# NATIONAL BUREAU OF STANDARDS REPORT

3853

PERFORMANCE OF THE COLEMAN INVERTED GASOLINE LANTERN, T-53-5

by

Selden D. Cole
and
Paul R. Achenbach

Report To

Headquarters, Quartermaster Research & Development Command
Quartermaster Research & Development Center
U. S. Army

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| NBS PROJECT | | NBS REPORT |
|---|---|---|
| 1003-20-4832 | December 30, 1954 | 3853 |

Performance Of The Coleman Inverted Gasoline Lantern, T-53-5

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Building Technology Division

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# PERFORMANCE OF THE COLEMAN INVERTED GASOLINE LANTERN T-53-5

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ABSTRACT

Tests were made of several specimens of a newly-developed inverted gasoline lantern, T-53-5, manufactured by the Coleman Company to investigate the pressures generated in the fuel tank in high ambient temperatures, the ability of the lanterns to operate satisfactorily on leaded gasoline, and the likelihood of the lanterns exploding if the pressure regulator failed to function. The tests on four specimens showed that the majority of the lanterns would not restrict the fuel tank pressure to the desired limit of 50 lb/sq.in. in an ambient temperature of 130°F when the tank was filled completely at the time of lighting. One of four failed to control the pressure to the same limit in an ambient temperature of 110°F. The lanterns developed tank pressures ranging from 300 to 450 lb/sq.in. when allowed to burn uncontrolled without a pressure regulator valve. The tanks did not explode and remained pressure tight, but the lanterns were not luminous for pressures above about 100 lb/sq.in. and flames issued from the top of the stack on the lanterns. The lanterns operated poorly on leaded gasoline requiring cleaning of the orifice every few minutes in some cases. In normal operation some of the operating knobs and the lantern bail became too hot for manipulation with bare hands.

## 1. INTRODUCTION

At the request of the Headquarters, Quartermaster Research and Development Command, Natick, Mass. four inverted lanters, T53-5, manufactured by the Coleman Co. were tested in ambient temperatures ranging from 90°F to 130°F to determine the maximum temperature at which the pressure regulator valve in the lanterns would limit the fuel tank pressure to 50 lb/sq in. The pressure regulators are preset at the factory to limit the tank pressure at approximately 30 lb/sq in. by throttling the flow of liquid fuel from the tank and allowing the gasoline vapor from the tank to escape to the fuel orifice at the mantle through a by pass tube.

Five specimens were also operated on leaded gasoline to determine whether lead deposits would affect their operation and to observe the usefulness of the orifice cleaning needle.

In response to a subsequent request three of the same specimens were operated without the pressure regulators to determine whether they would explode or reach some maximum fuel tank pressure in ambient temperatures up to 125°F.

## 2. TEST PROCEDURE

An unleaded gasoline purchased under Federal Specification VV-G-109 Gasoline, Unleaded, was used for these tests to avoid possible variations in performance due to lead deposits in the generator or orifice. Each lantern was operated for two hours or more in an ambient temperature between 75°F and 85°F to ascertain that the pressure regulator valve was functioning.

For the tests of the pressure regulators the four lanterns were suspended from the ceiling of an insulated test room with a one foot clearance at the top and 20 in. between adjacent points of suspension. The temperature of the test room was maintained at the desired level by means of a thermostatically controlled electric heater.

A pressure gage was attached to the fuel tank of each lantern through the gasoline fill cap and for some of the tests a thermocouple was installed below the liquid surface in the gasoline tank of each lantern. Each fuel tank

was pumped up to a pressure of 30 lb/sq in. before lighting and again after the lantern was in full operation with a luminous mantle.

The same four lanterns and one additional specimen were operated on leaded gasoline in ambient temperatures of approximately 80°F and 130°F to observe whether or not the fuel orifice became stopped up and to evaluate the effectiveness of the orifice cleaning needle.

For the investigation of the explosion hazard the lanterns were installed one at a time in a concrete-lined half-underground chamber designed for such tests. A pressure gage was mounted in a safe place and connected to the fuel tank by means of a small bore copper tube. A thermocouple was used to remotely observe the temperature of the liquid fuel in the tank. These tests were made without artificially heating the chamber because preliminary trials showed that very high pressures would be generated without high ambient temperatures when the lanterns were operated without the pressure regulators.

## 3. TEST RESULTS

The results observed during the tests are shown in Figures 1 to 8 in which the ambient temperature and the fuel tank pressure and temperature, when observed, are plotted for the duration of the test period.

Effect of Quantity of Fuel in Tank on Pressure Rise: Figures 1 and 2 provide a comparison of the results obtained on two specimens when the tests were started with the fuel tank three-fourths filled and completely filled respectively, in an ambient temperature of 130°F. When starting with the tank three-fourths full lantern No. 1 attained a maximum pressure of 39 lb/sq. in. and lantern No. 2 a maximum of 31 lb/sq.in. in two hours operation, after which the pressures in both decreased steadily for the next 3-1/4 hours to a value of 12 lb/sq.in. At the end of 5-1/4 hours of operation both lanterns were pumped up to a pressure of 30 lb/sq.in. The pressure in both fuel tanks began to decrease again after the pumping operation. This sequence of events is shown in Figure 1.

When the tests of these same two lanterns were initiated with a full tank of gasoline and a tank pressure of 30 lb/sq.in., specimen No. 1 exceeded a pressure of 50 lb/sq. in. three times, the first time occurring 1-1/4 hours after lighting as shown in Fig. 2. In each case when the pressure reached 50 lb/sq.in. the lantern was removed from the hot room and placed in a room at a temperature of about 80°F until the pressure decreased to 30 lb/sq.in. after which it was returned to the hot room. Lantern specimen No. 2 reached a maximum pressure of 40 lb/sq.in. after 1-3/4 hours operation and then decreased gradually to a pressure of 13 lb/sq.in. after 5-3/4 hours operation.

A comparison of Figures 1 and 2 indicates that the amount of fuel in the tank had some effect on the pressure rise in both specimens. In the case of specimen 1 the pressure exceeded the specified limit three times when the test was started with a full tank of fuel. The effect of the quantity of gasoline in the tank on pressure rise could be explained on the basis of the difference in the amount of tank surface exposed to liquid fuel on one side and hot flue gases on the other side around the central flue. Presumably all of the liquid-backed tank surface around the flue would be evaporating surface for the liquid fuel.

