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DEPARTMENT OF THE INTERIOR

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AN OUTLINE OF EQUIPMENT
USEFUL FOR
HYDROLOGIC STUDIES

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HYDROLOGIC LABORATORY

DENVER, COLORADO



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By A. I. Johnson

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Open-File Report

Hydrologic Laboratory
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CONTENTS

| | Page |
|--|------|
| Introduction ----- | 1 |
| Equipment outline ----- | 2 |
| Office techniques ----- | 2 |
| Surveying ----- | 6 |
| Meteorological investigation ----- | 8 |
| Measurement of water level or pressure ----- | 10 |
| Measurement of flowing water ----- | 12 |
| Well or borehole exploration ----- | 14 |
| Well-construction equipment ----- | 16 |
| Surface and subsurface exploration ----- | 18 |
| Laboratory ----- | 22 |

ILLUSTRATIONS

| | |
|---|----|
| Figure 1. Stereoscopes for aerial-photographic interpretation -- | 3 |
| 2. Projectors, plotters, and accessories for aerial- photographic interpretation ----- | 4 |
| 3. Miscellaneous equipment used for a variety of hydro- geologic office techniques ----- | 5 |
| 4. Surveying equipment ----- | 7 |
| 5. Equipment used for meteorological observations ----- | 9 |
| 6. Equipment for measurement of water level or pressure -- | 11 |
| 7. Equipment used for measurement of flowing water ----- | 13 |
| 8. Equipment for well or borehole exploration ----- | 15 |
| 9. Well-construction equipment ----- | 17 |

ILLUSTRATIONS--Continued

| | Page |
|---|------|
| 10. Sampling equipment ----- | 19 |
| 11. Equipment for surface and subsurface exploration ----- | 20 |
| 12. Equipment for measurement of soil moisture in the field ----- | 21 |
| 13. Equipment for laboratory analysis of rock and soil materials ----- | 23 |

AN OUTLINE OF EQUIPMENT USEFUL FOR HYDROLOGIC STUDIES

By A. I. Johnson

INTRODUCTION

Hydrology normally is considered to be a specialty within the fields of engineering and geology. Because of the great variety of technical problems encountered, there are many other specialties used by the hydrologist; for example, soil mechanics, soil physics, geophysics, and petroleum engineering. Thus, the hydrologist in general practice can rarely expect to become familiar with all of the special equipment and procedures now available or to keep up with the rapidly increasing amount of equipment and procedures being developed daily.

Methods and equipment used for hydrologic investigations range widely from those for the simple reconnaissance-type study to those for the more elaborate detailed-type study. In all of these studies, the proper equipment may mean the difference between obtaining the correct answers to a hydrologic problem or arriving at false conclusions. Thus, the hydrologists should be--in fact, must be--constantly searching for the application of new materials, new equipment, and new techniques to their hydrologic studies.

This paper presents an outline which lists equipment the hydrologist uses, or may find useful, in carrying out a hydrologic investigation. The outline was originally prepared by the author in 1955 as a training aid for short courses on ground-water hydrology, and for foreign hydrologists as part of government-sponsored training in this country and abroad. Because of continued interest and need, the original outline has been broadened and brought up to date to form the present paper. This outline should not be construed to completely cover either the whole field of hydrology or the broad scope of related disciplines, but it should remind the hydrologist of most equipment he is likely to need for his particular investigation.

The equipment is listed under nine major headings, according to its primary use. Equipment has not been listed in any particular order under the principal headings, and the items listed, or the order in which they have been listed, should not be considered as a recommendation for any particular item. The outline has been double-spaced purposely and some space has been left at the end of each section so each reader may add in notes on the various equipment or list new equipment as it becomes known. Some of the equipment is illustrated in the figures accompanying the outline. More detailed information on specific equipment may be obtained by referring to references listed in U.S. Geol. Survey Water-Supply Paper 1779-Z by the author, "Selected References on Laboratory and Field Methods in Ground-water Hydrology," 1963.

EQUIPMENT OUTLINE

A. Office Techniques

1. Stereoscopes (lens, mirror, prism, combination)
2. Photogrammetric projectors
3. Photogrammetric plotters, sketchmaster (vertical, oblique)
4. Stereocomparagraph
5. Height-finder, stereometer, parallax bar, parallax ladder
6. Slope-measuring instrument, stereo-slope comparator
7. Profile plotter
8. Pantograph
9. Isometrograph, perspective-isometric attachment for drafting
machine
10. Contour spacer, spacing divider
11. Proportional divider
12. Area-measuring instrument, planimeter, map measurer
13. Aluminum note covers, with leather case
14. Conducting-paper analog plotter
15. Slide rule, calculator, computer
16. Microscope (monocular, binocular, petrographic polarizing)
17. Sand-identification folder, tube or tray, gravel-identification
tube
18. Rock-color chart, soil-color chart

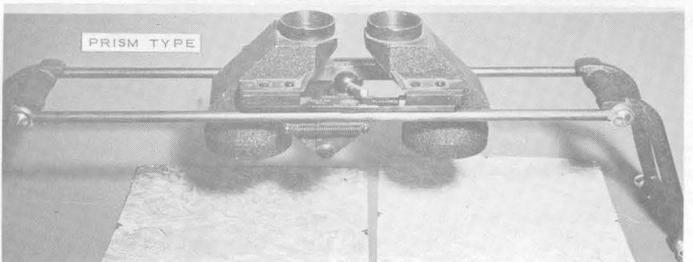
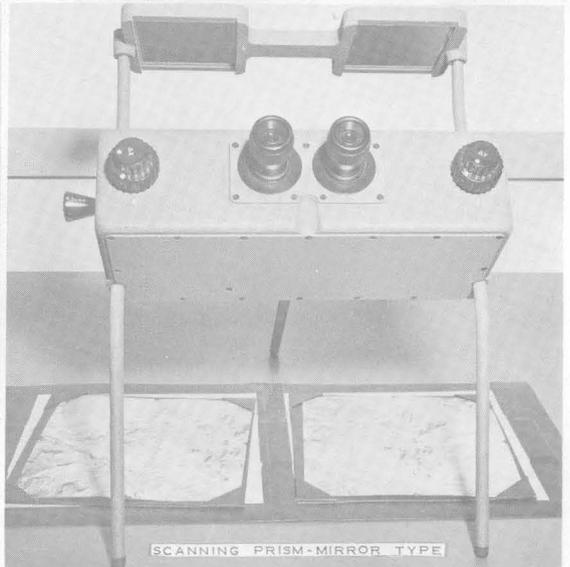
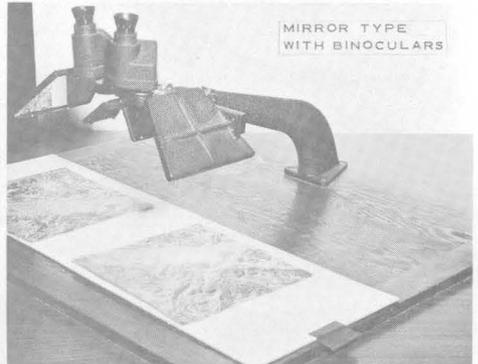
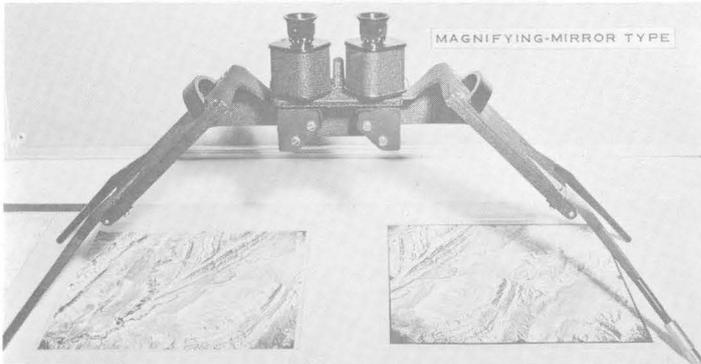
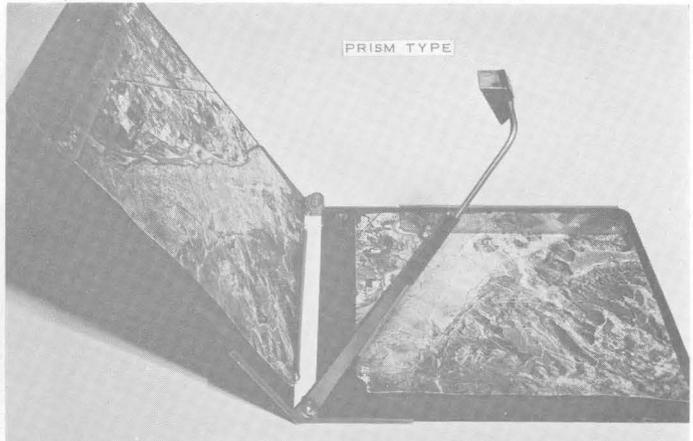


FIGURE 1 - STEREOscopes FOR AERIAL-PHOTOGRAPHIC INTERPRETATION.

