AD 19360

Armed Services Technical Information Agency

Reproduced by

DOCUMENT SERVICE CENTER

KNOTT BUILDING, DAYTON, 2, OHIO

The following ESPIONAGE NOTICE can be disregarded unless this document is plainly marked RESTRICTED, CONFIDENTIAL, or SECRET.

NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

CHEMICAL ENGINEERING DEPA

NORTHWESTERN TECHNOLOGICAL

EVANSTON, ILLINOIS

NORTHWESTERN UNIVERSITY

Evanston, Illinois

The Tecrnological Institute September 30, 1953

Letter of Transmittal

Chief of Naval Research
EXOS:ONR:N66
Serial No. 20450
Washington 25, D. C.

Attention: Commanding Officer

Dear Sir:

Attached is the report on the results of the demonstration and utilization of the caustic process for removing excess carbon dioxide from submarine atmospheres as carried out on the submarine Haddock as a part of Operation Hideout. Operation Hideout was carried out to determine the maximum carbon dioxide concentration that personnel could withstand over long periods of time.

Operation Hideout was begun early in 1953 after several months of preparation and required a means to remove excess carbon dioxide in order to maintain its content in the atmosphere at the desired value. The caustic process served this purpose excellently and, in addition, removed smoke and odors to a remarkable degree according to submarine and medical officers who were familiar with submarine conditions.

The attached report covers the data and information obtained on the caustic unit which was operated during Operation Hideout.

Sincerely yours,

L. F. Stutzman, Director
Project 130
Chemical Engineering Department

LFS:MF
Encl.

This docu... reviewed in accordance with OPNAV ... paragraph 5. The security classification ... is correct.

Date: 11/12/53

... of ... Research (Code 466)

CHEMICAL ENGINEERING DEPARTMENT
NORTHWESTERN TECHNOLOGICAL INSTITUTE
Evanston, Illinois

OPERATION HIDEOUT REPORT

September 30, 1953

NR 266-001
(N6 ori 158-03)

Respectfully submitted,

September 30, 1953

Director [signature]

Executive Director [signature]

ABSTRACT

Operation Hideout took place from January 19, 1953 through March 19, 1953. This operation, organized to study extensively the prolonged exposure of personnel to high concentrations of carbon dioxide, utilized the caustic scrubber for the removal of excess carbon dioxide. This scrubber, developed by Northwestern Technological Institute, was in operation during the "closed up" portion of the operation, between January 27, 1953 and March 10, 1953. Since the carbon dioxide content of the air in this operation was higher than the design basis of the scrubber (1.5% compared to 1%) and the personnel was less than a regular submarine crew, the scrubber was operated intermittently.

The installation was a success in that the desired carbon dioxide content of the air was maintained at the desired 1.5% value.

The scrubber operation was as expected. It removed carbon dioxide at an average rate of 9.77 pounds per hour at an average caustic utilization of 90.3%. The removal rate and caustic utilization was expected to be higher than the values obtained for 1% carbon dioxide in air. This increase in caustic utilization at these conditions would permit a greater than 12% decrease in the required caustic storage. The absence of odors and cigarette smoke in the submarine was commented on by Navy personnel familiar with submarine operation, and this condition can be attributed to the scrubber.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DISTRIBUTION LIST

The following offices are being sent copies of this report in the amount shown.

Office	No. of Copies
Commanding Officer, Office of Naval Research 346 Broadway, New York 13, New York	1
Commanding Officer, Office of Naval Research 801 Donahue Street, San Francisco 24, California	1
Commanding Officer, Office of Naval Research 1030 East Green Street, Pasadena 1, California	1
Officer in Charge, Office of Naval Research, Branch Office London, Navy No. 100, Fleet Post Office, New York, New York	1
Chief of Naval Research, Department of the Navy (Code 466), Washington 25, D. C.	10
Commanding Officer, Office of Naval Research 86 East Randolph Street, Chicago 1, Illinois	2
Chief, Bureau of Ships (Code 549) Department of the Navy, Washington 25, D. C.	1
Commander, Mare Island Naval Shipyard (Code 371), Vallejo, California	1
Officer in Charge, U. S. Naval Medical Research Laboratory U. S. Naval Submarine Base, New London, Connecticut	1
Chief, Bureau of Medicine and Surgery (Code 51) Department of the Navy, Washington 25, D. C.	1
Chief of Naval Operations (Op-311) Department of the Navy, Washington 25, D. C.	1
Chief of Naval Operations (Op-316) Department of the Navy, Washington 25, D. C.	1
Director, Naval Research Laboratory (Code 3230) Department of the Navy, Washington 20, D. C.	1
Director of Research, Northwestern Technological Institute Evanston, Illinois	1
Chemical Engineering Department Northwestern Technological Institute, Evanston, Illinois	1

CAUSTIC PROCESS

CARBON DIOXIDE REMOVAL SYSTEM

OPERATION HIDEOUT

Reported by
B. J. Sollami

INTRODUCTION

Operation Hideout was initiated to bring closer to realization exact knowledge of the carbon dioxide concentrations which personnel might be able to withstand when exposed to it for extended periods. This information is necessary in order to design accurately equipment to control the carbon dioxide concentration of the atmosphere of a submarine.

The era of the perfect submarine is fast approaching. Up to the present time a limiting factor in submarine submergence was the power availability within the submarine when completely submerged. Submarines are electrically powered and when submerged obtain their power supply from storage batteries which require frequent recharging for which the submarine must surface. Since the submergence time was limited by power, the limitations on length of submergence by personnel was often not critical. The development of power sources, particularly nuclear, has reached a stage where the power source on the submarine will no longer be a limiting factor for governing the submergence time. With this recent development in atomic research, the atomic-power submarine will have a continuous supply of energy for operation and therefore it will be capable of staying submerged for long periods. This development has progressed to where two nuclear powered boats, Nautilus and Sea Wolf, are under construction.

With the realization of a perfect submarine the human factor becomes critical. What are the maximum concentrations of various constituents in air that humans can stand? Carbon dioxide is one of the principle constituents that must be studied to determine the concentration that personnel can withstand. Since personnel generate carbon dioxide, the concentration can quickly build up to a point where the personnel are adversely affected. Figure 1 shows the time required for the concentration of carbon dioxide to reach a given value in an isolated space. Parameters are shown for various values of free volume available per person. In Operation Hideout the free volume per person was approximately 1000 cubic feet. This plot is based upon the carbon dioxide generated by a person exhibiting moderate movement, sitting, or movement of arms and head as in desk activity with only occasional walking.[1] A sleeping person would generate carbon dioxide at a much lower rate so that the daily average generation rate (night and day) is slightly lower.[4]

The normal concentration of carbon dioxide in the atmosphere is 0.03%. While it is possible to maintain the atmosphere in any closed space at this low carbon dioxide concentration the equipment required to perform the task would or could be tremendous. Such would be the case in a submarine containing 60 to 100 men or more.

The equipment required to remove excess carbon dioxide increases in size as the tolerable concentration limit is decreased. It is therefore desirable to maintain this upper carbon dioxide concentration as high as possible. The upper concentration limitations have been studied by

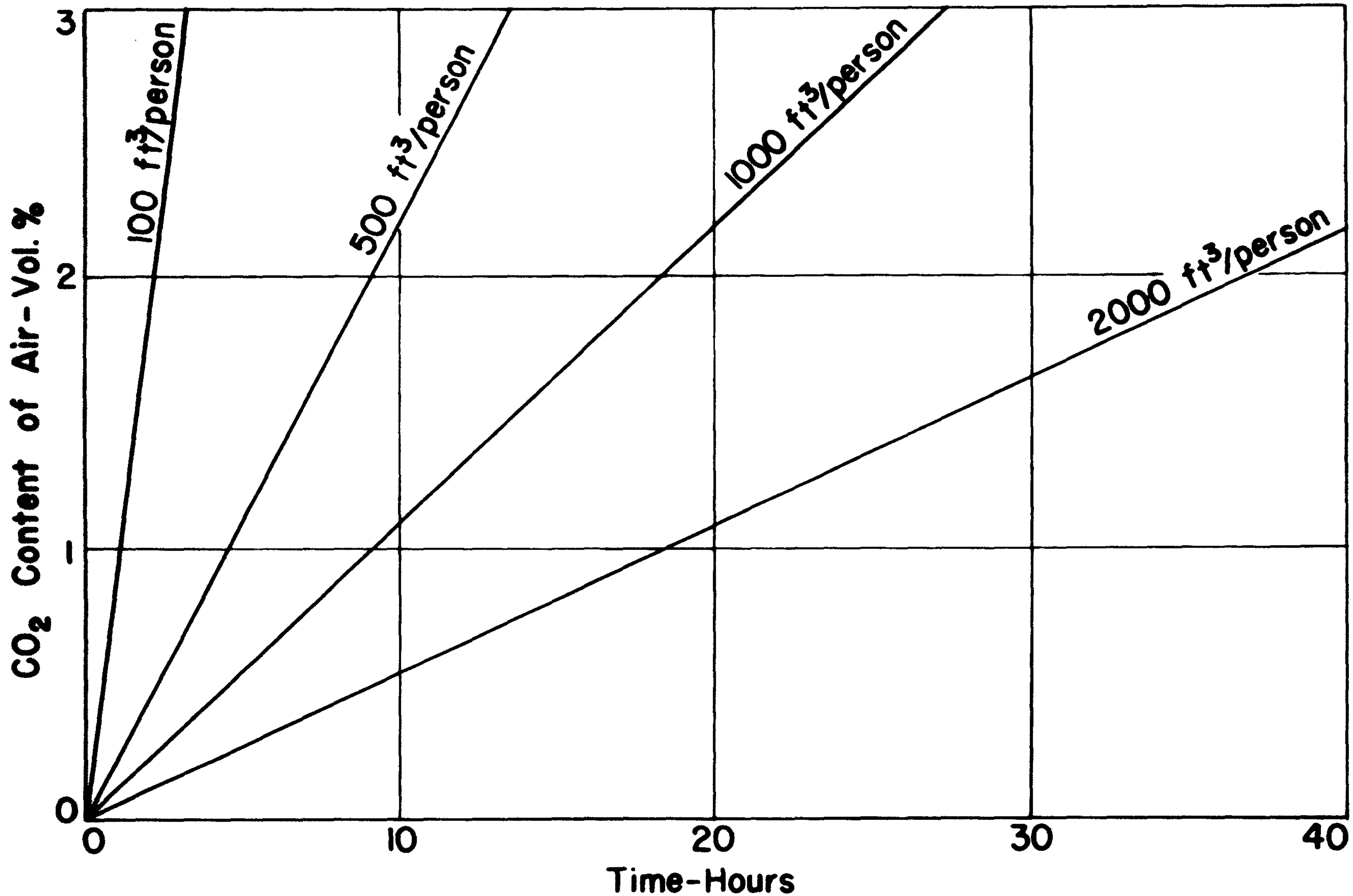


FIGURE 1

CO_2 Buildup In Air In Isolated Space

Temperature - 80°F.
Pressure - 1 atm.

medical personnel for some time and indications that the upper limit was 1.5% were now being verified. Operation Hideout was then designed to verify on a comprehensive scale this maximum carbon dioxide concentration.

In order to obtain the value of this maximum carbon dioxide concentration, which could then be used for design purposes on carbon dioxide removal equipment on future submarines, arrangements were made for the Medical Research Laboratory to carry out the necessary test.

Operation Hideout was thus instituted by the Medical Research Laboratory at the U. S. Naval Submarine Base at New London, Connecticut. This work was very successfully organized and carried out under the command of Commander Gerald J. Duffner, MC, USN, officer in charge of the Medical Research Laboratory. The Project officer for the test was Lt. Pierce P. Newman, MC, USN, whose tireless efforts were responsible for the success of the test. Lt. Newman prepared and coordinated the details, set the experiment in operation and supervised its execution. Lt. Newman was very ably assisted by Chief Torpedoman's Mate James D. Evans, USN, as well as having the complete cooperation of the volunteers, working details, and all the other medical officers and men who were involved with Operation Hideout.

The test itself required that the carbon dioxide concentration be kept from building up above 1.5±0.1%. The caustic unit was capable of doing this. The unit was available and could be installed quickly and adapted easily although it had not been engineered for actual installation in a submarine. Lt. Commander F. M. Fellows of the Office of Naval Research arranged for the use of the caustic unit for this test.

Upon the completion of the arrangements to use the caustic unit for the removal of carbon dioxide, a conference at the United States Naval Submarine Base at New London between the Medical Research Laboratory and Northwestern Technological Institute was arranged to work out the details of the scrubber installation. This conference in November, 1952, was arranged for the purpose of determining the availability of equipment, materials, and supplies required in the installation of the carbon dioxide removal apparatus. The means for obtaining needed materials when such were unavailable for purchase or loan on the base was determined. The availability of utilities was also determined. Other details of the test were discussed and what the proposed plans for the test were as of that date.

Late in December of 1952 final plans were formulated and rigging of the submarine for the test was initiated. On December 29, 1952, Mr. Sollami, a representative of the Chemical Engineering Laboratory of Northwestern Technological Institute, went to New London to follow the installation and operation of the caustic carbon dioxide removal system.

The test was to be carried out aboard the submarine U. S. S. Haddock (SS231). The submarine was not chosen to simulate conditions aboard a submarine but principally because it provided a very satisfactory test chamber. To build a chamber a large expenditure of $30,000 or more would have been required, whereas the adaptation of the submarine resulted in a very modest expense. It was originally planned to moor this submarine in the Thames River alongside pier 13. These plans were subsequently changed, and the Haddock was moored outboard of the submarine tender, Proteus. This resulted in considerably more effort and inconvenience in carrying out the test but was a necessary navy procedure. A work barge was then moored outboard of the Haddock; the submarine thus was between the Proteus and the barge. The barge served as operating base and a storage depot.

Only five of the nine compartments of the Haddock, a fleet type submarine, were used in the test. Reading from bow to stern the five compartments were as follows: forward torpedo room, forward battery compartment, control room, after battery compartment, and forward engine room. The remaining four compartments were isolated from the test compartments. The free volume space in the test section was estimated at approximately 23,000 cubic feet.

For the test 22 seamen and one medical officer, Lt. Commander Ralph E. Faucett, the commanding officer, were sealed in the submarine in these five compartments for sixty days, January 19, 1953 to March 19, 1953. Without carbon dioxide removal equipment in an isolated space of 23,000 cu. ft. with 23 men generating carbon dioxide at a rate equivalent to that associated with moderate movement the carbon dioxide concentration would reach a value of 1.5% in approximately 14 hours.[1] This can be seen from Figure 1. In the Haddock, in addition to the 23 volunteers, were white rats, guinea pigs, physiological and psychological testing equipment, and the atmospheric control equipment. All this was housed in the five compartments of the Haddock which were used for this experiment.

In the determination of the effect of the 1.5% carbon dioxide atmosphere many medical examinations were required. These included the physiological, psychophysiological, psychological, and sociological tests. The medical aspects of the test were the sole responsibility of the Medical Research Laboratory at the New London Submarine Base, whose activities were guided by the Project officer, Lt. Newman, under the command of Commander G. J. Duffner. This medical phase will, of course, not be discussed in any manner in this report.

The public interest of Operation Hideout can be shown by the large amount of publicity which it had received during and after its completion. Figure 2 is an example of one of many news releases which emanated from this experiment. This article appeared in The New York Herald Tribune on Wednesday, February 11, 1953. The importance of determining the maximum allowable concentrations of carbon dioxide for prolonged exposure is brought out in the article.

RESTRICTED 9

THE WEATHER

Today: Increasing cloudiness, with moderate to fresh northerly winds.

Temperatures Yesterday: Max., 38.5; Min., 25.9.
Today's Probable Range: Max., 39; Min., 25.
Humidity at 3 p. m. Yesterday: 40%.
Expected Humidity This Afternoon: 40-30%.

Detailed Report and Map—Page 37

NEW [Y...] Herald [Tribune]

European Editio[n]

112th Year VOL. CXII NO. 38,804

230 West 41st Street, New York 36, N. Y.
Telephone PEnnsylvania 6-4000

WEDNESDAY,

[N]o Decision [O]n Blockade [O]f Red China

[D]ulles and Bradley [R]eport to Senators

[W]iley Asserts Shipment of Arms to Formosa Is Al[...] ['s] 'Improving'

[...]win
10.—Sec-
[...]er Dulles
[...]ng the
[...]mmit-
[...]tion
[...]ck-

c
y
[...]ld
[...]use.
Wil.
After
[...]o-hour
[...]n. Bra
[...]ked abou
[...]rlier in t
step up .
[...]e Nationali.
Indicating t.
[...]me from the .
[...]id: "It is stepp[...]
[...]s improved." [...]
[...]te.
Secretary Dulles

23 Men Sealed in Submarine In Navy Test for Atom-Run Craft

New London Volunteers Started Trial Last Month; Goal Is to Find How Long Crews Can Stay Under

[...] Herald Tribune Bureau

WASHINGTON, Feb. 10.—Navy officials disclosed today that twenty-two sailors and a medical officer, who volunteered for the experiment, have been "bottled up" in a moored submarine at New London, Conn., since mid-January in a two-month test to determine how long crews can remain submerged in atomic-power submarines of the future.

The craft in the test is the Haddock, a reserve submersible. The experiment is being conducted under the direction of Comdr. Gerald Duffner, of the Navy Medical Corps, who enters the sealed vessel daily through an air lock in the forward torpedo room to make observations and test the condition of those aboard. The Haddock is not submerged but merely tied up alongside a pier at the New London Submarine Base, although she is as fully sealed as if she were under water.

The Haddock is said to be equipped with an "air-scrubbing" machine to remove carbon dioxide from the craft's constantly rebreathed air and a device to manufacture oxygen from sea water and continually replenish the submarine's atmosphere with life-sustaining air.

Navy officials said the purpose of the experiment is to determine the tolerance of submarine crews over long periods to higher-than-normal concentrations of carbon dioxide in the air.

It was said that air containing more than 3 per cent carbon dioxide is considered highly dangerous by submarine experts, but that the concentrations during the Haddock test probably would run as high or higher at times than 2 per cent. This gas, which is not poisonous but has a "smothering" effect that can be fatal if too high a percentage is present in breathing air, is a by-product of human respiration.

In the past its accumulation aboard submarines has been controlled by chemicals that have a high affinity for carbon dioxide and remove it from the air by absorption. Since atomic submarines are expected to be able to remain submerged almost indefinitely because their power plants will not consume air, the present tests are designed to find out the human-endurance factor aboard such craft.

DEVELOPED BY CHEMICAL ENGINEERING LABORATORY NORTHWESTERN UNIVERSITY

Says Mail Supports Ban [...]e Trial Spectators, 8-1

Union Among Opponents; Pat Ward [...]in, Reported Naming 25 to 50 Men

[...]ewis
[...]ge Francis L.
[...]ted decision
[...]lic from the

because "this case will be steeped in filth."

Among those strongly against Judge Valente's Monday ruling

Bonn Arr[ests] 4 Nazis, B[...] Their Tro[...]

Links Them to [...] Held by the Br[...]

Freikorps, Their G[...] Denounced as Pl[...] to Restore Hitle[r...]

By Gaston Coblen[tz]

From the Herald Tribune B[ureau]

Copyright, 1953, New York Herald [Tribune]

BONN, Feb. 10.—Four l[...] a Nazi-type conspiratorial [...] at least 1,000 men, ca[...] Freikorps Deutschland [...] Free Corps), were arrest[ed] by the West German gov[...] The group was ordered b[y] [In]terior Ministry to dissolve [...]tive para-military cadres.

The government said [...] Freikorps, which has bee[n] in Hamburg and Bremen, [...] with a ring of neo-Nazi [...] headed by Werner Nau[mann] [t]op-ranking official of Pa[ul] Goebbels' Propaganda [...] Seven leading members [...] Naumann ring were jaile[d] British High Commission [...]

The four arrested today [...]

HELMUTH BECK-BROICHS[...] former major in the Gross[...]land Division and one of [...] founders of the Br[...] (Brotherhood), an extrem[e] organization of former [...] Army officers.

ALFRED FRAUENFELD, a [...]schluss Gauleiter (distric[t]) of the Vienna Nazis. He [...] organizer of the Austrian [...] in the early 1930s.

HERMANN LAMP, a Freiko[rps] and former S. S. (Nazi Eli[te]) troops leader.

EBERHARD HAWRANKE, S. A. (Storm Troop) leader of the Freikorps in Breme[n]

Parallel to 1920s

Figure 2

RESTRICTED

Underlined in the news release is the statement about the equipment used to remove the carbon dioxide from the air. This equipment was designed, built, and laboratory tested for the Office of Naval Research by this laboratory, and Operation Hideout afforded the opportunity to demonstrate the effectiveness of the process. It is this equipment, as underlined in the news release, and its operation during Operation Hideout which is the substance of this report.

This equipment had been designed for the Office of Naval Research to remove 7.5 pounds of carbon dioxide per hour from an atmosphere having a concentration of 1% carbon dioxide. With the exception of the inlet gas composition, which is 1.5% in the test, and other factors which it directly affected, the unit was operated according to the design specifications.

Because of the more rigorous design requirements of the unit and because the number of men was 23 (instead of the normal complement of about 80) the carbon dioxide removal rate would be too great and the carbon dioxide content of the air would be too low for this test. This required auxiliary controls to turn the scrubber on when the carbon dioxide concentration reached a certain level and to turn the scrubber off when the carbon dioxide concentration fell below a certain level. The plans called for controlling the carbon dioxide concentration at 1.5±0.1%, but the electronic gear actually controlled much more accurately than this. Allowance for human error in the calibration of the instrument would still maintain this accuracy.

The equipment arrangement made it possible to control the carbon dioxide content at any reasonable concentration that might have been desired. The oxygen was controlled at 20.5±0.5%, and the carbon dioxide content was controlled at 1.5±0.1%.

EQUIPMENT AND INSTALLATION

The installation of the caustic process equipment aboard the Haddock was begun on December 30, 1952.

Caustic Process

The caustic process equipment was designed to remove 7.5 pounds of carbon dioxide per hour from an atmosphere having a concentration of 1% carbon dioxide. This rate of carbon dioxide removal was based upon the theoretical exhalation from a full complement (approximately 80 men) of a fleet type submarine during its actual operation.

Detailed design specifications for the caustic unit, operating data, and operating curves are presented in this project's previous report.(3) This unit, developed for the Office of Naval Research, is a non-regenerative type carbon dioxide removal apparatus. In non-regenerative systems either the absorbing materials can not be reused or it is more expedient to discard the materials rather than to go through another process which may be very complex, intricate, cumbersome or uneconomical to prepare the materials for reuse. Such is the case with the sodium carbonate formed when carbon dioxide reacts with sodium hydroxide in the caustic unit.

For this non-regenerative system there is an 80% utilization of the sodium hydroxide when the unit is operated according to the design conditions. The operating characteristics for the caustic system are presented in Table 1.

These operating conditions were very closely followed by the unit as installed for Operation Hideout. The conditions

Table 1

OPERATING CHARACTERISTICS FOR THE CAUSTIC UNIT

Rates of streams		
Air rate	90	lb. mols/hr.
	539	scfm
	600	cfm at 80°F and 750 mm. Hg.
Liquid recycle rate	60	gpm
Caustic (28.5%) feed rate	59.6	lb/hr.
Water feed rate--theoretical	127.1	lb/hr.
net		(Depends on humidity)
Effluent liquid rate	186.7	lb/hr.
Defoamer rate	1	fluid ounce/hr.
Pressures		
Tower operating pressure	1	atma.
Pressure drop in tower	9	inches H_2O
Compositions (Theoretical)		
Air in	1	% CO_2
Air out	0.8	% CO_2
Liquid feed (composite)	2.5	N NaOH
	Nil	Na_2CO_3
Effluent liquid	0.5	N NaOH
	2.0	N Na_2CO_3
CO_2 removed from air	7.5	lb/hr.
Caustic utilization	80	%

that were not duplicated included the compositions of the inlet air and effluent air and the composition of the effluent liquid streams. The composition of the inlet air during this test was 1.5% carbon dioxide instead of 1% carbon dioxide. This change in condition then resulted in changed conditions for the outlet air composition and effluent liquid composition.

An increase in the carbon dioxide content of the air fed to the equipment permits the system to operate with a higher driving potential which results in an increase in the carbon dioxide absorption rate. Thus, the scrubber, which was designed to remove 7.5 pounds of carbon dioxide per hour with an inlet carbon dioxide concentration of 1%, should remove carbon dioxide at a rate above 7.5 pounds per hour with an inlet carbon dioxide concentration of 1.5%.

If the flow rates of the air and liquid streams (including the caustic feed solution) are not changed, this increased carbon dioxide absorption rate will take place which will in turn increase the utilization of the caustic to greater than the 80% value.

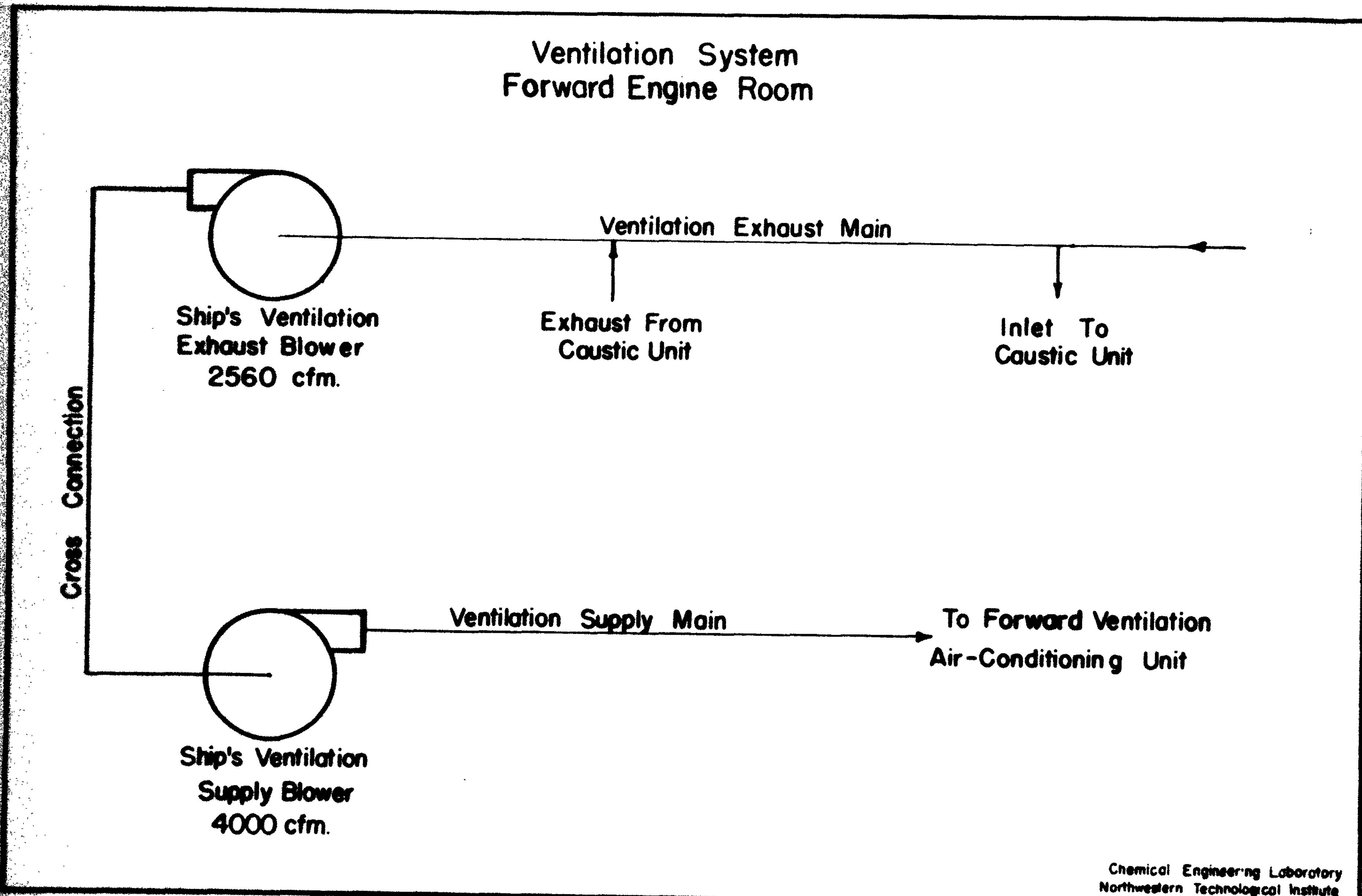
<u>Location of Scrubber</u>

It was desired to locate the scrubber in an inconspicuous place where it would not interfere with the conduction of the tests by the medical personnel. In addition it was necessary to locate it where it could be conveniently connected to the ventilation system and without altering the boat's structure. It was also desirable, but not necessary, to install the unit where it might be observed and any improper operation noted.

The possible alternate locations for the carbon dioxide removal equipment and the methods of connecting the system were discussed at the November meeting. The simplest and easiest installation was desired, because the installation was temporary and the allotted installation time was short.

In the early plans as discussed in November, the forward torpedo room wasn't included in the test compartments, and therefore the scrubber and blower were to be located in the forward engine room. For the connection of the caustic unit it was planned to have the inlet to the unit's blower and the exhaust from the unit tied into the same duct of the ship's ventilation system. The carbon dioxide rich air was to be drawn from a point slightly upstream from the point at which the carbon dioxide lean air was to be returned to the duct. This is illustrated in Figure 3.

Late in December when final plans were being formulated, the plans called for the carbon dioxide and oxygen control equipment to be placed in the forward torpedo room which would then be a part of the test space of the Haddock. The final decision to use the forward torpedo room as a part of the test space and to house the control gear in this compartment permitted the scrubber to be installed also in this compartment. The installation of the scrubber here was advantageous on several counts. It permitted the watch of the control gear to observe also the scrubber operation. The installation of the equipment was simplified. The work space was larger permitting more freedom for personnel around the



CAUSTIC UNIT AIR CONNECTIONS--OPERATION HIDEOUT FLOWSHEET

Figure 3

equipment for observation. Access to the scrubber direct from the top deck was now possible, and the scrubber could be inspected without the necessity of passing through the remaining test compartments.

Equipment Required

The equipment required for this installation can be divided into two groups. The primary group consists of the equipment required to accomplish the desired results. This would include that which would be required in a regular, routine installation. It would include the absorption tower, the recirculation pump, and the caustic feed flow controller.

The secondary group would consist of equipment needed because of the temporary nature of the installation. Also the improvisations and equipment required to observe or measure the operation to demonstrate its action more accurately.

Source of Equipment and Supplies

The major items of equipment such as the absorption tower, proportionating feed pump, defoamer, liquid recirculation pump, blower, and other equipment which might be needed in the test were shipped from Northwestern Technological Institute. Much of this equipment was borrowed from the facilities of the Chemical Engineering Department. The equipment shipped from Evanston is listed in Table 2. Also included in this table are pertinent materials and supplies needed for the test.

It was determined at the November meeting that supplies such as pipe, pipe fittings, sheet metal, duct work, and electrical supplies other than those in Table 2 could be procured

Table 2

MATERIAL SHIPPED FROM NORTHWESTERN TECHNOLOGICAL INSTITUTE FOR USE IN OPERATION HIDEOUT

Quantity	Description	Identification Number
2	Transfer pumps	Ch E P55
1	Hills McCanna proportionating pump	Ch E P51
		Ch E P134
1	Portable lightning mixer	Ch E M7
2	Displacement water meters	Ch E M34A
1	Recycle pump	Ch E 35
		Ch E P39
1	Blower (U. S. War Dept. No. 50870)	M E 8
1	Hasting airmeter	Ch E A23
1	Flowrite airmeter	Ch E A23
1	Carbon dioxide regulator	Ch E R119
2	Schutte Koerting rotameters	Ch E R80
		Ch E R64
2	Manometers	Ch E 85A
		Ch E 88B
1	Electric timer	Ch E T11
1	Absorption tower	....
1	Defoamer	....
8	No. 2 - 16" x 25" x 2" fiber glass dust-stop filters	....
8 cu ft	Berl saddles	....
5	Disconnect switches	....
5	Starters	....
3	Tower blower adapters	....
-	2", 1/2", and 1/4" piping and valves	....
3	Goggles	....
4	Pair rubber gloves	....
5	Dust masks	....
25	Cotton pad refills for masks	....
80	100 lb. drums sodium hydroxide	....

through the stores at New London and would therefore not have to be shipped from Evanston.

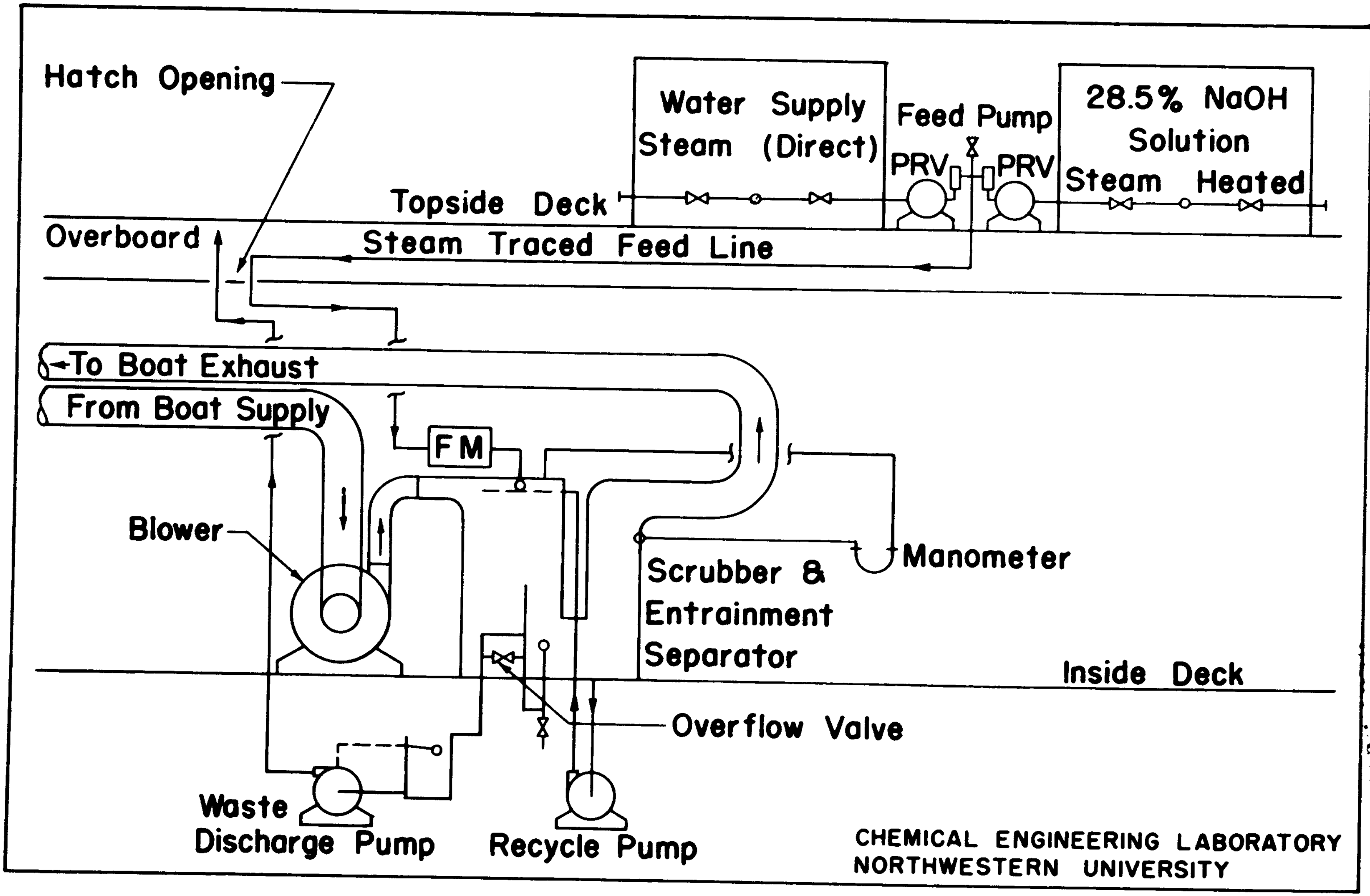
The electrical equipment which was available for use in this test required either 220 volt or 110 volt 60 cycle A. C. current. It would have been undesirable to purchase direct current motors specifically for this test because of the cost and time required for its procurement. This became unnecessary because the Haddock had been stripped of its batteries and power was to be fed to the boat from shore installations.

The exact equipment required for the process was unavailable in many cases so that oversize equipment was used and throttled to produce the proper characteristics. The air blower was an example of such equipment. The blower used was considerably oversize.

Scrubber Installation

To install the scrubber it was necessary to cut it and reweld it inside the boat. The scrubber and the other auxiliary equipment which were installed are illustrated in the flowsheet, Figure 4. This included all equipment of both groups, the primary group needed for a standard installation, and the secondary group needed to demonstrate its operation and to improvise for the temporary installation.

The air was pulled from the ventilation system by the blower, forced through the scrubber and entrainment separator and back to the ventilation system. The carbon dioxide was removed from this air stream by the caustic solution in the scrubber. The intimate contact required between the caustic solution and the air is accomplished by circulating the solution through packing material in the scrubber by pumping liquid from



CO_2 Removal--Caustic Unit--Operation Hideout Flowsheet

Figure 4

the bottom with the recycle pump and feeding it back into the top of the scrubber through a liquid distributor.

To replace the caustic which has been used, fresh caustic is fed into the system. The caustic solution comes from the temporary caustic and water supply tanks and is fed into the system by metering pumps. A flow meter (FM) is also placed in this feed line to verify the flow rate.

The used caustic solution flows out of the scrubber through an overflow on the sump. This could be pumped directly to the sea, or let flow to one of the tanks or to the bilge and pumped out periodically. This installation utilized a small waste tank and a centrifugal pump. The waste tank level was controlled by a liquid level controller.

The equipment installed inside the submarine in the forward torpedo room consisted of the scrubber, blower, recycle pump, discharge pump, waste sump tank, displacement liquid meter, and manometer. All these items were placed just forward of the after bulkhead and sonar gear on the port side (left side) of the forward torpedo room. This equipment covers an area approximately 9 feet long and 2 feet wide.

Compactness of the equipment for this set-up was not required or desired. The installation was temporary, because the authorities did not permit any changes in the submarine structure. As a result the equipment was spread out in a long narrow band. This allowed more space in the middle of the compartment for personnel traffic. Figures 5, 6, 7, 8, and 9 show different views of the installation of this equipment in

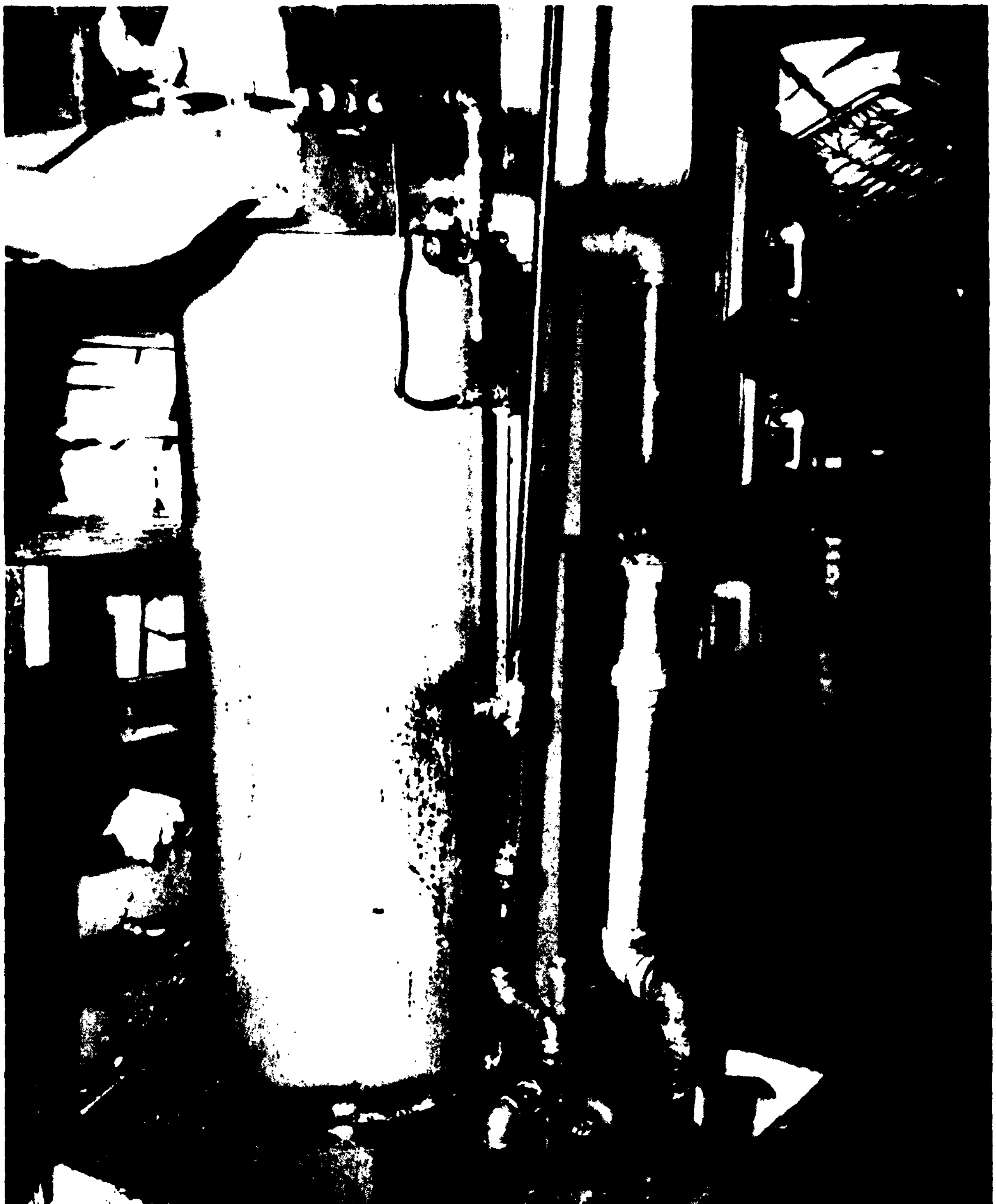


PHOTO-101

Figure 5

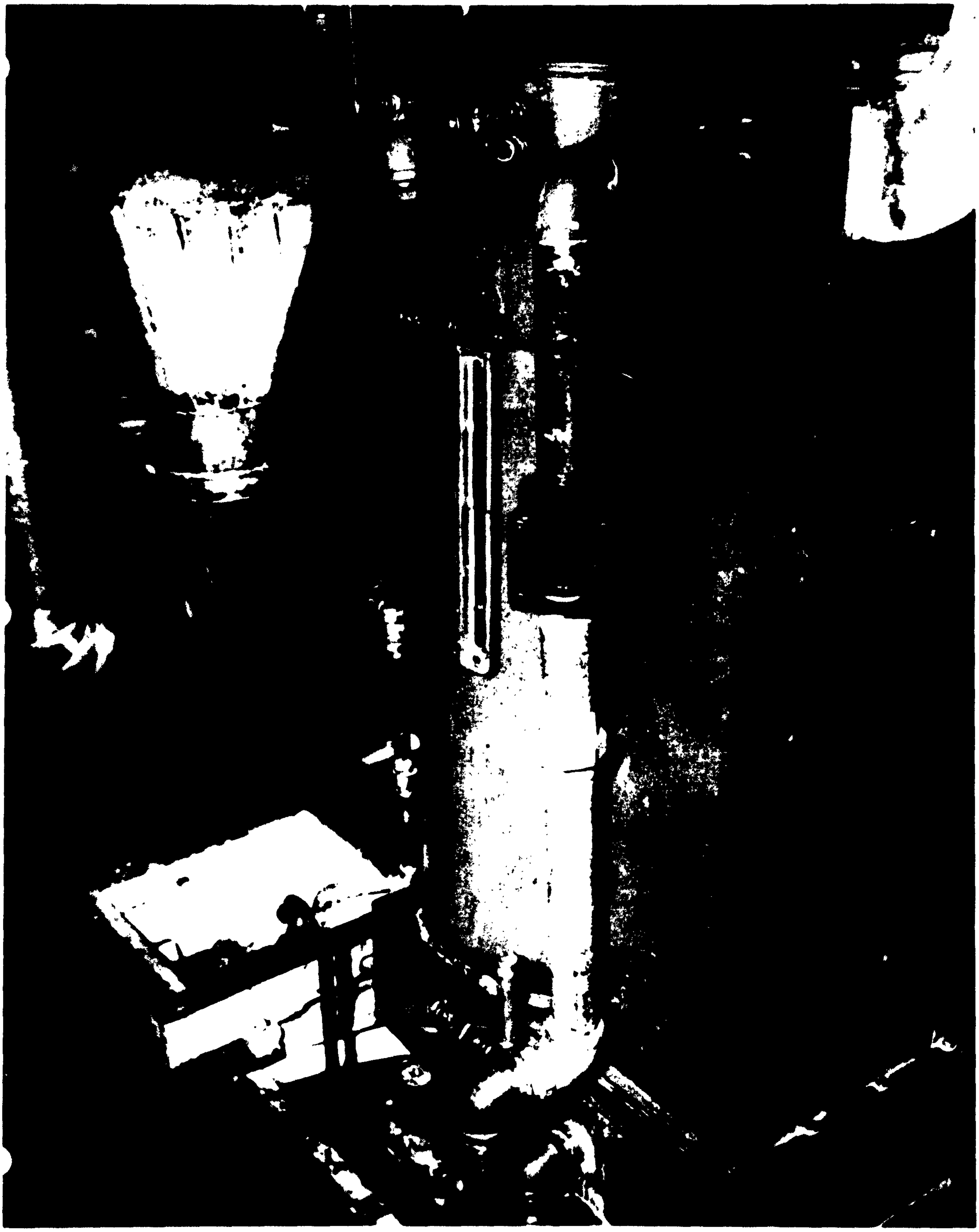


PHOTO-102

Figure 6

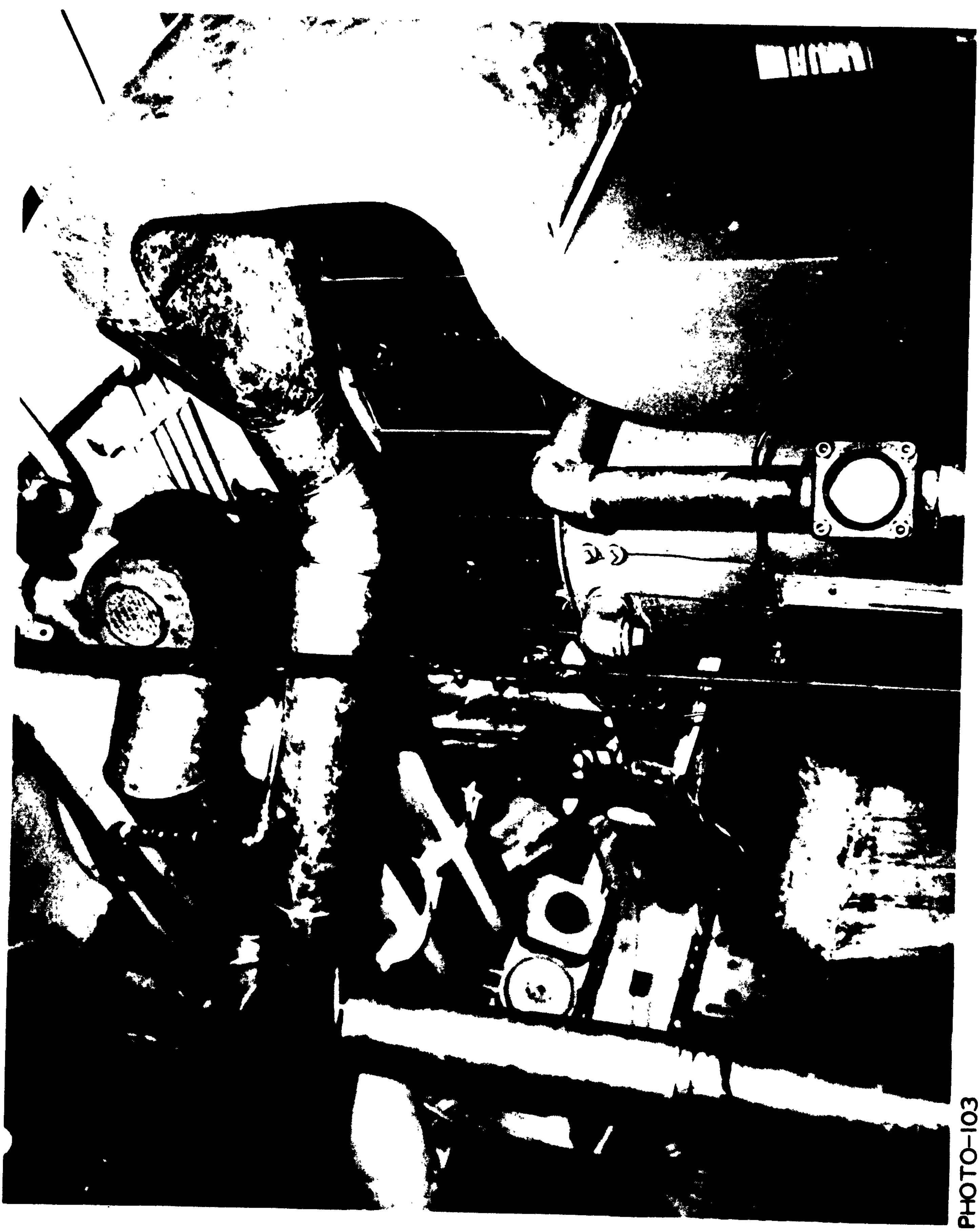


Figure 7

PHOTO-103

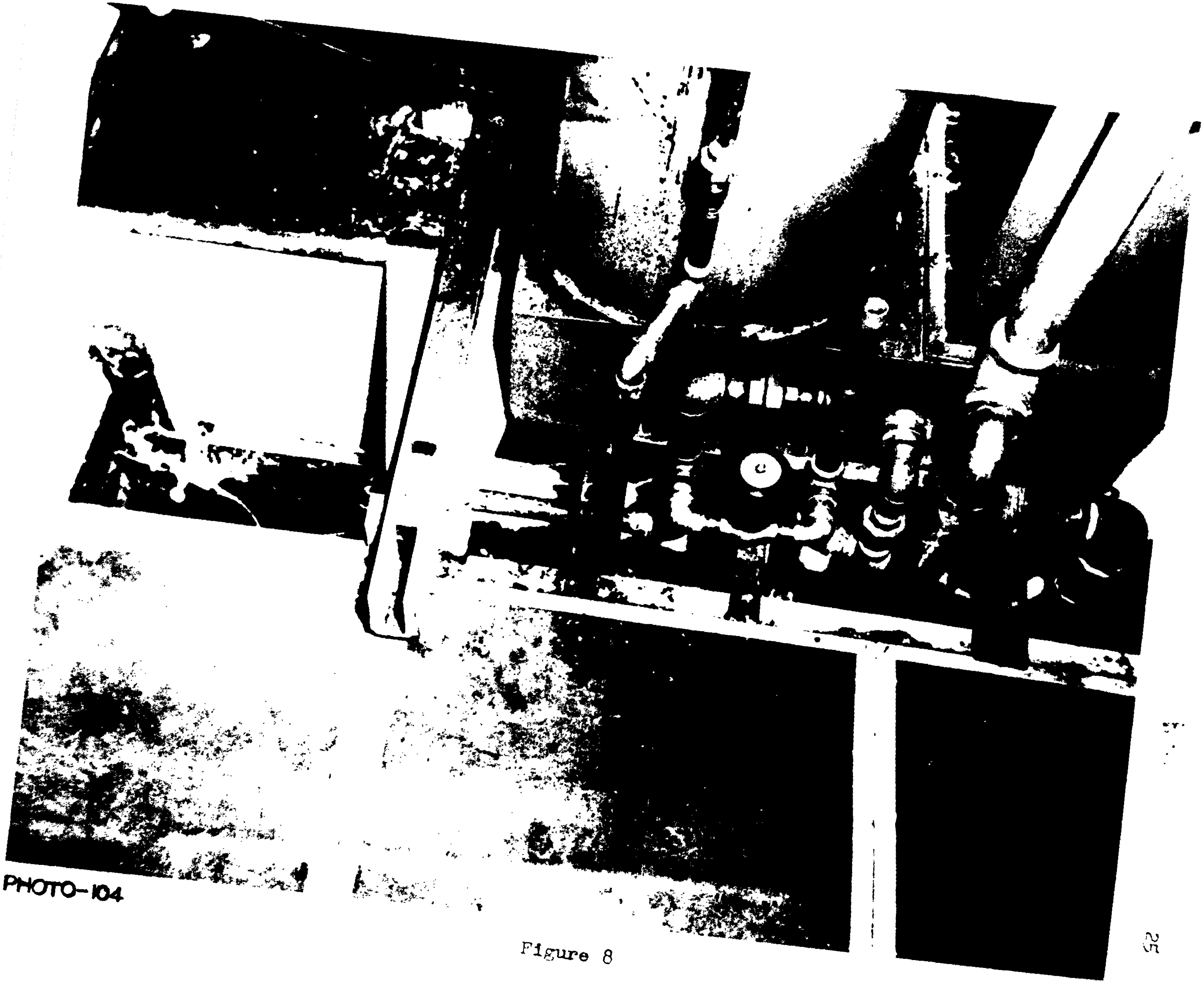


PHOTO-104

Figure 8

PHOTO-105

Figure 9

the forward torpedo room. The scrubber was placed on the platform deck with the deck plate removed. This was done so that observation could be maintained on the other equipment which had to be installed in the space below the unit. This is clearly shown in Figures 8 and 9. The blower shown in Figure 6 was bolted to strongbacks which in turn were anchored by clamps to the platform deck supports. This blower was also mounted on rubber pads in order to decrease any vibrational noises.

The capacity of the blower shown in this figure exceeds considerably the air flow rate desired for a carbon dioxide scrubber. This process would require a blower similar to the battery blower, but none were available for this test. No blower of the exact size was available at Northwestern Technological Institute. However, for the temporary installation this large oversized blower was used and throttled to the proper rate.

A manometer was connected to the inlet and outlet of the tower. This was used as a measure of the air flow through the unit. It could also be used as an indicator for detecting any excessive foaming of the solution within the scrubber, detecting any stoppages in the fiber glass dust-stop, or detecting any other operational problems. It was mounted in the front of the scrubber and is visible in Figures 5, 6, and 7.

A top view of the space below the platform deck on which the scrubber was placed is more clearly shown in Figure 8. This figure shows the recycle lines to and from the scrubber, the liquid level control for the sump on the scrubber, and the waste liquid tank with the float type liquid level control. Figure 9 is a picture of the same below deck area directly below the scrubber showing the space limitation in which the recycle and waste discharge pumps and waste tank were installed. In the background of this figure the waste discharge tank is faintly visible.

Figure 5 is a view of the scrubber and the electrical power panel from which the unit operated. The equipment mounted on this panel included disconnect switches, starting relays, motor starters, an electrical timer, and an analytical time delay relay.

The air lines to the inlet and outlet of the scrubber and the liquid inlet line are shown best in Figure 7. These lines were installed for functional use only with what materials were available. The winding nature of these ducts would not be desirable or necessary in a regular installation. The ducts very excellently served the purpose of conducting the air stream between the ventilation system and the scrubber.

The air supply to the carbon dioxide scrubber is essentially similar to that originally proposed with the exception that the connections are made at the terminals of the ship's venilation system. The connections to the supply main can be seen in Figure 7. The main is continued and opens behind the chain fall. A damper in this line near the outlet controls the air supply to the forward torpedo room. The outlet from the entrainment separator is looped back in order that it could be connected to the ventilation exhaust main. This is tied into the exhaust ventilation main in a manner similar to the connection to the supply ventilation main.

Both the waste discharge stream and the feed solution liquid stream go to the outside of the boat through a dummy hatch. These lines can be seen going to the hatch, which is visible in the upper left hand corner of Figure 7. The feed solution goes through the displacement type water meter located on top of the carbon dioxide scrubber and then to the unit. This meter is shown in Figures 5 and 7.

With the exception of the control equipment the above is the entire equipment which was installed in the forward torpedo room. Some of this equipment was installed for test purposes and will not be required on a final unit.

Caustic Storage and Method of Feed

It was determined at the November meeting that the 28.5% caustic feed solution could be stored either on the pier or on the work barge. From there the solution could be pumped by a proportionating pump into the Haddock to the unit through the high salvage line. With these plans it would have been necessary to run a flexible line between the barge and the submarine. To insure that the line would remain intact during shifting and to insure that the line would not freeze would have resulted in difficult but solvable problems.

As the final plans became formulated in December it was deemed possible to store the caustic solution on the bow of the submarine. This was much more convenient. This storage was, of course, a temporary measure for use in this test only. The feed solution could be stored in several manners in a regular installation.

The concentrated solution of caustic could be mixed as it was needed on the boat or else the entire supply could be mixed and stored as such. For the former method the pure sodium hydroxide must be stored inside the submarine as solid and a solution made with sea water during the time the caustic unit is in operation. The mixing of the concentrated caustic aboard the submarine would require additional equipment and a strict enforcement of the safety requirements. This would be similar to handling the carbon dioxide absorbent presently used aboard submarines. The storage of the solid sodium hydroxide and the additional mixing equipment would require space inside the submarine, and the actual mixing aboard the submarine would be undesirable. In the latter, the solution can be mixed aboard submarine tenders or ashore with fresh water or sea water whichever was accessible. This solution can then be stored in a ballast tank or in plastic bags, both of which do not affect the available space inside the submarine. There are probably other possibilites, but up to date the storage in plastic bags appears to show the greatest promise.

The use of plastic bags for stowage was based on the condition that they be placed outside the pressure hull of the submarine in the free flooding main ballast tanks which are between the pressure and outer hull and are separated by light athwartship bulkheads. These plastic bags would be manifolded together so that the 28.5% caustic solution can be drawn from any one or all of the containers. In this way the storage of the solution would not require any space which is so vital inside a submarine. The caustic solution in the bags being exposed to sea pressure could be easily utilized by allowing this pressure to force the required solution into the scrubber. This matter of storage is discussed in greater detail as to the structure, construction, and arrangement of the plastic bags in this project's previous reports.(2,3)

However, since the installation for Operation Hideout was a temporary one and was for only a short duration, the use of the plastic bags for stowage was not warranted. Instead, the more temporary arrangement of using large metal tanks was adopted. The sodium hydroxide and the dilution water tanks were placed on the bow of the Haddock forward of the forward escape trunk hatch. The caustic solution strength was 28.5%, which is the strength that is proposed to store the caustic in plastic bags.

The freezing point of 28.5% sodium hydroxide is 3°C below the freezing point of water, or -3°C. If the caustic solution were stored in plastic bags, it would be surrounded by sea water. The coldest sea water is about -2°C.(5) Therefore, the concentration of the caustic was so chosen that the solidification of the solution would occur below the freezing point of sea water.

The water to be used in this process would normally be drawn from the sea. This could have been done in this test but would possibly have resulted in problems due to the debris in the river. This is not serious since strainers could have been provided and cleaned, but since even a temporary interference in the carbon dioxide content of the air might influence the medical tests and would be undesirable, it was decided to use clean water. To insure an adequate supply in case of an interruption of service from shore installations, a holding tank for a reserve was provided. Other problems such as plugging of the line due to freezing also influenced the choice of using a storage tank where better control could be maintained.

The storage tanks used for the liquids were available in the salvage depot at New London and were utilized because of their accessibility rather than for the purpose for which they were intended. These tanks had to be altered to allow for drainage and for heating facilities to be installed. Figure 10 shows a view of the top deck installation including the two storage tanks. The larger of the tanks appearing in the background was used for caustic storage and the other for water storage.

