Instrumentation of Urban Hydrology Monitoring Sites in Southeast Florida

Water-Resources Investigations 79-37

PREPARED IN COOPERATION WITH THE
BROWARD COUNTY TRANSPORTATION DEPARTMENT • BROWARD COUNTY ENVIRONMENTAL QUALITY CONTROL BOARD • DADE COUNTY DEPARTMENT OF ENVIRONMENTAL RESOURCE MANAGEMENT • SOUTH FLORIDA WATER MANAGEMENT DISTRICT • FLORIDA DEPARTMENT OF TRANSPORTATION • FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

U.S. GEOLOGICAL SURVEY

John R. Gray

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No.

4. Title and Subtitle

INSTRUMENTATION OF URBAN HYDROLOGY MONITORING SITES IN SOUTHEAST FLORIDA

5. Report Date

6.

7. Author(s)
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8. Performing Organization Rept. No. USGS/WRI-79-37

9. Performing Organization Name and Address
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10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Geological Survey
325 John Knox Road
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Tallahassee, Florida 32303

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes

16. Abstracts An instrumentation system developed and built in laboratories of the U.S. Geological Survey, Reston, Va., has been used since 1974 to collect synchronized rainfall, runoff, and water-quality data from urban basins. A number of field modifications were made to adapt the system to local hydrologic conditions and for collection of data on about 350 rainstorms at four sites in south Florida.

The instrumentation system measures rainfall at three sites, records two pressure or water-level readings for flow computations, and collects and refrigerates up to 24 water samples and rainfall-quality samples. Rainfall and runoff data are recorded every 36 seconds on a six-channel analog recorder so that all variables are time-synchronous.

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17. Key Words and Document Analysis. 17a. Descriptors

Instrumentation, Stormwater, Urbanization, Surface water, Rain gage, Water quality flume, Stilling well, Velocity meter, Runoff

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution.	UNCLASSIFIED	43
	20. Security Class (This Page) UNCLASSIFIED	22. Price

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

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South Florida Water Management District
Florida Department of Transportation
Florida Department of Environmental Regulation

July 1979

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

For use of those readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply inch-pound units	By	To obtain metric units
acres	0.4047	hectares (ha)
feet (ft)	0.3048	meters (m)
inches (in.)	25.4	millimeters (mm)

INSTRUMENTATION OF URBAN HYDROLOGY MONITORING
SITES IN SOUTHEAST FLORIDA

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ABSTRACT

An instrumentation system developed and built in laboratories of the U.S. Geological Survey, Reston, Va., has been used since 1974 to collect synchronized rainfall, runoff, and water-quality data from urban basins. A number of field modifications were made to adapt the system to local hydrologic conditions and for collection of data on about 350 rainstorms at four sites in south Florida.

The instrumentation system measures rainfall at three sites, records two pressure or water level readings for flow computations, and collects and refrigerates up to 24 water samples. These data are recorded every 36 seconds on a six-channel analog recorder so that all variables are time-synchronous.

Rainfall is measured using a commercially available tipping bucket gage and can be connected to the system directly or through telephone lines. An electric current is passed through the gage for each tip and the number of tips is recorded to determine rainfall amount and intensity.

Flow in the storm sewer is computed from pressure measurements in a U-shaped venturi-type constriction or, when the constriction is not used, from water levels. Pressures in the approach to the constriction and the throat of the constriction are sensed by a constant flow gas purge system and transmitted to remotely located pressure transducers for measurement. Water levels are measured in stilling wells using float-actuated potentiometers.

Runoff samples are collected and the time of collection recorded at selected multiples of 36 seconds in twenty-four 2-liter containers by use of a pump and rotating distributor. The water-sampling system is started by an electronic signal triggered by a predetermined stage in the storm sewer. Samples are refrigerated until transferred to the laboratory for analysis. The control section of the system provides for automatic sampler activation, preselected time intervals between samples, and preselected sample volume.

The collection of quality of rainfall was determined to be an integral part of Florida urban stormwater hydrology after the study was begun. Therefore, bulk precipitation sampling, collected in open plastic funnels, was added to the data collection program. Subsequently, an automated collector was developed and added to the instrumentation system capable of collecting both bulk precipitation and wetfall-only samples.

INTRODUCTION

The Clean Water Act of 1972 (Public Law 92-500) sets pollution abatement goals for public waters including treatment of urban runoff. In the rapidly developing urban areas of south Florida, much of the runoff enters canals designed to drain the land and prevent flooding. These canals recharge the Biscayne aquifer, a permeable, limestone formation which is the source of most public water supplies. The need for quantity and quality data of stormwater runoff into these canals is increasingly important in order to assess potential effects on the areal water resources.

Urban basins are by design small in size and contain significant amounts of imperviousness. Channels are not open but usually consist of sewer pipes connected to drain inlets. Runoff is short-lived due to the small basin size and the channeling of water through the sewer system. Therefore, the time interval of sampling urban hydrologic data must be much shorter than that of large natural basins. Because the sewers are not readily accessible for use of conventional streamflow measuring equipment, and because of the short time of events, new methods must be used to gage or measure sewer flow. Additionally, because the emphasis of stormwater studies is water-quality oriented, procedures and equipment must be available for automatically sampling the runoff.

An instrumentation system capable of measuring and recording rainfall and runoff data and collecting and preserving water-quality samples was developed and built by the U.S. Geological Survey (Smoot and others, 1974). Instrumentation systems of the U.S. Geological Survey (USGS) type were installed at four sites in south Florida (fig. 1). Figure 2 shows the components of the instrumentation system: the rainfall gage; the rainfall-quality sampler; the flume or U-shaped constriction for measuring discharge; the runoff-quality sampling component with intake, pump, distributor, and refrigerator; and the data recording component.

The system shown in figure 2 differs from the one described by Smoot and others (1974) in that the strip chart recorder and new peripheral devices have been designed and built specifically for the south Florida studies. These new devices include the event clock, rainfall-quality sampler, and equipment monitoring by telephone.

Four small urban basins, ranging in size from 15 to 60 acres, were instrumentated for the south Florida stormwater studies. Land use was

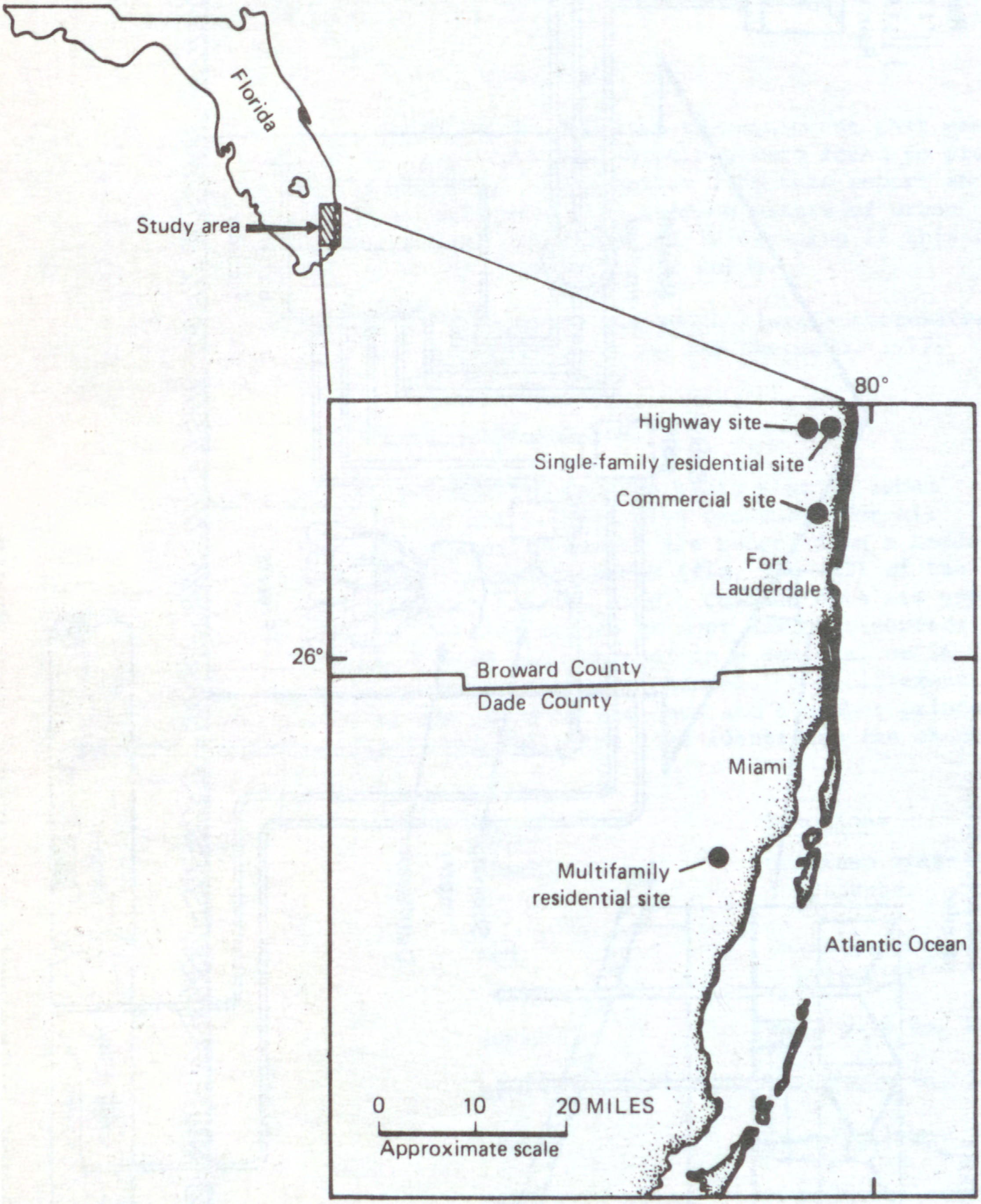

Figure 1.--Map showing location of stormwater runoff sites.

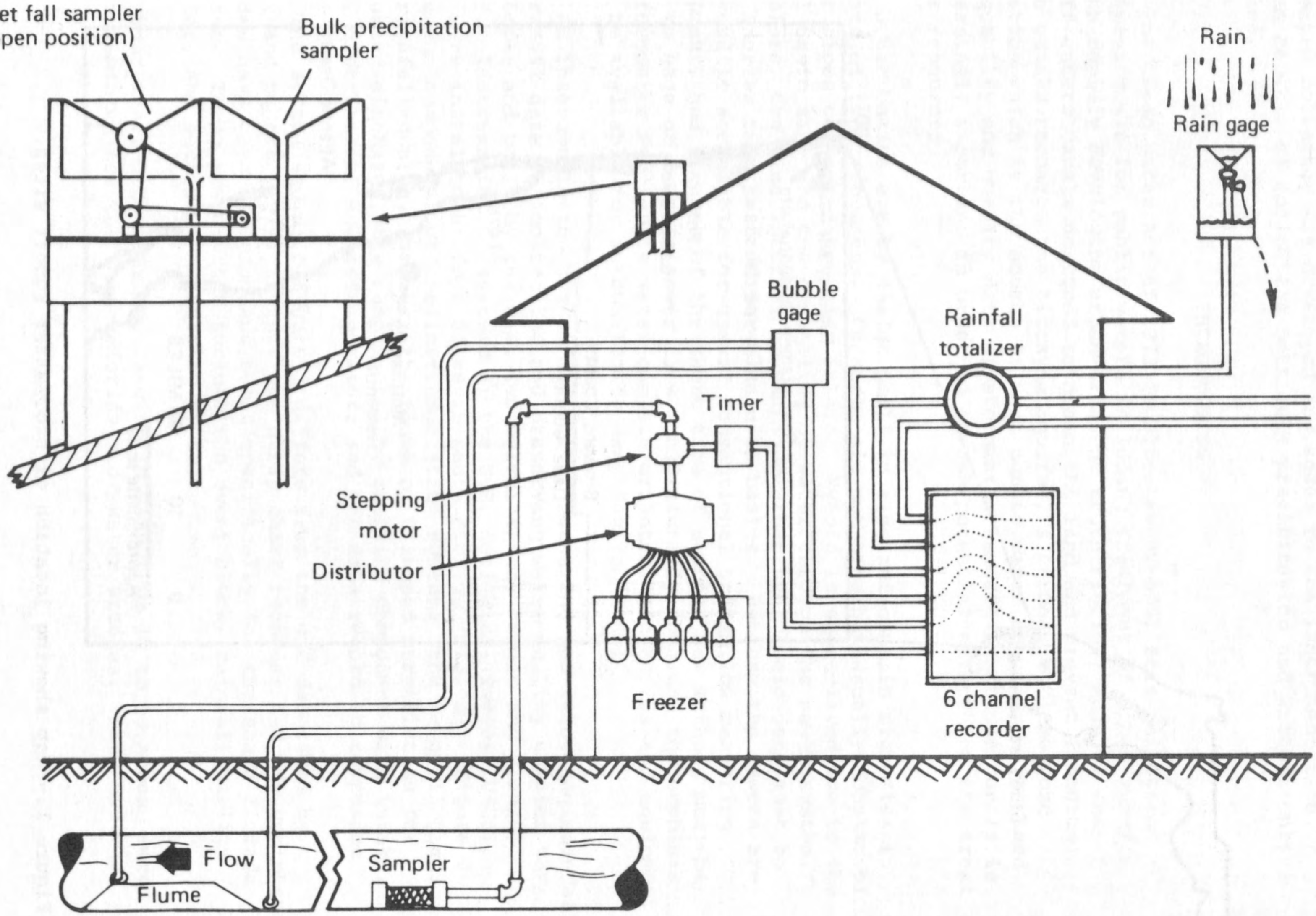

Figure 2.--Components of stormwater runoff system.

different for each urban basin and included sites with predominantly single-family residential, highway, commercial, and multifamily residential (apartments) land uses. All four sites involved only stormwater flows--no baseflow or sustained flow occurred in the sewers. Two sites were completely dry between storm events, one site had varying amounts of standing water between events, and one site was completely submerged, with pooled water between storm events.

