OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

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IN-CELL SOUND TRANSMISSION SYSTEM

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ABSTRACT

To transmit sounds from the High Radiation Level Examination Laboratory (HRLEL) cells, a simple, rugged, and inexpensive sound system has been developed, fabricated, and tested. The massive shielding walls effectively attenuate the in-cell sounds needed to monitor operations and minimize ennui. To conserve cell space and minimize cost and maintenance, a single unit is desired to provide both general and local listening.

Standard components have been adapted to the needs and conditions of remote manipulation. An omnidirectional microphone unit with wide-range response and good fidelity is molded into a radiation-resistant rubber jacket to aid in electrical coupling and protect against in-cell abuse. The pickup is connected to a wall jack, directly for general listening and through a specially designed jumper for local listening. The wall mount connects with an out-of-cell speaker that has a headphone attachment.

Initial test results are encouraging and show that use of the system in the HRLEL will reduce operator fatigue, decrease the need for equipment maintenance, and improve productivity. The design, criteria, operating performance, and cost of the portable system are presented with selected illustrations.

INTRODUCTION

Six years of experience in the Postirradiation Examination Laboratory have demonstrated that hearing the sounds of the operations being performed in a hot cell are an invaluable aid to the operator. In the High Radiation Level Examination Laboratory (HRLEL), the tightness of the cells required to prevent escape of radioactive contamination will also reduce sound transmission. Not only does the lack of sound contribute to the tension and tedium of remote manipulation, but also it deprives the operator of information needed for safe and

efficient use of his equipment. The sounds of machinery, running water, and dropping objects are often invaluable. For example, the tuning of an ultrasonic tank is best accomplished by the detection of the changes in tone. The proper rate to feed material into an abrasive cutoff wheel is judged by the sound of the wheel and motor. The sound of an overloaded motor should enable the operator to call for maintenance or discontinue an operation before serious damage occurs.

To overcome this loss of hearing and to compensate in part for the loss of sense of feel in performing mechanical operations with remote manipulators, an inexpensive sound system has been developed for use in the HRLEL. Analyses of the types of sounds arising in the operations to be performed indicated that a flexible system is desirable, capable of both general and local pickup. The general pickup would transmit all cell background noise, such as motor noises and the noises caused by sliding objects over the steel table decks. The local pickup would transmit the sound of the diamond dressing of the grinding wheel, the sound of tuning the ultrasonic tanks, or any other sound that is needed to give the operator a better feel of the specific manipulation he is performing.

DESIGN CRITERIA

The hot-cell environment and the nature of remote operations impose several limitations on the sound system. The pickup must function with minimum maintenance in the neighborhood of chemical and metallurgical operations performed on highly radioactive materials in a confined space. Therefore, it should be resistant to radiation damage and corrosive vapors and unaffected by high humidity. It should be sufficiently rugged to withstand the shock of inevitable blows from the remote movement of specimens and equipment.

The type of operation also imposes limitations on the pickup. It must be omnidirectional to pick up the sounds from many pieces of equipment when used as a general pickup and to simplify placement when used as a local pickup. It must be portable by the remote manipulators to enable its use wherever it is needed in the cell. Finally, it should

have a reasonably high fidelity so that sounds will be reproduced sufficiently well to enable detection of abnormal operation.

The choice of either headset or speaker should be available for reproducing the in-cell sounds. A headset enables the operator to concentrate on the sounds originating with his operation without the distraction of background from the out-of-cell operating area. On the other hand, speakers are necessary to monitor continuously running equipment when it is not immediately related to an experiment in progress.

A very reliable system is desired. This is obvious from the difficulty of repair and replacement of components in the cells. In addition, the system is depended upon as a guardian of other in-cell equipment. Low cost and ease of installation are desirable insofar as they are compatible with the other requirements.

DESCRIPTION OF SOUND SYSTEM

A schematic diagram of the in-cell sound system is shown in Fig. 1. The system is essentially a conventional intercommunication system, except that only one-way transmission is required. The important differences from conventional sound systems are the modifications made to meet the conditions of operation in the shielded cells.

Basic Components

Microphone

The system uses a miniature lavalier microphone, the Electro-Voice Model 649B.[1] It was chosen because of its size, excellent resistance to mechanical shock, lack of directional limitations, and use of a metallic diaphragm, which can withstand high humidity, extreme temperatures, and corrosive atmospheres. A standard Mallory phone plug[2] Model 76 was adapted to the microphone by a nylon transition piece. For general pickup, this enables the microphone to be plugged into a standard Mallory jack[2] Model A1 mounted in the cell.

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[1]Manufactured by Electro-Voice, Inc., Buchanan, Michigan.

[2]Manufactured by P. R. Mallory & Co., Indianapolis, Indiana.

