CORPS OF ENGINEERS, U. S. ARMY

MISSISSIPPI RIVER COMMISSION

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POTAMOLOGY INVESTIGATIONS

PRELIMINARY DEVELOPMENT
OF
INSTRUMENTS FOR THE MEASUREMENT OF HYDRAULIC FORCES
ACTING IN A TURBULENT STREAM

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

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OF HYDRAULIC FORCES ACTING IN A TURBULENT STREAM

INTRODUCTION

1. As a part of its study of revetment failures on the lower Mississippi River, the Waterways Experiment Station has undertaken a comprehensive investigation to determine the hydraulic forces acting on the revetment due to turbulent flow. The need for determining the nature and magnitude of these forces is set forth in Report No. 5 of the Potamology Investigations series entitled "Field Investigation of Reid Bedford Bend Revetment, Mississippi River," dated June 1948. Reference is also made to this report for facts pertaining to the authority for, and the history of the general study of the Reid Bedford Bend revetment. Especial reference is made to pages 9-11 of this report, wherein is presented a brief discussion of turbulence forces and their effects on revetment stability.

2. At the outset of this investigation it was apparent that special instruments would have to be developed to measure the forces of river turbulence which affect the stability of revetment and its supporting bank. It is the purpose of this report to describe initial work in the development of suitable instruments for the measurement of these forces and the problems encountered in the use of these instruments under field conditions during the period July 1947 to June 1948.

3. Three major difficulties were encountered during the field tests; insufficient waterproofing of electrical elements, freezing of the pressure cells due to silt passing the bellows protective screens, and

physical damage to equipment by floating debris. The first could have been avoided by extensive laboratory testing, the second resulted from insufficient knowledge as to the type of protection required, and the third was a calculated risk having no practical solution. However, imminent high water necessitated premature installation of the equipment or a delay of one year in field testing. The former course was chosen. While the difficulties encountered in the field prevented the procurement of factual data concerning the forces of turbulence and their effects on the stability of revetment, the knowledge acquired from these tests will be used in the design of improved instruments for subsequent work in this field.

4. Three general types of instruments were required for the investigation; instruments capable of measuring pressure differential between two points on the revetment or in the revetment foundation, instruments capable of measuring actual movement or flapping of the revetment, and instruments capable of measuring the magnitude and direction of velocity over the revetment. Of these three general types, the first and second were constructed and tested in the field. The third type, the momentary velocity and direction instrument, is still in the development stage. Correspondence was conducted with commercial concerns, institutions, government agencies, and individuals in an effort to locate and procure instruments and instrument components of the general types suitable for the study of revetment behavoir on the Mississippi River. A list of those contacted with the nature of the request made and the reply received is given in the Appendix of this report.

DEVELOPMENT PROGRAM

Pressure Instruments

5. Two types of pressure-measuring instruments were developed. One was an instrument for measuring differential pressures between two points relatively close together, while the other was designed for measuring differential pressures at greater distances. The former instrument was a single element device and is referred to hereinafter as a differential pressure cell, while the latter instrument, referred to hereinafter as differential hydrostatic pressure cells, consisted of two hydrostatic pressure cells placed some distance apart and connected electrically in such a manner as to indicate the difference in pressure between the two cells.

Differential Pressure Cell

6. Description. The differential pressure cell developed consisted of two bellows connected ~~together~~ mechanically by means of a metal shaft. In the initial design, at about midway between the two bellows the shaft was connected to a small metal beam on which were mounted bonded strain gages. These gages were so mounted on the beam that a movement of the beam due to a differential pressure on the two bellows caused a change of electrical resistance in the gages. The gages were so connected electrically that this change in resistance could be amplified and recorded. The resistance changes recorded were to be calibrated in terms of differential pressures.

7. Laboratory work was performed on the bonded strain gage type differential pressure cell, but, in view of the many technical difficulties

encountered, this development was set aside when even greater promise was shown in tests on a bellows type cell utilizing a different type of "pickup" or bellows movement indicator.

8. The new pickup, and the one finally used, was a very small differential transformer which has only recently become available commercially from the Schaevitz Engineering Company. The pressure cell incorporating this pickup unit is shown in photograph 1 before assembly and in photograph 2 after assembly. Plate 1 is a cross-sectional drawing of the cell showing the component parts. In order to be able to eliminate any air that might be trapped around the bottom bellows after installation, a small copper tube was incorporated in the cell through which the trapped air could be pumped out after the instrument was covered with water. This tube was then cut off and the opening soldered over in order to have the bottom chamber open to no pressure other than that at the bottom face of the cell. Both the bottom and top chambers were covered with 80 mesh per inch screen wire for the purpose of keeping trash and sand out of the chambers. The bellows selected for this cell were flexible enough so that a differential pressure of 0.15 p.s.i., applied to the cell would displace the transformer core a sufficient distance to give a voltage output sufficient to be recorded with a high degree of resolution after being suitably amplified. All joints about the bellows were soldered in order to prevent leakage. The connecting electrical leads were of a very high quality shielded rubber covered cable, placed in copper tubing for additional

shielding both electrically and mechanically. For the purpose of waterproofing, the copper tubing came out of the cell through a packing gland, and as a further precaution against water entering the cell the copper tubing was crimped several times near the cell.

9. Principle of Operation. The differential transformer core, which was free to move with respect to the windings, was fixed to the connecting shaft between the bellows. The transformer unit was so constructed that with the primary winding energized with 6-volt alternating current and the core in a certain zero or balance position, the output voltage of the secondary winding was zero. If the core was moved to another position, a voltage was produced in the secondary winding, and this voltage was proportional to the core displacement from the null or zero position. Therefore, with the pressure cell properly assembled and the pressures on the two bellows equal, the voltage output was zero, but with a differential pressure on the two bellows, a transformer core displacement took place, thereby causing a voltage output from the transformer secondary winding proportional to the differential pressure or core displacement. By means of an amplifier, a recorder, and a circuit for detecting the direction of core displacement properly connected to the cell by means of a connecting cable, the differential pressures existing on the cell were recorded.

10. Laboratory Test and Calibration. Due to the immediate need of pressure cells, nine of the small differential transformer type were constructed, assembled, and calibrated. The calibration consisted of putting the cell in its normal operating position and connecting it to a

calibrating assembly such as is shown in photograph 3. The secondary coil of the pressure cell was connected electrically to a Brush amplifier through the connecting cable to be used with the cell when installed, and the output signal of this amplifier was connected to a voltmeter. The primary transformer coil was excited by a 6-volt, 60-cycle power transformer; this input voltage was indicated by a second voltmeter. Air pressure was applied to both bellows of the pressure cell to simulate the static head that would appear on the cell. Differential pressures were applied to the bellows both in a positive and negative direction at several values of static heads. The calibration of all the cells revealed that as the static head changed, the zero output or balance condition of the cell also changed to some extent. It was further determined that the voltage output of the cell was not as linear with respect to the differential pressure as was expected, although this condition would not preclude satisfactory interpretation of any readings which might be obtained from the cell after installation. Further observations determined that similarity existed in the over-all reaction of all the cells. Due to the limited time allowed before installation, this was the extent of the laboratory development and calibration of these pressure cells.

<u>Differential Hydrostatic Pressure Cells</u>

11. <u>Description and Pinciple of Operation</u>. The pressure cells for measuring differential pressures between two points on the top side of the revetment consisted of two hydrostatic pressure cells of the bonded strain gage type. Each cell consisted of a phosphobronze metal disc

about .038 inches in thickness and 4 inches in diameter. On the disc was cemented two bonded strain gages in such a position that, when a pressure was applied to the disc, one strain gage was put in tension and the other in compression. This action caused one strain gage to increase and the other to decrease in electrical resistance. The two gages in each pressure cell were connected by means of electrical cables to a common junction box in which they were connected electrically to form a Wheatstone bridge circuit. The gages were also connected in such a manner that, when the Wheatstone bridge was properly energized and an equal pressure was applied to each of the pressure cells, the electrical signal from them cancelled and produced a resulting zero signal. If the pressure on one cell was greater or less than on the other, the resulting electrical signal would be proportional to the difference in pressure. By amplifying the resulting electrical signal these pressures could be recorded.

