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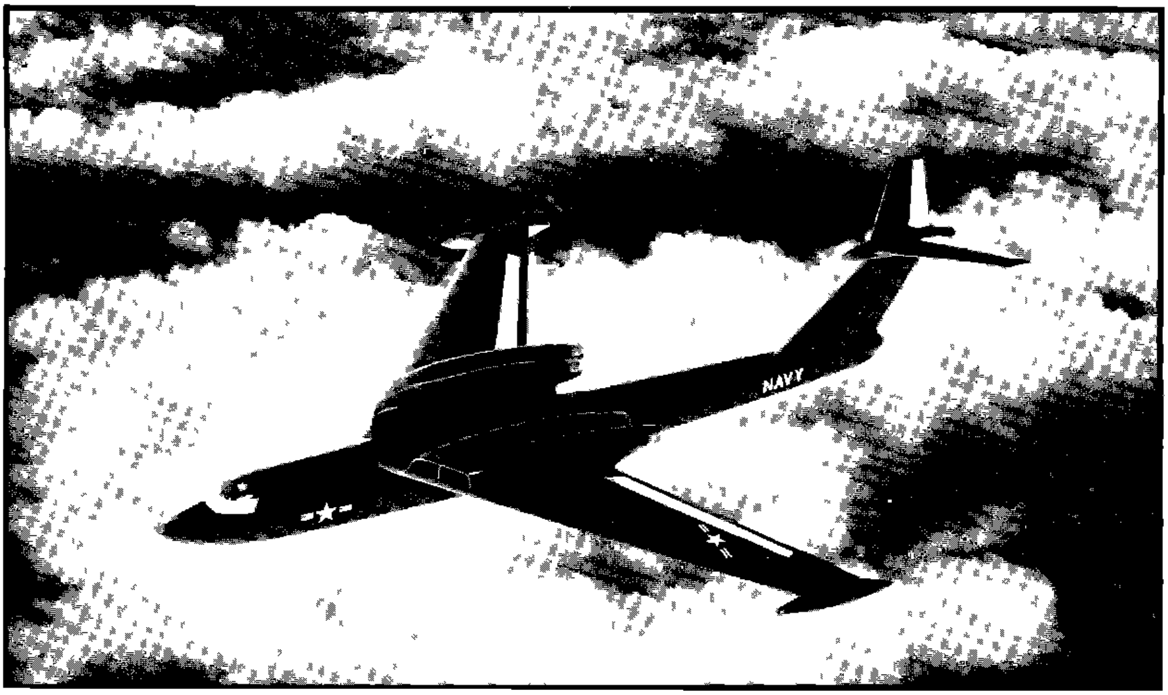

A REPORT ON

THE DEVELOPMENT AND EVALUATION OF A FIRE-EXTINGUISHING SYSTEM FOR THE MARTIN YP6M AIRPLANE

April 1960

Prepared by

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THE DEVELOPMENT AND EVALUATION OF A

FIRE-EXTINGUISHING SYSTEM FOR

THE MARTIN YP6M AIRPLANE

TECHNICAL DEVELOPMENT REPORT NO. 409

April 1960

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This report has been reviewed and is approved for distribution.

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Director
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THE DEVELOPMENT AND EVALUATION OF A FIRE-EXTINGUISHING SYSTEM FOR THE MARTIN YP6M AIRPLANE

ABSTRACT

Evaluation tests were conducted on the fire-extinguishing system proposed for the Martin YP6M airplane powerplant using a steel mockup of the YP6M airplane nacelle and simulated airflows for flight and surface operating conditions.

Results of these tests showed that the proposed system was inadequate. It was redesigned and modified to provide effective extinguishment of fires.

The cause and probability of explosion occurring in the XP6M and YP6M nacelle configurations during extinguishing tests were investigated.

TA 59-213.1

PURPOSE

The purpose of these studies was to evaluate a proposed fire-extinguishing system and to develop an effective fire-extinguishing system for the Martin YP6M airplane.

Tests were also conducted to determine the probability and cause of explosions that occurred in the nacelle during extinguishing tests.

The evaluation studies and development work on the extinguishing system were conducted by the Civil Aeronautics Administration's Technical Development Center, Indianapolis, Indiana, at the request of the Bureau of Aeronautics, Department of the Navy, under Order NAer 0128, Appropriation 17X1319.80 R&DN, Account 46810, BuControl 15995, Program 8015, O/C 079.

SUMMARY

A fire-extinguishing system, proposed for the YP6M airplane and designed by the Martin Company, was evaluated using a steel mockup of one of the YP6M airplane nacelles. Evaluation of the system was accomplished by conducting quantity and rate-measurement tests, by measuring nacelle extinguishing agent concentrations during discharge of the system, and by full-scale fire-extinguishing tests. The nacelle airflows for flight and surface operating conditions were simulated during the tests.

Explosive hazard studies were conducted on the XP6M cooling air configuration and a modified cooling air system whereby the rotational air flows were replaced by straight fore-to-aft flow. JP-4 fuel was released in the nacelle at various rates and locations and the results of delayed spark and open flame ignition were observed.

INTRODUCTION

The Bureau of Aeronautics, Department of the Navy, requested that an evaluation be made of a fire-extinguishing system proposed by the Martin Co. for the YP6M airplane. The Civil Aeronautics Administration Technical Development Center (TDC) previously had evaluated the fire-extinguishing system of the prototype airplane, the XP6M; however, because of the major modifications incorporated in the Y model powerplants, a new extinguishing system was designed and an evaluation of the system was desirable. Following the evaluation studies on this system, it was redesigned and the revised system was evaluated.

The evaluation studies and development work on the YP6M extinguishing systems covered by this report were conducted during the period January 1 to August 22, 1957, at TDC under sponsorship of the Department of the Navy. Also covered in this report is a limited study of the explosive hazard observed previously during tests on the XP6M-1 airplane powerplant. These studies were conducted during the period March 23 to July 1, 1956, and were made to determine if the unusual design of the engine nacelle, plus the rotational type of cooling airflow, contributed greatly to the explosive hazard in the earlier design.

The test nacelle used for the extinguishing tests was the mockup of the XP6M No. 1 nacelle modified to conform to the YP6M configuration, with the outer casing of an Allison J71 jet engine installed. The extinguishing system to be tested was installed in the test article. Operational conditions of the YP6M aircraft were simulated within the nacelle by providing ram air from a 1750-hp blower at the forward end and by providing aspiration at the rear of the nacelle by two 100-hp blowers.

The test nacelle used for the explosive hazard study was the mockup of the XP6M-1 airplane No. 1 nacelle. Several aluminum blowout panels were installed on the test article to reduce damage to the installation caused by explosions resulting from both fire and explosion hazard tests.

An observation room adjacent to the test cell contained the control panel, time recorder, temperature gages, manometers, and other equipment used in the tests.

EVALUATION OF NO. 1 FIRE-EXTINGUISHING SYSTEM

a. Description of the System. The No. 1 fire-extinguishing system provided by the Martin Co. is shown in Fig. 1. For test purposes, tubing, fittings, directional-valve, and agent containers were connected in the same manner as in the YP6M airplane.

In the original design of this system by the manufacturer, agent quantity requirements were determined by the formula given in an earlier Technical Development Report.[1] These calculations were determined prior to the removal of the firewall separating the compressor section from the exhaust section. The formula used was as follows:

$$Q = 0.02 (V) + (0.25) W_a$$

where

Q = pounds of agent required for extinguishment.

W_a = pounds of air per second passing through the zone at cruising speed.

V = net volume of zone in cubic feet.

Since the above formula was derived for a condition of high airflow and smooth inner surfaces, a turbulence factor of 2 was used to compensate for the rough interior of this nacelle.

The original values of airflow and zone volumes used by the Martin Co. and the calculated values of agent requirements were as follows:

[1]Harvey L. Hansberry, "Aircraft Fire Extinguishment, Part V, Preliminary Report on High-Rate-Discharge Fire-Extinguishing Systems for Aircraft Power Plants," Technical Development Report No. 260, February 1956.

TABLE I

QUANTITY OF EXTINGUISHING AGENT AND DISTRIBUTION

Zone	Net Volume (cu.ft.)	Airflow (lb./sec.)	Formula (X factor)	Agent Quantity Required (lb.)	Expected Distribution (lb.)
Accessory	2.4	0.30	$0.04V + 0.5W_a$	0.25	0.38
Compressor	82.0	2.1	$0.04V + 0.5W_a$	4.33	5.12
Exhaust	27.0	6.6	$0.04V + 0.5W_a$	4.38	5.5
Total				8.96	11.00

Tests were conducted under simulated flight conditions with the cooling air ducts open and an airflow rate of 9.0 pounds per second. Those conducted under simulated surface operation were made with the ducts closed and airflow rates of 7.0 and 3.0 pounds per second.

All full-scale evaluation studies of the extinguishing system were conducted using bromotrifluoromethane ($CBrF_3$) as the agent in quantities of 11 and 18 pounds. The agent containers were Walter Kidde spheres equipped with a valve outlet for 1 1/4-inch o.d. tubing. A 378-cubic-inch container was used for discharging 11 pounds of agent and a 630-cubic-inch container was used for discharging 18 pounds of agent. Calculated fill ratios were 50 per cent.

b. Scope of Tests. The evaluation of the No. 1 YP6M extinguishing system was accomplished by:

1. Measuring the quantity of agent discharged from each nozzle outlet.

2. Determining the effective duration of agent discharge.

3. Measuring the agent concentrations resulting from the discharge of the system under simulated flight and surface conditions.

4. Determining the effectiveness of the system in extinguishing fires under simulated flight and surface operating conditions.

c. Agent Distribution Carbon tetrachloride was substituted for $CBrF_3$ in determining the amount of extinguishing agent that would be discharged from each nozzle outlet and to obtain the distribution of agent to each zone. The specific gravity of $CBrF_3$ and carbon tetrachloride are 1 577 and 1.595, respectively. The discharged agent was collected in excelsior-filled containers placed under each nozzle. These containers were weighed before and after each test. The extinguishing agent container was filled with 11 pounds of agent and pressurized with nitrogen to 350 psi for each test. A total of four tests were conducted.

The results of the distribution measurements made on the No 1 system are given in Table II. This table shows the average quantities discharged from nozzles in each zone for the four tests. The quantities are given as percentages of the total charge in the agent container. For purposes of comparison, the calculated expected distribution of agent is shown.

TABLE II

AVERAGE RESULTS OF FOUR DISTRIBUTION TESTS ON THE NO. 1 YP6M EXTINGUISHING SYSTEM

Zone(1)	Outlets	Agent Quantity Obtained (per cent of total)	Expected Distribution(3) (per cent of total)
Compressor	A, B	43.6	46.5
Burner	C, D	48.3	50.0
Accessory	E	1.4	3.5
Loss(2)		6.7	

(1) No firewall separation of compressor and burner zones.

(2) The loss of 6.7 per cent could have been due to agent left in the system and loss due to evaporation and leakage.

(3) Calculated desired distribution.

d. Effective Duration of Agent Discharge. A 16 mm movie camera was used to determine the duration of effective discharge of agent by the extinguishing system. The extinguishing bottle was filled with 11 pounds of $CBrF_3$, and pressurized with nitrogen to 350 psi. Two tests were conducted, and examination of the movie film showed the duration of effective discharge to be approximately 1.1 seconds.

e. Agent Concentration Measurements. Extinguishing agent concentration measurements were obtained by using an agent concentration recorder[2] to sample and record the concentration of extinguishing agent from sampling tubes installed at 18 locations throughout the nacelle. See Figs. 2, 3, and 4.

The following procedure was used in measuring the extinguishing concentrations:

1. Approximate rate of airflow through the nacelle was established to simulate the test conditions.

2. Operation of the agent concentration recorder was started.

3. The extinguishing system was discharged and agent concentrations recorded.

Agent concentration measurements were conducted under simulated flight and surface conditions using bromotrifluoromethane agent in quantities of 11 and 18 pounds pressurized with nitrogen to 350 psi in four tests and 600 psi in two tests. The results of the agent concentration tests are shown graphically in Figs. 5 to 10, inclusive. The relative concentration measured at each sampling tube location is presented in the curves. Also shown is the maximum percentage of agent concentration existing simultaneously in all areas of the nacelle for a duration of 1/2-second. It will be noted that agent concentrations in some areas were well below the recommended minimum requirement of 15 per cent for a duration of 1/2-second for all six tests.

f. Fire-Extinguishing Tests. Five full-scale fire-extinguishing tests were conducted under simulated flight conditions existing after enactment of flight fire emergency procedures. The test fires burned JP-4 fuel at the rate

[2]James D. New and Charles M. Middlesworth, "Aircraft Fire Extinguishment, Part III, An Instrument for Evaluating Extinguishing Systems," Technical Development Report No. 206, June 1953.

of 4.7 gpm and were located as shown in Fig. 11. Four tests were conducted using 11 pounds of bromotrifluoromethane ($CBrF_3$) agent and one test was conducted using 18 pounds of agent. A 378-cubic-inch container was used for discharging 11 pounds, and a 630-cubic-inch container was used for discharging 18 pounds of agent. All containers were pressurized to 350 psi with nitrogen. After establishing approximate rates of airflow through the nacelle required to simulate the test condition, the procedure for conducting the fire-extinguishing tests was as follows:

	Elapsed Time from Start (sec.)
1. Ignitor and primer fuel were turned on.	0
2. Main fuel (JP-4) to fire was turned on.	5
3. Ignitor and primer fuel were turned off.	10
4. Extinguishing agent was discharged.	15
5. Main fuel to fire was turned off.	25

The results of the fire tests are shown in Table III. Only one of the five test fires was extinguished. This fire was located at Position 2, Fig. 11. Three of the other four tests resulted in explosions after the fires appeared to be extinguished.

EVALUATION OF NO. 2 FIRE-EXTINGUISHING SYSTEM

a. Description of System. As a result of the tests on the original YP6M, the fire-extinguishing system was redesigned by the Martin Co. This design was submitted to this Center for evaluation. The revised or No. 2 fire-extinguishing system is shown in Fig. 12.

Tests were conducted using bromotrifluoromethane ($CBrF_3$) as the agent in quantities of 15 pounds and pressurized with nitrogen to 600 psi. To maintain a 50 per cent fill ratio, a Walter Kidde 536-cubic-inch sphere, equipped with a valve outlet for 1 1/4-inch-o.d. tubing, was used.

