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REMOTE MAINTENANCE TESTING
July 1, 1979 - June 30, 1980

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ABSTRACT

The results of remote handling and remote maintenance testing at the Remote Maintenance Test Facility (RMTF) from July 1, 1979, through June 30, 1980, are presented. Specific test arrangements and test results from the RMTF of such items as a sample bottle evacuation system, in-cell TV camera support, Krypton encapsulation, remote pipe cutting and welding, and dissolver closure drive shaft coupling in support of several projects and general plant maintenance are discussed.

SUMMARY

For approximately six years, the RMTF has maintained a program at the Idaho Chemical Processing Plant (ICPP) for evaluating and testing remote handling maintenance of designated plant equipment in plant upgrade and plant expansion projects. This report covers the sixth year of this effort. Equipment mocked up, tested, and evaluated during this period included a sample bottle evacuation system, an in-cell TV camera support, a solids sampler valve replacement system, a dissolver top electrical connector and drive shaft coupling, a coaxial cable slip ring assembly for TV transmission, and remote pipe cutting and welding.

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I. INTRODUCTION

With the ever increasing effort to reduce both individual and total plant personnel radiation exposures to "as low as reasonably achievable" (ALARA) levels, the development and use of plant equipment specifically designed for remote maintenance and the development of the associated remote handling techniques have become increasingly important. Assumed future reductions in personnel exposure limits will further emphasize remote maintenance as a viable approach. This report covers the sixth year's efforts at the Remote Maintenance Test Facility (RMTF) in mocking up and testing remote equipment[a] and handling techniques. Previous annual reports on this testing were as follows: ICP-1081[1] (1974-1975), ICP-1113[2] (1975-1976), ICP-1143[3] (1976-1977), ICP-1170[4] (1977-1978), and ENICO-1008[5] (1978-1979).

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[a] The use of a commercial name for equipment or material used in the testing program or the appearance of equipment or material in one of the illustrations in this report is not to be construed as an endorsement of that brand, nor is it implied that this is the only equipment or material of its kind that is available.

II. OBJECTIVES

Reducing personnel radiation exposures to ALARA levels during the maintenance of failed plant equipment, and improving plant on-stream time are the primary objectives of the remote maintenance effort. In most cases, the failed equipment will be remotely replaced rather than remotely repaired. Following removal, the equipment item will be decontaminated to a low level of residual contamination and then repaired by direct maintenance.

Indications are that in many instances plant downtime can be greatly reduced through the use of remote equipment replacement, since extensive plant decontamination to "acceptable radiation levels" will not be required for the replacement. At the present time, only the more failure-prone equipment items, based on ICPP operating experience with comparable equipment, are being designed for remote replacement. Marginal failure items are being installed with quick-release connectors for direct maintenance, and long-lived items are being installed for total direct maintenance. Decontamination and plant downtime would be required for replacement of the direct maintenance items.

Verifying the remote handling aspects of mocked-up equipment relative to the final installation is also an objective of remote maintenance testing.

III. TEST FACILITIES

The RMTF located in the Materials Test Reactor Building, was used for all mockup and testing of remote maintenance items during this sixth year's effort. The RMTF consists of a master-slave test area and a wall-mounted manipulator test area, both of which are briefly described in the following paragraphs.

The master-slave area (Figure 1), which is designed to simulate a process hot cell, is approximately 4.6 m (15 ft) long, 6.1 m (20 ft) wide, and 4.6 m (15 ft) high. Associated with this area are three mocked-up wall sections, each containing a pair of master-slave manipulators and a mock viewing window. The wall sections are mounted on heavy-duty casters for flexibility of equipment arrangements. An overhead bridge crane and a bridge-mounted manipulator (Figure 1) are also provided in the master-slave area of the RMTF. This area is used to simulate all process cells where remote handling is done by master-slave manipulators or by manipulation from above through a cell hatch opening with a bridge crane and/or a bridge-mounted manipulator.

The wall-mounted manipulator area (Figure 2) is designed to simulate a process cell arrangement where many remotely replaceable items can be located on one wall and where remote operations can be performed using a single wall-mounted manipulator and a small, in-cell bridge crane. The structure comprising this area is approximately 12.2 m (40 ft) high, 3.1 m (10 ft) wide, and 18.3 m (60 ft) long. The remotely replaceable items are located on the cell wall opposite the wall-mounted manipulator and are readily accessible for remote changeout studies. In the RMTF, large air-lifts, process off-gas filter units, valves, and remotely replaceable pump units have been mounted on this wall for changeout studies using the single wall-mounted manipulator and the bridge crane. Two portable simulated viewing windows are located on the manipulator side of the area for viewing studies. Television (TV) units, including both normal and three-dimensional, are also used in the viewing and changeout studies. A video tape unit included with one of the TV monitors has been used extensively for taping complete remote handling operations for playback for operator training and other purposes.

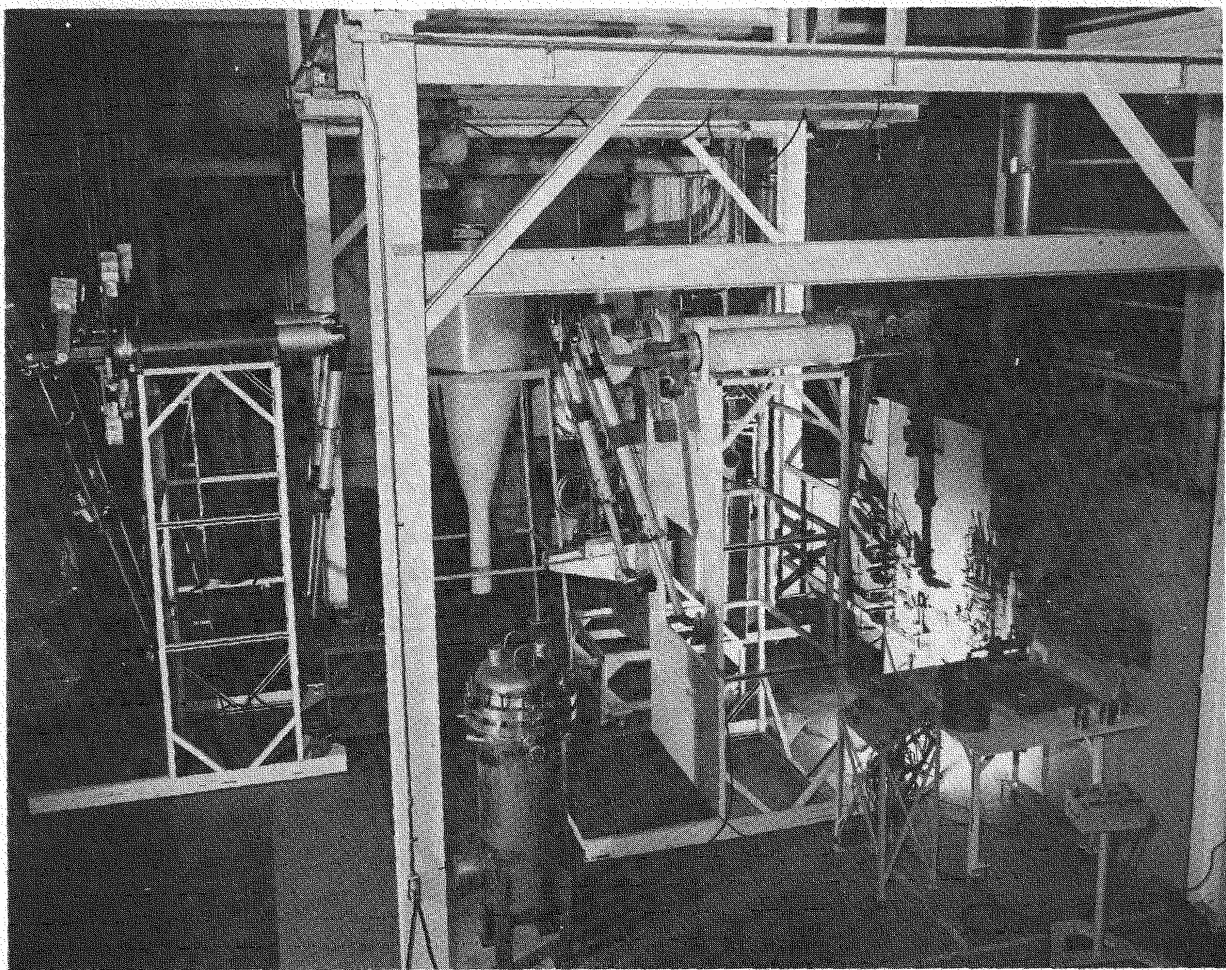

Fig. 1 Master-Slave Area

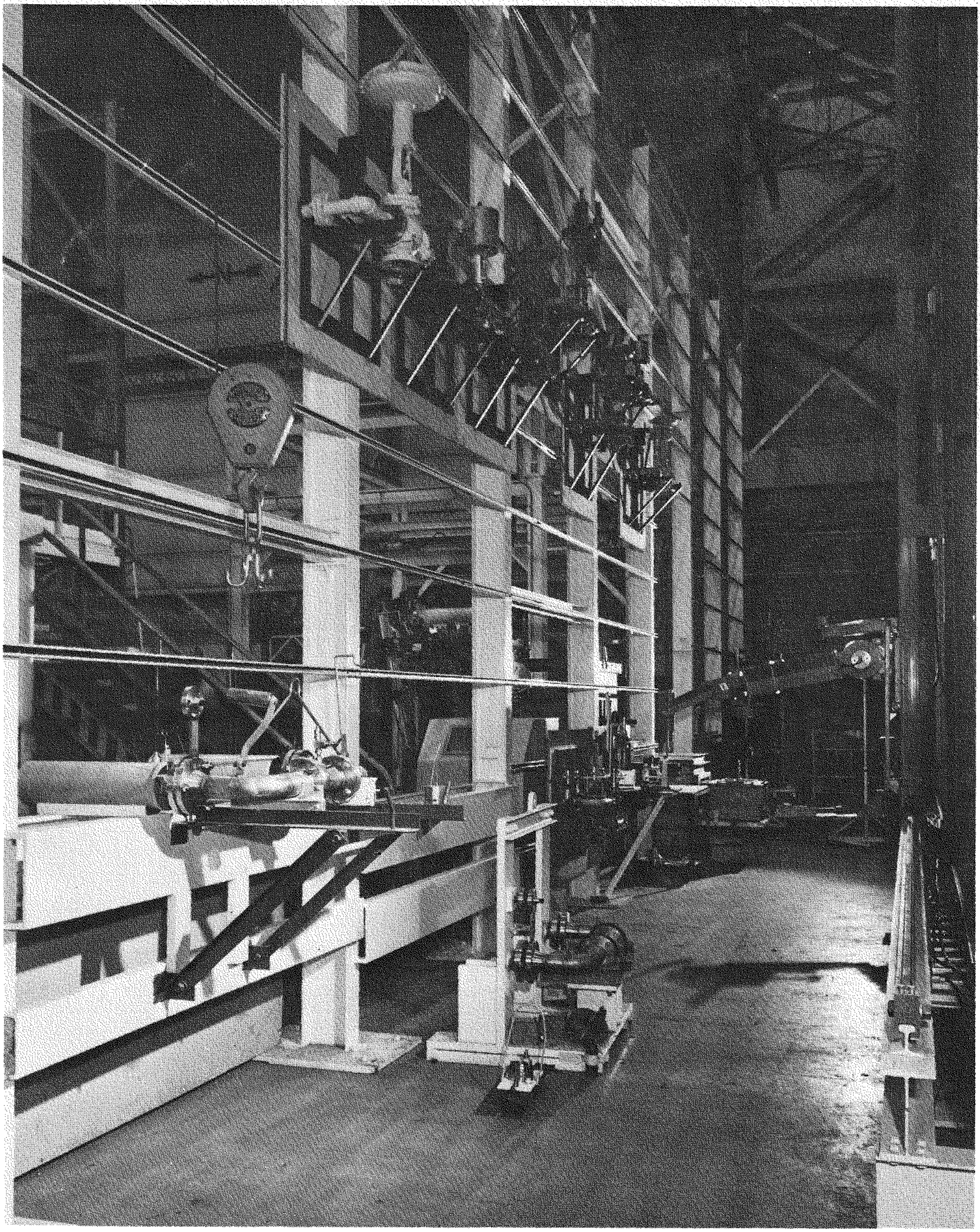

Fig. 2 Wall-Mounted Manipulator Area

IV. REMOTE HANDLING DESIGN

All remote studies started during the fifth year were completed in the sixth year, and a number of new studies started. The new studies included sample bottle evacuation, solids sampler valve replacement, TV camera support, dissolver top closure replacement, inspection flange removal, krypton encapsulation study, and remote pipe cutting and welding.