12. Laboratory Test and Calibration. The hydrostatic differential pressure cells were assembled and connected electrically as expected to be connected in the installation. Due to the strain gages in the cells not being absolutely balanced in resistance, and because of inequalities of resistances of the connecting leads, considerable time was required to assemble (as determined experimentally) a balancing pad of resistors to be connected to the indicating end of the leads to provide a properly compensated output signal. This pad was successfully completed but due to limited time available a final calibration could not be made before

installation. It was planned that the calibration would be made after readings were taken at the field installation, with reasonable expectation of satisfactory interpretation of records.

Mat Movement Instrument

13. Description and Principle of Operation. There are several commercial instruments designed to indicate position. However, since there were no known recorders for any of these instruments, it became necessary that an instrument be developed in order to have the mat position or movement recorded. Since a recorder was readily available for recording resistance or potential change, a mat movement transmitter was designed consisting of a Wheatstone Bridge, one half of the bridge consisting of a ten-turn precision potentiometer and the other half consisting of a pad of properly matched resistors. A pinion gear mounted on the shaft of the potentiometer was arranged to mesh with a rack fastened to the concrete mat, while the body of the instrument was clamped to a pipe support fixed in the river bank. Thus any vertical movement of the mat would cause the rack to move, thereby turning the pinion gear and the potentiometer arm. Movement of the potentiometer arm caused variations in voltage output of the electrical circuit which were to be recorded in terms of units of mat movement. The design permitted a two-foot range of vertical movement with side sway being eliminated by the ball and swivel assembly. The instrument is shown in photograph 4 ready for installation.

14. Laboratory Test and Calibration. In order to use the potentiometer with the recording equipment available, it was necessary to have a full bridge circuit work into the recording equipment. This was accomplished by empirical development of a matching resistance pad the same as was required for the differential hydrostatic pressure cells. The position of the rack was calibrated in comparison to recorder pen position by means of a standard height gage incorporated with the rack.

Velocity and Current Direction Instruments

15. A great amount of research and correspondence has been conducted on the velocity and current direction instruments. Unfortunately, all available commercial velocity meters operate on the principle of counting revolutions of cups or propellers for a period of time, and, since momentary velocities are desired, these velocity meters are not considered suitable. Furthermore, the requirements for determining the direction of the current, the difficulty of placing the instrument in the river and knowing its exact location, and proper waterproofing complicate the problem considerably. Due to the large forces acting on a body suspended in turbulent water, there is a very high probability that the instrument may be lost. Floating debris adds to this hazard. Also, instruments sent to the bottom of the river may become entangled in irregular river bed crevices, etc. Retrievement without damage to or loss of instruments thus fouled is difficult. These problems have been discussed with representatives of various commercial concerns manufacturing instruments which might be

adaptable to the problem at hand. Correspondence has also been conducted with research laboratories and other government agencies on the problem. However, the efforts expended have not as yet produced a satisfactory instrument for measuring the velocity and current direction in a river, and no such instruments were included in the field installation presently under discussion.

FIELD INSTALLATION

Location

16. A section of the articulated concrete mattress near range 52 where the current velocities were believed to be greatest during high river stages was selected as the test site for the installation of the pressure measuring instruments. This section extended 20.5 ft along the bank and 14 ft down the slope providing a horizontal area of 273 square feet over which pressure changes could be studied during the following high-water season. Depths of flow over the section at bank full stage ranged from 27 to 31 ft. Plate 2 shows the layout of the pressure instruments as installed in the test section. The mat movement instrument was installed where a 9-ft diameter hole 4 ft deep had developed under the revetment about 150 ft downstream from and at approximately the same elevation as the pressure measuring instruments.

Installation

17. The layout consisted of eight pressure instruments for measuring the differential pressures between the top and bottom of the articulated

concrete blocks, one set of pressure cells for measuring the difference in pressure between the tops of two blocks some distance apart, three pressure instruments for measuring the differential pressures between points at the surface of the soil in the bank and at depths of 6 inches, 18 inches, and 36 inches below the surface, and one mat movement instrument for measuring the vertical movement of a section of mat spanning a hole under the revetment. Photograph 5 shows a differential pressure cell placed in the revetment before the block was remolded around it. The same cell is shown in photograph 6 after the concrete block was remolded. The cells for measuring the differential pressures between points at the surface of the soil in the bank and at 6 inches, 18 inches, and 36 inches below the surface are shown in photograph 7 installed before the concrete block was remolded over them. The mat movement instrument is shown in photograph 8 as installed.

RESULTS

Operations During High Water

18. Pressure Measuring Instruments. After the instruments were covered by water, insulation tests were made on the leads of each of the pressure measuring instruments. Tests were also made at various times thereafter until removed. The insulation values on all the pressure instruments when the first readings were taken were too low to expect good results. However, the pressure cell having the best insulation resistance was used as a test cell. A specially built amplifier which included a circuit for determining the direction of the pressure applied

to the cell was connected to the test cell. Despite all efforts spent on improving and changing the amplifying and recording equipment, very little or no pressure changes could be detected from the test cell or any other cell in the test section.

19. Mat Movement Instrument. Soon after the instrument was covered with water, an insulation test was made. The insulation value was found to be very low. The resistance between each lead and ground was about 1500 ohms. Due to this low insulation value, it was apparent that no readings could be expected from this instrument. However, the insulation tests were repeated at intervals.

Investigations After High Water

20. Pressure Measuring Instruments. After the water surface had receded below the instruments, the pressure cells were examined to determine the cause of the improper operations. An inspection of the top bellows chamber revealed that despite the 80 mesh per inch screen cover, very fine sand had become packed around the top bellows of the cell. The water again covered the instruments after the sand had been cleaned from around the top bellows of one cell. For several days this instrument was very responsive to waves and tow wash. However, the water surface only reached approximately 30 inches above the cell and then receded below it. Photograph 9 shows a pressure cell just removed from the installation. The hole in the screen was made after the water had receded below the instruments. Photograph 10 shows the same cell with the top cap removed and the sand packed around the bellows. In photograph 11 the same cell is shown with some sand

removed to show the bellows. An analysis of the sand removed from a pressure cell indicated that approximately 53 per cent of it passed a 200 mesh per inch screen. The analysis curve as shown in plate 3 indicates that some of the sand should not have passed the protective screen. No explanation can be offered for this discrepancy.

22. Mat Movement Instrument. After the water had receded below the instrument, it was found that the copper tubing over the connecting cable had been broken at the instrument and the instrument was damaged due to being struck by floating debris. Further observations revealed that the gear box had been packed with very fine sand. Water was found inside the instrument, which accounted for the very low insulation resistance.

