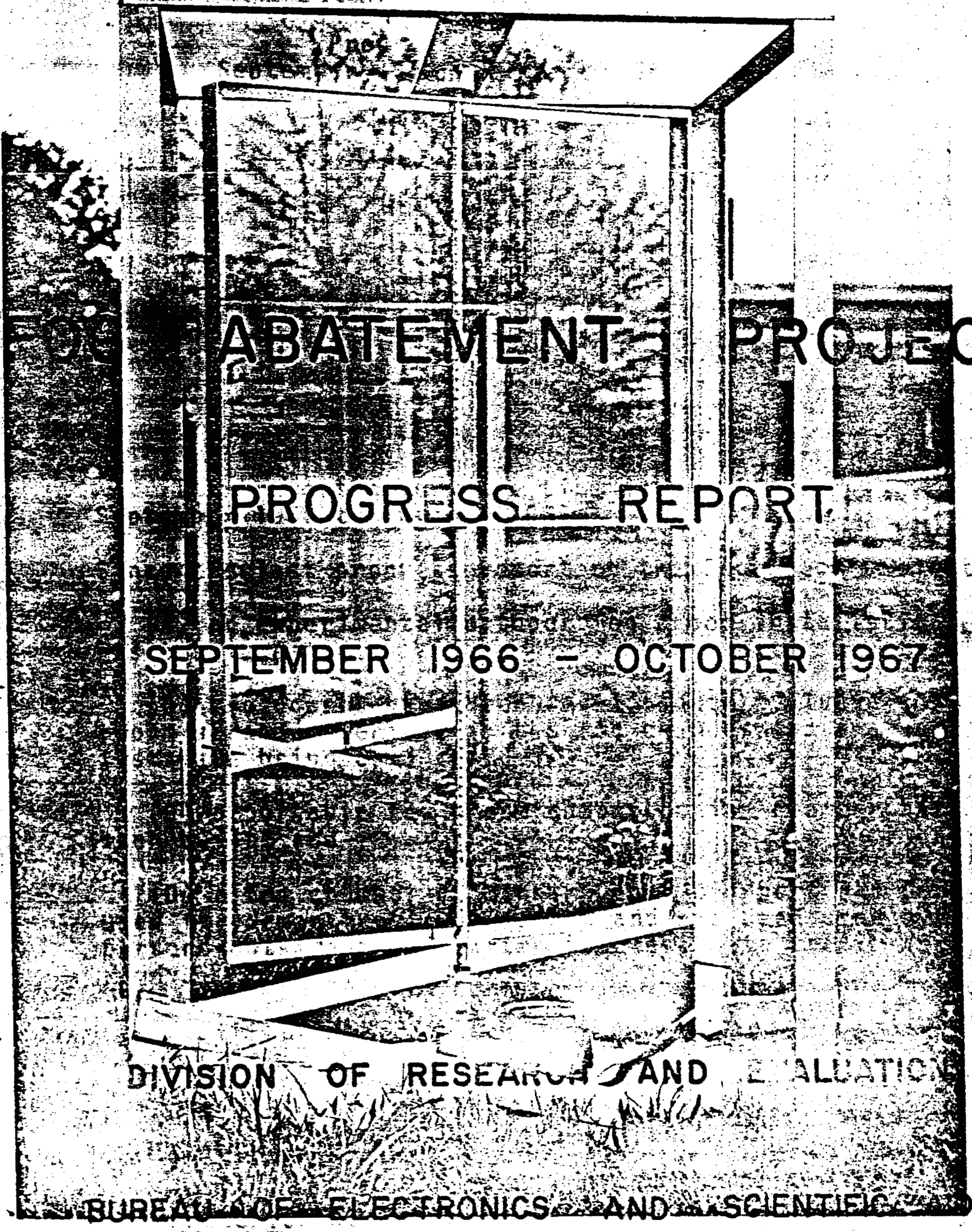
68-007-7767

NEW JERSEY DEPARTMENT OF TRANSPORTATION



FOG ABATEMENT PROJECT

PROGRESS REPORT

SEPTEMBER 1966 - OCTOBER 1967

DIVISION OF RESEARCH AND EVALUATION

BUREAU OF ELECTRONICS AND SCIENTIFIC AIDS

NOVEMBER 1967

68-007-7767

FOG ABATEMENT PROJECT
Progress Report
September 1966 - October 1967

SUMMARY

This report covers the time interval from September 1966 to October 1967.

Since the last progress report on the Fog Broom Project:

(A) an experimental outdoor fog broom installation has been created,

(B) procedures have been developed to evaluate fog broom strand materials in the fog chamber and evaluation tests are being conducted,

(C) a portable fog broom demonstration chamber has been built, and

(D) a fog chamber at Mercer County Airport has been used for demonstration purposes and has been used by persons outside the Department to evaluate their fog removal devices.

