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THE DESIGN, DEVELOPMENT, AND CONSTRUCTION OF A HIGH-PRESSURE ME--ETC(U)
SEP 69   D W CAUDY , J S GLASGOW   N00014-66-C-0199

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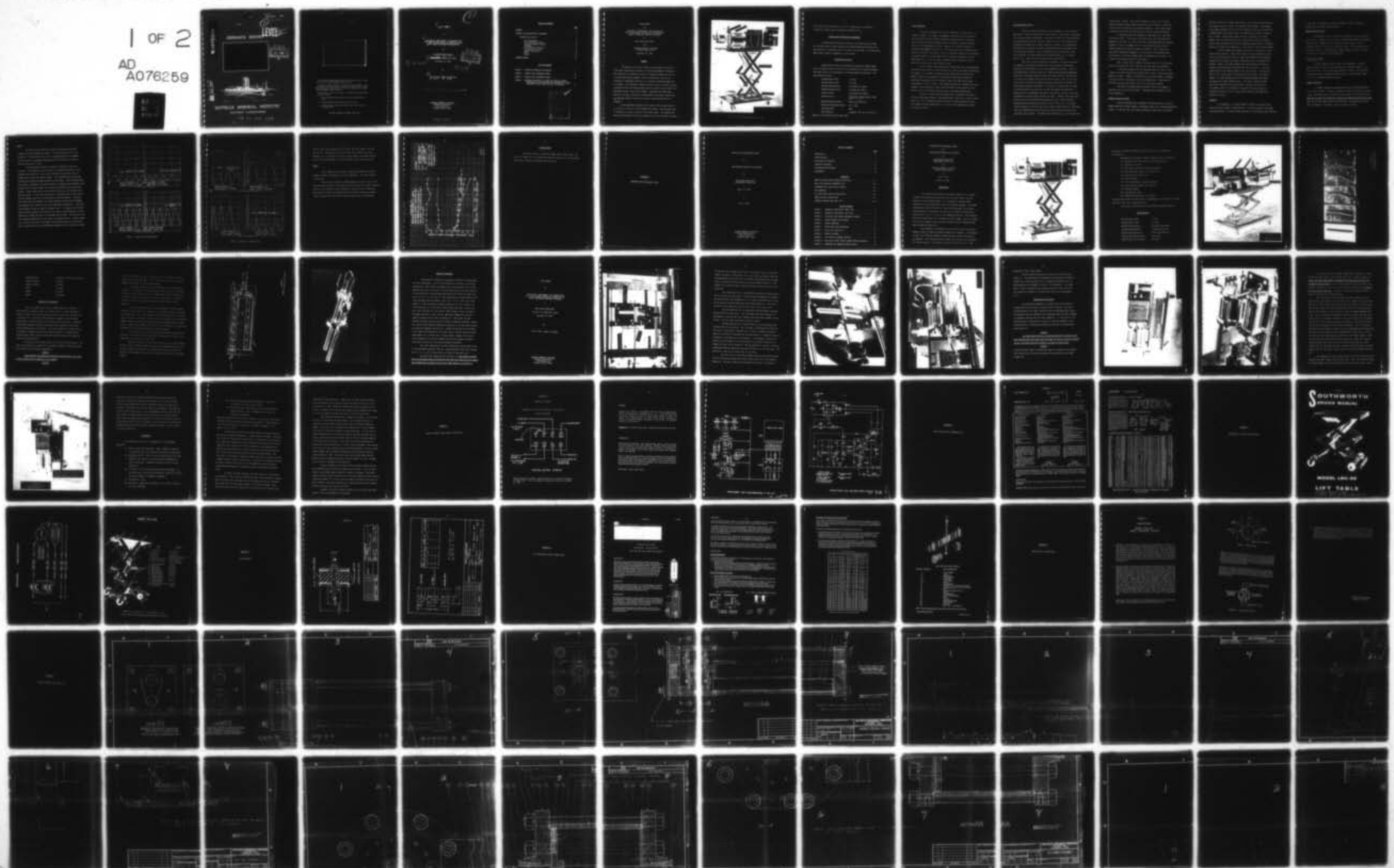

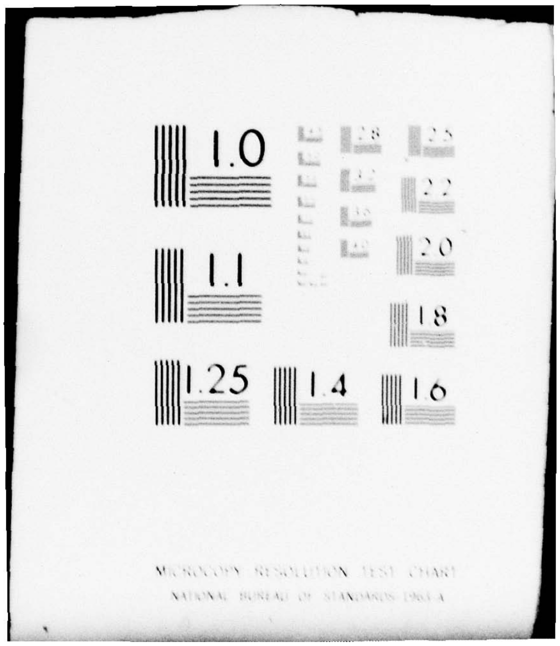
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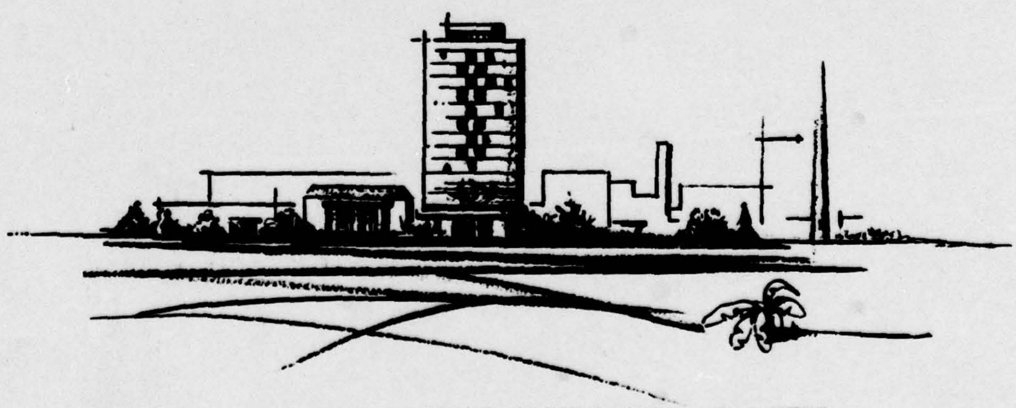
RESEARCH REPORT



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(9) FINAL REP[redacted]T

on

(6) THE DESIGN, DEVELOPMENT, AND CONSTRUCTION OF A HIGH-PRESSURE MECHANICAL RESPIRATOR FOR TESTING UNDERWATER BREATHING APPARATUS

to

THE UNITED STATES NAVY

(15) [redacted] N00014-66-C-0199

September 30, 1969

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by

(10) Don W. Caudy, James S. Glasgow

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FINAL REPORT

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THE DESIGN, DEVELOPMENT, AND CONSTRUCTION OF A HIGH-PRESSURE MECHANICAL RESPIRATOR FOR TESTING UNDERWATER BREATHING APPARATUS

to

THE UNITED STATES NAVY

from

BATTELLE MEMORIAL INSTITUTE
Columbus Laboratories

September 30, 1969

SUMMARY

A mechanical respirator (Figure 1) was designed and built to functional requirements furnished by the Navy Experimental Diving Unit. The respirator is intended to provide a standard breathing test for use in evaluating diving equipment. With the respirator, tests can be conducted at atmospheric pressure or to pressures simulating 2000 feet of seawater. The respirator remains exterior to the test chambers during pressurized tests of diving equipment and all controls are available for adjustment without entering the chamber. Equipment for adding heat, moisture, and CO_2 to the gases being breathed is provided, although the CO_2 addition system is limited to pressures simulating 1500 feet of seawater.

The mechanical respirator will breathe tidal volumes from 0.5 to 4 liters at rates of 5 to 60 breathes per minute. The breathing rate is indicated by a meter mounted on the control panel. By changing cam plates the breathing curve can be adjusted such that the exhale-to-inhale

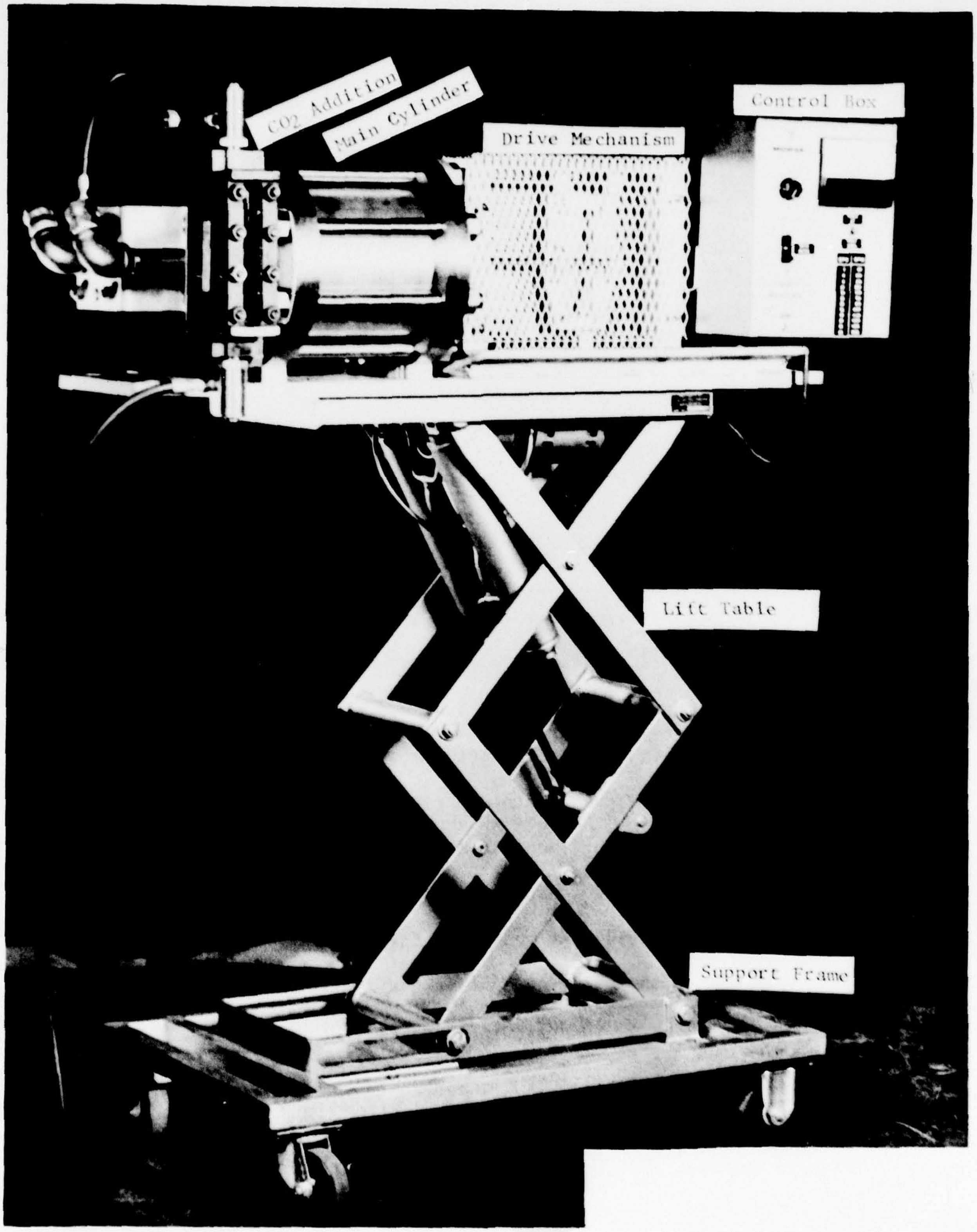


FIGURE 1. COMPLETED MECHANICAL RESPIRATOR

time ratio can be varied from 1.0 to 1.3. Hourmeters are provided to record test duration and total machine operating time.

RESULTS AND DESCRIPTION OF EQUIPMENT

A high-pressure mechanical respirator was constructed according to functional specifications supplied by the Navy Experimental Diving Unit. The respirator is described, and its features are discussed, in the Operations Manual which appears as Appendix A of this report.

Engineering Activity

Engineering activity on the mechanical respirator program began with a literature search to check for the availability of similar equipment that would fulfill the requirements of the Experimental Diving Unit. The requirements included:

Maximum Tidal Volume	4 liters
Minimum Tidal Volume	1/2 liter
Maximum Breathing Rate	60 breaths per minute
Minimum Breathing Rate	5 breaths per minute
Exhaust Stroke	CO_2 and moisture added
Breathing Curve	Sinusoidal, exhale/inhale stroke ratio = 1.2 to 1
Maximum Working Pressure	2000 ft H_2O (890 psi)
Maximum Breathing Resistance	36 in. H_2O
Instrumentation	None
Power Required	5 amperes, 110 volt, 60 cycle a-c

However, no applicable devices were found.

Drive Mechanism

The drive mechanism was the first component to be considered. To generate variable curve shapes, programmable controllers such as Data-Trak and Stata-Trak controllers made by Research Incorporated were considered. These controllers had the advantage that an infinitely variable breathing curve could be programmed into them. However, the tracking response of available programmable controllers is too slow to use the full program chart width at 60 breaths per minute. Also, the available controllers are designed to control hydraulic systems which call for expensive equipment of fairly high complexity. It was felt that a simpler drive system which could be repaired or altered more easily should be used.

Next, a slider crank inversion was considered as the drive mechanism. By offsetting the center of crank rotation for a given crank arm and connecting rod length, it is possible to obtain varying exhale/inhale stroke ratios. However, because of kinematically unacceptable connecting rod angles no satisfactory mechanism could be designed to meet the tidal volume range requirement of 1/2 to 4 liters. This mechanism should be considered in future designs if the variation of tidal volume (and hence stroke length) is only three or four to one rather than the eight to one range required here.

Finally, a scotch-yoke type mechanism was considered and found to fit all of the specifications. The exhale/inhale stroke ratio could be varied from 1.0 to 1.3 by changing a simple cam plate, and the mechanism could be very simple and easily maintained. As a result, this mechanism was chosen for the drive system.

Gas Displacement Device

The next problem considered was the development of a gas displacement device. Those considered were a metal bellows, a bellofram, a diaphragm, and a piston-cylinder arrangement. A positively sealed device which required no lubrication was desired. For this reason, the first three displacement mechanisms mentioned were strongly considered. However, the diaphragm and bellofram were configured such that the breathing curve would depend upon the breathing resistance. Since a reproducible curve was desired, these were discarded. The metal bellows was discarded because of its limited service life. This left only the piston and cylinder device.

This type of device presented two problems. The pistons and rods of commercial fluid power cylinders made for the required internal gas pressure were too massive for use in the mechanical respirator. Since it was decided that the piston should be a double-acting pressure-compensated system the differential pressure across the piston should not exceed about 3 psi and a much lighter piston and rod could be used. Also, at the time this project was begun the commercial pistons and cylinders available for high pressure required lubrication. As a result, it was decided to design a special piston and cylinder for use with the mechanical respirator. A Rulon piston-cup arrangement requiring no lubrication, offered by the Dixon Corporation of Bristol, Rhode Island, was chosen. However, when these seals were put into service difficulties immediately arose. While the Dixon Corporation had indicated that an axial friction force of 5 to 10 pounds could be expected on the rod, the force actually ranged from 50 to 100 pounds. Also, the 0.060-inch-thick Rulon A piston cups caused severe wear on the stainless steel cylinder. To improve wear characteristics, the cylinder was chrome plated. However, the friction remained too high so the cups and pistons underwent several design modifications in an attempt to lower the friction force yet maintain good sealing properties. After several weeks of modification effort the 0.060-inch-thick piston cups were discarded.

A ring-type piston was designed and fabricated with rings made of 3/8-inch Teflon. The friction force was low and the ring-type piston appeared to work well, but tests showed that the leakage rate was excessive. Attempts to lower the leakage rate, such as spring-loading the ring to improve normal force, were only partly successful. Also, during these tests metal flakes which appeared to be coming from the stainless-steel wool packing in the bubble chamber were found embedded in the teflon. As a result the stainless steel wool was removed.

Next, a piston with a teflon O-ring was tried, but this ring was severely worn after six hours' operation and this method was abandoned.

It was then proposed that the stainless steel wool found in the cylinder could have affected the original Rulon A cups, so they were tested again to no avail. Finally, 0.030-inch-thick cups were ordered to decrease the normal force of the piston cup on the cylinder wall. These cups did not leak, wore well with fairly low friction, and were accepted.

The piston rod packing seals are made of Rulon A and appear to seal well with low friction and wear. These were also purchased from the Dixon Corporation.

Moisture Addition System

Several mechanisms were considered for adding moisture to the air. Among these were a bubble chamber, an atomizer system, and a wicking evaporative system. It was felt that the wicking evaporative system would not provide sufficient moisture for large tidal volumes. After a few qualitative tests with ceramic and felt wicking, this approach was discarded. The atomizer system seemed feasible but would be more complicated and less reliable than a bubble chamber type system in which the exhaled gas is bubbled through a pool of water. Several tests were conducted to determine if a bubble chamber would add sufficient moisture. These tests resulted in relative humidity above 90 percent for air after passing through the bath. Therefore, because of efficiency and simplicity, it was decided to use a bubble chamber.

A bubble chamber was designed and built, but in practice it presented several problems. Large tidal volumes at high breathing rates produced such a high gas flow rate that water was expelled from the chamber. Several baffle, packing, and bypass systems were tried to alleviate this problem. Finally, the bubble chamber ports were located such that the vigorous bubbling expells the excess water into the piston. It is then pumped back into the bubble chamber on the return stroke. An effort was made to find a sight glass for observing the water level in the bubble chamber, but sight glasses rated for the required pressure were nearly as large as the bubble chamber itself. As a result, upper and lower water level checking valves are provided to monitor the water level. The chamber capacity is sufficient to provide 100 percent humidity to initially dry gas at 70 F at 2 liters tidal volume and 30 breaths per minute for 10 hours.

<u>Plumbing</u>

All plumbing, i.e., bubble chamber, cylinder, and piping, were constructed from standard schedule 80 and schedule 40 stainless steel pipes and pipe fittings. The rated working pressure of the plumbing exceeds 2500 psi in each case. the flanges on the bubble chamber and main cylinder are designed for an 890 psi working pressure.

Breathing Rate Controls

Several speed control units were considered for use as breathing rate controls. Because of its infinitely variable speed range and relatively high efficiency compared to the ZERO-MAX and other systems, a silicon-controlled rectifier (SCR) drive system was chosen. A disadvantage of the SCR drive system is a slow response low-speed regulation system. However, it should be sufficient for this application.

CO_2 Injection System

The CO_2 injection system consists of a regulator to provide gaseous CO_2 at 700 psi and a flow meter and micro-metering valve for controlling the flow. For a system gage pressure of 700 psi, the flow meter indicates the flow in standard liters per minute. The flow meter range is 0.4 to 2.6 standard liters per minute.

Chamber Penetrator

A viewport adapter was designed and built to provide penetration into the test chambers. Should the chamber be needed for another use during a test, the adapter has two quick-action ball valves for shutting off flow. Care Must Be Taken To Be Absolutely Certain That These Valves Are Open During Use. The porthole adapter welds were inspected by dye-penetrant tests and X-ray photography, and showed no signs of cracks or porosity.

Tests

The unit was hydrostatically tested by pressurizing the main cylinder and bubble chamber with water. The rated pressure of the unit is 890 psi. To insure safe use, the unit was pressurized in 10 complete cycles from zero to pressures ranging from 1350 to 1600 psi, and then to 1350 psi and held for 1 hour.

After hydrostatic testing, a series of reliability tests was conducted. An endurance test was conducted to determine reliability under simulated use conditions. As the test continued, the friction force increased and the motor was heavily loaded. Upon dismantling the system the cylinder wear problem discussed earlier was discovered. After chrome-plating the cylinder, spirometer tests were conducted to determine the breathing curve profiles and the tidal volumes of the various cam plates at each crank arm setting. During these tests, with the Rulon piston cup, the friction force again increased. At this time the efforts to decrease friction force without causing leakage resulted in the modification discussed earlier. The spirometer tests were not repeated, but remain relevant since the piston leakage was negligible both before and after the final seal modification. A few typical spirometer curves are shown in Figures 2 and 3. In Figures 2 and 3 spriometer recorder indicator moves from left to right as time progresses, and the exhale curve ranges from zero to the maximum tidal volume. The portion of the curve sloping downward and to the right is the exhale portion. Figure 2 shows two curves run with the 1.0 cam plate, which should produce a pure sinusoid. The top curve was run with the mechanical respirator set at 500 rpm or 20 bpm

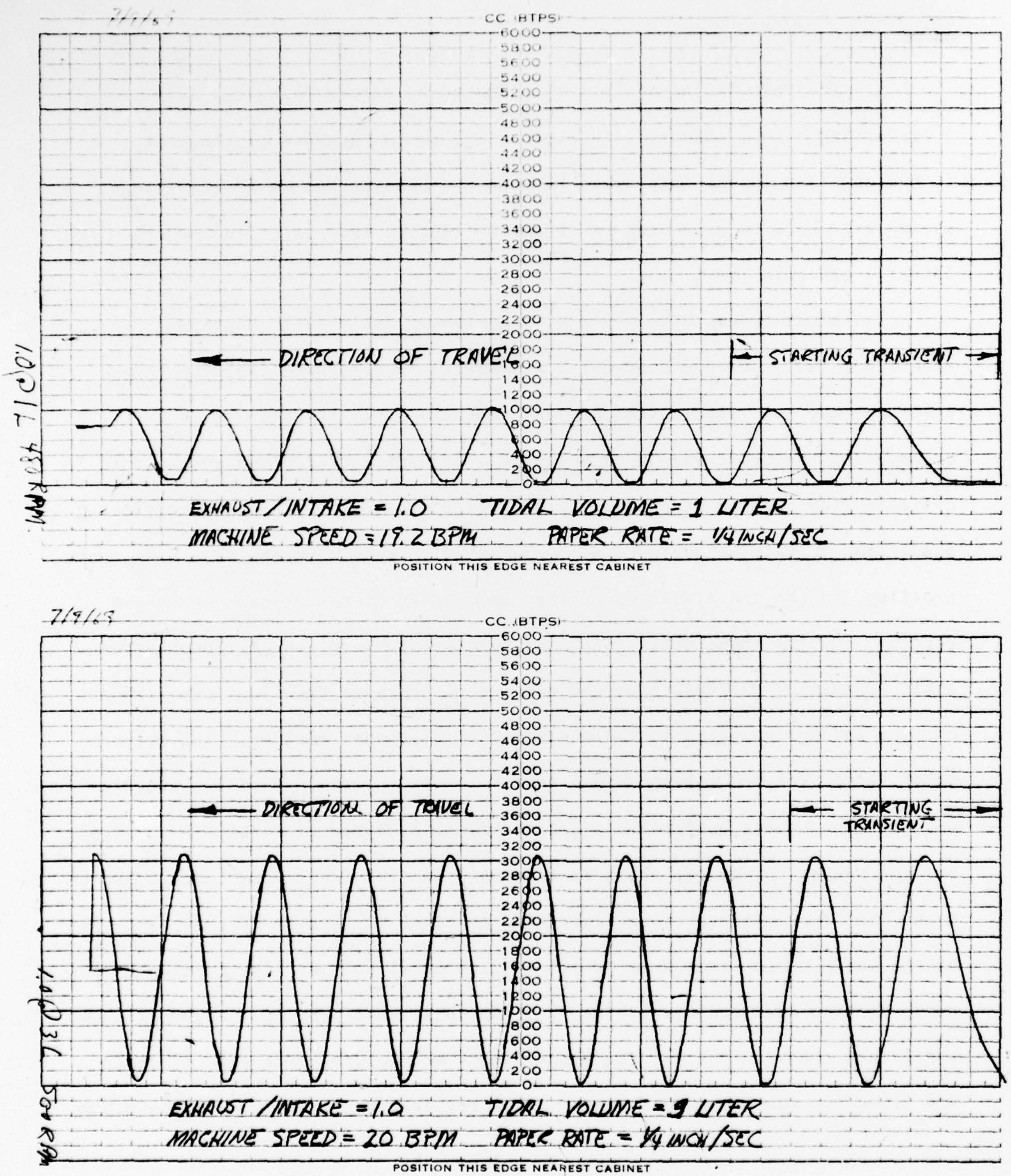
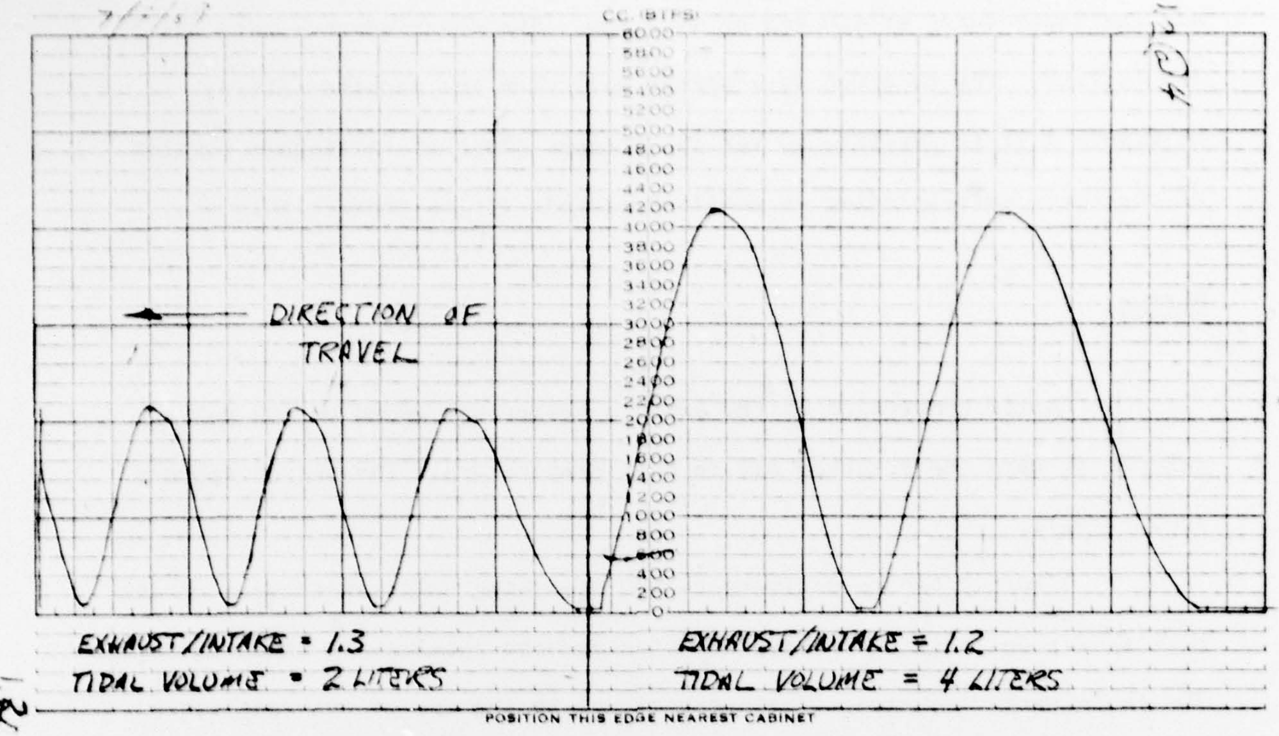


FIGURE 2. LEAKAGE TEST SPIROMETER CURVES



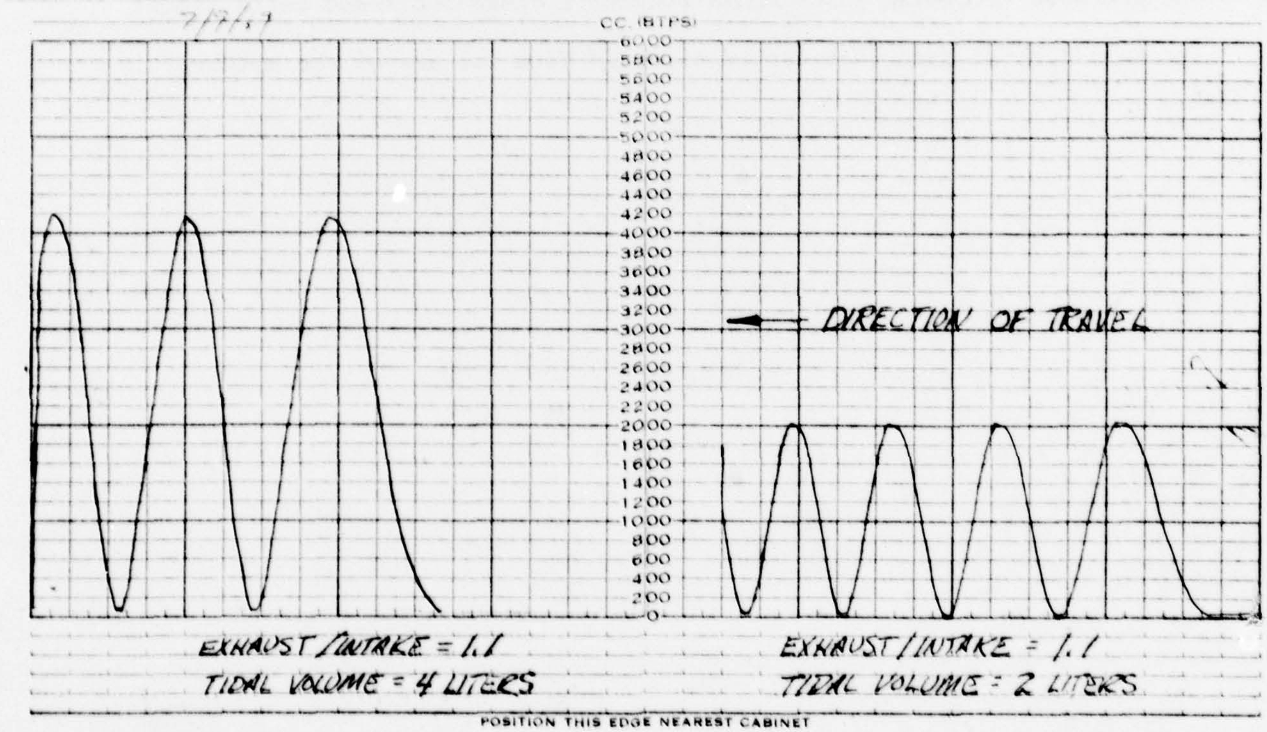


FIGURE 3. LEAKAGE TEST SPIROMETER CURVES

and the lower curve at 480 rpm or 19.2 bpm. The chart advance rate was 1/4 in./sec. The observed rate agrees well with the machine setting. On Figure 3 it is possible to see the steeper slope of the inhale portion of the curve corresponding to exhale-to-inhale ratios greater than one.

Heater

After completion of the unit, a heater was added on the bubble chamber to warm the breathed air to body temperature. The heater appears to work well.

Shortly before delivery to EDU breathing resistance tests on the Mark IX without canisters were conducted and the results are shown in Figure 4. The tests were conducted to gain experience in the use of the respirator. The pressure recording instrumentations were crude but these tests demonstrate a typical data that can be expected from the use of the machine.

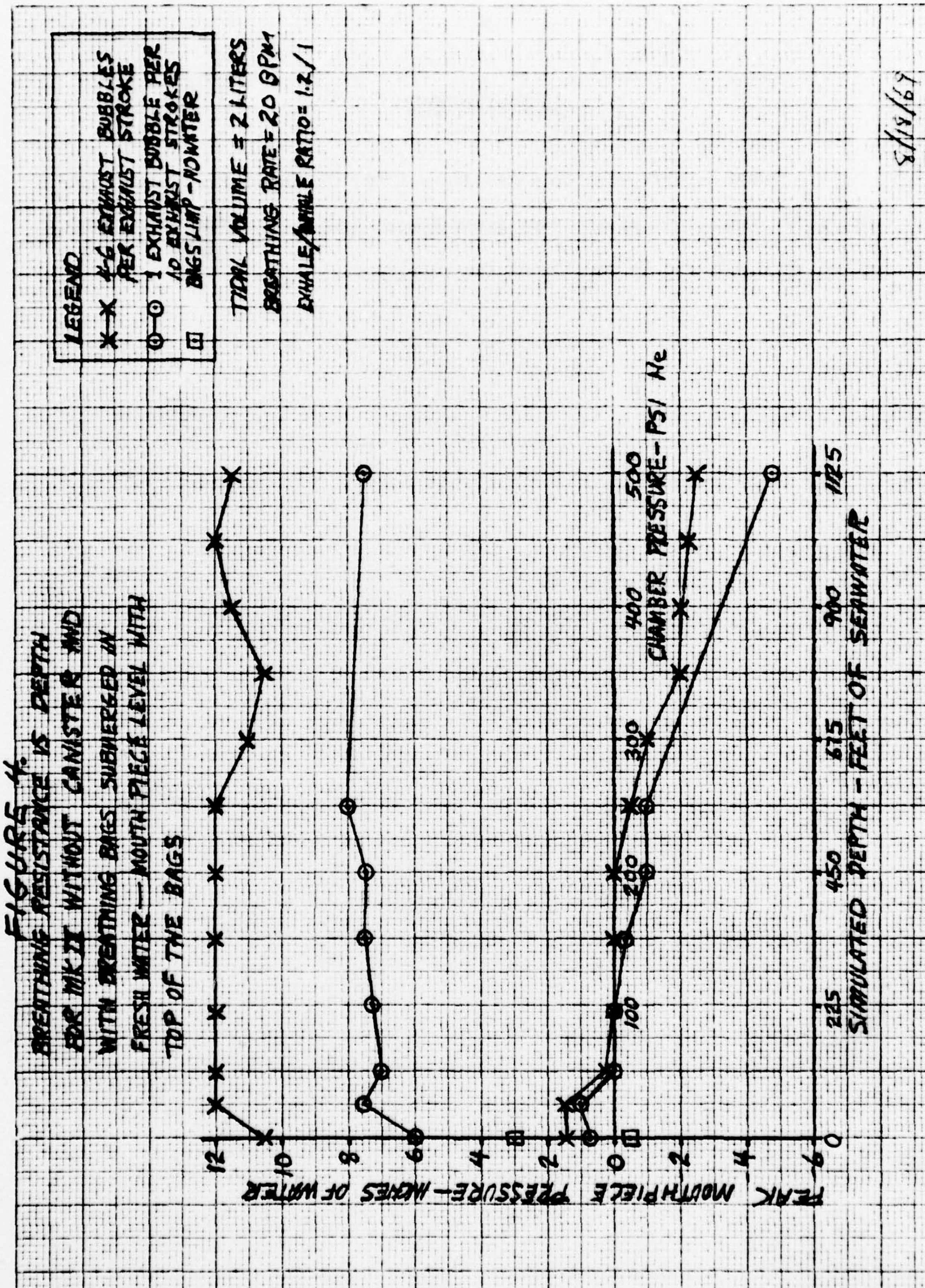


FIGURE 4.
BREATHING RESISTANCE VS DEPTH FOR MK IX WITHOUT CANISTER AND WITH BREATHING BAGS SUBMERGED IN FRESH WATER — MOUTH PIECE LEVEL WITH TOP OF THE BAGS
LEGEND
4-6 EXHAUST BUBBLES PER EXHAUST STROKE
1 EXHAUST BUBBLE PER 10 EXHAUST STROKES
BAGS LIMP - NO WATER
TIDAL VOLUME = 2 LITERS
BREATHING RATE = 20 BPM
EXHALE/INHALE RATIO = 1.2/1
PEAK MOUTH PIECE PRESSURE - INCHES OF WATER
12
10
8
6
4
2
0
2
4
6
0
225
450
675
900
1125
SIMULATED DEPTH - FEET OF SEAWATER
100
200
300
400
500
CHAMBER PRESSURE - PSI He
8/19/69
D.W.C.
KEUFFEL & ESSER CO.

