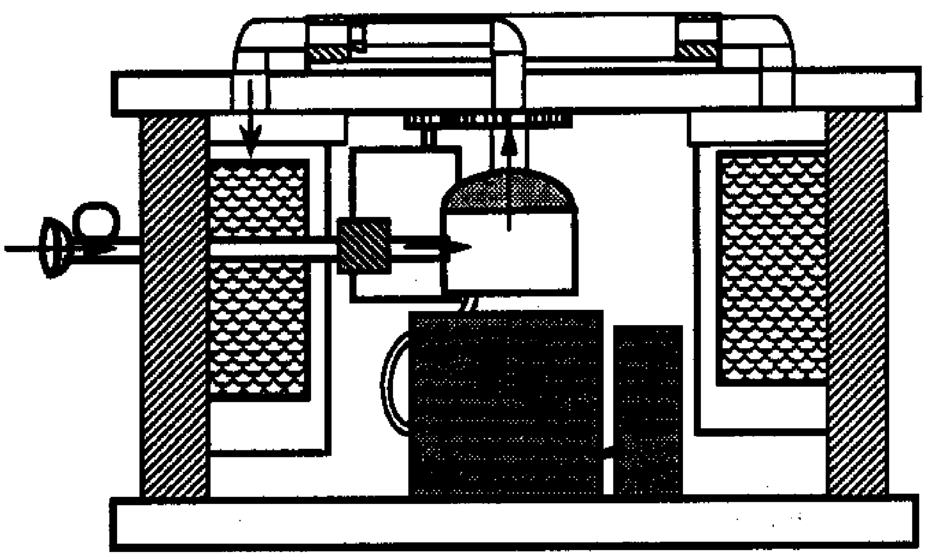
H.U.S.T.L.E.

HELLACIOUS UNDERWATER SAMPLING of THE LARVAE in the ESTUARY



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FALL/SPRING SEMESTER 1988/1989

Acknowledgements:

We would like to thank the following people for their invaluable help with this project :

Kathy and Muriel for all their help with the rush orders.

Bob Blake and Bob Doucette for their advice, machine work and tolerance with a motly band of clueless engineers and scientists.

Dr. Irish for his help and advice.

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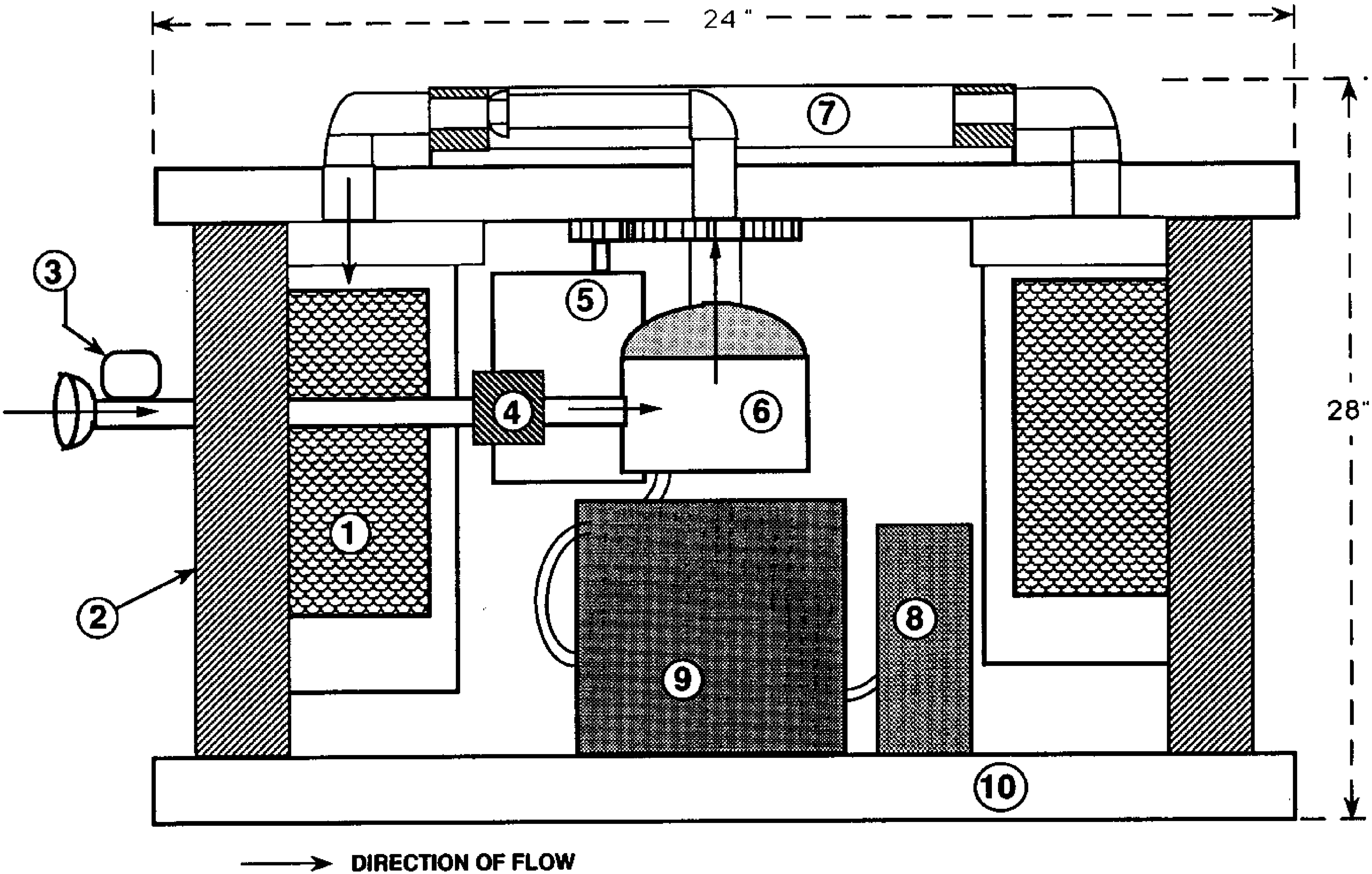
OVERVIEW

Drifting microscopic particles are found in the upper hundred meters of the oceans. Most of these particles is plankton, plant and animal microorganisms too small to do anything but drift with the ocean's currents. The plankton of the ocean provides a rich food source but it is unevenly distributed. Plankton masses are concentrated in areas of rich food supply, estuaries and upwellings. They are further distributed according to areas of favorable temperature. The plankton moves with this favorable fluid "mass". Project HUSTLE attempts to monitor this movement using a stationary sampler designed to take samples automatically.

The automated sampler is programmed with respect to sample volume and duration. The specific initiation time and sequential sampling intervales are all directed by a single board controller. At each sampling interval, the controller will coordinate the rotating arm that selects a sample container, the pumping duration, salinity reading and tesmperature reading. After all preprogrammed samples have been collected, the data held in the controller can be downloaded into a personal computer for analysis.

When initiated, the pump will drive the water into the sampler past a flowmeter, which monitors the water flow. A rotating spout directs the water flow into the containers. After each sample is taken, the rotating spout turns and purges the influent tube. The water is filtered through mesh which has been afixed to the sample containers. The sample is preserved by formalin in a sponge located at the bottom of the container. The sample containers, twelve in all, are easily removed and the sample then transferred to a jar for analysis in the lab. A conceptual schematic of the sampler is shown in Figure 1.

The sampler is powered by a lead oxide battery. This provides power for the driver, motor and electronics. The battery is housed on the sampler and is easily accessable for recharging.



PROJECT H.U.S.T.L.E. SCHEMATIC

FIGURE 1

COMPONENT SUMMARY :

1. PVC SAMPLE CHAMBERS (12) / 75 MICRON MESH
2. PVC SUPPORT COLUMNS
3. WATER INTAKE / PROBE HOUSING
4. OMEGA ROTARY FLOW METER
5. E.A.D. STEP MOTOR / GEAR SYSTEM.
6. RULE 1500 GPH BILGE PUMP
7. WATER DISTRIBUTOR MECHANISM
8. IKOLITE DIVE HOUSING / ELECTRONICS
9. GEL CELL BATTERY /HOUSING - 15 A-HR/12 VOLT
10. TOP AND BASE FRAME PLATE - 3/4" PVC SHEET

FIGURE 1 CONTINUED

Background

Zooplankton sampling techniques are often cumbersome and ill-suited for current research. The development of a portable, pump oriented sampler has several advantages over the previous sampling methods such as boat-towed plankton nets. These advantages include reliable measurements of the filtered volume, depth control and control of the filtering process with the possible use of several mesh sizes (Miller & Jedkins, 1981).

To distinguish these advantages it is important to test and compare the different results between pump sampling and net towing. A comparision of the taxonomic composition of zooplankton samples taken with a pump and a boat-towed net in a tropical, mangrove-dominated estuary. These tests revealed significant correlations in the rank order of abundance of the major taxa captured by the two methods (Dixon & Robertson, 1986). Two distinctions did appear however, when comparing less abundant taxa collected by the two different methods. The plankton net captured greater densities of rarer zooplankton taxa, such as chaetognaths, polychaete larvae and larvaceans, than did the pump samples. The pump samples contained more abundant numbers of gastropod and bivalve larvae. The patchiness of zooplankton could contribute to the greater mean densities of less abundant taxa because the net encompasses a greater area during sampling. The ability of some zooplankton to swim rapidly might allow them to avoid the pump intake and cause their exclusion from the sample (Singarajah, 1969). The HUSTLE samples, however, can more easily be controlled by means of flow rate, measured water volume, and mesh size alterations. The benefits of a sample taken under controlled conditions are an asset to the researcher.

Project HUSTLE designed a portable plankton sampler to outperform previous plankton samplers and fulfill current research needs. The HUSTLE sampler is a portable, self-contained system that can easily be handled and carried by two people. Once the fully automated sampler is placed at the desired depth, no further human interaction is needed during sampling.

The design features of the HUSTLE sampler are geared towards research flexibility. The Ikelite containers housing the electronics and battery allow for complete submergence. The proposed plexiglass enclosure will prevent dilution of the preservative. The greatest flexibility provided by the HUSTLE sampler is the large number of samples that can be collected over a predetermined time period with the aid of a microprocessor. The twelve sample containers are constructed of 3" diameter PVC tubes with 75 micron Nytex. The relatively large number of samples obtainable, automated collecting operations and its ability to be submersed are three advantages of the HUSTLE sampler not provided by the EZY-ZOOP portable pumping system (Dixon & Robertson, 1986).

The HUSTLE sampler exceeds the ability of the O'HARA sampler (O'Hara, 1984) in at least two aspects : The HUSTLE sampler has a self contained power supply which the O'HARA sampler lacks. This incorporated power supply increases the depth at which the sampler can be utilized. Secondly, the salinity and temperature probes of the HUSTLE sampler provide a more accurate and detailed picture of the sample enviroment. The O'HARA sampler, although simple in design, cannot provide these useful measurements at the time of sampling.

PRELIMINARY TESTING

Initial zooplankton collection, for the determination of sample volume, mesh size, and mesh area, was completed at the Jackson Estuarine Lab on Great Bay in October and November. Refer to Figure 2 (next page) for typical zooplankton densities. The trial runs consisting of filtered water through a 75 micron mesh yielded plankton densities of approximatly 50 plankton per 60 liters of water (sample size). This sample size of 60 liters (16 gallons) per sample was selected as the design sample volume.

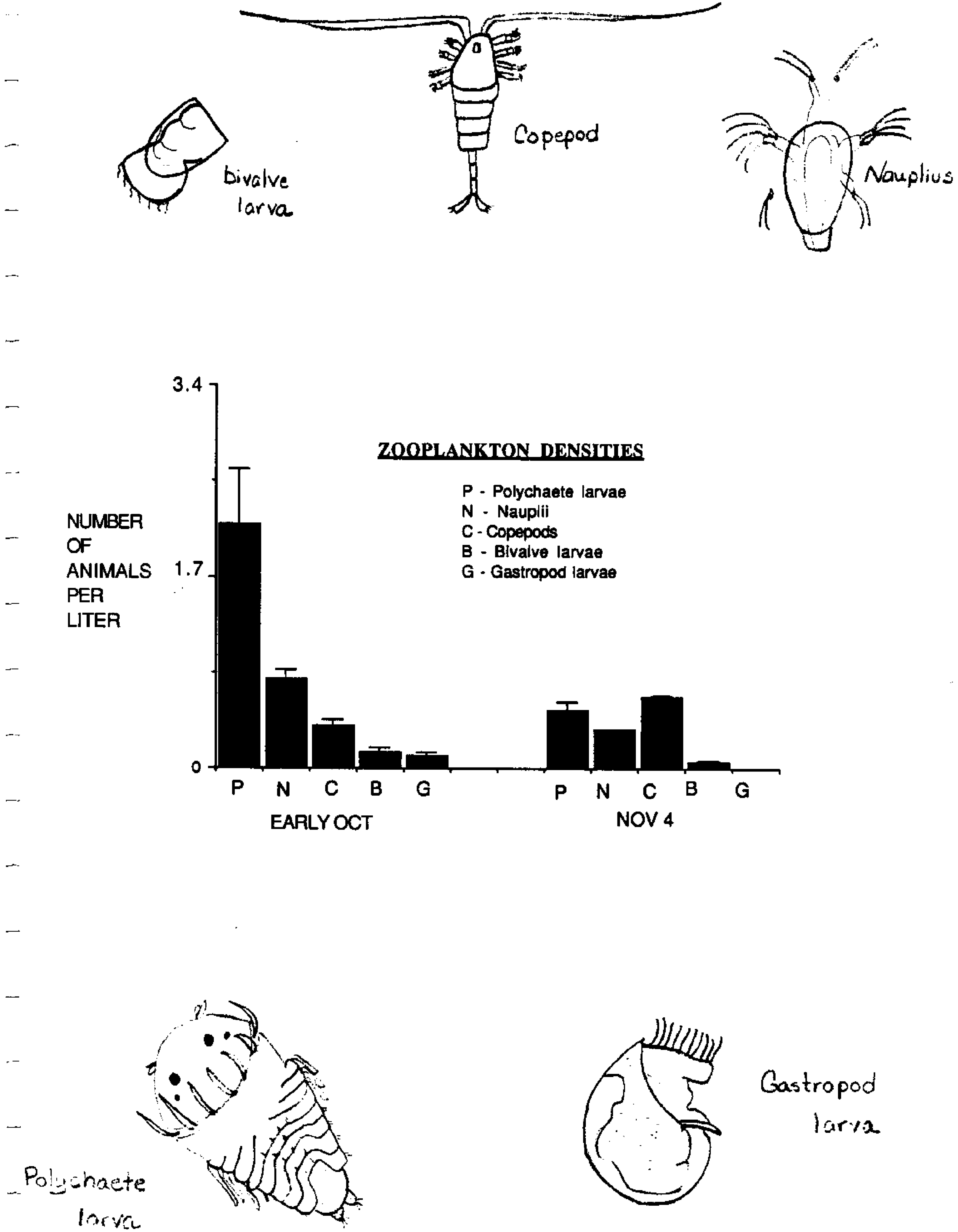

bivalve larva
Copepod
Nauplius
ZOOPLANKTON DENSITIES
P - Polychaete larvae
N - Nauplii
C - Copepods
B - Bivalve larvae
G - Gastropod larvae
NUMBER OF ANIMALS PER LITER
3.4
1.7
0
P N C B G
EARLY OCT
P N C B G
NOV 4
Polychaete larva
Gastropod larva

Figure 2

DESIGN AND CONSTRUCTION CRITERIA

Design Requirements:

I. Mechanical

<u>Objective:</u> The plankton sampler was to be designed to take twelve separate samples over a twenty four hour period with aproximatly sixty liters of water (16 gallons) pumped for each sample. One of the major design constraints on the mechanical aspects of the sampler was to minimize the amount of corrodable materials used in construction. The size and weight were also to be kept to a minimum with the total sampler weight being no more than eighty pounds. The water distribution system was to allow purging of the water line between samples. A maximum operating depth was set at sixty feet. The sampler was also to be designed for bottom mounting in the estuary with a means of adjusting the location of the water intake inlet. All electronic components were to be sealed appropriately with water-proof lines running between the various containers. A means was to be provided for optional enclosure of all sample containers to prevent the possible dilution of fixative soaked in the sample container's sponges should testing reveal the need.

II. Electronics

<u>Objective:</u> With one of the objectives for the project having been computer control and programmability, a single board microcontroller was chosen as the core of the electronic system. The controller allowed for interface between a step motor driver, pump driver, temperature and salinity probes, and a flowmeter. Capabilities for flexible timing and ease of overall use were the main goals.

The control system specifications were as follows:

a. The control of sampling times and durations for 12 separate plankton samples.
b. The monitoring and storage of the flowmeter output value during pumping.

c. The retrieval and storage of temperature and salinity values at a variable interval over the sampler implementation time (up to two days).
d. Interface with the pump and step motor drivers so as to allow control of sample selection and pump timing.
e. Ability to download the retrieved data into a personal computer running communication software.

III. Probes

Probes were selected to measure temperature, salinity, and dissolved oxygen. These measurements were deemed necessary to study the movement of the zooplankton. The desired probe specifications were as follows:

a. temperature +/-0.01 deg C
b. salinity +/-0.1ppt
c. The main criteria for the dissolved oxygen probe was economic feasability.

IV. Housings and Battery

The electronics and battery needed to be enclosed in reliable water proof containers. A reliable battery with adequate power supply was also needed. A water proof wiring system would have to be made to connect the containers. Do to the frequent use by data collection and battery recharging, the housings were to be easily accessable.

The Specifics:

1. Mechanical

Discussion

Frame:

Based on the initial design criteria, PVC was chosen as frame material for its resistance to corrosion, ease of machinability and relatively inexpensive cost (compared to other available plastics). Three quarter inch thick PVC sheet was used for the top and bottom portions of the frame (Drawing Number 1 in the appendix) in order to allow a good amount of space for tapping threads and mounting the sampler's components to the top and bottom of the frame. The 3/4" thickness was also desired to allow a groove of sufficient depth to be cut for the placement of an optional plastic sheet to enclose the sample containers. This optional sheet would be used to prevent the dilution of the formalin fixative mentioned earlier.

Schedule 80 PVC pipe was used for the support columns (2 3/4 " nominal diameter) in order to provide a sturdy support (Drawing 2 in the appendix). The columns are positioned by the use of half inch thick PVC disks machined to fit inside the pipe and glued to the inner surface of the top and bottom plates of the frame. The disks were machined for a sliding fit with the columns on the top plate to provide easy removal of the upper section. On the bottom the disks were machined for a tight fit with the PVC pipe. The pipe was glued to both the bottom plate and sides of the disks. After a design change allowing easier access to the electronics containers, the PVC columns were enlarged by cementing another piece of pipe to the top of the column. The top portion of this addition to the support column was machined appropriately for a proper fit with the PVC spacing slugs.