EFFECTIVENESS Page 7

Report prepared by

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(A) OUTDOOR FOG BROOM INSTALLATION

From September 1966 to December 1966, plans were finalized and requests were made for material and equipment for the first outdoor experimental fog broom installation. The area in front of Fernwood Shops, Parkway Avenue, Trenton, New Jersey, was selected for the site. Bids were requested for the fencing around the site, and for the manufacture of the first twenty fog brooms. During this time, the experiments being conducted in the fog chamber at Mercer County Airport were video-taped as part of the research project. A colored motion picture with a narration of these experiments was prepared for presentation to the Highway Research Board in January 1967.

By the end of January 1967, the fence around the installation was completed. FABCON Engineers Company, Trenton had received the bid to fabricate the brooms, and were in process of making the fog broom frames. Also, a requisition was submitted to the Electrical Bureau of the Department for the installation of all the equipment involved in the electrical operation of the system.

The fog broom assemblies were completed by the 1st of April. Members of the Bureau of Electronics and Scientific Aids completed the brooms by winding, by hand, the nylon strands on the rotating part of the frame. These twenty brooms were then placed in the fenced-in enclosure at 16-foot intervals. The Texas Instriment Recorder for recording fog density and the photoelectric system were received. These devices were calibrated and put on test in the Airport fog chamber. At this time, it was decided to have outside contractors install the electrical power to the site.

Next, the photoelectric automatic control system was installed. The installation could not be tested because by the end of April the electrical power had yet to be installed by Public Service. Members of the Bureau wired the separately fused A.C. broom motors to their respective junction boxes.

Once the electrical power had been connected, the fog detection system was aligned and the solar cell fog density monitoring system was installed. Because the Texas Instriment Recorder would malfunction and therefore be unreliable, it was sent back to the Texas Instrument Company repair shop. When it was returned, the recorder was tested at the fog chamber and then installed at the fog broom installation in the outer guardhouse. Also located in the guardhouse were the wind direction and velocity meters with their associated translators and power supply, and the main power panel board. Trim-potentiometers were connected across the solar cell electrical outputs in order to adjust and calibrate the input to the Texas Instrument Recorder.

On June 30, 1967, the fog broom installation, designed to measure the effectiveness of removing fog by twenty fog brooms, became operational.

To make this site automatic, a photoelectric device is used to detect the fog. For example, a light source transmits a beam of light to the photoelectric cell. When the fog becomes dense enough, the light beam is interrupted and closes a relay which turns on the fog brooms and its associated data-gathering equipment. When the fog has been abated, the photoelectric system automatically turns off the equipment. Security guards at Fernwood have been very cooperative in notifying the Bureau whenever the system turns on automatically or when fog has seeped into the area. Each time a phone call is received from the security guards, no matter what time of day it is, a member from the Bureau inspects the site and makes a report.

For this experimental installation the most promising fog broom strand material evaluated was used. Various types of strands were tested in the fog chamber. These tests and their results will be more fully discussed later in this report in Section (B). Monofilament nylon strand was considered the most effective. Each of the twenty brooms was wound with approximately one half mile of this nylon strand.

A one-fifteenth (1/15) horsepower, 115 volt, A.C. motor with a speed reducing gear train is used to revolve the broom. Tests at the fog chamber demonstrated that the speed of rotation is important and critical. Below ninety r.p.m. the broom is not effective. At high speeds, above one hundred and ten r.p.m., the broom becomes a fan which just redistributes the fog but does not abate it. However, at ninety r.p.m., the brooms in the test chamber effectively removed the fog. This ninety r.p.m. is now considered the standard speed for the brooms with all other speed evaluation tests measured against it.

The brooms are spaced at 16-foot intervals for a total distance of 320 feet along the Avenue. This 16-foot spacing is arbitrary and will be evaluated against other spacings at a future date.

Wind direction and wind velocity are recorded thus mapping the fog movement through the installation. A five solar cell fog monitoring system measures the fog density around the brooms. This density data is referenced against a sixth fog density monitor which is 60 feet from the site. The reference density monitor measures the fog density as the fog seeps into the fog broom area. Clearing of fog by the brooms can be noted by the change in the fog density values between the reference monitor which should remain constant and the monitors in the installation which should show a decrease in fog density. Each solar cell electrical output is across the Texas Instrument Recorder.

Operational Problems with the Fog Broom Equipment

Since June 29, 1967, two broom frames have been replaced because of broken strands. The A.C. motor for the # one broom became noisy and overheated. It was removed and repaired. The motor was out of service from August 16 to September 29. Repairs to the motor included: adding shielded bearings, a new starting coil, replacement of the stator windings, cleaning, baking, and painting. These motors are classified as being weather proof; however, this doesn't mean that they are waterproof. Inspection showed that water had seeped into the motor which rusted it and provided a low resistance path to ground. The noise that had been noticed was from rusted bearings. The gear train, which had remained adequately greased, was trouble free. It is likely that all of the fog broom motors will have to be waterproofed. This can be done to the A.C. motors by replacing the open bearings with shielded bearings, dipping the stator and rotor windings in epoxy resin, and replacing the open starting switch with an oil filled capacitor starting switch. With the D.C. motors used in the fog chamber, it is more difficult to have them waterproofed because the commutator and brushes are exposed and cannot be encapsulated. Therefore, it would be best to coat the field and armature windings with epoxy resin and then seal the motor itself with silicone rubber as a firm gasket. A request has been made to have this process done to one motor. If this waterproofing proves satisfactory, the remaining A.C. and D.C. motors will be processed.

