U. S. ATOMIC ENERGY COMMISSION
REGION V
DIVISION OF COMPLIANCE

Vendor Inspection Report
Primary System Pumps

Vendor:	Electric Steel Corporation (ESCO) 2141 N. W. 25th Avenue Portland, Oregon
Report Number:	ESCO 69-2
Components Inspected For:	Not applicable. Inspection visit for purpose of process evaluation.
Date of Visit:	June 10-11, 1969
Inspectors:	W. E. Vetter 7-14-69 W. E. Vetter (Responsible) W. E. Vetter / FOR 7-14-69 Uldis Potapovs Construction Inspector, CO:II
Report Reviewed By:	G. S. Spencer 7/14/69 G. S. Spencer Senior Reactor Inspector, CO:V
Application Requirements on Product Inspected:	Indian Point No. 1 and 2. Inspection made with reference to ASME Code Sections I, III and VIII, Divisions 1 and 2, Special Ruling Case 1355-2, and ASME, Sections III and IX in general.

INTRODUCTION

The ESCO Corporation was visited for the purpose of making an evaluation of the quality of the electroslag (E-S) welding operation being used to assemble nuclear reactor primary system components (pump casings and pipe elbows). In addition to individual evaluation on the part of Compliance personnel, this report reflects ESCO personnel response to a list of questions generated by DRL personnel prior to the visit. In general, the evaluation was performed on a "two category basis"; i.e., QA-QC and metallurgical considerations. Mr. Potapovs concentrated on metallurgical aspects and the inspector on QA-QC aspects concerned with the E-S welding programs. Personnel contacted during the visit included:

Mr. F. P. Schwab - Manager, Atomic Power Department, ESCO
Mr. O. S. Tuerck - Manager, Inspection (QA-QC) & Assistant to the President, ESCO
Mr. B. Groshart - Manager, QA-QC, ESCO
Dr. W. H. Rice - Welding and Metallurgical Consultant, ESCO
Mr. R. F. Richmond - Project Engineer, APD, ESCO
Mr. F. Hunt - QA Supervisor (Welding), ESCO
Mr. W. A. Harkins - Project Engineer, Connecticut Edison Co.
Mr. G. W. Wasilenko - Project Engineer, Connecticut Edison Co.

Following a request to the writer, Messrs. Harkins and Wasilenko participated in the tour, demonstration and discussion activities of the visit on an "interest only" basis. That is, none of the Division of Compliance activities (including specific requests for information and/or records for review) were "docket" or "license" oriented.

CONCLUSIONS

Upon completion of the E-S welding program evaluation effort, a Management Interview was held with the below listed individuals:

Mr. O. S. Tuerck - Manager of Inspection and Assistant to the President, ESCO
Mr. F. P. Schwab - Manager, Atomic Power Department, ESCO
Mr. B. Groshart - Manager, QA-QC, ESCO
Dr. W. H. Rice - Welding and Metallurgical Consultant, ESCO
Mr. W. A. Harkins - Project Engineer, Connecticut Edison Co.
Mr. G. W. Wasilenko - Project Engineer, Connecticut Edison Co.

The significant results of the E-S welding program evaluation were discussed as follows.

Both the inspector and Potapovs commented that the overall results of the evaluation effort indicated that E-S welding was being performed with maximum attention to quality and that a comprehensive process control program appeared to be in effect. Following this, Potapovs stated that a review of the ESCO E-S welding procedures appeared to be consistent with good practice and code requirements except that the procedures provided for current and voltage variations in excess of those allowed in Special Code Ruling Case 1355-2. The inspector pointed out that, although the procedures did appear to be partially inconsistent with code requirements, observation of the E-S welding process and a review of records indicated that the code requirements were being met and requested comments. Dr. Rice agreed that the E-S welding procedures did, indeed, fall short of code requirements in the area of current and voltage. Following additional discussion, Mr. Tuerck stated that appropriate changes in the procedures would be considered on a priority basis.

The inspector discussed the E-S welding QA-Qc programs briefly to say that, with one possible exception, the programs seemed to be adequate. The exception was the fact that records of critical welding parameters; i.e., current, voltage and wire feed speeds, are not being maintained during the welding process. Mr. Tuerck commented that, as in the case of the previously mentioned procedure discrepancy, immediate consideration would be given to corrective action.

DISCUSSION

As stated earlier, the electroslag welding program was reviewed segmentally as a function of two, specific categories - metallurgical and QA-QC. The two categories are discussed in report Sections A and B, below, wherein a list of questions generated by DRL personnel has been augmented by the inspector and Mr. Potapovs.

