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# A TIME RELATED AUTOMATIC TOTAL-LOAD SEDIMENT SAMPLER

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## ABSTRACT

A total-load, automatic, sediment sampler was developed and tested for use with small runoff measuring flumes. The system collects individual, total-load, sediment samples which provide periodic sediment concentration data during a runoff event. The system consists of two parts, the sampler and the collector. The sampler is a vertical slot that traverses on a horizontal rail through the flow at the flume's exit. The traverse speed is regulated by flow depth and aliquot size. The collector is a revolving table with a capacity of 18 2-liter ($\approx$ 0.5 gal) bottles. Table rotation is regulated by a timer and a new bottle is filled with each traverse. The time of each traverse is recorded on the stage record. The system is powered by a 12-volt, DC battery charged by a solar generator, which allows using the system in remote areas where conventional electrical power is not available.

## INTRODUCTION

Increased awareness of environmental protection has intensified the need for sedimentation-erosion data. Such data is needed to calibrate mathematical models of portions of the hydrologic and erosion cycle.

Historical procedures and instruments for measuring stream sediment load vary widely with some of them still in use. These methods vary with the stream size sampled. For rivers, depth-integrated or point samples have been obtained by individuals wading or with samplers suspended from cableways or bridges. The data can be greatly improved, in quality and quantity, if collected automatically at remote sites. In recent years, battery-operated pumping samplers have been extensively used to obtain point samples of suspended sediment. Pumping samplers are of limited value in many areas because they sample temporal, but not spatial, variability.

In sediment sampling of plots and small streams, collection basins have been used to sample the coarse sediment; finer sediments are sampled by fixed slots, Coshocton wheels, etc. Pumping samplers have also been used (Miller, 1969) and when equipped on a pivoting arm (Harrold, 1967), they can obtain proportionate samples from various positions in the flow depth.

All these samplers have serious limitations under certain circumstances. The wading and cable-suspended samplers do not sample the total load because they do not travel through the entire flow depth. Considerable effort is required in cleaning the tank of multislot divisors. In addition, obtaining a representative sample from the tank is difficult. Our automatic total-load sampler overcomes many limitations of these other samplers.

## WALNUT GULCH TOTAL-LOAD SAMPLER

Figure 1 shows the logic used to control the operation of the Walnut Gulch sampler. The sampler operation is actuated from the flume's water-level recorder with a microswitch activated by a gear on the recorder (Figure 2). The start of a flow initiates the timing sequence. In the small ephemeral streams of the semiarid Southwest, the hydrographs are generally sharp-peaked and of very short duration. Therefore, we used a 3-min sample interval, although the sampler can accommodate other sampling intervals.