1. FAST Sample Bottle Evacuation Chamber

The Fluorinel and Storage Facility (FAST) liquid sampling system which has been previously described,[6] is based on a double-ended sampling needle that is inserted into an evacuated sample bottle. The vacuum in the sample bottle draws the liquid sample into the bottle from a liquid reservoir. To assure a maximum vacuum in the sample bottle during sampling, a Sample Bottle Evacuation Chamber was developed for use in the sampling cell. Figure 3 shows a 20 ml serum bottle being evacuated. The serum bottle is sealed by a commercially available serum bottle stopper and an aluminum crimp-on seal ring. With a slight modification to the evacuation chamber design, standard 5 ml teardrop sample bottles can also be evacuated.

Removal of the evacuation chamber from the sample cell for maintenance is shown in Figure 4 and requires removing one retaining pin in the chamber support bracket and disconnecting a quick disconnect fitting to the vacuum line.

In numerous tests, the FAST evacuation chamber proved effective for the purpose intended. The unit is simple, small, reliable, and inexpensive. Based on these tests, an evacuation chamber is being incorporated into the FAST facility to assure obtaining adequate process samples.

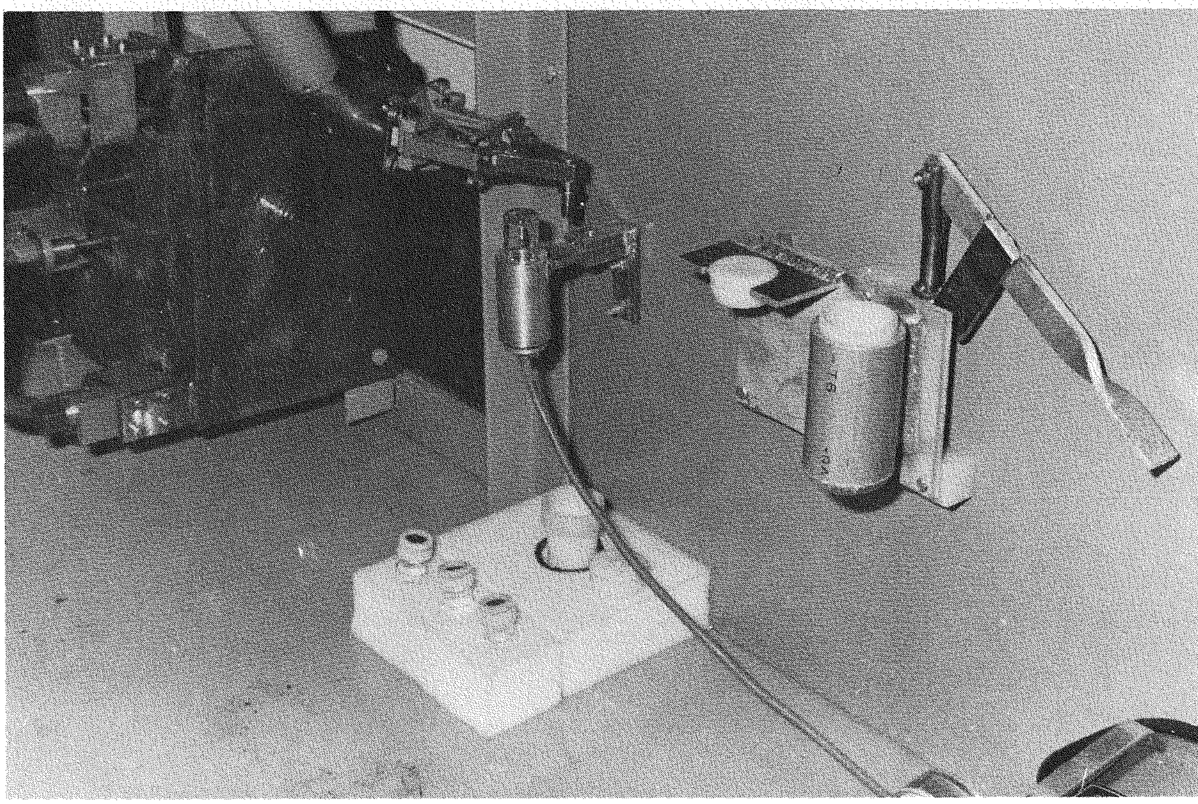

Fig. 3 Sample Bottle Evacuation Chamber

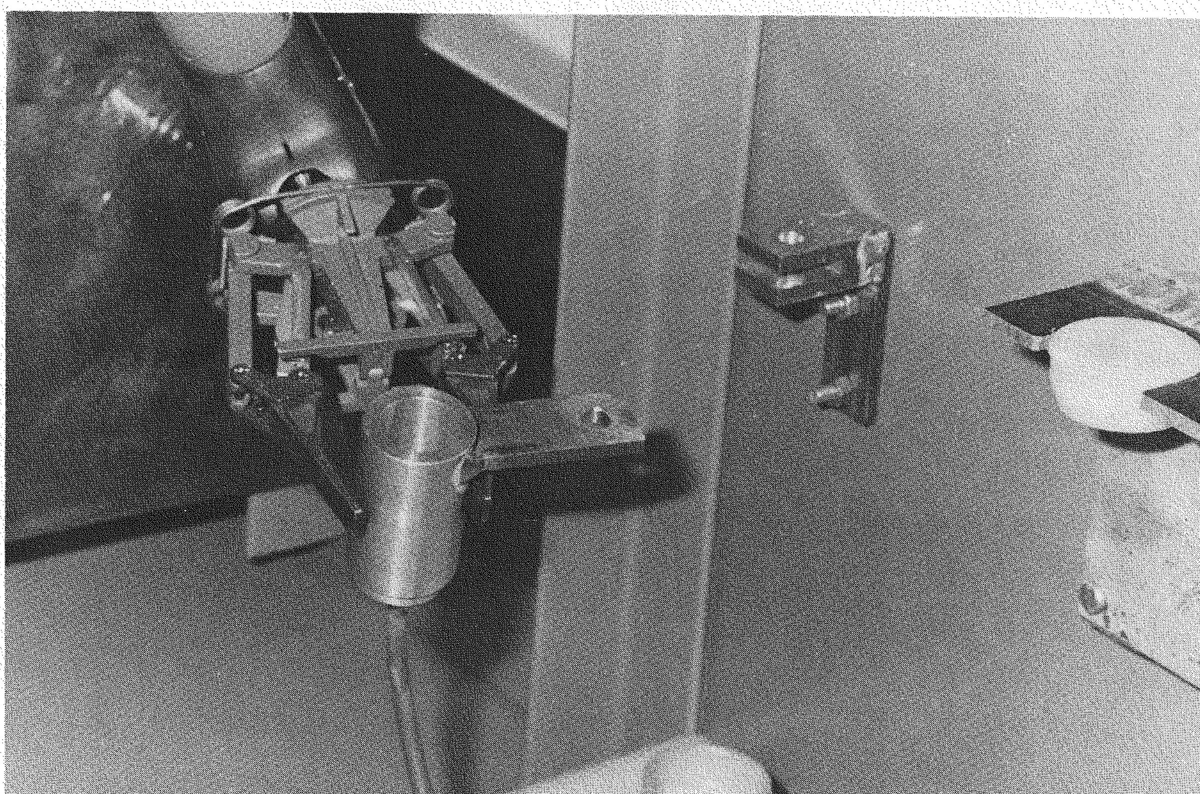

Fig. 4 Evacuation Chamber Removal

2. NWCF Solids Sampler Valve Replacement

The NWCF Solids Sampler Air Operated Valve Assembly, as previously described,[7] consists of a remotely removable support plate on which are mounted the valves and the air operators required for the NWCF solids sampler. As originally designed, failure of a single valve or a single air operator required disconnecting all the air and solids sample lines and removing the complete assembly (Figure 5). Because this required both time consuming and unnecessary efforts, the mockup was modified to allow removal of a single unit for replacement (Figure 6) by disconnecting two tubing fittings, a quick disconnect air line, and a locking pin. The NWCF solids sampler will reflect this change.

3. NWCF TV Camera Support System

A TV Camera Support System[8] was developed to provide viewing capability in areas of the NWCF not equipped with viewing windows. In these process cells, viewing must be provided by portable TV units located to give the best possible view of the maintenance operation with a clear stable picture. Some operations may require two TV units for adequate visibility.

Recent modifications to the TV system included relocating the TV camera lifting bail and lifting point and improving the alignment requirements. The bail arrangement reported previously[8] was attached to the upper part of the pan and tilt unit and placed the entire lifting force on the tilt bearing and plactic shaft. The modified lifting bail (Figure 7) supports the pan and tilt unit and the TV camera from below which is normal for this unit. The modification also minimizes damage potential to the unit.

An additional modification to the camera unit was to replace the prototype electrical connector with a production unit. This change provided the TV camera with a standard electrical plug, and also eliminated the binding that had been experienced with the prototype unit.