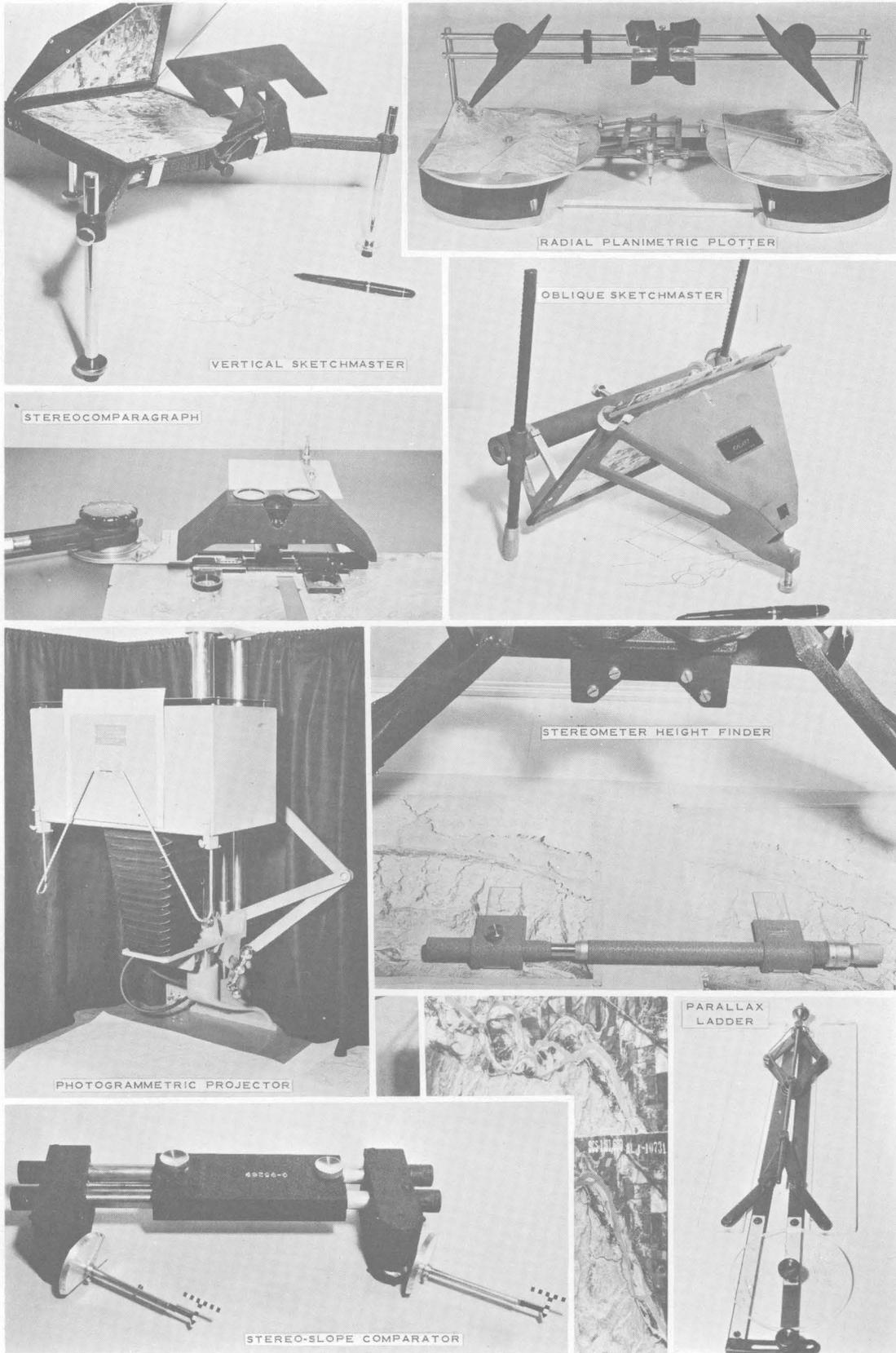


FIGURE 2 - PROJECTORS, PLOTTERS, AND ACCESSORIES FOR PHOTOGRAPHIC INTERPRETATION.

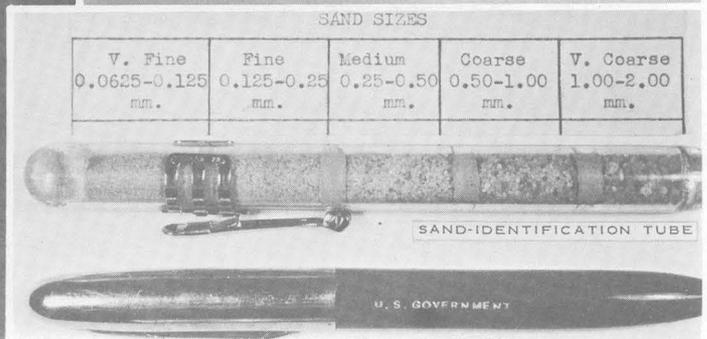
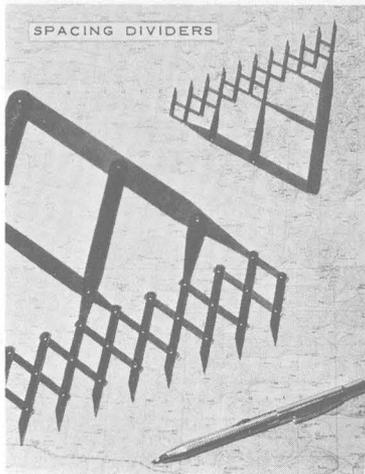
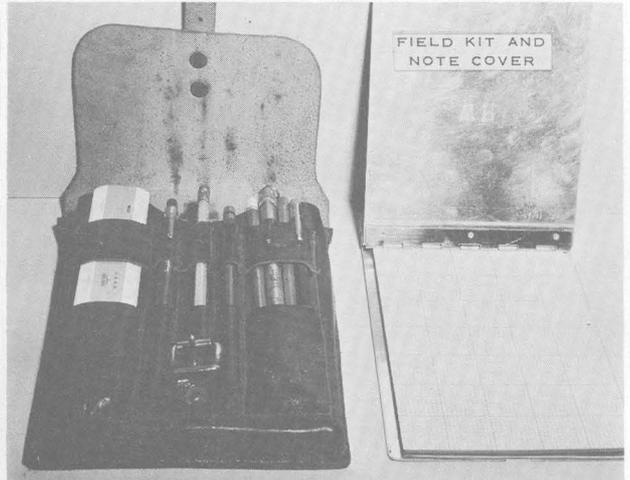
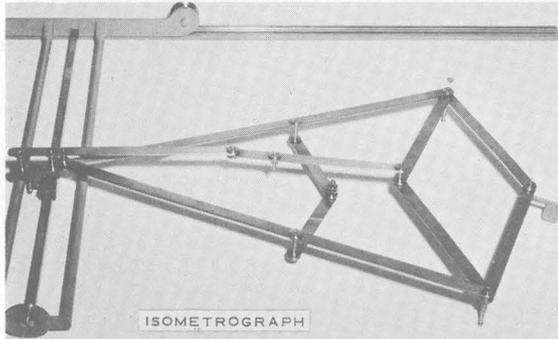


FIGURE 3 - MISCELLANEOUS EQUIPMENT USED FOR A VARIETY OF HYDROGEOLOGIC OFFICE TECHNIQUES.