Provisions were necessary to keep the solutions in a liquid state for the duration of the test. Since these liquids were exposed to the cold winter weather, arrangements were necessary to keep the caustic and water in the storage tanks from freezing. Steam was admitted directly into the water tank since the condensate could be used as dilution water. For the caustic solution, however, the steam was introduced

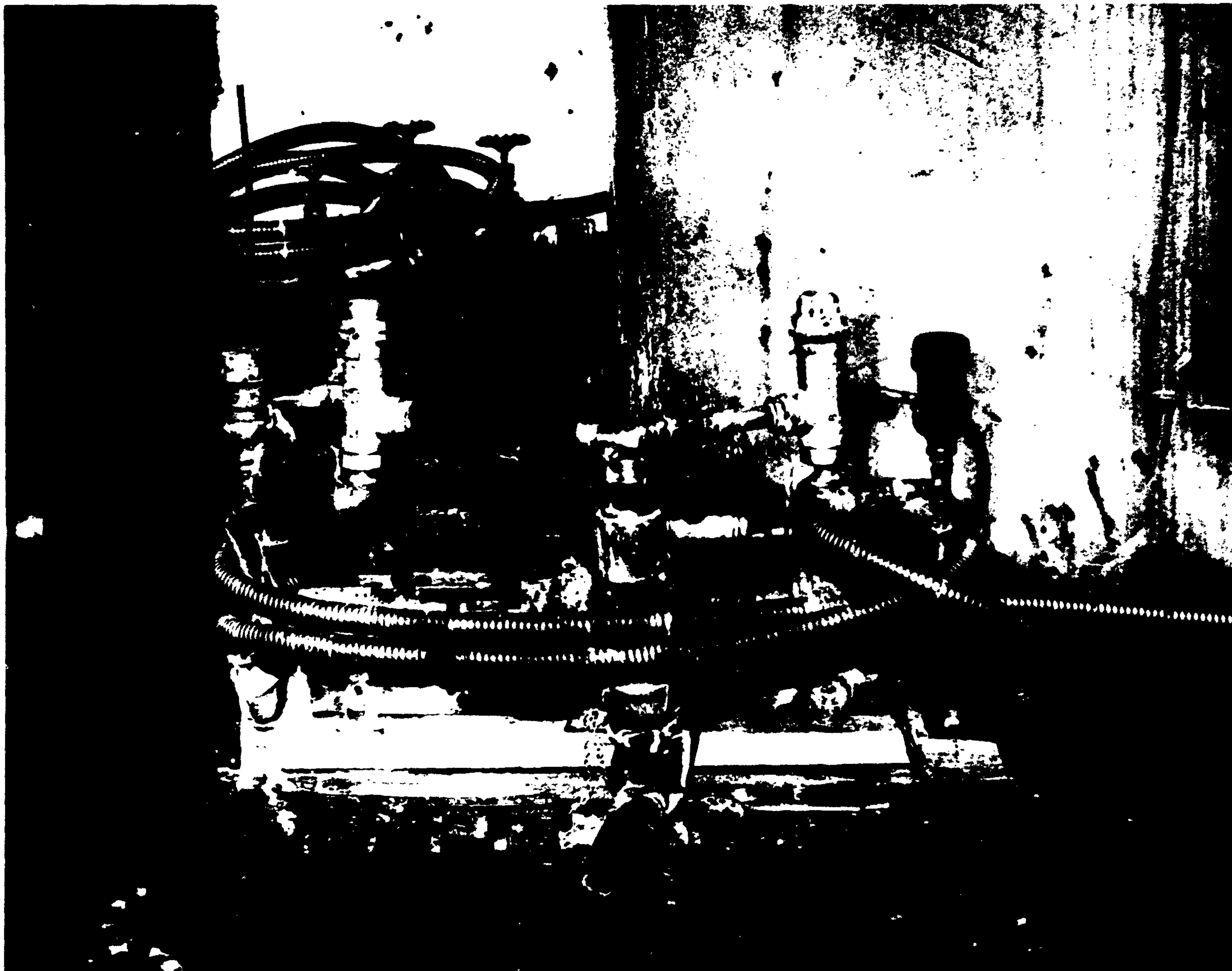


PHOTO-106

Figure 10

into coils which were installed in the caustic storage tank, and the condensate was discharged overboard.

Installed next to the storage tanks were the metering pumps (driven by a single motor). In this temporary installation the metering pump was used primarily to meter and control the flow since the head of the tank would have been sufficient to provide the flow. This metering pump could and would normally be replaced by a flow controller. The pump is seen in Figure 10. The proportionating pump is equipped with an air dome to give a cushioning effect to the flowing liquid stream and is equipped with a pressure relief valve downstream to insure the proper flow when the pump is operating. The choice of putting the feed pumps near the feed tanks rather than inside at the unit had no special reason. With installation on the top deck, one, instead of two, lines had to be steam traced, and the noise of the pumps which was not a necessary function of the unit would not be imposed unnecessarily on the personnel. The proportionating pump was kept warm by wrapping two loops of flexible piping around it and covering this with a wooden box.

The transfer lines from the tanks to the pump were traced with 1/2" copper tubing through which steam flowed. Both of these lines were wrapped together with 4" wide canvas strips in order to insulate the warm lines from the atmosphere. The wrapped lines from the tanks to the pump and the flexible piping can be seen in Figure 10. The transfer line conveying the feed solution from the pump to the dummy hatch was similarly wrapped. This line then proceeded through the dummy hatch to the liquid displacement meter on top of the caustic unit.

Control Equipment

Since the continuous operation of the scrubber would have resulted in a carbon dioxide concentration much lower than the desired value it was necessary to make provisions for preventing this situation. It could be accomplished by any of the following methods.

1. Run the scrubber continuously and introduce extra carbon dioxide from tanks to take care of the excess capactiy of the scrubber.

2. Run the scrubber continuously but at operating conditions much below design specifications.

3. Run the scrubber intermittently and maintain the concentration between narrow limits.

The generation rate would not be constant throughout a twenty-four hour day because of the variation in the activity of the personnel. The entrance and exit of the medical teams and observers resulted in an even more variable total generation rate.

The second method was not a desirable one because it would give no true indication of the capabilities of the scrubber. Also because of the variations in the carbon dioxide generation rate, it would be very difficult to follow the generation rate with the removal rate. The time lag would be great and the ability to maintain the carbon dioxide concentration at exactly the 1.5% level would have been difficult. The carbon dioxide concentration would tend to fluctuate over a wide range.

The first method would require the consumption of considerable carbon dioxide from the tanks, about 6 pounds an hour, or about 6000 pounds for the test.

The third method had the most desirable conditions and was the method actually used. This method called for intermittent operation of the scrubber. The turning on and off could have been done manually whenever the concentration so indicated that one or the other should be done. It could also be done automatically by electronic controls. These permit the concentration to be controlled over a finer range and permit a much more reliable control in that they eliminate the human error.

The electronic equipment used in Operation Hideout for controlling the atmosphere of the submarine at the proper level of carbon dioxide was installed on the starboard side of the forward torpedo room directly opposite the scrubber. Figure 11 shows most of the equipment, particularly the Gow Mac carbon dioxide analyzers and the Brown continuous balance potentiometers. Just a small portion of the equipment shown was used for control of the caustic unit. The oxygen content was also controlled and provisions were included for adding oxygen as needed and for even adding carbon dioxide if the concentration became too low. These were all controlled by this panel.

The equipment for controlling the carbon dioxide content consisted of a Gow Mac analyzer, a Brown potentiometer, and a Liston Becker carbon dioxide analyzer. The two Gow Mac units,

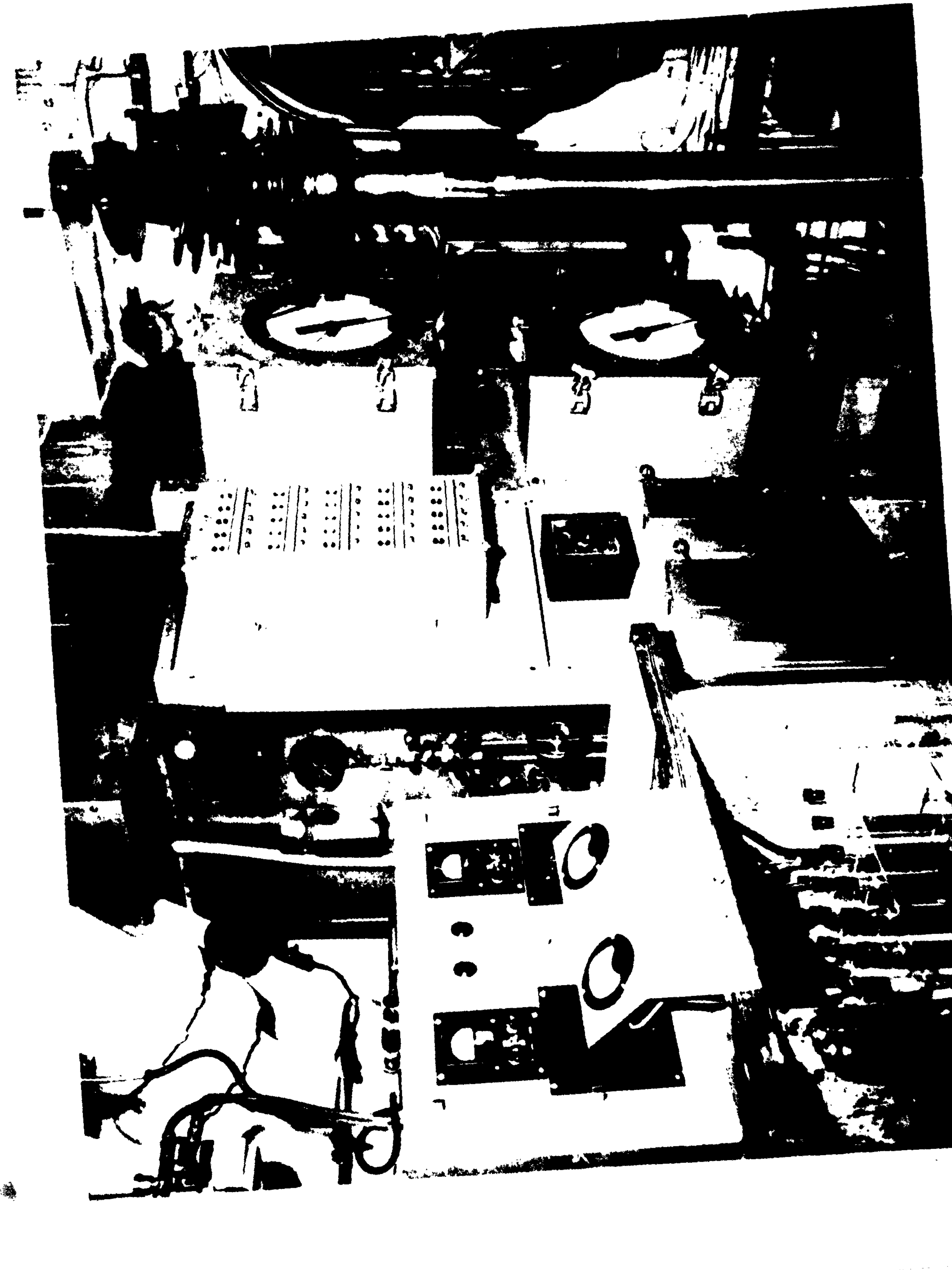


Figure 11

PHOTO-107

only one of which was used, are seen on the left in Figure 11, and the necessary drying and ascarite U-tubes are below it. Three potentiometers, the middle one of which was used for the scrubber control, are located on the right. The Liston Becker is not visible in the figure.

The Gow Mac analyzed the air stream and sent a weak signal to the potentiometer, which responded to this signal. If the poteniometer deviated from the limited range for which it was set, the scrubber either started or stopped, depending on which end of the range was crossed. This hookup had a tendency to drift. The Liston Becker instrument was used to calibrate the Gow Mac - Brown combination, and the Liston Becker was in turn calibrated with standard gases.

The Gow Mac operates on the thermal conductivity principle. The air was drawn from the ship's ventilation supply main at a constant rate of 5 cubic centimeters per minute. A Stedman pump aided in pulling this sample at the desired rate from the duct and through the instrument. This air stream must be dried, and this drying is accomplished by passing the stream through indicating silica gel in the U-tubes pointed out in the figure. The dried air is then passed through one side of the Gow Mac instrument. After this passage the air must be stripped of its carbon dioxide and redried before passing it through the other side of the instrument. This is done by passing the air stream successively through U-tubes containing indicating ascarite and silica gel. The dry carbon dioxide-free air is then passed through the other side of the Gow Mac. The difference in thermal conductivity of the air stream under these two conditions sets up an electrical direct current signal of very small magnitude.

The signal from the Gow Mac was sent to the breaker-type amplifier in the Brown potentiometer. The potentiometer amplified the electrical signal. The output from the amplifier operates a control motor which drives the indicator arm as seen on the face of the potentiometer in Figure 11. The smallest division visible in the dial of the potentiometer was equivalent to approximately 0.01% carbon dioxide (or the main divisions between numbers was approximately 0.1% carbon dioxide). The range of the potentiometer can be set so that as the arm, which indicates the composition, moves out of the range a micro-switch is operated which then activates the necessary switches for the scrubber. The equipment was sensitive enough to control the carbon dioxide concentration at $1.5 \pm 0.03\%$. Due to the drifting tendencies the actual sensitivity would be less accurate.

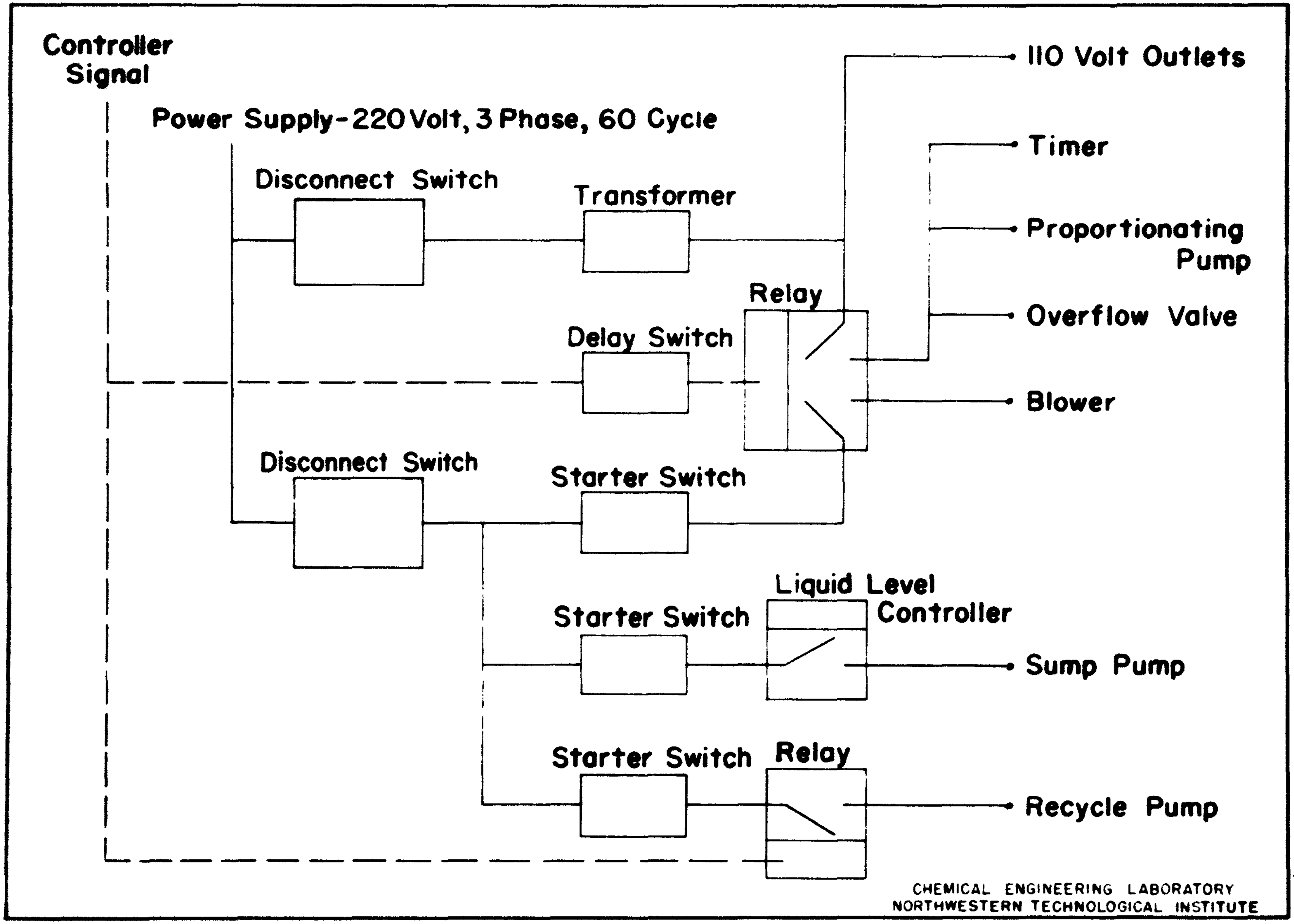
This tendency to drift was corrected by periodic checks with a Liston Becker instrument. The Liston Becker is an infra red analyzer. This analyzer was first calibrated with two gases of known constant composition. The carbon dioxide content of the boat's atmosphere was then determined and if a drift in the Gow Mac - Brown system had occurred, the instrument was reset. This consisted of resetting the Brown for a new scale range that corresponded to the proper carbon dioxide content range. These Liston Becker analyses were made once an hour when possible. The instrument performed double duty and was not always available.

Electric Power Connections

The power required for the scrubber installation included 110 volt and 220 volt alternating current. This power, in fact all power on the boat, was supplied from shore installations. The elctrical equipment involved on the scrubber included the feed pump (110 volts), recycle pump (220 volts), overside pumps (220 volts), blower (220 volts), overflow valve (110 volts), and timer (110 volts). All equipment was connected through switches directly to the power supply. The overside pump switch was actuated by a liquid level controller in the overflow sump. All other switches were actuated by electrical signals from the Brown potentiometer. These connections are shown in Figure 12. The solid connecting lines represent power supply wires, and the dashed lines represent wires carrying electrical control signals.

The delay switch is necessary because of the liquid holdup in the packing. When the equipment is shut down, this holdup volume drains down into the sump and must be held there to permit efficient operation when the scrubber is next started. When it is necessary to start again, the recycle pump starts first, redistributing this solution through the packing. This arrangement eliminates any low utilization of the caustic solution and prevents the air from picking up solution from a high liquid level in the sump. These two effects are minor, however.

The switches were all located on a panel visible in Figure 5. On the top row were (1) the main disconnect switch (220 volt, 3 phase) for the scrubber which controlled all power except that to



CAUSTIC UNIT ELECTRICAL FLOWSHEET--OPERATION HIDEOUT

Figure 12

the 110 volt transformer, and (2) the 0.01 to 1000 minute electrical timer (110 volts). In the second row were (1) the starting relay switch for blower, feed pump, and timer, and (2) the disconnect switch (220 volt, 3 phase) for the transformer which is the 110 volt, single phase source. In the third row were (1) the waste pump starter switch (220 volt, 3 phase), (2) the adjustable time delay relay (0-120 seconds), and (3) the recycle pump starter switch. In the bottom row was the starting relay switch for the recycle pump.

EXPERIMENTAL PROCEDURE

Operation Hideout

The duration of the operation was from January 19, 1953 until March 19, 1953 or a total of 60 days. All personnel and equipment were on board, and the test got underway at 0915 o'clock on January 19. Ventilation with the outside atmosphere was maintained until 1300, January 27. During this interval the carbon dioxide concentration of the submarine air was essentially the same as it is in the normal atmosphere. At 1300 o'clock on January 27 the outside hatches were closed, at which time the submarine atmosphere was essentially isolated. The carbon dioxide content of the submarine atmosphere began to build up, reaching the control content of 1.5% at 2000 o'clock. From this time until the ship's ventilation was again opened to the outside atmosphere this isolated air was recirculated through the submarine. The excess carbon dioxide which was generated was removed, and the oxygen which was consumed was replaced, but the nitrogen, argon, and any other inert gases recirculated essentially unchanged throughout the isolation period.

At 2000 o'clock on March 10 the ship's ventilation was again opened to the outside atmosphere. The personnel were then breathing essentially carbon dioxide-free air again. At 1400 o'clock on March 19 the test was completed, and the personnel left the boat.

The scrubber was used during the period January 27 through March 10 when the atmosphere was isolated and the excess carbon dioxide had to be removed.

Operation Preparation

After the equipment was installed, the preliminary testing consisted of insuring that all equipment operated, that the lines were clear, and that proper operating conditions could be attained and maintained.

The strong caustic solution was made up in sufficient quantity to last for the entire test. The amount made up was 29,030 pounds, which quantity only partially filled the tank used for the storage. All of this caustic made up was not used during the test. Approximately 6000 pounds remained to be disposed of at the end of the test.

Operation

The operation of the equipment was quite simple. Since the scrubber was turned on and off at the proper time by the electronic equipment shown in Figure 11, the required work consisted of periodic inspections to verify the proper operation, making readings and taking and analyzing samples to determine the exact carbon dioxide removal rate.

The operation of the scrubber consisted of intimately contacting the air and caustic solution by passing them through the 1 inch Berl saddles in the scrubber. The carbon dioxide reacts with the caustic solution according to the following reaction and is removed from the air.

$$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$$

The fresh sodium hydroxide solution (2.5N) is metered into the scrubber at a constant rate by the proportionating pumps. These pumps were calibrated and set to deliver the proper amount of water and 28.5% caustic solution. The volume of the diluted solution was checked by a displacement flow meter. The flow meter reading was actually less accurate than the calibration of the feed pumps. It served best to check against failure in the feed line such as a freeze which might either drastically reduce the flow or hold valves open and permit an excessive flow. After reacting with the carbon dioxide, the spent solution flowed out the overflow and was pumped overboard. In passing through the scrubber over 80% of the sodium hydroxide has been converted to sodium carbonate.

Readings taken during the test included (1) the meter reading on the feed stream, (2) the reading of the electrical timer, and (3) the manometer reading of the tower pressure drop. The carbon dioxide content of the air in the ventilation system as determined by the Liston Becker and the carbon dioxide content of four compartments as determined by the Dwyer were also recorded.

The meter reading checked the feed pump operation. The timer reading indicated the time the scrubber was in operation and the time of operation of the feed pumps. The recirculating pump always operated 30 seconds before the rest of the equipment went into action, and it was the latter time which was important and which was measured. This time was the scrubber operating time which was used to determine the carbon dioxide removal rate per hour. It was also the time used to measure the operating time of the feed pumps and thus the feed volume.

The manometer measured the pressure drop of the air stream through the scrubber. After setting the air rate on a properly functioning tower the manometer could be used to detect pluggage in the entrainment separator or of the packing (increase of ΔP), a pluggage of the liquid distributor (decrease of ΔP), an excessively high liquid level in the sump (an increase in ΔP), and several other possible occurrences.

Samples of the liquid solution fed into the scrubber and of the effluent solution leaving the tower were taken at frequent intervals. Quick approximate analyses were performed immediately aboard the submarine. These analyses were also used to check the operation of the feed stream. A variation in the sodium hydroxide normality would indicate trouble due to freezing in either the water or the caustic feed solution. A variation in the carbonate-hydroxide ratio in the effluent stream would also indicate a pluggage in the line of either solution or of both solutions.

The samples for precise analyses were taken to the laboratory on the barge. These analyses were used to determine the carbon dioxide removal rate effected by the scrubber.

The carbon dioxide removal rate could also be obtained by the air analyses, but the method was more difficult to carry out and was considered to be less accurate than the liquid analysis. In addition the conditions of the tower are more difficult, if not impossible, to determine from the air analyses alone.

The only difficulty during the test was in the feed of the caustic solution to the scrubber. This was due principally to freezing of the lines. The pumps should have a discharge head greater than the suction head. Pressure control valves placed downstream of the pump were susceptible to failure. This all resulted in the precautions to check the feed streams.

Liquid Analyses

The compositions of the solutions were determined by both approximate and precise analyses for different purposes, as previously described.

The precise analyses were made in the analytical space provided on the work barge. A seaman was specially trained to carry out these analyses, and the technique was frequently checked by the engineer who duplicated the analyses.

The classical method for a volumetric analysis of a strong base containing carbonate was followed. The normality of the hydroxyl ion, carbonate ion, and their sum, the sodium ion normality, were determined.

Into a clean Erlenmeyer flask (250 ml) a measured portion of the liquid sample was pipetted. To this was added a solution of barium chloride in excess of the theoretical amount required to react with the carbonate ion and remove it as a precipitate. The solution was then diluted with distilled water and two drops of phenolphthalein indicator were added. The supernatant liquid now contains essentially no carbonate ion. This slurry is then titrated with standard hydrochloric acid (ca. 0.1N) until colorless. The hydroxide ion has then been neutralized, but the carbonate is still intact as the solid barium carbonate.

Two drops of methyl orange indicator were then added and the titration continued until the solution color changed from yellow to orange. During this second addition of hydrochloric acid, the barium carbonate dissolves and reacts with the acid and carbon dioxide is liberated. The solution is then boiled to expel all the liberated carbon dioxide which has remained in solution. During boiling the solution will change color back to yellow. After cooling the solution, the titration is continued until the solution again turns orange. At this point all the carbonate ion has been neutralized, and the resulting carbon dioxide has been released from the solution.

The normalities of hydroxide, carbonate, and sodium ions present in the original sample can then be determned from the normality and volume of hydrochloric acid used and the volume of the original sample. The hydroxide normality is determined from the amount of acid required to reach the phenolphthalein end point, the carbonate normality from the acid needed to reach the methyl orange end point from the phenolphthalein end point, and the sodium normality from the total quantity of acid used. The compositions of the inlet and effluent liquid streams were then used to determine the amount of carbon dioxide removed by the scrubber.

The results of these analyses were precise, and as a result, required considerable time. This delay was too long to be useful in determining the operating conditions of the scrubber. As a consequence, therefore, a quick, abbreviated analysis was made when needed so that any trends in the operation of the caustic unit could be more closely followed. These were carried out in the forward torpedo room. In these analyses the sodium ion concentration was of principal interest. Approximate results, which were satisfactory, could be obtained quite rapidly by titrating a sample to the methyl orange end point without the addition of barium chloride. From these titrations any major changes in the concentrations of the solutions entering or leaving the scrubber could be immediately detected, and the adjustments could be made as necessary.

Pump Calibration

The pump for the feed solution was a piston type positive displacement pump. Its discharge rate could be varied by the length of the piston stroke. The discharge volume could be calculated directly from the piston displacement and a knowledge of the slippage. The discharge rates at various piston displacements were determined by measuring the discharge. This was done by measuring it both by volume and by weight.

TREATMENT OF DATA

All the pertinent data are tabulated in Table 7 in the Appendix. Each page represents the data of one day's operation. The information presented included the readings taken, the analyses of the submarine air, the analyses of the liquid samples, the calculations of the carbon dioxide absorbed, and the carbon dioxide absorption rate.

The operating time of the unit is an approximate indication of the carbon dioxide removal rate or the carbon dioxide generation rate. The cumulative operating time for each day is thus plotted vs. the time of the day. These are Figures 21 through 62 in the Appendix. An average for all days of the cumulative operating time of the scrubber at each hour of the day was determined, tabulated in Table 3, and plotted in Figure 13. Similar averages were prepared for weekdays only, Figure 14; weekends only, Figure 15; Saturdays only, Figure 16; and Sundays and holidays only, Figure 17.

The breakdown of these data between weekdays and weekends was made because the personnel were on "holiday routine" on Saturdays, Sundays, and the one holiday. The results were expected to be somewhat different between weekdays and weekends. These data are all listed in Table 3.

The carbon dioxide absorbed presented in Table 7 were based on the amount of caustic solution passing through the scrubber as measured by the liquid flow meter and the concentration of the

Table 3

CAUSTIC UNIT AVERAGE OPERATING TIME

Time of Day	Caustic Unit Operating Time				
	All Days (42)	Week Days (29)	Week Ends (13)	Saturdays (6)	Sundays and Holidays (7)
O'clock	Minutes	Minutes	Minutes	Minutes	Minutes
0000	0.00	0.00	0.00	0.00	0.00
0100	8.27	8.34	8.13	9.20	7.21
0200	14.77	14.50	15.37	17.79	13.30
0300	19.67	19.17	20.78	22.49	19.32
0400	23.26	22.08	25.89	25.28	26.42
0500	27.81	27.20	29.18	27.00	31.03
0600	31.99	32.40	31.46	29.75	32.93
0700	38.26	39.78	34.88	32.20	37.17
0800	45.50	47.60	40.83	35.26	45.60
0900	55.38	59.02	47.25	38.36	54.87
1000	70.14	77.06	54.73	42.74	65.00
1100	85.18	96.11	60.81	50.78	69.42
1200	98.48	111.90	68.55	61.03	75.00
1300	109.94	125.76	74.64	69.32	79.20
1400	123.24	141.56	82.38	75.54	88.24
1500	137.73	158.91	90.47	83.93	96.08
1600	154.46	178.68	100.43	92.59	107.15
1700	168.00	194.55	108.78	100.77	115.64
1800	180.05	207.00	119.92	109.24	129.07
1900	193.43	221.61	130.58	121.46	138.40
2000	205.95	234.38	142.54	132.71	150.96
2100	216.03	244.94	153.76	143.88	162.22
2200	226.27	254.98	164.43	154.82	172.66
2300	235.08	264.47	171.80	162.46	179.80
2400	244.48	274.64	179.52	167.76	189.60

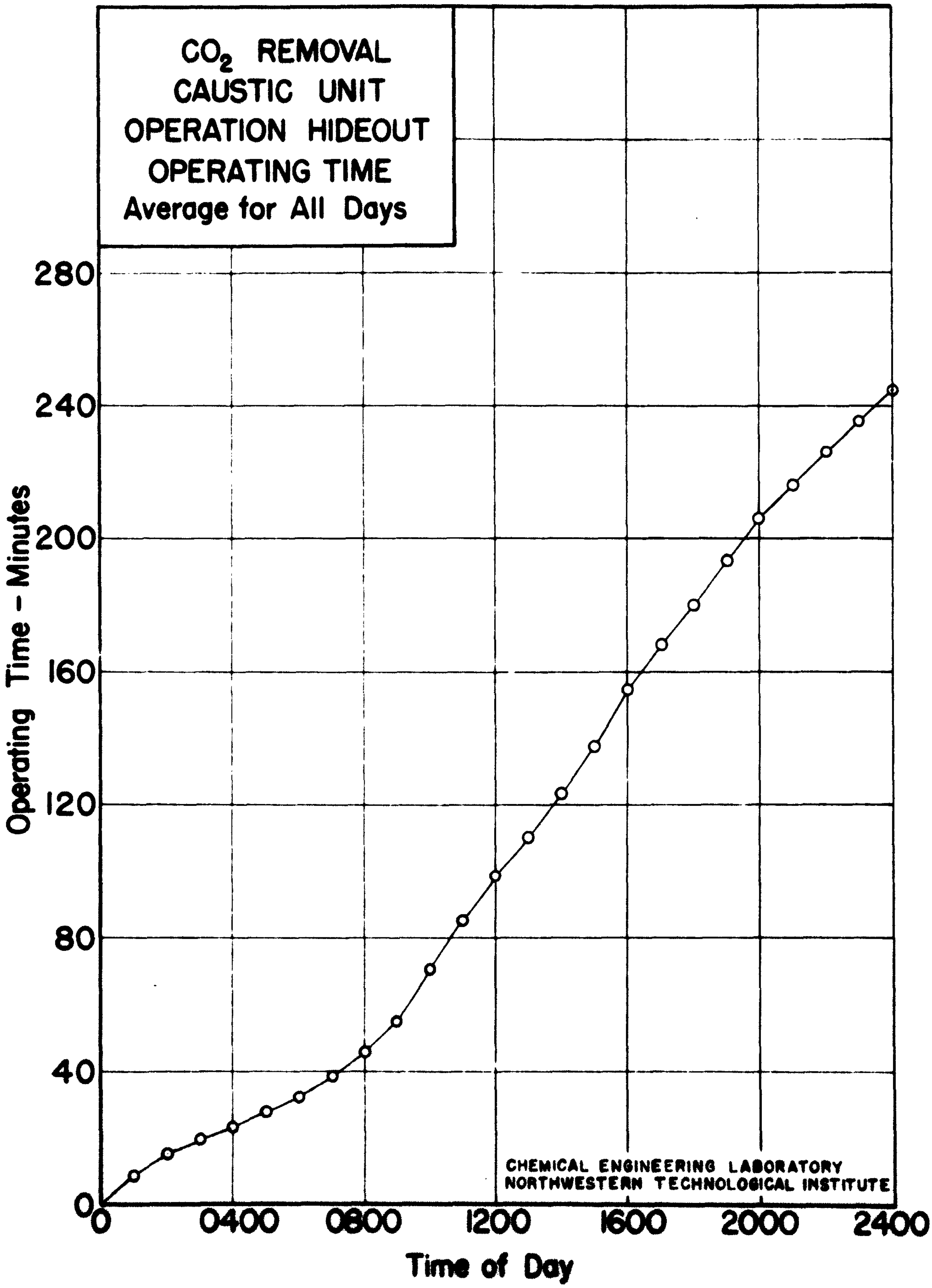

CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
Average for All Days
Operating Time - Minutes
280
240
200
160
120
80
40
0
0
0400
0800
1200
1600
2000
2400
Time of Day
CHEMICAL ENGINEERING LABORATORY
NORTHWESTERN TECHNOLOGICAL INSTITUTE

Figure 13

RESTRICTED

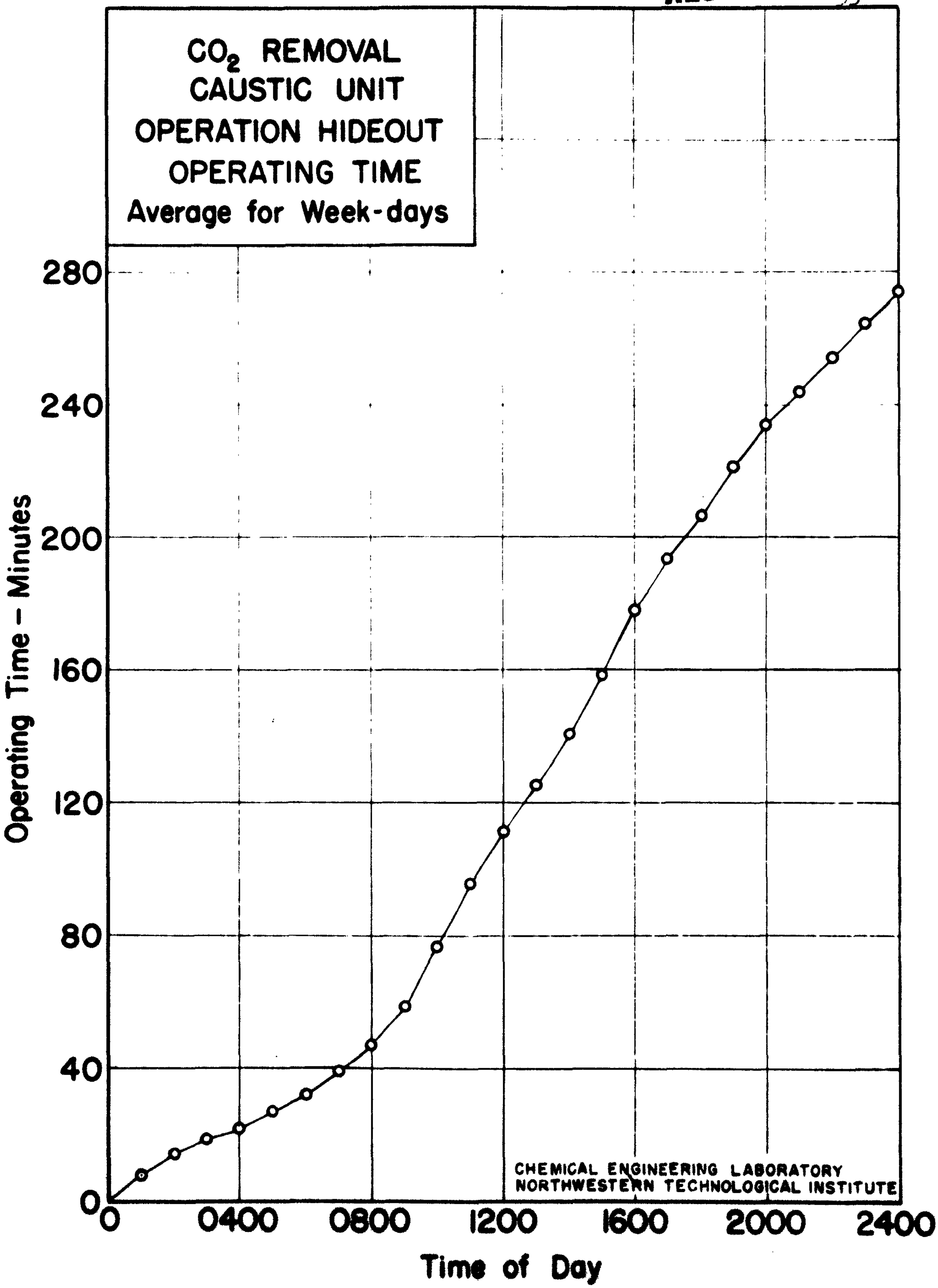


Figure 14

RESTRICTED

RESTRICTED

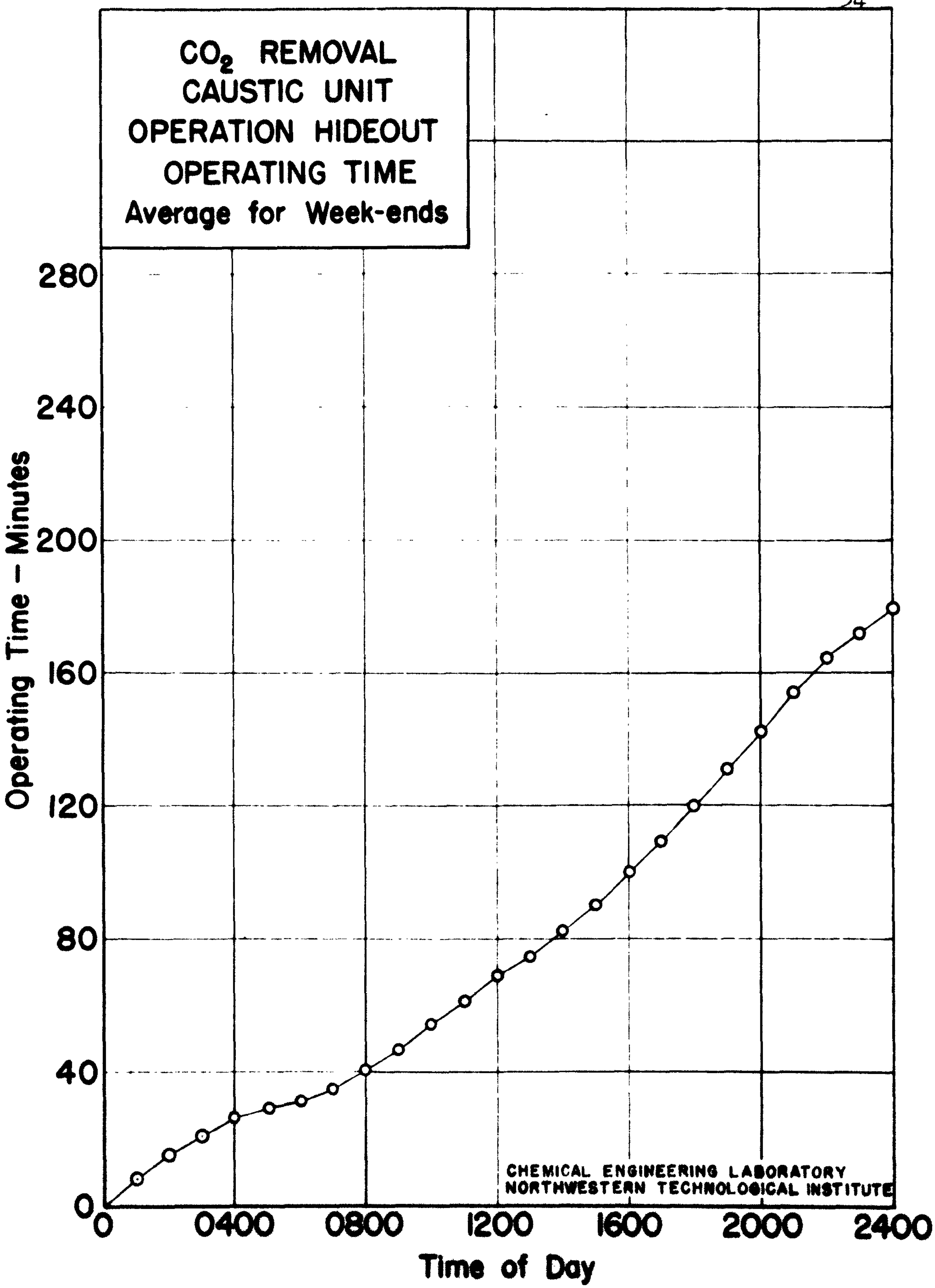


Figure 15

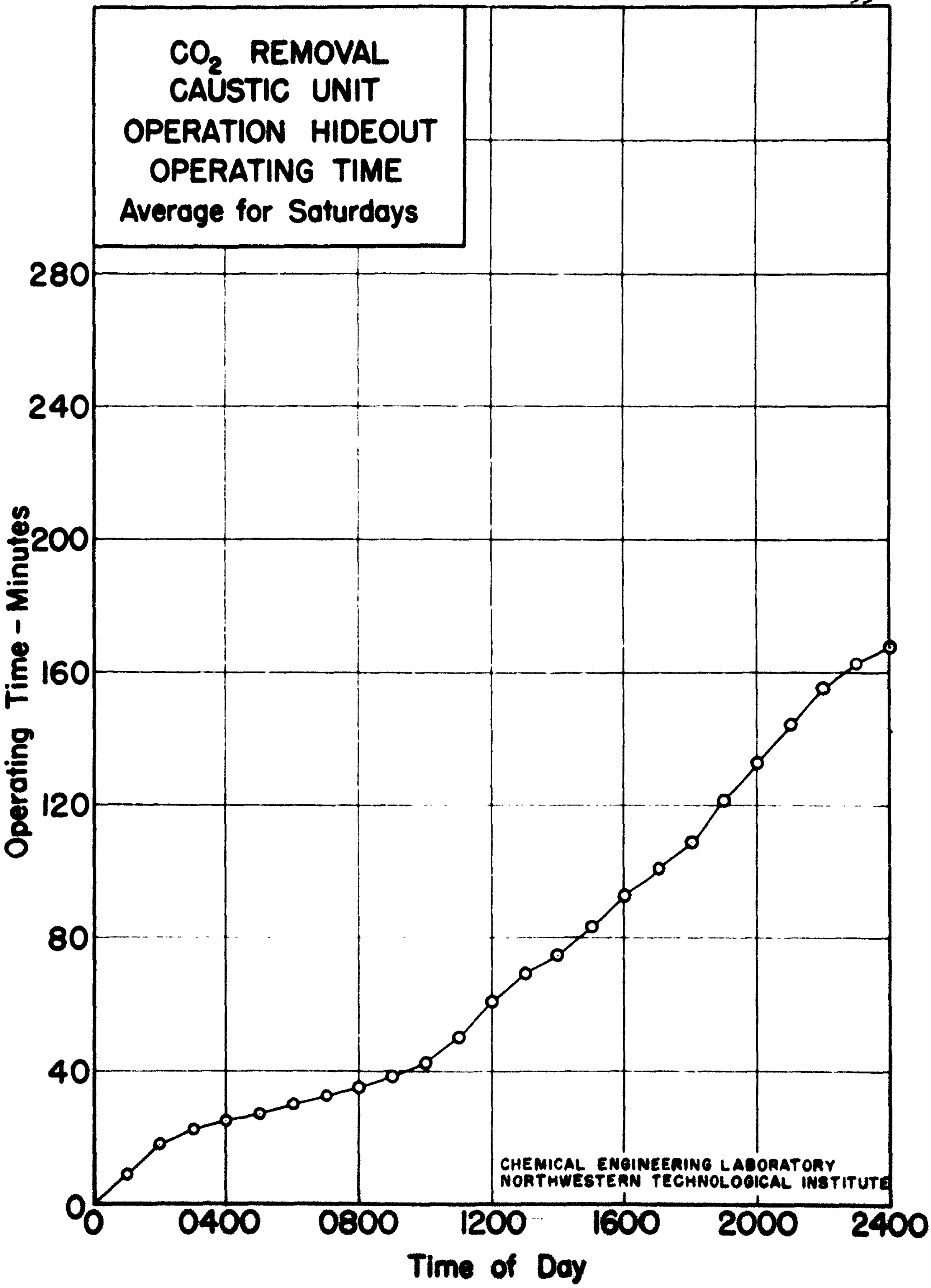
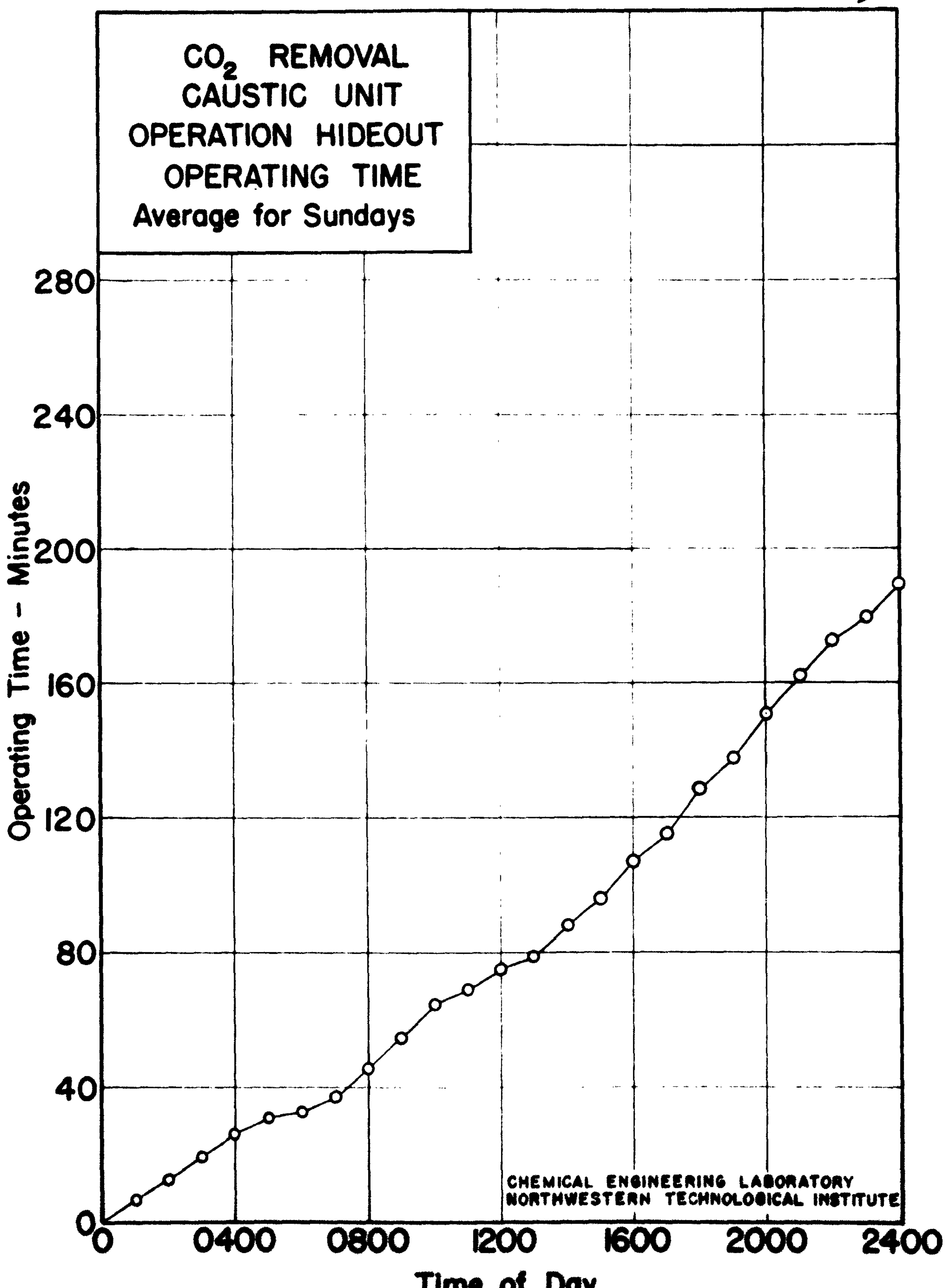

CO₂ REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
Average for Saturdays
Operating Time - Minutes
280
240
200
160
120
80
40
0
0
0400
0800
1200
1600
2000
2400
Time of Day
CHEMICAL ENGINEERING LABORATORY
NORTHWESTERN TECHNOLOGICAL INSTITUTE

Figure 16



CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
Average for Sundays
Operating Time - Minutes
0
40
80
120
160
200
240
280
0
0400
0800
1200
1600
2000
2400
Time of Day
CHEMICAL ENGINEERING LABORATORY
NORTHWESTERN TECHNOLOGICAL INSTITUTE

Figure 17

carbonate ion as obtained in the analysis of the liquid effluent. The equation for obtaining these values is shown in Note 3 on the first page of Table 7.

A more rigorous determination of the amount of carbon dioxide absorbed was measured by the amount of solution passing through the scrubber and the amount of conversion of the hydroxide ion to the carbonate ion as obtained in the exact analysis of the liquid effluent. The net feed solution flow was determined from the pump, the operating time, and was adjusted for evaporation losses and leakage past the pump when such existed. The total operating time for each day, the total carbon dioxide absorbed each day, and the carbon dioxide absorption rate for each day are tabulated in Table 4. A plot of the carbon dioxide absorbed each day is plotted vs. the date in Figure 18. Also, a plot of the carbon dioxide absorption rate vs. the date is presented in Figure 19.

Table 4

OPERATING TIME AND CO_2 ABSORPTION
DAILY SUMMARY

Date	Operating Time	Carbon Dioxide Absorbed	
		Total	Rate
	Minutes	lbs	lbs/hr
January			
28	329.19	65.33	11.90
29	312.48	51.59	9.90
30	243.28	20.94	5.16
31	123.10	7.90	3.85
February			
1	140.05	9.73	4.18
2	245.59	31.30	7.65
3	219.13	32.45	8.89
4	225.81	31.66	8.40
5	211.13	27.89	7.90
6	198.42	25.74	7.80
7	159.65	17.39	6.51
8	187.59	26.65	8.51
9	241.35	27.08	6.74
10	168.33	26.31	9.40
11	181.23	33.05	10.91
12	290.25	53.32	11.02
13	229.72	41.16	10.75
14	138.69	24.77	10.72
15	137.21	20.24	8.84
16	278.97	45.67	9.82
17	330.18	53.48	9.72
18	311.82	51.00	9.81
19	262.07	41.14	9.41
20	279.74	46.04	9.88
21	207.58	35.13	10.15
22	170.62	31.10	10.95
23	229.06	39.56	10.37
24	301.87	50.16	9.97
25	281.44	47.80	10.19
26	367.18	60.62	9.91
27	325.06	55.44	10.23
28	214.50	39.36	10.99
March			
1	224.62	40.65	10.87
2	275.15	50.75	11.06

Table 4 (cont.)

OPERATING TIME AND CO_2 ABSORPTION

Date	Operating Time	Carbon Dioxide Absorbed	
		Total	Rate
	Minutes	lbs	lbs/hr
March			
3	334.57	56.21	10.07
4	320.33	52.66	9.84
5	340.93	54.87	9.66
6	234.37	41.23	10.54
7	163.07	27.58	10.14
8	238.06	38.10	9.60
9	346.67	55.21	9.55
10	312.43	44.11	8.52
		1632.37	9.77

	Total	Rate
Total and rate (all days)	1632.37	9.77
Total and rate (weekdays)	1274.21	9.94
Total and rate (Saturdays, Sundays, and Holidays)	358.16	9.21
Total and rate (Saturdays only)	152.13	9.07
Total and rate (Sundays and Holidays only)	206.03	9.31

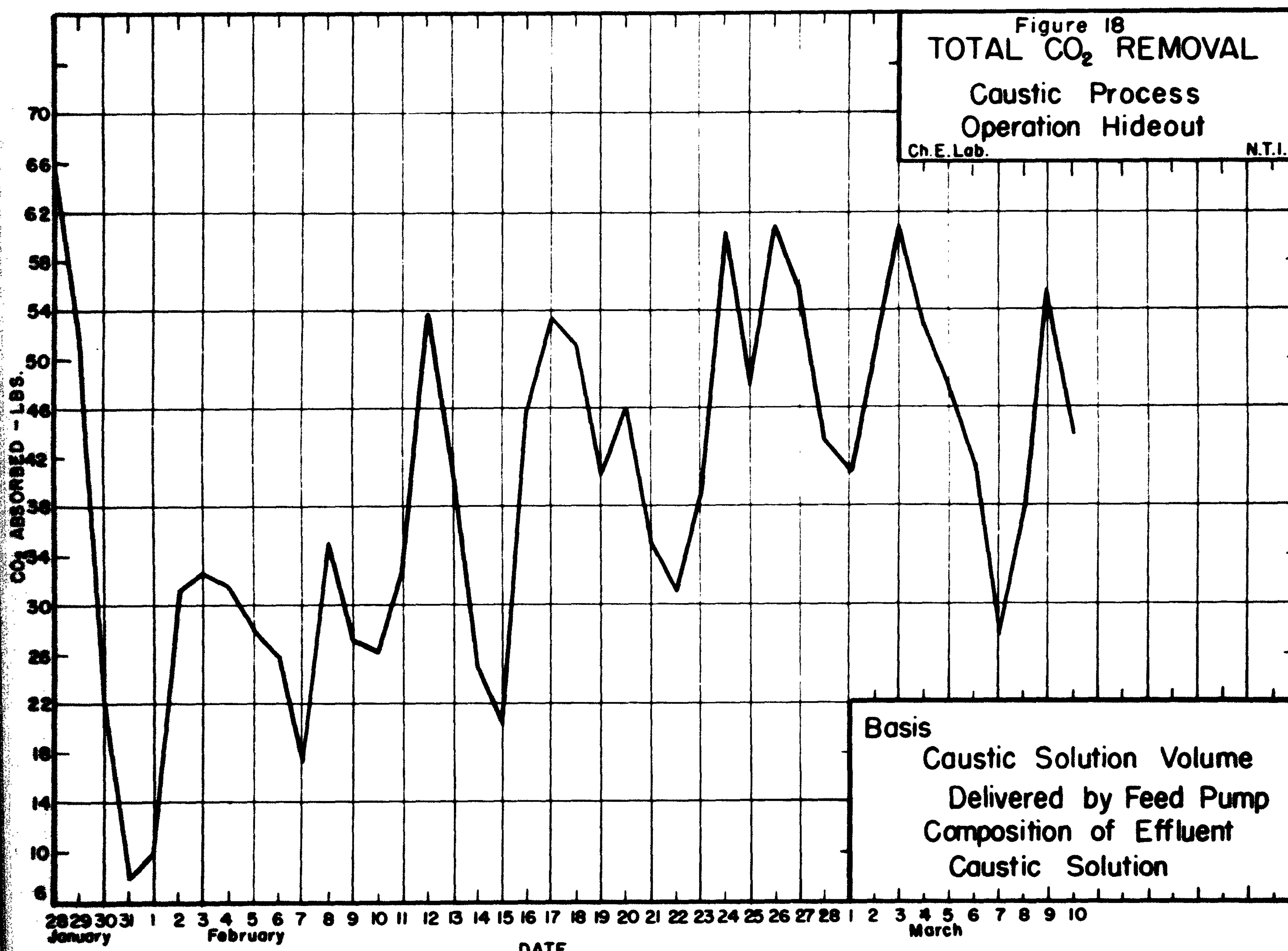


Figure 18
TOTAL CO_2 REMOVAL
Caustic Process
Operation Hideout
Ch.E.Lab.
N.T.I.
Basis
Caustic Solution Volume
Delivered by Feed Pump
Composition of Effluent
Caustic Solution
CO_2 ABSORBED - LBS.
70
66
62
58
54
50
46
42
38
34
30
26
22
18
14
10
6
28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 1 2 3 4 5 6 7 8 9 10
January
February
March
DATE

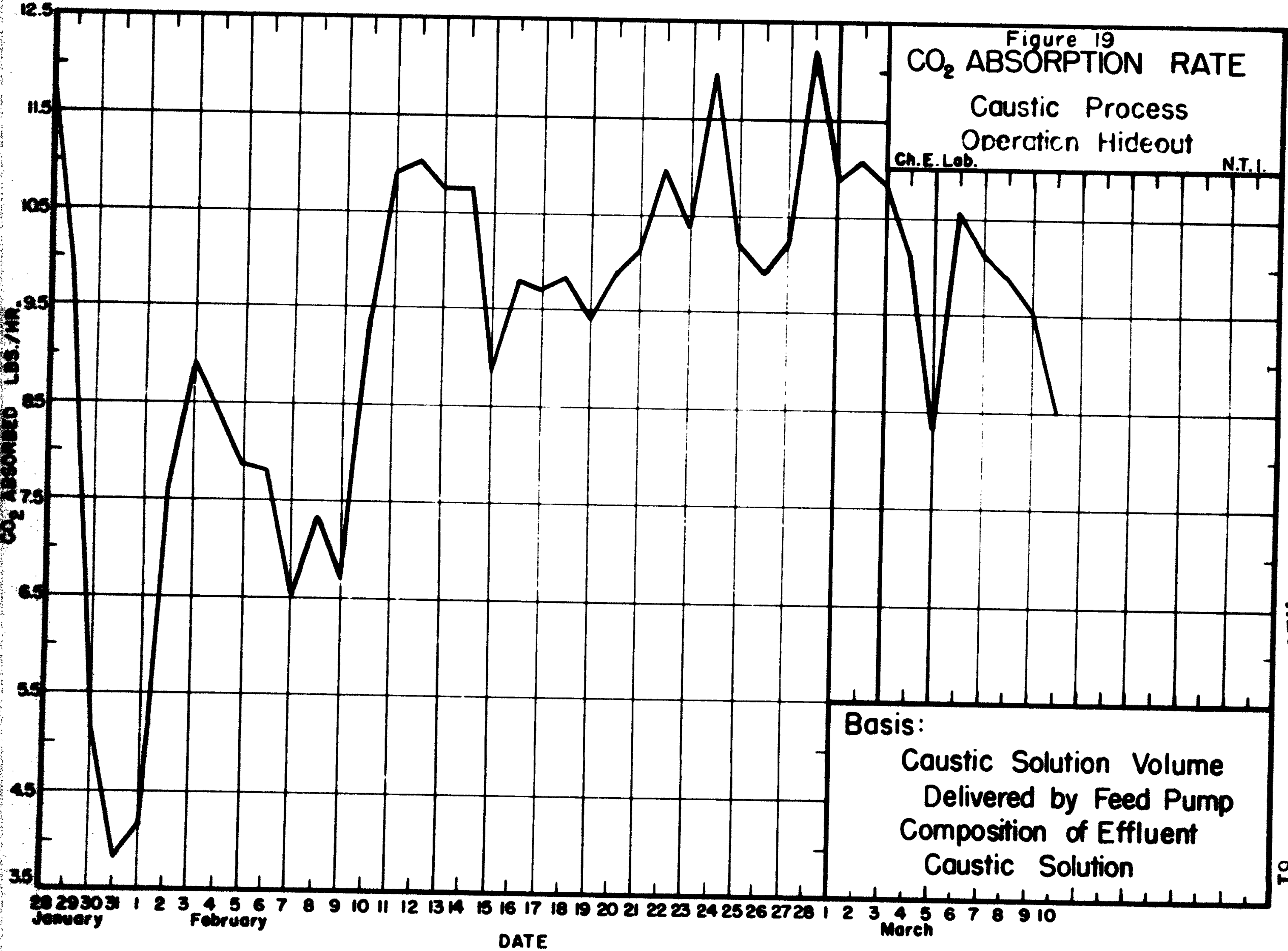


Figure 19
CO_2 ABSORPTION RATE
Caustic Process
Operation Hideout
Ch.E. Lab.
N.T.I.
Basis:
Caustic Solution Volume
Delivered by Feed Pump
Composition of Effluent
Caustic Solution
CO_2 ABSORBED LBS./HR.
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 1 2 3 4 5 6 7 8 9 10
January
February
March
DATE

INTERPRETATIONS OF RESULTS

An observation of Figure 13, the cumulative operating time of the scrubber vs. the time of the day shows a low operating time and thus a low carbon dioxide generation rate between midnight and 0800. About 0600 the scrubber operating time begins to increase until 0900 at which time it reaches its maximum operating time per hour. This maximum operating time is maintained until 2000 o'clock at which time the operating time begins to decrease. This pattern is even more pronounced in Figure 14 which is for weekdays only.