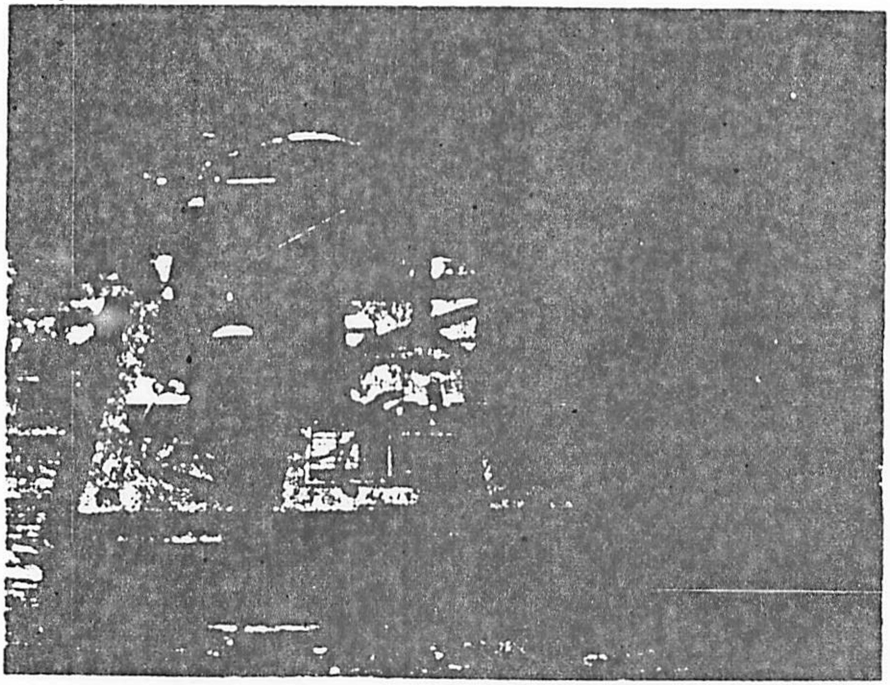
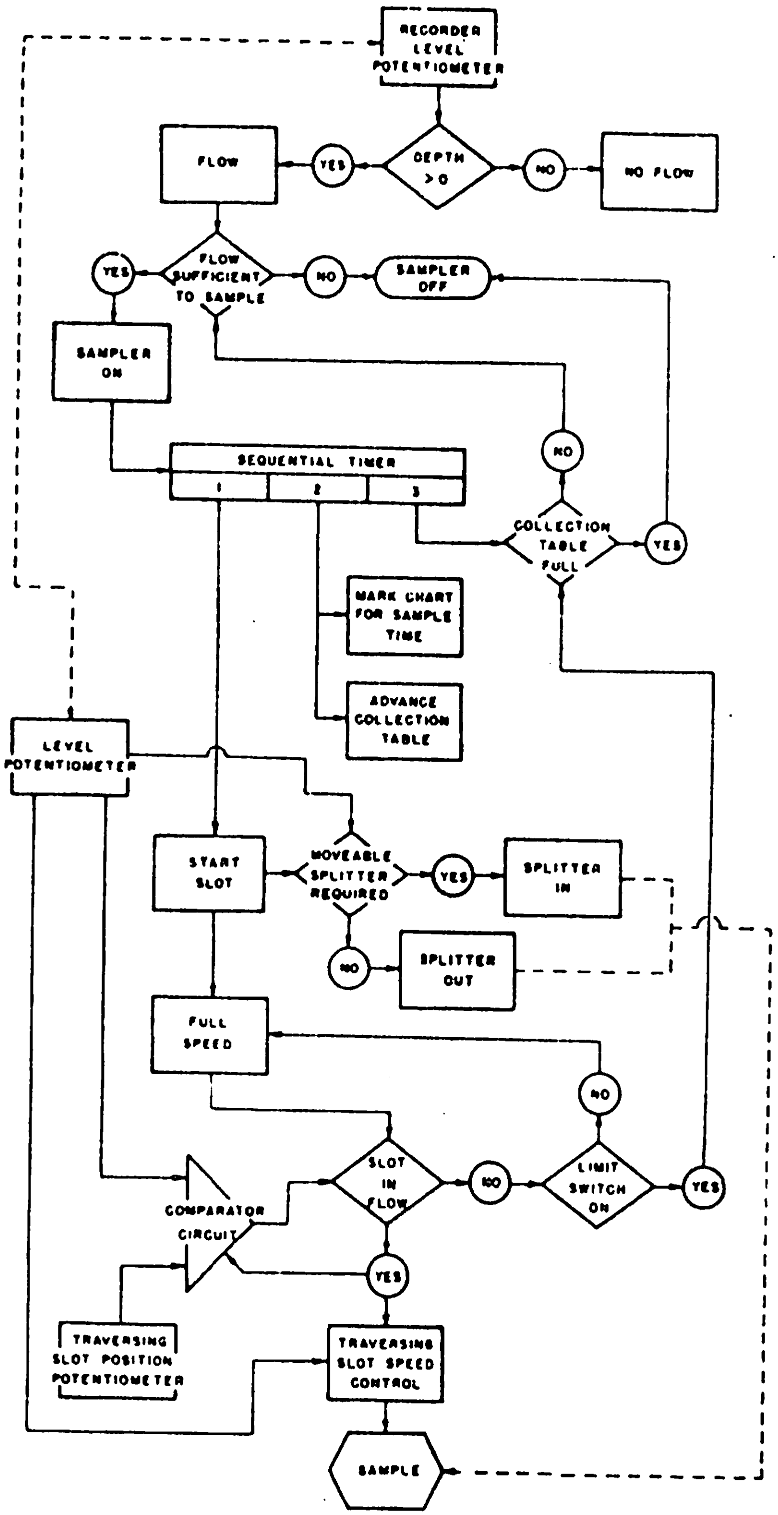


FIGURE 2. Water level recorder showing; 1) chart marking apparatus, 2) level potentiometer, and 3) OFF/ON microswitch.

Flow diagram of [illegible] sequence



The sampler was designed to obtain a water-sediment aliquot (particle sizes $\leq$ 12 mm) of the total flow at preset time intervals. Each sample is maintained separately for correlation with the hydrograph. In addition, the sampler was designed to operate automatically from a solar-charged DC battery.

The basic design (Figures 3 and 4) of the unit incorporates the traversing slot developed by Dendy (1973) and portions of the Chickasha sampler (Miller, 1969). The traversing slot has been mounted on an H-flume, a trapezoidal-throated flume (Replogle, 1971), and a supercritical flume in field applications. The sediment sample collection table of the Chickasha sampler is used for sample storage.