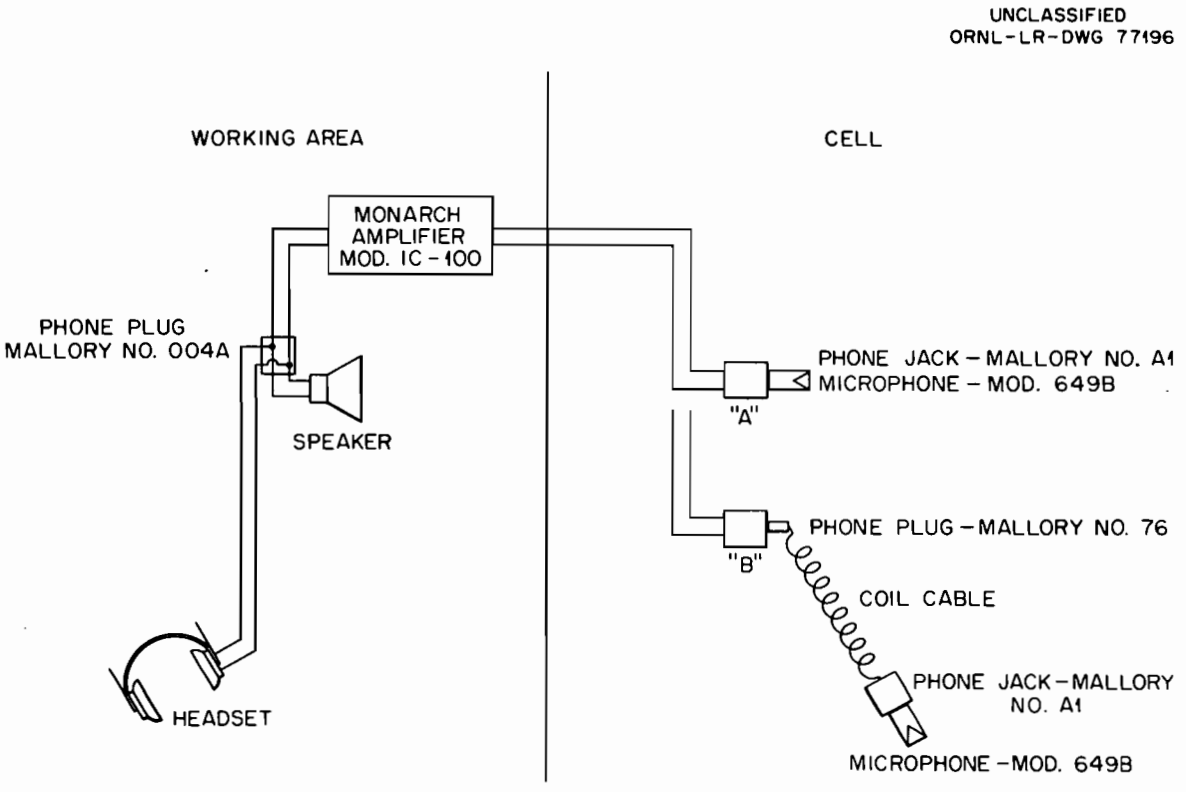

Fig. 1. Schematic Drawing of In-Cell Sound Transmission System.

Amplifier—Speaker

The amplifier—speaker combination is a single unit of a Monarch all-transistor intercom,[3] modified with a phone jack. This amplifier is inexpensive and readily available, and it performs satisfactorily. Figure 2 shows the amplifier mounted on a mockup of a HRLEL cell, with headphones attached and in use, during a test of the system.

Headset

A Clevite Model BA-206-1[4] headset is provided for individual undistracted listening and detection of local sounds of extremely low level. When this is not needed, the 4-in. PM speaker in the intercom is used.

Adaptation to Hot-Cell Use

To enable safe remote handling of the pickup and remote connection of the pickup for local listening, it was necessary to pot the pickup in a radiation-resistant rubber and to provide a jumper and hanger clamp that could be remotely connected. These pieces are shown in Fig. 3.

Potting of the Microphone

To protect the microphone, it is potted in GE RTV-60 Silicone Rubber.[5] Samples of this rubber show only a slight hardening after irradiation in a gamma field to an accumulative dose greater than 6×10^6 r. The first portion of rubber is poured around the microphone-plug assembly in an aluminum mold designed to give a 45° concave entrance cone at the microphone end to enhance sound pickup and a 45° convex cone at the plug end to facilitate coupling. The final portion of rubber is injected through a hole in the mold cap to ensure a full mold and a sound casting. Vent holes around the periphery of the cap allow gases

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[3]Monarch Electronics International, Inc., North Hollywood, California.

[4]Product of Clevite Electronic Components, Cleveland 14, Ohio.

[5]Product of General Electric Company, Silicone Products Division, Waterford, New York.

