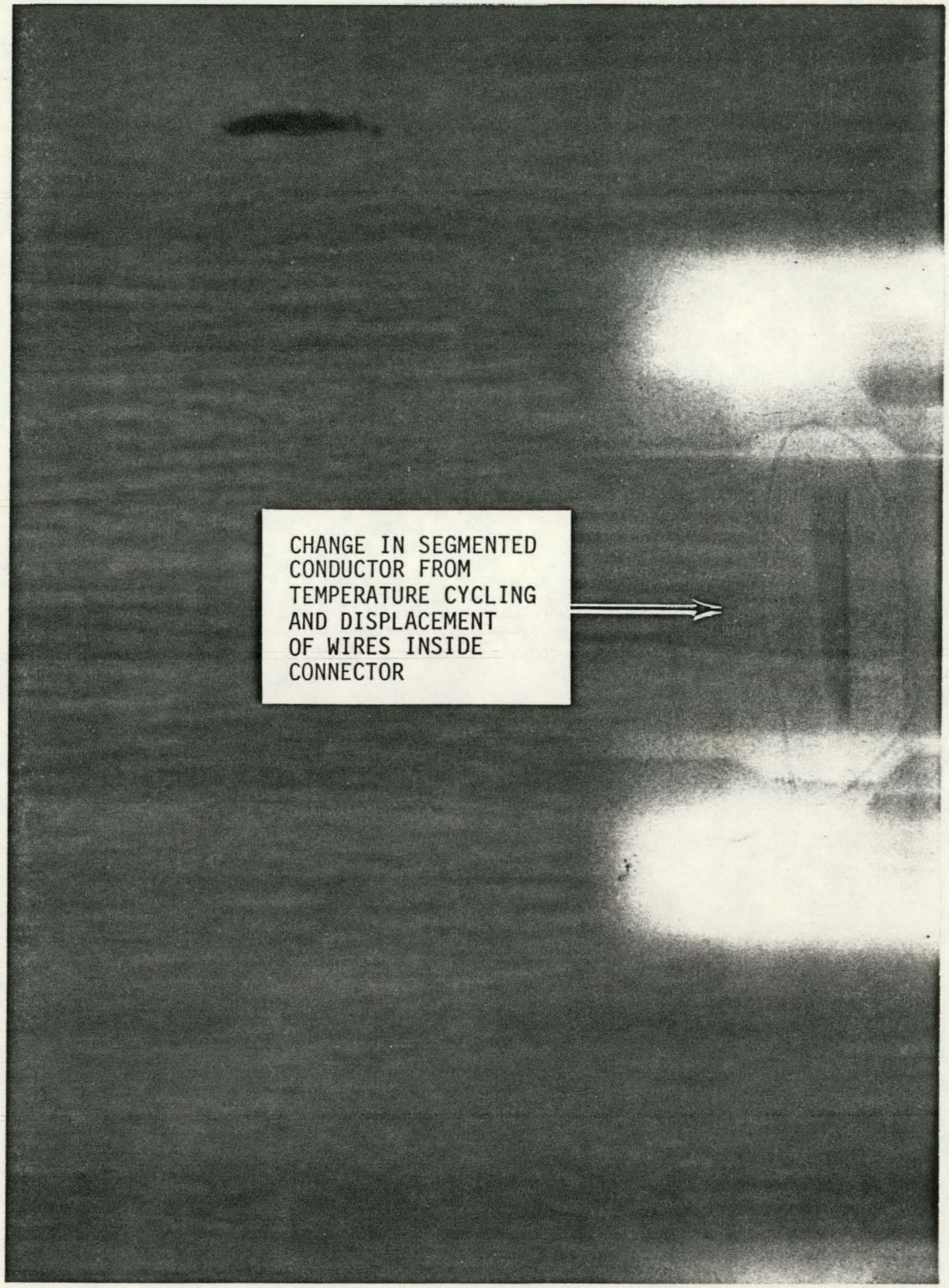


FIGURE 6. Conductor in Crimped Area of 230 kV Connector