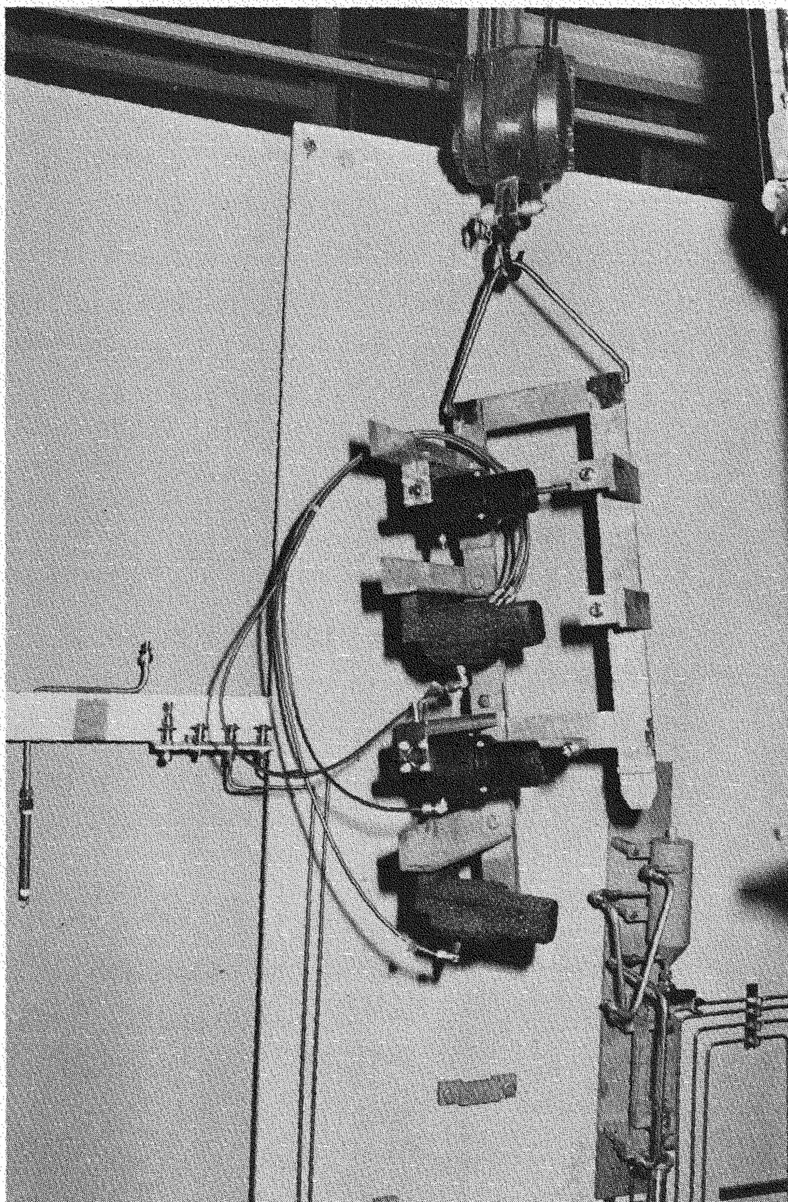

Fig. 5 Removal of Complete Solids Sampler Assembly

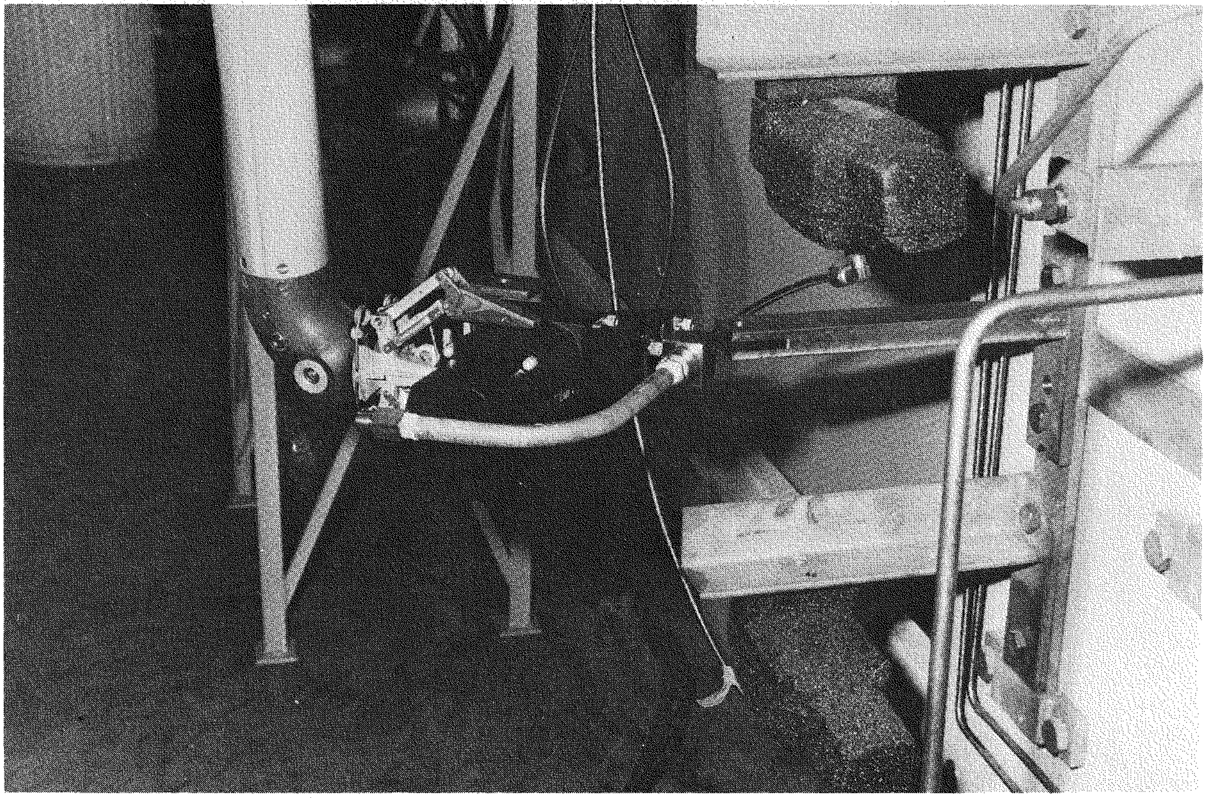

Fig. 6 Removal of Single Solids Sampler Valve

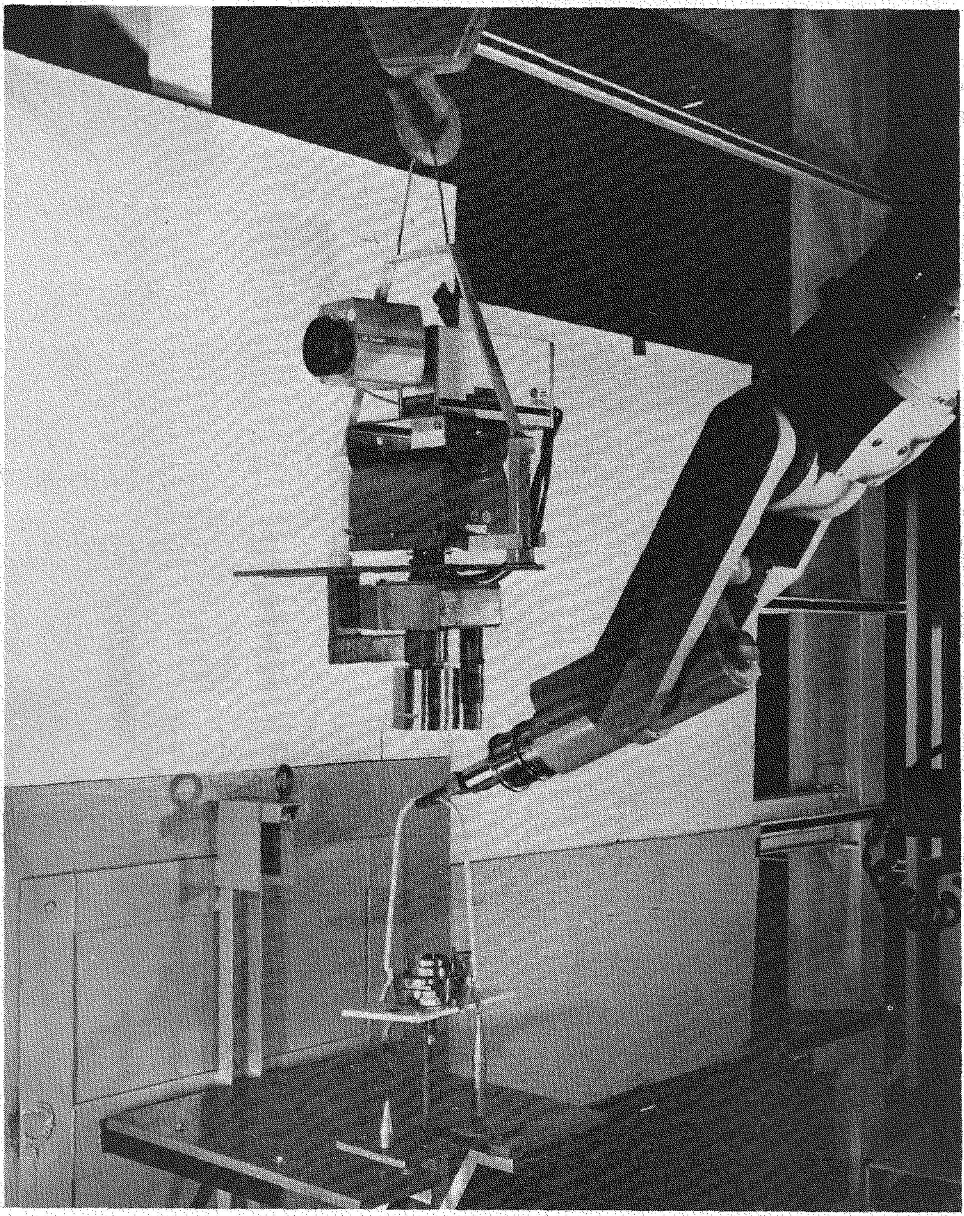

Fig. 7 TV Camera Modified Lifting Bail

4. FAST Dissolver Top Electrical Connector

The FAST Project dissolvers are designed with power-operated top closures which are remotely replaceable. Removal of the drive motor requires unbolting the unit with an impact wrench and disconnecting the power and control cable connector. The original arrangement of this equipment can be seen in Figure 8 and 9 which show the connector engaged and disengaged ready for removal with the drive motor. In this arrangement, the rather lengthy power and control cable must be removed with the drive motor.