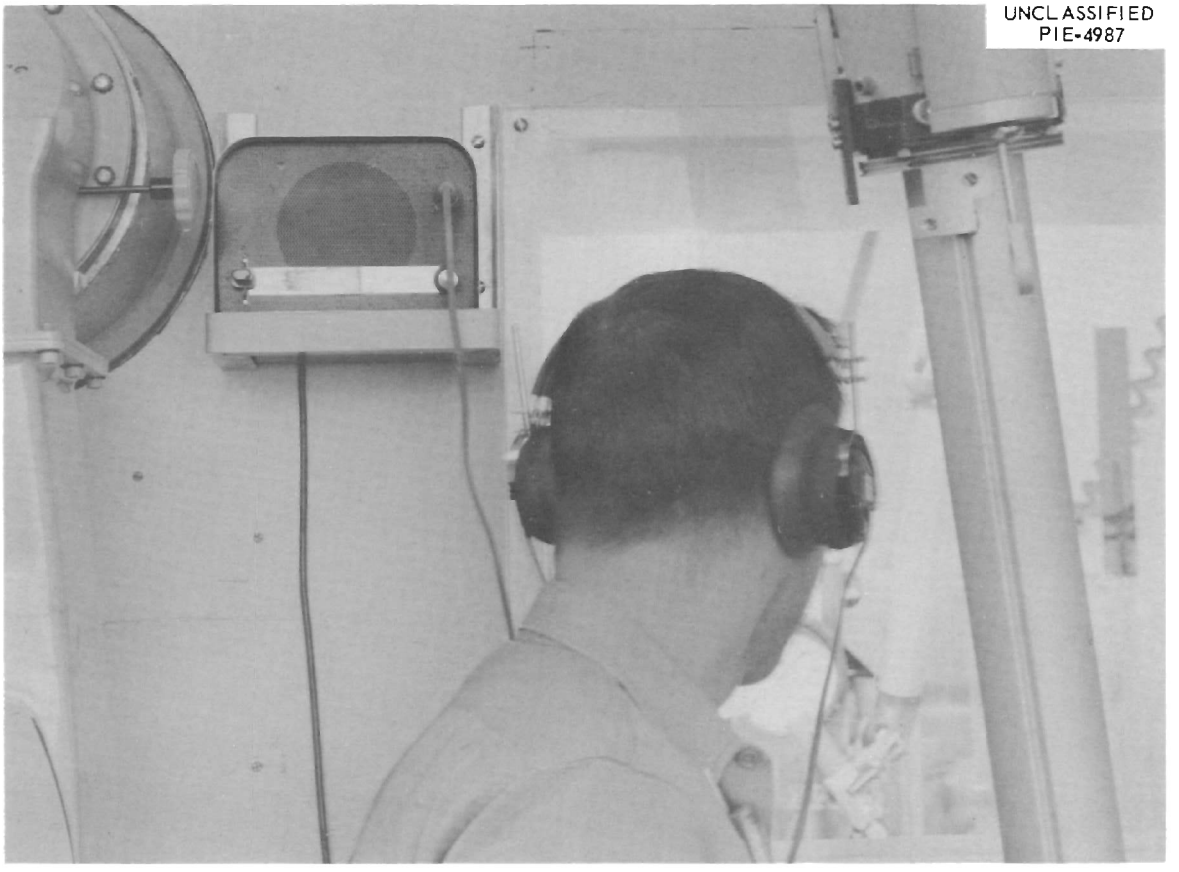

Fig. 2. View of Operating Face of Cell Mockup, Showing Mounted Amplifier—Speaker and Operator Using Headset.

