

NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

EVALUATION OF SCUBA PRO MARK I, MARK V
AND MARK VII OPEN CIRCUIT SCUBA REGULATORS

LETTER REPORT 7-71

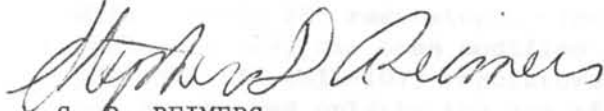
by

R. Y. IHA
S. D. REIMERS

AD #759-983

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Submitted



S. D. REIMERS
LTJG, USNR
Project Officer

Approved



W. I. MILWEE, JR.
LCDR, USN
Officer in Charge
Acting

NAVY EXPERIMENTAL DIVING UNIT

WASHINGTON NAVY YARD

WASHINGTON, D.C. 20390

EDU:RYI:jt

3960

Ser: 637

31 AUG 1971

From: Officer in Charge, Navy Experimental Diving Unit
To: Supervisor of Diving

Subj: Letter Report 7-71, Evaluation of SCUBA PRO MARK I, MARK V and
MARK VII Open Circuit SCUBA Regulators

Ref: (a) NEDU Letter Report 5-70 to NAVSHIPS OOC EDU:SDR:mcc 3960
Ser 923 of 29 Dec 1970. Evaluation of SCUBA PRO MARK I
and MARK V Open Circuit SCUBA Regulators
(b) SCUBA PRO ltr to NAVSEC of 15 Apr 1971
(c) NAVSEC ltr to SCUBA PRO 6124B:LEG:emm 4123/24169 Ser 1120-
6124B of 8 Jun 1971

Encl: (1) Exploded View, SCUBA PRO MARK I and MARK V SCUBA Regulators
(2) EDU Breathing Resistance Test Apparatus for Open Circuit
SCUBA Regulators (Single Hose)
(3) Breathing Resistance vs Depth Curves for SCUBA PRO MARK I
(MIL-101) Regulator No. 160565
(4) Breathing Resistance vs Depth Curves for SCUBA PRO MARK V
(MIL-105) Regulator No. 160634
(5) Breathing Resistance vs Depth Curves for SCUBA PRO MARK VII
(MIL-107) Regulator No. 160658

1. Reference (a) reported the SCUBA PRO MARK I and MARK V unacceptable because the inhalation resistance of all the regulators tested was unsatisfactory within a portion of the range of regulator adjustments that can be made by a diver in the water.

2. Reference (b) requested resubmission for qualification testing of the SCUBA PRO MARK I (MIL-101), MARK V (MIL-105) and MARK VII (MIL-107) single hose demand air regulators modified for military use. Reference (c) approved retesting of subject regulators.

3. Three SCUBA PRO Regulators; MARK I (MIL-101) Serial number 160565, MARK V (MIL-105) Serial number 160634 and MARK VII (MIL-107) Serial number 160658, were delivered to the Navy Experimental Diving Unit and subsequently tested in May 1971.

4. Enclosure (1) contains an exploded view of the standard MARK I and MARK V SCUBA PRO regulators. The adjustment knob (item 11, sheet 1 of enclosure (1)) has been modified for the MARK I (MIL-101), MARK V (MIL-105) and MARK VII (MIL-107) regulators such that the resistance adjustment may be changed only by the use of a special tool provided by SCUBA PRO.

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The only difference between the three regulators (modified or unmodified) is in their first stages. The MARK V (MIL-105) first stage will take two second stages whereas the MARK I (MIL-101) will take only one. The MARK VII (MIL-107) is basically a MARK V (MIL-105) with a sonic alarm added to the first stage which actuates when the supply pressure falls below approximately 250 psig.

5. The test apparatus used and the method used for interpreting the data are described in enclosure (2). The regulators were tested in both wet and dry modes.

6. All regulators were not tested in the conditions of maximum inhalation resistance and minimum inhalation resistance as tested in reference (a) since regulator adjustments can not be made by a diver in the water. All regulators were tested with the inhalation resistance adjustment preset at SCUBA PRO prior to delivery at NEDU.

7. Test results are contained in enclosures (3), (4) and (5) and summarized as follows:

a. Measured exhalation resistance levels are within MIL-R-24169A limits when tested in the dry mode for supply pressures above 250 psig.

b. Measured inhalation resistance levels for the MARK I (MIL-101) and MARK V (MIL-105) regulators are within MIL-R-24169A limits when tested in the dry and wet modes for supply pressures above 250 psig. High measured initial inhalation resistances (spikes) in the wet mode are expected since it takes more effort to initially move the mass of water against the diaphragm. These spikes are a characteristic common to single hose regulators when tested wet, and are reported here for the first time for record purposes only. The spikes have little to no physiologic significance since they are very narrow, and therefore represent very little physiologic work.

c. Measured inhalation resistance levels for the MARK VII (MIL-107) regulator are within MIL-R-24169A limits when tested in the dry and wet modes for supply pressures above 500 psig. Resistance levels do not meet MIL-R-24169A limits at 250 psig when the sonic alarm is actuated.

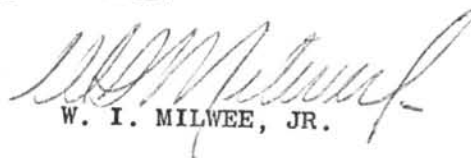
d. Measured exhalation resistance levels in the wet mode are slightly above MIL-R-24169A limits below 50 feet, 25 feet and 40 feet for the MARK I (MIL-101), MARK V (MIL-105) and MARK VII (MIL-107) regulators, respectively.

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8. In view of the test results the SCUBA PRO MARK I (MIL-101) and
MARK V (MIL-105) single hose regulators are considered acceptable for
use in the U.S. Navy and for placement on applicable qualified products
listings.

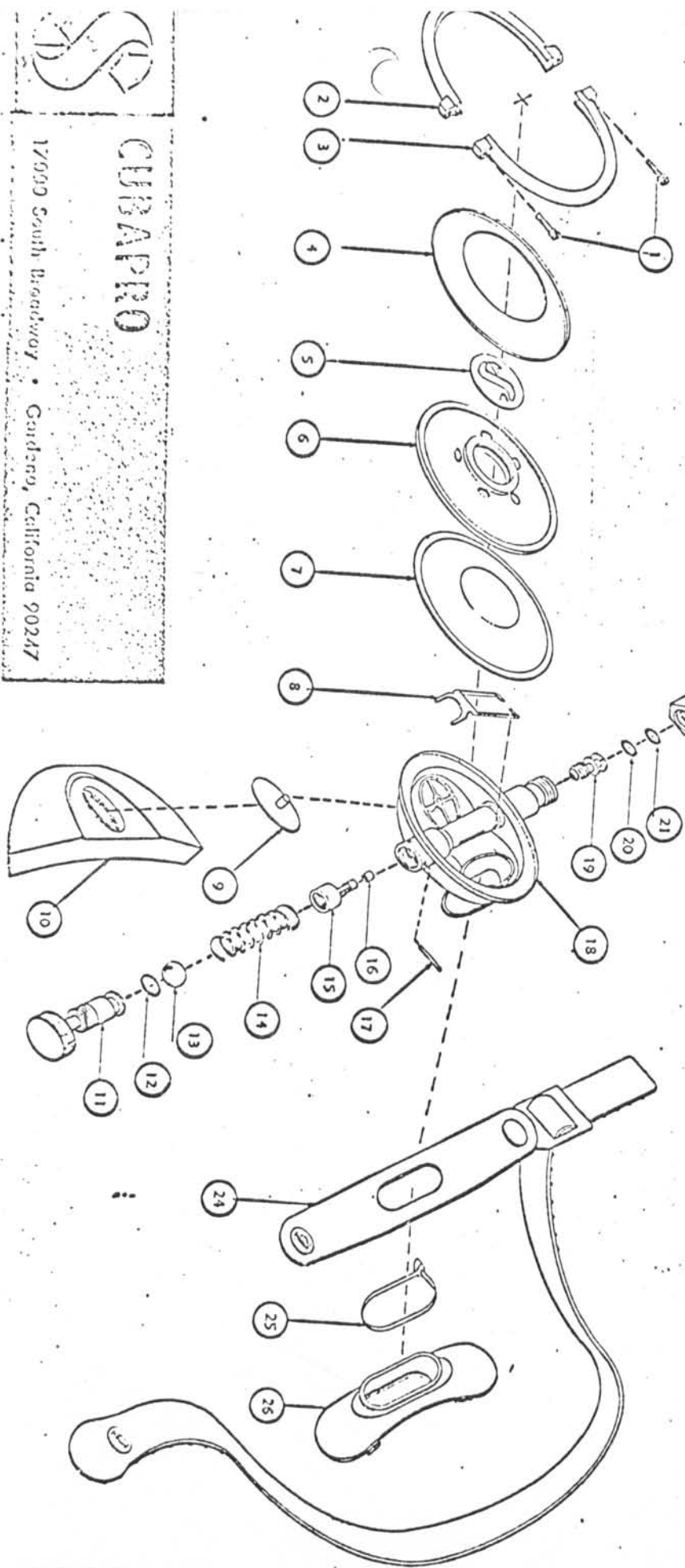
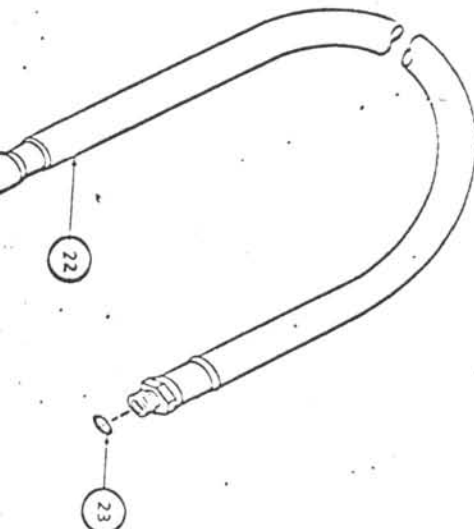
9. It is recommended that further evaluation be performed on the
MARK VII (MIL-107) regulator to determine whether the sonic alarm
meets material certification requirements.