Maintaining proper alignment of the photoelectric fog detector system has presented a continuous problem. It was found that alignment was critical. The light source and photoelectric cell are spaced 50 feet apart. To shade the photocell from ambient light, it was necessary to add a two inch diameter tube three feet long to the photocell. Due to the narrow tube opening and the 50 foot distance, a slight movement of either device will cause the system to malfunction. For examples, a strong wind, the ground around the posts settling, or the screws loosening on the brackets can cause mis-alignment. Every time this device malfunctions, the entire fog broom system is turned on. Another problem encountered was that the photoelectric cell received light from the immediate area around the light source. A four-sided black box arrangement with the light source inside corrected this situation. These additions made the automatic system wholly dependent on the light source. On July 10, a call was received indicating that the fog brooms were running but there was no fog in the area. Inspection of the site showed that condensation had built up on the lens of the photoelectric cell. This reduced the light beam enough to turn on the equipment. Four one-sixteenth holes were drilled in the bottom of the case to allow air to circulate and prevent condensation.

Experience has shown that a fairly heavy fog is needed to turn on the brooms. It would be better to turn on the brooms in a light fog so as to keep the fog from increasing. This can be done by adjusting the sensitivity of the photoelectric cell relays. Plans are being formulated to develop a better automatic system and do away with the present system because of the problem of alignment and ambient light.

Problems have also occurred with the solar cell fog monitoring system. Several times condensation has appeared on the solar cells which caused the measurement to drift. This condition usually occurred after heavy rains. It was noted that the solar cell tubes are parallel to the ground which makes it possible for rain water to drain into the tubes. This problem can be reduced if not eliminated by tilting the tubes towards the ground. By raising the solar cell device six inches and lowering the light source by six inches and then aligning the system this condition can be met.

The second-hand wind direction and velocity equipment has not proven satisfactory in regard to dependability. On July 10, a short time after the equipment was installed, the power supply burnt up and was replaced with the only remaining spare. Since that time no problems have been experienced with the wind detection equipment, power supply, translators or meters, except for the inkpens. The pen elements have been a consistent source of trouble which resulted in the wind equipment being out of operation most of the time. To solve this problem and at the same time increase utilization of the Texas Instrument Recorder, attempts will be

[redacted]

made to redesign the system to allow the signal output of the translators to be fed directly into the Texas Instrument; thereby, doing away with the two wind meters. This would also place all recorded data on one chart.

On September 8, 1967, the first data-gathering fog occurred. The fog seeped into the Fernwood area from the southwest at approximately two miles per hour. At 5:43 a.m., the fog brooms turned on automatically. They ran for thirty-seven minutes and then automatically turned themselves off. It should be emphasized that this was the first fog and that several fogs will be needed to adjust the automatic controls and data-gathering equipment. However, the recorded data showed a partial clearing of fog at the installation. The chart indicated that the fog detection system will have to be made more sensitive so it will turn on in a lighter fog and start clearing fog before the fog becomes heavy. Since this first fog the detection system has been adjusted to be more sensitive to light fog, however, lack of fog at the site has limited its evaluation.

Again, on October 17, 1967, fog seeped into the Fernwood area from the southwest at approximately zero to one mile per hour. Because the fog was not heavy enough to turn on the brooms automatically, they were started manually at 5:20 a.m. in order to obtain information. Visibility towards Parkway Avenue was about 500 feet. At 6:40 a.m., the brooms were stopped. Visibility at this time was about 900 feet looking toward Olden Avenue. Clearing of the fog seemed to be occurring naturally. The observer noticed no change in fog density as a direct result of the brooms - but it must be pointed out that at that time it was still dark. Twenty minutes later when the sky became lighter, it was quite obvious that the fog had been successfully abated in the immediate area. The importance of the electronic recorder proved itdelf when the observer could not detect the effectiveness of the brooms because of the night darkness but the data from the recorder showed that the brooms were in fact clearing the fog in that area.

With each fog occurrence, more is being learned not only about the characteristics of the brooms but also about the data equipment. It is still too early to make value judgements pertaining to the installation because the installation is still being refined and upgraded. However, including all the data and experience received at the installation and at the fog chamber, a substantial foundation has been laid for fulfilling the goals of this project.

(B) EVALUATION OF FOG BROOM STRANDS

The choice of the 8 lb. test nylon monofilament strands for use in the fog broom construction appears to be a good one. However, it is felt that some other material may possibly be superior and this thought has prompted the series of experiments. For example, some other strand may be superior in fog particle pick-up, mechanical strength, or outdoor weathering. The materials used for comparison with the 8 lb. test nylon monofilament were made available to us by representatives of various manufacturers. The assignment of summer help to the Bureau of Electronics and Scientific Aids made it possible to continue the experiments with little interruption.

Much more time than was anticipated was spent in attempting to amend the test conditions to get more consistent readings. The various test conditions are detailed and are a part of this report. A table summarizing the test results is also appended.