The operating time is nearly constant throughout a 24-hour day on weekends as shown in Figure 15. When the weekends are separated into Saturdays and Sundays, it is found that it is principally on Sunday that the rate is nearly constant throughout the 24-hour period. It is interesting to note that the rate is high between midnight Friday and 0200 on Saturday, after which it tapers off rapidly and is maintained at a low rate until 0900 when the rate increases again.

The amount of carbon dioxide absorbed each day is presented in Figure 18. The result of low activity on weekends is, of course, reflected here also. Sundays fall on February 1, 8, 15, 22, March 1 and 8. Saturdays and Sundays generally show a lower amount of carbon dioxide removal, which reflects a lower amount of carbon dioxide generated. The test ended at 2000 on March 10, so the value for that day does not represent a full 24-hour period.

The rate of carbon dioxide absorption is shown in Figure 19.

The low values obtained through February 9 can be attributed to analysis difficulties. The preparation and standardization of an acid, and the training of an analyst were problems in this period. Data obtained for later dates, the accuracy of which was more exact, indicates that these early values are undoubtedly low. Since no means were available for adjusting these values, no attempt was made to do so.

The average carbon dioxide removal rate for the 42 days was 9.77 pounds per hour. This is higher than the 7.50 pounds per hour which the unit was designed to remove from air with 1% carbon dioxide. A higher value than 7.5 was expected and the test verified the exact value of this rate. The rate over the last 27 full days was 10.6 pounds per hour. The high absorption rate at a higher per cent carbon dioxide in the air was indicated in a chart in a previous report,(3) though the value presented there was conservative.

A result of the increased absorption was an increase in the conversion of the caustic to the carbonate. This was a result indirectly attributed to the 1.5% carbon dioxide content of the air. The conversion normally ranged between 85% and 94%, while it would have been 80% if the unit had been operating under the original design conditions. This result was also expected.

An exact average of the conversion of the caustic would be difficult to obtain without many more analyses of the liquid effluent. However, a weighted average was obtained by weighting the percent conversions for each day's liquid analyses to get a daily weighted average. The weighted average percent conversions of caustic for each day are listed in Table 5 and are plotted in Figure 20. The simple overall average was obtained by averaging the daily weighted averages, and the weighted overall average by averaging the weighted percent conversions. The averages are respectively 87.4 and 90.3%. The values of the weighted daily averages and the overall averages are quite accurate since the percent conversion varied over a narrow range throughout the test.

The chain of interacting influences reach a stabilized point at which the tower operates. The amount of carbon dioxide absorbed depends on the value of $K_g a$, the mass transfer coefficient, and the driving potential, $(\Delta y)_m$ in the equation

$$N = K_g aVP(\Delta y)_m$$

where N is the pounds of carbon dioxide absorbed per hour, V is the scrubber volume, and P is the total pressure of the system.

The increase in the inlet carbon dioxide concentration from 1% to 1.5% would tend to increase the amount of carbon dioxide absorbed, N, by 50%. With no change in the rate of feed of the caustic solution, the percent conversion would increase. As the percent conversion increases, the value of the $K_g a$ decreases. An absorption increase slightly less than 50% would thus be expected. The $K_g a$ could be maintained constant by increasing the feed rate of the caustic solution so that the conversion of hydroxide ion to carbonate ion was the 80% design figure. The first procedure

Table 5

CAUSTIC UTILIZATION

DAILY WEIGHTED AVERAGE

Date	Utilization	Date	Utilization
	Percent		Percent
January		February	
28	88.8	18	88.0
29	89.4	19	86.9
30	90.2	20	88.8
31	95.9	21	90.9
February		22	90.8
1	96.7	23	84.6
2	91.0	24	89.2
3	87.2	25	90.6
4	92.3	26	87.2
5	87.5	27	86.3
6	90.4	28	86.9
7	85.9	March	
8	86.0	1	85.2
9	88.2	2	91.9
10	74.9	3	90.5
11	72.6	4	90.1
12	74.7	5	87.7
13	76.8	6	89.5
14	75.2	7	92.1
15	75.7	8	93.9
16	87.2	9	93.2
17	88.8	10	90.9

Simple Overall Average 87.4

Weighted Overall Average 90.3

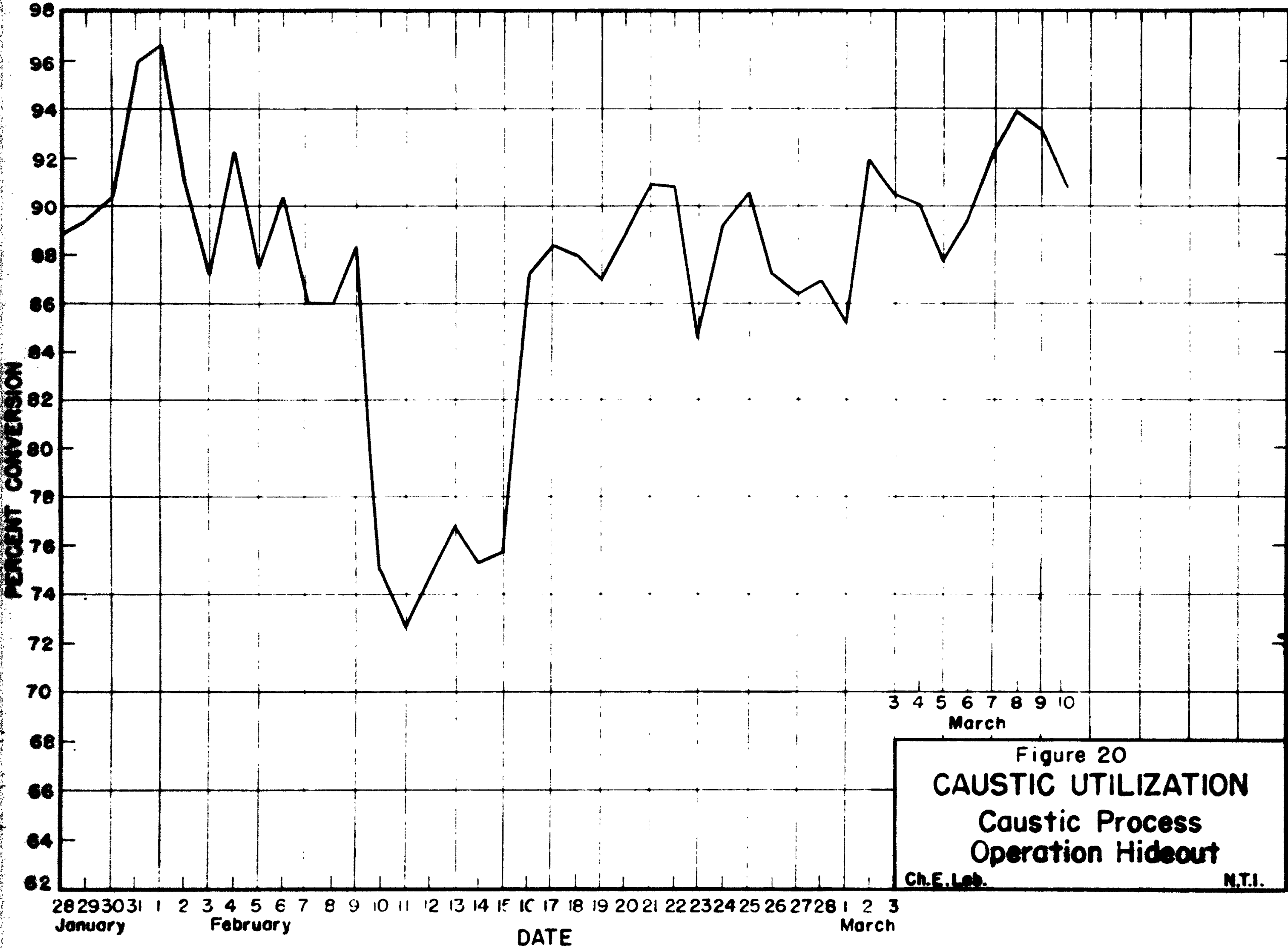


Figure 20
CAUSTIC UTILIZATION
Caustic Process
Operation Hideout

was followed since it was felt the additional increase in carbon dioxide absorption would not be as important as the increase in utilization of the caustic.

The average amount of carbon dioxide removed per day (33.9 pounds) does not equal the previously determined amount of carbon dioxide that 23 humans would generate(4) in one day (50.7 pounds). If only the data between the dates 2/11/53 through 3/9/53 are used, which are considered more reliable, the average carbon dioxide removed per day is 43.9 pounds. These values are shown in Table 6.

There are several factors in this operation which [illegible] account for the deviation:

(1) The average activity of the personnel may be lower than that required to generate carbon dioxide at the average rate.

(2) There may be exchange of air with the outside air.

(3) There may be leakage due to a slight pressure differential between the submarine interior and the surroundings.

Item one can undoubtedly account for part of this deviation. During weekdays only, when the activity was probably at more nearly the average rate, the average carbon dioxide removed during the whole test was 43.9 pounds per day. During the 27 days from 2/11/53 through 3/9/53 the average carbon dioxide removed was 49.4 pounds per day. These values are respectively 6.8 and 1.3 pounds less than the accepted rate.

The generation rate of one person at rest was given as 0.50 cfh(1) or 33.8 pounds per day for 23 men. Activity on weekends might better be compared to this value. The average carbon dioxide removed per day over weekends was 27.6 pounds (average over whole test) and 32.9 pounds (average over period 2/11/53 through 3/9/53). These values are respectively 6.2 and 0.9 pounds less than the previously determined value.

A source of carbon dioxide loss would be present if the boat pressure was slightly greater than the outside pressure and there was a leak. The carbon dioxide loss would depend on the rate of this leak. This leak could not continue very long without equalizing the pressure or requiring that more air be supplied to the inside of the submarine. Since nitrogen would also be lost in a leak, added oxygen along could not compensate for the leak since its feed rate was governed by the percent of oxygen in the submarine air. Either nitrogen or air must also be supplied to the interior of the submarine. The carbon dioxide loss would depend on the leak rate, and if the leak rate was uniform, the carbon dioxide loss would be fairly constant. The figures arrived at by various assumptions for the carbon dioxide loss during weekdays and during weekends are about the same and might be accounted for in this manner.

At the conclusion of Operation Hideout, Dr. Nichols made a leak test on the submarine that was used and obtained a 4.68% leakage in 12 hours. Assuming a net volume in the submarine of 23,000 cu. ft., this leak rate would indicate a loss of 23.8 cu. ft. of carbon dioxide per day or approximately 2.75 pounds per day of carbon dioxide if the volume is measured at 60°F and 760 mm. Hg.

Another factor to be considered is the exchange of air between the submarine and its surroundings. This could be due to the breathing of the submarine through small openings and would be caused by changes in barometric pressure and by air temperatures both inside and outside. It could be due to exchange through the air lock due to traffic entering and leaving. This would depend on the traffic volume and should be higher on weekdays when the medical teams and other personnel were observing or inspecting. These extra personnel would also contribute to the carbon dioxide generation, however, and it is possible that these two factors essentially cancelled each other.

The interchange of air for each passage through the hatch cannot be determined accurately. With some assumptions and estimates, an order of magnitude of the possible carbon dioxide loss through this means can be indicated. Let it be assumed that the hatch has a volume of approximately 50 cubic feet and that the air in this volume approaches within 0.2% of the concentration of the atmosphere on the other side of the open hatch. That is, when the hatch is opened to the submarine interior and a man enters or leaves the hatchway, the air in the hatchway has 1.3% carbon dioxide. When the hatch is opened to the outside and a person enters or leaves, the air has a carbon dioxide content of 0.2%. The net loss of carbon dioxide per opening is

$$50\ (.013-.002)\ \text{cu. ft./passage}$$

or

$$\frac{50}{379}(100)(.013-.002) = .1375 \text{ lb mols/100 passages}$$
$$= 6.05 \text{ lbs/100 passages}$$

This is based on an average temperature and pressure of 60°F and 760 mm. Hg.

It is apparent from the preceding analysis that there could be a loss of carbon dioxide to the outside. The loss of air that must contain this carbon dioxide is

$$\frac{(1)}{(44)}\frac{(379)}{(.015)}(1) = 574 \text{ cu. ft./lb of carbon dioxide lost}$$

If the assumptions are very accurate, then on a weekend, about 15 openings of the hatch in a 24-hour period would account for the carbon dioxide loss during the last 27 full days of the test. This would mean an exchange of air of about 500 cubic feet.

The oxygen concentration was maintained at a value essentially the same as the ambient air. If this concentration had been essentially different, the oxygen consumption could be used to check the carbon dioxide deviations.

The possible losses of carbon dioxide are indicated as possibilities since it is also possible that there were no appreciable losses and the values obtained, properly adjusted, should be used as the basis of carbon dioxide generation in future planning.

The variation of the carbon dioxide absorbed per day can be attributed thus to several factors. The variation of the carbon dioxide absorption rate can be attributed to variation in the liquid analyses. Sources of error are in the analyses themselves and in the sample procurement. Precautions were taken to minimize both of these.

Another cause of the variation would be the gas analyses. If one day the carbon dioxide concentration was kept consistently high (for example 1.6%) and another day the concentration was maintained consistently low (1.4%), there would be a deviation of the absorption rate. Such a gas composition variation would cause a variation in the rate of about 13%.

A slight variation in the value of the carbon dioxide absorbed per day is due to the clock which was used. The clock gained such that after several days it would be necessary to set it back a half hour. On such days the elapsed time was about 24-1/2 hours in one day. This factor would tend to be smoothed out and become unimportant in the averages.

An observation of the chart, Figure 18, for carbon dioxide absorption indicates an upward trend in the carbon dioxide removal as the test proceeded. Even when the early days of the test are discounted, a slight trend is in evidence.

CONCLUSIONS AND RECOMMENDATIONS

The conclusion drawn from this test was that the equipment excellently performs the task for which it was designed. It removes carbon dioxide at the desired rate with adequate utilization of the caustic. The scrubber was designed to maintain a 1% carbon dioxide atmosphere. Since in Operation Hideout it was required to maintain a 1.5% carbon dioxide atmosphere, the removal rate and per cent of caustic utilization were higher than the design values. These results were expected.

The scrubber is expected to remove or reduce the concentration of all base reactive material from air and to absorb physically many other materials. The caustic solution is saturated with air and will not absorb any oxygen or nitrogen. The caustic solution will remove chlorine and acrolein, for example. The odors, cigarette smoke and other fumes were very low in the opinion of veteran submarine personnel, and this lack of odors and smoke can be attributed to their removal by the caustic scrubber.

The research which is required in the future on this caustic system can be divided under two principle headings, (1) the adaptation of the unit to the submarine and the final design of a unit, and (2) the improvement of the system. The work to be done is outlined below.

1 Build a package unit for the actual conditions and requirements for standard installation on a submarine. This would require close liaison with navy personnel familiar with navy requirements.

1.1 A knowledge would be required of the space available, the size, shape and location of this space. Whether the available space is in one or several pieces must be known.

1.2 Design and build the equipment to fit this space.

1.2.1 Procure a recycle pump of the proper sound and power characteristics.

1.2.2 Determine the blower source, whether the available blowers could be utilized for the unit if desired, or if a blower must be provided.

1.2.3 Study the method of disposal of waste. This would determine if waste was to be discharged continually or periodically.

1.2.4 Determine minimum sea pressure during which unit would be operating. This would determine whether a feed pump was necessary.

1.2.5 Procure a flow control device for automatically controlling feed rates.

1.2.6 Determine if it were desirable to have unit controlled from a carbon dioxide analyzer. If required, procure an instrument and adapt it to the scrubber. If scrubber is to be turned on manually when carbon dioxide analysis indicates that it should, a single switch would be sufficient.

2 Study methods to improve the unit.

2.1 Study the physical design to obtain a more streamlined unit without affecting the efficiency of the unit.

2.2 Study alternate methods of contacting to determine if a reduction in equipment volume, fluid flow rates, and power requirements can be attained.

2.2.1 Study contacting with spray nozzles.

2.2.2 Study contacting with porous plates.

2.2.3 Study contacting with other means.

2.3 Study use of alternate materials to determine if reduction of items in 2.2 can be attained. This would include studies on such material as potassium hydroxide.

ACKNOWLEDGMENT

The Chemical Engineering Laboratory of Northwestern Technological Institute would like to acknowledge the assistance given to us by the personnel of the Medical Research Laboratory under the command of Commander G. J. Duffner. We would like to express our appreciation to all the personnel and particularly to the following:

Lt. Commander R. E. Faucett, Officer in Charge of Haddock

Lt. P. P. Newman, Project Officer

Lt. G. Nichols, Jr.

Chief J. D. Evans

Chief J. J. MacArthur

ET3 J. Elais

ET3 K. D. Merrill

ET3 D. T. Millspaw

FN J. King, Jr.

SN R. Fisher

All other members of the working party

All other volunteers on the Haddock

BIBLIOGRAPHY

1. Gray, J. S., Northwestern University, personal communication.
2. Report 22, September 30, 1951, Northwestern Technological Institute, Chemical Engineering Laboratory, Submarine Habitability Project N6 ori 158-03.
3. Report 23II, December 31, 1951, Northwestern Technological Institute, Chemical Engineering Laboratory, Submarine Habitability Project N6 ori 158-03.
4. Schaefer, K. E., Studies of Carbon Dioxide Toxicity: (1) Chronic Carbon Dioxide Toxicity in Submarine Medicine, MRL No. 181, 10, pp. 156-176.
5. Sverdrup, Johnson, and Fleming, THE OCEANS, Prentice-Hall, New York (1946).

APPENDIX

(Pages 79 through 121)

Table 7

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 27 January 1953

Time (1)	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer (2) 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition Inlet: OH^-	$CO_3^=$	Na^+	Outlet: OH^-	$CO_3^=$	Na^+	CO_2 Absorbed: Net (3)	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol.%	min.	min.	"H_2O	$ft.^3$	$ft.^3$	$ft.^3/hr.$	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
2000	2.4	1.8				—	0000			268.79											CO_2 reached 1.5%
2030	2.1	1.5																			
2100	1.35	1.5																			Experiment Started
2130																					
2200																					
2230							0000			268.79											
2300						20.3															
2330						20.5	1.72			268.85	0.06	2.09									
2400						20.3	15.80	15.80		269.43	0.61	2.32	2.49	0.04	2.53	0.19	2.39	2.58	2.00	7.61	

(1) Data recorded at nearest half hour at which they were taken.

(2) Dwyer Analyzer at 4 locations
1. Forward Torpedo Room
2. Forward Battery Room
3. After Battery Room
4. Forward Engine Room

(3) CO_2 Absorbed = (feed solution net flow, $ft.^3$)$\left(\frac{liters}{ft.^3}\right)\left(\frac{1}{2}\right)\left(\frac{44}{454}\right)$($CO_3^=$ outlet) = 1.372 ($ft.^3$ feed) ($CO_3^=$ outlet) = lbs. CO_2

(4) Chemicals changed or battery charged in instrument for CO_2 control (Gow Mac). Readings within $\pm$ 30 min. of this time are subject to error.

(5) Scrubber running continuously for extended period, on 1444, off 1709 o'clock.

(6) No reading because scrubber is running.

(7) Feed displacement type meter failed.

(8) End of recorder roll for speedomax. recorder.

(9) Clock used as basis of clock time was reset.

(10) Extra water added to tower to dilute solution.

(11) Concentration based on normality of 0.242 for standard acid. This normality was found to be high.

(12) Speedomax recorder inoperative.

(13) Low pressure air being bled into submarine at the rate of 3 cfm in order to analyze the enclosed atmosphere for trace substances. Air bleeding started at 1350 and ended at 1711.

(14) CO_2 added to submarine to increase percentage.

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 28 January 1953

Time (1)	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Timer Reading	Time Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000						20.0	15.80		10.3"	269.43			2.49	0.04	2.53	0.19	2.39	2.58			
0030						20.3	22.33	6.53	app.	269.70	0.27	2.48									
0100		1.4	1.5	1.4	1.4	20.2	22.33	6.53		269.73	0.30	2.76									
0130						20.5	28.23	12.43		269.93	0.50	2.41									
0200		1.7	1.6	1.5	1.5	20.7	31.08	15.28		270.01	0.58	2.28									
0230						20.7	34.78	18.98		270.20	0.67	2.12									
0300		1.6	1.3	1.1	1.0	20.6	41.02	25.22		270.43	1.00	2.38									
0330						20.5	43.80	28.00		270.53	1.10	2.36	2.48	0.01	2.49	0.29	2.35	2.64	3.54	7.61	
0400		1.3	1.2	1.3	1.1	20.4	50.38	34.58		270.81	1.37	2.38									
0430						20.3	64.30	48.50		271.32	1.89	2.34									
0500		1.5	1.4	1.5	1.4	20.2	68.42	52.62		271.55	2.12	2.42									
0530						20.2	69.67	53.87		271.60	2.17	2.42									
0600		1.5	1.5	1.4	1.5	20.2	78.42	62.62		271.97	2.54	2.43									
0630						20.3	78.42	62.62		271.97	2.54	2.43									
0700		1.3	0.5	0.6	0.6	–	83.08	67.28		272.11	2.68	2.39									
0730						–	90.08	74.28		272.45	3.02	2.44									
0800		1.1	1.3	1.3	1.2	–	90.08	74.28		272.45	3.02	2.44									
0830						–	90.08	74.28		272.45	3.02	2.44									
0900		1.2	1.4	1.3	1.2	20.3	90.08	74.28		272.45	3.02	2.44									
0930						–	93.08	77.28		272.55	3.12	2.42									
1000		1.0	1.4	1.4	1.3	20.0	102.44	86.64		272.95	3.52	2.44									
1030						–	102.44	86.64		272.95	3.52	2.44									
1100		1.3	1.4	1.4	1.4	19.7	107.07	91.27		273.13	3.70	2.43									
1130						–	107.07	91.27		273.13	3.70	2.43									
1200		1.1	1.2	1.1	1.3	–	122.83	107.03		273.78	4.35	2.44									
1230						–	130.60	114.80		274.09	4.66	2.44									
1300		1.4	1.3	1.2	1.3	–	130.60	114.80		274.09	4.66	2.44									
1330						–	130.60	114.80		274.09	4.66	2.44									
1400		1.7	1.6	1.4	1.5	–	136.88	121.08		274.28	4.85	2.40									
1430	1.9					–	149.52	133.72		274.85	5.42	2.43							26.28	14.90	
1500		1.4	1.4	1.4	1.4	–	(5)			(5)											Scrubber
1530	1.8					–	(5)			(5)						0.56	4.44	5.00			running
1600		1.3	1.1	1.2	1.4	–	(5)			(5)											continu-
1630						21.0	(5)			(5)											ously.
1700		1.0	1.1	0.5	0.7	20.95	(5)			(5)											From 1444
1730						20.95	294.48	278.68		280.88	11.45	2.47									to 1709
1800		1.3	1.2	1.3	1.2	20.8	294.48	278.68		280.88	11.45	2.47									
1830						20.85	294.48	278.68		280.88	11.45	2.47									
1900		1.5	1.3	1.3	1.1	20.8	300.16	284.36		281.13	11.80	2.49									
1930						20.75	305.76	289.96		281.37	11.94	2.47									
2000		1.5	1.4	1.5	1.2	20.70	312.98	297.18		281.61	12.18	2.46									
2030						20.70	312.98	297.18		281.61	12.18	2.46									
2100		1.7	1.5	1.8	1.6	20.08	312.98	297.18		281.61	12.18	2.46									
2130						20.61	320.48	304.68		281.98	12.55	2.47									
2200		1.5	1.5	1.5	1.4	20.59	327.51	311.71		282.26	12.83	2.47									
2230						20.55	327.51	311.71		282.26	12.83	2.47									
2300		1.5	1.5	1.5	1.5	20.5	330.84	315.04		282.39	12.96	2.47									
2330						20.44	337.49	321.69		282.67	13.24	2.47									
2400		1.6	1.3	1.6	1.3	20.45	344.99	329.19		283.00	13.57	2.47					3.40		63.10	11.50	Estimate on $N_{CO_3^=}$

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 29 January 1953

Time (1)	CO_2 Conc. in Air: Listen Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH	Inlet CO_3	Inlet Na^+	Outlet OH	Outlet CO_3	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.6	1.3	1.6	1.3	20.45	344.99			283.00											
0030						20.4	346.10	1.11		283.03	0.03	1.62									
0100		1.3	1.6	1.6	1.5	20.4	350.46	5.47		283.21	0.21	2.30									
0130						20.4	351.02	6.03		283.24	0.24	2.39									
0200		1.5	1.4	1.6	1.4	20.32	361.05	16.06		283.66	0.66	2.47									
0230						20.25	361.83	16.84		283.70	0.70	2.49									
0300		1.4	1.3	1.3	1.5	20.3	362.24	17.25		283.74	0.74	2.57									
0330						20.25	365.30	20.31		283.85	0.85	2.51									
0400		1.5	1.4	1.4	1.5	–	365.59	20.60		283.87	0.87	2.53									
0430						20.2															
0500		1.6	1.6	1.6	1.5	20.2	374.89	29.90		284.26	1.26	2.53									
0530						20.35	398.68	53.69		285.48	2.48	2.77									
0600		1.6	1.7	1.7	1.6	20.35	420.95	75.96		286.25	3.25	2.57									
0630						20.35															
0700		1.8	1.6	1.6	1.6	–	477.27	132.28		288.96											Probable Record Error
0730						–															
0800		1.2	1.2	1.2	1.3	–															
0830						20.18	477.73	132.74		288.68	5.68	2.57									
0900		1.3	1.3	1.3	1.1	20.08	477.73	132.74		288.68	5.68	2.57									
0930						20.02	477.73	132.74		288.68	5.68	2.57									
1000		1.4	1.4	1.6	1.5	20.00															
1030						20.00	487.00	142.01		289.08	6.08	2.57									
1100		1.1	1.1	1.5	1.4	20.0	489.23	144.24		289.18	6.18	2.57									
1130						20.0	491.73	146.74		289.28	6.28	2.57									
1200		1.5	1.4	1.5	1.4	20.0	497.70	152.71		289.55	6.55	2.57									
1230						20.25	513.52	168.53		290.24	7.24	2.58									
1300		1.5	1.4	1.5	1.3	20.4	519.43	174.44		290.49	7.49	2.58	2.35	0.06	2.41	0.30	2.38	2.68			
1330																					
1400		1.5	1.4	1.5	1.5	20.5	527.38	182.39		290.85	7.85	2.58							25.6	8.42	
1430						20.5	527.38	182.39		290.85	7.85	2.58									
1500		1.5	1.4	1.4	1.4	20.5															
1530						20.5	563.08	218.09													
1600	1.55	1.4	1.3	1.3	1.3	20.4	583.49	238.50		291.05	8.05	2.03									
1630						20.5	591.81	246.82		291.05(7)											Meter Failed
1700		1.6	1.6	1.6	1.6	20.5	595.96	250.97		(7)											
1730						20.5	595.96	250.97		(7)											
1800		1.7	1.7	1.7	1.7	20.45	596.48	251.49		(7)											
1830						20.45	610.11	265.12		(7)											
1900		1.5	1.6	1.6	1.7	20.5	615.80	270.81		(7)											
1930						20.6	615.80	270.81		(7)											
2000		1.6	1.7	1.6	1.5	20.5	618.23	273.24		(7)											
2030						20.5	621.63	276.64		(7)											
2100		1.5	1.4	1.3	1.4	–	625.71	280.72		(7)											
2130						20.51	634.11	289.12		(7)											
2200		1.5	1.5	1.4	1.5	20.41	638.01	293.02		(7)											
2230(4)							642.19	297.20		(7)											
2300		1.4	1.3	1.5	1.4	20.5	644.80	299.81		(7)											
2330						20.5	651.09	306.10		(7)											
2400		1.3	1.3	1.3	1.5	20.47	657.47	312.48		(7)											

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 30 January 1953

Time (1)	CO_2 Conc. in Air: Liston Becker	CO_2 Conc. in Air: Dwyer Analyser 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.3	1.3	1.3	1.5	20.47	657.47	2.28		(7)											Feed Meter Failed
0030						20.45	659.75	13.14		(7)											
0100		1.2	1.4	1.4	1.6	20.62	670.61	16.93		(7)											
0130						20.48	674.40	24.02		(7)											
0200		1.5	1.4	1.5	1.4	20.5	681.49			(7)											
0230						20.5															
0300		1.5	1.3	1.5	1.5	20.47															
0330						20.43															
0400		1.5	1.3	1.4	1.4	20.56															
0430						20.51															
0500		1.4	1.4	1.5	1.3	20.45	687.66	30.19		(7)											
0530						20.45	689.47	32.00		(7)											
0600		1.4	1.5	1.5	1.5	20.45	689.80	32.33		(7)											
0630						20.5	690.25	32.78		(7)											
0700		1.4	1.4	1.4	1.4	20.5	691.14	33.67		(7)											
0730						–	697.96	40.49		(7)											
0800		1.4	1.4	1.4	1.4	–	698.62	41.15		(7)											
0830																					
0900(4)		1.4	1.4	1.5	1.3	20.5	705.41	47.94		(7)											
0930						20.5															
1000		1.3	1.4	1.4	1.4	20.45	714.98	57.51		(7)			2.24	0.03	2.27	0.21	1.94	2.15			
1030						20.5	727.48	70.01		293.29											
1100		1.4	1.5	1.5	1.4	–															
1130						20.5															
1200		1.5	1.5	1.5	1.3	20.5	761.78	104.31		294.77	1.48	2.59									
1230						20.5	763.65	106.18													
1300		1.4	1.4	1.3	1.3	–	768.51	111.04													
1330						–															
1400		1.5	1.4	1.5	1.5	–															
1430						–															
1500		1.2	1.2	1.2	1.2	20.5	804.40	146.93		296.56	2.27	1.77									
1530						–															
1600		1.2	1.3	1.1	1.2	–															
1630						–															
1700		1.3	1.1	1.1	1.1	20.5	842.20	184.73		298.20	4.91	2.57									
1730						–															
1800		1.2	1.2	1.2	1.1	20.55	848.30	190.83		298.46	5.17	2.57									
1830						20.5	857.47	200.00		298.46	5.17	2.57									
1900		1.5	1.4	1.5	1.5	20.5	861.75	204.28		298.46	5.17	2.57									
1930						20.5	868.56	211.09		298.50	5.21	2.22									
2000		1.4	1.4	1.4	1.4	–															
2030						–															
2100		1.4	1.3	1.5	1.4	–															
2130						–															
2200(4)		1.4	1.4	1.3	1.4	–															
2230						20.5	893.18	235.71		299.47	6.18	2.24									
2300		1.5	1.4	1.2	1.3	20.5	898.63	241.16		299.70	6.41	2.25									
2330						–															
2400		1.4	1.5	1.4	1.4	20.45	900.75	243.28		299.76	6.47	2.24							17.21	7.22	Elapsed time 13-1/2hrs

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 31 January 1953

Time	CO_2 Conc. in Air: Liston Becker	CO_2 Conc. in Air: Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.4	1.5	1.4	1.4	20.45	900.75			299.76											Saturday (Holiday Routine)
0030						20.49															
0100(1)		0.7	1.0	0.3	1.1	20.49	905.39	4.64		299.98	0.22	2.84									
0130						20.5															
0200		0.6	1.0	0.8	0.3	20.5	912.09	11.34		300.23	0.47	2.49									
0230						20.44															
0300						20.5															
0330						20.6	914.12	13.37		300.30	0.54	2.42									
0400						20.48															
0430						20.5															
0500						20.45															
0530						20.5															
0600						20.5															
0630																					
0700																					
0730						20.5	921.58	20.83		300.61	0.85	2.45									
0800			1.6			20.5															
0830						20.5	923.88	23.13		300.70	0.94	2.44									
0900			1.6			20.6															
0930						20.5															
1000		1.3	1.4	1.4	1.3	20.5	925.15	24.40		300.75	0.99	2.43									
1030						20.5	926.22	25.47		300.79	1.03	2.43									
1100		1.2	1.3	1.3	1.4	20.5	929.22	25.47		300.94	1.18	2.49									
1130						20.5	930.85	30.10		301.00	1.24	2.47	1.09	0.02	1.11	0.12	1.10	1.22			
1200(1)		1.2	1.1	1.2	1.1	20.5	936.30	35.55		301.12	1.36	2.30									
1230						20.5	936.59	35.84													
1300		1.2	1.2	1.1	1.2	20.5	940.00	39.25		301.25	1.49	2.28									
1330(1)						20.5	943.27	42.52		301.40	1.64	2.31									
1400(4)		1.0	1.1	1.2	1.2	20.5															
1430						20.5	943.27	42.52		301.40	1.64	2.31									
1500		1.5	1.5	1.6	1.5	20.5	946.65	45.90		301.42	1.66	2.17									
1530						20.5	952.64	51.89		301.68	1.92	2.22									
1600		1.6	1.4	1.5	1.5	20.42	958.96	58.21		301.94	2.18	2.25									
1630						20.55															
1700		1.5	1.5	1.4	1.5	20.5	965.19	64.44		302.17	2.41	2.24									
1730						20.4	969.73	68.98		302.34	2.58	2.24									
1800		1.5	1.5	1.4	1.5	20.46	976.92	73.17		302.62	2.86	2.25									
1830						20.45															
1900		1.4	1.5	1.3	1.5	20.48	988.05	87.30		303.06	3.30	2.27									
1930						20.5															
2000(4)	1.52	1.4	1.4	1.4	1.5	20.46	998.50	97.75		303.49	3.73	2.29									
2030						20.50	998.50	97.75		303.49	3.73	2.29									
2100		1.3	1.2	1.4	1.4	20.50	004.98	104.23		303.76	4.00	2.30									
2130						20.45	004.98	104.23		303.76	4.00	2.30									
2200		1.5	1.3	1.5	1.4	20.45	004.98	104.23		303.76	4.00	2.30									
2230						20.50	015.71	114.96		304.18	4.42	2.31									
2300		1.4	1.3	1.5	1.5	20.50	015.71	114.92		304.18	4.42	2.31									
2330						20.45	021.73	120.98		304.42	4.66	2.31									
2400		1.4	1.4	1.4	1.4	20.51	023.85	123.10		304.50	4.74	2.30							7.14	3.49	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 1 February 1953

Time	CO_2 Conc. in Air: Lisben Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol.%	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.4	1.4	1.4	1.4	20.51	023.85			304.50											Sunday (Holiday Routine)
0030						20.45															
0100		1.3	1.2	1.4	1.5	20.50	029.02	5.17		304.73	0.23	2.67									
0130						20.60	031.89	8.04		304.84	0.34	2.54									
0200(1)		1.4	1.4	1.4	1.4	20.51	033.60	9.75		304.90	0.40	2.46									
0230(1)						20.52	034.76	10.91		304.95	0.45	2.47									
0300(1)		1.3	1.4	1.4	1.4	20.5	038.50	14.65		305.09	0.59	2.42									
0330(1)						20.5															
0400(1)		1.4	1.3	1.5	1.4	20.6	040.08	16.23		305.14	0.64	2.37									
0430(1)						20.45	041.90	18.05		305.22	0.72	2.39									
0500		1.4	1.4	1.5	1.4	20.5															
0530						20.5	041.90	18.05		305.22	0.72	2.39									
0600		1.4	1.5	1.4	1.5	20.55															
0630(1)						20.5	042.89	19.04		305.75	1.25	3.94									
0700(1)		1.4	1.4	1.5	1.4	20.55															
0730(4)(1)						20.55															
0800		1.4	1.4	1.5	1.4	20.48	061.86	38.01		306.08	1.58	2.49									
0830						20.45															
0900		1.4	1.3	1.5	1.3	20.55	068.85	45.00		306.36	1.86	2.48									
0930						20.48															
1000		1.4	1.3	1.5	1.4	20.45	077.01	53.16		306.72	2.22	2.51									
1030						20.45															
1100(1)		1.3	1.3	1.5	1.5	20.45	079.70	55.85		306.85	2.35	2.52									
1130						20.46															
1200		1.4	1.3	1.4	1.4	20.45	082.63	58.78		306.96	2.46	2.51									
1230						20.46															
1300		1.5	1.5	1.5	1.5	20.45	084.58	60.73		307.08	2.58	2.55									
1330						20.44															
1400		1.5	1.5	1.5	1.5	20.5	091.06	67.21		307.40	2.90	2.59									
1430						20.45															
1500		1.5	1.4	1.6	1.4	20.45	097.92	74.07		307.79	3.29	2.67									
1530						20.47															
1600		1.5	1.5	1.5	1.5	20.5	101.21	77.36		307.94	3.44	2.67									
1630(1)						20.5															
1700		1.5	1.5	1.5	1.5	20.51	102.21	78.36		308.00	3.50	2.68									
1730						20.49	115.30	99.45		308.65	4.15	2.72									
1800		1.5	1.5	1.5	1.5	20.5	123.74	99.89		309.14	4.64	2.79									
1830						20.5	125.26	101.41		309.21	4.71	2.79									
1900		1.5	1.5	1.5	1.5	20.5															
1930						20.5	127.92	104.07		309.38	4.88	2.81									
2000(4)		1.5	1.5	1.6	1.5	20.5	129.00	105.15		309.45	4.95	2.82									
2030						20.5							2.07	0.17		2.25	0.02	0.86	0.88		
2100(1)		1.5	1.3	1.4	1.5	20.5	145.14	121.29		310.27	5.77	2.85									
2130						20.55	152.63	128.78		310.72	6.22	2.90									
2200(1)		1.4	1.4	1.5	1.4	20.45	157.87	134.02		311.08	6.58	2.95									
2230(1)						20.45															
2300		1.5	1.4	1.5	1.5	20.5	161.60	137.75		311.65	7.15	3.11									
2330						20.16	162.87	139.02		311.78	7.28	3.14									
2400		1.5	1.5	1.5	1.5	20.5	163.90	140.05		312.12	7.60	3.26							8.95	3.84	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 2 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dryer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition Inlet: OH	$CO_3^=$	Na^+	Outlet: OH	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.5	1.5	20.5	163.90			312.12											
0030						20.6	168.70	4.80		312.19	0.07	0.86									
0100(1)		1.5	1.5	1.4	1.4	20.5	174.00	10.10		312.50	0.38	2.26									Nearest 1/2 hour
0130						20.5															
0200		1.5	1.4	1.4	1.5	20.5															
0230						20.6	175.61	11.71		312.57	0.45	2.31									
0300		1.5	1.4	1.5	1.5	20.5	179.01	15.11		312.70	0.58	2.30									
0330						20.6	180.10	16.20		312.75	0.63	2.33									
0400		1.5	1.5	1.4	1.4	20.45	182.55	18.65		312.86	0.74	2.38									
0430						20.50	184.35	20.45		312.93	0.81	2.38									
0500		1.5	1.4	1.5	1.5	20.50	186.43	22.53		313.02	0.90	2.40									
0530						20.6	187.46	23.56		313.07	0.95	2.42									
0600		1.5	1.4	1.5	1.4	20.50	187.46	23.56		313.07	0.95	2.42									
0630						20.40	188.52	24.62		313.10	0.98	2.39									
0700		1.6	1.5	1.5	1.5	20.40	191.73	27.83		313.23	1.11	2.39									
0730						20.50	195.59	31.69		313.38	1.26	2.39									
0800(4)		1.5	1.5	1.6	1.5	20.50	200.46	36.56		313.59	1.47	2.41									Chemicals changed
0830						20.50	206.28	42.38		313.83	1.71	2.42									
0900		1.5	1.5	1.5	1.5	20.50	219.61	55.71		314.32	2.20	2.37									
0930						20.90	225.94	62.04		314.63	2.51	2.43									
1000		1.6	1.6	1.6	1.5	20.51	243.52	79.62		315.34	3.22	2.43									
1030						20.49	249.96	86.07		315.62	3.50	2.44									
1100		1.6	1.5	1.6	1.3	20.49	256.90	93.00		316.94*	3.82	2.46									*Reading probably
1130						20.50				317.42*	4.30										1.00 less than
1200		1.5	1.5	1.6	1.5	20.50	276.72	112.22		317.78*	4.66	2.48									this due to error
1230(1)						20.6	289.34	125.49		317.32	5.20	2.49									in reading
1300		1.5	1.5	1.5	1.5	20.42	296.07	132.17		317.62	5.50	2.50									
1330						20.75	301.79	137.89		317.85	5.73	2.49									
1400		1.5	1.4	1.5	1.4	20.49	311.09	147.19		318.25	6.13	2.50									
1430						20.50	318.94	155.04		318.60	6.48	2.51									
1500		1.5	1.5	1.4	1.3	20.5	326.25	162.35		318.92	6.80	2.51									
1530						20.45	338.61	174.21		319.46	7.34	2.53									
1600(1)		1.5	1.5	1.5	1.5	20.64	344.56	180.66		319.72	7.60	2.52									Nearest 1/2 hour
1630						20.65	348.29	184.39		319.86	7.74	2.52	2.16	0.15	[illegible].31	0.22	2.00	2.22			
1700		1.5	1.4	1.6	1.4	20.5	353.92	190.02		320.11	7.99	2.52									
1730						20.5	359.17	195.27		320.32	8.20	2.52									
1800		1.5	1.4	1.5	1.5	20.5															
1830						20.55	365.49	201.59		320.60	8.48	2.52									
1900(1)		1.5	1.5	1.6	1.6	20.9	372.28	208.38		320.88	8.76	2.52									Nearest 1/2 hour
1930(4)						20.8	372.28	208.38		320.88	8.76	2.52									Chemical changed
2000		1.5	1.5	1.6	1.6	20.65	384.54	220.64		321.44	9.32	2.53									
2030						20.7	388.06	224.16		321.57	9.45	2.53									
2100		1.5	1.5	1.5	1.5	20.65	391.37	227.47		321.70	9.58	2.53									
2130						20.55	396.41	232.51		321.92	9.80	2.53									
2200		1.5	1.5	1.6	1.5	20.55	401.40	237.50		322.14	10.02	2.53									
2230						20.45	401.40	237.50		322.14	10.02	2.53									
2300		1.5	1.5	1.5	1.5	20.45	403.54	239.64		322.23	10.12	2.53									
2330						20.55	406.22	242.32		322.35	10.23	2.53									
2400		1.5	1.4	1.5	1.5	20.55	409.49	245.59		322.50	10.38	2.54							28.48	6.97	

CAUSTIC SCRUBBER FOR CO_2–OPERATIONAL TEST

Date: 3 February 1953

Time	CO_2 Conc. in Air					O_2 Conc.	Operational Time		Tower	Feed Solution			Liquid Composition						CO_2 Absorbed		Remarks
	Liston Becker	Dwyer Analyzer 1	2	3	4		Timer Reading	Net Time	ΔP	Meter Reading	Net Flow	Flow Rate	Inlet OH^-	$CO_3^=$	Na^+	Outlet OH^-	$CO_3^=$	Na^+	Net	Rate	
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	$ft.^3$	$ft.^3$	$ft.^3$/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.4	1.5	1.5	20.55	409.49			322.50											Nearest 1/2 hr.
0030(1)						20.49	413.48	3.99		322.67	0.17	2.56									" "
0100(1)		1.5	1.5	1.4	1.5	20.49	413.48	3.99													" "
0130(1)						20.5	413.48	3.99		322.67	0.17	2.56									" "
0200(1)		1.5	1.3	1.5	1.5	20.75	415.16	5.67		322.74	0.24	2.54									" "
0230(1)						20.61															" "
0300(1)		1.5	1.5	1.5	1.5	20.6															" "
0330(1)						20.55															" "
0400(1)		1.5	1.5	1.5	1.5	20.6	415.16	5.67		322.74	0.24	2.54									" "
0430						20.55															
0500		1.5	1.6	1.5	1.5	20.5															
0530						20.55															
0600		1.6	1.5	1.5	1.5	20.5															
0630						20.4															
0700		1.5	1.5	1.5	1.5	20.48															
0730						20.45															
0800		1.5	1.6	1.6	1.5	20.5															Chem. Changed
0830(4)						20.4															
0900		1.5	1.5	1.5	1.5																
0930						20.4	441.92	32.43		323.18	0.68	1.26									
1000		1.5	1.6	1.6	1.4	20.5	455.78	46.29		323.30	0.80	1.04									
1030							455.78	46.29		323.30	0.80	1.04	8.21	0.23	8.44	0.11	1.75	1.86			
1100		1.4	1.4	1.5	1.4	20.5	465.68	56.19		323.45	0.95	1.01									
1130						20.55	465.68	56.19		323.45	0.95	1.01									
1200		1.5	1.5	1.6	1.5	20.54	473.89	64.40		323.54	1.04	0.97									
1230						20.50	480.63	71.14		323.60	1.10	0.93									
1300		1.5	1.5	1.5	1.5	20.50	480.63	71.14		323.60	1.10	0.93									
1330						20.60	488.03	78.54		323.72	1.22	0.93									
1400		1.6	1.5	1.5	1.5	20.50	489.29	79.80		323.81	1.31	0.98									
1430						20.59															
1500		1.5	1.5	1.6	1.5	20.6	517.73	108.24		324.12	1.62	0.90									
1530						20.65															
1600		1.5	1.5	1.5	1.6	20.5	539.61	130.12		324.54	2.04	0.94									
1630						20.55	541.04	131.55		324.57	2.07	0.94									
1700		1.5	1.5	1.6	1.5	20.55	548.56	139.17		324.83	2.33	1.00									
1730						20.55	553.54	144.15		325.05	2.55	1.06									
1800		1.5	1.5	1.5	1.5	20.55	556.78	147.29		325.14	2.64	1.08									
1830						20.55															
1900		1.5	1.5	1.5	1.5	20.55															Chem.Changed
1930(4)						20.55	594.77	185.28		326.68	4.18	1.35									
2000		1.5	1.5	1.5	1.5	20.5															
2030						20.5	605.22	195.73		327.11	4.61	1.41									
2100		1.7	1.5	1.5	1.5	20.55	605.22	195.73		327.11	4.61	1.41									
2130						20.52	617.72	203.23		327.42	4.92	1.45									
2200		1.5	1.5	1.5	1.5	20.5	612.72	203.23		327.42	4.92	1.45									
2230						20.5	615.53	206.04		327.54	5.04	1.47									
2300		1.5	1.6	1.5	1.5	20.5	619.07	209.58		327.68	5.18	1.48									
2330						20.55	624.78	215.29		327.90	5.40	1.50							13.2	3.61	
2400		1.5	1.5	1.5	1.6	20.55	628.62	219.13		327.98	5.48	1.51									

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 4 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition, Inlet: OH	$CO_3^=$	Na^+	Outlet: OH	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.5	1.6	20.55	628.62			327.98											
0030						20.5															
0100		1.5	1.5	1.5	1.3	20.6															
0130						20.5	641.96	13.34		328.60	0.62	2.79									
0200		1.5	1.4	1.5	1.3	20.55															
0230						20.5															
0300		1.4	1.5	1.5	1.3	20.55	652.53	23.91		329.05	1.07	2.69									
0330						20.45															
0400		1.3	1.4	1.4	1.3	20.5	655.97	27.35		329.17	1.19	2.61									
0430						20.8	658.55	29.93		329.27	1.29	2.59									
0500		1.4	1.4	1.4	1.3	21.0 ?															
0530																					
0600		1.3	1.4	1.4	1.4																
0630																					
0700		1.5	1.5	1.5	1.5																
0730																					
0800		1.5	1.5	1.4	1.5		667.21	38.59		329.60	1.62	2.52									
0830(4)						20.9	672.30	43.68		329.82	1.84	2.53	2.41	0.06	2.47	0.41	2.38	2.79	6.00	8.24	Chemicals Changed
0900		1.5	1.5	1.5	1.4	20.85	673.43	44.81		329.85	1.87	2.50									
0930						20.75	685.43	56.81		330.35	2.37	2.50									
1000		1.5	1.5	1.7	1.5	20.65															
1030						20.6	705.57	76.95		331.18	3.20	2.50									
1100		1.5	1.6	1.7	1.5	20.55	720.08	91.46		331.79	3.81	2.50									
1130						20.5	725.09	96.47		332.00	4.02	2.50									
1200(1)		1.5	1.5	1.5	1.5	20.45	731.36	102.64		332.26	4.28	2.50									Nearest 1/2 hr.
1230						20.5	739.23	110.61		332.57	4.59	2.49									
1300		1.5	1.5	1.5	1.4	20.55	739.23	110.61		332.57	4.59	2.49									
1330						20.6	755.75	127.13		333.25	5.23	2.47									
1400		1.5	1.5	1.6	1.4	20.5	755.75	127.13		333.25	5.23	2.47									
1430(1)						20.5	763.99	135.37		333.58	5.60	2.48									Nearest 1/2 hr.
1500		1.5	1.5	1.6	1.5	20.5															
1530						20.5	781.02	152.40		334.27	6.29	2.48									
1600		1.6	1.5	1.6	1.4	20.5	786.52	157.90		334.60	6.62	2.52									
1630						20.5	786.52	157.90		334.60	6.62	2.52									
1700		1.6	1.4	1.5	1.5	20.5	792.93	164.31		335.75	*6.77	2.47									Prob. Record Error 1.00 ft.^{3} less
1730						20.5	798.19	169.57		335.06	7.08	2.51									
1800		1.5	1.5	1.6	1.5	20.55	805.60	176.98		335.28	7.30	2.47									
1830						20.5	811.85	183.23		335.53	7.55	2.47									
1900		1.5	1.4	1.5	1.4	20.55	814.85	186.23		335.94	7.96	2.56									
1930						20.7	826.05	197.43		336.1	8.02	2.44									
2000		1.5	1.3	1.5	1.3	20.7	830.70	202.08		336.30	8.33	2.47									
2030						20.55															
2100(4)		1.5	1.4	1.5	1.4	20.6	841.94	213.32		336.73	8.75	2.46									Chemicals Changed
2130						20.55															
2200		1.5	1.5	1.5	1.5	20.5															
2230						20.5															
2300		1.7	1.8	1.6	1.7	20.5	847.78	219.16		336.97	8.99	2.46									
2330						20.5															
2400		1.6	1.6	1.7	1.6	20.55	854.43	225.81		337.25	9.27	2.46							20.85	6.88	
																		Total	26.85	7.15	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 5 February 195[illegible]

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition Inlet: OH^-	$CO_3^=$	Na^+	Outlet: OH^-	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.6	1.6	1.7	1.6	20.55	854.43			337.25											
0030						20.6	855.69	1.26		337.29	0.04	1.90									
0100		1.5	1.5	1.6	1.5	20.60	855.69	1.26													
0130						20.58	855.69	1.26		337.29	0.04	1.90									
0200		1.5	1.5	1.6	1.5	20.55	861.76	7.33		337.54	0.29	2.37									
0230						20.60	861.76	7.33		337.54	0.29	2.37									
0300		1.5	1.5	1.5	1.4	20.60															
0330						20.55															
0400		1.5	1.5	1.6	1.5	20.55															
0430						20.50	861.76	7.33		337.54	0.29	2.37									
0500(8)		1.5	1.5	1.5	1.5	20.50															(8) End of 1st
0530																					Recorder Roll
0600		1.5	1.5	1.5	1.5	20.50															
0630						20.55															
0700		1.6	1.6	1.6	1.5	20.6															
0730						20.5	866.21	11.78		337.33*			2.42	0.06	2.48	0.39	1.94	2.33			
0800		1.5	1.4	1.4	1.4	20.5	867.55	13.12													Prob. Record Error
0830						20.5	874.28	19.85		338.06	0.81	2.45									
0900		1.5	1.6	1.7	1.4	20.55	882.66	28.23		338.41	1.16	2.47							2.16	6.52	
0930						20.75	898.27	43.84		339.04	1.79	2.45									
1000		1.5	1.6	1.5	1.5	20.5	900.74*	46.31		339.16	1.91										Prob. Record. Error
1030						20.55	900.24*	45.81		339.16	1.91										" "
1100		1.7	1.6	1.6	1.6	20.5															
1130						20.6	900.24*	45.81		339.16	1.91										" "
1200		1.8	1.6	1.8	1.7	20.55	903.31	48.88		339.27	2.02	2.48									
1230						20.5	903.31	48.88		339.27	2.02	2.48									
1300		1.5	1.5	1.6	1.6	20.5	909.15	54.72		339.44	2.19	2.40									
1330						20.5	914.32	59.89		339.66	2.41	2.41									
1400		1.7	1.6	1.8	1.6	20.45	920.35	65.92		339.90	2.65	2.41									
1430						20.6	923.90	69.47		340.05	2.80	2.42									
1500		1.6	1.5	1.5	1.5	20.5	950.87	96.44		341.22	3.97	2.47									
1530	1.72(1)					20.45	960.52	106.09		341.65	4.40	2.49									
1600		1.5	1.6	1.5	1.4	20.75	984.92	130.49		342.72	5.47	2.52									Nearest 1/2 hr.
1630						20.75	990.87	136.44		342.97	5.72	2.52									
1700		1.5	1.4	1.5	1.4	20.62	996.95	142.52		343.24	5.99	2.52									
1730						20.60	003.73	149.30		343.52	6.27	2.52									
1800		1.5	1.6	1.6	1.5	20.55	005.09	150.66		343.57	6.32	2.52									
1830						20.60	008.58	154.15		343.70	6.45	2.51									
1900		1.6	1.6	1.6	1.6	20.57	010.18	155.75		343.75	6.50	2.50									
1930(4)						20.50	012.28	157.85		343.85	6.60	2.51									Chemicals changed
2000		1.6	1.6	1.5	1.5	20.55	018.18	163.75		344.10	6.75	2.47									
2030						20.50	026.10	171.67		344.42	7.17	2.51									
2100		1.6	1.6	1.5	1.5		028.01	173.58		344.50	7.25	2.51									
2130						20.51	032.72	179.29		344.66	7.41	2.48									
2200		1.6	1.5	1.5	1.5	20.5	040.42	185.99		345.00	7.75	2.50									
2230						20.45	046.28	191.85		345.23	7.98	2.50									
2300		1.5	1.5	1.5	1.5	20.40	050.48	196.05		345.38	8.13	2.49									
2330						20.50	059.63	205.20		345.77	8.52	2.49									
2400		1.5	1.6	1.5	1.5	20.5	065.56	211.13		346.00	8.75	2.49	2.34	0.11	2.45	0.28	1.99	2.77	21.70	6.80	
																		Total	23.86	6.78	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 6 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	$CO_3^=$	Na^+	Outlet OH^-	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol.%	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.6	1.5	1.5	20.5	065.56			346.00			2.34	0.11	2.45	0.28	1.99	2.27			
0030(1)						20.45	070.38	4.82		346.19	0.19	2.37									
0100		1.5	1.5	1.5	1.5	20.5	072.25	6.69		346.27	0.27	2.42									Nearest 1/2 hr.
0130						20.5	073.90	8.34		346.52*	0.52										
0200		1.3	1.3	1.3	1.4	20.45	078.50	12.94		346.62*	0.62										Prob. Record Error
0230						20.45	079.79	14.23		346.57	0.57	2.40									" " "
0300		1.4	1.5	1.3	1.3	20.45															
0330	1.47					20.45	080.30	14.74		346.58	0.58	2.36									
0400		1.3	1.3	1.4	1.3	20.35	082.66	17.10		346.67	0.67	2.35									
0430						20.55	082.66	17.10													
0500	1.40	1.5	1.6	1.5	1.4	20.55															
0530						20.55	082.65	17.10		346.67	0.67	2.35									
0600		1.4	1.3	1.3	1.3	20.55															
0630						20.60															
0700		1.5	1.5	1.5	1.3	20.60															
0730						20.6	088.20	22.64		346.88	0.88	2.33									
0800		1.5	1.5	1.5	1.4	20.55															
0830						20.55															
0900		1.3	1.4	1.5	1.4		099.94	34.38		347.34	1.34	2.34	2.76	0.08	2.84	0.24	1.97	2.21	3.62	6.33	
0930(4)						20.55	107.80	42.24		347.68	1.68	2.39									
1000		1.3	1.3	1.2	1.3		107.80	42.24		347.68	1.68	2.39									Chemicals Changed
1030						20.6	121.06	55.50		348.22	2.22	2.40									
1100		1.4	1.4	1.5	1.5	20.6	121.06	55.50		348.22	2.22	2.40									
1130						20.5															
1200		1.4	1.4	1.4	1.4	20.5	136.07	70.51		348.86	2.86	2.43									
1230						20.5	136.07	70.51		348.86	2.86	2.43									
1300		1.5	1.5	1.5	1.5	20.4	144.18	78.62		349.18	3.18	2.43									
1330(1)						20.45	153.02	87.46		349.56	3.56	2.44									
1400		1.6	1.5	1.5	1.4	20.45	155.41	89.85		349.67	3.67	2.45									Nearest 1/2 hr .
1430						20.45	159.79	94.23		349.84	3.84	2.45									
1500		1.5	1.6	1.6	1.6	20.50	168.85	103.29		350.21	4.21	2.47									
1530						20.50	172.49	106.93		350.34	4.34	2.44									
1600		1.4	1.5	1.6	1.5	20.50	186.23	120.67		350.98	4.98	2.48									
1630						20.51	192.86	127.30		351.25	5.25	2.47									
1700		1.4	1.4	1.6	1.5	20.51	199.44	133.88		351.53	5.53	2.48									
1730						20.5	203.14	137.58		351.67	5.67	2.47									
1800		1.4	1.8	1.6	1.6	20.49	208.17	142.61		351.87	5.87	2.47									
1830						20.5															
1900		1.5	1.6	1.6	1.6	20.5															
1930						20.52	219.43	153.87		352.34	6.34	2.47									
2000		1.6	1.6	1.6	1.4	20.5	224.82	159.26		352.57	6.57	2.48									
2030						20.65	229.52	163.96		352.76	6.76	2.47									
2100		1.5	1.4	1.5	1.5	20.5	243.59	178.03		353.39	7.39	2.49									
2130(4)						20.5															
2200		1.4	1.5	1.6	1.5	20.55	246.72	181.16		353.50	7.50	2.48									Chemicals Changed
2230						20.5	251.97	186.41		353.72	7.72	2.48									
2300		1.5	1.3	1.5	1.4	20.5															
2330						20.5	263.98	198.42		354.24	8.24	2.49									
2400	1.44(1)	1.5	1.5	1.6	1.4	20.5	263.98	198.42		354.24	8.24	2.49	1.46	0.18	1.64	0.19	1.94	2.13	18.37	6.72	
																	Total		21.99	6.66	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 7 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.44(1)	1.5	1.5	1.6	1.4	20.5	263.98			354.24			1.46	0.18	1.64	0.19	1.94	2.13			Nearest 1/2 hr Saturday (Holiday Routine)
0030						20.5															
0100		1.5	1.4	1.4	1.4	20.5	269.98	6.00		354.46	0.24	2.40									
0130						20.5	273.52	9.54		354.63	0.39	2.45									
0200	1.43	1.6	1.5	1.5	1.4	20.5															
0230						20.5	285.67	21.69		355.15	0.91	2.52									
0300		1.5	1.5	1.5	1.5	20.5	287.08	23.10		355.21	0.97	2.52									
0330	1.43					20.55	287.08	23.10		355.21	0.97	2.52									
0400		1.5	1.5	1.5	1.5	20.55	287.08	23.10		355.21	0.91	2.52									
0430						20.55															
0500(1)		1.3	1.4	1.3	1.2	20.55	288.55	24.57		355.25	1.01	2.47	1.66	0.05	1.71	0.28	1.77	2.05			Nearest 1/2 hr
0530						20.55															
0600		1.3	1.3	1.3	1.3	20.5															
0630						20.5															
0700		1.3	1.3	1.3	1.3	20.55															
0730						20.5	292.80	28.82		355.43	1.19	2.48									
0800		1.3	1.3	1.3	1.3	20.5	293.69	29.71		355.47	1.23	2.48									
0830(4)						20.5															
0900		1.5	1.4	1.5	1.4	20.45	299.97	35.99		355.76	1.52	2.53									Chemicals changed
0930						20.55															
1000		1.5	1.4	1.6	1.5	20.50															
1030						20.50															
1100		1.5	1.4	1.5	1.4	20.7	301.10	37.12		355.79	1.55	2.51									
1130						20.6	308.42	44.44		356.00	1.76	2.38									
1200		1.6	1.5	1.5	1.5	20.55	314.59	50.61		356.35	2.11	2.50									
1230						20.5	320.49	56.51		356.62	2.38	2.53									
1300		1.6	1.5	1.7	1.6	20.45	323.59	59.61		356.75	2.51	2.53									
1330						20.4	324.77	60.70		356.79	2.55	2.52									
1400		1.6	1.6	1.6	1.6	20.4	329.96	65.98		357.03	2.79	2.54									
1430						20.9	329.96	65.98		357.24	3.00	2.73									
1500		1.5	1.6	1.5	1.5	20.9															
1530						high	338.15	74.17		357.37	3.13	2.53									
1600		1.5	1.5	1.6	1.6	21.0	342.71	78.73		357.55	3.31	2.52									
1630						21.0	347.11	83.13		357.74	3.50	2.53									
1700		1.6	1.4	1.5	1.5	21.0	354.31	90.33		358.05	3.81	2.53									
1730(1)						21.0	360.07	96.09		358.29	4.05	2.53									
1800(4)		1.6	1.5	1.5	1.5	21.0															Nearest 1/r Hr Chemicals changed
1830						21.0	364.75	100.77		358.50	4.26	2.54									
1900		1.5	1.5	1.5	1.5	21.0	374.09	110.11		359.09	4.75	2.59									
1930						21.0	381.72	117.74		359.22	4.98	2.54									
2000		1.6	1.5	1.5	1.4	21.+	381.72	117.74		359.22	4.98	2.54									
2030	1.46(1)					21.+	398.27	134.29		359.95	5.71	2.55									
2100		1.6	1.4	1.4	1.5	21.+	407.97	143.99		360.35	6.11	2.55									Nearest 1/2 Hr.
2130	1.48(1)					21.+	414.30	150.32		360.64	6.42	2.56									
2200	1.46(1)	1.6	1.4	1.5	1.5	20.85															Nearest 1/2 Hr.
2230						20.82	419.64	155.66		360.88	6.64	2.56									Nearest 1/2 Hr.
2300(1)	1.48	1.6	1.5	1.5	1.5	20.78	419.64	155.66		360.88	6.64	2.56									Nearest 1/2 Hr.
2330						20.75	423.63	159.65		361.05	6.81	2.56									
2400		1.6	1.5	1.6	1.4	20.72	423.63	159.65		361.05	6.81	2.56									
																			16.52	6.22	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 8 February 1953