W. I. MILWEE, JR.

Copy to:
NAVSEC 6124B
NAVSHIPS OOC-142

| CAT. NO. | DESCRIPTION | PRICE |
|----------|-----------------------|-------|
| 109-51 | Second Stage Complete | 50.00 |
| 109-73 | Screw (2 Req.) | .15 |
| 109-71 | Threaded Clamp | 1.50 |
| 109-72 | Unthreaded Clamp | 1.50 |
| 109-70 | Cover Ring | 3.00 |
| 109-69 | Insignia Plate | .75 |
| 109-63 | Cover | 1.80 |
| 109-62 | Diaphragm | 3.00 |
| 109-61 | Demand Valve Lever | 3.00 |
| 109-64 | Exhaust Valve | .50 |
| 109-65 | Exhaust Tee | 3.50 |
| 109-9 | Adjustment Knob | 2.00 |
| 109-7 | O' Ring | .35 |
| 109-55 | Spring Pod | .50 |

| # | CAT. NO. | DESCRIPTION | PRICE |
|----|----------|---------------------|-------|
| 14 | 109-57 | Spring | 1.80 |
| 15 | 109-56 | Poppet | 1.00 |
| 16 | 109-55 | Seat Assembly | 1.00 |
| 17 | 109-60 | Stop Pin | .30 |
| 18 | 109-52 | Case Assembly | 10.00 |
| 19 | 109-54 | Adjustable Orifice | 2.50 |
| 20 | 109-53 | O' Ring | .40 |
| 21 | 101-6 | O' Ring | .35 |
| 22 | 108-61 | Hose | 6.50 |
| 23 | 101-9 | O' Ring | .35 |
| 24 | 108-62 | Neck Strap Assembly | 3.00 |
| 25 | 108-63 | Mouthpiece Strap | .25 |
| 26 | 108-64 | Mouthpiece | 1.50 |



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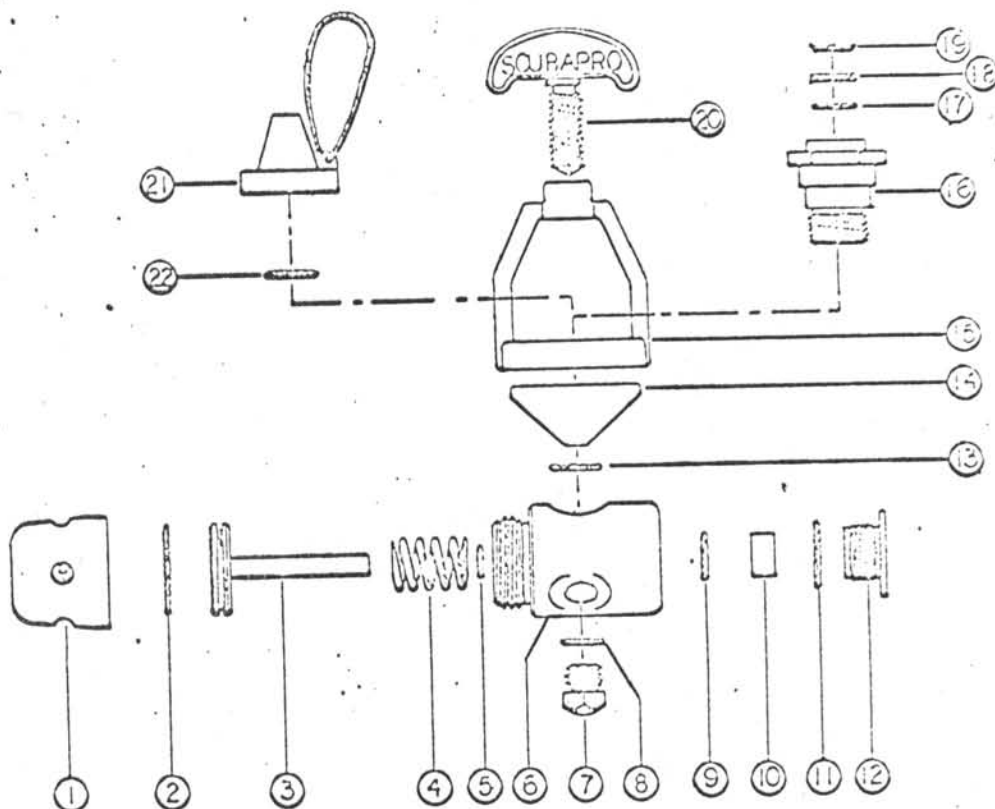
CUBAPRO



SCUBAPRO

3105 E. Harcourt St./Compton, Calif. 90221

101-1
MK 1 FIRST STAGE



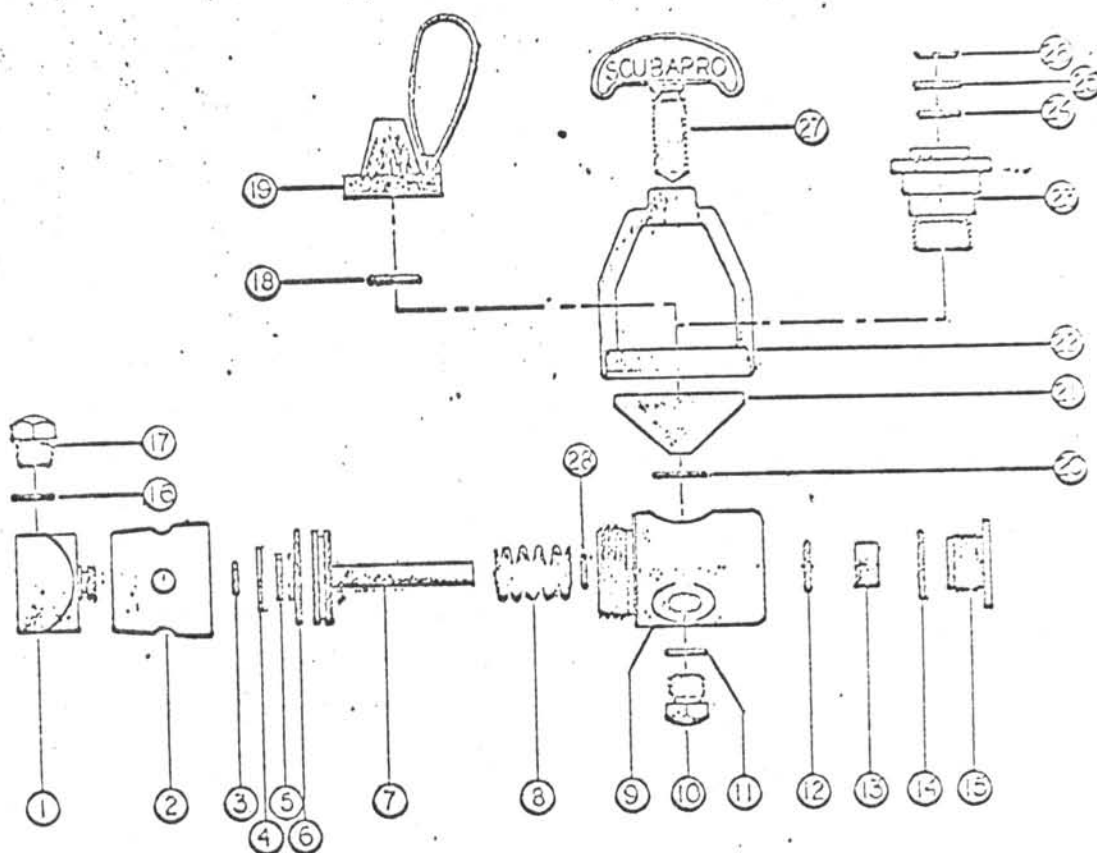
| # | CAT. NO. | DESCRIPTION | PRICE | # | CAT. NO. | DESCRIPTION | PRICE |
|----|----------|---------------|-------|----|---------------|----------------------|-------|
| 1 | 101-2 | CAP | 6.00 | 13 | 101-12 | 'O' RING | .40 |
| 2 | 101-3 | 'O' RING | .40 | 14 | 101-14 | SADDLE | 4.00 |
| 3 | 101-4 | PISTON | 20.00 | 15 | 101-15 | YOKE | 4.50 |
| 4 | 101-5 | SPRING | 3.00 | 16 | 101-16 | YOKE RETAINER | 4.00 |
| 5 | 101-6 | 'O' RING | .35 | 17 | 101-17 | 'O' RING | .35 |
| 6 | 101-7 | BODY | 9.00 | 18 | 101-18 | FILTER | .65 |
| 7 | 101-8 | PLUG | .75 | 19 | 101-19 | RETAINER | .40 |
| 8 | 101-9 | 'O' RING | .35 | 20 | 101-20 | YOKE SCREW | 1.75 |
| 9 | 101-10 | 'O' RING | .40 | 21 | 101-21 | PROTECTION CAP ASSY. | 1.00 |
| 10 | 101-11 | SEAT | 2.50 | 22 | 101-22 | 'O' RING | .40 |
| 11 | 101-12 | 'O' RING | .40 | | 101-1 | FIRST STAGE COMPLETE | 50.00 |
| 12 | 101-13 | SEAT RETAINER | 3.00 | | | | |
| | | | | 2 | Enclosure (1) | | |