TABLE III

RESULTS OF FIRE-EXTINGUISHING TEST ON NO. 1 SYSTEM

Test No.	Test Condition	Measured Airflow (lb./sec.)	Weight[1] of Agent (lb)	Fire Location (see Fig. 11)	Fuel Rate (gpm)	Results
1	Flight[2]	8.94	11	2	4.7	Fire not extinguished.
2	Flight	8.96	11	6	4.7	Fire extinguished.
3	Flight	8.95	11	2	4.7	Fire not extinguished. Small explosion occurred.
4	Flight	8.94	11	4	4.7	Severe explosion.
5	Flight	8.95	18	4	4.7	Severe explosion.

(1) $CBrF_3$ pressurized to 350 psi.

(2) Simulated flight conditions, following enactment of flight fire emergency procedure (engine shutdown), estimated airflow = 9.0 lb/sec.

b. Scope of Tests. The evaluation of the No. 2 YP6M fire-extinguishing system was accomplished by the same test procedure as that used for the original system.

c. Agent Distribution. The results of the distribution measurements made on the No. 2 system are given in Table IV. The extinguishing bottle was filled with 15 pounds of carbon tetrachloride (CCl_4) pressurized with nitrogen to 600 psi for each test. A total of three tests were conducted.

TABLE IV

AVERAGE RESULTS OF DISTRIBUTION
TESTS ON NO. 2 YP6M EXTINGUISHING SYSTEM

Outlets	Per Cent of Total Charge
A	31.0
B	25.0
C	15.5
D	16.7
Total	88.2
Loss(1)	11.8

(1) The loss of 11.8 per cent could have been due to evaporation, leakage, and agent left in the system.

d. Effective Duration of Agent Discharge. A 16 mm movie camera was used to determine the duration of effective discharge of agent by the extinguishing system. The extinguishing bottle was filled with 15 pounds of $CBrF_3$ and pressurized with nitrogen to 600 psi. Effective discharge time as viewed by the film was approximately 1.23 seconds.

e. Agent Concentration Measurements. Using the same equipment and procedure as that used on the No. 1 system, agent concentration measurements were obtained under simulated flight and simulated surface conditions using $CBrF_3$ pressurized with nitrogen to 600 psi. The results of the agent concentration tests are shown in Figs. 13 and 14.

MODIFICATION OF NO. 2 EXTINGUISHING SYSTEM

In order to obtain a more uniform distribution of agent throughout the nacelle, changes were made to nozzles A, C, and D to increase the agent delivered to areas of low concentration. See Fig. 15.

Utilizing the information obtained from the previous agent concentration tests, a change first was made to nozzle A outlet and then checked by measuring the agent concentrations with the agent concentration recorder. The design of the final configuration was obtained by making several modifications to the nozzle outlets and conducting tests after each modification to measure agent concentrations resulting from the discharge of agent from the modified system with nacelle airflows simulating both airplane flight and surface operating conditions.

The development of the fire-extinguishing system continued until all areas except the top forward area measured agent concentrations above 15 per cent for a duration of 1/2-second. Methyl bromide was substituted for $CBrF_3$ (bromotrifluoromethane) for a portion of these tests and used in quantities of 15 pounds, pressurized to 600 psi with nitrogen.

EVALUATION OF FINAL VERSION OF YP6M FIRE-EXTINGUISHING SYSTEM

The evaluation of the final configuration was accomplished by conducting tests to measure the agent concentrations resulting from the discharge of the system under simulated flight and surface conditions, and by conducting a limited amount of full-scale fire tests. Tests also were conducted to determine the effectiveness of larger quantities of agent.

$CBrF_3$ agent was used in the tests in quantities of 15, 18, and 30 pounds. A 536-cubic-inch container was used for discharging 15 pounds, a 630-cubic-inch container was used for discharging 18 pounds, and two 536-cubic-inch containers were used for discharging 30 pounds of agent. All containers were pressurized to 600 psi with nitrogen.

a. Agent Concentration Measurements. Tests were conducted using the same equipment and procedure as that used in previous tests to measure agent concentrations resulting from the discharge of $CBrF_3$ from the fire-extinguishing system with nacelle airflows simulating both airplane flight and surface operating conditions.

From the results of these tests, the minimum concentration of agent produced for a period of 1/2-second was determined for all areas of the nacelle and are shown in Figs. 16 to 21, inclusive, and a comparison of the test results using various quantities of agent is shown in Table V. Also shown in Table V for two flight tests are minimum concentrations with pickup No. 15, located in the top forward area of the nacelle, eliminated. The discharged agent in this area was dispersed very quickly because of the type and velocity of the cooling airflow.

b. Fire-Extinguishing Tests. The first full-scale fire-extinguishing test was conducted at simulated flight conditions using 15 pounds of $CBrF_3$. The test fire was located in the lower forward area (Position 1, Fig. 11) and burned JP-4 fuel at the rate of 4.7 gpm. Reignition occurred in less than 10 seconds after discharge of agent and resulted in a severe explosion. A similar test was made using 30 pounds of agent and again resulted in a severe explosion.

TABLE V

RESULTS OF EXTINGUISHING AGENT CONCENTRATION MEASUREMENTS ON FINAL SYSTEM

Test Condition	Measured Airflow (lb./sec.)	Weight of Agent (lb.)	Minimum(1) Concentration (per cent)	Minimum(2) Concentration (per cent)
Flight	9.36	15	13.0	19.0
Flight	9.3	18	16.0	20.0
Flight	9 3	30	22.8	
Surface	2.97	15	20.0	
Surface	3.01	18	23.0	
Surface	3.02	30	34.5	

(1) Minimum concentration of agent at all points in the nacelle simultaneously for a duration of 1/2-second. Values are in terms of per cent relative concentrations in air.

(2) Minimum concentration of agent for a duration of 1/2-second with pickup No. 15 eliminated.

An increase in agent quantity appeared to provide extinguishment, but did not prevent reignition, possibly from re-entry of external flames or from hot surfaces produced by the test fire. A thermocouple was placed on the lower external side of the engine intake shroud.

This shroud was fabricated from cold rolled steel 0.030-inch thick, and it was found that a temperature of approximately 1300° F. existed when a test fire burned JP-4 fuel at the rate of 4.7 gpm for a period of 10 seconds in this lower forward area. When the fire burned for 5 seconds, the maximum shroud temperature measured was 550° F.

A limited number of fire tests then were conducted by releasing the extinguishing agent after the JP-4 fuel had burned for 5 seconds and flooding the external surface of the nacelle with CO_2 to prevent reignition from outside the nacelle. The results of these tests indicated that reignition was occurring from hot surfaces and that a fire could be extinguished in this lower front area if the extinguishing agent was released after the JP-4 fuel burned for 5 seconds instead of 10 seconds.

An additional test was conducted under simulated flight conditions with the test fire located in the top front section (Position 3), and two tests were conducted under simulated surface operating conditions. The results of these fire-extinguishing tests are shown in Table VI.

XP6M EXPLOSIVE HAZARD STUDY

a. Description of Cooling Airflow Systems. The cooling air inlets of the XP6M airplane are shown in Fig. 22. The elbow inlets were located aft of the fire walls and provided a counterclockwise rotation in Zone 1 and a clockwise rotation in Zone 2.

A revised, straight-through airflow system, having four inlets entering through the forward firewall of Zone 1, is shown in Fig. 23. This was accomplished by removing the two elbow inlets in Zone 1 and ducting air into the front of the nacelle through four 2-inch-diameter openings placed approximately 90° apart. An air outlet was installed in the bottom of the nacelle in the rear section of Zone 1.

b. General Test Procedure. The study of the explosive hazard resulting from the release of a flammable fluid in the XP6M-1 test nacelle under simulated flight conditions was accomplished by releasing JP-4 fuel within the nacelle and providing delayed ignition with an electric spark or a small gasoline fire. The number of aluminum panels blown out during a test gave an indication of the relative force of the resulting explosion.

TABLE VI

RESULTS OF FIRE-EXTINGUISHING TESTS ON FINAL SYSTEM

Test No.	Test Condition	Measured Airflow (lb./sec.)	Weight of Agent(1) (lb)	Fire(2) Location	Fuel Rate (gpm)	Duration(3) of Test Fire (sec.)	Flooding of Test Cell with CO_2	Results
1.	Flight	9.4	15	1	4.6	10	No	Severe explosion.
2.	Flight	9.6	30	1	4.9	10	No	Severe explosion.
3.	Flight	8 8	30	1	4 7	5	Yes	Fire extinguished
4.	Flight	9.0	15	1	4.7	5	Yes	Fire extinguished
5	Flight	9 0	15	1	4 8	5	No	Fire extinguished.
6.	Flight	9 0	15	3	4 3	5	Yes	Fire extinguished.
7	Surface	3.08	15	1	5.1	10	No	Fire extinguished.
8.	Surface	3 12	15	5	5.0	10	No	Fire extinguished

(1) $CBrF_3$ pressurized to 600 psi.

(2) Position 1 - located in lower front section.
Position 3 - located in top front section.
Position 5 - located lower outboard side forward of midframe

(3) Fire duration at time extinguishing agent was released.
Fuel continued to flow for 10 seconds after release of agent

The following procedure was used for conducting the explosion tests:

1. Establish approximate rates of airflow through the nacelle required to simulate the test condition. Zone 1, 2.1 lb./sec.; Zone 2, 6.6 lb./sec.

2. Start JP-4 fuel flowing through a nozzle from a position where a fuel leak could occur.

3. Turn on the ignition source after a predetermined time following the release of the JP-4 fuel.

Tests were conducted with JP-4 fuel directed as follows:

1. Into the lower cooling air inlet of the straight-through airflow system.

2. Toward an area approximately 8 inches to the outboard side of the lower cooling air inlet.

3. Toward an area approximately 8 inches inboard of the lower cooling air inlet.

4. Toward and striking an engine component causing fuel to spray into the lower nacelle area.

5. Into the lower outboard forward section.

c. Results and discussion. A total of 158 tests were conducted using the normal rotational type of airflow. Fifty-one test runs resulted in explosions of various intensity. Severe explosions resulted when the fuel was directed toward the front of the nacelle in Zone 1 and was intercepted by the cooling air coming from the left side air inlet. A very severe explosion resulted in one test when an electric spark was used to ignite the fuel-air mixture 5 seconds after the JP-4 fuel was released at a rate of 2.5 gpm. In order to reduce the amount of damage to the nacelle from the explosion tests, a fuel rate of 1.80 gpm was used subsequently for Zone 1 tests.

An explosion occurred in Zone 2 when JP-4 fuel was released at the rate of 2.65 gpm when a small gasoline fire was used as the ignition source. The fuel was released just aft of the firewall where the afterburner fuel line comes through.

A total of 73 tests were conducted using the straight-through airflow system of which 15 resulted in explosions of various intensities. Severe explosions occurred when delayed ignition was provided for JP-4 fuel directed toward the front of the nacelle and into or intercepting the lower cooling airstream.

A severe explosion, probably caused by JP-4 fuel accumulated between the deep structural members of the nacelle during previous test runs, occurred in one test.

CONCLUSIONS

The original fire extinguishing system, proposed for use in the YP6M airplane powerplants, is ineffective in extinguishing JP-4 fuel fires occurring in the nacelle. Inadequate distribution of agent, rather than insufficient quantity, is the cause of extinguishing system failure.

The final extinguishing system developed during the test program provides adequate distribution and quantity of agent (15 pounds of $CBrF_3$) to extinguish all flames from JP-4 fires. Eighteen pounds of agent is required to produce 15 per cent concentrations in all nacelle areas for a 1/2-second period. Explosive reignition from hot steel surfaces may occur following extinguishment of 10 second or longer duration fires.

Delayed ignition of JP-4 fuel, released in the nacelle by a fuel system failure, may be expected to produce an explosion of severe magnitude.

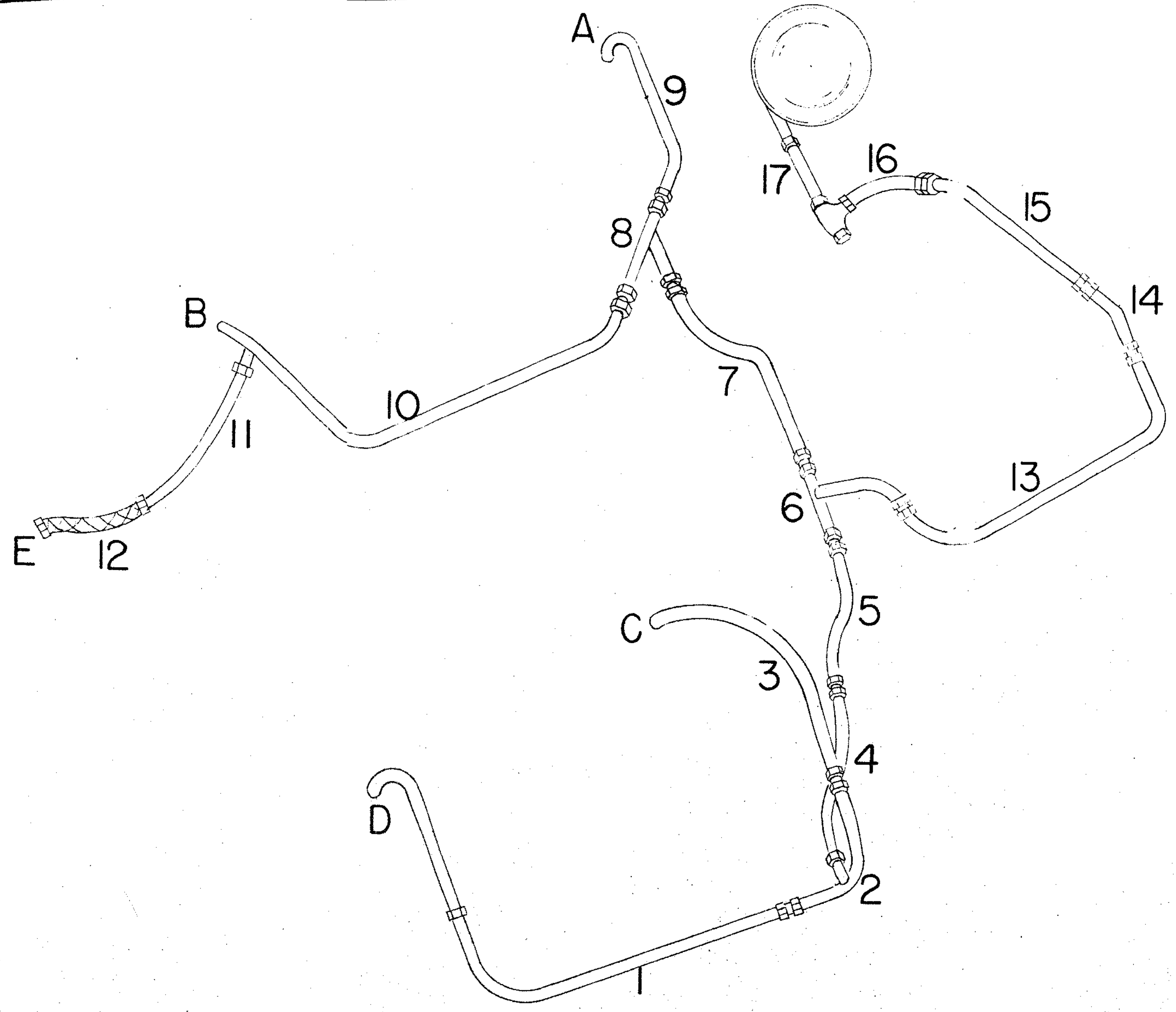
The relatively large quantity of nacelle cooling air, the elevated temperature of this air, the rotational type of cooling air circulation, the large recessed volumes between very deep nacelle structural ribs and bulkheads, and the confining nature of the nacelle-engine space, all contribute to a serious explosive hazard found present in the XP6M powerplant.