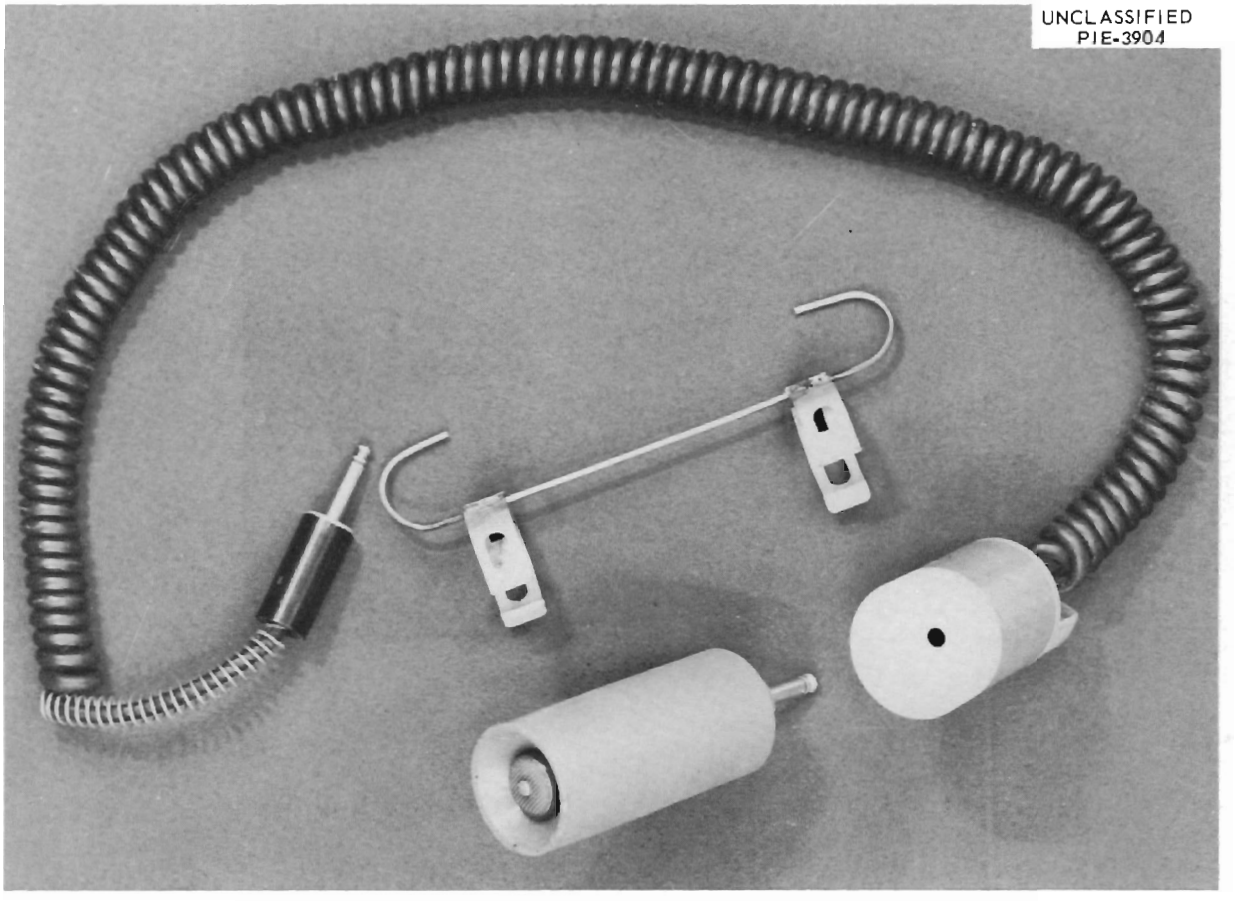

Fig. 3. Potted Microphone, Remote Jumper, and Hanger Clamp.

to escape. Figure 4 shows the completed pickup assembly. Figure 5 is a cutaway view of the assembly showing microphone, transition piece, phone plug, and RTV rubber potting.

Jumper Assembly

For general listening, the pickup is normally plugged into a wall-mounted jack at the in-cell end of the transmission line. When local listening is needed near certain equipment, a jumper is needed to connect the pickup to the wall jack. The jumper consists of a phone jack with special adapter connected by 36 in. of two-conductor coil cord to a phone plug fitted with a compression spring. The jack is a Mallory Model A1 built into a nylon transition piece designed to receive the pickup. The plug, shown in Fig. 6, is a Mallory Model 76 with the compression spring added to facilitate the remote coupling of the plug with the wall-mounted jack. An insulating washer separates the plug from the washer on the spring base.

Hanger Clamp

Some device is needed to support the pickup in local use. A simple clamp was fabricated from stainless steel wire and two standard spring clips, as shown in Fig. 7. The clips are of proper size to hold the pickup and the jack adapter body. Attachment of the clamp to the pickup is shown in Fig. 8.

Magnetic hangers were considered but were ruled out because of the extensive use of nonmagnetic stainless steel for the in-cell equipment.

OPERATION

The in-cell sound system has been installed and operated in a mockup of a HRLEL cell. The performance has been very satisfactory. In local application, it was possible to hear the ticking of a timer at 12 in. despite a relative high background noise level, as shown in Fig. 9. The remote assembly and disassembly of the components for local listening can be completed in less than 2 min.