SCUBAPRO

3105 E. Harcourt St./Compton, Calif. 90221

105-1
MK 5 FIRST STAGE



| # | CAT. NO. | DESCRIPTION | PRICE | # | CAT. NO. | DESCRIPTION | PRICE |
|---|----------|-----------------|-------|----|----------|----------------------|-------|
| 1 | 105-2 | SWIVEL | 8.00 | 16 | 101-9 | 'O' RING | .35 |
| 2 | 105-3 | CAP | 6.00 | 17 | 101-8 | PLUG | .75 |
| 3 | 101-17 | 'O' RING | .35 | 18 | 101-22 | 'O' RING | .40 |
| 4 | 105-5 | WASHER | .35 | 19 | 101-21 | PROTECTION CAP ASSY. | 1.00 |
| 5 | 105-6 | SWIVEL RETAINER | .50 | 20 | 101-12 | 'O' RING | .40 |
| 6 | 101-3 | 'O' RING | .40 | 21 | 101-14 | SADDLE | 4.00 |
| 7 | 101-4 | PISTON | 20.00 | 22 | 101-15 | YOKE | 4.50 |
| 8 | 101-5 | SPRING | 3.00 | 23 | 101-16 | YOKE RETAINER | 4.00 |
| 9 | 101-7 | BODY | 9.00 | 24 | 101-17 | 'O' RING | .35 |
| 0 | 101-8 | PLUG | .75 | 25 | 101-18 | FILTER | .65 |
| 1 | 101-9 | 'O' RING | .35 | 26 | 101-19 | RETAINER | .40 |
| 2 | 101-10 | 'O' RING | .40 | 27 | 101-20 | YOKE SCREW | 1.75 |
| 3 | 101-11 | SEAT | 2.50 | 28 | 101-6 | 'O' RING | .35 |
| 4 | 101-12 | 'O' RING | .40 | | 105-1 | FIRST STAGE COMPLETE | 50.00 |
| 5 | 101-13 | SEAT RETAINER | 3.00 | | | | |
| | | | | 3 | | Enclosure (1) | |

EDU BREATHING RESISTANCE TEST APPARATUS FOR OPEN CIRCUIT SCUBA REGULATORS (SINGLE-HOSE)

Breathing resistance studies are conducted on open circuit SCUBA regulators supplied to the Navy Experimental Diving Unit in accordance with the following procedures and utilizing the following equipment.

I. Equipment Used

a. Mechanical respirator; the respirator used is a replacement to the one described in Experimental Diving Unit Research Report 2-61 and produces essentially the same condition at the regulator mouthpiece. Its exact characteristics will be described in EDU Evaluation Report 1-71.

b. Statham Instruments Differential Pressure Transducer, model PR23-ID-300 or 350, ± 1 PSID, 13V max.

c. Sanborn 964 or 150 Recorder

d. Recompression Chamber

e. Regulator Testing Box

II. Equipment Set Up

The test equipment is set up as shown in figure 1. The mechanical respirator is set up to deliver 2 liters per breath and 20 breaths per minute. The waveform used is a sinusoid with an exhalation time to inhalation time ratio of 1.1 to 1. A detailed arrangement of the regulator in the regulator testing box is shown in figure 2. The end of the breathing pipe was specially formed to fit tightly into the mouthbit without creating any flow restrictions. The differential pressure transducer is connected to the mouthpiece so that it indicates the pressure difference between the mouthpiece and ambient pressure in the chamber.

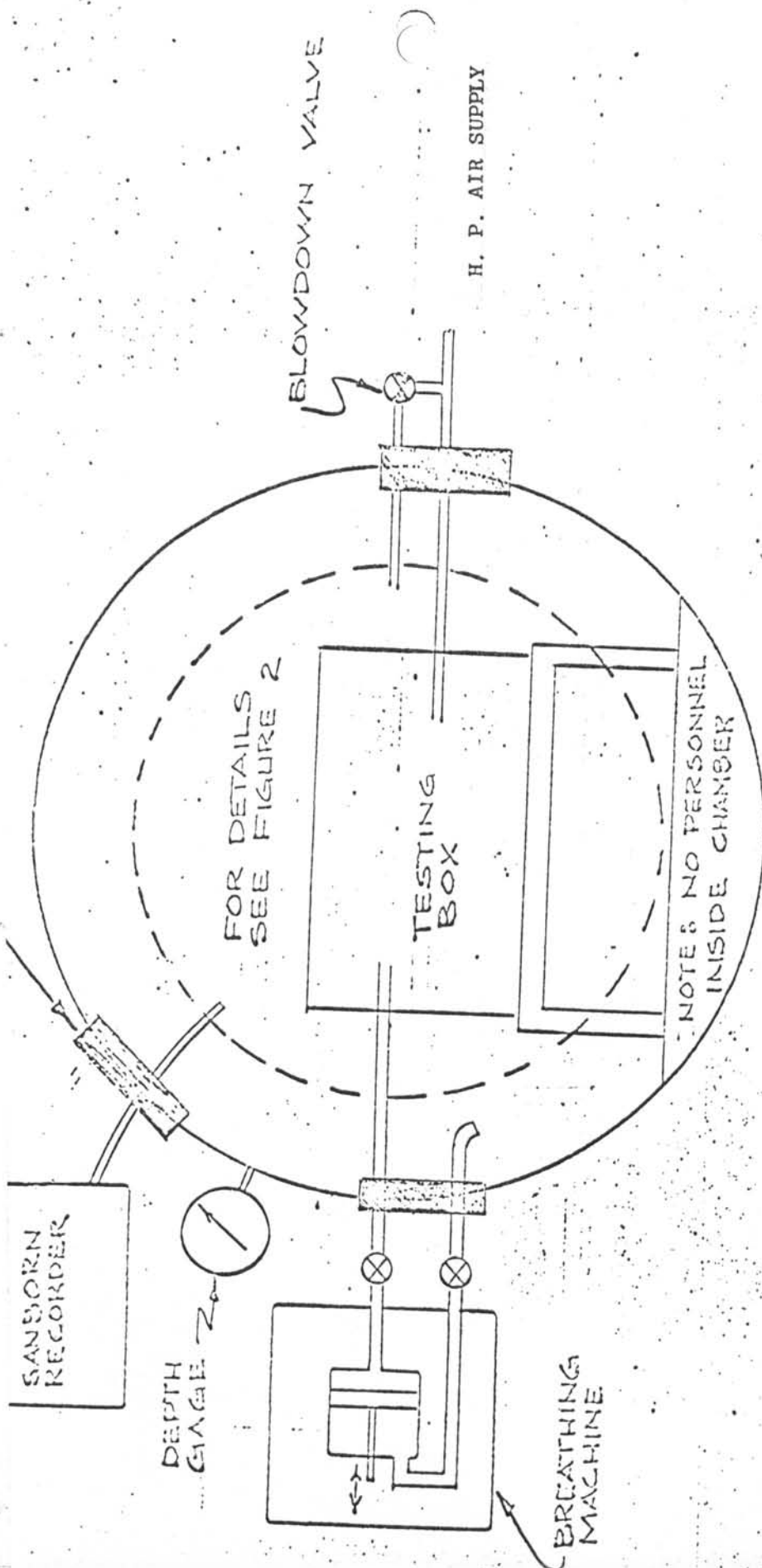
III. Procedure

The test equipment shown in figure 1 is used to test the regulators in a "wet" or a "dry" environment.

The "wet" environment is produced by adding water to the regulator testing box to the level shown; allowing the regulator to be tested while immersed in water. The pressure differentials between the mouthpiece and ambient during inhalation and exhalation are recorded with the transducer and Sanborn recorder. During "wet" testing, the differential pressure readings from the transducer contain a component due to the weight of the water above the regulator. During these tests the maximum pressure differentials (for inhalation and exhalation) are measured from the "zero flow condition pressure" measured at the time between the inhalation and exhalation cycles when no net flow is passing through the regulator.

"Dry" testing is accomplished using the same equipment and set up with the exception that water is not present in the regulator testing box. During the "dry" testing, when there is no inherent differential pressure caused by the water, the maximum pressure differentials are measured directly from the transducer "0 differential" condition (same as the "zero flow" condition above).

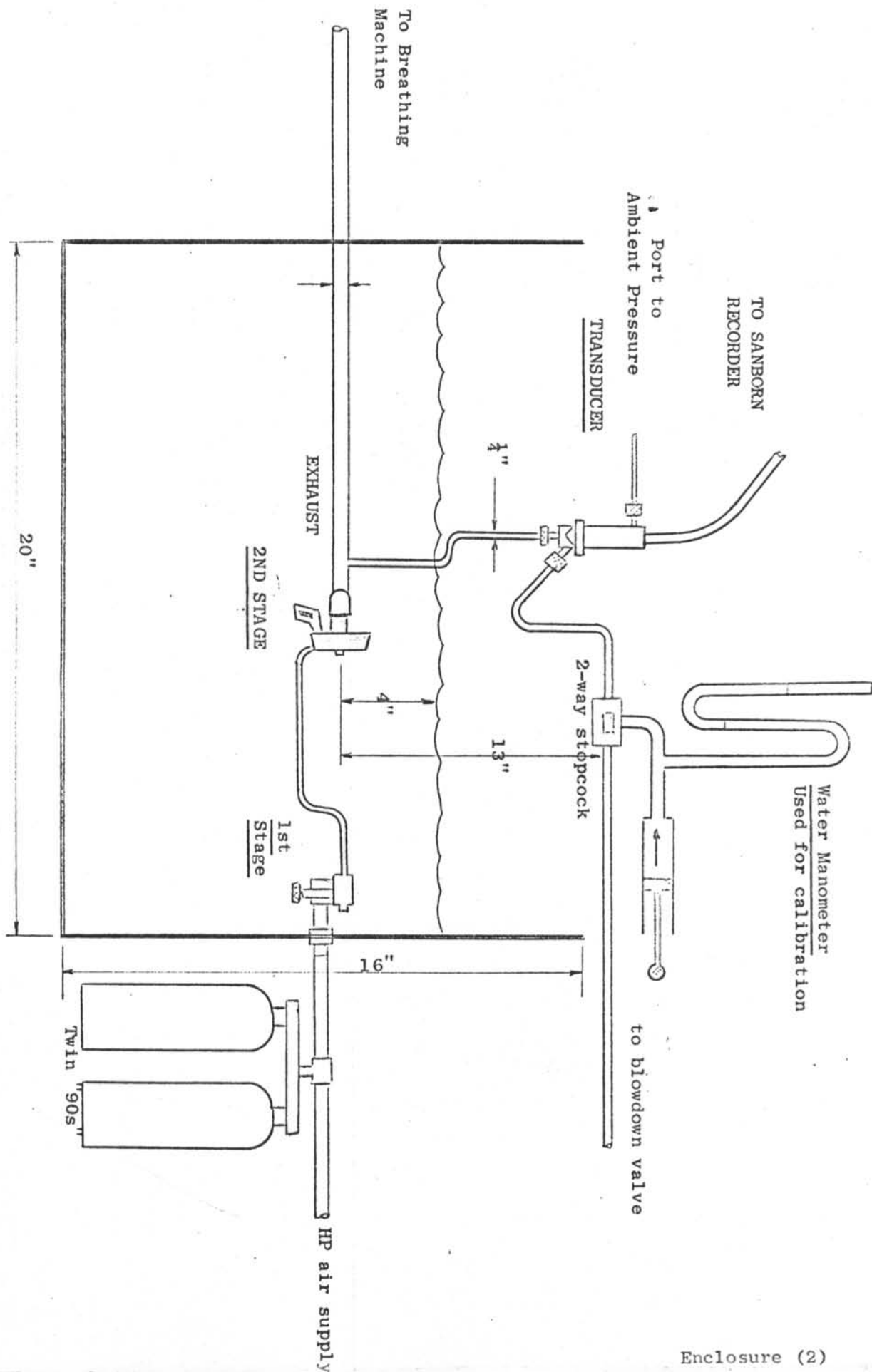
Peak inhalation and exhalation pressures are measured at 25 foot increments from 0 to the equivalent of 200 feet of sea water.