Purpose and Scope

The purpose of this report is to describe the equipment that was developed and used, and to illustrate how solutions were found to problems encountered in collecting the data. Information from this report should be useful to officials in understanding the complex nature of urban hydrology instrumentation, and to investigators in deciding if this type of system is applicable to their data gathering needs.

Several reports covering aspects of the south Florida stormwater studies have been published elsewhere (Mattraw and Sherwood, 1977; Mattraw, 1978; and Miller and others, 1978).

DATA RECORDER AND TIMER

The instrumentation system built for the south Florida urban hydrology studies uses a strip chart, or analog recorder, for all timekeeping functions. Six channels of data are recorded on a Leeds and Northrup,[1/] multipoint, time-sharing recorder (fig. 3). All of the channels are recorded on a chart 6.5 in. wide. Colored dots are used in lieu of a continuous black ink line common on most analog recorders. The time required to sense and record each channel is 6 seconds, or 36 seconds between two data points on the same channel. The different channels are identified by the color of the dots and a number printed by every 25th dot per channel. The following list identifies the channels and channel functions.

Channel no.	Color	Functions
1	black	Upstream stage or pressure.
2	red	Downstream stage or pressure.
3	green	Rain gage No. 1.
4	blue	Rain gage No. 2.
5	brown	Rain gage No. 3.
6	purple	Sample collection.

[1/] The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

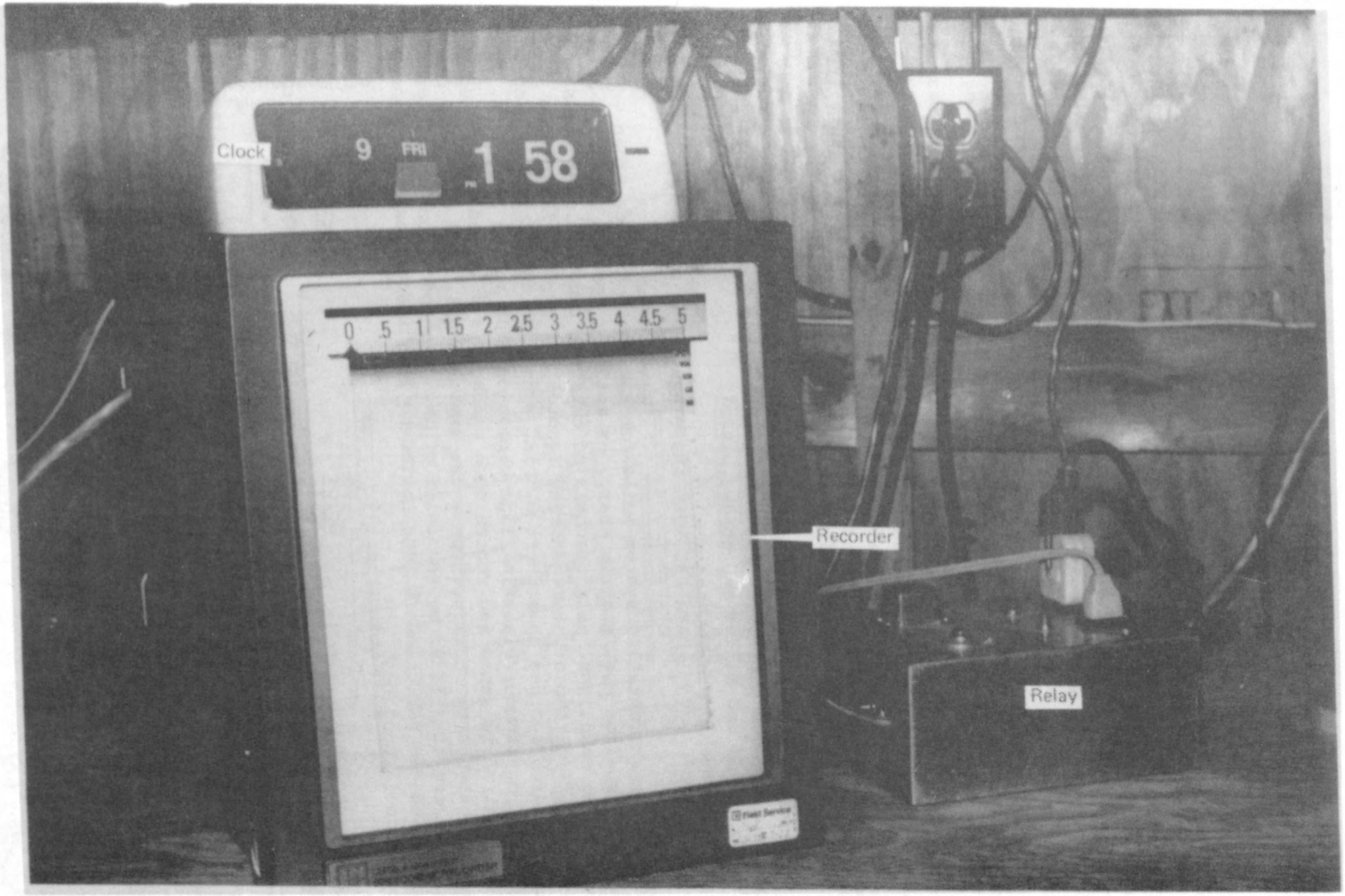

Figure 3.--Photograph showing recorder, clock, and recorder turn-on relay.

A chart speed of 6 in. per hour was needed to expand the hydrograph sufficiently to interpret the six data channels. At this speed the recorder uses 12 ft of chart paper per day. The recorder runs continuously, not only recording storm data but also recording data between storms. The data between storms are not needed, consume chart paper, and are costly to process.

To eliminate the unwanted collection of data between storms, a method of turning on the recorder at the start of a storm event was needed. The problem was solved by building a relay (fig. 3) which serves as an interface between the powerline source and the recorder. Before the storm event occurs, the relay connects electrical power to the digital clock circuit. At the first tip of the rain gage bucket (which defines the start of an event) the relay latching coil is energized, transferring the power from the digital clock circuit to the recorder circuit. The recorder is turned on and the clock (fig. 3) is turned off with the start time and date showing on the clock face. A schematic of the relay is shown in figure 4.

The clock used is a Copal electric digital clock, Model 707, with date, day, hour, half day (a.m. or p.m.), minutes, and alarm (not used). This type of clock was chosen because all information necessary for event start time are on cards attached to a rotating drum. The electric clock motor rotates the drum and flips the cards over to show the time, day, and date.

The latching relay used in the recorder turn-on system is the Potter and Brumfield KBP117DG with a 20-pin socket mounted in a Bud AC404 aluminum chassis. Current to the relay is conducted by a standard power cord. The relay contains a standard house receptacle mounted in the chassis. The connecting tabs have been removed from the receptacle so each half is electrically isolated, permitting the recorder to be plugged into one half and the clock into the other half. The reset for the relay is a momentary contact, single pole, single throw (SPST) switch located between the 12V-dc source and the release coil in the relay. A red indicator lamp was put in the recorder circuit and an amber lamp in the clock circuit for convenience in identifying the activated (hot) circuit.

With the recorder turn-on system operating, the recorder would remain in a nonactive mode until the first tip of the rain gage. Then the recorder would turn on and begin sensing and recording the six channels of data. The recorder continued to record data until serviced and reset by field personnel, usually within 12 hours of the beginning of a storm event.

The recorders used were very reliable, giving almost trouble-free operation between yearly servicing by company technicians. The recorders required routine replacement of ink wheels and printing belts, and alinement of strip chart guides.

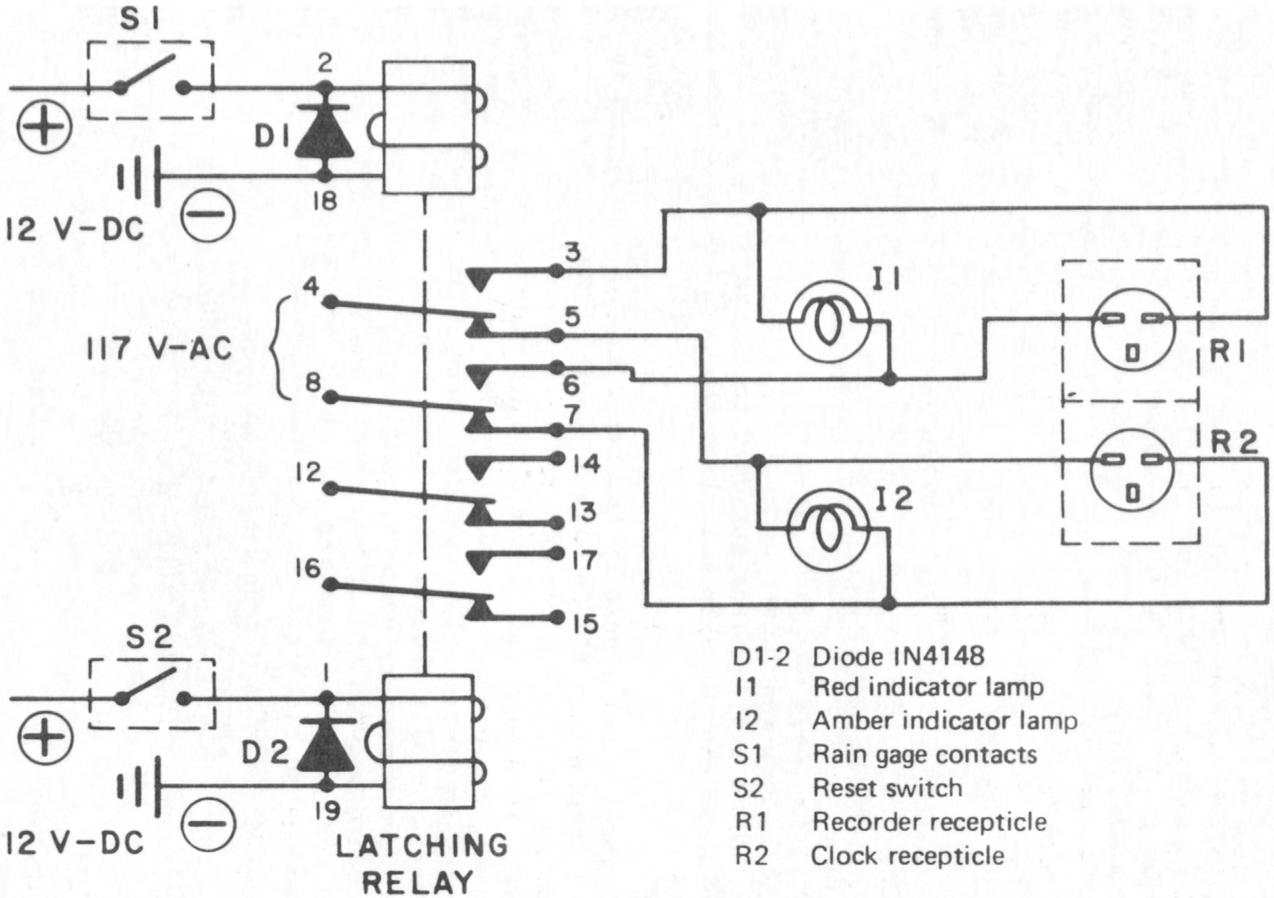

Figure 4.--Diagram of wiring of recorder turn-on system.

SYSTEM STATUS BY TELEPHONE

After the automatic recorder turn-on device was attached to the system, it was evident that many hours were being wasted visiting stations to see if the recorders were running. The fourth site, installed later in the study, was equipped with a telephone and an answering system. The answering system was designed and built by GFA Engineering of Miami, Fla., and gave the status of the system, by code, when the telephone at the site was called.