Effect of Ambient Temperature on Pressure Rise: Because one of the two specimens used in the first two tests developed excessive tank pressures in an ambient temperature of 130°F when started with a full tank of gasoline, four specimens were used for additional tests at ambient temperatures in the range from 110°F to 130°F. These results are shown graphically in Figures 3 to 6, inclusive. Figure 3 shows the pressures developed in the four lanterns when filled with gasoline and pumped to a pressure of 30 lb/sq. in. and placed in an ambient temperature of 130°F.

Lanterns Nos. 1, 3 and 4 exceeded 50 lb/sq.in. pressure in approximately one hour, at which time they were turned off and removed to a room ambient temperature of approximately 80°F to cool off. In about one hour the lanterns were lighted, pumped to 30 lb/sq.in. pressure and allowed to burn for about one hour at an ambient temperature of 80°F

at which time they were returned to the hot room. Lanterns Nos. 1 and 4 again exceeded 50 lb/sq.in. pressure. Lantern No. 3 reached a pressure of 43 lb/sq.in. after which the pressure gradually decreased to a value of 25 lb/sq.in. at the end of the test. Specimen No. 2 never exceeded a pressure of 42 lb/sq.in. during the entire test.

Figure 4 shows the results obtained when the four lanterns were started in the same manner as for the preceeding test but placed in an ambient temperature of 110°F. Lantern No. 1 developed a pressure in excess of 50 lb/sq.in. and when removed to a cooler space, went out, and could not be relighted. The maximum pressures developed in the fuel tanks of lanterns 2, 3 and 4 were 28, 37, and 41 lb/sq.in., respectively.

Figure 5 shows the results obtained when lanterns Nos. 2, 3 and 4 were operated in the same manner as before except that the ambient temperature varied between 110°F and 126°F, during the first four (4) hours, leveling off at 120°F after that time. Lantern No. 1 could not be started for this test. Lantern No. 2 did not exceed a pressure of 32 lb/sq.in. and in general the pressure followed the variations in ambient temperature. Lantern No. 3 exceeded a pressure of 50 lb/sq. in. after one hour and ten minutes and dropped to a pressure of 10 lb/sq.in. in less than one-half hour when placed in an ambient temperature of approximately 80°F. When returned to the hot room the pressure immediately increased and in less than one and one-half hours had exceeded 50 lb/sq.in. Lantern No. 4 increased in pressure to 45 lb/sq.in. in 1-3/4 hours but then decreased steadily in pressure until the end of the test.

Figure 6 shows the results obtained when Lanterns No. 1 and 4 were placed in a room at a steady ambient temperature of 130°F with a full tank of gasoline. In approximately 1-1/2 hours both specimens had exceeded a pressure of 50 lb/sq.in. and when removed to an ambient temperature of 80°F the pressure dropped to 20-25 lbs/sq.in. After returning the lanterns to the hot room, the pressure of both reached 40 lb/sq.in. and then decreased steadily with time for the remainder of the 6-1/4 hour test.

Figures 3 to 6 show that three of the four specimens would not limit the fuel tank pressure to 50 lb/sq.in. in an ambient temperature of 130°F and one of the four would not limit the pressure to the same value in an ambient temperature of 110°F. These figures also indicate a relation between ambient temperature and maximum fuel tank pressure even when the 50 lb/sq.in. limit was not reached.

<u>Exchange of Pressure Regulators</u>: Prior to test 7 a thermocouple was placed in the fuel tank of each of two of the lanterns previously tested, Nos. 1 and 2, and the pressure regulators were exchanged. During the earlier tests lantern No. 1 had failed to control its fuel tank pressure for ambient temperatures of 110°F or above whereas lantern No. 2 had controlled its pressure for all ambient temperatures up to 130°F. The pressures and temperatures recorded during this test are plotted against time in Figure 7.

Lantern No. 1 reached a fuel tank pressure of 50 lb/sq.in. in 3-1/4 hours and was moved to an ambient temperature of approximately 80°F until the pressure decreased to 30 lb/sq.in. It was then returned to the hot room, but it did not again exceed a pressure of 30 lb/sq.in. Lantern No. 2 did not increase in pressure at all above the initial value of 30 lb/sq.in., but operated for 6 hours at pressures between 25 and 30 lb/sq.in.

The temperature pattern in both lanterns followed that of the pressure. The temperature of the fuel in lantern No. 1 rose steadily to a value of 293°F corresponding to the fuel tank pressure of 50 lb/sq.in. After the lantern was cooled off and was returned to the hot room the temperature rose briefly to a value of 265°F and then decreased gradually. The fuel temperature in lantern No. 2 rose steadily during the first 2 hours of the test to a value of 235°F after which it remained between 235°F and 240°F for the remainder of the test.

A comparison of Figures 2 and 7 indicates that lantern No. 2 did not produce fuel tank pressures in excess of 40 lb/sq.in. with its own pressure regulator or the one originally installed on lantern No. 2, whereas lantern No. 1 produced pressures in excess of 50 lb/sq.in. with both of

these same pressure regulators. These results indicate that the pressure regulator was not the significant factor determining pressure rise in these two speciments, and suggests that other differences in construction between the two specimens were responsible for the differences in pressure rise.

A pressure of 50 lb/sq.in. was observed in lantern No. 1 after one hour operation in test 2, see Figure 2, whereas 3-3/4 hours elapsed before this same pressure developed in test 7, see Figure 7. This difference is probably accounted for by the difference in the initial ambient temperature in the two tests. The test was started in an ambient temperature of 72°F in Figure 7, whereas it was started in an ambient temperature of 120°F in Figure 2.

Operation With Leaded Gasoline: The four lanterns used for the previous tests were operated on a leaded gasoline in an ambient temperature of 130°F, and these same four lanterns and one new and unused specimen were operated on leaded gasoline in an ambient temperature of 80°F. to determine whether lead deposits would obstruct the fuel orifice and to observe the functioning of the orifice cleaning needle built into the lantern. Table 1 summarizes the results observed in the two series of tests.

Each test was started with a fuel tank pressure of about 20 lb/sq.in. and the orifice cleaner was used whenever the luminosity indicated obstruction of the orifice. The pressure regulator valves on lanterns 1 and 2 remained interchanged for the tests with leaded gasoline as they had been for the last preceding test and lantern 4 was tested without a pressure regulator valve.

The results in Table 1 show that only lantern No. 1 operated as much as 1 hour on leaded gasoline without clogging of the orifice. The other lanterns required cleaning at intervals ranging from 1 minute to 40 minutes to maintain a suitable luminosity. Lanterns 2, 3, 4 and 5 went out completely one or more times during the tests and the orifice cleaning needle was bent and inoperable at the end of the tests in lanterns 3 and 4.