ACKNOWLEDGMENT

The authors wish to acknowledge LCDR. Milwee, LCDR. Herron, and Mr. T. W. James, all of the Navy Experimental Diving Unit, for the guidance which they provided in developing the respirator.

APPENDIX A

OPERATION AND MAINTENANCE MANUAL

OPERATION AND MAINTENANCE MANUAL

for a

HIGH-PRESSURE MECHANICAL RESPIRATOR

for

THE UNITED STATES NAVY
EXPERIMENTAL DIVING UNIT

August 26, 1969

by

Don W. Caudy

BATTELLE MEMORIAL INSTITUTE
Columbus Laboratories
505 King Avenue
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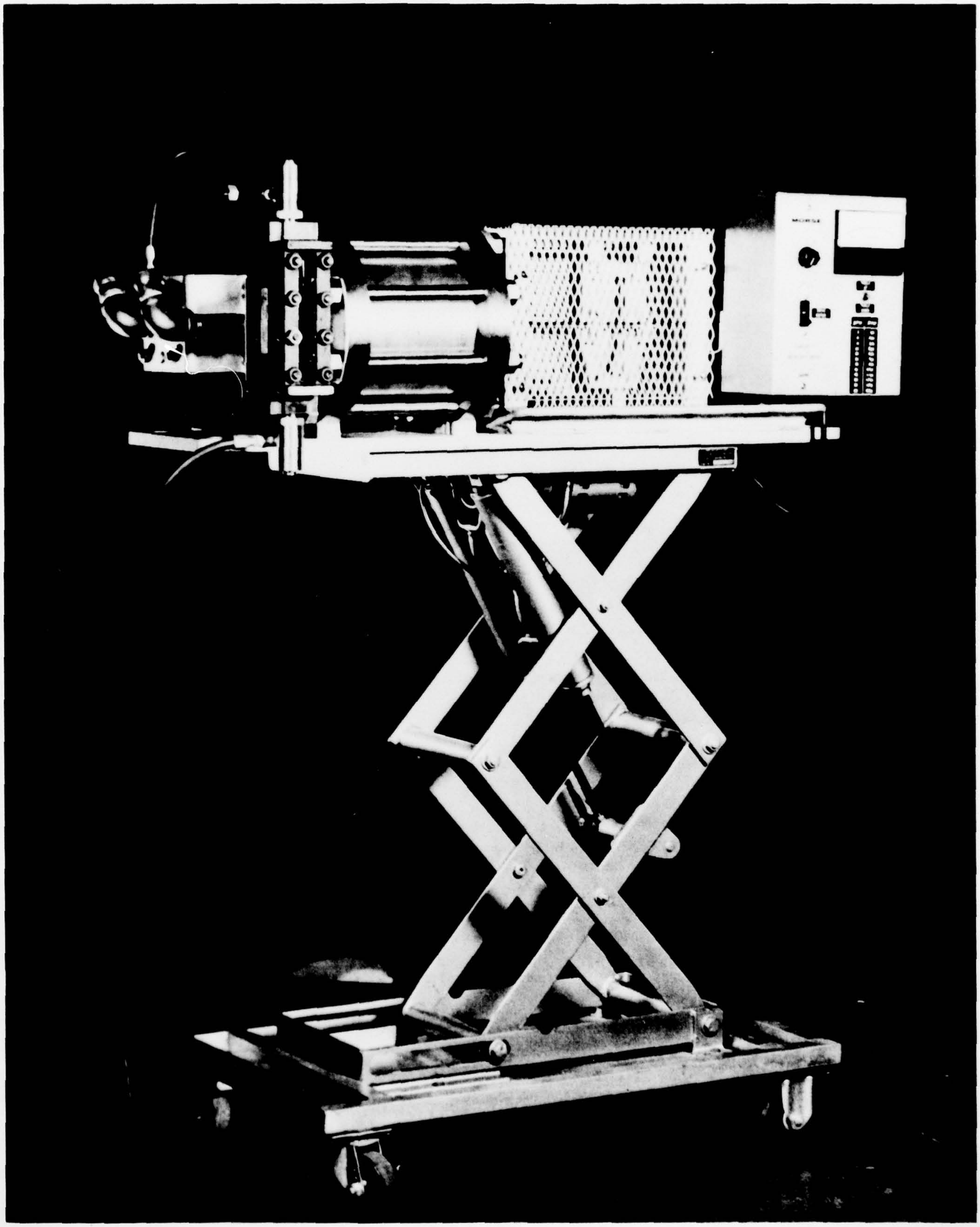
DESCRIPTION

The high-pressure mechanical respirator (Figure 1) is a single-cylinder piston pump with provision for the addition of heat, CO_2 and moisture to the "breathed" gases. It is designed to simulate human respiration for the evaluation of diver life support equipment. The tidal volume may be varied from 0.5 to 4 liters by positioning a cam follower. The flow pattern is sinusoidal, but the ratio of exhaust-to-intake time can be set at 1.0, 1.1, 1.2, or 1.3 by changing cam plates. The repiratory rate can be varied from 5 to 70 breaths per minute (bpm). CO_2 can be added at 0.4 to 2.6 standard liters per minute (slpm), and the "breathed" gases may be heated and humidified.

The respirator is designed to be used with the wet pot and main chamber at EDU to pressures simulating 2000 feet of seawater. An exception to this is the 1500 feet seawater maximum working pressure limitation on CO_2 addition. This limitation exists because the flow meter is calibrated for 700 psig CO_2 gas. CO_2 becomes a liquid at 875 psi and 72 F. Thus,



CO_2 cannot be handled to 2000 feet without diluting it in another gas or heating it.

The mechanical respirator, shown in Figures 1 and 2, consists of:

(1) Aluminum frame and casters for lift-table support

(2) Hydraulic lift table

(3) Morse SCR 3/4-hp drive motor and controller

(4) Morse worm gear reducer, 25:1 gear ratio

(5) Cam and slider drive system

(6) Morse Tach-Pak

(7) 7.75-inch-diameter cylinder and piston

(8) Hour meters-resettable and cumulative

(9) Humidity chamber

(10) CO_2 addition system

(11) Humidity chamber heater (not shown)

The respirator weighs 475 pounds and is approximately 45 in. long, 22 in. wide, and 29 in. high in its lowered position.

The various flow pattern ratio cam plates are shown in Figure 3.

SPECIFICATIONS

Maximum Tidal Volume	4 liters
Minimum Tidal Volume	1/2 liter
Maximum Breathing Rate	60 breaths per minute
Minimum Breathing Rate	5 breaths per minute
Maximum Working Pressure	2000 ft H_2O (890 psi)
Maximum Breathing Resistance	36 in. H_2O
Maximum Heat Addition Rate	380 Watts

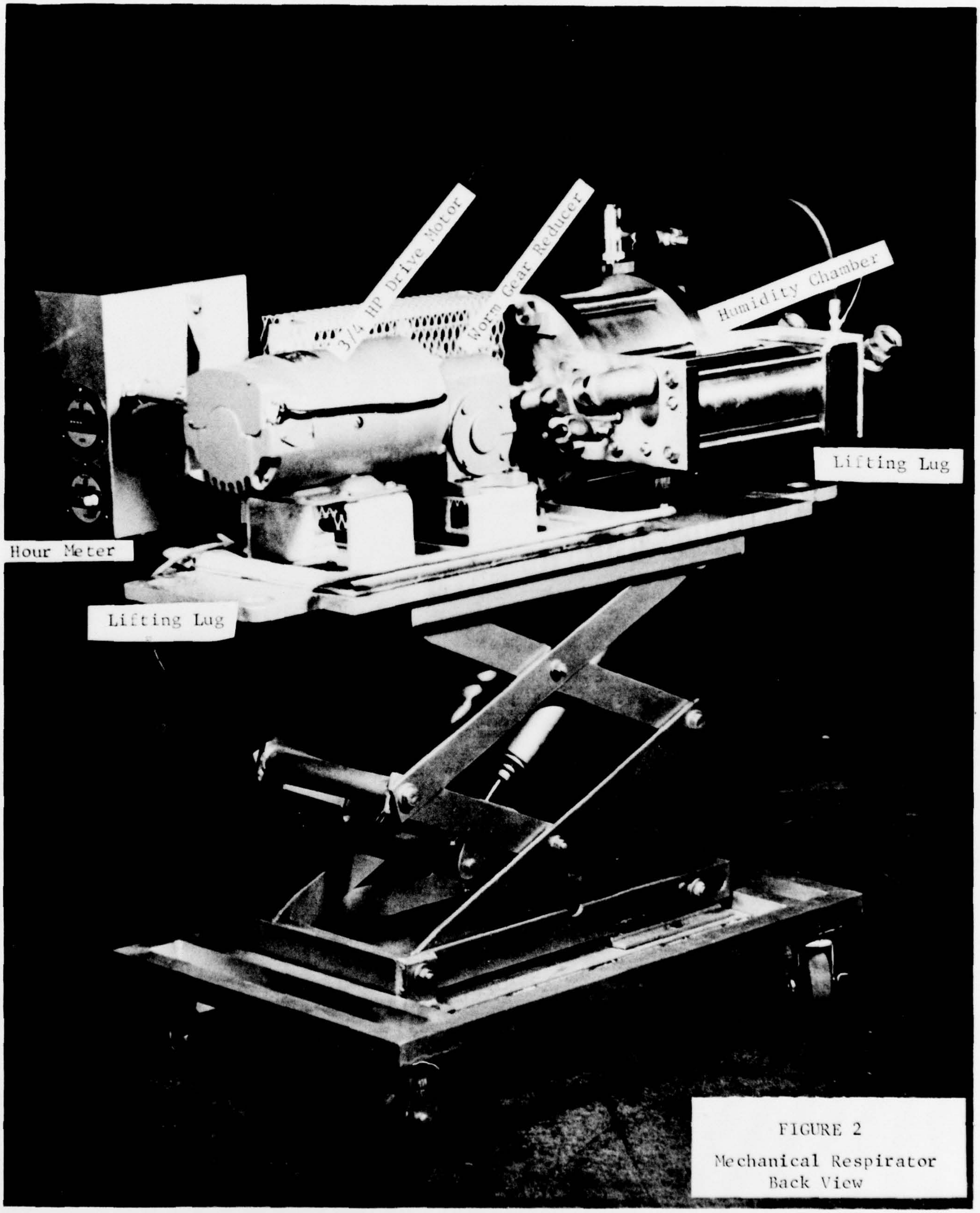


FIGURE 2
Mechanical Respirator
Back View

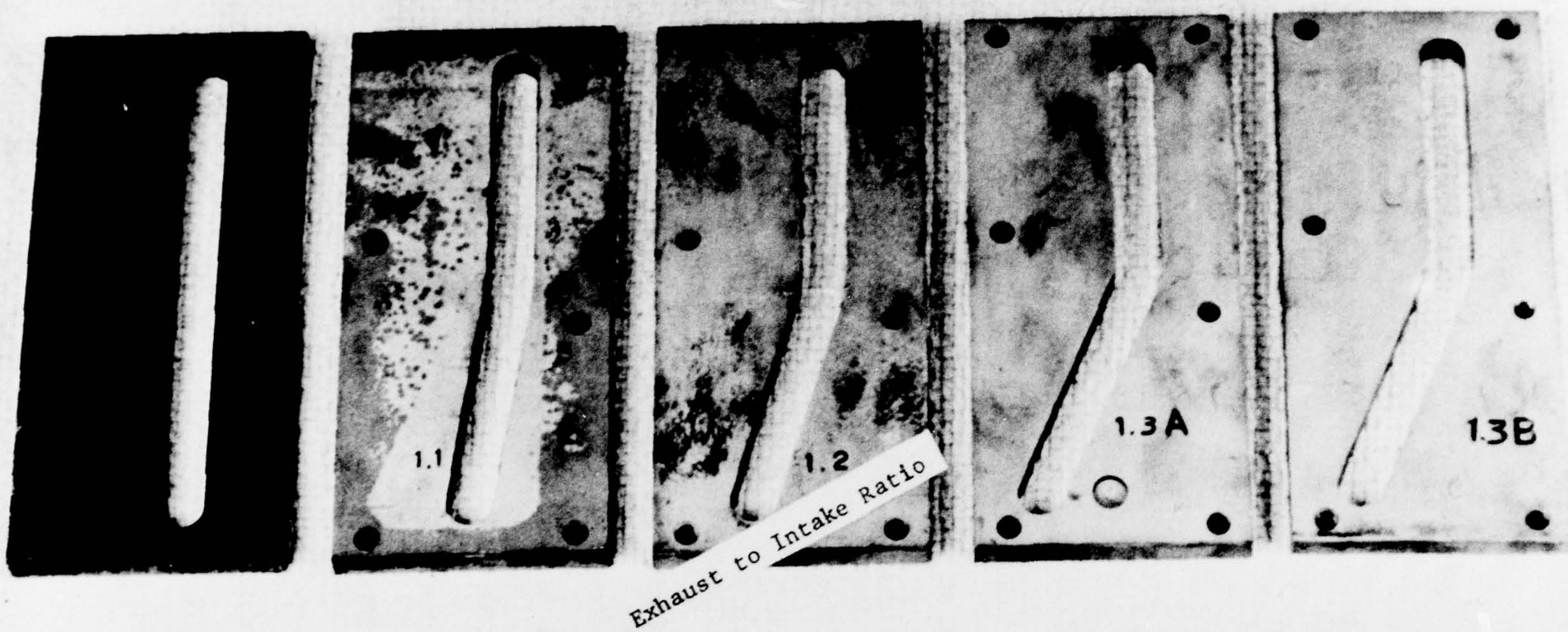


FIGURE 3

Cam Plates for Varying
Breathing Pattern

Power Required	10 amperes, 110 volt, 60 cycle a-c
Height Collapsed	29 inches
Height Extended	53 inches
Width	22 inches
Length	45 inches
Weight	475 pounds.

PRINCIPLES OF OPERATION

The silicon controlled rectifier (SCR) drive motor, through a 25:1 gear reduction, transmits power to an output shaft at a speed regulated to within 5 percent of the base speed from no load to full load. The motor can be reversed and is protected from overload by a magnetic circuit-breaker. Shaft speed is varied by means of the knob on the control panel. A modified scotch-yoke mechanism translates the gearbox shaft rotation to the linear reciprocating motion of the piston. The ratio of exhaust-to-intake time can be changed by changing the cam plates shown in Figure 3. Varying the cam follower among various positions along the crank arm controls the length of the stroke (tidal volume).

The motion of the piston forces air in and out of the cylinder. One side of the cylinder is connected to the humidity chamber and the other side has a connection for pressure compensation.

WARNING!

WHEN OPERATING THE MECHANICAL RESPIRATOR UNDER PRESSURE, BOTH SIDES OF THE CYLINDER MUST BE CONNECTED TO THE CHAMBER.

WARNING!

If this is not done, one side of the piston will be subjected to a much higher pressure than the other. Very large forces will result which will damage the equipment or cause personal injury.

The humidity chamber is used to add moisture to the gas being breathed. It is designed such that the water supply inside is sufficient to moisturize initially dry 70 F air to 100 percent relative humidity for 10 hours at 30 bpm and 2 liters tidal volume. The moisture is added by bubbling the intake gas through the water during the intake stroke (Figure 4).

A heating tape warms the air passing through the bubble chamber. The heat output of the tape is regulated by a percentage controller mounted on the main control box. This controller regulates the percent of time the tape is energized. The heater should be used in conjunction with the humidity chamber to make up for heat taken from the humidity chamber water by evaporation. Otherwise the chamber will cool the air to about 60 F in evaporating enough moisture to maintain 100 percent relative humidity.

CO_2 is added to the system by metering it through a high-pressure flow meter. The pressure in the flow meter is maintained at 700 psi, and a continuous flow is metered into the line.

When the respirator is used within the wet pot or the main chamber, the hose from the humidity chamber and the pressure-compensating hose from the main chamber are attached to the viewport penetrator (see Figure 5). Otherwise the equipment to be tested is attached to the outlet of the bubble chamber.

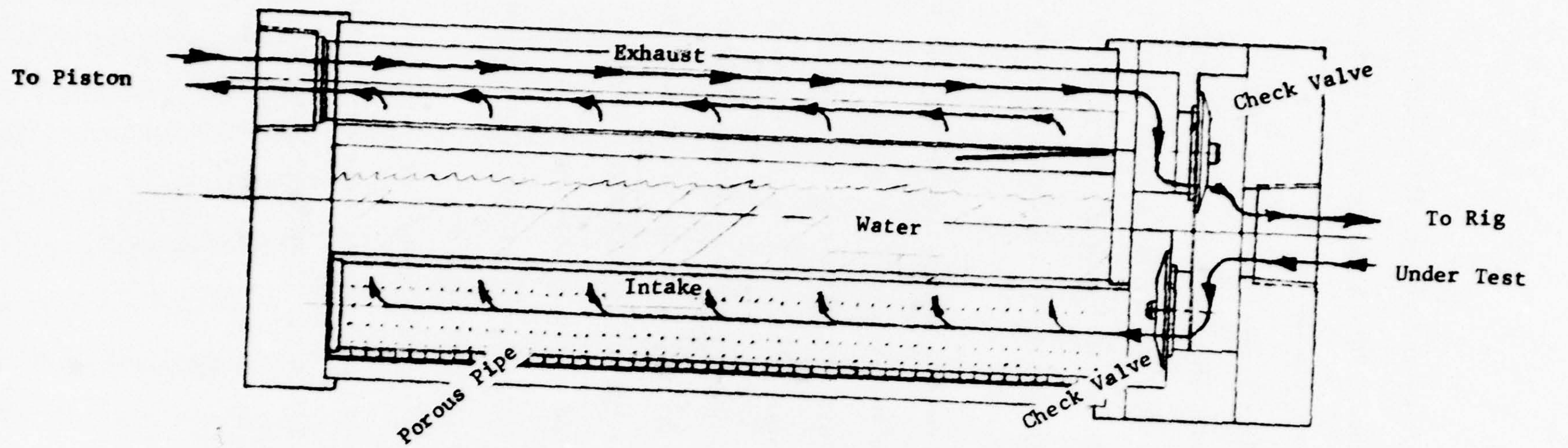


FIGURE 4
Bubble Chamber Flow Pattern

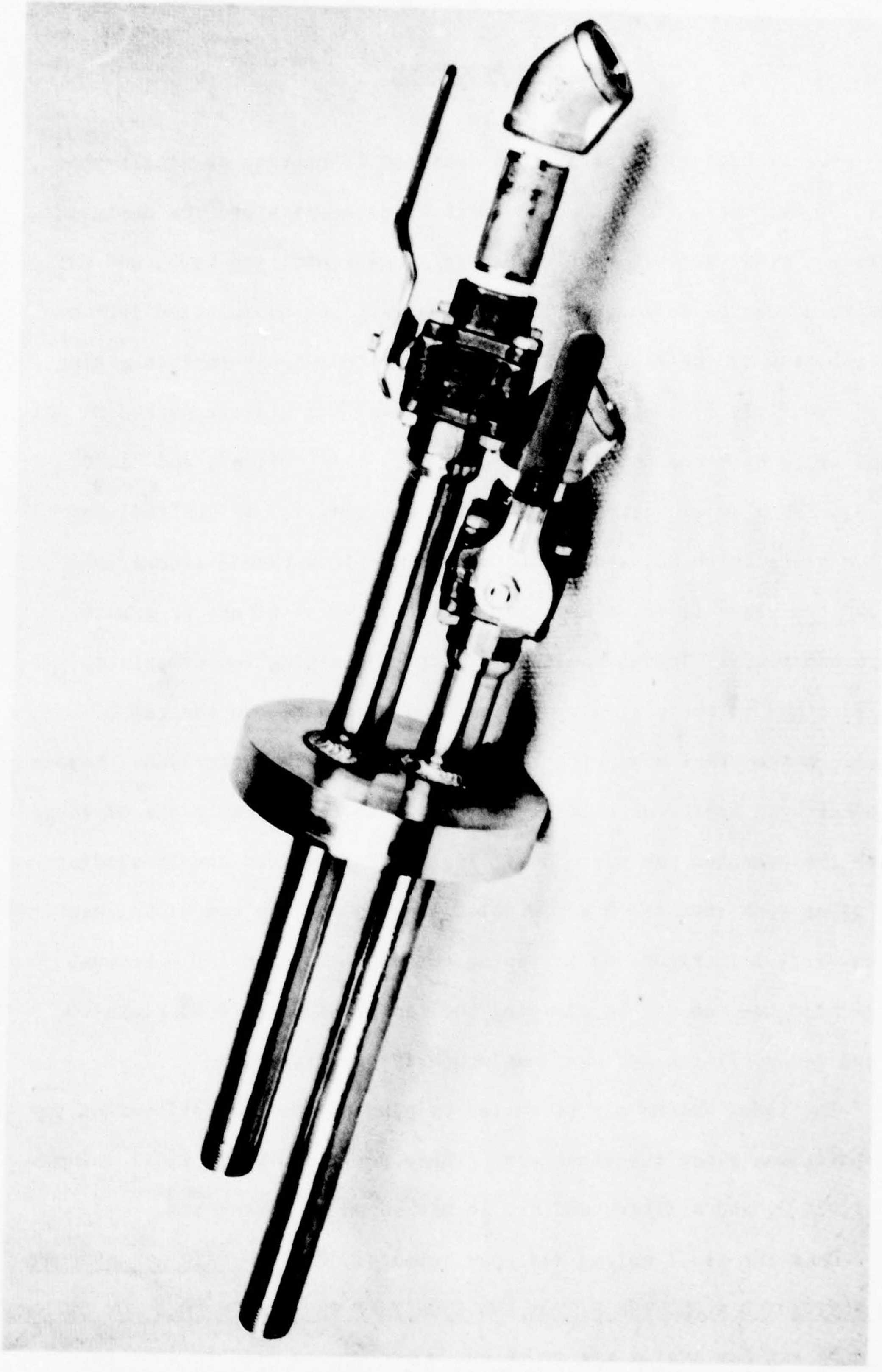


FIGURE 5
Wetpot Connector

OPERATING PROCEDURE

The mechanical respirator is designed to operate on single-phase, 115 volt, 60-Hz power. To set up the mechanical respirator, the desired flow pattern, tidal volume, respiratory rate, heat addition rate, and CO_2 addition rate must be selected. The flow pattern may be selected from one of four patterns by choosing among cam plates with exhaust-to-intake time ratios of 1.0, 1.1, 1.2, and 1.3. The cam plates are clearly marked on the front and edges with the numbers "1.0", "1.1", "1.2", "1.3A", and "1.3B" (Figure 3). When an exhaust-to-intake time ratio of 1.3 is desired, the "1.3A" cam plate is to be used for tidal volumes less than 2 liters, and the "1.3B" cam plate is to be used for tidal volumes 2 liters or greater. To change cam plates, loosen the two capscrews clamping the cam plate support carriage to the piston rod (Figure 6). Then remove the cam follower from the crank arm using the special screwdriver provided. Remove the 6 socket head capscrews holding the cam plate to the cam plate carriage and slide the unwanted cam plate out. Install the desired cam by sliding it into place such that the 6 screw holes line up and the cam plate identifying number (1.1 in Figure 6) is facing outward. Replace the 6 screws. Do not tighten the two screws clamping the cam plate support carriage to the piston rod until the rod has been properly positioned.

The tidal volume may be varied by placing the cam follower at any of five positions along the crank arm. These positions yield tidal volumes of 0.5, 1, 2, 3, and 4 liters and are so marked on the crank arm.

Once the tidal volume has been selected, the <u>CAM CARRIAGE SUPPORT MUST BE POSITIONED ALONG THE PISTON ROD SUCH THAT THE PISTON DOES NOT CONTACT THE CYLINDER END CAP DURING ITS CYCLE BUT COMES WITHIN 1/16 INCH OF IT</u>.

FINAL REPORT

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THE DESIGN, DEVELOPMENT, AND CONSTRUCTION OF A HIGH-PRESSURE MECHANICAL RESPIRATOR FOR TESTING UNDERWATER BREATHING APPARATUS

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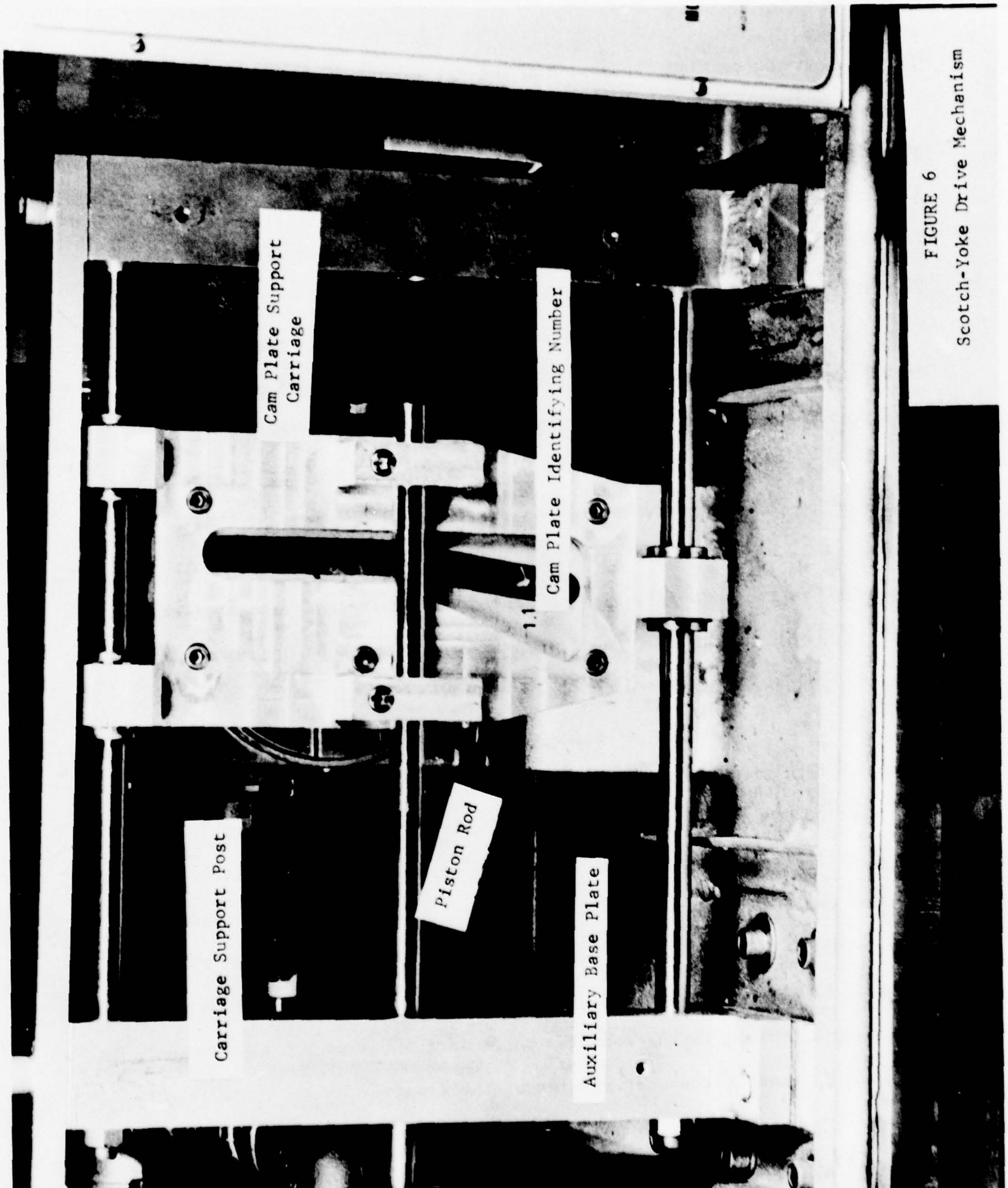


FIGURE 6
Scotch-Yoke Drive Mechanism

To position the carriage support run the drive motor until the cam plate support carriage is positioned as far to the right as possible; then move the piston rod to the right until it touches the gage block when the gage block is placed between the piston rod and the upright (Figure 7). Now tighten the 2 capscrews which clamp the cam plate support carriage to the piston rod.

The respiratory rate is controlled by adjusting the speed control on the front of the control box. The speed may be determined by dividing the speed shown on the tachometer by 25. A table is provided on the front of the control box which shows this relationship (Figure 1). The unit is turned on by the main drive switch on the front of the control box.

The heat addition rate is regulated by the percentage controller mounted above the hour meters. The percentage controller regulates the percentage of time the heat tapes wrapped around the bubble chamber receive current. The heat tapes are rated at 380 watts total.

The CO_2 addition rate is controlled by the micro-metering valve located behind the flow meter. The flow meter is calibrated such that the flow rate of CO_2 added is indicated as if it were at standard conditions when the flow meter is maintained at 700 psig and 70 F. A regulator has been included for supplying CO_2 at this pressure. At atmospheric pressure the needle valve adjustment is very delicate and care should be taken not to damage the float in the flow meter. The CO_2 addition is limited to pressures simulating 1500-feet depths and flow rates in the 0.4 to 2.6 slpm range. The flow rate is read at the center point of the float.

The water level in the bubble chamber should be maintained between the inlet pipe and the upper level valve on the right side of the chamber (Figure 8). The water capacity is sufficient for 10 hours' operation at

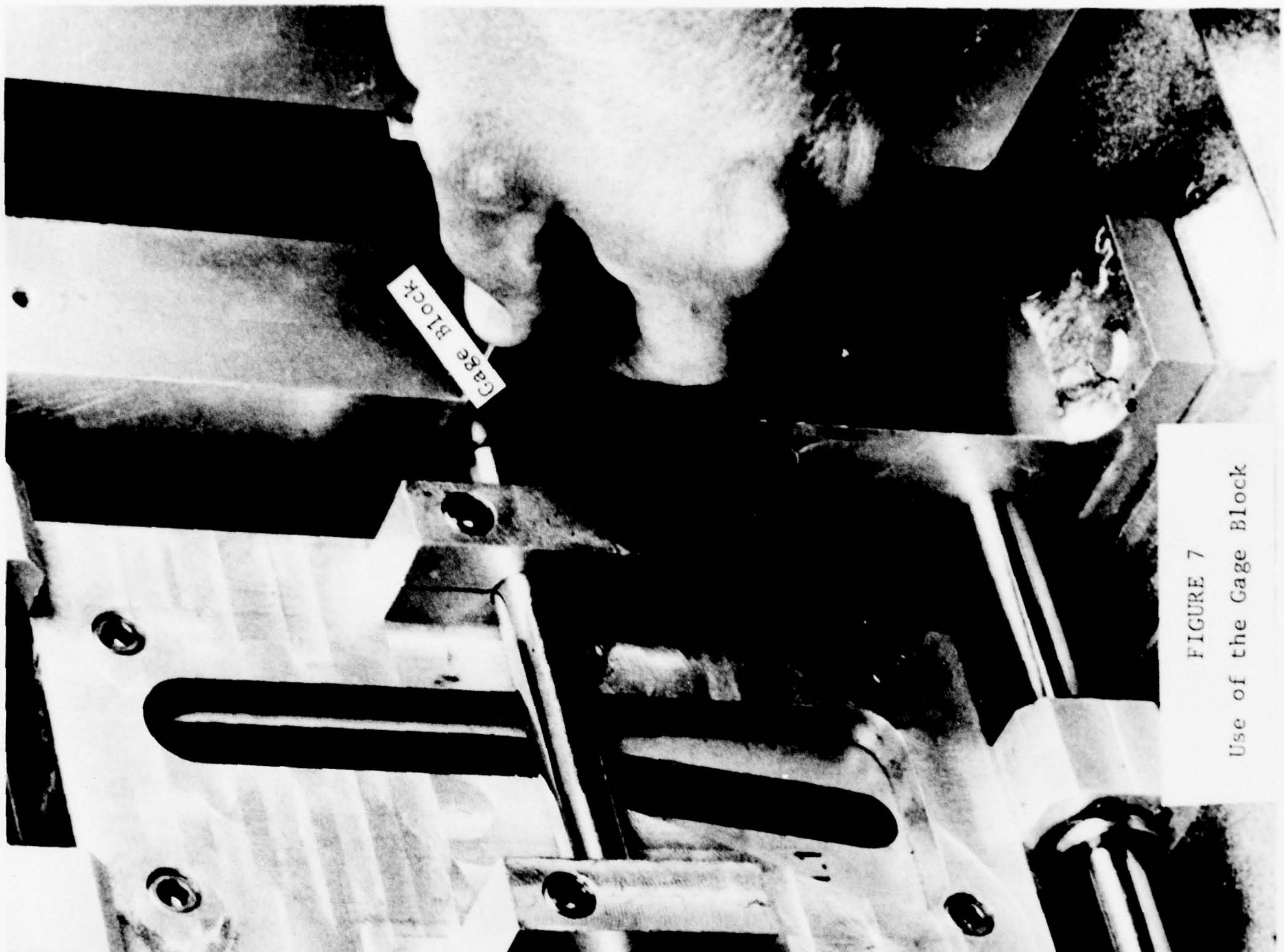


FIGURE 7
Use of the Gage Block

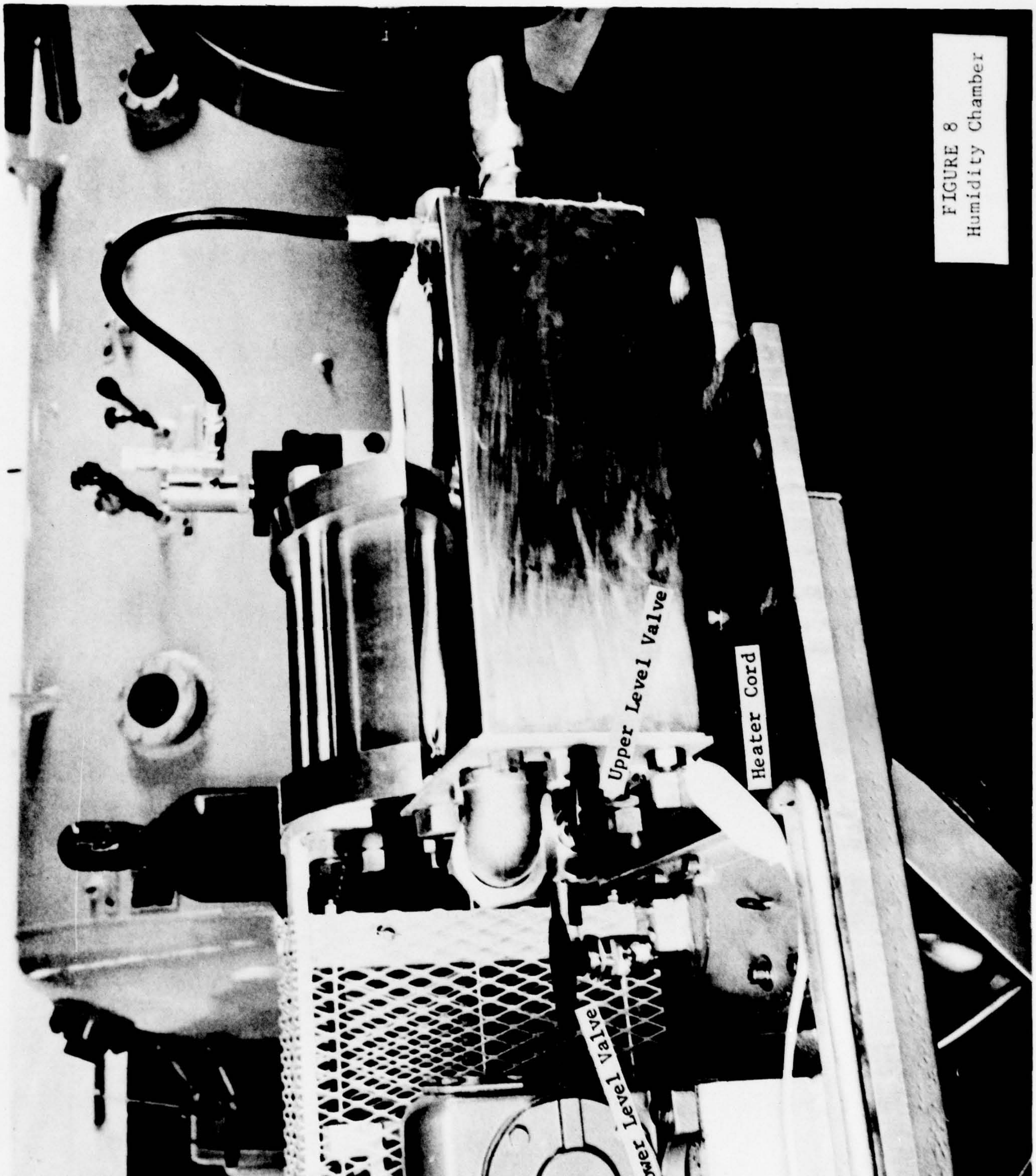


FIGURE 8
Humidity Chamber

30 bpm and 2 liters tidal volume.