A. Quality Assurance - Quality Control

1. Experience

The ESCO Corporation has been actively engaged in E-S welding programs since early in 1966. Since first being qualified by the state code inspector, according to Mr. Schwab, ESCO E-S operators have completed approximately 3100 feet of E-S weldment. The weldment footage involves primary coolant system pump casings and primary coolant piping elbows for nuclear reactor systems as well as pump casing and elbows (24 pumps and 90-100 elbows) for large, non-nuclear, water systems. E-S weld thicknesses have varied from 3.5 to 19.5 inches. According to Mr. Groshart, none of the E-S weldments have suffered in-service deformation, cracking, or other forms of unsatisfactory performance.

2. E-S Performance Standards

The ESCO E-S welding processes and E-S welders have been qualified by the State of Oregon Bureau of Labor, Boiler and Pressure Vessel Division, Code Inspection personnel. ESCO records indicate that E-S welding procedures and welders have been qualified for E-S welds of up to, and including, 21 inches in thickness. The E-S welding qualifications records indicate that the qualification of procedures has been based on ASME Qualification Procedure No. 21 and that the material of qualification was SA 351 stainless steel.

The ESCO records also revealed that both the E-S welding procedures and welders are qualified for one, two and/or three wire operations. A review of the welder qualification records established that a daily check is made to assure that each E-S welder is currently qualified. This check is performed by the Welding Operations QA Supervisor by reference to a "tickler file" which permits a rapid qualification, versus qualification expiration date, check for each welding process and each welder. The records indicated that all welders (E-S operators) have been qualified according to the provisions of ASME Section IX.

3. Technological Development Provisions

According to Mr. Schwab, a significant and continuing effort has been expended by ESCO to maintain a position of leadership in all phases of welding technology. To support this effort, a fully equipped and staffed laboratory has been provided. The laboratory is equipped to perform all of the essential material testing functions - including chemical, macro and micro analysis of test coupons. Mr. Schwab also said that a program of metallurgical research and one concerned with new products development are both headed by key personnel and that the progress of these programs is monitored formally, as well as informally, by the ESCO Board of Directors.

4. Heat Treating

A complex of three heat treating furnaces is located in the components assembly portion of the ESCO plant area. Each of the furnaces is designed for a particular application and is fitted with instrumentation to facilitate control. Recording instrumentation is provided. None of the instrumentation is dual, which would permit calibration verification, but the instrumentation is checked on a frequent, periodic basis against standards to assure accuracy. These checks are performed by QA-QC personnel.

Component parts are air and/or water cooled depending upon individual requirements. Components required to be air cooled are cooled at a rate consistent with purchase specifications (standards and codes) by post heating residence times involving both the furnace and outside furnace ambient temperatures.

Water cooled components are quenched in the plant quench tank which is located about 25 feet in front of and below the floor level of the main (largest) heat treat furnace. Water cooling rates are controlled by a quench tank cold water injection system which consists of a series of eight-inch diameter water lines which inject water at the bottom of the tank, from all four sides, toward the center of the tank.

According to Mr. Schwab, the quench tank water supply (city tap water) is checked for composition and conductivity. The tests are performed by the Charlton Laboratory, located in Portland, Oregon, and the most recent tests establish the following typical quench tank water properties.

pH	6.8
Total solids	30.0 ppm (residue on evaporation)
Specific conductivity	24.0 µmhos/square cc @ 25°C
Alkalinity (bicarbonate)	5.5
SiO2	11.8
Ca	2.1
Mg	1.6
Fe	0.11
Al	0.44
Mn	<0.02
Na	0.8
K	0.2
Cl	3.9
SO4	1.5
NO3	<0.01
Fluorine	<0.01
Free Chlorine	0.6

5. E-S Welding Equipment

During the visit on June 10, 1969, ESCO personnel performed a routine E-S test block weld for qualification purposes (see Figures 2 and 3, attached). The test block was SA 351 stainless steel and was approximately eight inches thick. The weld was being performed in accordance with ASME Qualification Procedure No. 21 (two wire) and two qualified E-S welders were in attendance at the time of the inspector's observations. According to Mr. Groshart, all E-S welding is performed with a minimum of two qualified E-S welders in attendance. He added that, for very complex E-S welding operations, as many as four qualified E-S welders are utilized. Figures 1, 2 and 3, attached, are sketches of the ESCO E-S welding equipment and reflect observations made by the inspector during the test block E-S welding operation on June 10, 1969. As shown on the sketches, the E-S equipment includes an independent power supply (transformer-to-bus).

Observations by the inspector on June 10 indicate that voltage fluctuations are well within procedure specifications and that only minimal adjustment activities are required. According to Mr. Hunt, a formerly-qualified E-S welder, essentially no fluctuation in voltage occurs during routine, steady condition welding (i.e., after the initial slag pool has been formed and wire feed speeds have been stabilized).

