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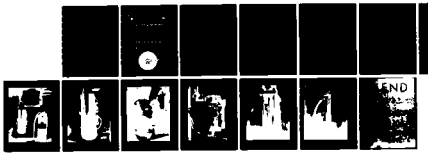

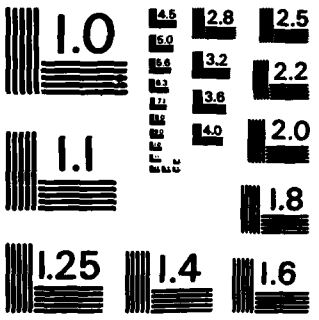

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NAVY EXPERIMENTAL DIVING UNIT
REPORT NO. 14-84

OPERATING AND MAINTENANCE GUIDELINES FOR THE KINERGETICS© ENVIRONMENTAL CONTROL SYSTEM

Carbon Dioxide Scrubber Model DH-10 and
Heat Exchanger Model CCU-01

By:

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

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By:

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MAY 1984

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An environmental control system consisting of the Kinergetics, Inc. (6029 Resada Blvd., Tarzana, CA 91356) Carbon Dioxide Scrubber Model DH-10 and Heat Exchanger Model CCU-01 has previously been evaluated as suitable for installation in standard U.S. Navy two-lock aluminum recompression chambers. This report provides installation and operating guidelines and may be used as a basis for writing operating procedures for the two units. Manufacturer's instructions should be followed for installation. A method of measuring

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chamber carbon dioxide concentration, such as chemical detection tubes, must be used to determine when to change carbon dioxide absorbent canisters. For planning purposes, predicted canister durations for the scrubber under specified conditions of 3 occupants or less, 75°F (24°C) internal temperature, and no external ventilation or breathing apparatus overboard dump are 3.5 hours at 30 Feet of Sea Water (FSW), 1.5 hours at 60 FSW, and 1.0 hour at 165 FSW. The heat exchanger requires a minimum of 2 gallons per minute of water or water/propylene glycol mixture, chilled to a maximum temperature at the chamber ranging from 86°F (30°C) for an ambient air temperature of 82°F (28°C), to 36°F (2°C) for an ambient air temperature of 110°F (43°C), in order to keep the chamber internal temperature below 85°F (30°C).

ABSTRACT

An environmental control system consisting of the Kinergetics, Inc. (6029 Resada Blvd., Tarzana, CA 91356) Carbon Dioxide Scrubber Model DH-10 and Heat Exchanger Model CCU-01 has previously been evaluated as suitable for installation in standard U.S. Navy two-lock aluminum recompression chambers. This report provides installation and operating guidelines and may be used as a basis for writing operating procedures for the two units. Manufacturer's instructions should be followed for installation. A method of measuring chamber carbon dioxide concentration, such as chemical detection tubes, must be used to determine when to change carbon dioxide absorbent canisters. For planning purposes, predicted canister durations for the scrubber under specified conditions of 3 occupants or less, 75°F (24°C) internal temperature, and no external ventilation or breathing apparatus overboard dump are 3.5 hours at 30 Feet of Sea Water (FSW), 1.5 hours at 60 FSW, and 1.0 hour at 165 FSW. The heat exchanger requires a minimum of 2 gallons per minute of water or water/propylene glycol mixture, chilled to a maximum temperature at the chamber ranging from 82°F (28°C) for an ambient air temperature of 86°F (30°C), to 36°F (2°C) for an ambient air temperature of 110°F (43°C), in order to keep the chamber internal temperature below 85°F (30°C).

Key Words:

Environmental Control System
Carbon Dioxide
Scrubber
Recompression Chamber
Heat Exchanger
Canister Duration
HP Sodasorb
Chill Water