## TABLE 1

## SUMMARY OF TESTS WITH LEADED GASOLINE

| Lantern No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Ambient Temperature 130°F** | | | | | |
| Initial Fuel Charge, cc | 850 | 1080 | 750 | 900 | |
| Duration of Test, min. | 60 | 60[a] | 58[a,c] | 14 | |
| Pressure Range, lb/sq.in. | 25-30 | 28-33 | 20± | 20-60 | |
| No. of Times Orifice was Cleaned | 0 | 2 | 6 | 0 | |
| Range of Time Increment Between Cleanings, min. | -- | 5-17 | 1-23 | -- | |
| **Ambient Temperature 80°F** | | | | | |
| Initial Fuel Charge, cc | 1080 | 1080 | 1080 | 900 | 1080 |
| Duration of Test, min. | 220 | 195[a] | 39[a,c] | 44[a,c] | 70[b] |
| Pressure Range, lb/sq.in. | 21-26 | 30-34 | 20-34 | 20-47 | 20-32 |
| No. of Times Orifice was Cleaned | 1 | 3 | 8 | 4 | 5 |
| Range of Time Increment Between Cleanings, min. | 18 | 35-40 | 2-8 | 8-19 | 9-24 |

a. Lantern went out at end of test.
b. Lantern went out three times during test period.
c. Orifice clogged and needle bent at the end of the test.

Lantern No. 4 without a pressure regulator developed an excessive fuel tank pressure in an ambient temperature of 130°F, but the fuel tank pressure did not exceed 47 lb/sq.in. during the several short periods of luminous operation in an ambient temperature of 80°F.

These tests showed generally unsatisfactory operation on leaded gasoline.

General Operating Characteristics: When a lantern was burning normally at all times the operating handle of the eccentric stem assembly on the orifice cleaner was too hot to handle with the bare hand so a pair of pliers was used to turn it to clean the orifice. It was also observed that when the lantern was left standing for 24 hours or longer, after prolonged burning, that the eccentric stem assembly froze so that the eccentric rod would twist rather than turn in the packing gland. When this happened there was no sure indication of the relative location of the cleaning needle tip to the orifice except the manner of burning after lighting.

It was also observed that the lantern bail became too hot to handle with the bare hands when the lantern was suspended by it from a ceiling hanger. Furthermore, the air pump handle became excessively hot requiring some protection for the hands if additional pressure was required in the fuel tank a few minutes after ignition.

Explosion Tests: Three of the lanterns used for the preceding tests were operated on unleaded gasoline without pressure regulator valves to determine whether they would explode or reach some limiting fuel tank pressure. Lanterns 1, 3 and 4 were used for this purpose.

This series of tests was conducted in a concrete chamber 4 ft. wide, 4-1/2 ft. high, and 8 ft. long located partially underground for just such purposes. A door 30 in. wide and 30 in. high provided access to the interior of the chamber. The lanterns were operated one at a time in in the chamber with the temperature and pressure in the fuel tank being measured remotely by means of a thermocouple and a pressure gage with a capillary tube connection to the tank.

Each lantern was checked for its burning characteristics and mantle formation by being lighted according to prescribed methods and allowing it to burn under observation until a fuel tank pressure of 50 lb/sq.in. was indicated. After this preliminary operation the lantern was filled with gasoline and placed in the explosion chamber where it was lighted according to directions and pumped up to a pressure of approximately 30 lb/sq.in. to start the test. All tests were conducted in the existing ambient temperature of 50°F and lower since it was observed that the ambient temperature was not critical.

Figure 8 shows the pressure and temperature in the fuel tanks of the three lanterns plotted against time. Lantern No. 1 had not previously been operated at a fuel tank pressure in excess of 50 lb/sq.in., but during this test it reached a pressure of 300 lb/sq.in. and a fuel temperature of 400°F in approximately 2 hours after which both the temperature and pressure decreased.

During a previous test in the explosion chamber lantern No. 3 attained a tank pressure of 300 lb/sq.in. after which it was completely dismantled for inspection as indicated in Figure 9. During the second test of lantern No. 3, the results of which is plotted in Figure 8, a maximum pressure of about 320 lb/sq.in. was attained in 50 minutes after lighting and a maximum temperature of 445°F about 69 minutes after lighting.

During two previous trials in the explosion chamber lantern No. 4 attained a fuel tank pressure of 300 lb/sq.in. after which it was partially dismantled as indicated in Figure 10. During the third test of lantern No. 4, the results of which are plotted in Figure 8, a maximum pressure of 450 lb/sq.in. was attained in 45 minutes after lighting and the fuel temperature was 550°F, 47 minutes after lighting and still rising.

In all cases the pressure dropped rapidly after the maximum had been reached due to depletion of the gasoline supply in the fuel tank. The temperatures did not start to decrease as soon as the pressure decreased. The pressures and temperatures did not rise quite as rapidly during the first test of lanterns 3 and 4 as shown for the tests

on Figure 8. Presumably the pressure and temperature rose more rapidly in the second and third tests because of the contact between the stack and the bulges in the fuel tank.

Figure 10 shows clearly the six bulges on the inside surface of the tank around the stack. It is believed that these distortions started at a pressure of about 125 lb/sq.in. because the inside wall of the tank hit the stack with a resounding crack as each bulge occurred. The contact between the inside wall of the tank and the stack was so tight that the stack had to be forcibly pressed out of the tank in lantern No. 3. The top of the fuel tank was also bulged slightly but this is not as clearly visible in the photographs as the bulges inside the tank. A new undistorted tank is shown in Figure 11 for comparison.

All of the fuel tanks were pressure tight at the conclusion of the tests. In all cases the lanterns burned with a white light until some pressure between 80 and 100 lb/sq.in. was reached, after which the gasoline burned in the glass globe breaking out at the top of the stack at a pressure between 100 and 125 lb/sq.in. where it assumed the appearance of a gas stove burner. Small candle size flames appeared also at the valve handle fittings, at the air pump, and at the gas fill tube cap.

## 4. CONCLUSIONS

The tests made of several specimens of the Coleman inverted lantern T-53-5 indicated the following conclusions:

a. The lanterns were not uniform in their performance at elevated ambient temperatures. Three out of four specimens tested failed to limit the fuel tank pressure to 50 lb/sq.in. in an ambient temperature of 130°F and one out of four specimens failed to limit the pressure to the same value in an ambient temperature of 110°F. These results did not appear to be caused by failure of the pressure regulator valve.

b. The quantity of gasoline in the tank at the time of lighting the lantern affected the tendency for excessive pressures to develop.

c. The lanterns did not operate satisfactorily on leaded gasoline.

d. The orifice cleaner needles were easily bent during the cleaning operation and the stem of the operating cam was inclined to freeze in the packing gland.

e. The operating handles of the air pump and the orifice cleaner and the lantern bail were too hot for the bare hands during normal operation of the lantern.

f. The fuel tanks buckled but did not explode nor develop leaks when operated without the pressure regulator valves although tank pressures up to 450 lb/sq.in. were observed. Flames issued from the top of the stack at tank pressures about 100 to 125 lb/sq.in. thus entailing some fire hazard if located near combustible material.

g. Further development of this item is required to make it satisfactory for military use.