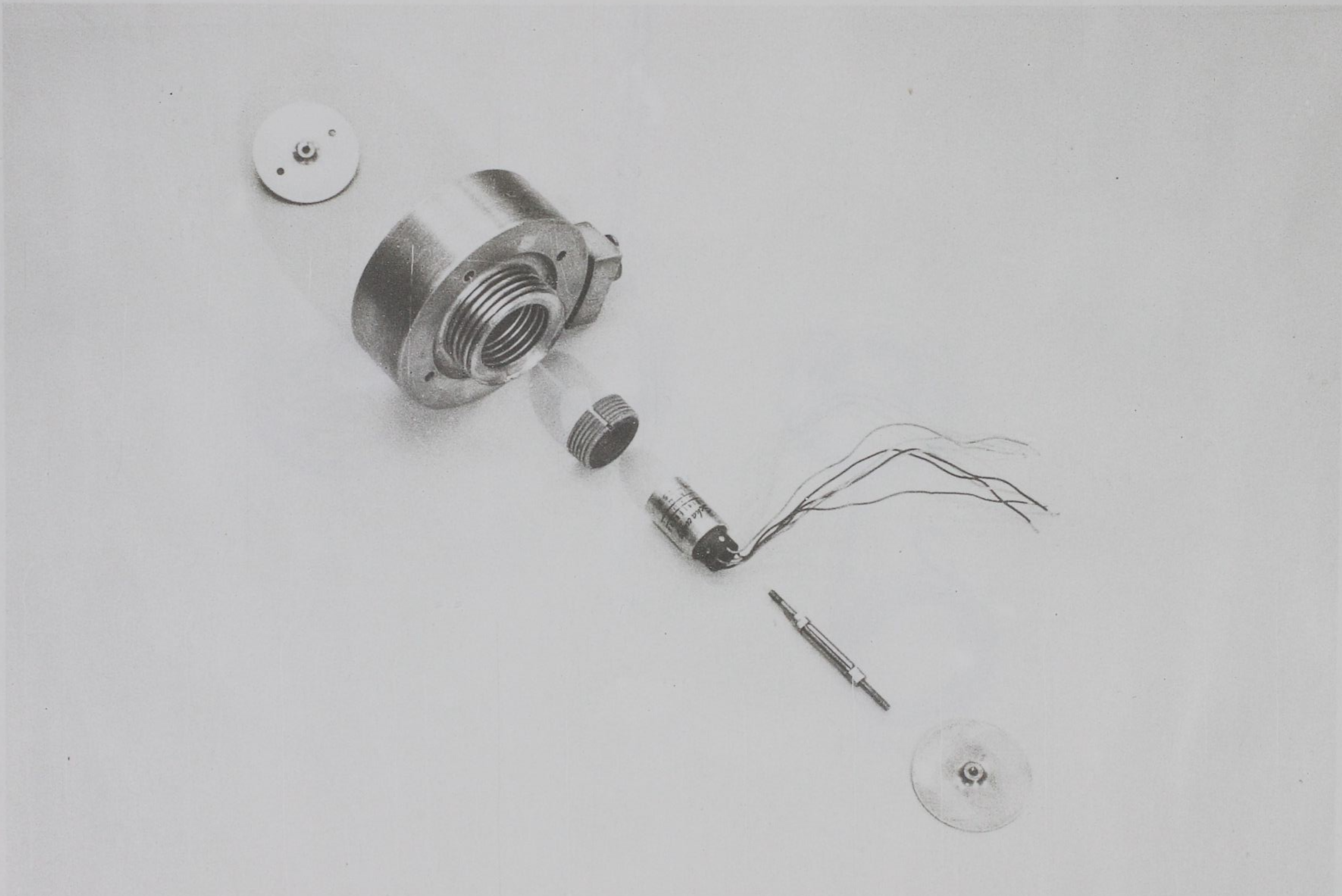
CONCLUSIONS

23. The results obtained from the installation emphasized the importance of good waterproofing and the magnitude of the problem involved in obtaining it for long periods of under water operation. Even though the hydraulic information desired from the instrument installation was not obtained, very valuable information and knowledge was gained that will be of use in the design and installation of instruments in the future. The primary cause for the differential pressure instruments not operating was due to the fine river sand entering the top bellows chamber through the fine mesh screen and packing around the top bellows, thereby preventing the instrument from reacting to the differential pressures. It is apparent that some indication of pressure changes would have been received, despite the low insulation values, had not the sand been packed around the bellows. The water entering the instruments was due to

insufficient waterproofing and soldered joints not being watertight for a long period of submergence. Low insulation resistance on the mat movement instrument was due to the copper tubing covering the connecting cable being broken by floating debris and allowing water to enter the instrument. Since the gears became packed with sand due to being covered, it can be concluded that any mechanical operating mechanism placed in the river for a long period of time should not be placed in a chamber or pocket where sand may settle, collect, and pack around the mechanism.

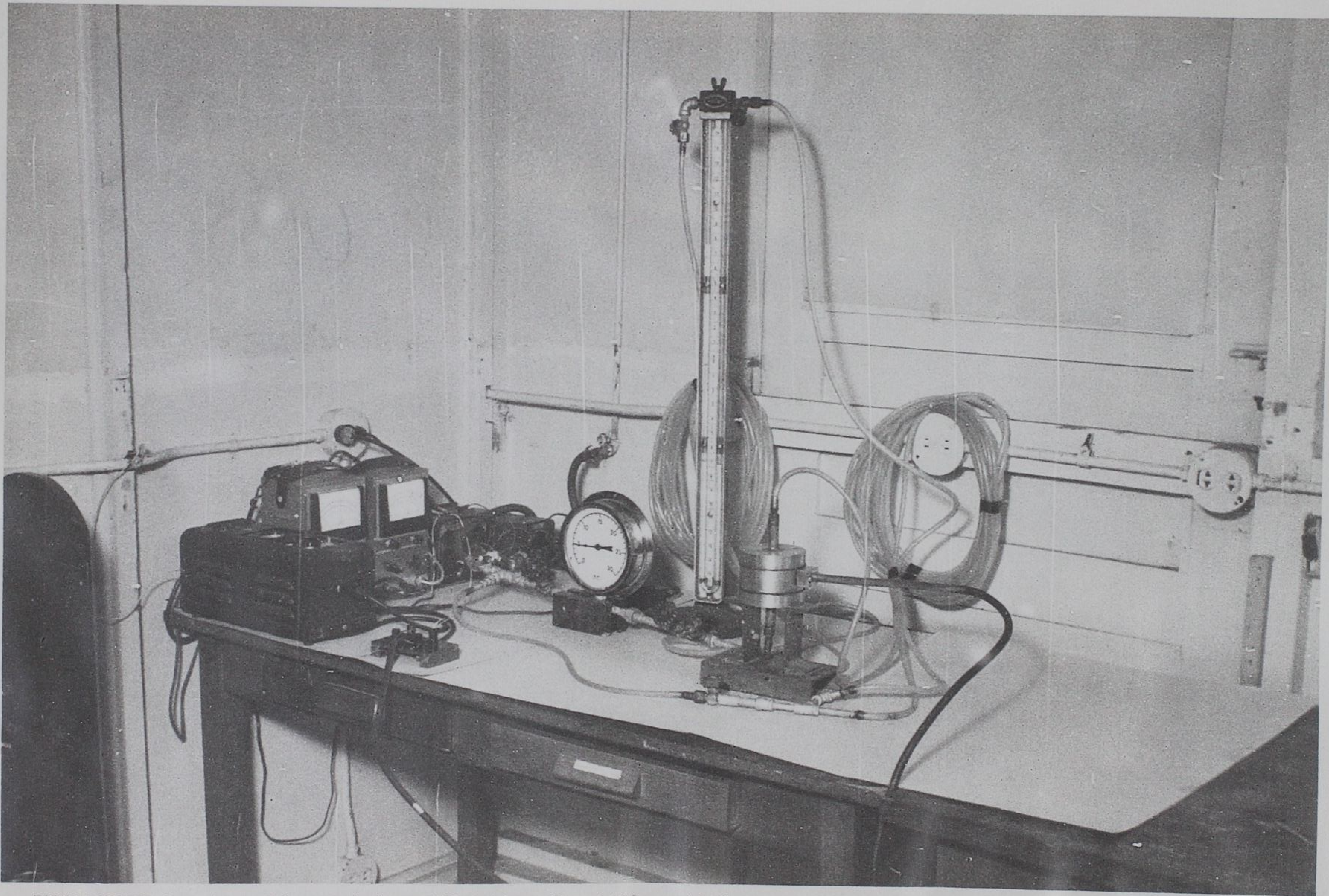
24. Work will continue on the development of instruments required for the measurement of the hydraulic forces acting on a revetted river bank. The valuable information received from the installation at Reid Bedford Bend will be used to improve the design of future instruments and installation methods.