6. Code Inspection

ESCO does not include a code inspector in their organization structure. Rather, all code welding procedures and welder qualifications tests (including E-S) are witnessed by the Oregon State Code Inspection staff. Compliance with code requirements is maintained by the ESCO QA-QC staff. The QA-QC organization structure includes a supervisory slot with a primary responsibility for assuring that E-S welding procedures and welders are code qualified. The E-S welding operations are under the continuous observation of the QA-QC organization, according to Mr. Groshart, and subject to routine review to assure that maximum quality welds are produced.

7. E-S Welding Program QA-QC Provisions

The ESCO QA-QC program was previously reviewed (see CO Report Nos. 50-275/69-3 and 50-237/69-5, Appendix A, dated April 14, 1969) and was found to be adequate. During the current visit, it appeared obvious that all of the QA-QC efforts applied to conventional welding programs were applied, equally, to the E-S welding programs. To determine the scope and effectiveness of QA-QC efforts relative to the E-S programs, records associated with unidentified (utility) reactor coolant pump casings were reviewed with Messrs. Groshart and Hunt. Pertinent information obtained as a result of the review is listed.

a. A Nondestructive Testing (NDT) record form is prepared by the QA organization on the basis of code, welding procedure and purchase specification requirements. This form "follows" the valve casing from the time that the component halves are introduced to the E-S welding process (weld prep program) and must be approved by the QA staff prior to release of the casing for shipment. Each step of the E-S weld process, including all repair efforts and NDT efforts, is listed on this form and must be "signed off" by a QC inspector (initial stamp) before the next, sequential step can be initiated.

b. During the E-S welding operation, the procedures require that any problems or anomalies encountered are to be noted on the traveler form and flagged for NDT attention. An example of use of this requirement, according to Mr. Hunt, would be an unusual appearance of the "heat spot" (see Figure 1, attached) which follows the weld as the weld pool rises. Hunt explained that E-S welders have learned to relate an abnormal heat spot appearance to a potentially bad weld and, therefore, mark any such areas noted during the weld operation for special NDT attention.

c. The E-S welding records were reviewed and considered to be somewhat inadequate in that no records of critical procedure parameter values, such as voltage, current, wire speed and wire travel frequency and dwell, are maintained except in the case of test block welds.

Both Mr. Groshart and Mr. Hunt, the latter being one of the first ESCO people to be qualified as an E-S welder, commented that (1) the nature of the E-S welding process is such that welds are "good or bad" as a function of a "continuing process" and (2) that the process could not continue unless the procedures were followed. That is, out-of-bounds conditions would be indicated by the appearance of the weld. For this reason, Groshart explained, it must be assumed that all process parameters are in-bounds if a successful weld is performed. Groshart explained, further, that if process parameters had been compromised during the weld, heat spot appearances and/or other indices would become manifest and the NDT traveler sheet would so indicate. The inspector pointed out that records of the subject parameter values (at least voltage, current and wire speed) on an hourly basis would seem to be appropriate, not only in the category of QC records but as backup records to support the existence of QA programmatic efforts in the event of weld failure occurrence at some future date.

Mr. Wasilenko commented at this time to say that he, too, felt that maintenance of records as discussed should be considered and that a particular motivation should be the possibility of a weld failure at some future time.

Later, during further discussion and review of this matter, Mr. Groshart informed the inspector that the subject records were, in fact, being maintained for some of the E-S welded components as a function of individual purchase specifications. Groshart identified the utility involved and it was demonstrated that current, voltage and wire speed were recorded on an hourly basis throughout the welding operation. The vendor, at the conclusion of the visit, was considering the advisability of recording current, voltage and wire speed during all E-S welding operations (see the Conclusions Section of this report).

8. Nondestructive Testing

According to a review of QC records and comments by Mr. Groshart, Nondestructive Testing (NDT) of finished E-S welds is consistent with code requirements in that radiography is performed in accordance with ASME Code Case 1355-2. As provided for by Code Case 1355-2, Ultrasonic Testing (UT) is not performed (UT testing is required by inference only when ferritic materials are used). In any event, Groshart said that attempts to perform UT tests were unsuccessful because of the large grain structure in the SA 351 stainless steel. He said that the large grain structure causes "back reflections" during UT testing such that meaningful test results could not be obtained.

In addition to the radiographic testing, ESCO has elected to perform 100 percent liquid penetrant (LP) testing of all E-S welds. Although LP testing is not required by Code, Groshart said the tests were performed on the E-S welds in keeping with standard practice which requires 100 percent LP testing of the remainder of the component involved.

B. Metallurgical Considerations

1. General Comments

a. ESCO uses a modified ARCOS (Belgium) welding machine and Miller, constant voltage, 60 cycle AC power supply for all production electroslag (ES) welding.

b. Only 1/8"-diameter wire and one type of flux (ARCOS BV-1) is used.

c. Unless requested by the costomer, fabrication test plates are not used in production welding. Run-off tabs are too short to be representative of the weld metal.

d. Pump casings are not solution annealed following the welding operation.

e. The weld form factor is not specifically controlled. However, indirect control results from limits imposed on the process variables.

f. Hot cracking has not been a problem. ESCO believes that high ferrite contents (typically 20-40%) eliminates cracking.

g. ESCO confirmed a general consensus that the mechanical properties of E-S weld metal is not as good as those of the base metal.