The telephone was answered electronically, and if there was no tone, the recorder was not running. A monotone sound meant the rainfall gage had tipped at least one time (0.01 in. of rainfall) and the recorder was running. A varying high-low sound meant that criteria for sampling had been met and the sampler should be sampling or that a set of samples had been collected. The combination of recorder turn-on relay and system status by telephone saved many vehicle miles and man-hours in unnecessary inspection trips.

RAINFALL GAGE

The rainfall gage is a commercially available tipping bucket type, similar to model P501 manufactured by Weather Measure Corp. shown in figure 5. Each tip of the bucket (0.01 in. of rainfall) produces an electrical contact closure of about 0.1-second duration. Each contact closure causes a stepping motor to move the slider on a continuous rotation potentiometer one-hundredth of a revolution. The output from the potentiometer is sensed by the recorder such that 1 in. of rainfall (100 tips of the bucket) causes the pen to move the full width of the paper.

The rainfall measuring component of the system has the ability to measure and record rainfall from three locations in the basin. The gages may be connected directly by wire or indirectly through telephone lines. The lines to the gages are powered by a direct current (dc) power supply of 24V. Current passes through the mercury-wetted contacts of the tipping bucket when it tips, to a relay with 10-amp contacts. The relay coil resistance is determined by the amount of current returning on the rain gage line. The normally closed relay contacts are used to connect a 4200 μF, 40WVdc capacitor to the power supply for charging. When the relay is energized, the capacitor discharges through a stepping motor, moving the potentiometer slider one-hundredth of a revolution (fig. 6). The power supply without the capacitor will not produce sufficient current to operate the stepping motor.

When rain gage systems are connected through telephone lines, the higher resistance reduces the amount of current available to the relay coils. A reverse-biased diode placed across the rain gage contacts with a reversing switch (fig. 7) was added to the rain gage line. This permits measuring the line current. A rheostat placed in the line is

Figure 5.--Photograph showing commercial tipping bucket rain gage with collector removed.

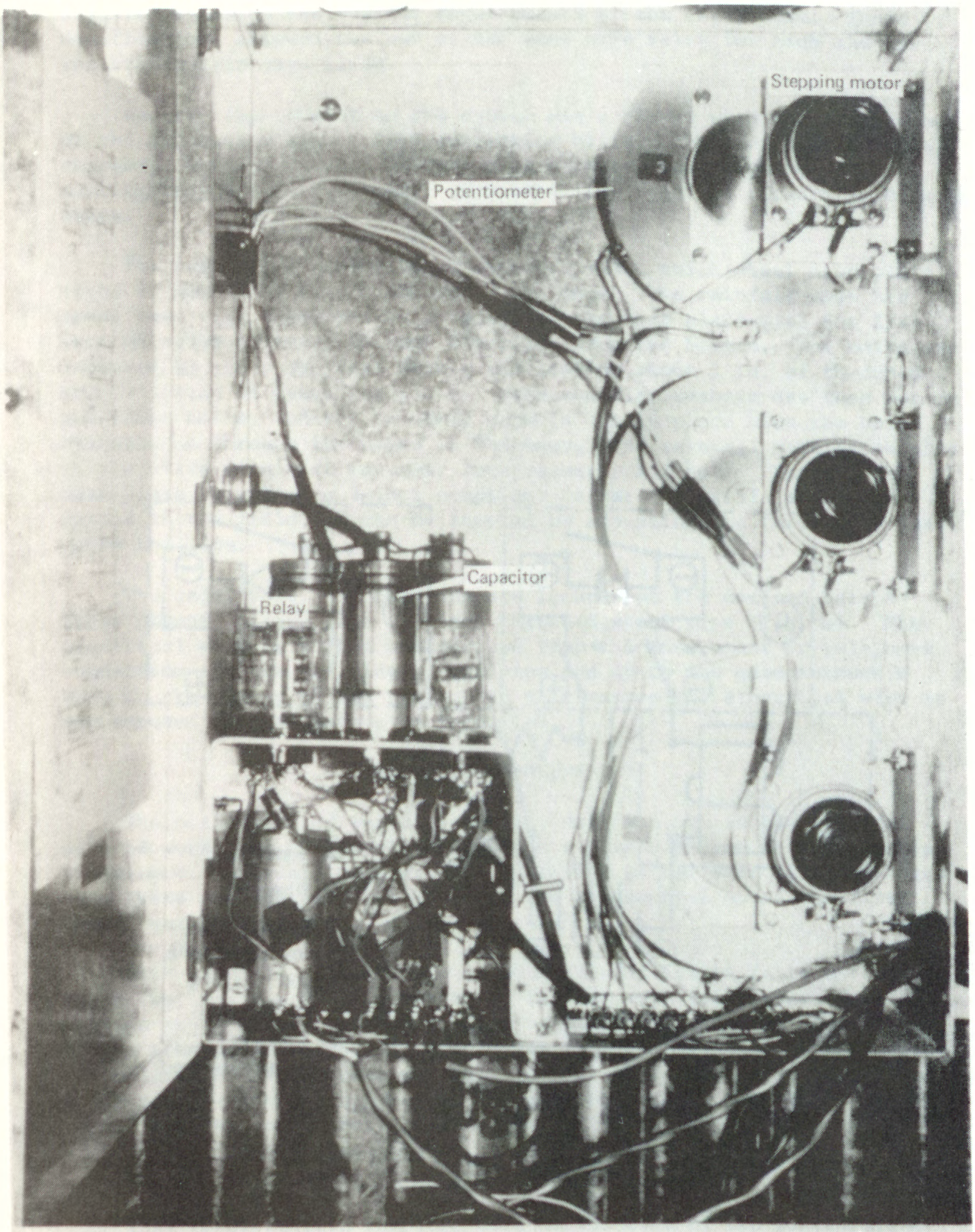

Figure 6.--Photograph showing potentiometer, stepping motor, relay, and capacitor.

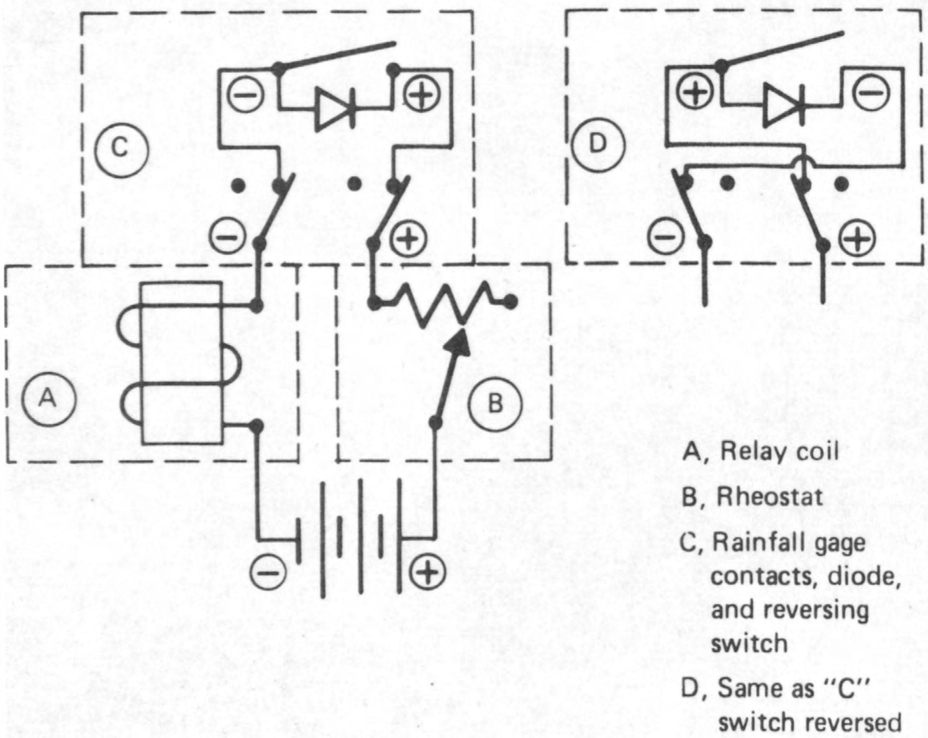

Figure 7.--Modified rainfall gage electrical system.

adjusted to match the current requirements of the relay coil. These modifications allowed the use of the same size relay for high and low resistance rain gage lines.

Another improvement to the system was achieved with the replacement of the capacitors with a 12-V automobile battery equipped with a trickle charger. A fully charged battery will energize the stepping motor continuously for long periods. The capacitor required recharging between steps.

The rain gages were mounted on a 0.25-inch thick steel base plate (fig. 8) about the same diameter as the gage. The rainfall gage has three legs with holes and is attached to the base plate with the 1/4-inch carriage bolts up through the plate from the bottom. The bolts are attached to the base plate with a nut leaving about 1 in. of threaded bolt sticking up above the plate. Nuts and flat washers are then put on the three bolts, and the rainfall gage is set in place with the bolts sticking up through the holes in the legs. The rainfall gage is secured to the plate with flat washers, lock washers, and nuts. Beneath the base plate is welded a 3-inch coupling. After the rainfall gage is placed in the field, it can be leveled by adjusting the three nuts just below the legs.

The gage, base, and coupling are located at the desired height above ground surface with a 3-inch threaded steel pipe (fig. 9). The electrical wire is placed underground from the instrument or telephone connection through the side of the pipe and up to the gage through a hole in the center of the plate. In this manner the electrical wire is not exposed to the weather or vandalism.

RAINFALL SAMPLERS

The collection of rainfall-quality data was not in the original plan of work, but was started, and then evolved, as the data collection progressed. Rainfall samples were collected at all four sites although only three samples were collected at the residential site, the first basin instrumented.

Bulk rainfall is a mixture of both rainfall which falls during a storm (wet fall) and dry atmospheric fallout (dry fall) which falls between storm events. It is sampled by placing a catching vessel open to the atmosphere which allows both wet fall and dry fall to accumulate. The collection of separate wet fall and dry fall samples requires separate instruments which are exposed to the atmosphere only during the rainfall period and the nonrainfall period, respectively.

Bulk Precipitation Sampler

Bulk precipitation samplers were constructed of two polyethylene funnels with top diameters of 11 in. (fig.10). With this size of

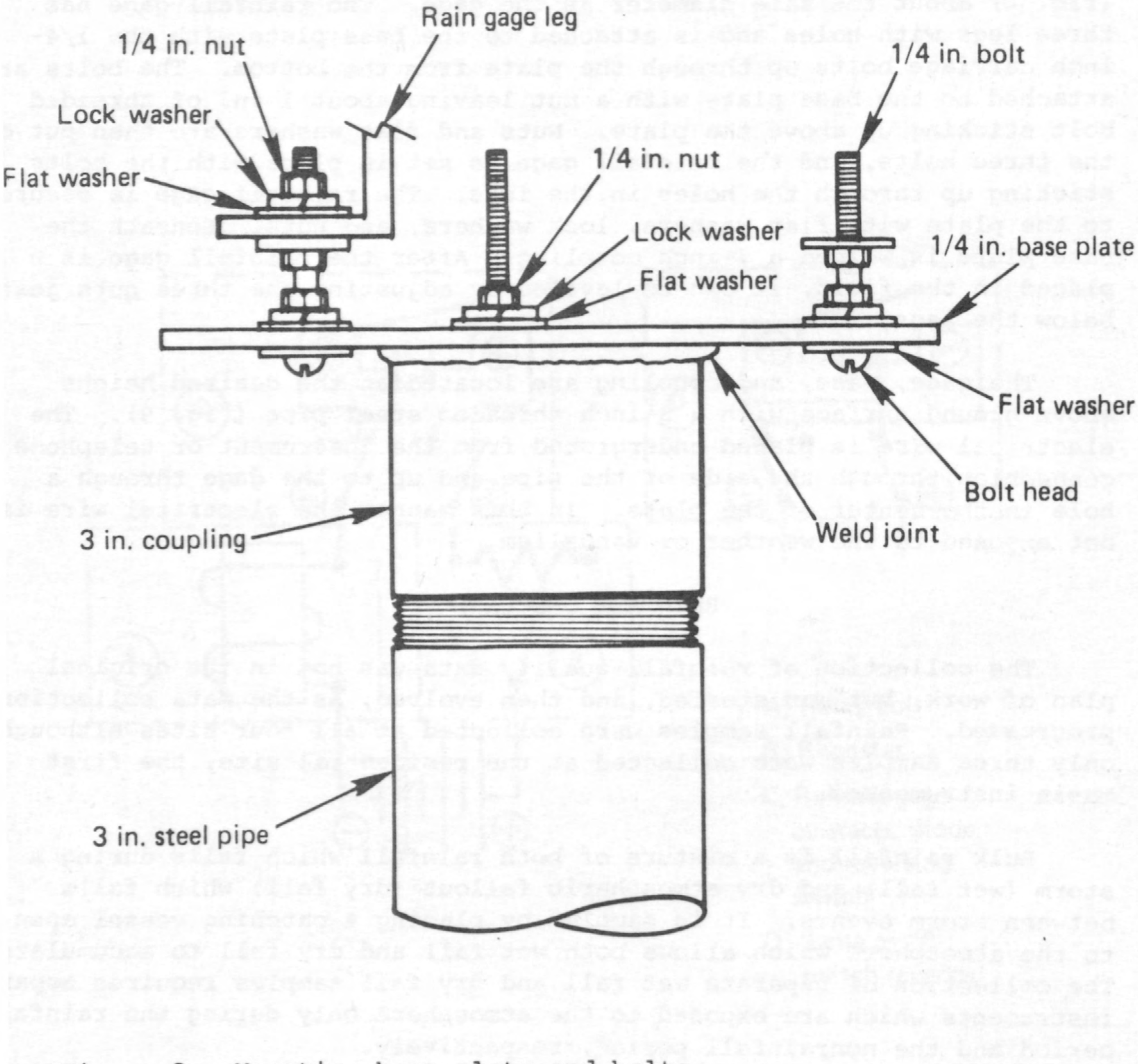

Figure 8.--Mounting base plate and bolts.