PHOTOGRAPHS

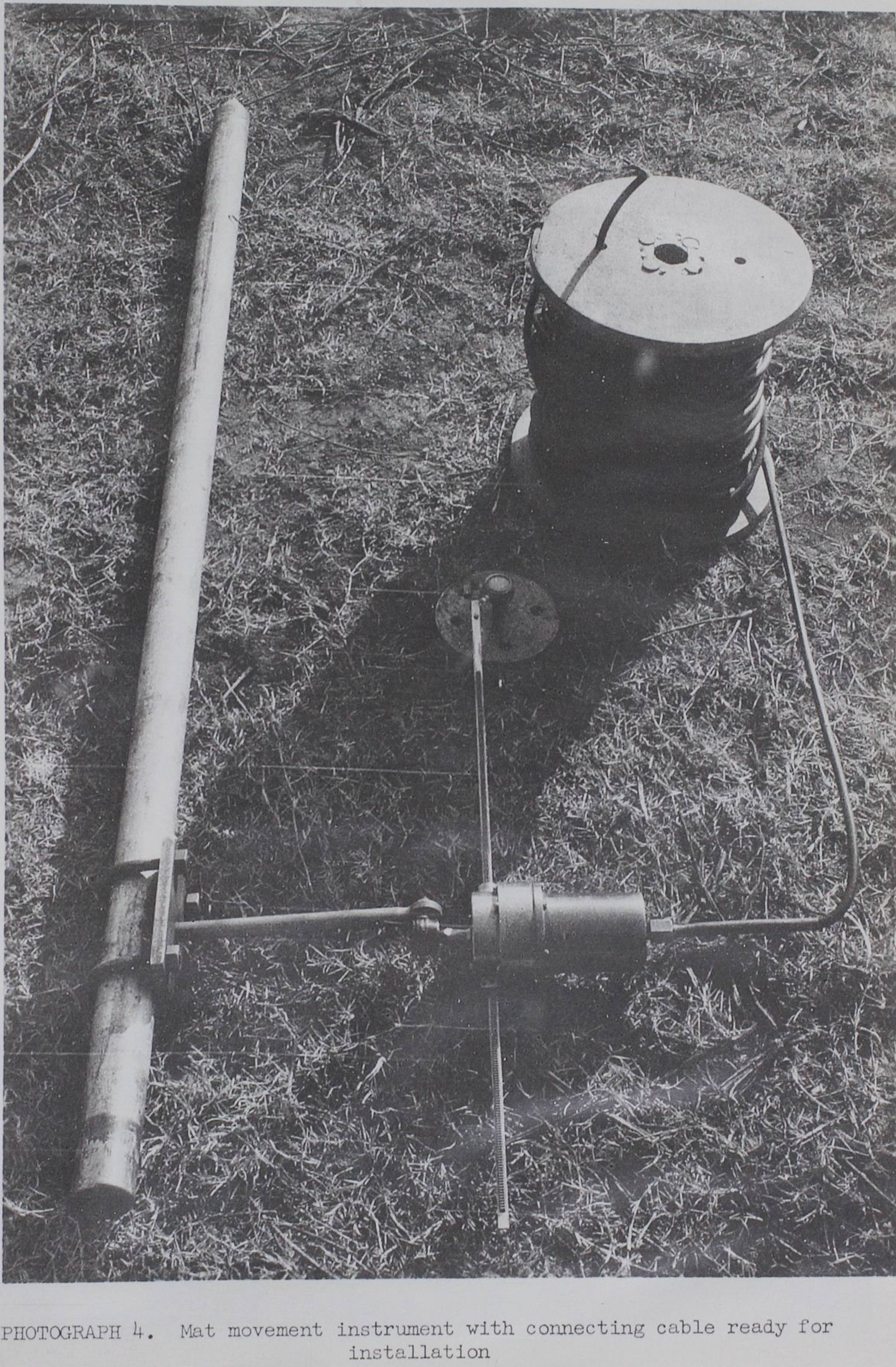


PHOTOGRAPH 1. Differential pressure cell using differential transformer as electrical pick-up -- unassembled

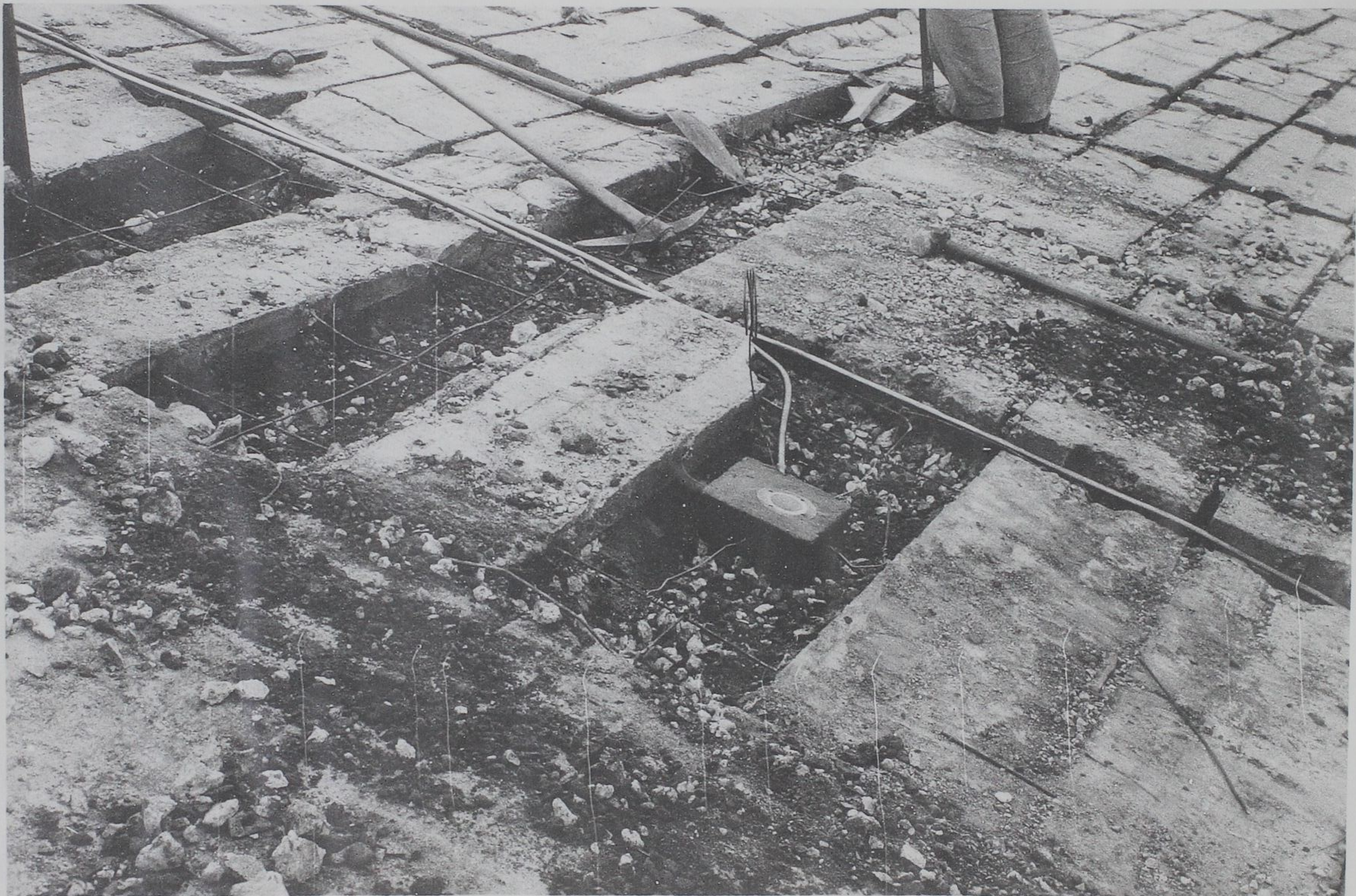
PHOTOGRAPH 2. Differential pressure cell using differential transformer as electrical pick-up -- assembled