INTRODUCTION

The two-lock aluminum recompression is in common use in the U.S. Navy. In most chambers, atmosphere control consists primarily of continuous or frequent ventilation, which has the disadvantages of high air usage, high chamber noise levels, poor temperature control, and high operator effort. These disadvantages are particularly acute during longer treatments and in hot climates. Commercially manufactured systems which provide heating and cooling, and remove carbon dioxide from chamber atmosphere are available. One such system, the Kinergetics, Inc. (6029 Resada Blvd., Tarzana, CA 91356) Environmental Control System (ECS) consisting of a Carbon Dioxide Scrubber Model DH-10 and a Heat Exchanger CCU-01 has been tested at the Navy Experimental Diving Unit (1), (2), and is suitable for installing in standard two-lock aluminum recompression chambers. This report describes operating guidelines and may be used as a basis for writing operating procedures for the Kinergetics® ECS. Since carbon dioxide level is a function of the carbon dioxide production rate and of canister flow rate, and not of chamber size, these instructions can be used for chambers which are smaller or moderately larger than a U.S. Navy standard two-lock aluminum chamber. The canister duration limits given in this report are based on three chamber occupants, although there may be fewer or greater number of occupants depending on the circumstances.

Carbon Dioxide Scrubber Model DH-10

1. Installation (Figures 1, 2)

The manufacturer's instructions should be followed. A 24 volt electrical power supply must provide sufficient capacity and may be either AC or DC. One power supply may be used to power both the carbon dioxide scrubber and the heater-chiller unit if the capacity is sufficient. The power supply, whether battery or transformer, must be outside the chamber. All switches must be outside the chamber. An electrical penetrator with the proper current carrying capacity must be used to carry power into the chamber.

The Scrubber should be placed so that air flow at top and bottom of the unit is unobstructed, preferably in a vertical position on the end bulkhead of the inner lock of the chamber.

2. Set Up

HP Sodasorb (W. R. Grace & Co., Atlanta, GA 30336) must be carefully packed into the canister of the scrubber, as full as possible while still permitting the lid to be closed (Figure 3). A minimum of approximately 8 pounds (3.6 kg) will be required. The canister is then replaced on the unit and fastened by the snap-locks.

3. Operation

The carbon dioxide scrubber is normally turned on at the beginning of chamber use and kept on throughout a treatment except during canister changes.

Carbon dioxide levels must be monitored at least every half hour, using chemical detection tubes (e.g. Draeger CH 23501) or other approved means. The sampling location should be in mid-chamber to obtain the mixed chamber CO_2 and not the canister effluent CO_2 which is expected to be near zero. The canister should be changed when mixed chamber CO_2 level reaches 1.5% SEV. Note that with chemical detection tubes no correction for depth is required and the concentration can be taken directly from the tube.

Table 1 shows predicted canister durations, rounded down to the nearest half hour. The table can serve as a guideline for chamber operators in stocking HP Sodasorb but should not be used in lieu of CO_2 monitoring equipment for determining where to change canisters because various factors will influence the actual canister durations. They are expected to be longer if there are fewer chamber occupants, if an oxygen breathing system with an overboard dump is used or if the chamber is periodically ventilated. Cold temperatures, improper packing of the canister, and increased CO_2 production from chamber occupants may shorten the duration. If canister changes are being made much more frequently than predicted by Table 1, monitoring canister effluent can help in determining whether the HP Sodasorb is depleted or if the flow rate through the canister is too low. When canister effluent exceeds 0.5% SEV, the HP Sodasorb is depleted and must be replaced. If the difference between mixed chamber CO_2 and canister effluent CO_2 exceeds 0.75% SEV (60 FSW or shallower) or 1.0% SEV (165 FSW), the canister flow rate is probably too low. In this case, first check the power supply for adequate voltage. If nothing can be done about the power supply or CO_2 production cannot be decreased (e.g. tenders are working hard at resuscitation) then supplementary ventilation will be required.

Oxygen levels should also be measured every half hour or more often, and ventilation will be required if the level of O_2 reaches 30% by volume. A portable Teledyne oxygen monitor or other approved equipment can be used for determining O_2 levels.

4. Routine Maintenance

Immediately after use, the power to the unit should be turned off. The canister is then removed, all used HP Sodasorb discarded, and dust wiped from the interior of the canister. No other routine maintenance is required.

If rapid need for the chamber is expected, the canister may be refilled with fresh HP Sodasorb, placed in double-wrapped airtight plastic bags, and stored in a convenient location above freezing temperatures inside or outside the chamber. When properly sealed, a prepacked canister will have a shelf life equal to the HP-Sodasorb. However, if a canister is used which has been pre-packed for a long time, monitoring of chamber CO_2 as recommended in this report will ensure that CO_2 levels stay below recommended maximums.