Time	CO_2 Conc. in Air: Liston Becker	CO_2 Conc. in Air: Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.6	1.5	1.6	1.4	20.72	423.63			361.05											Sunday (Holiday Routine)
0030						20.70	425.09	1.46		361.11	0.06	2.47	1.39	0.07	1.46	0.26	1.57	1.83	0.13	5.30	
0100(4)	1.55	1.7	1.5	1.6	1.6	20.65	432.33	8.70		361.42	0.37	2.55									Chemicals Changed
0130						20.60															
0200	1.38	1.5	1.4	1.4	1.5	20.60															
0230	1.55(1)					20.55	433.43	9.80		361.46	0.41	2.51									Nearest 1/2 Hr.
0300	1.5(1)	1.5	1.5	1.5	1.5	20.50	435.28	11.65		361.55	0.50	2.58									"
0330	1.54(1)					20.5	436.54	12.91		361.60	0.55	2.56									"
0400		1.5	1.5	1.4	1.5	20.45															
0430						20.50	446.10	22.47		362.00	0.95	2.54	2.34	0.04	2.38	0.19	1.46	1.65	1.90	5.07	
0500		1.4	1.5	1.5	1.5	20.48															
0530						20.43	449.62	25.99		362.15	1.10	2.54									
0600	1.54(1)	1.5	1.6	1.4	1.5	20.50	449.62	25.99		362.15	1.10	2.54									
0630						20.50	455.32	31.69		362.38	1.33	2.52									
0700	1.52(1)	1.5	1.5	1.5	1.5	20.50	455.32	31.69		362.38	1.33	2.52									
0730	1.53(1)					20.50	458.18	34.55		362.49	1.44	2.50									
0800		1.6	1.5	1.6	1.5	20.5	460.60	36.97		362.59	1.54	2.50									
0830						20.5															
0900		1.6	1.5	1.5	1.5	20.45	474.58	50.95		363.18	2.13	2.51									
0930						20.45															
1000		1.5	1.5	1.5	1.5	20.45															
1030(1)						20.5	476.20	52.57		363.26	2.21	2.52									Nearest 1/2 Hr.
1100		1.5	1.5	1.5	1.5	20.4	478.07	54.44		363.33	2.28	2.51									
1130						20.4	483.09	59.46		363.55	2.50	2.52									
1200		1.5	1.4	1.5	1.5	20.45															
1230						20.4	485.00	61.37		363.64	2.59	2.53									
1300		1.5	1.6	1.3	1.6	20.45															
1330						20.4	491.05	67.42		363.09*											Prob. Reporting Error
1400		1.6	1.3	1.3	1.5	20.4															
1430						20.6															
1500		1.5	1.5	1.5	1.5	24.0*	493.57	69.94		364.03	2.98	2.56									Prob. Reporting Error
1530						24.0*	498.96	75.33		364.25	3.20	2.55									
1600		1.5	1.4	1.4	1.4	20.45	516.84	93.21		365.05	4.00	2.57									
1630	1.50					20.4	525.18	101.55		365.38	4.33	2.56									
1700		1.5	1.4	1.4	1.5	20.42	530.10	106.47		365.60	4.55	2.56									
1730						20.5	535.52	111.89		365.83	4.78	2.56									
1800		1.5	1.3	1.4	1.4	20.45	544.17	120.54		366.20	5.15	2.56									
1830						20.48	549.07	125.44		366.41	5.36	2.56									
1900		1.4	1.4	1.4	1.3	20.55	554.04	130.41		366.63	5.58	2.57									
1930(4)	1.49																				Chemicals Changed
2000		1.5	1.4	1.4	1.4	20.48	569.89	146.26		367.31	6.26	2.57									
2030						20.50	576.56	152.93		367.60	6.55	2.59									
2100		1.5	1.5	1.5	1.5	20.55															
2130	1.5(1)					20.50	585.45	161.82		368.00	6.95	2.58									Nearest 1/2 Hr.
2200	1.55	1.5	1.5	1.5	1.4	20.50	590.23	166.60		368.20	7.15	2.58									
2230	1.5					20.45															Nearest 1/2 Hr.
2300	1.58	1.5	1.5	1.5	1.4	20.45	595.68	172.05		368.42	7.37	2.56									
2330	1.54					20.4	607.10	183.47		368.83	7.78	2.54									
2400	1.52	1.5	1.4	1.5	1.5	20.45	611.22	187.59		369.10	8.05	2.57					1.82*		17.70	6.43	Estimate on $NO_3^=$
																		Total	19.61	6.27	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 9 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition Inlet: OH	$CO_3^=$	Na	Outlet: OH	$CO_3^=$	Na	CO_2 Absorbed: Net	Rate	Remarks
O'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	Norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.52	1.5	1.4	1.5	1.5	20.45	611.22			369.10											
0030(4)						20.4	614.32	3.10		369.24	0.14	2.71	2.74	0.09	2.83	0.37	2.22	2.59	0.43	8.24	Chemicals Changed
0100	1.50	1.5	1.3	1.5	1.4	20.5	622.57	11.35		369.59	0.49	2.59									
0130						20.5	626.82	15.60		369.77	0.77	2.96									
0200	1.52	1.5	1.3	1.3	1.3	20.45	630.53	19.31		369.94	0.84	2.61									
0230						20.48	630.53	19.31		369.94	0.84	2.61									
0300	1.52	1.4	1.4	1.4	1.4	20.50	632.97	21.75		370.04	0.94	2.59									
0330						20.50	632.97	21.75		370.04	0.94	2.59									
0400	1.55	1.5	1.4	1.5	1.5	20.5	632.97	21.75		370.04	0.94	2.59									
0430						20.5	640.04	28.82		370.34	1.24	2.58	3.67	0.12	3.79	0.44	2.51	2.95	3.79	8.85	
0500		1.5	1.5	1.5	1.5	20.5	640.04	28.82		370.34	1.24	2.58									
0530						20.5	641.93	30.71		370.41	1.31	2.56									
0600		1.5	1.5	1.5	1.5	20.55	641.93	30.71		370.41	1.31	2.56									
0630						20.5	641.93	30.71		370.41	1.31	2.56									
0700		1.5	1.5	1.5	1.5	20.5	648.75	37.53		370.72	1.62	2.59									
0730						20.5	653.93	42.71		370.93	1.93	2.71									
0800		1.7	1.5	1.6	1.5	20.6	661.45	50.23		371.26	2.16	2.58									
0830						20.5	662.22	51.00		371.29	2.19	2.58									
0900		1.6	1.5	1.5	1.4	20.4	670.90	59.68		371.66	2.56	2.57									
0930						20.4	680.50	69.28		372.66	3.56	3.08									
1000		1.5	1.5	1.5	1.5	20.5	690.42	79.20		372.49*	3.39										
1030(4)						20.5	700.87	89.65		372.95	3.85	2.58									Prob. Record Error
1100		1.4	1.5	1.5	1.5	20.5	707.50	96.28		373.33	4.23	2.64									Battery Charged
1130						20.5	718.27	107.05		373.67	4.57	2.56									
1200		1.5	1.6	1.6	1.5	20.5	718.27	107.05		373.67	4.57	2.56									
1230						20.5	718.96	107.74		373.69	4.59	2.56									
1300		1.4	1.5	1.5	1.5	20.7															
1330						20.5	718.96	107.74		373.69	4.59	2.56									
1400		1.6	1.5	1.6	1.4	20.4	725.72	114.50		374.00	4.90	2.57									
1430						20.5															
1500		1.5	1.5	1.5	1.5	20.4															
1530																					
1600		1.4	1.5	1.5	1.4	20.5	761.84	150.62		375.52	6.42	2.56									
1630						20.5	770.93	159.71		375.90	6.80	2.55									
1700		1.5	1.6	1.4	1.5	20.5	770.93	159.71		375.90	6.80	2.55									
1730						20.5	775.42	164.20		376.07	6.97	2.55									
1800		1.5	1.4	1.4	1.4	20.5	775.42	164.20		376.07	6.97	2.55									
1830						20.5	782.81	171.59		376.35	7.23	2.53									
1900		1.5	1.5	1.4	1.4	20.4	789.58	178.36		376.60	7.50	2.52									
1930						20.5	791.35	180.13		376.67	7.57	2.52									
2000	1.63(1)	1.5	1.5	1.6	1.5	20.5	791.35	180.13		376.67	7.57	2.52									Nearest 1/2 Hr.
2030	1.56(1)					20.5															" "
2100		1.6	1.6	1.6	1.6	20.5															
2130(4)						20.5	834.25	223.03		378.34	9.24	2.49									Chemicals Changed
2200(1)		1.5	1.5	1.5	1.5	20.5	839.97	228.75		378.57	9.47	2.48									Nearest 1/2 Hr.
2230	1.50					20.5	846.58	235.36		378.85	9.75	2.49									
2300	1.52(1)	1.5	1.5	1.5	1.5	20.5															Nearest 1/2 Hr.
2330						20.5															
2400	1.52	1.5	1.5	1.5	1.5	20.5	852.57	241.35		379.09	9.99	2.48	2.175	0.81	2.256	0.209	1.623	1.832	19.48	5.50	
																		Total	23.70	5.90	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 10 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.52	1.5	1.5	1.5	1.5	20.5	852.57			379.09	0		2.175	0.081	2.256	0.209	1.623	1.832			
0030						20.58	852.57	0		379.09	0										
0100		1.5	1.5	1.5	1.5	20.5	863.88	11.31		379.46	0.37	1.96									
0130						20.55	863.88	11.31		379.46	0.37	1.96									
0200		1.5	1.5	1.5	1.5	20.5															
0230						20.51															
0300		1.5	1.6	1.5	1.5	20.46	869.49	16.92		379.66	0.57	2.02									
0330						20.5															
0400		1.5	1.5	1.5	1.6	20.45	871.42	18.85		379.73	0.64	2.04	0.995	0.021	1.016	0.141	1.395	1.536	1.22	3.90	
0430						20.55															
0500		1.5	1.5	1.5	1.5	20.5															
0530						20.5															
0600		1.5	1.5	1.6	1.5	20.5	873.25	20.68		380.08										Reading	Probable Error
0630						20.6															
0700		1.5	1.4	1.5	1.5	20.45															
0730(4)						20.5															Chemicals changed
0800		1.5	1.5	1.5	1.5	20.5	879.40	26.83		379.80	0.71	1.59									
0830						20.4	885.66	33.09		379.81	0.72	1.31									
0900		1.5	1.5	1.5	1.4	20.4	888.14	35.57		379.90	0.81	1.37									
0930						20.4															
1000		1.5	1.5	1.5	1.5	20.45	892.92	40.35		380.00	0.91	1.35									
1030						20.45	903.82	51.25		380.03	0.93	1.09									
1100		1.4	1.4	1.5	1.4	20.50	909.30	56.73		380.24	1.15	1.22									
1130						20.50	914.95	62.38		380.45	1.36	1.31									
1200		1.5	1.4	1.5	1.4	20.5	920.56	67.99		380.70	1.61	1.42									
1230						20.50	923.72	71.15		380.92	1.83	1.54									
1300		1.4	1.4	1.6	1.4	20.48	927.42	74.85		381.00	1.91	1.53									
1330						20.50	929.94	77.37		381.10	2.01	1.56									
1400		1.4	1.5	1.5	1.4																
1430						20.3															
1500		1.5	1.5	1.5	1.4																
1530						20.5	949.28	96.71		381.96	2.87	1.78									
1600		1.5	1.5	1.6	1.5	20.6	950.70	98.13		382.02	2.93	1.79									
1630						20.6	955.37	102.80		382.20	3.11	1.82									
1700		1.5	1.5	1.5	1.5	20.5	960.45	107.88		382.47	3.38	1.88									
1730						20.5															
1800		1.5	1.5	1.5	1.5																
1830						20.48	987.08	134.51		383.52	4.43	1.98									
1900	1.53(1)	1.5	1.5	1.5	1.5	20.5	993.16	140.59		383.79	4.70	2.01									
1930(4)	1.46					20.5	998.43	145.86		384.00	4.91	2.02									Chemicals changed (Nearest 1/2 hr)
2000		1.4	1.5	1.4	1.5	20.5	000.51	147.84		384.10	5.01	2.03									
2030						20.45	006.82	154.25		384.37	5.28	2.05									
2100		1.3	1.4	1.4	1.5	20.45															
2130						20.5	015.78	163.21		384.76	5.67	2.08									
2200		1.4	1.3	1.3	1.4	20.5															
2230						20.45															
2300		1.4	1.4	1.3	1.5	20.6	020.90	168.33		384.99	5.90	2.10									
2330						20.58															
2400		1.5	1.5	1.4	1.4	20.55	020.90	168.33		384.99	5.90	2.10	7.74	0.131	7.871	0.905	2.440	3.345	17.60	7.07	
																		Total	18.82	6.72	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 11 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition, Inlet: OH^-	$CO_3^=$	Na^+	Outlet: OH^-	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.4	1.4	20.55	020.90			384.99			7.74	0.131	7.871	0.905	2.440	3.345			
0030	1.45					20.5	026.05	5.15		385.23	0.24	2.80									
0100	1.52	1.5	1.4	1.6	1.5	20.48	026.05	5.15		385.23	0.24	2.80									
0130						20.43															
0200	1.47	1.4	1.5	1.5	1.4	20.50	031.13	10.23		385.47	0.48	2.82									
0230	1.48					20.53															
0300	1.49	1.4	1.5	1.4	1.5	20.55															
0330						20.5	032.82	11.92		385.52	0.53	2.67									
0400		1.4	1.5	1.5	1.4	20.5	036.62	15.72		385.70	0.71	2.71									
0430	1.48(1)					20.5	036.62	15.72		385.70	0.71	2.71									Nearest 1/2 hr.
0500	1.47(1)	1.5	1.5	1.5	1.5	20.5	040.40	19.50		385.87	0.88	2.71	3.900	0.111	4.011	1.610	2.700	4.310	3.26	10.01	"
0530						20.45	040.40	19.50		385.87	0.88	2.71									
0600		1.5	1.5	1.5	1.5	20.5	040.40	19.50		385.87	0.88	2.71									
0630						20.5	040.40	19.50		385.87	0.88	2.71									
0700		1.5	1.4	1.5	1.5	20.5	040.40	19.50		385.87	0.88	2.71									
0730						21.0	040.40	19.50		385.87	0.88	2.71									
0800(4)		1.5	1.5	1.4	1.4		040.40	19.50		385.87	0.88	2.71									Chemicals changed
0830							040.62	19.72		385.91	0.92	2.80									
0900		1.5	1.4	1.5	1.5	20.7															
0930						cal	043.93	23.03		386.04	1.05	2.74									
1000		1.6	1.4	1.5	1.5	cal	047.59	26.69		386.13	1.14	2.56									
1030						cal	053.71	32.81		386.30	1.31	2.40									
1100		1.5	1.4	1.5	1.5	cal	062.03	41.13		386.68	1.69	2.47									
1130						20.1	064.66	43.76		386.79	1.80	2.47									
1200		1.2	1.5	1.5	1.5	20.4	068.94	48.04		386.97	1.98	2.47									
1230						20.2	068.94	48.04		386.97	1.98	2.47									
1300		1.6	1.4	1.5	1.5	20.5	068.94	48.04		386.97	1.98	2.47									
1330						20.3	073.51	52.61		387.12	2.13	2.43									
1400		1.5	1.5	1.5	1.6	20.5	077.31	56.41		387.27	2.28	2.43									
1430						20.4	C81.40	60.50		387.35	2.36	2.34									
1500		1.6	1.6	1.5	1.5																
1530	1.61					20.3	090.71	69.81		387.68	2.69	2.31									
1600		1.6	1.6	1.6	1.4	20.6	112.58	91.68		388.42	3.43	2.31									
1630						20.55															
1700		1.6	1.6	1.5	1.5	20.5	117.83	96.93		388.61	3.62	2.24									
1730						20.48															
1800		1.5	1.5	1.6	1.6	20.45	126.86	105.96		388.92	3.93	2.23									
1830						20.5															
1900		1.6	1.5	1.5	1.5	21.0	145.15	124.25		389.57	4.58	2.21									
1930						20.8															
2000		1.6	1.6	1.5	1.5	20.8															
2030	1.50					20.6	172.61	151.71		390.40	5.41	2.14									
2100(4)		1.5	1.5	1.5	1.5	20.5	176.00	155.10		390.54	5.55	2.15									Chemicals changed
2130	1.50					20.3	182.07	161.17		390.75	5.76	2.14									
2200		1.5	1.5	1.5	1.5	20.49	188.77	167.87		390.91	5.92	2.12									
2230	1.52(1)					20.45	189.62	169.72		391.02	6.03	2.13									Nearest 1/2 hr.
2300	1.52(1)	1.5	1.5	1.5	1.5	20.45	194.70	173.80		391.20	6.21	2.14									"
2330						20.6	197.89	176.99		391.30	6.31	2.14									
2400	1.51(1)	1.5	1.5	1.5	1.5	20.55	202.13	181.23		391.45	6.46	2.14	3.115	0.093	3.208	0.982	2.765	3.747	21.18	7.87	"
																	Total		24.44	8.09	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 12 February 1953

Time	CO_2 Conc. in Air: Liston Becker	CO_2 Conc. in Air: Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol.%	min.	min.	"H_2O	$ft.^3$	$ft.^3$	$ft.^3/hr$	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.5	1.5	20.55	202.13			391.45			3.115	0.093	3.208	0.982	2.765	3.747			
0030						20.5	202.92	0.79		391.68	0.23	17.50									
0100	1.49 (1)	1.4	1.5	1.5	1.4	20.5	212.65	10.52		391.84	0.39	2.22									Nearest 1/2 hr
0130						20.5	216.09	13.96		391.95	0.50	2.15									
0200		1.5	1.5	1.5	1.9	20.5	219.18	17.05		392.05	0.60	2.11									
0230	1.49(1)					20.5	220.78	18.65		392.1	0.65	2.09									Nearest 1/2 hr
0300		1.5	1.5	1.5	1.4	20.5	223.60	21.47		392.19	0.74	2.07									
0330						20.5	226.04	23.91		392.28	0.83	2.08									
0400		1.5	1.5	1.4	1.4	20.5	226.04	23.91		392.28	0.83	2.08	2.785	0.108	2.893	0.973	2.877	3.850	3.27	8.23	
0430						20.45	228.92	26.79		392.33	0.88	1.97									
0500		1.4	1.4	1.5	1.5	20.5															
0530						20.7															
0600		1.4	1.5	1.5	1.5	20.4	232.36	30.23		392.51	1.06	2.10									
0630 (1)						20.55	233.38	31.25		392.55	1.10	2.11									Nearest 1/2 hr
0700		1.5	1.5	1.5	1.5	20.4															
0730						20.45	240.78	38.65		392.79	1.34	2.08									
0800		1.5	1.5	1.5	1.5	20.55	242.61	40.48		392.85	1.40	2.08									
0830 (4)						20.4															Chemicals changed
0900		1.4	1.5	1.5	1.4	20.5	256.96	54.83		393.32	1.87	2.05									
0930						20.6															
1000 (4)		1.6	1.6			20.46	275.30	73.17		393.98	2.53	2.07									Battery charged
1030						20.5															
1100		1.6	1.5	1.4	1.5	20.55	274.08	81.95		394.28	2.83	2.07									
1130						20.7															
1200		1.6	1.5	1.6	1.6	20.5	295.53	93.40		394.68	3.23	2.07									
1230						20.6															
1300		1.7	1.6	1.5	1.5	20.5	313.38	111.25		395.20	3.75	2.02									
1330						20.48															
1400		1.7	1.7	1.7	1.6	20.5	315.68	113.55		395.28	3.83	2.02									
1430						20.5															
1500		1.6	1.6	1.6	1.5	20.4	322.27	120.14		395.52	4.07	2.03									
1530						20.6							2.545	0.111	2.656	1.035	2.830	3.865	12.58	7.83	
1600		1.6	1.5	1.5	1.5	20.5	338.27	136.14		396.08	4.63	2.04									
1630						20.5															
1700 (1)		1.7	1.7	1.7	1.7	20.5	344.72	142.59		396.29	4.84	2.04									Nearest 1/2 hr
1730						20.45	359.16	157.03		396.79	5.34	2.04									
1800		1.7	1.7	1.6		20.45															
1830	1.56					20.45															
1900	1.51					20.55															
1930 (4)	1.51					20.5	423.63	221.50		398.09	7.54	2.04									Chemicals changed
2000 (1)	1.51					20.45	437.10	234.97		399.44	7.39	2.04									Nearest 1/2 hr.
2030						20.45	449.93	247.80		399.86	8.41	2.04									
2100	1.47					20.5	467.24 *			399.98	8.53										Questionable Value
2130	1.4					20.5	456.12 *			400.09	8.64										" "
2200						20.5	468.92	266.79		400.18	8.73	1.96									
2230	1.49					20.5	478.68	276.55		400.37	8.92	1.94									
2300						20.5							6.210	0.123	6.383	0.802	2.750	3.552	18.30	7.02	
2330	1.52					20.6	482.41	280.28		400.64	9.19	1.97									
2400						20.6	492.38	290.25		400.98	9.53	1.97									
																		Total	34.15	7.43	

RESTRICTED

Date 13 February 1953

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	/hr ft.^{3}	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000						20.6	492.38			400.98											
0030	1.50					20.55															
0100	1.52					20.5	493.87	1.49		401.03	0.05	2.01									
0130						20.5	494.54	2.16		401.05	0.07	1.94									
0200	1.53					20.48															
0230						20.48															
0300	1.48					20.48	502.60	10.22		401.35	0.37	2.17									Nearest 1/2 hr
0330	1.47(1)					20.7															
0400						20.7															
0430	1.48					20.65															
0500						20.6															
0530	1.50					20.6															
0600						20.55															
0630	1.51					20.5															
0700						20.45	506.26	13.88		401.49	0.51	2.20	4.195	0.091	4.286	2.238	2.650	4.888	1.85	8.01	
0730						20.49															
0800						20.4	508.99	16.61		401.60	0.62	2.24									
0830						20.4															
0900(4)		1.5	1.6	1.5	1.5	20.6	531.90	39.52		402.38	1.40	2.13									Chemicals changed
0930						—	536.69	44.31		402.54	1.56	2.11									
1000		1.5	1.5	1.4	1.5	20.4	541.16	48.78		402.63	1.65	2.03									
1030						20.4															
1100		1.5	1.4	1.5	1.5	20.4	547.64	55.26		402.94	1.96	2.13	3.190	0.098	3.288	1.194	2.920	4.114	5.80	8.42	
1130						20.6	554.57	62.19		402.97	1.99	1.92									
1200		1.5	1.4	1.5	1.4	20.52	567.14	74.76		403.01	2.03	1.63									
1230						20.6	573.11	80.73		403.22	2.24	1.66									
1300		1.5	1.4	1.5	1.4	20.54	583.10	90.72		403.54	2.56	1.69									
1330						20.45	587.97	95.59		403.69	2.71	1.70									
1400		1.5	1.4	1.5	1.5	20.5	594.64	102.26		403.91	2.93	1.72									
1430						20.45															
1500	1.54	1.5	1.4	1.4	1.5	20.48															
1530	1.52(1)					20.48	622.19	129.81		404.70	3.72	1.72									Nearest 1/2 hr.
1600 (10)	1.52	1.6	1.5	1.6	1.5	20.50							2.247	0.052	2.299	0.163	2.810	2.973	6.79	5.47 (10)	Water added
1630	1.51					20.5	642.32	149.94		405.41	4.43	1.77									
1700	1.50	1.6	1.4	1.6	1.4	20.5															
1730	1.51					20.5	662.47	170.09		406.03	5.05	1.78									
1800		1.5	1.5	1.4	1.5	20.5															
1830						20.5	677.80	185.42		406.78	5.80	1.88									
1900	1.47	1.5	1.5	1.5	1.5	20.45	684.48	192.10		406.98	6.00	1.87									
1930						20.5	691.40	199.02		407.18	6.20	1.87									
2000	1.45	1.5	1.5	1.5	1.5	20.5	696.01	203.63		407.38	6.40	1.89									
2030(4)						20.8	698.46	206.08		407.42	6.44	1.88									Chemicals changed
2100	1.46	—	—	—	—	20.7	708.72	216.34		407.76	6.78	1.88									
2130	1.47(1)					21.55*															*Prob. Record Err
2200	1.48	1.5	1.5	1.5	1.5	20.55															
2230	1.52					20.5															
2300	1.495	1.5	1.5	1.5	1.5	20.5	711.16	218.78		407.85	6.87	1.88	3.072	0.075	3.147	1.064	2.580	3.644	11.15	7.53	
2330	1.54					20.5															
2400	1.495	1.5	1.5	1.5	1.5	20.5	722.10	229.72		408.23	7.25	1.89									
																		Total	25.59	7.02	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 14 February 1953

Time	CO_2 Conc. in Air					O_2 Conc.	Operational Time		Tower	Feed Solution			Liquid Composition						CO_2 Absorbed		Remarks
	Liston Becker	Dwyer Analyzer 1	2	3	4		Timer Reading	Net Time	ΔP	Meter Reading	Net Flow	Flow Rate	Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	Net	Rate	
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/Hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	Saturday(Holiday Routine)
0000	1.495	1.5	1.5	1.5	1.5	20.4	722.10			408.23											
0030	1.49					20.52	727.99	5.79		408.43	0.20	2.07									
0100		1.5	1.5	1.5	1.5	20.49	732.46	10.36		408.59	0.36	2.08									
0130	1.47					20.49	738.24	16.14		408.79	0.56	2.08									
0200		1.5	1.5	1.5	1.5	20.48															
0230	1.47					20.48	741.40	19.30		408.91	0.68	2.11									
0300	1.48	1.5	1.5	1.5	1.5	20.45															
0330						20.50															
0400	1.49	1.5	1.5	1.5	1.5	20.48															
0450	1.48					20.50															
0500		1.5	1.6	1.4	1.5	20.50	742.43	20.33		408.95	0.72	2.12									
0530						20.48															
0600		1.4	1.4	1.5	1.5	20.42															
0630						20.40															
0700		1.5	1.5	1.6	1.5	20.35	744.42	22.32		409.04	0.81	2.18	4.020	0.089	4.109	1.892	2.687	4.579	2.98	[illegible]	
0730						20.70															
0800		1.5	1.5	1.5	1.5	20.70	747.69	25.59		409.15	0.92	2.16									
0830						20.60															
0900	1.44	1.5	1.5	1.5	1.5	20.52	751.44	29.34		410.29	2.06	4.21									
0930						20.50	758.89	36.79		410.57	2.34	3.82									
1000	1.48	1.5	1.5	1.5	1.5	20.50	762.70	40.60		410.72	2.49	3.68									
1030(4)						20.50	768.95	46.85		410.89	2.66	3.41									
1100(10)	1.43	1.5	1.5	1.5	1.5	20.50	778.96	56.86		413.84	5.61	5.92									
1130	1.46					20.45	785.15			414.06	5.83	5.55						3.25(11)			(11)Used Acid as 0.242N
1200	1.47	1.5	1.5	1.5	1.5	20.50	790.10			414.24	6.01	5.30									
1230	1.47						790.10	68.00		414.24	6.01	5.30									
1300(9)	1.46	1.5	1.4	1.5	1.5	20.50	796.67		10.1	414.47	6.24	5.02									
1330	1.50					20.45	796.67			414.47	6.24	5.02						4.12 (11)			(9) Clock turned back 1/2 Hr.
1400	1.50	1.5	1.5	1.5	1.5	20.5	796.67			414.47	6.24	5.02									
1430	1.50					20.5	800.90			414.68	6.45	4.91									
1500	1.50	1.5	1.5	1.5	1.5	20.45	800.90			414.69	6.45	4.91									
1530						20.5	802.68		10.4	414.70	6.47	4.82	2.930	0.113	3.043	0.950	2.528	3.478	9.25	9.55	
1600	1.52	1.5	1.5	1.5	1.5	20.45	806.16			414.83	6.60	4.71									
1630						20.5	809.69			414.93	6.70	4.59									
1700	1.50	1.5	1.5	1.5	1.5	20.5	811.41	89.31		415.03	6.80	4.57									
1730						20.45															
1800(8)		1.5	1.5	1.5	1.5													5.1 (11)			Used Acid as 0.242N End of 2nd roll Water added
1830(10)	1.55					20.4	816.24	94.14		419.77	11.54	7.36									
1900	1.51	1.5	1.5	1.5	1.5	20.4	826.66			420.12											
1930						20.45	829.14	107.04		420.21											
2000	1.48	1.5	1.5	1.5	1.5	20.4															
2030						20.45	839.72	117.62		420.59	12.36	6.31									
2100	1.48	1.5	1.5	1.5	1.5	20.43	846.54			420.83											
2130						20.45															
2200	1.49	1.5	1.5	1.5	1.5	20.48	851.10	129.00		421.00											
2230						20.46	852.46			421.05											
2300	1.50	1.5	1.5	1.5	1.5	20.45	856.72			421.20			3.050	0.096	3.146	0.412	2.482	2.894	6.26	6.96	
2330						20.44	860.79	138.69		421.32	13.09	5.67									
2400		1.5	1.5	1.5	1.5	20.45	860.79	138.69		421.32	13.09	5.6[illegible]									
																	Total		18.89	8.20	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 15 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Timer Reading	Time Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.5	1.5	20.45	860.79			421.32											
0030						20.5															Sunday(Holiday Routine)
0100	1.45	1.5	1.5	1.5	1.5	20.45	867.75	6.96		421.61	0.29	2.50									
0130						20.5															
0200	1.48	1.5	1.5	1.5	1.5	20.45	868.62	7.83		421.62	0.30	2.30									
0230						20.55															
0300	1.48	1.5	1.5	1.5	1.5	20.5	870.46	9.67		421.69	0.37	2.30									
0330						20.4															
0400	1.49	1.5	1.5	1.5	1.4	20.45	873.40	12.61		421.80	0.48	2.28									
0430	1.51					20.4	873.40	12.61		421.80	0.48	2.28									
0500		1.5	1.5	1.5	1.5	20.4	873.40	12.61		421.80	0.48	2.28									
0530						20.4	873.40	12.61		421.80	0.48	2.28									
0600	1.50	1.5	1.5	1.5	1.5	20.4	874.21	13.42		421.83	0.51	2.28									
0630	1.51					20.4	874.21	13.42		421.83	0.51	2.28									
0700		1.5	1.5	1.5	1.5	20.4	876.30	15.51		421.92	0.60	2.32									
0730						20.4	878.90	18.11		422.01	0.69	2.29									
0800		1.5	1.5	1.5	1.5	20.55	880.22	19.43		422.05	0.73	2.25									
0830 (4)	1.51					20.4	881.45	20.66		422.10	0.78	2.27									
0900	1.51	1.5	1.5	1.5	1.5	20.4															Chemicals changed
0930	1.44					20.6															
1000	1.47	1.5	1.5	1.5	1.5	20.5	896.80	36.01		422.65	1.33	2.22						6.3 (11)			Used acid as 0.242N
1030	1.47					20.4															
1100		1.5	1.6	1.5	1.5	20.3															
1130	1.52					20.35									14.4 (11)			7.0 (11)			
1200	1.52	1.5	1.5	1.5	1.5	20.6	898.30	37.51	10.7	422.72	1.40	2.24	9.060	0.159	9.219	1.547	2.545	4.092	4.89	7.82	Used acid as 0.242N
1230						20.45	899.75	38.96		422.77	1.45	2.23			10.6 (11)			7.5 (11)			
1300	1.53	1.5	1.5	1.5	1.5	20.6	902.11	41.32		422.85	1.53	2.22									
1330						20.5	908.46	47.67		423.07	1.75	2.20									
1400		1.5	1.5	1.5	1.5	20.45															
1430	1.59					20.5	912.82	52.03		423.23	1.91	2.20									
1500	1.42	1.4	1.4		1.5	20.4	918.25	57.46		423.42	2.10	2.19			4.84 (11)			7.3 (11)			Used acid as 0.242 N
1530 (10)	1.54					20.55	918.25	57.46		430.65	9.33	9.74									
1600	1.49	1.5	1.5		1.5	20.5	922.64	61.35	10.4	430.79	9.47	9.19	2.612	0.086	2.598	0.186	1.488	2.674	1.72	4.23	Water added
1630						20.48	924.80	64.01		430.85	9.53	8.93									
1700	1.51					20.4	931.68	70.89	10.6	431.08	9.76	8.26						3.15 (11)			Used acid as 0.242N
1730						20.52	936.12	75.33		431.20	9.88	7.87									
1800		1.5	1.5	1.5	1.5	20.42	941.91	81.12	9.2	431.38	10.06	7.44									
1830	1.52					20.4	943.18	82.39	9.2	431.43	10.11	7.36			10.9 (11)			3.8 (11)			Used acid as 0.242N
1900	1.52	1.5	1.4	1.5	1.5	20.5	951.28	90.49	9.2	431.70	10.38	6.88			6.0 (11)			4.1 (11)			Used acid as).242N
1930 (10)						20.5	955.31	94.52		433.86	12.54	7.96									Water added
2000 (10)		1.6	1.5	1.5	1.5	20.52	964.32	103.53		436.33	15.01	8.70									Water added
2030						20.48															
2100	1.49	1.6	1.5	1.5	1.5	20.50	971.83	111.04		436.60	15.28	8.26									
2130						20.52															
2200	1.54	1.5	1.5	1.5	1.5	20.52	983.38	122.59		437.00	15.68	7.67									
2230						20.43															
2300	1.51	1.5	1.5	1.5	1.4	20.50	992.15	131.36		437.30	15.98	7.30	2.647	0.090	2.737	0.219	2.096	2.305	9.72	8.39	
2330						20.5															
2400	1.51	1.5	1.5	1.5	1.5	20.51	998.00	137.21		437.56	16.24	7.10									
																		Total	16.43	7.52	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 16 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyser 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition, Inlet: OH^-	$CO_3^=$	Na^+	Outlet: OH^-	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	$ft.^3$	$ft.^3$	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.51	1.5	1.5	1.5	1.5	20.51	998.00			437.56											
0030						20.5	998.00			437.56											
0100	1.51	1.5	1.5	1.5	1.5	20.52	002.62	4.62		437.71	0.15	1.95									
0130	1.51					20.5															
0200	1.51	1.5	1.5	1.5	1.5	20.5	002.62	4.62		437.71	0.15	1.95									
0230						20.5	007.50	9.50		437.89	0.33	2.08									
0300	1.47	1.5	1.5	1.5	1.5	20.5	008.90	10.90		437.95	0.39	2.15									
0330						20.5															
0400	1.49	1.5	1.5	1.5	1.5	20.48	008.90	10.90		437.95	0.39	2.15									
0430						20.45															
0500		1.5	1.5	1.5	1.5	20.48															
0530						20.50															
0600	1.50	1.5	1.5	1.5	1.5	20.47															
0630						20.48															
0700		1.5	1.6	1.5	1.5	20.5							9.270	0.238	9.508	1.188	2.640	3.828	1.41	7.78	
0730						20.48	009.90	11.90		437.97	0.41	2.07									
0800		1.5	1.6	1.6	1.5	20.43	009.90	11.90		437.97	0.41	2.07									
0830(4)(9)						20.55															
0900		1.5	1.4	1.5	1.5	20.48	021.10	23.10	10.5	438.40	0.84	2.18			4.40(11)			6.9(11)			Clock turned back 15 minutes
0930						20.49	033.64	35.64		438.85	1.29	2.17									
1000		1.5	1.5	1.6	1.5	20.48	034.68	36.68		438.88	1.32	2.16									
1030						20.45	035.14	37.14		438.91	1.35	2.18									
1100		1.6	1.6	1.5	1.5	20.44	037.64	39.64		439.03	1.47	2.23									
1130						20.45	038.99	40.99		439.51	1.95	2.85									
1200		1.5	1.5	1.5	1.6	20.50	057.04	59.04		439.93	2.42	2.46									
1230						20.5	060.43	62.43		440.25	2.69	2.59									
1300		1.5	1.5	1.6	1.5	20.48	065.66	67.66	10.3	440.48	2.92	2.59						4.95(11)			
1330						20.5	081.13	83.13		440.75	3.19	2.30									
1400		1.6	1.5	1.5	1.5	20.4	086.99	88.99		440.75	3.19	2.30									
1430						20.43	099.01	101.01		441.21	3.65	2.17									
1500		1.6	1.6	1.6	1.6	20.4															
1530	1.505					20.35	124.53	126.53		442.20	4.64	2.20									
1600		1.6	1.6	1.6	1.5	20.38	125.22	127.22		442.22	4.66	2.20									
1630						20.48															
1700	1.59					20.54															
1730						20.5	153.62	155.62	9.2	442.99	5.43	2.09	2.300	0.095	2.395	0.293	2.500	2.793	17.30	7.17	
1800		1.5	1.4	1.5	1.5	20.45															
1830						20.65															
1900	1.66	1.5	1.4	1.5	1.5	20.52															
1930	1.67					20.5															
2000		1.6	1.5	1.5	1.5	20.43	180.61	182.61		443.56	6.00	1.97									
2030	1.58					20.50	(6)			(7)											(6) Scrubber running
2100		1.6	1.5	1.5	1.5	20.5	(6)			(7)											
2130	1.56					20.4	(6)		10.1	(7)					2.3	0.11		2.3			(7) Meter failed
2200		1.5	1.5	1.5	1.5	20.5	(6)			(7)											
2230	1.54					20.5	242.82	244.82		(7)											
2300	1.50	1.5	1.5	1.5	1.4	20.6				(7)											
2330	1.50					20.6	243.26	245.26		(7)											
2400		1.5	1.5	1.5	1.5	20.5	276.97	278.97	10.0	444.02			2.540	0.091	2.631	0.149	2.485	2.634	14.65	7.13	
																		Total	33.36	7.16	

Inlet at 0700 was 15.5(11) and outlet 6.5(11)

RESTRICTED

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 17 February 1953

Time	CO_2 Conc. in Air					O_2 Conc.	Operational Time		Tower	Feed Solution			Liquid Composition						CO_2 Absorbed		Remarks
	Liston Becker	Dwyer Analyzer					Timer Reading	Net Time	ΔP	Meter Reading	Net Flow	Flow Rate	Inlet			Outlet			Net	Rate	
		1	2	3	4								OH^-	$CO_3^=$	Na^+	OH^-	$CO_3^=$	Na^+			
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.5	1.5	20.5	276.97		10.0	444.02			2.540	0.091	2.631	0.149	2.485	2.634			
0030	1.47					20.6															
0100		1.5	1.5	1.5	1.5	20.5	286.91	9.94													
0130	1.47					20.45	286.91	9.94													
0200		1.4	1.5	1.5	1.4	20.75	286.91	9.94													
0230	1.49					20.7	286.91	9.94													
0300	1.49	1.5	1.5	1.5	1.5	20.7	286.91	9.94													
0330						20.7	291.34	14.37													
0400	1.50	1.5	1.5	1.5	1.5	20.7	293.68	16.71													
0430	1.51					20.65	294.89	17.92		444.52	0.50	1.67									
0500	1.51	1.5	1.5	1.5	1.5	20.65	295.76	18.79		444.57	0.55	1.76									
0530	1.51					20.62	296.65	19.68		444.67	0.65	1.98									
0600	1.55	1.5	1.5	1.5	1.5	20.6	298.42	21.45		444.78	0.76	2.13									
0630						20.6	303.44	26.47		444.98	0.96	2.18									
0700		1.5	1.5	1.5	1.5	20.45	320.84	43.87	10.1	445.25	1.23	1.68	2.443	0.108	2.551	0.347	2.505	2.852	4.22	5.78	
0730						20.45															
0800		1.5	1.5	1.5	1.5	20.5															
0830						20.45															
0900		1.5	1.5	1.5	1.5	20.51	335.40	58.43		445.55	1.53	2.09									
0930						20.53															
1000		1.5	1.6	1.5	1.5	20.6	363.15	86.18		446.36	2.34	1.63									
1030 (12)						20.6															Gov Mac out
1100 (12)		1.5	1.5	1.6	1.5	20.5	385.00	108.03		447.28	3.26	1.81									" "
1130 (12)						20.5															" "
1200 (12)		1.5	1.5	1.5	1.5	20.45			10.3						2.46			2.77			" "
1230 (12)						20.46															" "
1300 (12)(4)		1.6	1.6	1.5	1.6																" "
1330 (12)																					" "
1400 (12)	1.59	1.5	1.8	1.6	1.5	20.5															" "
1430	1.54					20.55	448.90	171.93	10.3						2.46			2.77			
1500	1.52	1.5	1.5	1.5	1.4	20.5	468.93	191.96	10.3	450.48	6.46	2.02	2.373	0.074	2.447	0.394	2.428	2.822	17.42	7.06	
1530	1.54					20.52															
1600	1.58	1.5	1.4	1.5	1.4	20.48															
1630	1.56					20.47															
1700	1.55	1.5	1.5	1.5	1.4	20.47															
1730	1.51					20.5	528.35	251.38		452.76	8.74	2.09									
1800		1.5	1.4	1.5	1.4	20.5	532.14	255.17		452.91	8.89	2.09									
1830	1.59					20.5															
1900	1.45	1.5	1.5	1.5	1.5	20.45	555.35	278.38		453.78	9.76	2.10									
1930	1.52					20.45	557.41	280.44		453.88	9.86	2.11									
2000	1.51	1.5	1.4	1.5	1.4	20.5	557.45	280.48		453.90	9.88	2.12									
2030	1.51					20.5															
2100	1.49	1.4	1.3	1.5	1.5	20.55	577.28	300.31		454.68	10.66	2.13									
2130	1.49					20.5	580.79	303.82		454.84	10.82	2.14									
2200	1.49	1.5	1.4	1.5	1.5	20.5	584.28	307.31		454.98	10.96	2.14									
2230	1.49					20.5	592.26	315.29		455.19	11.17	2.13									
2300		1.5	1.5	1.5	1.4	20.5	598.44	321.47		455.45	11.43	2.13									
2330	1.48					20.5	605.30	328.33	10.4	455.75	11.73	2.14	2.647	0.066	2.713	0.217	2.587	2.904	18.72	8.24	
2400	1.46	1.5	1.5	1.5	1.5	20.5	607.15	330.18		455.94	11.92	2.17									
																		Total	40.36	7.37	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 18 February 1959

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na	Outlet OH^-	Outlet $CO_3^=$	Outlet Na	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.46	1.5	1.5	1.5	1.5	20.5	607.15			455.94											
0030	1.54					20.5															
0100		1.4	1.5	1.4	1.4	20.5															
0130						20.5	614.37	7.22		456.14	0.20	1.66									
0200	1.49	1.5	1.5	1.3	1.4	20.5	617.07	9.92		456.34	0.40	2.41									
0230						20.5															
0300	1.5	1.5	1.5	1.4	1.5	20.5	618.85	11.70		456.43	0.49	2.51									
0330						20.5															
0400	1.48	1.5	1.5	1.5	1.5	20.5	620.42	13.27		456.55	0.61	2.76									
0430						20.48	620.42	13.27		456.55	0.61	2.76									
0500	1.53	1.5	1.4	1.5	1.5	20.48															
0530						20.6	636.41	29.26		457.18	1.24	2.54									
0600	1.53	1.5	1.5	1.5	1.5	20.48	638.30	31.15		457.30	1.36	2.62									
0630	1.51					20.47	647.50	40.35		457.66	1.72	2.56									
0700	1.52	1.5	1.5	1.4	1.4	20.43	652.85	45.70	10.4	457.97	1.93	2.53	2.438	0.123	2.561	0.402	2.638	3.040	6.98	9.17	
0730						20.55	656.27	49.12		458.00	2.06	2.52									
0800		1.5	1.4	1.5	1.4	20.5															
0830						20.43	667.77	60.62		458.52	2.58	2.55									
0900		1.5	1.4	1.5	1.3	20.5	672.88	65.73		458.72	2.78	2.54									
0930						20.4	684.44	77.29		459.20	3.26	2.53									
1000		1.4	1.4	1.5	1.3	20.4	692.55	85.40		459.70	3.32	2.68									
1030	1.54					20.5	700.61	93.46	10.8	459.97	3.93	2.52			2.39	0.22	2.62	2.84	7.19	9.03	
1100	1.57	1.5	1.4	1.5	1.4	20.5															
1130	1.57					20.45															
1200	1.51	1.5	1.5	1.4	1.4	20.45	729.36	122.21	10.8	460.07	4.13	2.03			2.42	0.23	2.58	2.81	0.71	1.48	
1230						20.45	743.36	136.21		461.58	5.64	2.48									
1300	1.50	1.4	1.5	1.5	1.4	20.4															
1330	1.53					20.6															
1400	1.53	1.3	1.4	1.5	1.5	20.45	767.13	159.98	10.2	462.55	6.61	2.43			2.39	0.15	2.58	2.73	8.79	13.98	
1430	1.47					20.5	787.33	180.18		463.35	7.41	2.47									
1500	1.515	1.4	1.4	1.5	1.4	20.5							2.438	0.056	2.494	0.382	2.453	2.835	2.69	7.98	
1530						20.48															
1600	1.53	1.4	1.3	1.5	1.4	20.4	803.17	196.02		464.04	9.10	2.48									
1630	1.50					20.5															
1700		1.5	1.4	1.4	1.5	20.5	827.70	220.55	10.2	465.05	9.11	2.48			2.42	0.27	2.39	2.66	5.57	8.28	
1730	1.52					20.5	834.95	227.80		465.34	9.40	2.48									
1800	1.50	1.5	1.5	1.5	1.5	20.5	842.31	235.16		465.65	9.71	2.48									
1830	1.50					20.5	851.52	244.37		466.01	10.07	2.47									
1900		1.5	1.5	1.5	1.4	20.55															
1930	1.50					20.5	862.64	255.49		466.48	10.54	2.48									
2000	1.51	1.5	1.5	1.5	1.4	20.5	866.63	259.48		466.65	10.71	2.48									
2030						20.6	874.02	266.87		466.94	11.00	2.47									
2100	1.54	1.5	1.5	1.5	1.4	20.5	881.30	274.15		467.23	11.29	2.47									
2130						20.5	887.17	280.02		467.45	11.51	2.47									
2200	1.52	1.5	1.5	1.4	1.4	20.5	895.95	288.80		467.82	11.88	2.47									
2230						20.5															
2300	1.52	1.6	1.5	1.5	1.4	20.5	912.83	305.68		468.52	12.58	2.47	2.420	0.062	2.482	0.281	2.548	2.829	12.14	8.55	
2330						20.6	918.97	311.82		468.88	12.94	2.49									
2400	1.51	1.5	1.5	1.5	1.4	20.4															
																		Total	44.07	8.66	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 19 February, 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.51	1.5	1.5	1.5	1.4	20.4															
0030						20.5	931.75			469.28											
0100	1.53	1.6	1.5	1.5	1.5	20.5															
0130						20.5	939.81	8.06		469.58	0.30	2.23									
0200	1.50	1.5	1.5	1.5	1.5	20.5	944.36	12.61		469.76	0.48	2.28									
0230						20.5	945.11	13.36		469.81	0.53	2.38									
0300	1.51	1.5	1.5	1.5	1.5	20.5															
0330						20.5	951.15	19.40		470.08	0.80	2.47									
0400	1.50	1.4	1.5	1.6	1.5	20.5	954.00	22.25		470.18	0.90	2.43									
0430						20.5															
0500	1.49	1.4	1.4	1.5	1.4	20.55															
0530						20.5															
0600	1.515	1.5	1.5	1.5	1.4	20.48															
0630						20.5															
0700	1.51	1.5	1.4	1.5	1.5	20.49	958.60	26.85	14.0	470.41	1.13	2.53	2.354	0.079	2.433	0.395	2.533	2.928	3.92	8.75	
0730						20.56	974.19	42.44		471.02	1.74	2.46									
0800		1.5	1.4	1.5	1.4	20.48															
0830						20.5															
0900		1.5	1.4	1.5	1.4	20.7	006.16	74.41		471.90	2.52	2.03									
0930						20.5	013.08	81.33		471.95	2.57	1.97									
1000		1.5	1.5	1.5	1.5	20.45															
1030						20.45															
1100		1.4	1.4	1.5	1.4	20.5															
1130						20.45			10.5						2.39	0.12	2.69	2.81	5.67	6.25	
1200	1.49	1.5	1.5	1.5	1.4	20.45	079.40	147.65		472.75	3.47	1.41									
1230	1.485					20.45			10.5												
1300		1.5	1.4	1.5	1.5	20.5	094.31	162.56		473.32	4.04	1.49			2.43	0.29	2.56	2.85	4.80	3.55	
1330	1.485					20.5	103.55	171.80		473.52	4.24	1.48									
1400 (13)		1.4	1.4	1.4	1.4	20.45															(13) Low Pressure air bled into submarine at 3 cfm. Started at 1350 and finished at 1711
1430 (13)	1.53					20.5	119.67	187.92		474.00	4.72	1.51									
1500 (13)		1.4	1.0	1.3	1.2	20.45	119.67	187.92		474.00	4.72	1.51									
1530 (13)	1.46					20.45	119.67	187.92		474.00	4.72	1.51									
1600 (13)	1.45	1.4	1.0	1.2	1.2	20.5	119.67	187.92		474.00	4.72	1.51									
1630 (13)						20.4	119.67	187.92		474.00	4.72	1.51									
1700 (13)		1.3	1.4	1.4	1.4	20.6	119.67	187.92		474.00	4.72	1.51									
1730						20.5	119.67	187.92		474.00	4.72	1.51									
1800		1.5	1.5	1.5	1.5	20.5	119.67	187.92		474.00	4.72	1.51									
1830	1.55					20.5	129.37	197.62	10.0	474.31	5.03	1.53	2.760	0.040	2.800	0.362	2.310	2.672	3.13	5.37	
1900	1.51	1.5	1.4	1.5	1.4	20.5	131.96	200.21		474.41	5.13	1.54									
1930	1.47					20.5	145.66	213.91		474.82	5.54	1.55									
2000		1.5	1.4	1.5	1.4	20.5															
2030						20.5	147.19	215.44		474.84	5.56	1.55									
2100	1.52	1.3	1.4	1.5	1.5	20.5	150.36	218.61		474.96	5.68	1.56									
2130						20.4	154.49	222.74		475.05	5.77	1.55									
2200	1.52	1.4	1.4	1.4	1.5	20.5	158.66	226.91		475.14	5.86	1.55									
2230						20.4	168.35	236.60		475.43	6.15	1.56									
2300	1.52	1.3	1.3	1.3	1.4	20.4	172.45	240.70	[illegible]	475.60	6.32	1.58	2.253	0.079	2.232	0.291	2.560	2.851	4.53	6.30	
2330						20.5	174.45	242.70		475.83	6.55	1.62									
2400	1.53	1.3	1.2	1.3	1.3	20.5	181.04	249.29		475.88	6.60	1.59									
																		Total	22.05	5.49	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 20 February [illegible]

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.53	1.3	1.2	1.3	1.3	20.5	181.04			475.88											
0030	1.50					20.45	187.90	6.86		476.12	0.24	2.10									
0100		1.6	1.5	1.3	1.3	20.4	191.38	10.34		476.21	0.33	1.91									
0130	1.52					20.45	194.61	13.57		476.31	0.43	1.90									
0200		1.5	1.3	1.1	1.3	20.5	196.74	15.70		476.40	0.52	1.99									
0230	1.55					20.45															
0300	1.49	1.1	1.4	1.0	1.2	20.48	213.06	32.02		476.92	1.04	1.95									
0330	1.42					20.6															
0400		1.3	1.5	1.0	1.1	20.5															
0430(14)	1.41					20.45															(14)CO_2 added at 0416, 0502 and 0520
0500(14)	1.40	1.1	1.1	1.0	1.2	20.55															
0530(14)	1.415					20.6															
0600		1.2	1.3	1.4	1.2	20.55															
0630	1.49					20.52															
0700	1.54	1.4	1.4	1.2	1.4	20.5	214.99	33.95		476.97	1.09	1.93	2.395	0.128	2.523	0.308	2.598	2.906	3.88	6.85	
0730	1.50					20.45	225.97	44.93		477.37	1.49	1.99									
0800(9)		1.4	1.4	1.5	1.4	20.47	242.69	61.65		477.93	2.05	2.00									Clock turned back 25 min.
0830	1.48					20.4	259.27	78.23		478.47	2.59	1.99									
0900		1.5	1.4	1.5	1.4	20.5	259.27	78.23		478.47	2.59	1.99									
0930						20.4	273.48	92.44	10.6	478.97	3.09	2.01			2.54	0.35	2.57	2.92	2.05	7.23	
1000	1.482	1.4	1.4	1.5	1.4	20.4	286.85	105.81		479.42	3.54	2.01									
1030						20.5	295.52	114.48		479.72	3.84	2.01									
1100		1.4	1.2	1.4	1.3	20.5	303.58	122.54		480.00	4.12	2.02									
1130(4)	1.43					20.45	311.31	130.27		480.25	4.37	2.01									
1200	1.49	1.4	1.3	1.4	1.3	20.4	312.90	131.86		480.31	4.43	2.02									
1230						20.4	326.74	145.70		480.77	4.89	2.01									
1300	1.47	1.5	1.3	1.5	1.4	20.5	327.53	146.49		480.79	4.91	2.01									
1330	1.50					20.45	327.53	146.49		480.79	4.91	2.01									
1400		1.5	1.4	1.5	1.4	20.5	327.96	146.92		480.79	4.91	2.01									
1430	1.52					20.4	341.81	160.77		481.25	5.37	2.00									
1500		1.5	1.4	1.5	1.5	20.5	353.49	172.45	10.3	481.65	5.77	2.01	2.360	0.062	2.422	0.296	2.530	2.826	9.28	6.97	
1530	1.46					20.5	368.69	187.65		482.19	6.31	2.02									
1600		1.5	1.5	1.5	1.4	20.4	374.53	193.49		482.38	6.50	2.02									
1630	1.48					20.4	382.96	201.92		482.67	6.79	2.02									
1700	1.49	1.5	1.5	1.5	1.4	20.45	386.38	205.34		482.77	6.89	2.01									
1730						20.4	390.90	209.86		482.91	7.03	2.01									
1800	1.48	1.5	1.4	1.5	1.4	20.45	395.99	214.95		483.09	7.21	2.01									
1830						20.45	396.90	215.86		488.11	7.23	2.01									
1900	1.51	1.5	1.5	1.5	1.5	20.4	399.25	218.21		483.18	7.30	2.01									
1930						20.4	409.41*	228.37		483.38*	7.50										Prob.Rec.Error
2000	1.55	1.5	1.5	1.5	1.5	20.5	405.68*	224.64		483.38*	7.50										Prob.Rec.Error
2030						20.45	413.59	232.54		483.65	7.77	2.00									
2100	1.53	1.5	1.4	1.5	1.5	20.50	427.38	246.34		489.13	8.25	2.01									
2130						20.5	431.95	250.91		484.29	8.41	2.01									
2200	1.50	1.4	1.4	1.4	1.5	20.45	438.55	267.51		484.52	8.64	2.01									
2230						20.45	446.04	265.00		484.79	8.91	2.02									
2300	1.495	1.5	1.4	1.4	1.3	21.0	453.42	272.38	10.6	485.05	9.17	2.02	2.410	0.056	2.466	0.339	2.467	2.806	11.47	6.88	
2330						21.0	458.92	277.88		485.22	9.34	2.02									
2400	1.45	1.4	1.4	1.4	1.4	21.0	460.78	279.74		485.29	9.41	2.02									
																		Total	31.68	6.98	