Two hour meters are mounted on the side of the control box (Figure 2). The lower meter is resettable for monitoring the length of a given test, while the upper unit is a sealed nonresettable unit for determining the total length of service of the respirator. The lower meter is reset by pushing in and rotating the knob on the dial front. Both meters are connected to the main drive switch and are energized by it.

TRANSPORTATION PROCEDURE

The mechanical respirator is provided with caster wheels for transportation from one area to another without carrying. For transporting between floors where facilities exist for handling heavy objects, the respirator may be collapsed into a relatively small but heavy package by completely lowering the lift table (Figure 9). If the unit is to be lowered through a large hatch or trap door, it may be attached to the lifting device by the large lugs provided at each end of the main base plate (Figure 2).

WARNING!

THE LOWER FRAME ON THE CO_2 FLOW METER END MUST BE SECURED TO THE MAIN CYLINDER BASE PLATE SINCE THE LIFT TABLE TOP PIVOTS AT THE END OPPOSITE THE CO_2 FLOW METER AND CAN BE DAMAGED IF ALLOWED TO SWING FREELY.

WARNING!

Secure the lower frame to the main base plate by looping a chain through the lifting lugs on the CO_2 flow meter end and around the lower frame (Figure 10).

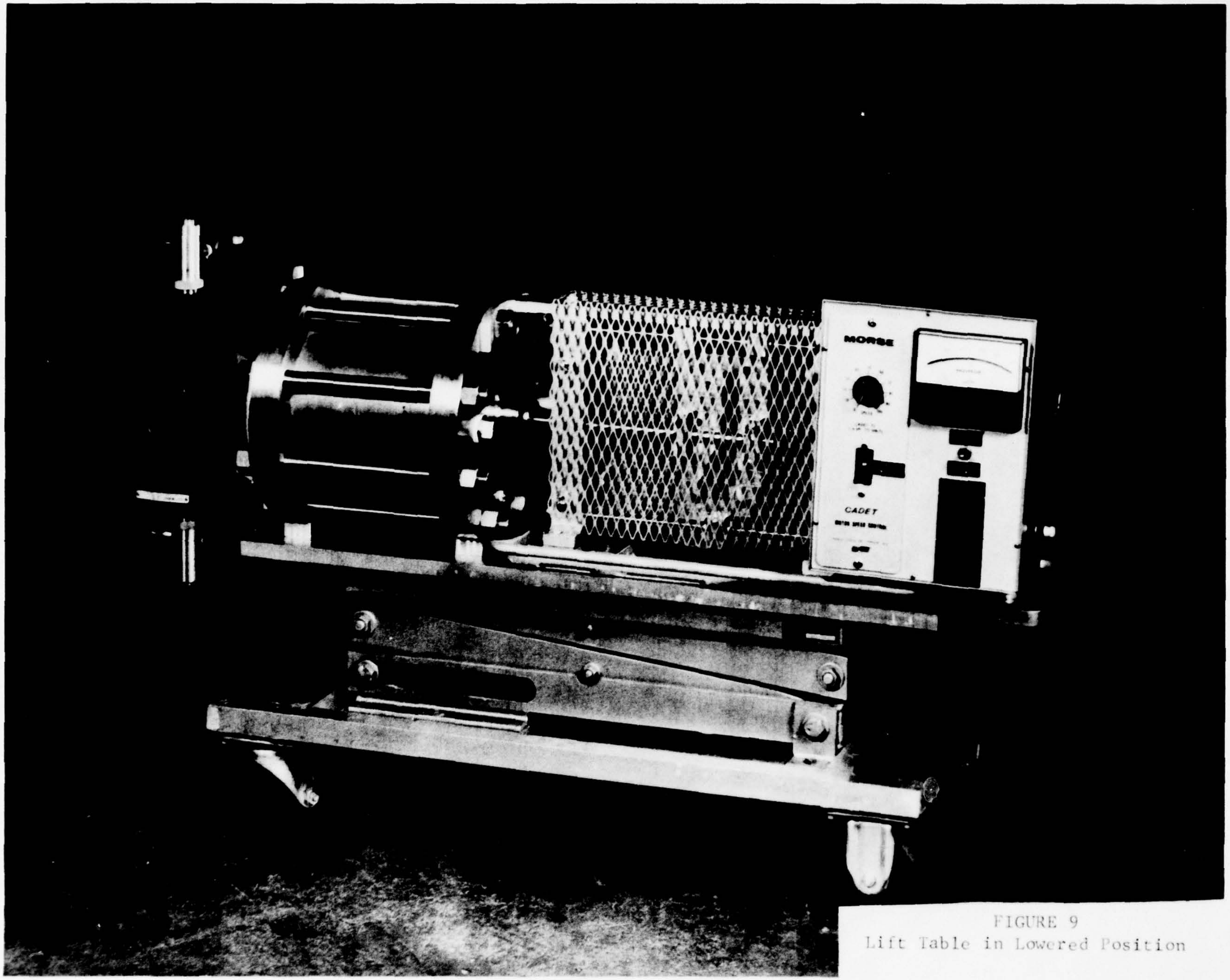


FIGURE 9
Lift Table in Lowered Position

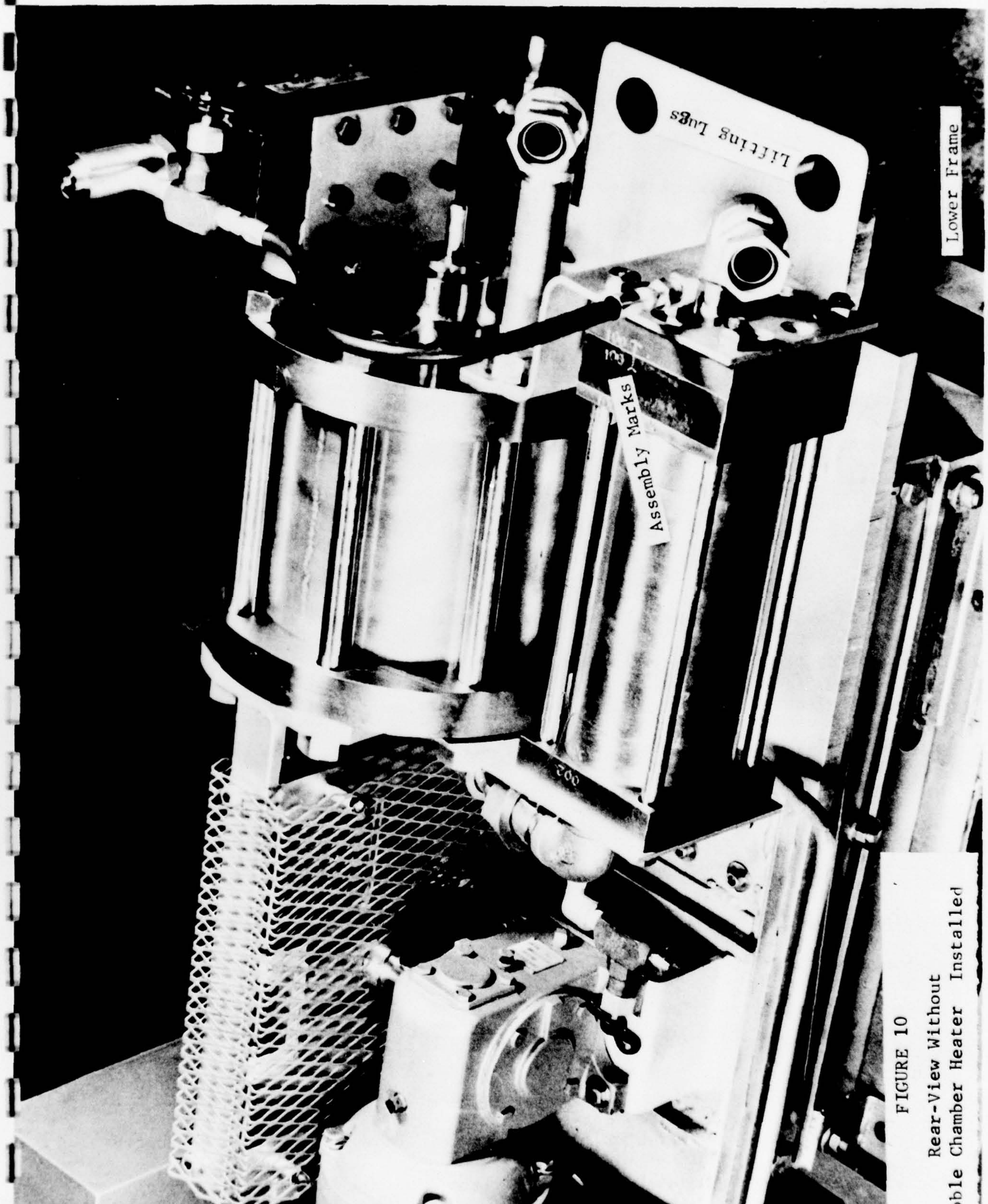


FIGURE 10
Rear-View Without
Bubble Chamber Heater Installed

If the unit must pass through a small hatch or manhole, it may be stood on end and lowered, CO_2 flow meter end first, as shown in Figure 11. AGAIN, THE LOWER FRAME SHOULD BE SECURED TO THE BASE PLATE OR DAMAGE CAN BE DONE TO THE LIFT TABLE. Also, oil may run out the top vent plug on the gearbox. Replace this vent with a solid plug for transportation, reinstall the vent plug for operation. Care must be taken not to damage the hour meters and control box by rough handling.

The respirator may also be broken down into two-man units for hand carrying. To do this, ten capscrews must be removed from the auxiliary base plate. Two of these fasten the auxiliary base plate to the lift table, and the other eight fasten the auxiliary base plate to the main base plate. The wire mesh protective cover should be removed for easier removal of the screws. Next, two capscrews clamping the cam plate support carriage to the piston rod must be loosened (Figure 6). Now, the two bolts must be removed from the top of the carriage support posts (Figure 6), and the two 7/8-inch cylinder bolts holding this brace should be loosened. Pull the two dowel pins (the pins with washers attached for ease of gripping) from the auxiliary base plate, and disconnect the cord connecting the control box to the lift table and the cord connecting the control box to the bubble chamber. Slide the auxiliary base plate axially off the piston rod. Remove the capscrew holding the main base plate to the lift table (located under the bubble chamber) and lift the main base plate, complete with the cylinder and bubble chamber, off the lift table. Now the unit may be easily transported by two men.

To reassemble the unit, place the main base plate complete with the cylinder and bubble chamber upon the lift table. Insert the capscrew beneath the bubble chamber to hold the main base plate upon the lift table. Slide

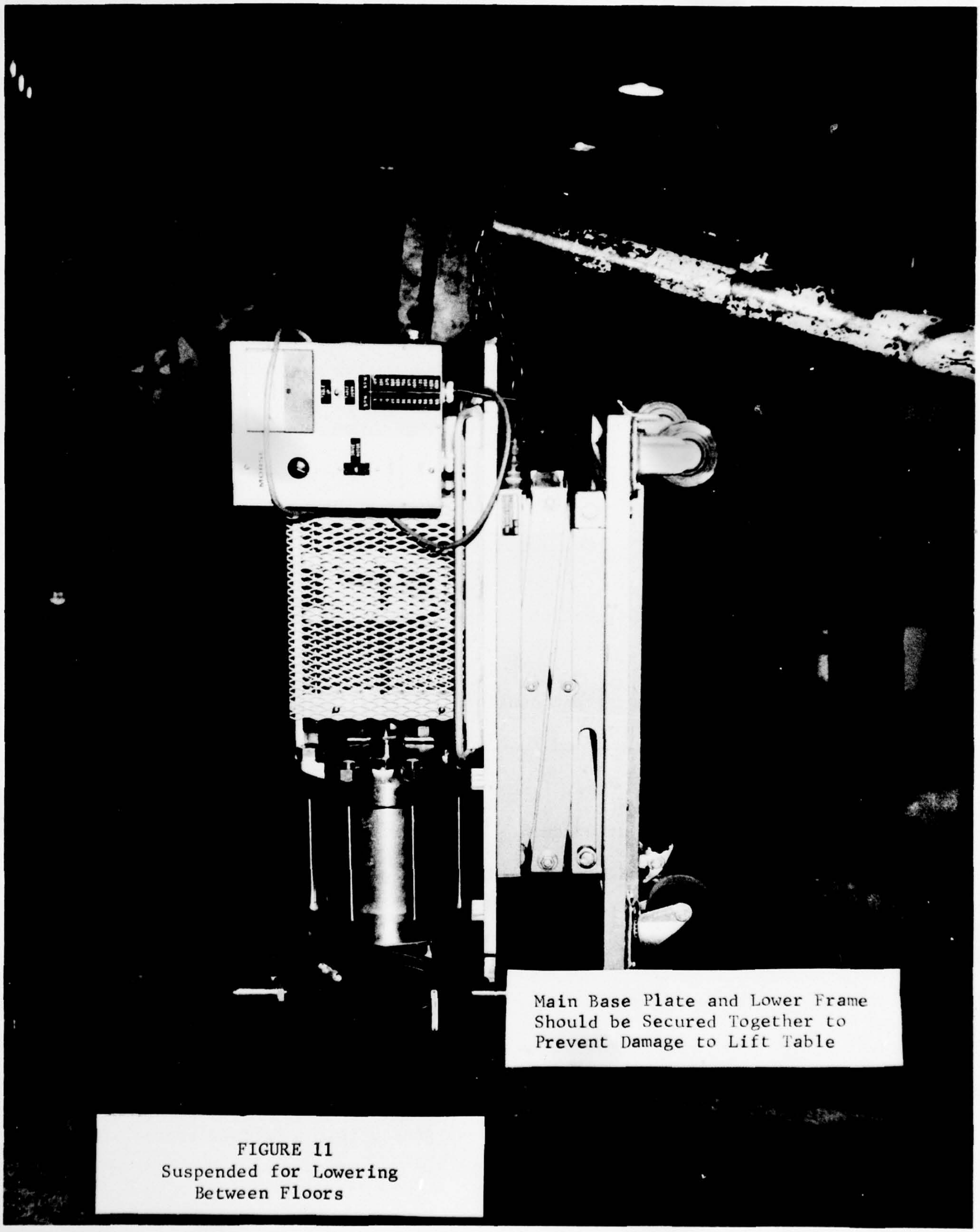


FIGURE 11
Suspended for Lowering
Between Floors

the auxiliary base plate back onto the main base plate and insert the dowel pins. Position the main base plate upon the lift table such that the two screws holding the auxiliary base plate to the lift table can be inserted. Replace all the capscrews taken out including the two capscrews in the carriage support posts. After tightening the screws, slide the cam plate support carriage along the piston rod to be sure it slides freely. Plug in the cord connecting the control box to the lift table and the cord connecting the control box to the heater. Set up the desired cam plate and cylinder position as discussed under operating procedure. The unit should be ready for operation.

MAINTENANCE

The following lubrication is recommended for the mechanical respirator:

(1) Electric motor and controller - none. Appendix A contains a wiring guide and instructions for the motor and controller.

(2) Worm-gear reducer - keep oil level to check plug at all times. Change oil at 6-month to one-year intervals depending upon service conditions. Appendix B contains a sheet of recommended oils.

(3) Lift table - the lift table should need no maintenance. If the table fails to perform satisfactorily, check the oil level. The Service Manual is included in Appendix C.

(4) Cam follower - none.

(5) Cam plates - apply any clean grease to the surface contacted by the cam follower.

(6) Cam plate carrier support ball bushings - lubricate occasionally with heavy oil or grease.

(7) Air-cylinder bore, piston shaft seals and piston shaft support bearings - none. Drawings for the seals are included in Appendix D.

The CO_2 flow meter may need periodic cleaning. If the float shows signs of sticking, follow the procedures outlined in Appendix E. The Tach-Pak may be calibrated according to instructions included in Appendix F if it appears to be in error.

The piston cups and V-ring gland packings are nonlubricated and may require occasional replacement if leakage becomes a problem. Two extra sets of each are included with the machine. To replace the V-ring packing set, remove the clamping nut from the cylinder end cap and move the piston slowly such that a pressure is built up behind the V-ring packing; this should force the packing out. Install the new set such that the point of the V of the rings is directed axially outward from the cylinder. The direction of the packing is important because these seals are made such that a higher pressure insures a tighter seal. To replace the packing set nearest the drive system, the unit must either be dismantled as discussed under transportation procedures or the piston rod must be removed as discussed below.

To replace the guide bearings and piston cups, the cylinder must be dismantled. This is done by removing the eight 7/8-inch-diameter cylinder bolts, including those supporting the bubble chamber and the CO_2 regulator. Also, remove the rear end support bracket for the bubble chamber. Then unscrew the dowel pin which aligns the rear end plate of the cylinder from underneath the main base plate. Remove the two large capscrews holding the rear end plate to the main base plate and slide the end plate off of the piston rod. Also, remove the cylinder by sliding it axially off the piston. To remove the piston and rod, loosen the two capscrews that clamp it to the cam support carriage and slide it out of the end flange.

The old guide bearings may be removed by screwing a 1/4-inch pipe tap into the bearing and pulling outward. The new Rulon bearings are installed by gently tapping them in place with a soft-headed (plastic) hammer. The piston cups are replaced by removing the 12 screws clamping the 2 disks of the piston together and separating them. If the piston is removed from the rod for any reason it must be replaced such that the set screw is within the flat on the shaft with the hub of the piston directed to the short end of the shaft. Also, make sure the O-ring between the piston hub and the piston shaft is in place before reassembly. The bearings and V-ring seals were purchased from the Dixon Corporation of Bristol, Rhode Island, 02809, under the Battelle Memorial Institute Purchase Order No. Z-393 of March 25, 1969. The piston cups were purchased under Battelle Memorial Institute Purchase Order No. Z-9279 of August 20, 1969. Drawings of the seals are included in the drawing set.

Before reassembly the O-rings on both the bubble chamber and the main chamber should be checked and replaced as necessary. Also, the check valves in the bubble chamber should be replaced if necessary. The bubble chamber and main cylinder exterior pieces have been numbered to assist during reassembly (Figure 10). Be sure that the numbers and dotted lines match up after assembly. The shims and dowel pins located between the main cylinder and the main base plate should be in place.

Appendix G contains assembly drawings for the cylinder and bubble chamber to aid in disassembly and reassembly.

APPENDIX A

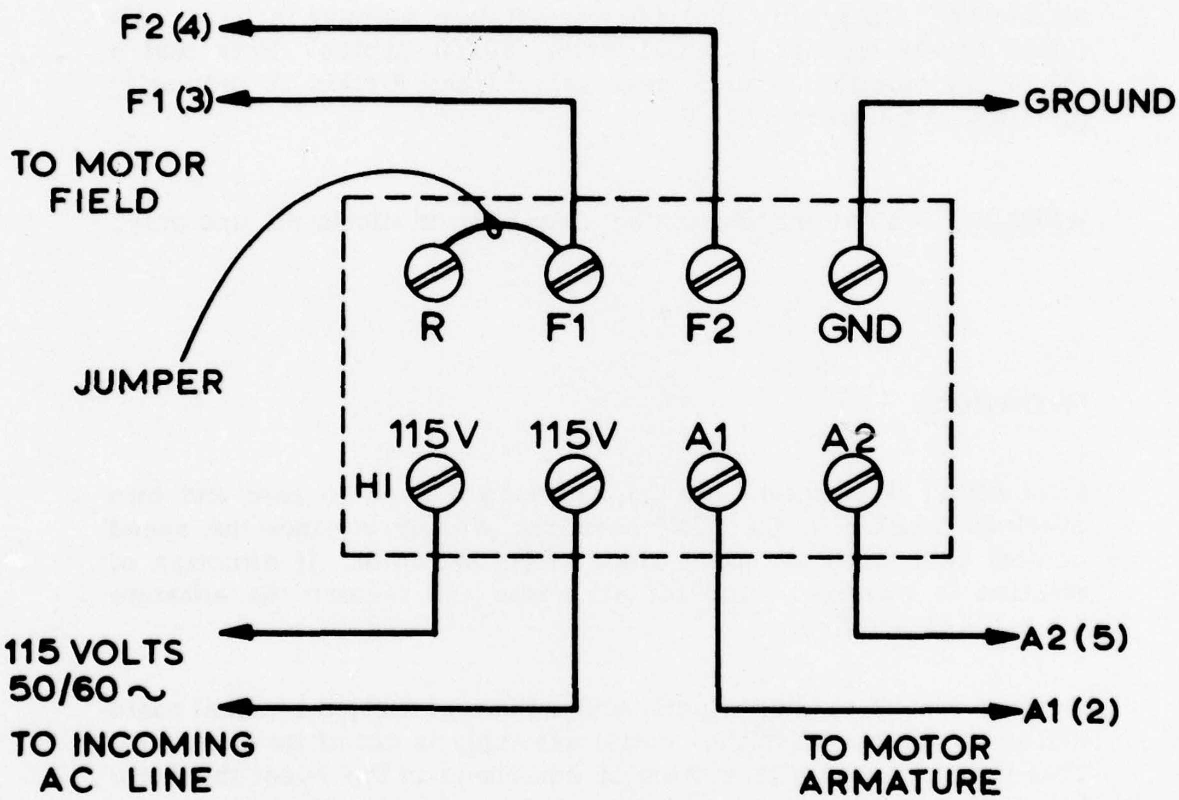
MORSE SCR MOTOR SPEED CONTROL INSTRUCTIONS

APPENDIX A

INSTRUCTIONS

MORSE SCR MOTOR SPEED CONTROLS

CADET SERIES



INSTALLATION WIRING

When connected as shown, motor shaft will turn clockwise (looking at pulley end). For ccw rotation, disconnect power and reverse A1 - A2.

WIRING

Connect the system in accordance with the wiring diagram shown above, using #16 wire for ratings of 1/4 - 1/3 - 1/2 hp and #14 wire for 3/4 hp. Make sure that the correct line voltage is used. All Cadet drives operate from 115 volts, 50/60 cycles. Note that a jumper is required between terminals F1 and R (this is ordinarily installed at the factory).

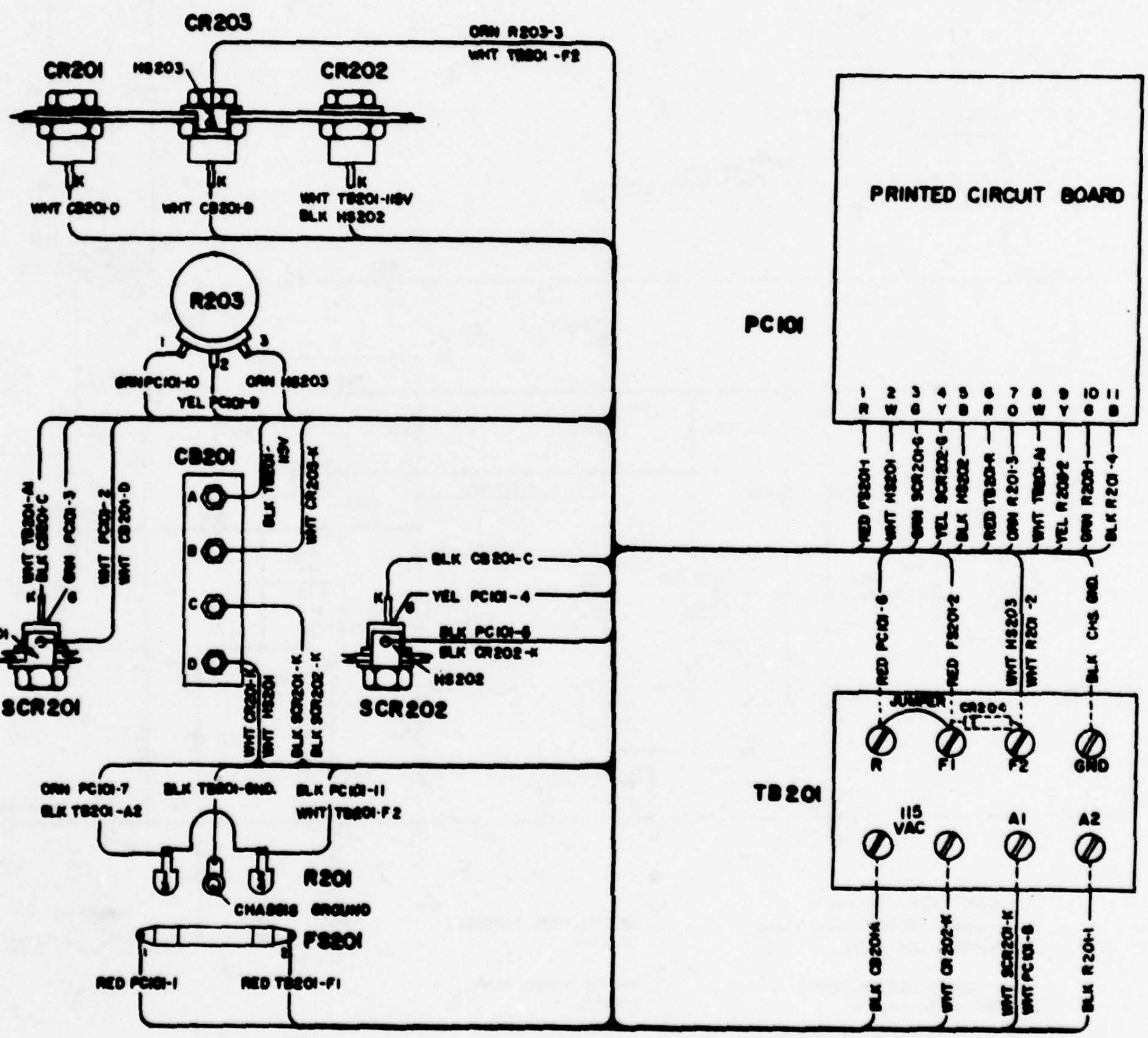
WARNING For external switching, break the incoming AC line only.

OPERATION

After wiring is complete, turn speed control knob to zero and turn overload breaker to the "ON" position. Slowly advance the speed control knob until the motor shaft starts to rotate. If direction of rotation is incorrect, turn off all power and reverse the armature leads. (A1 and A2).

Note: A fuse is located directly under the installation terminal board and is accessible when the control assembly is out of its enclosure. This fuse is only for protection of equipment in the event the motor has been wired to the control incorrectly, and should never require replacement during ordinary service.

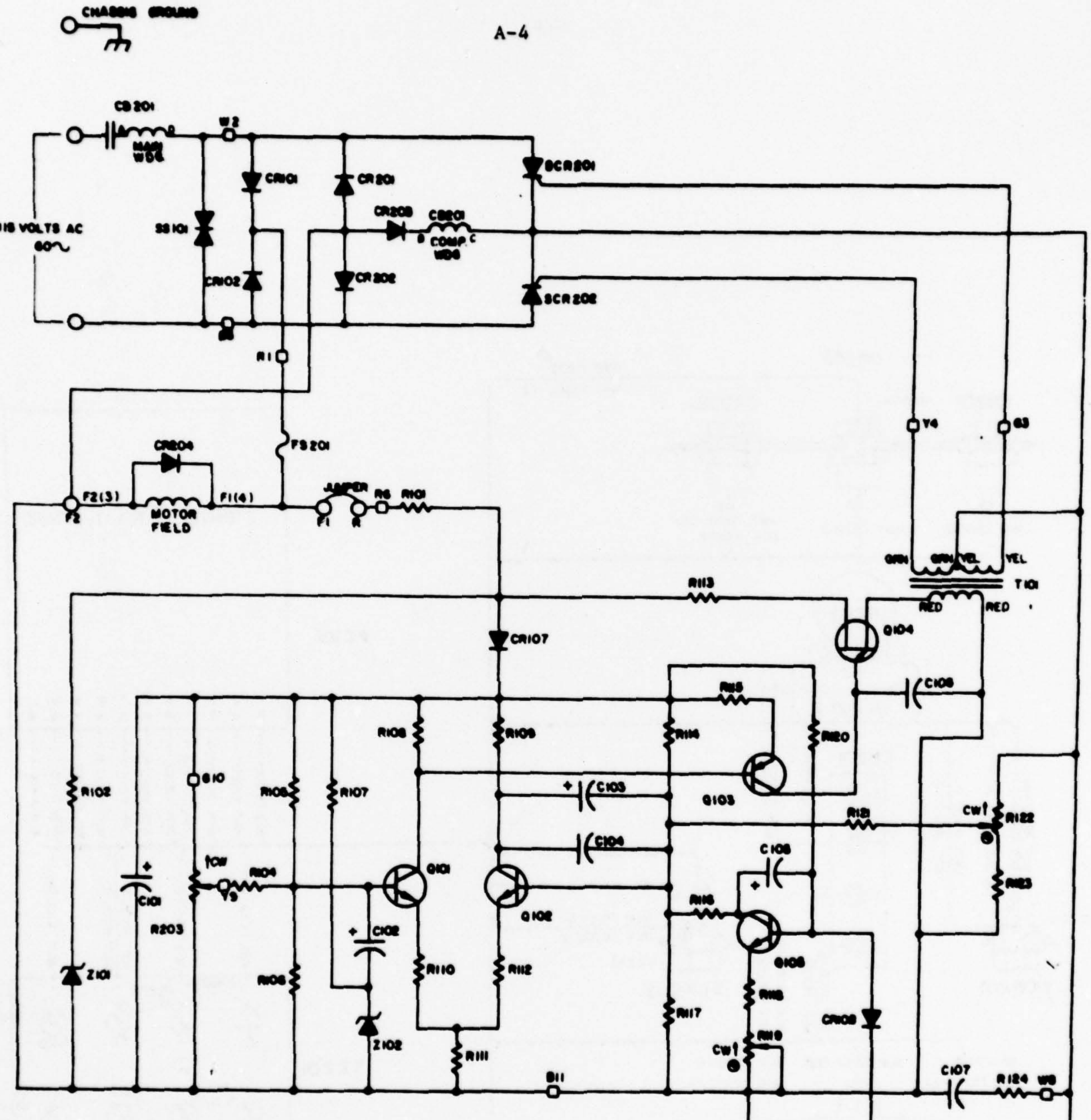
Fuse Type 1 AMP 250V AGC-1



WIRING DIAGRAM -CADET MOTOR SPEED CONTROL, 1/4 THRU 1/2 HP

REV. B XC3402
REV. A XC3383

1201310 MAY 23, 1967



COMPONENT NUMBERS

100 SERIES - PRINTED CIRCUIT BOARD
200 SERIES - MAIN CHASSIS

INTERNAL ADJUSTMENTS

R 203 - SPEED CONTROL
R 119 - IR COMPENSATION (FACTORY)
R 122 - MAXIMUM SPEED (FACTORY)

F2 ○ MAIN CONTROL TERMINALS (TYPICAL)

W2 □ PRINTED CIRCUIT BOARD (TYPICAL)

SCHEMATIC DIAGRAM – CADET MOTOR SPEED CONTROL, 1/4 THRU 1/2 HP.

REV B [illegible]
REV A [illegible]
[illegible] MAY 23, 1967

APPENDIX B

MORSE GEAR REDUCER RECOMMENDED OILS

APPENDIX B

E-D LUBRICATION

MORSE®

FORM 5046-001

BULLETIN NO. 34

ITHACA, NEW YORK 14850

January, 1968

For Enclosed Worm Gear Units Only. A worm gear unit is only as good as the oil which is used. During the first few days of operation, a worm gear unit will run hot. Unless the temperature exceeds 200°F. there is no cause for alarm. Keep oil level up to check plug at all times. Change initial oil fill after 2 weeks operation and after that at six months to one year intervals depending on the service conditions.

OIL COMPANY NAME	MEDIUM OIL	HEAVY OIL
Atlantic Refining Co.	Mogul Cyl. Oil	Atlantic Capital Cyl. Oil
Cities Service Oil Co.	Optimus No. 6	Optimus No. 5
Continental Oil Co.	Inca Cyl. Oil	Zuni Cyl. Oil
Famous Lubricants, Inc.	Gear Life Worm Gear Lube No. 140	Gear Life Worm Gear Lube No. 25
Gulf Refining Co.	Senate Cyl. Oil A	Senate Cyl. Oil C
Houghton & Co., The E. F.	Medium Worm Gear Oil	M. E. Worm Gear Oil
Keystone Lubricating Co.	WG-1	WGA
Pure Oil Co.	Dark Clipper	No. 650 Z Cylinder
Richfield Oil Co.	Richfield Cyl. Oil W. S.	Richfield Superheat Valve Oil
Shell Oil Co.	Shell Valvata Oil No. J-78 or Macoma 72	Shell Valvata Oil No. J-83 or Macoma 78
Sinclair Refining Co.	Moduc Cyl. Light	Superheat Valve
Socony Mobil Oil Co.	Mobile—Cyl. Oil No. 600W or Mobil Compound DD	Mobile—Cyl. Oil No. 600W or Mobil Compound FF
Standard Oil Co. of Ind.	American Worm Gear Oil or Amogear compound No. 5	American Cylinder Oil No. 196-L or Amogear Compound No. 6
Humble Oil and Refining Co.	Cylestic No. T-140 or Pen-O-Led No. 5	Cylestic No. T-190 or Pen-O-Led No. 6
Sun Oil Co.	Occident Cyl. Oil	Occident Cyl. Oil
Texas Co.	Texaco Honor Cyl. or Meropa No. 3	Texaco No. 650T Cyl. Oil or Meropa No. 6
Tidewater Assoc. Oil Co. (N.Y.)	Tycol Valve	Tycol G. A.
The companies and oils shown above are typical. Any other make of oil of the same type and grade should be satisfactory. Your oil supplier should be able to select a similar oil. If an E.P. Oil is used, be sure it is not the type that is corrosive to a bronze gear. Units running at slow speeds should carry extra high oil level.	This oil is to be used in all worm gear reducers for operation at room temperatures from 41° to 90°F. For temperatures from 0° to 40°F., dilute this oil with very light oil of the same basic crude. The use of kerosene is not recommended. Viscosity S.U. Range @ 210°F.—120-150	This oil is to be used in all worm gear reducers for operation at room temperatures from 91° to 120°F. This oil should also be used for slow speeds (less than 100 RPM input) for operation at room temperatures from 41° to 90°F. Viscosity S.U. Range @210°F.—150-190

For Enclosed Helical Gear Reducers and Miter Gear Units. These reducers require the same lubrication care as the transmission and differential in your automobile. For room temperatures above 20°F. use automotive transmission oil or multipurpose gear oil, SAE90 weight. For temperatures below 20° use SAE80 weight.

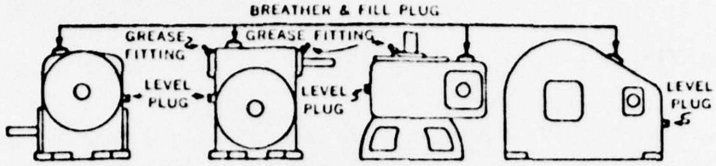
Grease Fittings.

Grease every 100 hours of running time with about ⅜" ball of good bearing grease. DO NOT OVER-LUBRICATE.

GENERAL NOTES—Worm gear oil is very sticky—To fill units it is most easily handled with a pump or gun.