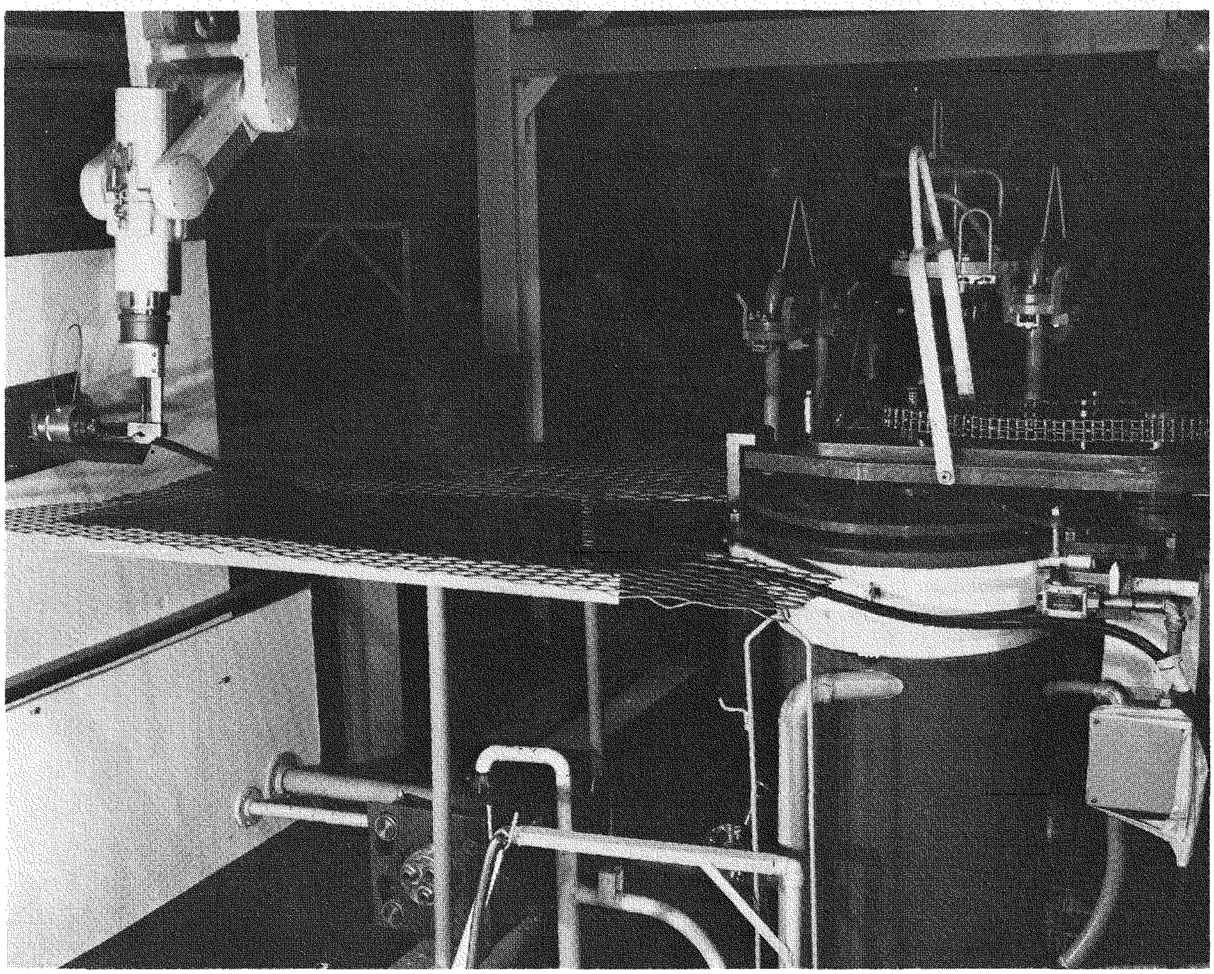

Fig. 8 Original Electrical Connector Arrangement Engaged

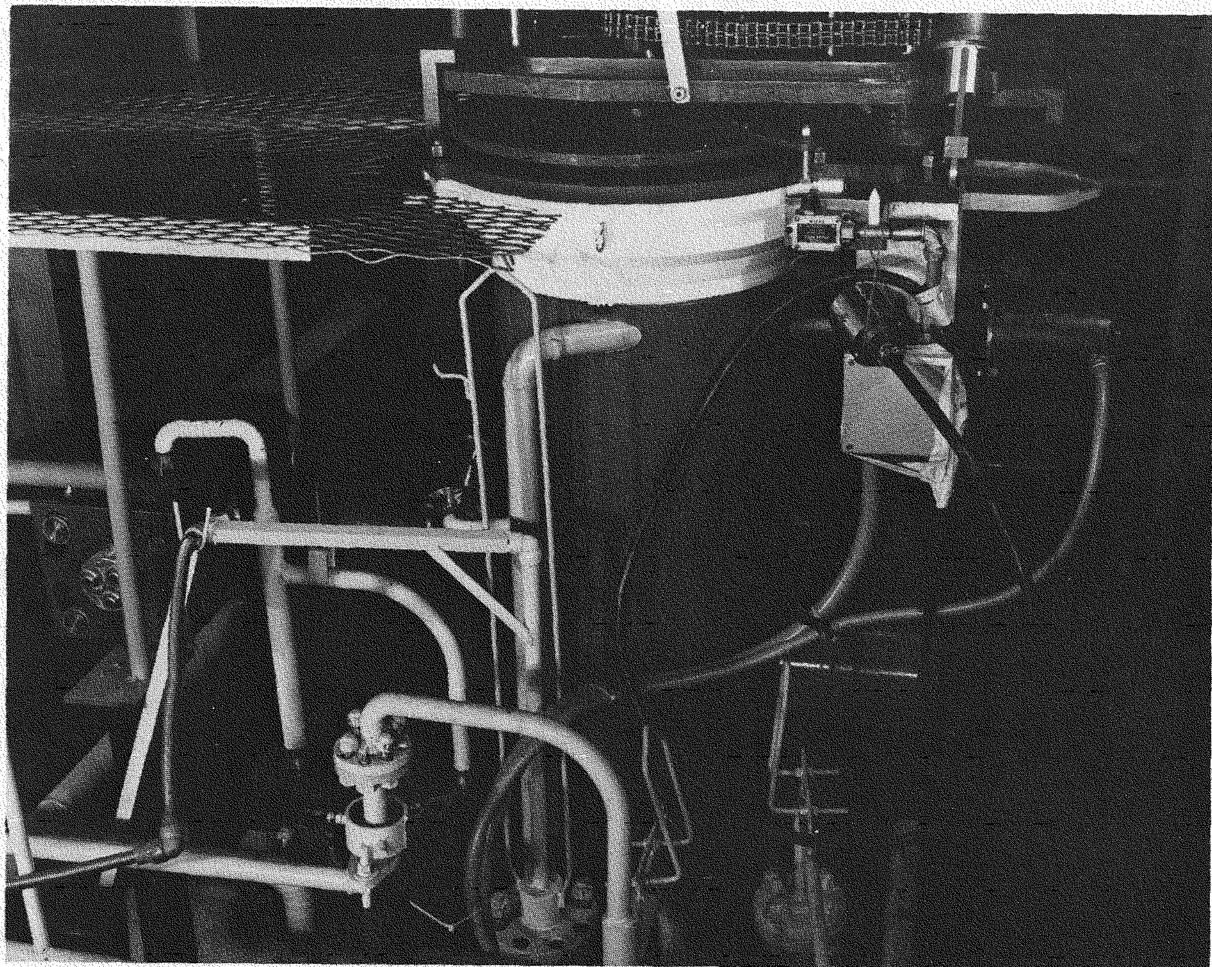

Fig. 9 Original Electrical Connector Arrangement Disengaged

because this arrangement was somewhat unwieldy and certainly not optimum for remote operations, the electrical connector was relocated from the cell wall to the drive motor (Figure 10). This change eliminated the need to remove the power cable with the motor, permitted installation of a permanent, better protected power cable; and increased the remotability of the motor.

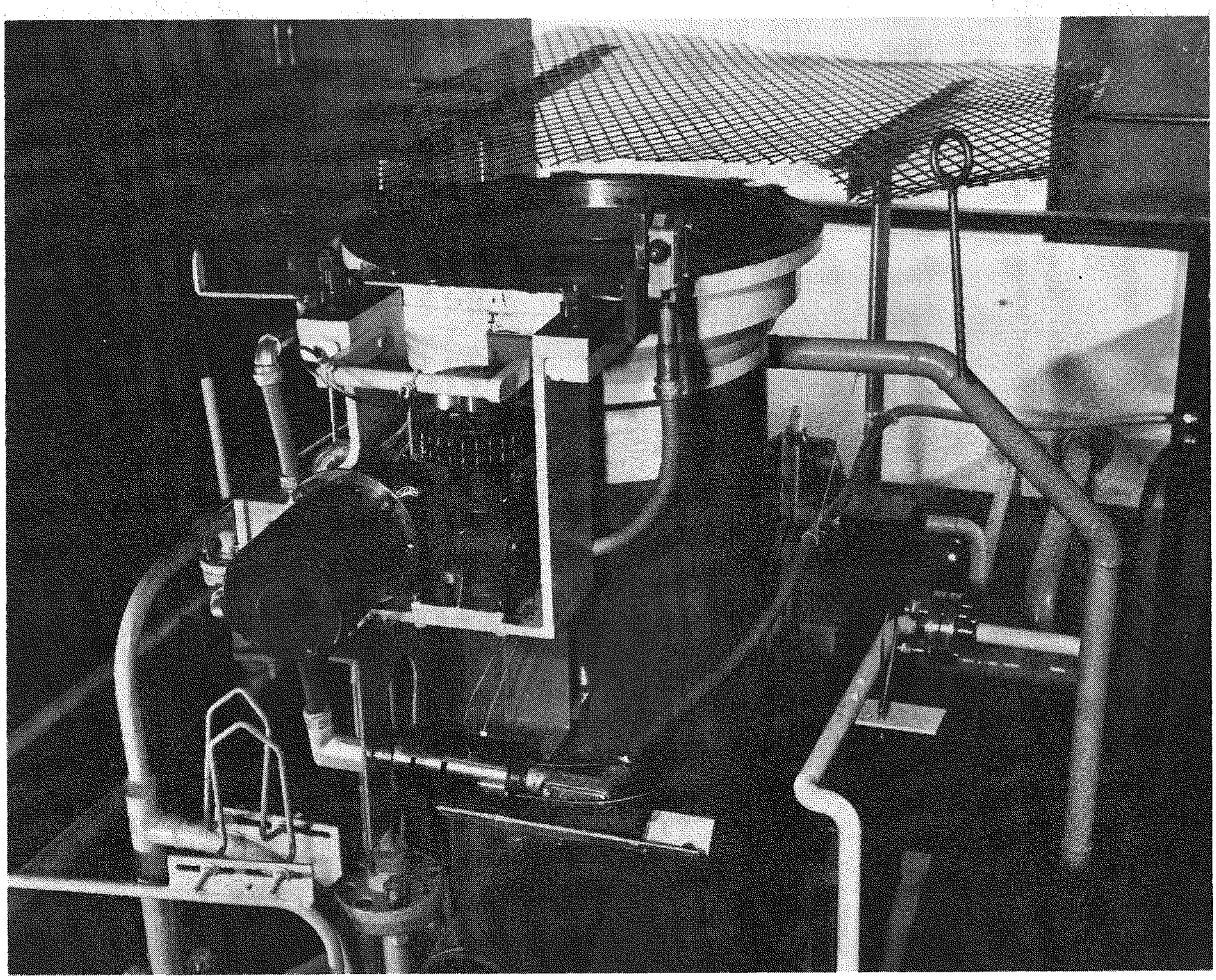

Fig. 10 Final Electrical Connector Arrangement

5. FAST Dissolver Closure Drive Shaft Coupling

Removal and reinstallation testing of the FAST dissolver closure mechanism,[9] indicated a binding tendency in the splined drive shaft connector between the closure mechanism and the drive motor.

In an attempt to alleviate this problem, several different types of connectors were evaluated including double tapered pins (Figure 11), a straight toothed (square jawed) positive clutch (Figure 12), and a double straight pin (with tapered ends) connector (Figure 13).