FUEL TANK PRESSURE VS TIME - (TANK 3/4 FULL AT START)

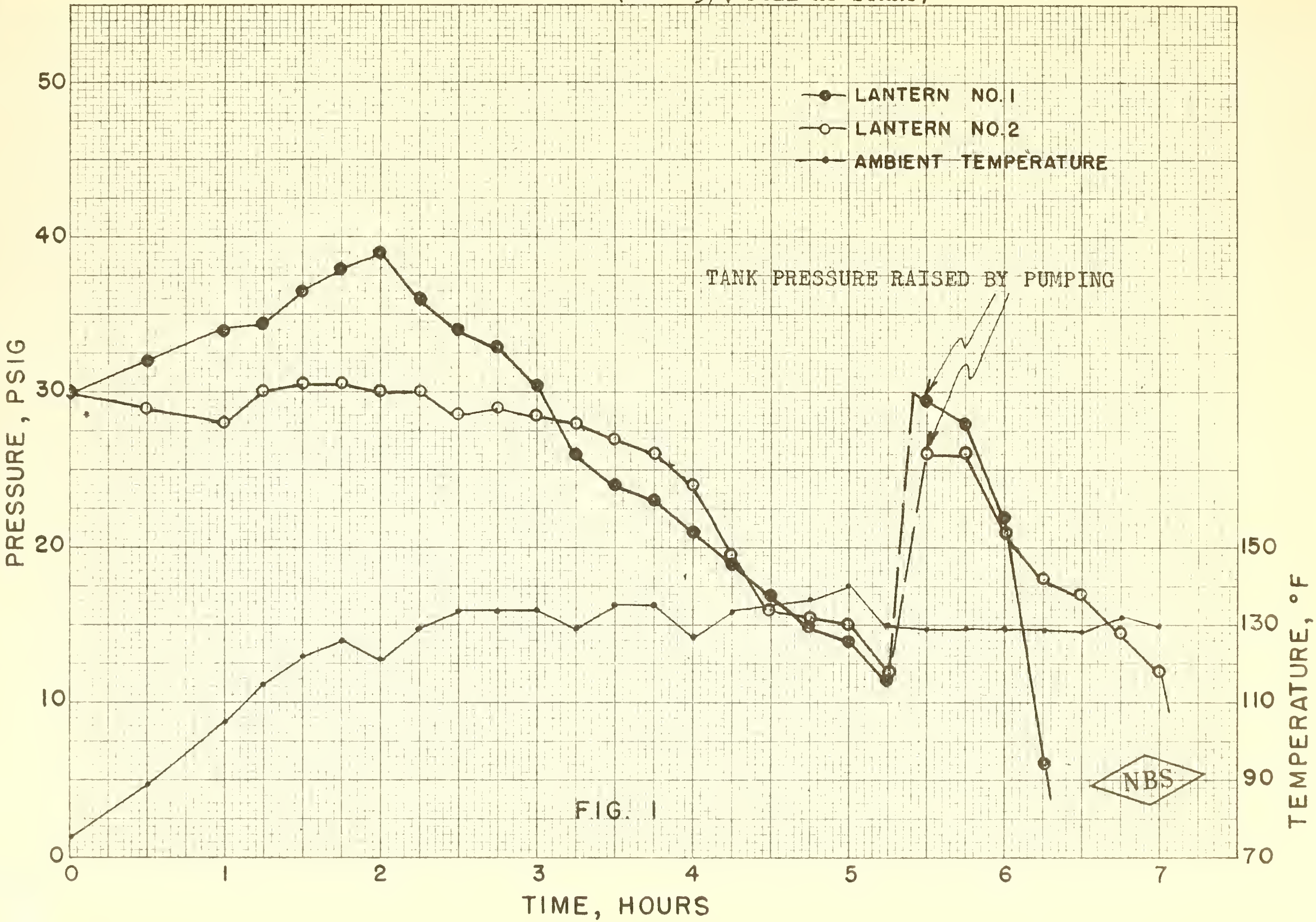


FIG. 1

FUEL TANK PRESSURE VS TIME - (TANK FULL AT START)