HYPERBARIC CHAMBER AT E.D.U.

BREATHING RESISTANCE TESTING APPARATUS

FIGURE 1

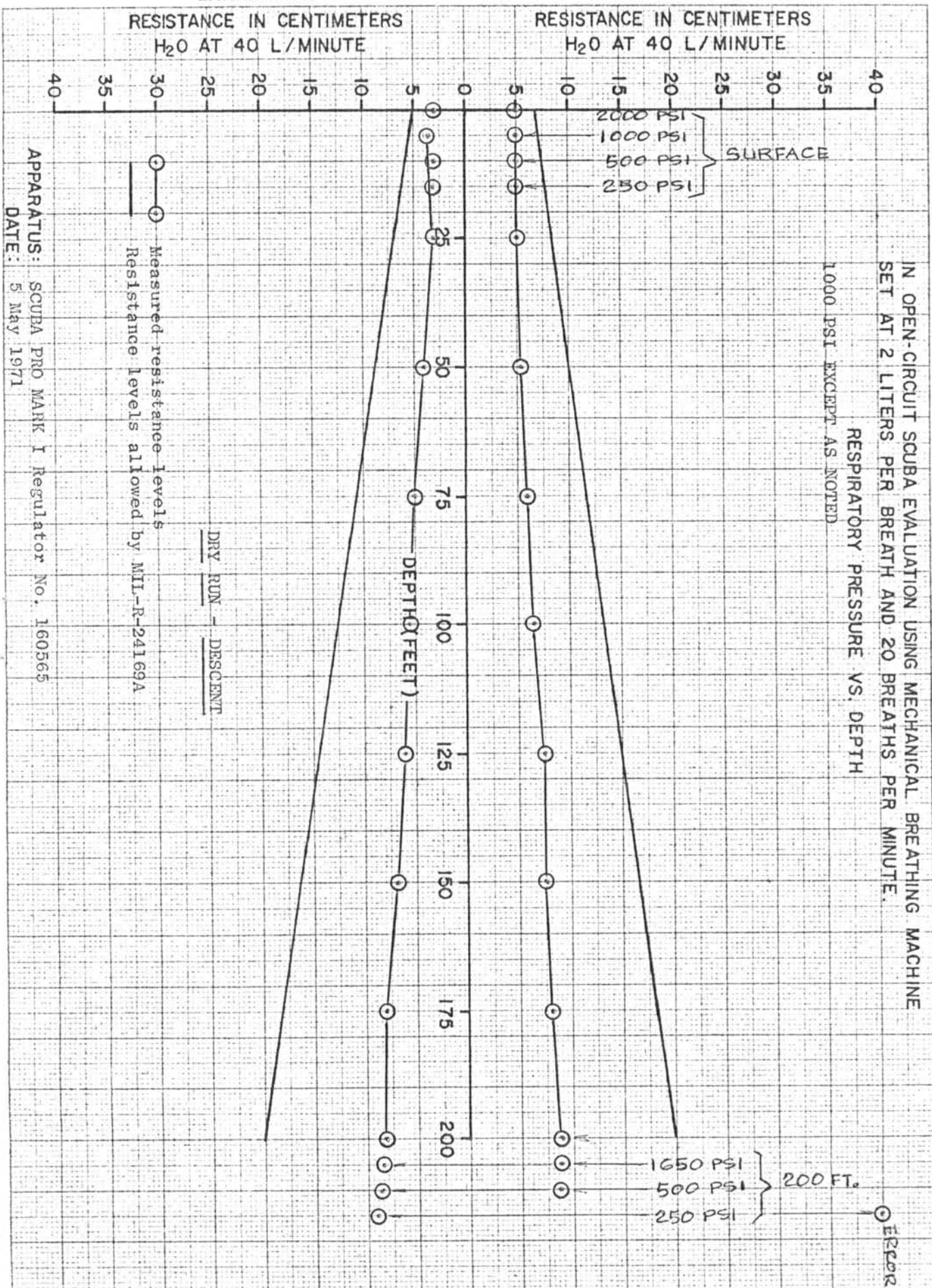


REGULATOR TESTING BOX DIMENSIONS
FIGURE 2

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED

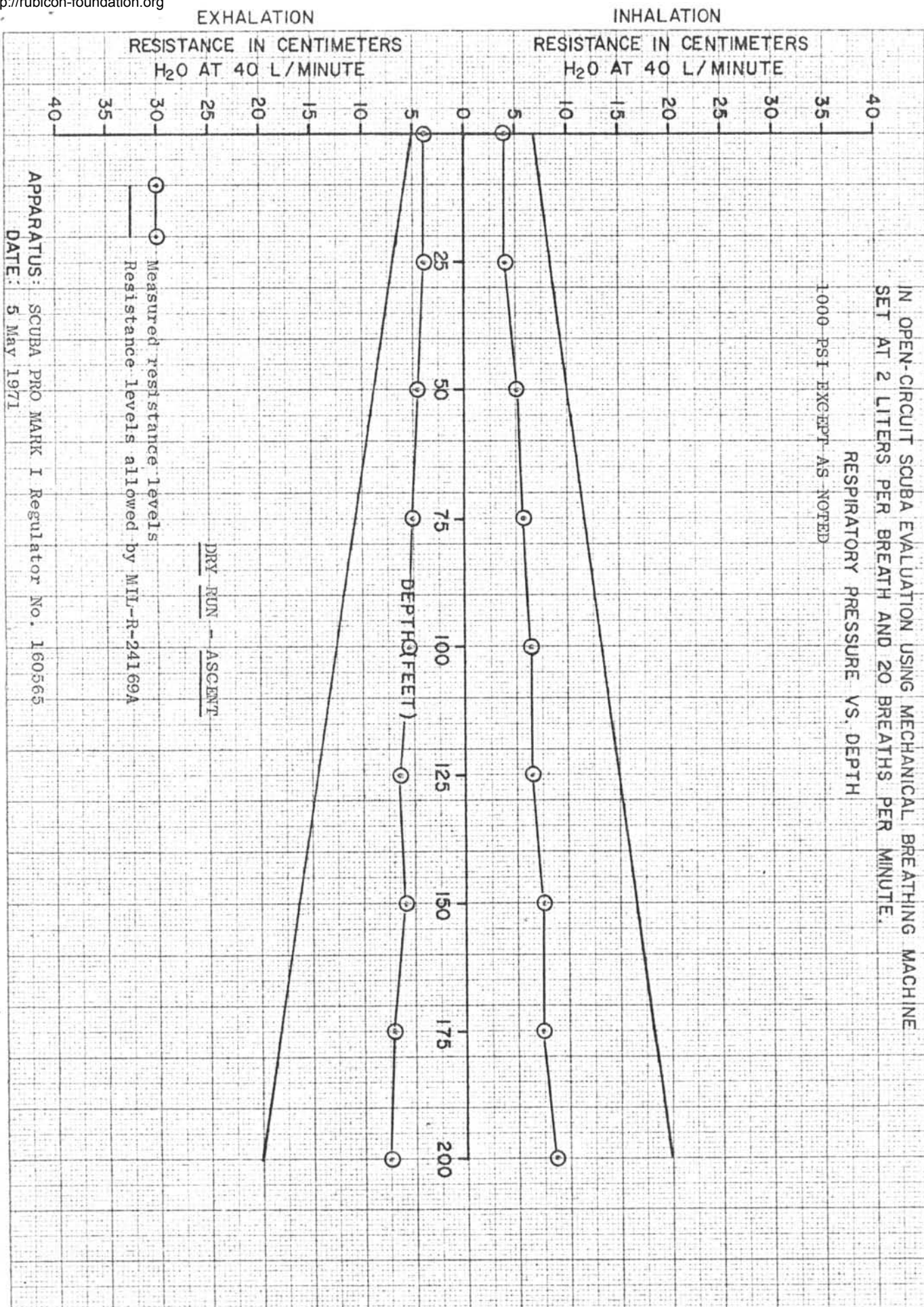


DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

1000 PSI EXCEPT AS NOTED



APPARATUS: SCUBA PRO MARK I Regulator No. 160565

DATE: 5 May 1971

EXHALATION

INHALATION