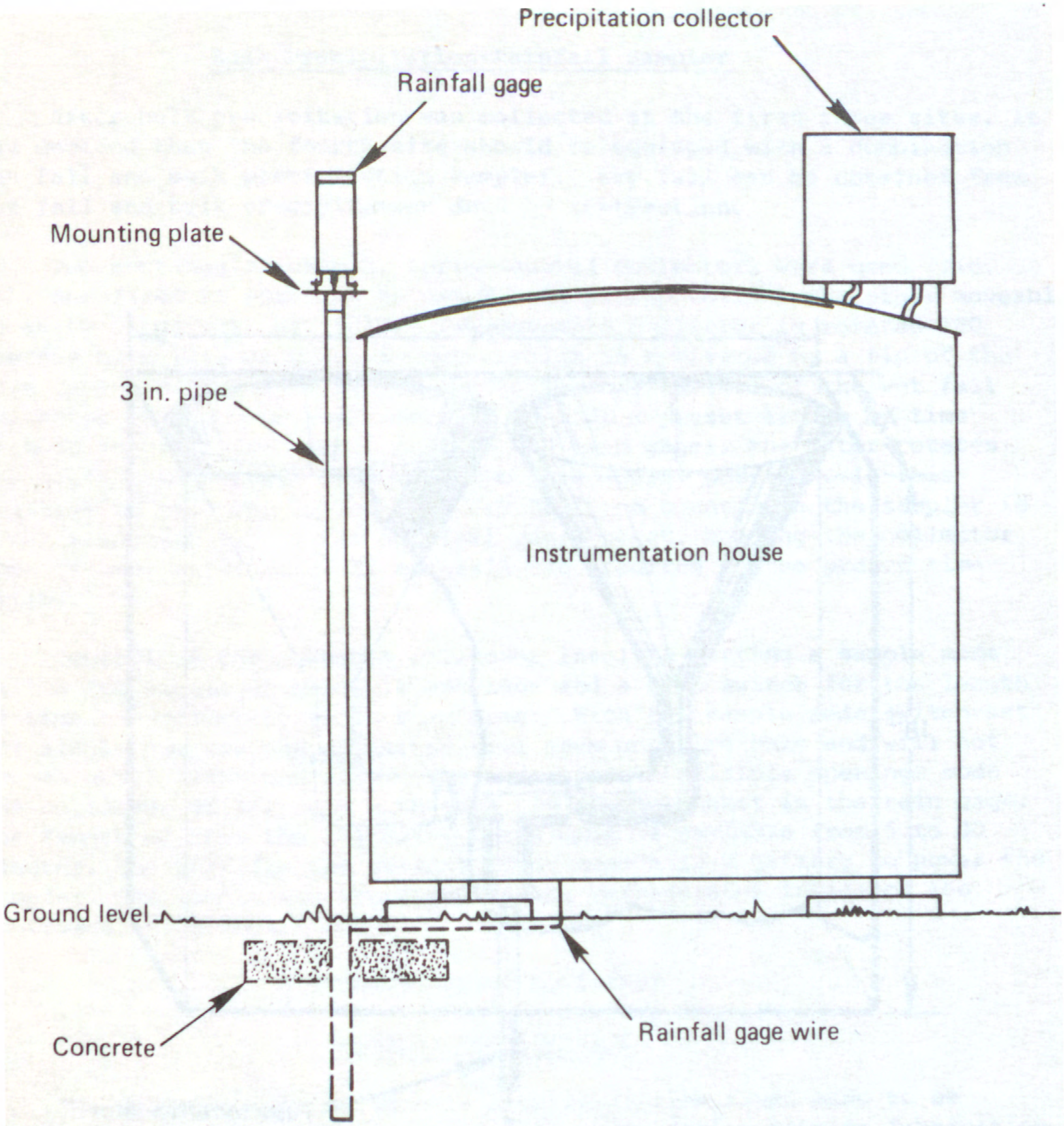

Figure 9.--Rainfall gage mounted on site.

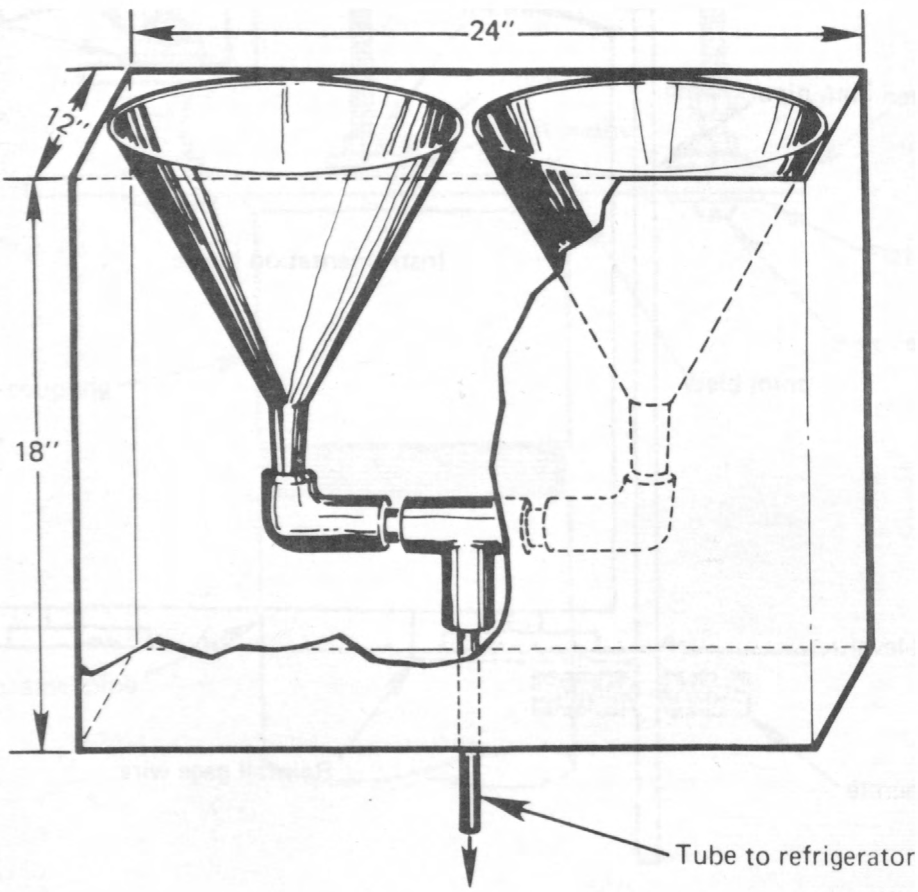

Figure 10.--Bulk precipitation sampler.

openings, approximately 0.65 in. of rainfall was needed to obtain a 2-liter sample. The funnels were housed in a rectangular-shaped sheet metal box. In addition to functioning as a mount and support for the funnels, the housing also hides the assembly from view, thereby reducing the chances of vandalism. The two funnels are connected with vinyl tubing to sample bottles located in the refrigerator within the instrumentation shed.

Bulk Precipitation-Rainfall Sampler

After bulk precipitation was collected at the first three sites, it was decided that the fourth site should be equipped with a combination wet fall and bulk precipitation sampler. Dry fall can be obtained from wet fall and bulk precipitation data by subtraction.

Two rectangular-shaped, teflon-coated collectors were used (fig. 11), one fixed in position to catch bulk precipitation, the other moveable so as to catch only wet fall. The moveable collector is rotated 180 degrees by a 12-V dc electric motor which is activated by a tip of the rain gage bucket. This places the collecting surface of the wet fall collector in the open (up) position. After a preset length of time without rainfall (no bucket tips on the rain gage), the motor rotates the collecting surface back to the closed (down) position. In this position it will not collect any dry fall. A counter on the sampler is reset with each tip of the rainfall gage bucket, keeping the collector open as long as 0.01 in. of rainfall has occurred in the preset time period.

Control of the moveable collector involves setting a sample mode switch for single or multiple openings and a time switch for the length of time the collector is to stay open. With the sample mode switch set for single sample, the collector will open one time only and will not reopen until reset manually. When switched to multiple openings mode the collector will reopen with each tip of the bucket in the rain gage. The length of time the collector stays open is variable from 5 to 30 minutes. The unit for the present study used a 12-V battery to power the sampler. The sample was preserved by the refrigerator inside of the instrumentation shed.

DISCHARGE GAGING EQUIPMENT

U-shaped Constriction

The U-shaped constriction is a critical flow flume made to be inserted into a circular pipe (fig. 12). The design permits fabrication in two half-sections for easy transportation and installation. Two piezometer taps are used for observing water pressure; one located 1/2-pipe diameter upstream of the flume entrance and one located 1-3/8 pipe diameters downstream of the flume entrance.

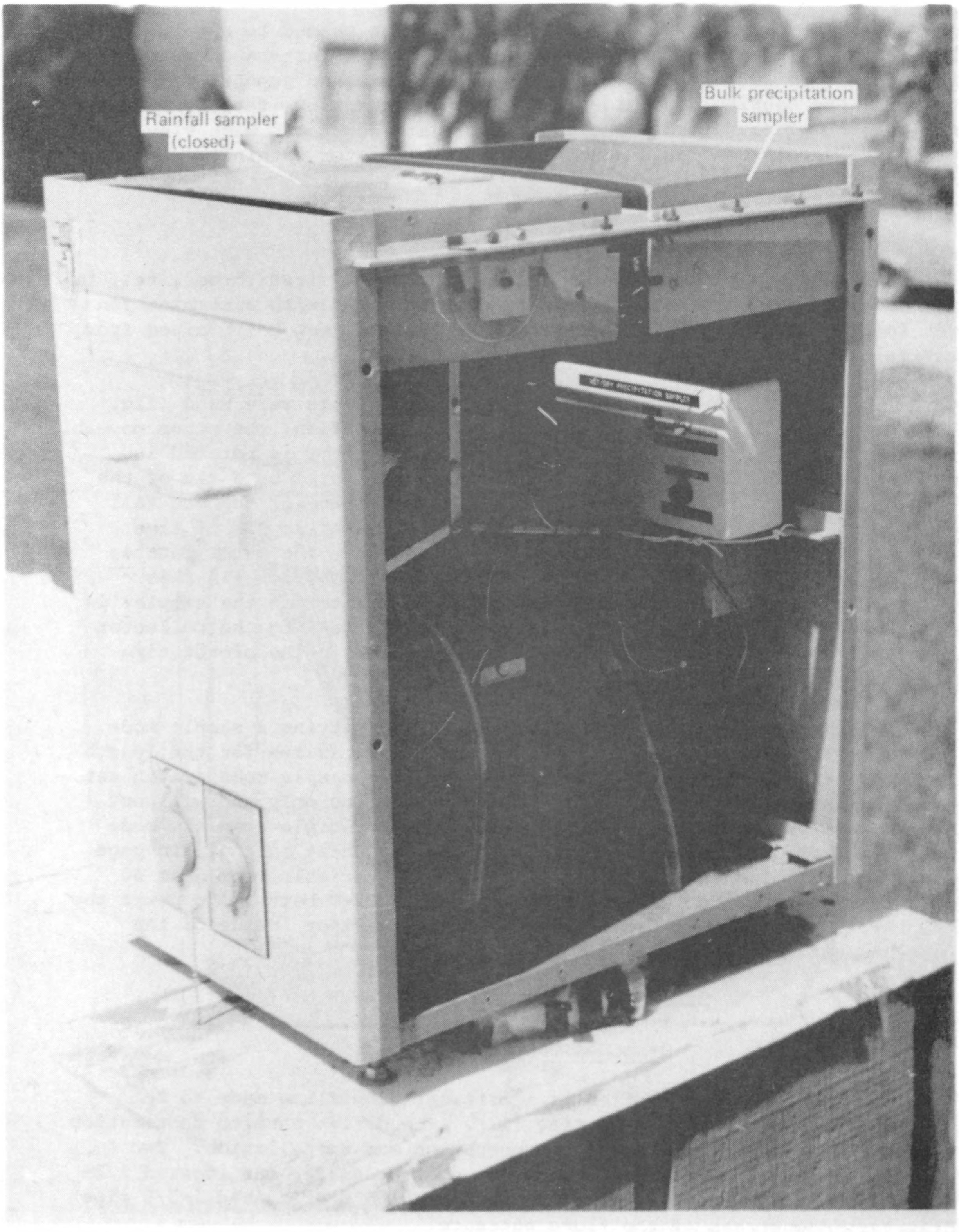

Figure 11.--Photograph showing bulk precipitation and rainfall (closed) sampler.