In general, results were inconclusive, but it appears that the nylon monofilament surpassed any of the yarns used in terms of water collected from the fog. A polyester (dacron) monofilament may be slightly superior in this respect, but further evaluation is indicated.

Further study is being made of the factors contributing to the variable results and the experiments will continue.

Compilation of Test Conditions and Discussion of Data

The intent of these experiments with fog broom strand material was to make comparisons between the 8 lb. test nylon monofilament material and various other materials. A standard broom of our conventional construction and the unknown of like configuration were operated in the same fog environment and under the same conditions. To minimize variables such as position in the room and motor drive speed, the brooms were interchanged for a like number of runs made each way.

A table giving the results of the runs under different test conditions and with the different strand materials is a part of this report. (page 18). For an understanding of the results reference must be made to the test conditions compiled under this section of the report.

Test Conditions A. (runs 1 & 2)

This condition is the same as that used during the initial laboratory investigation of strand size, material and spacing, and broom rotation speed. Elaborate detail is, therefore, not repeated here. A tray 30-1/2" x 3" deep having a petcock for draining off water, was centrally secured under the rotating broom member. A duct 5" wide with a 1" right angle flange extended the vertical height of the broom on each side.

Two brooms equipped as described were placed in a small partitioned section of the fog room. The polyethylene curtain did not completely seal the section but left an opening of about two feet at the top. A collimated light source, an overall light path of 20 feet and a photocell detector were used to measure fog density. The room was fogged until the photocell output was 4.5 microamperes. Then the two brooms were rotated at 90 r.p.m. until the fog was cleared corresponding to a reading of 25 microamperes.

After five cycles of fogging and clearing, the water collected in the trays was measured. The broom rotors were then switched so that their positions in the room section and the motor drives were interchanged. Equal cycles were thus made and the measurements recorded.

In the table the broom position is defined as "front, back" or "right, left". It is interesting to note more water was collected in one position than in the other, regardless of the strand material. The inconsistent readings shown in the Test Result Table led to a procedure modification.

Test Conditions B. (runs 3 & 4)

Same as "A" except the partition was removed and eight atomizing nozzles (out of the 19 previously used) closest to the brooms under test were turned off. The test brooms were started rotating at the start of fogging. Fogging continued for 20 minutes. Brooms continued rotating until the room cleared to 25 microamperes.

In general, the results of test condition "B" were less widely dispersed except for a few "wild cat" readings in run 4, for which no ready explanation could be found. This resulted in a change to "C".

Test Conditions C. (run 5)

Same as "B" except the broom speed was changed from 90 r.p.m. to 50 r.p.m.

It was thought that uncontrolled variations in fog broom speeds could influence the water collected. Vindication of the speed variations theory is substantiated by gradual deterioration of the D.C. motors used in the fog room. After selecting two motors with almost equal speeds, a series of runs were made at 50 r.p.m. Surprisingly, the water collected increased about three time over that at 90 r.p.m. However, the amounts were still widely at variance and led to inconclusive results.

A run was made with conditions like "B" except the brooms were not rotated. The water collected in the trays measured 29 and 30 milliliters. The time taken for equivalent clearing (25 u A) increased about 1-1/2 times.

Test Conditions D. (run 6)

It was at this point verified by repeating test conditions "A" (classical) that nine brooms, seven of standard construction (no trays or ducts), dispelled fog from the chamber faster at 90 r.p.m. than at 50. The better performance of the water collected brooms at the slower speed is attributed to the modification of adding water collecting ducts and a pan. No tabulized data are recorded for this run.

Test Conditions E. (runs 7 & 8)

Conditions "C" were continued but the comparison test material was changed from 1050 denier nylon yarn to 840 denier nylon yarn.

The reference material, 8 lb. test nylon monofilament, seems superior, but the results are not conclusive.

Test Conditions F. (run 9)

The locations of the brooms under test were shifted to a more central position in the fog chamber and motors having very close to the same rotation speed selected. Two nozzles were turned off, others oriented so that no direct spray would hit the test brooms. Other conditions were like "E".

The attempt of changing test broom positions in the room did not eliminate the rather wide disparity in readings. As shown in the Test Results Table, the 8 lb. test nylon monofilament is superior.

Test Conditions G. (run 10)

In order to decide the optimum speed for the brooms with added water collecting trays and ducts a series of runs were made at 25 and 75 r.p.m., other conditions were like "F".. These were compared with the water collected at 50 and 90 r.p.m., previously taken. The optimum speed is 50 r.p.m., so it was decided to use this speed for all additional evaluation runs.

Test Conditions H. (run 11)

Same as "F" except the rotation direction of the brooms was reversed. Apparently, a direction change was made at about condition "C" and was not restored. The flange on the ducts is oriented so that a clockwise (viewed from the top) rotation is desired. The comparison test material was changed from the 840 denier nylon yarn to 840 denier polyester yarn.

This run was interrupted because of the discovery of the wrong direction of rotation. The data are not included in the table.