Heater-Chiller Unit Model CCU-01

1. Installation (Figures 1, 4)

The manufacturer's instructions should be followed. The electrical supply information found above for the carbon dioxide scrubber applies to the heater-chiller unit. A suitable penetrator must also be used for the supply and return of water, and this penetrator may replace a glass view port in the chamber. The external water supply may be carried through permanently installed pipes or a suitable hose (Garden Hose, FSN 9C14720 00 720 5334 will carry either cold or hot water). Long pipes or hoses may be insulated to conserve energy losses. A suitably sized flow meter, such as the Rotometer type must be installed in the water system (Figures 5, 6). The most convenient location is at the outflow port outside the chamber. Chill water may be obtained from any available source such as a ship's chill water system or a portable chill water unit. The chill water supply must provide at least 2 gallons per minute (8 L/min) at a temperature cool enough to cool the chamber during the warmest weather expected. Table 2 was calculated from the graph of Figure 3 in reference 2, and lists maximum chill water supply temperature for adequate chamber cooling at various environmental air temperatures. Chill water temperature is measured at the chamber inlet.

The chill water system may contain either water or a water/propylene glycol mixture. The manufacturer recommends a water to propylene glycol ratio of 75% to 25%. In all cases of ambient temperatures in which cooling is required, the chamber is assumed to be shaded from direct sunlight. If the chamber is exposed to the direct rays of the sun, an awning must be erected over the chamber, as the heater-chiller will not cool the chamber adequately when it is in direct sunlight.

Heating the chamber is usually less critical than cooling, since cold occupants can be given protective clothing. A source of heated water or water/propylene glycol mixture at 120°F (49°C) at 2 gallons per minute (8 L/min) should provide adequate heating. If a flexible hose is used it must be designed to withstand hot water, and the garden hose noted above will serve.

2. Set Up

The pipes, hoses, and heat exchanger should be visually inspected for leaks. The water flow meter should be calibrated if there is any question of adequate flow by using a bucket to measure the outflow through the flow meter for 1 minute. Precise calibration is not necessary, but the flow must be 2 gallons per minute as a minimum. A thermometer for the chamber interior should be available and should be of a type which <u>does not contain mercury</u>.

3. Operation

Either chilled or heated water may be circulated through the heat exchanger, depending on the ambient conditions. The interior of the chamber

must be kept below 85°F (30°C). Once appropriate water is circulating, the blower of the heat exchanger is turned on or off as needed to provide the necessary cooling or heating.

4. Routine Maintenance

Water from condensation accumulates in the unit and must be drained occasionally during use and after completion of chamber operation. Open the condensate drain valve, drain any water into a suitable container, and discard.

Lint may collect on the fins of the heat exchanger. It is combustible and may also reduce the efficiency of the unit. Lint removal should be done during normal periodic chamber cleaning. Only compressed air suitable for diver's breathing air should be used for this purpose inside the chamber. Lint removal should be done only when the chamber is not in operation.

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1. Schwartz, H.J.C., Robinson, P.H., Schram, D.K. and Sarich, A.J.; Evaluation of a Carbon Dioxide Scrubber in a Two-Lock Recompression Chamber, Navy Experimental Dving Unit Report 6-84, March 1984.

2. Sarich, A.J. and Schwartz, H.J.C.; A Thermodynamic Analysis of An Aluminum Recompression Chamber with Heat Exchanger, Proceedings, Fourteenth Annual International Diving Symposium, New Orleans, LA, February 1984, pp 1-10, with Errata Sheet.