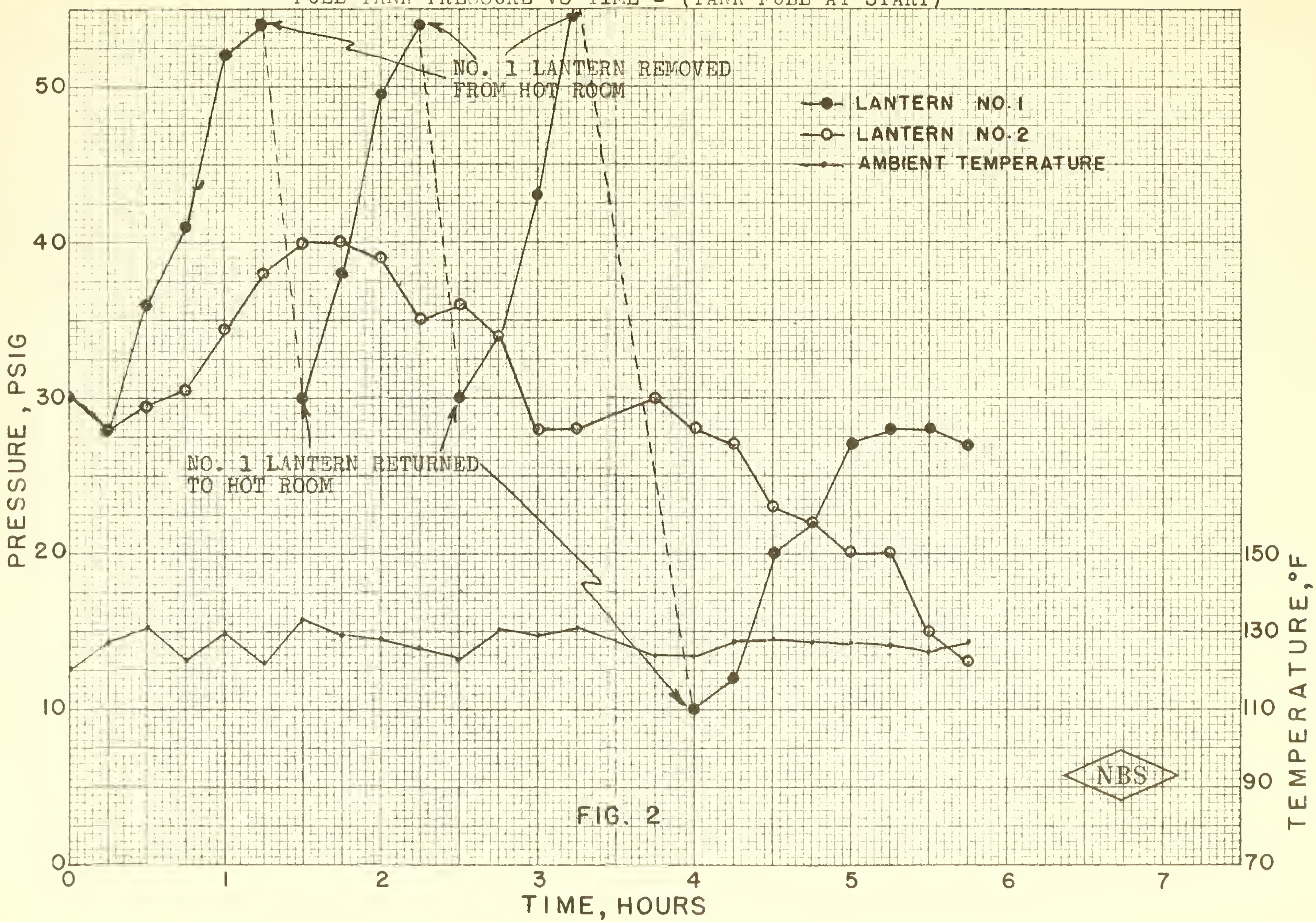


FIG. 2

FUEL TANK PRESSURE VS TIME - (TANK FULL AT START)

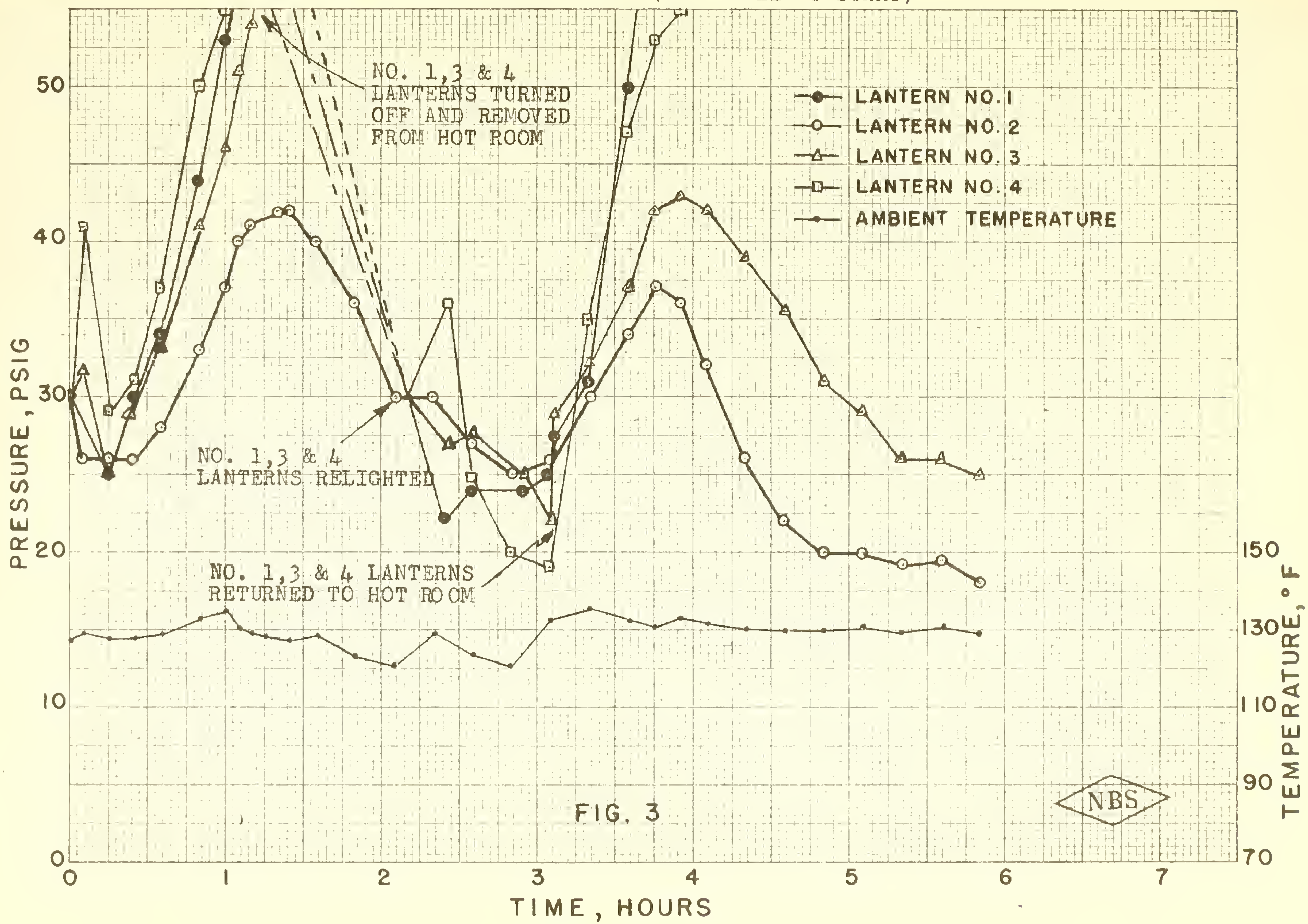


FIG. 3

FUEL TANK PRESSURE VS TIME - (TANK FULL AT START)