The traversing slot (1.3 cm (0.5 in) wide) (Figure 3), is chain driven and is normally in an out-of-flow position. The electronic circuitry causes the slot to move rapidly from this normal position to the edge of the flow, determined by comparing the water level position and traversing-slot position potentiometers. This rapid travel from the edges of the flow is a time- and power-conserving necessity. The speed of the slot in the flow is preset and determined from a depth-indicating potentiometer mounted on the water-level recorder. For a given depth, with the sample proportion of the discharge involved, the speed is set to collect an approximate 2-liter aliquot of the water-sediment mixture. After the slot has traversed the flow, it proceeds rapidly to the OFF position at either flume edge, out of the flow, and power to the drive motor is cut off by a switch at either end of the drive system. Sampling speeds range from 0.6 cm/sec (.25 in/sec) to 22 cm/sec (8.5 in/sec). The 10 preset speed/depth controls can be varied depending on the capacity of the flow-measuring structure. A complete sampling cycle is set for 3 min which includes: 1) a slot traverse, 2) mark sample time, 3) rotate collection table, and 4) determine if flow is sufficient to start another cycle (logic diagram in Figure 1).

The stationary slots or splitters receive the sample from the traversing slot and split the sample. These slots (1.3 cm (.5 in) wide) are evenly spaced below the flume exit (Figures 5 and 6). The center-to-center spacing between stationary slots is set to equal the exit width of the traversing slot which assures sampling of the total flow.

A fixed splitter installed in the drain tube from the stationary slots splits the sample; half is discharged back to the stream and half continues to the sample collector.

Samples are stored in a sample storage shelter located adjacent to the flume. The sample storage area must be provided so each sample can flow by gravity to its respective receptical. In applications by