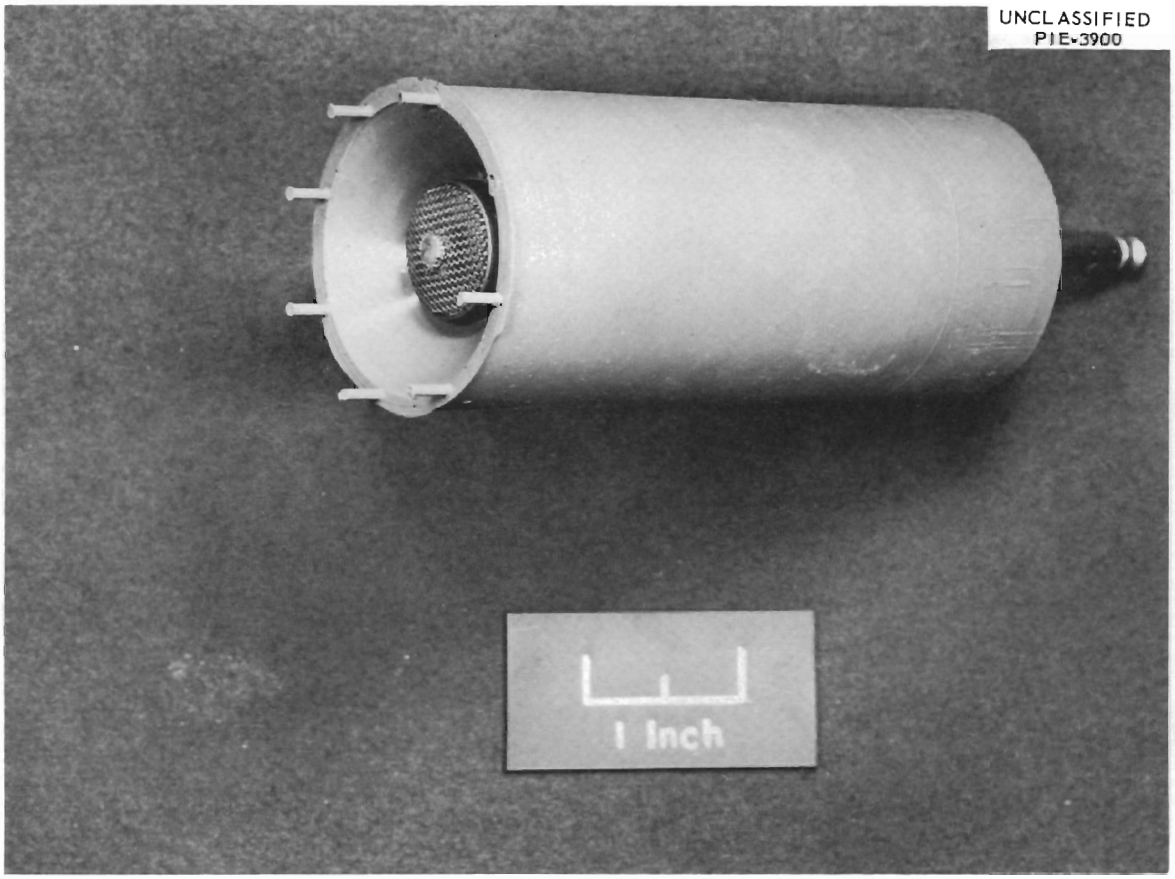

Fig. 4. Completed Pickup Assembly After Potting in Silicone Rubber.

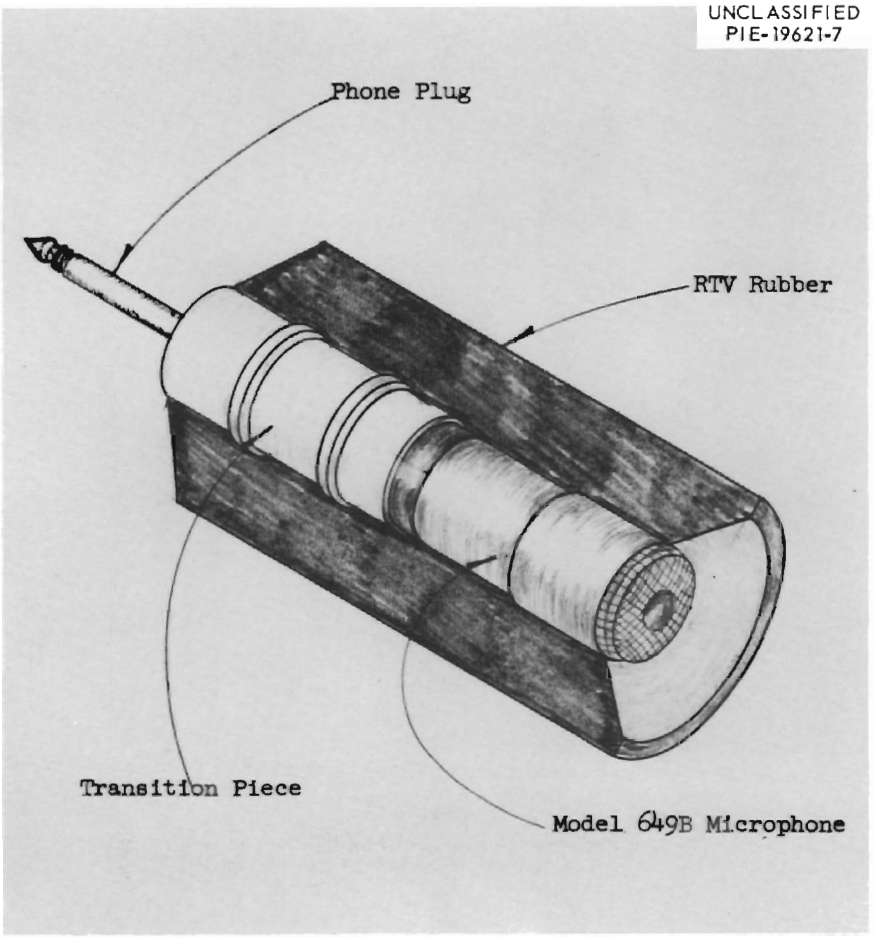

Fig. 5. Cutaway View of Pickup.