B. Surveying

1. Brunton compass
2. Forester's compass, surveyor's compass
3. Hand level
4. Abney level
5. Altimeter (standard, micro)
6. Altitude barometer
7. Engineer's level (dumpy, wye, precise, self-leveling) and tripod
8. Transit and tripod
9. Alidade (high-standard, explorer, pendulum), with plane table
and tripod
10. Theodolite and tripod
11. Sextant
12. Electronic distance-measuring device
13. Distance-measuring wheel, precise odometer
14. Air-borne profile recorder
15. Level rod, stadia rod, range pole
16. Chain tapes, chaining pins or arrows, tension handle, tape-repair
kit

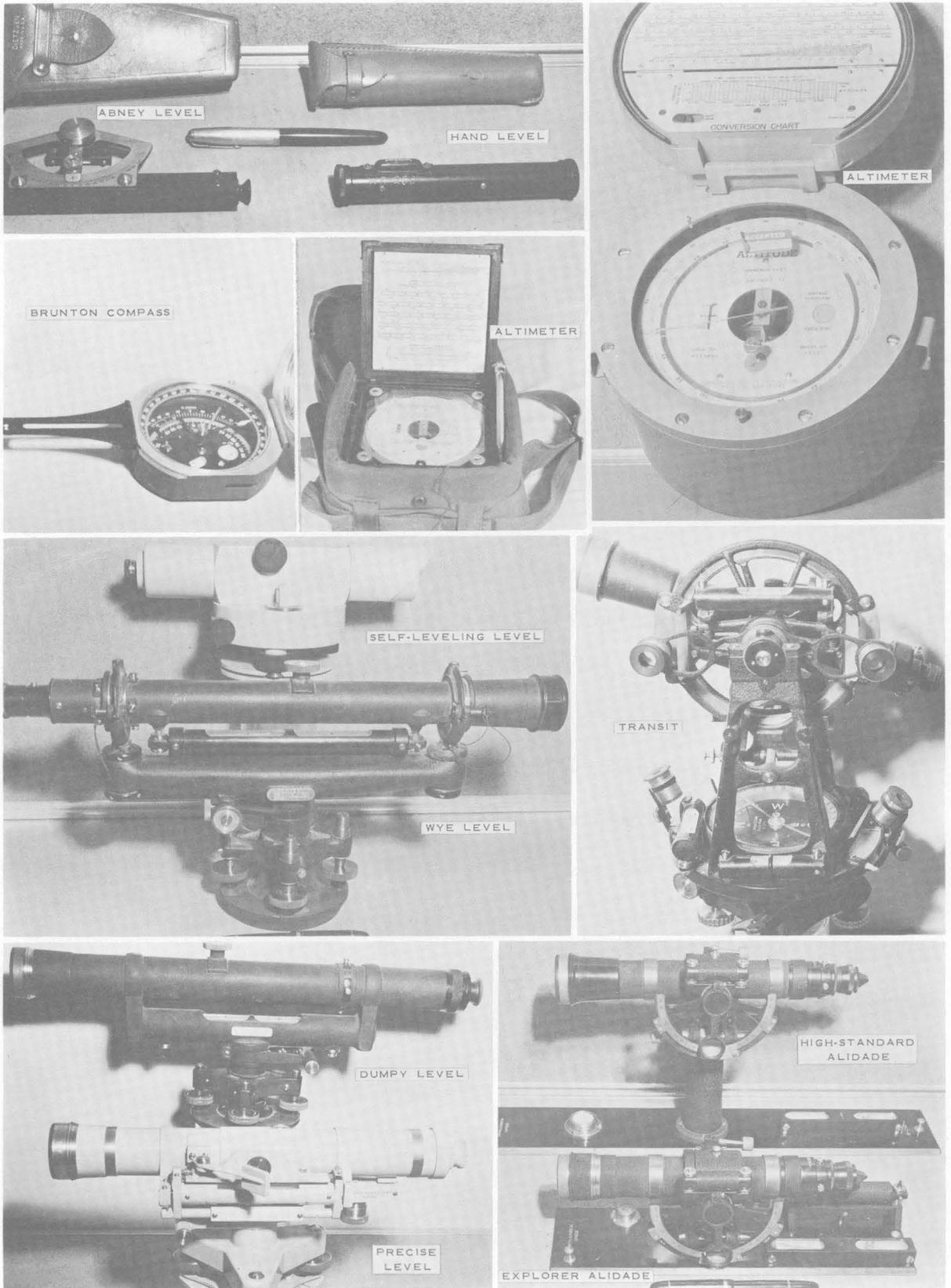


FIGURE 4 - SURVEYING EQUIPMENT.

C. Meteorological Investigation

1. Thermometer (maximum, minimum), thermograph
2. Rain and snow-gage (recording, non-recording)
3. Rain-duration autograph
4. Snow-sampling tube and weighing scale
5. Snow-measuring probe or staff
6. Evaporation pan, with stilling well, recording evaporation gage
7. Atmometer (white-bulb, black-bulb)
8. Wind-speed indicator or recorder, anemometer
9. Thermal radiometer, pyrhelimeter, pyrhellograph
10. Cummings radiation integrator
11. Hygrometer, humidity recorder
12. Psychrometer (sling, thermocouple)
13. Hygrothermograph
14. Sunshine-duration transmitter or recorder
15. Dew gage, dew-duration recorder
16. Barometer (mercurial, aneroid), barograph (standard, micro)
17. Instrument shelters
18. Radar
19. Air-borne meteorological transmitters