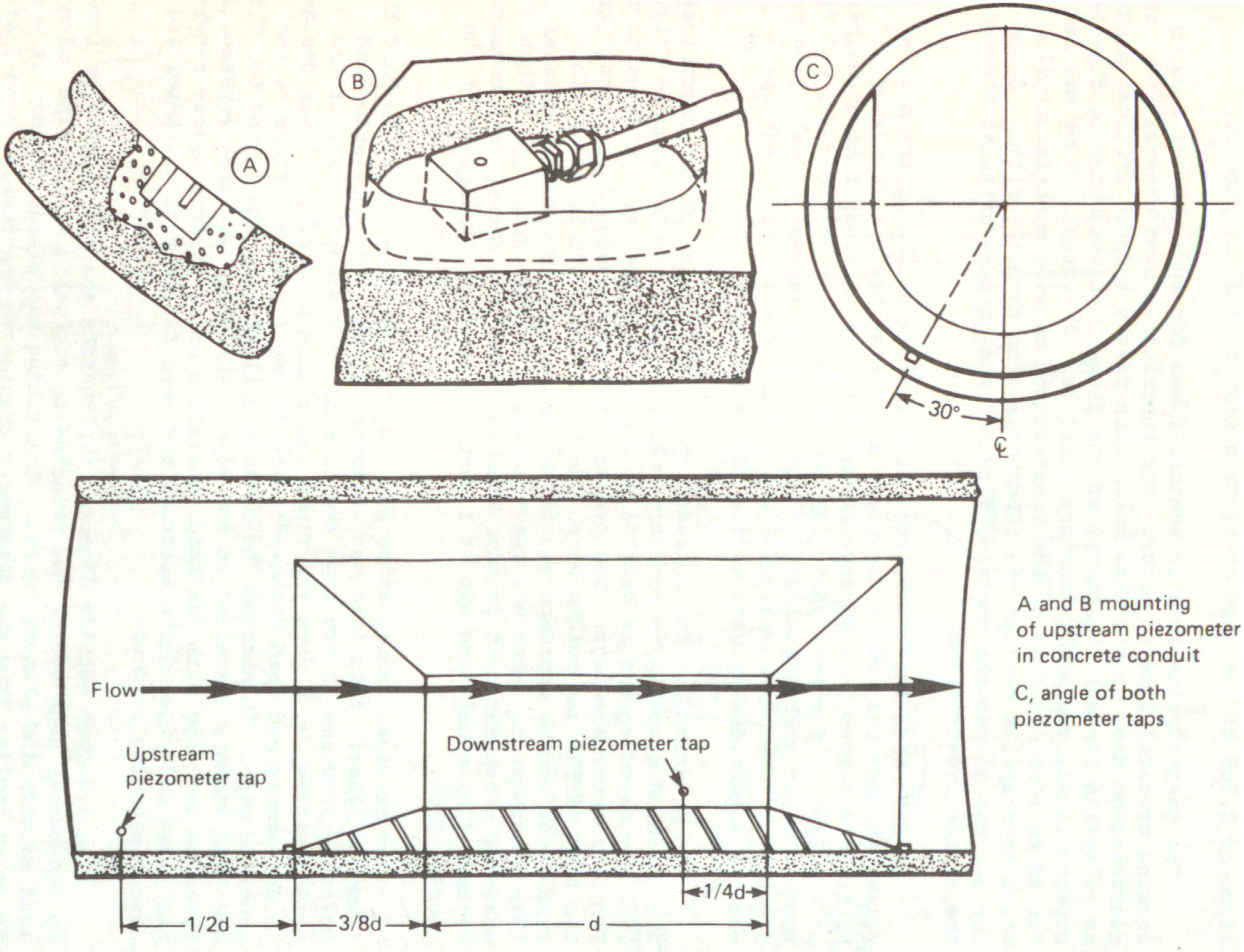

Figure 12.--U-shaped constriction.

The flume has a theoretical accuracy of ±5 percent under both open-channel and full pipe (surcharged) conditions. The flume is considered to be self cleansing and any silting upstream from the constriction is expected to flush out on the next rise. The cross-sectional area of the flume is 0.709 of the pipe area, or a reduction of 29 percent.

The constriction acts as venturi flume for open-channel flow by causing critical flow to occur. For subcritical open-channel flow, the constriction dams up the flow which then passes through critical depth as it spills through the throat of the flume. If the oncoming flow is supercritical, two conditions are possible. A hydraulic jump may be forced to form upstream of the constriction causing subcritical flow which then spills through the throat, passing through critical depth; for steeper slopes the oncoming flow may remain supercritical throughout the entire constriction.

As discharge increases, the water surface on the upstream side rises, touches the top of the pipe, and fills the full flow area. Further increases in discharge triggers full pipe conditions downstream of the flume. For full pipe flow the flume may be considered a modified venturi meter where headloss through the flume is used to calculate the discharge. Discharge ratings are available for each of these open-channel conditions as well as for full pipe flow.

The pressures in the approach and in the throat of the constriction are measured remotely by potentiometer type pressure transducers (fig. 13). Dry nitrogen gas is bubbled at a constant rate through tubes to the two piezometer openings. The pressure at each opening is reflected to the head of the gas column where the transducers are located. The transducer on the approach gas column measures only pressure greater than atmospheric. However, the transducer on the throat gas column measures pressures both greater than and less than atmospheric because certain flow conditions create a partial vacuum in the throat of the constriction.

The original installation plan was to use epoxy cement to hold the flume in place. This idea was abandoned because of ventilation and moisture problems in the pipe and because of the possibility of the cement setting up before the flume was alined properly. It was decided to use screws and lead anchors to attach the fiberglass flume to the concrete pipe. Countersunk holes were drilled into the lip of the flume and lead anchors installed in the pipe. The flume was then replaced and fixed to the pipe with flathead, stainless steel screws. Spaces between the flume and pipe on the upstream end were filled with quick-setting cement patching compound.

The 3/8-inch outside diameter tubing from the two piezometer taps to the bubble gage system was attached to the walls of the pipe using lead anchors and plumbers strap. The tubing was placed so that it would be on an incline from the piezometer opening to the bubble gages inside

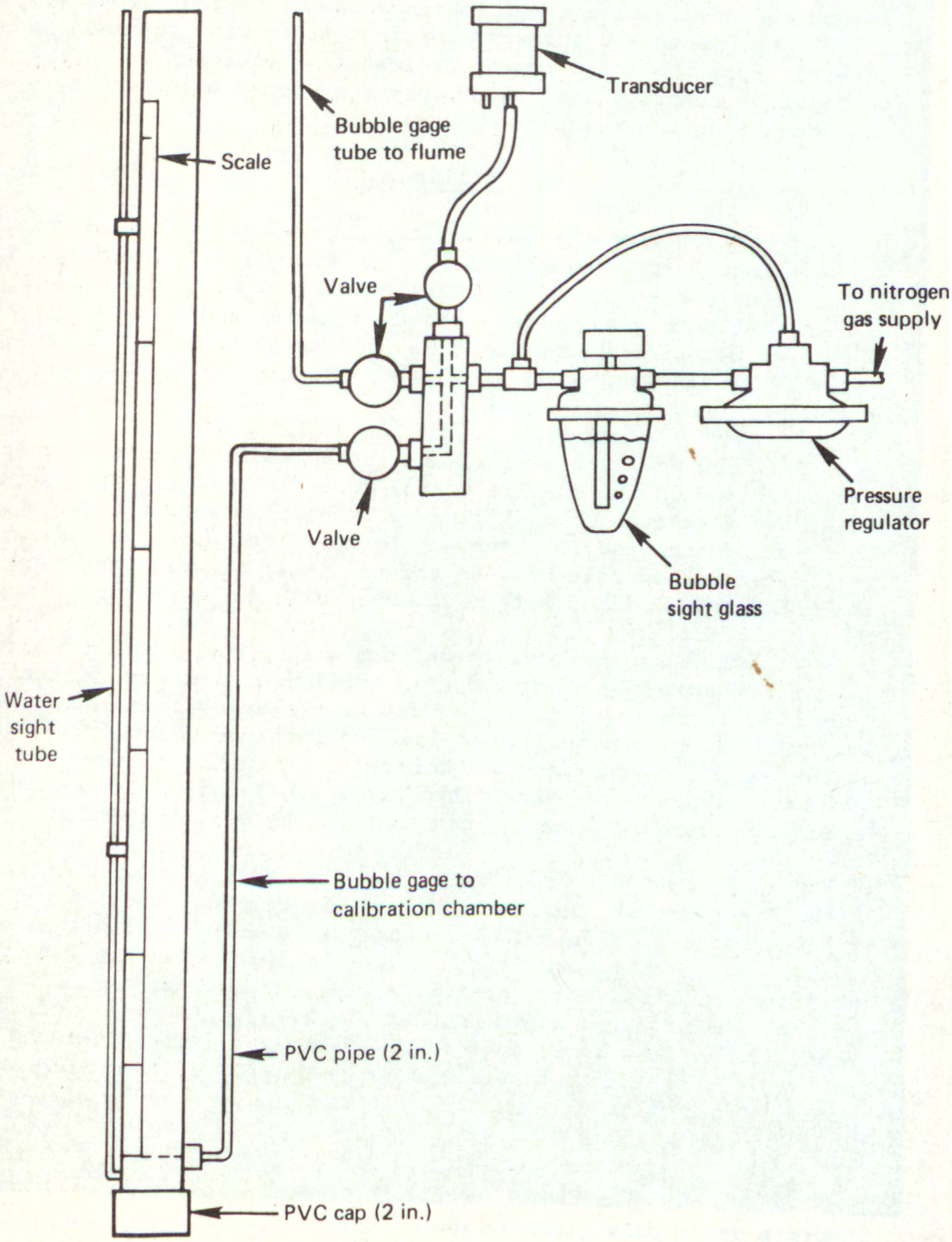

Figure 13.--Calibration column.

the instrumentation shed. This reduced the probability of accumulating debris within the tubing. The tubing was attached to the throat piezometer opening before the flume was set in place and attached to the pipe. A hole for the upstream piezometer was chiseled out of the pipe and the piezometer cemented in place with patching compound.

The head measuring system was calibrated with a column of water located inside the instrumentation shed. Figure 13 shows the calibration column equipped with a sight tube and scale. Using valves (fig. 14) to divert the gas to a piezometer in the test column, the head is read directly from the scale to the nearest one-hundredth of a foot. These calibration readings are scaled on the recorder using the zero and span adjustments on the recorder control unit.

Stilling Well

Storm flow from the multifamily site is discharged through a 4-foot culvert into Snapper Creek Canal. The storm sewer enters the canal below water surface and is submerged at all times. The installation of a flume and bubble gage head measuring system under these conditions was abandoned because of expense, time, and engineering problems. The accuracy of the flume with full pipe, subcritical flow at all times, was also questioned.

Stilling wells (fig. 15) were installed at the discharge point in the canal and in the culvert at the nearest inlet 190 ft upstream. With these two locations, the difference in head between the two wells could be recorded and used in a culvert formula for calculating discharge. The difference in head between the two stilling wells has been termed the "DELTA HEAD" (ΔH), a term commonly used in hydraulics.

The stilling wells were equipped with float, counterweight, and pully, mechanically connected to a continuous rotation potentiometer (fig. 16). One revolution of the potentiometer is equal to 1 foot of head change and one full change on the recorder chart. The potentiometers are connected to the recorder control unit in the same manner as the pressure transducers, except the wires are longer and are run through waterproof conduit from the recorder to the stilling wells.

The ΔH system is calibrated in much the same manner as the flume. Each potentiometer is set at zero on the recorder and rotated one revolution to show full scale, and back to zero. Using this method the head measurement is arbitrary as long as both heads are set equal with no flow. As stormwater enters the drainage system, the upstream stage will become higher than the downstream level, and this difference in head, or ΔH, is used to compute the discharge. The float and potentiometer are more sensitive to sudden and large changes in head than an alternative bubble gage system.