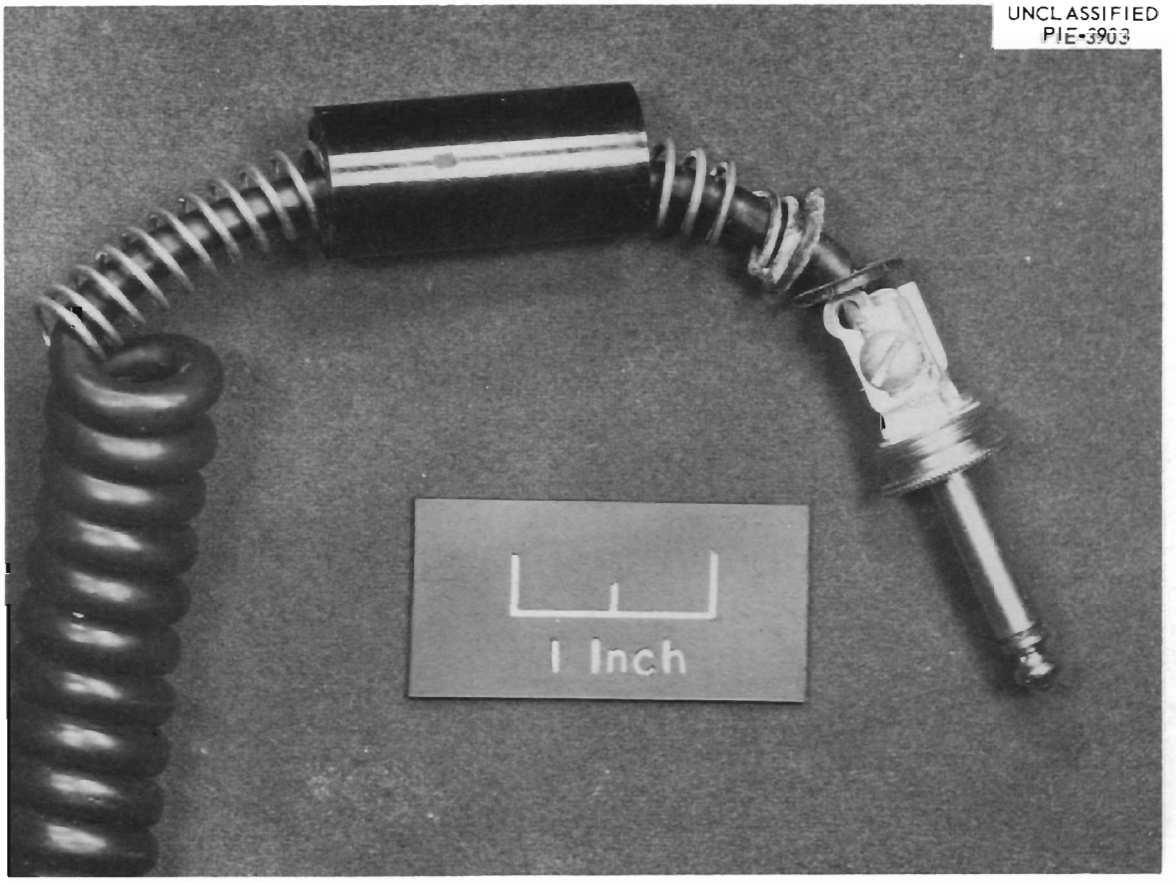

Fig. 6. Exploded View of the Jumper Plug.