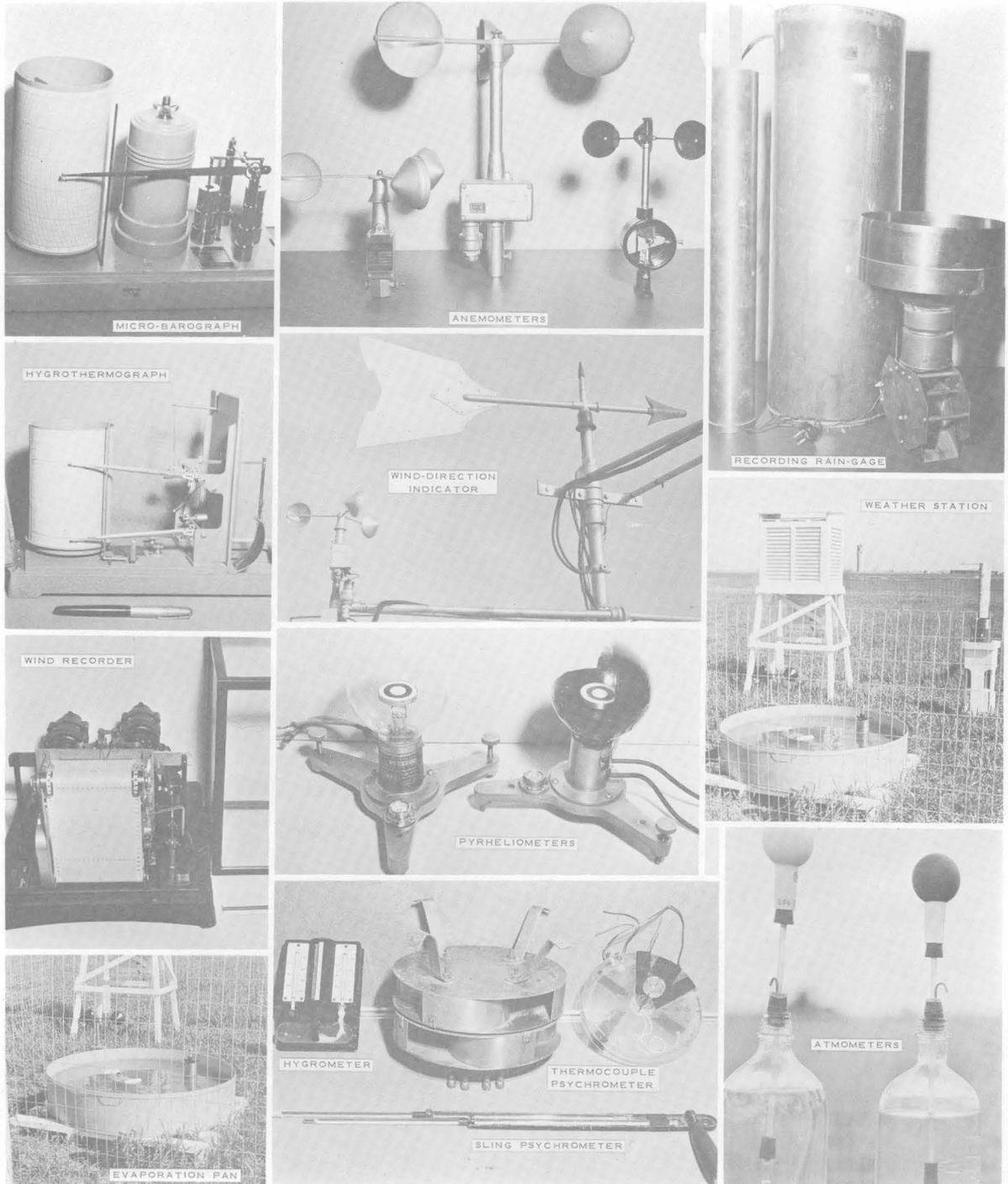


FIGURE 5 - EQUIPMENT USED FOR METEOROLOGICAL OBSERVATIONS.

D. Measurement of Water Level or Pressure

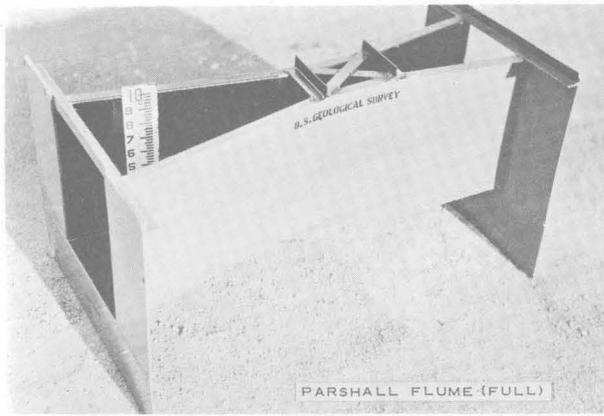
1. Hook gage, point gage
2. Staff gage, chain gage, wire-weight gage
3. Steel tapes, and tape-mending kit
4. Electric water-level tape or line, and reel
5. Lead weights, percussion weight
6. Water-level recorder (float, air-line, electrical, pressure transducer, digital, telemeter)
7. Recorder attachments for small-diameter wells (Drescher, Koopman, bubbler, surface-follower)
8. Pressure gage or recorder (Bourdon-tube, electrical transducer)
9. Manometer (U-tube, well-type, flexible)
10. Soil plug
11. Water-level indicating paste, chalk, ground cork
12. Plumber tools, and assorted pipe fittings
13. Recorder shelters
14. Observation-well or hydrologic-station signs



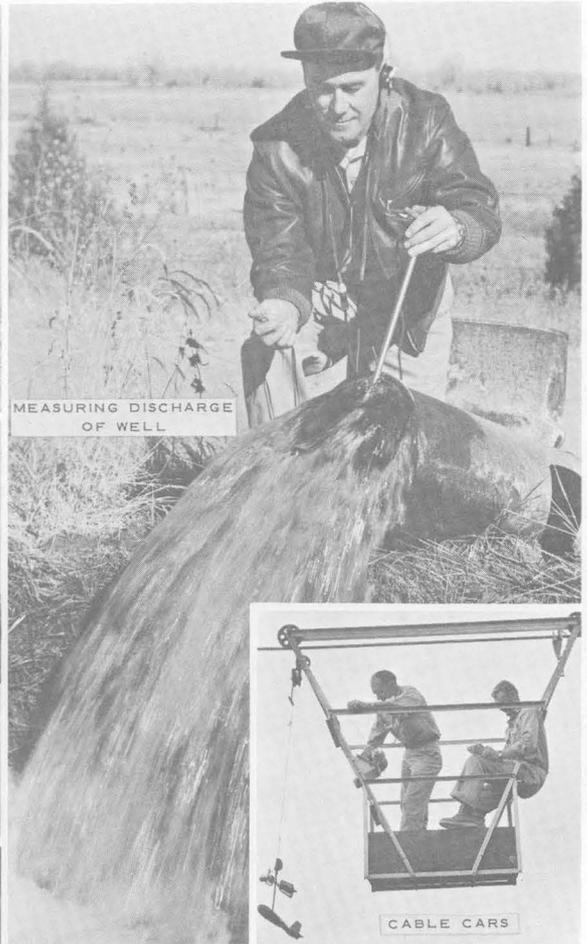
FIGURE 6 - EQUIPMENT FOR MEASUREMENT OF WATER LEVEL OR PRESSURE.

E. Measurement of Flowing Water

1. Velocity methods (dye, float, salt, radioactive)
2. Weir (contracted or suppressed, rectangular, 90°V-notch, Cipolletti)
3. Orifice (free or submerged, contracted or suppressed)
4. Parshall flume (full, modified)
5. Pitot tube
6. Current meter (Price, pygmy, Hoff, photoelectric)
7. Ultrasonic velocity gage
8. Volumetric-measurement or weighing equipment
9. California pipe method (horizontal, vertical)
10. Venturi meter
11. Variable-area float-type flowmeter
12. Flow-nozzle
13. Orifice plate or meter
14. Propeller-type flowmeter
15. Electrical turbine-type flowmeter
16. Bellows flowmeter
17. Hot-wire or thermister flowmeter
18. Electromagnetic flowmeter
19. Ultrasonic flowmeter
20. True mass-rate flowmeter
21. Stopwatch, electrical timer or counter
22. Cable-ways and cable-cars, bridge crane, vehicle crane, boat boom

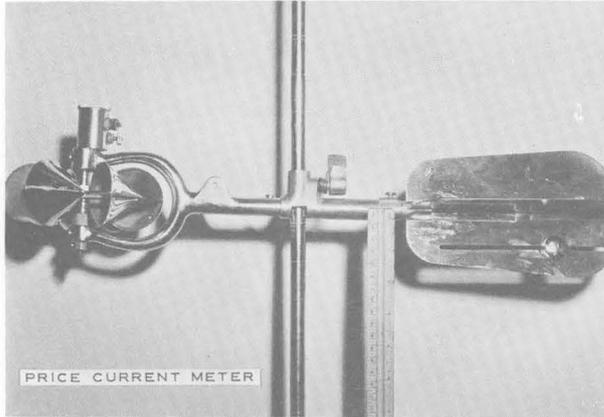


PARSHALL FLUME (FULL)