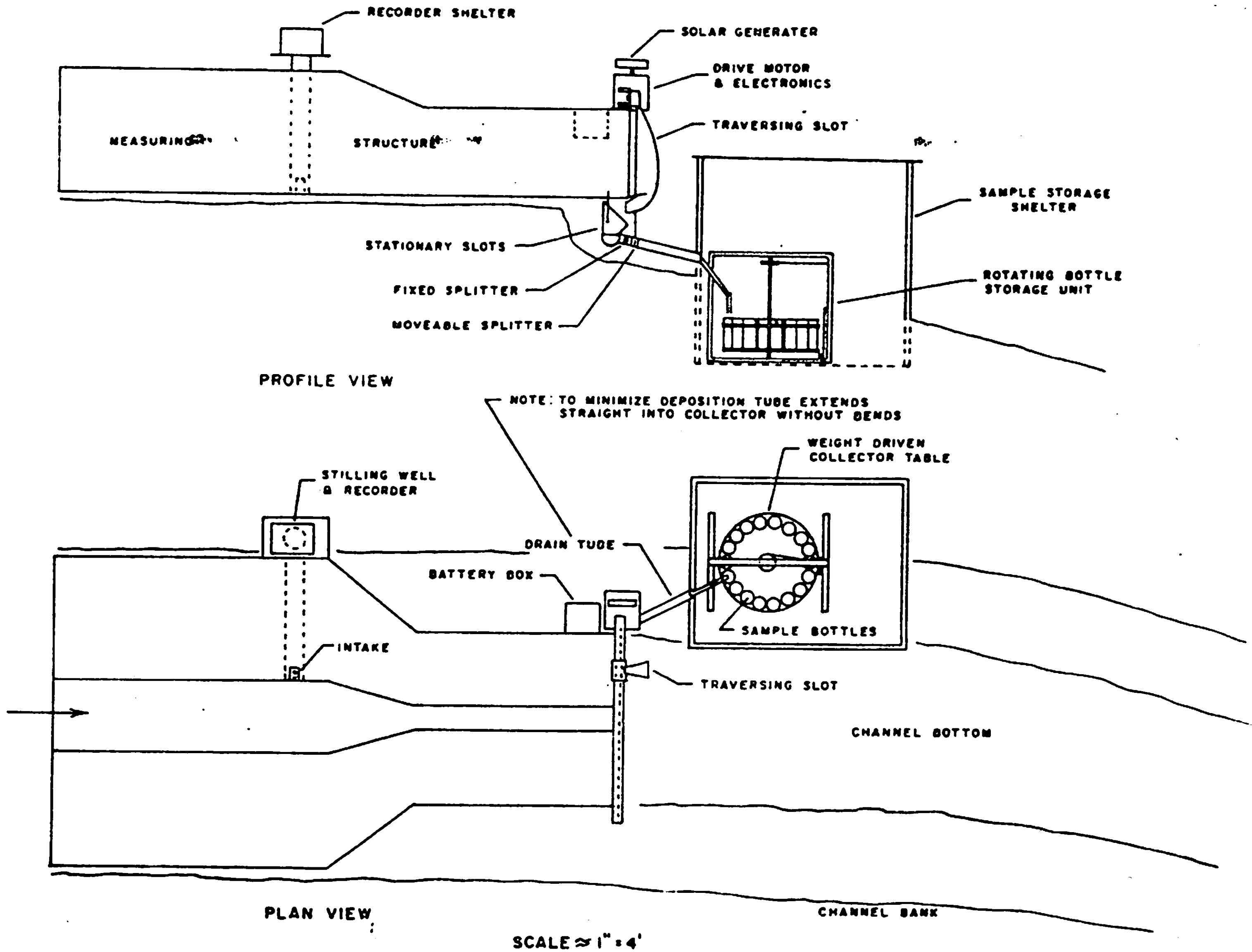



FIGURE 3. Plan and profile views of the sampler system adapted to a 2.2 $m^3$/sec (78 cfs) trapezoidal flume.

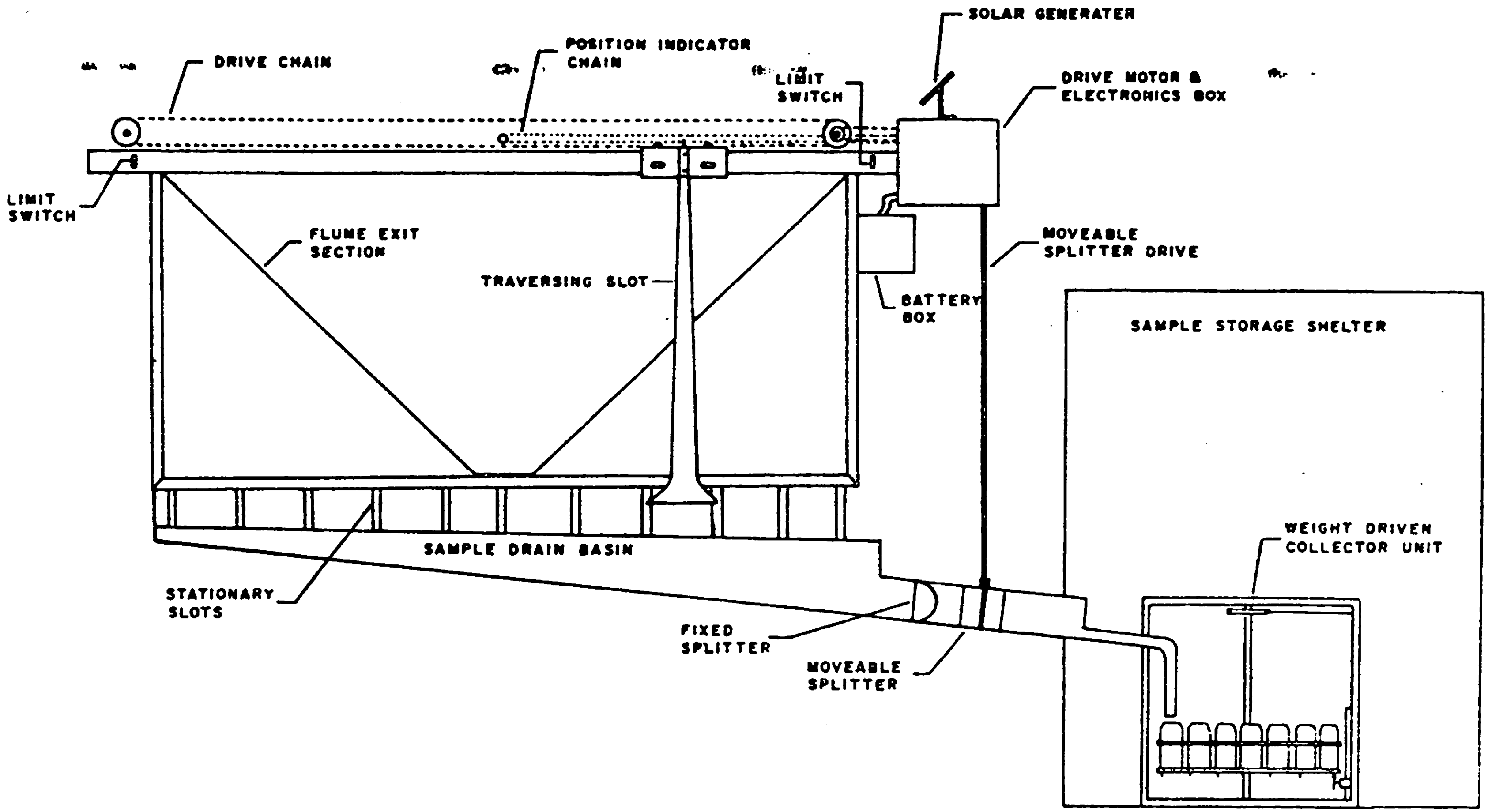



FIGURE 5. SCHEMATIC OF SAMPLER DETAILS LOOKING UPSTREAM INTO FLUME (NOT TO SCALE)