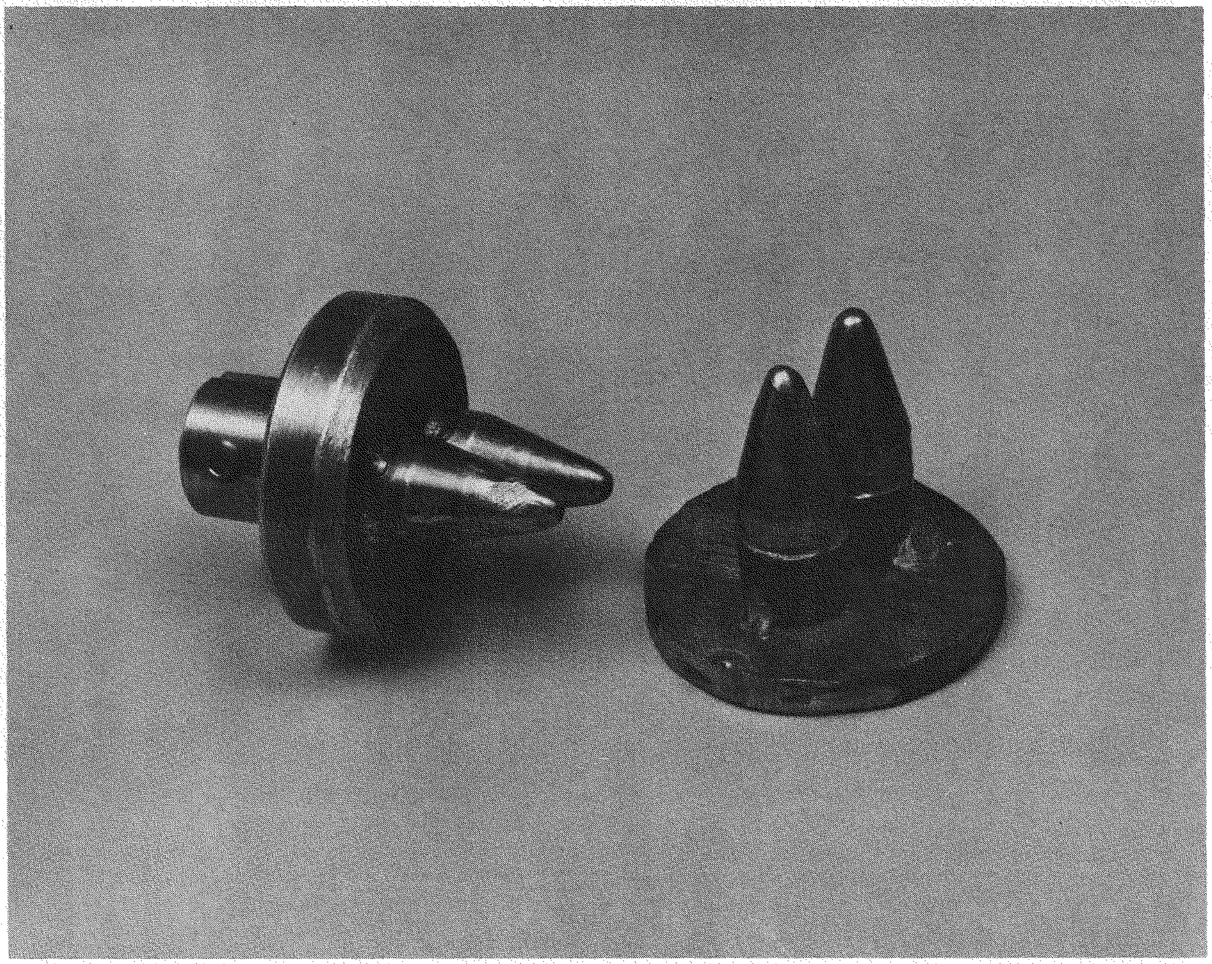

Fig. 11 Double Tapered Pin Shaft Connector

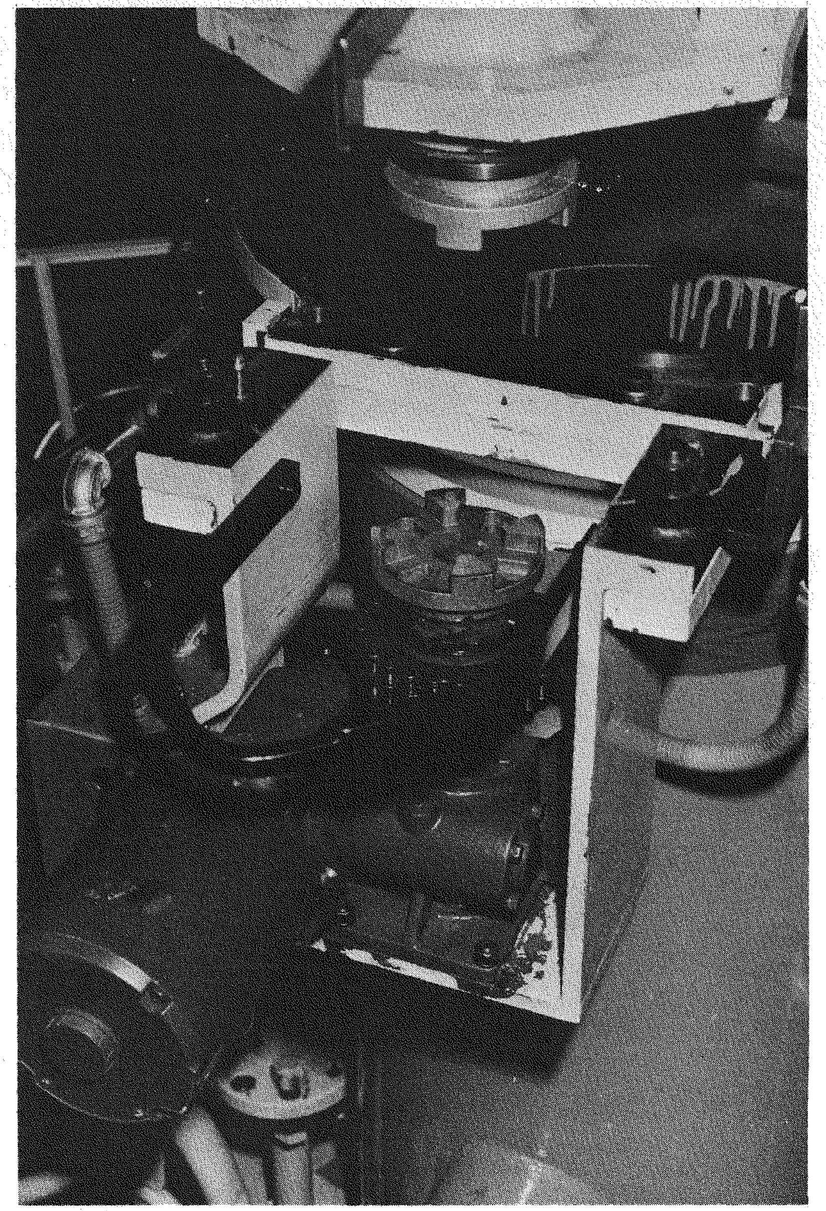

Fig. 12 Straight Toothed Positive Clutch Connector

Fig. 13 Double Straight Pin Connector

6. Inspection Flange Removal Guide

Several inspection ports are located on vessels throughout the NWCF where inspection of vessel internals may be either desirable or required after long-term plant operation. Removal and replacement of the inspection ports will be accomplished through cell ceiling hatches using a bridge crane and an overhead electro-mechanical manipulator. The vessel inspection will then be accomplished with TV cameras and lights. An early evaluation of inspection port removal[7] indicated some minor binding while sliding the port onto the alignment and guide pin. However, the binding was not considered serious enough to require a design change. Recent structural and piping additions in some of the cells in the NWCF, however, have increased the distance the manipulator must reach to engage the inspection ports on some vessels. This has in turn affected the accuracy and speed with which the required remote operations can be performed. As a result of this problem, preliminary investigations have been made of ways to provide additional support and guidance to the flange covers during these remote operations. Although the effort is still incomplete, preliminary investigations indicate a V-form guide attached to the vessel with a corresponding guide attached to the flange (Figure 14) may be a viable option. Additional investigations into this and other possible solutions will result in a proposed fix.

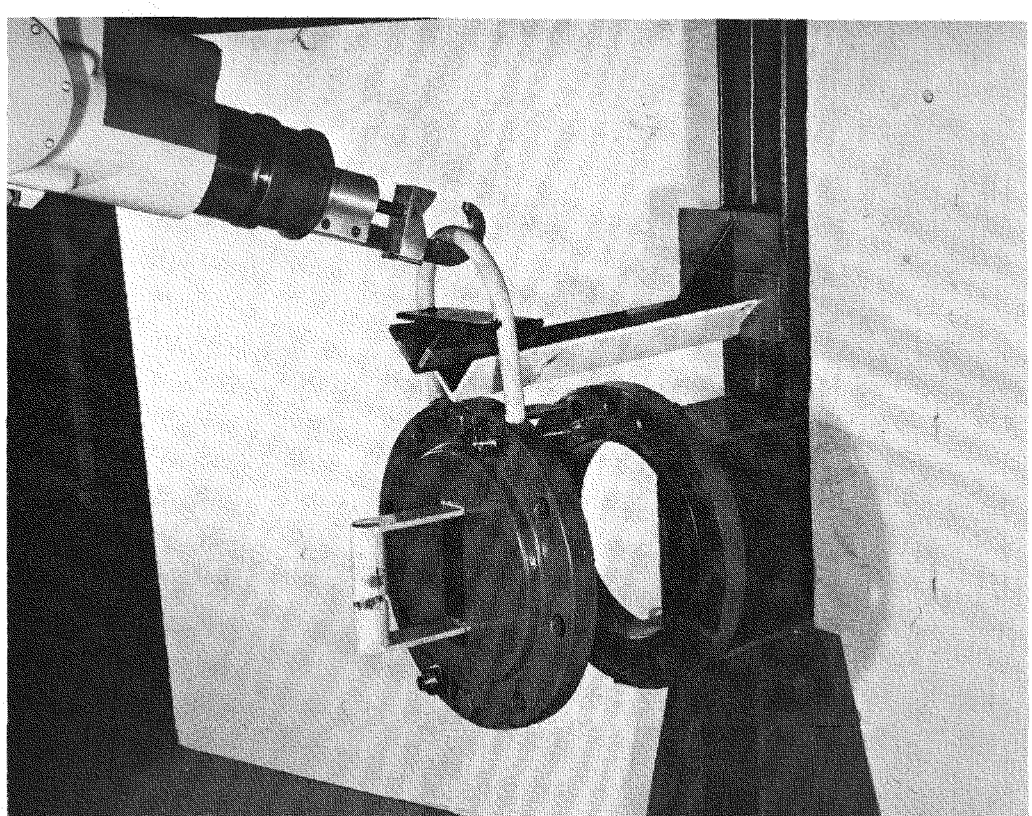

Fig. 14 Preliminary Flange Removal Guide Arrangement

7. Krypton Encapsulation

The design basis of the Krypton-85 Immobilization Program is encapsulation and immobilization of the Krypton-85 from a plant which reprocesses 2000 MTY of LWR fuel per year. Prior to encapsulation, the Krypton will be purified so that the Xenon content in the gas is less than 10%. After encapsulation, storage of the encapsulated material is necessary for at least 100 years to permit the Kr-85 decay (10.73 yr. half life).