CAUSTIC SCRUBBER FOR CO_2- OPERATIONAL TEST

Date 21 February, 1953 [illegible]ICTED

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	$ft.^3$	$ft.^3$	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.45	1.4	1.4	1.4	1.4	21.0	460.78			485.29											Saturday (Holiday Routine)
0030	1.50					21.0	465.27	4.49		485.45	0.16	2.14									
0100	1.49	1.5	1.5	1.4	1.4	21.0	471.41	10.63		485.66	0.37	2.09									
0130						20.98	476.98	16.20		485.86	0.57	2.11									
0200		1.4	1.5	1.5	1.5	20.97	478.84	18.06		485.94	0.65	2.16									
0230	1.52					20.92	479.94	19.16		485.95	0.66	2.07									
0300	1.50	1.5	1.5	1.5	1.5	20.87	482.47	21.69		486.08	0.79	2.19									
0330						20.83	482.47	21.69		486.08	0.79	2.19									
0400	1.51	1.5	1.4	1.5	1.5	20.75	488.27	27.49		486.27	0.98	2.14									
0430	1.48					20.72															
0500		1.5	1.5	1.5	1.5	20.68	489.21	29.43		486.29	1.00	2.04									
0530	1.51					20.62															
0600	1.50	1.5	1.5	1.5	1.4	20.55	497.60	36.82		486.55	1.26	2.05									
0630						20.52															
0700		1.5	1.5	1.5	1.5	20.5	502.33	41.55	10.9	486.71	1.42	2.05	2.438	0.075	2.513	0.276	2.560	2.836	4.98	7.19	
0730	1.51					20.45	504.23	43.45		486.75	1.46	2.02									
0800	1.52	1.5	1.5	1.5	1.5	20.45	504.70	43.92		486.76	1.47	2.01									
0830						20.40	507.90	47.12		486.87	1.58	2.01									
0900	1.49	1.5	1.4	1.5	1.5	20.40	508.93	48.15		486.90	1.61	2.01									
0930	1.50					20.4	511.37	50.59		487.00	1.71	2.03									
1000		1.5	1.5	1.5	1.5	20.5	513.99	53.21		487.09	1.80	2.03									
1030	1.51					20.45	522.00	61.22		487.38	2.09	2.05									
1100	1.49	1.4	1.4	1.3	1.4	20.45	525.28	64.50		487.51	2.22	2.07									
1130						20.5	532.67	71.89		487.79	2.50	2.09									
1200	1.52	1.5	1.5	1.5	1.5	20.45	537.80	77.02		487.94	2.65	2.06									
1230						20.45	544.41	83.63		488.18	2.89	2.07									
1300	1.51	1.5	1.5	1.5	1.5	20.4	549.70	88.92		488.35	3.06	2.06									
1330	1.52					20.5				488.43	3.14										
1400		1.5	1.5	1.6	1.5	20.6	555.23	94.45		488.54	3.25	2.06									
1430	1.49					20.5	556.90	96.12		488.59	3.30	2.06									
1500		1.5	1.5	1.5	1.5	20.5	560.02	99.24		488.68	3.39	2.05									
1530	1.54					20.5	560.02	99.24		488.68	3.39	2.05									
1600	1.52	1.5	1.5	1.4	1.4	20.5	571.38	110.60	9.1	489.10	3.81	2.07	1.625	0.073	1.698	0.311	2.528	2.839	8.28	7.20	
1630						20.5	576.22	115.44		489.25	3.96	2.06									
1700	1.53	1.5	1.5	1.4	1.4	20.47															
1730	1.51					20.48															
1800	1.53	1.5	1.5	1.5	1.4	20.5	588.92	128.14		489.66	4.37	2.05									
1830						20.85															
1900	1.54	1.5	1.5	1.5	1.5	20.7	607.14	146.36		490.28	4.99	2.05									
1930	1.54					20.6	618.23	157.45		490.69	5.40	2.06									
2000	1.52	1.4	1.5	1.5	1.4	20.55	620.61	159.83		490.73	5.44	2.04									
2030						20.50	626.51	165.73		490.87	5.58	2.02									
2100	1.55	1.5	1.5	1.4	1.5	20.48	627.05	166.27		490.88	5.59	2.02									
2130						20.50	637.68	176.90		491.23	5.94	2.01									
2200	1.52	1.5	1.5	1.5	1.5	20.5	648.12	187.34		491.59	6.30	2.02									
2230						20.5	652.14	191.36		491.71	6.42	2.01									
2300	1.52	1.6	1.5	1.5	1.5	20.4															
2330						20.5	666.07	205.29	10.2	492.20	6.91	2.02	2.460	0.036	2.496	0.212	2.565	2.777	10.9	7.72	
2400	1.55	1.6	1.5	1.5	1.5	20.45	668.36	207.58		492.24	6.96	2.01									
																		Total	24.16	7.06	

ICTFD

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 22 February, 195[illegible] ICTED

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr	
0000	1.55	1.6	1.5	1.5	1.5	20.45	668.36			492.24											Sunday (Holiday Routine)
0030						20.42	672.86	4.50		492.40	0.16	2.13									
0100		1.4	1.5	1.5	1.5	20.4	674.67	6.31		492.44	0.20	1.90									
0130	1.54					20.4	677.34	8.98		492.49	0.25	1.67									
0200		1.5	1.4	1.5	1.5	20.4	689.05	20.69		492.90	0.66	1.91									
0230	1.56					20.42															
0300		1.4	1.4	1.5	1.5	20.43	689.75	21.39		493.24	1.00	2.81									
0330	1.48					20.4	700.19	31.83		493.27	1.03	1.94									
0400	1.49	1.3	1.3	1.4	1.4	20.45															
0430	1.51																				
0500(14)	1.43	1.4	1.3	1.4	1.3	20.42															
0530						20.4															CO_2 Added at 0506
0600	1.50	1.5	1.4	1.3	1.4	20.5															
0630	1.49					20.45															
0700	1.47	1.4	1.5	1.4	1.4	20.45	702.94	34.58		493.40	1.16	2.01									
0730						20.42															
0800	1.52	1.5	1.4	1.4	1.4	20.45	703.31	34.95	10.1	493.42	1.18	2.03	1.849	0.115	1.964	0.146	2.686	2.832	4.34	7.46	
0830						20.5	707.39	39.03		493.58	1.34	2.06									
0900	1.53	1.4	1.4	1.4	1.4	20.45	711.84	43.48		493.75	1.51	2.08									
0930	1.53					20.5															
1000	1.52	1.4	1.4	1.4	1.4	20.5	721.15	52.79		494.04	1.80	2.05									
1030						20.5	721.15	52.79		494.04	1.80	2.05									
1100	1.52	1.4	1.4	1.5	1.5	20.5	725.29	56.93		494.16	1.92	2.02									
1130	1.52					20.5	732.41	64.05		494.43	2.19	2.05									
1200		1.5	1.5	1.5	1.5	20.45	732.41	64.05		494.43	2.19	2.05									
1230	1.52					20.5	736.29	67.93		494.58	2.34	2.07									
1300	1.52	1.5	1.5	1.5	1.5	20.5	740.41	72.05		494.72	2.48	2.07									
1330						20.45	743.25	74.89		494.82	2.58	2.07									
1400	1.55	1.5	1.5	1.5	1.5	20.4	753.11	84.75		495.14	2.90	2.05									
1430						20.4	759.27	90.91		495.35	3.11	2.05									
1500	1.53	1.5	1.4	1.5	1.5	20.4	763.36	95.00	9.2	495.48	3.24	2.05	2.406	0.054	2.460	0.248	2.713	2.961	7.65	7.65	
1530	1.53					20.45	766.94	98.58		495.60	3.36	2.05									
1600		1.5	1.4	1.5	1.5	20.50	767.35	98.99		495.60	3.36	2.05									
1630						20.45	772.00	103.64		495.79	3.55	2.06									
1700	1.54	1.5	1.5	1.4	1.5	20.45	777.25	108.89		496.00	3.76	2.07									
1730						20.43	785.62	117.26		496.30	4.06	2.08									
1800(4)	1.52	1.5	1.4	1.4	1.5	20.50	790.69	122.33		496.45	4.21	2.06									Chemicals changed
1830						20.50															
1900	1.54	1.4	1.5	1.5	1.4	20.50	802.21	133.85		496.90	4.66	2.09									
1930	1.47					20.5	812.10	143.74		497.25	5.01	2.09									
2000	1.51	1.5	1.4	1.4	1.5	20.5	818.93	150.57		497.48	5.24	2.09									
2030						20.5	821.12	152.76		497.53	5.29	2.08									
2100	1.55	1.4	1.4	1.4	1.5	20.5	826.47	158.11		497.69	5.45	2.07									
2130						20.5	826.47	158.11		497.69	5.45	2.07									
2200	1.49	1.5	1.5	1.4	1.5	20.5	827.40	159.04		497.72	5.48	2.07									
2230						20.5	829.31	160.95		497.78	5.54	2.07									
2300	1.54	1.5	1.4	1.5	1.5	20.5	829.31	160.95		497.78	5.54	2.07									
2330						20.5	832.09	163.73	10	497.89	5.65	2.07	2.830	0.058	2.888	0.339	2.652	2.991	8.76	7.63	
2400	1.55	1.5	1.5	1.5	1.5	20.5	838.98	170.62		498.13	5.89	2.07									
																		Total	20.75	7.62	

ICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 23 February 1953

RESTRICTED

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet CO_3	Inlet Na^+	Outlet OH^-	Outlet CO_3	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	$ft.^3$	$ft.^3$	$ft.^3/hr.$	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	(Holiday Routine)
0000	1.55	1.5	1.5	1.5	1.5	20.5	838.98			498.13											
0030						20.48	846.19	7.21		498.39	0.26	2.16									
0100	1.54	1.5	1.5	1.5	1.5	20.47	849.06	10.08		498.47	0.34	2.02									
0130						20.48															
0200	1.54	1.5	1.5	1.5	1.5	20.48	854.28	15.30		498.65	0.52	2.04									
0230						20.45	857.13	18.15		498.75	0.62	2.05									
0300	1.53	1.5	1.5	1.5	1.5	20.47	860.78	21.80		498.85	0.72	1.98									
0330						20.8	866.78	27.80		499.05	0.92	1.99									
0400	1.51	1.5	1.5	1.5	1.5	20.72	866.78	27.80		499.0[illegible]	0.92	1.99									
0430						20.69															
0500	1.53	1.5	1.5	1.5	1.4	20.62	873.25	34.27		499.25	1.12	1.96									
0530						20.6	875.54	36.56		499.35	1.22	2.00									
0600	1.54	1.5	1.4	1.5	1.5	20.6	875.63	36.65		499.35	1.22	2.00									
0630						20.55	876.87	37.89		499.38	1.25	1.98									
0700	1.55	1.5	1.5	1.5	1.5	20.55	878.42	39.44	[illegible].6	499.43	1.30	1.98	2.915	0.058	2.973	0.467	2.685	3.152	4.78	7.28	
0730						20.45	891.13	52.15		499.96	1.83	2.11									
0800	1.52	1.5	1.4	1.5	1.5	20.5	893.22	54.24		500.05	1.92	2.12									
0830						20.5	894.92	55.94		500.07	1.94	2.08									
0900	1.56	1.5	1.5	1.5	1.5	20.5	903.24	64.26		500.34	2.21	2.06									
0930						20.5	908.93	69.95		500.54	2.41	2.07									
1000	1.54	1.5	1.5	1.4	1.5	20.45	912.86	73.88		500.68	2.55	2.07									
1030						20.5	918.48	79.50		500.84	2.71	2.05									
1100	1.54	1.5	1.5	1.5	1.5	20.5	919.52	80.54		500.86	2.73	2.03									
1130						20.5	925.47	86.49		501.09	2.96	2.05									
1200	1.49	1.5	1.5	1.5	1.5	20.5	934.00	95.02		501.42	3.29	2.08									
1230						20.45															
1300		1.5	1.5	1.5	1.5	20.5	934.11	95.13		501.43	3.30	2.08									
1330	1.53					20.5	945.37	106.39		501.8[illegible]	3.72	2.10									
1400		1.5	1.6	1.5	1.5				10.2							0.23	2.73	2.96	9.05	8.11	
1430	1.56					20.45	950.20	111.22		502.04	3.91	2.11									
1500	1.56	1.5	1.5	1.5	1.5	20.5	959.82	120.90		502.39	4.26	2.11									
1530						20.5	970.54	131.56		502.80	4.67	2.13									
1600	1.52	1.5	1.5	1.5	1.5	20.45	989.47	150.49	10.2	503.57	5.44	2.17	2.724	0.062	2.786	0.552	2.544	3.096	6.00	8.16	
1630						20.50	992.70	153.72		503.68	5.55	2.17									
1700	1.48	1.5	1.5	1.5	1.4	20.5	995.10	156.12		503.80	5.67	2.18									
1730						20.5	996.63	157.65		503.86	5.73	2.18									
1800	1.51	1.5	1.5	1.5	1.5	20.5	999.84	160.86	10.3	503.99	5.86	2.19				0.27	2.65	2.92	1.05	8.83	
1830						20.45	006.18	167.20		504.20	6.07	2.18									
1900	1.53	1.5	1.5	1.5	1.5	21.00	011.83	172.85		504.40	6.27	2.18									
1930						20.92	021.15	182.17		504.73	6.60	2.17									
2000	1.52	1.5	1.5	1.5	1.5	20.85	027.59	188.61		504.94	6.81	2.17									
2030						20.80	034.85	195.87		505.20	7.07	2.17									
2100	1.51	1.5	1.5	1.5	1.5	20.8	038.14	199.16		505.33	7.20	2.17									
2130						20.75	040.44	201.46		505.38	7.25	2.16									
2200	1.52	1.5	1.5	1.5	1.5	20.70	042.85	203.87		505.47	7.34	2.16									
2230						20.65															
2300	1.53	1.5	1.5	1.5	1.5	20.6	046.54	217.56		505.98	7.85	2.16	2.728	0.078	2.806	0.374	2.667	3.041	7.75	7.75	
2330						—															
2400	1.53	1.5	1.4	1.5	1.5	20.5	068.04	229.06		506.40	8.27	2.17									
																			Total 28.63	7.91	

CAUSTIC SCRUBBER FOR CO_2- OPERATIONAL TEST

Date 24 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.53	1.5	1.4	1.5	1.5	20.5	068.04			506.40											
0030						20.42	075.89	7.85		506.72	0.32	2.45									
0100	1.50	1.5	1.5	1.5	1.5	20.5															
0130						20.5	083.77	15.73		506.92	0.52	1.98									
0200	1.51	1.5	1.5	1.5	1.5	20.5															
0230						20.5	089.84	21.80		507.05	0.65	1.79									
0300	1.50	1.5	1.4	1.5	1.5	20.5	090.82	22.78		507.15	0.75	1.98									
0330							090.63	22.59		507.23	0.83	2.20									
0400	1.51	1.5	1.4	1.5	1.4	20.5															
0430						20.65															
0500	1.51	1.5	1.4	1.4	1.5	20.58	103.00	34.96		507.47	1.07	1.84									
0530						20.53	105.27	37.23		507.55	1.15	1.85									
0600	1.50	1.5	1.5	1.4	1.4	20.52															
0630						20.50	113.98	45.94		507.81	1.41	1.84									
0700	1.52	1.5	1.5	1.5	1.5	20.42	116.37	48.33	10.4	507.85	1.45	1.80	1.682	0.061	1.743	0.394	2.670	3.064	5.30	6.58	
0730	1.52					20.4	122.78	54.74		508.12	1.72	1.89									
0800		1.5	1.5	1.5	1.4	20.5	130.13	62.09		508.38	1.98	1.91									
0830						20.4	130.81	62.77		508.39	1.99	1.90									
0900		1.5	1.4	1.5	1.5	20.4	130.81	62.77		508.39	1.99	1.90									
0930						20.45	135.92	67.88		508.59	2.19	1.94									
1000		1.5	1.5	1.5	1.5	20.40	142.61	74.57		508.81	2.41	1.94									
1030						20.4	159.64	91.60	10.3	509.41	3.01	1.97			2.43	.19	2.66	2.85	5.68	7.88	
1100		1.4	1.5	1.5	1.4	20.4	174.57	106.53		509.96	3.56	2.01									
1130 (9)	1.53					20.5	186.20	118.16		510.39	3.99	2.03									Clock turned back 1/2 hour, elapsed time is 1 hr.
1200		1.4	1.4	1.5	1.4	20.5	186.20	118.16		510.39	3.99	2.03									
1230	1.63					20.5	186.20	118.16		510.39	3.99	2.03									
1300 (4)	1.55	1.4	1.5	1.5	1.5	20.4	211.50	143.46	10.3	511.33	4.93	2.06			2.39	0.19	2.51	2.70	6.61	7.63	
1330	1.53					20.45	222.45	154.41	10.3	511.74	5.34	2.07									
1400	1.49	1.4	1.5	1.5	1.5	20.45	231.13	163.09		512.03	5.63	2.07									
1430	1.50					20.5	239.82	171.78		512.33	5.93	2.07									
1500		1.4	1.5	1.5	1.5	20.4	255.13	187.09	10.1	512.91	6.51	2.09	2.130	0.058	2.188	0.288	2.495	2.783	5.40	7.43	
1530	1.49					20.5	257.80	189.76		512.99	6.59	2.08									
1600	1.52	1.4	1.5	1.5	1.4	20.5	262.21	194.17		513.12	6.72	2.08									
1630						20.45	272.19	204.15		513.52	7.12	2.09									
1700	1.52	1.3	1.4	1.4	1.4	20.5	272.95	204.91		513.55	7.15	2.09									
1730						20.6	275.35	207.31		513.62	7.22	2.09									
1800	1.54	1.4	1.4	1.4	1.4	20.4	288.09	220.05		514.09	7.69	2.10									
1830	1.50					20.4	296.86	228.82		514.41	8.01	2.10									
1900		1.4	1.5	1.5	1.4	20.4	309.61	241.57		514.88	8.48	2.11									
1930	1.46					20.5	321.26	253.22		515.30	8.90	2.11									
2000		1.4	1.5	1.4	1.4	20.5	324.90	256.86		515.42	9.02	2.11									
2030	1.51					20.5	333.27	265.23		515.71	9.31	2.11									
2100		1.4	1.4	1.4	1.4	20.5	342.30	274.26		516.04	9.64	2.11									
2130	1.50					20.5															
2200		1.4	1.5	1.5	1.4	20.5	348.80	280.76		516.25	9.85	2.11									
2230	1.51					20.5															
2300		1.5	1.4	1.4	1.4	20.5	359.21	291.17		516.70	10.30	2.12									
2330	1.50					20.5			10.2				2.420	0.060	2.480	0.296	2.550	2.846	13.26	7.64	
2400		1.5	1.4	1.4	1.4	20.6	369.91	301.87		517.01	10.61	2.11									
																	Total		36.25	7.49	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 25 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/mn	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.4	1.4	1.4	20.6	369.91			517.01											
0030	1.51					20.58	378.07	8.16		517.25	0.24	1.76									
0100	1.50	1.5	1.4	1.5	1.5	20.52	378.67	8.76		517.26	0.25	1.71									
0130						20.48															
0200	1.48	1.5	1.5	1.5	1.4	20.48	381.34	11.43		517.35	0.34	1.78									
0230	1.48					20.45	382.48	12.57		517.38	0.37	1.77									
0300	1.48	1.5	1.5	1.5	1.4	20.44	382.48	12.57		517.38	0.37	1.77									
0330	1.49					20.48	382.48	12.57		517.38	0.37	1.77									
0400	1.56	1.4	1.4	1.5	1.4	20.48	382.48	12.57		517.38	0.37	1.77									
0430						20.48	390.94	21.03		517.69	0.68	1.94									
0500	1.49	1.4	1.4	1.4	1.4	20.45															
0530						21.00															
0600	1.53	1.4	1.5	1.4	1.4	21.0	39[illegible].05	27.14		517.92	0.91	2.01									
0630	1.47					20.5	403.94	34.03		518.14	1.13	1.99									
0700		1.4	1.4	1.3	1.4	20.5	406.12	36.21		518.19	1.18	1.96									
0730						20.5			9.6				2.345	0.063	2.408	0.313	2.530	2.843	4.09	6.77	
0800		1.5	1.4	1.5	1.5	20.5															
0830							419.25	40.34		518.66	1.65	2.01									
0900		1.5	1.4	1.5	1.5		424.99	55.08	9.8	518.85	1.84	2.00			2.82	0.18	2.60	2.78	1.67	7.65	
0930																					
1000		1.4	1.5	1.4	1.4				10.0						2.85	0.21	2.64	2.85	0.687	7.18	
1030							457.01	87.10		520.11	3.10	2.14									
1100		1.4	1.4	1.5	1.4		469.53	99.62		520.59	3.58	2.16									
1130						20.5	471.53	101.62		520.69	3.68	2.17									
1200		1.4	1.4	1.5	1.5	20.4	471.53	101.62	10.1	520.69	3.68	2.17			2.71	0.24	2.57	2.81	6.49	8.36	
1230						20.4	492.65	122.74		521.52	4.51	2.20									
1300	1.56	1.5	1.4	1.5	1.5	20.4	492.65	122.74		521.52	4.51	2.20									
1330	1.53					20.4	510.01	140.10		522.18	5.17	2.21									
1400	1.51	1.5	1.5	1.5	1.5	20.4	517.33	147.42	10.2	522.45	5.44	2.21			2.38	0.20	2.59	2.79	6.24	8.18	
1430						20.4															
1500	1.47	1.5	1.5	1.5	1.5	20.4	536.21	166.30		523.19	6.18	2.23									
1530	1.49					20.5															
1600		1.5	1.6	1.5	1.4	20.3	551.58	181.67	10.2	523.76	6.75	2.23	2.307	0.072	2.379	0.291	2.595	2.886	4.65	8.15	
1630	1.51					20.4	561.63	191.72		524.15	7.14	2.23									
1700		1.5	1.5	1.6	1.5	20.4	570.98	201.07		524.50	7.49	2.24									
1730	1.50					20.4	578.32	208.41	10.3	524.78	7.77	2.24			2.42	0.26	2.65	2.91	3.70	8.31	
1800		1.5	1.5	1.5	1.5	20.3															
1830	1.50					20.4	586.63	216.72		525.10	8.09	2.24									
1900		1.5	1.4	1.5	1.5	20.4	592.57	222.66		525.29	8.28	2.23									
1930	1.53					20.4															
2000		1.5	1.5	1.5	1.5	20.4	613.94	244.03		526.11	9.10	2.24									
2030						20.3	615.98	246.07		526.18	9.17	2.24									
2100	1.49	1.5	1.5	1.5	1.5	20.3	626.29	256.38		526.55	9.54	2.23									
2130						20.4															
2200	1.53	1.5	1.5	1.5	1.5	20.4															
2230						20.4	630.48	260.57		526.72	9.71	2.24									
2300	1.54	1.5	1.5	1.5	1.5	20.4	633.62	266.71	8.2	526.83	9.82	2.23	2.398	0.062	2.46[illegible]	0.180	2.648	2.828	7.44	8.08	
2330						20.4															
2400	1.53	1.5	1.5	1.5	1.5	20.4	651.35	281.44		527.51	10.50	2.24						Total	34.967	7.95	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 26 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dryer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH	Inlet $CO_3^=$	Inlet Na^+	Outlet OH	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000		1.5	1.5	1.5	1.5	20.4	651.35			527.51											
0030	1.53					20.4	659.05	7.70		527.83	0.32	2.49									
0100	1.57	1.5	1.6	1.6	1.6	20.4	663.41	11.06		527.99	0.48	2.60									
0130						20.5	664.75	13.40		528.03	0.52	2.33									
0200	1.53	1.5	1.6	1.5	1.6	20.5	666.74	15.39		528.13	0.62	2.42									
0230	1.51					20.4	678.78	27.43		528.59	1.08	2.36									
0300	1.5	1.5	1.6	1.5	1.5	20.45	684.58	33.23		528.82	1.31	2.37									
0330						20.46	684.58	33.23		528.82	1.31	2.37									
0400	1.53	1.5	1.5	1.5	1.5	20.4	687.55	36.20		528.92	1.41	2.34									
0430						20.4	692.51	41.16		529.10	1.59	2.32									
0500	1.51	1.6	1.5	1.5	1.5	20.4	695.42	44.07		529.20	1.69	2.30									
0530						20.4	699.17	47.82		529.35	1.84	2.31									
0600	1.50	1.6	1.5	1.5	1.5	20.4	701.89	50.54		529.47	1.96	2.33									
0630						20.4	706.06	54.71		529.64	2.13	2.34									
0700		1.5	1.5	1.5	1.5		716.54	65.19		530.05	2.54	2.34									
0730							725.04	73.69		530.29	2.78	2.26									
0800		1.6	1.6	1.6	1.5		725.04	73.69	10.0	530.29	2.78	2.26	2.760	0.066	2.826	0.422	2.624	3.046	10.00	8.14	
0830							735.18	83.83		530.76	3.25	2.33									
0900		1.5	1.6	1.6	1.5		747.22	95.87		531.20	3.69	2.31									
0930							767.26	115.91		531.99	4.48	2.32									
1000		1.6	1.5	1.5	1.5		779.41	128.06	10.0	532.50	4.99	2.34			2.38			2.84			
1030	1.50						805.03	153.68		533.49	5.98	2.33									
1100	1.46	1.5	1.5	1.5	1.5		819.66	168.31		534.05	6.54	2.33									
1130(4)	1.4						836.07	184.72		534.65	7.14	2.32									Chemicals changed
1200	1.47	1.5	1.5	1.5	1.5	20.5	836.07	184.72		534.65	7.14	2.32									
1230	1.48					20.45	836.07	184.72		534.65	7.14	2.32									
1300	1.55	1.6	1.5	1.6	1.5	20.4	836.07	184.72	10.0	534.65	7.14	2.32			2.42			2.81			
1330	1.55					20.5	850.38	199.03		535.15	7.64	2.30									
1400		1.6	1.5	1.6	1.5	20.45	866.12	214.77		535.78	8.27	2.31									
1430	1.51					20.4	870.66	219.31		535.95	8.44	2.31									
1500	1.50	1.6	1.6	1.6	1.5	20.4	875.57	224.22	10.1	536.12	8.61	2.30	2.420	0.042	2.462	0.331	2.557	2.888	20.40	8.13	
1530	1.52					20.4	889.94	238.59		536.65	9.14	2.30									
1600	1.50	1.6	1.5	1.5	1.5	20.5	903.51	252.16		537.17	9.66	2.30									
1630						20.4	916.70	265.35		537.70	10.19	2.30									
1700	1.53	1.6	1.5	1.6	1.6	20.4															
1730						20.45	929.86	278.51		538.18	10.67	2.30									
1800	1.52	1.5	1.5	1.5	1.5	20.50	935.42	284.07		538.38	10.87	2.30									
1830						20.40	944.16	292.81		538.70	11.19	2.29									
1900	1.53	1.5	1.6	1.5	1.6	20.4	951.41	300.06		538.97	11.46	2.29									
1930						20.5	958.51	307.16		539.23	11.72	2.29									
2000	1.50	1.6	1.5	1.6	1.5	20.5	960.87	309.52		539.31	11.80	2.29									
2030						20.5	971.70	320.35		539.75	12.24	2.29									
2100	1.46	1.5	1.5	1.5	1.5	20.5	981.91	330.56		540.12	12.61	2.29									
2130						20.45	990.47	339.12		540.45	12.94	2.29									
2200	1.51	1.5	1.5	1.5	1.5	20.45															
2230						20.5															
2300	1.51	1.5	1.4	1.5	1.5	20.5	009.96	358.61		541.61	13.70	2.29									
2330						20.5	015.44	364.09		541.41	13.90	2.29									
2400	1.50	1.6	1.5	1.5	1.5	20.5	018.53	367.18	10.0	541.50	13.99	2.29	2.776	0.085	2.861	0.390	2.501	2.891	18.43	7.82	
																	Total		48.83	7.99	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 27 February 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower ΔP	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.50	1.6	1.5	1.5	1.5	20.5	018.53		10.0	541.50			2.776	0.085	2.861	0.390	2.501	2.891			
0030						20.5	025.69	7.16		541.81	0.31	2.60									
0100	1.47	1.5	1.6	1.5	1.5	20.5	035.56	17.03		542.18	0.68	2.40									
0130						20.5	035.56	17.03		542.18	0.68	2.40									
0200	1.52	1.6	1.4	1.6	1.5	20.5	035.56	17.03		542.18	0.68	2.40									
0230						20.5	041.49	22.96		542.40	0.90	2.35									
0300	1.49	1.5	1.5	1.5	1.5	20.5	041.49	22.96		542.40	0.90	2.35									
0330	1.50					20.5	041.49	22.96		542.40	0.90	2.35									
0400	1.5	1.6	1.4	1.5	1.5	20.5	041.49	22.96		542.40	0.90	2.35									
0430	1.52					20.5	046.55	28.02		542.58	1.08	2.31									
0500	1.51	1.6	1.5	1.5	1.5	20.5	047.90	29.37		542.63	1.13	2.31									
0530						20.45															
0600		1.6	1.5	1.5	1.5	20.5	062.00	43.47		543.06	1.56	2.15									
0630	1.50					20.4															
0700	1.54	1.5	1.4	1.5	1.5	20.5	082.78	64.25	10.3	543.98	2.48	2.32	2.777	0.082	2.859	0.408	2.495	2.903	8.48	7.92	
0730	1.49					20.5															
0800	1.47	1.5	1.5	1.5	1.5	20.4															
0830						20.5	101.25	82.72		544.67	3.17	2.30									
0900		1.6	1.5	1.5	1.5	20.5			10.3						2.73			2.92			
0930						20.45															
1000		1.5	1.5	1.5	1.5	20.5	132.22	113.69		545.88	4.38	2.31									
1030						20.5															
1100		1.5	1.5	1.5	1.5	20.53	158.07	139.54	10.3	545.93	4.43	2.19			2.84			3.0			
1130	1.47					20.45															
1200 (4)	1.45	1.6	1.6	1.5	1.5	20.45	177.61	159.08		547.72	6.22	2.35									
1230						20.45															
1300	1.56	1.5	1.5	1.5	1.5	20.5			10.2												
1330	1.60					20.5									2.54			3.0			
1400	1.565	1.6	1.6	1.5	1.5	20.45	211.03	192.50		549.09	7.59	2.37									
1430	1.47					20.5															
1500		1.5	1.5	1.5	1.4	20.5			10.3				2.455	0.055	2.510	0.418	2.698	3.116	18.90	8.83	
1530						20.5	227.15	208.62		549.68	8.18	2.35									
1600	1.5	1.6	1.5	1.5	1.5	20.5															
1630						20.5	248.22	229.69		550.53	9.03	2.36									
1700	1.46	1.5	1.5	1.5	1.5	20.55	261.30	242.77	10.3	551.07	9.57	2.37			2.50			3.12			
1730						20.6				551.63	10.13										
1800	1.49	1.5	1.6	1.5	1.5	20.6	276.19	258.66		551.63	10.13	2.35									
1830						20.6	282.78	264.25		551.86	10.36	2.35									
1900	1.50	1.5	1.5	1.6	1.5	20.5	289.84	271.31		552.12	10.62	2.35									
1930						20.5	289.84	271.31		552.12	10.62	2.35									
2000	1.51	1.5	1.5	1.5	1.5	20.5	305.53	287.00		552.71	11.21	2.34									
2030						20.5	312.97	294.44		553.00	11.50	2.34									
2100	1.54	1.5	1.5	1.5	1.5	20.5	312.97	294.44		553.00	11.50	2.34									
2130						20.5	317.43	298.90		553.15	11.65	2.34									
2200	1.52	1.5	1.5	1.5	1.5	20.5	323.67	305.14		553.37	11.87	2.33									
2230						20.5	331.70	313.17		553.63	12.13	2.32									
2300	1.50	1.5	1.5	1.5	1.5	20.5	334.37	315.84		553.72	12.22	2.32									
2330						20.5	334.37	315.84		553.72	12.22	2.32									
2400	1.53	1.5	1.5	1.5	1.5	20.5	343.59	325.06	10.15	554.02	12.52	2.31	2.433	0.080	2.513	0.418	2.582	3.000	15.65	5.08	
																		Total	43.03	7.95	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date 28 February, 1953

Time	CO_2 Conc. in Air: Listen Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.53	1.5	1.5	1.5	1.5	20.5	343.59		10.5	554.02			2.433	0.080	2.513	0.418	2.582	3.000			
0030	1.50					20.45															
0100	1.50	1.4	1.5	1.5	1.5	20.5															
0130						20.5	372.--			554.98	0.96										
0200	1.48	1.5	1.5	1.5	1.5	20.5	379.47	35.88		555.25	1.23	2.06									
0230						20.5															
0300	1.47	1.5	1.5	1.4	1.5	20.5	390.97	47.38		555.65	1.63	2.06									
0330	1.47					20.53	390.97	47.38		555.65	1.63	2.06									
0400		1.4	1.5	1.4	1.5	20.5	397.44	53.85		555.86	1.84	2.05									
0430	1.49					20.4															
0500		1.5	1.5	1.4	1.5	20.4															
0530	1.50					20.4	402.77	59.18		556.05	2.03	2.06									
0600		1.5	1.5	1.5	1.5	20.4															
0630	1.54					20.5															
0700	1.52	1.4	1.5	1.4	1.5	20.5	410.91	67.32		556.35	2.33	2.08									
0730	1.48					20.5	416.63	73.04		556.56	2.54	2.09									
0800		1.5	1.5	1.5	1.5	20.45															
0830	1.495					20.52															
0900		1.5	1.4	1.4	1.4	20.5			10.2						2.77			3.08			
0930						20.5															
1000		1.5	1.4	1.4	1.4	20.5															
1030						20.45	428.40	84.81	10.2	557.02	3.00	2.12			2.85			3.16			
1100	1.53	1.5	1.5	1.5	1.5	20.5															
1130						20.45															
1200		1.5	1.5	1.5	1.4	20.5									2.77			3.12			
1230						20.55	446.12	102.53		557.70	3.68	2.15									
1300	1.53	1.5	1.5	1.5	1.5	20.5							3.068	0.066	3.134	0.466	2.737	3.203	13.80	8.08	
1330 (9)						20.5															
1400	1.49	1.5	1.5	1.5	1.5	20.45	466.10	122.51		558.59	4.57	2.24									Clock turned back 1/2 hour Elapsed time 1 hour
1430						20.45															
1500	1.5	1.5	1.5	1.5	1.5	20.50	479.63	136.04		558.98	4.96	2.19									
1530						20.52			10.1						2.77			3.08			
1600	1.48	1.5	1.5	1.5	1.5	20.45	483.90	140.31		559.14	5.12	2.19									
1630						20.5	488.41	144.82		559.32	5.30	2.20									
1700	1.51	1.5	1.5	1.5	1.5	20.5	494.04	150.45		559.54	5.52	2.20									
1730						20.5	501.60	158.01		559.84	5.82	2.21									
1800	1.51	1.5	1.5	1.5	1.5	20.5	507.42	163.83	10.0	560.07	6.04	2.21	2.792	0.047	2.839	0.449	2.682	3.131	8.72	8.52	
1830						20.5	507.42	163.83		560.07	6.04	2.21									
1900	1.55	1.5	1.5	1.5	1.5	20.5	507.42	163.83		560.07	6.04	2.21									
1930 (4)						20.5															
2000	1.52	1.5	1.5	1.5	1.5	20.5	525.29	181.70		560.77	6.75	2.23									Chemicals changed
2030						20.3	527.15	183.56		560.86	6.84	2.24									
2100	1.56	1.5	1.5	1.5	1.5	20.3	529.89	186.30		560.96	6.94	2.24									
2130						20.5	540.68	197.09		561.39	7.37	2.24									
2200	1.50	1.5	1.5	1.5	1.5	20.4	546.50	202.91		561.63	7.61	2.25									
2230						20.5	550.48	206.89		561.79	7.77	2.25									
2300	1.52	1.5	1.5	1.5	1.5	20.5	554.01	210.42		561.93	7.91	2.26									
2330						20.5	557.10	213.57		562.05	8.03	2.26									
2400	1.52	1.5	1.5	1.5	1.5	20.5	558.09	214.50	8.0	562.10	8.07	2.26	2.630	0.054	2.684	0.290	2.948	3.238	8.22	9.72	
																	Total		30.74	8.59	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 2 March 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition Inlet: OH^-	$CO_3^=$	Na^+	Outlet: OH^-	$CO_3^=$	Na^+	CO_2 Absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	"H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr	norm	norm	norm	norm	norm	norm	lbs	lbs/hr.	
0000	1.51	1.5	1.5	1.5	1.5	20.53	782.71			570.84											
0030						20.5	787.46	04.75		571.00	0.16	2.02									
0100	1.[illegible]4	1.5	1.5	1.5	1.5	20.5	788.22	05.51		571.04	.20	2.18									
0130						20.5															
0200	1.[illegible]	1.5	1.5	1.5	1.5	20.45	790.84	8.13		571.10	.26	1.92									
0230						20.5	797.09	14.38		571.36	.52	2.17									
0300	1.52	1.5	1.5	1.5	1.5	20.5	797.09	14.38		571.36	.52	2.17									
0330						20.5	799.15	16.44		571.43	.59	2.15									
0400	1.50	1.5	1.5	1.5	1.5	20.5	801.86	19.15		571.54	.70	2.19									
0430						20.5	806.50	23.79		571.72	.78	1.97									
0500	1.5	1.5	1.5	1.5	1.5	20.5	809.44	26.73		571.84	1.00	2.24									
0530						20.5	809.44	26.73		571.84	1.00	2.24									
0600	1.52	1.5	1.5	1.5	1.5	20.5	809.44	26.73		571.84	1.00	2.24									
0630						20.5	809.44	26.73		571.94	1.00	2.24									
0700		1.5	1.5	1.5	1.5	20.55	816.08	33.37	10.0	572.09	1.25	2.25	2.680	0.065	2.745	0.308	2.888	3.196	4.95	8.90	
0730						20.6	818.81	36.10		572.18	1.34	2.23									
0800		1.5	1.6	1.6	1.5																
0830 (.)							827.74	45.03		572.57	1.73	2.31									Chemicals Changed
0900		1.5	1.5	1.5	1.5				10.3						2.77			3.16			
0930							846.20	63.49		573.27	2.43	2.30									
1000		1.5	1.5	1.5	1.5																
1030																					
1100		1.5	1.6	1.6	1.5	20.3	874.23	91.52		574.40	3.56	2.33									
1130	1.[illegible]					20.3			10.2						2.77			3.12			
1200		1.5	1.5	1.6	1.5	20.5	897.26	114.55		575.28	4.44	2.33									
1230	1.54					20.6	906.80	124.09		575.64	4.80	2.32									
1300	1.56	1.6	1.6	1.6	1.5	20.5	919.60	136.89		576.10	5.26	2.31									
1330						20.5	947.95	165.24	10.1	577.04	6.20	2.25			2.54			3.08			
1400	1.41	1.5	1.5	1.5	1.5	20.5	952.55	169.84		577.08	6.24	2.20									
1430						20.3	952.55	169.84		577.08	6.24	2.20									
1500		1.5	1.5	1.5	1.5	20.4	952.65	169.94		577.17	6.33	2.23									
1530						20.5	952.65	169.94	9.8	577.17	6.33	2.23	2.368	0.064	2.432	0.273	2.835	3.108	19.75	8.68	
1600	1.52	1.6	1.5	1.5	1.5	20.4															
1630	1.49					20.5	981.69	192.98		578.13	7.29	2.20									
1700	1.47	1.5	1.5	1.5	1.5	20.55															
1730						20.5	993.37	210.66		578.50	7.66	2.18									
1800	1.48	1.5	1.5	1.5	1.4	20.6	999.24	216.53		578.68	7.84	2.17									
1830						20.5	008.41	225.70		578.95	8.11	2.16									
1900	1.50	1.5	1.5	1.5	1.5	20.5	010.62	227.91		579.00	8.16	2.15									
1930						20.5															
2000	1.48	1.5	1.5	1.6	1.5	20.5	025.07	242.36		579.42	8.58	2.12									
2030						20.5	034.02	251.31		579.66	8.76	2.09									
2100	1.50	1.5	1.5	1.5	1.5	20.5	036.90	254.19		579.74	8.90	2.10									
2130						20.5	043.74	261.03		579.91	9.07	2.08									
2200	1.48	1.5	1.5	1.5	1.5	20.5	047.05	264.34		580.00	9.16	2.08									
2230						20.48	053.36	270.65		580.15	9.31	2.06									
2300	1.51	1.5	1.5	1.6	1.6	20.5															
2330						20.45	055.27	272.56		580.22	9.38	2.06									
2400	1.5	1.5	1.5	1.5	1.5	20.5	057.86	275.15	10.2	580.28	9.44	2.06	2.715	0.067	2.782	0.202	2.775	2.977	11.83	6.15	
																		Total	36.53	7.69	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 3 March 1953

Time	CO_2 Conc. in Air: Liston Becker	CO_2 Conc. in Air: Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower Δ P	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Liquid Composition Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	$ft.^3$	$ft.^3$	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.5	1.5	1.5	1.5	1.5	20.5	057.86		10.2	580.28			2.715	0.067	2.782	0.202	2.775	2.977			
0030						20.4	065.82	[illegible].96		580.48	0.20	1.51									
0100	1.49	1.5	1.5	1.5	1.5	20.4															
0130						20.45	071.65	13.79		580.64	0.36	1.57									
0200	1.49	1.5	1.5	1.5	1.4	20.45	080.70	22.84		580.91	0.63	1.65									
0230	1.50					20.45	080.70	22.84		580.91	0.63	1.65									
0300	1.49	1.5	1.4	1.5	1.5	20.5	084.12	26.26		581.00	0.72	1.65									
0330						20.5	084.12	26.26		581.00	0.72	1.65									
0400	1.50	1.5	1.5	1.5	1.5	20.6	092.95	35.09		581.24	0.96	1.64									
0430						20.5	094.09	36.23		581.27	0.99	1.64									Chemicals Changed
0500 (4)	1.49	1.5	1.5	1.5	1.4	20.5	097.66	39.80		581.36	1.08	1.63									
0530	1.48					20.5	100.54	42.68		581.46	1.18	1.66									
0600	1.46	1.5	1.4	1.5	1.5	20.6	100.54	42.68		581.46	1.18	1.66									
0630						20.55	100.54	42.68		581.46	1.18	1.66									
0700	1.50	1.5	1.5	1.5	1.5	20.5	100.54	42.68		581.46	1.18	1.66									
0730							106.36	48.50	10.0	581.60	1.32	1.63	2.413	0.081	2.494	0.326	2.684	3.010	4.85	6.00	
0800		1.5	1.5	1.5	1.5		108.66	50.80		581.69	1.41	1.67									
0830							117.82	59.96		581.96	1.68	1.68									
0900		1.5	1.5	1.4	1.4		124.81	66.95	10.3	582.14	1.86	1.67			2.77			3.00			
0930							138.05	80.19		582.51	2.23	1.67									
1000		1.5	1.5	1.5	1.4		154.95	97.09		582.97	2.69	1.66									
1030																					
1100		1.5	1.5	1.4	1.5		173.66	115.80	9.8	583.54	3.26	1.69			2.50			2.96			
1130						20.6	178.34	120.48		583.69	3.41	1.70									
1200		1.4	1.5	1.4	1.3	20.4	186.50	128.64		583.95	3.67	1.71									
1230						20.5	193.74	135.98		584.20	3.92	1.73									Clock turned back 25 min.
1300 (9)	1.52	1.4	1.4	1.4	1.3	20.4															
1330						20.4	225.29	167.43	9.9	585.21	4.93	1.77			2.46			2.85			
1400	1.51	1.5	1.4	1.5	1.4	20.45	237.40	179.54		585.72	5.44	1.82									
1430																					
1500	1.52	1.5	1.5	1.4	1.4	20.5															
1530						20.3	274.84	216.98		586.76	6.48	1.79									
1600	1.51	1.4	1.4	1.4	1.4	20.48	290.29	232.43		587.26	6.98	1.80									
1630						20.5	297.30	239.44		587.48	7.20	1.80									
1700	1.53	1.4	1.4	1.4	1.4	20.45															
1730	1.53					20.5			10.1				2.460	0.062	2.522	0.256	2.595	2.851	20.9	6.57	
1800	1.53	1.4	1.4	1.4	1.4	20.47	323.50	265.64		587.60	7.32	1.65									
1830						20.5	356.29	298.43		589.43	9.15	1.84									
1900	1.47	1.4	1.4	1.4	1.4	20.45															
1930						20.5															
2000	1.47	1.4	1.4	1.4	1.4	20.45															
2030						20.5	365.29	307.43		589.72	9.44	1.84									
2100	1.47	1.4	1.4	1.4	1.4	20.5	365.29	307.43		589.72	9.44	1.84									
2130						20.4	365.29	307.43		589.72	9.44	1.84									
2200	1.48	1.4	1.4	1.4	1.4	20.4	375.82	317.96		590.09	9.81	1.85									
2230						20.4	375.82	317.96		590.09	9.81	1.85									
2300	1.50	1.5	1.4	1.4	1.5	20.5	375.82	317.96		590.09	9.81	1.85									
2330						20.5	383.68	325.82		590.35	10.07	1.85									
2400	1.50	1.4	1.4	1.4	1.4	20.5	392.43	334.57		590.65	10.37	1.86									
																	Total		25.75	6.45	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 4 March 1953

Time	CO_2 Conc. in Air					O_2 Conc.	Operational Time		Tower	Feed Solution			Liquid Composition						CO_2 Absorbed		Remarks
	Liston Becker	Dwyer Analyser					Timer Reading	Net Time	Δ P	Meter Reading	Net Flow	Flow Rate	Inlet			Outlet			Net	Rate	
		1	2	3	4								OH^-	$CO_3^=$	Na^+	OH^-	$CO_3^=$	Na^+			
o'clock	vol.%	%	%	%	%	vol. %	min.	min.	" H_2O	$ft.^3$	$ft.^3$	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.50	1.4	1.4	1.4	1.4	20.5	392.43			590.65											
0030						20.5	399.55	7.12		590.90	0.25	2.11									
0100	1.51	1.5	1.5	1.4	1.4	20.5	399.55	7.12		590.90	0.25	2.11									
0130						20.5	417.60	25.17		591.49	0.84	2.00									
0200	1.48	1.4	1.5	1.4	1.5	20.5	419.57	27.14		591.57	0.92	2.03									
0230						20.5	419.57	27.14		591.57	0.92	2.03									
0300	1.48	1.5	1.5	1.5	1.5	20.5	419.57	27.14		591.57	0.92	2.03									
0330							420.02	27.59		591.68	1.03	2.24									
0400	1.51	1.5	1.5	1.5	1.5	20.5	420.18	27.75		591.70	1.05	2.27									
0430	1.51					20.4															
0500		1.4	1.6	1.5	1.5	20.3															
0530	1.51					20.3	433.49	41.06		592.02	1.37	2.00									
0600	1.56	1.5	1.5	1.5	1.5	20.4	437.87	45.44		592.13	1.48	1.95									
0630	1.49					20.55	444.80	52.37		592.39	1.74	1.99									
0700	1.50	1.5	1.6	1.5	1.5		446.46	54.03		592.48	1.83	2.03									
0730							451.15	58.72		592.63	1.98	2.02									
0800		1.5	1.6	1.5	1.5		456.91	64.48	10.0	592.83	2.18	2.03	2.460	0.052	2.512	0.286	2.560	2.846	7.65	7.12	
0830							476.04	73.61		593.54	2.89	2.36									
0900		1.6	1.5	1.5	1.4		481.76	89.33		593.74	3.09	2.08									
0930							495.47	103.04	10.4	594.31	3.66	2.13			2.50			2.77			
1000		1.5	1.6	1.5	1.5																
1030							511.19	118.76		594.74	4.09	2.07									
1100		1.5	1.5	1.5	1.5		521.13	128.70	10.3	595.09	4.44	2.07			2.46			2.77			
1130							530.71	138.28		595.42	4.77	2.07									
1200	1.50	1.5	1.6	1.6	1.5	20.4	532.61	140.18		595.65	5.00	2.14									
1230						20.4	544.48	152.05	10.1	595.87	5.22	2.06			2.50			2.76			
1300	1.54	1.5	1.6	1.6	1.5	20.5	547.70	155.27		596.00	5.35	2.07									
1330	1.51					20.5	570.91	178.48		596.85	6.20	2.08									
1400	1.49	1.6	1.6	1.6	1.5	20.5	576.96	184.53		597.05	6.40	2.08									
1430						20.5	585.39	192.96		597.34	6.69	2.08									
1500	1.51	1.6	1.6	1.6	1.5	20.45	592.53	200.10		597.58	6.93	2.08									Chemicals Changed
1530 (4)						20.5															
1600	1.51	1.5	1.6	1.6	1.5	20.5	612.47	220.04	10.0	598.28	7.63	2.08	2.475	0.036	2.511						
1630						20.45															
1700	1.52	1.6	1.5	1.6	1.5	20.5	627.10	234.67		598.77	8.12	2.08									
1730						20.5	629.48	237.05		598.86	8.21	2.08									
1800	1.50	1.5	1.5	1.5	1.5	20.45	639.80	247.37		599.19	8.54	2.07									
1830						20.4															
1900	1.51	1.5	1.5	1.5	1.5	20.45	653.51	261.08		599.70	9.05	2.08									
1930						20.5	654.60	262.17		599.75	9.10	2.08									
2000	1.51	1.5	1.5	1.5	1.5	20.5	668.78	276.35		600.23	9.58	2.08									
2030						20.5	679.20	286.77		600.60	9.95	2.08									
2100	1.52	1.5	1.5	1.5	1.5	20.5	685.76	293.33		600.84	10.19	2.08									
2130						20.5	690.45	298.02		601.00	10.35	2.08									
2200	1.505	1.5	1.5	1.5	1.5	20.5	695.41	302.98		601.12	10.47	2.07									
2230						20.5	701.11	308.68		601.35	10.70	2.08									
2300	1.49	1.5	1.5	1.5	1.5	20.5	706.11	313.68		601.52	10.87	2.08									
2330						20.5	707.19	314.76	10.0	601.55	10.90	2.08	2.465	0.062	2.527	0.270	2.500	2.770	29.9	7.17	
2400	1.50	1.5	1.5	1.5	1.5	20.5	721.76	320.33		601.74	11.09	2.08									
																	Total		37.55	7.16	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 5 March 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyser 1	2	3	4	O_2 Conc.	Operational Time: Timer Reading	Net Time	Tower ΔP	Feed Solution: Meter Reading	Net Flow	Flow Rate	Liquid Composition: Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 absorbed: Net	Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	$ft.^3$	$ft.^3$	ft^3/hr	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.50	1.5	1.5	1.5	1.5	20.5	712.76			601.74											
0030						20.5	716.58	3.82		601.86	0.12	1.88									
0100	1.52	1.5	1.5	1.5	1.5	20.5	734.96	22.20		602.52	0.78	2.11									
0130						20.45	737.61	24.95		602.61	0.87	2.10									
0200	1.50	1.5	1.5	1.5	1.5	20.5	741.70	28.94		702.74	1.00	2.07									
0230	1.50					20.5															
0300	1.50	1.5	1.5	1.5	1.5	20.45	750.60	37.84		603.03	1.29	2.05									
0330	1.49					20.5	750.60	37.84		603.03	1.29	2.05									
0400	1.50	1.5	1.5	1.5	1.5	20.5	752.03	39.27		603.10	1.36	2.08									
0430						20.5	760.00	47.24		603.37	1.63	2.07									
0500	1.53	1.5	1.5	1.5	1.5	20.5	764.87	52.11		603.53	1.79	2.06									
0530						20.5	764.87	52.11		603.53	1.79	2.06									
0600	1.53	1.5	1.5	1.5	1.5	20.5	764.87	52.11		603.53	1.79	2.06									
0630						20.4	764.87	52.11		603.53	1.79	2.06									
0700	1.52	1.5	1.5	1.5	1.5	20.5	764.87	52.11		603.53	1.79	2.06									
0730 (4)						20.5															Chemicals changed
0800		1.5					776.71	63.95		603.95	2.21	2.07									
0830							788.30	75.54		604.37	2.63	2.09									
0900		1.5	1.5	1.5	1.5				10.3						2.58			2.77			
0930							807.94	95.18	10.4	605.11	3.37	2.12	2.558	0.109	2.667	0.357	2.518	2.875	11.60	7.32	
1000 (9)		1.5	1.5	1.5	1.4		821.60	108.84		605.60	3.86	2.13									Clock turned back 5 min.
1030																					
1100	1.49	1.5	1.5	1.5	1.5		853.66	140.90		605.80	4.06	1.73									
1130						20.5															
1200	1.48	1.5	1.5	1.5	1.5	20.5	873.83	161.07		606.54	4.80	1.79									
1230						20.45	882.73	169.97		607.88	.14	2.17									
1300	1.52	1.5	1.5	1.5	1.5	20.5			10.0						2.46			2.83			
1330						20.5															
1400	1.50	1.5	1.5	1.5	1.5	20.5	903.69	190.93		608.63	6.89	2.17									
1430						20.5															
1500	1.50	1.5	1.5	1.5	1.5	20.5	930.13	217.37		609.38	7.64	2.11									
1530						20.5	943.43	230.67		609.88	8.14	2.12									
1600	1.48	1.5	1.5	1.5	1.5	20.5	949.61	236.85	10.4	610.10	8.36	2.12	2.420	0.062	2.482	0.356	2.468	2.824	16.9	7.16	
1630						20.5	956.24	243.48	10.3	610.34	8.60	2.12			2.46			2.77			
1700	1.51	1.5	1.5	1.5	1.5	20.5	962.50	249.74		610.55	8.81	2.12									
1730						20.5	969.01	256.25		610.80	9.06	2.12									
1800	1.50	1.5	1.5	1.5	1.4	20.48	977.00	264.24		611.07	9.33	2.12									
1830						20.5	983.88	271.12	10.4	611.13	9.39	2.08			2.51			2.77			
1900	1.50	1.5	1.5	1.5	1.5	20.5	989.00	276.24		611.50	9.76	2.12									
1930						20.5	997.30	284.54		611.82	10.08	2.13									
2000	1.50	1.5	1.5	1.5	1.5	20.5	009.04	296.28		612.22	10.48	2.12									
2030	1.49					20.5	013.88	301.12		612.40	10.66	2.12									
2100	1.51	1.5	1.5	1.5	1.5	20.5	016.34	303.58		612.50	10.76	2.13									
2130						20.5	023.32	311.56		612.73	10.99	2.12									
2200	1.47	1.5	1.5	1.5	1.5	20.5	035.89	323.13		613.17	11.43	2.12									
2230						20.5															
2300	1.48	1.7	1.7	1.7	1.8	20.5	044.04	331.28	10.5	613.45	11.71	2.12	2.440	0.045	2.485	0.348	2.487	2.835	11.42	7.27	
2330						20.5	050.04	337.28		613.67	11.93	2.12									
2400	1.46	1.5	1.5	1.5	1.5	20.5	053.69	340.93		613.79	12.05	2.12					Total		39.97	7.24	

RESTRICTED

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: March 6, 1953

Time	CO_2 Conc. in Air: Liston Becker	CO_2 Conc. in Air: Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower Δ P	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Liquid Composition Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	$ft.^3$	$ft.^3$	$ft.^3/hr.$	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.46	1.5	1.5	1.5	1.5	20.5	053.69			613.79											
0030	1.47					20.45	055.11	1.42		613.83	0.04	1.69									
0100	1.51	1.4	1.5	1.5	1.4	20.5	055.11	1.42		613.83	0.04	1.69									
0130	1.51					20.45	055.11	1.42		613.83	0.04	1.69									
0200	1.50	1.5	1.5	1.5	1.5	20.45	060.21	6.52		614.02	0.23	2.12									
0230	1.49					20.5	060.21	6.52		614.02	0.23	2.12									
0300	1.52	1.5	1.5	1.5	1.5	20.55	060.21	6.52		614.02	0.23	0.12									
0330						20.5	062.75	9.06		614.11	0.32	2.13									
0400	1.49	1.5	1.5	1.5	1.5	20.55	062.75	9.06		614.11	0.32	2.13									
0430						20.52															
0500	1.49	1.6	1.6	1.6	1.5	20.5															
0530						20.5															
0600	1.49	1.6	1.6	1.7	1.6	20.48															
0630						20.5															
0700		1.6	1.6	1.6	1.6																
0730																					
0800 (4)		1.6	1.6	1.6	1.6								2.334	0.189	2.523	0.370	2.515	2.885	1.102	7.30	Chemicals changed
0830									9.7												
0900		1.6	1.6	1.6	1.6	20.5	070.47	16.78		614.36	0.57	2.04						2.70			
0930						20.6	075.50	21.81	10.0	614.66	0.87	2.39									
1000		1.6	1.6	1.6	1.6	20.5															
1030						20.4									2.56			2.76			
1100		1.6	1.6	1.6	1.5	20.48	127.47	73.78	10.3	616.64	2.85	2.32									
1130													2.540	0.082	2.622	0.281	2.508	2.789	8.69	8.05	
1200	1.53	1.6	1.6	1.6	1.5				10.2												
1230						20.4															
1300	1.49	1.6	1.6	1.6	1.6	20.5	156.86	103.17		617.25	3.46	2.01									
1330						20.5	156.86	103.17		617.25	3.46	2.01									
1400	1.53	1.6	1.6	1.6	1.6	20.45	159.72	106.03		617.86	4.07	2.30									
1430						20.52	165.69	112.00		618.07	4.28	2.29									
1500	1.50	1.6	1.6	1.6	1.6	20.6	181.45	127.76		618.65	4.86	2.28									
1530	1.51					20.48									2.50			2.75			
1600	1.51	1.6	1.6	1.6	1.6	20.48			9.8												
1630						20.48	198.68	144.99		619.27	5.48	2.27	2.378	0.062	2.440	0.288	2.503	2.791	9.98	7.57	
1700	1.52	1.5	1.5	1.6	1.5	20.48	206.72	153.03	9.9	619.55	5.76	2.26									
1730						20.45															
1800	1.51	1.5	1.5	1.6	1.5	20.5	225.27	171.58		620.24	6.45	2.26									
1830						20.48	229.46	175.77		620.38	6.59	2.25									
1900	1.47	1.6	1.5	1.5	1.5	20.45	235.09	181.40		620.57	6.78	2.24									
1930						20.43															
2000	1.48	1.6	1.5	1.5	1.5	20.52	249.66	195.97		621.10	7.31	2.24									
2030	1.53					20.45	253.52	199.83		621.23	7.44	2.23									
2100	1.44	1.6	1.5	1.5	1.5	20.5															
2130	1.56					20.4															
2200	1.48	1.7	1.7	1.7	1.6	20.5	266.79	213.10		621.71	7.92	2.23									
2230	1.48					20.6	275.42	221.73		622.02	8.23	2.23									
2300	1.50	1.8	1.7	1.7	1.7	20.5	282.41	228.72		622.26	8.47	2.22									
2330 (4)						20.4	285.53	231.84		622.34	8.55	2.21	2.462	0.060	2.522	0.305	2.503	2.808	10.03	7.40	Chemicals changed
2400	1.49	1.7	1.6	1.6	1.6	20.5	288.06	234.37	10.0	622.47	8.68	2.22					Total		29.80	7.62	