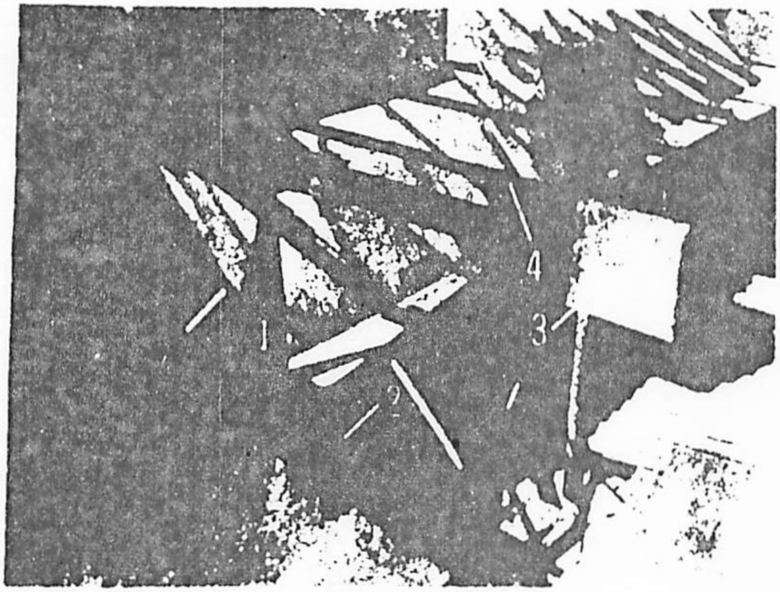
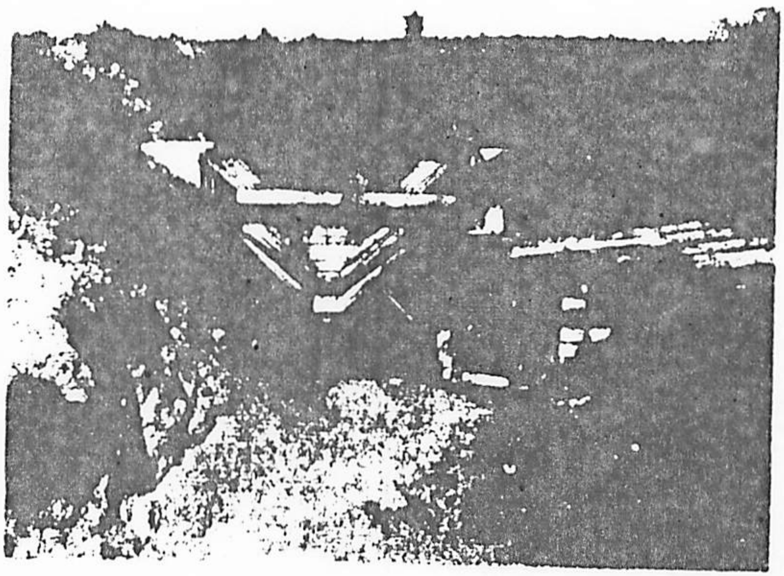



FIGURE 4. A closeup of the sampler system showing: 1) the traversing slot near the flume centerline, 2) the below flume splitters, 3) drive motor and electronic control box, and 4) chain drive mechanism.

FIGURE 6. A view looking upstream showing the traversing slot in its normal position at the flume edge. The concrete block structure houses the sample collector table and spare bottles.



the Southwest Watershed Research Center, a storage area was excavated in the channel bank adjacent to the flow-measuring structure. The hole was protected with either a large culvert pipe, set vertically in the bank, or a cement-block structure. Because the ephemeral streams in the Southwest are normally dry, special care has not been taken to make water-tight storage areas which would be required in areas with perennial or intermittent streams.

The samples are collected on a rotating table which is patterned after the Chickasha sampler (Miller, 1969). The sample collector receptacle was modified to accommodate the larger sample bottles and the timing mechanism was replaced by the overall sampler control timer and logic mechanism (Figure 1).