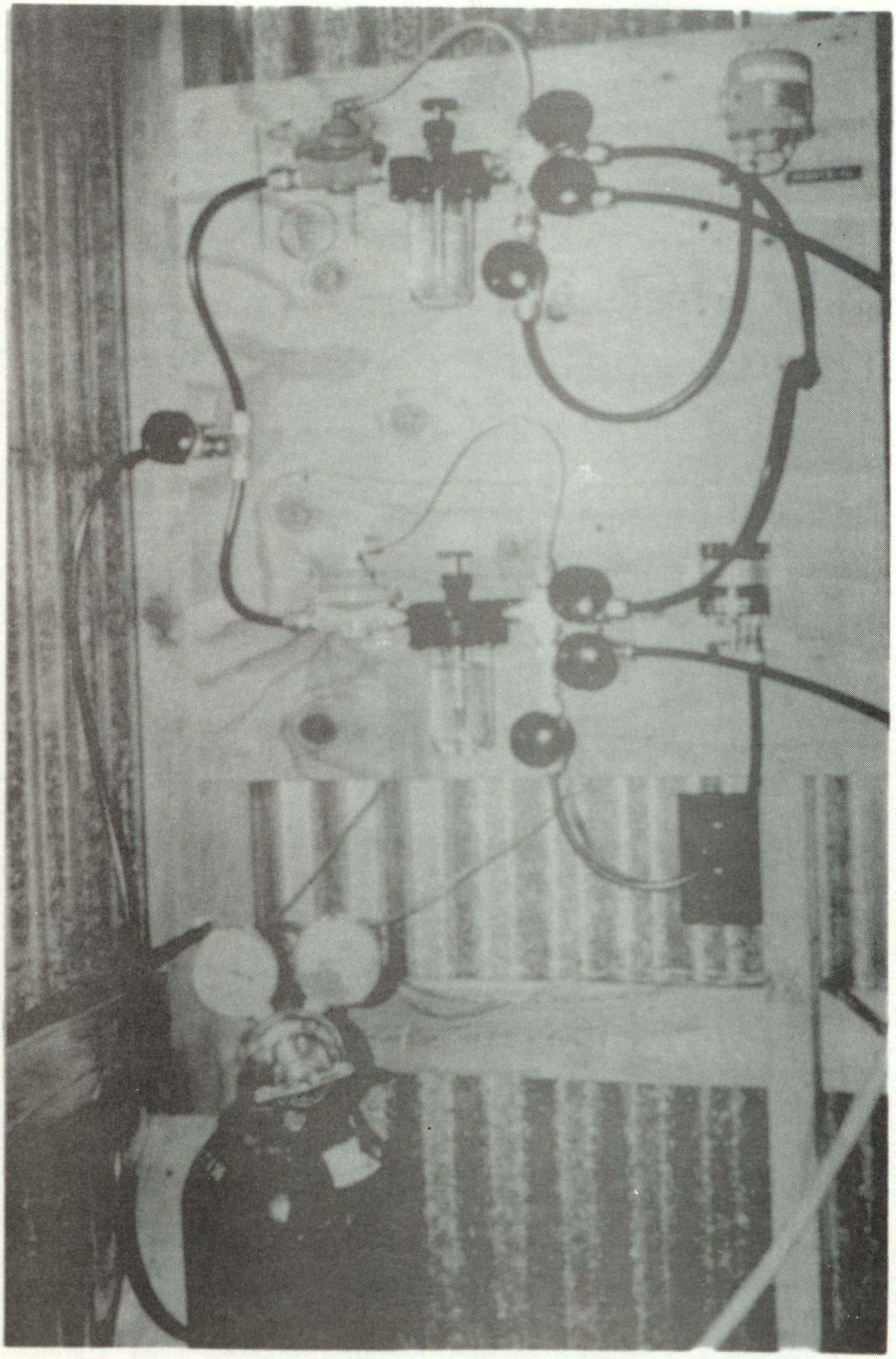

Figure 14.--Photograph showing bubble gage assembly with sight glasses, transducers, and regulators.

Figure 15.--Photograph showing stilling well installed in parking area.

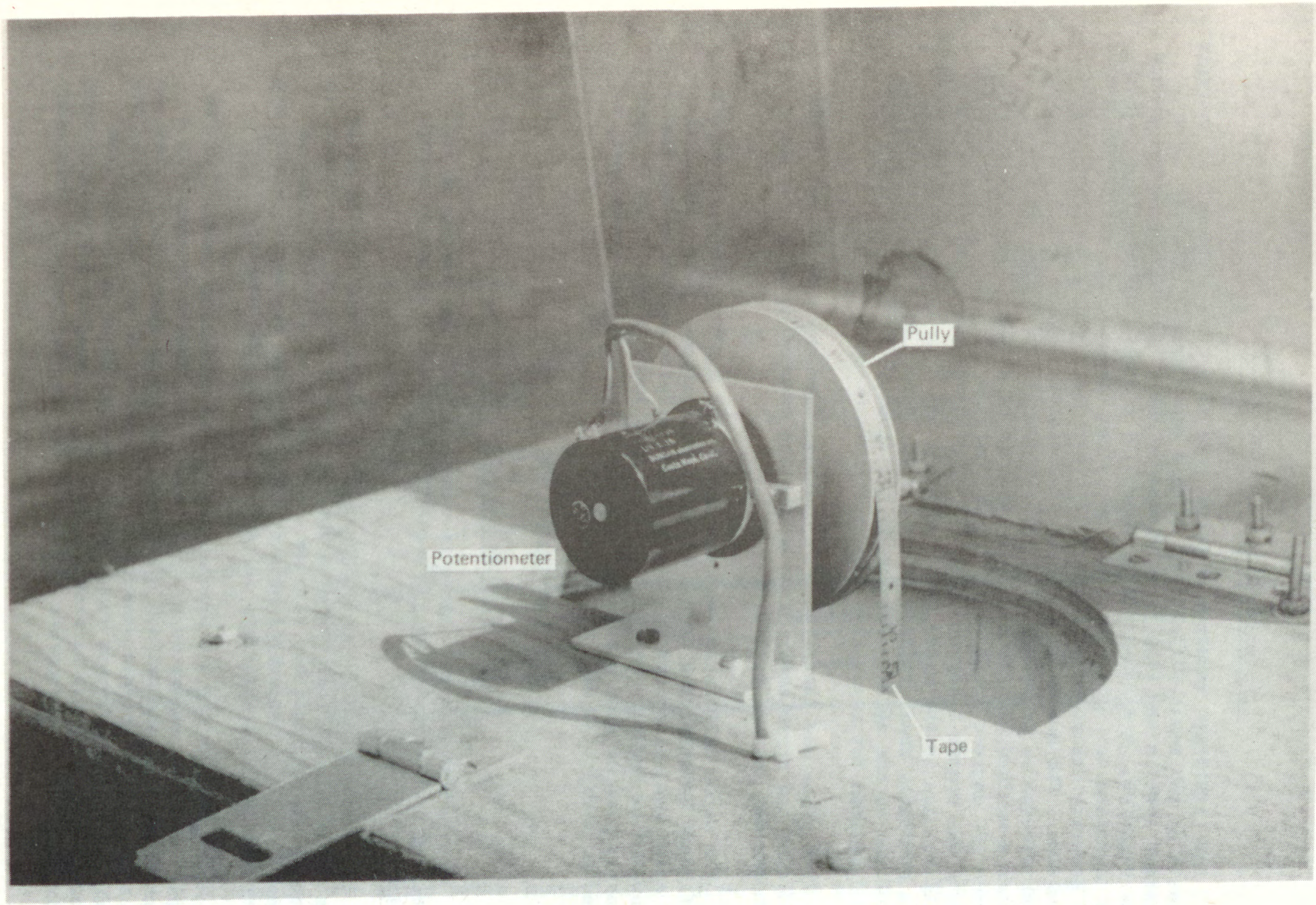

Figure 16.--Photograph showing water level potentiometer with tape and pulley.

Electromagnetic Velocity Meter

Low flow stage readings from the ΔH system were difficult to interpret because of the small differences in head experienced. However, with a constant area in the full pipe, discharge could very easily be calculated from velocity. A Marsh-McBirney Model 201 portable water current meter was installed to: (1) verify the ΔH system computation, (2) increase the accuracy during low flow, and (3) test the meter in an urban gaging condition. The Model 201 consists of a sensor probe attached by a cable to an electronic processor with meter readout. The probe, enclosed inside a moulded plastic housing, consists of a pair of electrodes spaced 180 degrees apart on the sensor surface (fig. 17). Water flowing around the sensor interacts with the electromagnetic field to produce a small voltage in the water near the probe which is sensed by the electrodes. This extremely small voltage is amplified, demodulated, filtered, and displayed on the meter. For use in the stormwater case, the meter had to be adapted for use with a recorder and a dc power supply.

The probe was installed 3 ft upstream from the outfall and in the middle of the storm sewer using a mounting bracket made from 1- by 2-inch channel iron (fig. 17).

The meter calibration was checked at the U.S. Geological Survey's Gulf Coast Hydroscience Center before installation. After installation the meter was calibrated against a standard Price current meter during natural flow events. An additional calibration was made using a large capacity pump to pump water from the canal and into the storm sewer in order to verify low-flow measurements.

SAMPLER SYSTEM

Sampler Control

The sampler system, when activated, controls collection of water level and precipitation measurements as well as collection of water-quality samples.

In a normally dry runoff channel, a predetermined rise in water level caused by a storm event is used to turn on the sampler system. In a runoff channel that has varying water levels or a culvert that is normally full, a predetermined difference between two water levels, one upstream and one downstream, is used to turn on the sampler.

The recorder has one channel designated to record "sample" or "no sample" which is sensed every 36 seconds. The sample frequency is a function of this channel and can be set to sample every 36, 72, 144, or 288 seconds. The sample criteria may be reached at any time during the recording cycle, and this turns on the sample indicator light. The runoff sample pump may be started, stopped, or samples may be collected during the time the recorder is sensing the sample channel. This means

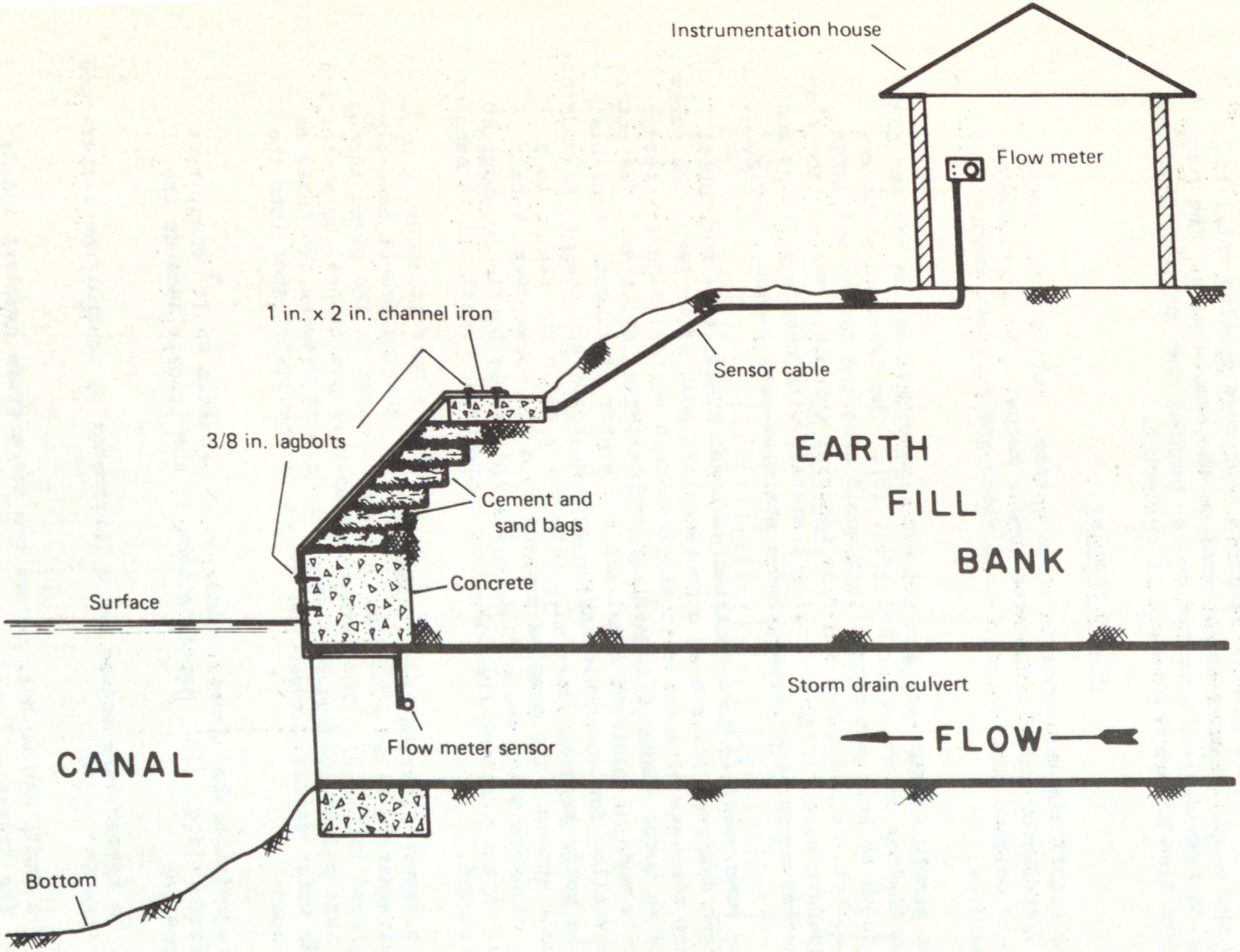

Figure 17.--Velocity meter installed in culvert with detail of flow sensor.

there is always a minimum of 36 seconds and a maximum of 66 seconds delay between the signal to sample and actual sample collection. When the sample light comes on, the recorder continues cycling until it reaches the sample channel which turns on the sample pump. The pump runs for 36 seconds (one recorder cycle) priming the pump and flushing the intake line before the sample is collected.