RECOMMENDATIONS

Modification of the originally proposed extinguishing system to conform to the final system described in this report is recommended. At least 18 pounds of bromotrifluoromethane agent should be used.

Every possible provision for preventing inadvertent release of JP-4 fuel in the nacelle compartment should be made.

Future design modifications of the nacelle should avoid the conditions indicated in this report as factors contributing to an explosion hazard.



NO.	LENGTH	I. D.	TUBE VOLUME CUBIC INCHES
1	55.25	.585	14.82
2	FITTING		
3	21.5	.585	5.77
4	14.5	.944	10.1
5	19	.944	13.2
6	FITTING		
7	27.63	.944	19.3
8	FITTING		
9	20	.585	5.36
10	48.13	.585	12.9
11	18	.335	1.59
12	10	.335	.92
13	56.63	1.125	56.2
14	10	1.125	9.95
15	37.5	1.125	37.2
16	13.63	1.125	13.56
17	8.5	1.125	8.45

APPROX. VOL. OF TUBING 209.32

APPROX. VOL. OF FITTINGS 33.20

APP. VOL. OF TUBE & FITTINGS 242.52

SPHERE VOLUME 378

TOTAL VOLUME OF SYSTEM 620.52

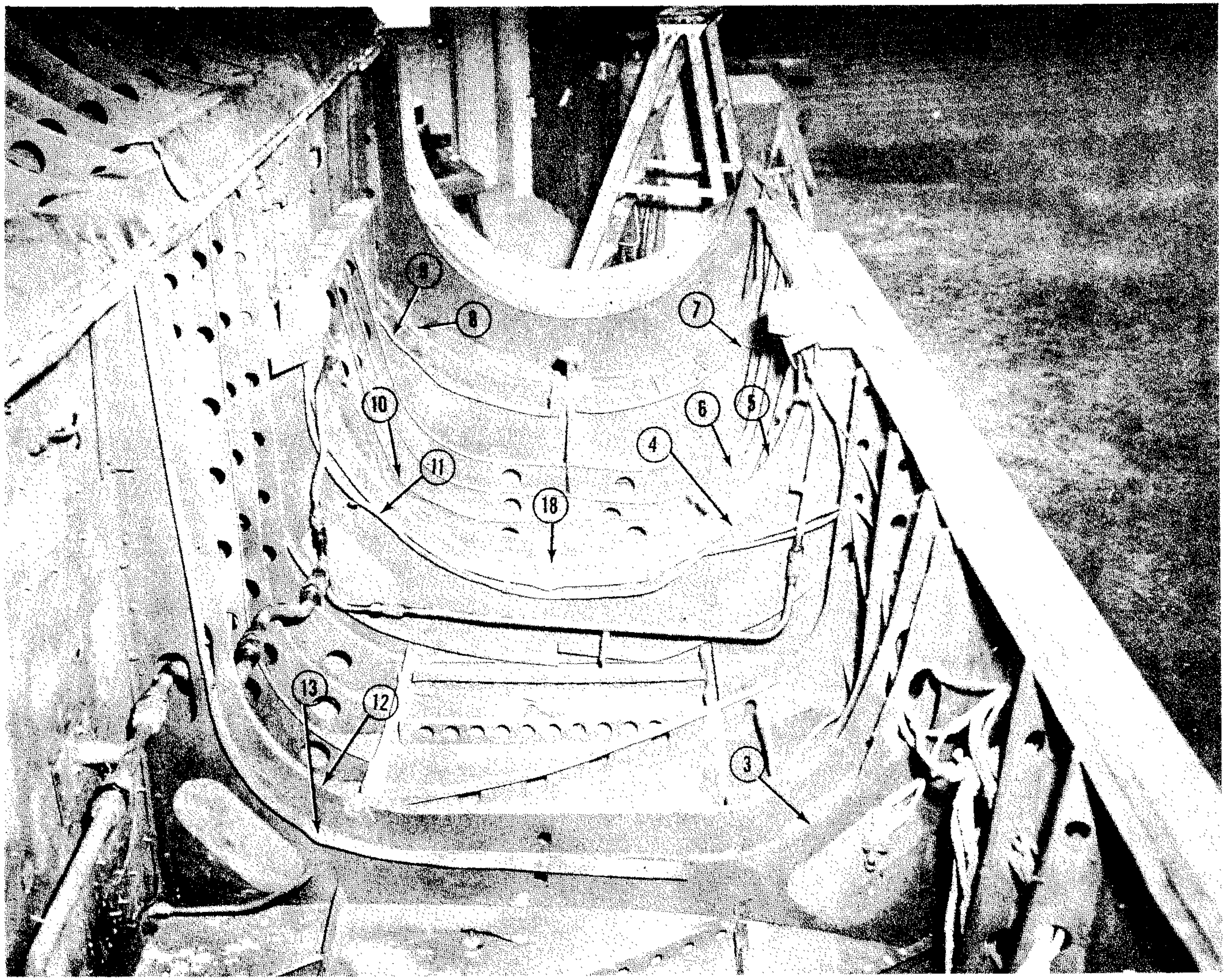
	OUTLETS
FORWARD	A B
REAR	C D
NOSE	E

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

NO. I FIRE EXTINGUISHING SYSTEM

Task No. 59-213.1

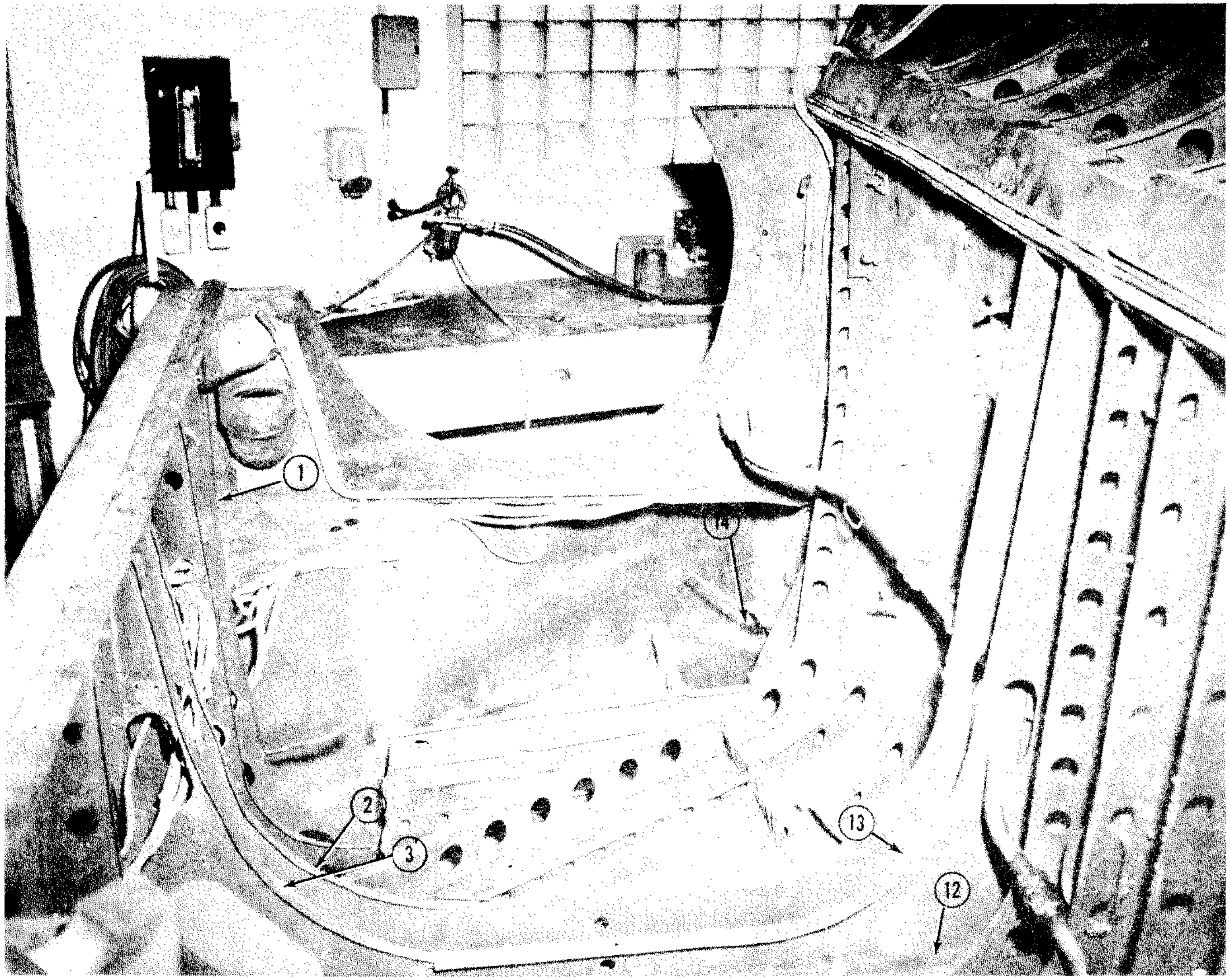
FIG. I



LOCATION OF SAMPLING TUBES
IN LOWER AFT NACELLE AREA