2. Welding Equipment (See Figures 1, 2 and 3, attached)

One basic electroslag welding unit is used in all production welding. This unit is an ARCOS welding machine, adaptable to one, two or three wire feed and was originally imported from Belgium. The unit has been extensively modified by ESCO, mainly to improve the wire feeding and oscillation mechanisms. A Miller constant voltage AC power supply provides the welding current. The contact tubes are made from copper-tungsten material (supplied by Mallory Corporation) and possess excellent electrical properties. No feeding or electrical contact problems are encountered except that heat erosion of the contact tube is an economic consideration. Also, wire distortion resulting from positive feed mechanisms (crimping) has been an undersirable situation due to electrode tip wear caused by the crimped surface of the wire acting as a file.

Water-cooled copper shoes are used on both sides of the weld. In most of the heavy section production welding (such as the Westinghouse pump casings), the inside shoe is stationary and covers the entire length of the weld, while the outside shoe follows the weld progression.

3. Filler Metal and Flux

The majority of nuclear castings produced by ESCO conform to ASTM-A351 grades CF8 or CF8M (casting equivalent of types 304 and 316). In practice, ESCO alloy designations are used. Welding wire is purchased to ASTM A371, ER308 (or ER308L), and ER316 to match the two casting compositions. Several filler metal suppliers are utilized. ES welding of a test plate was observed during the inspection (see Figure 2, attached).

The exact chemical composition of the flux is not available, although analysis performed by ESCO has shown it to be more than 50% calcium fluoride, with the balance largely lime. All flux is baked at 1,000°F prior to use.

4. Process Qualification and Acceptability Verification

a. Procedure Qualification

A general procedure is used as a basis for all ES welding at ESCO. Although this procedure is apparently written in accordance with ASME Code Case 1355, it is quite general and does not comply with all restrictions of the essential variables specified in the Code Case in that Case 1355 requires requalification of the procedure for a change of 10% or more in the voltage or 20% or more in the amperage over or under the average amperage used in qualifying the original procedure. The ESCO general welding procedure specifies voltage range of 38-56 volts and current range of 475-800 amperes, both values being considerably outside the Code Case tolerances (see the Conclusions Section of this report). However, in actual production welding, these parameters were maintained at a very constant level.

It is also noted that post-weld heat treatment is listed as an essential variable by Code Case 1355, whereas the ESCO general welding procedure simply states that postheating shall be as specified in the manufacturing procedure for the order.

b. Development Studies

The inspector reviewed results of ESCO electroslag process evaluation work which was largely conducted prior to formal qualification of the ES welding procedure and its use in production welding. For an 8-inch CF8M curved plate, simulating pump casing geometry, typical mechanical properties were as follows:

	Base Metal	All Weld Metal
Ultimate Tensile Strength (ksi)	85 - 86	75 - 78
.2% Yield Strength (ksi)	43 - 46	34
% Elongation	50 - 54	43
% Reduction of Area	60 - 65	46 - 60

Standard charpy-V room temperature values for the base metal ranged between 90 and 150 ft./lb. Weld metal values were, in general, significantly lower, ranging from about 50 to 100 ft./lb., although one value as low as 36 ft./lb. was recorded. There appeared to be no real correlation between the notch orientation with respect to the weld and energy absorption values for the limited number of charpy specimens evaluated in each position (notch orientation was indicated on data sheets).

c. Fabrication Test Plates

ESCO does not make fabrication test plates unless specifically requested by the customer, in which case ESCO will supply the plate and may keep excess material for their own evaluation.

Special plates are also prepared for specific purposes: A test plate has been prepared for Oak Ridge National Laboratory for use in developing a radiographic scanning procedure. In that particular test plate, the effects of stopping and restarting the ES welding process have been investigated. No detectable weld defects were found following a 30-second interruption of the welding process. A one-minute interruption produced a small indication of possible lack of fusion at the base metal interface.

The production weld run-off tabs are too short to satisfactorily represent the weldment properties and, consequently, are not used for weld evaluation.