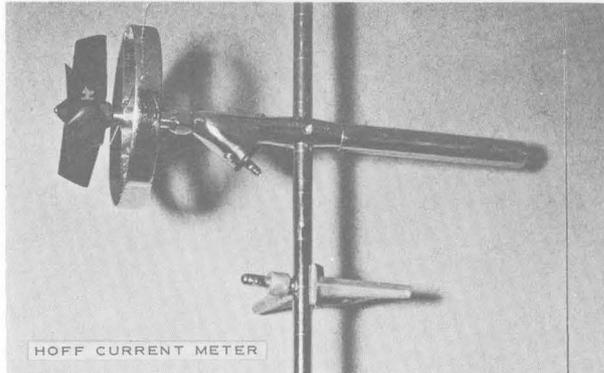


MEASURING DISCHARGE OF WELL

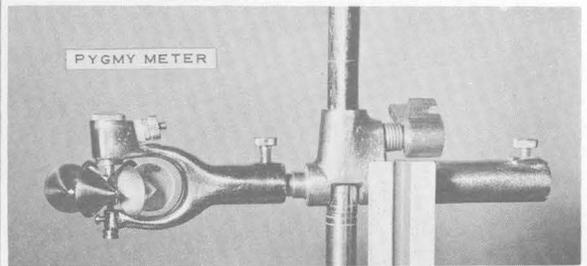
CABLE CARS



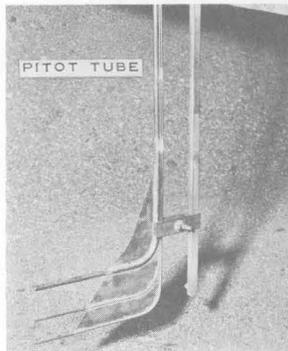
PRICE CURRENT METER



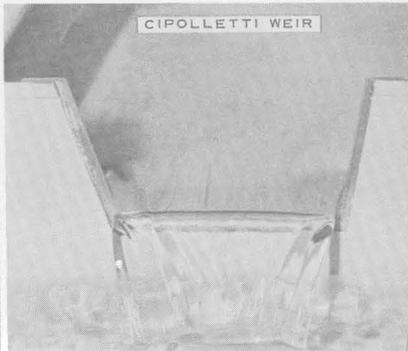
HOFF CURRENT METER



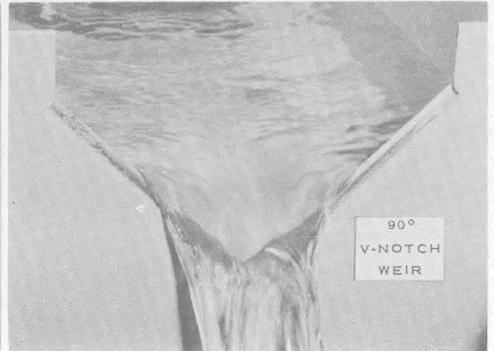
PYGMY METER



PITOT TUBE



CIPOLLETTI WEIR



90° V-NOTCH WEIR

FIGURE 7 - EQUIPMENT USED FOR MEASUREMENT OF FLOWING WATER.

F. Well or Bore-hole Exploration

1. Depth-to-water equipment (see Section D)
2. Portable chemical-quality kits
3. Portable pH comparator, meter, or recorder
4. Water-sampler (ball-valve, flap-valve, messenger, electronic)
5. Fluid-conductivity (resistivity) meter, recorder, or logger
6. Thermometer (mercury, electrical), temperature recorder or logger
7. Electric logger (spontaneous potential, single-point, short normal, long normal, lateral, microlog, induction)
8. Radioactivity logger (gamma ray, neutron)
9. Fluid-velocity logger (vane-type, electrical)
10. Caliper logger
11. Dipmeter, inclinometer
12. Casing finder, casing-collar locator
13. Borehole magnetometer (magnetic susceptibility, magnetic field)
14. Acoustic velocity logger
15. Formation tester
16. Borehole seismic equipment
17. Selective-electrode logger
18. Bottom-hole pressure-sensing device
19. Borehole camera (still, movie, television)
20. Borehole packers, drill-stem test packers

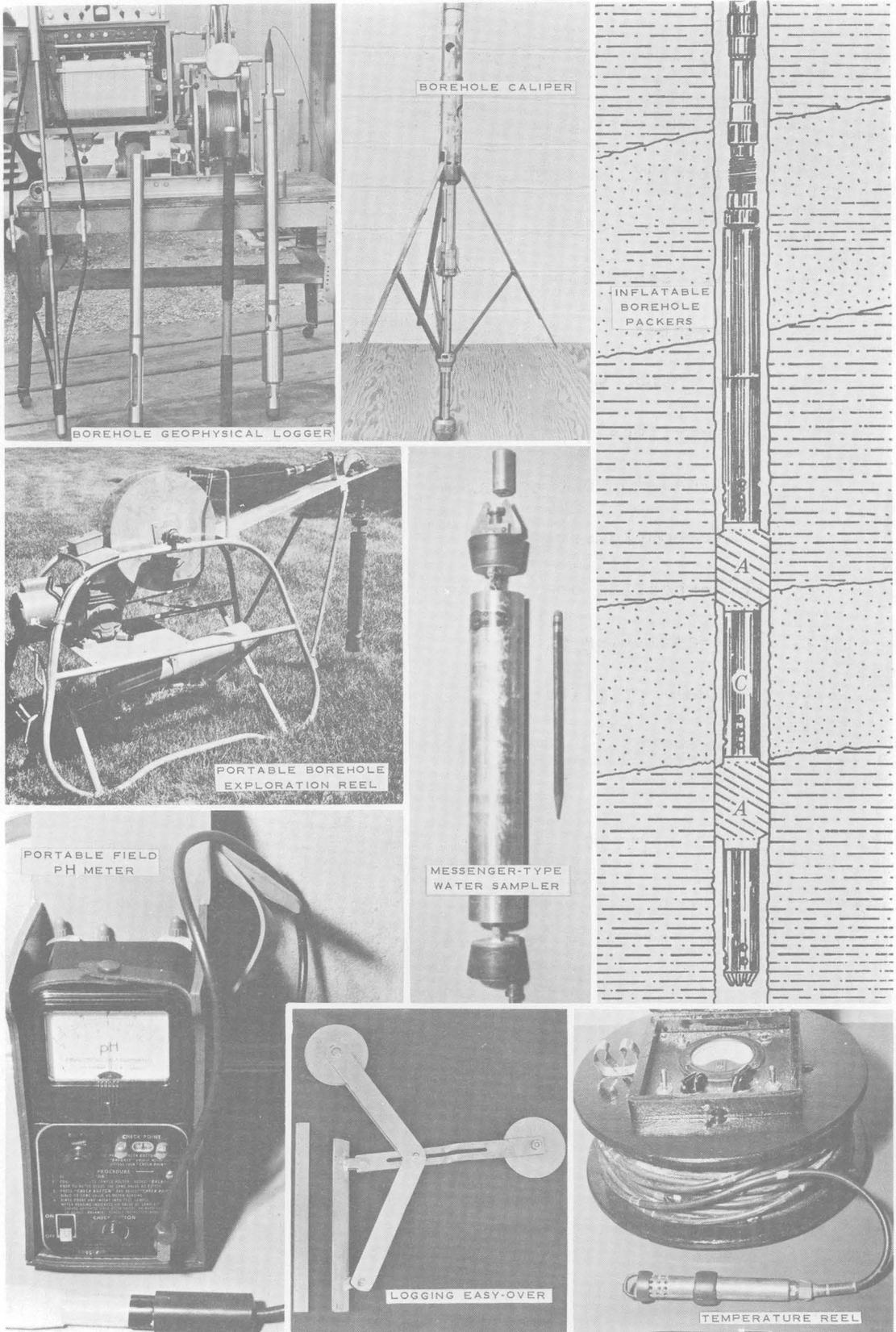


FIGURE 8 - EQUIPMENT FOR WELL OR BOREHOLE EXPLORATION.

G. Well-Construction Equipment

1. Pipe and casing (metal, plastic, concrete, wood)
2. Perforator, slotter, ripper
3. Well screen (metal, plastic, porous concrete)
4. Drive "sand" point, jetting point
5. Piezometer
6. Pump (hand, windmill, plunger, jet, air-lift, turbine, centrifugal, propeller, submersible)
7. Well-development equipment (surge block or plunger, bailer, air-compressor, pump)
8. Well-shooting or fracturing equipment
9. Well-cementing equipment
10. Gravel- or filter-pack material