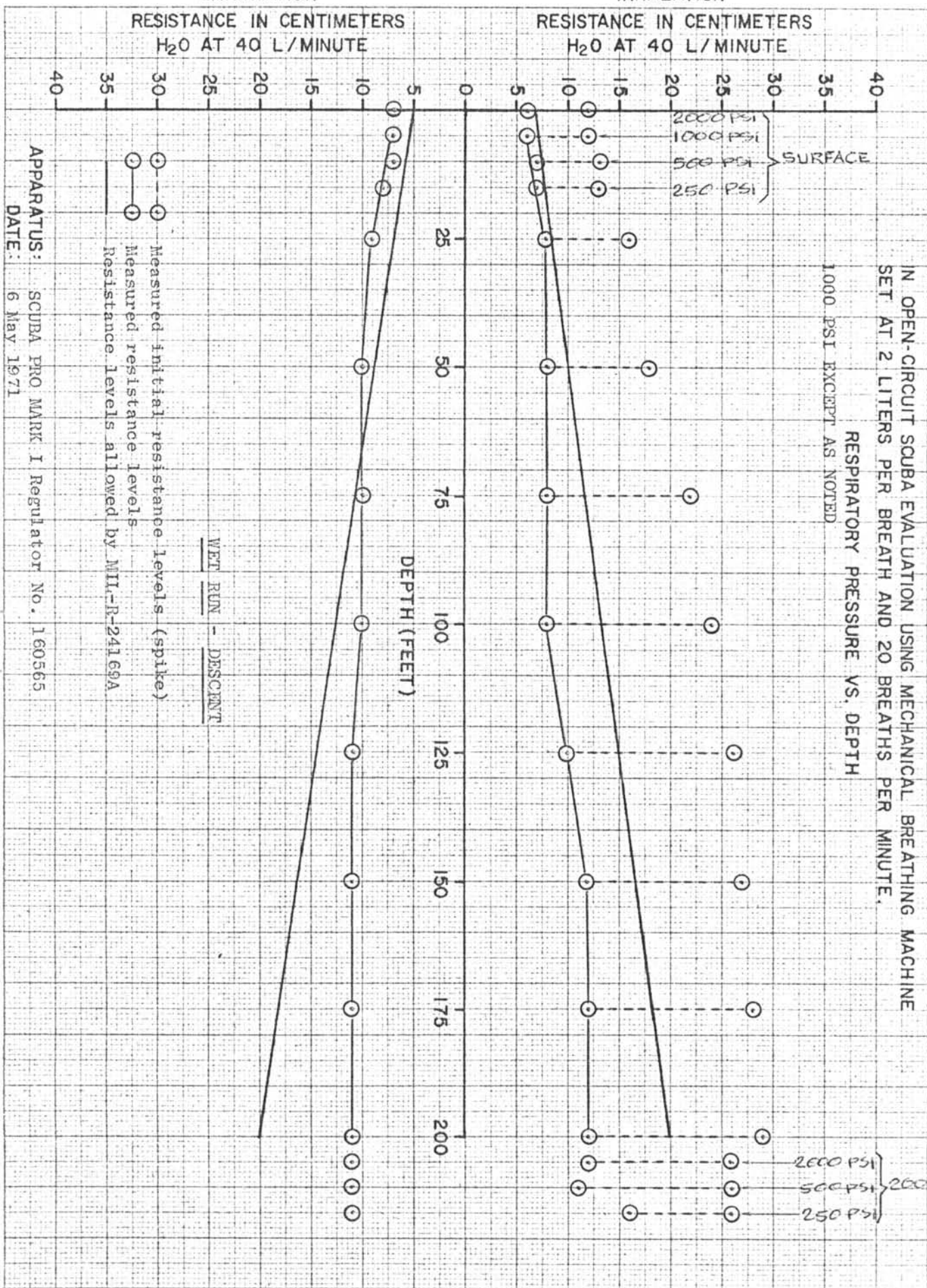
RESISTANCE IN CENTIMETERS
H₂O AT 40 L/MINUTE

RESISTANCE IN CENTIMETERS
H₂O AT 40 L/MINUTE

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

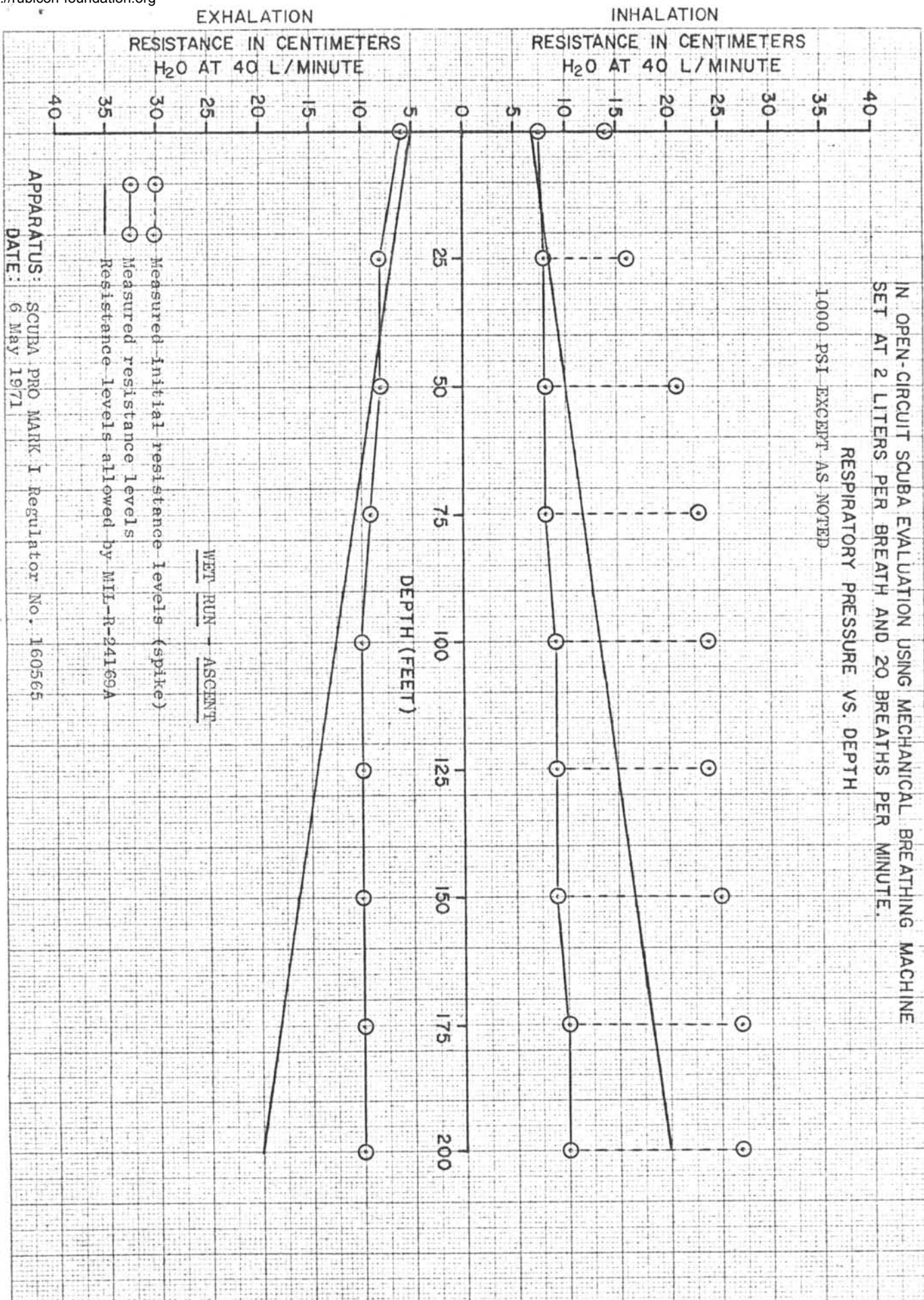
RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED



DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

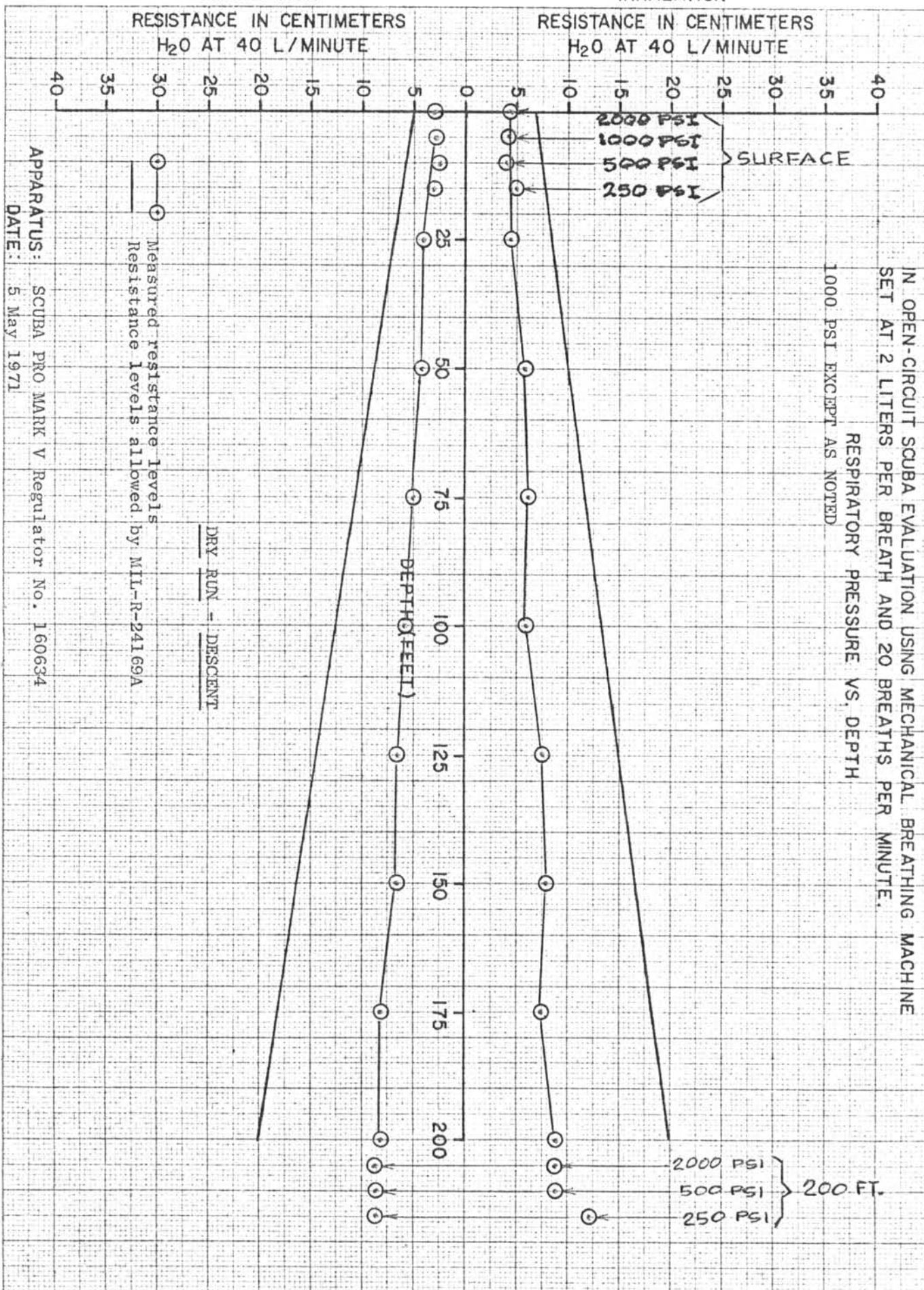
RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED



DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED

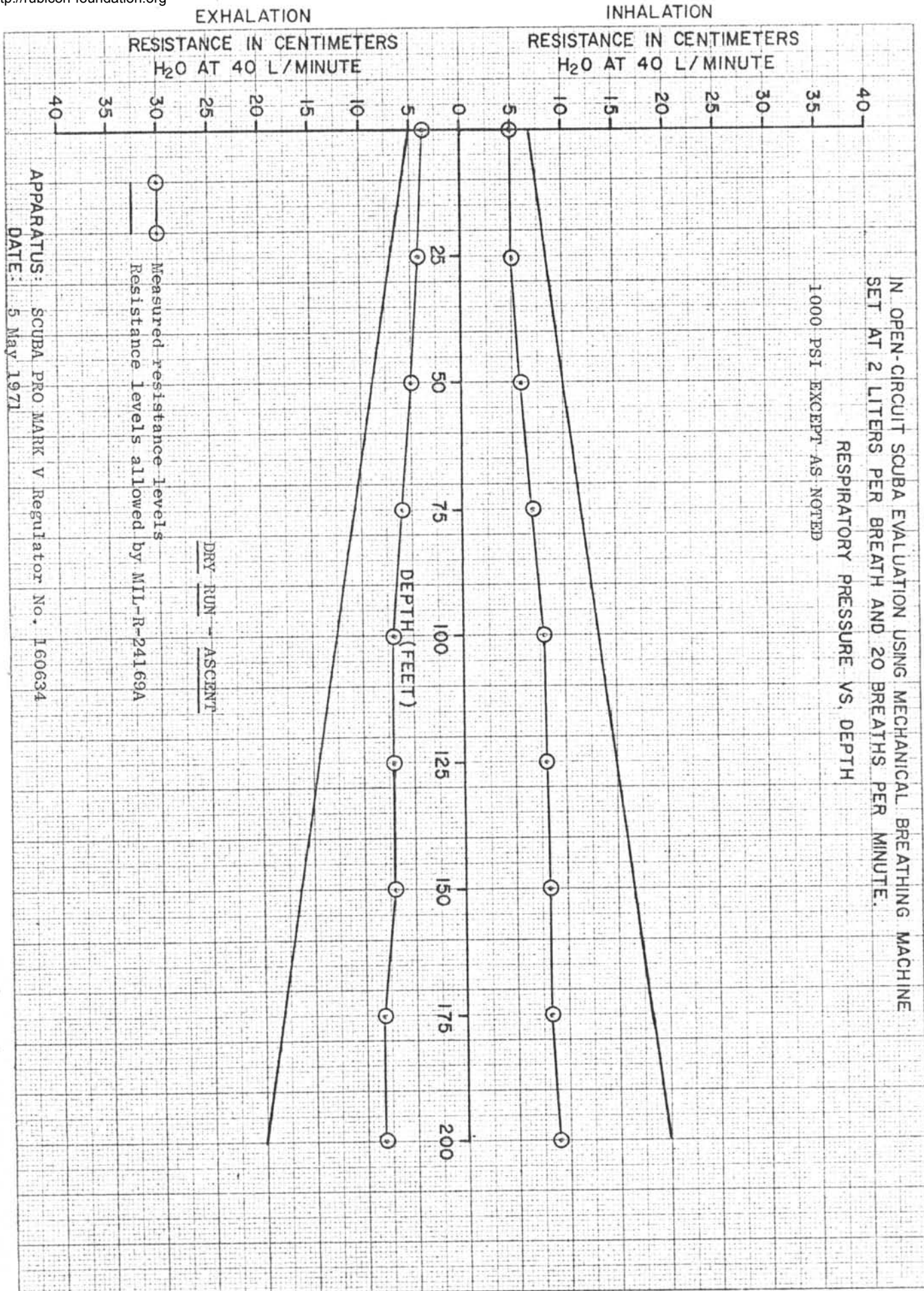


DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

1000 PSI EXCEPT AS NOTED



APPARATUS: SCUBA PRO MARK V Regulator No. 160634
DATE: 5 May 1971

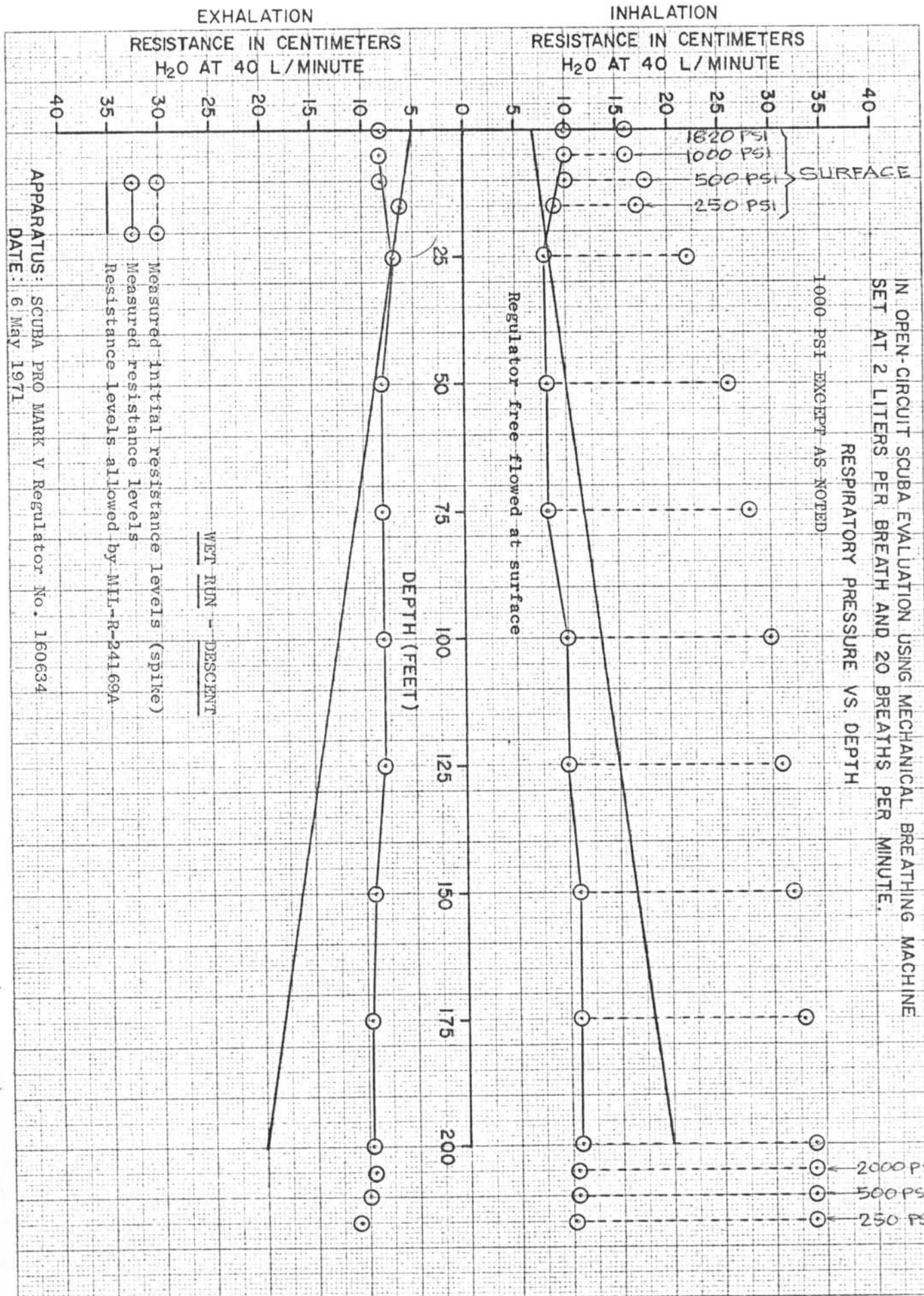
K&E 10 X 10 TO THE CM. 359T-14G
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANY, NY 12206