In order to provide air purging and water drainage during the sampler's entry or removal from the water, holes were drilled in the side at the top and bottom of the PVC columns. The top and bottom plates of the frame were bolted together with 1/2" thick stainless steel threaded rod (bolts, rod and washers were all zinc plated).

The sampler containers are attached to the top plate of the frame using a press fit with mating PVC sleeves which were glued to the top of the frame. The sample containers are free standing except for the press fit with the sleeves.

Zinc plated stainless steel handles were mounted to the top plate of the frame. Additionally four eye hooks were mounted to the bottom plate for attaching dive weights to the sampler.

Water Distribution System :

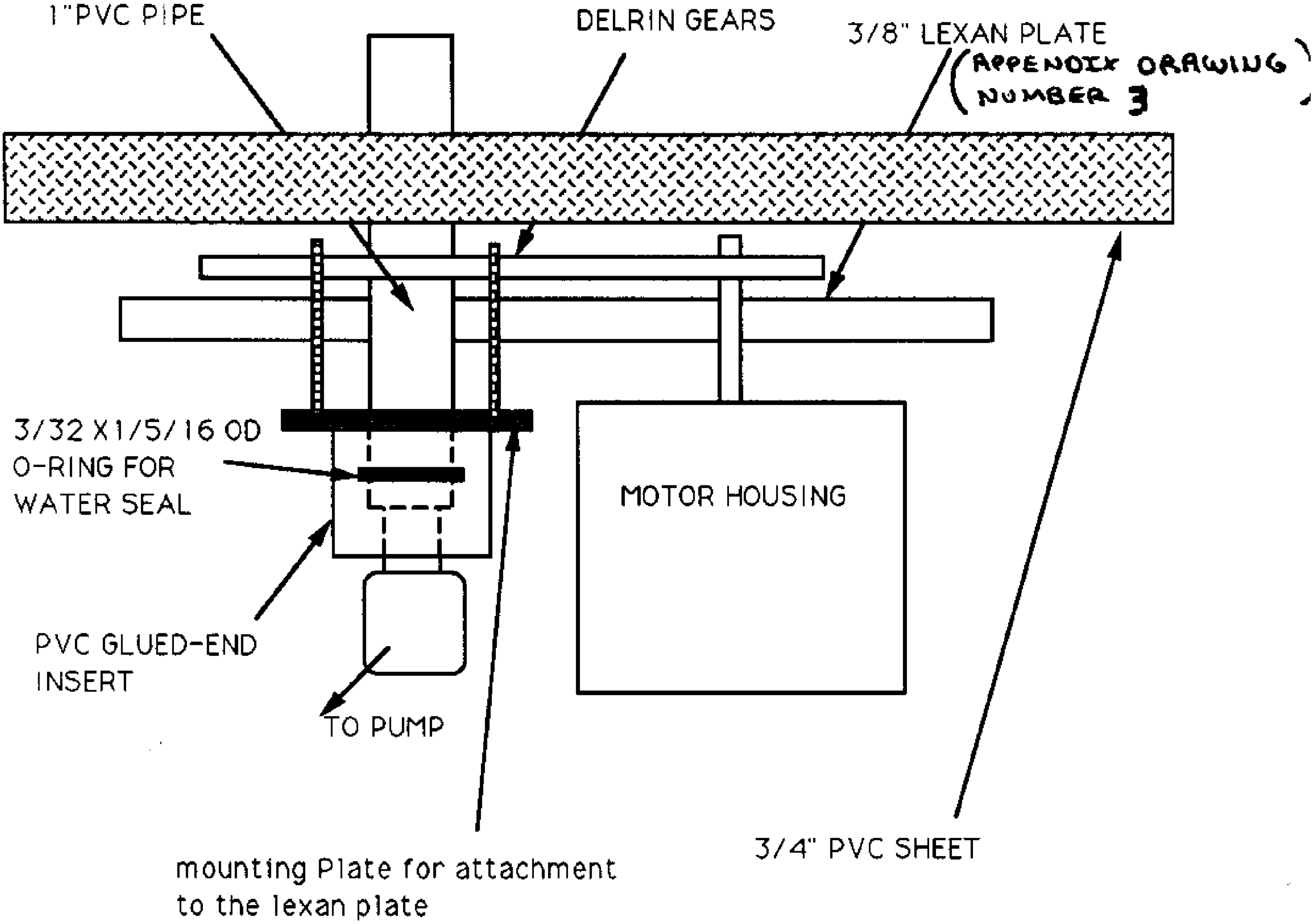
The samplers water distribution system includes :

a. A step motor/gear system to control the motion of a rotating arm.
b. A rotating arm to engage with the distributor ring.
c. A distributor ring to direct the flow of water to the appropriate container or purge hole.
d. Check valves mounted in line to the sample containers to seal the containers before and after sampling.
e. A 1500 gph bilge pump to drive the flow.
f. A flow meter to monitor water flow.

The motor driving the rotating mechanism is an Eastern Air Devices model LA34AGK-9 permanent magnet stepping motor (see appendix, page A1) with a maximum torque output of 188 oz.inches. The motor was chosen for its high torque capabilities due to uncertainties in the estimates for the total frictional load of the system. The choice was made to pick a motor with much more than the estimated torque for the prototype model with the idea of working down in motor sizes in future models of the plankton sampler.

The motor was housed in 4 1/2" ID acrylic pipe with 1" thick acrylic caps on each end ; one screwed on, the other removable through stainless steel clamps. O-rings in the acrylic caps were used for a water seal. The housing is attached to a 3/8" thick lexan plate (drawing 7 appendix) , which is bolted to the top plate of the frame. The motor's 3/8" diameter shaft was coupled to a 1/4" diameter shaft inside the housing. The 1/4" shaft exits the housing and passes through an ikelite sealing fixture attached to the housing's bottom plate (see drawings 2 through 7 in appendix) . The shaft drives a gear system consisting of two delrin spur gears. The pinion gear is mounted on the 1/4" shaft and the larger gear on the 1" thick (nominal) schedule 80 PVC pipe. The action of the gears causes the rotation of the PVC pipe. The pipe is connected on one end to a waterproof bearing made from standard PVC pipe fixtures (see Figure 3 next page).

The pump, a 1500 gph Rule bilge pump is attached to this bearing. The 1 " PVC shaft is constrained in motion and slides against two delrin bearings (drawings 4 and 5 in the appendix). The gear is mounted to the PVC shaft by a hub screwed into the top



SCHEMATIC SETUP OF O-RING BEARING FOR WATER SEAL TO ROTATING SHAFT

Notes : PVC Glued-End Connection was machined for fit with the o-ring.
The PVC schaft was turned to hold the o-ring in place.

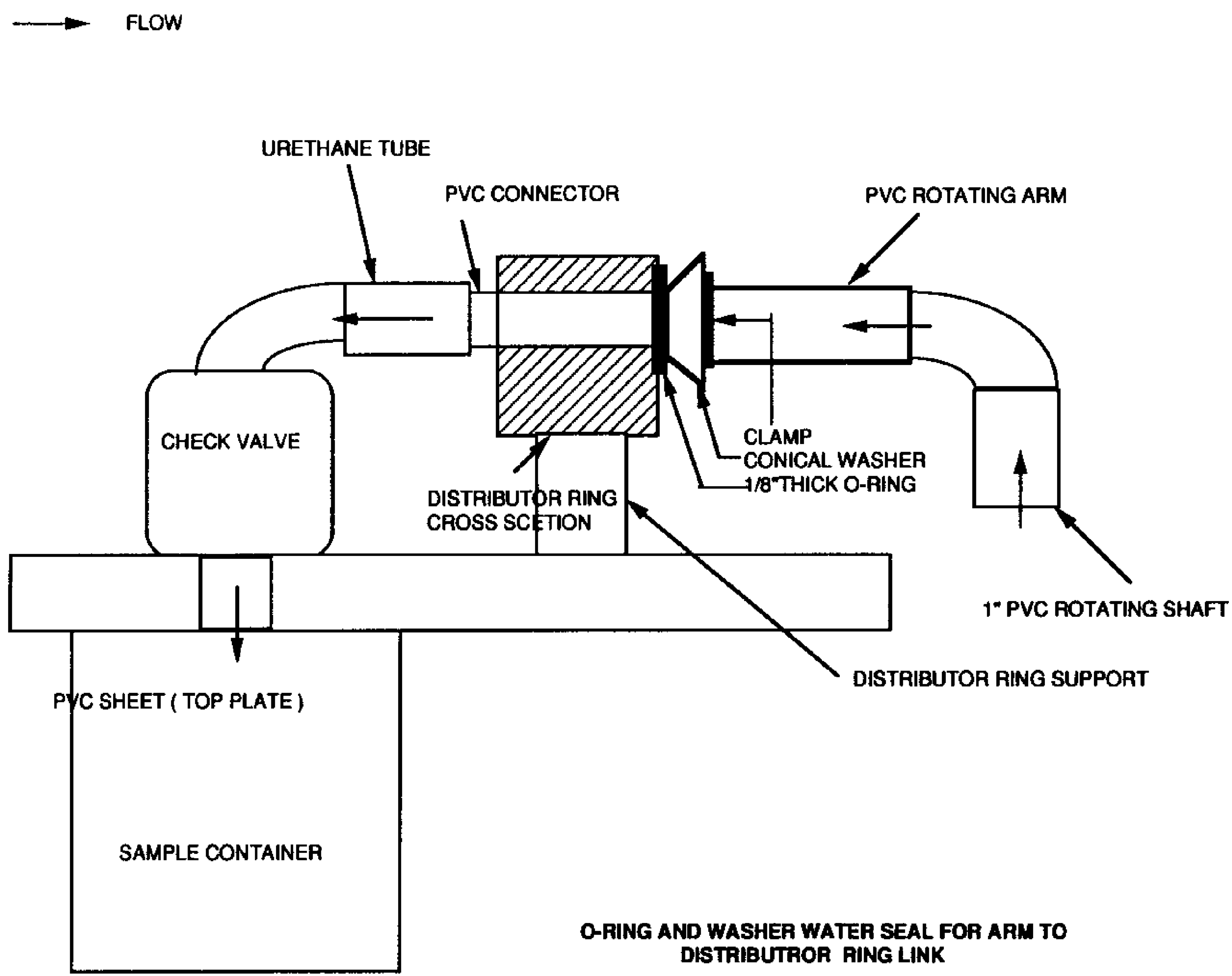
FIGURE 3

of the gear (drawing 6, appendix). The other end the pipe is attached to the rotating arm which butts up against the distributor ring. A watertight seal is maintained between the rotating arm and the distributor ring (drawing 8 appendix) by a conical rubber washer which surrounds the end of the PVC arm (3/4 " OD) and an O-ring cemented to the washer. The O-ring provides the actual contact between the arm and the distributor ring while the conical washer gives the o-ring shape and support (see Figure 4 page after next).

Flow exits the distributor ring and enters a container during sampling or discharges into the area surrounding the sampler during purging. The flow entering the sample containers passes through a spring loaded check valve used to seal off the containers before and after sampling. The check valves chosen (Nibco T480 spring checks) are standard plumbing equipment used to prevent back-flow in heating systems. They were selected mainly on the basis of cost (approximately $7.50 each) and opening force. Experimentation with the valves indicated that they cut down the pumping capacity too much and the springs were cut shorter in order to reduce the load on the pump and increase flow. The valves still contribute the greatest head loss in the flow. It was desired to use check valves with a lighter opening force but the only ones found were of laboratory quality and expensive (30 to 50 dollars each) due to construction with high performance materials (teflon housings, sapphire balls and seats). Future plankton samplers will be designed without the the need of valves to seal the sample containers or design and construction of check valves with more acceptable performance and cost will be initiated.

Water is driven in the system by a 1500 gph Rule bilge pump (see appendix, page A2) which was suspendended from the top plate of the frame . The 1500 gpm pump was chosen to account for head losses and to provide more pumping power should a greater amount of water filtration be desired for plankton sampling.

In line between the water intake and the pump, suspended from the top plate of the frame, is an Omega FP5300 paddle wheel flow sensor (see appendix, page A3) which interfaces with the controller to monitor the flow rate during pumping. This was done in order to determine the exact amount of water pumped in each sample. This system then can monitor any losses in pumping due to drop-off in battery performance



O-RING AND WASHER WATER SEAL FOR ARM TO DISTRIBUTROR RING LINK

NOTE : FIGURE NOT TO SCALE

FIGURE 4

and the possible increase in flow restriction due to the clogging of the mesh in the sample containers, a possible concern for the bottom mounted application of the plankton sampler. This particular flow sensor was selected based on cost effectiveness (250 dollars for the sensor and mounting fitting), its ability to handle the amount of flow, and its simplicity. The meter was not designed for underwater submersion as was the case with most of the flow meters researched. Engineers at the Omega corporation were consulted and indicated that the meter should be able to handle underwater applications but that this was was not a standard usage for the meter. Any possible leak points in the meter were filled with epoxy on the advice of the Omega engineers as a precaution for possible water damage to the meter's electronic components.

II. Electronics

Overview: The control of the sampling times and durations along with the analog to digital conversions needed for the insistu data retrieval was accomplished through the microcontroller's software and onboard hardware. The microcontroller's software controllable input/output lines made the interface to pump and step motor straight forward. A block diagram of the control system is given in Figure 5 (next page).

Construction of interfaces for temperature and conductivity probes was needed . The flowmeter's output was sinusoidal and a peak detection circuit was used to capture its output. A step motor driver which can be interfaced to a CMOS based system, such as the microcontroller used, was chosen for the control of sample changes. A relay based circuit was used for the control of the pump. The correct balance of software and hardware was the main overall goal for the production of a functioning system.

Discussion: The heart of the control system is the Tattletale Model IV Microcontroller from the Onset Computer Corp. of Falmouth, Ma. The microcontroller's connector to the prototype board is shown with the connections used, in the schematic of Figure 6 (next page). The system has the following features:

a. 32k bytes of data and program storage.
b. Built in TTBASIC data retrieval oriented programming language.
c. 11 separate 10 bit analog to digital converter inputs.

CONTROL SYSTEM

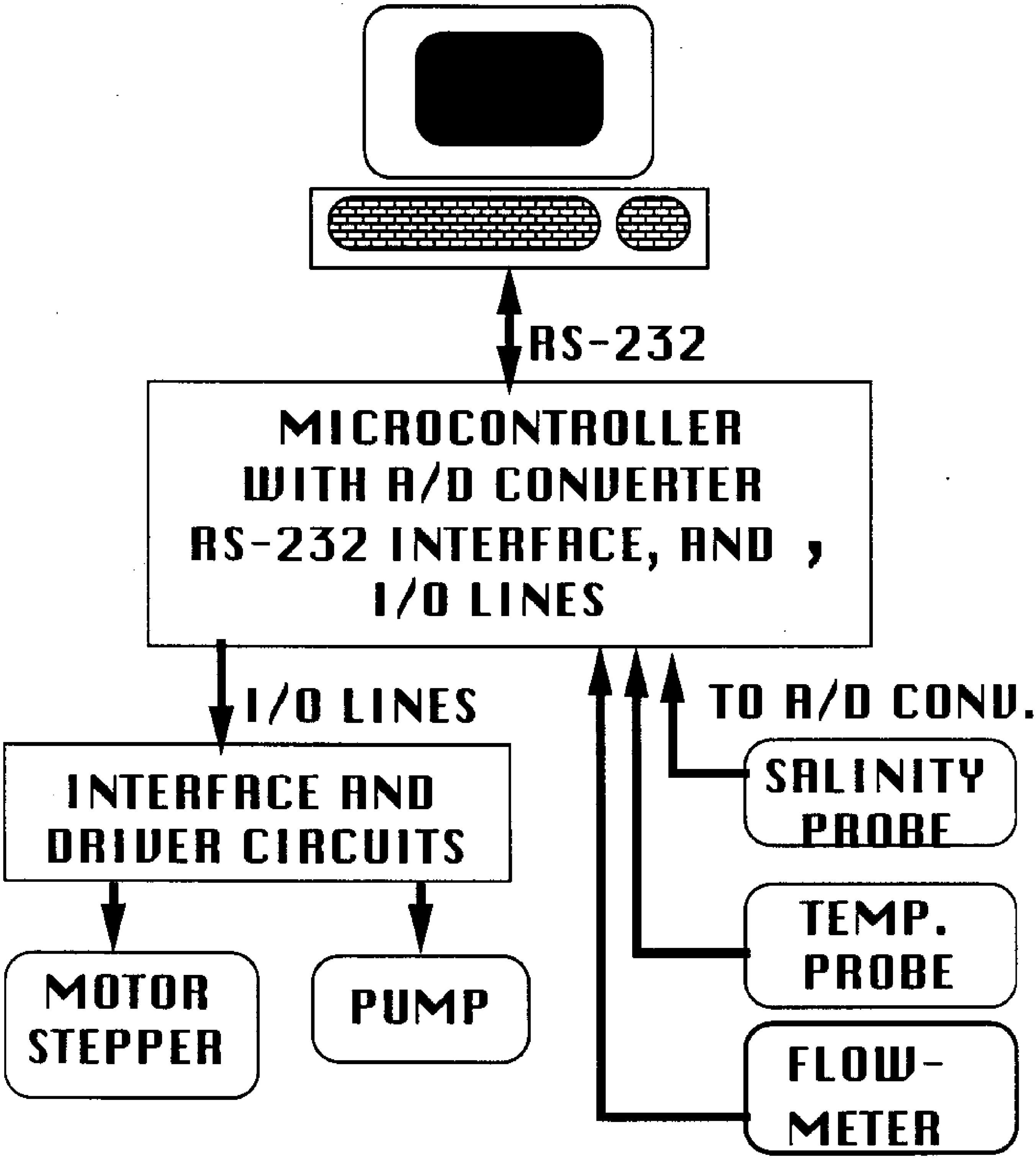
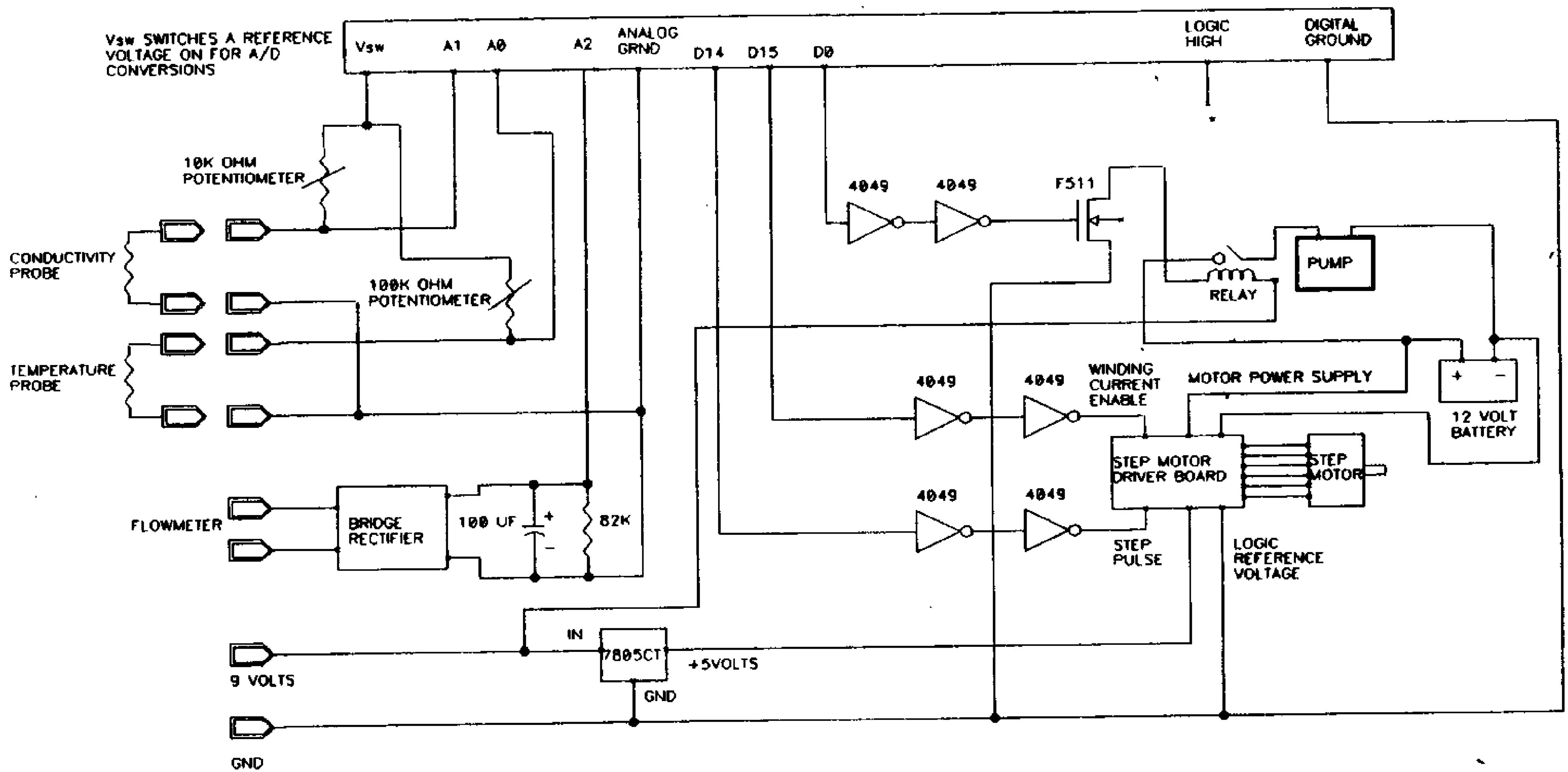