PHOTOGRAPH 3. Assembly used in calibrating the differential pressure cells

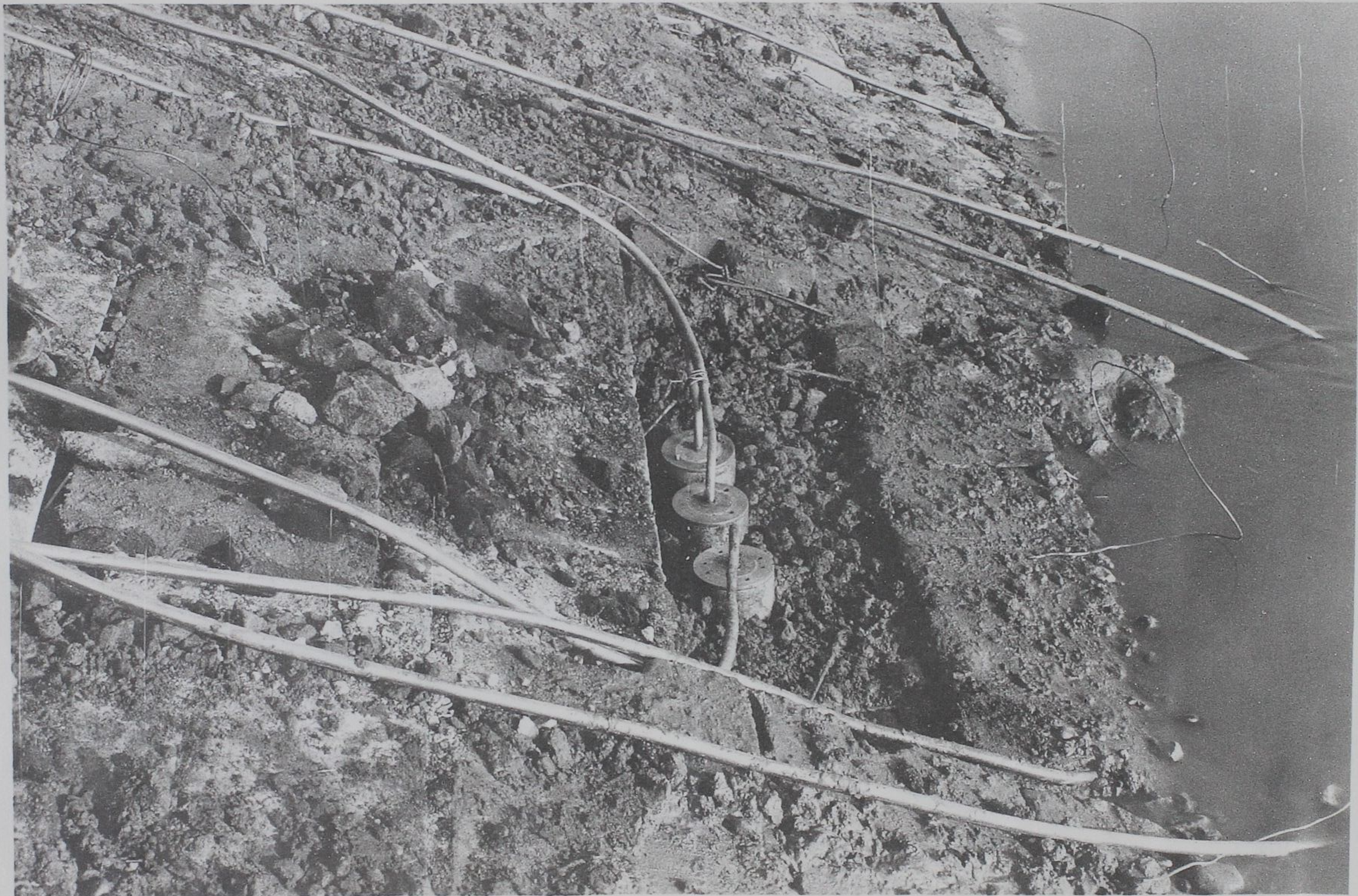


PHOTOGRAPH 4. Mat movement instrument with connecting cable ready for installation

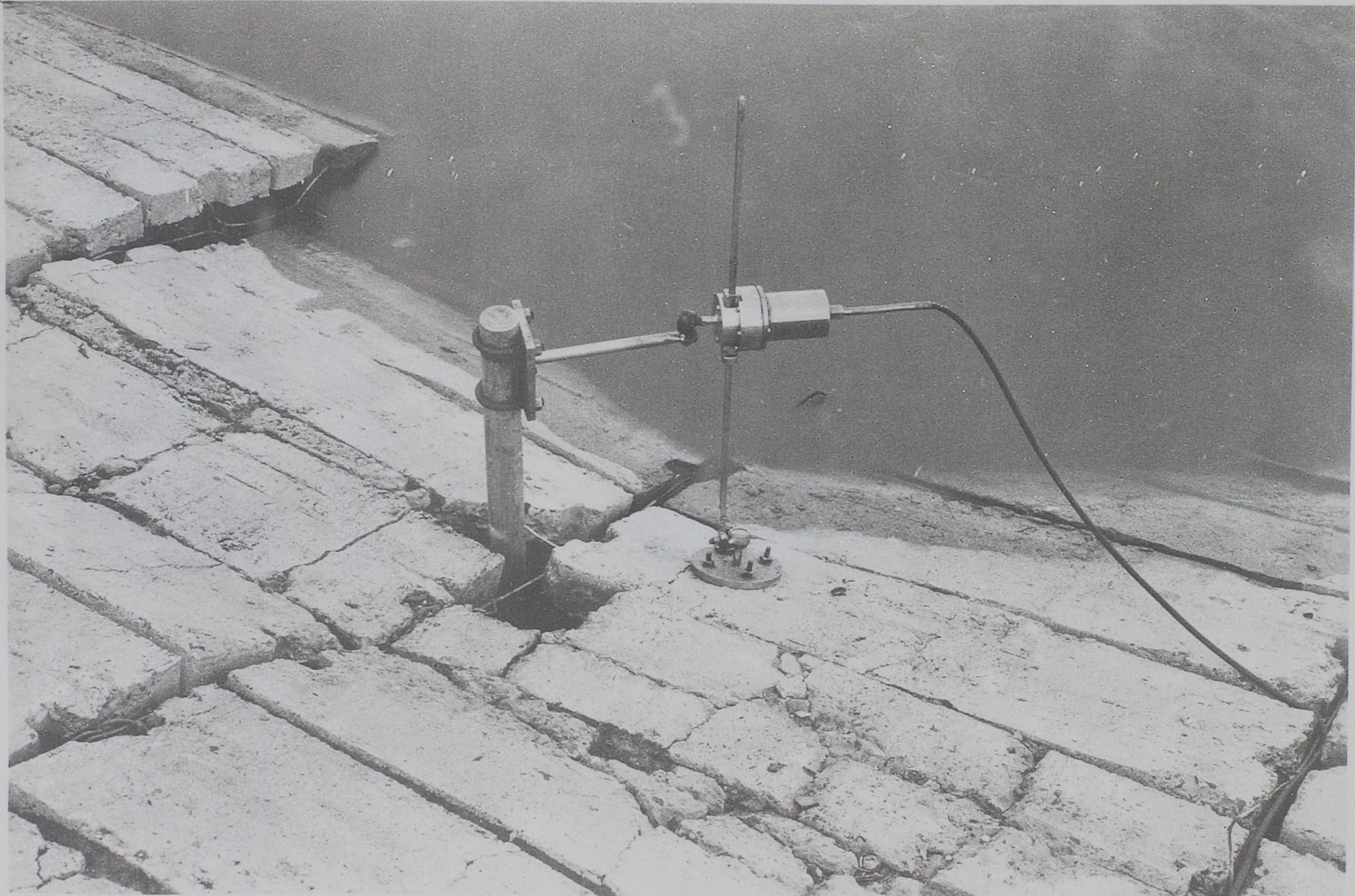


PHOTOGRAPH 5. Differential pressure cell installed in revetment before concrete block is remolded around it