Test Conditions I. (run 12)

The conditions were changed so that the room was fogged for 30 minutes, then cleared for 20 minutes, the brooms under test rotating all the while. A plastic cover was put over the top of the frames. Positions, etc., were the same as F. except a different motor was selected for the comparison broom.

The 8 lb. test standard is somewhat superior.

Test Conditions J. (run 13)

Same as "I" except 1100 denier polyester yarn was substituted for the 840 denier polyester yarn. The 8 lb. test standard seems decidedly superior.

Test Conditions K. (run 14)

Same as "I" except polyester monofilament was substituted for the 1100 denier polyester yarn. The polyester monofilament appears slightly superior.

A summary of the measurements indicate that the 8 lb. test nylon monofilament standard was superior in water collecting qualities to any of the yarns. The superiority was greatest when compared with the higher denier yarns. A denier is the weight in grams of 9000 meters length of material. Perhaps the polyester monofilament material is superior to the nylon monofilament. It may be noted that it has the disadvantages of lower tensile strength.

Materials Used for Comparisons

Nylon monofilament 8 lb. test Gem, Gudebrod Bros. Silk Co.

Nylon yarn 1050-175 1/2 Z-702 bright, du Pont

Nylon yarn 840-140 1/2 Z-702 bright, du Pont

Polyester yarn 840-192-R02-68 bright, du Pont

Polyester yarn 1100-192-R02-68 bright, du Pont

Polyester monofilament 500-ME 1924 SA-NC 410-06, du Pont

Considerations for Further Tests

1. Determination of the constancy of the light source - photocell detector system.

2. Improvement in water collecting adjuncts to the rotating fog brooms. A design objective would be to create less disturbance to the conventional design as indicated by rotation speed.

3. Removal of disturbing factors such as non-rotating brooms from the chamber, as it is known that these contribute to fog dispelling.

4. The significance of such a factor as the ratio of closure width, determined by effective total strand diameter, and the overall winding width. The effect of this factor on water collected with different broom rotation speeds.

5. Evaluation of many new sample materials recently received from du Pont as well as samples from other manufacturers.

(C) PORTABLE FOG BROOM DEMONSTRATOR

At the suggestion of the Office of Public Information of the N.J. Department of Transportation, a portable fog chamber demonstrator was built. It was completed by the end of August 1967 in time to be used at the N.J. State Fair from September 18 to 24, 1967. Even though the Fog Broom Abatement Project is still in the research stage, it has been introducted to the public through several news releases and by an article in Time Magazine. This demonstrator gives the public and interested agencies a good opportunity to see the brooms and judge their effectiveness. For example, at the State Fair about five thousand people watched the demonstrations.

The fog chamber is 16 feet long, eight feet wide and seven feet high, big enough to hold two brooms. It requires about three minutes to fog the chamber and two minutes to clear the fog to the point at which the rear wall of the chamber is visible. The chamber has four nozzles to produce fog from compressed air mixed with water. It also has one overhead light, one automobile headlight, one automobile fog light, and one pair of automobile taillights. When the chamber is fogged up, these taillights, located at the back of the chamber, are not visible. When the brooms are turned on these taillights become visible within six seconds and then become progressively brighter.

After the Fair, the chamber was moved to the Mercer County Airport. When it is not in use as a demonstrator, the portable fog chamber will be used by this Bureau as an environmental test chamber. Permanent compressed air, water and electrical outlets are being installed at the Airport lab for this chamber. These connections will be constructed so the chamber can be easily disconnected from these sources. The fog broom motors used at the State Fair were constant speed A.C. motors. These motors will be replaced by variable speed A.C. motors in case future tests call for variable speed evaluations.

(D) THE FOG CHAMBER AT THE MERCER COUNTY AIRPORT

The Bureau has always maintained a policy of sharing our research experiences and keeping interested agencies informed of our results. In keeping with this policy, the fog chamber has been utilized to demonstrate in actual fog conditions the effectiveness of the fog brooms. During this last year, over one hundred interested persons have viewed a fog broom demonstration. A look at the log book of persons who visited the fog laboratory shows people came from the Franklin Institute, the Navy Weather Research Facility in Norfolk, Va., R.C.A. Laboratories in Princeton, Bendix Corporation, the N.J. State Police and many other companies and agencies.

In cooperation with this Bureau, Mr. Lawrence Macrow, Consulting Engineer in industrial air conditioning systems, made use of the fog chamber at Mercer County Airport twice to test an invention of his for use in fog abatement. The device operates on a principle similar to that of the fog brooms. Fog laden air is passed through a cone-shaped unit revolving at 100 r.p.m. which is tightly laced with synthetic fiber. Moisture, which collects on the strands, is forced to the periphery by centrifugal action. The whole unit is encased in an aluminum cylinder approximately one foot in diameter, two feet long, and open at both ends.

The initial tests showed the design to be inadequate. Air did not flow through the cylinder, actually only and in-and-out turbulence was developed. Due to the results of the first series of tests, a fan was added to the device to pull foggy air through the cone. Also a larger device utilizing a larger fan and cone (about 30") was built and tested.