FIGURE 5



* USED TO POWER THE IINVERTER INTEGRATED CIRCUIT

FIGURE 6

d. 16 programmable digital input/output lines.
e. Low current drain configuration.
f. Built in software programmable real time clock.
g. Easily integrated prototype board for the construction of support circuits.

The Tattletale's software controlled digital I/O lines are used to produce the step pulse and winding current enable signals of the step motor driver along with the pump relay control line. Three of the 11 A/D inputs are used for the salinity, temperature and flow sensor inputs. The flow chart of Figure 7 (next page) outlines the operation of the sampling control and data downloading program listing (see appendix, page A9). The program prompts for the sampling times (in military hours) then begins a salinity and temperature retrieval loop (once every 5 minutes). When the hour of the first sample is reached the control is sent to the sample pumping routine. In this routine the line is purged, the sample container is selected and the 5 minute plankton pumping test begins (as outlined in the documentation). During the pumping duration the flowmeter value is retrieved every second. The program loops through each of the 12 selected sample times then waits for a carriage return from the host terminal. When the return is received (after connection of the controller to a terminal via an RS-232 cable) a menu lisiting the data downloading options is provided. A second program, also listed, provides the same basic features as the first except the temperature and salinity sampling rate was changed to every 30 seconds and the sampling time is entered in minutes. The changes allow a higher resolution in enviromental parameters while collecting samples over a much smaller period of time (as small as 12 minutes.)

The microcontroller was interfaced to each of the separate sub-assemblies such as the step motor via the prototype board and connector. The lower left section of the circuit schematic shows the wiring setup for the system. The heart of the step motor control area is the D200 Stepping Motor Driver from Eastern Air Devices of Dover, New Hampshire. This device is designed for use with the step motor selected to meet the mechanical specifications. The pinout diagram of the board is given on page A7 of the Appendix. Inputs of interest here are the step puse and current enable along with the ground and reference voltages. Logic level control inputs are compatible with the CMOS outputs of the microcontroller. A logic-high voltage reference must be provided

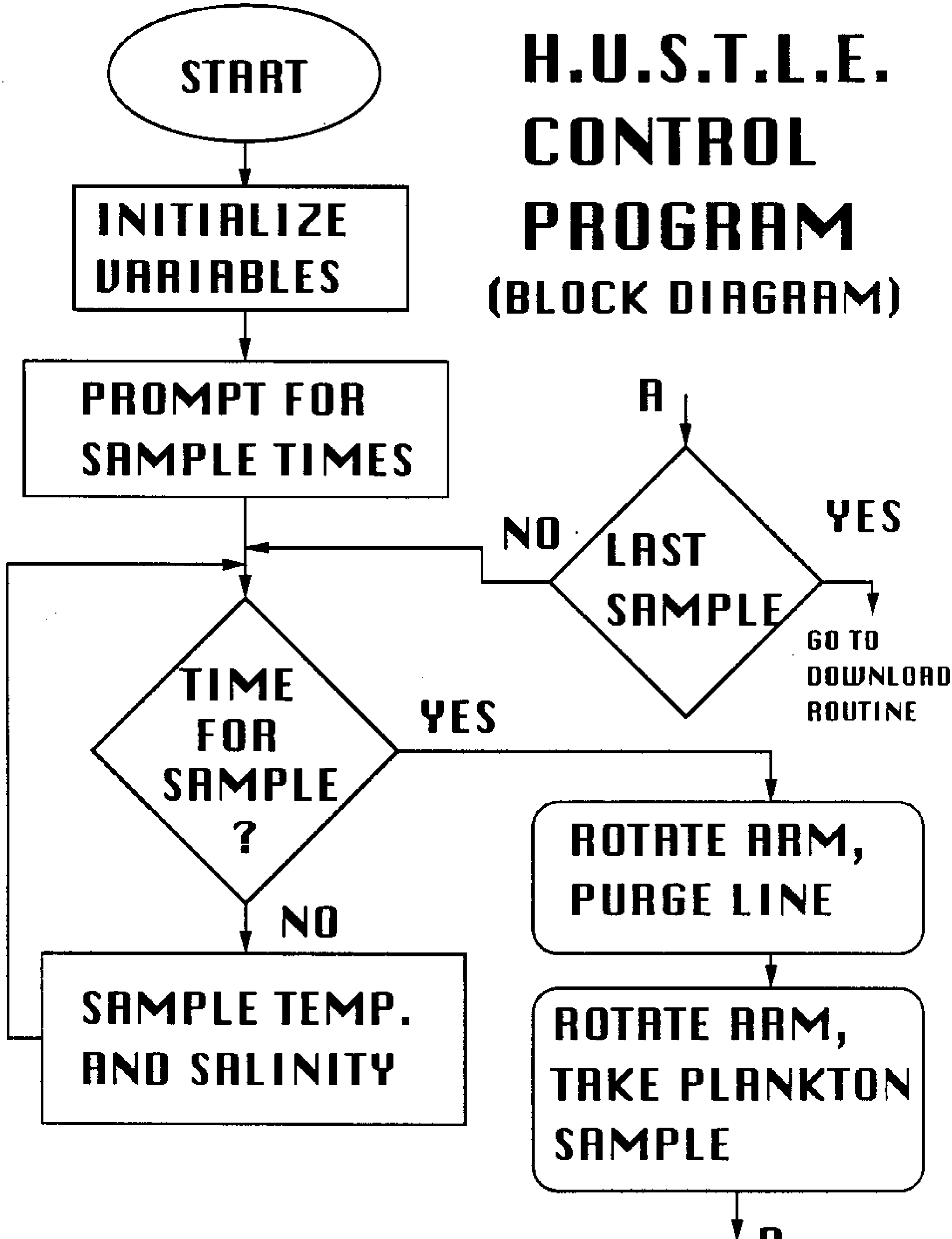

H.U.S.T.L.E.
CONTROL
PROGRAM
(BLOCK DIAGRAM)
START
INITIALIZE VARIABLES
PROMPT FOR SAMPLE TIMES
A
LAST SAMPLE
NO
YES
GO TO DOWNLOAD ROUTINE
TIME FOR SAMPLE ?
YES
NO
ROTATE ARM, PURGE LINE
SAMPLE TEMP. AND SALINITY
ROTATE ARM, TAKE PLANKTON SAMPLE
A

FIGURE 7

for the driver to distinguish a step pulse and a current enable request. Due to this reference input's relatively high current drain, the voltage was provided via a 7805CT 5 volt regulator connected to the same 9 volt input as the pump relay. The high voltage input comes from the rechargeable 12 volt battery. Six connections are needed for interface between the motor and driver and are color coded to assure proper connection. The full copper connecting scheme was chosen to assure the high torque/low speed performance. Phase current timing during operation is crucial and thus these connections must be correct. Allowing for lower battery drain, the current enable line of the driver, when brought low stops the quiescent winding current flow from the battery. This line must be high during motor operation. A schematic provided by Eastern Air Devices, for the driver, is given on page A8 of the Appendix. The driver current output must match the motor's rated current and can be adjusted via an onboard potentiometer. The setting of this current was performed using an ammeter; thus assuring proper motor operation.

The pump control provided an isolation problem; that is, a 12 volt relatively high current device must be controlled by a CMOS level output. Two CMOS inverters were connected in series with their output sent to the gate of an N channel MOSFET as shown in the circuit schematic. The MOSFET is capable of handling the 28 mA produced by the 9 volt source across the relay coil. When the pump control line goes high the gate of the MOSFET reaches approximately 5 volts thus turning on the transistor (drain to source a virtual short). The relay coil is excited, closing the switch and the 12 volt source is connected to the pump. The relay contacts are rated at 28 volts, 10 amps, which was well in line with our specifications. Since the switching rate was very slow the response time of the relay was not a drawback.

Output from the flowmeter is in the form of a sinusoidal waveform, where the peak to peak voltage has a magnitude of 1 volt per ft/sec. The peak value of this signal must be derived for an analog to digtial conversion to be performed. The circuit used is shown in the schematic of Figure 6. A full wave rectifier bridge was used to provide a complete positive going waveform, then a resistor and capacitor were connected across the recitifier's output thus providing a DC reference. The RC time constant was chosen as follows to assure a constant signal (small ripple signal on the DC value):

$$\text{Ripple Voltage} = \frac{\text{Peak Voltage}}{2*f*R*C},$$

where f is the frequency of the sinusoidal signal. The ratio of the ripple voltage to the peak voltage was chosen to be 1/100 (ripple signal 40dB below the peak value). The frequency of the sinusoidal signal varies with flow and thus a minimal value of 6 Hz yielded the best result (designing for worst case).

$$2*f*R*C = 100, \quad \text{or} \quad R*C = 8.3$$

Choosing the capacitance as a common value, C=100 uF the resistance becomes 83k ohms. Voltage drops from the bridge retifier's diodes must be accounted for in the data results. The device is factory calibrated so a reference flowmeter must be used to calibrate the voltage ouput with actual flow rates. Once the voltage offset is determined the flow rate over the desired operating range can be calculated. Through preliminary results the offset was found to be 0.6 volts. A certain amount of error, or loss in sensitivity was expected because of the A/D conversion process. The reference voltage of the A/D converter is independent of the voltage input from the flowmeter. A spike or noise signal causing a change in the reference voltgae, but not affecting the flowmeter ouput will produce slightly altered results. Considering the data is to be integrated over time and only a small percentage of points are to be affected greatly, volume flow results should still be representative of any flow rate changing trend.

The temperature and conductivity probes used are from Martek Instruments Inc. The thermister temperature probe has an ambient resistance vaalue of 5.5k ohms. In the schematic of Figure 6 the probe interface set-up is shown. By connecting the thermister and a 10k ohm potentiometer in a voltage divider configuration, the voltage output taken at the resistances junction is proportional to the temperature. The reference voltage is supplied from the Vsw line on the microcontroller. This Vsw line is set to +5 volts 150 microseconds before any A/D conversions are performed so that the current drain from any probes will be minimal. The conductivity probe is connected in the same configuration as the thermister except a 100k ohm potentiometer was used. In both cases the potentiometers were adjusted to a value close to the nominal value of resistance for each probe, reached at the amibient enviromental conditions during use. The Vsw line is also used for the conductivity sensor reference, which assures no polarization during measurement. The temperature and conductivity A/D conversions are performed using a ratiometric method; that is the output taken from the voltage dividers are proportional to the reference voltage. The value stored by the A/D process is this ratio between voltages. Reliable and repeatable results are obtained because of the noise immunity provided by this operation.

The temperature probe was calibrated using a reference water tank of regulated temperature. A calibration probe was used for the base temperature measurement. Pairs of temperature and A/D conversion values were recorded over the temperature range 3 to 19 degrees Celsius. A plot of this data is provided in Figure 8 (next page). The curve-fit approximation for this plot is also provided and given by the following function:

$$\text{Temperature} = -26.437+0.28473*X - 3.3255e{-4}*X^2$$

Conductivity probe calibration required a temperature reference for a water sample of known salinity. The salinity of the water was 21 ppt and its temperature was varied from 3 to 17 degrees Celsius. Using the correlated temperature, conductivity A/D output and known salinity value, the equation of state for seawater was used to determine the conductivity, which is given by:

$$C = [2.1923+0.12842*(T^{1.032}/(1+T^{.032}))e^{.0029T}]* [(S/(1+S^{.1243}))e^{(-.000978*S-.0000165*(S-35)*(T-20))}]$$

where S is the salinity in ppt and T is the temperature in degrees Celsius.
The data produced from the A/D values and the computed conductivities is plotted in Figure 9 (next page). The equation given by:

Temprature Calibration Data From Thermistor Probe

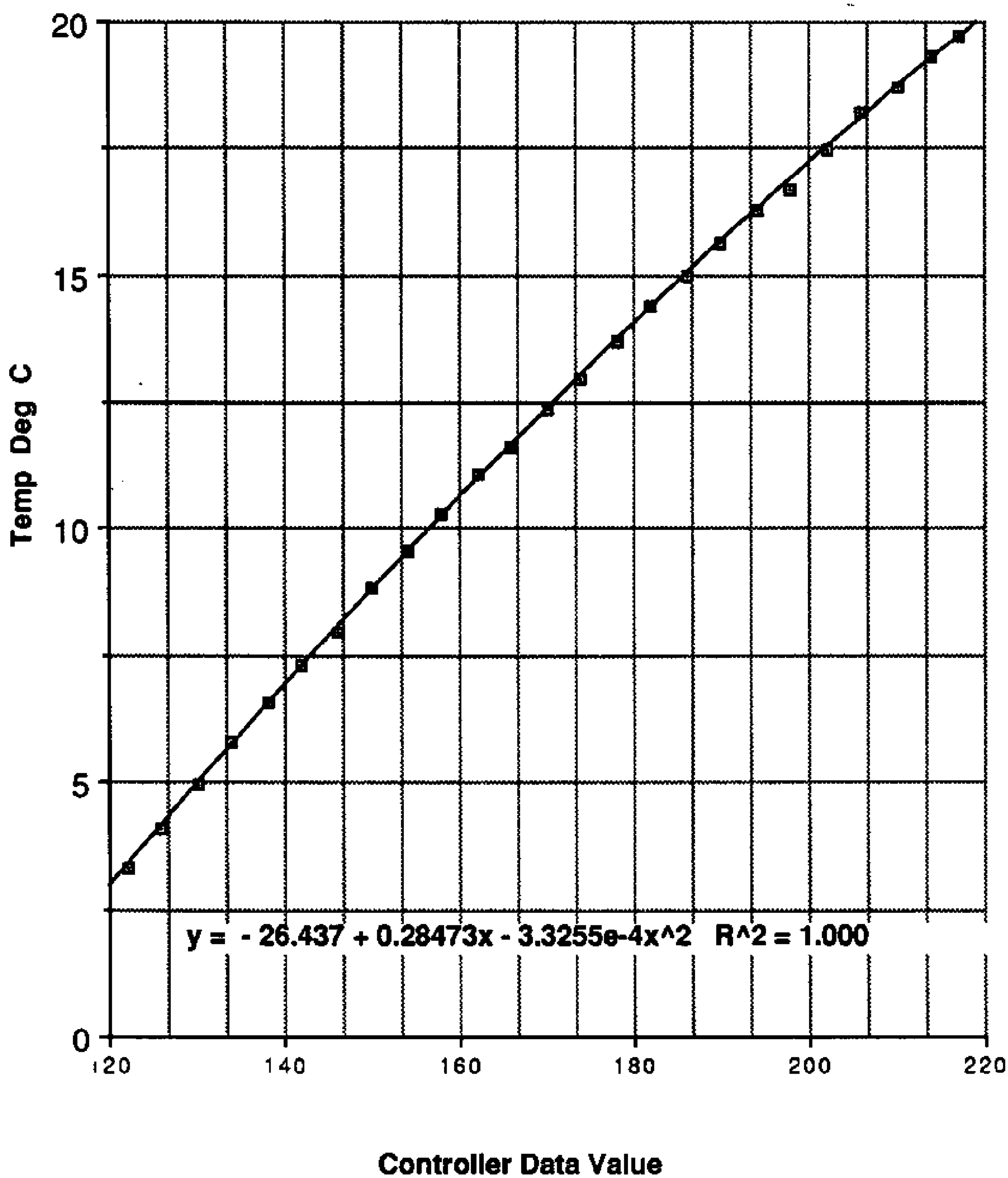


FIGURE 8

Conductivity Calibration Data

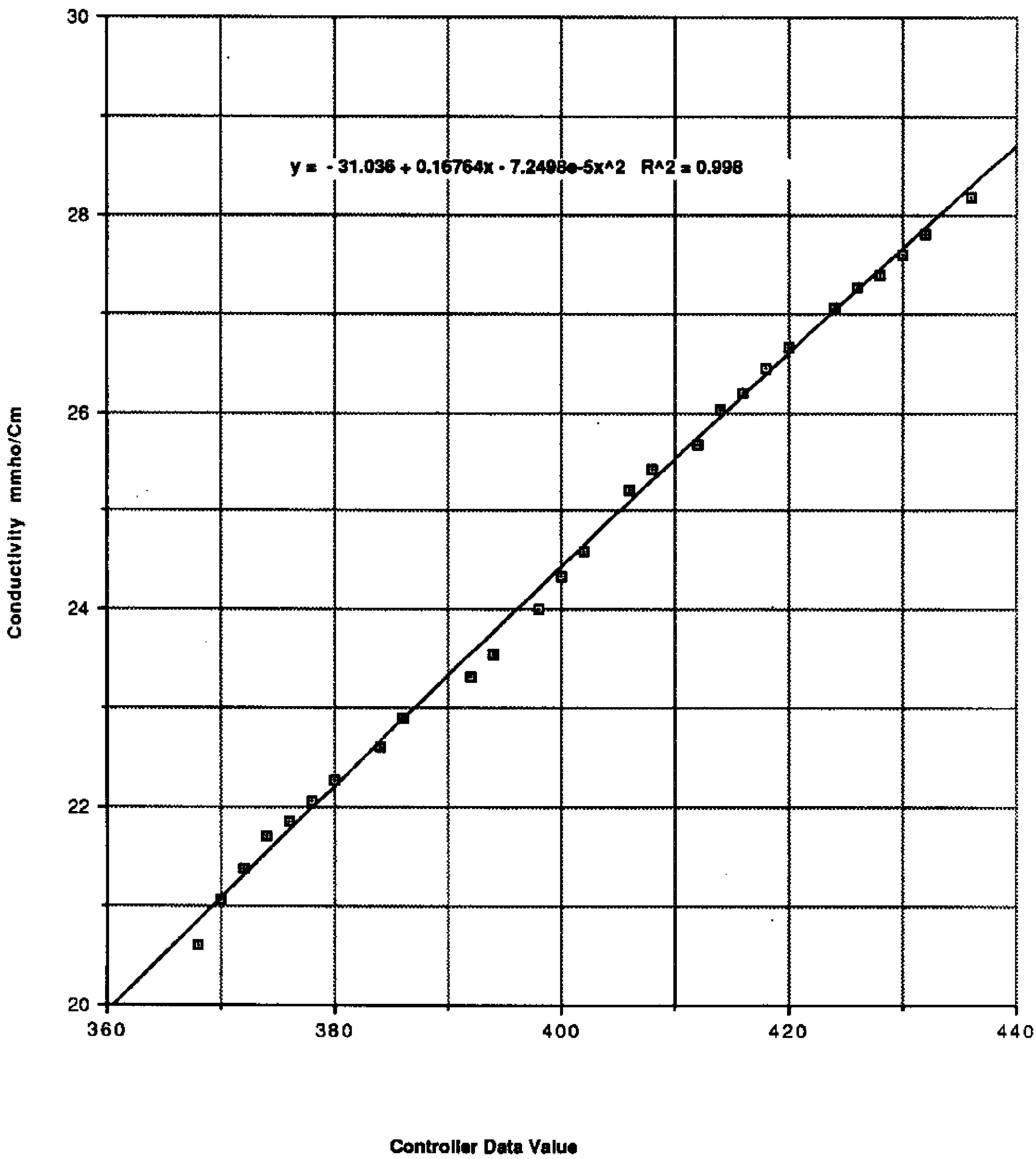


FIGURE 9

Conductivity = -31.036+0.16764*X-7.2498*X^2 , where X is the Controller Data Value.

was a curve-fit approximation for the plot and is used in the data analysis section of the microcontroller program.

III. Probes

Overview: The variables needed for each sample are temperature, conductivity, salinity and dissolved oxygen. Selection of probes for this project was extremely limited because of budget constraints and the high cost of both salinity and dissolved oxygen sensors. Many companies offerred water quality measuring instruments that measured temperature, conductivity, pH, true dissolved oxygen, salinity, and pressure but at a high cost (approximatly 2000 dollars for a multiple set-up with desired accuracy).

Discussion: To measure temperature, a simple thermister could be used. They can be easily calibrated to work with any system.

For measuring salinity, one first needs to measure temperature, conductivity and pressure. Salinity has only a small dependence on pressure. Since pressure is negligible in our operating range, it was disregarded to avoid an added expense. Conductivity probes which operated in the desired range (0-100 mS/cm) were difficult to find. Most probes had a range 0-50 mS/cm.

The goal was to measure salinity to +/-0.1 ppt. For that degree of accuracy, the conductivity would have to be measured to +/-0.1mS/cm. Most conductivity probes could only measure to +/-1.0 which would give a salinity accuracy of about +/-0.2 to +/-1.5. Due to the high cost, a conductivity probe was not purchased but instead borrowed. The dissolved oxygen probe was not included due to previously cited reasons.

IV. Housings

Overview: In designing housings for the electronics, it was important to have a practical and reliable housing at a low cost. The battery had to be large enough so that it could continually give the necessary voltage requirement. The wiring had to be easy to replace. Another requirement involved the water proofing of the wire as it enters the housing unit.

Discussion: Two Ikelite housings were purchased as enclosures for the electronics and battery. The reason for the purchase of two housings as opposed to one large housing involved the hazard of battery acid corroding the electronics. The Ikelite housings were preferred over in-shop constructed plexiglass ones since these were not guaranteed against leaks. The size constraints on the housings bought did not warrant a need for custom fabrication.

In wiring the apparatus, PVC adapters were used to run wire between the housings. The wires were protected in vinyl tubing and sealed with silicon. Ideally, the purchase of special connectors would have been preferred but budget constraints limited the options.

In sizing a battery for the sampler, the sum of all the amp hours for each source and the addition of a safety factor of 1.5 came to 9 amp hours. Since battery sizes were not offered in the amp hours needed, a larger size was chosen, 15 amp hours. The battery selected was well within the design requirements however it could not supply sufficient current to the 1500 gph pump (6.5 amp\ draw at 12 volts). This limited the maximum flow rate of the pump to 1000 gph. In reference to previous discussion of the pump requirements, this figure still exceeds the minimum requirements needed. Testing of the battery yielded favorable performance in terms of long term constant power demand as observed by running the pump continuously for two hours and monitoring the flow with the flowmeter.

FINAL TESTING

The testing of the constructed prototype plankton sampler will occur during the week of May 1- May 5 at the Jackson Estuarine Laboratory in the estuary of Great Bay. Several test runs of differing preprogrammed time periods will occur. Plankton samples will be counted after splitting the actual sample several times with a Folsom splitter. Counting of the zooplankton types shown in figure 1 will be done with the use of Bogarov trays and dissecting scopes.

References:

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Herman, A.W., M. R. Mitchell, and S. W. Young, 1984. A continuous pump sampler for profiling copepods and chlorophyll in the upper oceanic Layers. Deep-Sea Research, 31A: 439-450.

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Mackas, D. L., and R. W. Owen, 1982. Temporal and spatial resolution of pump sampling systems. Deep-Sea Research, 29A: 883-892.

Miller, C. B. and D. C. Judkins, 1981. Design of pumping systems for sampling zooplankton, with description of two high capacity samplers for coastal studies. Biological Oceanograpgy, 1: 29-56.

O'Hara, F. C., 1984. Description of a new automatic plankton sampler that collects and preserves multiple samples over a period of several days. Hydrobiology, 111: 103-105.

Wiebe, Peter H., K. H. Burt, S. H. Boyd and A. W. Morton, 1976. A multiple opening/closing net and environmental system for sampling zooplankton. Journal of Marine Research, 34: 313-326.

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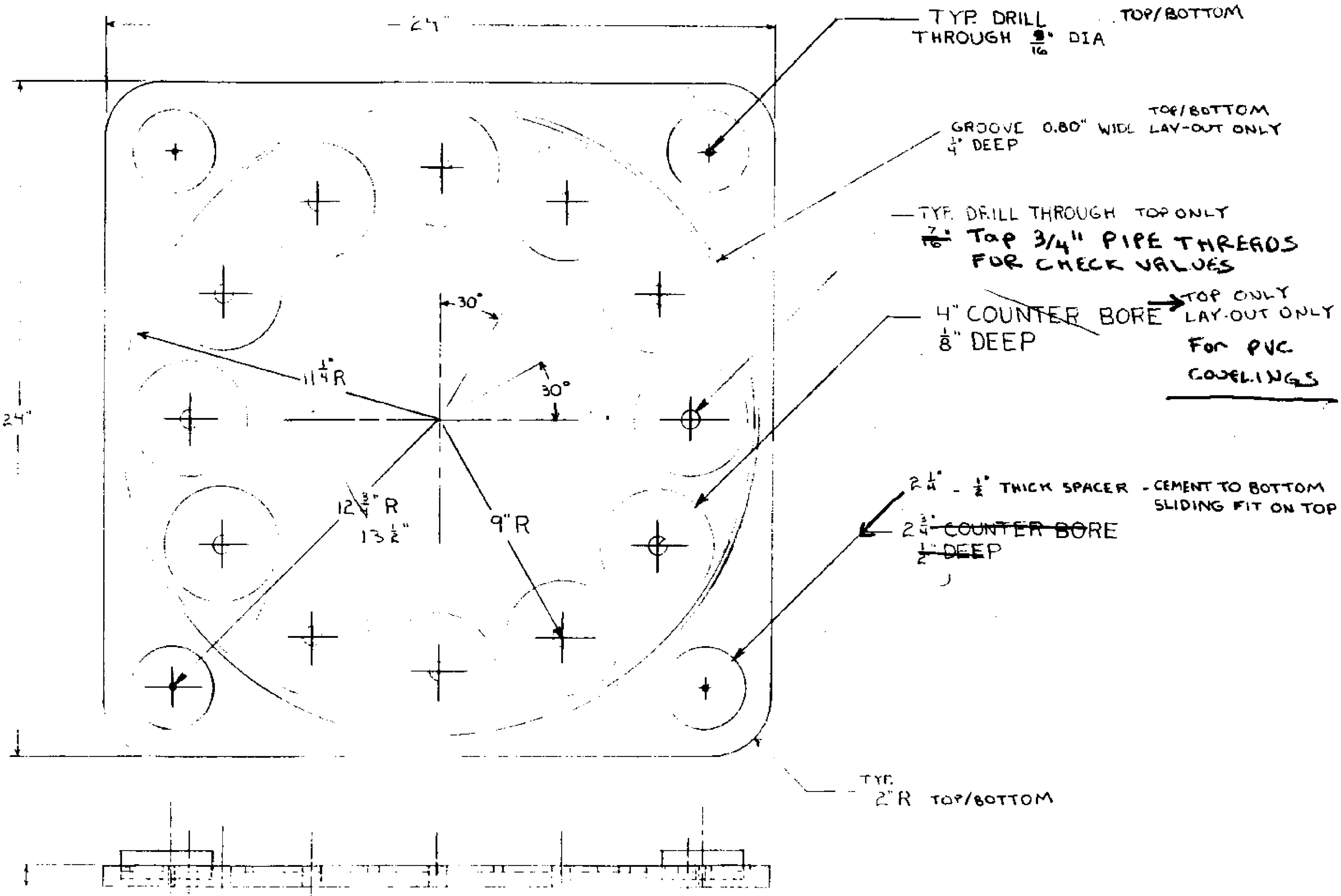
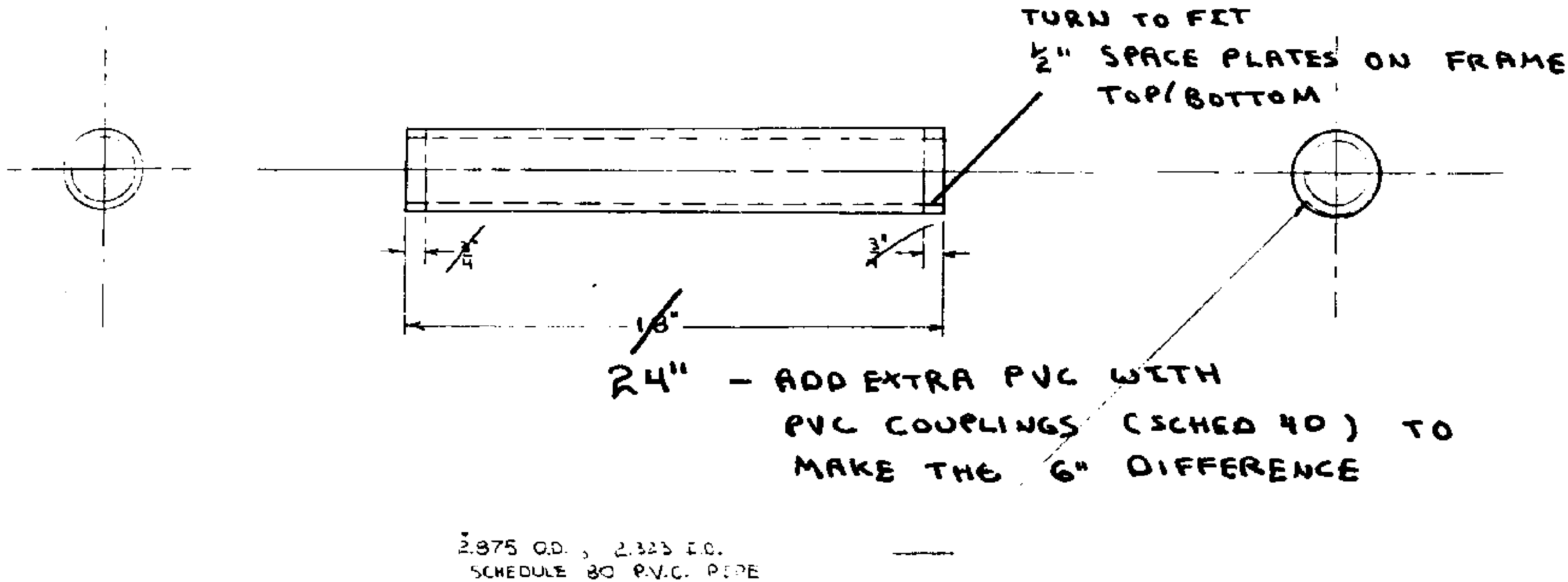
Applied Physics Laboratory: A division of the University of Washington, Seawater Parameter Subroutines.

TOP/BOTTOM PLATE AS BUILT



APPENDIX - DRAWING 1

NOTE: INCOMPLETE DRAWING -



DRAWING NOT TO SCALE

②

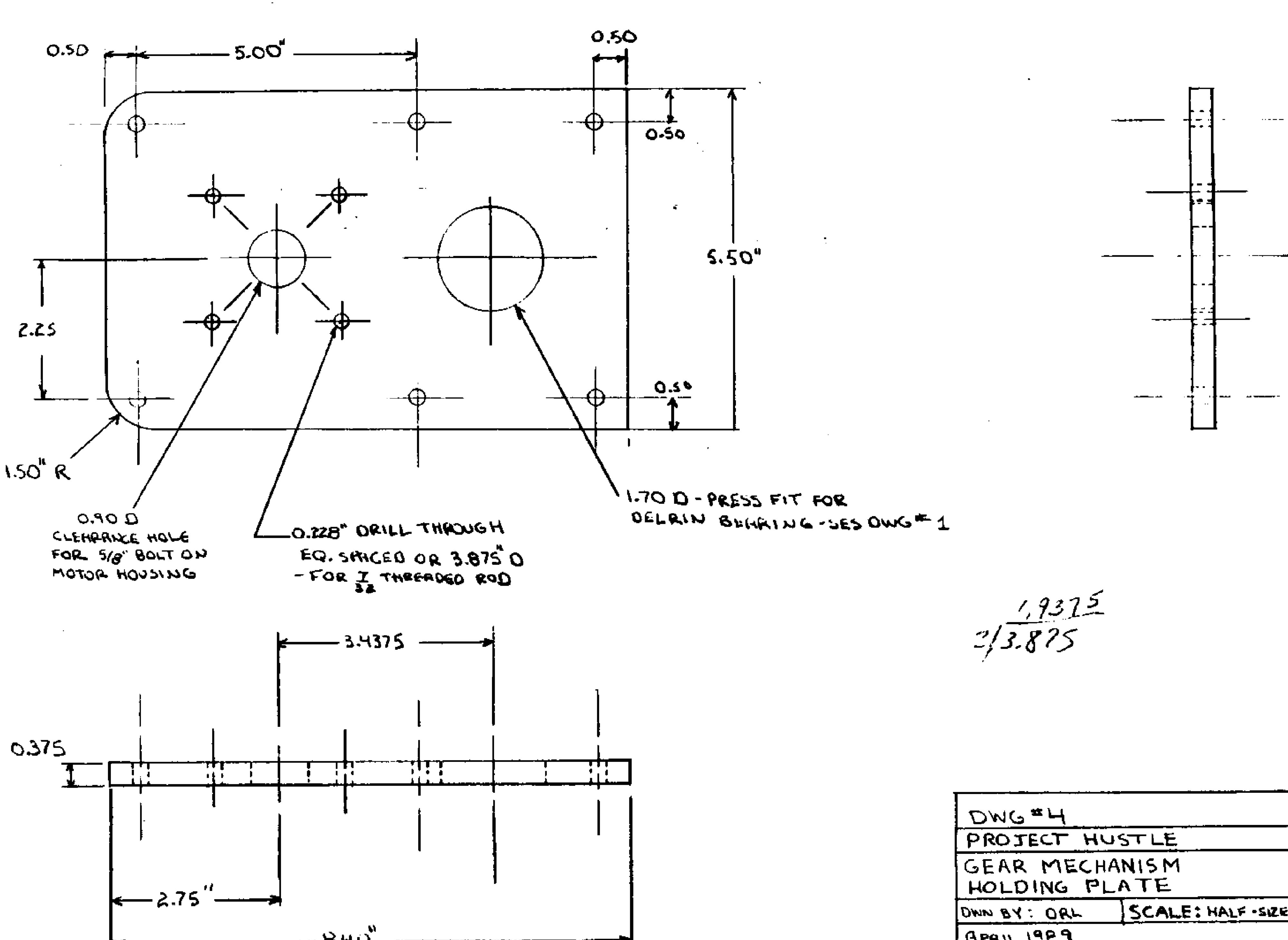
PROJECT H.U.S.T.L.E.