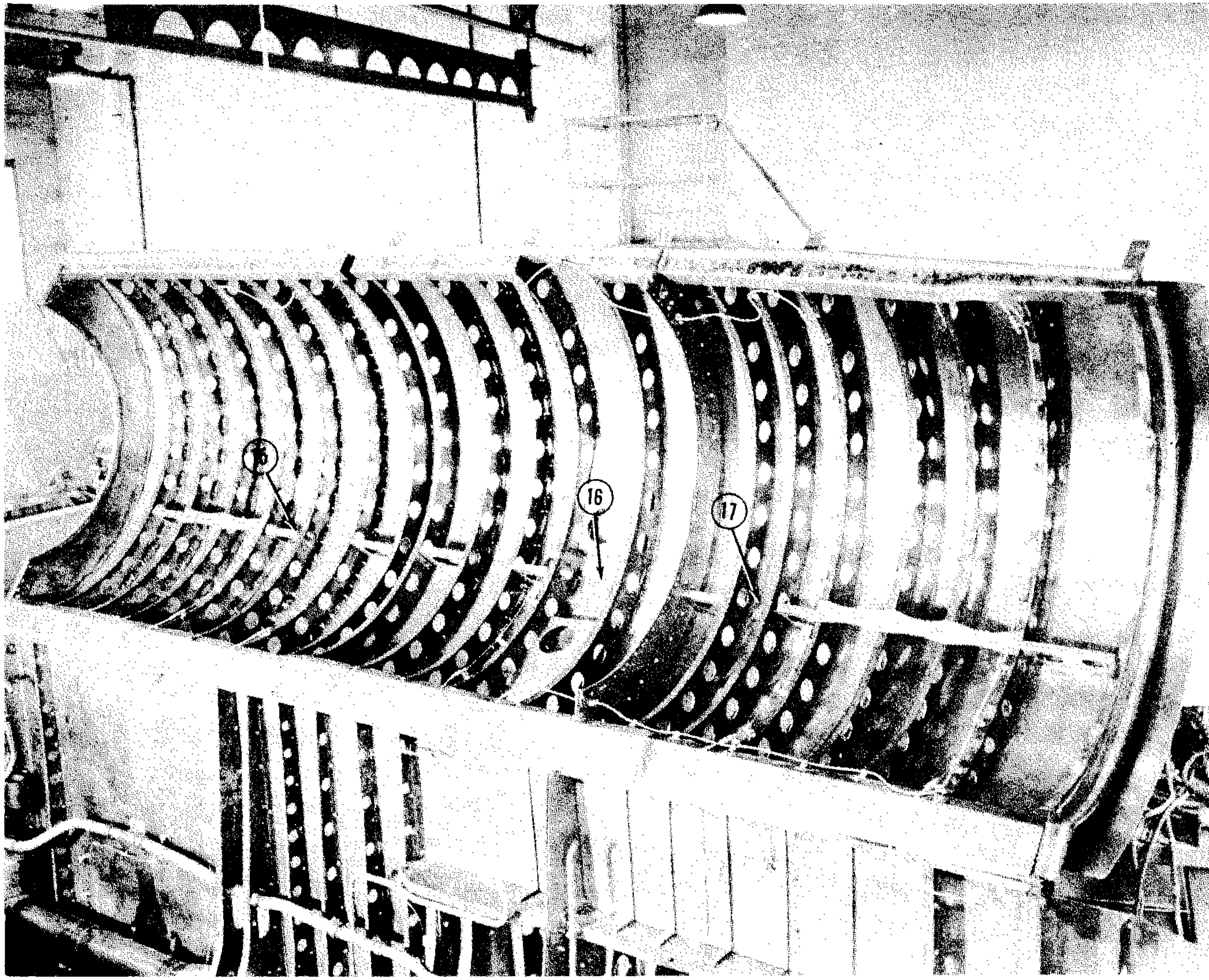
FIG. 2

Task No. 59-213.1



LOCATION OF SAMPLING TUBES IN
LOWER FOWARD NACELLE AREA

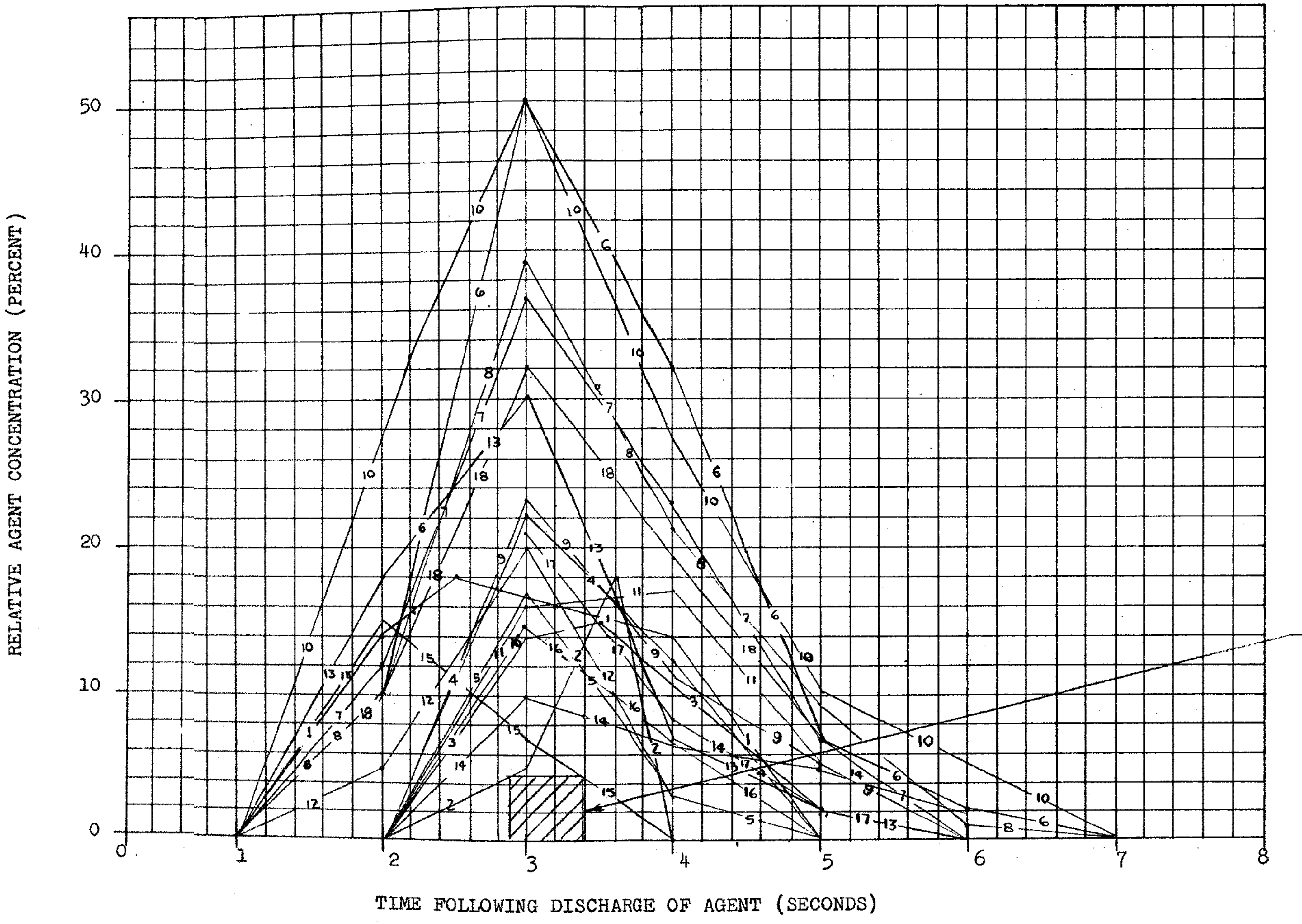
FIG. 3



LOCATION OF SAMPLING TUBES
IN NACELLE TOP DOORS

FIG. 4

Task No. 59-213.1



SURFACE OPERATING CONDITIONS
WITH AFTERBURNING:
AIRFLOW - 7.5 LB./SEC.
AGENT - 11.0 LB. CB_rF_3
AGENT PRESSURIZATION - 350 PSI

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO. 1
(NO. 1 EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 5

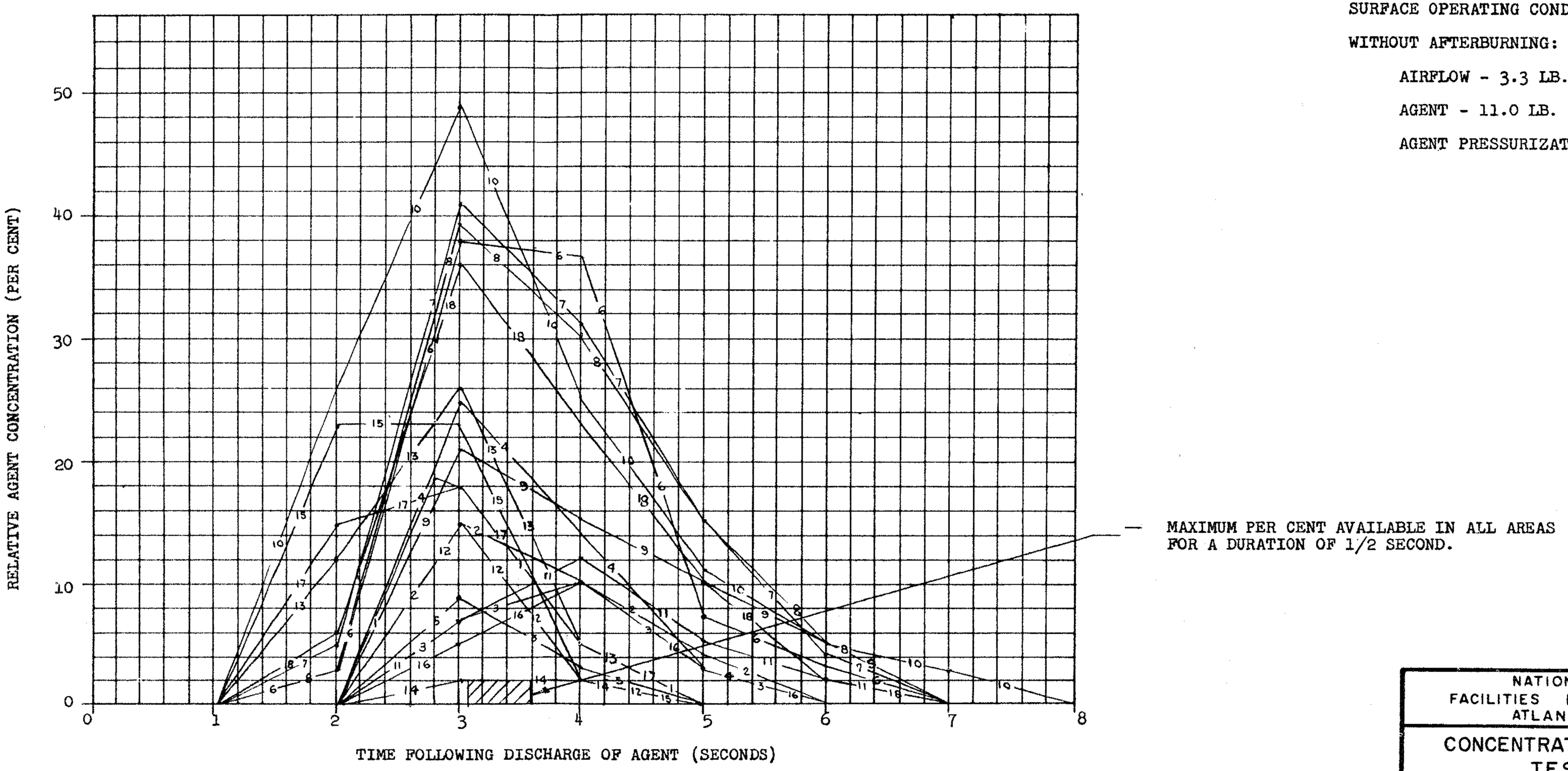
SURFACE OPERATING CONDITIONS

WITHOUT AFTERBURNING:

AIRFLOW - 3.3 LB./SEC.

AGENT - 11.0 LB. CB_rF_3

AGENT PRESSURIZATION - 350 PSI



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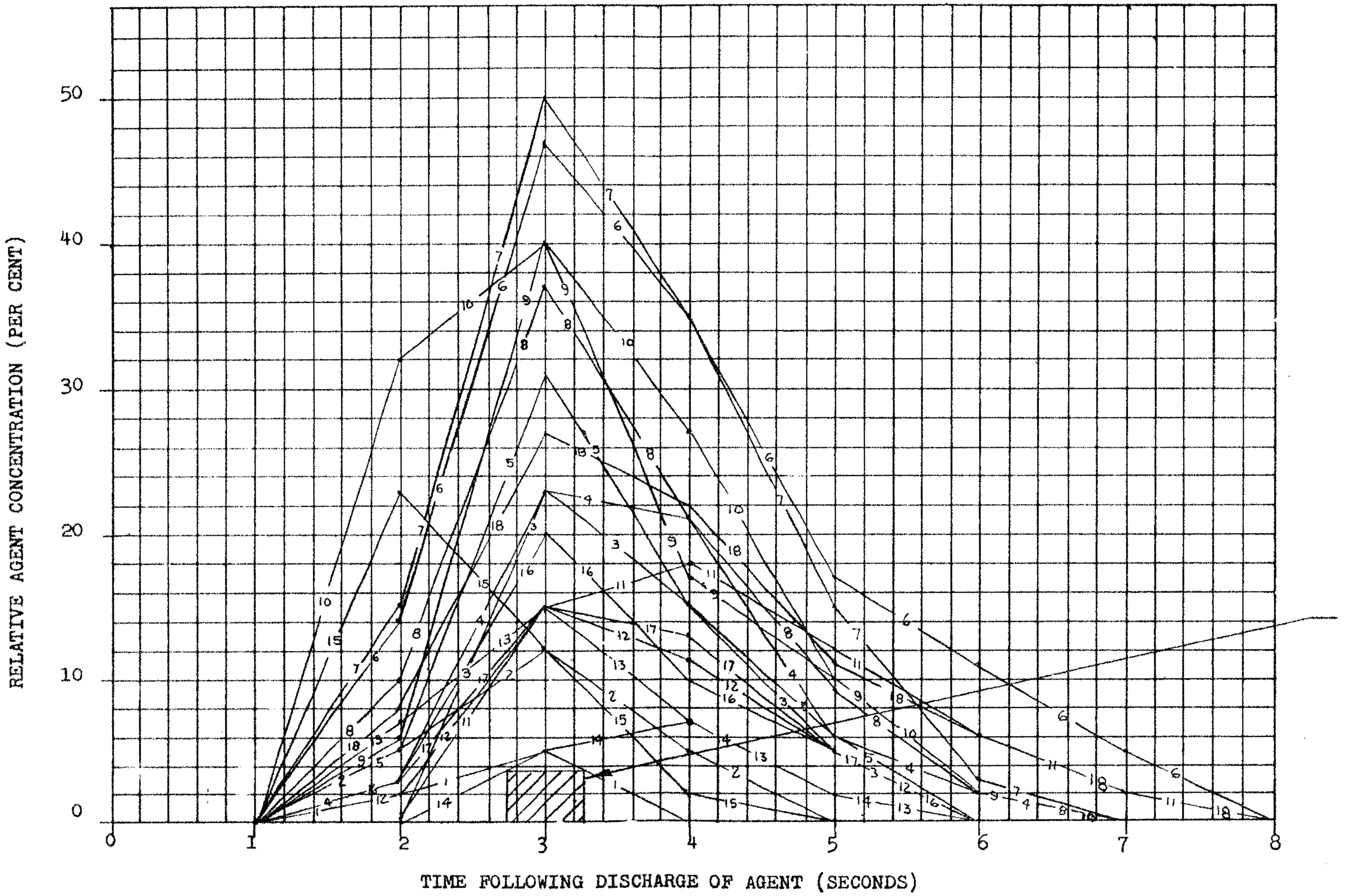
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO. 2
(NO.1 EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 6



FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.6 LB./SEC.

AGENT - 11.0 LB. CB_rF_3

AGENT PRESSURIZATION - 350 PSI

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO.3
(NO.1 EXTINGUISHING SYSTEM)

Task No. 59-213.1

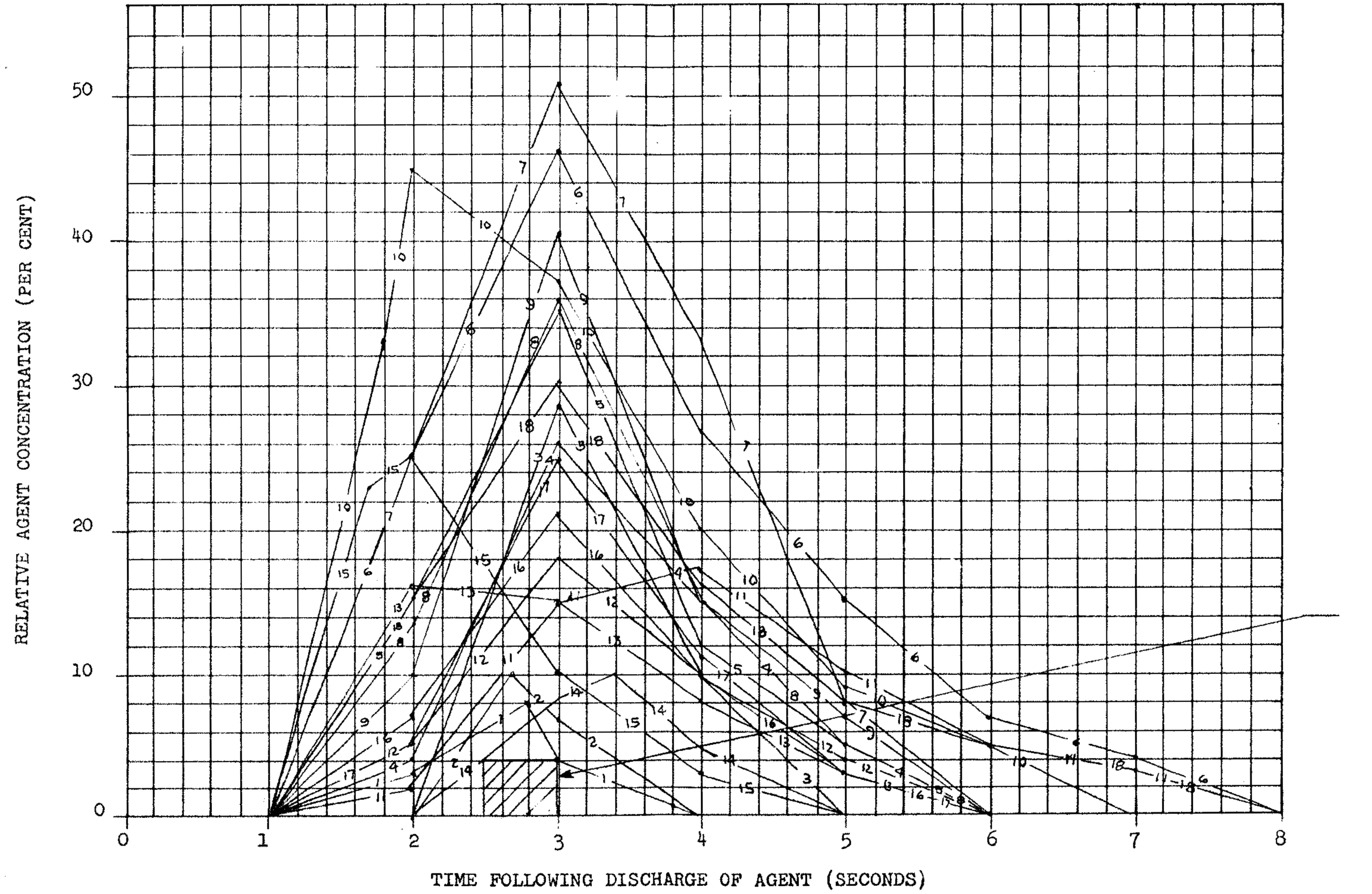
FIG. 7

FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.5 LB./SEC.