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

1000 PSI EXCEPT AS NOTED



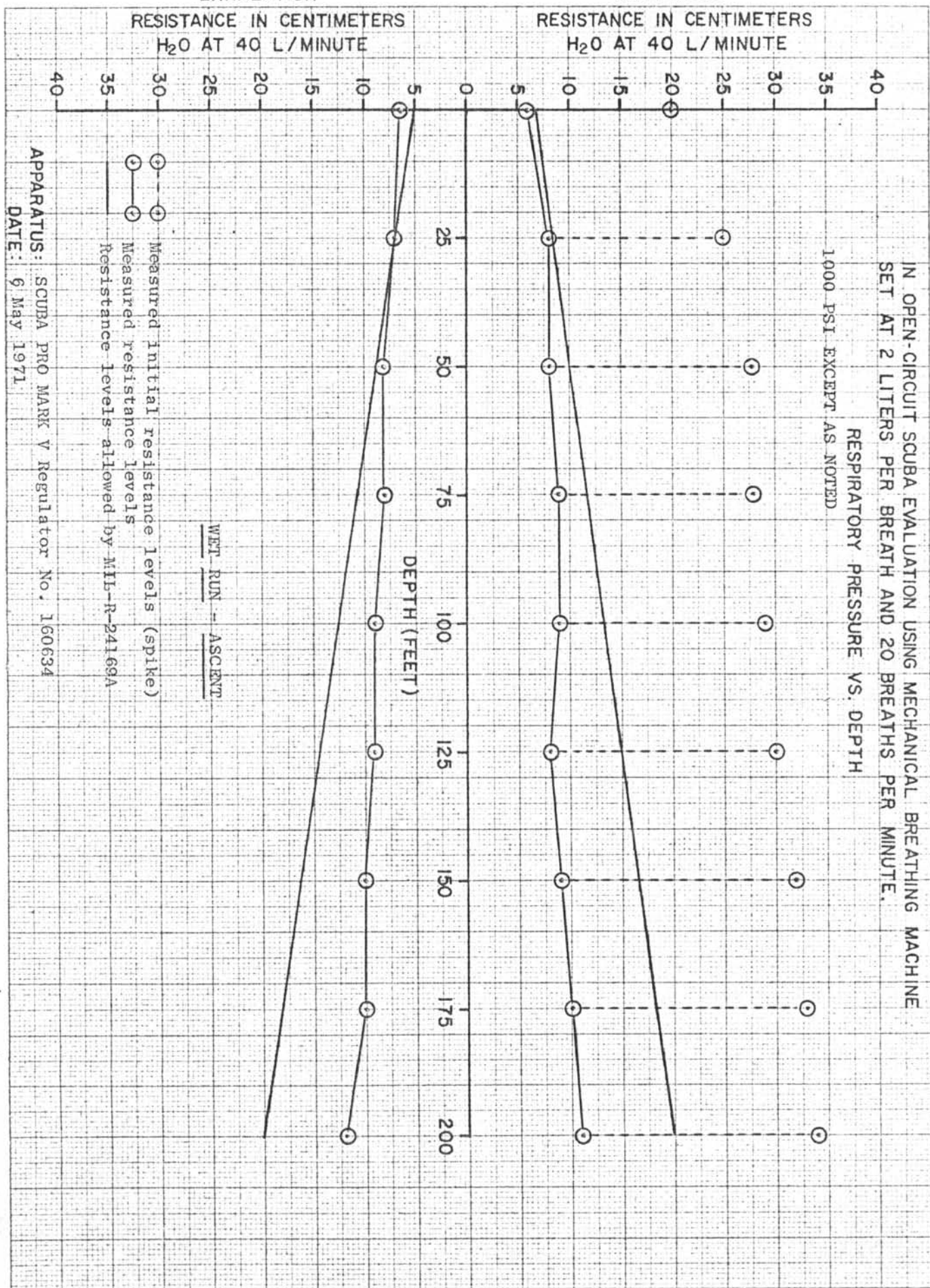
APPARATUS: SCUBA PRO MARK V Regulator No. 160634
DATE: 6 May 1971