PHOTOGRAPH 6. Differential pressure cell installed in revetment after concrete block is remolded around it



PHOTOGRAPH 7. Three differential pressure cells for measuring differential pressures between the soil surface and at three different depths installed before concrete block is remolded over them



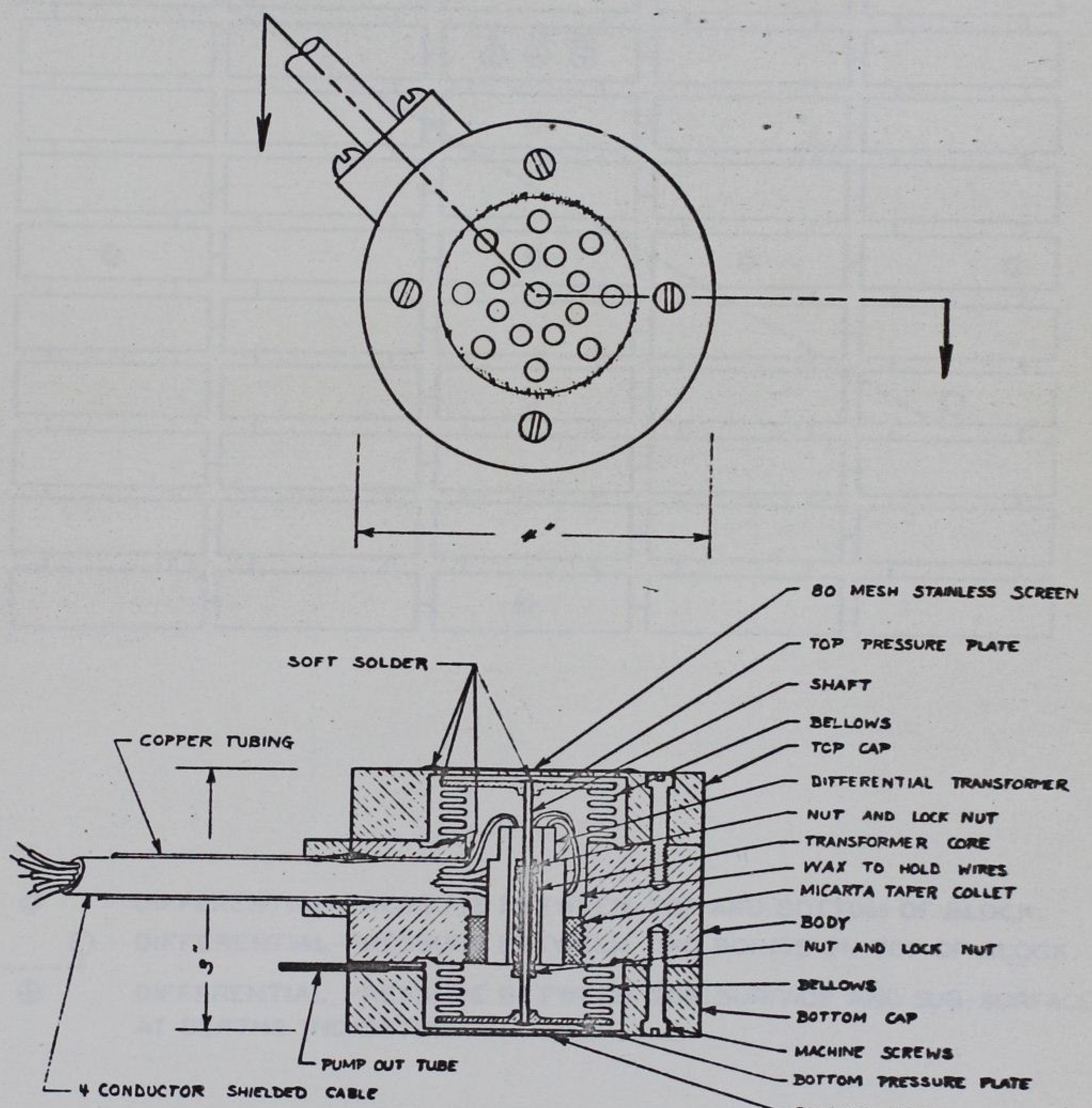
PHOTOGRAPH 8. Mat movement instrument installed on the revetment ready for operation except for copper tubing being placed over the connecting cable

PHOTOGRAPH 9
Differential pressure cell just removed from installation

PHOTOGRAPH 10
Differential pressure cell just removed from installation with top cover cap removed

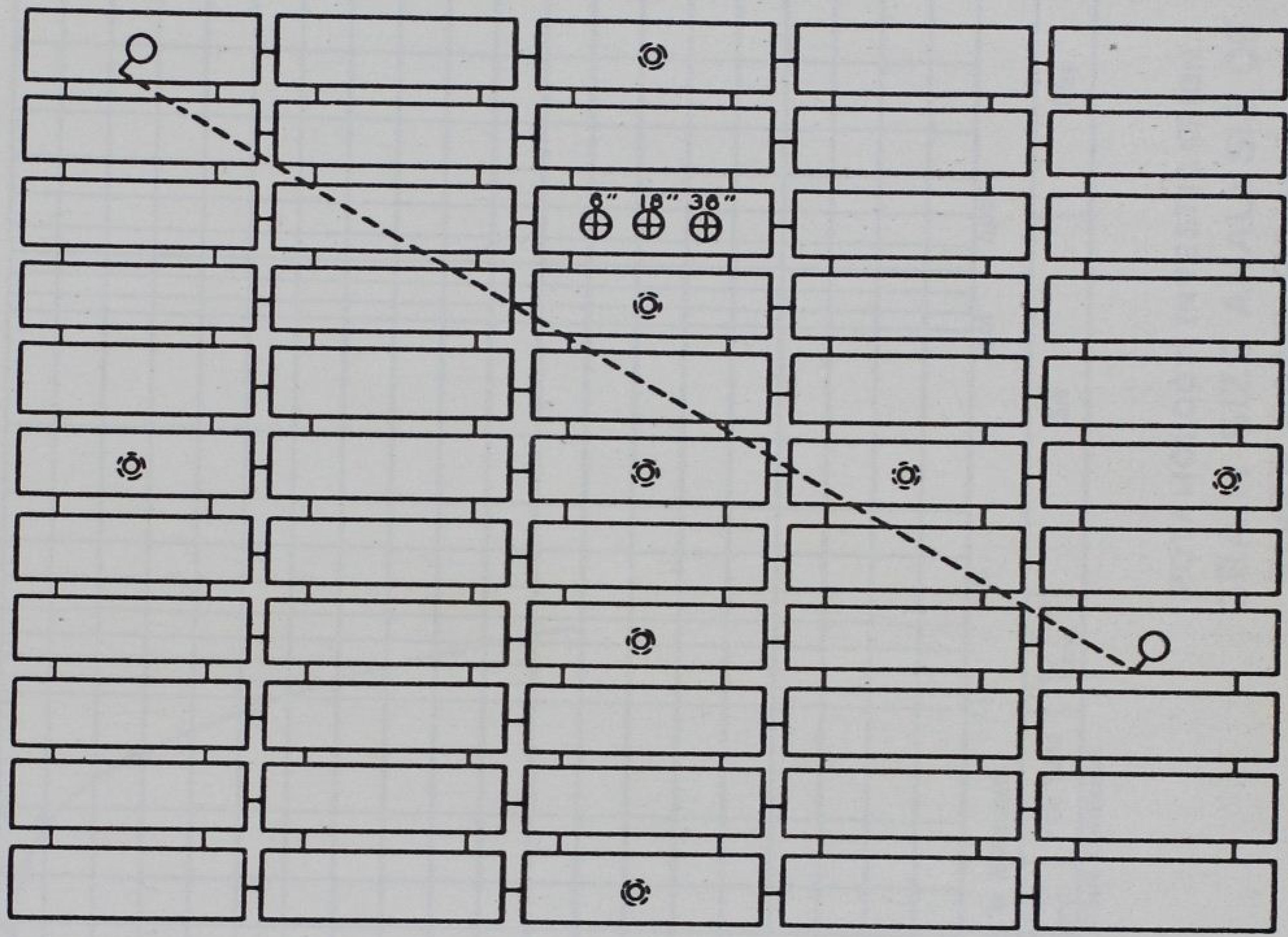
PHOTOGRAPH 11
Differential pressure cell just removed from installation with top cover cap removed and some sand removed from around the bellows

PLATES



POTAMOLOGY INVESTIGATION

DIFFERENTIAL PRESSURE CELL
TRANSFORMER TYPE



DIFFERENTIAL PRESSURE BETWEEN TOP AND BOTTOM OF BLOCK.