AGENT - 11.0 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

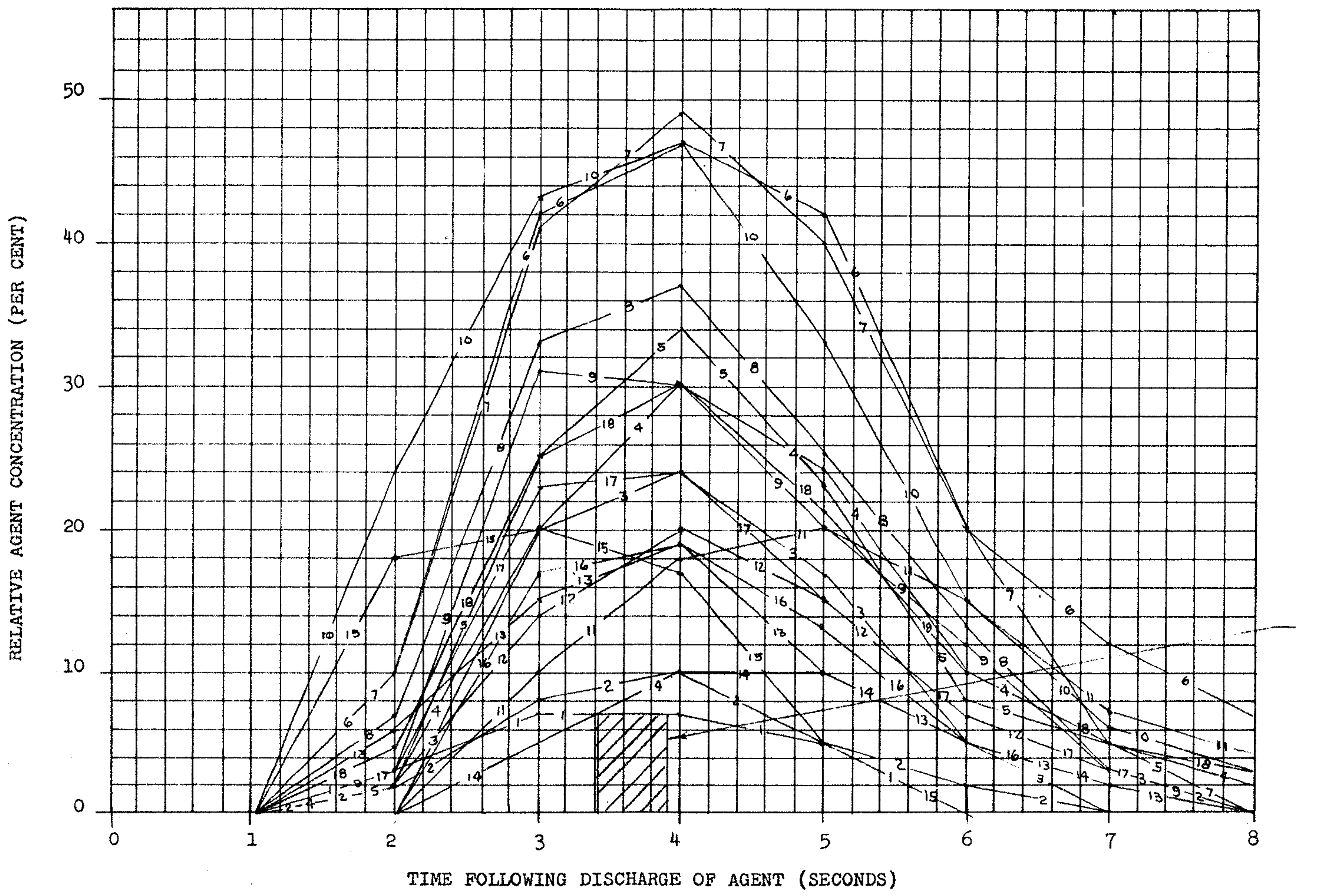


NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO. 4
(NO.1 EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 8



FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.5 LB./SEC.

AGENT - 18.0 LB. CB_rF_3

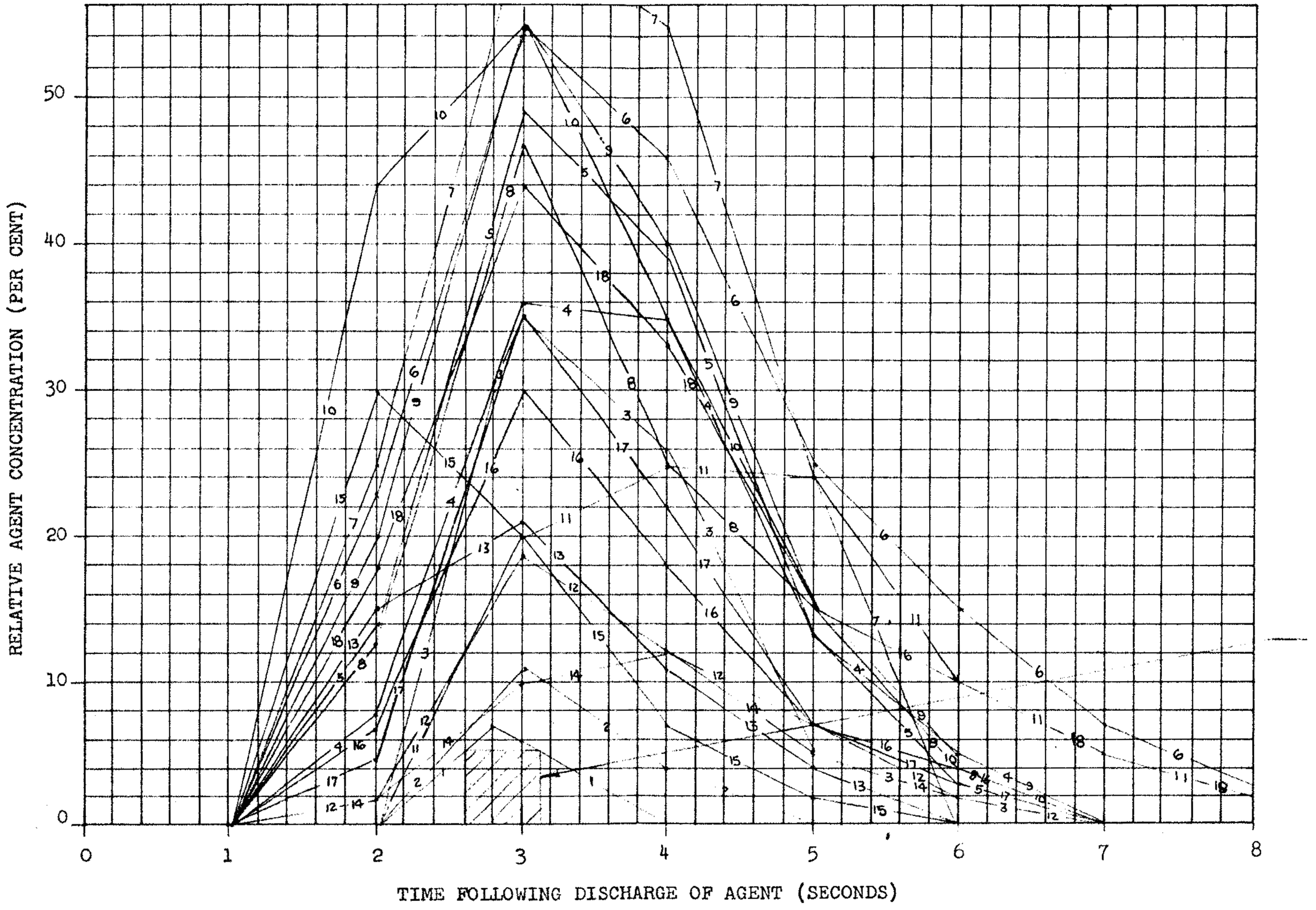
AGENT PRESSURIZATION - 350 PSI

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO. 5
(NO. 1 EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 9



FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.5 LB./SEC.

AGENT - 18.5 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

MAXIMUM PER CENT AVAILABLE IN ALL AREAS FOR A DURATION OF 1/2 SECOND

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO. 6
(NO. 1 EXTINGUISHING SYSTEM)

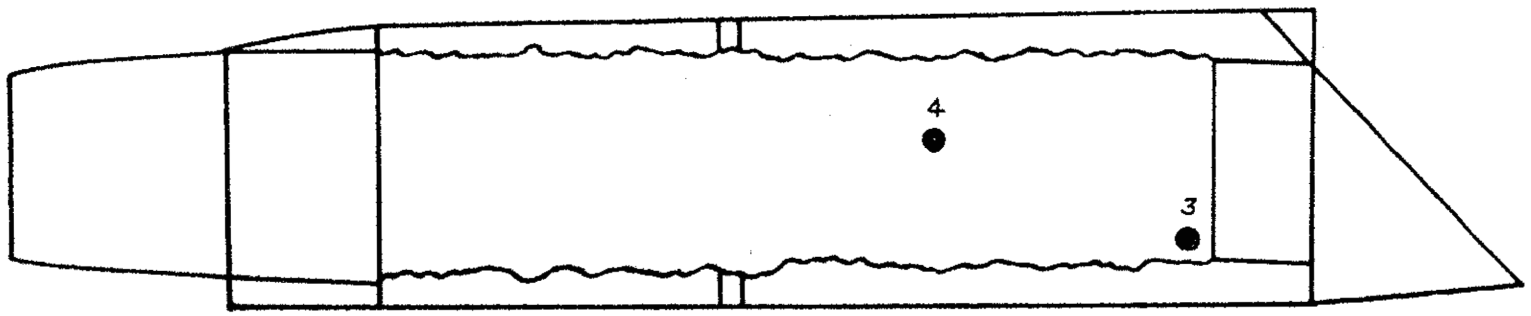
Task No. 59-213.1

FIG. 10

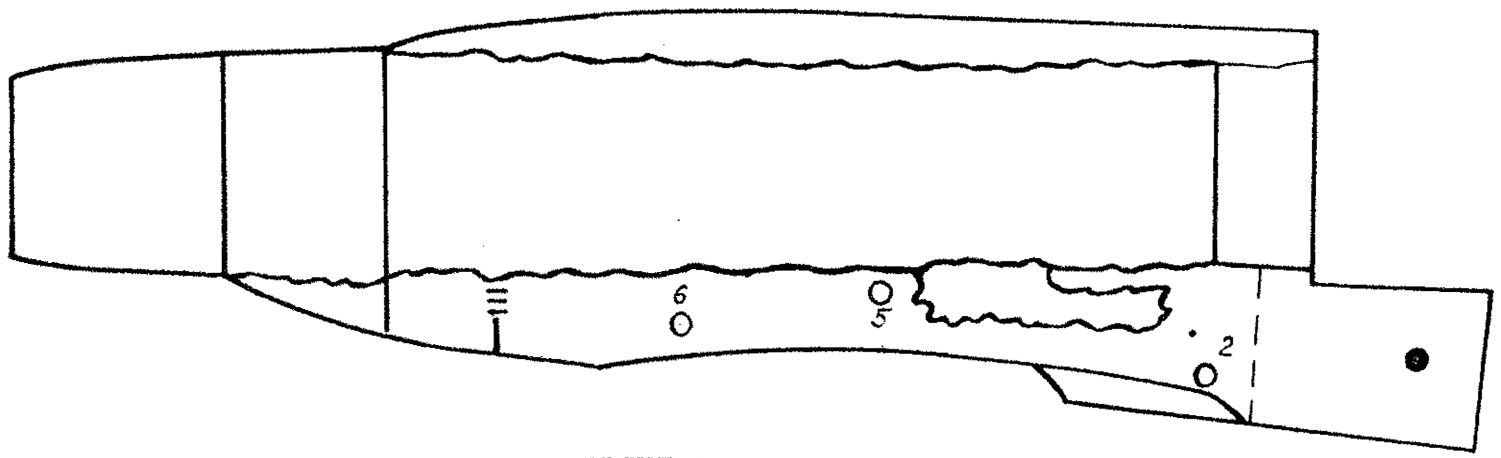
LEGEND:

● FIRE NOZZLES LOCATED ON RIGHT SIDE AND TOP DOORS

○ FIRE NOZZLES LOCATED ON LEFT SIDE



TOP VIEW



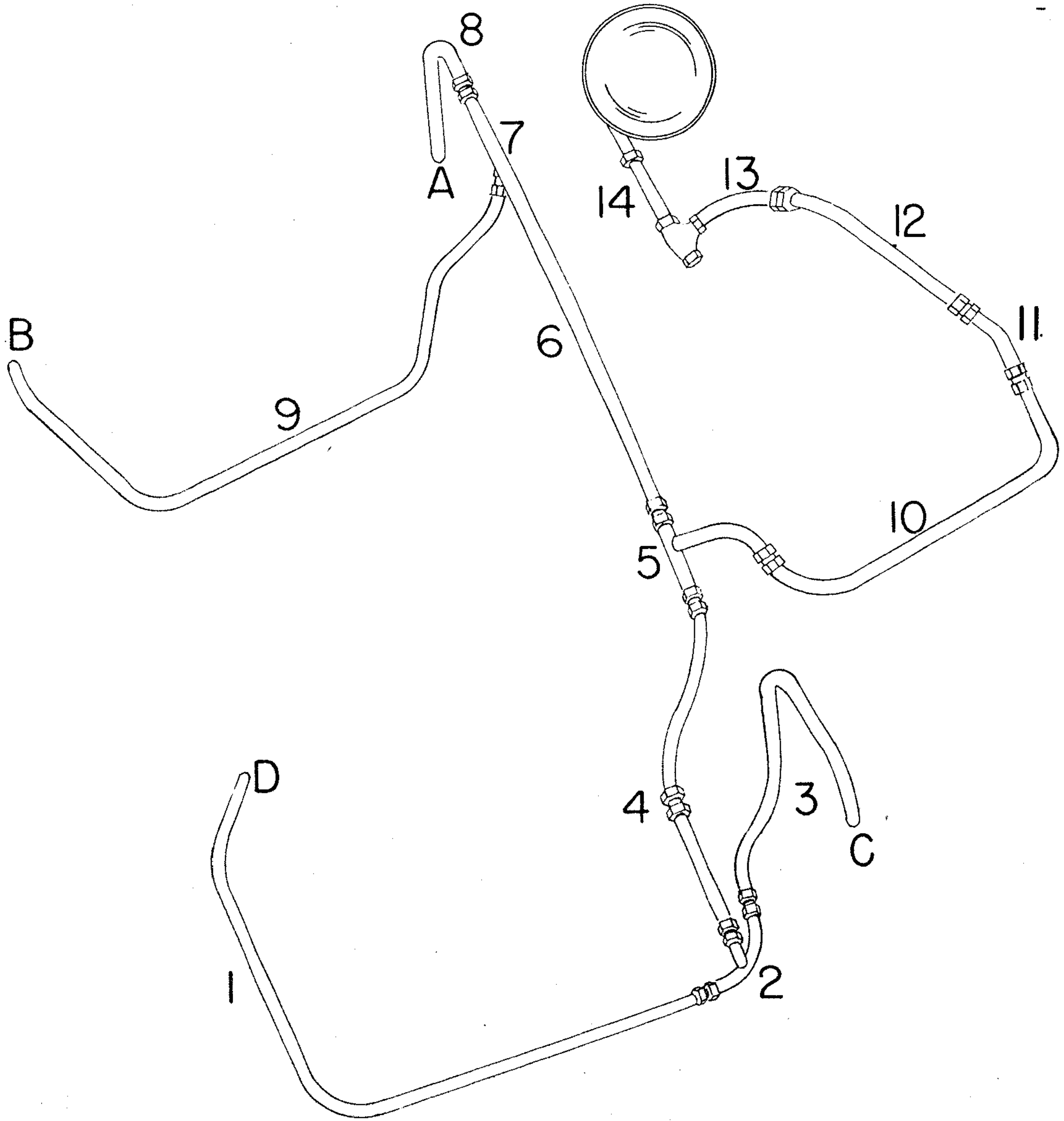
RIGHT SIDE VIEW

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER ATLANTIC CITY, N.J.

TEST FIRE LOCATIONS
YP6M NO. 1 POWER PLANT

59-213.1

FIG. 11



NO.	LENGTH	I. D.	TUBE VOLUME CUBIC INCHES
1	56.75	.438	8.56
2	FITTING		
3	25	.438	3.76
4	46	.688	17.1
5	FITTING		
6	34	.938	20.35
7	FITTING		
8	13	.688	4.84
9	59	.688	21.9
10	56.63	1.125	56.2
11	10	1.125	9.95
12	37.5	1.125	37.2
13	13.63	1.125	13.56
14	8.5	1.125	8.45

APPROX. VOL. OF TUBING	201.88
APPROX. VOL. OF FITTINGS	26.47
APP. VOL. TUBE & FITTINGS	228.35
SPHERE VOLUME	536.00
TOTAL VOLUME OF SYSTEM	764.35

	OUTLETS
FORWARD COMPT.	AB
REAR COMPT.	CD

NATIONAL [illegible]

NO. 2 FIRE EXTINGUISHING SYSTEM

Task No. 59-213.1

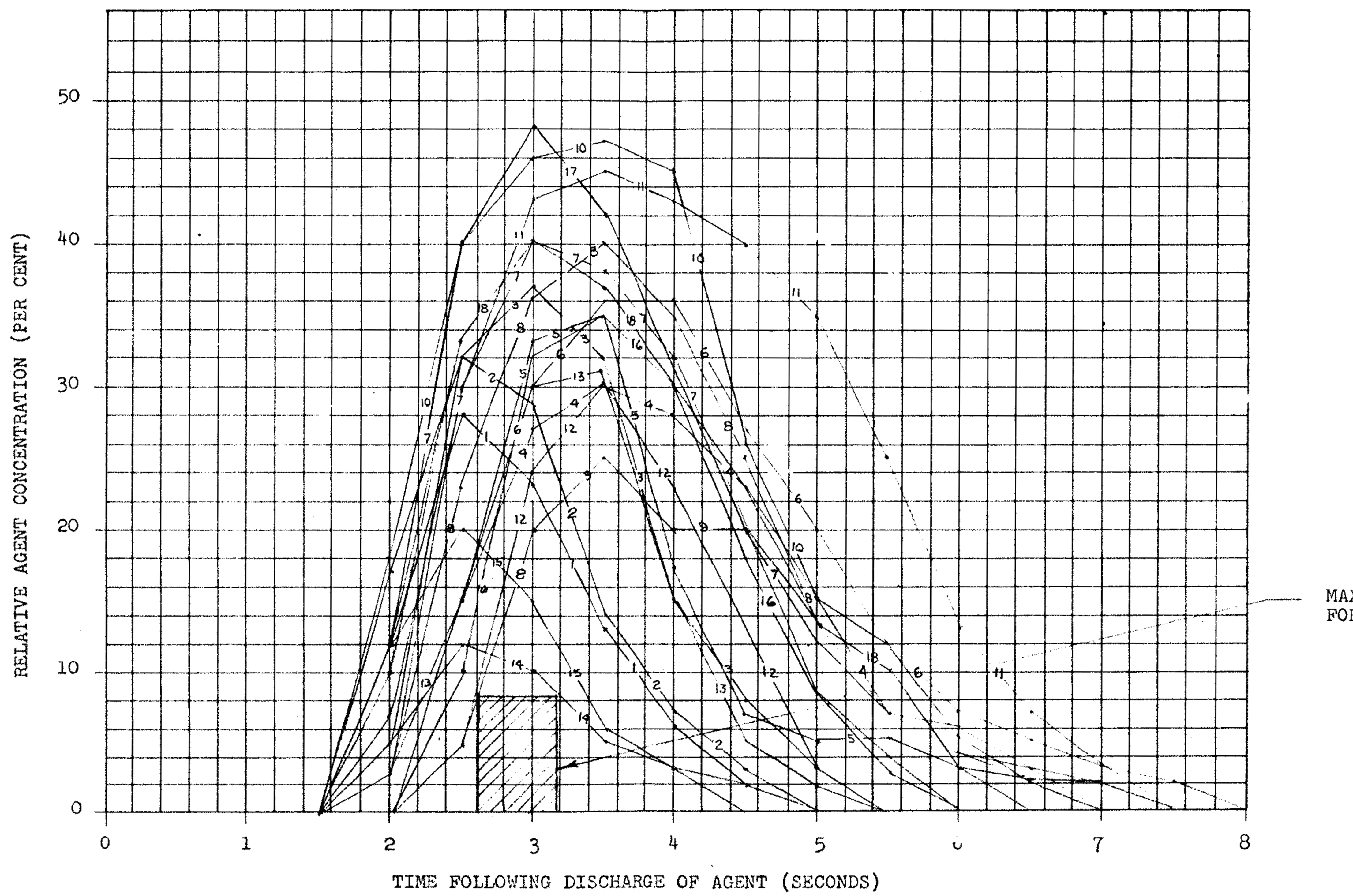
FIG. 12

FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.0 LB./SEC.

AGENT - 15.0 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

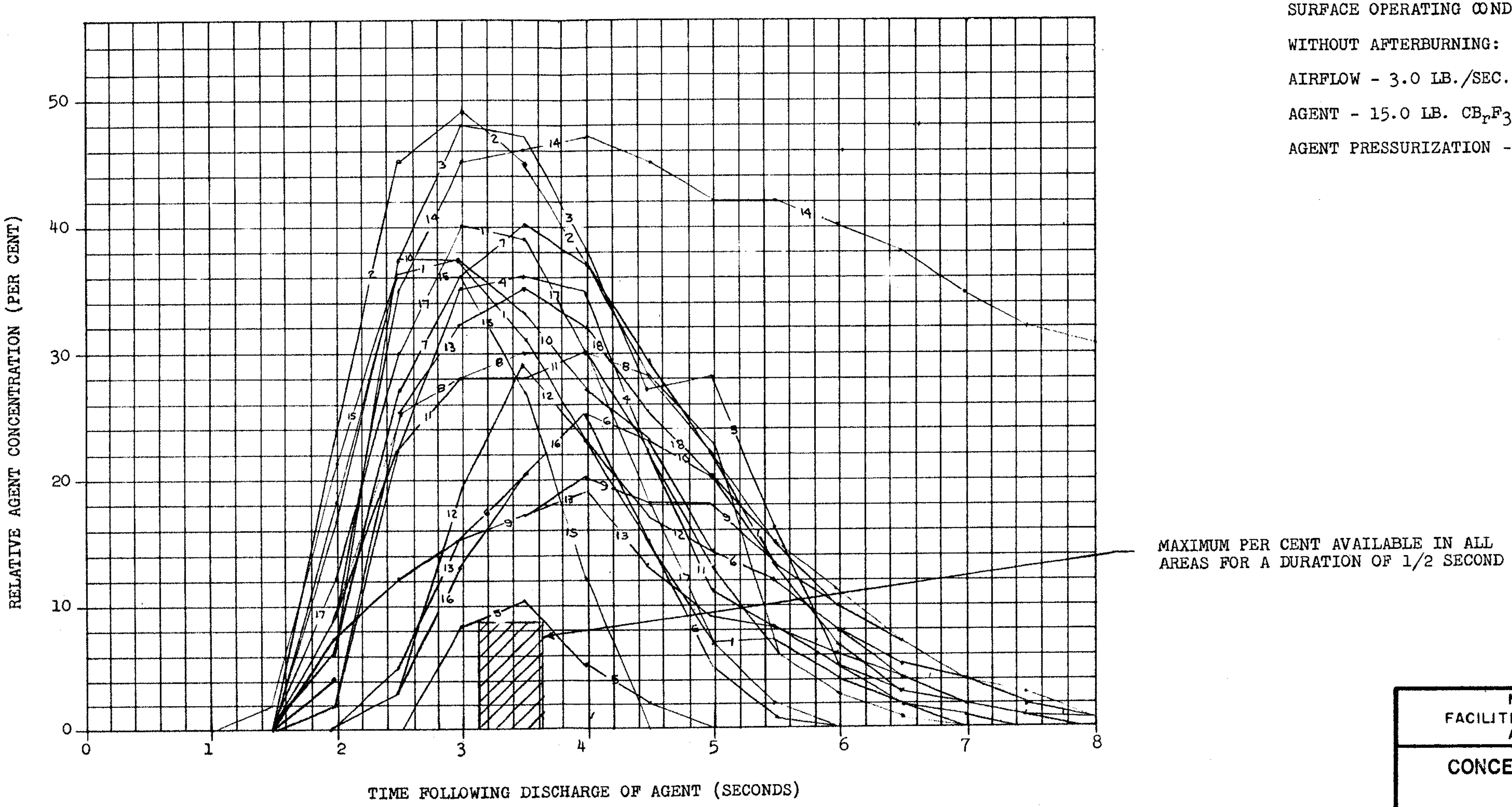


NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO. 1
(NO. 2 EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 13



SURFACE OPERATING CONDITIONS

WITHOUT AFTERBURNING:

AIRFLOW - 3.0 LB./SEC.

AGENT - 15.0 LB. CB_rF_3

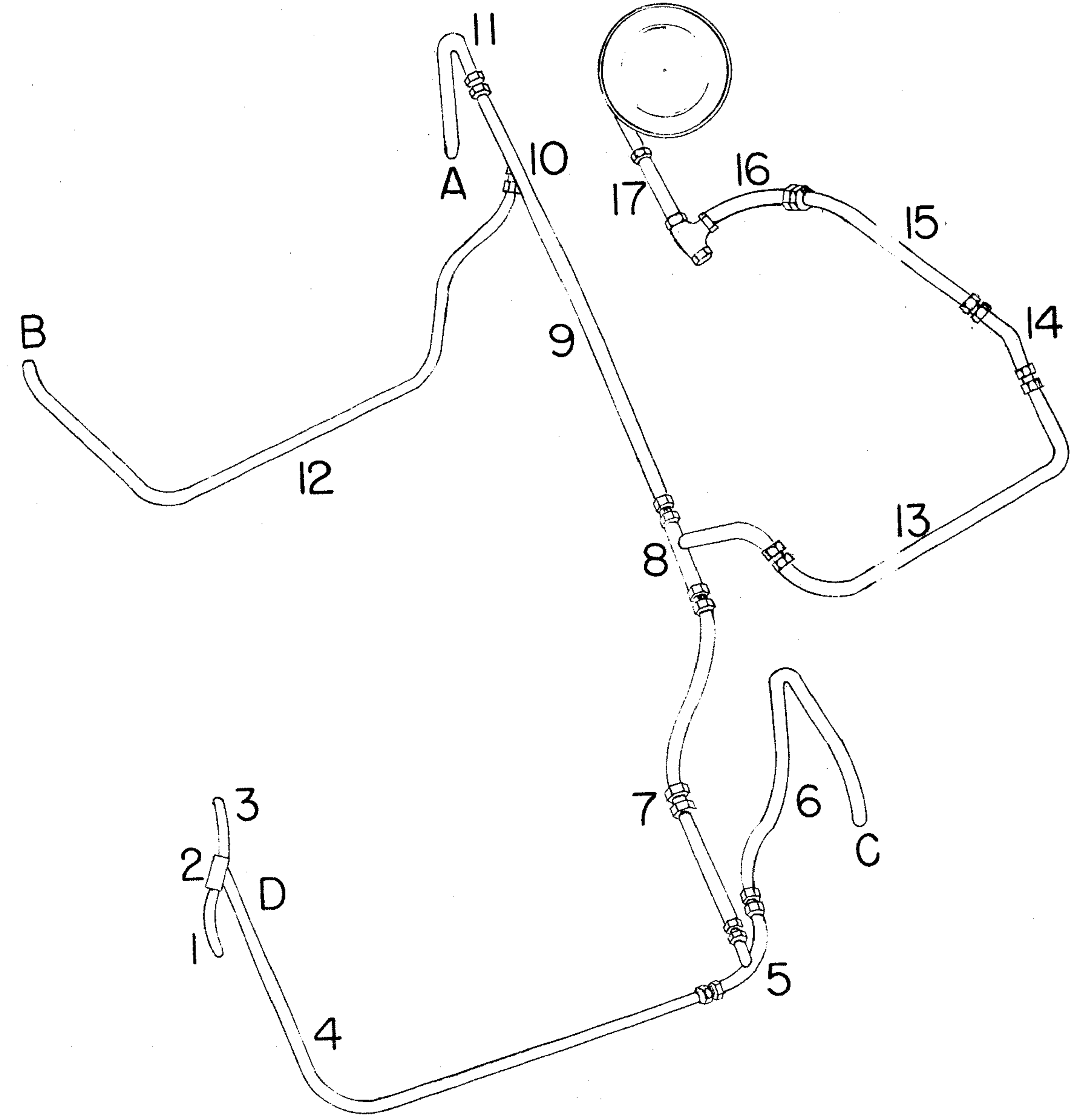
AGENT PRESSURIZATION - 600 PSI

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION
TEST NO.2
(NO.2 EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 14