The method being investigated by the ICPP Technical Department is zeolite encapsulation in which the Kr-85 is adsorbed on zeolite at 600°C and 28,000 psi pressure. The conceptual design of the facility in which encapsulation would take place includes two areas in which remote equipment and handling techniques will be required (Figure 15), the High Pressure Encapsulation Room and the Materials Handling, Sealing, and Storage Room. The High Pressure Encapsulation Room would contain the following remote equipment:

(1) A shielding window with a fragment protection cover.

(2) One pair of master-slave manipulators.

(3) A bridge-mounted electro-mechanical manipulator.

(4) A monorail or bridge-mounted hoist.

(5) A closed circuit TV system (CCTV).

(6) A transfer dolly to operate between the encapsulation room and storage room. The need for this equipment would be dependent upon the type of hoist required in the encapsulation room.

(7) Handling tools designed for opening the high pressure vessel and removing the Kr canister.

This equipment would be used to perform the following remote tasks:

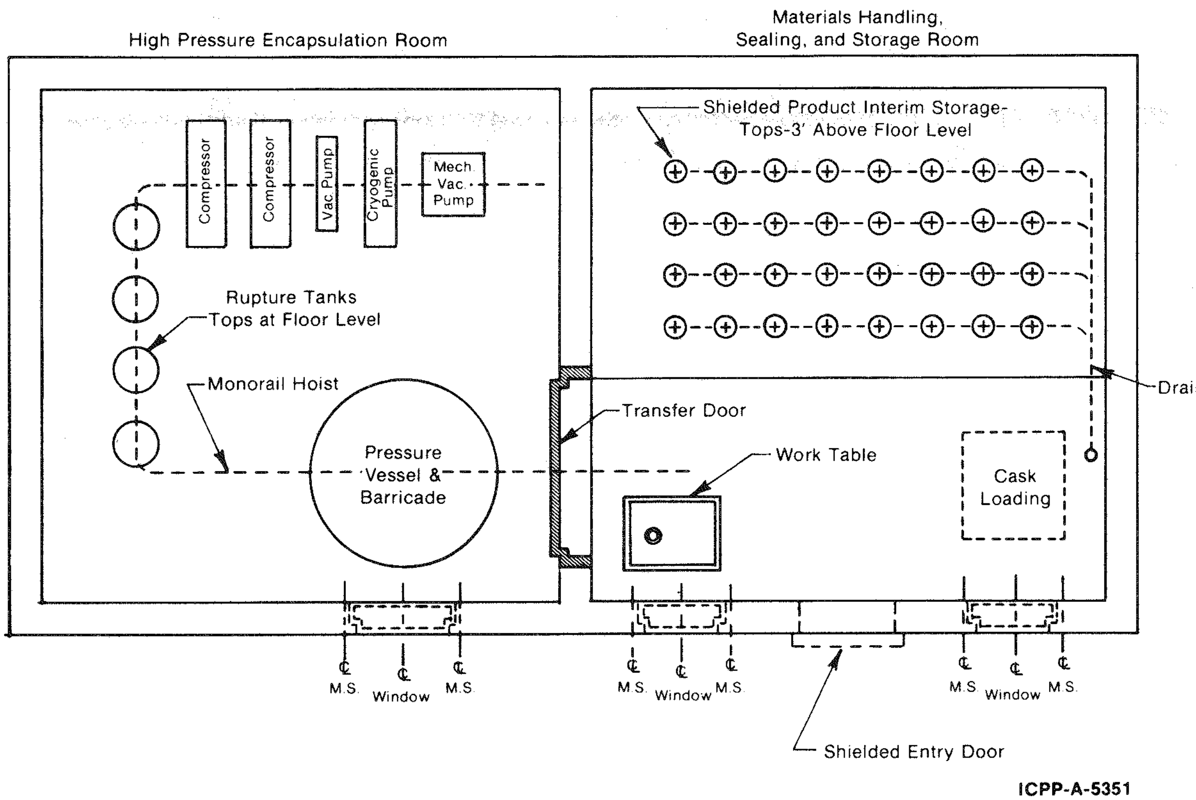

Fig. 15 Krypton-85 Encapsulation Facility Conceptual Design

(1) Open and replace the window fragment shield.

(2) Open the barricade closure in the pressure vessel barricade.

(3) Move a yoke assembly.

(4) Open the pressure vessel closure.

(5) Open and close the sealed transfer door between the encapsulation room and the sealing and storage room.

(6) Attach a lifting assembly to the encapsulation canister and remove the canister from the high pressure vessel.

(7) Transfer the encapsulation canister from the encapsulation room to the sealing and storage room.

In the Materials Handling, Sealing, and Storage Room, the needed remote equipment would include the following:

(1) Two shielding windows.

(2) Two pair of master-slave manipulators.

(3) A bridge-mounted electro-mechanical manipulator.

(4) A crimping and seal welder.

(5) A tubing shear.

(6) A bridge-mounted hoist of sufficient capacity to handle the equipment in the storage room and any equipment moved into the storage room from the high pressure encapsulation room.

(7) Special work tables, tools, and etc.

This equipment would be used to perform the following remote tasks:

(1) Transfer the canister to the sealing and welding fixture.

(2) Seal weld the canister and remove any excess tubing.

(3) Transfer the canister to interim storage.

(4) Remove the canister from interim storage and load it into a shipping cask.

(5) Remove the shipping cask from storage room.

(6) Remove and replace the storage position plugs.

Two of the remote tasks listed for the High Pressure Encapsulation Room - "open the barricade closure in the pressure vessel barricade" and "open the pressure vessel closure" were thoroughly studied and evaluated to assure that these two important operations could be performed remotely. The study showed that performing these tasks remotely is feasible and that there are several commercially available high pressure closures which are suitable for the pressure vessel, all of which can be remotely disassembled and assembled.

As this program moves toward fruition, additional feasibility studies will be made to assist in conceptual design, these will be followed during title design by full-scale mockup and testing.

8. Remote Pipe Cutting and Welding

One of the more time consuming maintenance tasks in a reprocessing plant designed for contact (hands-on) maintenance that results in unavoidable radiation exposure to personnel, is the replacement of sections of radioactive process piping that have plugged or failed from errosion or corrosion. A system to perform this operation remotely would greatly reduce the associated radiation exposure. One must recognize, however, that space and access limitations and manipulator availability may preclude actual application of such a system in some existing plants.

As the first step in developing such a system, a literature survey was performed to identify reports on remote pipe cutting, beveling, and welding. Many articles on remote welding in hot cells and for special set-ups of well-defined and often-repeated operations were found, but none on remote pipe cutting and welding of radioactive process piping in a process cell. National Laboratories and equipment vendors were also contacted with the same result. Based on this information, a program was initiated at the RMTF to test equipment and procedures to remotely remove and replace (cut and weld) in-cell process piping.

The program has been divided into three phases:

(1) Remote cutting.

(2) Remote removal and replacement of the old pipe and alignment of the new pipe.

(3) Remote welding.

In early phase 1, a search was made for commercially available remote pipe cuttings and end preparation machines. The type of machines reviewed included lathe tools, bit cutting and beveling, roller cutters, abrasive wheel, portable power hack saw, and milling cutter. None, however, were found to be truly remote. A variable speed, portable, power hack saw, FEIN model 2000,[a] although not remote was determined to be readily adaptable for remote operation with a single handed manipulator. Therefore, this unit was obtained and prepared for the initial testing. Several lifting bails were added to the saw for handling in either the horizontal or vertical position (Figure 16). In addition, a saw mounting platform that could be remotely clamped to a pipe using a manipulator (Figure 17 and 18) was developed. The platform serves as a means of supporting the saw while cutting is taking place and is clamped to the pipe to be cut. Initial tests with this equipment have proven quite successful.