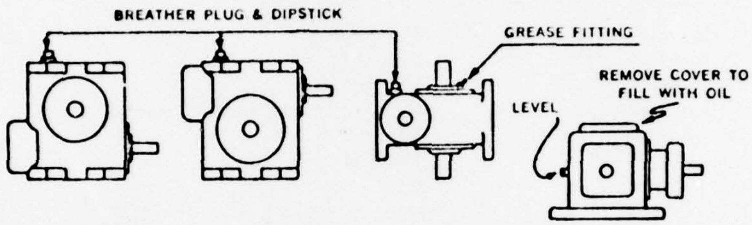
lubricating instructions — "L and H" reducers

Many Eberhardt-Denver Units are equipped with Plug Type Oil Levels. Remove Level Plug and fill Unit with oil until oil runs out Level hole. Breather and Fill Plug is at top of Unit. Grease Fittings are used to lubricate bearings above oil level. Grease every 100 hours running time.



lubricating instructions — "RW" reducers and miter boxes

RW units are equipped with a Breather-Dipstick Fill Plug. This Fill Plug should always be located at top of unit. Fill unit with oil to appropriate oil level line as indicated on dipstick. Units equipped with special dipsticks: fill with oil so dipstick dips into oil ¼". Grease Fittings are used to lubricate bearings above oil level. Grease every 100 hours running time. When mounting units in inverted position or on walls, be sure all bearings get proper lubrication. Miter Boxes do not require Breather Plugs.



"RW" reducers   miter boxes

oil capacity chart Eberhardt-Denver reducers

13LDB	½	Pt.
13LDV	½	Pt.
16LDB	¾	Pt.
17LB	¼	Pt.
17LT	¼	Pt.
17LV	¼	Pt.
21LB	1	Pt.
21LT	¾	Pt.
21LV	¾	Pt.
21LDB	1¼	Pts.
21LDV	1	Pt.
26LB	1½	Pts.
26LT	1½	Pts.
26LV	1¼	Pts.
26LDB	1¾	Pts.
26LDV	1½	Pts.
37LB	1½	Qts.
37LT	1½	Qts.
37LV	1¼	Qts.
37LDB	2	Qts.
37LDV	2	Qts.
10WB	¼	Pt.
10WT	¼	Pt.
10WV	¼	Pt.
13WB	½	Pt.
13WT	½	Pt.
13WV	½	Pt.
18WB	1	Pt.
18WT	¾	Pt.
18WV	1	Pt.
20WB	1¾	Pts.
20WT	1½	Pts.
20WV	1½	Pts.
20WDB	2	Pts.
20WDV	1¾	Pts.
25RWB	2½	Pts.
25RWT	2½	Pts.
25RWV	2¼	Pts.
25WDB	3¼	Pts.
25WDV	3	Pts.
30RWB	3¾	Pts.
30RWT	3¾	Pts.
30RWV	3¼	Pts.
30WDB	2½	Qts.
30WDV	2¼	Qts.
35RWB	3¼	Qts.
35RWT	3½	Qts.

35RWV	2½	Qts.
35WDB	3¾	Qts.
35WDV	3	Qts.
40RWB	3½	Qts.
40RWT	3½	Qts.
40RWV	3	Qts.
40WDB	3¾	Qts.
40WDV	3¼	Qts.
50RWB	1¾	Gals.
50RWT	1¾	Gals.
50RWV	1½	Gals.
50WDB	2¼	Gals.
50WDV	2	Gals.
60RWB	2¾	Gals.
60RWT	3	Gals.
60RWV	2½	Gals.
60WDB	3¾	Gals.
60WDV	3½	Gals.
70RWB	5¾	Gals.
70RWT	5¾	Gals.
70RWV	4½	Gals.
70WDB	7	Gals.
70WDV	6¼	Gals.
18V	1	Pt.
20V	1½	Pts.
20DV	1	Qt.
25V	1	Qt.
25DV	1¼	Qts.
30V	1¾	Qts.
30DV	2½	Qts.
35V	2¼	Qts.
35DV	2¾	Qts.
40V	3½	Qts.
40DV	4¼	Qts.
50V	1½	Gals.
50DV	1¾	Gals.
60V	2½	Gals.
60DV	2¾	Gals.
70V	4	Gals.
70DV	4½	Gals.
30VX Std.	3	Qts.
Inverted	2	Qts.
30DVX Std.	3¾	Qts.
Inverted	2¾	Qts.
35VX Std.	4¼	Qts.
Inverted	3¾	Qts.

35DVX Std.	4½	Qts.
Inverted	4	Qts.
40VX Std.	1¼	Gals.
Inverted	1	Gal.
40DVX Std.	1½	Gals.
Inverted	1¼	Gals.
50VX Std.	2	Gals.
Inverted	1¾	Gals.
50DVX Std.	2¼	Gals.
Inverted	2	Gals.
60VX Std.	3¾	Gals.
Inverted	2¾	Gals.
60DVX Std.	4¼	Gals.
Inverted	3¼	Gals.
70VX Std.	6	Gals.
Inverted	5	Gals.
70DVX Std.	7	Gals.
Inverted	5½	Gals.
90VX	11	Gals.
90DVX	12½	Gals.
110VX	16	Gals.
110DVX	18½	Gals.
25WHB Sec.	2½	Pts.
Primary	1	Pt.
25WHT Sec.	2½	Pts.
Primary	1	Pt.
25WHV Sec.	2¼	Pts.
Primary	1	Pt.
25HV Sec.	1	Qt.
Primary	1	Pt.
30WHB Sec.	3¾	Pts.
Primary	1	Pt.
30WHT Sec.	3¾	Pts.
Primary	1	Pt.
30WHV Sec.	3¼	Pts.
Primary	1	Pt.
30HV Sec.	1¾	Qts.
Primary	1	Pt.
30HVX Sec.	3	Qts.
Primary	1	Pt.
35WHB Sec.	3¼	Qts.
Primary	1	Pt.
35WHT Sec.	3½	Qts.
Primary	1	Pt.
35WHV Sec.	2½	Qts.
Primary	1	Pt.

35HV Sec.	2¼	Qts.
Primary	1	Pt.
35HVX Sec.	4¼	Qts.
Primary	1	Pt.
40WHB Sec.	3½	Qts.
Primary	1	Pt.
40WHT Sec.	3½	Qts.
Primary	1	Pt.
40WHV Sec.	3	Qts.
Primary	1	Pt.
40HV Sec.	3½	Qts.
Primary	1	Pt.
40HVX Sec.	1¼	Gals.
Primary	1	Pt.
50WHB Sec.	1¾	Gals.
Primary	1	Qt.
50WHT Sec.	1¾	Gals.
Primary	1	Qt.
50WHV Sec.	1½	Gals.
Primary	1	Qt.
50HV Sec.	1½	Gals.
Primary	1	Qt.
50HVX Sec.	2	Gals.
Primary	1	Qt.
60WHB Sec.	2¾	Gals.
Primary	1¼	Qts.
60WHT Sec.	3	Gals.
Primary	1¼	Qts.
60WHV Sec.	2½	Gals.
Primary	1¼	Qts.
60HV Sec.	2½	Gals.
Primary	1¼	Qts.
60HVX Sec.	3¾	Gals.
Primary	1¼	Qts.
70WHB Sec.	5¾	Gals.
Primary	2	Qts.
70WHT Sec.	5¾	Gals.
Primary	2	Qts.
70WHV Sec.	4½	Gals.
Primary	2	Qts.
70HV Sec.	4	Gals.
Primary	2	Qts.
70HVX Sec.	6	Gals.
Primary	2	Qts.

13GCT	½	Pt.
13GCV	½	Pt.
18GCT	¾	Pt.
18GCV	1	Pt.
20GCT	1½	Pt.
20GCV	1	Qt.
25GCT	1¼	Qts.
25GCV	1½	Qts.
30GCT	2	Qts.
30GCV	2½	Qts.
35GCT	3	Qts.
35GCV	3¾	Qts.
18SMR	¾	Pt.
18GCSMR	¾	Pt.
20SMR	1½	Pts.
20GCSMR	1½	Pts.
25SMR	1¼	Qts.
25GCSMR	1¼	Qts.
30SMR	2	Qts.
30GCSMR	2	Qts.
35SMR	3	Qts.
35GCSMR	3	Qts.
13GCDB	¾	Pt.
13GCDV	¾	Pt.
18GCDB	1	Pt.
18GCDV	1	Pt.
20GCDB	1	Qt.
20GCDV	1	Qt.
25GCDB	3¼	Pts.
25GCDV	1¼	Qts.
30GCDB	2½	Qts.
30GCDV	2½	Qts.
35GCDB	3¾	Qts.
35GCDV	2¾	Qts.
40GCDB	3¾	Qts.
40GCDV	4¼	Qts.
50GCDB	2¼	Gals.
50GCDV	1¾	Gals.
60GCDB	3¾	Gals.
60GCDV	2¾	Gals.
4M	¾	Pt.
6M	1	Qt.
8M	2	Qts.
12M	1½	Gals.
261H	1	Pt.
351H	1½	Qts.
521H	3	Qts.

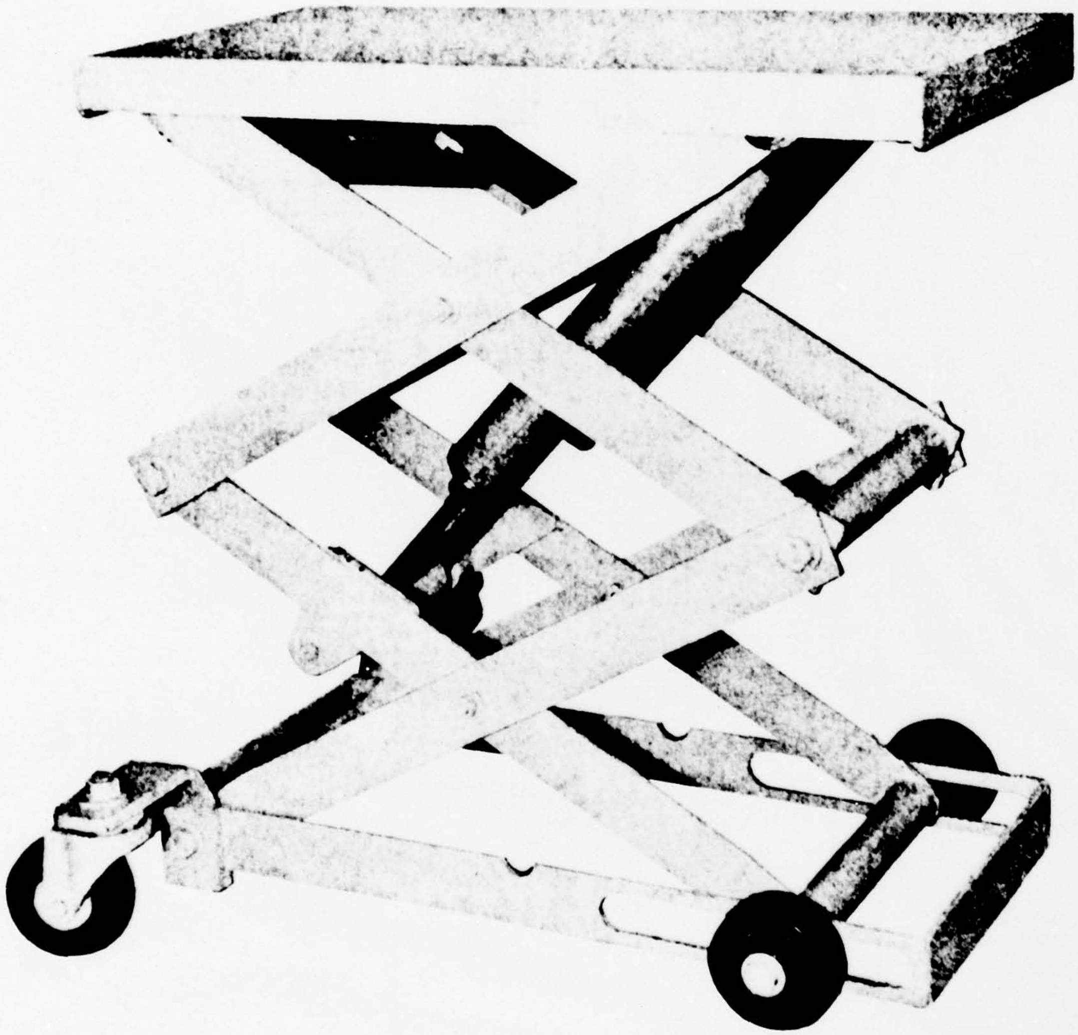
Eberhardt-Denver Plant — Morse Chain, Division of Borg-Warner Corporation
Denver, Colorado

APPENDIX C

SOUTHWORTH LIFT TABLE SERVICE MANUAL

APPENDIX C

SOUTHWORTH SERVICE MANUAL

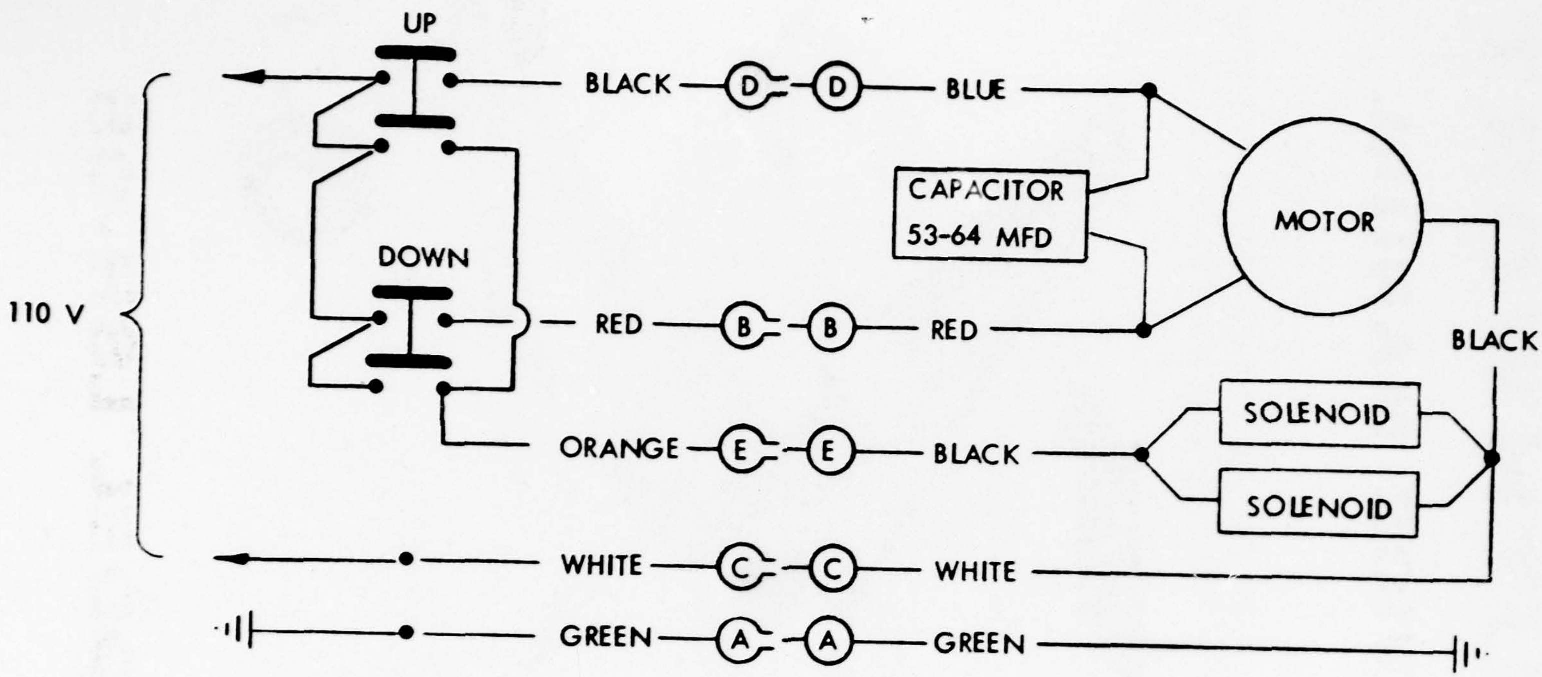


MODEL LSH-05

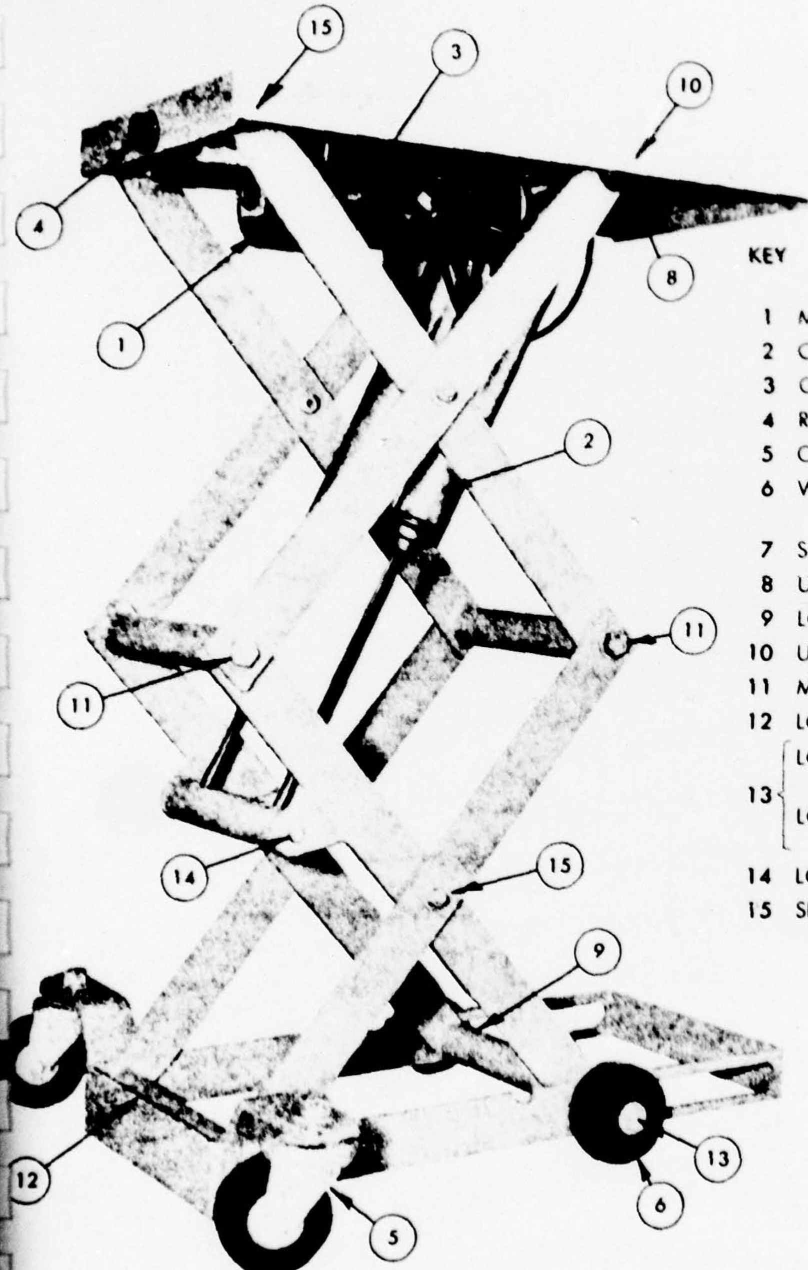
LIFT TABLE

SOUTHWORTH MACHINE COMPANY
30 WARREN AVENUE, PORTLAND, MAINE (04104)

WIRING DIAGRAM **MODEL LSH-05B (MINI-LIFT)**



MODEL LSH-O5B



KEY	NAME	PART NO.
1	MOTOR & PUMP	LSH-O5B-57MP
2	CYLINDER	LSH-O5B-57CYL
3	CAPACITOR	LSH-O5B-57CAP
4	RECEPTACLE	AMPHENOL #MS-3102A-18-11P
5	CASTER (Portable Model)	BASSICK #35689-1-XTS
6	WHEEL (Portable Model)	BASSICK #WD-91035 (For ½" Dia. Shaft)
7	SWITCH & CORD ASBY.	LSH-O5B-74
8	UPPER ROLLER	LSH-O5B-43
9	LOWER ROLLER	LSH-O5B-44
10	UPPER ROLLER ROD	LSH-O5B-49
11	MIDDLE HINGE BOLT	LSH-O5B-50
12	LOWER HINGE BOLT	LSH-O5B-53
13	LOWER ROLLER BOLT (Stationary Model)	LSH-O5B-51
13	LOWER ROLLER BOLT (Portable Model)	LSH-O5B-52
14	LOWER ROD FOR CYLINDER	LSH-O5B-48
15	SHOULDER SCREW	LSH-O5B-59

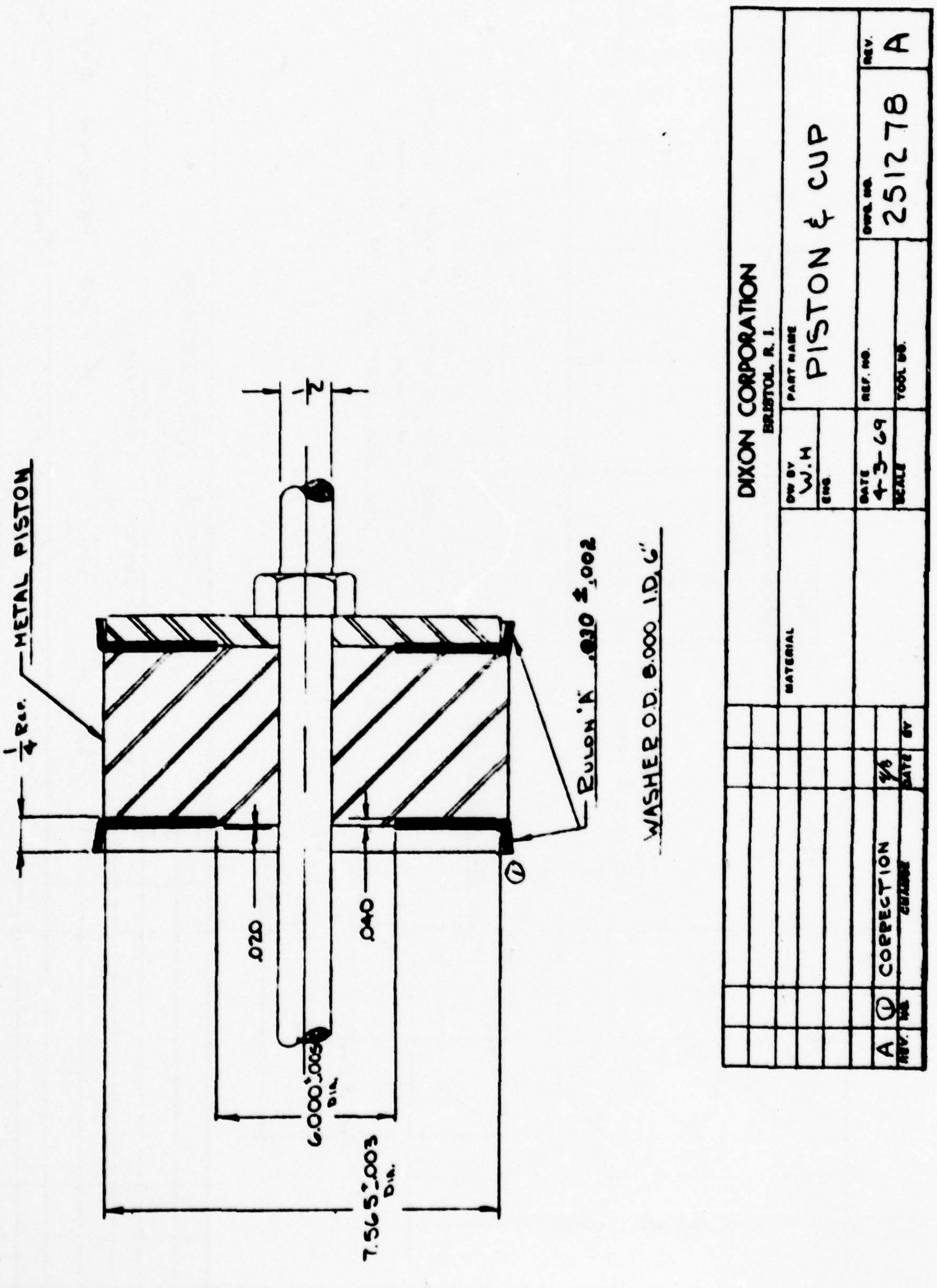
NOTE: When replacing Bolt 11, 12 or 13, leave Lock Nut ½ turn loose.

Unit was shipped with 70% SOHIO Renown #40, 30% SOHIO Renown #78 grade oil.

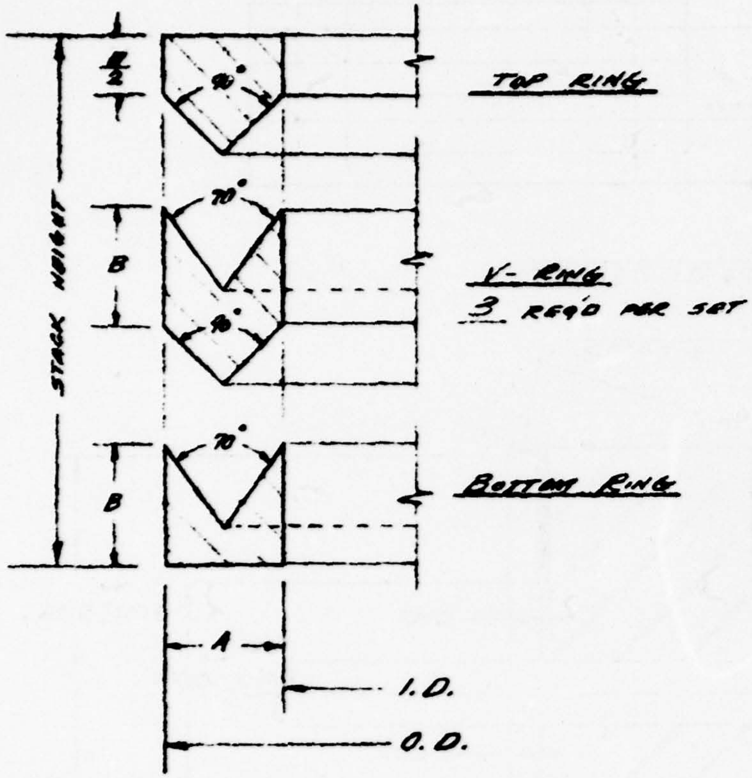
APPENDIX D

SEAL DRAWINGS

APPENDIX D



METAL PISTON
1/4 REF.
RULON 'A' .030 ±.002
WASHER O.D. 8.000 I.D. 6"
.020
.040
6.000±.005 DIA.
7.565±.003 DIA.
DIXON CORPORATION
BRISTOL, R. I.
PART NAME
PISTON & CUP
MATERIAL
DW BY W.H
DATE 4-3-69
DWG NO. 25127B
REV. A
A 1 CORRECTION



DASH NO.	O.D.	I.D.	A (REF.)	B	STACK HEIGHT
-1	.996	.502 +.004 -.000	1/4"	.250	1 1/8"

.010 MAX. FLAT ON SHARP CORNERS PRODUCED BY 70° ANGLE.

.040 MAX. FLAT ON 90° ANGLE

REV	NO.	CHANGE	DATE	BY

DIXON CORPORATION
BRISTOL, R. I.

MATERIAL: RULON "A"

DW BY: D.B.

ENG: [illegible]

DATE: 4-?-69

SCALE: NONE

PART NAME: V- RING PACKING SET

REF. NO.

TOOL NO.

DWG. NO: 152425

REV.

APPENDIX E

CO_2 FLOW METER CLEANING INSTRUCTIONS

APPENDIX E

X-1400

BROOKS INSTRUMENT DIVISION • HATFIELD, PENNSYLVANIA

IMPORTANT

PLEASE READ CAREFULLY! If you will first take the time to read these instructions [illegible] before [illegible]king the equipment, you will readily obtain the long term performance with low maintenance for which products of the [illegible] are well known.

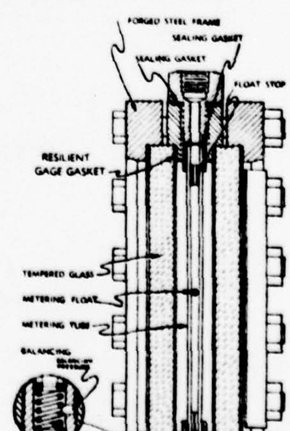
INSTALLATION AND OPERATING INSTRUCTIONS

Series 1400 High Pressure Gage Glass Rotameters

DESCRIPTION

Brooks Series 1400 High Pressure Rotameters are variable area, glass tube, flow rate indicating devices. They are designed for high pressure applications, above the normal limits of industrial glass tube rotameters. The basic flow rate metering elements are a tapered glass tube and a float. The glass metering tube in Series 1400 Rotameters is pressure equalized and enclosed in a high pressure gage with safety shielding. A small hole in the inlet fitting allows the fluid to fill the area between the outside of the metering tube and the inside of the gage. Flow cannot by-pass the metering tube because of the positive pressure applied by the tube retaining spring to maintain a leak-proof outlet seal.

MODEL 1432



UNPACKING

Carefully unpack the meter and inspect it for any shipping damage. Generally the floats are shipped within the meter, but on some larger units, the float is packed separately in the same shipping carton. Be sure that the metering float is not accidentally discarded with the packing material.

INSTALLATION

The meter should be mounted in a vertical position with the inlet (upstream flow line) connected to the bottom rotameter connection, and the outlet (downstream line) connected to the top connection. Should the rotameter not be mounted in a vertical position, accuracy and sensitivity may be affected. Be sure that the piping is adequately supported to prevent strain on the meter.

We strongly recommend installing a by-pass arrangement around the meter. By-pass piping (Fig. 1) permits the meter to be isolated from the flow line for servicing or cleaning.

OPERATION

Once the rotameter has been installed, it is ready for operation. The adapter fittings and the gage studs should not require adjustment since the meter has been pressure tested twice after assembly.

We suggest by-passing the first flow surge when the process is started up. Referring to Fig. 1, first, by-pass valve (C) fully and the control valve (D) slightly. Then, open the meter inlet and outlet valves (A & B respectively). After the inlet line has been purged of air, close the by-pass valve (C) slowly. This method brings the rotameter on stream smoothly; allows the float to start indicating the flow rate without bouncing.

For best results, the meter inlet and outlet valves (A & B) should remain fully open, permitting valve (D) to be used for complete flow control. This arrangement is consistent with good control practice to provide steady float operation. Fig. 2 illustrates how to read metering floats.

The rotameter is designed and calibrated for a specific set of fluid pressure, temperature, specific gravity and viscosity conditions. If these changed from those originally stated, the accuracy of the meter will be affected. See Brooks Bulletin T-022 for method of calculating a correction factor for changed conditions.

MAINTENANCE

Tube and Float Removal

If the float sticks inside the rotameter tube, it will be necessary to clean the tube. Use the following procedure to remove the float and tube:

1. Remove the inlet end fitting.
2. Remove the tube retaining spring, tube seal and tube seal gasket. This allows the float to come out the inlet. Care should be exercised so the float is not dropped or damaged in any way.
3. The tube may then be removed. A round wooden dowel, the approximate size of the outlet of the rotameter tube, may be used to push the tube out the inlet of the gage body. The rotameter tube is made of Borosilicate glass and may be cleaned with any suitable solvent.

Tube and Float Reassembly Procedure

1. Insert a wooden dowel into the outlet of the rotameter tube.
2. Push the rotameter tube, outlet end first, into the high pressure body, using the dowel to guide the tube up to the outlet fitting.
3. Install the tube seal gasket, tube seat, tube retaining spring and the O-ring seal. The above parts may be assembled in the inlet fitting and installed as an assembly with the inlet fitting.
4. Install the inlet fitting. Note that the inlet and outlet fittings are not identical; the inlet fitting has a small pressure balance hole. Excessive force is not required to tighten the inlet and outlet fittings.

Fig. 1 BY-PASS PIPING

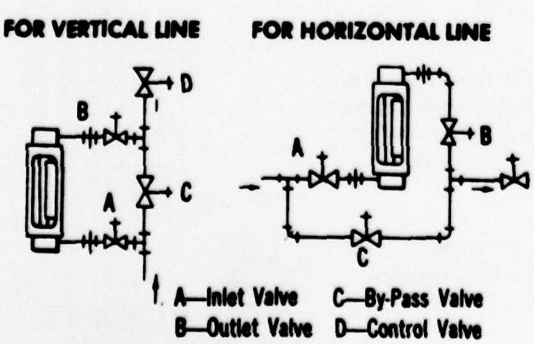
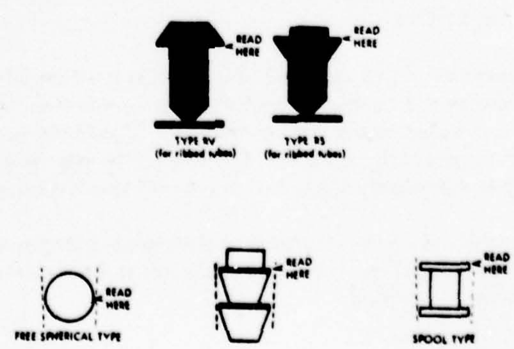


Fig. 2 HOW TO READ METERING FLOATS



Disassembly and Assembly of High Pressure Gage

This procedure is straightforward except that certain meters require their bolts tightened to a specified torque. Meter sizes 1 through 6 in Models 1432, 1435, 1438, 1441, 1452, and 1455 are equipped with a specially designed resilient gasket to seal the tempered glass of the gage and do not require tightening with a torque wrench.

All other Series 1400 Rotameters require the following assembly procedure:

1. The tightening operation should begin with the center set of studs, with torque applied to alternate sides about the center set of studs. In this manner the end studs will be tightened last. Final torque values should be reached by making three or more sequential passes in order to impose as little strain on the gage glass as possible. See Table 1 for torque values.

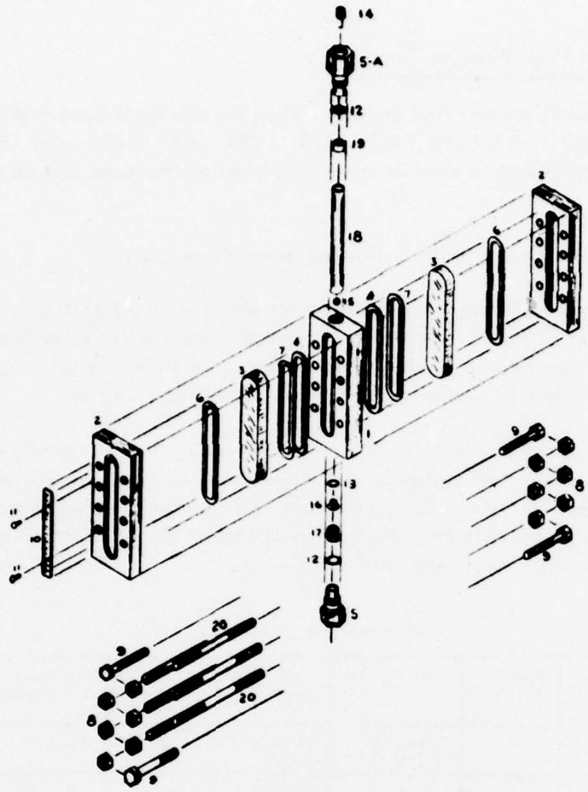
2. In order to achieve satisfactory operation and inspection tests, it is extremely important the torque values be maintained. The proper torque values have been applied at the factory prior to shipment, but some loss may occur during shipment from compression of the sealing gasket. It may also be necessary to perform periodic checks of torque values to insure maximum service life, particularly where service pressure fluctuates.