5. Control of Process Variables

a. Joint Preparation

A square joint with a nominal 1¼ inch gap is used in all production welding. Although the welding procedure does not set a specific tolerance on the gap width, Dr. Rice, ESCO's welding expert, indicated that in practice the maximum variation would be between 1 and 1½ inches. The gap is generally maintained on the low side, but interference with the wire feeders could be expected if the gap was less than 1 inch.

b. Electrical Characteristics

Welding is done with 60-cycle alternating current.

c. Welding Technique

Four operators are in attendance during a typical production weld, although as many as five are sometimes used. A two-man team controls the voltage and wire feed rate, and maintains proper operation of the feeding mechanism, as well as replenishing the flux as needed. One operator is inside the pump casing watching the stationary shoe for any metal leakage. The shoe is sealed to the casing I.D. with an asbestos and refractory sealing compound. The fourth operator's main duty is to assist the man inside the pump casing.

d. Welding Voltage

ESCO welding procedure specifies a voltage range of 38-56 volts. In practice, the voltage is maintained within much closer range (48-50 volts is typical). The welding of a customer's test plate was observed during the inspection. Momentary voltage fluctuations ranging from 40 to about 60 volts were observed, but the process had just been started and had not stabilized.

e. Welding Current

ESCO welding procedure specifies 475 to 800 amps, but closer range is achieved in production welding. The current is controlled by adjusting the wire feed rate.

f. Electrode Feed Rate

Electrode feed rate is not specified. It is used mainly to control the welding current and is recorded on the welding data sheet in terms of deposition rate.

g. Electrode Travel and Dwell

These parameters are adjusted according to the material thickness and are recorded on the welding data sheet. No specific limits are prescribed in the welding procedure but common practice is to provide for travel such that the inside and outside electrode tips approach to within 1/2 inch of the back (fixed) shoe and to within 3/4 inch of the front (traveling) shoe.

h. Slag Depth and Temperature

The slag depth is maintained at 3/4 to 1 inch, although no specific limits are set by the welding procedure. Dip-stick method is used to check the slag depth during production welding. Flux is replenished manually, using a pouring cup.

6. Heat Treatment

a. Base Metal (Castings)

Following the stripping from mold, the raisers are trimmed and castings are shot blasted to remove scale. Steel shot are used in this operation, but ESCO maintains that any ferrite contamination is oxidized and lost during the solution annealing treatment which follows. Acid pickling of castings has been explored but found to give unsatisfactory results. All castings are solution annealed at 2050°F and water quenched.

b. ES Welds

No preheating is used, providing the metal temperature is above 70°F. Welded fittings are generally solution annealed (2050°F + water quench) following the joining operation. This condition is usually specified by the customer. The pump casing are not annealed, mainly because of their size. Rice is of the opinion that because of the tremendous mass involved and the configuration of these units, effective quenching would not be possible and distortion of the internal components would be a problem.

7. Weldment Evaluations

a. Weld Form Factor

The weld form factor is not specifically considered in production welding, although it is indirectly controlled through the process variable discussed previously. ESCO has not explored to any significant extent the effect of changing welding parameters on the weld form factor or microstructure of the deposit. They are geared to production welding and consider studies of this type more in the realm of research and development and not as prerequisites to quality welds.

The inspector examined several macrographs from the weld development study discussed in Section B.4.(b). Weld width appeared to be about 2 to 2½ inches original gap nominally 1¼"). The dendritic solidification pattern converged at an acute angle, suggesting medium form factor values (2-3). No evidence of cracking or fissuring was observed.

b. Metallography of the Weldment

Typical photomicrographs from the same development study showed a duplex microstructure (austenite-ferrite) for both the base metal and weld deposit. The percentage of ferrite in the parent casting was estimated at about 20 to 40%, while the weld deposit contained somewhat less ferrite (about 20%). The ferrite distribution in the weld metal was considerably finer than in the base metal. The applicable photomicrograph captions suggested evidence of carbide precipitation at the austinite-ferrite boundaries; but because of the somewhat poor quality of the photomicrographs and relatively low magnification (250X), the extent of weld metal sensitization could not be established.

c. Resistance to Hot Cracking and Corrosion

ESCO has never encountered hot cracking in their experience with ES welding of austenitic stainless steels. Rice attributes this largely to the high ferrite contents of the weldment. The ferrite contents described in the previous paragraph are apparently typical of the ESCO production weldments. Magnetic check of several pump casings on the shop floor showed all to be strongly magnetic. Rice indicated that they liked to keep the ferrite contents high because it also increases tensile strength (ductility and impact strength are reduced) and corrosion resistance. The formation of sigma phase at the pump casing service temperatures was thought to be very unlikely.

The extent of sensitization of the weld zone and its effect on corrosion in service environment has received limited exploration. At the request of B&W, a boat sample had been taken from inside a pump casing (ES weld) and subjected to the Straus test. The results were reportedly favorable. Rice also pointed out that, because of the accelerated cooling in contact with the fixed shoe, sensitization at the inside surface of the casing should be reduced. Visual inspection of the test weld in progress at the time of the inspection tends to confirm this (rapid cooling rate at the inside shoe).