[a] Power Tools Inc., Pittsburgh, PA 15204

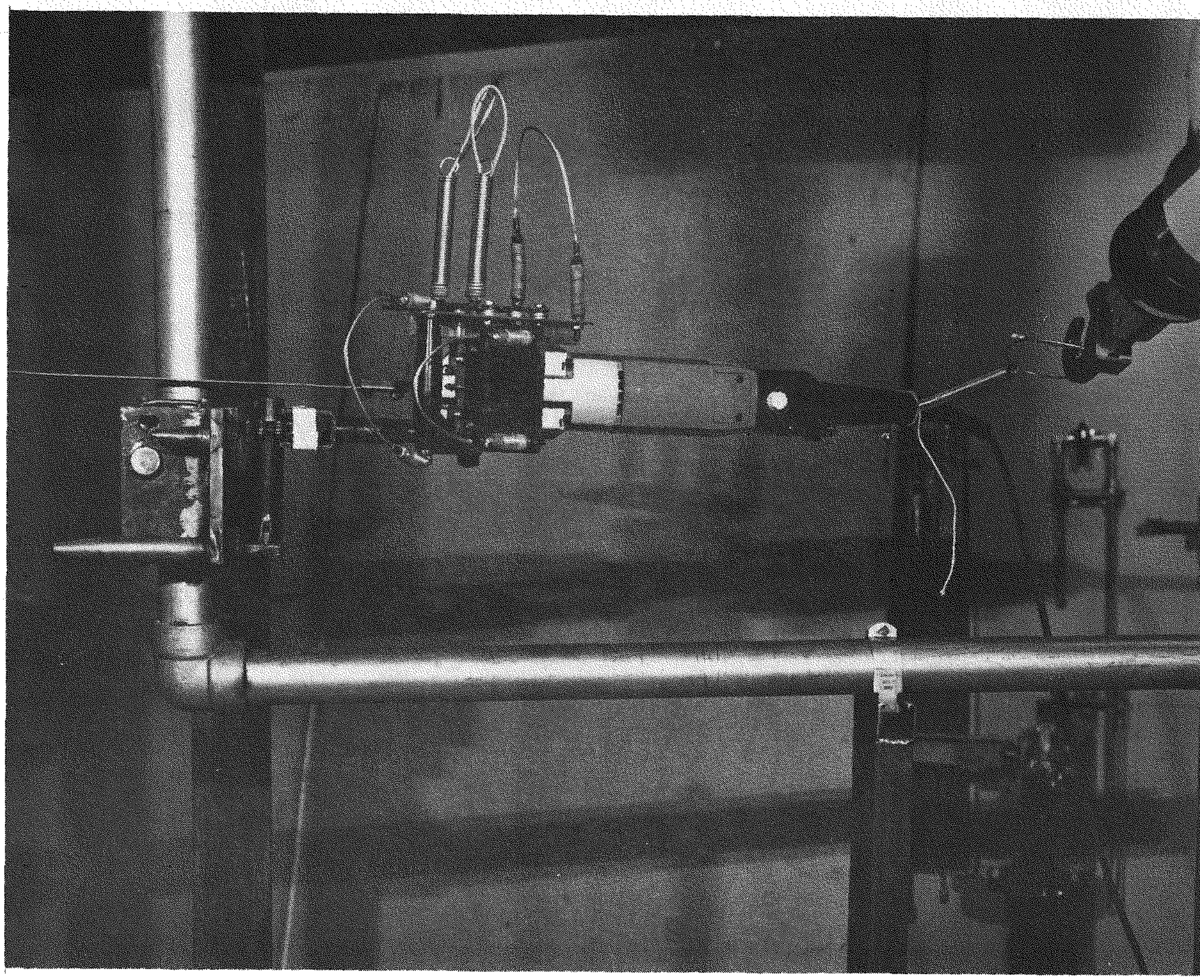

Fig. 16 Portable Power Hack Saw with Lifting Bails

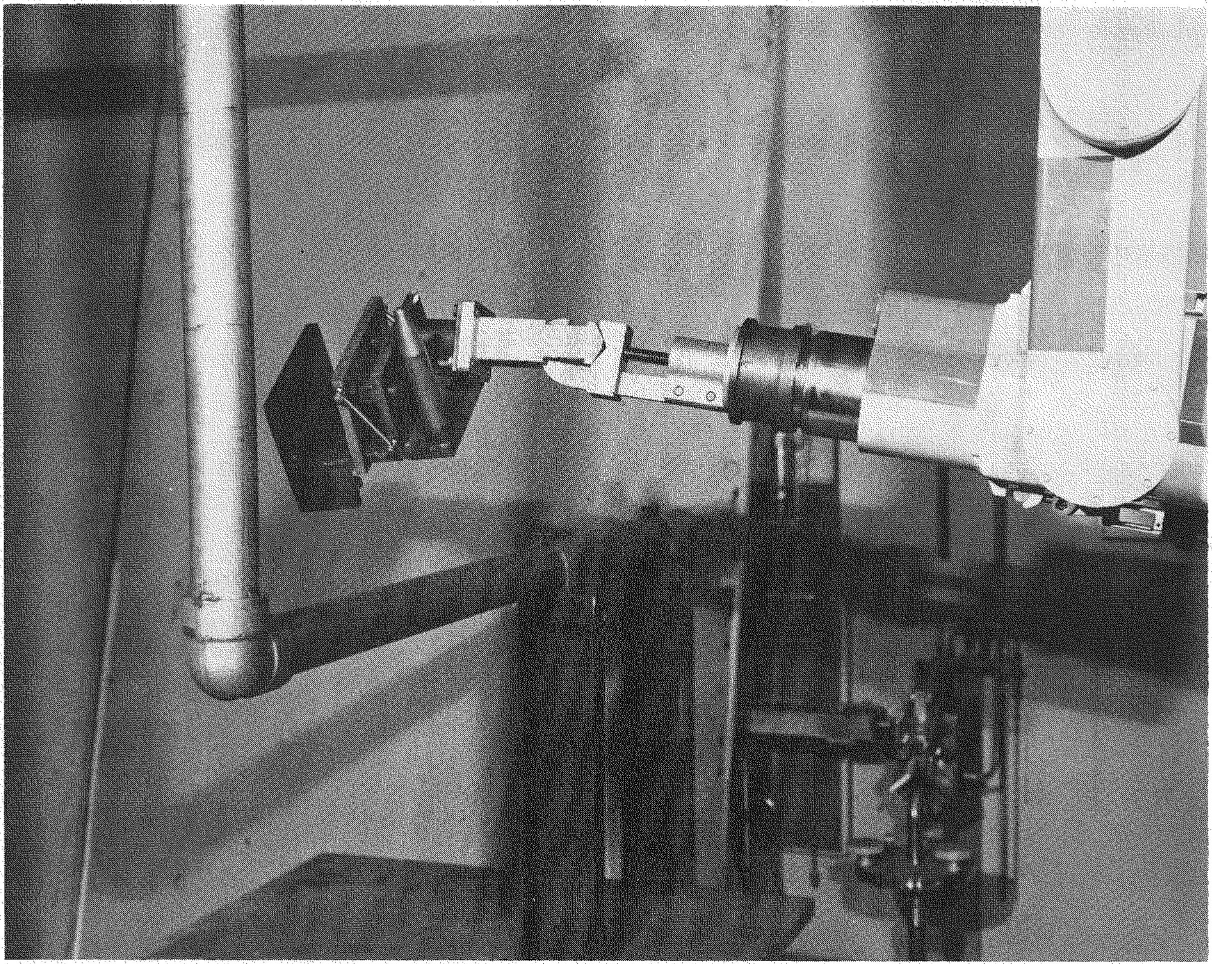

Fig. 17 Saw Mounting Platform Being Installed

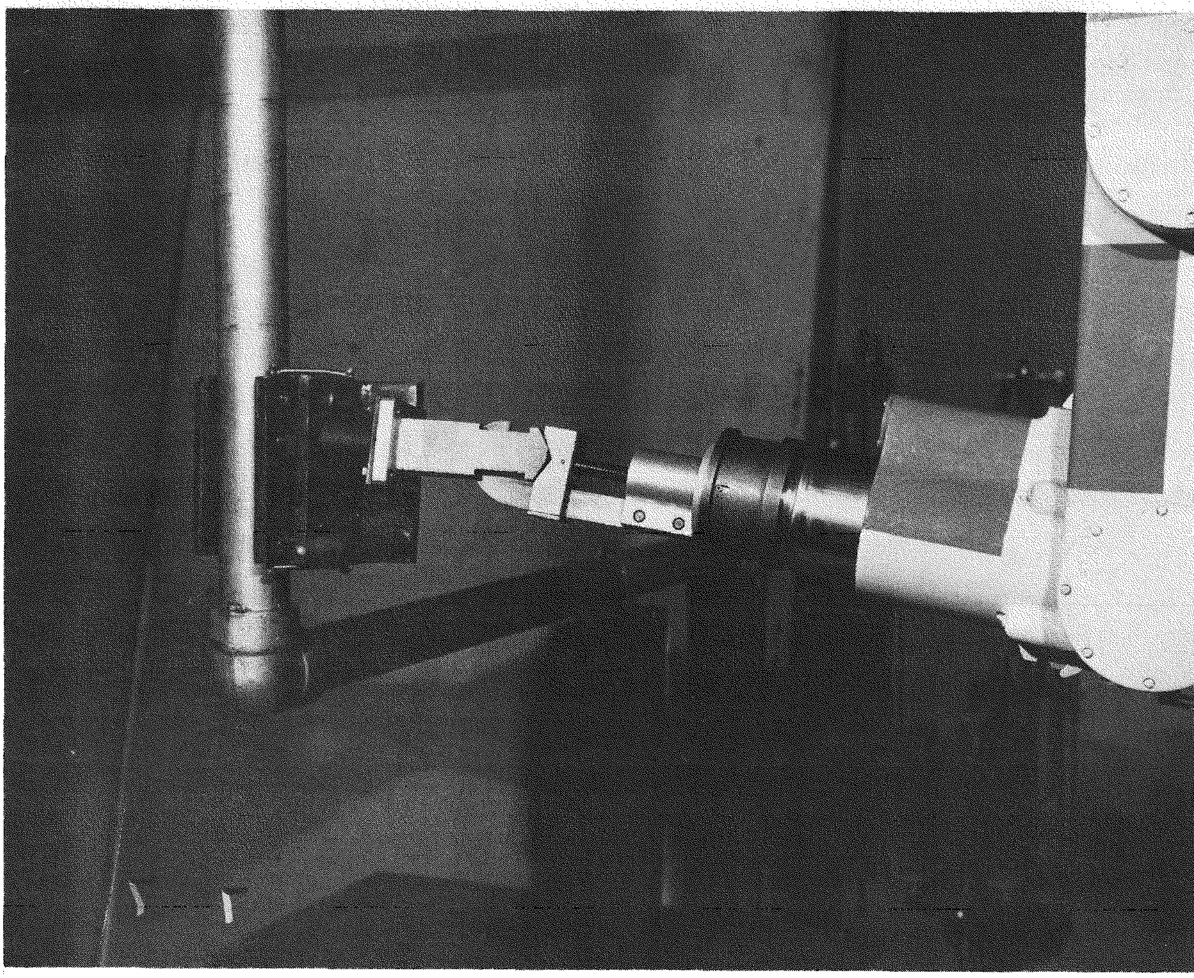

Fig. 18 Saw Mounting Platform Installed on Pipe

V. REMOTE HANDLING TEST RESULTS

1. Sample Bottle Evacuation Chamber

The mockup of the sample bottle evacuation chamber described in Section IV.1 was tested for remote operability with the master-slave manipulators in the sample cell mockup and performed satisfactorily. Evacuated sample bottles were consistently filled with a maximum volume of simulated sample. Because of the simple design of the assembly, frequent failure and changeout is not anticipated. However, testing has shown remote removal and replacement of the evacuation chamber is quickly and easily performed with master-slave manipulators. Based on these tests, this design is being incorporated into the FAST facility.

2. NWCF Solids Sampler Valve Replacement

The modified mockup of the solids sampler valve described in Section IV.2 was tested to verify the remote replaceability of a single unit. Removal and replacement of a single unit required approximately two minutes using master-slave manipulators with no apparent problem areas. The concept is being incorporated into the NWCF sampling system.

3. NWCF TV Camera Support

The TV camera support system designed to provide a clear stable TV picture for remote maintenance or inspection in locations not visible through the existing cell viewing windows has been mocked up and tested. The support system was described in Section IV.3. Remote handling tests were successful and the production unit electrical connector was disconnected and connected without difficulty. The NWCF TV system will reflect this change.

4. FAST Dissolver Top Electrical Connector

Two configurations of the FAST Project dissolver closure drive motor electrical connector were tested. The first arrangement, described in

Section IV.4, consisted of the long power cable attached to the drive motor. Removal of the motor also required removal of the power cable which made the unit difficult to handle remotely. The final arrangement located the electrical connector at the drive motor and resulted in an easy remote removal operation. The final arrangement also permitted a more permanent power cable installation which will be both longer lived and less troublesome.

5. FAST Dissolver Closure Drive Shaft Coupling

During removal testing of the FAST dissolver closure mechanism from the drive unit, a slight tendency for the original splined shaft to bind was experienced. A double tapered pin configuration (Figure 11 in Section IV.5) was tested and mated very easily. However, there was a tendency for the two connector halves of this unit to spread apart when torque was applied because of the opposing forces from the slopes of the pins. A straight toothed (square jawed) positive clutch connector (Figure 12, Section IV.5) was also tested and it too mated very easily. The difficulty with this connector, however, was the lack of self-alignment from side thrusts. A double straight pin (with tapered ends) connector (Figure 13, Section IV.5) was then tested and found to mate very easily. It was also found to be self-aligning if there is any side thrust. A double straight pin connector was therefore recommended for the FAST dissolver drive unit-to-closure mechanism connector.