High Pressure Gage Torque Values

Model No.	Meter Size	Connection Size (inches)	Scale Length (MM)	Safe Working Pressure PSI @ 200°F	Stud Torque (Foot-Pounds)
1407	1-7 8	1/2 Flg. 1/2 Flg.	127 & 150 127	1500* 1500*	60-65
1408	1-7 8	1/2 Flg. 1/2 Flg.	127 & 150 127	1500* 1500*	60-65
1409	1-6 7 8	1/4 NPT 3/8-1/2 NPT 1/2 NPT	127 & 150 127 127	1500 1500 1500	60-65
1410	1-6 7 8	1/4 NPT 3/8-1/2 NPT 1/2 NPT	127-150 127 127	1500 1500 1500	60-65
1411	5-6 7-8	1/4 NPT 3/8-1/2 NPT	240 240	1500 1500	60-65
1412	5-6 7-8	1/4 NPT 3/8-1/2 NPT	240 240	1500 1500	60-65
1413	5-8	1/2 Flg.	240	1500*	60-65
1414	5-8	1/2 Flg.	240	1500*	60-65
1432	7-8	3/8-1/2 NPT	127	3000	60-65
1433	5-6 7-8	1/4 NPT 3/8-1/2 NPT	240 240	3000 3000	60-65
1435	7-8	3/8-1/2 NPT	127	3000	60-65
1436	5-6 7-8	1/4 NPT 3/8-1/2 NPT	240	3000	60-65
1438	7-8	1/2 Flg.	127	3000*	60-65
1439	5-8	1/2 Flg.	240	3000*	60-65
1441	7-8	1/2 Flg.	127	3000*	60-65
1442	5-8	1/2 Flg.	240	3000*	60-65
1432	1-6	1/4 NPT	127-150	3000	Resilient seal
1435	1-6	1/4 NPT	127-150	3000	Resilient seal
1438	1-6	1/2 Flg.	127-150	3000*	Resilient seal
1441	1-6	1/2 Flg.	127-150	3000*	Resilient seal
1452	1-6	1/4 NPT	127-150	5000	Resilient seal
1455	1-6	1/4 NPT	127-150	5000	Resilient seal

* Indicated rating is for gage body only. Actual rating is that of flange installed

E-4



Series 1400 High Pressure Rotameter

DRAWING REFERENCE	PART DESCRIPTION
1	Liquid Chamber
2	Cover
*3	Gage Glass
*4	Resilient Gasket
5	Inlet Fitting
5-A	Outlet Fitting
*6	Cushion
*7	Gasket Retainer
8	Hex Nut - 1/2" 13-Heavy Semi-Finished
9	Hex Head Cap Screw - 1/2" 13 x 2-1/8" Lg.
10	Scale
11	Scale Screws #4-40 x 1/4" Lg.
*12	O-Ring
*13	Tube Seat Gasket
14	Outlet Float Stop Spring
*15	Float
16	Tube Seat
17	Tube Retaining Spring
*18	Metering Tube
*19	Tube Insert
20	Stud - 1/2" 13 x 5-5/8" Lg.

NOTE: When ordering parts specify serial number, size of meter and item number.

* Recommended Spare Parts

Printed in U.S.A.

APPENDIX F

MORSE TACH-PAK INSTRUCTIONS

APPENDIX F

INSTRUCTIONS

MORSE TACH-PAK®
SPEED INDICATING SYSTEM

1. GENERAL - The Tach-Pak is a solid state tachometer designed especially for use with Morse SCR Adjustable Speed Drives. The system consists of a Pickup Ring, Gear and Indicator. The Pickup Ring is designed for mounting directly to the Nema C face of the drive motor, and contains a magnetic pickup for sensing speed. The Gear mounts on the motor shaft and is positioned so that the teeth are in proximity to the pickup during rotation. The Indicator contains the necessary electronic circuitry to convert the speed signal into a visual indication on the meter.

2. INSTALLATION - Mount the pickup ring to the motor so that the machined recess in the ring fits over the rabbet on the motor face. Align the mounting holes in any one of four positions which will result in the desired cable location. Slide the gear onto the motor shaft, hub facing outward, and position it so that the teeth are in exact alignment with the pickup pole piece. The resulting air gap should be between .005 and .015 inch. Eccentricity should be negligible. Tighten the set screw securely. If the motor is to be foot mounted, and the flange not used, select the set of four short bolts and secure the pickup ring to the motor flange. If the motor is to be flange mounted to a reducer, select the long bolts and assemble the motor to the reducer with the pickup ring sandwiched between. Note: Some reducers may require the removal of the bell flange housing in order to install the longer bolts. Replace the motor key with the one included in the Tach-Pak kit.

   Panel mount the indicator in any suitable location up to 25 feet from the pickup. Refer to Figure 1 for panel cutout dimensions.

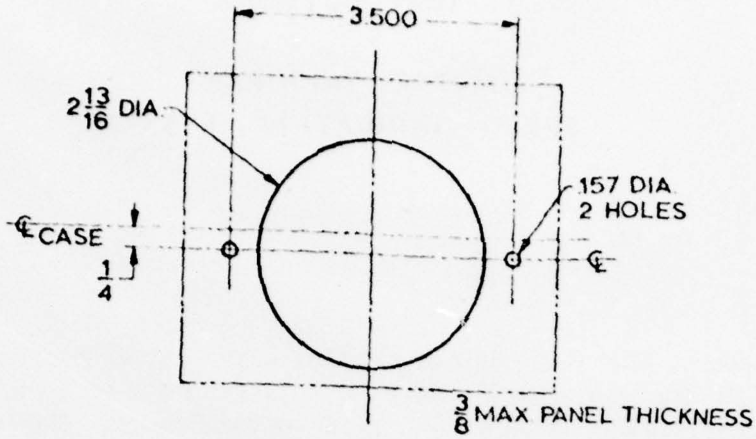


FIGURE 1 - PANEL DRILLING

3. WIRING - If the indicator is installed close to the motor, the pickup cable may be connected directly to the terminals on the back of the indicator assembly. If the distance is too great to permit this arrangement, the pickup cable should be terminated in a suitable junction box and the wiring extended as required. Pickup leads should not be run in conduit containing power wiring.

Connect 115 volts ac to the other terminals on the back of the indicator assembly. Approximately one (1) watt of power is required, therefore any convenient 115 volt, 50/60 cycle source may be used. A suitable source will be found at the installation terminal board of all Morse SCR drives.

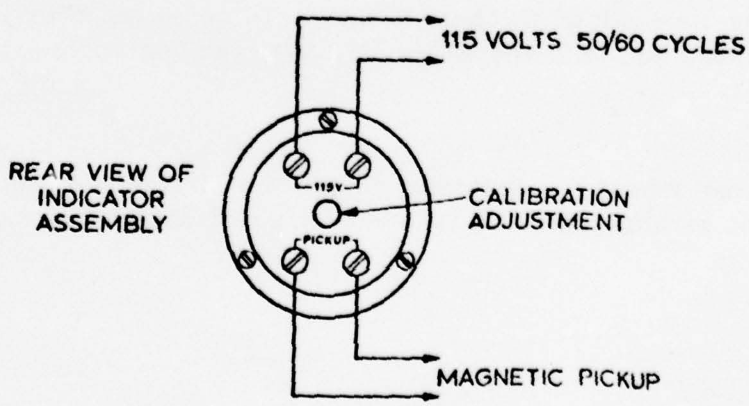


FIGURE 2 - INSTALLATION WIRING

4. OPERATION - With power applied to the indicator assembly, motor speed in either direction may be read directly on the meter. If the pointer is not at zero when the power is removed, adjust the zero-set on the front of the meter case. If the calibration is incorrect, adjust the calibrating potentiometer at the back of the indicator assembly. Remove the plug button for access.

Morse Chain Company
Ithaca, New York

APPENDIX G

ASSEMBLY DRAWINGS AND PARTS LIST

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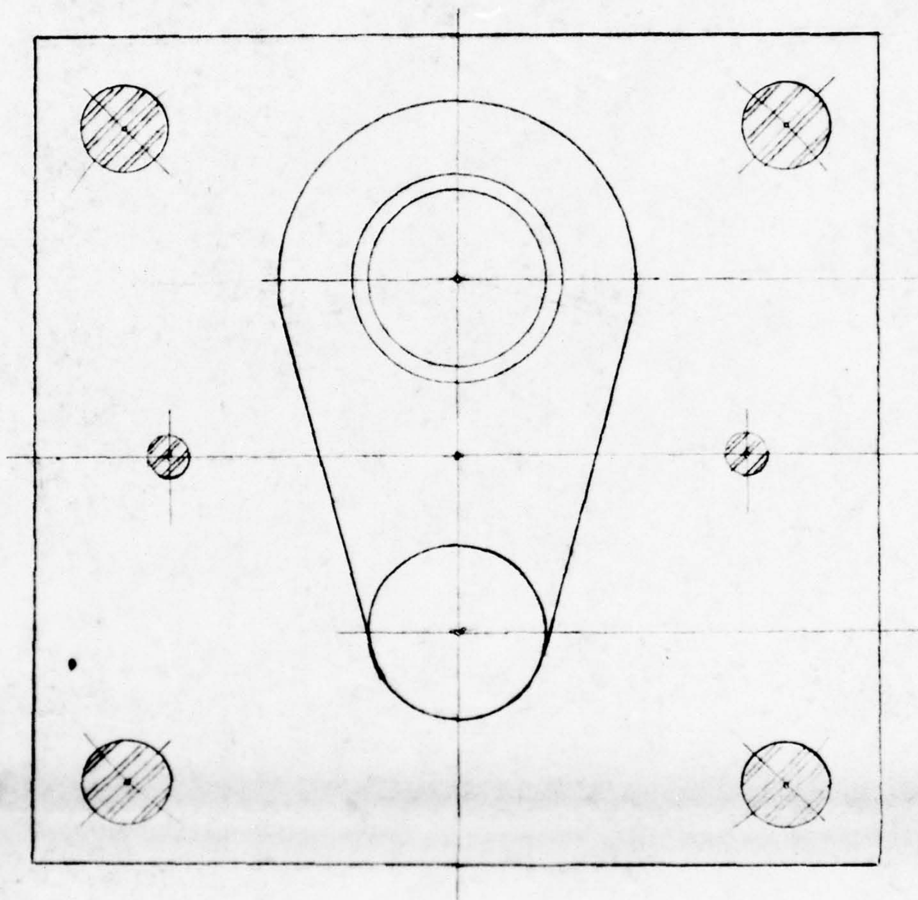

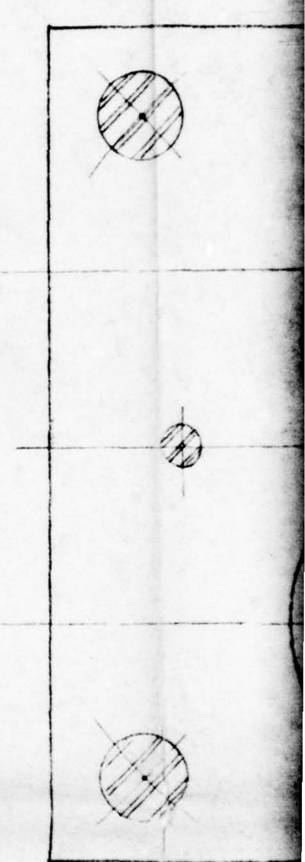

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VIEW B-B

SHOWING PROFILE OF MACHINING
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(WITH CONTROL VALVE REMOVED)

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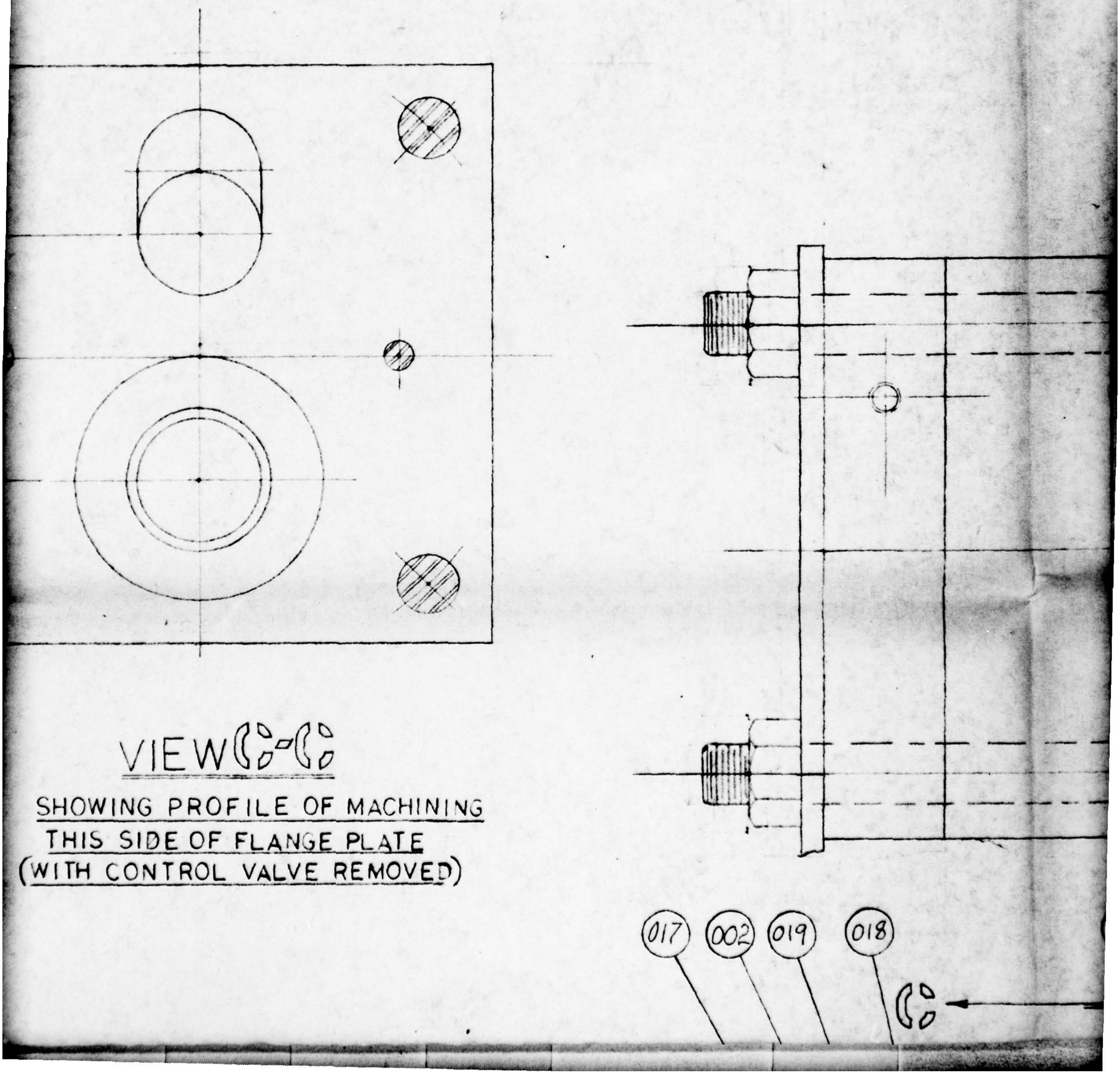

VIEW C-C

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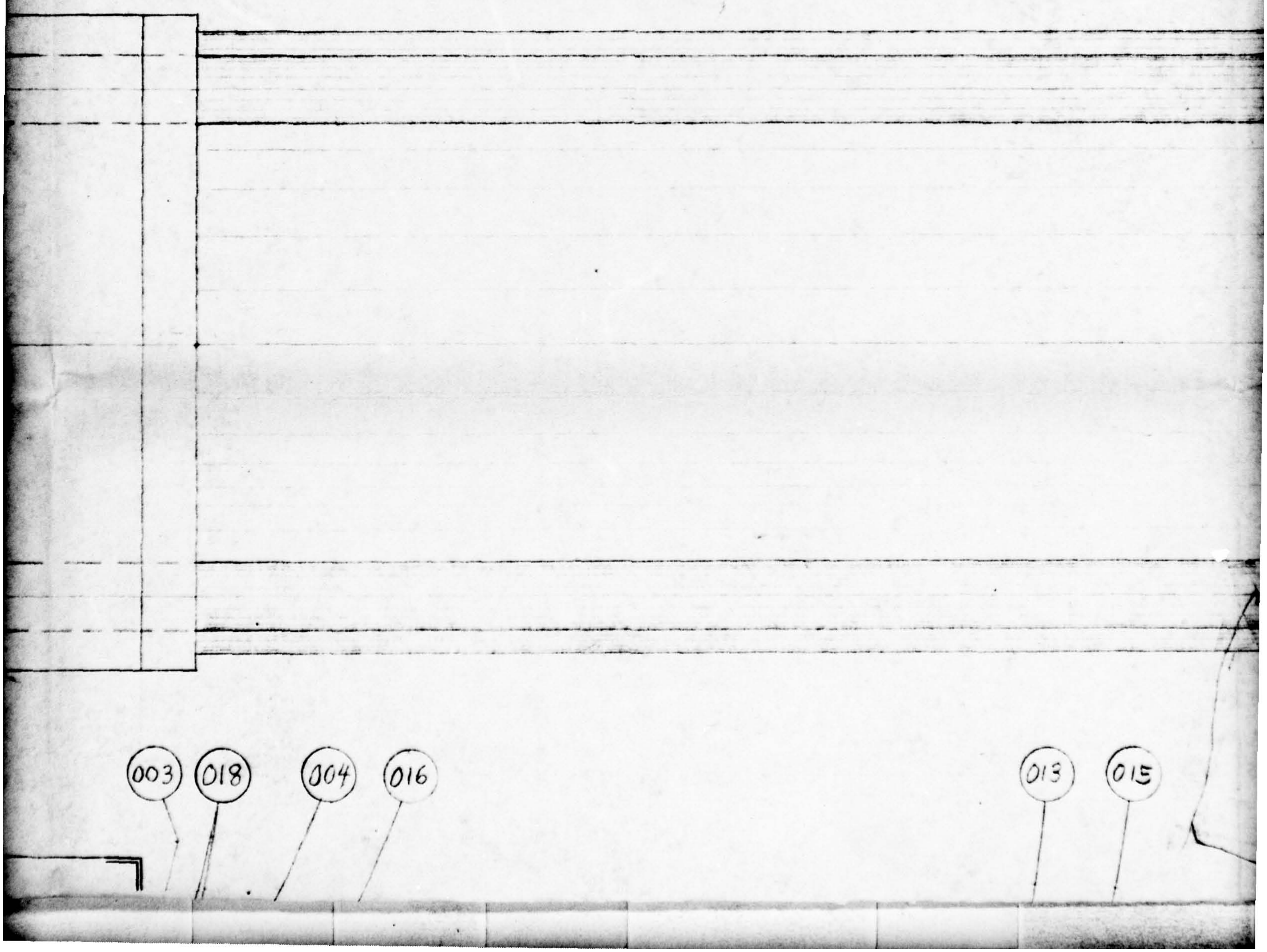

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LIST OF MATERIAL

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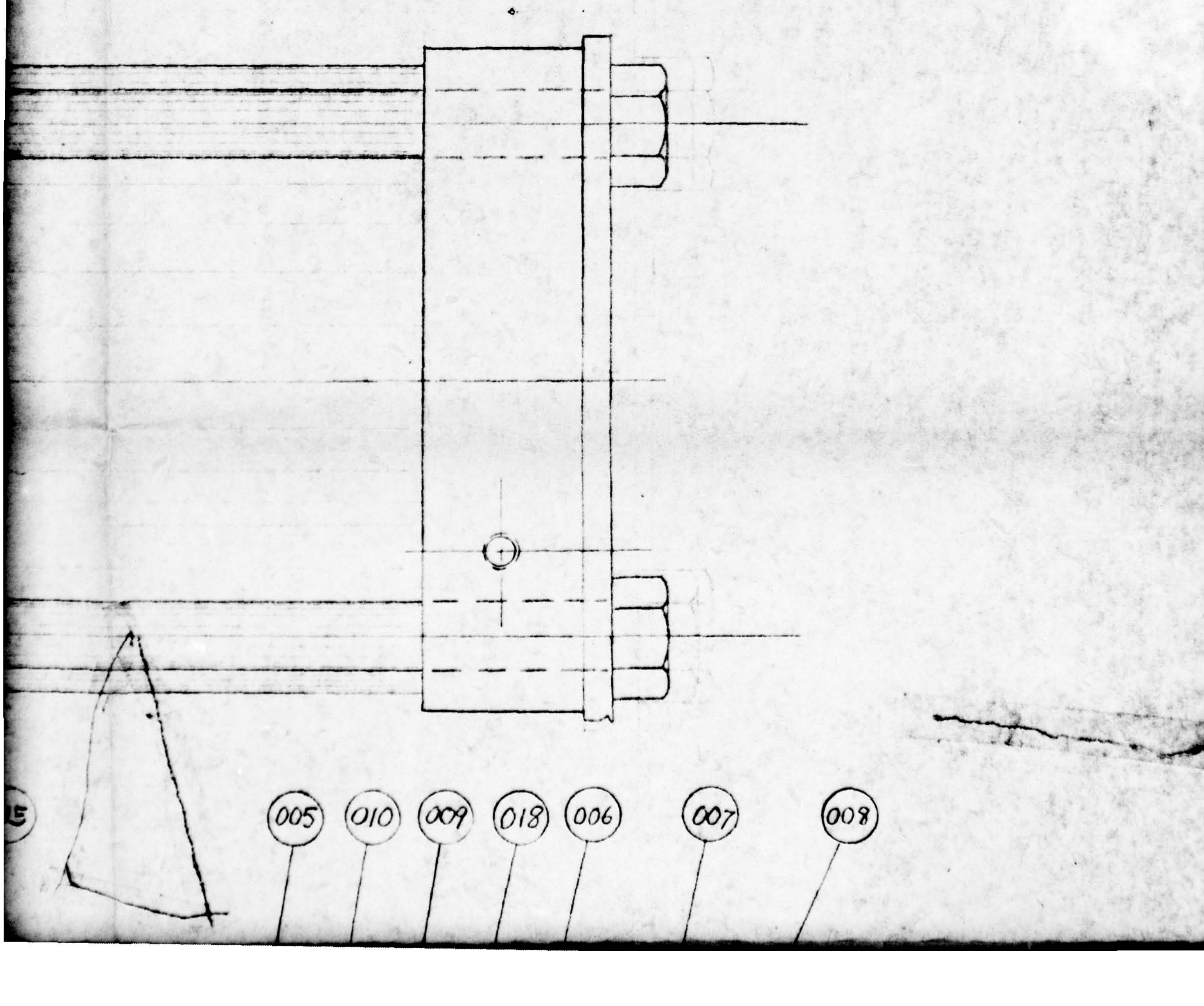

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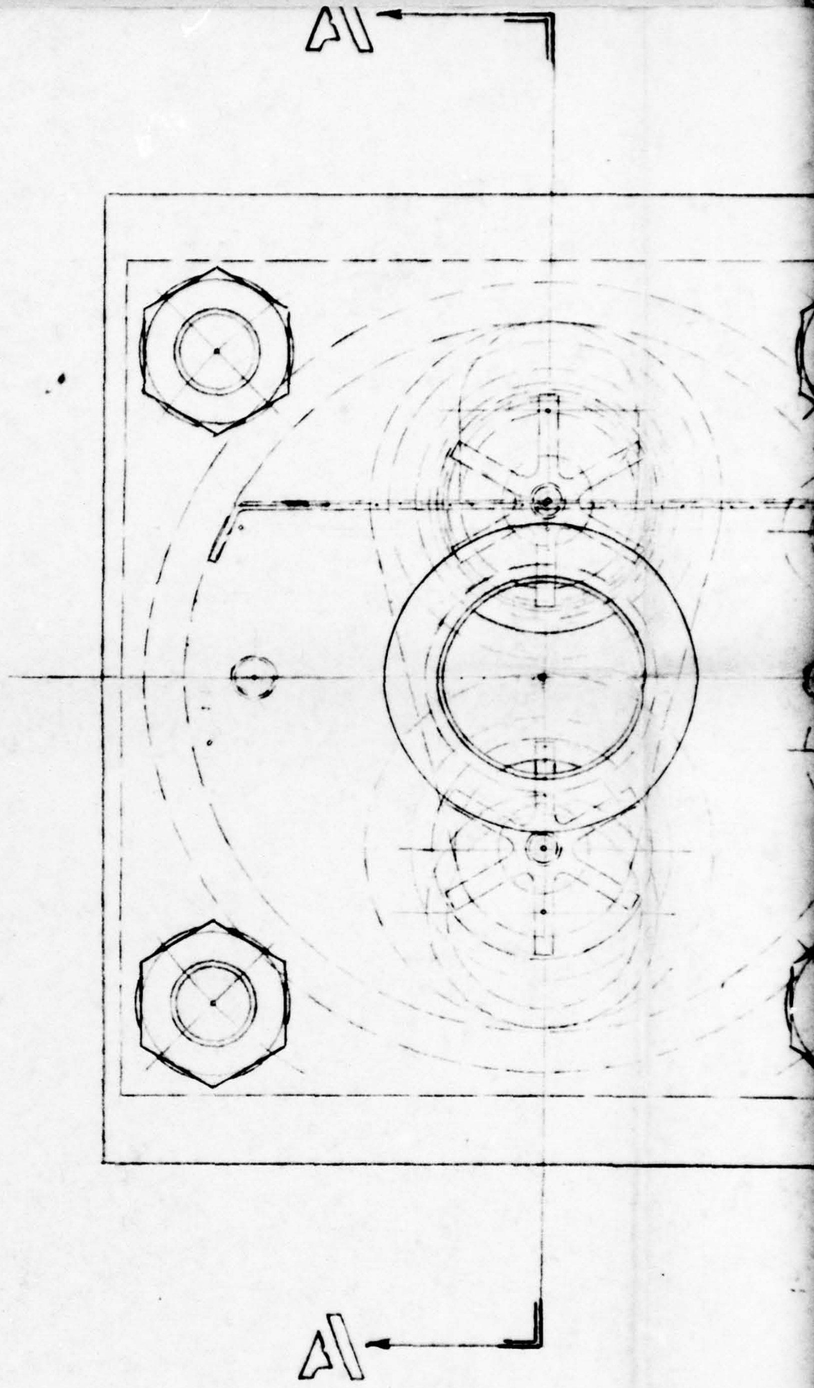

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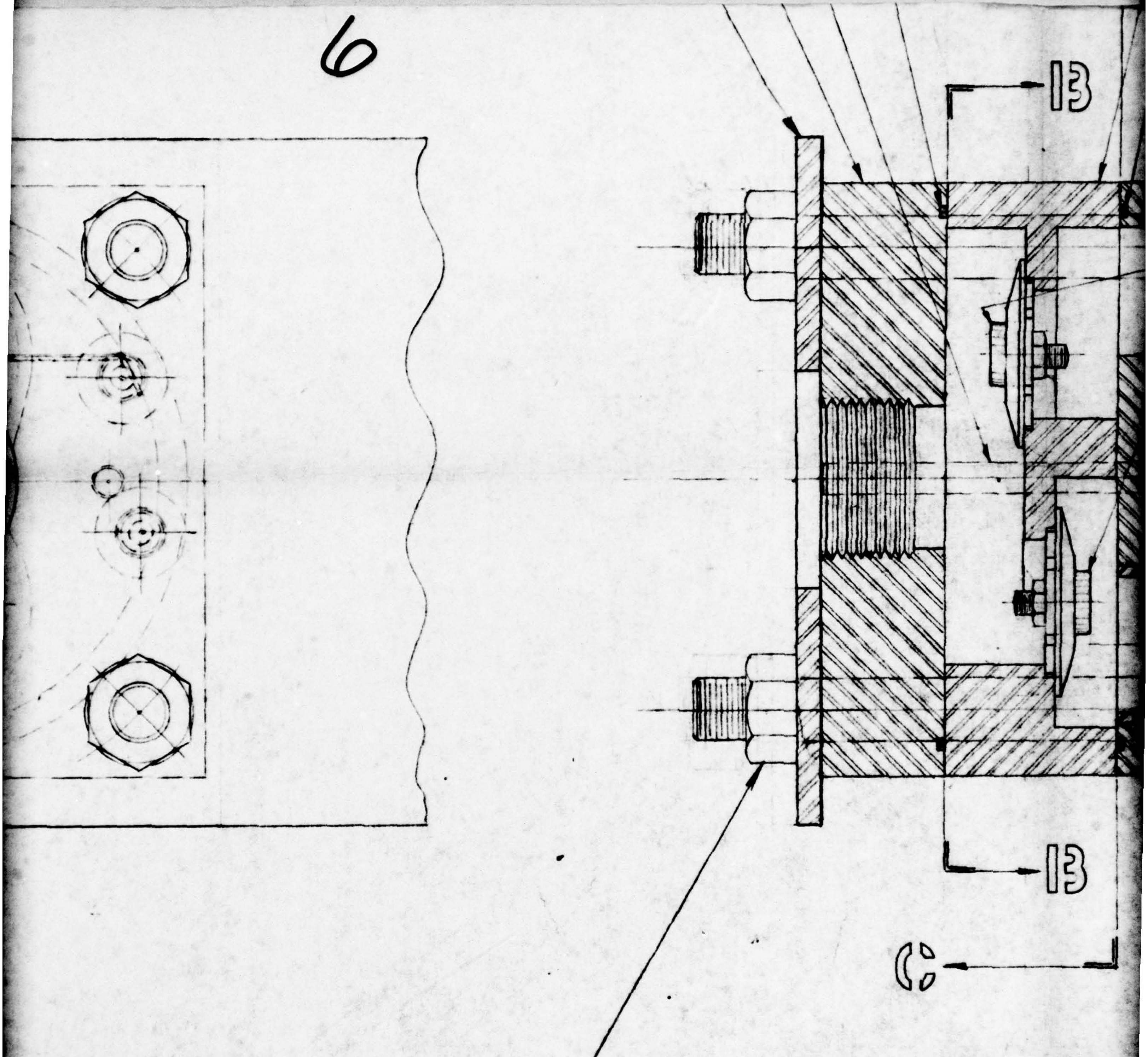

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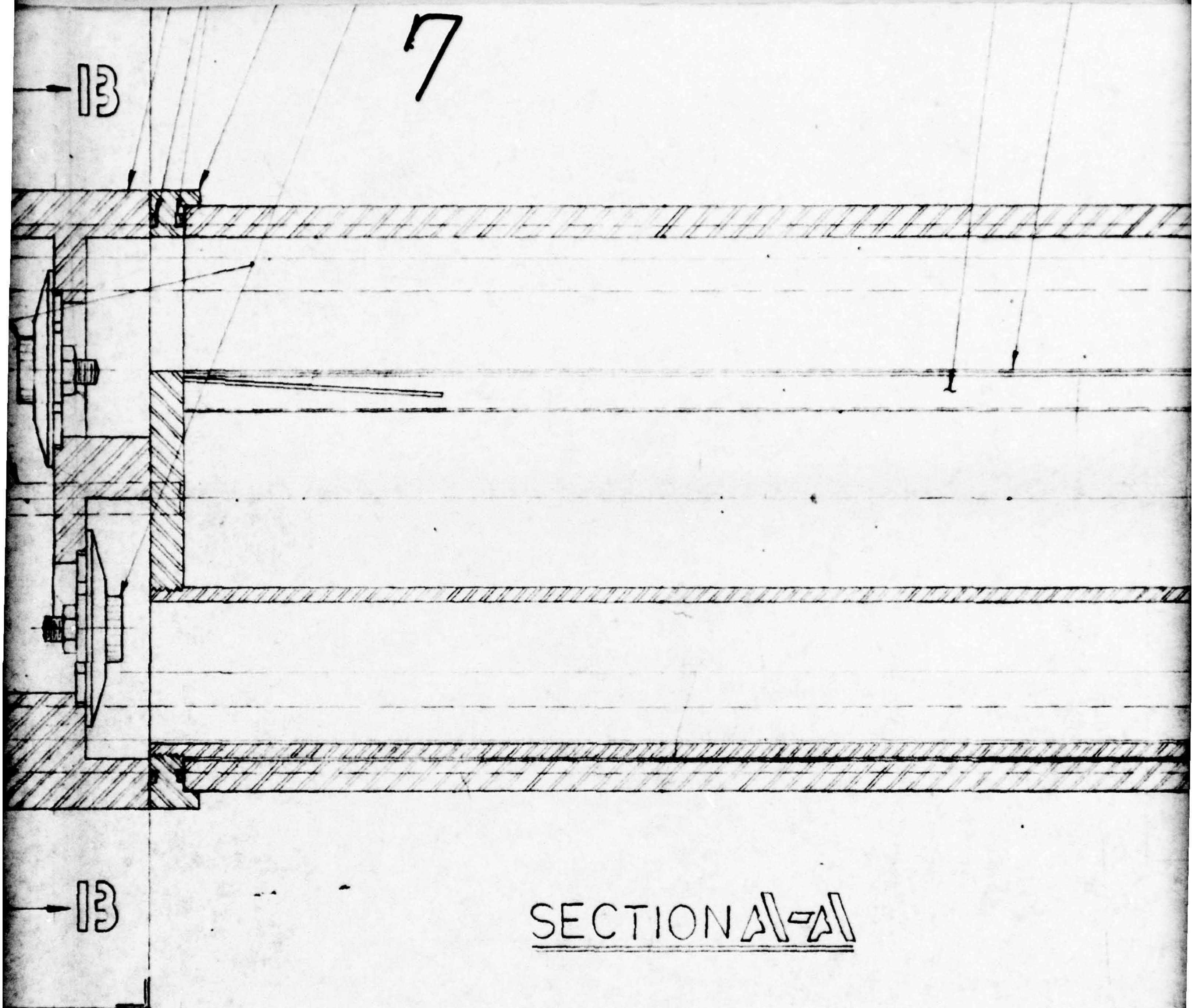

SECTION A-A

EX. NUT

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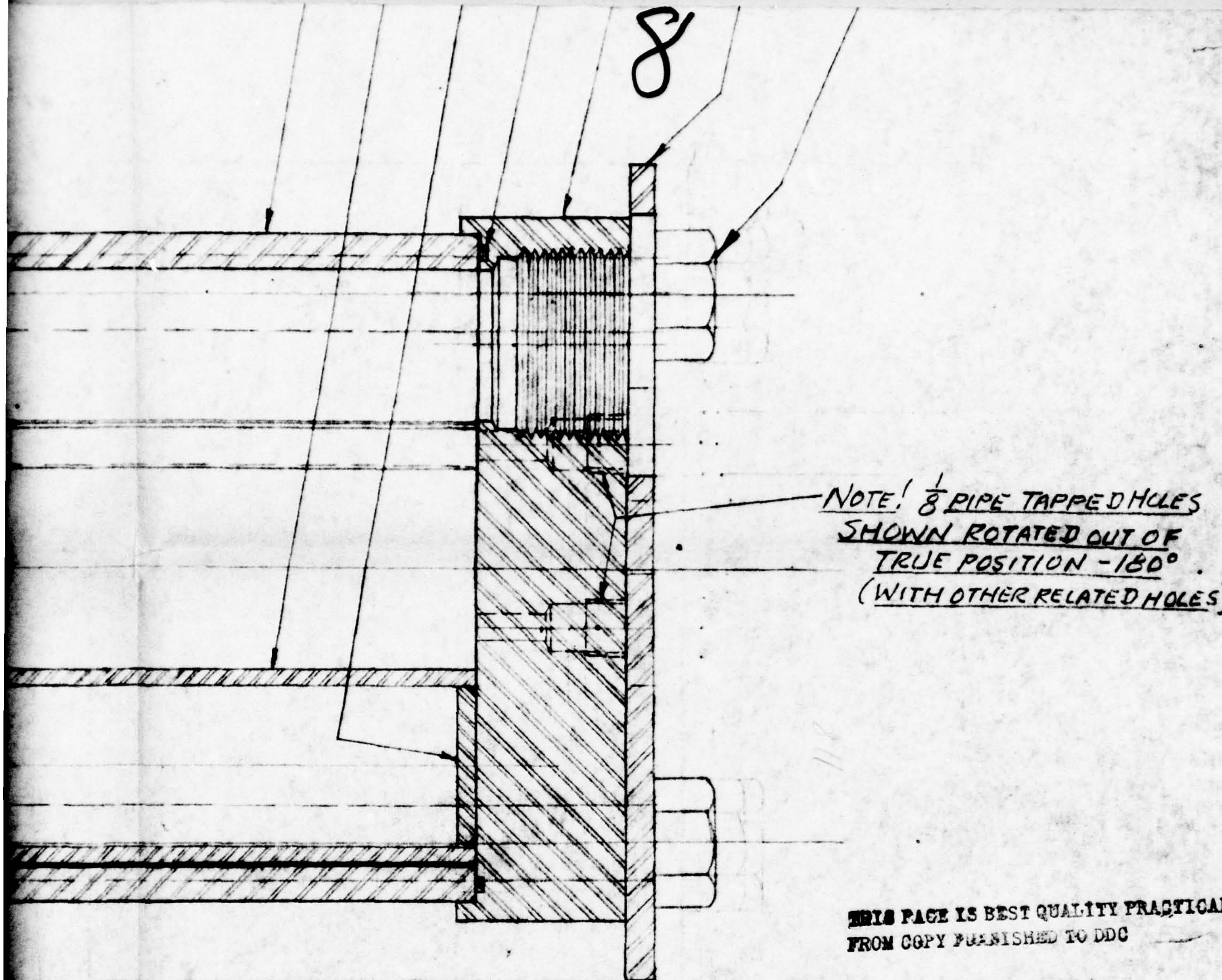