## Sampler Operation

The sampler operation is designed to obtain a relatively constant sample volume for laboratory analysis despite variations in stream discharge. Thus, because of the fixed slot sizes, the speed of the traversign slot must be varied to obtain this required volume. Experience with laboratory concentration determinations indicates that a 2-liter sample was sufficiently large.

A moveable splitter is needed on larger capacity flumes ot further reduce the amount of sample. If the flow discharge exceeds a predetermined amount, the moveable splitter, mounted in the drain tube, moves to the vertical center of the drain tube allowing half of the sample to continue to the collector table and the remainder to discharge into the stream.

Once the water-sediment aliquot passes these splits, it travels down the drain tube to the collector receptical. These bottles are placed in 18 numbered slots on a weight-driven, solenoid-controlled, round table. After each traverse, the table rotates one position, placing an empty bottle under the end of the drain tube. A time mark is made on the flow recording chart with a solenoid-activated pen after each sample is taken (Figure 2). This system continues at 3-min intervals until either all 18 bottles are filled or flow is insufficient for sampling.

## Sampler Controls

Figure 7 shows the electronic controls involved in the sampling scheme. The main sampler controls consist of the sequential timer, level and position potentiometers, and the motor speed control. Additional details are being prepared and will be available upon request.

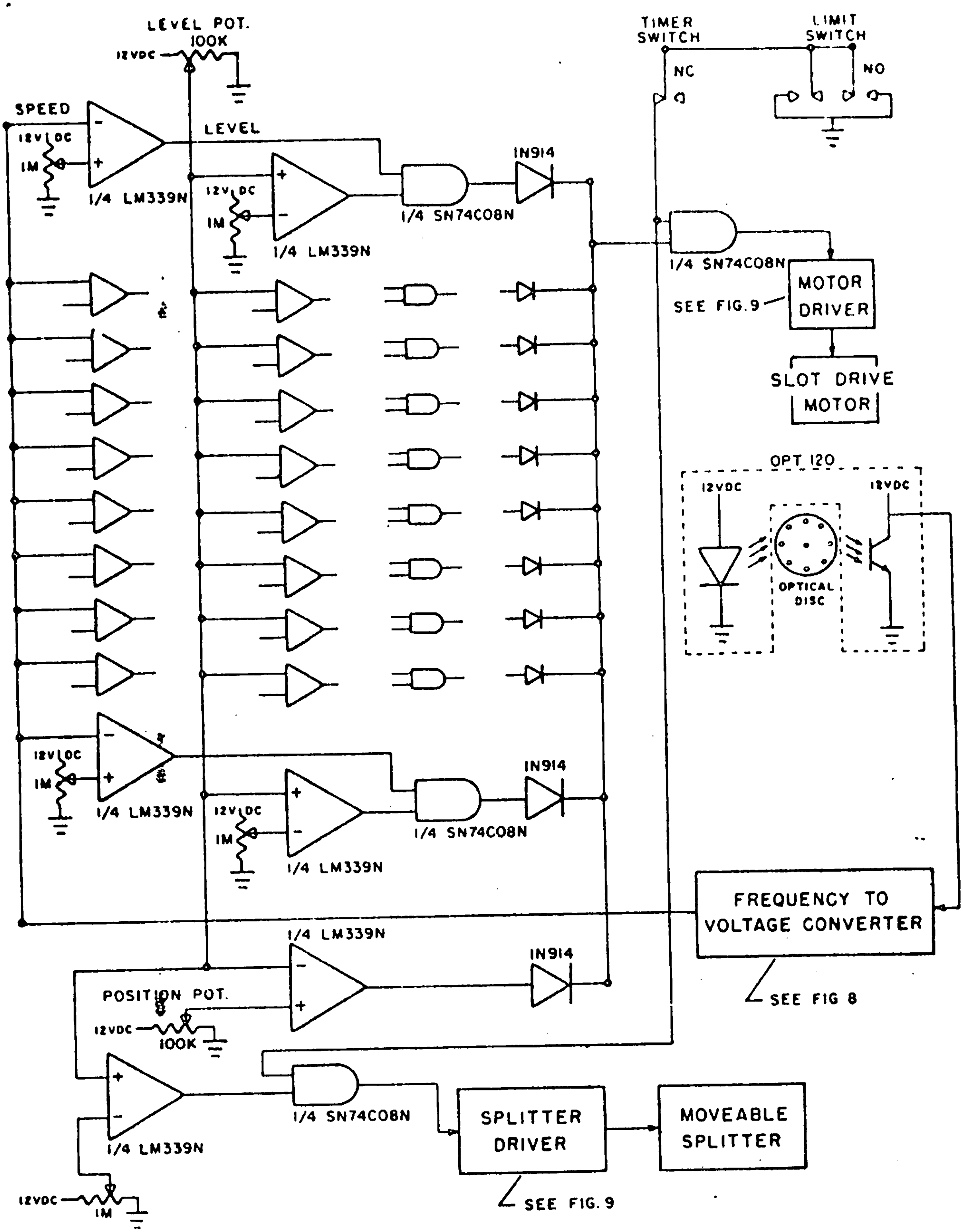



Figure 7. Electronic controls involved in the sample scheme.