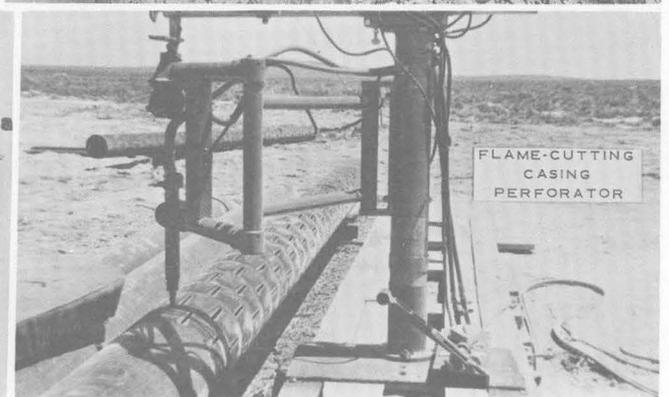
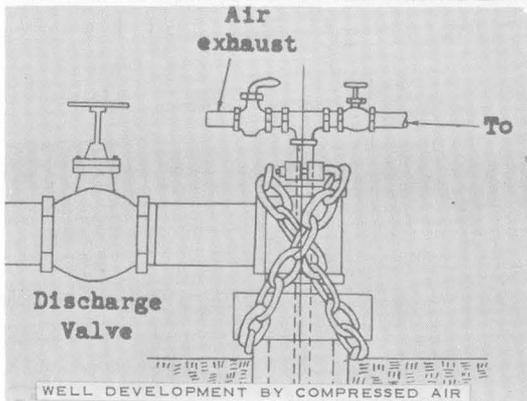
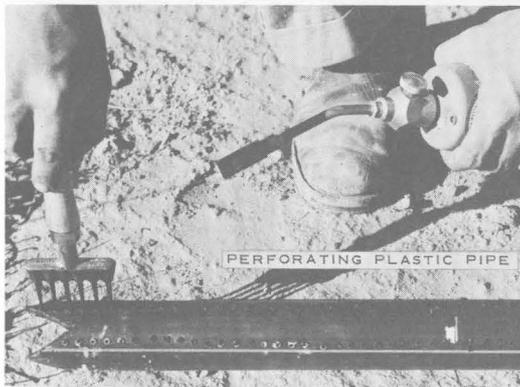
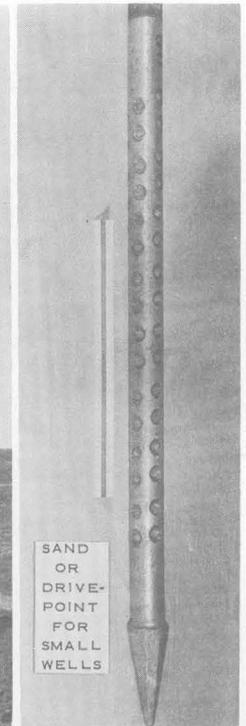
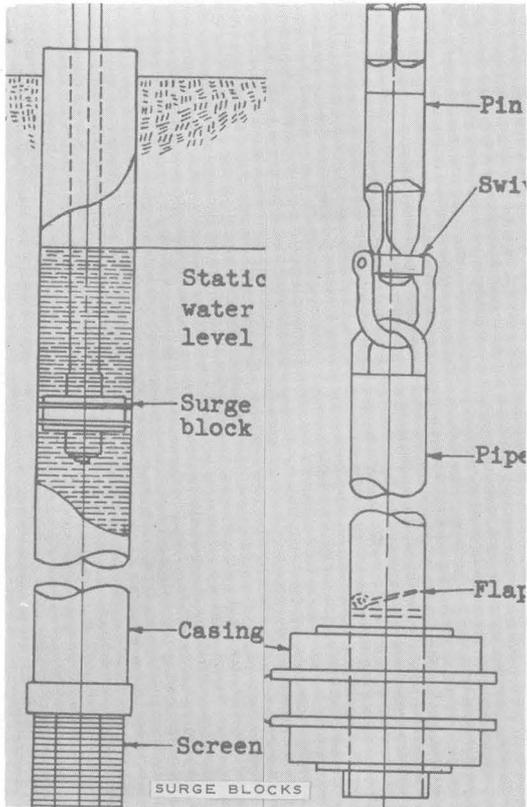


FIGURE 9 - WELL-CONSTRUCTION EQUIPMENT.

H. Surface and Subsurface Exploration

1. Electrical earth resistivity
2. Seismic (explosive, drop-weight, hammer, vibration, continuous sonic)
3. Magnetic
4. Gravity (gravimeter, torsion balance)
5. Infrared, microwaves, ultrasonics
6. Dip needle, metal finder, mine detector
7. Hand auger (Iowan, helical, pod, barrel, ship, bucket)
8. Power auger (helical continuous-spiral, disk, bucket)
9. Jetting, wash boring
10. Drilling (cable-tool or percussion, hydraulic or pneumatic rotary, reverse circulation)
11. Coring (diamond, chilled-shot, side-wall, continuous, percussion, wire-line)
12. Drilling-rate recorder
13. Drive samplers (open, split-barrel, thin-wall, free or fixed piston, composite with liners, gravity, explosive)
14. Sounding probes (point or cone, wash, split-barrel penetration, vane-shear)
15. Trenchers or excavating equipment for test trenches or test pits
16. Soil-moisture resistance blocks (Bouyoucos, Coleman)
17. Tensiometers (gage, manometer, transducer), pore-pressure cells
18. Nuclear moisture or density meters (surface, subsurface)
19. Infiltrimeters (single- or double-ring, sprinkling-type)
20. Tilt-meter

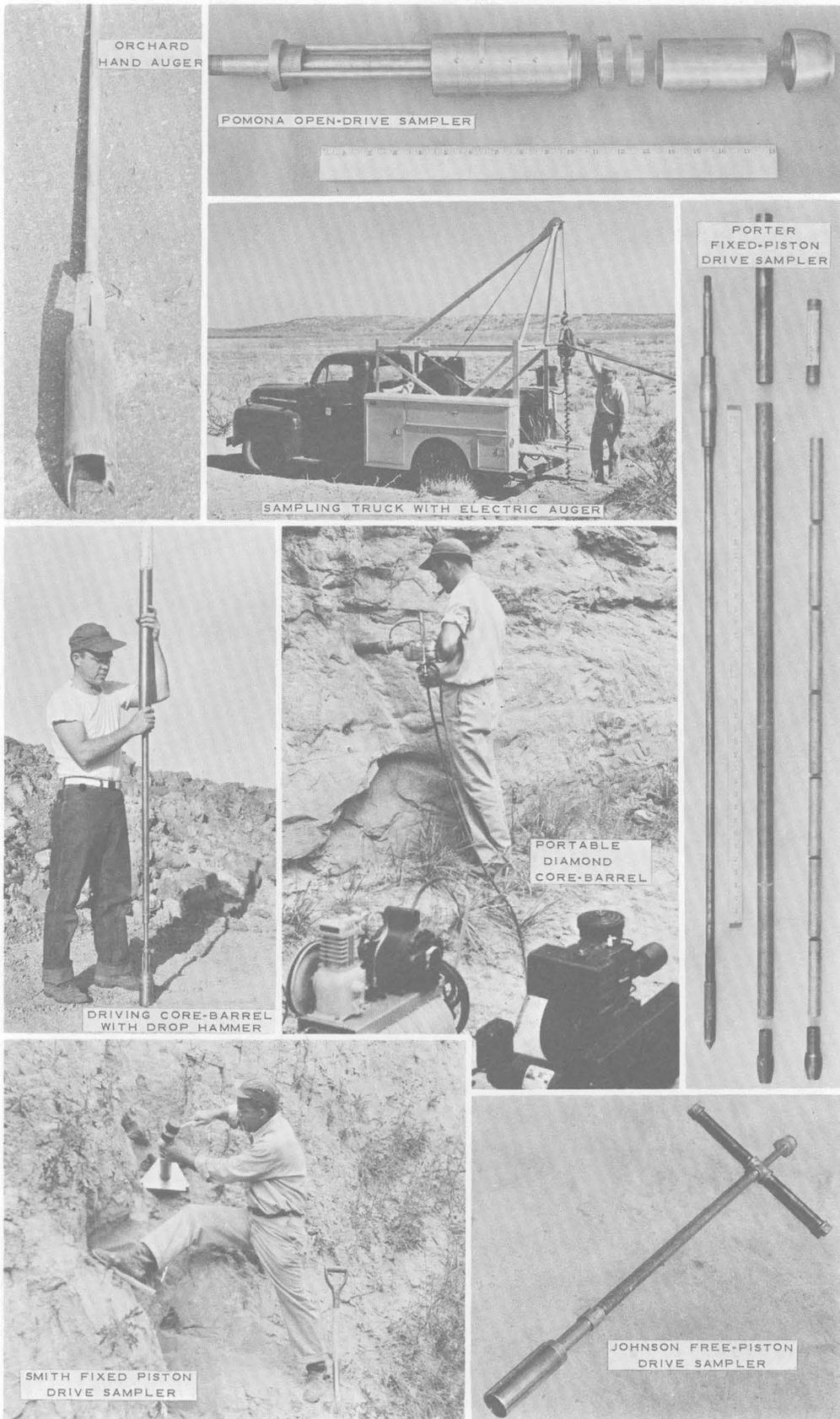


FIGURE 10 - SAMPLING EQUIPMENT.