Date: 7 March 1953

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Time	CO_2 Conc. in Air					O_2 Conc.	Operational Time		Tower	Feed Solution			Liquid Composition						CO_2 Absorbed		Remarks
	Liston Becker	Dwyer Analyzer 1	2	3	4		Timer Reading	Net Time	ΔP	Meter Reading	Net Flow	Flow Rate	Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	Net	Rate	
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.49	1.7	1.6	1.6	1.6	20.5	288.06		10.0	622.47			2.462	0.060	2.522	0.305	2.503	2.808			Dwyer replaced
0030						20.47	293.50	4.44		622.66	0.19	2.57									
0100	1.50	1.5	1.5	1.5	1.5	20.5															
0130						20.52															
0200	1.49	1.5	1.5	1.5	1.5	20.5															
0230						20.48															
0300	1.48	1.4	1.5	1.4	1.5	20.5															
0330						20.51															
0400	1.49	1.5	1.5	1.5	1.5	20.5															
0430						20.45	302.30	14.24		622.97	0.50	2.11									
0500	1.505	1.5	1.5	1.5	1.5	20.5	302.30	14.24		622.97	0.50	2.11									
0530						20.5	302.30	14.24		622.97	0.50	2.11									
0600	1.45	1.5	1.5	1.6	1.5	20.52	302.30	14.24		622.97	0.50	2.11									
0630						20.5	302.30	14.24		622.97	0.50	2.11									
0700	1.45	1.6	1.5	1.5	1.5	20.48	302.30	14.24		622.97	0.50	2.11									
0730						20.5	302.30	14.24		622.97	0.50	2.11									
0800	1.49	1.5	1.5	1.5	1.5	20.48	302.30	14.24		622.97	0.50	2.11									
0830	1.51					20.47	302.30	14.24		622.97	0.50	2.11									
0900	1.50	1.6	1.5	1.5	1.5	20.52	302.30	14.24	9.6	622.97	0.50	2.11	2.460	0.050	2.510	0.328	2.570	2.898	1.76	7.42	
0930	1.48					20.52	305.50	17.44		623.08	0.61	2.10									
1000	1.51	1.6	1.6	1.7	1.6	20.48	306.93	18.87		623.09	0.62	1.97									
1030						20.44															
1100	1.505	1.6	1.6	1.6	1.5	20.5	316.55	28.49		623.48	1.01	2.13									
1130						20.4	321.65	33.59	10.1	623.67	1.20	2.14						2.93			
1200	1.53	1.6	1.6	1.6	1.5	20.4	324.96	36.90	10.2	623.78	1.31	2.13	2.202	0.061	2.263	0.337	2.463	2.800	2.73	7.25	Pump setting changed to deliver 60.5 lbs/hr caustic and 151.0 lbs/hr water
1230						20.55	331.21	43.15		624.04	1.57	2.18									
1300	1.51	1.5	1.5	1.6	1.5	20.5	332.46	44.40		624.10	1.63	2.20			2.31			2.81			
1330						20.45	336.14	48.08	10.0	624.24	1.77	2.21									
1400	1.53	1.5	1.6	1.6	1.5	20.45	341.29	53.23		624.43	1.96	2.21									
1430	1.51					20.48	355.62	67.56		625.00	2.53	2.25									
1500	1.49	1.8	1.7	1.8	1.7	20.5	361.60	73.54		625.25	2.78	2.27									
1530						20.5	364.58	76.52		625.34	2.87	2.25									
1600	1.49	1.8	1.7	1.8	1.7	20.45	371.67	83.61		625.63	3.16	2.27									
1630						20.4	378.49	90.43		625.90	3.43	2.28									New pop-off valve installed
1700	1.49	1.7	1.7	1.7	1.7	20.35	378.49	90.43		625.90	3.43	2.28									
1730						20.38	378.49	90.43		625.90	3.43	2.28									
1800	1.54	1.6	1.5	1.6	1.6	20.38	384.43	96.37	10.2	626.13	3.66	2.28	2.407	0.048	2.455	0.243	2.450	2.693	7.89	7.95	
1830	1.51					20.35															
1900	1.47	1.5	1.5	1.6	1.5	20.45	404.69	116.63		626.96	4.49	2.31									
1930	1.51					20.55															
2000	1.51	1.5	1.5	1.6	1.5	20.45	414.96	126.[illegible]0		627.38	4.91	2.32									
2030						20.5	421.48	133.42		627.64	5.17	2.32									
2100	1.49	1.5	1.5	1.5	1.6	20.48	426.63	138.57		627.85	5.38	2.33									
2130						20.5	431.41	143.35		628.06	5.59	2.34									
2200	1.52	1.6	1.5	1.5	1.5	20.48	440.50	152.44		628.14	5.67	2.23									
2230						20.5	444.41	156.35		628.33	5.86	2.25									
2300	1.49	1.5	1.5	1.6	1.5	20.48	448.86	160.80		628.50	6.03	2.25									
2330						20.5															
2400	1.49	1.5	1.5	1.6	1.5	20.5	451.13	163.07		628.56	6.09	2.24						Total	12.38	7.72	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 8 March 1953

Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower P	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet OH^-	Inlet $CO_3^=$	Inlet Na^+	Outlet OH^-	Outlet $CO_3^=$	Outlet Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	$ft.^3$	$ft.^3$	$ft.^3/hr.$	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.49	1.5	1.5	1.6	1.5	20.5	451.13			628.56											
0030						20.5	451.13			628.56											
0100	1.50	1.6	1.6	1.6	1.5	20.5	451.13			628.56											
0130						20.5	451.13		10.4	628.56			2.295	0.042	2.337	0.139	2.498	2.637	0	0	
0200	1.51	1.6	1.6	1.6	1.5	20.5															
0230						20.5	471.81	20.68		629.36	0.80	2.32									
0300	1.51	1.6	1.6	1.6	1.6	20.5	477.75	26.62		629.60	1.04	2.34									
0330						20.5	488.44	37.31		630.02	1.46	2.35									
0400	1.50	1.6	1.6	1.6	1.5	20.5	497.95	46.82		630.39	1.83	2.35									
0430(4)	1.49					20.5															Chemicals changed
0500	1.50	1.6	1.6	1.5	1.5	20.5	503.02	51.89		630.62	2.06	2.38									
0530						20.5	503.02	51.89		630.62	2.06	2.38									
0600	1.49	1.6	1.6	1.5	1.5	20.5	503.02	51.89		630.62	2.06	2.38									
0630						20.4	508.38	57.25		630.76	2.20	2.31									
0700	1.50	1.6	1.7	1.6	1.6	20.5															
0730						20.4	515.62	64.49		631.08	2.52	2.34									
0800		1.5	1.5	1.5	1.5	20.5	521.49	70.36		631.30	2.74	2.34									
0830						20.4															
0900	1.50	1.5	1.5			20.5	529.13	78.00		631.60	3.04	2.34									
0930	1.52					20.4	548.19	97.06		632.38	3.82	2.36									
1000		1.5	1.5	1.5	1.5	20.5	555.38	104.25		632.68	4.12	2.37									
1030	1.44																				
1100	1.49	1.7	1.8	1.7	1.8	20.5															
1130						20.5															
1200	1.49	1.8	1.8	1.7	1.7	20.4	564.18	113.05		633.02	4.46	2.37									
1230						20.4															
1300						20.5	572.29	121.16	10.6	633.23	4.67	2.31	2.265	0.027	2.292	0.200	2.420	2.620	15.48	7.67	Dwyer repaired
1330	1.48					20.5	578.01	126.88		633.49	4.93	2.33									
1400		1.5	1.5	1.5	1.5	20.4	581.71	130.58		633.59	5.03	2.31									
1430	1.50					20.6	581.71	130.58		633.59	5.03	2.31									
1500	1.51	1.5	1.5	1.5	1.5	20.45	587.55	136.42	10.5	633.81	5.25	2.31			2.26			2.39			
1530						20.4	591.69	140.56		633.91	5.35	2.28									
1600	1.45	1.6	1.5	1.5	1.5	20.55	591.69	140.56		633.91	5.35	2.28									
1630						20.5															
1700	1.53	1.5	1.5	1.5	1.5	20.5															
1730						20.48	607.52	156.39	9.7	634.58	6.02	2.31	2.220	0.042	2.267	0.171	2.467	2.638	4.56	7.77	
1800	1.53	1.5	1.5	1.5	1.5	20.5	612.88	161.75		634.84	6.28	2.33									
1830						20.5	620.68	169.55		635.14	6.58	2.33									
1900	1.54	1.5	1.5	1.5	1.5	20.47															
1930						20.5	629.65	178.52		635.49	6.93	2.33									
2000	1.52	1.5	1.5	1.5	1.5	20.48	636.76	185.63		635.75	7.19	2.32									
2030						20.45															
2100	1.50	1.5	1.5	1.5	1.5	20.5	647.33	196.20		636.10	7.54	2.31									
2130						20.5	653.74	202.61		636.34	7.78	2.30									
2200	1.50	1.5	1.5	1.5	1.5	20.5	664.39	213.26		636.75	8.19	2.30									
2230 (4)	1.49					20.5	670.81	219.68		637.00	8.44	2.31									Chemicals changed
2300	1.50	1.5	1.5	1.5	1.5	20.5	674.95	223.82		637.15	8.59	2.30									
2330						20.5	680.16	229.03	12.0	637.33	8.77	2.30	2.297	0.054	2.351	0.167	2.433	2.600	9.17	7.58	
2400	1.50	1.5	1.5	1.5	1.5	20.5	689.19	238.06		637.69	9.13	2.30									
																	Total		29.21	7.65	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 9 March 1953

Time	CO_2 Conc. in Air					O_2 Conc.	Operational Time		Tower	Feed Solution			Liquid Composition						CO_2 Absorbed		Remarks
	Liston Becker	Dwyer Analyzer					Timer Reading	Net Time	P	Meter Reading	Net Flow	Flow Rate	Inlet			Outlet			Net	Rate	
		1	2	3	4								OH^-	$CO_3^=$	Na^+	OH^-	$CO_3^=$	Na^+			
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	$ft.^3$	$ft.^3$	$ft.^3/hr.$	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.50	1.5	1.5	1.5	1.5	20.5	689.19			637.69											
0030	1.50					20.5	689.19			637.69											
0100	1.58	1.5	1.5	1.5	1.5	20.5	695.97	6.78		637.95	0.26	2.30									
0130						20.5															
0200	1.51	1.5	1.5	1.5	1.5	20.5															
0230						20.5	710.03	20.84		638.51	0.82	2.36									
0300	1.51	1.5	1.5	1.5	1.5	20.5	713.32	24.13		638.60	0.91	2.26									
0330						20.5															
0400	1.50	1.5	1.5	1.5	1.5	20.5	718.98	29.79		638.82	1.13	2.28									
0430						20.48	722.44	33.25		638.95	1.26	2.27									
0500	1.51	1.4	1.5	1.5	1.5	20.50	725.31	36.12		639.06	1.37	2.28	2.290	0.038	2.328	0.142	2.410	2.552	5.15	7.54	
0530	1.51					20.45	730.12	40.93	10.2	639.25	1.56	2.29									
0600	1.53	1.5	1.5	1.5	1.5	20.45	731.43	42.24		639.31	1.62	2.30									
0630	1.49					20.45	738.04	48.85		639.60	1.91	2.35									
0700	1.51	1.5	1.5	1.5	1.5	20.45	738.04	48.85		639.60	1.91	2.35									
0730	1.51					20.45															
0800		1.5	1.6	1.5	1.5	20.48	745.40	56.21		639.83	2.14	2.28									
0830						20.5	747.30	58.11		639.93	2.24	2.31									
0900		1.5	1.6	1.5	1.5	20.52	752.02	62.83		640.13	2.44	2.33	2.265	0.069	2.3340	0.200	2.467	2.667	3.49	8.02	
0930						20.48	756.24	67.05	10.2	640.28	2.59	2.32									
1000		1.5	1.5	1.6	1.5	20.48	765.16	75.97		640.65	2.96	2.34									
1030						20.51									2.25			2.53			
1100		1.5	1.5	1.6	1.5	20.47	800.16	110.97	10.6	641.00	3.31	1.79									
1130						20.5	816.45	127.26		641.70	4.01	1.91									
1200		1.5	1.5	1.6	1.5	20.51	844.69	155.50		642.80	5.11	1.97									
1230						20.5															
1300	1.58	1.5	1.6	1.6	1.5	20.52							2.186	0.046	2.232	0.215	2.428	2.643	11.90	6.21	
1330	1.54					20.5	871.49	182.30	10.4	643.86	6.17	2.03									
1400	1.49	1.5	1.6	1.6	1.5	20.48	893.86	204.67		644.87	7.18	2.10			2.30			2.53			
1430	1.51					20.5			10.5												Meter failed
1500	1.53	1.6	1.6	1.5	1.5	20.47	908.77	219.58		644.87 (7)											
1530						20.5	922.41	233.22		(7)											
1600	1.52	1.6	1.7	1.6	1.5	20.51	923.37	234.18		(7)			2.120	0.065	2.185	0.145	2.414	2.559	6.58	7.62	
1630						20.5			10.4	(7)											
1700	1.52	1.5	1.6	1.6	1.6	20.5	940.20	251.01		(7)					2.31			2.50			
1730						20.5	948.95	259.76	10.5	(7)					2.21			2.50			
1800	1.49	1.5	1.5	1.5	1.5	20.5			10.4	(7)											
1830						20.5	963.32	274.13		(7)											
1900	1.50	1.6	1.5	1.5	1.5	20.5	969.96	280.77		(7)			2.207	0.059	2.266	0.169	2.353	2.522	6.56	7.42	
1930						20.5	976.46	287.27	10.4	(7)											
2000	1.50	1.5	1.5	1.5	1.5	20.5	982.82	293.63		(7)											
2030						20.4	986.02	296.83		(7)											
2100	1.54	1.5	1.5	1.5	1.5	20.5	989.99	300.80		(7)											
2130						20.5	996.14	306.95		(7)			2.102	0.054	2.156	0.161	2.340	2.501	2.82	7.40	
2200	1.50	1.5	1.5	1.5	1.5	20.5	999.40	310.21	10.6	(7)											
2230						20.5	016.66	327.47		(7)											
2300	1.51	1.6	1.5	1.5	1.5	20.6	023.92	334.73		(7)											
2330						20.5	023.92	334.73		(7)											
2400	1.52	1.5	1.5	1.5	1.5	20.6	035.86	346.67		(7)											
																		Total	36.51	7.07	

CAUSTIC SCRUBBER FOR CO_2 - OPERATIONAL TEST

Date: 10 March 1953 RESTRICTED

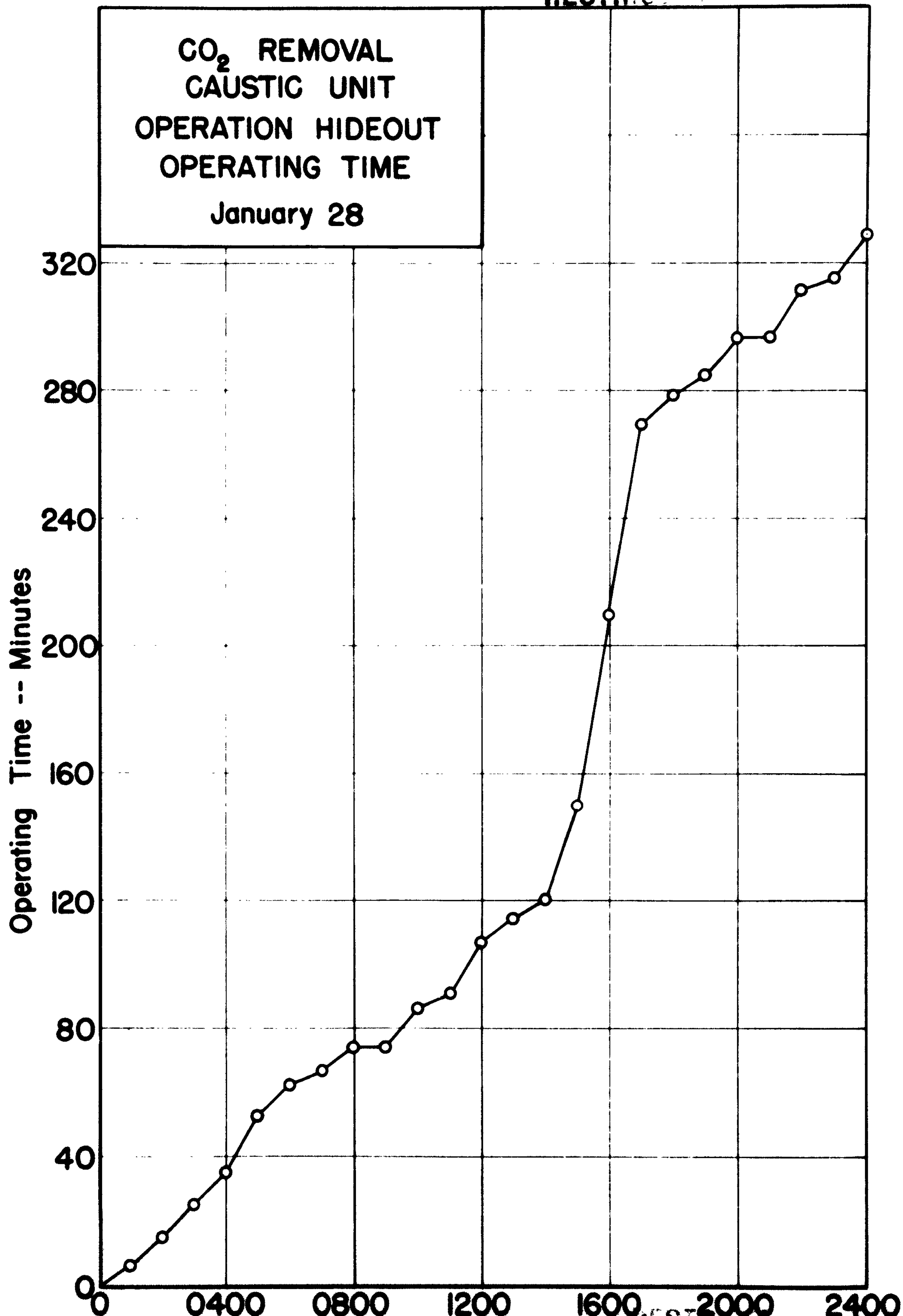
Time	CO_2 Conc. in Air: Liston Becker	Dwyer Analyzer 1	Dwyer Analyzer 2	Dwyer Analyzer 3	Dwyer Analyzer 4	O_2 Conc.	Operational Time: Timer Reading	Operational Time: Net Time	Tower P	Feed Solution: Meter Reading	Feed Solution: Net Flow	Feed Solution: Flow Rate	Liquid Composition Inlet: OH^-	Inlet: $CO_3^=$	Inlet: Na^+	Outlet: OH^-	Outlet: $CO_3^=$	Outlet: Na^+	CO_2 Absorbed: Net	CO_2 Absorbed: Rate	Remarks
o'clock	vol. %	%	%	%	%	vol. %	min.	min.	" H_2O	ft.^{3}	ft.^{3}	ft.^{3}/hr.	norm	norm	norm	norm	norm	norm	lbs.	lbs/hr	
0000	1.52	1.5	1.5	1.5	1.5	20.6	035.86			(7)											
0030						20.5	043.39	7.53		(7)											
0100	1.505	1.5	1.5	1.5	1.5	20.5	045.37	9.51		(7)											
0130						20.5	057.72	21.86		(7)											
0200	1.50	1.5	1.5	1.5	1.5	20.5	057.72	21.86		(7)											
0230						20.5	060.81	24.95		(7)											
0300	1.49	1.5	1.5	1.5	1.5	20.5	066.17	30.31		(7)											
0330						20.5	066.17	30.31		(7)											
0400	1.51	1.5	1.5	1.5	1.4	20.5	071.28	35.42		(7)											
0430						20.5	072.96	37.10		(7)											
0500	1.55	1.6	1.5	1.5	1.5	20.4	072.96	37.10		(7)											
0530	1.49					20.6	081.62	45.76		(7)											
0600	1.51	1.6	1.6	1.6	1.5	20.5				(7)											
0630						20.5	084.05	48.19		(7)											
0700	1.48	1.6	1.5	1.5	1.6	20.5	089.38	53.52	9.6	(7)			2.200	0.048	2.248	0.129	2.410	2.539	6.77	7.59	
0730							089.38	53.52		(7)											
0800		1.5	1.5	1.5	1.5		094.40	58.54		(7)											
0830							096.36	60.50		(7)											
0900		1.5	1.5	1.5	1.5		106.34	70.48	9.8	(7)					2.22			2.50			
0930							118.64	82.78		(7)											
1000		1.5	1.5	1.6	1.5				9.8	(7)			2.612	0.062	2.674	0.269	2.390	2.659	3.67	7.53	
1030							147.89	112.03		(7)											
1100		1.5	1.5	1.6	1.5				9.8	(7)					2.28			2.50			
1130	1.50						177.38	141.52		(7)											
1200	1.50	1.5	1.5	1.6	1.5	20.5	187.22	151.36	9.8	(7)					2.25			2.51			
1230						20.5				(7)											
1300	1.49	1.6	1.5	1.6	1.5	20.5	209.09	173.23		(7)											
1330						20.5			9.8	(7)			2.275	0.056	2.331	0.288	2.326	2.614	11.02	7.32	
1400	1.50	1.5	1.5	1.6	1.5	20.5	227.01	191.15		(7)											
1430						20.5	227.01	191.15	9.7	(7)					2.15			2.50			
1500	1.50	1.5	1.5	1.6	1.5	20.5	227.01			(7)											
1530						20.5	242.09	206.23		(7)											
1600		1.5	1.5	1.5	1.5	20.5			9.8	(7)			2.230	0.038	2.268	0.246	2.288	2.534	3.97	7.22	
1630	1.6					20.3				(7)											
1700	1.57	1.5	1.5	1.5	1.5	20.5				(7)											
1730	1.50					20.5	284.33	248.47	10.2	(7)					2.25			2.49			
1800	1.50	1.5	1.5	1.6	1.5	20.5	293.26	257.40		(7)											
1830						20.5	302.28	266.42		(7)											
1900	1.51	1.5	1.5	1.5	1.5	20.6			10.0	(7)			2.230	0.050	2.280	0.230	2.295	2.525	7.23	7.20	
1930						20.6	322.47	286.61		(7)											
2000	1.50	1.5	1.5	1.6	1.5	20.5	332.95	297.09		(7)											
2030	1.51					20.4	340.42	304.56	10.0	(7)			2.250	0.060	2.310	0.219	2.327	2.546	4.65	7.37	Experiment completed at 2037
2100	1.0																				
2130	0.7																				
2200	0.15																				
2230	0.15																				
2300	0.10																				
																		Total	37.31	7.35	

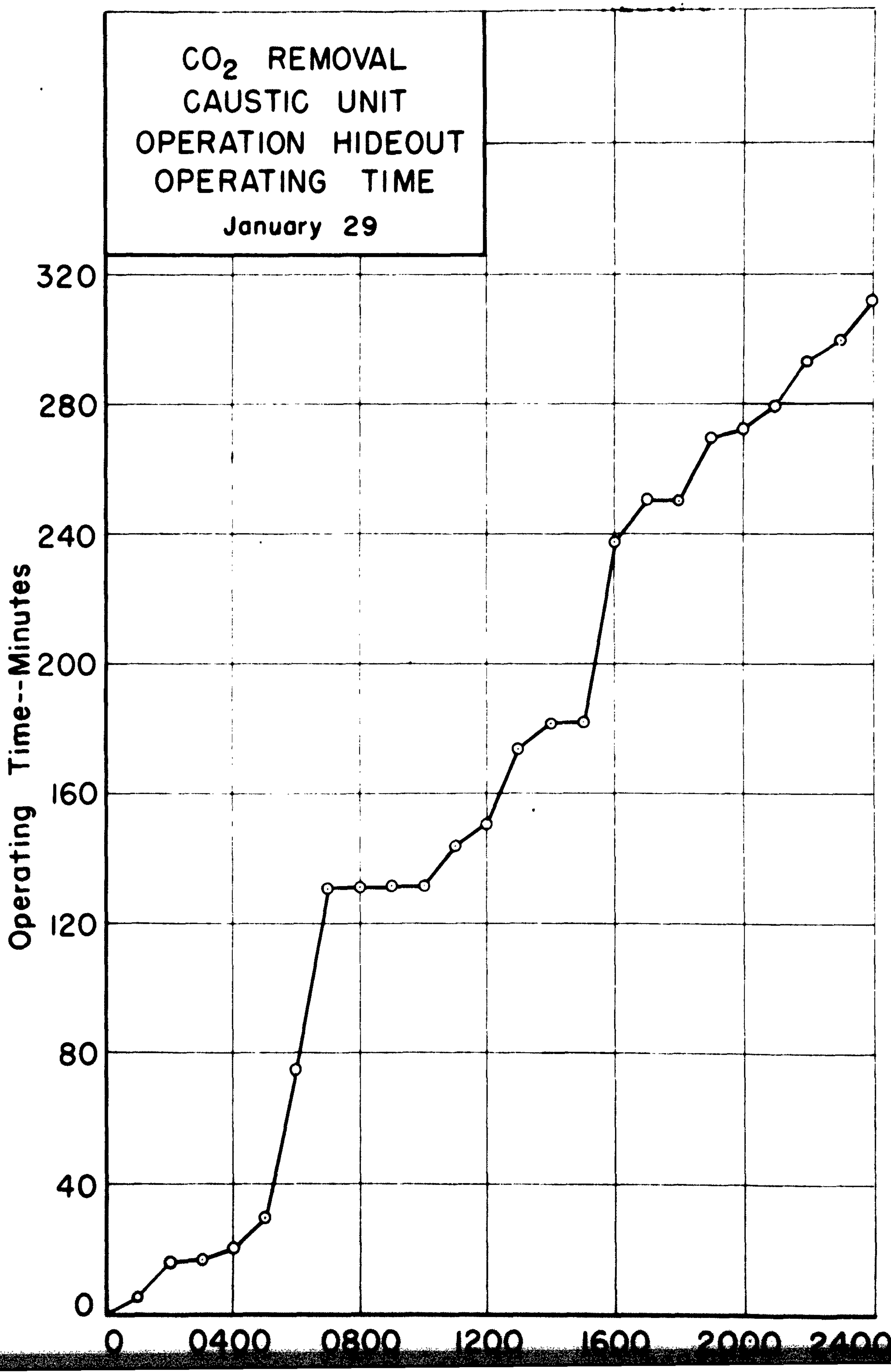
*Timer was stopped and scrubber ran approx. 12 min. calc. from the speedomax recorder. Timer started after 1500 when scrubber started

Scrubber Operation

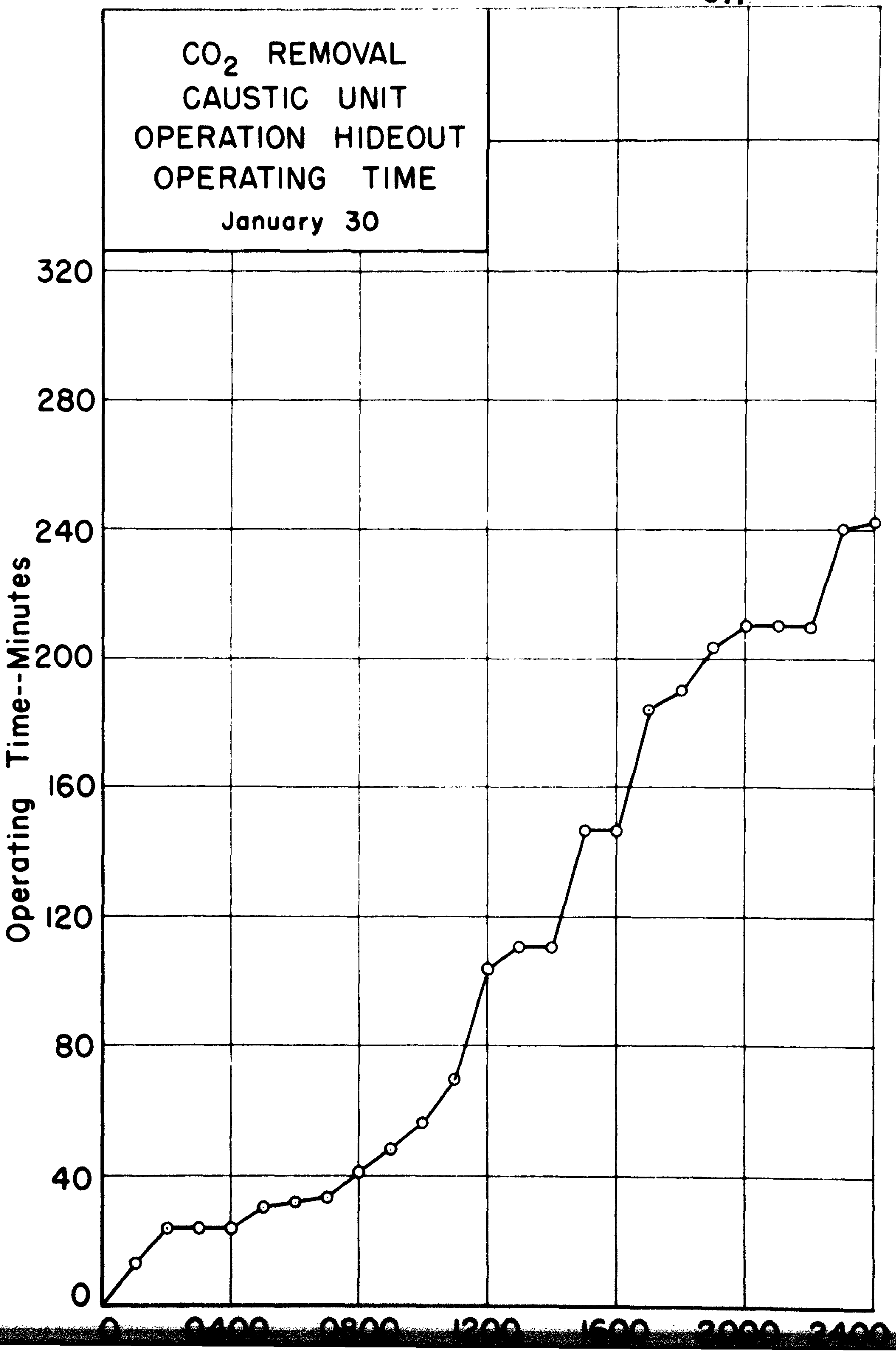
Operating Time vs. Time of Day

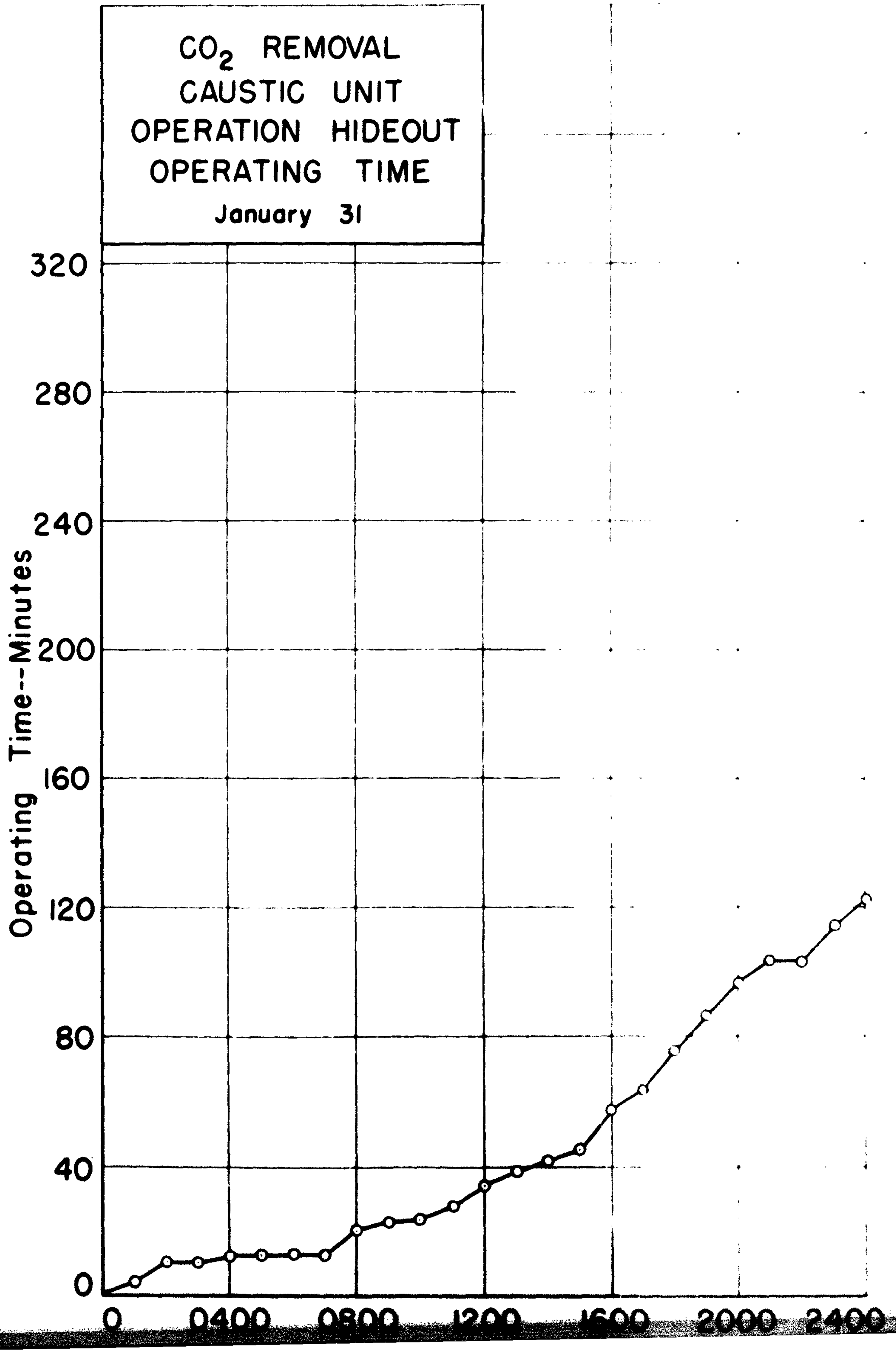
List of Figures for Detail Results by Days


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
January 28
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400

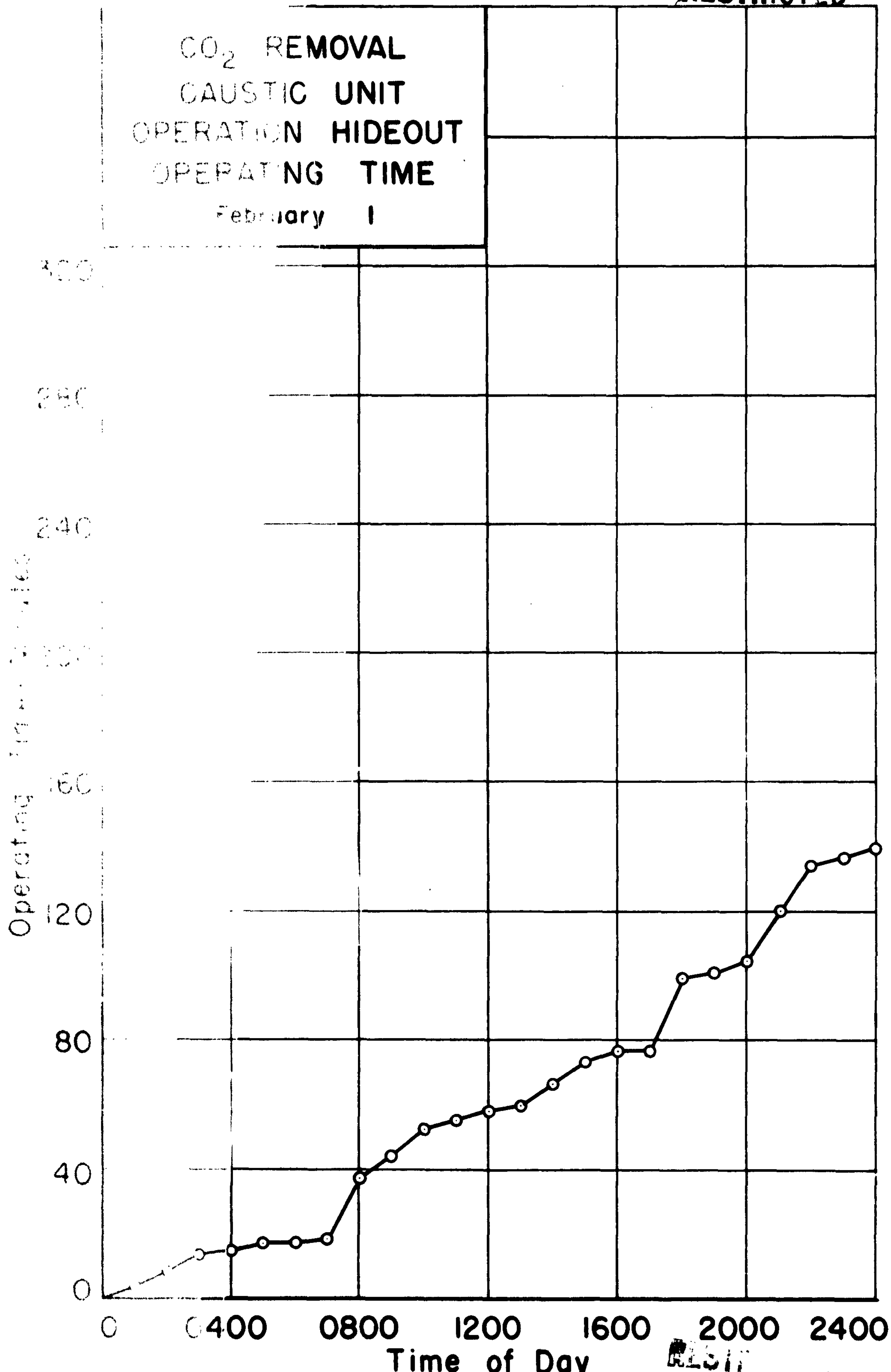


CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
January 29
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400

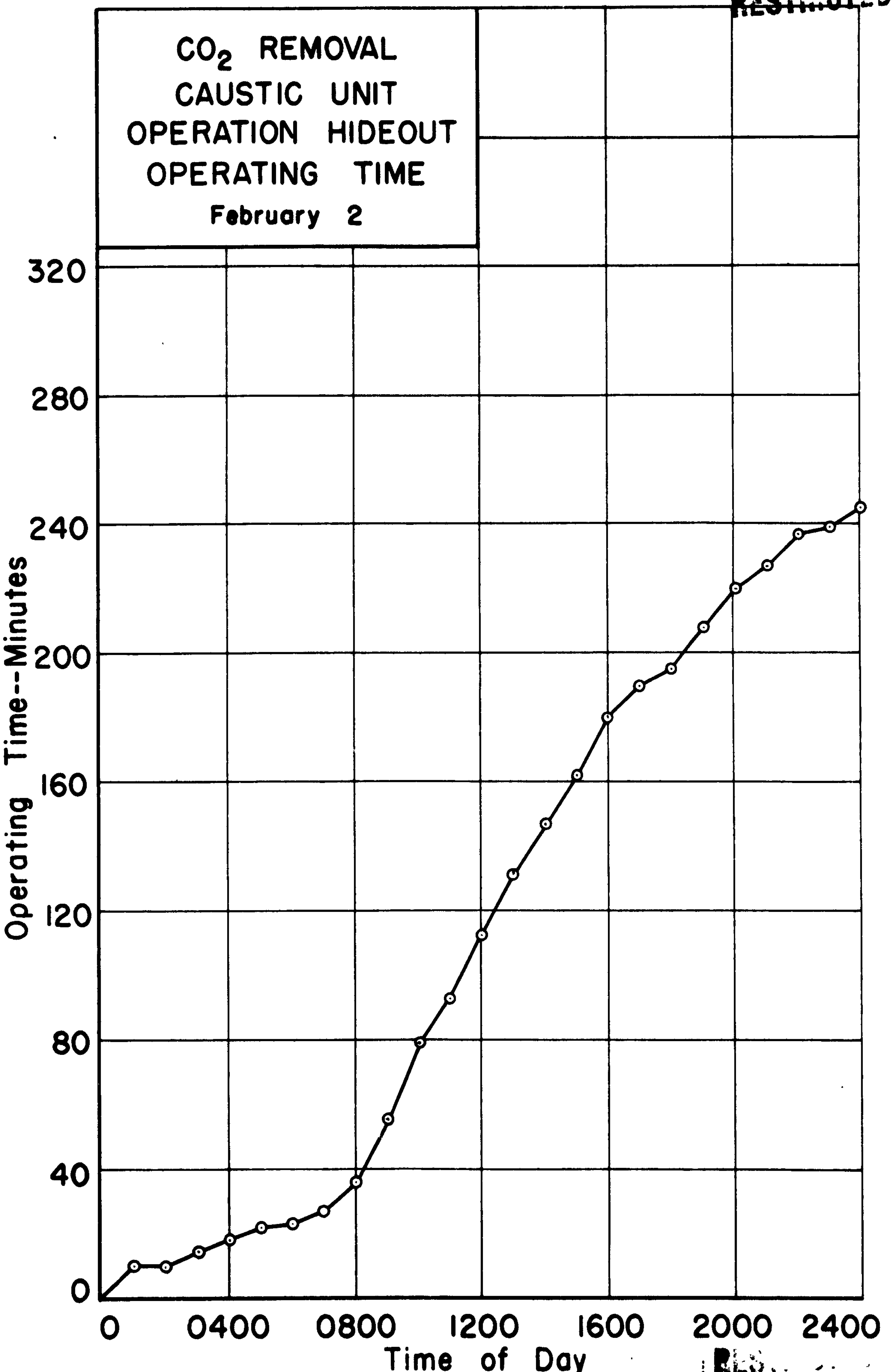

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
January 30
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400

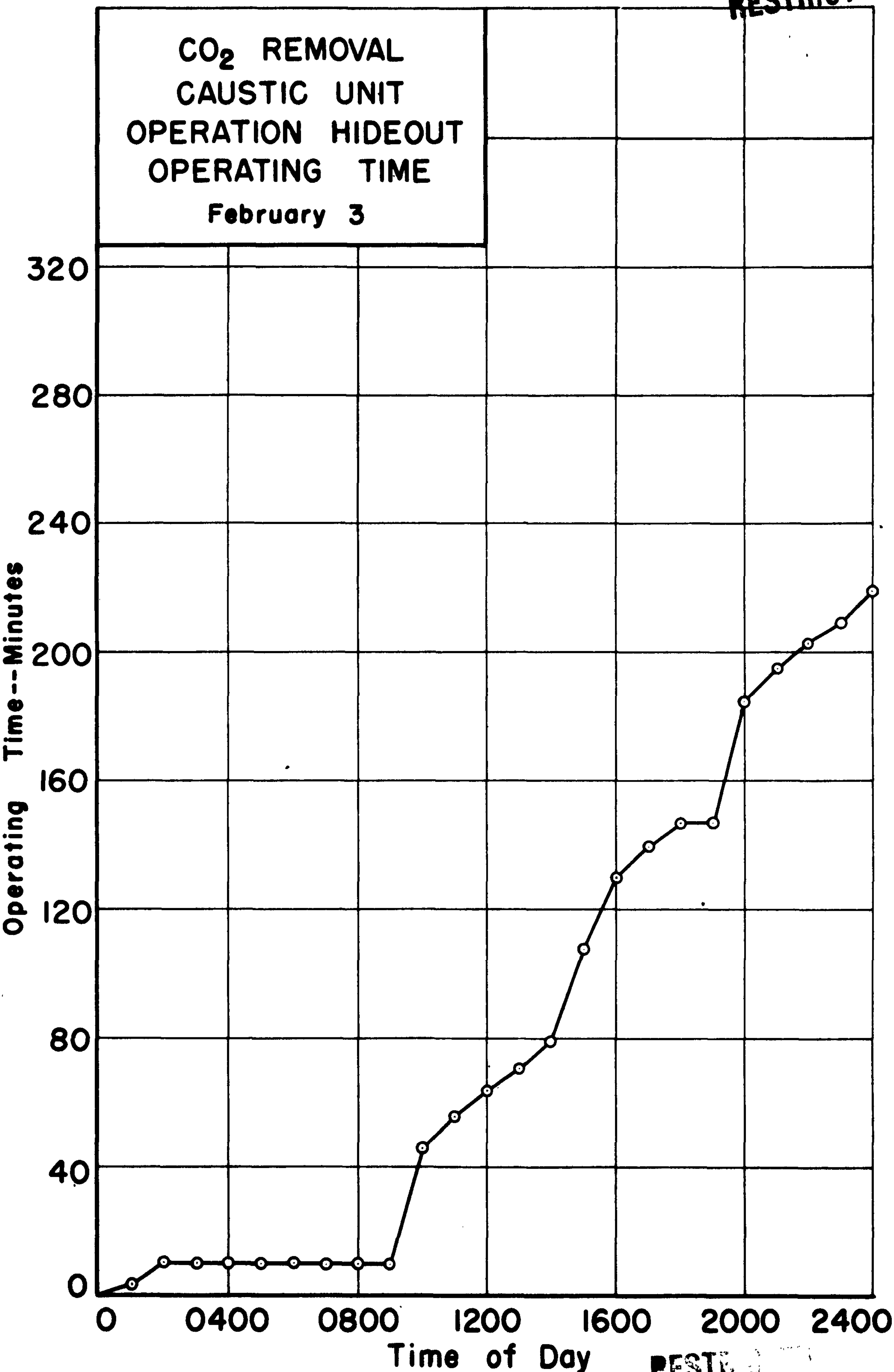

CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
January 31
Operating Time--Minutes
320
280
240
200
160
120
80
40
0
0
0400
0800
1200
1600
2000
2400

RESTRICTED



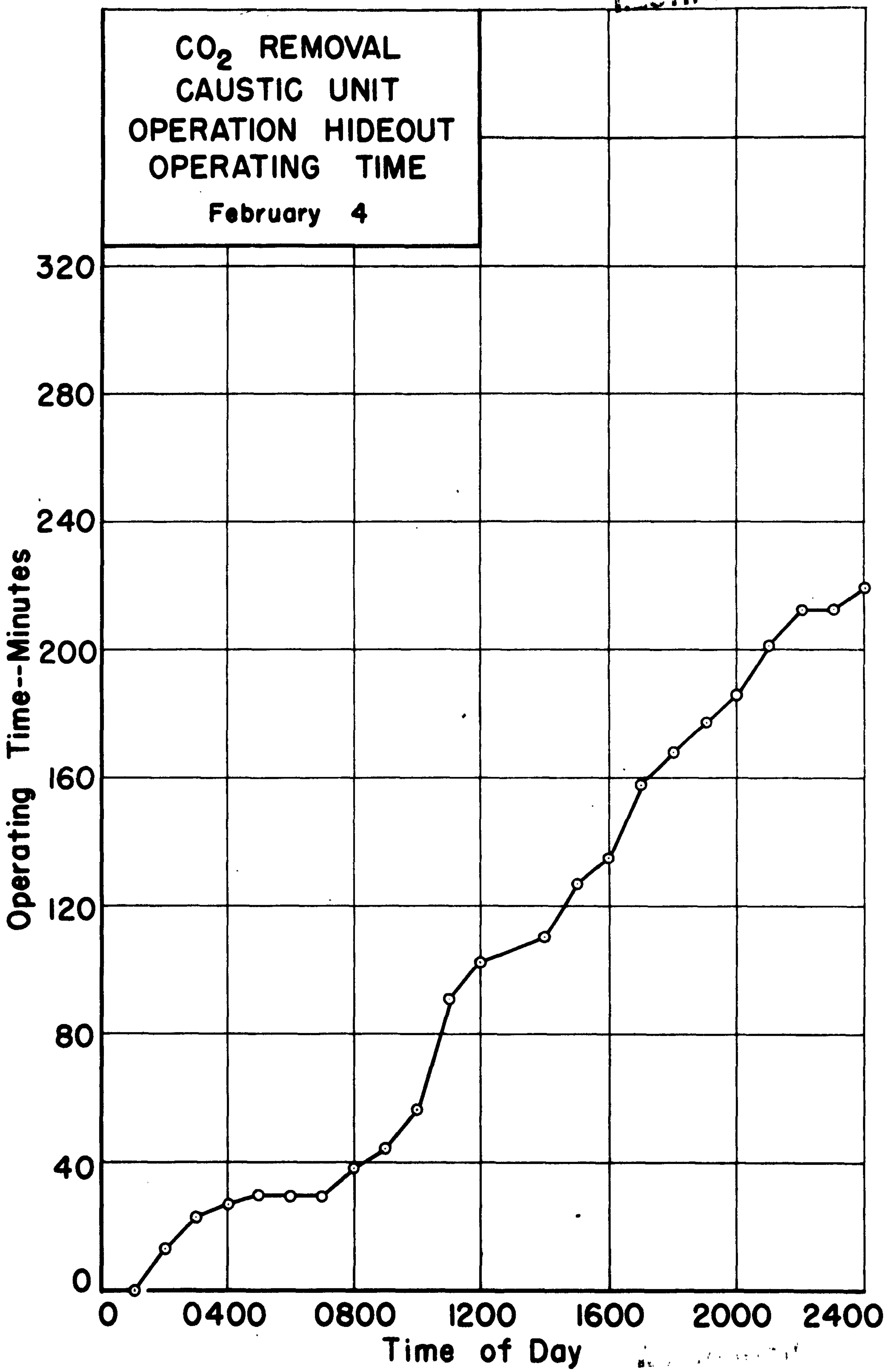
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 1
Operating
0
40
80
120
160
240
280
0
0400
0800
1200
1600
2000
2400
Time of Day


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 2
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day

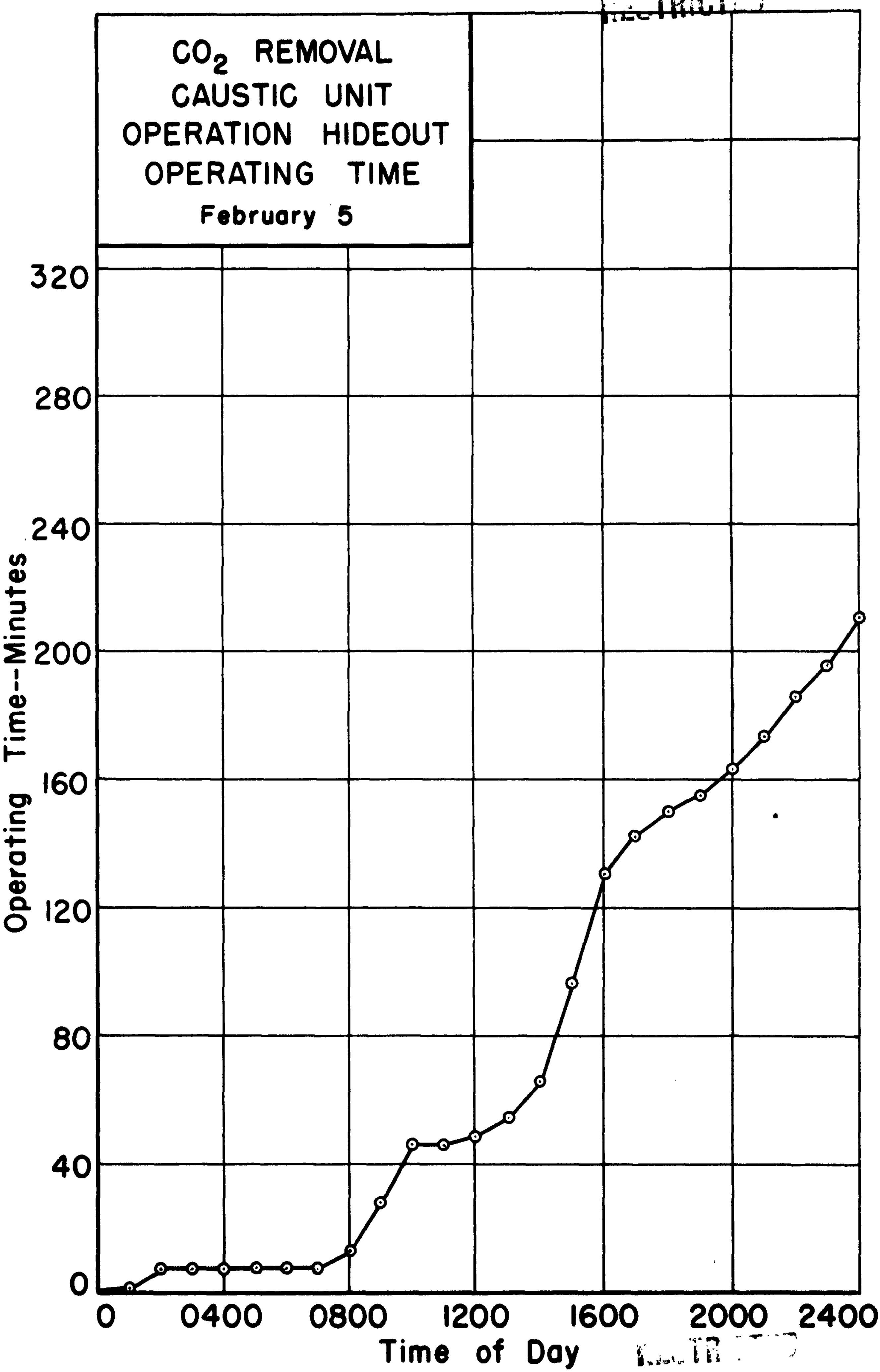


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 3
320
280
240
200
160
120
80
40
0
Operating Time--Minutes
0
0400
0800
1200
1600
2000
2400
Time of Day

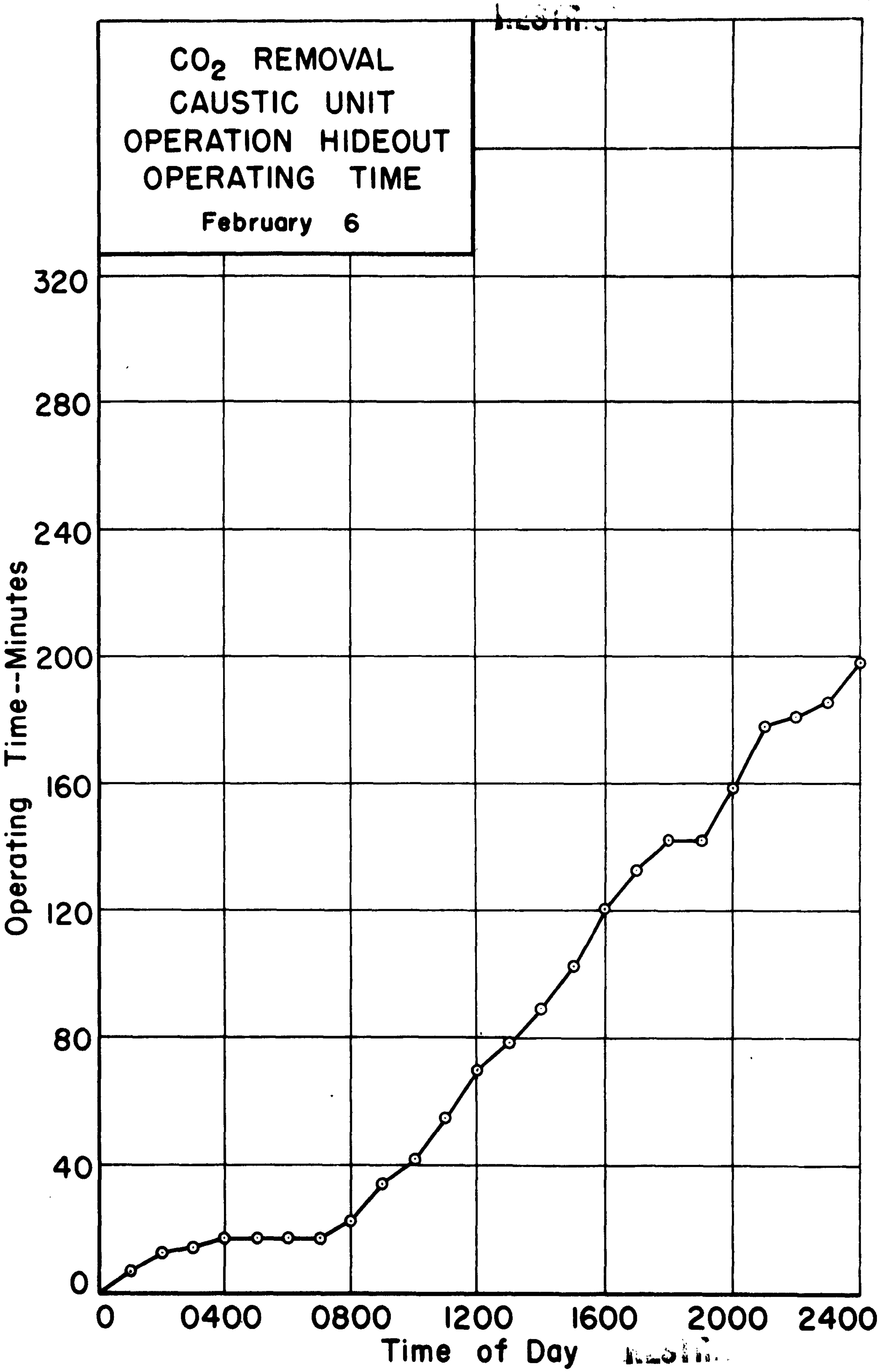
235



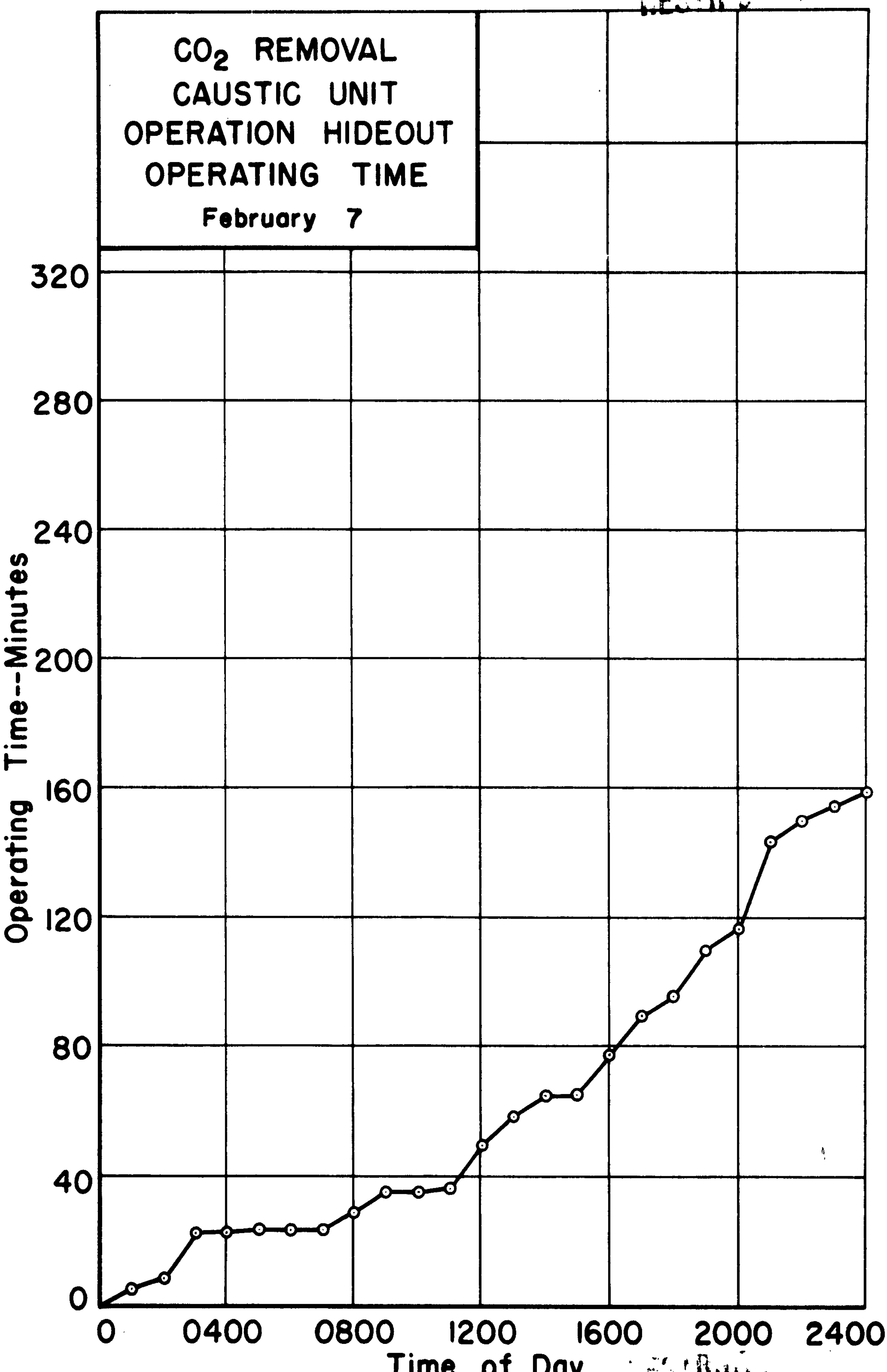
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 4
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day