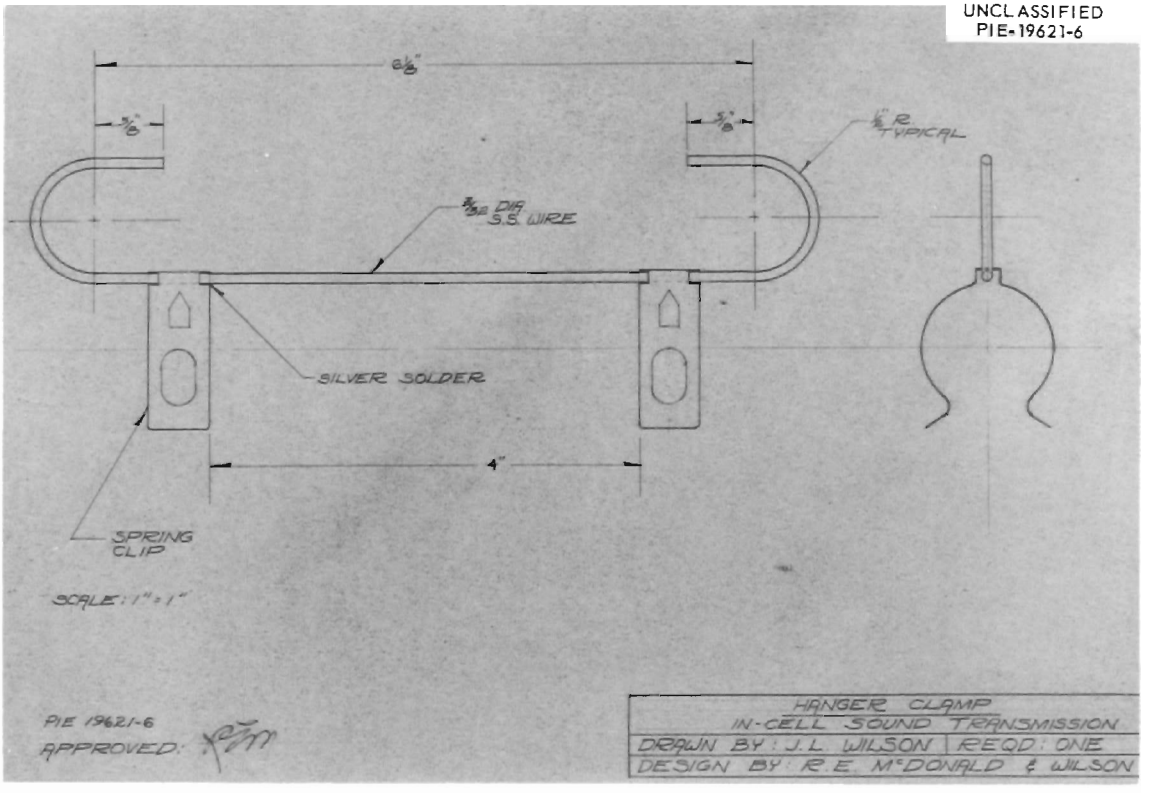

Fig. 7. Hanger Clamp for In-Cell Sound Transmission.

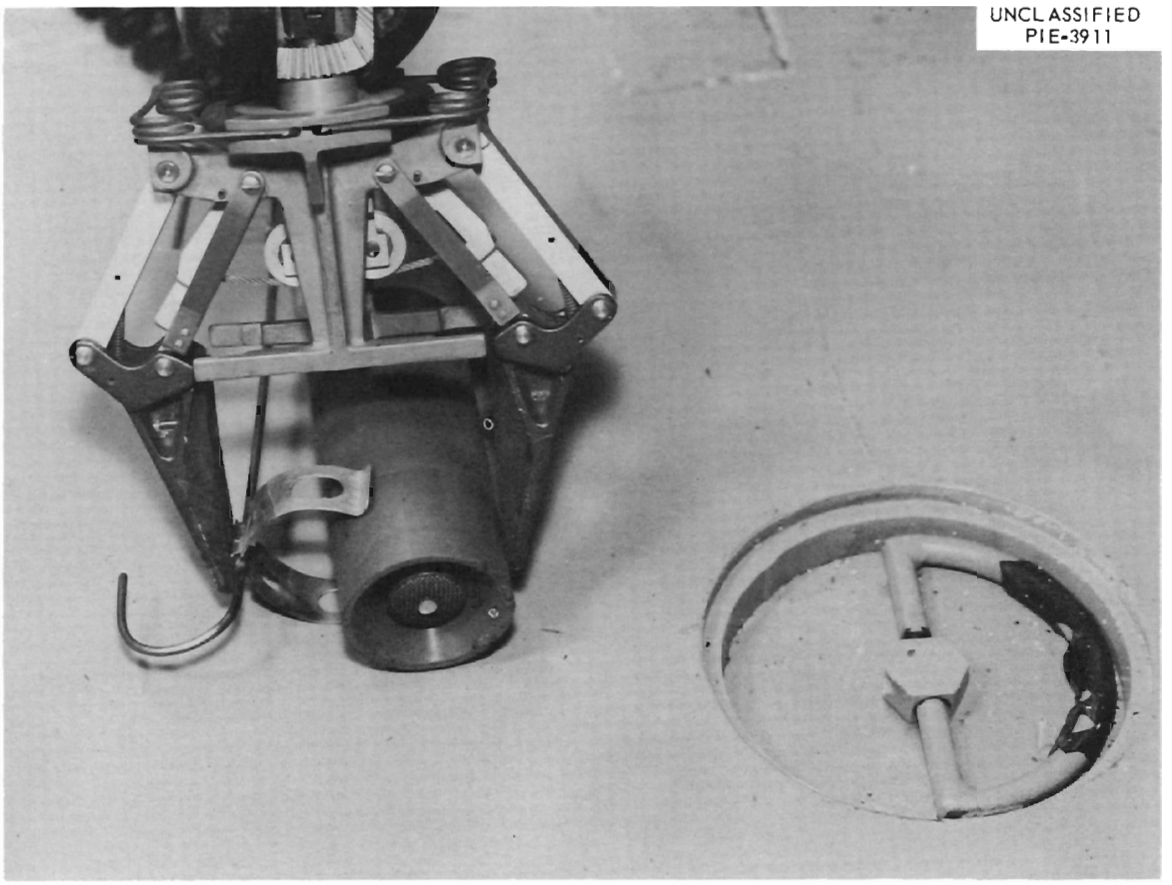

Fig. 8. Remote Attachment of the Hanger Clamp to the Pickup.