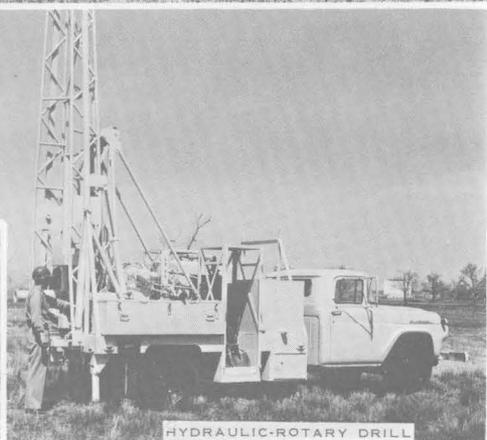
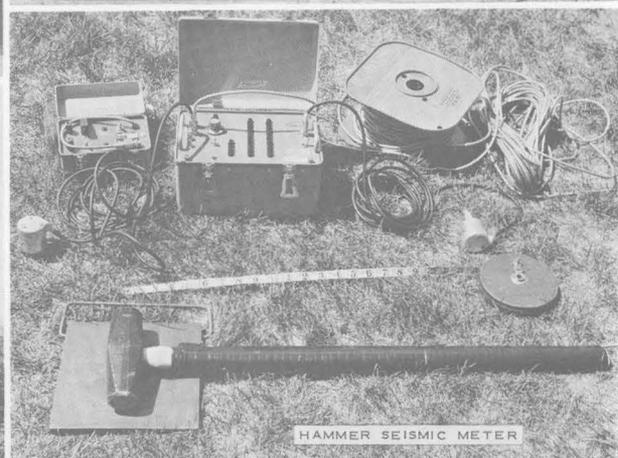
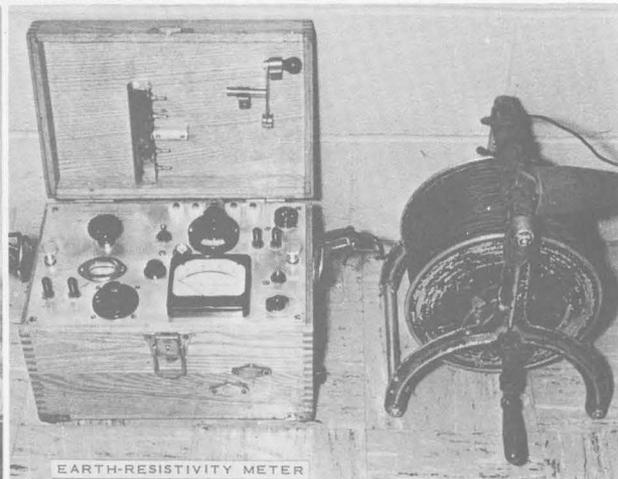
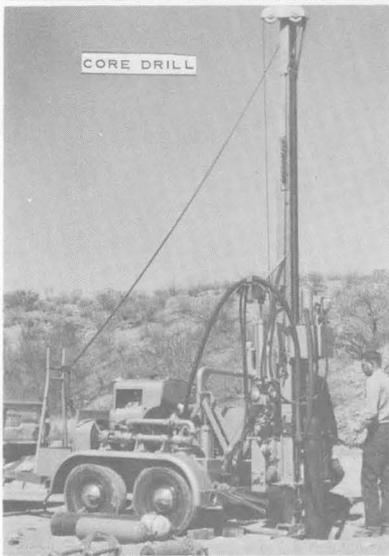
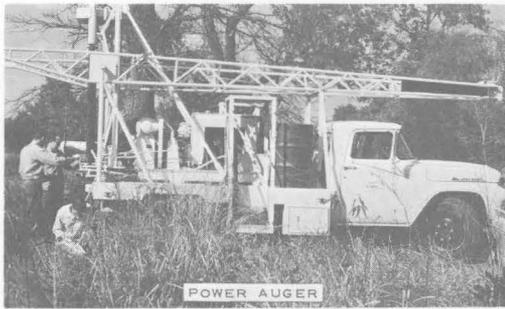
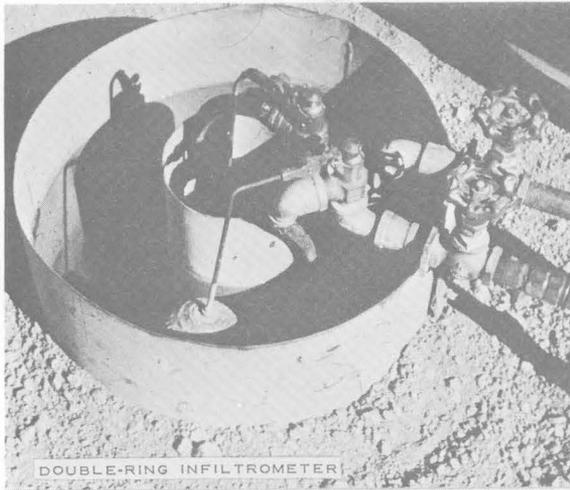
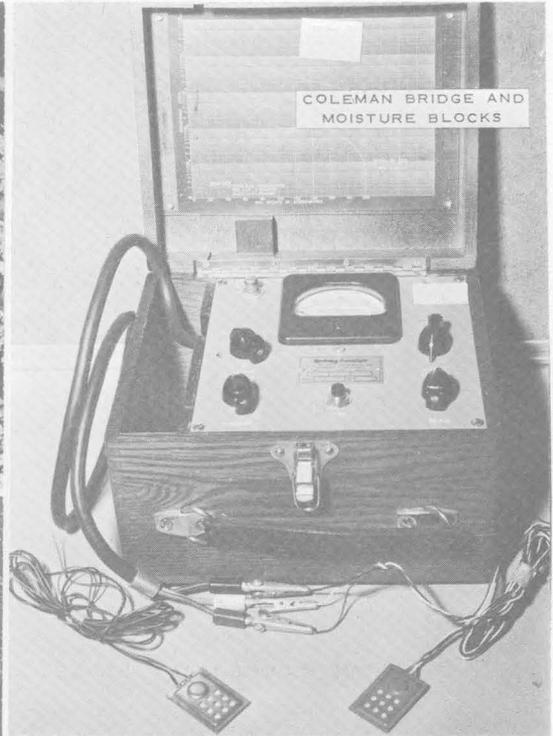


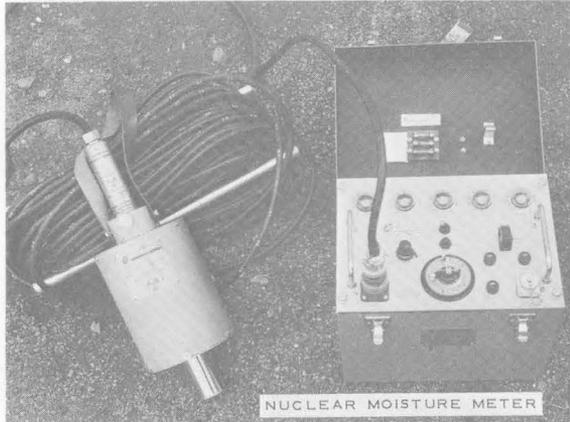
FIGURE 11 - EQUIPMENT FOR SURFACE AND SUBSURFACE EXPLORATION.