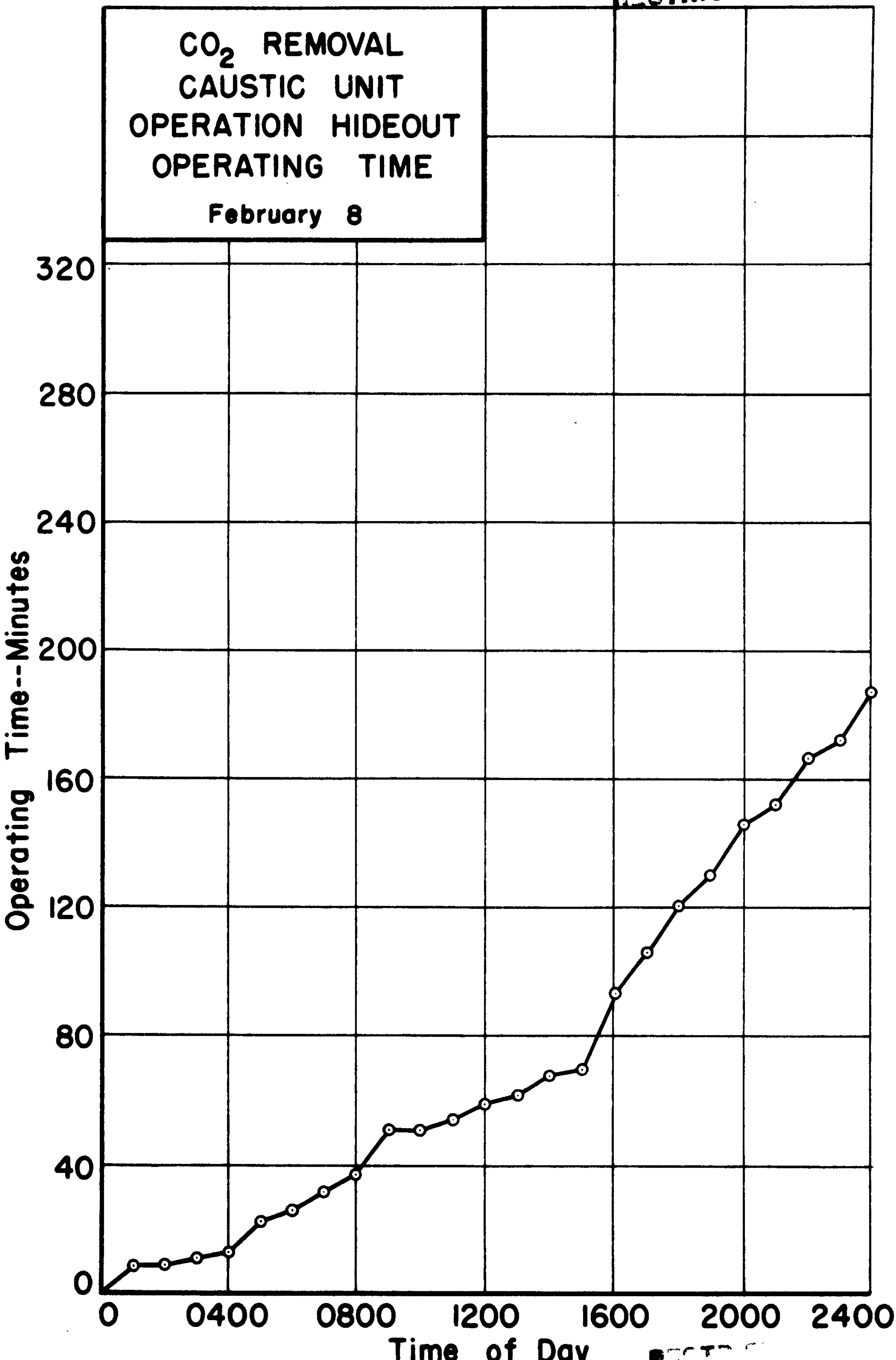
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 5
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day



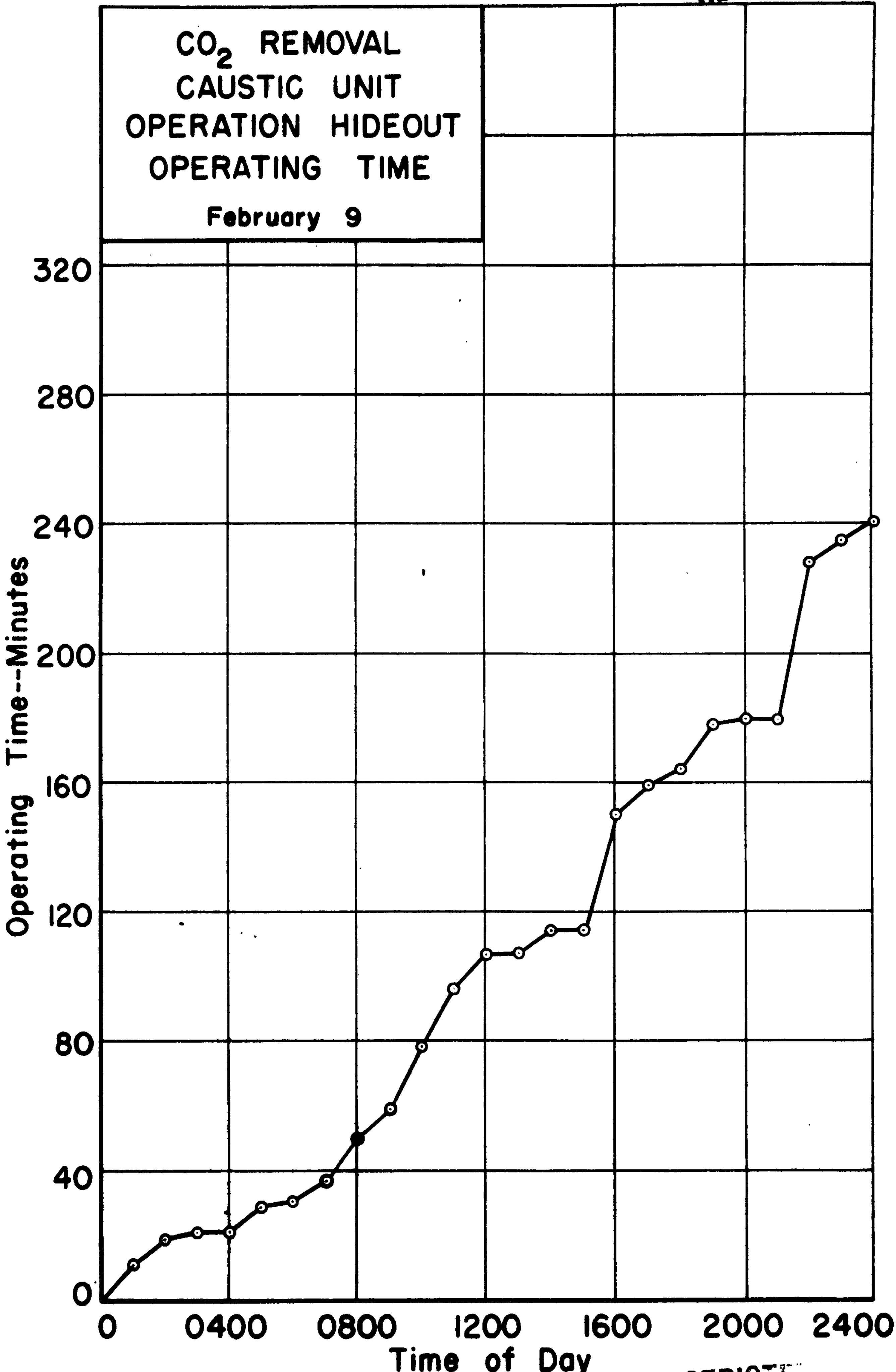
CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 6
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day

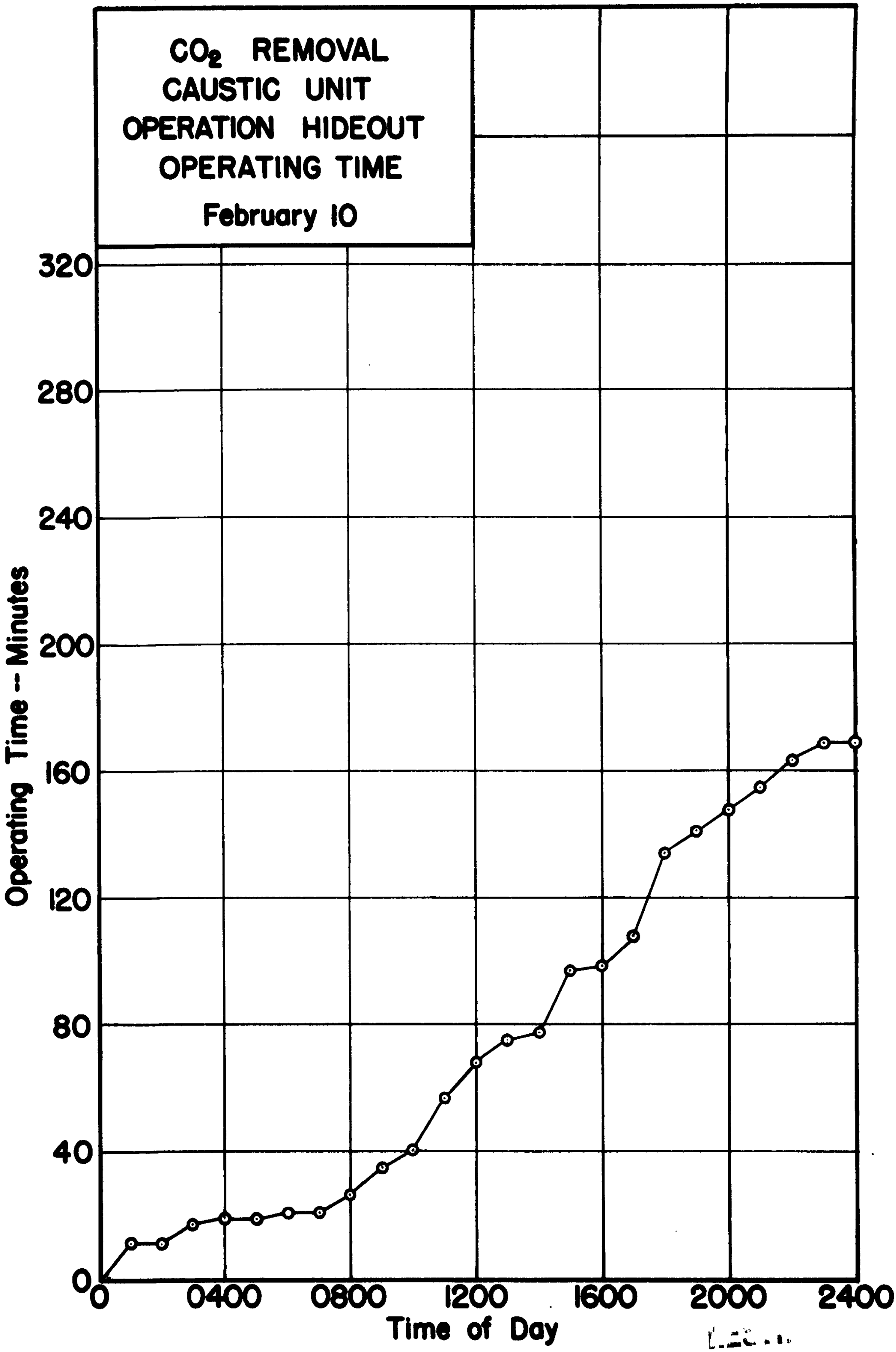


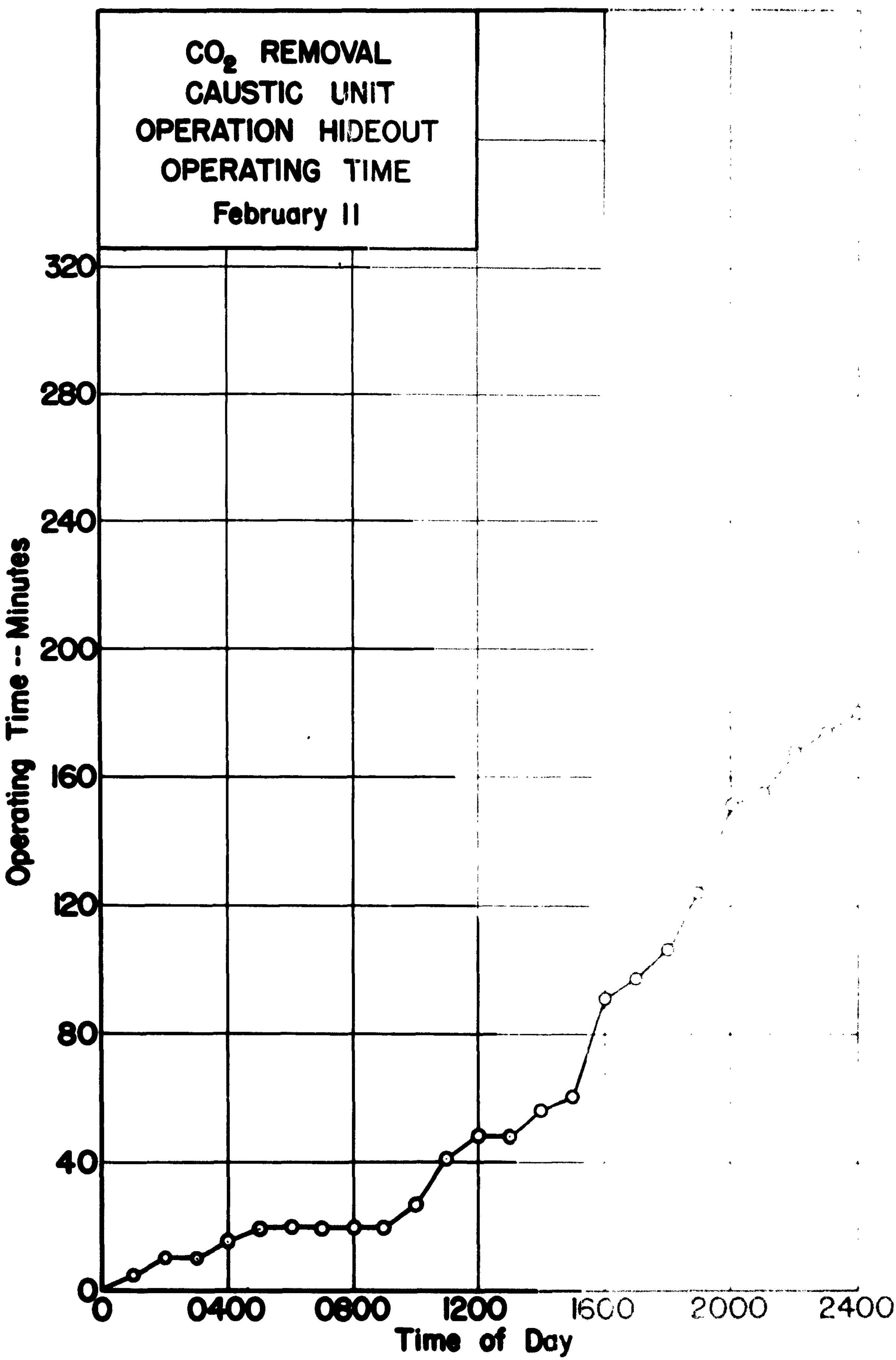
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 7
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day



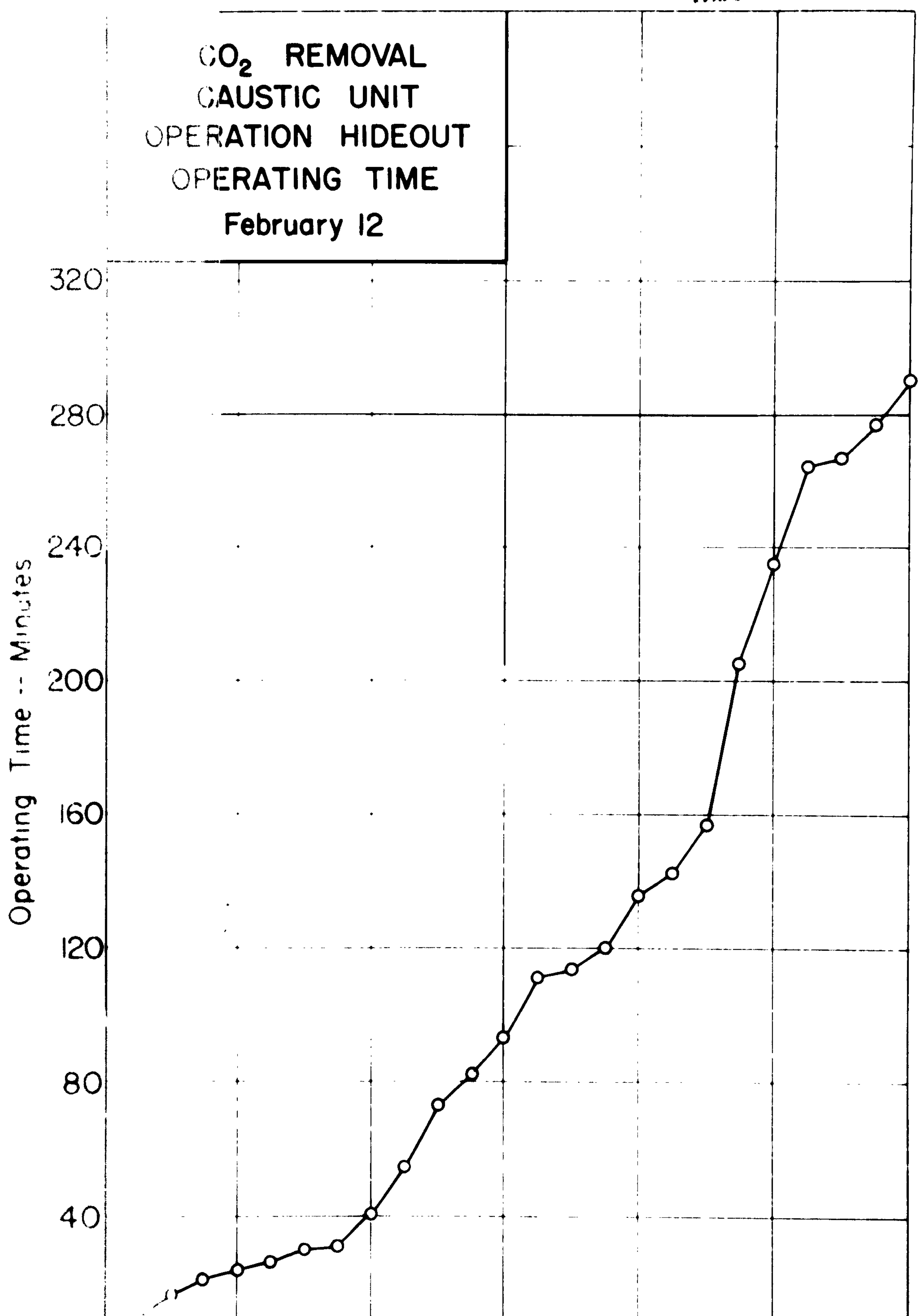
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 8
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day

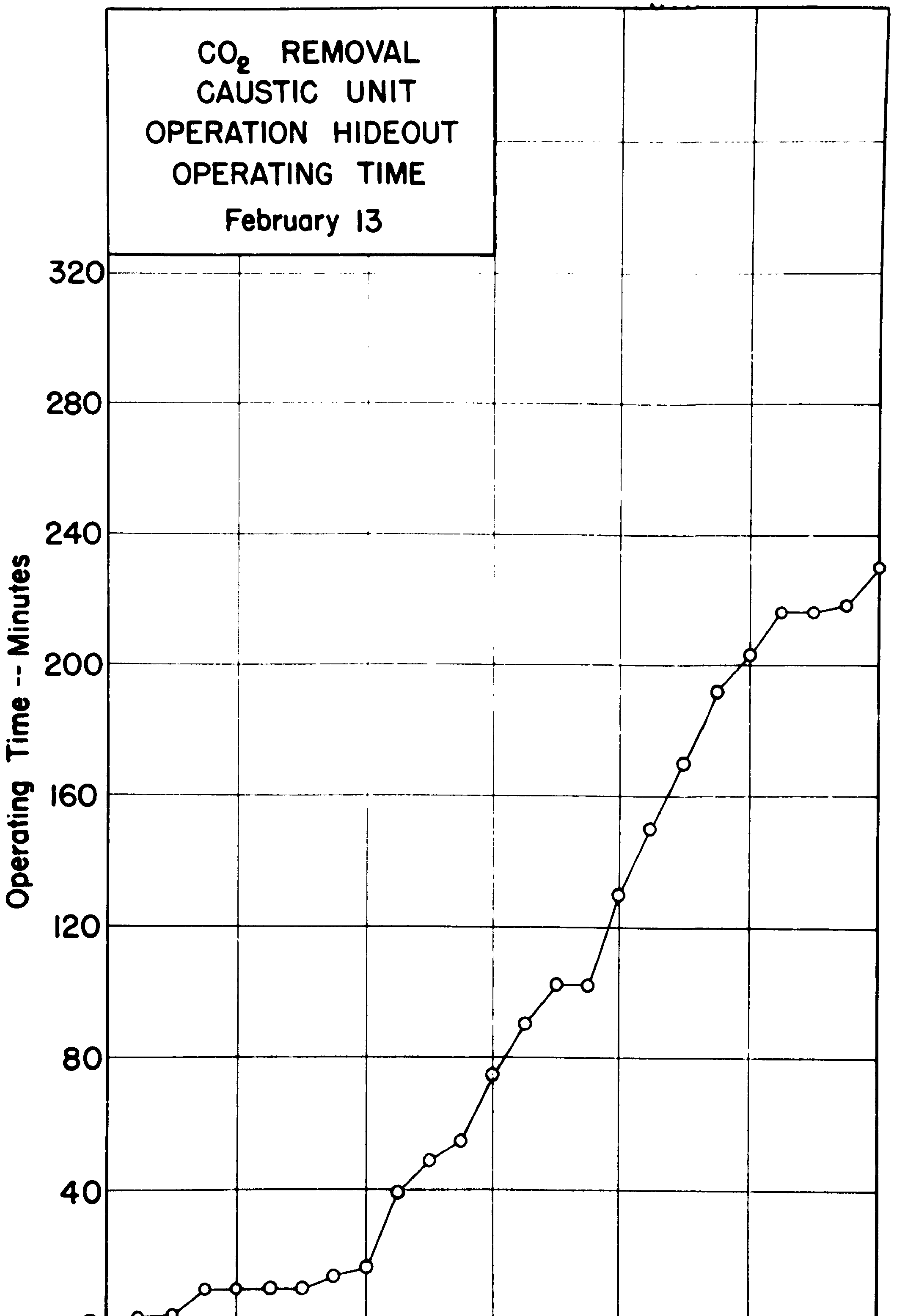

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 9
Operating Time--Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 10
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day

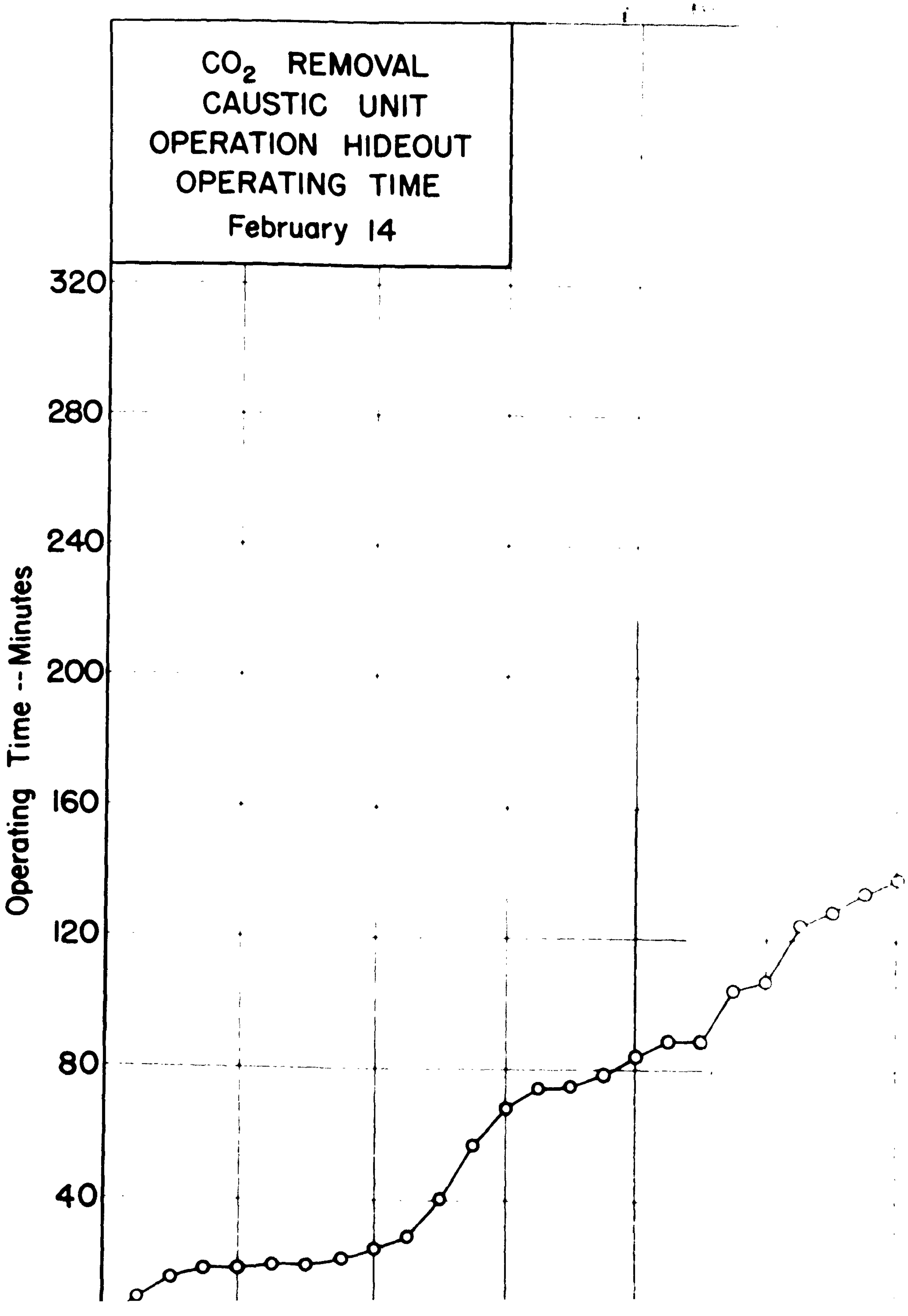


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 11
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0
0
0400
0800
1200
1600
2000
2400
Time of Day

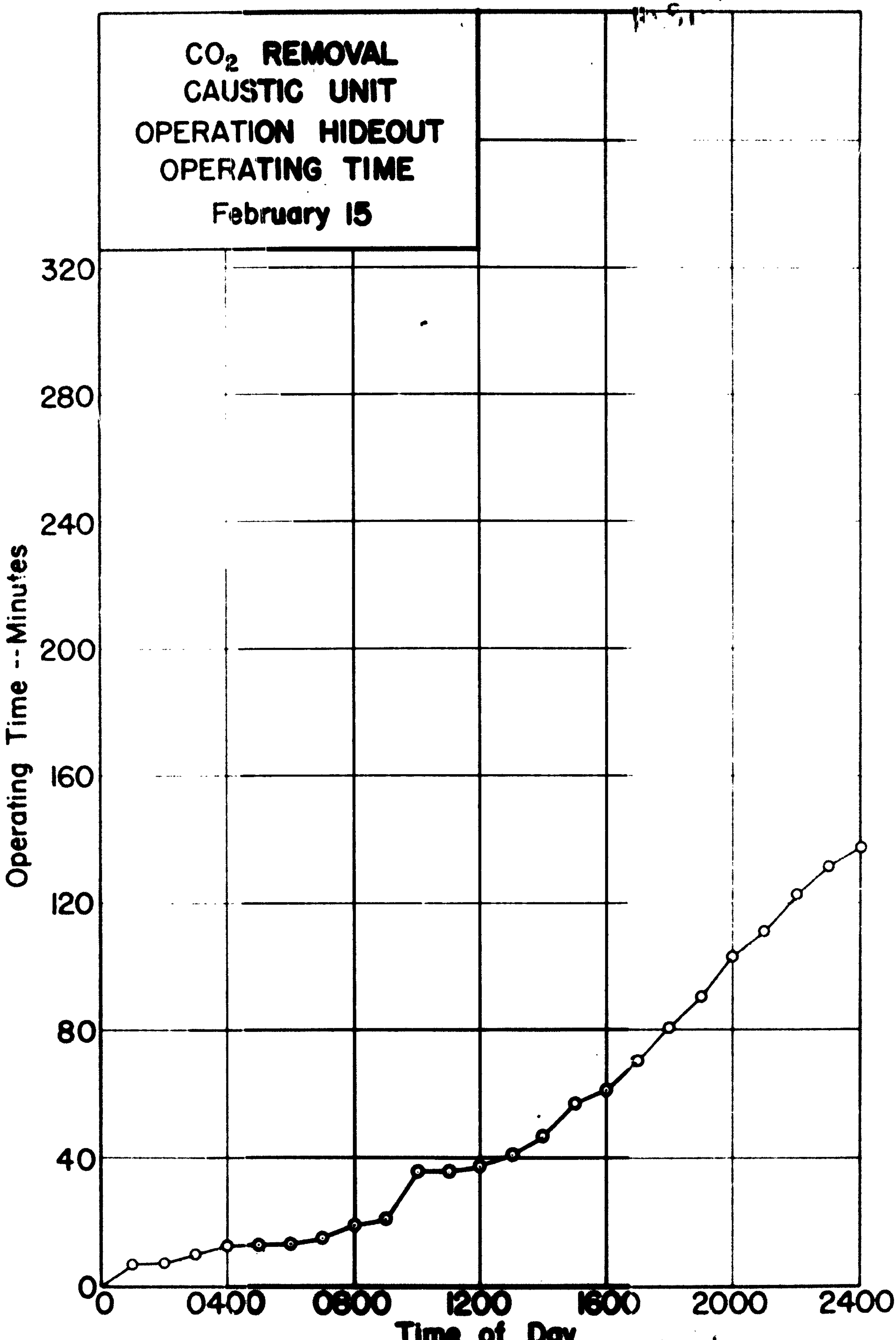

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 12
Operating Time -- Minutes
320
280
240
200
160
120
80
40



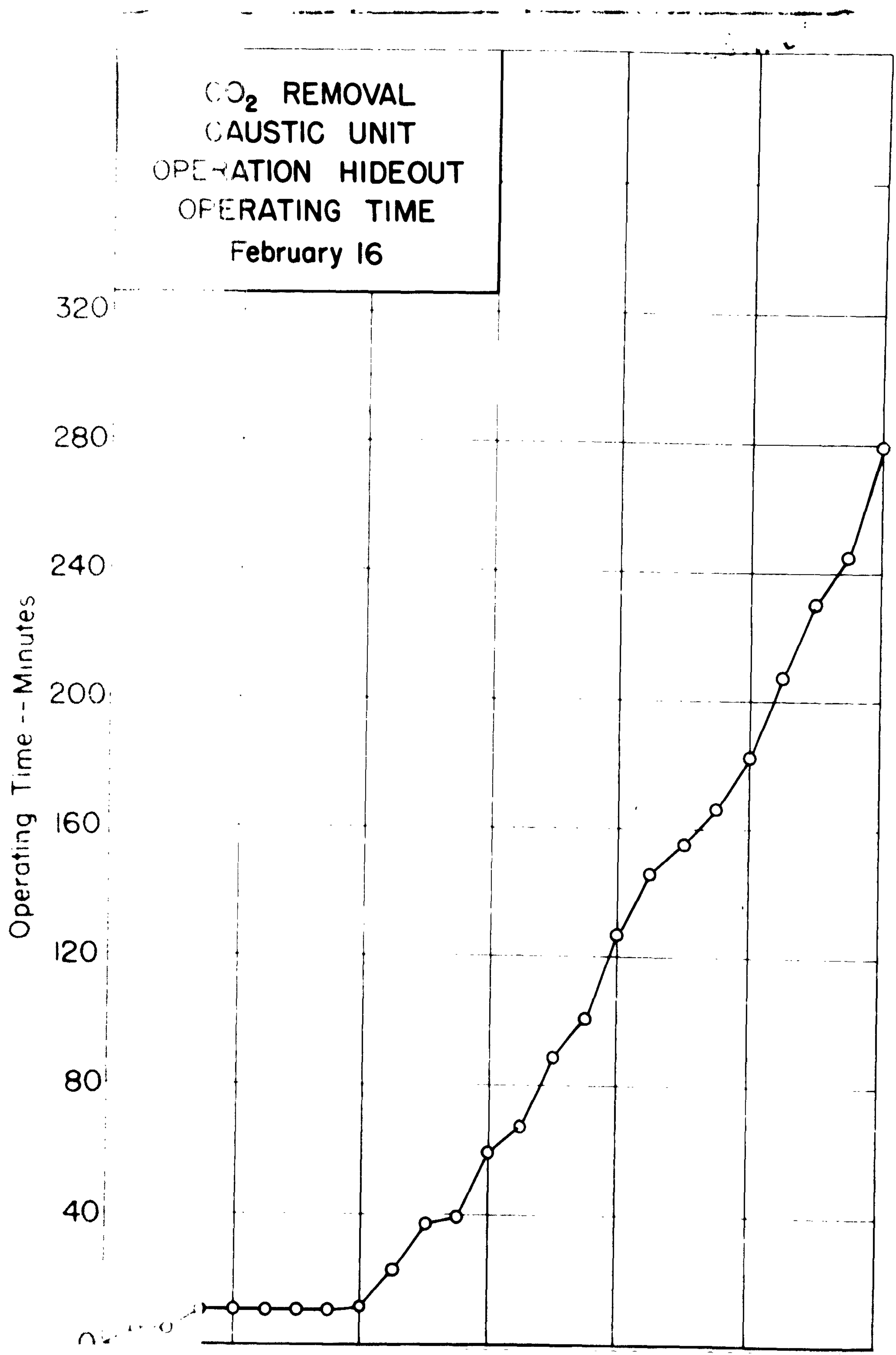
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 13
320
280
240
200
160
120
80
40
Operating Time -- Minutes



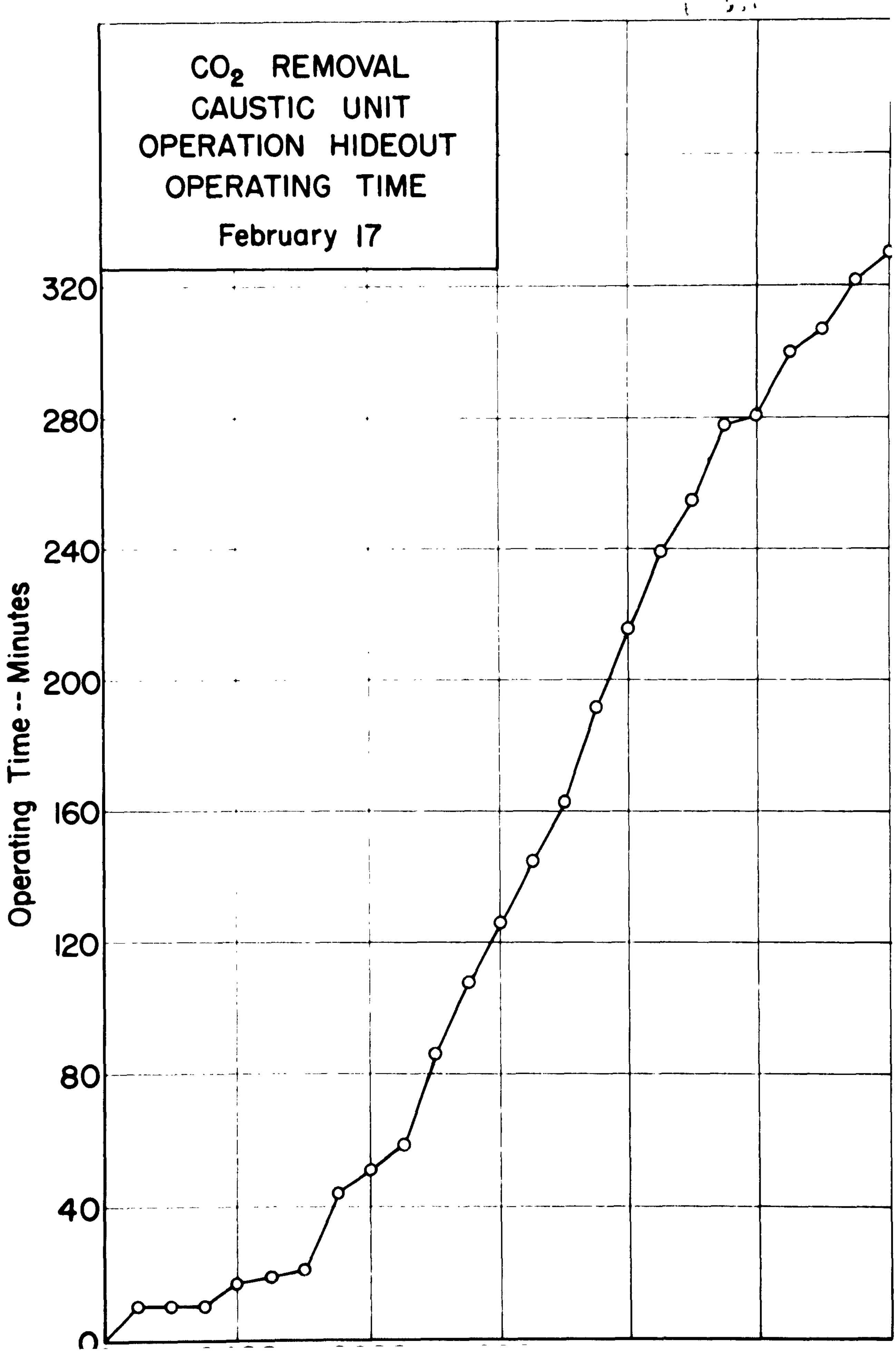
CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 14
320
280
240
200
160
120
80
40
Operating Time -- Minutes

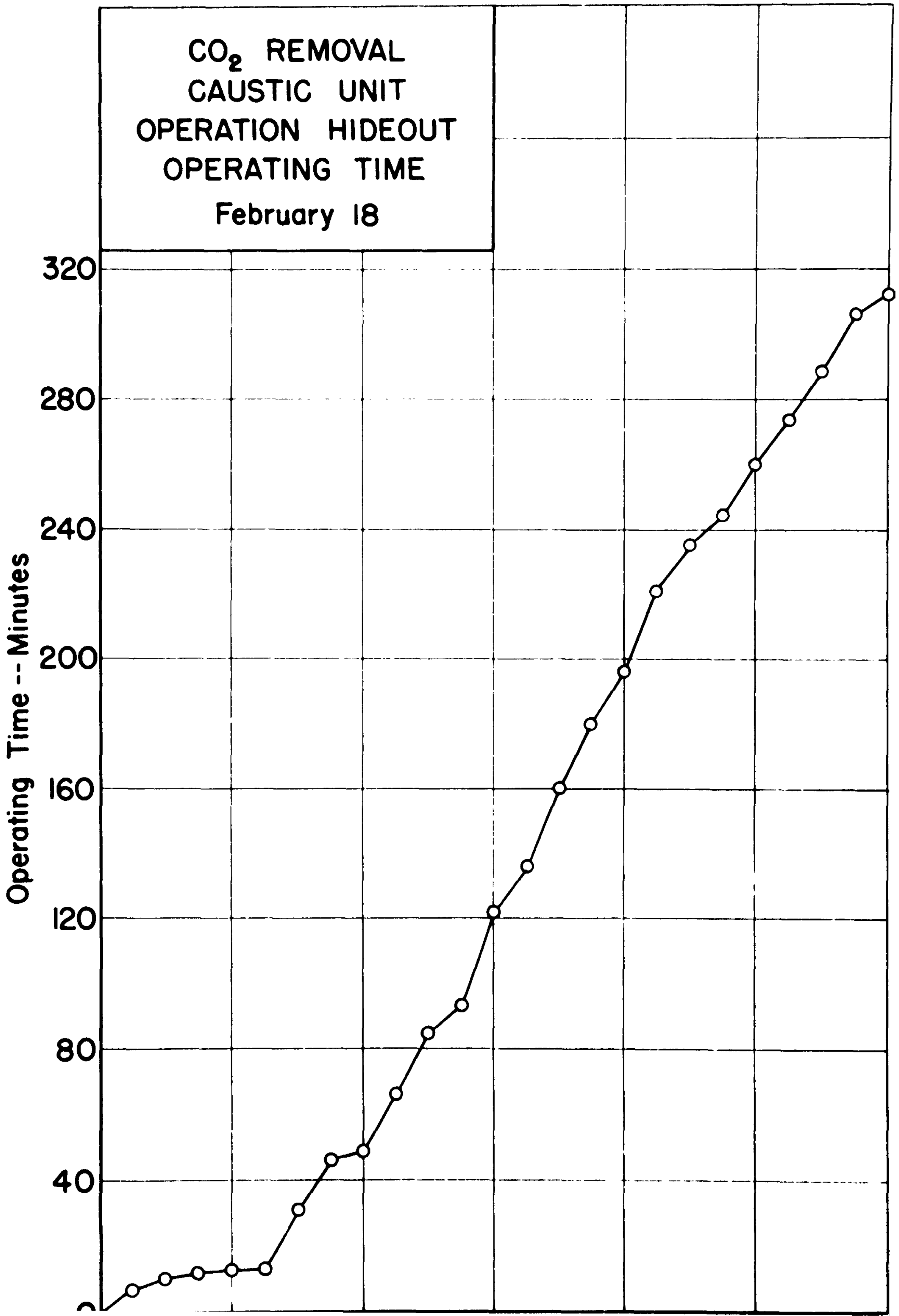


CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 15
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day

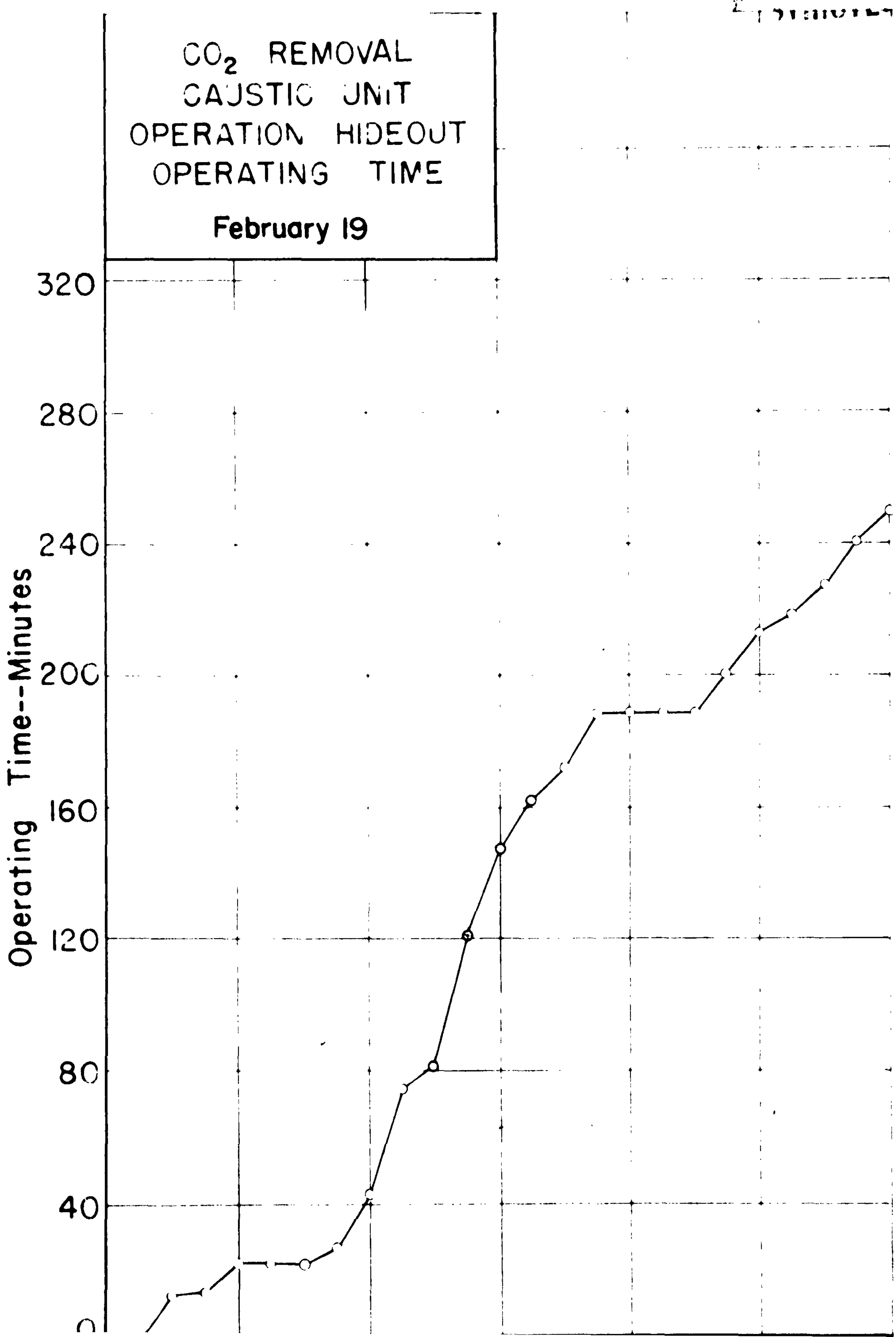


CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 16
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0

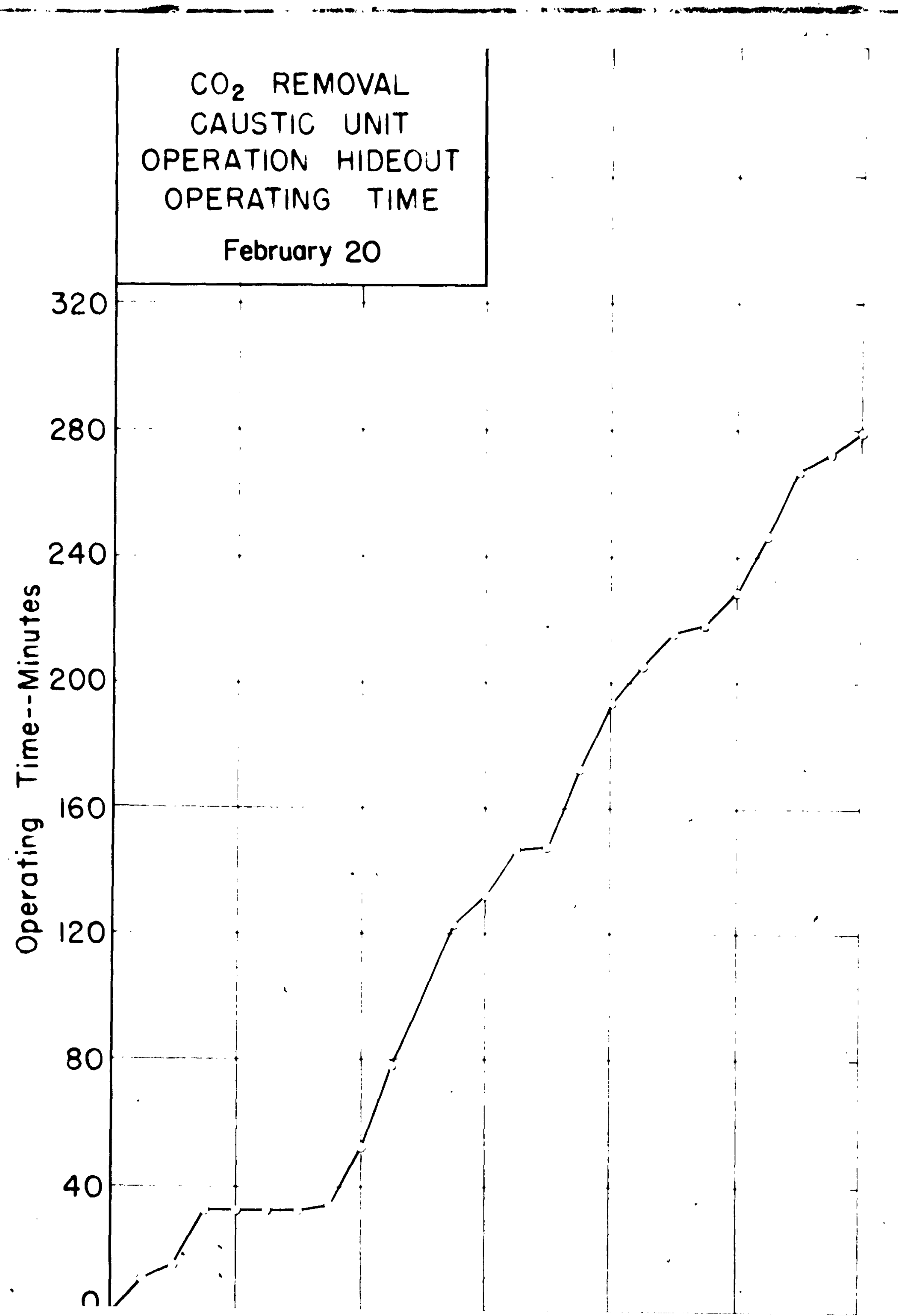

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 17
320
280
240
200
160
120
80
40
0
Operating Time -- Minutes



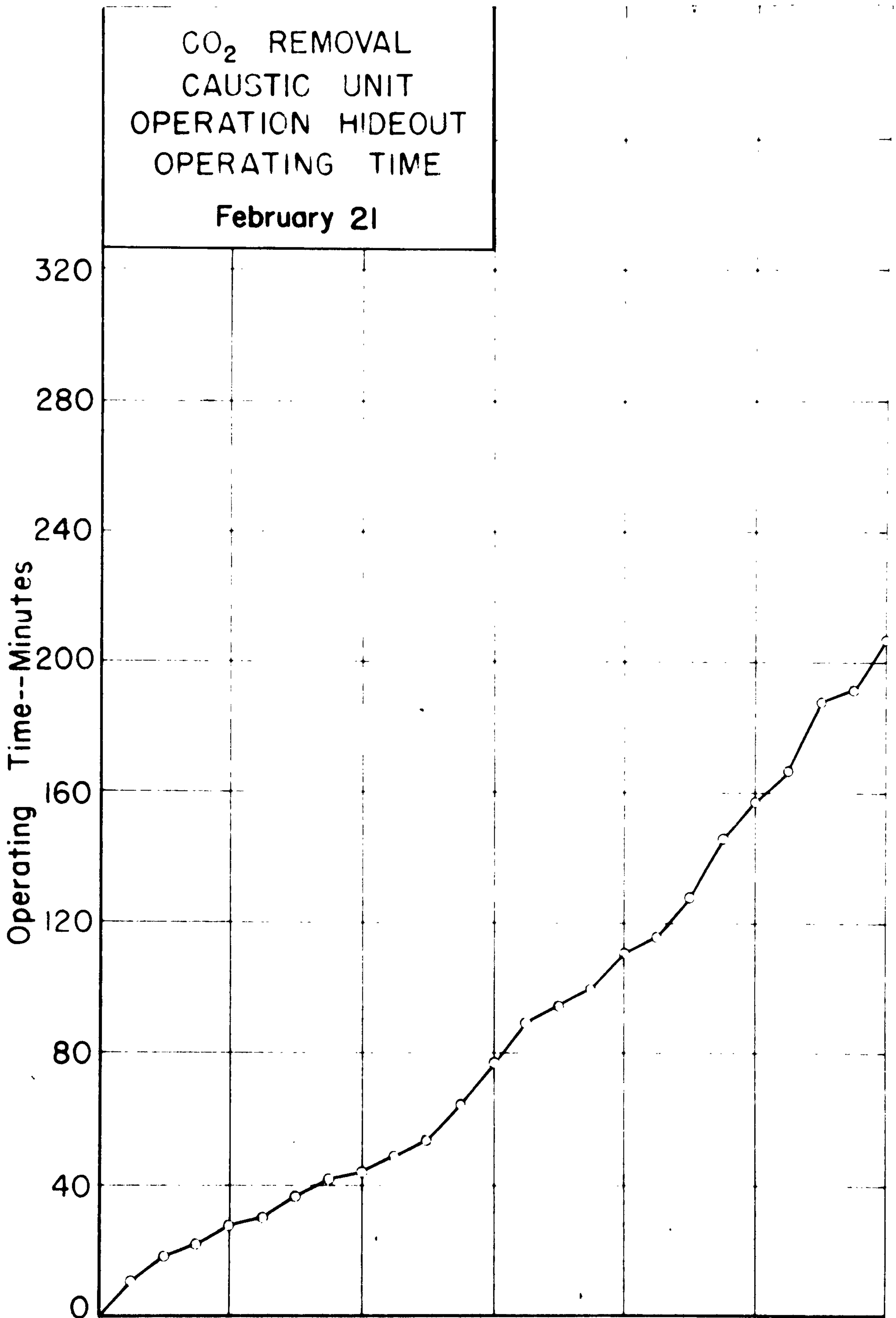
CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 18
320
280
240
200
160
120
80
40
Operating Time -- Minutes



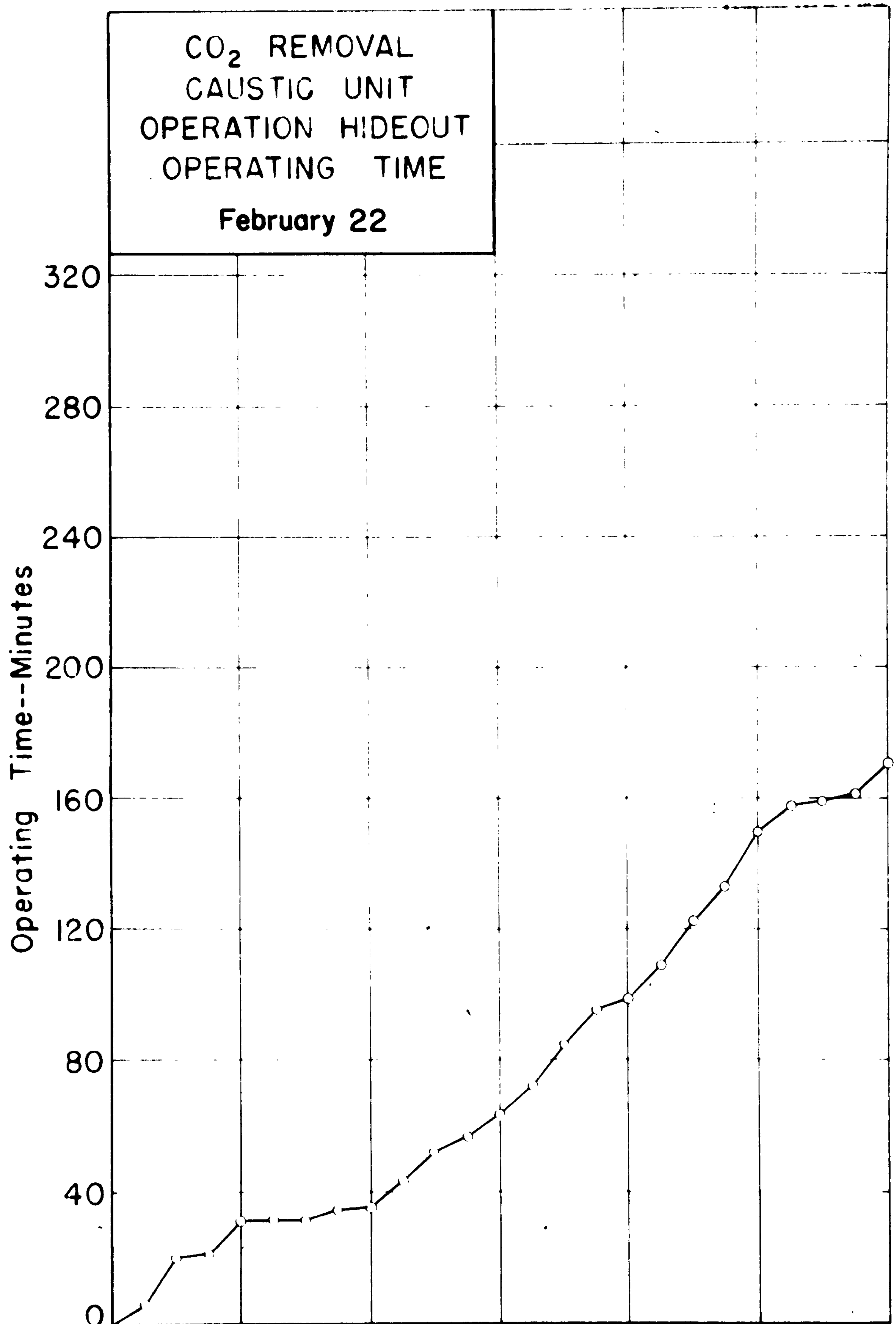
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 19
320
280
240
200
160
120
80
40
0
Operating Time--Minutes