The sequential timer is an electrical 12-VDC motor-type with detented, cam-activated switches. The first switch is on in the normally closed (NC) position with an OFF detent. This switch (No. 1 in Figure 1) allows the timer to make a complete 3-minute cycle after the sampler is turned on. The second and third switches are off in the normally open (NO) position with a 3-second ON detent. The second switch, (No. 2 in Figure 1) which controls the starting of the traversing slot, is activated approximately 5 seconds after the sequential timer is turned on. This switch overrides the motor speed-control, moving the traversing slot off the traverse limit switch. The third switch (No. 3 in Figure 1) is activated approximately 45 seconds after the sampler is turned on and controls both the marking of sample time on the water level recorder and the rotating of the collector table.

The level potentiometer is ganged with the water-level recorder so zero on the potentiometer equals zero flow on the water-level recorder (Figure 2). When the potentiometer is full-scale, water level on the recorder is maximum.

The traversing-slot position potentiometer is mounted near the edge of the flume exit. This position potentiometer is connected to the traversing slot so zero on the potentiometer is at the center line of the flume exit and the potentiometer maximum is at either edge of the exit.

The traversing slot potentiometer is turned by a small chain from the traversing slot to a sprocket mounted at the center of the flume exit to another sprocket mounted on the potentiometer. The position potentiometer is set to compensate for the ratio of water level at the recorder to flow width at the flume exit. During sample-taking, the output of the level potentiometer and position potentiometer are compared to determine the position of the traversing slot relative to the edge of the flow. If the position potentiometer output voltage is greater than that of the level potentiometer, the traversing slot is out of the flow and full power is applied to the motor-driven transistor circuit (Figure 8), driving the traversing slot at full speed either to the edge of the flow or to the traverse limit switch. When the outputs from the two potentiometers are equal or when the level is greater than the position output, the motor speed control is activated.

The speed control unit consists of 10 speed/level circuits. Each circuit has an adjustable speed potentiometer and a level potentiometer so various levels of speed and depth can be accommodated. The speed circuits incorporate the output of a frequency-to-voltage (FV) converter, the output of which is a function of motor speed (Figure 9). The FV unit is driven by an optical disk mounted on the rear of the traversing slot drive-motor shaft. If the FV output is less than a preselected amount, as adjusted for each of the speed potentiometers, power is applied to the motor. Conversely, if the FV output is greater than the preselected amount, no power is applied. This minimizes power