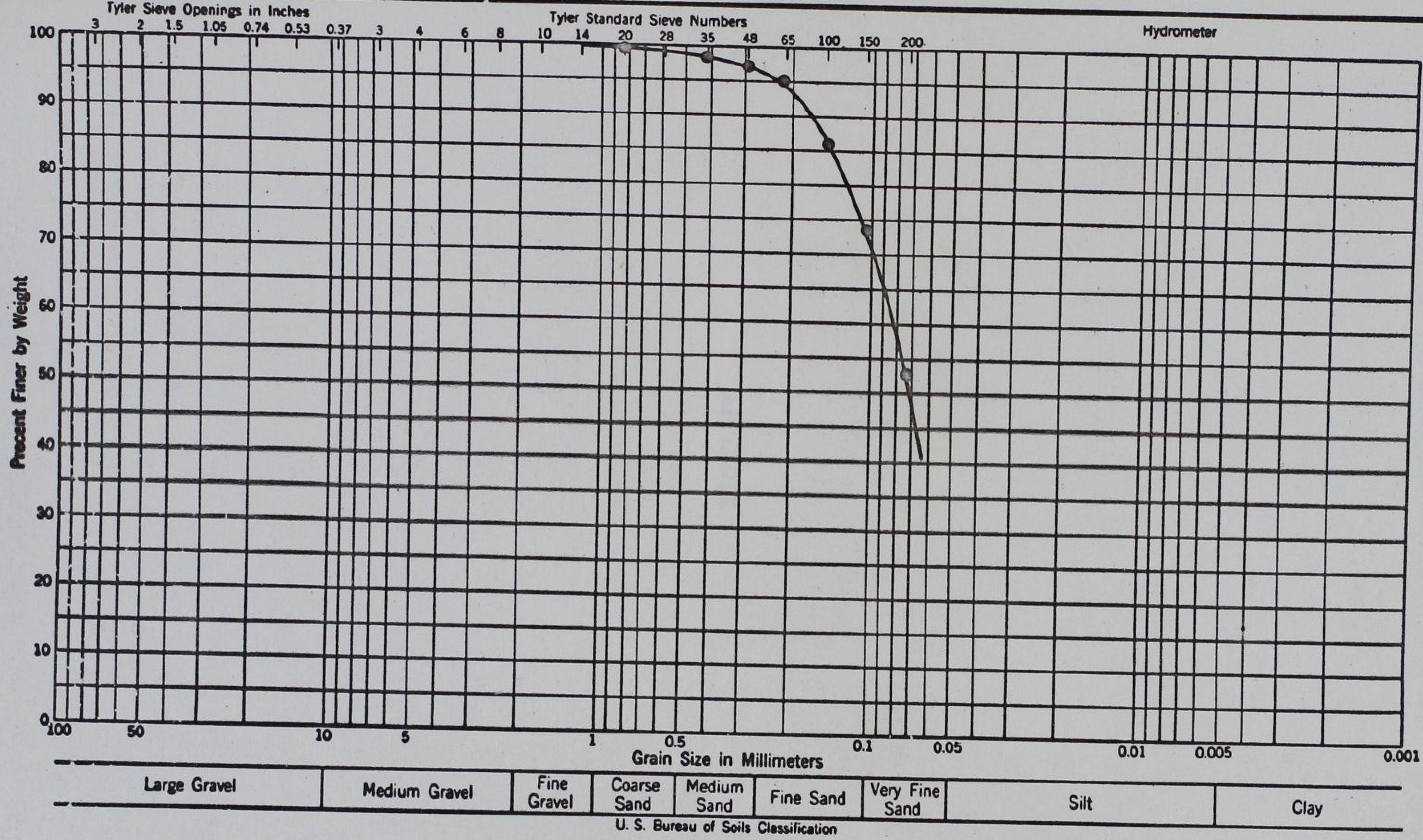
DIFFERENTIAL PRESSURE BETWEEN TWO POINTS ON TOP OF BLOCK.

DIFFERENTIAL PRESSURE BETWEEN SOIL SURFACE AND SUB-SURFACE AT DEPTHS INDICATED.

POTAMOLOGY INVESTIGATION

INSTRUMENTATION LAYOUT

REID BEDFORD BEND INSTALLATION



POTAMOLOGY INVESTIGATION

GRAIN SIZE ANALYSIS OF RIVER SAND FOUND IN DIFFERENTIAL PRESSURE CELLS

PLATE 3

APPENDIX

APPENDIX

COMMERCIAL CONCERNS, INSTITUTIONS, GOVERNMENT AGENCIES, AND INDIVIDUALS CONTACTED CONCERNING INSTRUMENTS AND INSTRUMENT COMPONENTS NEEDED FOR THE STUDY

Introduction

1. As stated in paragraph 4 of the basic report, commerical concerns, institutions, government agencies and individuals were contacted for the purpose of locating instruments and instrument components that might be used in making the study of revetment behavior on the Mississippi River. A list of those contacted with the nature of the request made and the reply received is given in this appendix. The commercial concerns contacted are grouped according to the following subjects:

a. Suppliers of war surplus equipment who replied.

b. Suppliers of war surplus equipment who did not reply.

c. Suppliers of thin and very tough sheet rubber for diaphragm material.

d. Suppliers of current meters.

e. Concerns having experience in measurement of subsurface current directions.

f. Those concerns to whom the entire instrument problem was described.

g. A company experienced in the measurement of small differential pressures in deep water.

h. A company believed able to supply a power supply of a particular type.

i. A company's description of their instrument to convert pointer displacement into an electrical signal.

j. A supplier of small electrically operated valves.

k. A company concerning their special instruments.

No grouping was made of the institutions, government agencies, and individuals contacted, which list follows the grouped listing of commercial concerns.

Contacts Made

Commercial concerns

2. Concerns handling surplus equipment were asked to supply descriptive literature on instruments and instrument parts applicable to the problem. Those from which replies were received and the nature of their response are as follows:

Pacific Airmotive Corporation, Burbank, California.

This firm referred our inquiry to Airmotive, Inc.

Airmotive, Inc., Burbank, California.

This firm stated that they did not have any of the desired instruments in stock.

Communications Equipment Company, Brooklyn, N.Y.

A request was made by this company for more specific requirements which were furnished. A second letter was received stating that they were not only unable to supply the desired instruments but also had endeavored to locate suitable instruments without success.

Durham Aircraft Services, Inc., Woodside, N.Y.

A reply was received giving the instruments available that might be suitable. The instruments were found to be unsuitable and the company so advised.

Heath Company, Benton Harbor, Michigan.

A form letter was received containing a folder describing some of the war surplus materials available.

Instrument Associates, Flushing, Long Island, N.Y.

Several small instruments were procured from this company from their list of available instruments.

Jack and Heintz Precision Industries, Inc., Cleveland, Ohio.

This company stated that they did not stock the instruments desired and gave the name of another company from whom they might be obtained.

Niagara Radio Supply Corporation, New York, N.Y.

One type of servo mechanism desired was stocked by this firm.

S. A. Long Company, Inc., Wichita, Kansas.

Instruments desired were not stocked by this concern.