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

1000 PSI EXCEPT AS NOTED

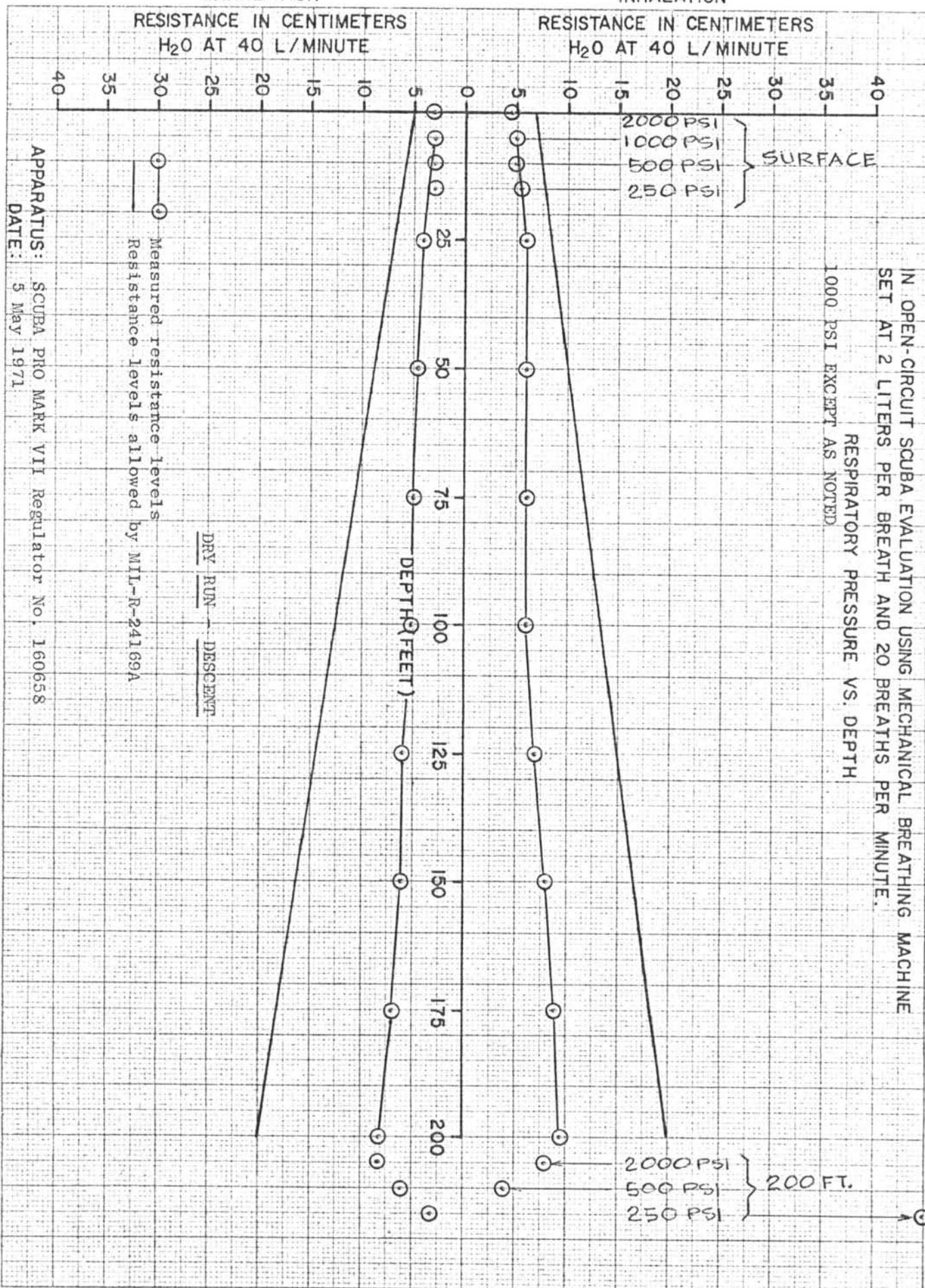


APPARATUS: SCUBA PRO MARK V Regulator No. 160634
DATE: 6 May 1971

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED

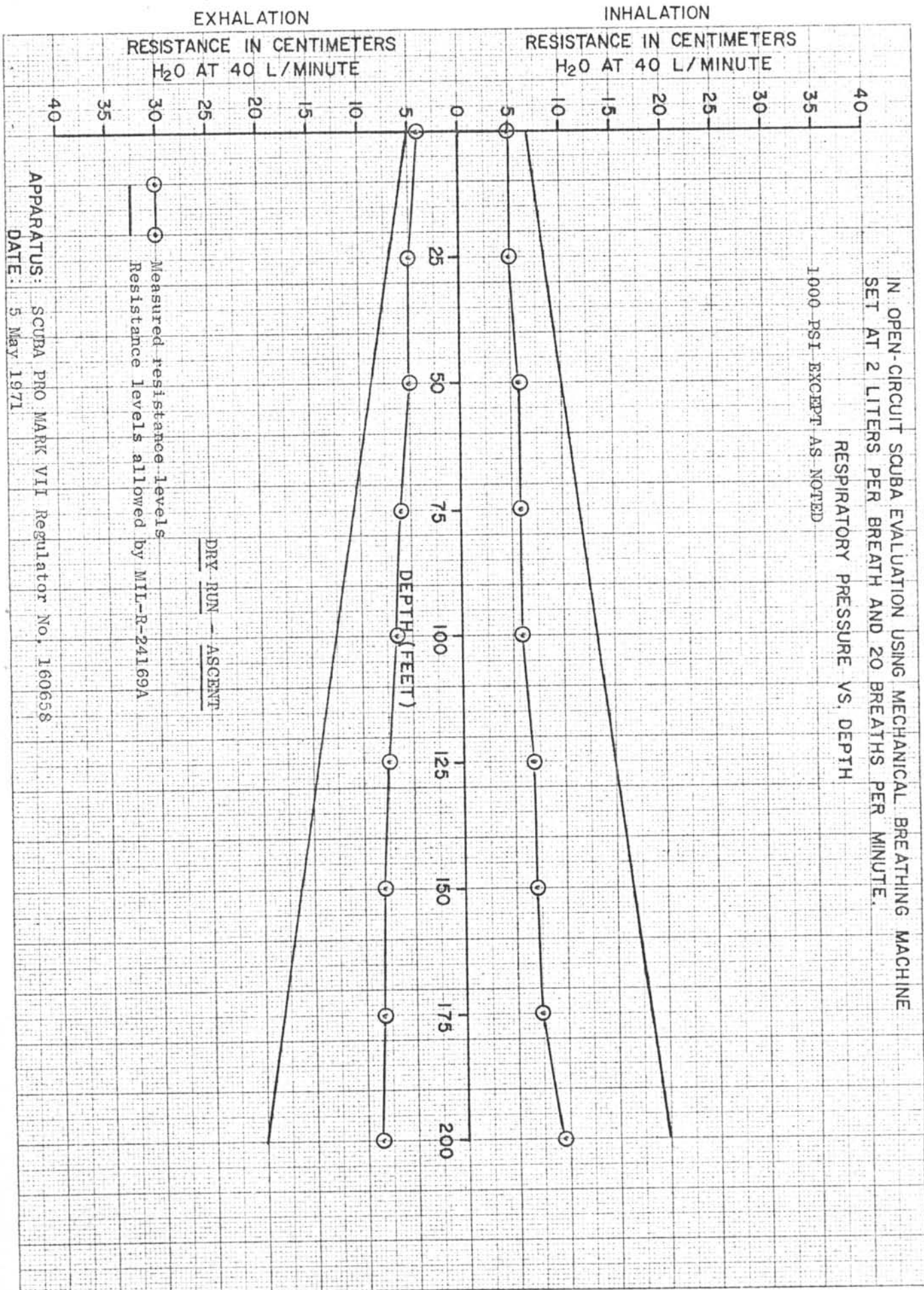


DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

1000 PSI EXCEPT AS NOTED

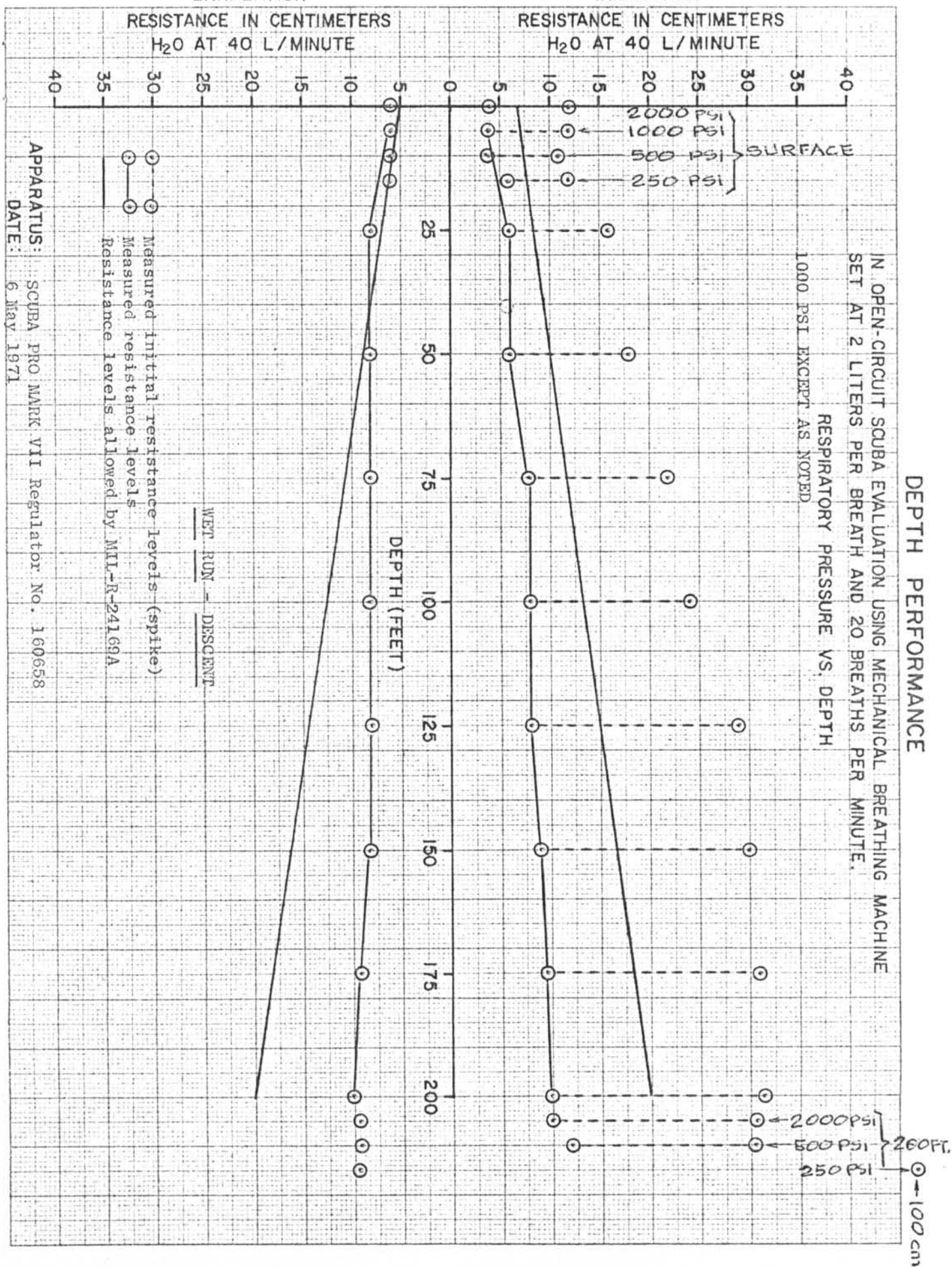


APPARATUS: SCUBA PRO MARK VII Regulator No. 160658
DATE: 5 May 1971

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

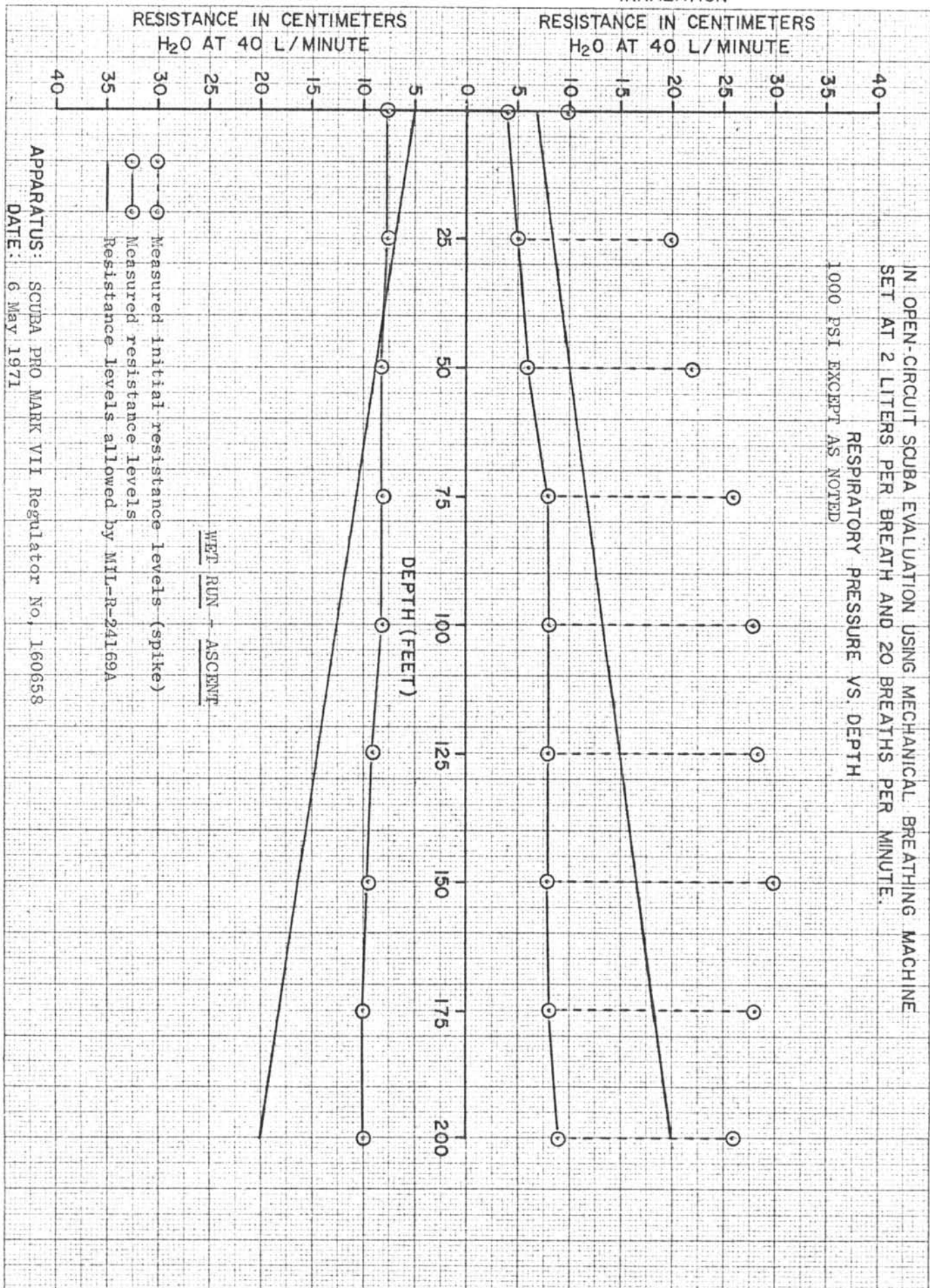
RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED



DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH
1000 PSI EXCEPT AS NOTED



Measured initial resistance levels (spike)
Measured resistance levels
Resistance levels allowed by MIL-R-24169A

WET RUN - ASCENT

APPARATUS: SCUBA PRO MARK VII Regulator No. 160658

DATE: 6 May 1971

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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| 13. ABSTRACT The military specifications for open circuit SCUBA regulators provide a mechanism by which commercial vendors may submit their regulators to the Navy Experimental Diving Unit for testing for possible approval for U. S. Navy use. Accordingly, three SCUBA PRO single hose regulators, Models MARK I (Mil-101), MARK V (Mil-105) and MARK VII (Mil-107), were tested at NEDU during May 1971. Models MARK I (Mil-101) and MARK V (Mil-105) were found to meet the requirements of the military specifications for single hose regulators, Mil-R-24169A, and were approved for U. S. Navy use. Model MARK VII (Mil-107) was not granted pending examination for conformance to Navy material certification requirements. | | | |

Unclassified

Security Classification

| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|--|--------|----|--------|----|--------|----|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| Breathing Apparatus Underwater Life Support Systems Diving | | | | | | |

Unclassified

Security Classification