NOTE: BALLOONED ARROWS REFER TO DRAWING NUMBER OF ITEM SHOWN

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TOLERANCE UNLESS OTHERWISE NOTED: FRAC. ± ANG. ± DEC.	NEXT ASSY. 080 / NO. REQ'D. 1	TITLE: BUBBLE CHAMBER ASSEMBLY
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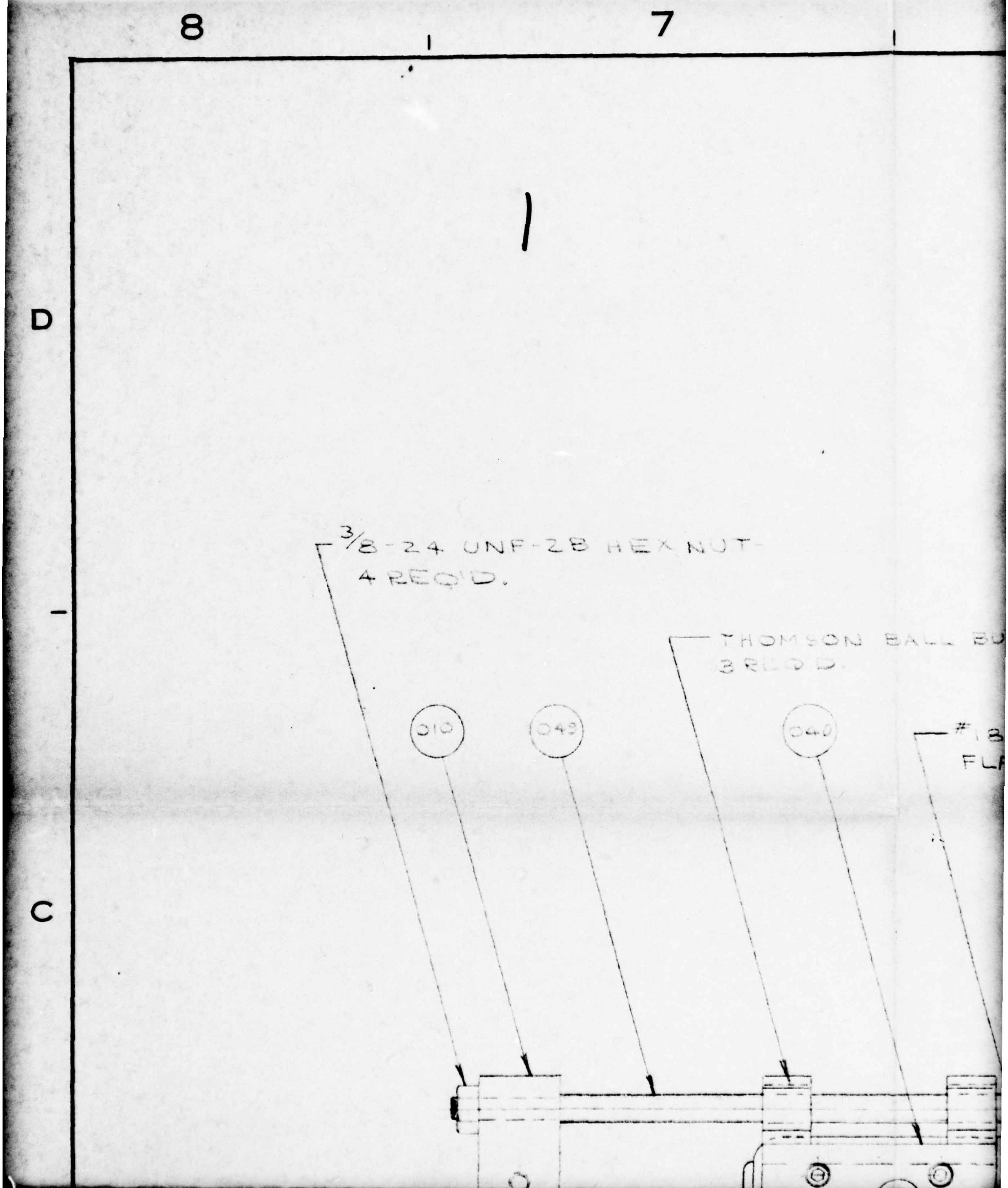
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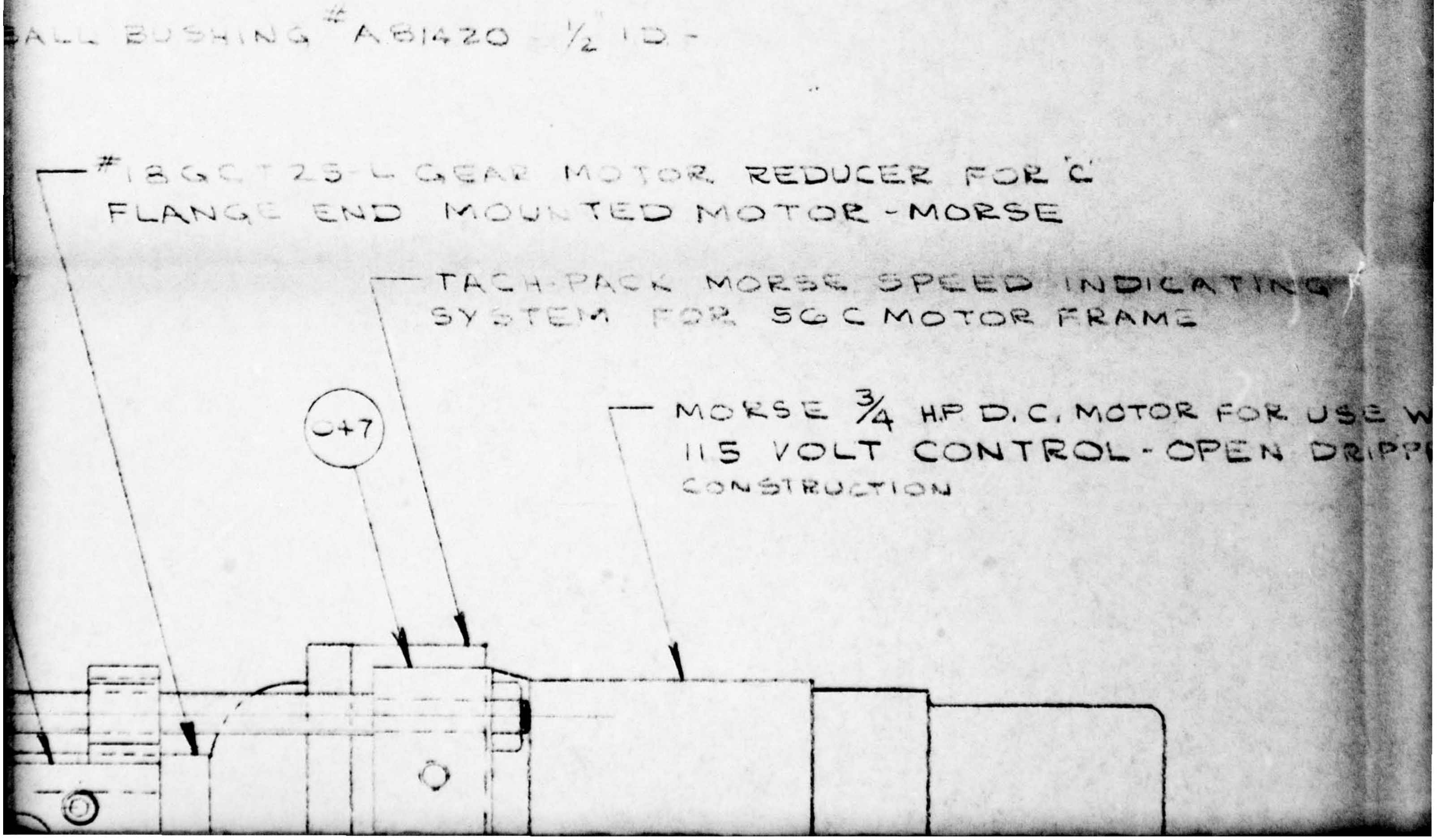
ALL BUSHING # A81420 1/2" I.D. -
#18GCT25-L GEAR MOTOR REDUCER FOR 'C'
FLANGE END MOUNTED MOTOR - MORSE
TACH-PACK MORSE SPEED INDICATING
SYSTEM FOR 56C MOTOR FRAME
0+7
MORSE 3/4 H.P. D.C. MOTOR FOR USE W
115 VOLT CONTROL - OPEN DRIPP
CONSTRUCTION

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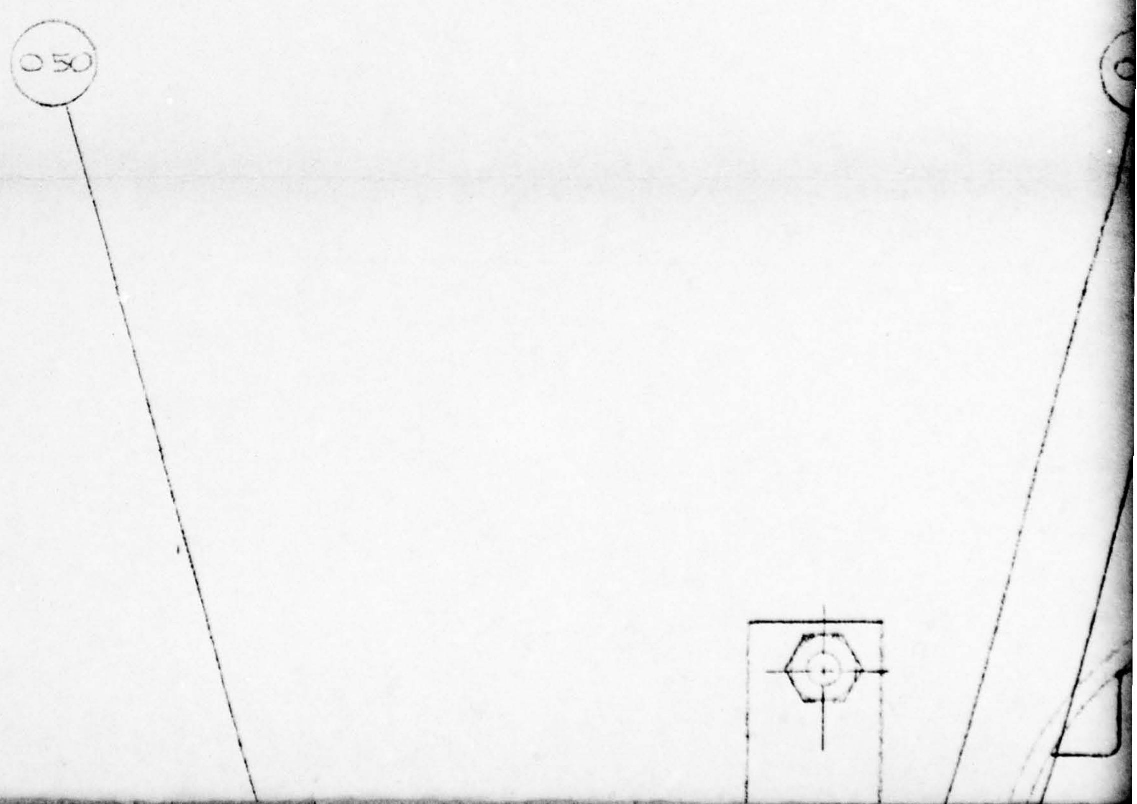
N DRIPPROOF



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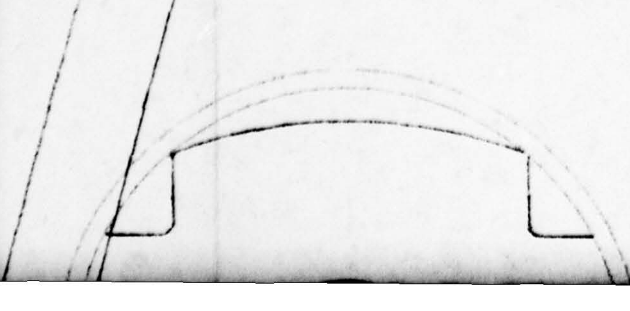
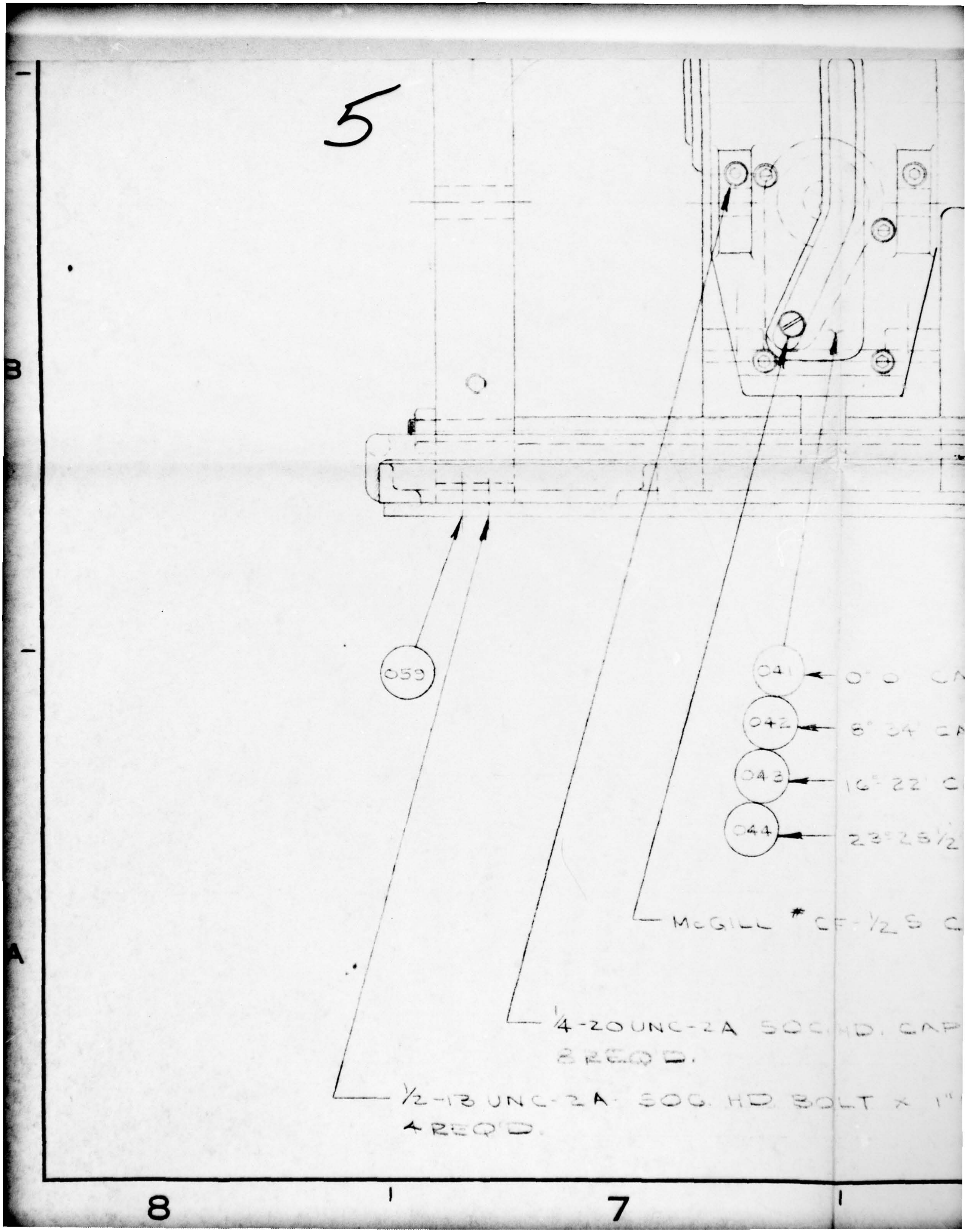
043

1/4-20 UNC-2A. SOC. HD. SET SCR. x 3/8 LONG-
2 REQD.

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McGILL # CF-1/2 S C
1/4-20 UNC-2A SOC. HD. CAP
8 REQ'D.
1/2-13 UNC-2A SOC. HD. BOLT × 1"
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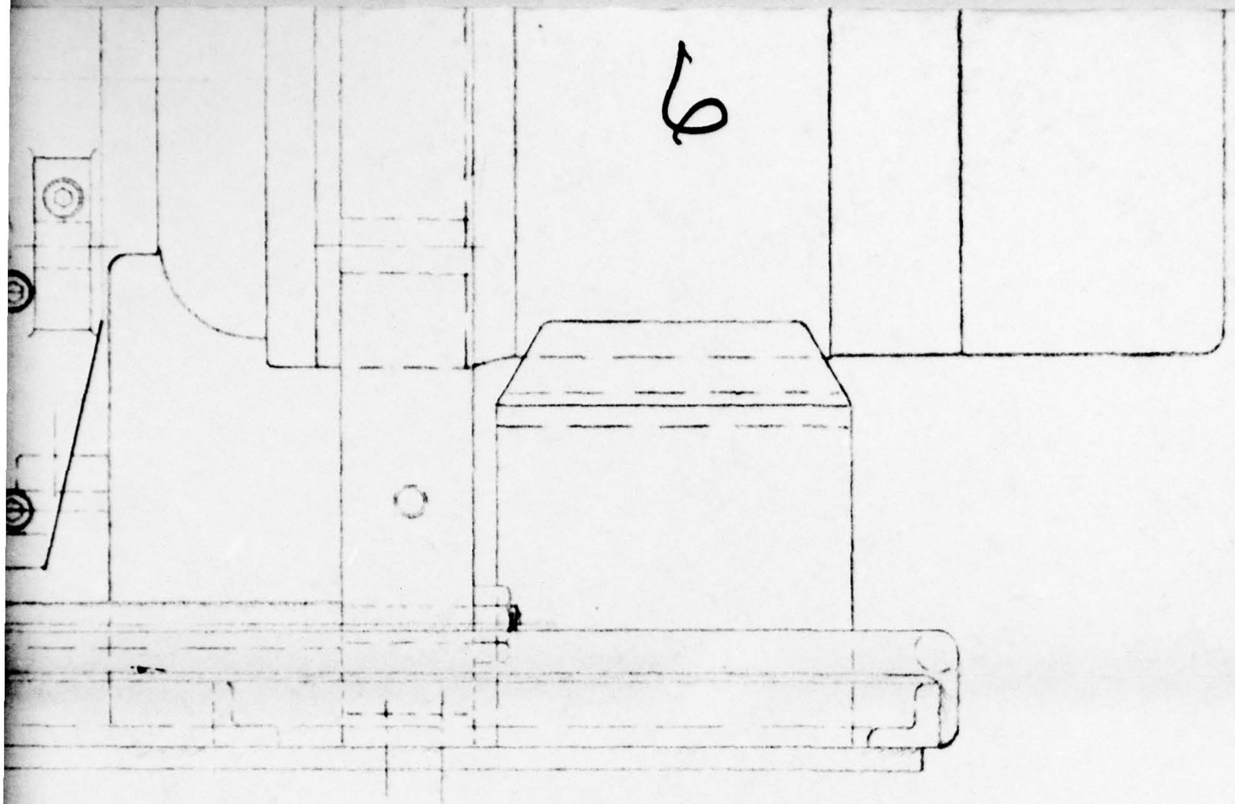

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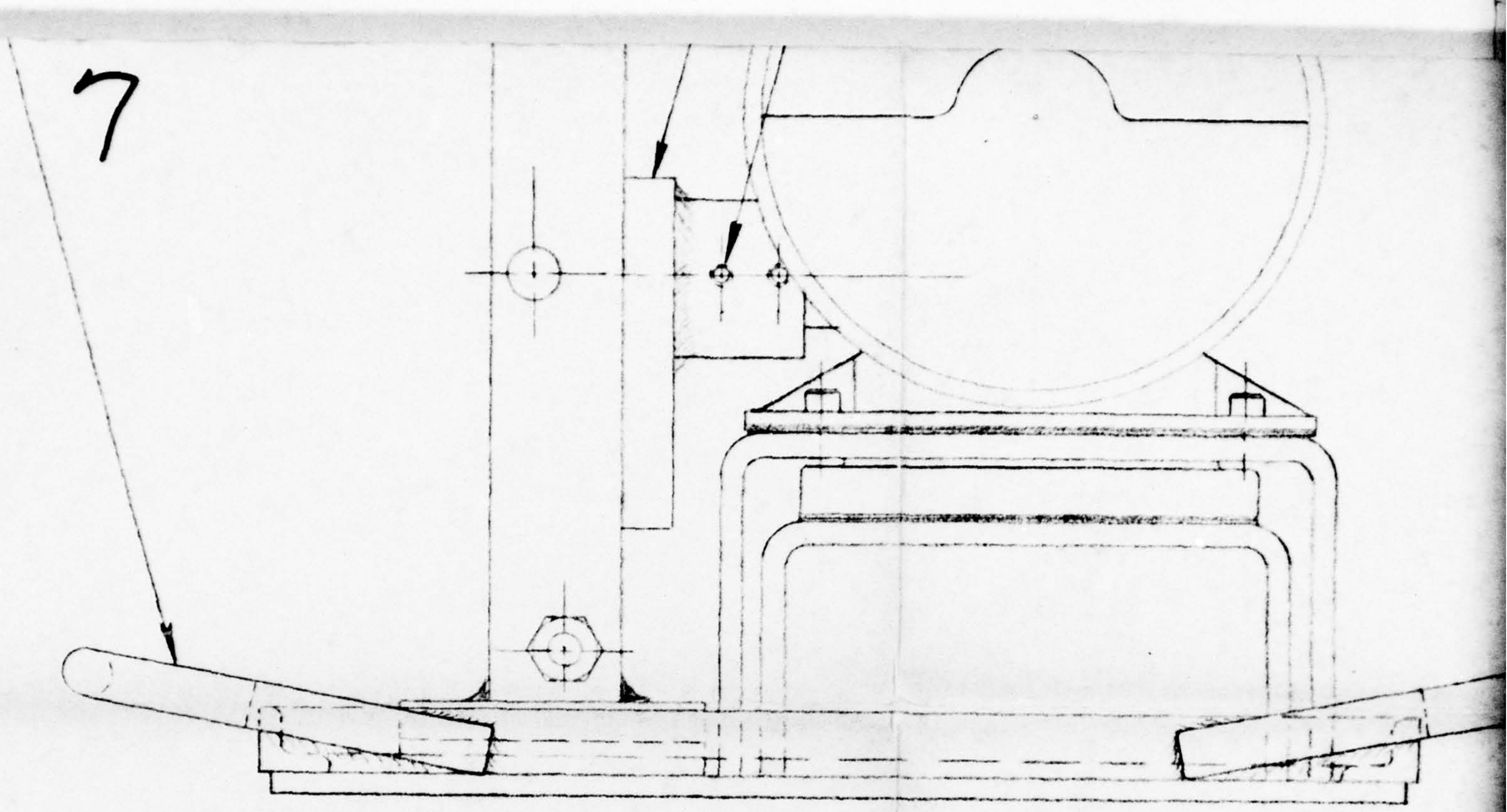

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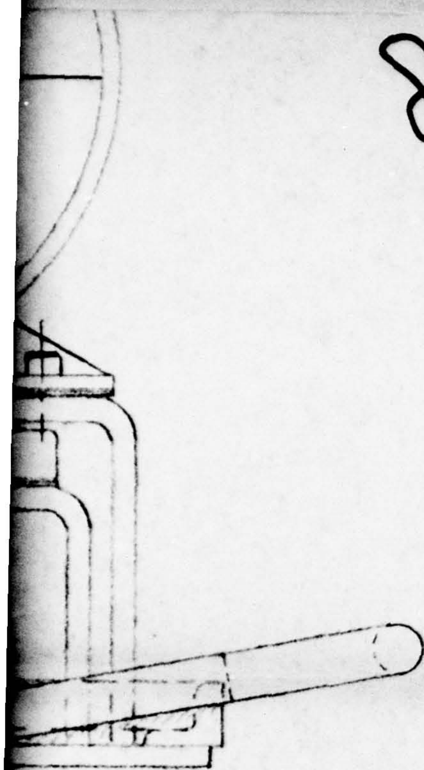

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COLUMBUS 1, OHIO

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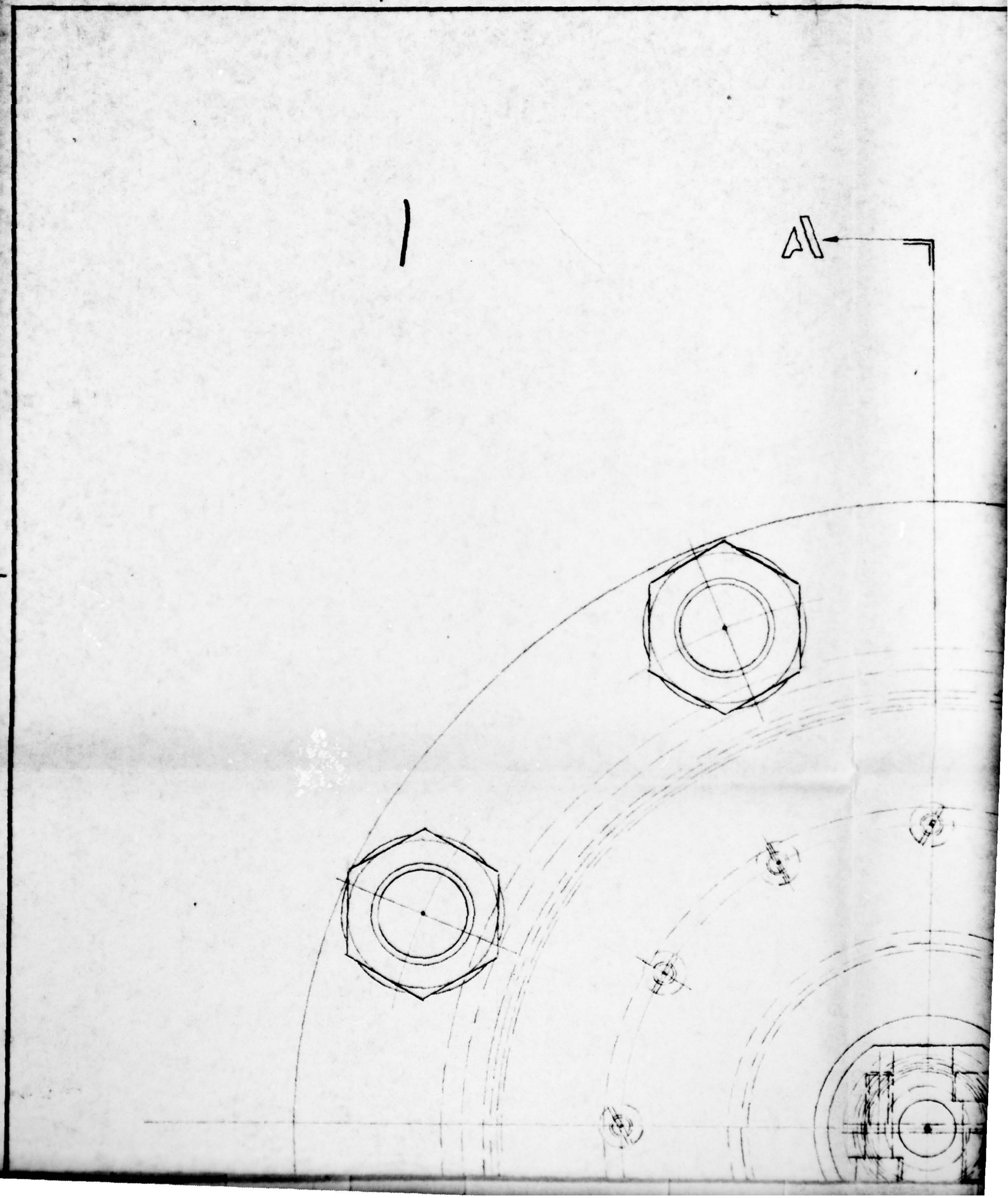

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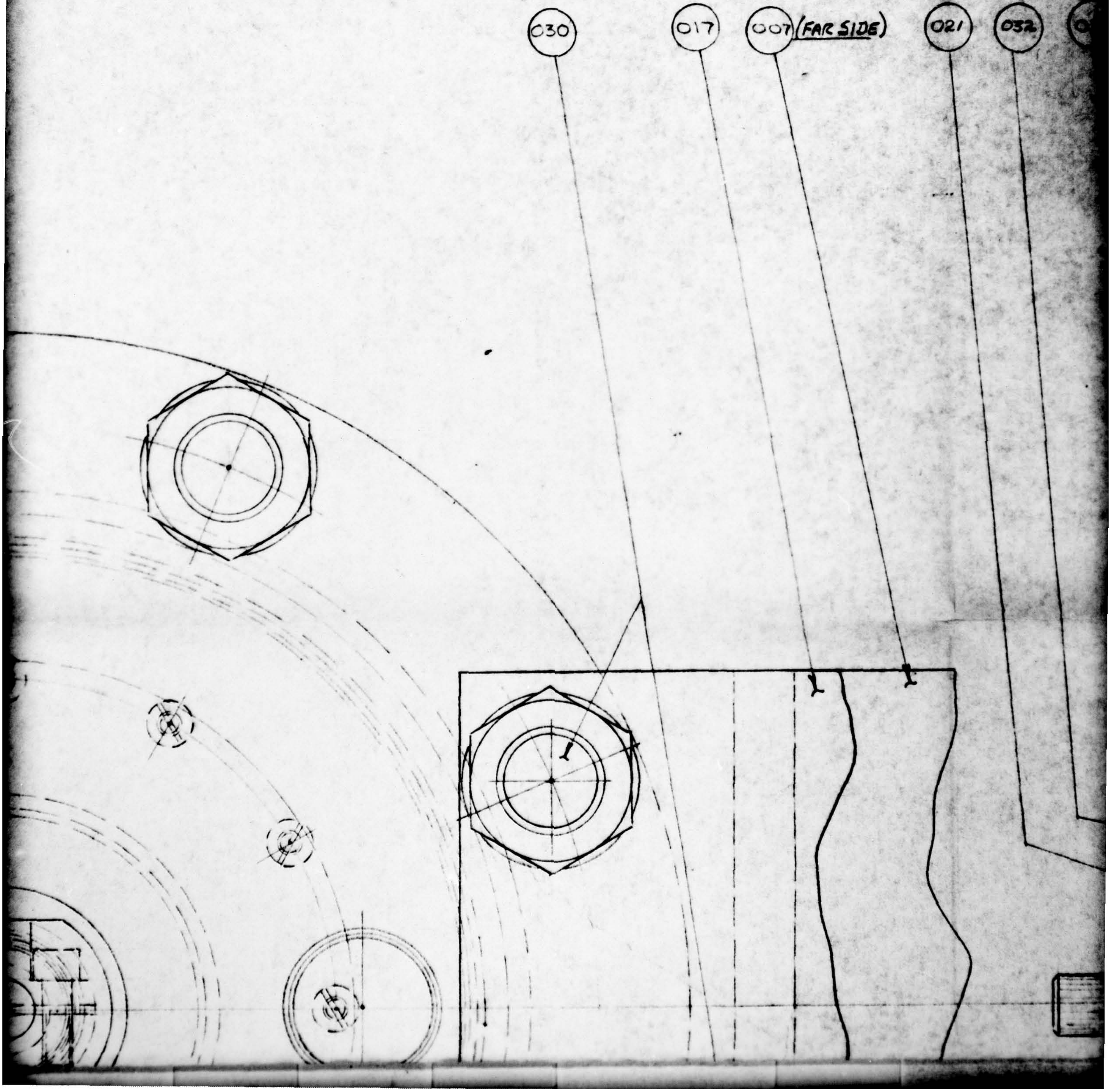

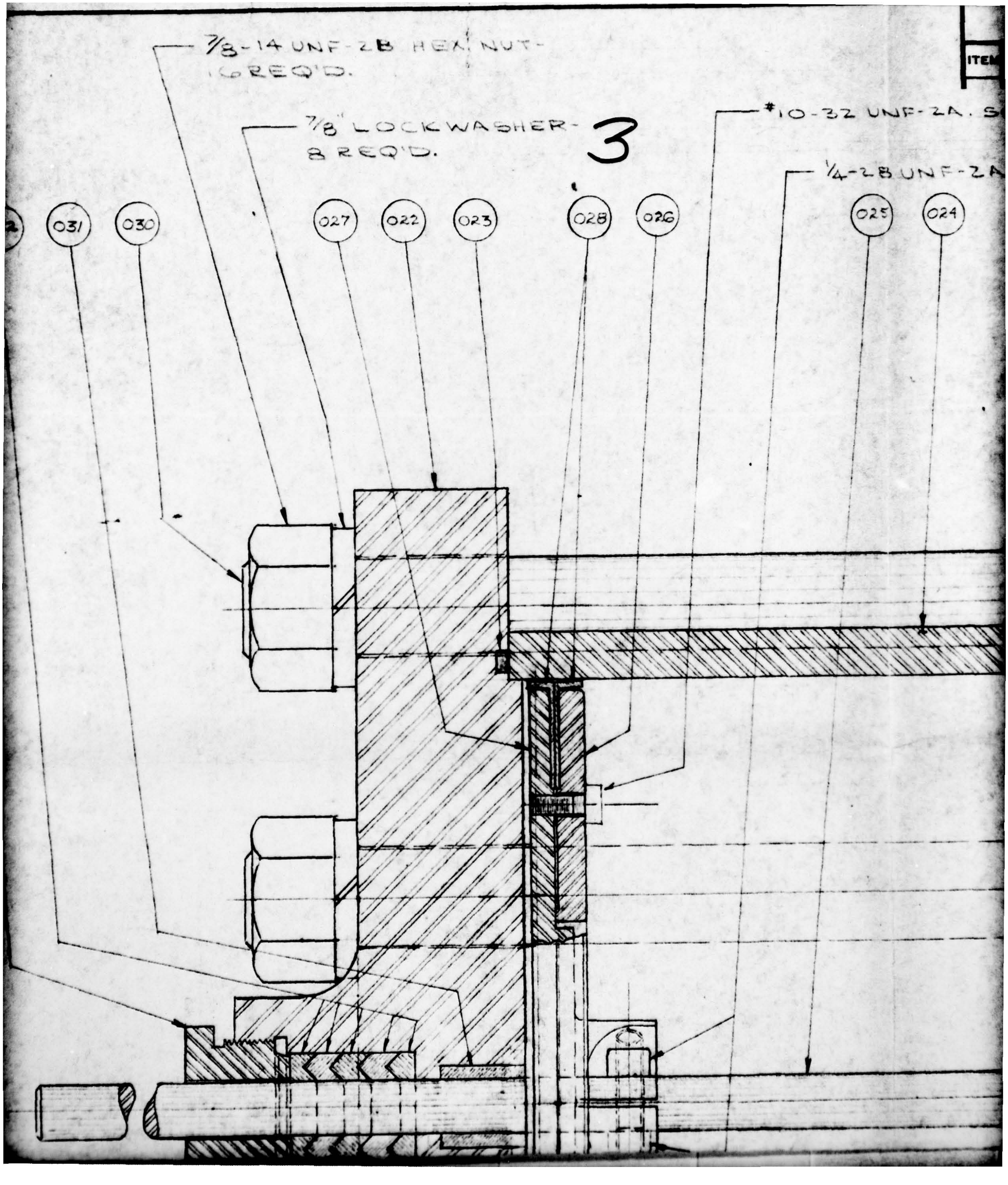
7/8-14 UNF-2B HEX NUT-
16 REQ'D.
7/8" LOCKWASHER-
8 REQ'D.
3
#10-32 UNF-2A. S
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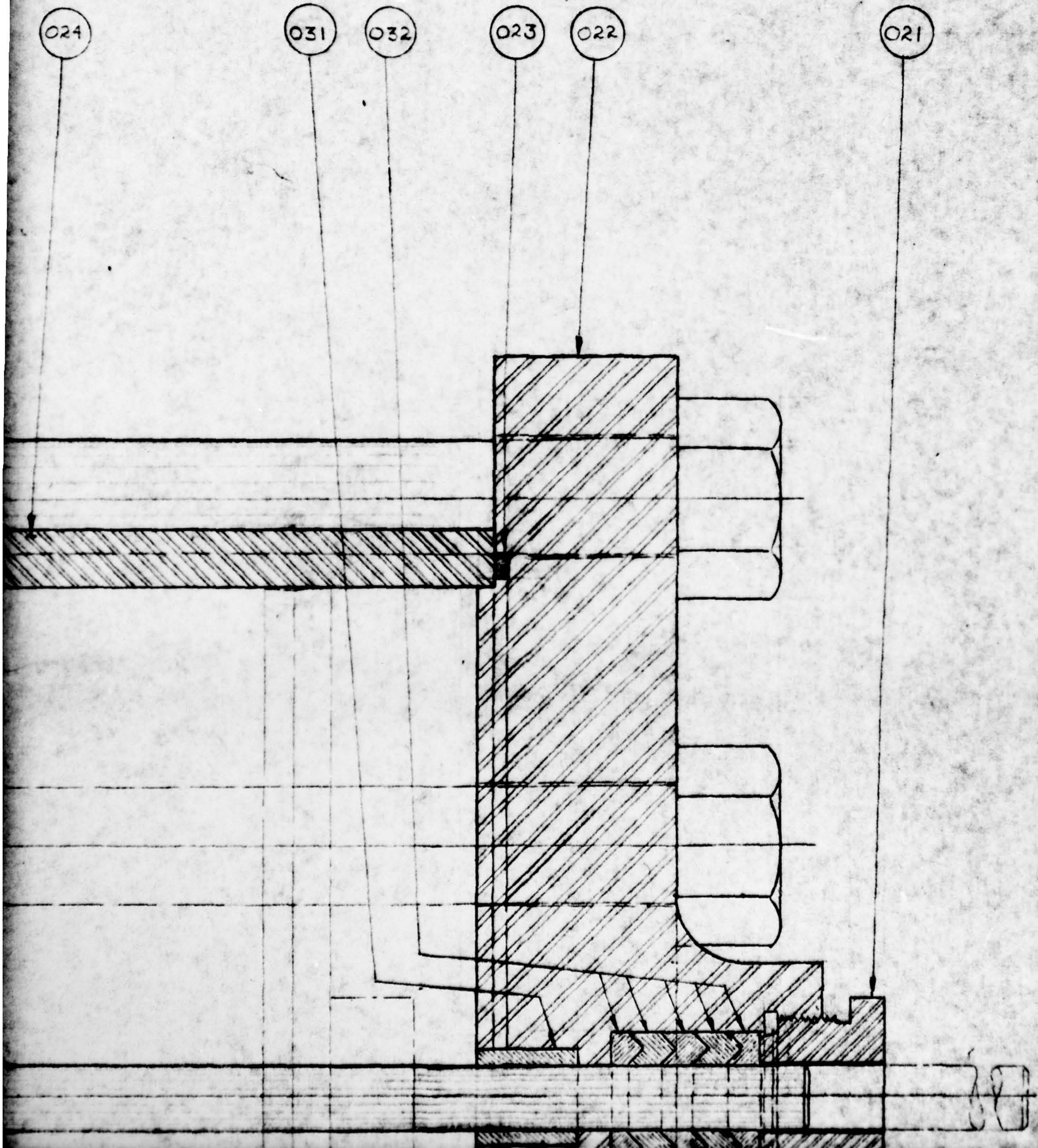
ITEM	DWG. NO.	SIZE	NO. REQ'D.	TITLE – DESCRIPTION

F-2A. SOC. HD. CAP SCR. x 1/2 LONG - 12 REQ'D.