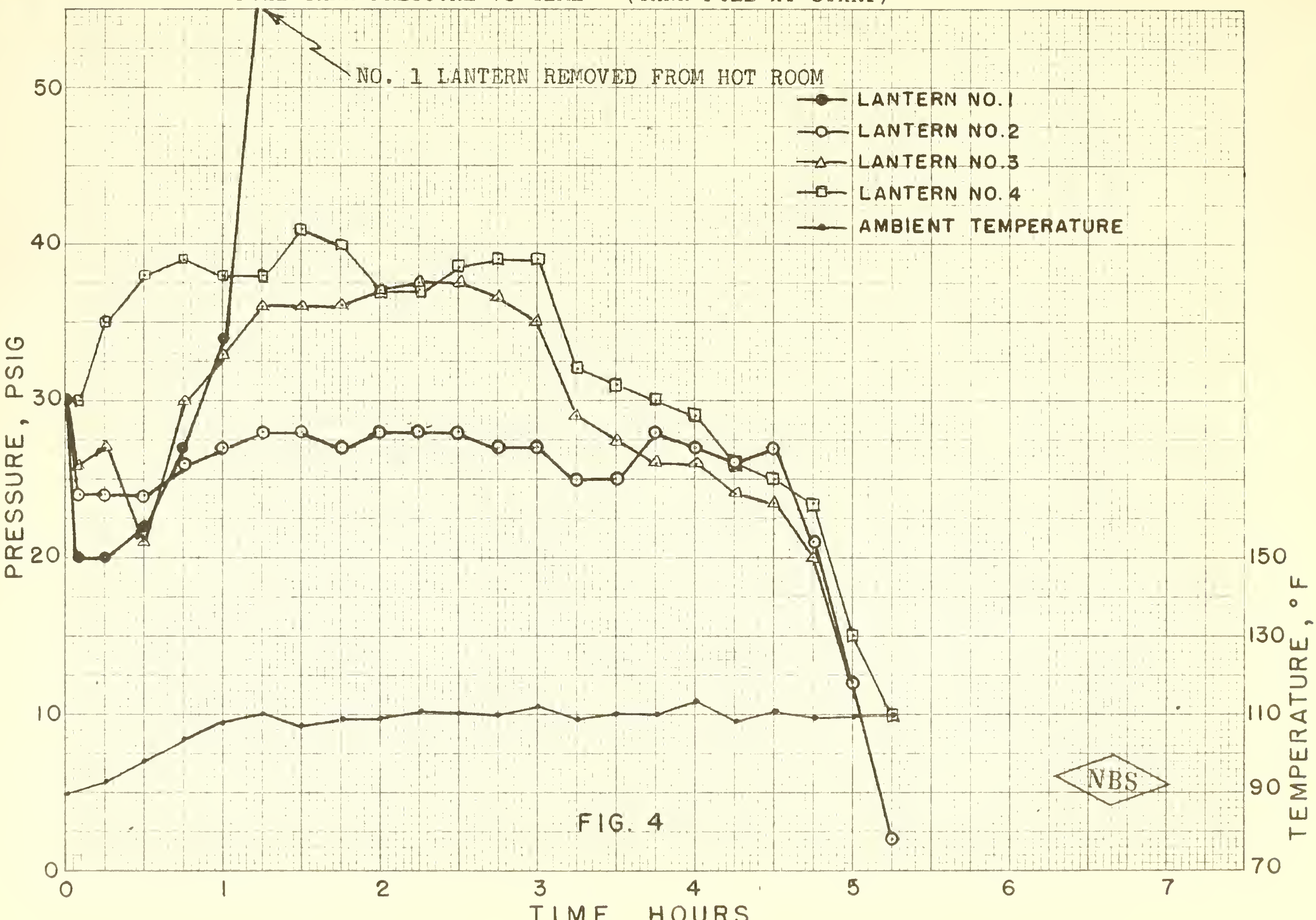


FIG. 4

FUEL TANK PRESSURE VS TIME -(TANK FULL AT START)

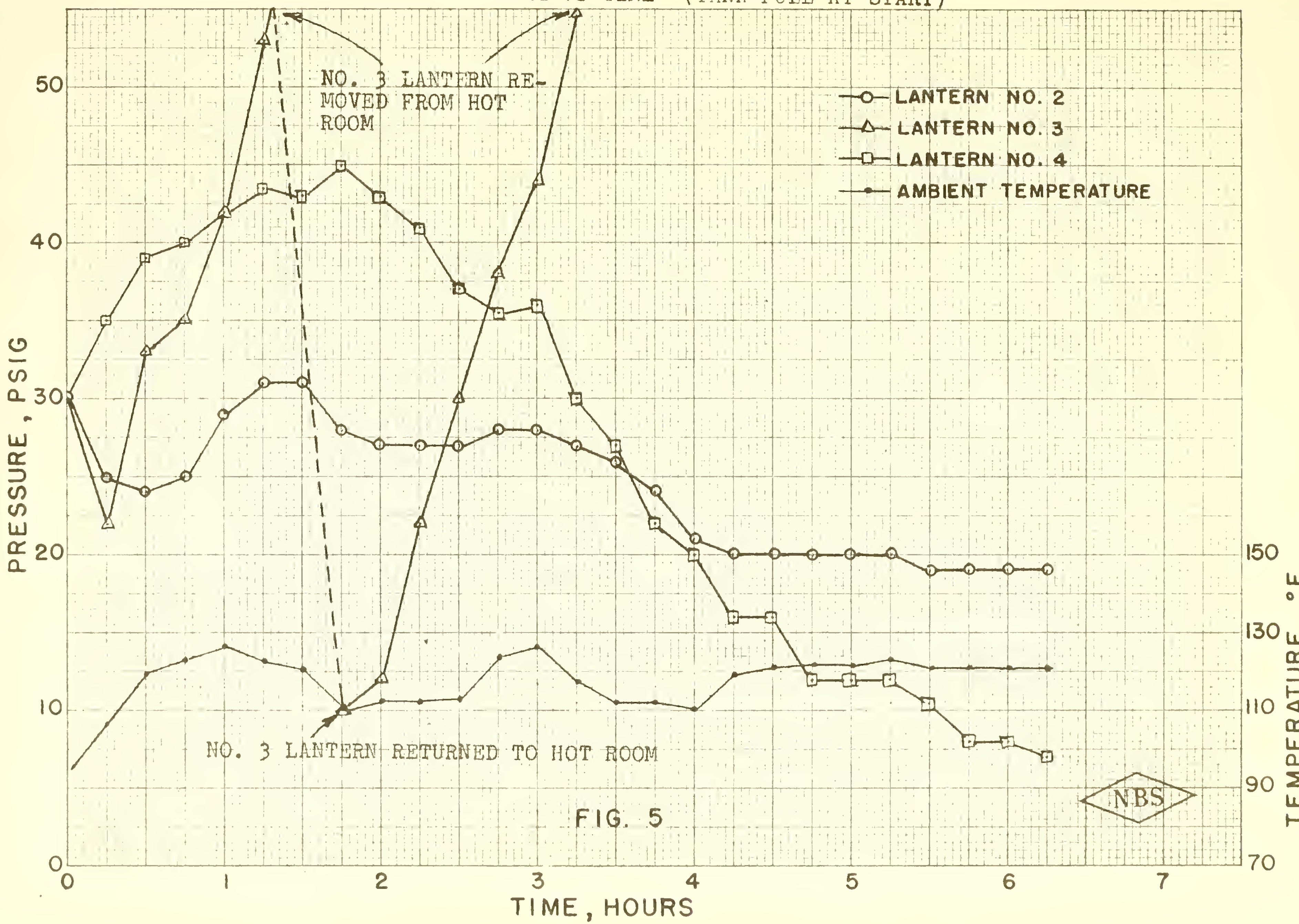


FIG. 5

FUEL TANK PRESSURE VS TIME -(TANK FULL AS START)