SCALE QUART & SIZE	APPROVED BY	DRAWN BY DAL
DATE FEB 89		REVISED

TOP & BASE PLATE SUPPORTS

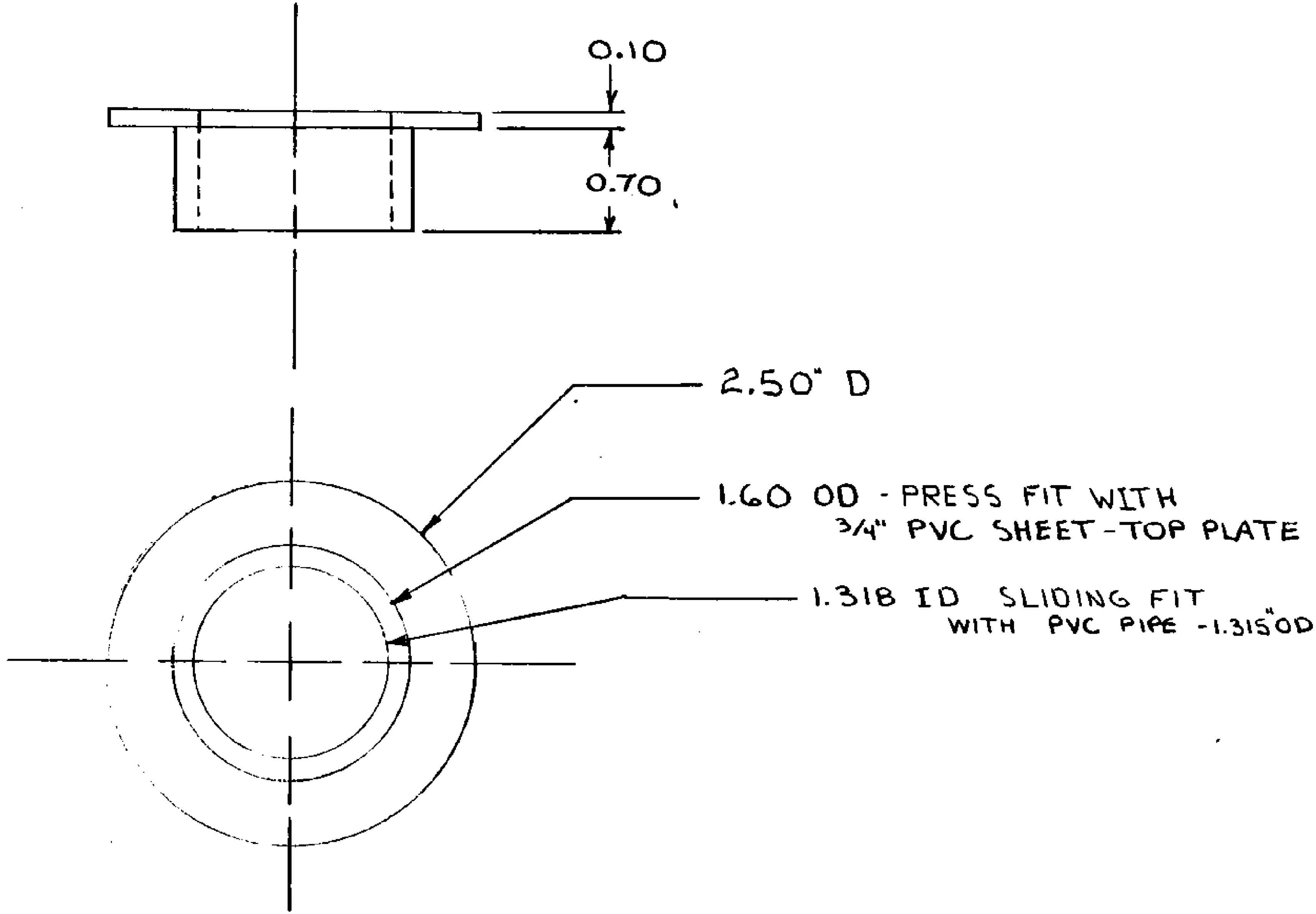
DRAWING NUMBER

APPENDIX
DRAWING 2



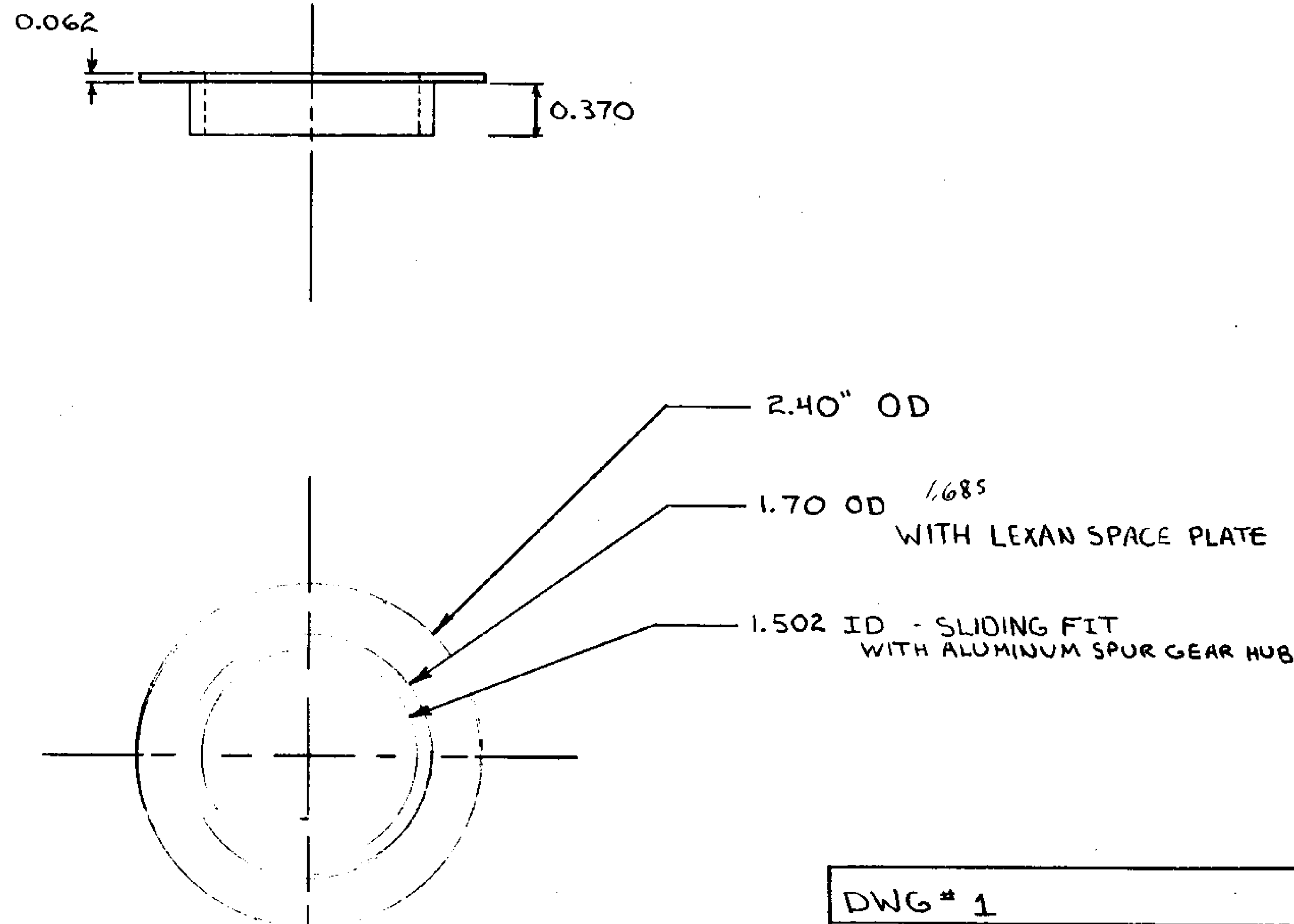
DWG #4	
PROJECT HUSTLE	
GEAR MECHANISM HOLDING PLATE	
DWN BY: ORL	SCALE: HALF-SIZE
APRIL 1989	

APPENDIX DRAWING 3



APPENDIX DRAWING 4

DWG # 2		
PROJECT H.U.S.T.L.E.		
DELRIN BEARING # 2		
DRWN: DRL	SCALE: FULL	4-89
TOLERANCES	X.XX ± 0.01 X.XXX ± 0.005	

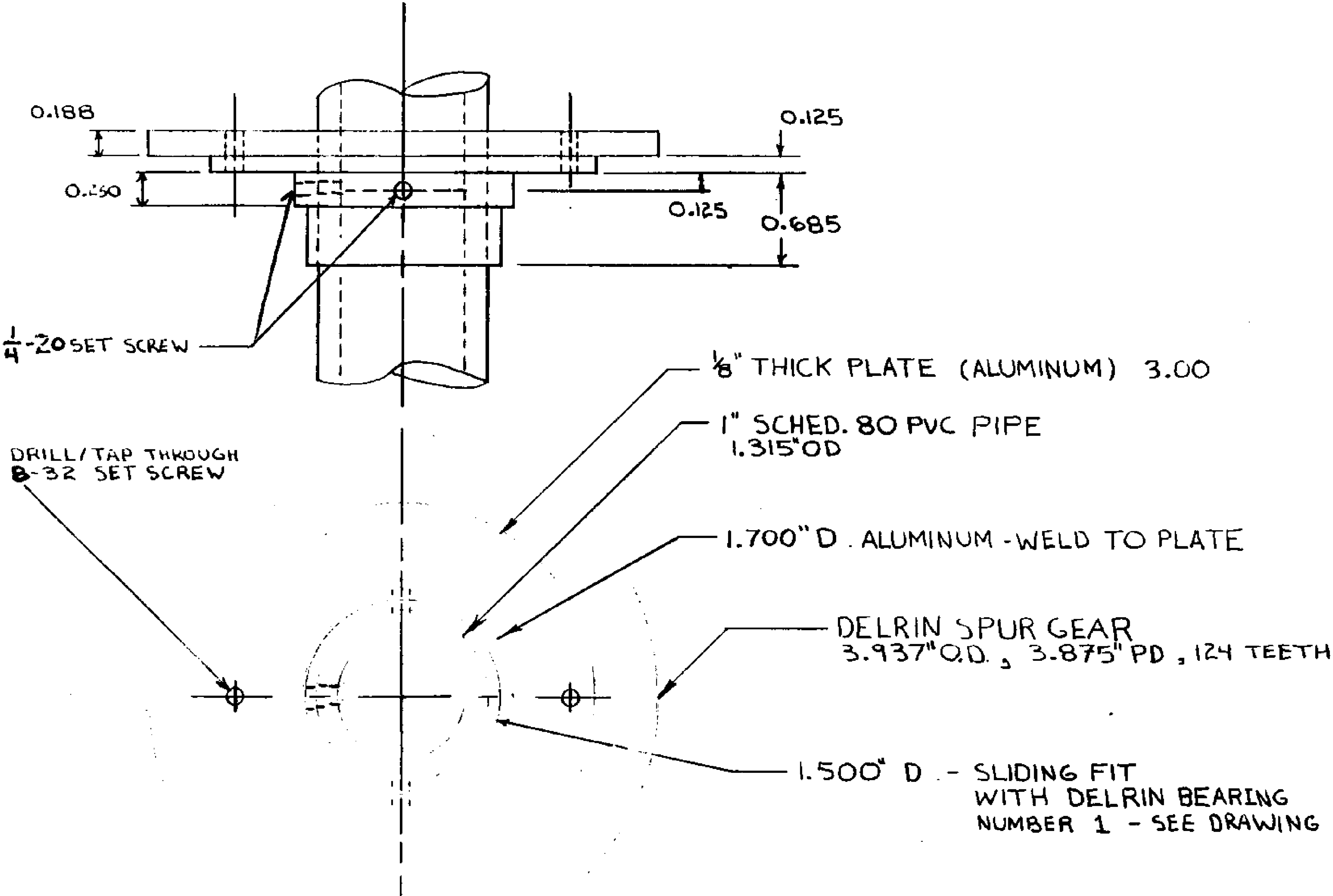


DWG # 1		
PROJECT H.U.S.T.L.E.		
DELRIN BEARING # 1		
DRWN: DRL	SCALE: FULL	4-89
TOLERANCES	X.XX ±0.01	
	X.XXX ±0.005	

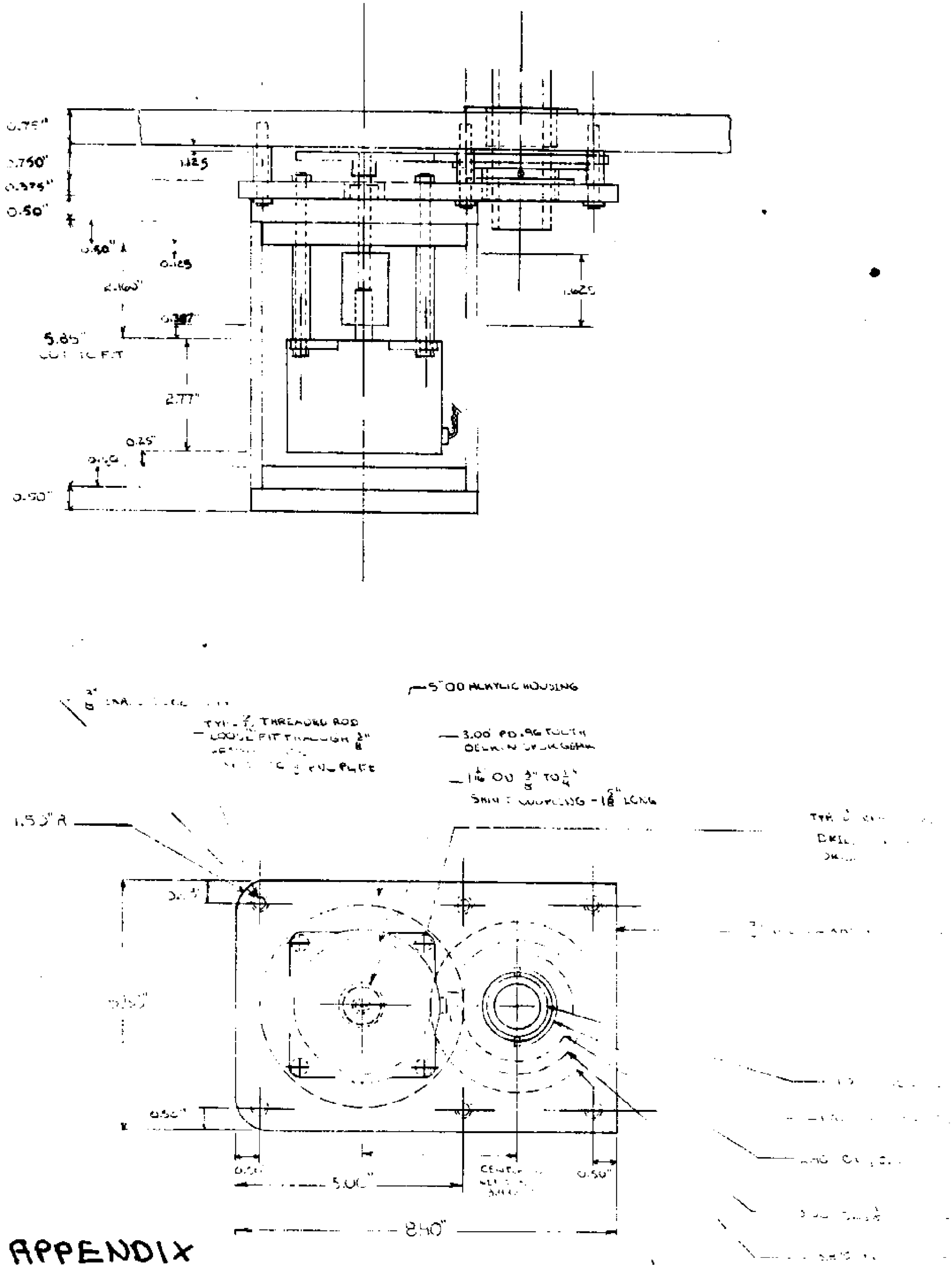
APPENDIX DRAWING 5

APPENDIX

DRAWING 6



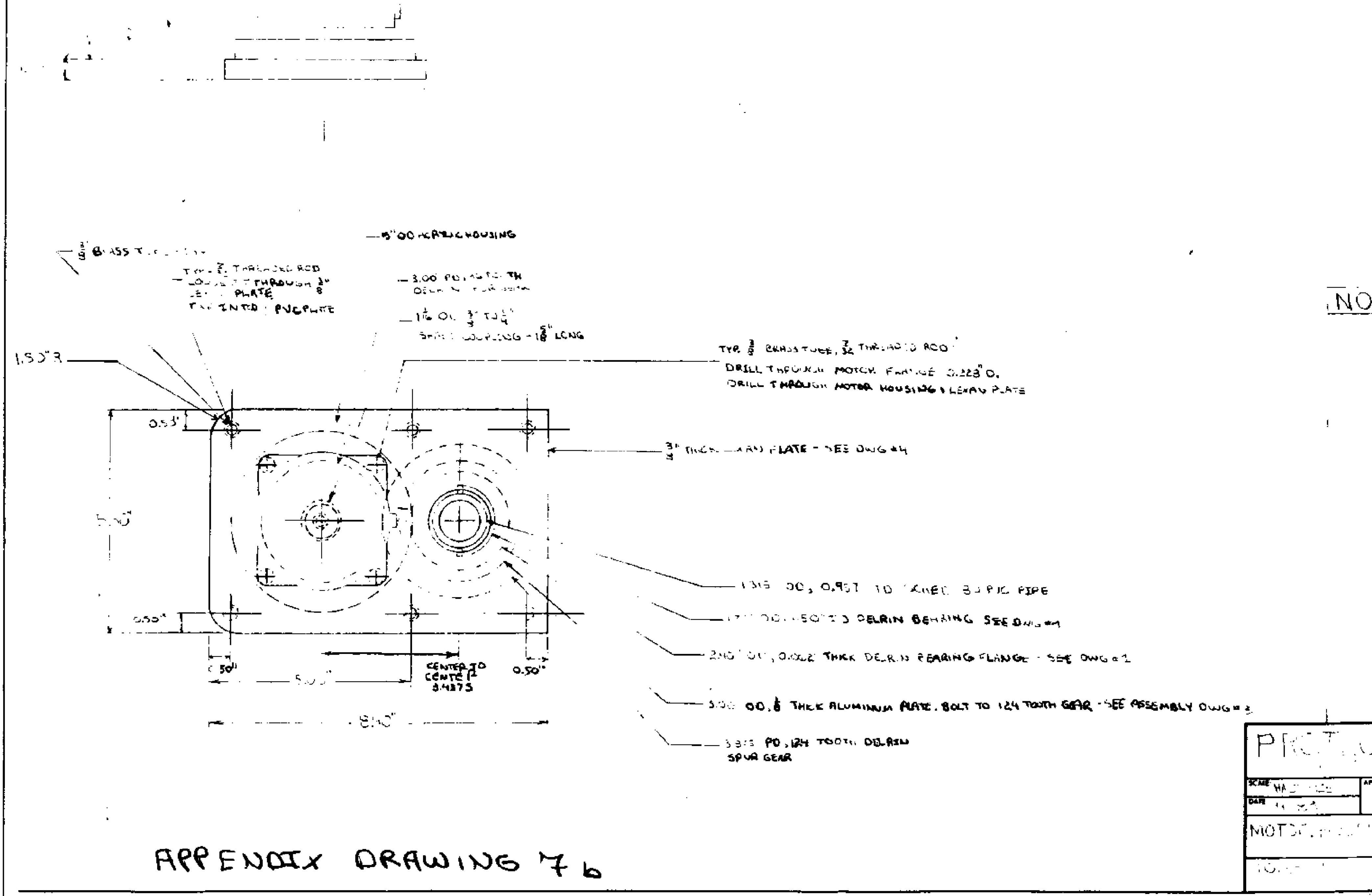
TOLERANCES	X.XX ± 0.01	ASSEMBLY DWG. #3
	X.XXX ± 0.005	PROJECT HUSTLE
		SPUR GEAR HUB
		DRN BY: DKL | SCALE: FULL | 4-E-1