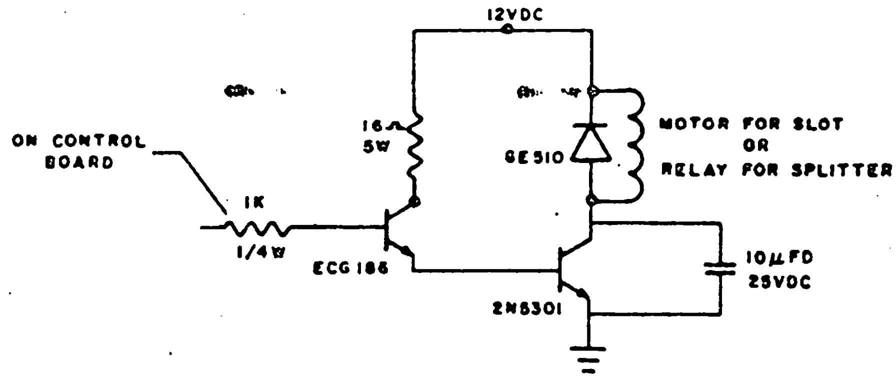



FIGURE 8. MOTOR OR SPLITTER DRIVER TRANSISTOR CIRCUIT

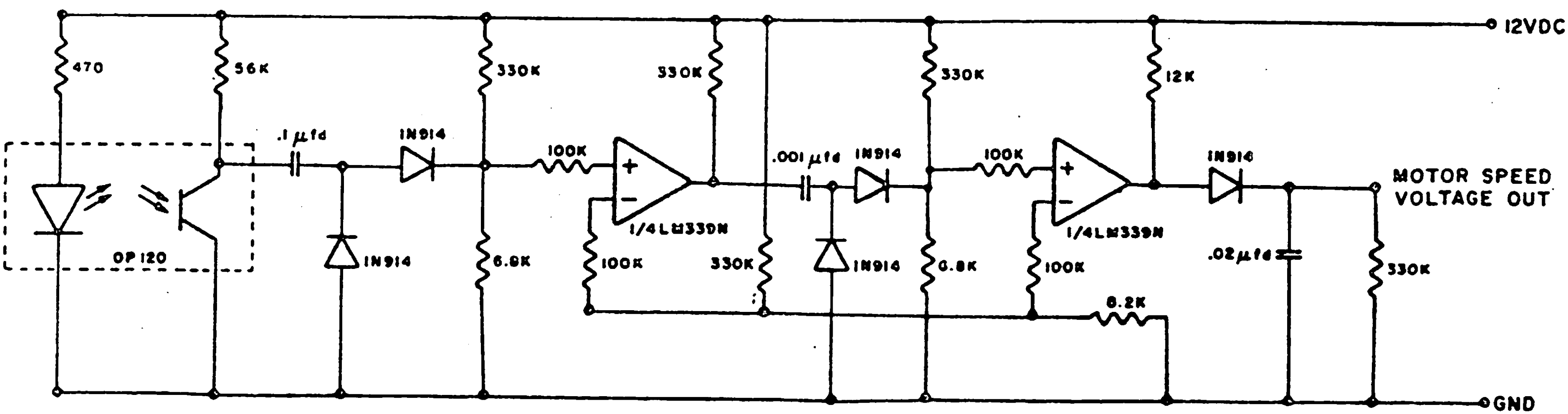



FIGURE 9. FREQUENCY TO VOLTAGE CONVERTER

loss through the motor drive transistor. The FV unit responds to conditions in excess of 1 MHz, so the motor speed is fairly constant. The level circuits use output from the recorder level potentiometer and compare this output to preselected outputs from the adjustable potentiometers of the level circuits. The particular traverse speed is selected by comparing the output from the level potentiometer of the recorder with the preselected level circuit potentiometers. For each of the 10 level circuits, there is a corresponding speed circuit. When the recorder level and the preset level agree, the appropriate speed circuit is used to power the traversing slot drive motor. The 10-speed adjustment potentiometers permit the "fitting" of water-level potentiometer output to the desired traverse motor speed; otherwise a special tapered level potentiometer would be required.

One of the 10 speed circuits is chosen by comparing the water level potentiometer with a series of preselected levels on the control board. The speed circuit selected by the control of the level circuits and a series of AND gates limits the routing of the output current of the gate to the holding AND gate. The holding AND gate input, when grounded by the limit switch, blocks the output of the control board and stops the traversing slot. Power for the moveable splitter is controlled by the holding AND gate and is activated only during the traverse time of the traversing slot (Figure 8).

The need for the moveable splitter in the sample drain line is determined by comparison of voltage output from the level recorder potentiometer and a separate preset level potentiometer.

Theoretically, the approximate power required to complete the filling of the 18 sample bottles is only 20% of the daily power produced by the 0.125 amp-hr/hr (average daylight) solar generator.

Table 1 is a condensed list of materials and their approximate cost for the construction of the complete sampler unit. These costs are based on using an FW-1 recorder with prices in the spring of 1975. The prices do not reflect any costs for the runoff measurement. Additional information, like model numbers, wiring details, etc., are being prepared and will be made available upon request.

The sampler's only application restriction is sufficient fall downstream to ensure that backwater and splash will not enter the below-flume splitters. Brush and debris problems can be controlled by installing small brushes vertically near each traverse limit switch so the traversing slot will rub across them and clean itself. Also, tilting the top of the slot away from the flume so debris would tend to ride up and off the slot will control debris build-up on the slot.

Table 1.

EQUIPMENT AND COSTS

| Equipment | Cost (dollars) |
|---|---|
| Water Level Recorder & Electronics | 311.00 |
| Traversing Slot Drive Mechanism | 116.00 |
| Traversing Slot | 100.00 |
| Stationary Splitter | 200.00 |
| Position Indicator | 39.00 |
| Moveable Splitter with Motor | 77.00 |
| Sample Drain Tube | 2.00 |
| Collector Table & Drive | 67.00 |
| Collection Bottles | 37.00 |
| Sample House & Excavation | 150.00 |
| Control Board & Related Electronics | 82.00 |
| Sequential Timer | 127.00 |
| 12 VDC Battery | 44.00 |
| Solar Generator | 43.00 |
| Total Sampler Cost | $1395.00* |

*This total does not include any labor costs except that involved in assembling the traversing slot, stationary splitter, and moveable splitter.

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