Servo-Tek Products Company, Clifton, N. J.

An up-to-date list of instruments available was received, and current lists have been received from time to time. From the information received a servo-mechanism recorder has been located, and a recorder has been procured on a loan basis for test purposes. Further correspondence was initiated in an effort to obtain a small range pressure transmitter to operate with the recorder made by this concern. Information was received that the war surplus pressure transmitters would not operate with their servograph recorder.

Supply Division, Inc., Robertson, Missouri.

According to their statement, instruments of the type desired are not stocked by this concern.

Surplex Sales, Chicago, Illinois.

This concern replied that they only had some parts of certain instruments desired.

Tab, New York, N. Y.

A list of instruments that could be furnished was sent, but a study of the list revealed that the instruments were not suitable.

Walter Ashe, St. Louis, Missouri.

A reply was received stating they did not have any of the instruments desired.

3. The following firms handling war surplus equipment were contacted, but no reply has been received from them to date:

Abell Distributing Company, Baltimore, Maryland.

American Surplus Products Co., Indianapolis, Indiana.

Arrow Sales, Inc., Chicago, Illinois.

Buffalo Radio Supply, Buffalo, New York.

Burstein-Applebee Co., Kansas City, Missouri.

Esse Radio Company, Indianapolis, Indiana.

G & M Equipment Company, Inc., Van Nuys, California.

C. W. Holmes Company, Columbus, Ohio.

Hershel Radio Company, Detroit, Michigan.

Leeds Radio Company, New York, N.Y.

McGee Radio Company, Kansas City, Missouri.

Snyder Aircraft Corporation, Chicago, Illinois.

United Aero Service, Inc., Charlotte, North Carolina.

United Surplus Materials, Chicago, Illinois.

W. C. Newman, Wichita, Kansas.

4. A thin and very tough sheet rubber was required for diaphragm material for transmitting hydraulic pressures to the bellows of a pressure cell. The firms contacted for this material and their responses are as follows:

Atlantic India Rubber Works, Inc., Chicago, Illinois.

Unable to meet specifications outlined to them.

B. F. Goodrich Co., Atlanta, Georgia.

Samples of rubber were submitted for trial, but the material was not suitable for our use.

Corduroy Rubber Co., Grand Rapids, Michigan.

Unable to supply the type of rubber desired.

E. I. Dupont De Nemours & Co., Wilmington, Delaware.

Unable to supply rubber desired as they do not manufacture any finished products, but they did suggest a company to manufacture a diaphragm.

Peerless Rubber Company, Chicago, Illinois.

Unable to supply rubber to our specifications.

Pioneer Rubber Company, Chicago, Illinois.

No reply received.

5. Information on ranges and availability of commercial current meters was sought from the following concerns:

E. S. Ritchie and Sons, Inc., Brookline, Massachusetts.

This concern was known as the agent for the Haskell current meter, but their reply to our letter gave the information that they had not manufactured the instrument for many years and no one now in their employ is familiar with it.

Keuffel and Esser Company, Hoboken, N. J.

The Ott current meter was formerly sold by this company, but information was received in their reply that the Ott meter had not been sold in the United States since the start of World War II.

6. Information on instruments for measuring subsurface ~~current~~ direction was sought from the following concerns:

Minneapolis-Honeywell Regulator Co., Minneapolis, Minnesota.

It was thought the "Electron Gun Compass for Aircraft" could be adapted for measuring current direction. However, the company stated that the instrument was still in a state of development and that the Waterways Experiment Station would be advised when it was ready to be placed on the market.

Sperry Gyroscope Company, Inc., Great Neck, N. Y.

Our request resulted in a visit from a representative of the company and a discussion of the problem, but no further assistance was obtained.

7. It was thought that some of the well known instrument companies might be interested in supplying a number of different kinds of instruments, therefore the entire problem was outlined to the following firms:

Eclipse-Pioneer, Division of Bendix Aviation Corporation, Teterboro, N. J.

A discussion was held with a company representative after the company had expressed interest in pressure measuring instruments but the company soon lost interest.

Trimount Instrument Co., Chicago, Illinois.

No reply received.

Statham Laboratories, Inc., Los Angeles, California.

A reply was received suggesting modification of one of their standard pressure transmitters and stating they could not give any assistance on the velocity-current direction problem.

8. The problem of measuring small differential pressures in deep water was presented to the Aeromarine Instrument Company of New York as

this company handles instruments for marine work. No reply has been received as of the date of this report and a tracer letter has been sent.

9. Bendix Aviation Corporation, Red Bank, New Jersey, was contacted concerning the furnishing of a dynamometer for supplying 28-volt, 400-cycle power. A reply was received stating they were unable to supply the machine.

10. A more detailed description of the no torque pickup for changing the angular displacement of an instrument pointer to an electrical signal was sought from Fairchild Instrument Corporation, Jamacia, New York. A reply containing descriptive bulletins giving the information requested was received. A second letter requesting information on the type of recorder recommended to be used with their instrument has not been answered to date.

11. General Controls Company, Atlanta, Georgia, was asked to supply information on a desired type of small electrically operated valve. The information was supplied and a valve purchased to be tried on a pilot pressure cell.

12. G. M. Giannini and Company, Inc., Pasadena, California, was asked for suggestions on the possibility of using certain of their instruments for measuring differential pressure, velocity, and current direction. A reply was received stating that they did not recommend their instrument for the work described.

<u>Institutions</u>

13. Institutions contacted were as follows:

University of California, Berkeley, California.

A request was made for more information on the instrument developed by them for measuring ocean waves generated by atomic bombs and used in the "Bikini Test." A reply was received stating that the subject instrument had certain limitations and deficiencies, discussing briefly other instruments developed by the University that might be better suited, and requesting more information on the problem at hand. This information was supplied and a second reply stated that the instruments developed by that institution were not believed to be suited for the problem. Recommendations were made as to the type pressure cell and recording equipment that should be used.

Woods Hole Oceanographic Institute, Woods Hole, Massachusetts.

A request was made for more information than had been published on the instrument developed by them for measuring ocean waves generated by atomic bombs and used in the "Bikini Test." A reply was received offering the loan of one of the instruments. The offer was accepted, but it was found that the instrument was not suited to the problem.

Government agencies

14. Government agencies contacted included:

Memphis District, Corps of Engineers, Memphis, Tennessee.

Photographs and drawings were received from this office of a velocity-current direction meter which is in use in the Memphis District. After study of the information, it was decided that the instrument could not be used because the measurements were to be made near a revetment containing steel which would affect the magnetic compass used in the instrument.

Tennessee Valley Authority, Knoxville, Tennessee.

This agency supplied a description and current direction meter developed in their hydraulics laboratory. No definite use was made of the material as the velocity meter used is not available and as it would be very difficult to reference the position indicator in the river.

Office of the Chief of Engineers, Washington, D.C.

Request was made for authority to purchase an Ott current meter from Dr. Ludwig A. Ott, Kempton, Bavaria, Germany. The requested authority was granted.

War Assets Administration, Jackson, Mississippi.

This government agency was requested to furnish information on available war surplus material that might be adapted to the problem. Their reply stated that no such material was listed.

<u>Individuals</u>

14. Individuals contacted were as follows:

Dr. Ludwig A. Ott, Kempton, Bavaria, Germany.

Information on the availability, cost, and delivery of an Ott current meter was requested. No reply has been received as of the date of this report.

Mr. George H. Hickox, Associate Director, Engineering Experiment Station, University of Tenness e, Knoxville, Tennessee.

A request was made to supply information on a velocity-current direction meter that was developed by the Tennessee Valley Authority under his supervision. His answer referred the Waterways Experiment Station to the hydraulics laboratory of the Tennessee Valley Authority.

Conclusion

15. Of those contacted some have not replied. If it is considered sufficiently important to the study, based on present requirements, additional effort will be made to obtain the information desired. Additional contacts will be made as the occasion arises in securing the best possible results in the required instrumentation.