Runoff Sampler

The runoff sampler consists of an intake, suction line, pump, sample distributor and refrigerated sample keeper. On a programmed electronic command the sampler is activated and collects twenty-four 2-liter samples.

The sample intake is a slotted PVC pipe with a cap on one end and reducing adaptor on the other end (fig. 18). The 1/8-inch slots are small enough to keep out debris that could clog the system and large enough to let the sediments and fine material through. The suction line is heavy-duty hose, 1/2-inch inside diameter, with neoprene lining and is connected to the PVC intake with a stainless steel hose clamp.

The pump, similar to a Continental model EC444, is a horizontal screw type designed for use as a suction-lift pump (fig. 19). The screw type pump consists of a rotor in the form of a helical single-thread worm and an outer stator with similar double-thread cavities. The rotor (screw) is made of polished metal and the stator of rubber. Flexible mountings allow for eccentric action between rotor and stator. At moderate speed the rotor presses water along the cavities in the stator in a continuous stream. The pump is powered by a 1/2 horsepower, V-belt driver, electric motor which fills a 2-liter sample bottle in about 10 seconds. After starting the pump runs continuously until all 24 samples are collected.

The sample distributor is a 48-position rotating faucet assembly which alternately fills a bottle, or returns water to the sewer through a drain hose (fig. 20). The rotating faucet is positioned, by a stepping motor, over a tube leading to a sample bottle or between two tubes so that the water spills through the bottom of the distributor into the drain hose.

The refrigerated sample holder is a converted 25 ft^3 chest type home freezer (fig. 21). Modifications to the freezer include the additions of:

1. a temperature sensor and a thermostat to control the temperature to 5°C, ±2°C,

2. a small fan to help reduce the temperature gradient inside the freezer,

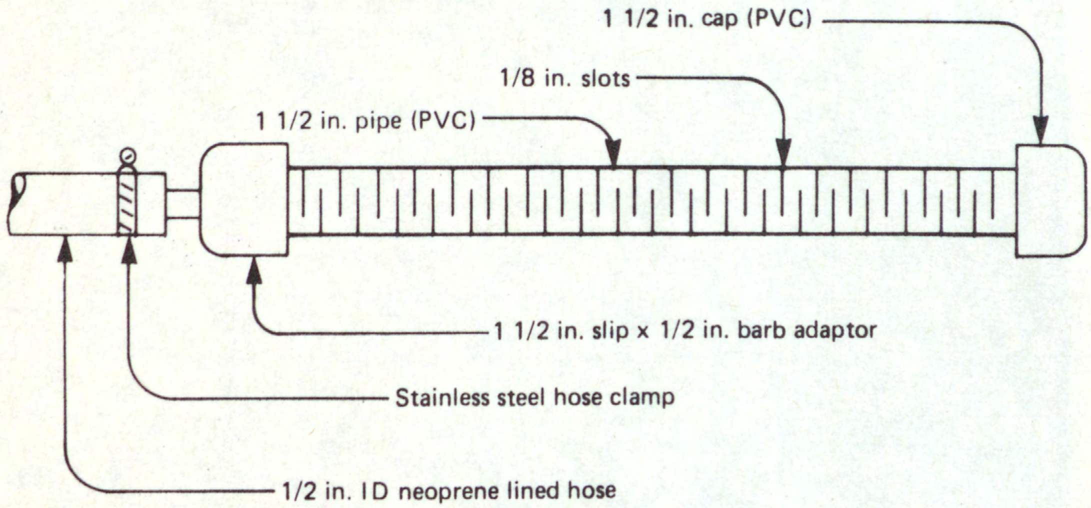

Figure 18.--Runoff sample intake.

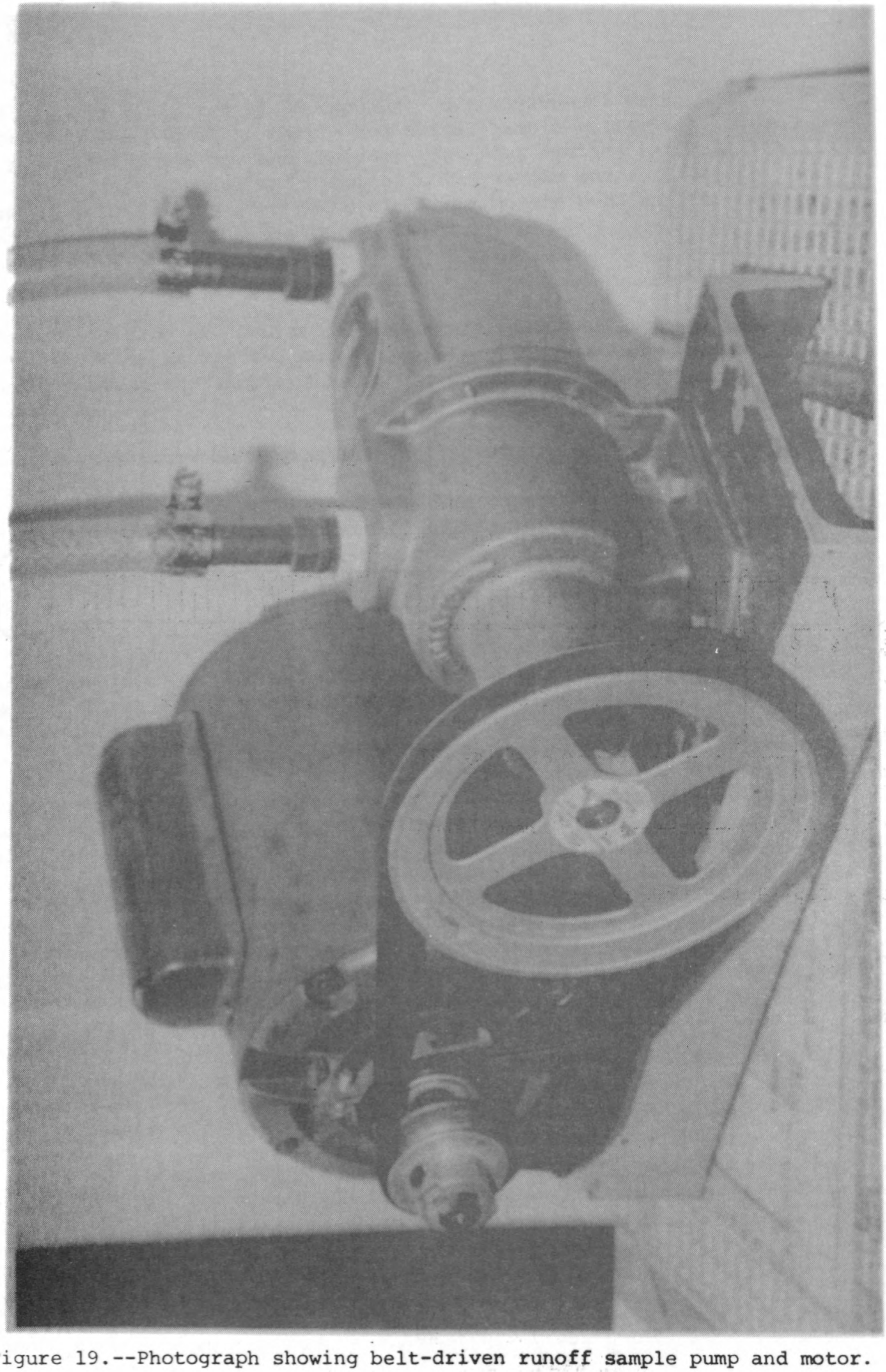

Figure 19.--Photograph showing belt-driven runoff sample pump and motor.

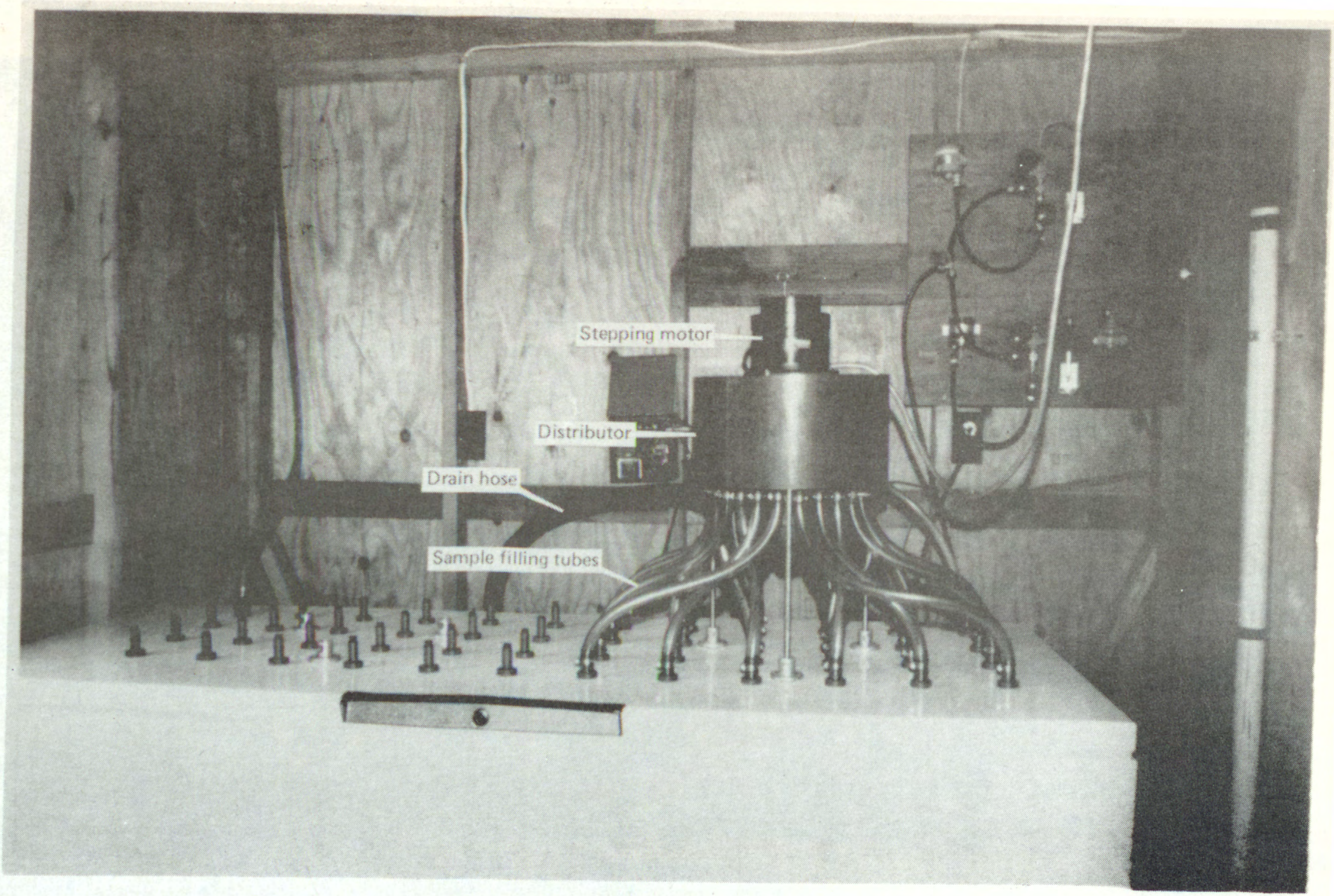

Figure 20.--Photograph showing runoff sample distributor, filling tubes, drain hose, and stepping motor.