8. Destructive and Nondestructive Testing Equipment and Equipment Calibration

ESCO has an adequately-equipped mechanical testing and physical metallurgy laboratory. The major equipment is listed below.

a. A 60,000 pound tensile machine with stress-strain recorder, equipped for room temperature as well as elevated temperature testing. The unit is calibrated yearly by the manufacturer.

b. Charpy impact testing machine with the associated specimen conditioning equipment. The unit has not been calibrated using Watertown arsenal specimens, but the swing is checked periodically in accordance with ASTM E23 to verify proper operation of bearings.

c. Gleeble equipment which is used mainly for alloy development work and solidification studies.

d. Several hardness testing machines (Rockwell and Brinnel) which are calibrated yearly by the manufacturer.

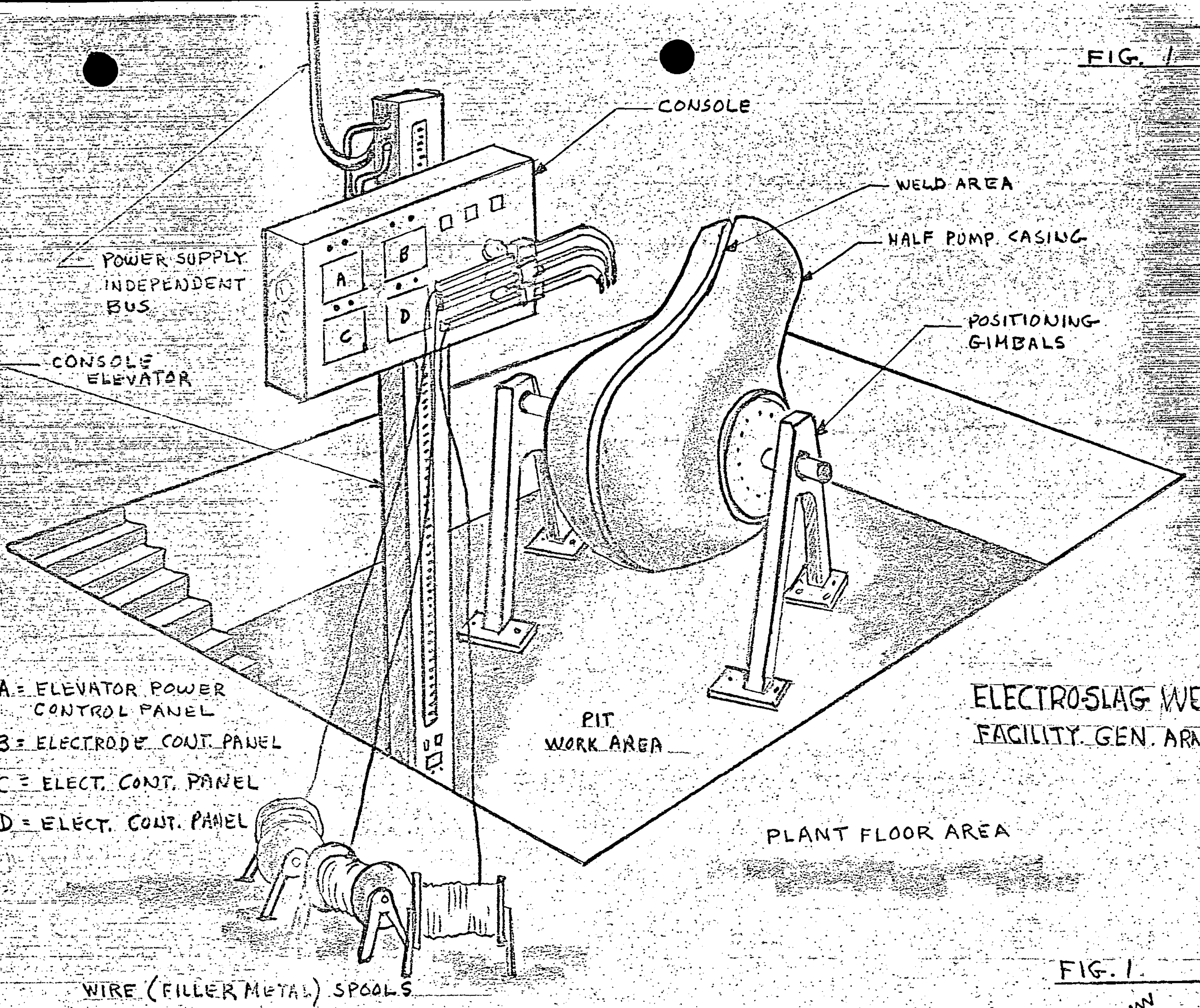
e. Drop weight tester.

In addition, complete metallographic facilities are available.

Nondestructive testing equipment includes radiographic (24 million volt betatron) ultrasonic and eddy current capability.