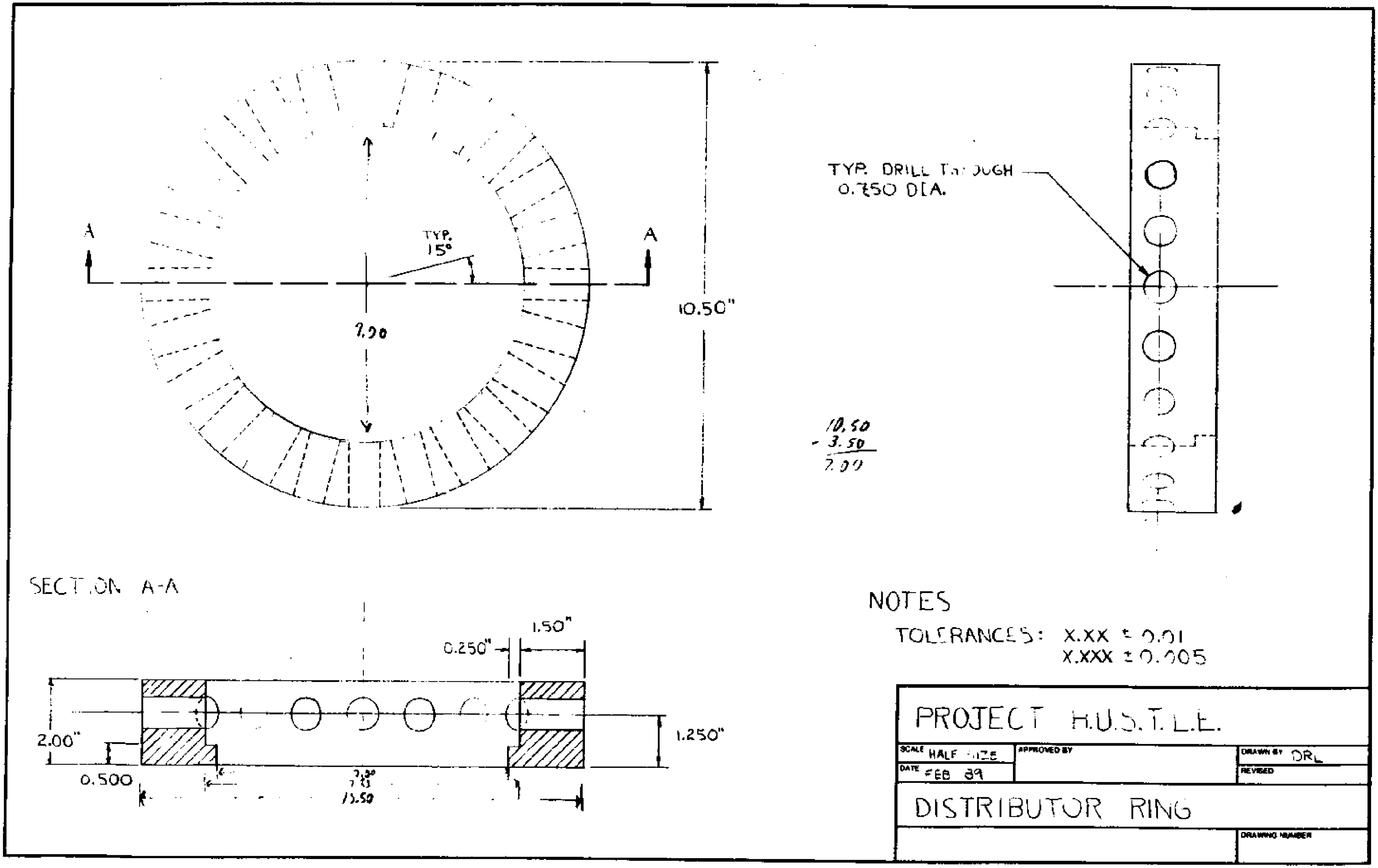
APPENDIX

DRAWING 7a

NOT TO SCALE



APPENDIX DRAWING 7b

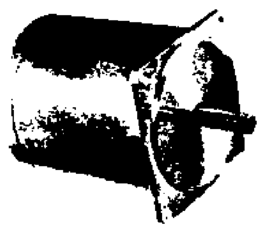


DRAWING NOT TO SCALE

APPENDIX DRAWING B

Permanent Magnet Stepping Motor 1.8°

Costs – ≈ 1400 Singles



EAD Size 34 permanent magnet DC stepping motors are precision bi-directional devices with position accuracy of ± 3% noncumulative. Motors are totally enclosed with permanently lubricated ball bearings. Standard motors have 6 leads. Motors with 5 or 8 leads can be furnished to meet existing applications. These motors are also available in 1.875, 5, and 15 degree step angles.

Drives

Phase Current
Run w 2 Phases On.

		4 PHASE UNI-POLAR CONNECTION							
		2 PHASES ENERGIZED				1 PHASE ENERGIZED			
MODEL NUMBER	STEP ANGLE	RATED VOLTAGE VOLTS	RATED CURRENT AMPS	PHASE RESISTANCE OHMS	PEAK TORQUE OZ.-IN.	RATED VOLTAGE VOLTS	RATED CURRENT AMPS	PHASE RESISTANCE OHMS	PEAK TORQUE OZ.-IN.
LA34AGK-1		1.7	4.72	0.36		2.4	6.68	0.36	
LA34AGK-2		2.6	3.06	0.85		3.7	4.35	0.85	
LA34AGK-4	1.8	5.3	1.61	3.30	188	7.5	2.27	3.30	188
LA34AGK-9		12.0	0.67	18.00		17.0	0.94	18.00	
LA34AGK-10		24.0	0.33	72.00		34.0	0.47	72.00	
LA34BJK-1		2.5	4.55	0.55		3.5	6.43	0.55	
LA34BJK-2		3.0	4.00	0.75		4.2	5.66	0.75	
LA34BJK-30	1.8	6.0	2.00	3.00	336	8.5	2.83	3.00	336
LA34BJK-31		12.0	1.04	11.50		17.0	1.48	11.50	
LA34BJK-32		24.0	0.55	44.00		34.0	0.77	44.00	
LA34CKK-2		2.2	7.10	0.31		3.1	10.03	0.31	
LA34CKK-1		2.8	5.38	0.52		4.0	7.69	0.52	
LA34CKK-3	1.8	4.3	3.58	1.20	496	6.1	5.08	1.20	496
LA34CKK-37		6.0	2.31	2.60		8.5	3.27	2.60	
LA34CKK-38		12.0	1.17	10.30		17.0	1.65	10.30	
LA34CKK-39		24.0	0.59	41.00		34.0	0.83	41.00	

		2 PHASE BI-POLAR SERIES CONNECTION							
		2 PHASES ENERGIZED				1 PHASE ENERGIZED			
MODEL NUMBER	STEP ANGLE	RATED VOLTAGE VOLTS	RATED CURRENT AMPS	PHASE RESISTANCE OHMS	PEAK TORQUE OZ.-IN.	RATED VOLTAGE VOLTS	RATED CURRENT AMPS	PHASE RESISTANCE OHMS	PEAK TORQUE OZ.-IN.
LA34AGK-1		2.4	3.34	0.72		3.4	4.72	0.72	
LA34AGK-2		3.7	2.17	1.70		5.2	3.06	1.70	
LA34AGK-4	1.8	7.5	1.14	6.60	235	10.6	1.61	6.60	235
LA34AGK-9		17.0	0.47	36.00		24.0	0.67	36.00	
LA34AGK-10		34.0	0.24	144.00		48.0	0.33	144.00	
LA34BJK-1		3.5	3.18	1.10		5.0	4.55	1.10	
LA34BJK-2		4.2	2.60	1.50		6.0	4.00	1.50	
LA34BJK-30	1.8	8.5	1.42	6.00	420	12.0	2.00	6.00	420
LA34BJK-31		17.0	0.74	23.00		24.0	1.04	23.00	
LA34BJK-32		34.0	0.39	88.00		48.0	0.55	88.00	
LA34CKK-2		3.1	5.00	0.62		4.4	7.10	0.62	
LA34CKK-1		4.0	3.85	1.04		5.6	5.38	1.04	
LA34CKK-3	1.8	5.1	2.54	2.40	620	8.6	3.58	2.40	620
LA34CKK-37		8.5	1.63	5.20		12.0	2.31	5.20	
LA34CKK-38		17.0	0.82	20.60		24.0	1.17	20.60	
LA34CKK-39		34.0	0.41	82.00		48.0	0.59	82.00	

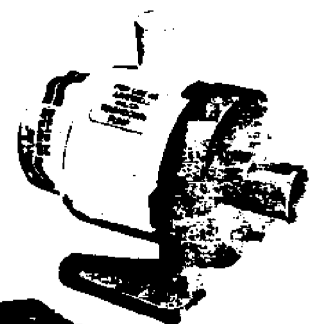
Note All parameter values are based on constant power dissipation

APPENDIX – A-1

Pump Specifications

	rule® 3500			rule® 2800	rule® 1800	rule® General Purpose		rule® 5 year	rule® 2000			rule® 1500	rule® 800	rule® 450	Replacement Power Modules
Model No.	14	16	15	A55D	A53D	17	19	09	10	11	12	02	20	25	23
Volts	12V	24V	32V	110V	110V	12V	32V	12V	12V	32V	24V	12V	12V	12V	12V
Capacity G.P.H.	3500	3500	3500	2800	1800	3000	3000	2000	2000	2000	2000	1500	800	450	800
Amps/Watts	15A	8A	6A	175W	100W	15A	6A	12A	12A	5A	6A	7A	4A	2A	4A
Height	7¼"	7⅛"	7⅛"	8¼"	7⅛"	5¼"	5¼"	6"	6"	6"	6"	6"	4"	3½	-
Width	4⅞"	4⅞"	4⅞"	4½"	4½"	8½"	8½"	4¼"	4¼"	4¼"	4¼"	4¼"	2½"	2¼"	-
Wt. lbs/oz.	5/4	5/4	5/4	5/8	3/0	5/10	5/10	2/15	2/14	2/14	2/14	2/10	14 oz	9 oz	11 oz
Switch Adapter	Yes	Yes	Yes	-	-	-	-	Yes	Yes	Yes	Yes	Yes	No	No	No
Price	$124.00	$129.00	$129.00	$129.00	$99.00	$129.00	$134.00	$97.00	$78.00	$83.00	$80.00	$66.00	$36.00	$27.00	$31.00
Hose	1½" Dia. Mod. #88			1½" Dia. Mod. #88	1⅛" Dia. Mod. #80	1½" Dia. Mod. #88		1⅛" Dia. Mod. #80					¾" Dia. Mod. #81		
Thru-Hull Fitting	1½" Dia. Mod. #59			1½" Dia. Mod. #59	1⅛" Dia. Mod. #60	1½" Dia. Mod. #59		1⅛" Dia. Mod. #60					¾" Dia. Mod. #61, #61S or #62		-
Hose Adapter	1½" to 1⅛" Mod. #67			1½" to 1⅛" Mod. #67	1⅛" to ¾ or ⅝" Mod. #69	1½" to ¾" Mod. #63		1⅛" to ¾" or ⅝" Mod. #69					-		-
Thru-Bulkhead Adapter	-			-	-	1½" to ¾" Mod. #63		-					-		-
Automatic Switch	31, 35, 37, 39, 35F, 37F			-	-	-		31, 35, 37, 39, 35F, 37F					35, 37, 39, 35F, 37F		-
Switch Adapter	Model #64			-	-	-		Model #65					-		-

General Purpose Pump



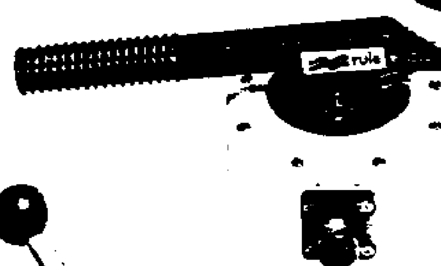
The 3000 G.P.H. rule GENERAL PURPOSE PUMP is designed for use as a washdown pump and/or to circulate water to your livewell tank(s). Heavy-duty construction for use on commercial or pleasure boats.

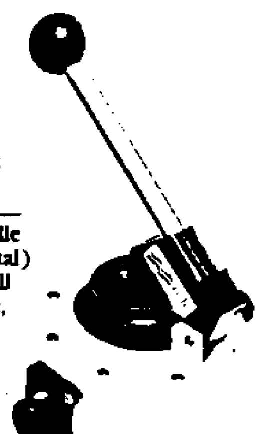
Because it is a submersible pump, it must be located below the water line to insure prime

Hand Pumps

Lever Pumps

Made of rugged non-corrosive materials, these self-priming diaphragm pumps are ideal for bilge pumping, clearing holding tanks and general fluid transfer. They may be mounted on a horizontal or vertical surface. Handles may be oriented in a variety of positions. Fittings accommodate 1⅛" or 1½" inside diameter (I.D.) hose.



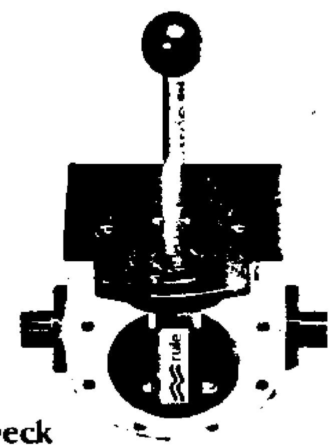


Removable Two Position Handle

The removable handle (vertical or horizontal) features a rubber ball grip for comfortable, positive pumping action.

Permanently Attached Handle

The most economical of the Rule Lever Pumps has a rugged, permanently attached horizontal handle.



Thru-Deck

Designed for thru-deck or thru-bulkhead mounting. The thru-deck fitting is equipped with a seal which discourages water pooling at the well. A removable handle with rubber ball grip insures positive pumping action and allows the options of being kept securely in the pump or stowed out-of-the-way.

Portable Pumps

Constructed of sturdy ABS plastic with comfort-grip handle providing smooth firm strokes. Available in 24" and 36" sizes—with, or without, hose.

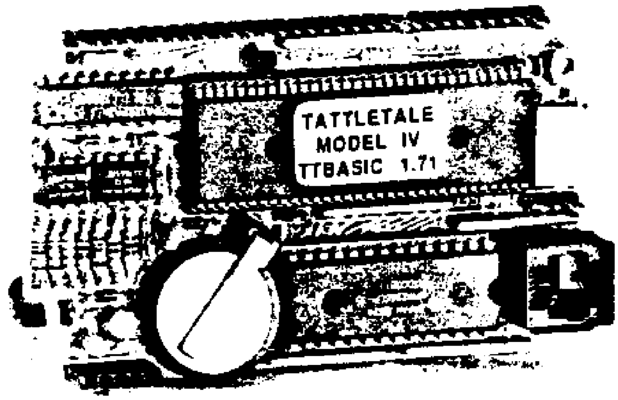
	Portable Pumps			
Model No.	164	165	167	168
Capacity	8 gpm	8 gpm	10 gpm	10 gpm
Hose Size	1⅛" I.D. Model #80	1⅛" I.D. Model #80	1⅛" I.D. Model #80	1⅛" I.D. Model #80
Size	24" w/o hose	24" w/ 2ft 1⅛" hose	36" w/o hose	36" w/ 4 ft. 1⅛" hose
Price	$18.00	$19.00	$19.50	$21.00

Lever Pumps					
Permanently Attached Handle		Removable & Two Position Handle		Thru-Deck	
141	142	144	145	147	148
12 gpm max	16 gpm max	12 gpm max	16 gpm max	12 gpm max	16 gpm max
1⅛" I.D. Model #80	1½" I.D. Model #88	1⅛" I.D. Model #80	1½" I.D. Model #88	1⅛" I.D. Model #80	1½" I.D. Model #88
14"L x 6⅝"W x 7⅛"H	14"L x 6⅝"W x 7⅜"H	15"L x 6⅝"W x 5"H (with handle)	15"L x 6⅝"W x 5"H (with handle)	6⅝"D x 6⅝"W x 9½H (w/o handle)	6⅝"D x 6⅝"W x 9½"H (w/o handle)
$42.00	$43.50	$48.50	$52.00	$63.50	$64.00

APPENDIX - A-2

Tattletale® Model IV

0-28K Storage
2 mA dormant



Tattletale Model IV

Features

- 32K for program, variables and storage
- Data storage expandable to 2 Megabytes
- 11-channel, 10-bit A-D ratiometric converter
- 16 programmable digital I/O lines
- 2.25" x 3.725" x 0.8" size
- 2-15 mA operating
- 2 mA dormant, 30 µA 'DONE'
- TTBASIC operating system
- Battery-backed RAM
- Onboard voltage regulator
- Onboard temperature sensor

Applications

Tattletale Model IV addresses applications where small size and low cost are the primary design considerations. Even so, the Model IV boasts extensive versatility with its 11-channel,10-bit A-D converter and 16 digital I/O lines. Instead of utilizing an EPROM, the Model IV maintains the user's program in RAM with an onboard lithium button cell. The lithium backup battery provides at least six months of data retention after the main battery has been removed or has dropped below 3 volts.

Applications requiring more data storage can take advantage of the 4MAT and 4PLUS boards to increase the Model IV's capacity to as much as two Megabytes, while allowing operation with average currents as low as 120 µA.