The results of the second series of tests at first seemed to indicate that the device was performing well. However, an ordinary twelve inch ventilating fan operating in the fog chamber cleared the fog as well as the device. The concensus is that the fog brooms, present in the chamber but not operating during the tests, were clearing the fog as the fan on the device moved air through the stationary strands. After the tests were conducted, it was indicated to Mr. Macrow that we would help to evaluate any further improved devices he might wish to submit.

TABLE OF TEST RESULTS

WATER COLLECTED, ML.

RUN	TEST COND.	BROOM POSITIONS	NYLON MONO. 8# TEST AVE.	DISPERSION	NYLON YARN 1050 DENIER AVE.	DISPERSION	REMARKS
1	A	front	100.		97.		8# test seems superior. Results not conclusive.
		back	95.		42.		
2	A	front	50.		57.		
		back	139.		72.		
3	B	front	53.2	32-61	47.6	44-49	same as above
		back	60.0	59-62	51.6	49-56	
4	B	front	63.4	61-68	57.8	52-69	
		back	70.8	68-74	116.5	51-269	
5	C	front	161.6	97-190	190.2	159-200	inconclusive
		back	244.8	230-258	217.6	209-229	
					NYLON YARN 840 DENIER		
7	E	front	215.2	172-235	182.0	169-190	8# test seems superior. Results not conclusive
		back	245.8	232-250	280.8	242-320	
8	E	front	237.4	215-270	186.8	180-200	
		back	340.4	335-347	337.4	280-387	
9	F	right	375.4	345-400	312.4	278-355	8# test superior
		left	464.6	410-492	409.0	350-479	
					POLYESTER YARN 840 DENIER		
12	I	right	395.0	380-410	389.6	382-400	8# test somewhat superior
		left	506.2	468-548	468.4	455-495	
					POLYESTER YARN 1100 DEN.		
13	J	right	368.2	350-379	179.0	165-190	8# test decidedl superior
		left	506.2	490-530	260.4	235-297	
					POLYESTER MONOFILAMENT		
14	K	right	313.0	285-330	321.2	267-382	polyester mono-filament slightl superior
		left	414.0	345-475	421.6	360-490	

A Report

on

Pilot Operation

of the

FOG SCREEN

by

Bureau of Structures & Materials

Research & Evaluation Division

New Jersey State Highway Department

Trenton, New Jersey

April 15, 1965

SUMMARY

This report was prepared to evaluate the effectiveness of a fog screen in a pilot operation under static conditions.

Presented herein is an evaluation of the pilot test operations as well as two comparable tests.

The fog screen cleared the fog in the curing room at the laboratory of the Highway Department and substantially reduced the water content in the atmosphere. The results of the tests indicate that additional pilot tests should be conducted under different and varying conditions.

Fog Screen

Pilot Operation

Purpose: To test on a pilot scale the effectiveness of the fog screen in condensing and/or dissipating fog.

Scope: This report covers the operation of a scale model fog screen in the concrete curing room of the Highway Department Laboratory under static conditions.

Background: The fog screen tests originated from an experiment being conducted at Antofagasta, Chile. The area surrounding Antofagasta is subjective to frequent dense, wind-driven fogs. German experimenters have erected in the mountain passes frames containing nylon strings. Wind drives the fog through the frames and the water in suspension collects on the nylon strings. Experimentation showed the moisture collected is not the result of condensation. The experimenters have concluded their screens have commercial potential, in relation to irrigation, etc.

Equipment: The frame for the fog screen was constructed of redwood stripes, the inside dimensions of which are 3'-10" by 2'-3". The frame is rotated around a central axis, motivation being effected by means of a fishing reel and string. Nylon strings were mounted vertically on the frames. They were of four pound test monofilament line and were placed 20 to the linear inch.

Procedure: The atmosphere in the curing room is controlled by means of a wet bulb/dry bulb recorder. This actuates the air and water supplies into the room as well as the room heater. Under normal operating conditions it is difficult to see from one end of the room (about 15') to the other due to the fog produced. The open volume of the room is 1695 cu ft.

During the tests conducted the water and heaters were deactivated in that there is no means of measuring their output. Wet buld and dry bulb temperatures were taken by means of a sling psychrometer.

Four tests were conducted relative to this investigation. Prior to each test identical conditions were established in the room.

(1) In the first test which was made as the control standard the only activity in the room was that of two investigators taking temperature readings. All outside sources of moisture were deactivated. The test ran for 13 minutes during which there was no apparent

change in the fog density and there was no measurable change in the moisture content.

(2) The second and third tests were the same as the first with the exception the fog screen was introduced and rotated at 75 rpm. The fog in the room started to dissipate after three minutes and the room was visually clear after six minutes. At the conclusion of the test (13 minutes) readings showed that 10% of the moisture in the atmosphere had been removed. Inspection of the screen showed water nodulars on the strings. The results of the test are tabulated on page 6 and shown graphically on page 7 .

(3) The fourth test was identical to the second and third with the exception that the frame was covered with 4 mil polyethelene sheets, and rotated at 75 rpm. As a result of this test there was no measurable change in the moisture content and only a slight (if any) lessening of the fog. The test time was again 13 minutes.