9. Weld Inspection and Repair

All welds are 100% radiographed. Attempts at ultrasonic testing have thus far been unsuccessful, mainly because of the dendritic solidification pattern and duplex microstructure. Rice indicated that development work is being continued (by ESCO and others) to find a satisfactory method of ultrasonically testing these castings. At the present time, ESCO is using ultrasonic equipment mainly to check casting wall thickness in inaccessible areas. Weld repairs are infrequent and, when required, are performed using either manual metal arc or the MIG process. Qualified welding procedures are available for both processes. Complete weld runouts or equipment breakdown resulting in stoppage is one cause of weld repair. In such cases, the ES weld is restarted and the interrupted area gauged out and manually rewelded. One of the problems associated with a complete cooldown is shrinkage of the weld gap above which causes mechanical problems on subsequent restart. Partial stoppages (up to about one minute) can be tolerated. This permits sufficient time to refeed the filler wire in a single wire process or replace a contact tube in two or three wire process. In the case of a partial stoppage, the corresponding weld area is marked and given special attention during the nondestructive testing.



ELECTRO-SLAG WELD FACILITY GEN. ARNGMNT

FIG. 1

WW

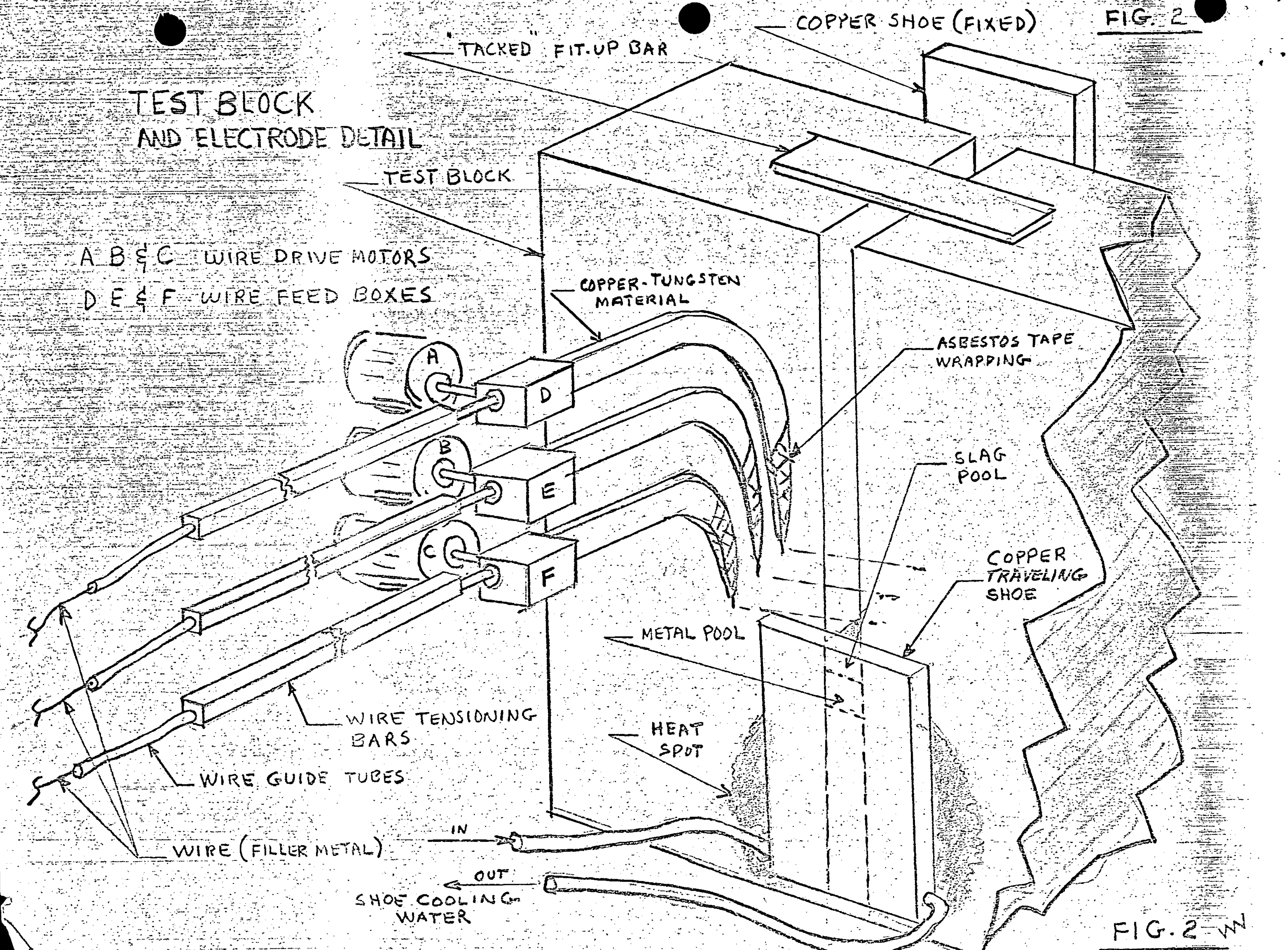

TEST BLOCK
AND ELECTRODE DETAIL
"TACKED" FIT-UP BAR
COPPER SHOE (FIXED)
TEST BLOCK
A B & C WIRE DRIVE MOTORS
D E & F WIRE FEED BOXES
COPPER-TUNGSTEN MATERIAL
ASBESTOS TAPE WRAPPING
A
B
C
D
E
F
SLAG POOL
COPPER TRAVELING SHOE
METAL POOL
WIRE TENSIONING BARS
HEAT SPOT
WIRE GUIDE TUBES
WIRE (FILLER METAL)
IN
OUT
SHOE COOLING WATER