6. FAST Spent Resin Transfer

Two mockups of the water treatment resin handling system for the FAST fuel storage pool were evaluated previously[10] and the results indicated minor viewing difficulties existed with each mockup. In both cases, the transfer table drive motors were located too close to the wall below the viewing window and could not be easily seen by the operator. Recommended changes included moving the motors to the opposite end of the table and mounting them vertically. Therefore, the two mockups were modified to incorporate the recommended changes and were retested. In Figure 19 the motor for one of the tables is in the new location and in Figure 20 is being removed easily by the master-slave manipulators. The motors can be

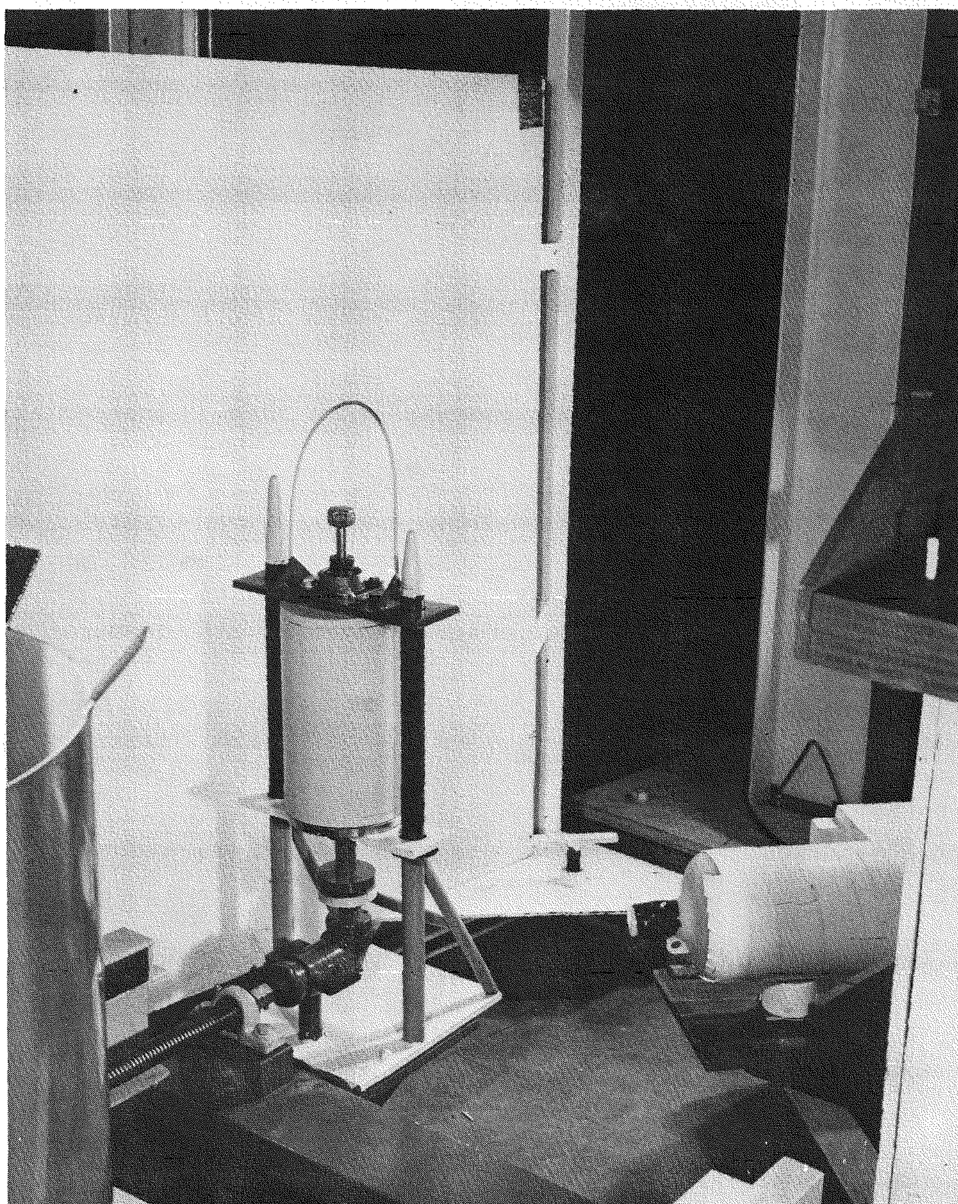

Fig. 19 Transfer Table Drive Motor Installed

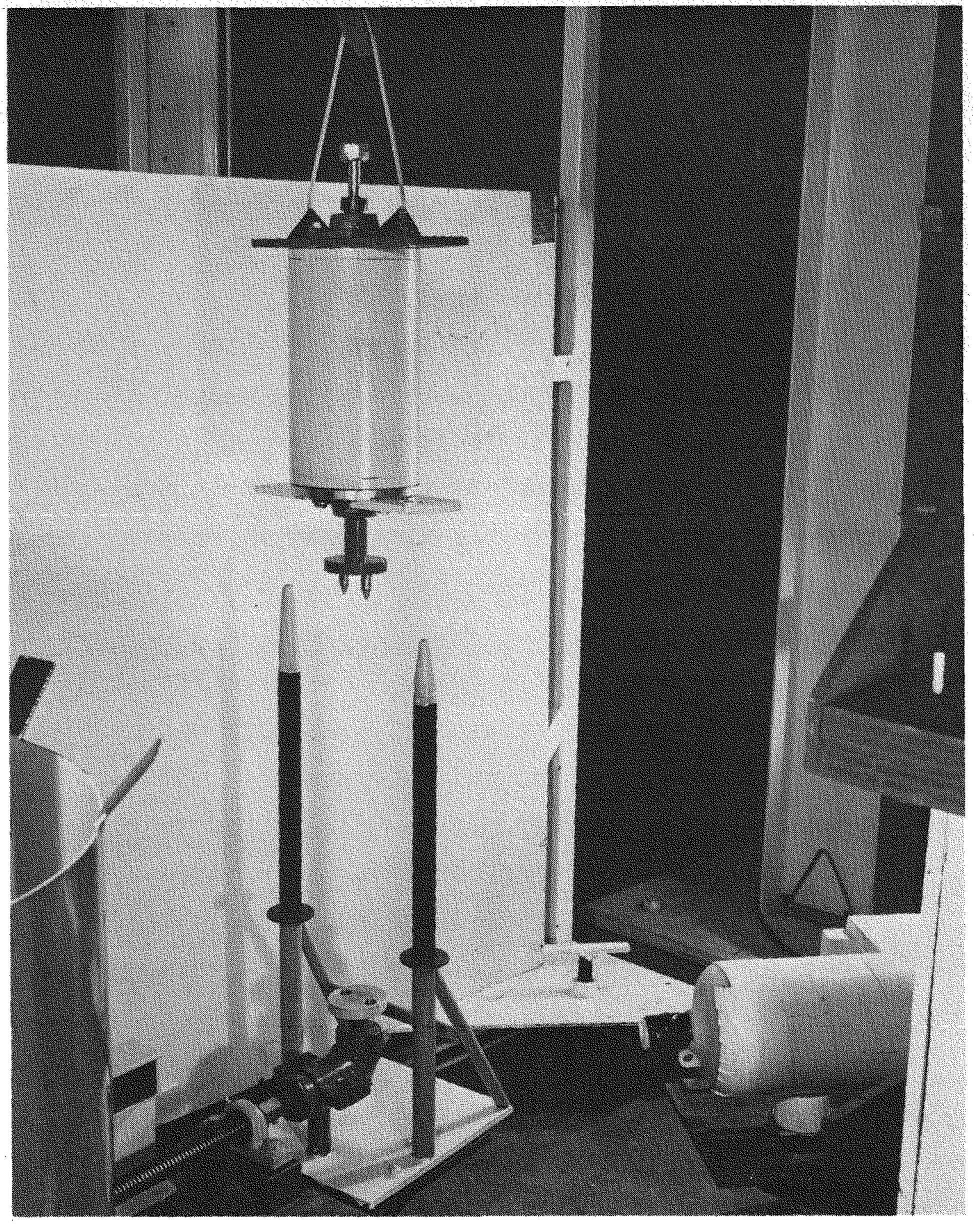

Fig. 20 Transfer Table Drive Motor Being Removed

clearly seen by the operator through the viewing window.

As can be seen in Figure 19 in the new location, the motor is clearly visible to the operator through the viewing window. In addition, the motor can now be easily removed (Figure 20) using master-slave manipulators.

7. Coaxial Cable Slip Ring Assembly

Remote operation of TV cameras while either scanning the inside of process vessels, or with the camera at varying distances from the TV monitor frequently leads to twisting the coaxial TV signal cable. As a result, a method of preventing this from occurring was needed. A slip ring assembly used with the video cable could permit continuous rotation of a TV camera if the ring did not interfere with the TV signal. The slip ring assembly could also be used with a cable reel for feeding video cable varying distances from the monitor.

An IEC-4-MOD model[a] slip ring assembly was obtained and installed in a video signal line between a signal switcher and a TV monitor. Signals were fed to the switcher and monitor from three TV cameras and a videotape recorder. For testing, the slip ring assembly was rotated several times with no discernible picture deterioration. In addition, light jarring of the assembly did not change the quality of the picture on the monitor.

8. 3-Bolt Flange Welding

Use of the holding-welding fixture described in ICP-1143[3] resulted in the satisfactory fabrication of several 3-inch pipe jumpers for the NWCF plant. Following fabrication, however, the 8-inch jumpers did not meet one of the requirements of the specification. The specification allowed a maximum gap of 0.0025 inches between mating flanges (measured at 12 equally

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[a] Manufactured by: IEC Corporation, 3100 Longhorn Blvd., Austin, Texas.

spaced points) after all welding was complete and with 70 foot-pounds torque on the three bolts. The 8-inch flanges exceeded the gap allowance because of flange face distortion from welding. Controlling the flange temperature by partially immersing the flange in cool water during welding did not prevent the warping. Therefore, a procedure was developed to stress relieve the weld by peening the weld area after each weld pass (except the root pass and the final pass) with a small pneumatic hammer equipped with a hardened rounded point of approximately 3/16 inch diameter. This procedure was followed, and did permit fabrication of the 8 in. pipe jumpers to specification requirements.

An alternate fabrication method was later proposed and consisted of making the flange to pipe stub weld prior to final flange facing. This method, however, has not yet been tested.

VI. FUTURE PLANS

Mockup and testing efforts of remote handling equipment have continued in support of two major projects during this year. Continuing efforts in the RMTF will include evaluating new detailed designs and additional remote maintenance equipment and techniques. Specifically, these tasks will include the following:

(1) Provide mockup and checkout support for FAST remote handling design.

(2) Checkout NWCF remote equipment systems operation (SO tests).

(3) Continue testing of remote cutting and welding techniques.

(4) Continue hands-on training sessions for NWCF operators.

(5) Mockup and test a method for calciner bubble cap replacement.

(6) Provide design review for general plant upgrade projects.

(7) Provide design review of the remote aspects of the solids retrieval facility.

VII. REFERENCES

1. R.T. Jacobs, Remote Maintenance Development, June 1974 - July 1975, ICP-1081 (October 1975).

2. R.D. Fletcher, ed., Remote Maintenance Development, July 1975 - July 1976, ICP-1113 (April 1977).

3. Idem, Remote Maintenance Development, July 1, 1976 - July 30, 1977, ICP-1143 (May 1978).

4. Idem, Remote Maintenance Development, July 1, 1977 - June 30, 1978, ICP-1170 (October 1978).

5. Idem, Remote Maintenance Testing, July 1, 1978 - June 30, 1979, ENICO-1008 (October 1979).

6. R.D. Fletcher, ed., ICP-1170, pp. 17-26.

7. Idem, ICP-1143, pp. 32-36.

8. Idem, ICP-1008, pp. 8-11.

9. Idem, ICP-1008, pp. 23-27.

10. Idem, ICP-1008, pp. 31-35.