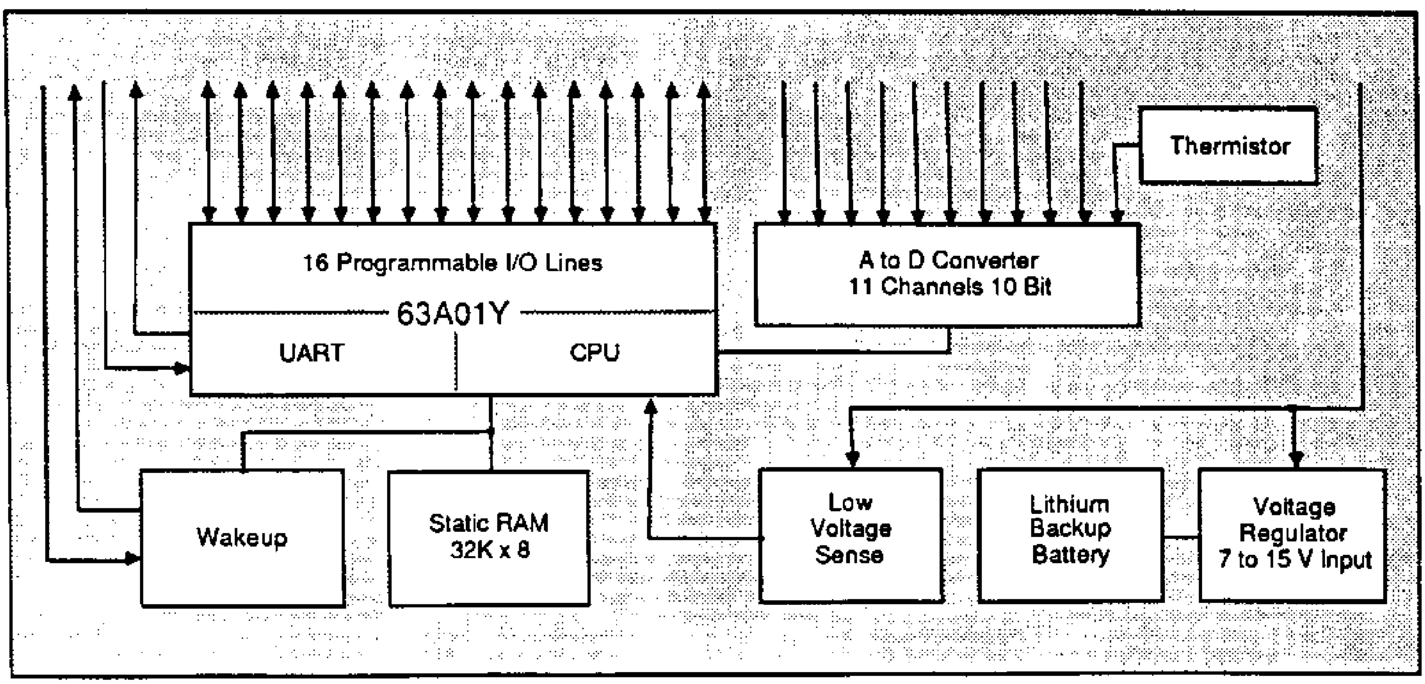
TTBASIC

The Model IV's version of TTBASIC takes advantage of the board's unique hardware.

1) The low power DONE mode places the Model IV in a dormant mode, reducing the current drain to 30 µA. The program will restart when the pushbutton on the interface cable or the board's 'wakeup' pins are momentarily connected.

2) The Model IV has a software real-time clock that will keep time as long as DONE is not executed.

3) The user can divide 28K among program, array variable storage and data storage.

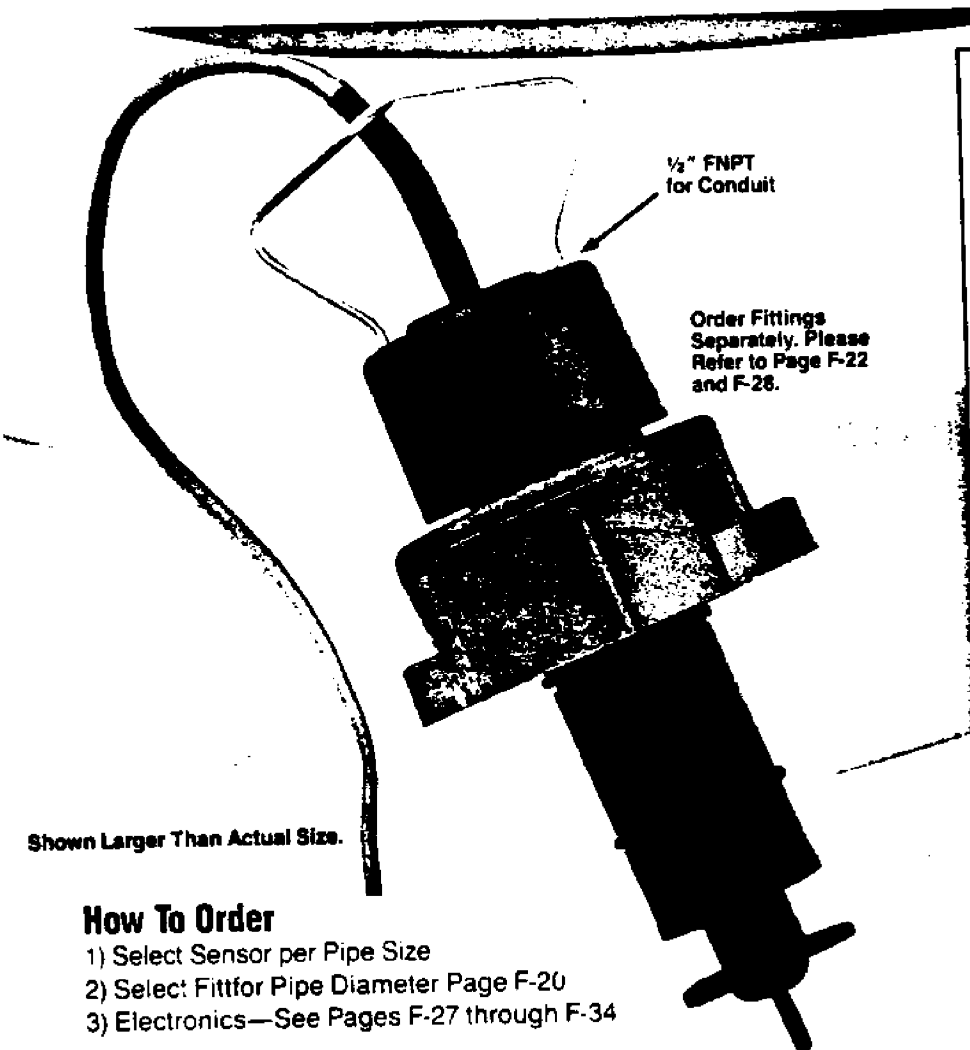


ONSET Computer Corp., P.O. Box 1030, 199 Main Street, N. Falmouth MA 02556 (617) 563-2267 TLX 469915

APPENDIX - A3

ACCURATE INDUSTRIAL FLOWMETER SY

Paddle Wheel Flow Sensors + Installation Fittings + Ele



Shown Larger Than Actual Size.

- For Liquids
- Low Pressure Drop
- Range: 1 to 50 FPS
- Inert to Most Acids and Bases
- ±1% Sensor Accuracy*
- Easy to Install and Maintain
- All Plastic Design Available

2 YEAR

WARRANTY

$160

How To Order

1) Select Sensor per Pipe Size
2) Select Fittfor Pipe Diameter Page F-20
3) Electronics—See Pages F-27 through F-34

SENSORS

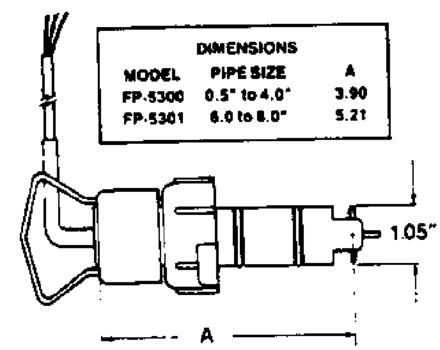
Model No.	Price	Accuracy*	Pipe Size
FP-5300	$160	± 1% full scale	0.5" to 4.0" Diameter
FP-5301	190		6.0" to 8.0" Diameter

*All installation fittings are supplied with a plug for use when sensor is removed for repair or cleaning.

NOTE: For all plastic unit with PVDF rotor shaft, add suffix "-AP" to sensor part number and add $31 to base price.

DIMENSIONS

MODEL	PIPE SIZE	A
FP-5300	0.5" to 4.0"	3.90
FP-5301	6.0 to 8.0"	5.21



SPECIFICATIONS:

Output Signal: Sine wave, 1 V p-p per ft./sec.
Output Frequency: 5-6 Hz per ft./sec.
Source Impedance: 8 K ohm
Range: 1-50 FPS
Linearity: ±1% full scale
Accuracy: ±1% full scale
Repeatability: ±0.5% full scale
Maximum Pressure: 200 PSIG max. at 68°F (20°C)
Maximum Temperature: PVC: 140°F max. @ 25 PSIG, CPVC: 180°F
Maximum Percentage of Solids: 1% of fluid volume
Pressure Drop: Equal to 8 ft straight pipe.
Material: Transducer Housing: glass-filled polypropylene; O-Rings: Viton; Shaft: Titanium; PVDF opt. Rotor: PVDF.
Cable Length: 25 ft., can be extended with copper wire to 200 ft.

The OMEGA® Series FP-5300 Flow Sensor is an electromechanical volumetric flow transducer which generates a sine-wave output with a frequency and amplitude linearly proportional to the rotor rotation velocity. Liquid flow rotates four permanent magnets past a coil, inducing an AC voltage proportional to this rotation rate. The frequency output is two cycles per rotation.

OMEGA's patented open-cell rotor design eliminates cavitation at flow rates up to 50 FPS for providing and maintaining superior linearity. Closed or solid rotor designs will cavitate at these velocities, creating a non-linear and non-repeatable signal.

The FP-5300 Flow Sensor is designed for operation in ½ inch through 4 inches, where flow is fully developed. In 6 to 8 inch pipes, the FP-5301 should be used. These sensors can be used with fluids containing particulate matter up to 1% of volume.

APPENDIX - A4

6301 CPU

The Model IV is based on the 6301 CPU chip. This part is a descendant of Motorola's 6800, but is all CMOS, and has a thoroughly enhanced instruction set that includes 8 bit x 8 bit multiply, and new bit setting and clearing functions. The instructions are fast and very complete. The 6301 has a built-in UART, two timers, 256 bytes of RAM and a host of I/O lines. Most of these features are invisible to the user. They are, however, responsible for TTBASIC's remarkably fast execution speed. The 6301's 4.9152 MHz crystal is adjusted within 5 ppm of its nominal frequency at room temperature, ensuring accurate timekeeping.

The Model IV's TTBASIC is resident in the 6301's 16K ROM.

16 Digital I/O Lines

The Model IV has 16 digital I/O lines which can be programmed individually as inputs or outputs. Most of these lines have specialized uses, as software UART, counter input, square wave output, shift register input and output, and interrupts.

Pins D14 and D15 have no alternate use. All other digital I/O pins have the same alternate uses as the Model II (see page 3).

These lines are available at 0.1" spaced 0.025" square pins, along with ground and +5V. Each pin is capable of driving one TTL load, and all are configured as inputs at power-up.

Battery Strap

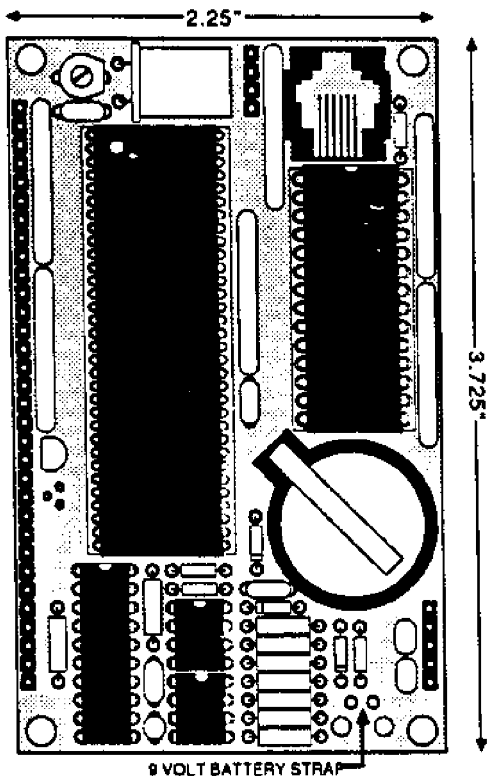
The Models II, III and IV have a 6" (15 cm) long battery connector attached to the board. This two-conductor wire is designed to connect to a 9-volt transistor radio battery or battery stack with the same snap-type connection.

Hardware UART

The UART is actually located on the 6301. Unlike Models II and III, the Model IV's drivers are mounted in the interface cable. The connections to the interface cable are made at a 6-pin modular socket on the corner of the board.

The UART is interrupt-driven and has a 256-byte input buffer. On power-up the UART runs at 9600 baud. As with Models II and III, the rate can be changed to 1200 or 300 baud using simple commands.

Two other lines are also available at the plug. When momentarily shorted, these lines can wake the Model IV from its low-power 'DONE' mode. These two lines as well as the serial in and out lines are located at a set of 0.025" square pins spaced 0.1" apart next to the modular connector.



Tattletale® Model IV

32K byte RAM

Virtually all of the Model IV's RAM is in a socketed 32K x 8 RAM chip. 4K is used for stack and system variables. The remaining 28K can be divided up in any way among program, array variables and data storage. The part is socketed to allow access to the 6301's address and data buses from an add-on card by connecting to the socket. This approach is used by the 4MAT datafile expansion board and its expansion board, the 4PLUS.

Lithium Battery

The Model IV has a lithium battery to retain program and data if the main battery is removed or drops below three volts. This battery has ample capacity to maintain the memory for six months at normal temperatures. The CR2032 battery is standard and available from a number of manufacturers.

10-bit, 11-channel A-D Converter

The Model IV's converter is designed to make conversions ratiometric to the Tattletale's nominal 5-volt supply. The reference input to the converter is brought to one of the pins. A one-ohm resistor mounted on the board shorts the reference input to the converter's switched supply, and should be removed if an external reference is to be used. If used as an absolute converter, its accuracy is degraded to slightly better than 8 bits due to the supply rejection characteristics of the converter.

Channel 10 measures a thermistor divider, and can be converted to tenths of a degree C using TTBASIC's TEMP function.

Voltage Regulator

The Tattletale has a voltage regulator built onto the board. The regulator will accept a 7- to 15- volt input and provides an average current of 20 mA, a little more than needed by the Model IV itself. The regulator is current limited so that accidentally shorting the supply out will not damage the board. The supply voltage is fixed at 5.00 ± 3%.

Should the supply voltage drop below 6.5 volts, the Model IV will drop into a 'DONE'-like dormant mode. No program or data will be lost and the program will automatically restart (from the lowest TTBASIC line number) as soon as the battery is replaced or recharged.

HD6303Y, HD63A03Y, HD63B03Y

CMOS MICROPROCESSING UNIT (MPU)

Preliminary
JANUARY, 1986

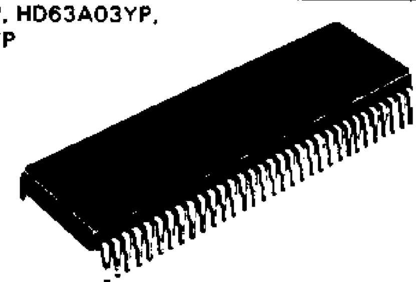
HITACHI

The HD6303Y is a CMOS 8-bit single-chip microprocessing unit which contains a CPU compatible with the CMOS 8-bit microcomputer HD6301V, 256 bytes of RAM, 24 parallel I/O pins, Serial Communication Interface (SCI) and two timers.

■ FEATURES

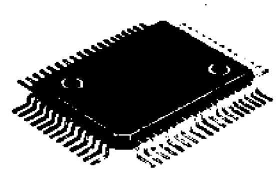
- Instruction Set Compatible with the HD6301V1
- 256 Bytes of RAM
- 24 Parallel I/O Pins
- Parallel Handshake Interface (Port 6)
- Darlington Transistor Drive (Port 2, 6)
- 16-Bit Programmable Timer
  - Input Capture Register × 1
  - Free Running Counter × 1
  - Output Compare Register × 2
- 8-Bit Reloadable Timer
  - External Event Counter
  - Square Wave Generation
- Serial Communication Interface (SCI)
  - Asynchronous Mode (8 Transmit Formats, Hardware Parity)
  - Clocked Synchronous Mode
- Memory Ready
  - 3 Kinds of Memory Ready
- Halt
- Error Detection
  (Address Error, Op-code Error)
- Interrupt — External 3, Internal 7
- Maximum 65k Bytes Address Space
- Low Power Dissipation Mode
  - Sleep Mode
  - Standby Mode (Hardware Standby, Software Standby)
- Minimum Instruction Execution Time — 0.5μs (f = 2MHz)
- Wide Range of Operation
  - V_{CC} = 3 to 5.5V (f = 0.1 to 0.5MHz)
  - V_{CC} = 5V ± 10% { f = 0.1 to 1.0MHz : HD6303Y; f = 0.1 to 1.5MHz : HD63A03Y; f = 0.1 to 2.0MHz : HD63B03Y }

HD6303YP, HD63A03YP, HD63B03YP



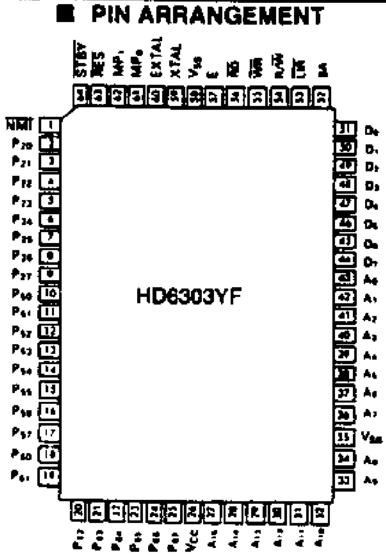
(DP-64S)

HD6303YF



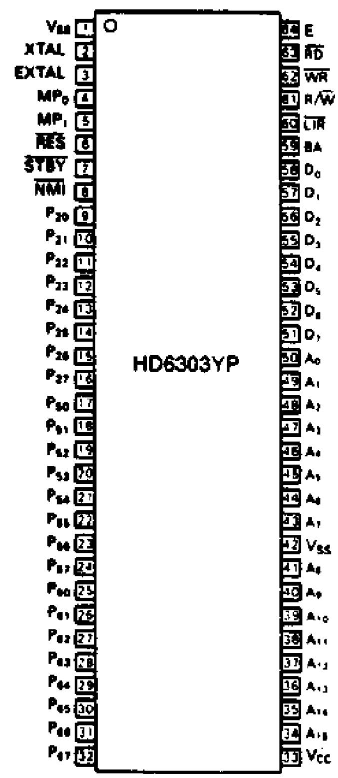
(FP-64)