4

UNF-2A SOC. HD. CAP SCR. x 3/4 LONG - 2 REQ'D.



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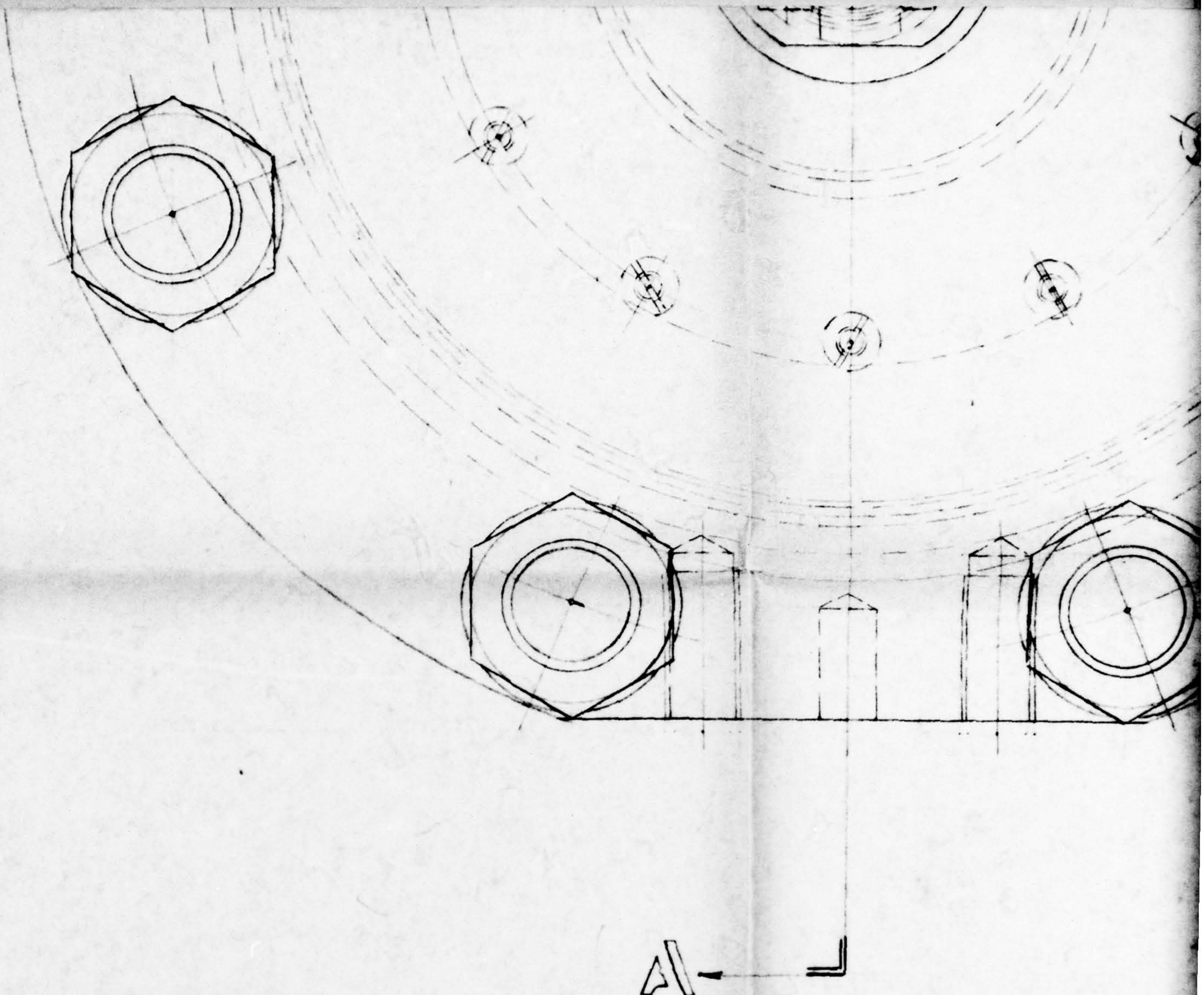

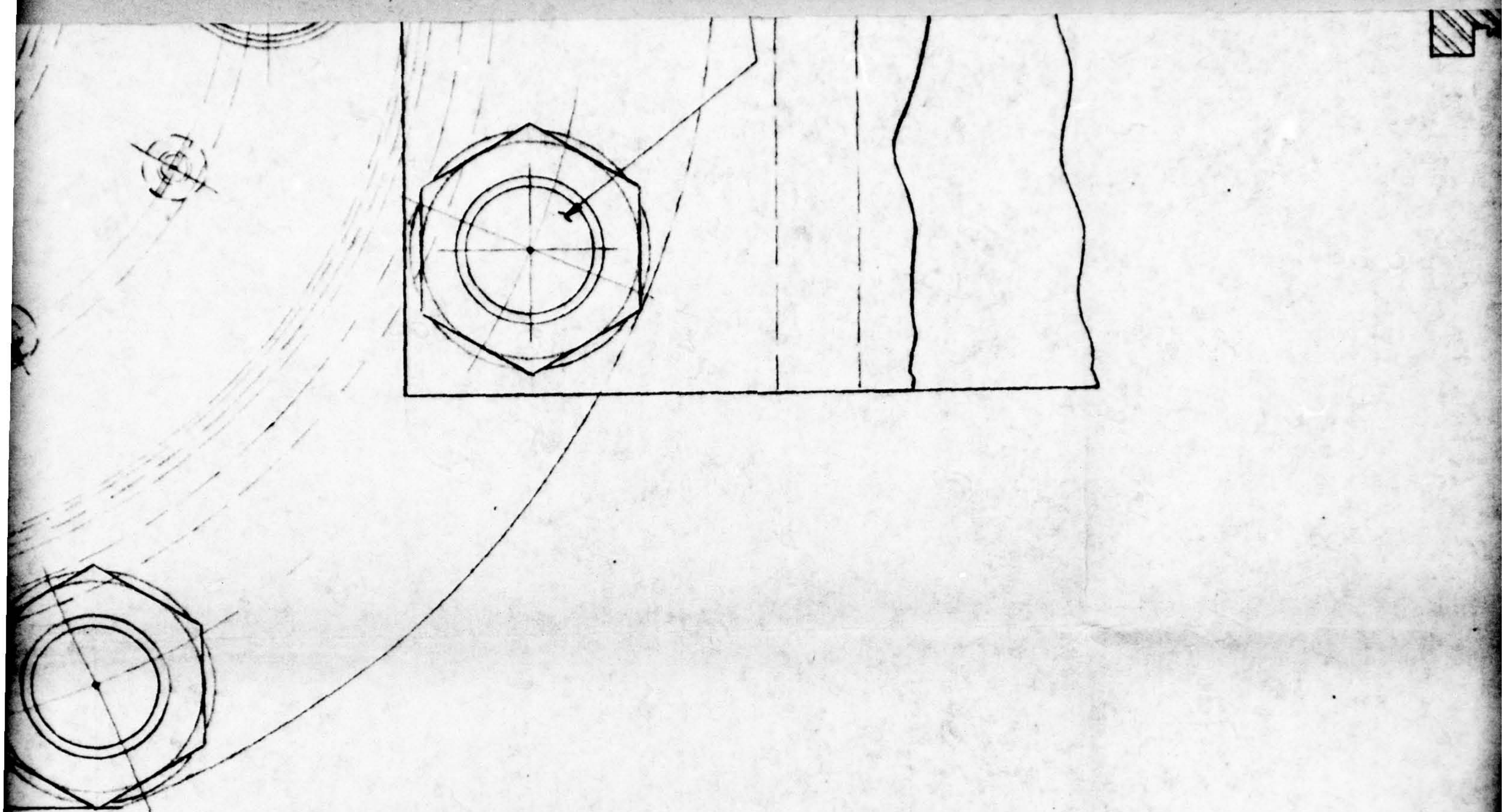

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NOTE: BALLOONED ARROWS REFER TO DW
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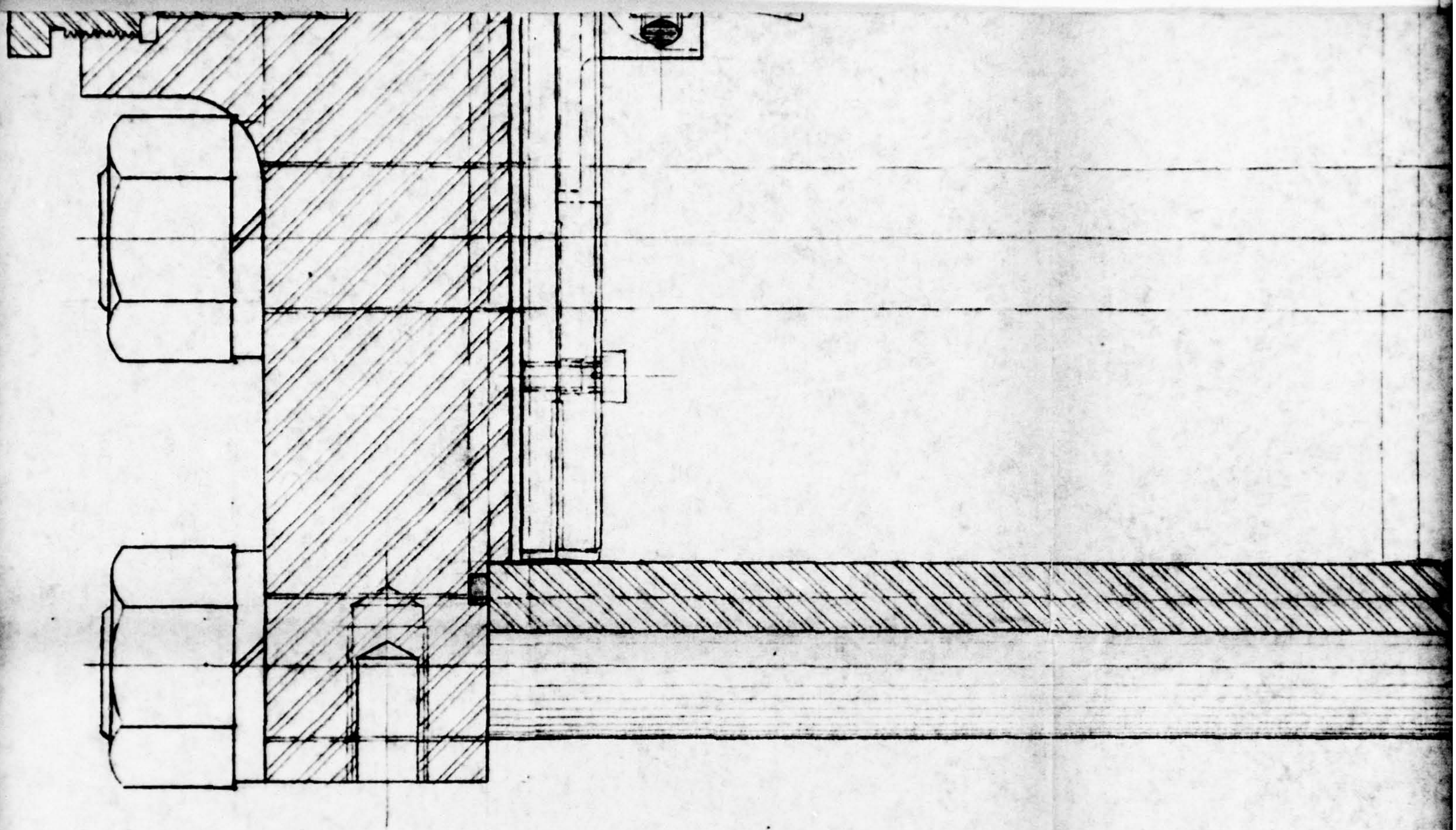

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SECTION A-A

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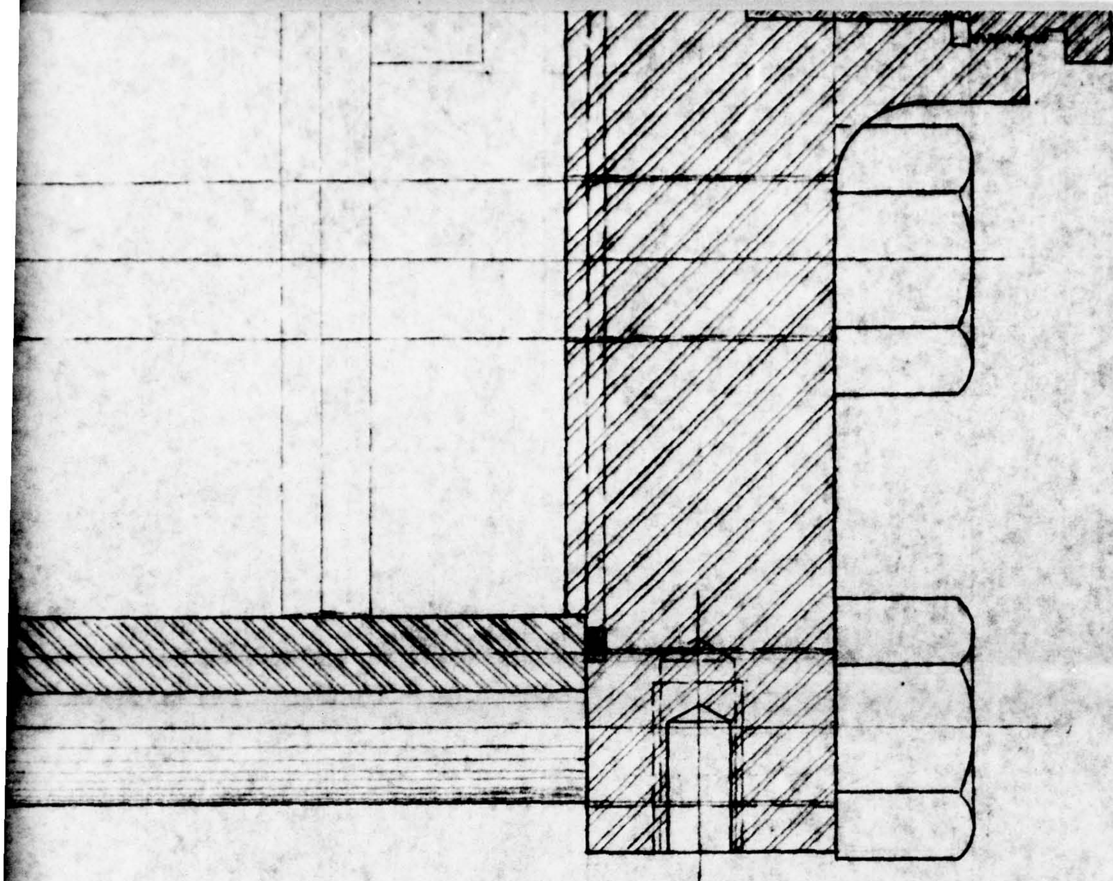

8

A-A

MAT'L. (COMMERCIAL TOLERANCES APPLY)				BATTELLE MEMORIAL INSTITUTE 505 KING AVE. COLUMBUS 1, OHIO
TOLERANCE UNLESS OTHERWISE NOTED			NEXT ASSY. / NO. REQ'D.	TITLE
FRAC. ±	ANG. ±	DEC.	1	CYLINDER ASSEMBLY
	DRAWN	CHECKED	PROJ. APP.	
BY	SHAFFER			
DATE			SCALE FULL / K-G	ACCT. NO. / DWG. NO. 020 / D
DIV.				

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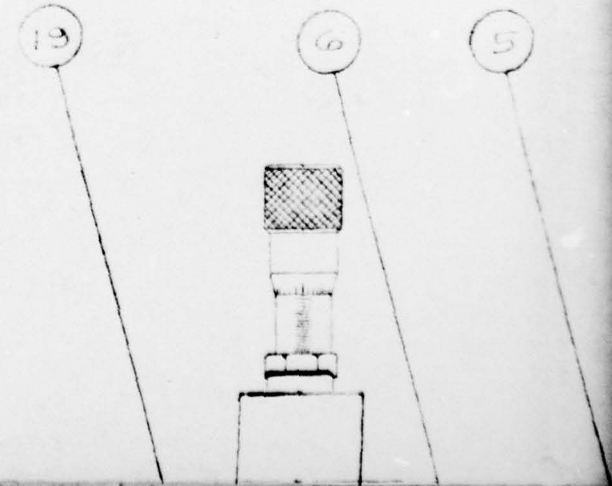
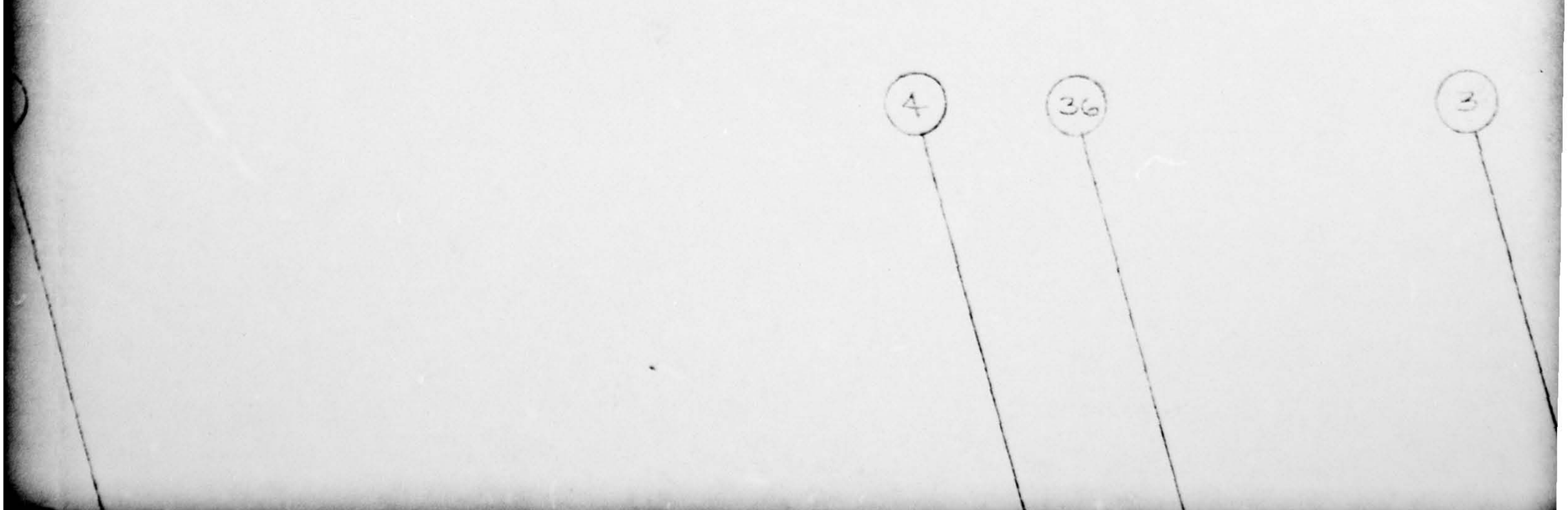


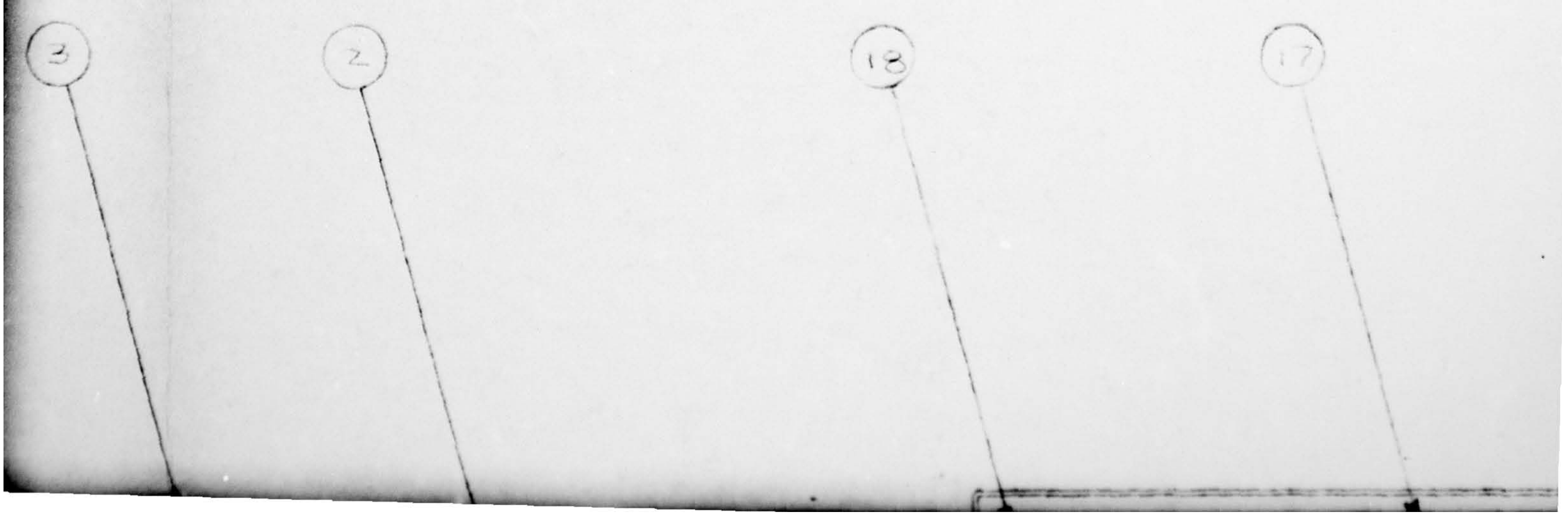
2



LIST OF MAT

ITEM	DWG. NO.	SIZE	NO REQ'D	T
37			16	5/16-18 UNC-2A S
38			4	1/2-13 UNC-2A. S
39			8	5/16-18 UNC-2A.
40				

3



AD-A076 259 BATTELLE MEMORIAL INST COLUMBUS OHIO COLUMBUS LABS F/G 6/11
THE DESIGN, DEVELOPMENT, AND CONSTRUCTION OF A HIGH-PRESSURE ME--ETC(U)
SEP 69 D W CAUDY, J S GLASGOW N00014-66-C-0199

UNCLASSIFIED NL

2 OF 2

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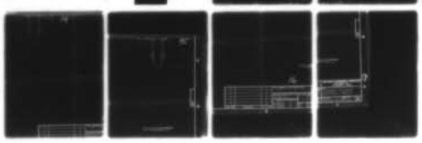
A076259



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DATE
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11-79
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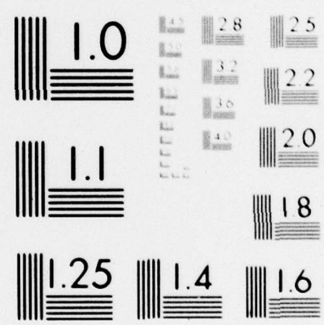


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

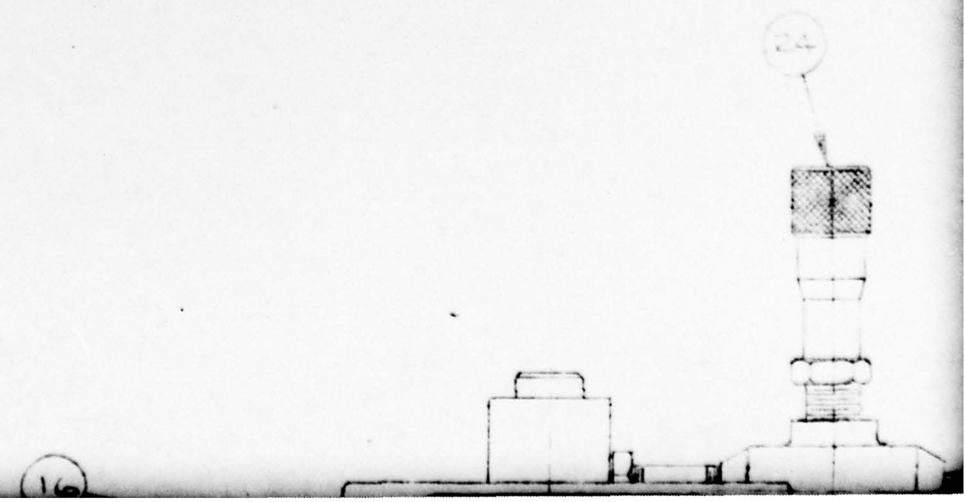
OF MATERIAL

TITLE – DESCRIPTION
-2A SOC. HD. SCR. x ¼" LONG - S.ST.
-2A. SOC. HD. SCR. x 2" LONG - S.ST.
-2A. SOC. HD. SCR. x ¾" LONG - S.ST.

3

LIST OF MATERIAL

ITEM	DWG. NO	SIZE	NO. REQ'D	TITLE – DESCRIPT
19			1	MODEL 1403 - TUBE NUMB BROOKS. HIGH PRESSURE
20			2	SB4686 BASSICK CASTER
21			1	LSH-93 - SOUTHWORTH LIFT T OPERATED - WITH ELECTRIC
22			2	4086-1-SERIES "08 BASSIC
23			2	#43F4-316 - WHITEY BA
24			1	#22RS4 - WHITEY MICRO
25			1	AEROQUIP #2651-4 HOSE - 412
26			3	1" CLOSE NIPPLE - S.ST.
27			1	1" x 2" NIPPLE - S.ST.
28			2	1" 90° ELBOW - S.ST.
29			1	1" UNION S.ST.
30			1	¼ x ⅛ REDUCER BUSHIN
31			1	⅛" CLOSE NIPPLE - S.S
32			1	⅛ x 3" NIPPLE - S.ST.
33			1	⅛ x ¼ COUPLING - S.ST
34			1	¼" 90° STREET ELBOW
35			1	¼" CLOSE NIPPLE - S
36			2	⅜-16 UNC-2A SOC. HD. SCR. x

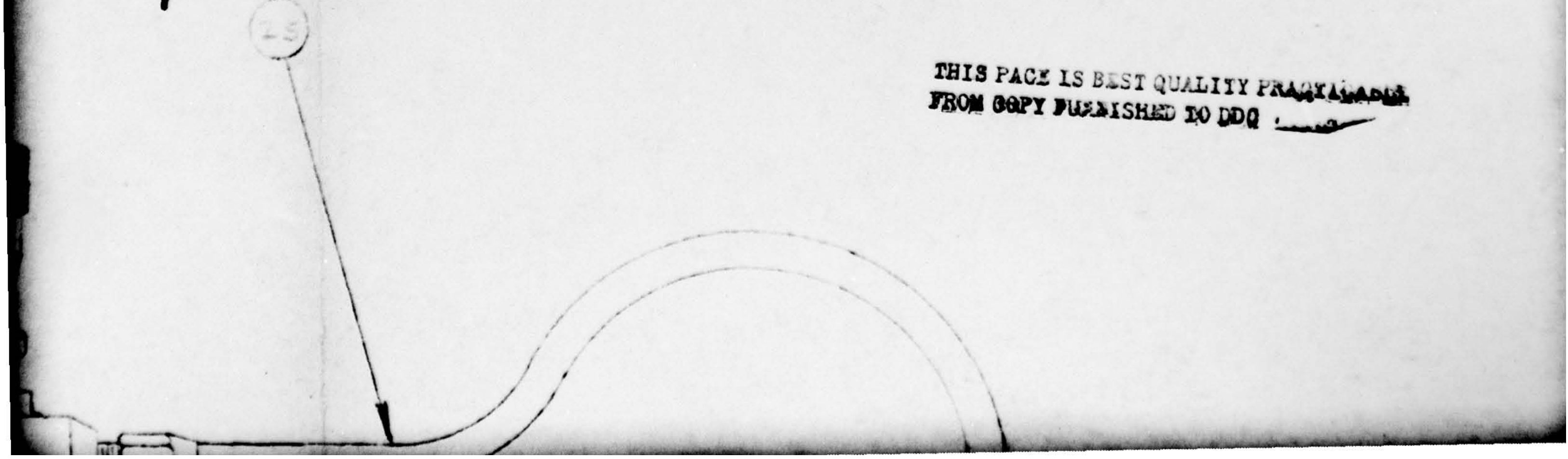


...DESCRIPTION
...UMBER 2-2-15-D ...URE FLOWMETER
...STER WHEEL - SIDE BRAKE
...LIFT TABLE - ELECTRICALLY ...TRIC CONTROL
...BASSICK RIGID CASTER WHEEL
... BALL VALVE
...ICRO METERING VALVE
...15 HOSE ASS'Y. ...- 412-4-4 EACH END
....ST.
...T
...T.
...SHING - S.ST.
...- S.ST.
...T.
...S.ST.
...BOW - S.ST.
...E - S.ST
...SCR. x 1" LONG - S.ST.

LIST OF MATERIAL

ITEM	DWG. NO.	SIZE	NO. REQ'D.	TITLE – DESCRIPTION
1	080	C	1	BUBBLE CHAMBER HEATER
2	102	D	1	SHROUD
3	099	D	1	DRIVE ASS'Y.
4	101	C	1	TOP BRACE
5	020	D	1	CYLINDER ASS'Y.
6	103	D	1	FLOWMETER BRACKET
7	061	D	1	MAIN BASE PLATE
8	063	A	2	MAIN BASE CYLINDER SUPPOR...
9	104	A	1	DOWEL - REMOVABLE
10	064	A	1	MAIN BASE CYLINDER DOW...
11	076	D	1	HYDRAULIC TABLE BASE
12	062	A	2	MAIN BASE - AUXILIARY BASE - DOW...
13			1	#EN-3512 HAYDON HOURMETER - 120V. A... 60 CYC. 000-999 RESETTABLE
14			1	CUTLER - HAMMER #B712K15 FLUSH MTG.
15			1	#EN-3512 HAYDON HOUR METER - 120V. AC. 60 CYC. 000-999
16			1	BRISCOE MFG. CO. #94-1 BRISKEAT PER... CO...
17			1	MORSE - TACH - PACK SPEED INDICATIN...
18			1	MORSE #75 CADET - SCR ADJ. SPEED C...