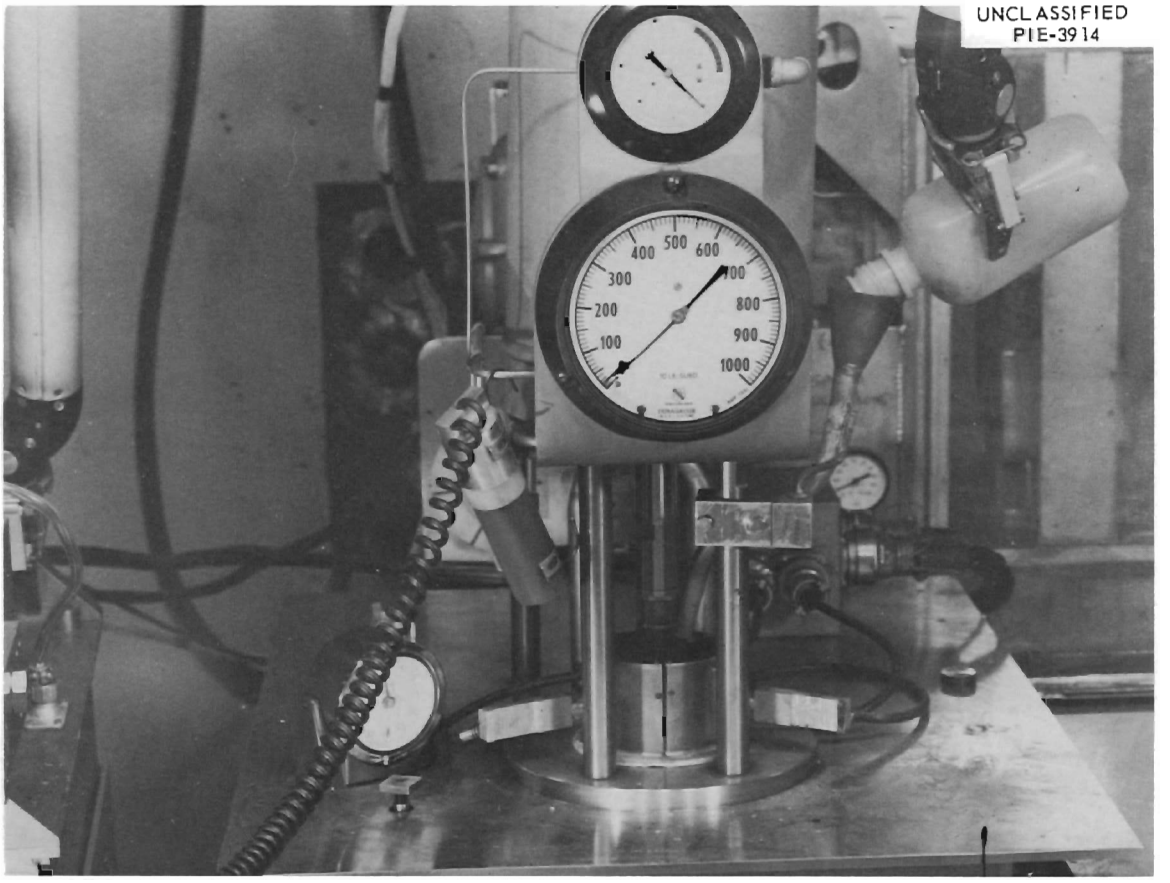

Fig. 9. Local Pickup in Operation at a Press for Mounting Metallographic Specimens.

COST OF MATERIALS

The approximate cost of components for the in-cell sound systems is given in the following:

Item	Cost
Microphone	$ 50.00
Amplifier	20.00
Headset	19.00
Accessories	5.00
Miscellaneous Parts and Materials	25.00
Total	$ 119.00

CONCLUSIONS AND RECOMMENDATIONS

To transmit sounds from the interior of the HRLEL cells to the operating area, a small, simple, inexpensive, and easily assembled system has been developed, fabricated, and tested. The system has been found to transmit effectively low-level sounds against a background of noise from operating machinery. Besides eliminating the operator fatigue that results from the diminished contact with his work, the sound system provides the operator with audible clues to the performance of his equipment. This aids in the control of moving equipment and permits detection of malfunctions in early stages when maintenance is easier.

ACKNOWLEDGMENT

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