TABLE 1

Predicted Intervals for Canister Change

For Planning Purposes

Conditions:
(1) Three Occupants or Less with only one working
(2) Approximately 75 F (24°C) or greater Internal Air Temperature
(3) DH-10 Scrubber Running at 24 Volts

DEPTH	TIME
30 FSW	3.5 Hours
60 FSW	1.5 Hours
165 FSW	1.0 Hours

TABLE 2

Chill Water Supply Requirements for Various Ambient Temperatures

Ambient Outside Air Temperature	Chill Water Temperature to maintain chamber temperature below 85°F (30°C)
86°F (30°C)	82°F (28°C)
88°F (31°C)	78°F (26°C)
90°F (32°C)	74°F (23°C)
92°F (33°C)	71°F (22°C)
94°F (34°C)	67°F (19°C)
96°F (36°C)	63°F (17°C)
98°F (37°C)	59°F (15°C)
100°F (38°C)	55°F (13°C)
102°F (39°C)	51°F (11°C)
104°F (40°C)	47°F (8°C)
106°F (41°C)	44°F (7°C)
108°F (42°C)	40°F (4°C)
110°F (43°C)	36°F (2°C)

NOTES: 1. Chamber must be shaded.

2. Water flow must be at least 2 gallons per minute (8 L/min).

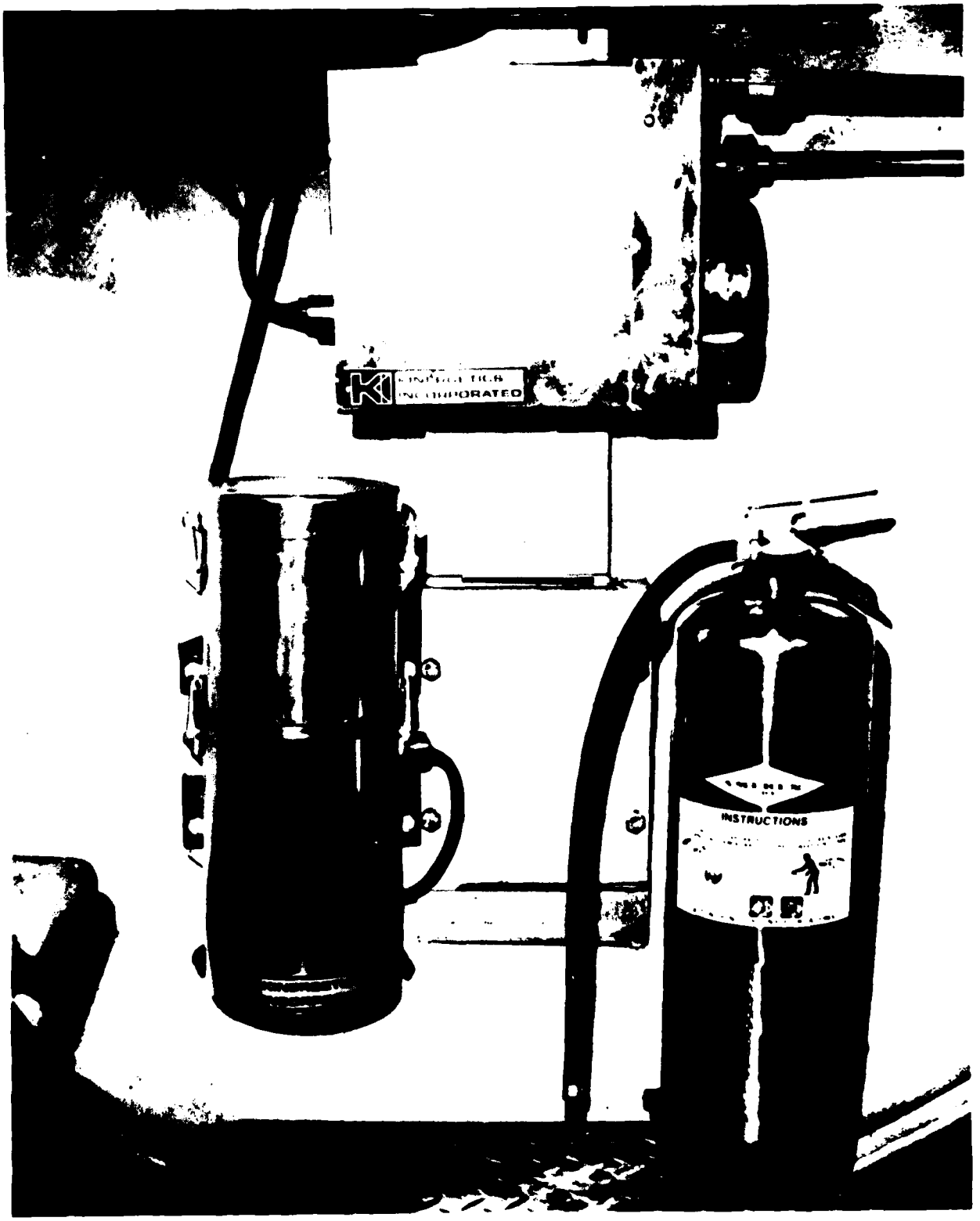


FIGURE 1. ECS System installed in a two-lock chamber. A fire extinguisher is included to give a size comparison.