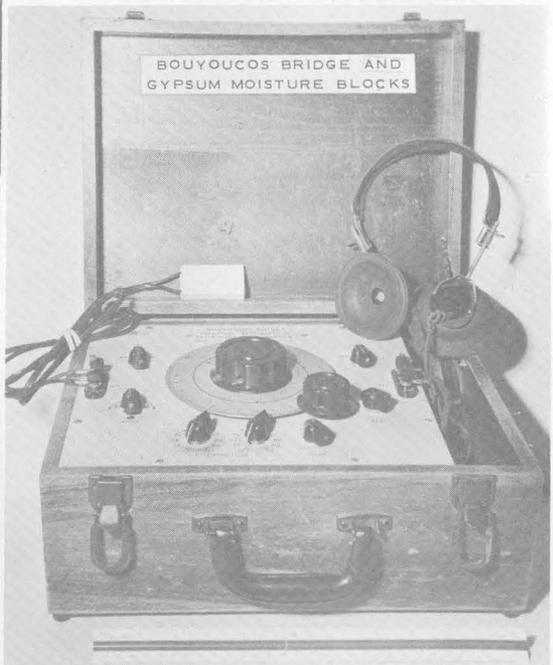
DOUBLE-RING INFILTRMETER



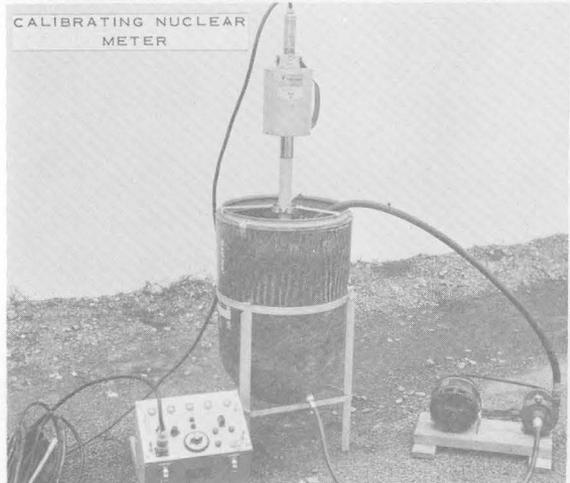
COLEMAN BRIDGE AND MOISTURE BLOCKS



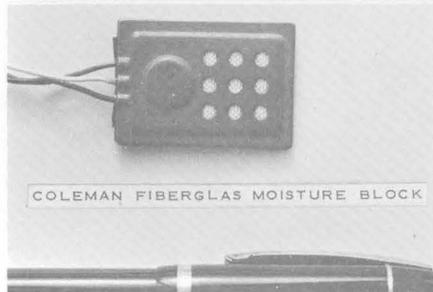
NUCLEAR MOISTURE METER



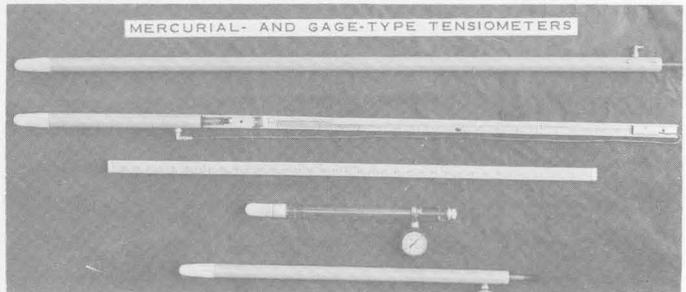
BOUYOCOS BRIDGE AND GYPSUM MOISTURE BLOCKS



CALIBRATING NUCLEAR METER



COLEMAN FIBERGLAS MOISTURE BLOCK



MERCURIAL- AND GAGE-TYPE TENSIO METERS

FIGURE 12 - EQUIPMENT FOR MEASUREMENT OF SOIL MOISTURE IN THE FIELD.

I. Laboratory

- 1. Balances**
- 2. Chemicals**
- 3. Laboratory furniture**
- 4. Glassware**
- 5. Ovens**
- 6. Sample packers (vibratory, gravity)**
- 7. Petrographic-analysis equipment**
- 8. Permeameters**
- 9. Rock-mechanics laboratory equipment**
- 10. Sieves and automatic shaker**
- 11. Soil-mechanics laboratory equipment**
- 12. Soil-moisture laboratory equipment**
- 13. Thermometers**
- 14. Centrifuges**

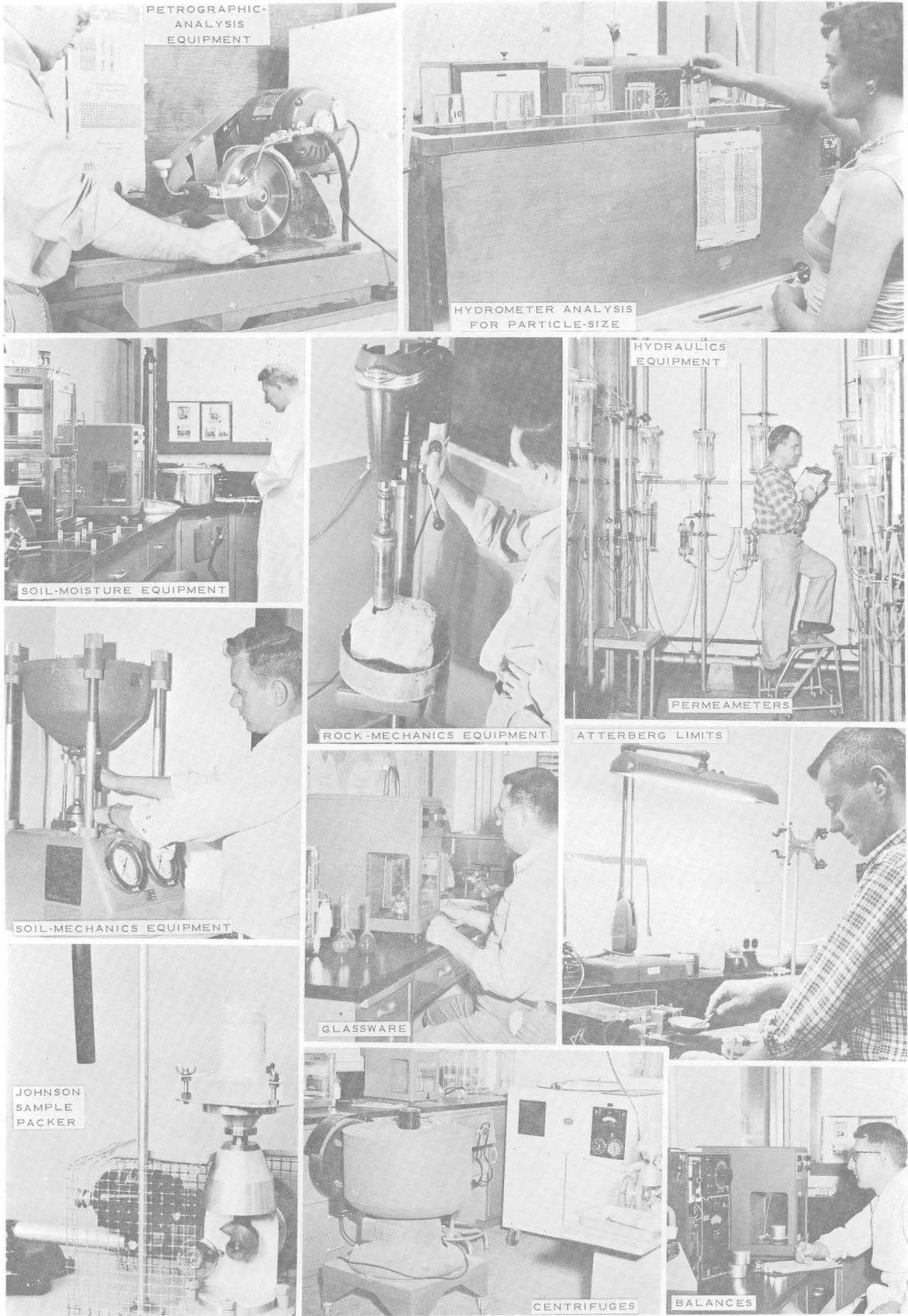


FIGURE 13 - EQUIPMENT FOR LABORATORY ANALYSIS OF ROCK AND SOIL MATERIALS.