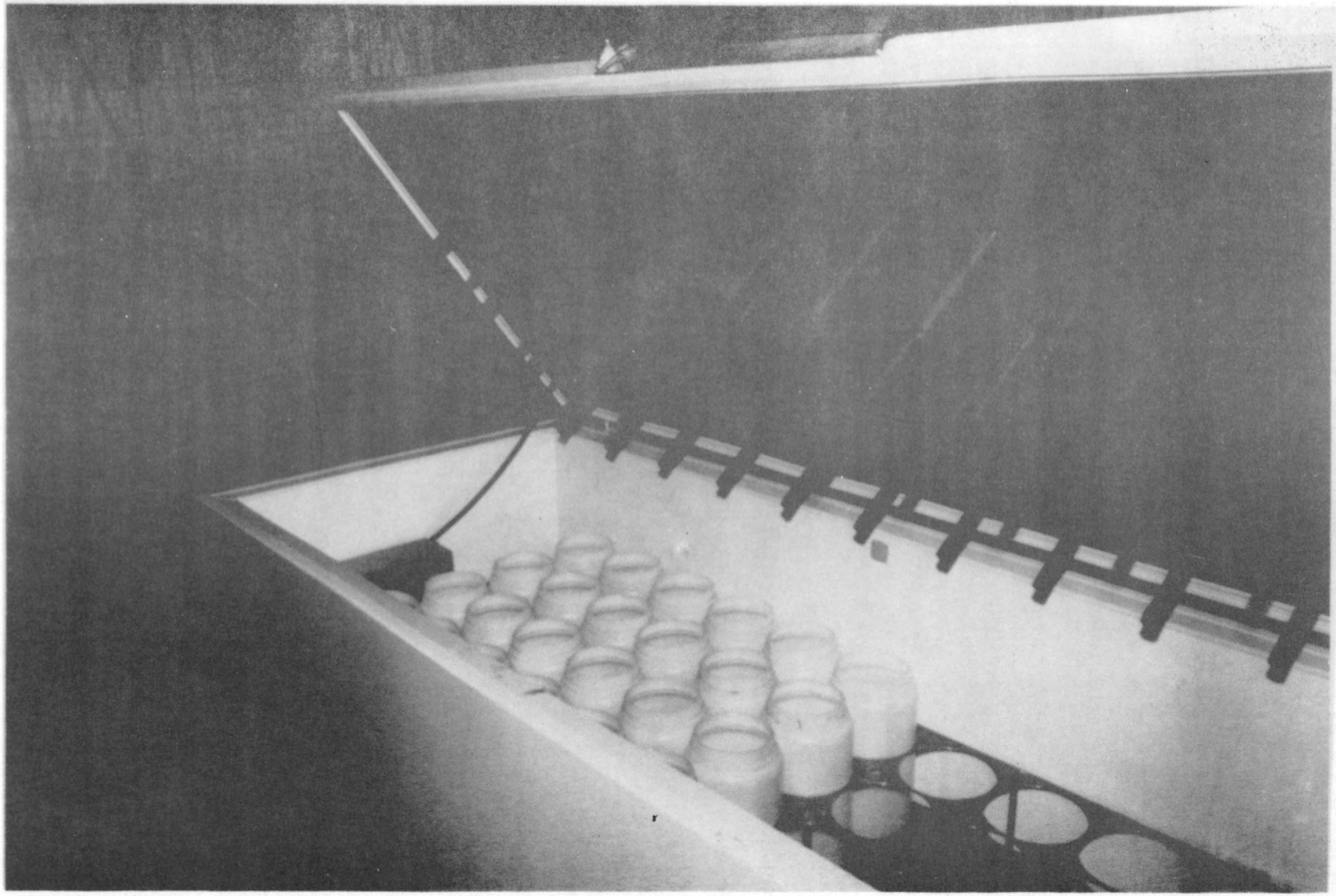

Figure 21.--Photograph showing freezer modified to hold samples.

3. a drain,

4. a support bracket to hold the sample bottles in place,

5. brackets to hold the distributor, and

6. PVC tubes throughout the lid to transport the water sample from the distributor to the bottle.

The sample refrigerator was designed to use standard 64-ounce polyethylene or polypropylene bottles. Most of the samples were collected in polypropylene bottles to minimize adsorption of dissolved species onto the walls of the bottles. To further decrease adsorption, the bottles were rinsed and reused. If small amounts of sediments were not put back into solution by mixing when the sample was poured off, the bottle was cleaned with a nylon bristle brush and rinsed before reuse.

DATA HANDLING

Data are received from the field in the form of six channel analog chart paper. The beginning and ending times for each storm are marked and excess chart paper is discarded. Sample times are computed from the storm record and storm data are entered on a log sheet (fig. 22).

Records with small amounts of rainfall and no measurable flow are filed together under one heading. Records with measurable flow are filed individually and in chronological order. Each storm event is placed in a file folder with the following information written across the top of the folder:

a. site name,
b. date,
c. event numbers,
d. sample number, and
e. comments.

Analog data are converted to digital record with an Autotrol digitizer (fig. 23). The digitized data are put on nine channel magnetic tape from which it can be read into a computer through the terminal in the office. A special urban stormwater data management system was developed by the USGS, (Wilson and others, 1978). The system is a random access file designed as user-oriented file for use with Fortran programs. The file was designed to accomplish the following objectives:

1. To store and edit digitized data at 1-minute time intervals on disk files accessible to Geological Survey computer terminals.

2. To create a system that can generate data reports and supply data to outside users on request.

EVENT NO.	DATE	RAIN START	RAIN STOP	RAIN GAGE NO. 3	RAIN GAGE NO. 4	RAIN GAGE NO. 5	FLOW COMPUTED	RUNOFF QUALITY EVENT NO.	PRECIPITATION BULK	PRECIPITATION WET	NOTES AND COMMENTS

Figure 22.--Urban hydrology data log sheet.

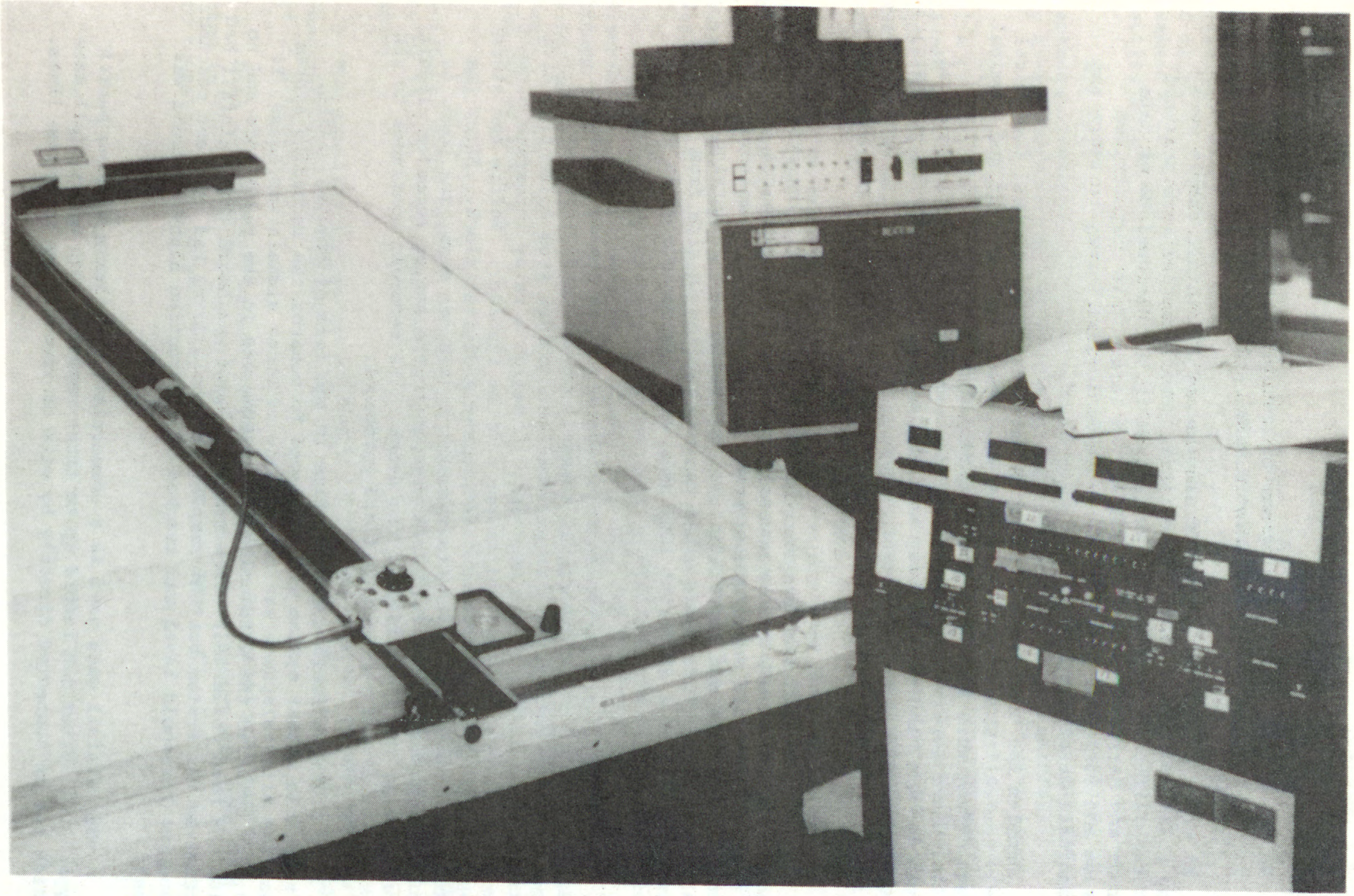

Figure 23.--Digitizer.

3. To create interface programs to retrieve data from the file for statistical and deterministic model applications.

At times as many as 24 runoff samples and 1 rainfall sample were being collected from each of three sites. These samples were analyzed at three different laboratories and stored in the National Water Data Storage and Retrieval System (WATSTORE), a large scale computerized storage and retrieval system used by the Geological Survey to store and disseminate water data.

Samples for trace metals analyses were mailed to the U.S. Geological Survey Central Laboratory in Atlanta, Ga. Those for nutrient and chemical oxygen demand were packed in ice and shipped by bus to the District Quality Water Service Unit in Ocala, Fla. Bacteria counts, biochemical oxygen demands, and conductivity analysis were performed in the subdistrict laboratory.

SUMMARY

Because urban basins are small in size and the resulting stormwater runoff is short-lived, it was necessary for the U.S. Geological Survey to develop and build an instrumentation system capable of measuring and recording rainfall and runoff data and collecting and preserving water-quality samples. Four small urban basins, ranging in size from 15 to 60 acres and each of a different land use, were instrumentated in south Florida from 1974 through 1978.

The heart of the instrumentation system is the analog recorder, which is capable of recording six channels of data and serves as the timekeeper for the system. To prevent the recorder from collecting data between storm events it was necessary to design a relay interface between the line source of electrical energy and the recorder. Before the storm event occurs the line power is used to run a digital clock. After the storm has caused the tipping rain bucket to tip one time, the power is shunted from the electrical clock circuit to the analog recorder circuit, thus showing the start time of the event. The recorder continues to run until visited and serviced by field personnel.

To decrease field servicing time in the form of station visits, a telephone answer system was developed to monitor the recording system. When the site telephone was called, one of three signals was heard. If no tone occurred the data collection system was in the ready mode and no data had been collected. If a monotone sound was heard then rainfall had activated the system but the sampler threshold level had not been reached. Once the threshold level was reached an alternating high-low sound was heard.

The rainfall gage used is a commercially available tipping bucket type. The system can record up to three separate sets of rainfall data which can be connected directly by wire or remotely by telephone lines.

Bulk precipitation samples were collected at all four sites. The collectors were constructed of two polyethylene funnels with diameters of 11 in. housed in a rectangular-shaped sheet metal box. The two funnels drain into vinyl tubing which carries the rainfall to sample bottles located inside of a refrigerator.

Wet fall was collected at the fourth site through the use of a rectangular-shaped, teflon-coated rotating pan. The pan was activated by a rain gage so that it opened up only during periods of rainfall.

Discharges for three storm sewers were calculated through the use of a critical flow flume, head-loss method. The critical flow flume caused critical flow to occur when the pipe was partially full so that equations describing critical flow could be used to calculate discharge. When the pipe was flowing full the construction acted as a venturi gage and two recorded pressure heads were used to calculate discharge.

At the fourth site the head at both the upstream and downstream ends of the last section of sewer were recorded. This difference in head was then used in an unsteady flow equation describing discharge in a submerged, full flow area culvert. At the same site an electromagnetic velocity meter was used to record a point velocity. The point velocity was related to mean velocity of the pipe and finally to discharge.

The water-sampler system is composed of an intake pump, a sample distributor, a refrigerator, a sample control, and a data recorder. The intake is a slotted PVC pipe connected to the intake line. The pump is a horizontal screw type consisting of a polished metal rotor inside of a rubber stator. Rotation of the rotor forces water through the stator and out of the pump.

The distributor is a 48-position rotating faucet. Twenty-four positions cause bottles located in the refrigerator beneath the distributor to be filled. The remaining 24 positions return waste water back to the sewer.

The sampling system was activated by the water level in the sewer. Once activated the sampler collected a sample every 36 seconds or multiples of 36 seconds.

Data are recorded on analog chart and then digitized onto magnetic tape in the office. A computerized data management system was developed to receive, store, manipulate, and output the data.

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