FIGURE 2. Kinergetics, Inc., Carbon Dioxide Scrubber, Model DH-10, installed in an aluminum two-lock chamber.

FIGURE 3. Packing the [illegible] with HP Sodasorb*.

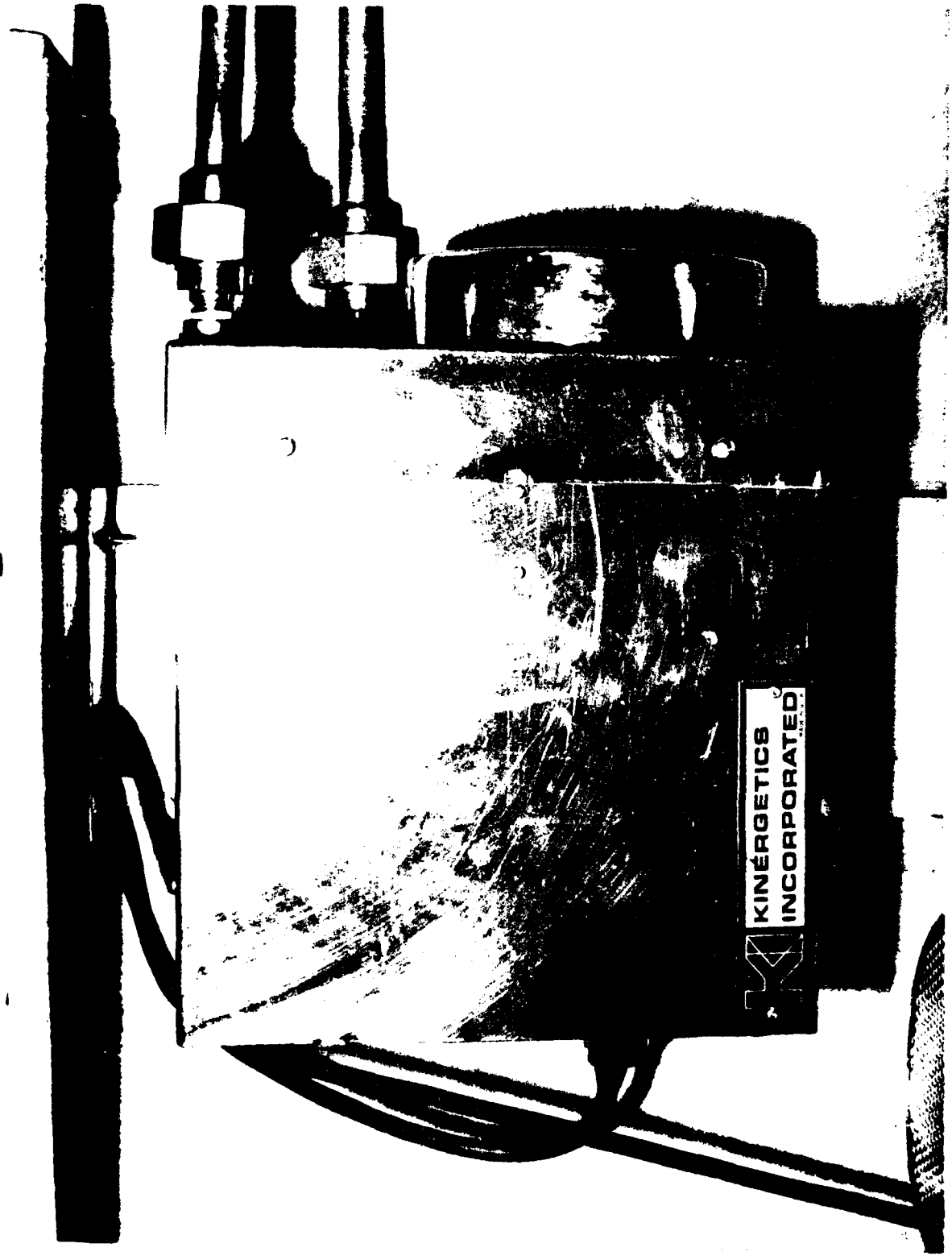


FIGURE 4. Kinergetics, Inc., [illegible]ter Unit, Model [illegible], instal[illegible] an aluminum [illegible]