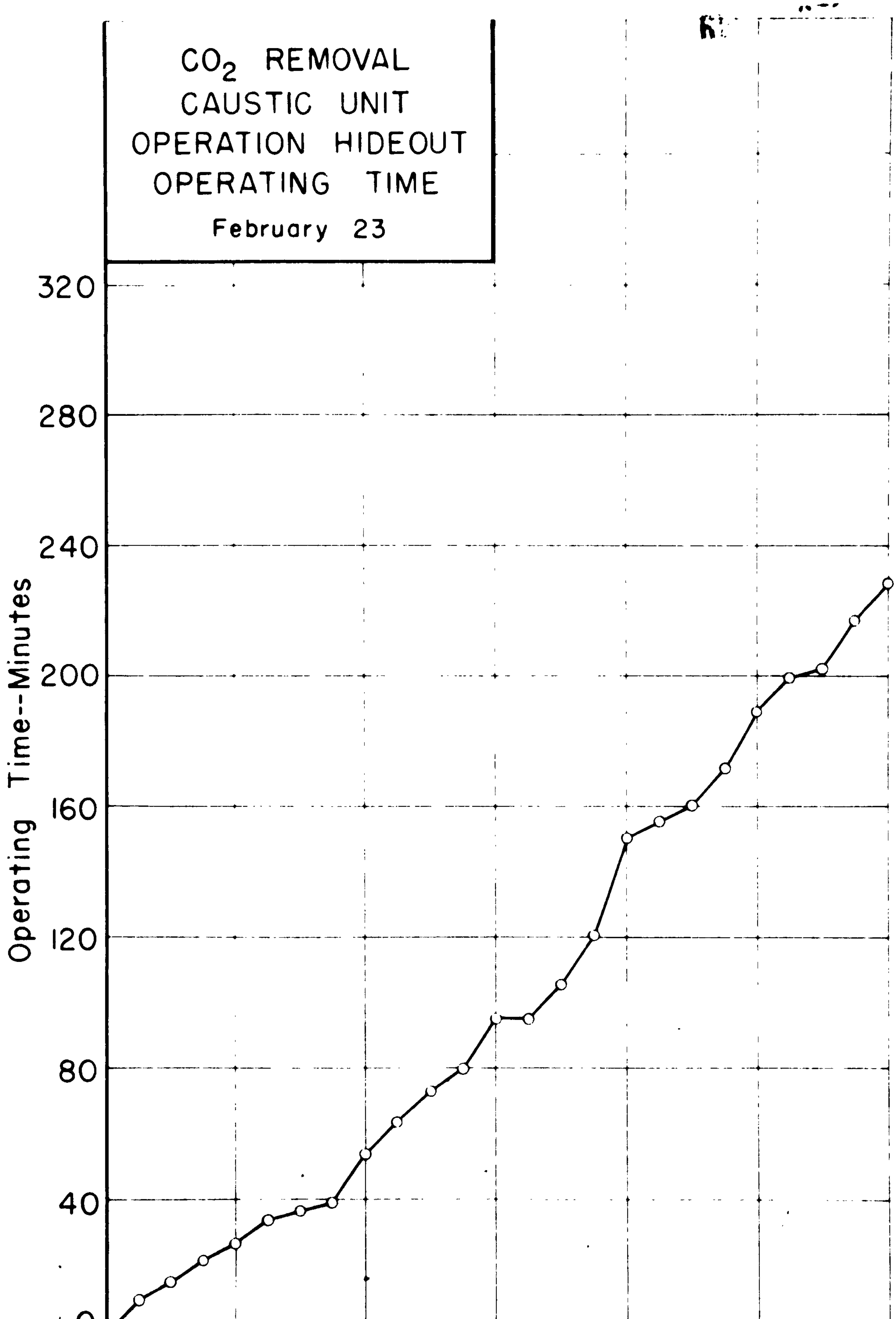
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 20
Operating Time--Minutes
320
280
240
200
160
120
80
40
0

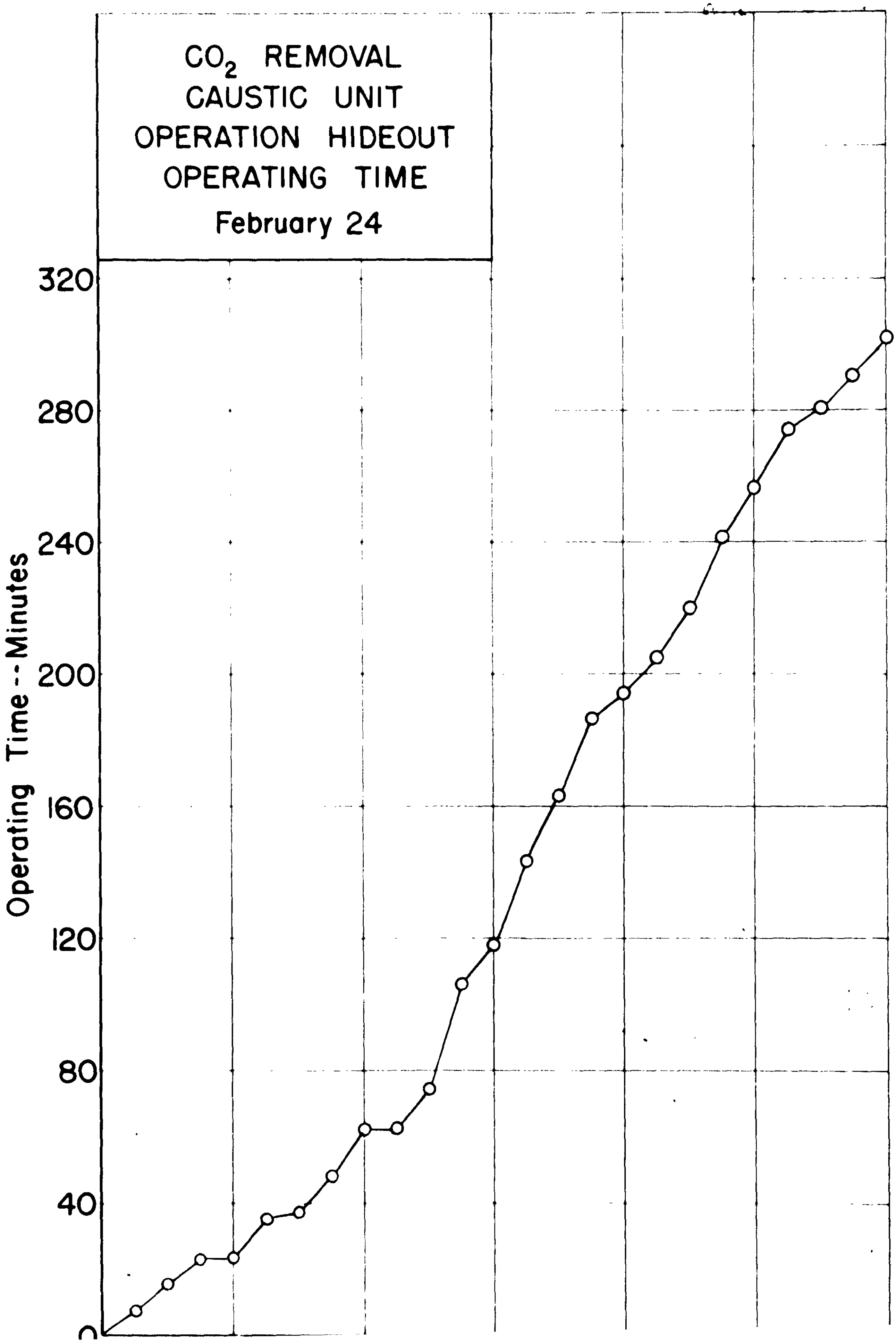


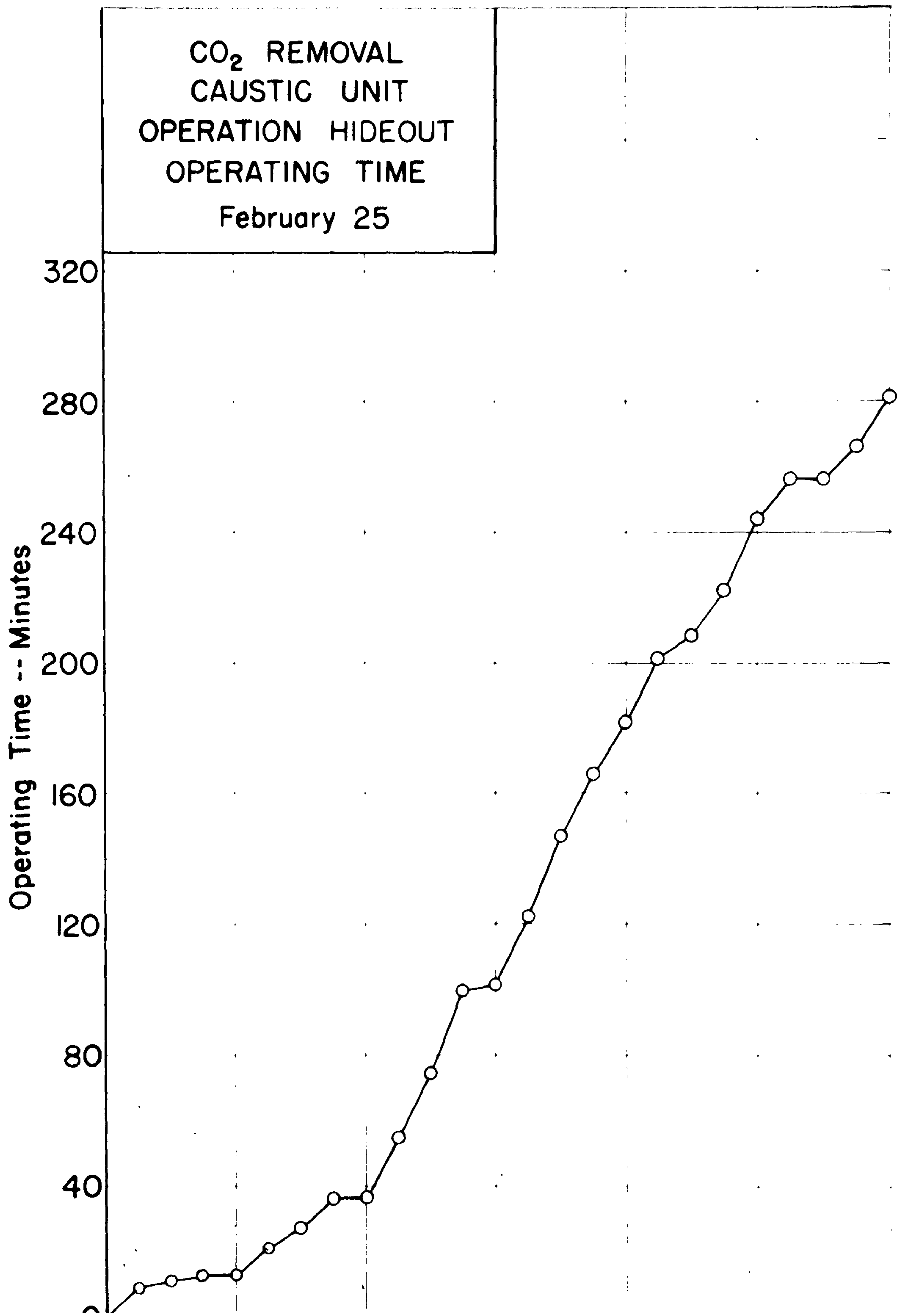
CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 21
Operating Time--Minutes
320
280
240
200
160
120
80
40
0

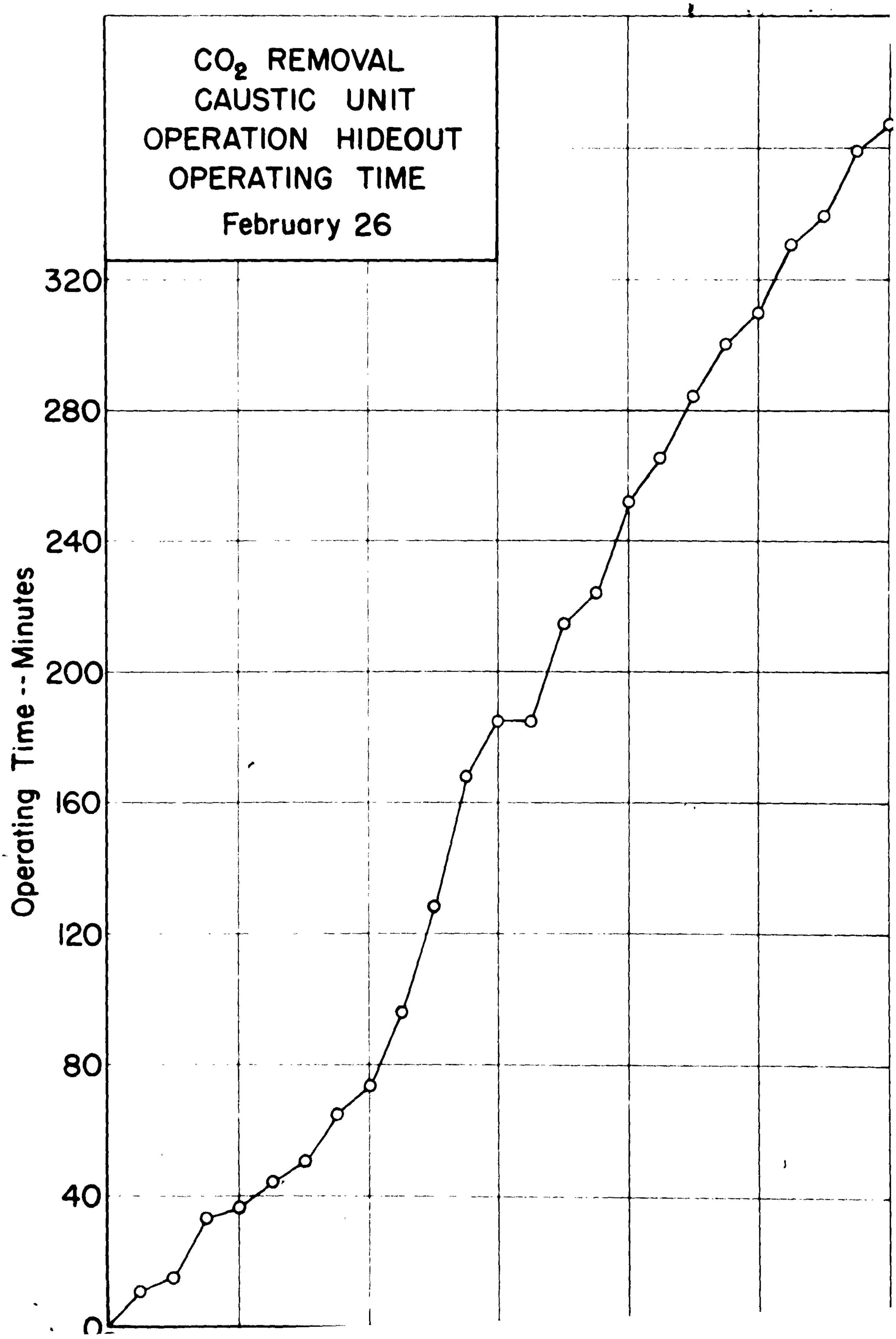


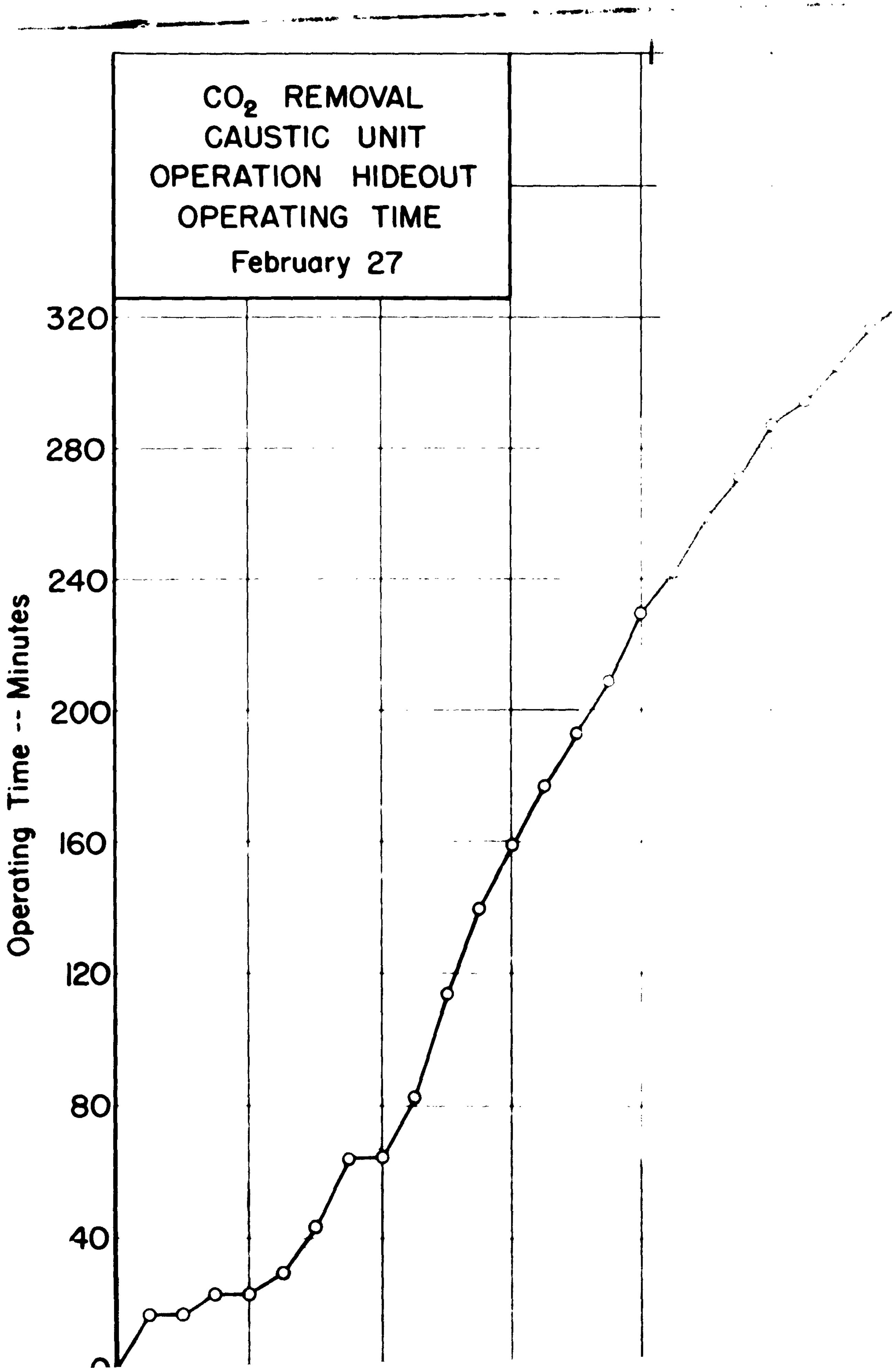
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 22
Operating Time--Minutes
320
280
240
200
160
120
80
40
0

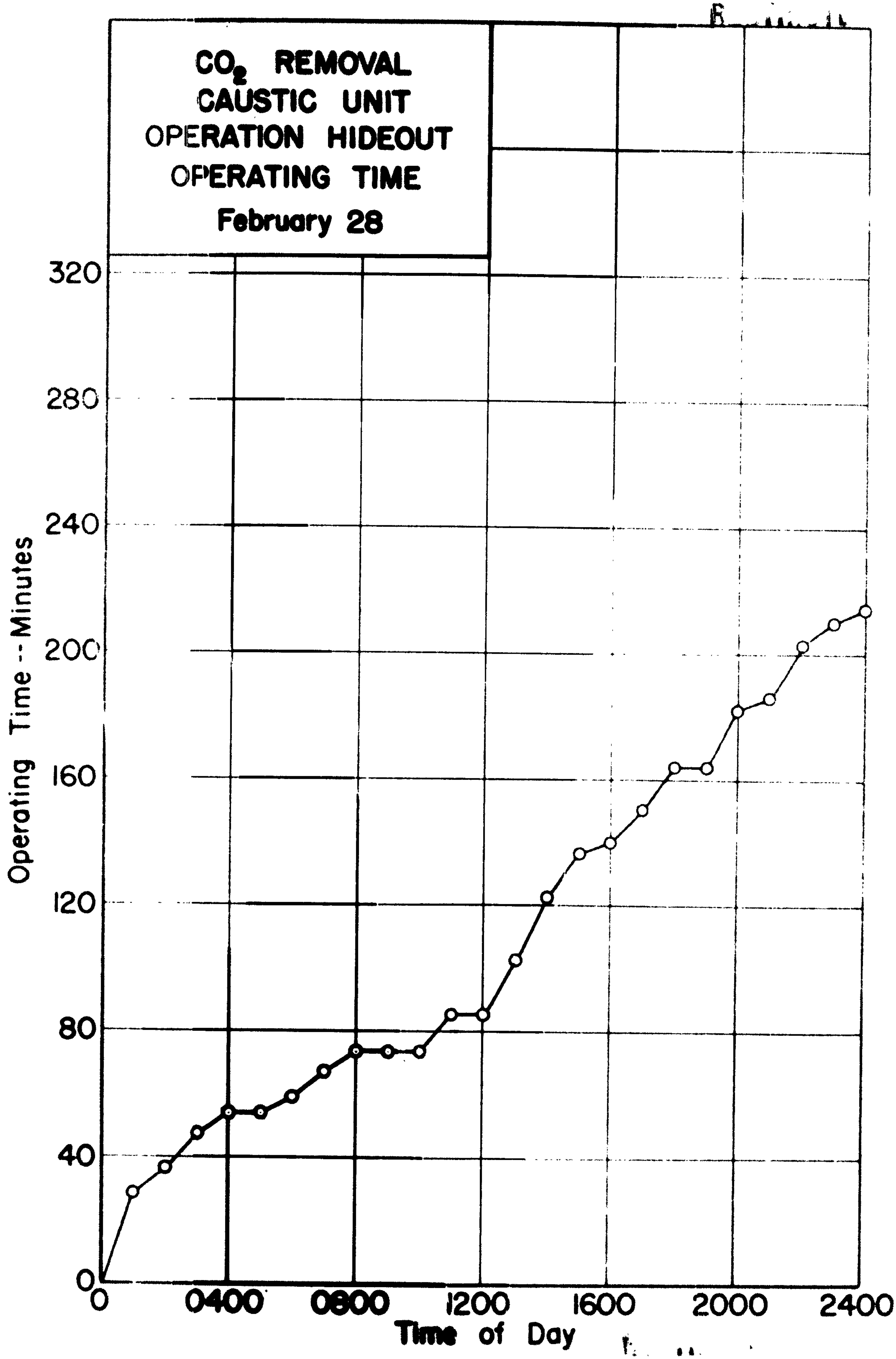

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 23
Operating Time--Minutes
320
280
240
200
160
120
80
40


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 24
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0

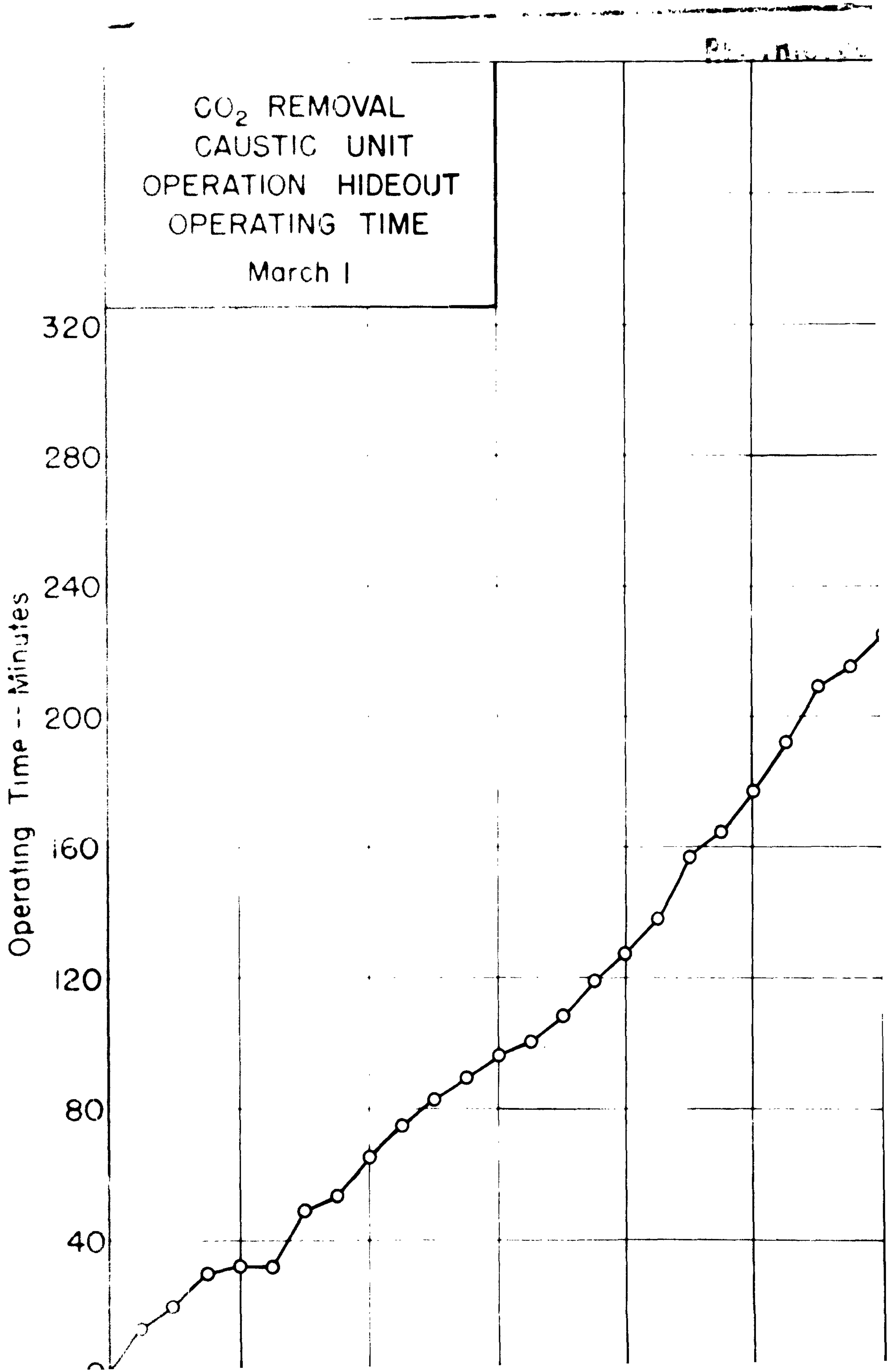

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
UNIT
OPERATING TIME
February 25
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 26
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320

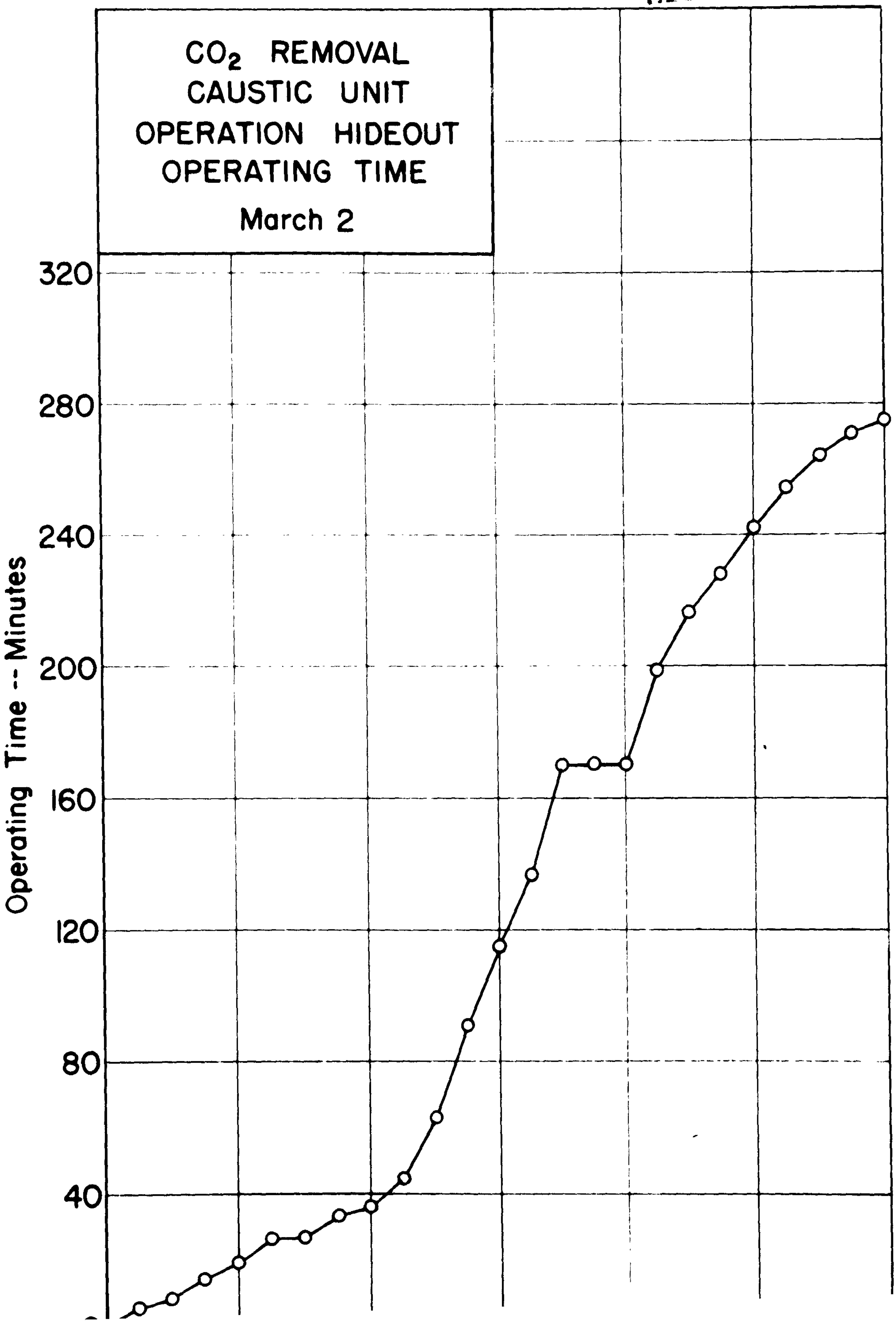

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 27
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0



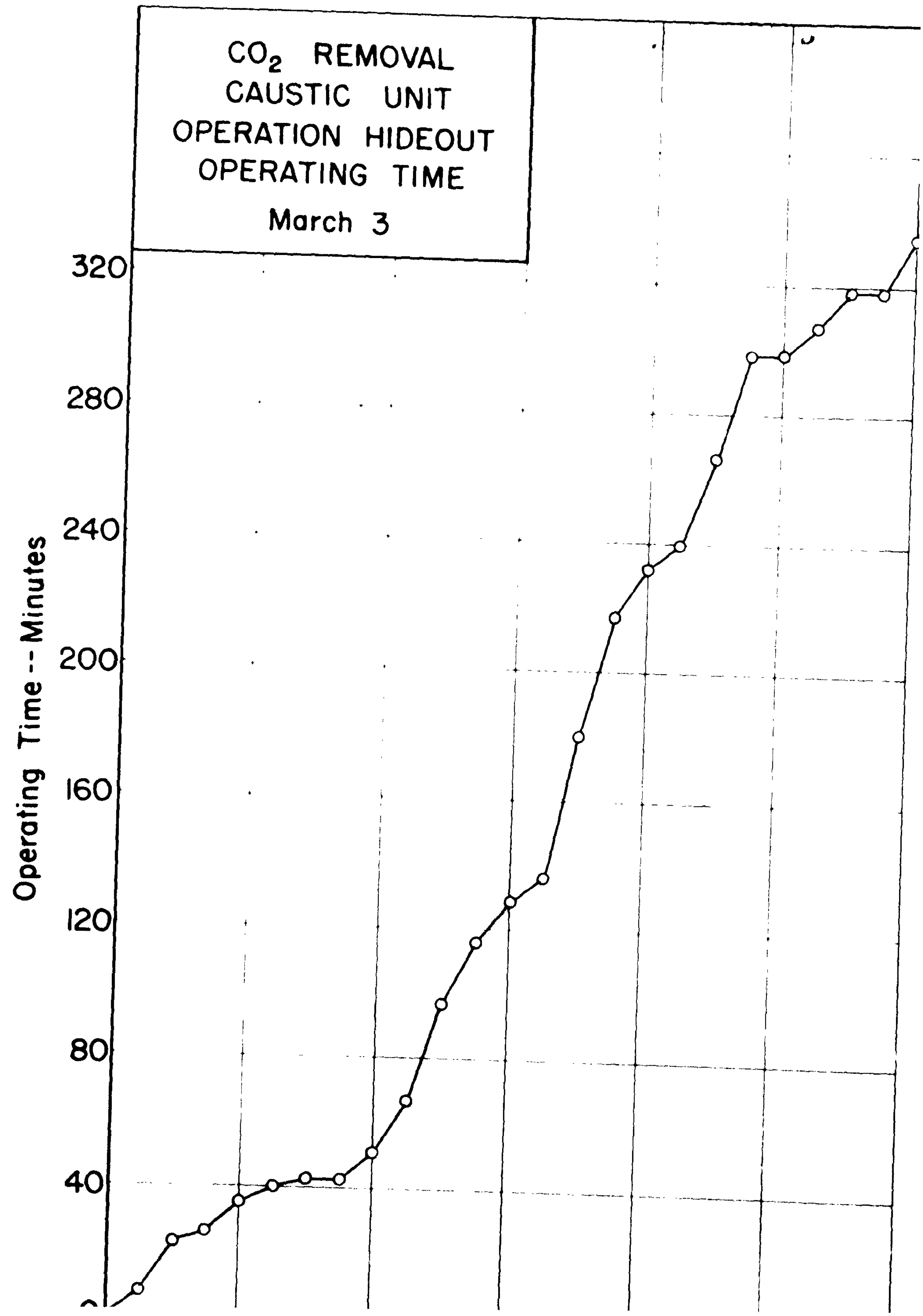
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
February 28
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day



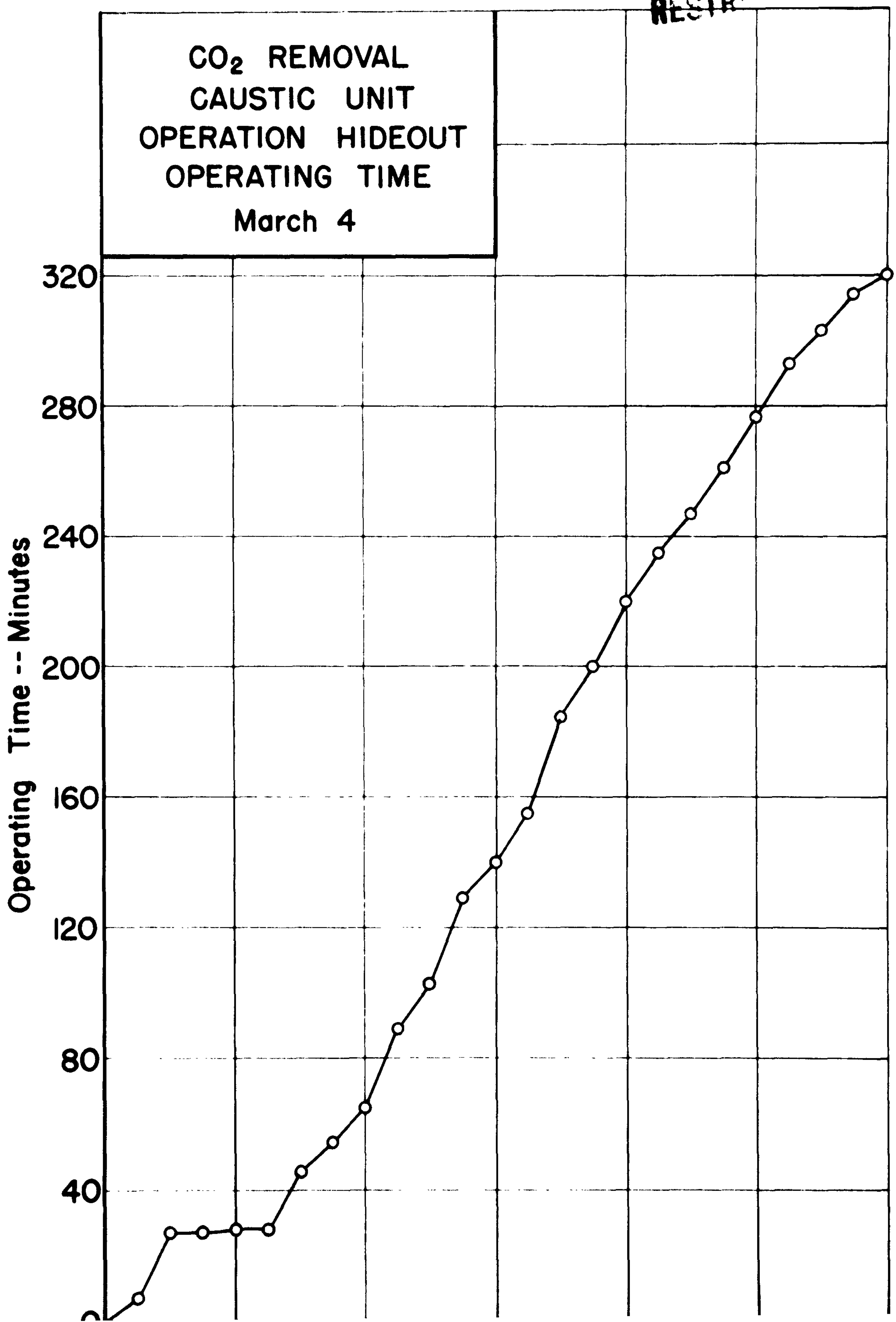
CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 1
320
280
240
200
160
120
80
40
Operating Time -- Minutes

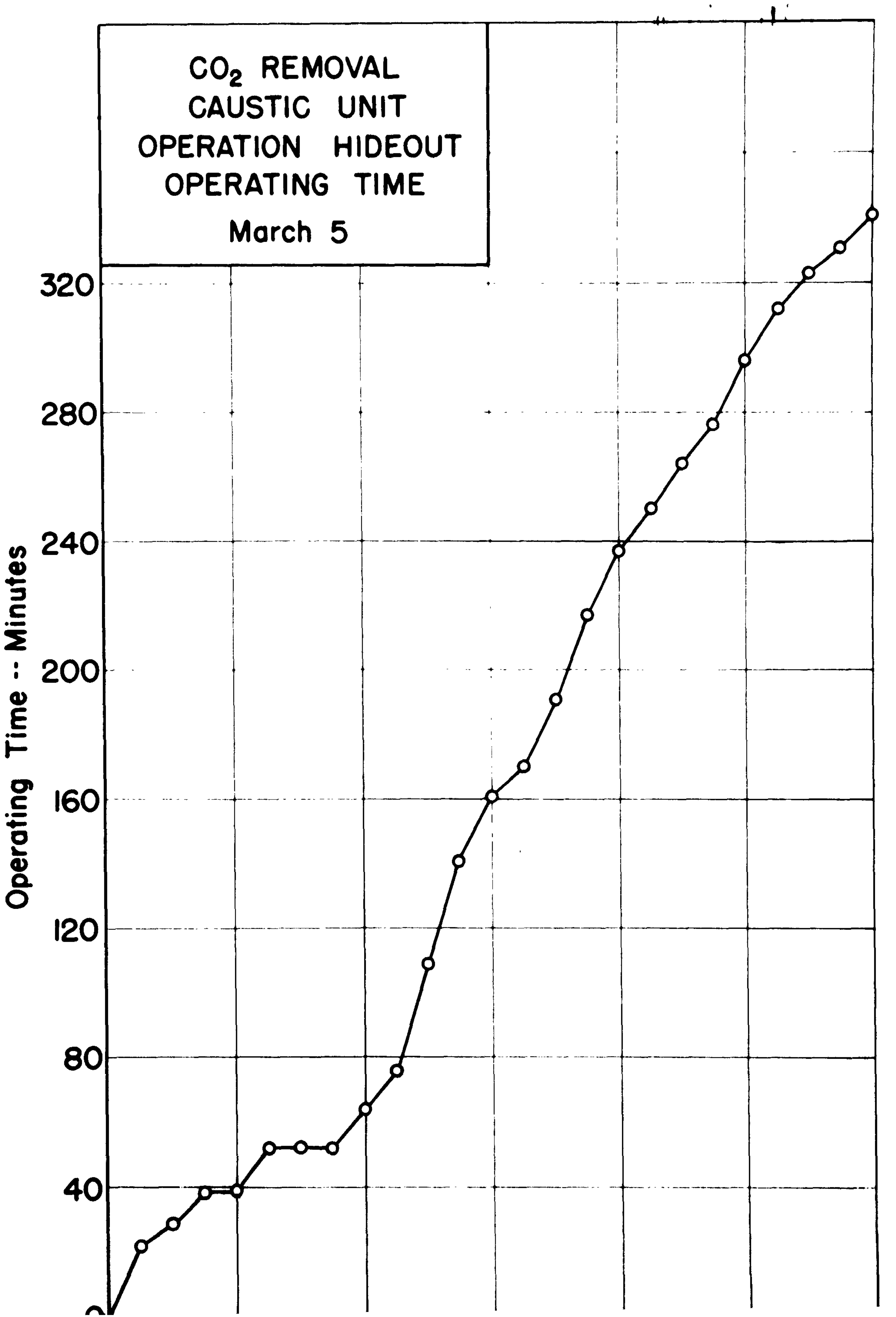


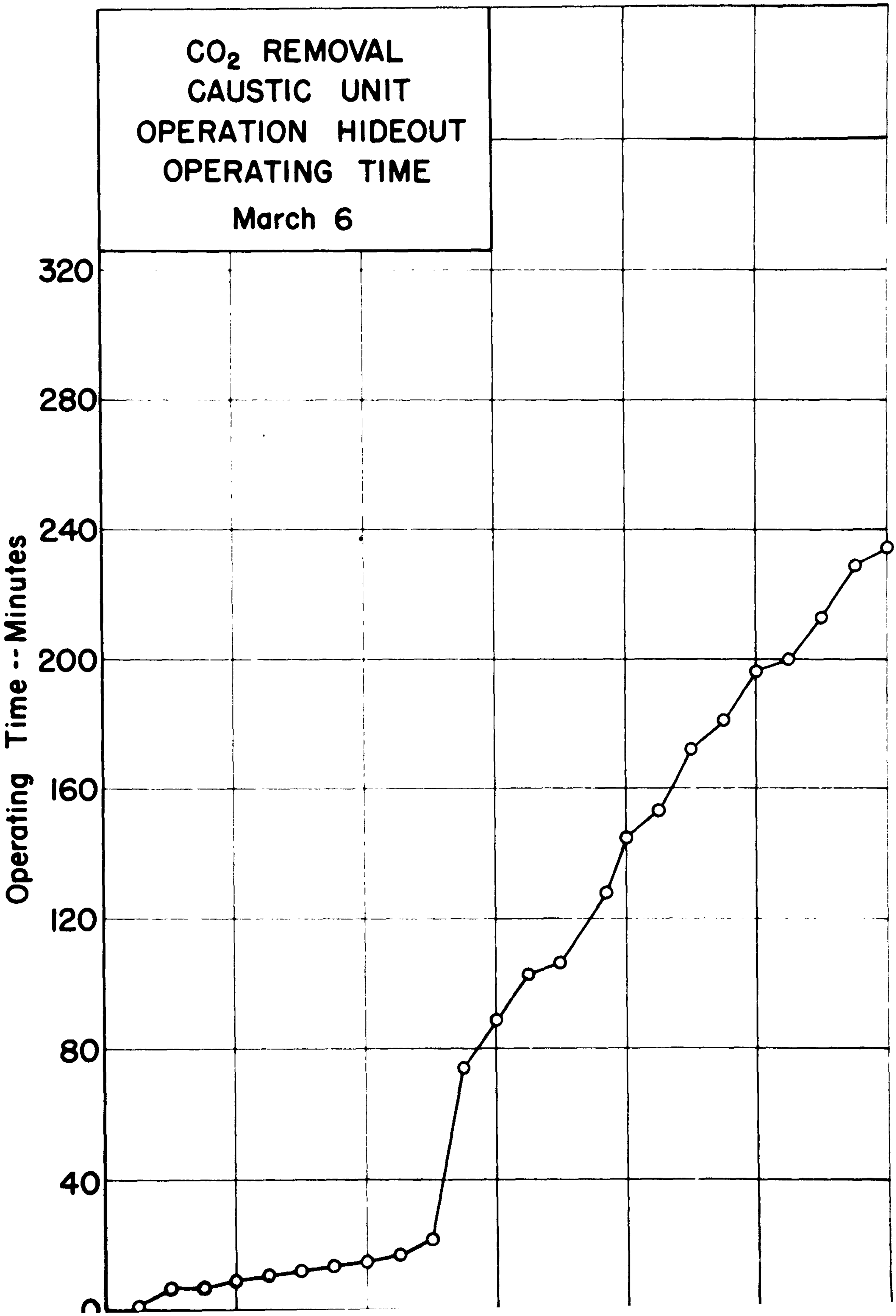
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 2
Operating Time -- Minutes
320
280
240
200
160
120
80
40



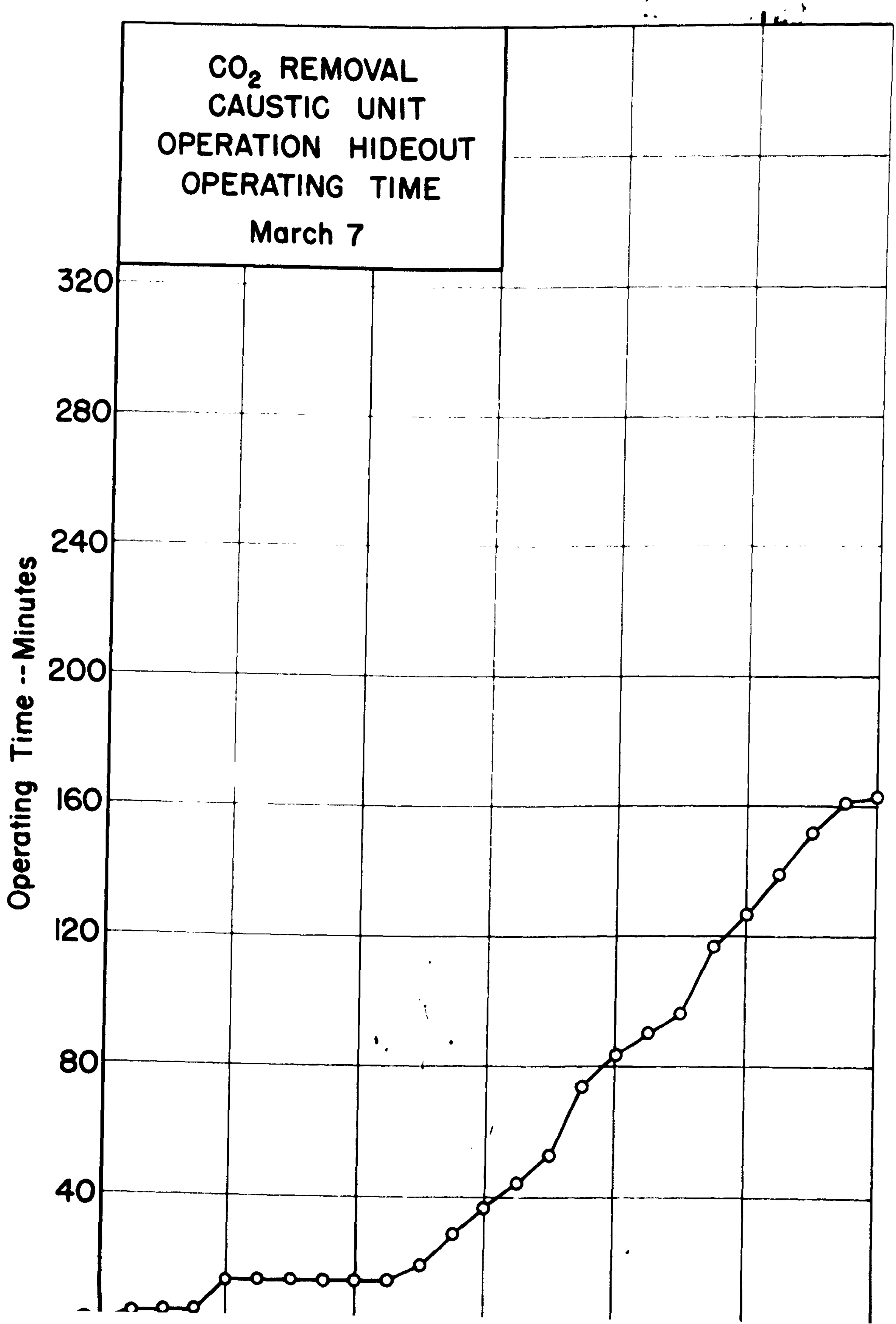
CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 3
Operating Time -- Minutes
320
280
240
200
160
120
80
40

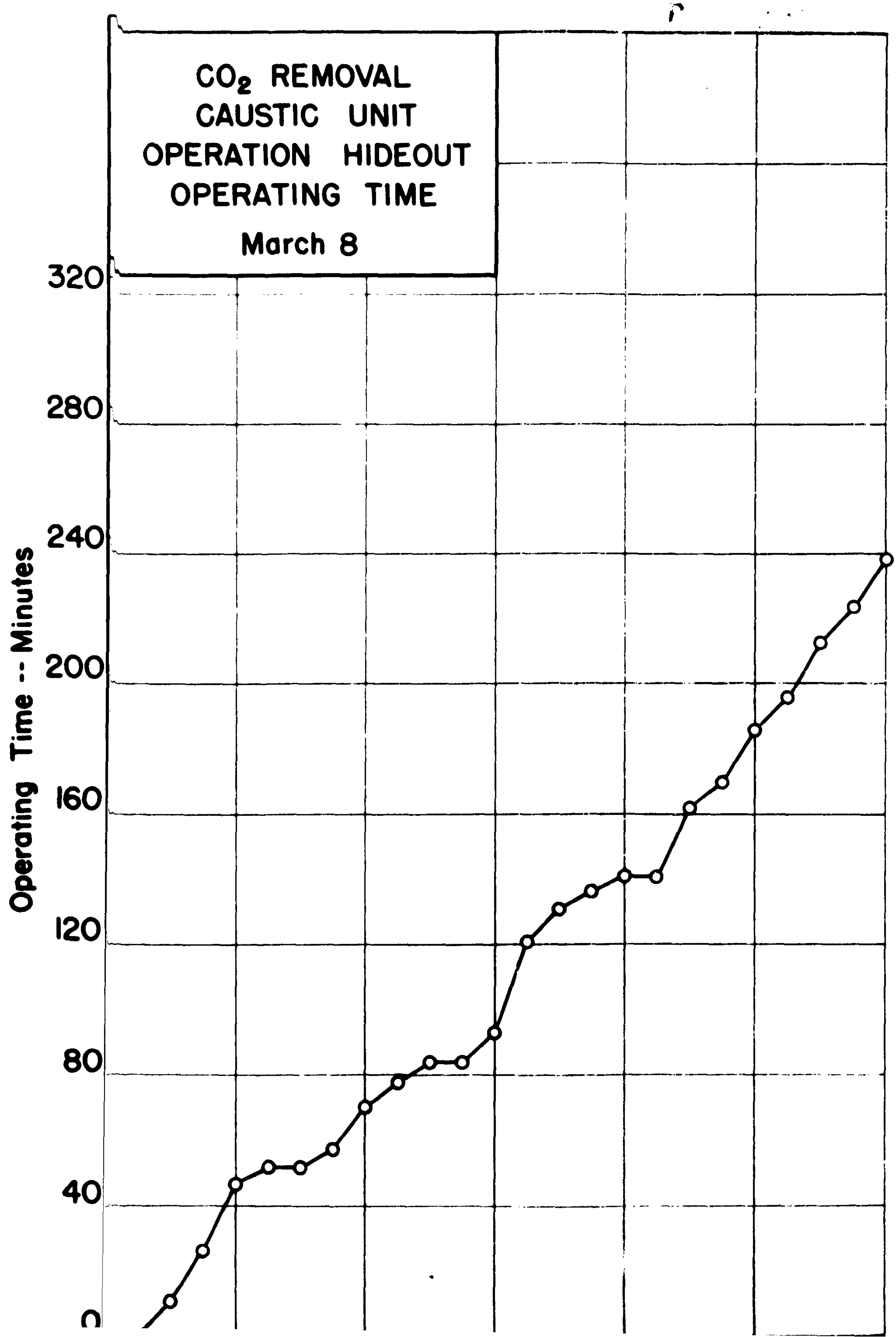

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 4
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0

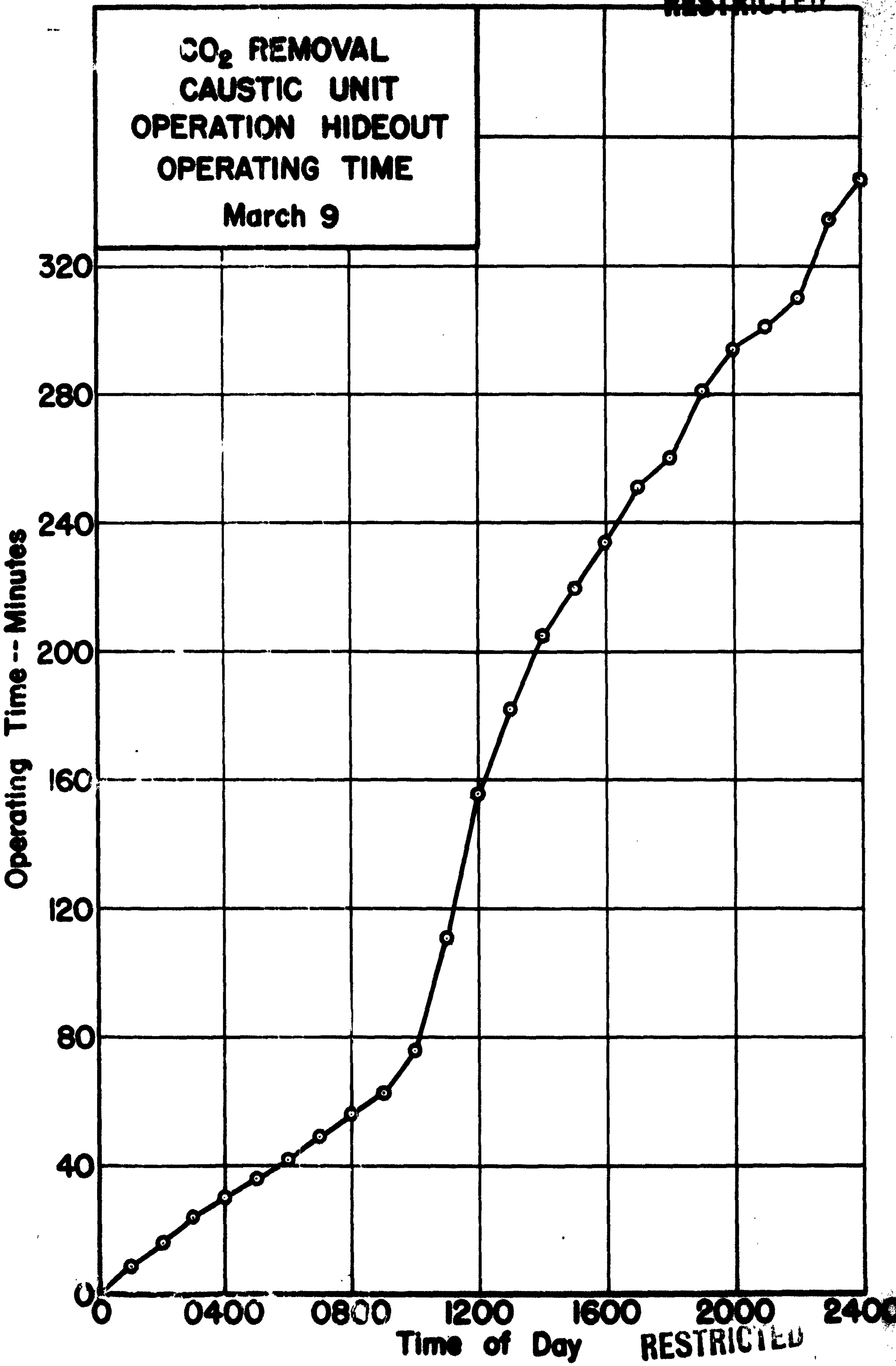

CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 5
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0



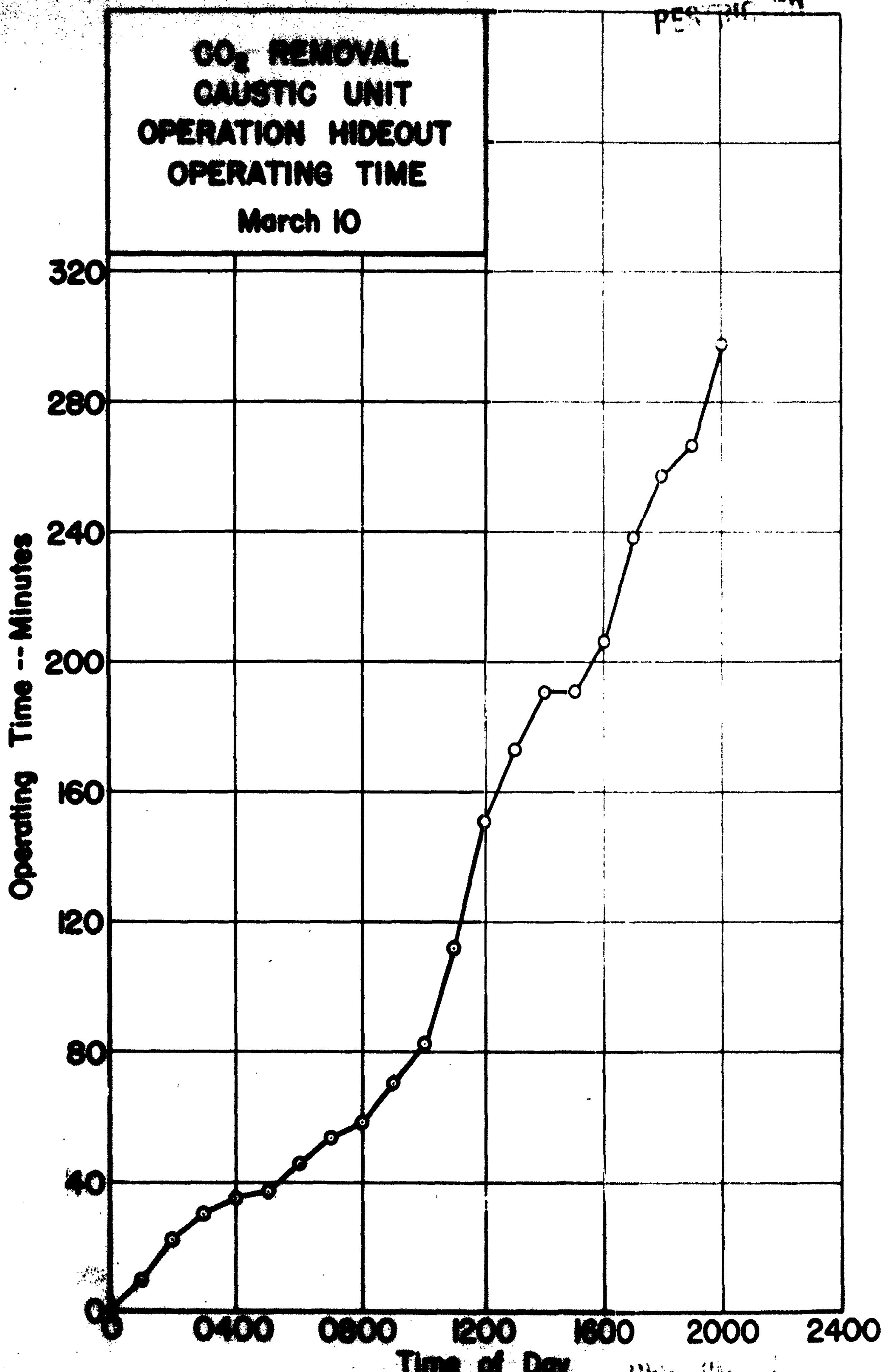
CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 6
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 7
320
280
240
200
160
120
80
40
Operating Time -- Minutes


CO2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 8
Operating Time -- Minutes
320
280
240
200
160
120
80
40
0



CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 9
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day



CO_2 REMOVAL
CAUSTIC UNIT
OPERATION HIDEOUT
OPERATING TIME
March 10
Operating Time -- Minutes
0
40
80
120
160
200
240
280
320
0
0400
0800
1200
1600
2000
2400
Time of Day