4



LIST OF MATERIAL

DWG. NO.	SIZE	NO. REQ'D.	TITLE — DESCRIPTION
080	C	1	BUBBLE CHAMBER HEATER ASS'Y.
102	D	1	SHROUD
099	D	1	DRIVE ASS'Y.
101	C	1	TOP BRACE
020	D	1	CYLINDER ASS'Y.
103	D	1	FLOWMETER BRACKET
061	D	1	MAIN BASE PLATE
063	A	2	MAIN BASE CYLINDER SUPPORT PAD
104	A	1	DOWEL-REMOVABLE
064	A	1	MAIN BASE CYLINDER DOWEL-FWD.
076	D	1	HYDRAULIC TABLE BASE
062	A	2	MAIN BASE-AUXILIARY BASE-DOWEL
		1	60 CYC. 000-999 RESETTABLE #EN-3512 HAYDON HOURMETER-120V. AC
		1	CUTLER-HAMMER #8712K15 FLUSH MTG. SWITCH
		1	60 CYC. 000-999 #EN-3512 HAYDON HOUR METER-120V. AC.
		1	CONTROLLER BRISCOE MFG. CO. #94-1 BRISKEAT PERCENTAGE
		1	MORSE-TACH-PACK SPEED INDICATING SYSTEM
		1	CONTROL MORSE #.75 CADET-SCR ADJ. SPEED DRIVE

5

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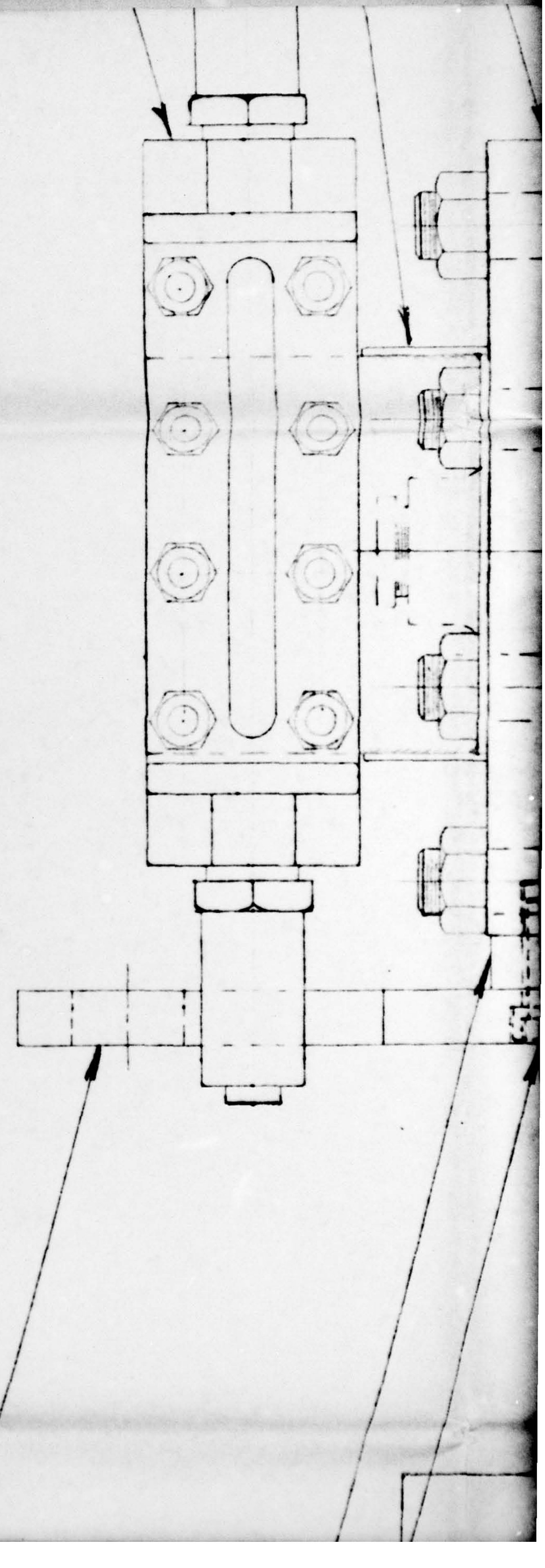

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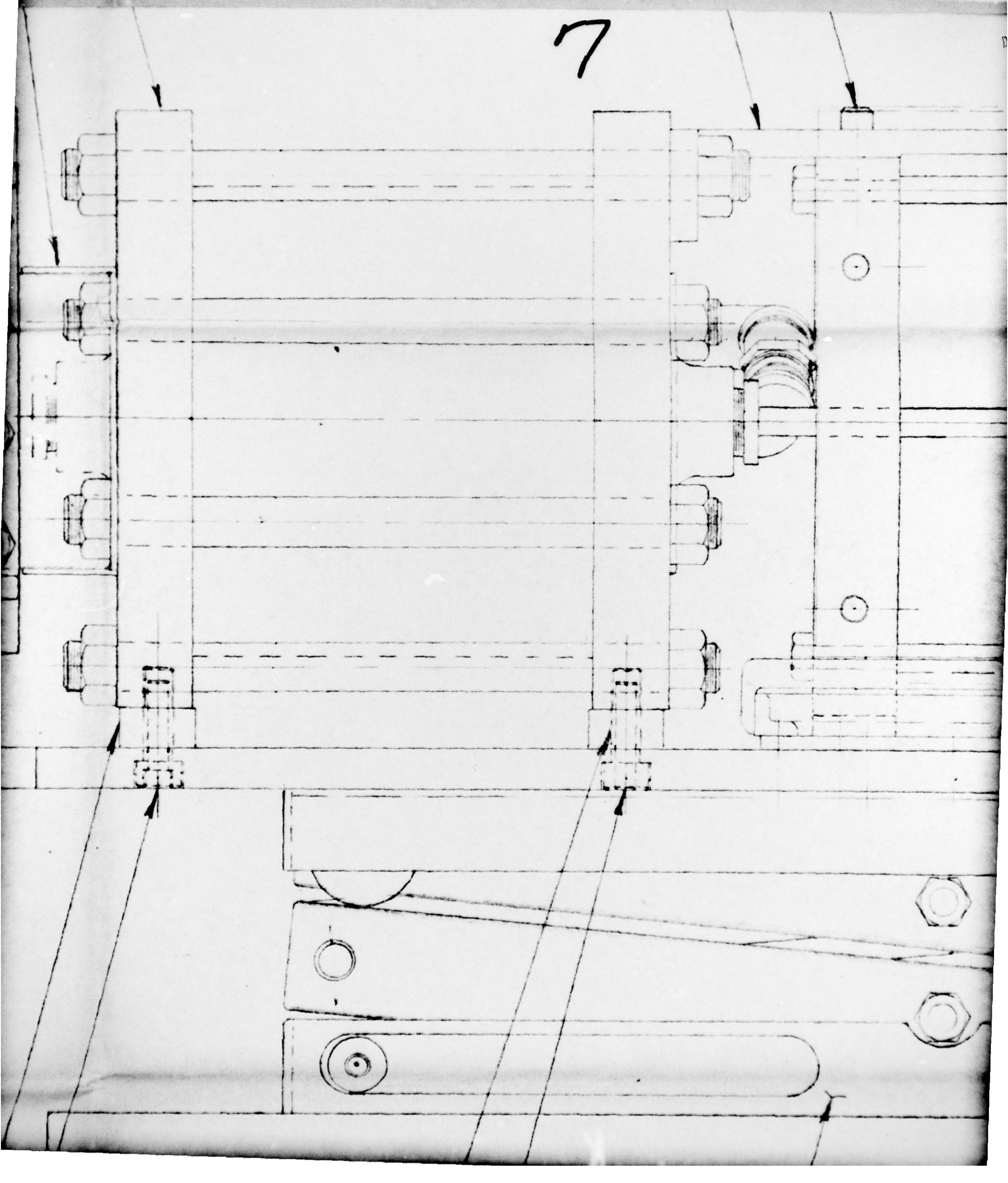
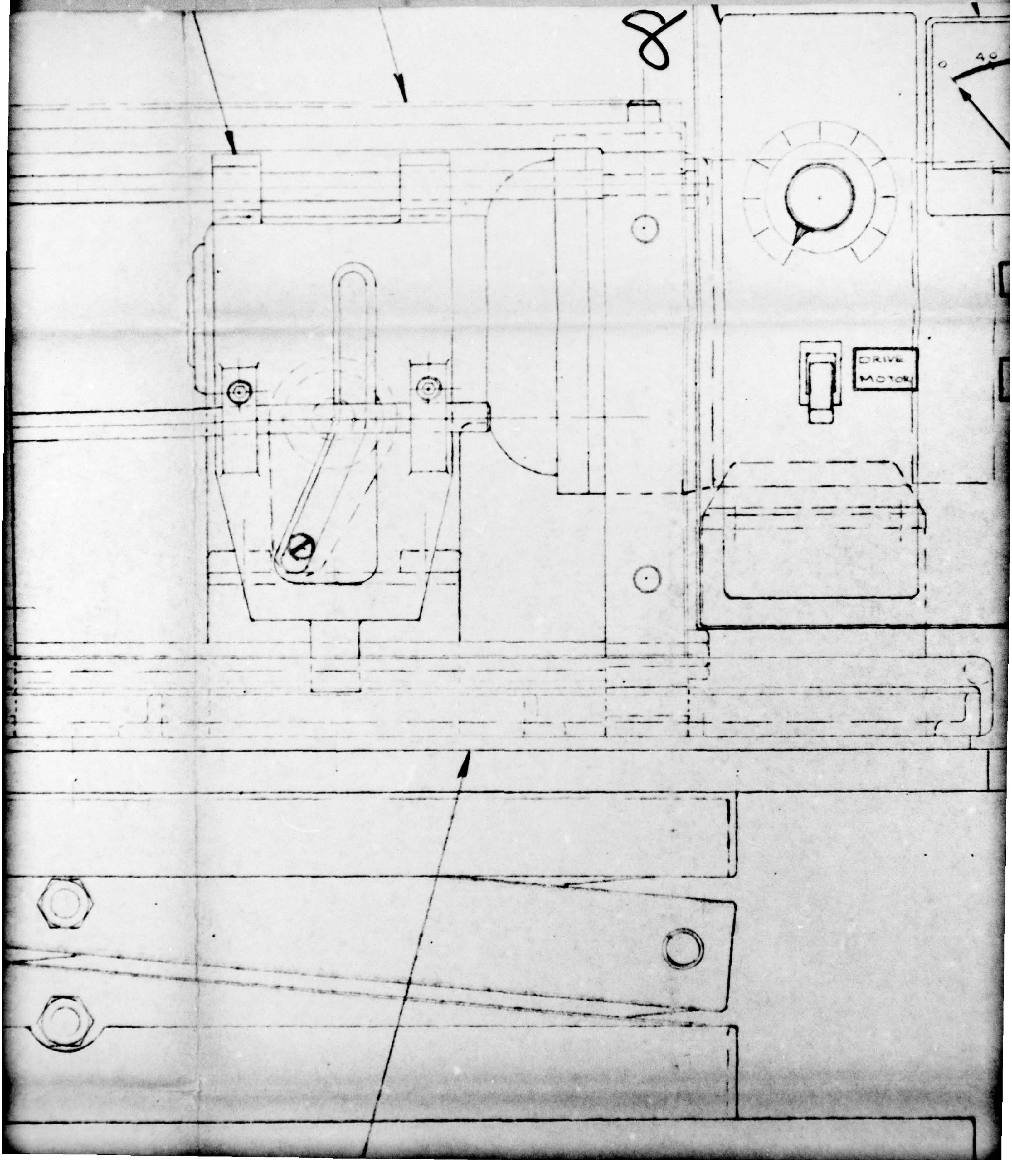
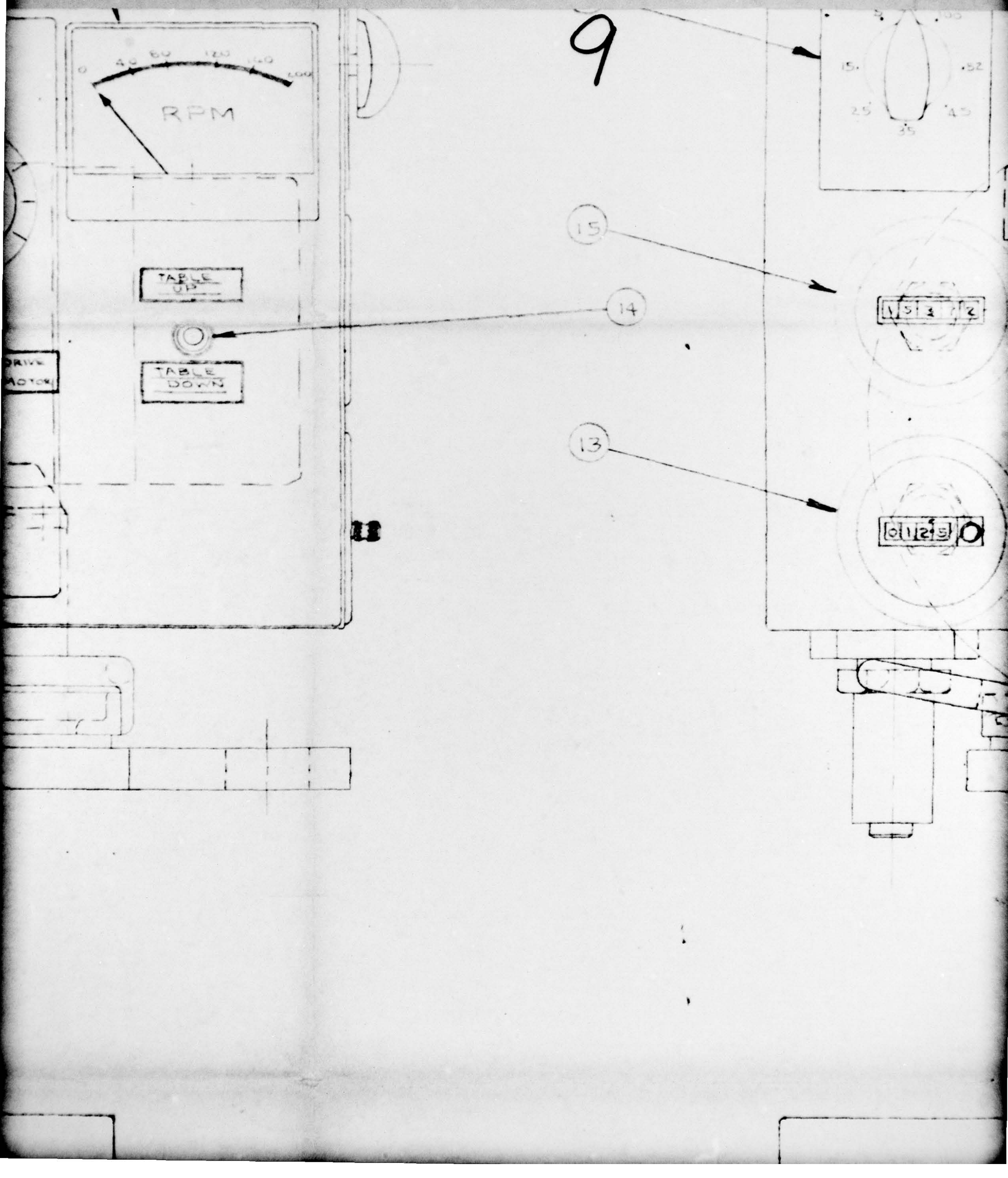
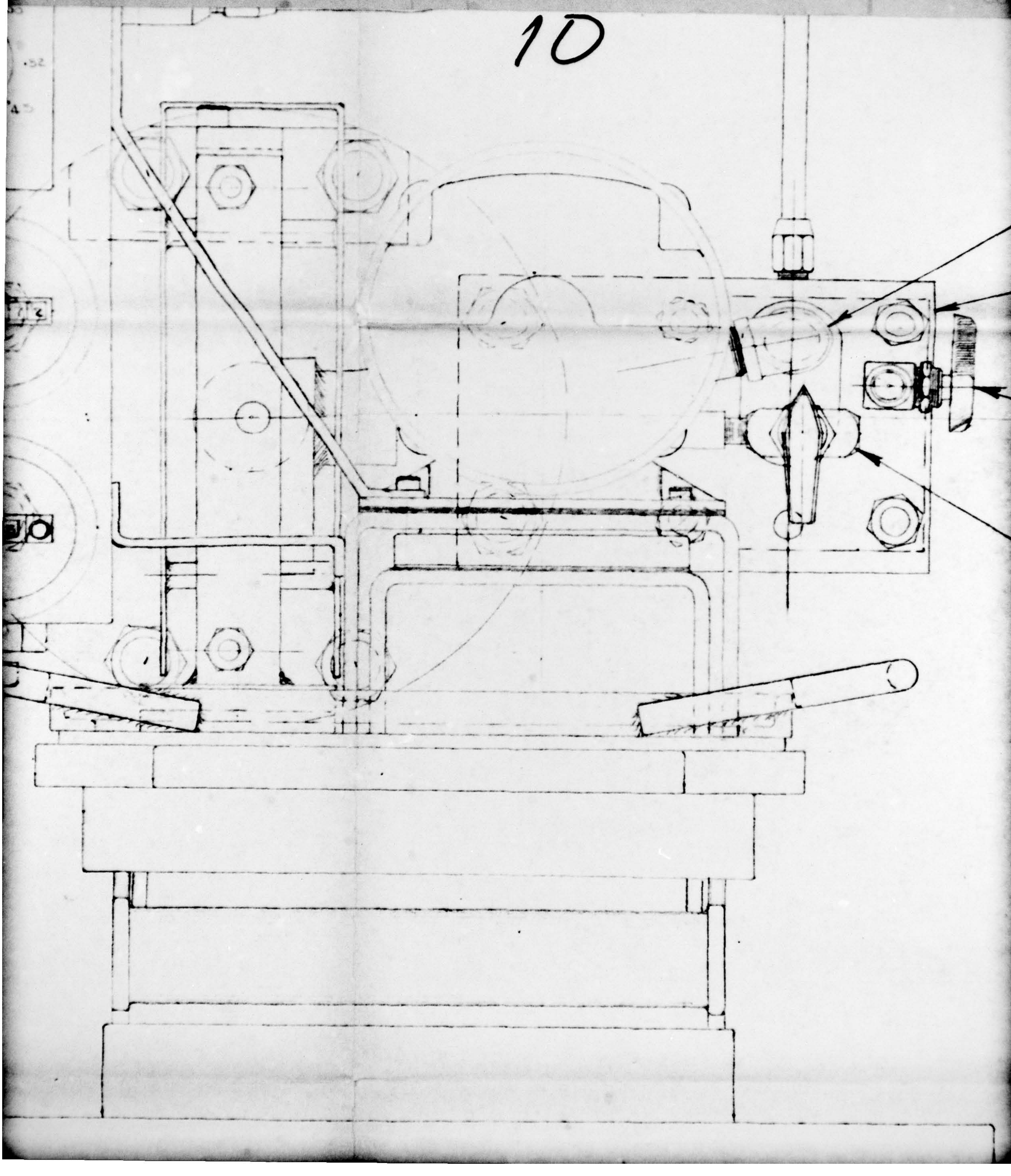
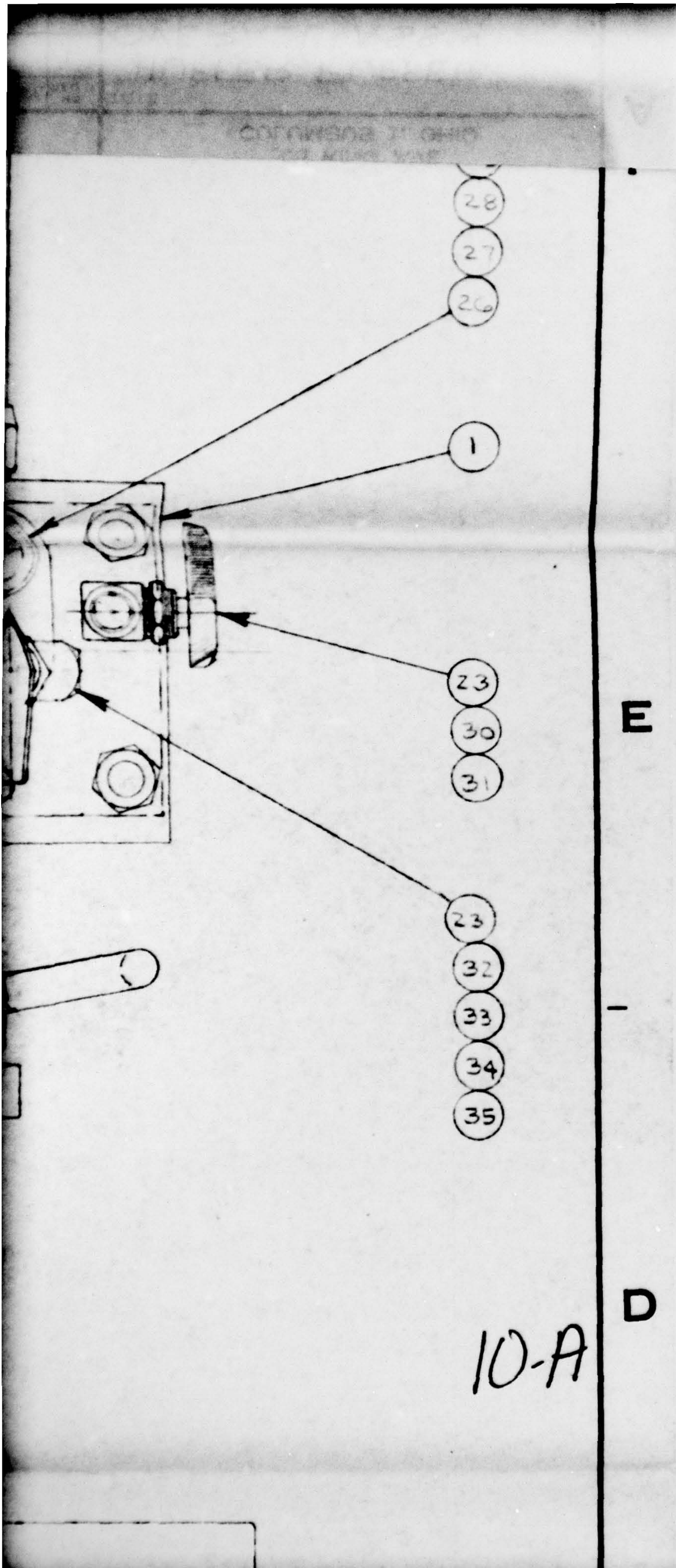



8
0
40
DRIVE
MOTOR


9
RPM
0
40
80
120
160
200
TABLE UP
TABLE DOWN
DRIVE
MOTOR
15
14
13





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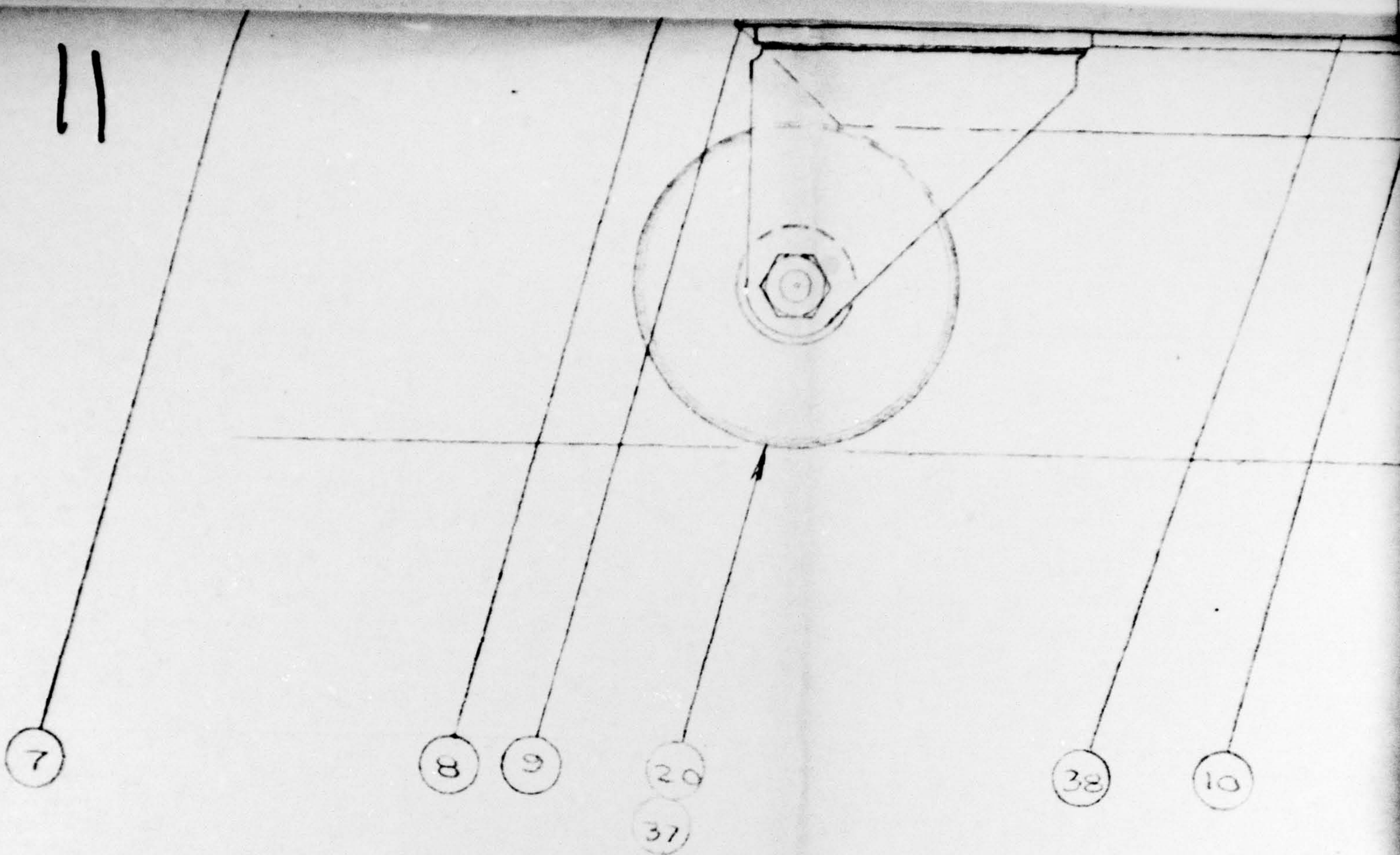
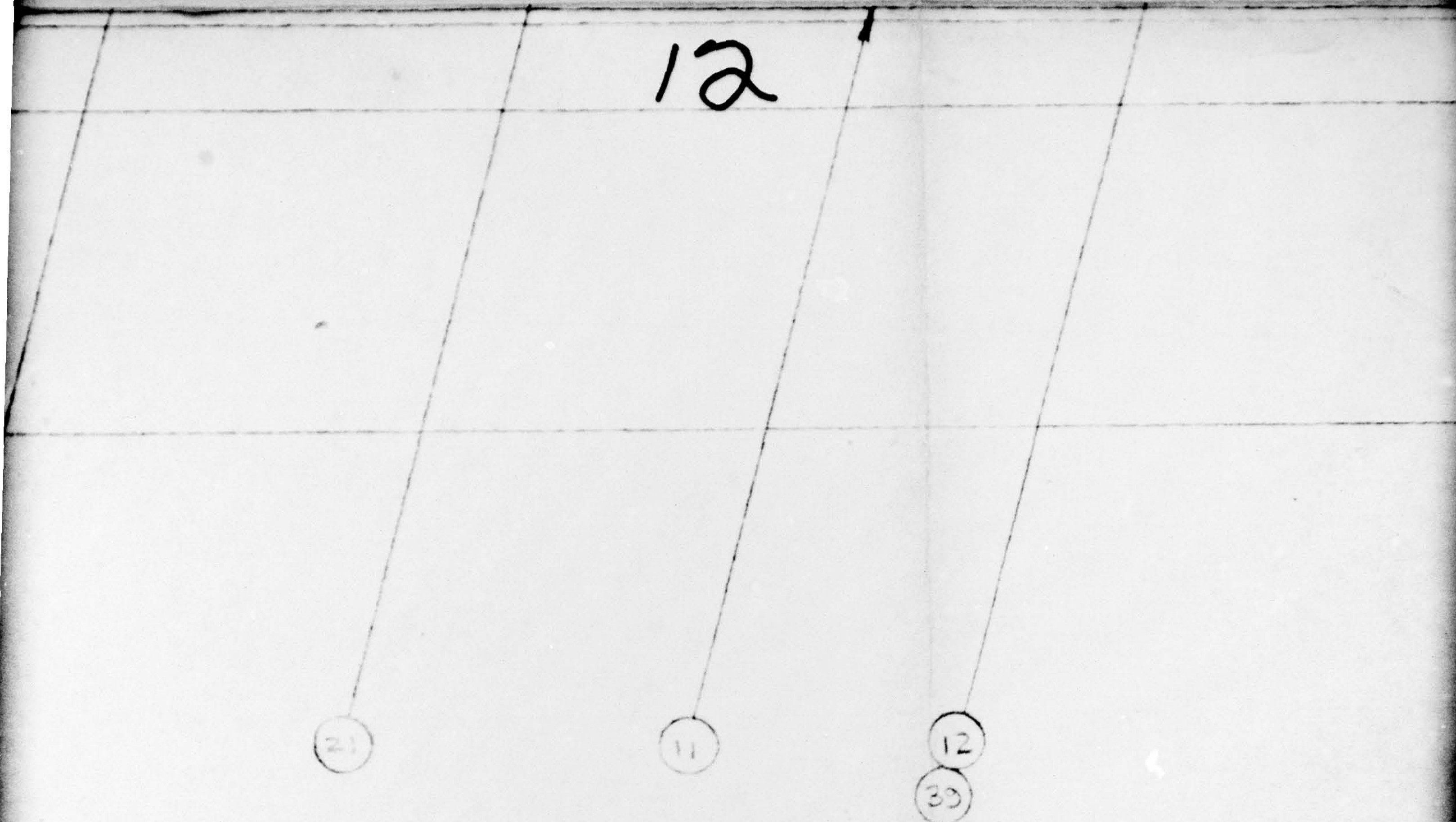
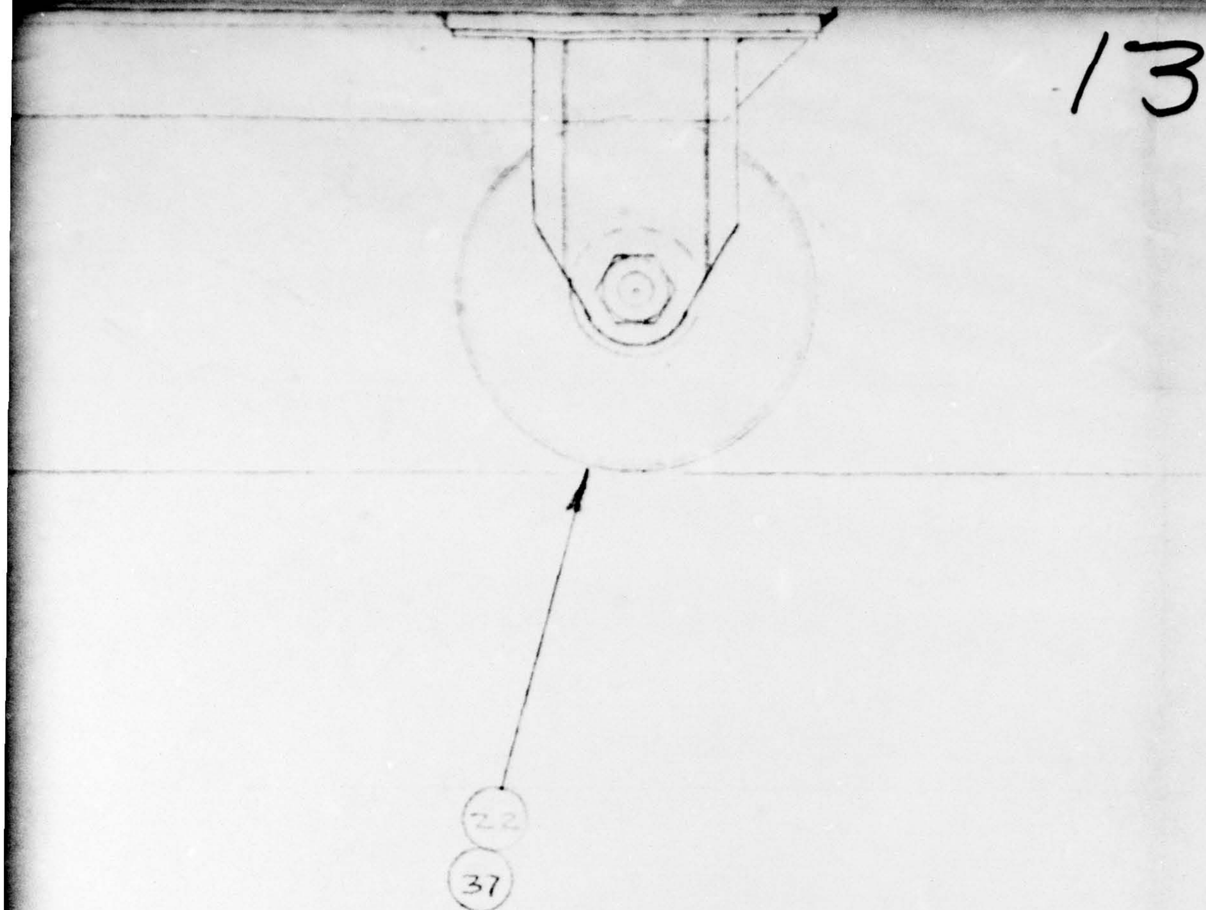
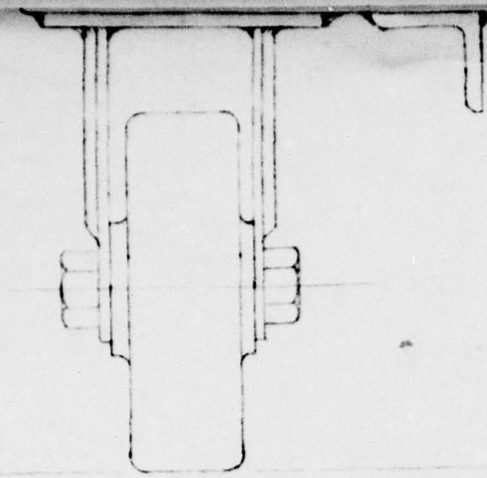



21
11
12
39


22
37



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MAT'L. (COMMERCIAL		
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TOLERANCE UNLESS OTHE		
FRAC.	ANG.	DEC.
±	±	

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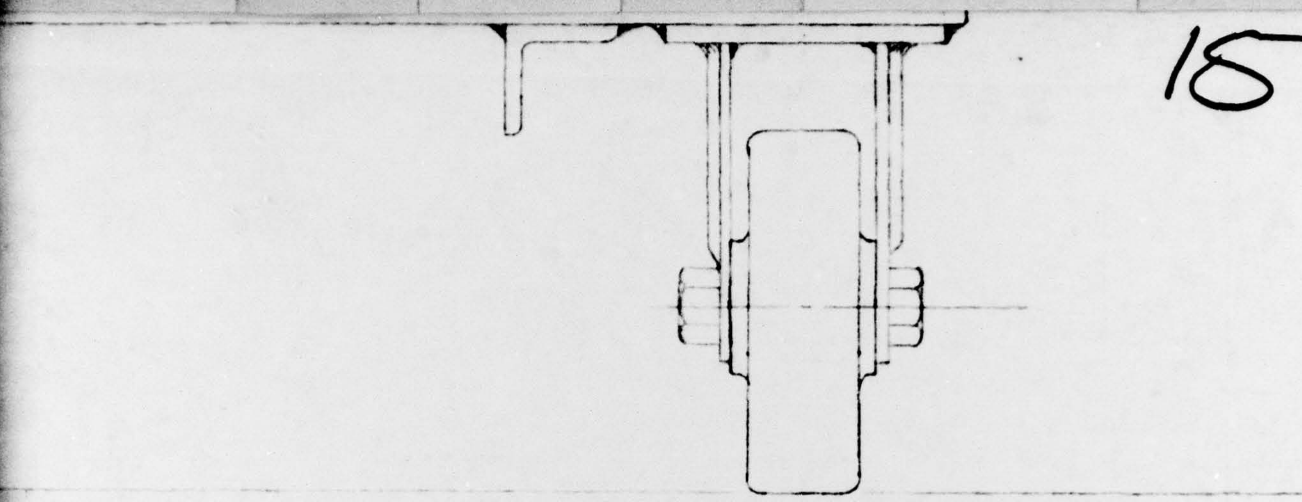

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16

					MAT'L. (COMMERCIAL TOLERANCES APPLY)					
					SEE LIST OF MAT'L.					
					TOLERANCE UNLESS OTHERWISE NOTED				NEXT ASSY.	NO. REQ'D.
					FRAC. ± ~	ANG. ± ~	DEC. ~			1
						DRAWN	CHECKED	PROJ. APP.		
					BY	RL				
					DATE	7/21/69			SCALE	K-G
ZONE	REV. LET.	REVISIONS	BY	DATE	DIV.	644			1/2=1	G

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FURNISHED TO DDC

17

A

—	BATTELLE MEMORIAL INSTITUTE 505 KING AVE. COLUMBUS 1, OHIO		
NO. REQ'D.	TITLE		
1	"HUFFER PUFFER" OVERALL ASS'Y.		
-G	ACCT. NO.	DWG. NO.	
G	7800-0031	100	E

1