NO.	LENGTH	I. D.	TUBE CUBIC	VOLUME INCHES
1	10.38	.438	1.56	
2	FITTING			
3	11.75	.438	1.77	
4	45	.438	6.78	
5	FITTING			
6	25	.438	3.76	
7	46	.688	17.1	
8	FITTING			
9	34	.938	20.35	
10	FITTING			
11	16	.638	5.95	
12	59	.688	21.9	
13	56.63	1.125	56.2	
14	10	1.125	9.95	
15	37.5	1.125	37.2	
16	13.63	1.125	13.56	
17	8.5	1.125	8.45	

APPROX. VOL. OF TUBING 204.53

APPROX. VOL. OF FITTINGS 26.79

APP. VOL. TUBE & FITTINGS 231.32

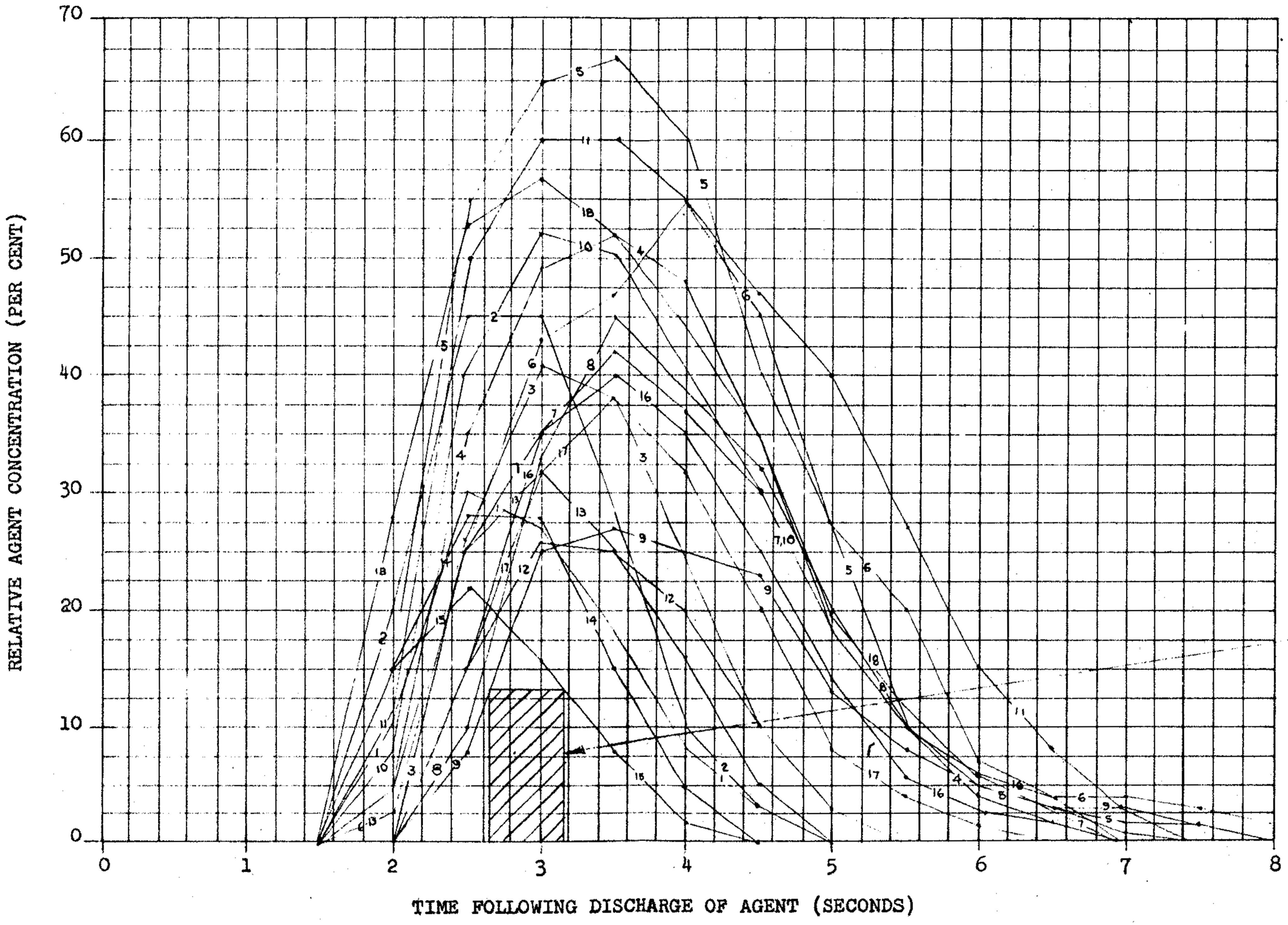
	OUTLETS
FORWARD	AB
REAR	CD

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

MODIFIED NO. 2 FIRE EXTINGUISHING SYSTEM

Task No. 59-213.1

FIG. 15



FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.36 LB./SEC.

AGENT - 15.0 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

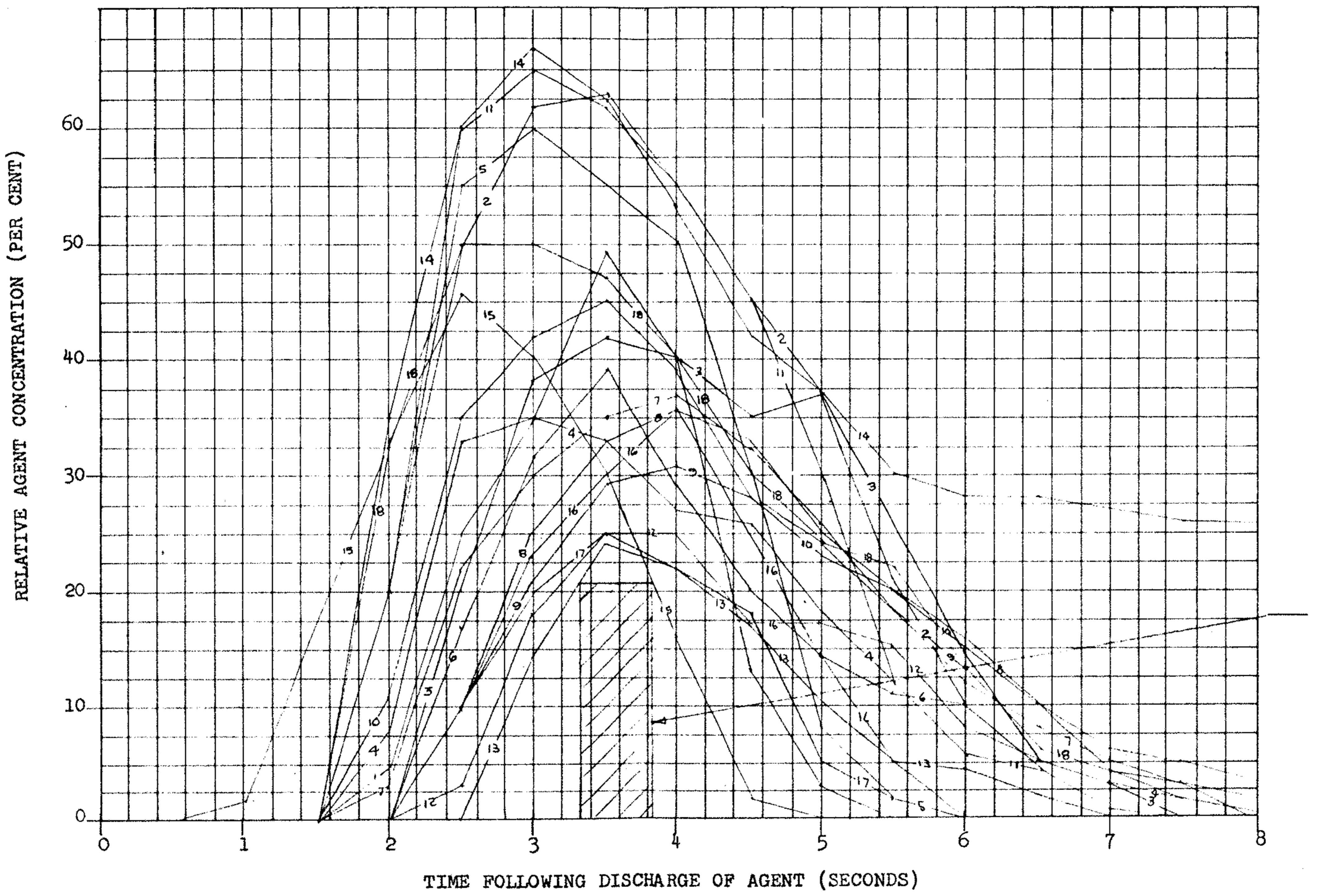
MAXIMUM PER CENT AVAILABLE IN ALL AREAS FOR A DURATION OF 1/2 SECOND

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION TEST NO. I (FINAL YP6M EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 16



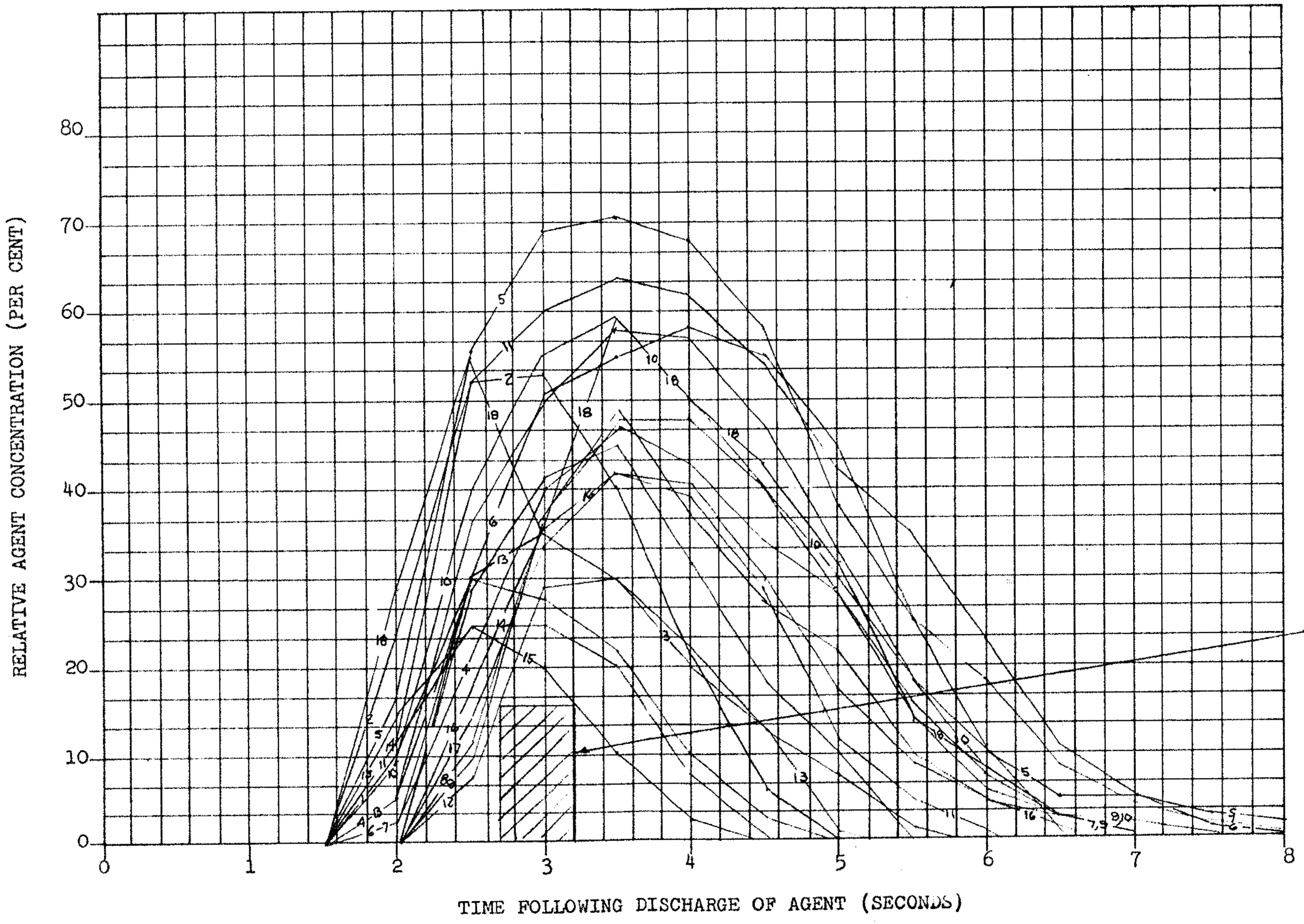
SURFACE OPERATING CONDITIONS
WITHOUT AFTERBURNING:

AIRFLOW - 3.0 LB./SEC.