Conclusions: The fog screen effectively cleared the curing room after six minutes of operation and substantially reduced the moisture content in the room. Two theories have been advanced as to principal involved in the operation and effectiveness of the screen:

(1) The water molecules being forced thru the screen forms larger units by combining with one another. These in turn condense on the screen.

(2) The movement of nylon strings thru the air produces an electrostatic charge. This attracted the water suspended in the atmosphere which in turn collected on the strings. (The creation of electrostatic charge with nylon is a common occurrence.)

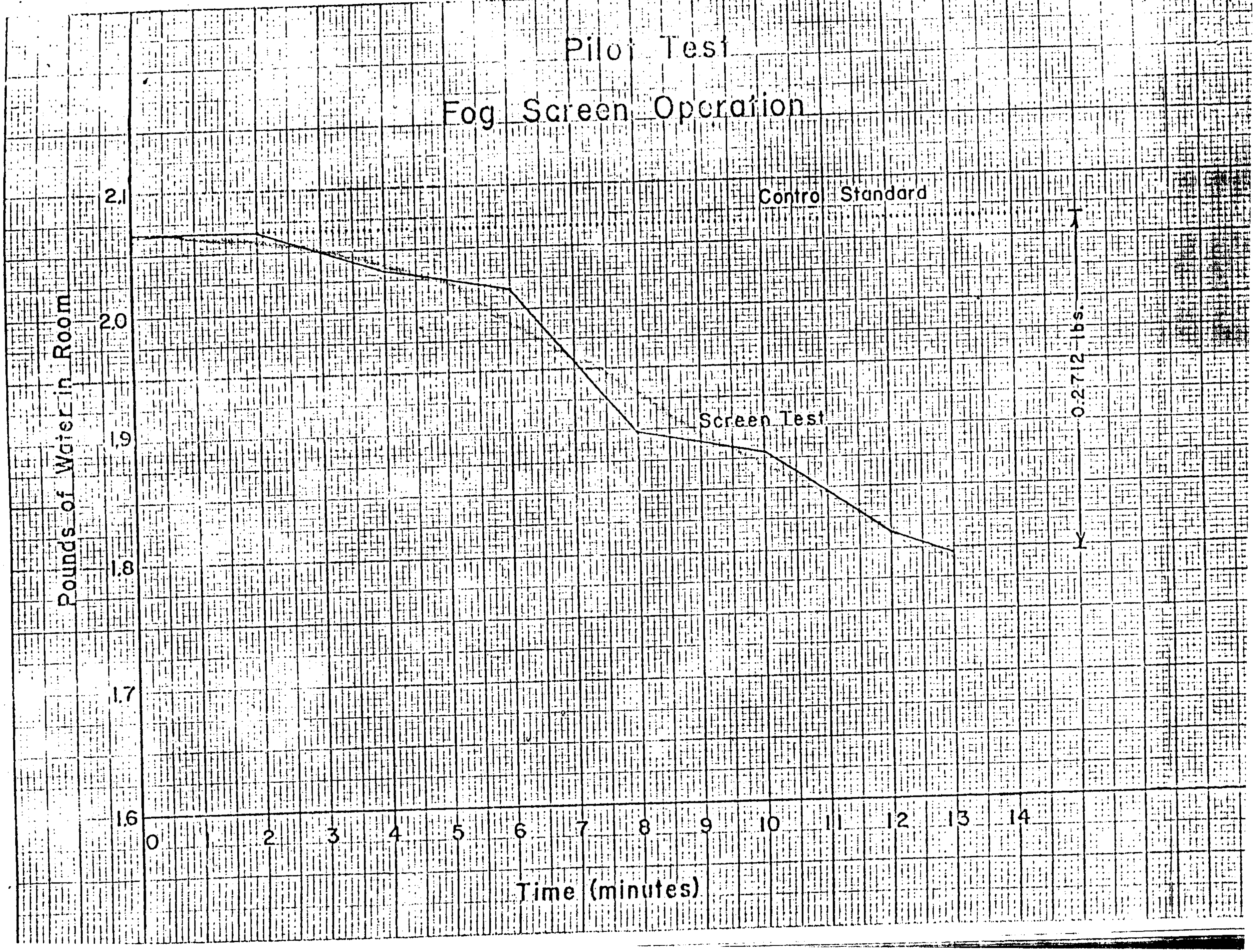
The latter theory is considered to be the more plausible. If the first were true, i.e. it resulted from fanning and mixing it is felt a measurable quantity of water would have been removed during the test with the polyethelene cover. The characteristic of the water nodulars on the fog screen also would indicate an electrical attraction. Although the Germans have not released details on their experiments in Chile they stated the principle involved was not one of condensation which it would be if the water removed was from mixing. It is possible the water removed is from a combination of the two theories.

It is felt that a significant amount of water was removed as a result of operating the fog screen. The results warrant additional pilot study of the screen application.

Of major note is the fact that the fog producing mechanism to the room had to be turned off during the test for control reasons. How effective the screen would be in an atmosphere where fog producing conditions persisted should be determined on a pilot scale prior to any field application.