■ PIN ARRANGEMENT

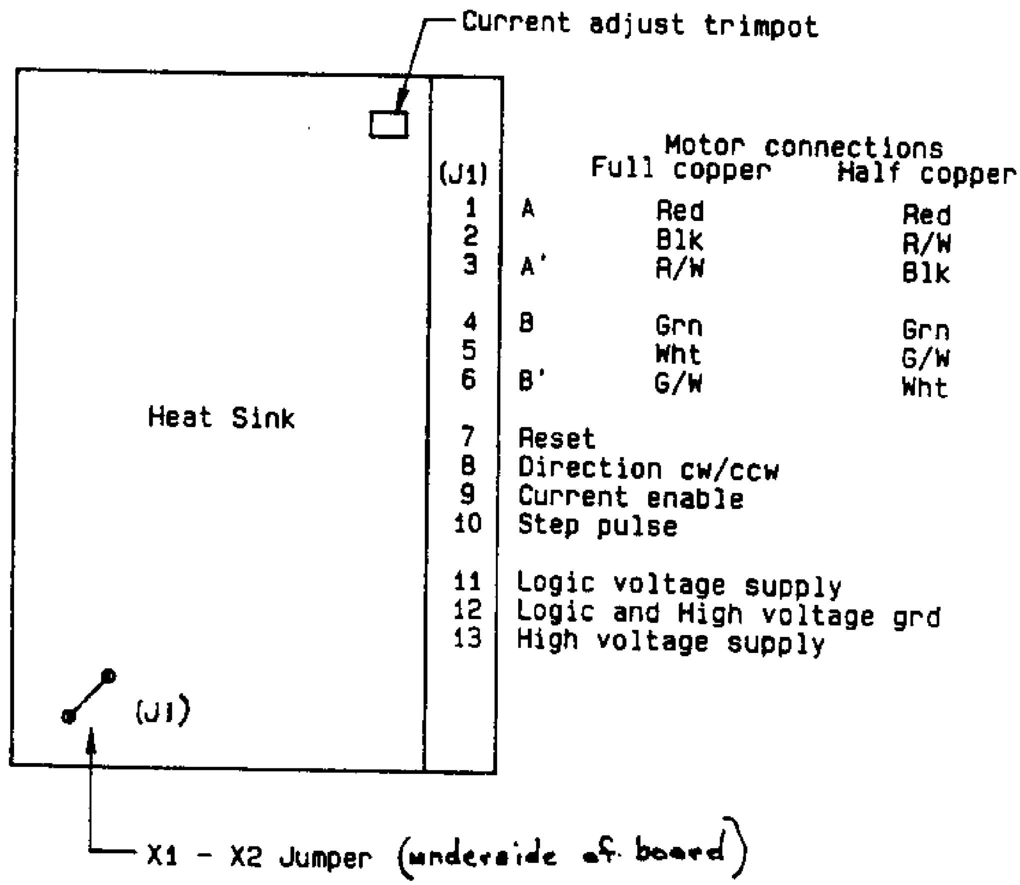


(Top View)

■ PIN ARRANGEMENT



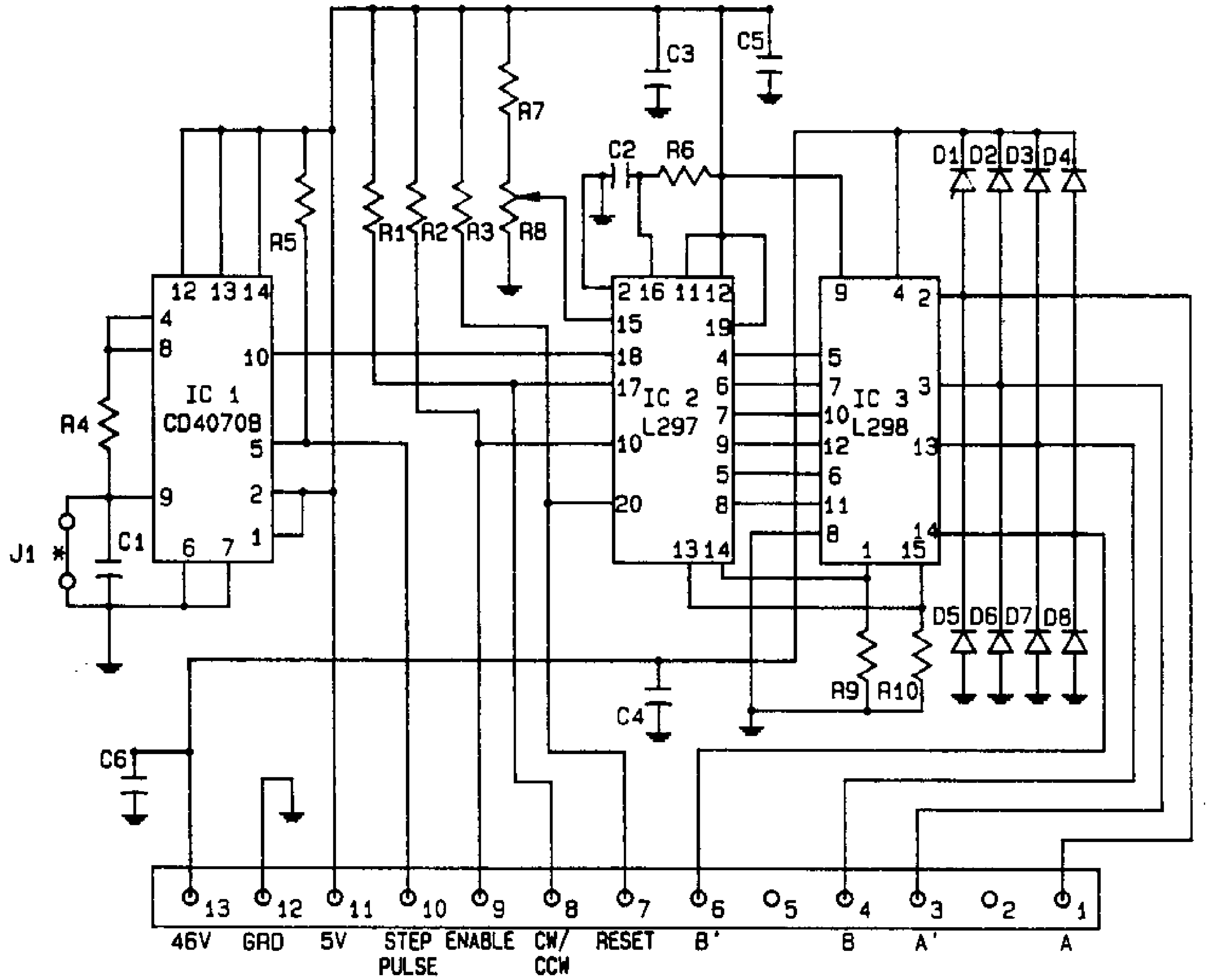
(Top View)



See Figure 2, the circuit schematic, for details on the half or X2 step mode selection via jumper J.

D200 CONNECTION DIAGRAM

Figure #1



* JUMPER J1: Factory Installed, x1 step mode. (1 half step for each step pulse)
User Removeable for x2 step mode. (2 half steps for each step pulse)

PARTS LIST

R1-R5 =10K	R9-R10 = .5 OHM 2 WATT	C1 = .001	D1-D8 = FR303
R6 =22K		C2 = .0033	
R7 =27K		C3, C4, C5 = .1	
R8 =10K POT		C6 = 100uf 50V	

CIRCUIT SCHEMATIC
Figure #2

APPENDIX - A8

```
  1  REM          THIS  PROGRAM  IS THE OPERATING SYSTEM FOR THE
             H.U.S.T.L.E.
  2 REM       REMOTE PLANKTON  SAMPLER (A  TECH 697 UNDERGRADUATE
             OCEAN
  3 REM        RESEARCH PROJECT).  THE SAMPLING TIMES ARE ENTERED
             DURING
  4 REM        PROGRAM EXECUTION  AND THE  SAMPLING DURATIONS ARE
             SELECTED
  5 REM         THROUGH CHANGES IN THE ACTUAL PROGRAM CODE.  ONCE
             THE
  6 REM       PROGRAM IS  EXECUTED, PROMPTS  ARE SELF-EXPLANATORY
             AND THE
  7 REM      TESTING PROCESS IS COMPLETELY CONTROLLED.
 10 PCLR 0,14,15
 15 FOR W=1 TO 10000
 20 NEXT W
 25 REM      ENTER THE DATA AND TIME
 30 INPUT 'ENTER THE YEAR (0-99) ' ?(5)
 35 INPUT 'ENTER THE MONTH (1-12) ' ?(4)
 40 INPUT 'ENTER THE DAY (1-31) ' ?(3)
 45 INPUT 'ENTER THE HOUR (0-23) ' ?(2)
 50 INPUT 'ENTER THE MINUTE (0-59) ' ?(1)
 55 INPUT 'ENTER THE SECOND (0-59) ' ?(0)
 60 STIME
 70 REM      ENTER THE 12 SAMPLING TIMES
 80 PRINT 'THE SAMPLING TIMES FOR EACH OF THE 12 SAMPLES'
 90 PRINT 'WILL NOW BE ENTERED.'
100 PRINT
110 FOR A =1 TO 12
120 PRINT 'ENTER THE HOUR FOR THE # ',A,' SAMPLE'
125 INPUT 'IN MILITARY TIME  ' @(A)
130 NEXT A
140 REM      SET POINTERS FOR DATA STORAGE
150 X=0
160 P=5000
170 REM      LOOP THROUGH EVERY 5 MINUTES, TAKING TEMP. AND SAL.
180 REM      SAMPLES AND CHECKING SAMPLE HOUR.
190 FOR B=1 TO 12
200 SLEEP 0
205 REM      STORE TEMP. AND SAL. VALUES.
210 STORE X,#1,CHAN(0)
220 STORE X,#2,CHAN(1)
230 RTIME
235 REM      STORE TIME OF TEMP. AND SAL. SAMPLE RETRIEVAL.
240 STORE X,#1,?(3)
250 STORE X,#1,?(2)
260 STORE X,#1,?(1)
270 SLEEP 30000
280 RTIME
290 IF @(B)=?(2) GOTO 1000
300 GOTO 200
1000 REM
1010 REM     T IS THE NUMBER OF 1.8 DEGREE MOVEMENTS/2 FOR
1020 REM     POSITIONING THE SAMPLER TO PURGE.  K IS THE NUMBER
```

```
1030  REM          OF  1.8  DEGREE  MOVEMENTS/2  FOR  PRE  SAMPLE
POSITIONING.
1040 REM
1050 PSET 15
1060 FOR L=1 TO T
1070 PSET 14
1080 PCLR 14
1090 NEXT L
1100 REM      TURN THE PUMP ON (PURGE LINE).
1110 PSET 0
1120 FOR Z=1 TO 1000
1130 NEXT Z
1140 PCLR 0
1150 REM      POSITION ARM FOR SAMPLING
1160 FOR L=1 TO K
1170 PSET 14
1180 PCLR 14
1190 NEXT L
1200 REM      PUMP FOR 2 MINUTES.
1210 PSET 0
1220 FOR Z=1 TO 120
1230 SLEEP 0
1240 REM      SAMPLE FLOWMETER OUTPUT EVERY SECOND.
1250 STORE P,#2,CHAN(2)
1260 SLEEP 100
1270 NEXT Z
1280 PCLR 0
1290 NEXT B
2000 REM       WAIT  FOR  RETURN  (TEST  DONE,  CONNECT  HOST TO
CONTROLLER)
2010 INPUT R
2020 PRINT '   DATA DOWNLOADING MENU   '
2030 PRINT
2040 PRINT '1 - CLEAR MEMORY'
2050 PRINT '2 - DOWNLOAD FLOWMETER DATA IN XMODEM FORMAT'
2060 PRINT '3 - DOWNLOAD TEMP. AND SAL. DATA IN XMODEM FORMAT'
2095 PRINT
2100 INPUT 'SELECT 1-3 ',R
2105 REM      BRANCH TO SELECTION
2110 IF R=1 GOSUB 3000
2120 IF R=2 GOSUB 4000
2130 IF R=3 GOSUB 5000
2140 GOTO 2100
3000 REM      CLEAR MEMORY SUBROUTINE
3005 X=0
3010 FOR C=0 TO 2000
3015 REM      STORE ZEROS IN THE DATAFILE LOCATIONS
3020 STORE X,#1,0
3030 NEXT C
3040 P=5000
3050 FOR C=0 TO 2000
3055 REM      STORE ZEROS IN THE DATAFILE LOCATIONS
3060 STORE P,#1,0
3070 NEXT C
```

```
3080 PRINT
3090 R=0
3100 RETURN
4000 REM     FLOWMETER DATA DOWNLOADING SUBROUTINE
4005 PRINT 'SET UP COMMUNICATION SOFTWARE TO RECEIVE DATA IN'
4010 PRINT 'XMODEM FORMAT AND PRESS ENTER TO START DOWNLOADING'
4015 PRINT 'FLOWMETER DATA'
4020 INPUT R
4025 REM     SEND DATA
4030 OFFLD 0,X
4040 PRINT 'DOWNLOAD COMPLETE'
4045 R=0
4050 RETURN
5000 REM     TEMPERATURE AND SALINITY DATA DOWNLOADING SUBROUTINE
5010 PRINT 'SET UP COMMUNICATION SOFTWARE TO RECEIVE DATA IN
     XMODEM'
5020 PRINT  'FORMAT AND PRESS ENTER TO START DOWNLOADING TEMP.
 AND'
5030 PRINT 'SALINITY DATA.'
5040 INPUT R
5045 REM     SEND DATA
5050 OFFLD 5000,P
5060 PRINT 'DOWNLOAD COMPLETE'
5070 R=0
5080 RETURN
```

```
   1 REM      THIS PROGRAM IS THE OPERATING SYSTEM FOR THE
             H.U.S.T.L.E.
   2 REM     REMOTE PLANKTON SAMPLER (A TECH 697  UNDERGRADUATE
             OCEAN
   3 REM      RESEARCH PROJECT).  THE SAMPLING TIMES ARE ENTERED
             DURING
   4 REM     PROGRAM EXECUTION AND THE SAMPLING DURATIONS ARE
             SELECTED
   5 REM      THROUGH CHANGES IN THE ACTUAL PROGRAM CODE.  ONCE
             THE
   6 REM     PROGRAM IS EXECUTED, PROMPTS ARE SELF-EXPLANATORY
             AND THE
   7 REM     TESTING PROCESS IS COMPLETELY CONTROLLED.
  10 PCLR 0,14,15
  15 FOR W=1 TO 10000
  20 NEXT W
  25 REM     ENTER THE DATA AND TIME
  30 INPUT 'ENTER THE YEAR (0-99) ' ?(5)
  35 INPUT 'ENTER THE MONTH (1-12) ' ?(4)
  40 INPUT 'ENTER THE DAY (1-31) ' ?(3)
  45 INPUT 'ENTER THE HOUR (0-23) ' ?(2)
  50 INPUT 'ENTER THE MINUTE (0-59) ' ?(1)
  55 INPUT 'ENTER THE SECOND (0-59) ' ?(0)
  60 STIME
  70 REM     ENTER THE 12 SAMPLING TIMES
  80 PRINT 'THE SAMPLING TIMES FOR EACH OF THE 12 SAMPLES'
  90 PRINT 'WILL NOW BE ENTERED.'
 100 PRINT
 110 FOR A =1 TO 12
 120 PRINT 'ENTER THE MINUTE FOR THE # ',A,' SAMPLE'
 125 INPUT @(A)
 130 NEXT A
 140 REM     SET POINTERS FOR DATA STORAGE
 150 X=0
 160 P=5000
 170 REM     LOOP THROUGH EVERY 30 SECONDS, TAKING TEMP. AND SAL.
 180 REM     SAMPLES AND CHECKING SAMPLE MINUTE.
 190 FOR B=1 TO 12
 200 SLEEP 0
 205 REM     STORE TEMP. AND SAL. VALUES.
 210 STORE X,#1,CHAN(0)
 220 STORE X,#2,CHAN(1)
 230 RTIME
 235 REM     STORE TIME OF TEMP. AND SAL. SAMPLE RETRIEVAL.
 240 STORE X,#1,?(3)
 250 STORE X,#1,?(2)
 260 STORE X,#1,?(1)
 270 SLEEP 3000
 280 RTIME
 290 IF @(B)=?(1) GOTO 1000
 300 GOTO 200
1000 REM
1010 REM     T IS THE NUMBER OF 1.8 DEGREE MOVEMENTS/2 FOR
1020 REM     POSITIONING THE SAMPLER TO PURGE.  K IS THE NUMBER
```

```
1030 REM     OF 1.8  DEGREE  MOVEMENTS/2  FOR  PRE  SAMPLE
POSITIONING.
1040 REM
1050 PSET 15
1060 FOR L=1 TO T
1070 PSET 14
1080 PCLR 14
1090 NEXT L
1100 REM     TURN THE PUMP ON (PURGE LINE).
1110 PSET 0
1120 FOR Z=1 TO 1000
1130 NEXT Z
1140 PCLR 0
1150 REM     POSITION ARM FOR SAMPLING
1160 FOR L=1 TO K
1170 PSET 14
1180 PCLR 14
1190 NEXT L
1200 REM     PUMP FOR 2 MINUTES.
1210 PSET 0
1220 FOR Z=1 TO 120
1230 SLEEP 0
1240 REM     SAMPLE FLOWMETER OUTPUT EVERY SECOND.
1250 STORE P,#2,CHAN(2)
1260 SLEEP 100
1270 NEXT Z
1280 PCLR 0
1290 NEXT B
2000 REM        WAIT FOR  RETURN (TEST  DONE, CONNECT HOST TO
CONTROLLER)
2010 INPUT R
2020 PRINT '   DATA DOWNLOADING MENU   '
2030 PRINT
2040 PRINT '1 - CLEAR MEMORY'
2050 PRINT '2 - DOWNLOAD FLOWMETER DATA IN XMODEM FORMAT'
2060 PRINT '3 - DOWNLOAD TEMP. AND SAL. DATA IN XMODEM FORMAT'
2095 PRINT
2100 INPUT 'SELECT 1-3 ',R
2105 REM     BRANCH TO SELECTION
2110 IF R=1 GOSUB 3000
2120 IF R=2 GOSUB 4000
2130 IF R=3 GOSUB 5000
2140 GOTO 2100
3000 REM     CLEAR MEMORY SUBROUTINE
3005 X=0
3010 FOR C=0 TO 2000
3015 REM     STORE ZEROS IN THE DATAFILE LOCATIONS
3020 STORE X,#1,0
3030 NEXT C
3040 P=5000
3050 FOR C=0 TO 2000
3055 REM     STORE ZEROS IN THE DATAFILE LOCATIONS
3060 STORE P,#1,0
3070 NEXT C
```

```
3080 PRINT
3090 R=0
3100 RETURN
4000 REM     FLOWMETER DATA DOWNLOADING SUBROUTINE
4005 PRINT 'SET UP COMMUNICATION SOFTWARE TO RECEIVE DATA IN'
4010 PRINT 'XMODEM FORMAT AND PRESS ENTER TO START DOWNLOADING'
4015 PRINT 'FLOWMETER DATA'
4020 INPUT R
4025 REM     SEND DATA
4030 OFFLD 0,X
4040 PRINT 'DOWNLOAD COMPLETE'
4045 R=0
4050 RETURN
5000 REM     TEMPERATURE AND SALINITY DATA DOWNLOADING SUBROUTINE
5010 PRINT  'SET UP COMMUNICATION SOFTWARE TO RECEIVE DATA IN
     XMODEM'
5020 PRINT 'FORMAT AND PRESS ENTER TO START DOWNLOADING TEMP.
     AND'
5030 PRINT`'SALINITY DATA.'
5040 INPUT R
5045 REM     SEND DATA
5050 OFFLD 5000,P
5060 PRINT 'DOWNLOAD COMPLETE'
5070 R=0
5080 RETURN
```