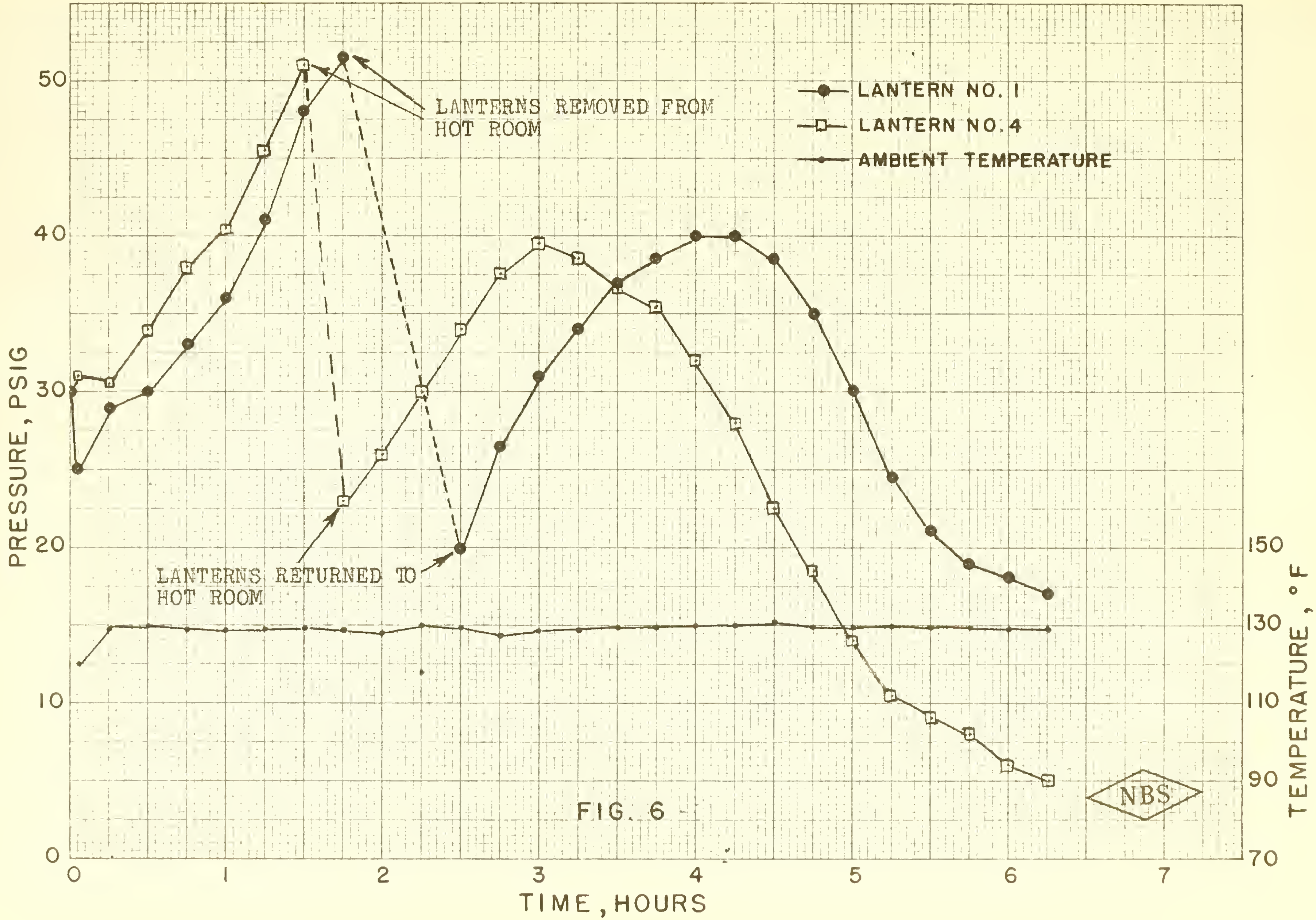


FIG. 6

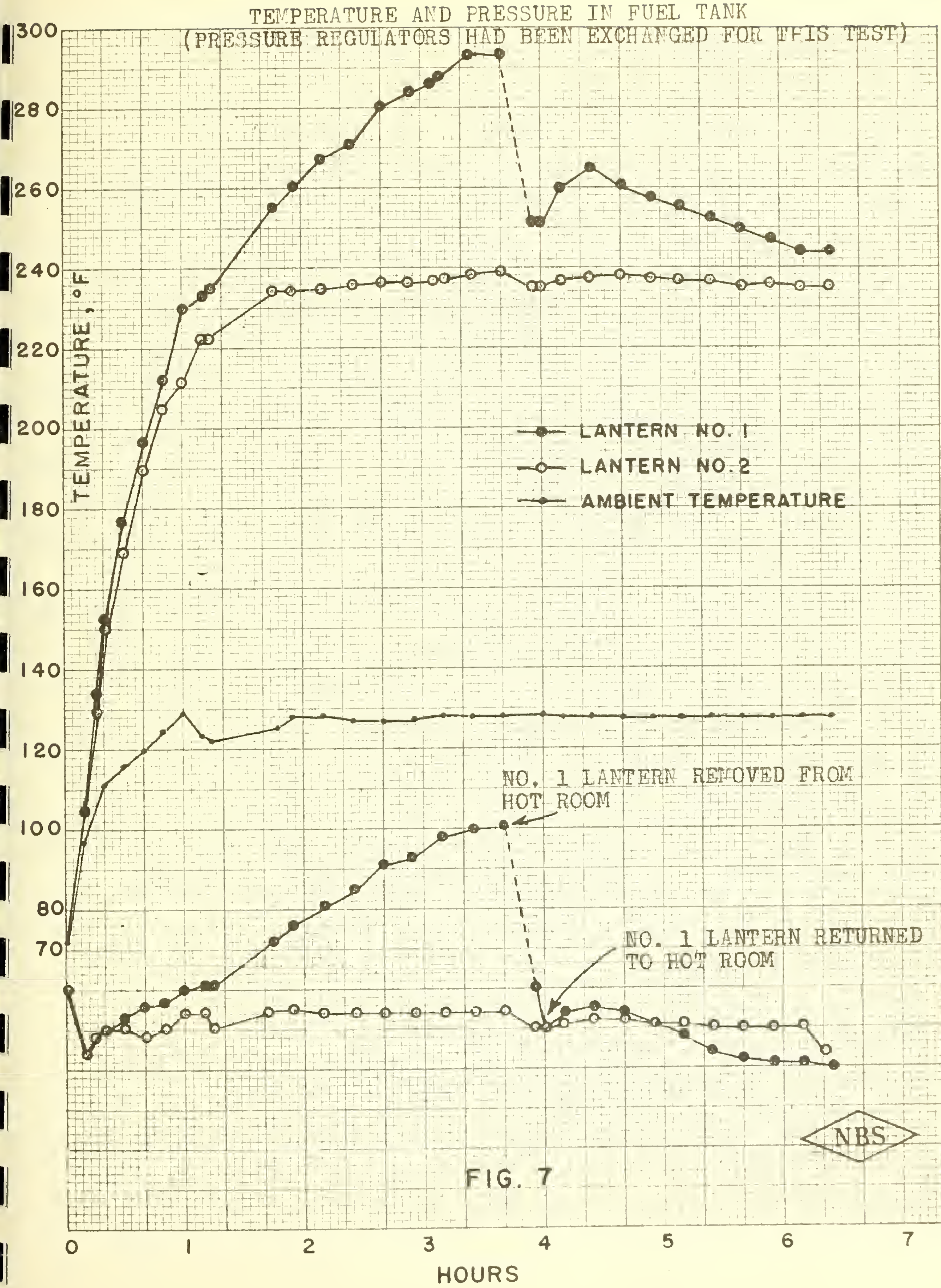
TEMPERATURE AND PRESSURE IN FUEL TANK
(PRESSURE REGULATORS HAD BEEN EXCHANGED FOR THIS TEST)
TEMPERATURE, °F
300
280
260
240
220
200
180
160
140
120
100
80
70
LANTERN NO. 1
LANTERN NO. 2
AMBIENT TEMPERATURE
NO. 1 LANTERN REMOVED FROM HOT ROOM