AGENT - 15.0 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER ATLANTIC CITY, N. J.
CONCENTRATION DISTRIBUTION TEST NO.2 (FINAL YP6M EXTINGUISHING SYSTEM)
Task No. 59-213.1 — FIG.17



FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.3 LB./SEC.

AGENT - 18.25 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

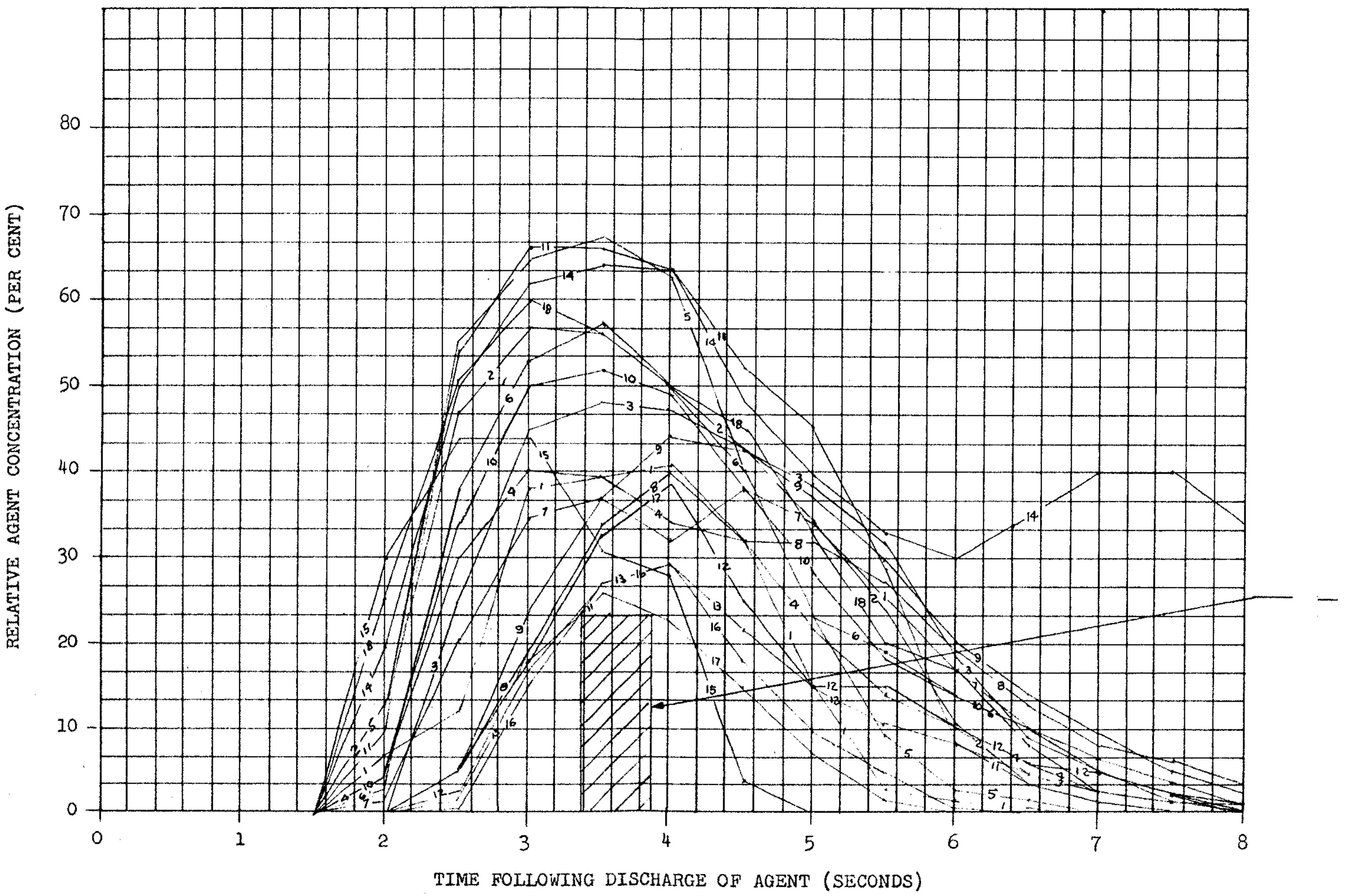
MAXIMUM PER CENT AVAILABLE IN ALL AREAS FOR A DURATION OF 1/2 SECOND

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION TEST NO.3 (FINAL YP6M EXTINGUISHING SYSTEM)

Task No. 59-213.1

FIG. 18



SURFACE OPERATING CONDITIONS WITHOUT AFTERBURNING:

AIRFLOW - 3.0 LB./SEC.

AGENT - 18.0 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION TEST NO. 4 (FINAL YP6M EXTINGUISHING SYSTEM)

Task No. 59-213.1

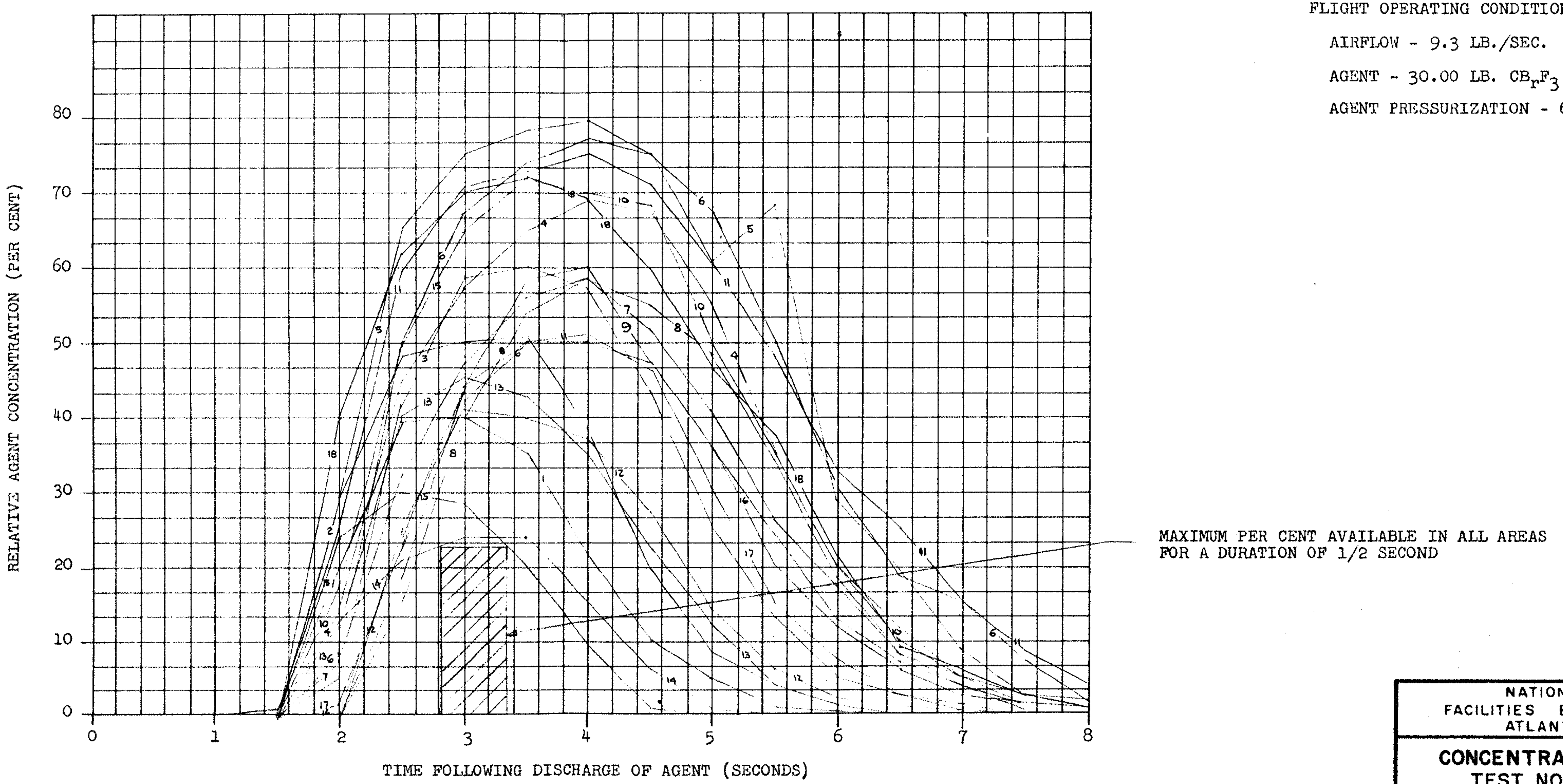
FIG. 19

FLIGHT OPERATING CONDITIONS:

AIRFLOW - 9.3 LB./SEC.

AGENT - 30.00 LB. CB_rF_3

AGENT PRESSURIZATION - 600 PSI

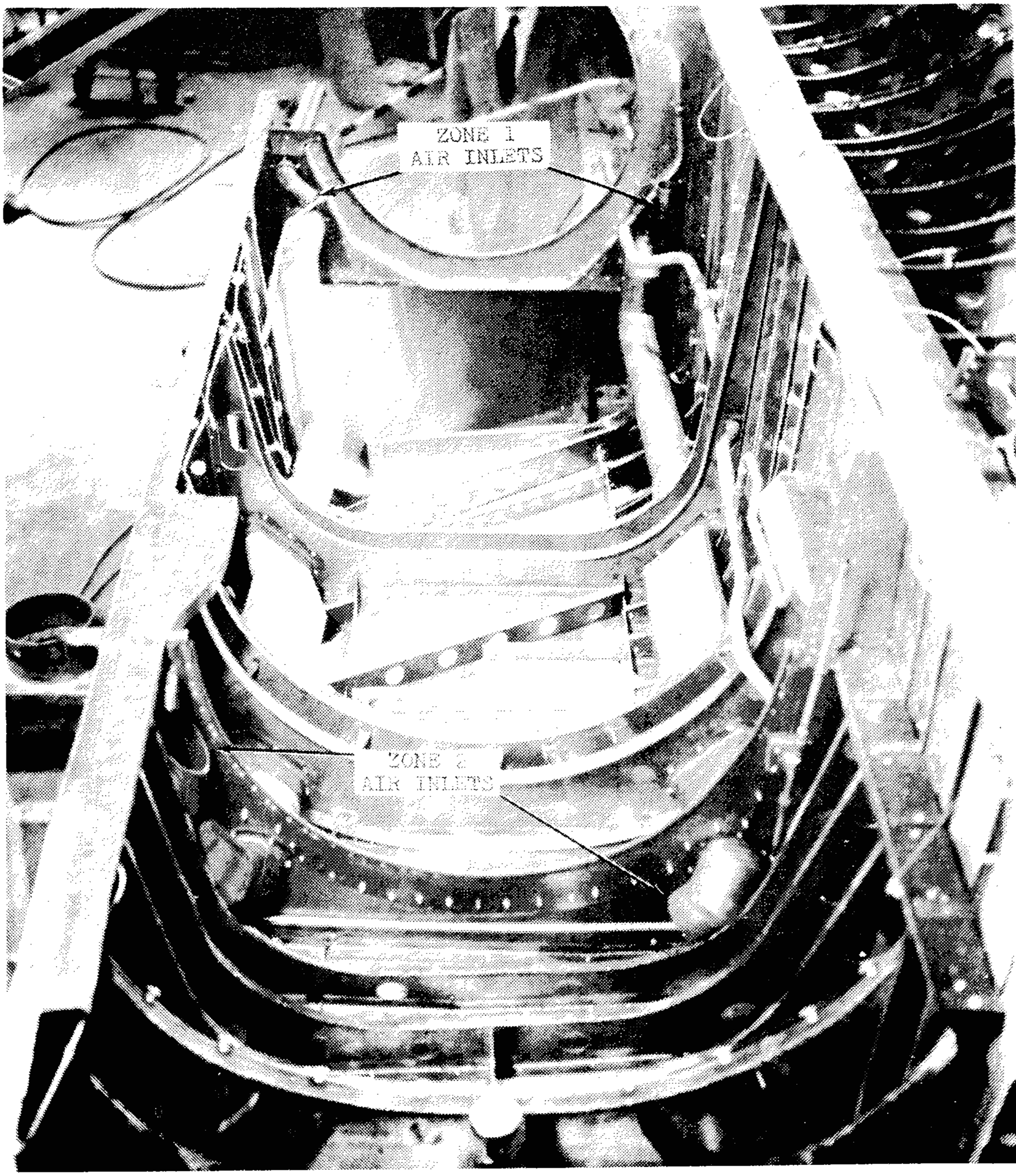


NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

CONCENTRATION DISTRIBUTION TEST NO.5 (FINAL YP6M EXTINGUISHING SYSTEM)

Task No. 59-213.1

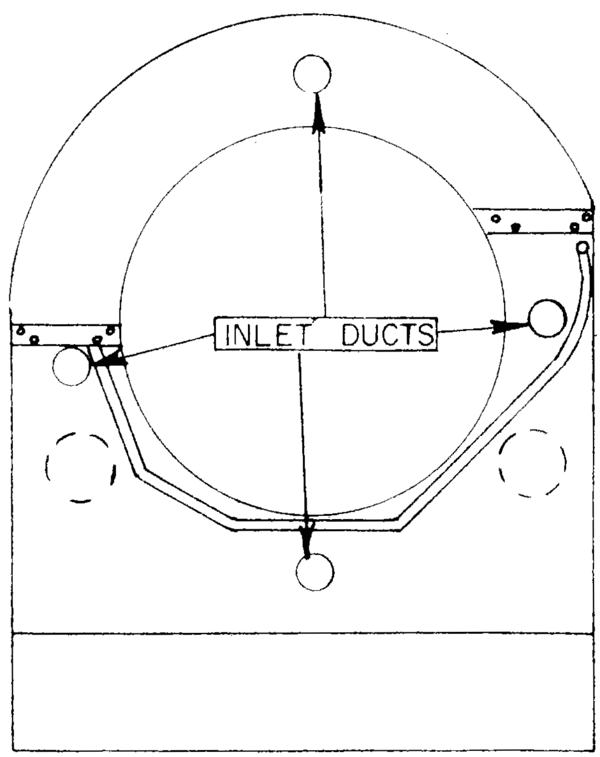
FIG.20



LOCATION OF AIR INLET DUCTS,
YP6M-1 NACELLE

Task No. 59-213.1

FIG. 22



LOCATIONS OF INLET DUCTS
THROUGH FORWARD FIRE WALL

Task No. 59-213.1

FIG. 23