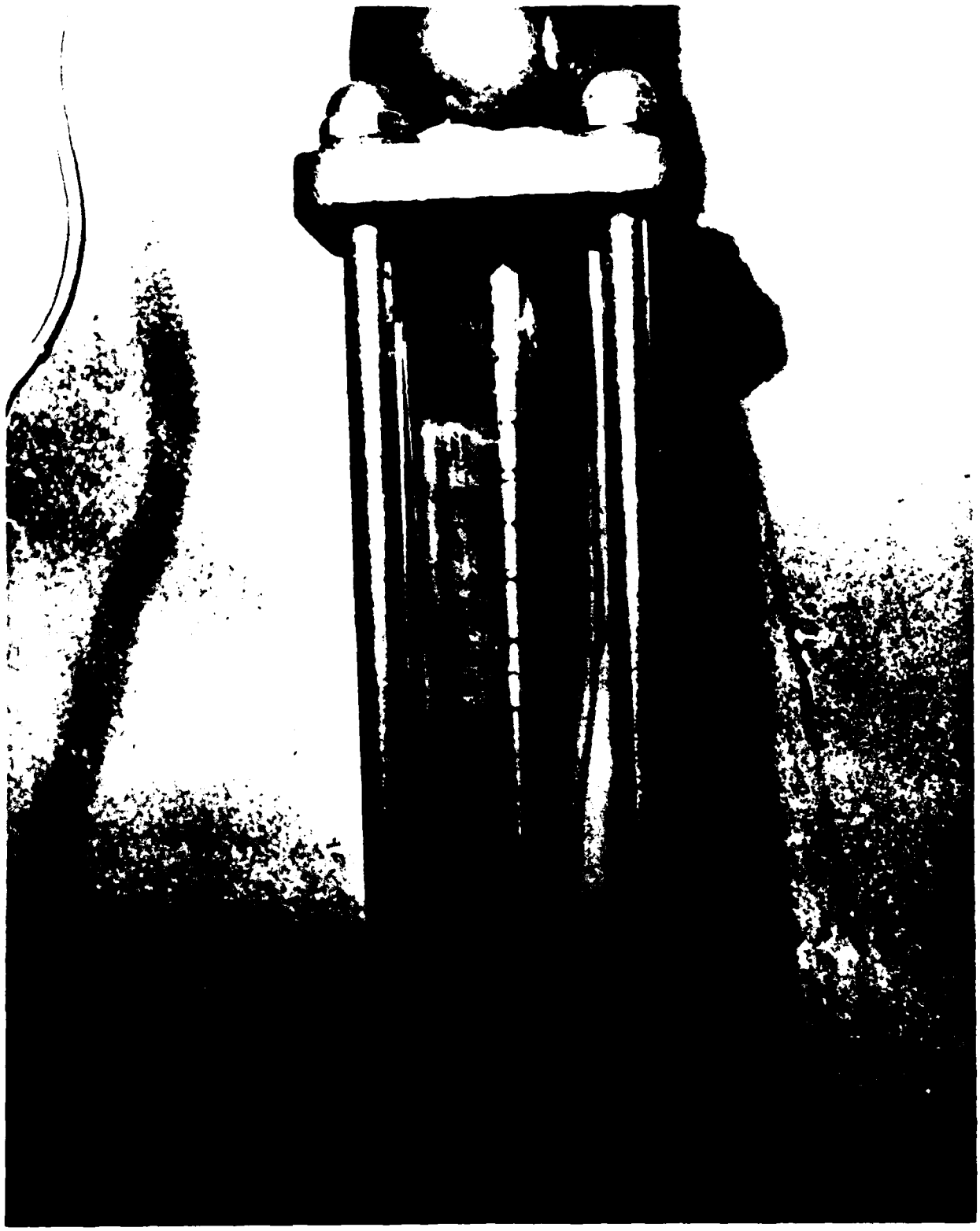
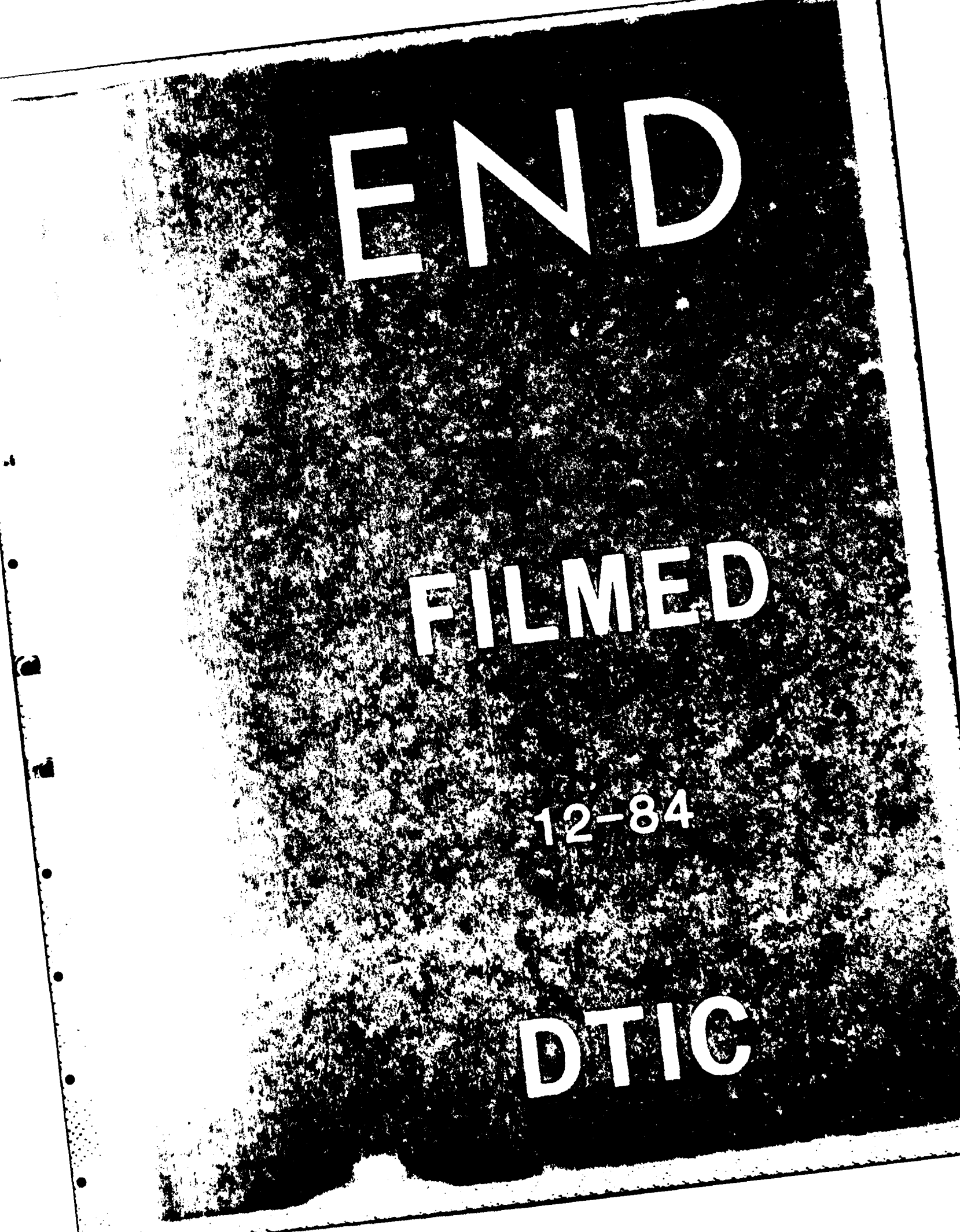


FIGURE 5. Rotometer Flow Mete , capacity 0-10 gallons per minute.

FIGURE 6. Flow Meter installed externally on an aluminum towed vehicle.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