NO. 1 LANTERN RETURNED TO HOT ROOM
60
50
40
30
20
10
0
PRESSURE, PSIG
NBS
0
1
2
3
4
5
6
7
HOURS

FIG. 7

TEMPERATURE AND PRESSURE IN FUEL TANK DURING EXPLOSION TESTS

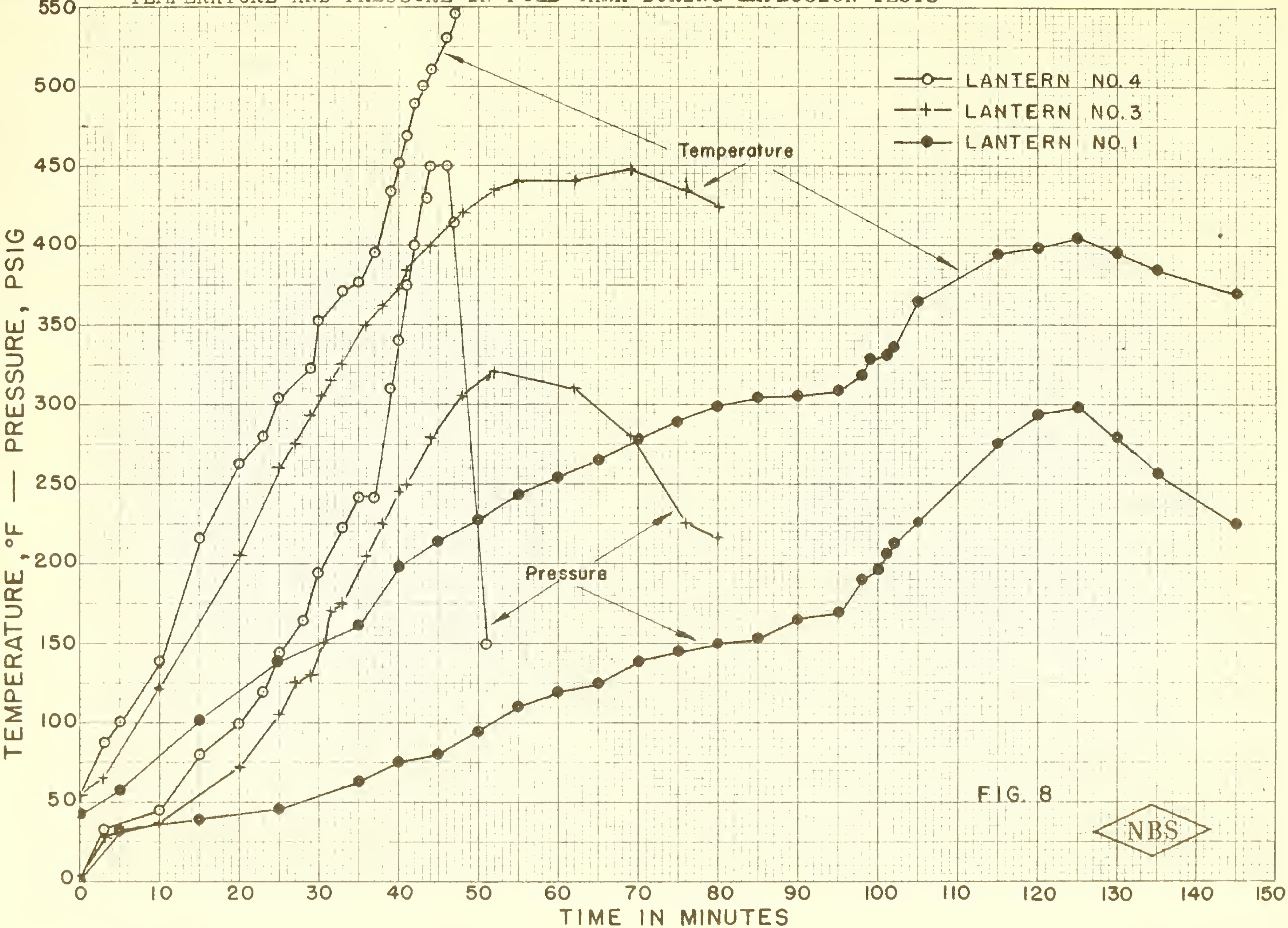


FIG. 8


FIG. 9


FIG. 10


FIG. 11

## THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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