FIG. 2

CROSS SECTION VIEW SHOWING ELECTRODES IN POSITION BETWEEN TWO HALVES OF TEST BLOCK (WALL SECTION VIEW)

FIG. 3

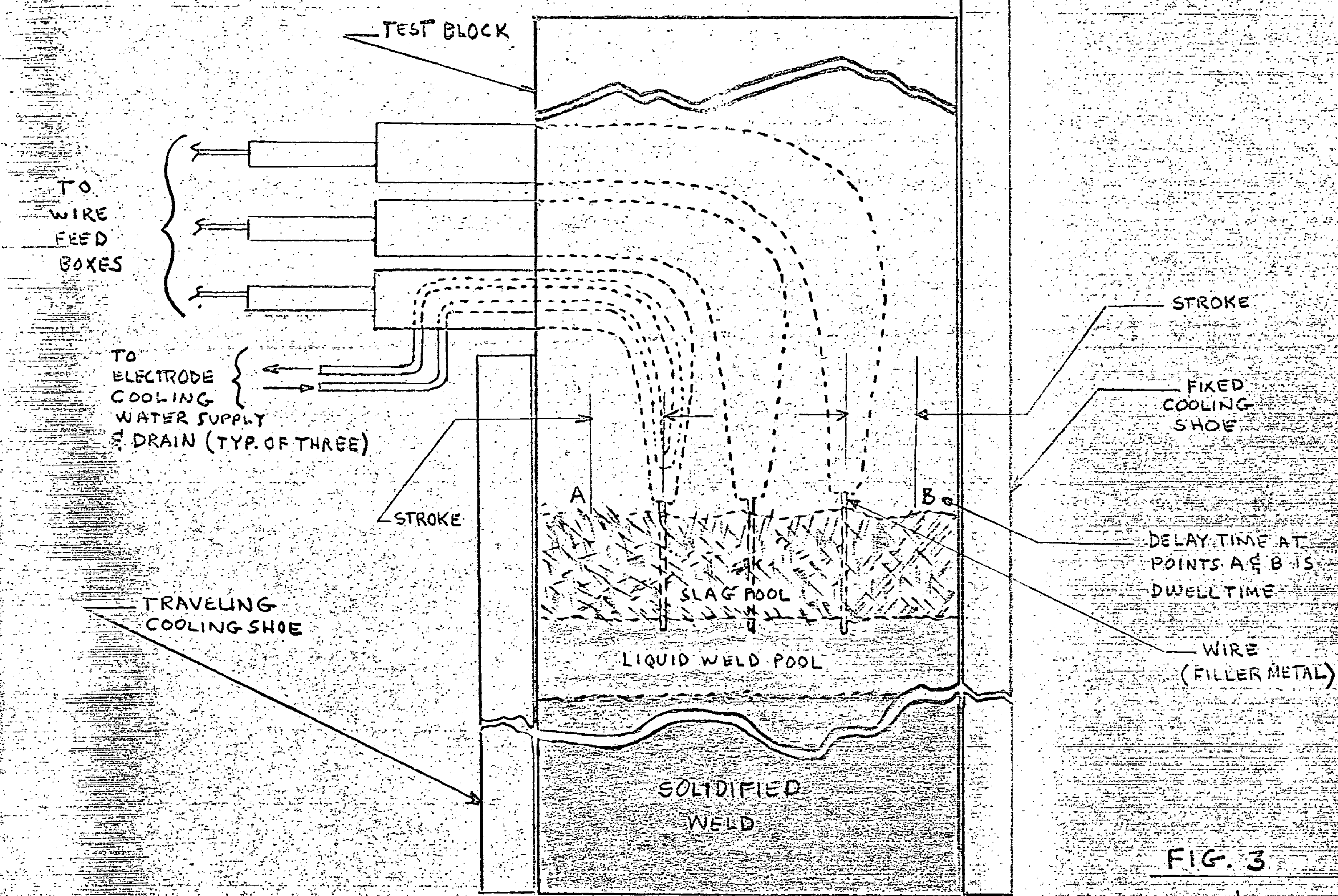


FIG. 3

W

1 of Allen