Additional study of the screen utilizing the curing room is deemed impractical. It must be recognized that very small quantities of moisture are being measured. With the equipment available any minor changes or improvements in the fan and/or its application would be difficult if not impossible to evaluate.

Recommendations: No conclusive recommendations can be made as a result of these tests as to the practical application of the fog screen. Additional pilot testing is apparently warranted.



Pilot Test
Fog Screen Operation
Control Standard
Screen Test
0.2712 lbs.
Pounds of Water in Room
2.1
2.0
1.9
1.8
1.7
1.6
0
2
3
4
5
6
7
8
9
10
11
12
13
14
Time (minutes)

68-004

MEMORANDUM

TO: W. R. Bellis

FROM: R. E. Borup

SUBJECT: PROGRESS REPORT ON FOG REMOVAL EXPERIMENTS

The basic experiment conducted in the fog chamber at the Mercer County Airport utilizes a "fog-broom" of the following basic parameters:

a. a framework 30 inches by 48 inches

b. wound with 8 lb. test monofilament nylon

c. parallel to the longer dimension

d. spaced at 20 lines per inch

operated on the following parameters:

a. rotated at about 90 r.p.m.

b. horizontally

c. with the vertical axis through the longer dimension

Figure 1. is a plot of the time required to remove fog to a predetermined level of visibility versus the number of fog brooms in use, varying from about 22 minutes when no brooms are used to about 5 minutes when ten brooms are operated.

The density of fog prior to a sweeping operation is reproducibly produced as measured by the electrical output of a photoelectric cell detector. The proper relative humidity of the chamber is established by repeatedly producing the fog and permitting it to dispel by itself without the use of the rotating brooms until two successive experiments require approximately 22 minutes to reestablish the predetermined level of visibility.

This predetermined level of visibility has been arbitrarily established as that visibility which exists when the output of the photoelectric cell detector is 23 microamperes. The reproducibly produced density of fog is arbitrarily established as that level of visibility which exists when the output of the detector is 6 microamperes when the lights in the fog chamber are on.

Data obtained from experiments involving these basic parameters are then used as "base-lines" for comparable experiments in which parameters are varied. At the present, single parameter variations are made and comparative experiments are conducted in single broom operation. That is, a basic broom is compared with a modified broom.

The effectiveness of the broom is measured by the improvement in visibility versus time, determined both by personal observation and by the output of the photoelectric cell detector. During operation of the broom a record is kept of the time required to produce a 17 microamp increase in the visibility meter reading.

The efficiency of the broom is being measured by determining the moisture collecting capacity of the broom. This is expressed in cubic centimeters of water collected per minute of broom operation.

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A metal collecting device which can be attached to the fog broom under test has been constructed. This collector has shields on each side so that it will collect the water droplets which are thrown off the broom by centrifugal force, as well as the droplets which run off the broom due to gravity.

Table I shows results obtained in our large fog room (6000 cu. ft.).

Our standard fog broom wound with 8 lb. test nylon collected an average of 5.8 c.c. of water per minute of operation. An experimental broom wound with dacron collected 4.8 c.c. of water per minute.

The nylon broom dispelled the fog in an average time of 19 minutes, and the dacron broom required an average of 21½ minutes.

A broom was wound with 8 lb. test nylon with the strands in the horizontal direction. This broom did not dispel fog as rapidly as the standard broom with the nylon in the vertical direction. (21 minutes vs. 19 minutes)

The assembly holding the standard broom was placed on its side and the broom rotated. The fog did not dissipate as rapidly as it did when the broom was rotating with its axis in the vertical position. (21.5 minutes vs. 19 minutes)

When we operate only one broom in our large fog room it requires a long time to compare the effectiveness and efficiency of various design brooms. Therefore, we have installed a movable plastic curtain so that a single fog broom can be tested in a portion of the fog room equal to about 20% of the original fog room volume. The time required for the fog to dissipate by itself in this smaller volume room is the same as for the original room, but the time required for dissipation with one broom in operation is considerably less.

Table II shows results obtained in the small fog room (1200 cu. ft.).

Strand spacings from 12 per inch to 24 per inch have been tried and it has been found that the closer the spacing the better the fog dissipating characteristics, providing the strands are not so close that the spaces between them fill up with water. A spacing of 20 per inch has been found to be optimum.

The brooms have been rotated at speeds from 50 to 130 r.p.m. At speeds above 90 r.p.m. the brooms act as fans and create air currents which would move fog from an uncleared area into the cleared area. The fog dispelling ability of the brooms decreases when the speed of rotation is reduced below 90 r.p.m. Therefore, 90 r.p.m. has been selected as the optimum speed to be used with brooms of our standard design.

Experimental brooms have also been constructed using 30 lb. test and 60 lb. test monofilament nylon. These nylon strands stretched so much that the strands stuck together and the brooms fanned the fog with very little fog dissipation.

Enameled copper wire was tried, but this stretched, and the strands stuck together. Stainless steel wire also stretched and the strands stuck together. We are now investigating the possibility of using one or more layers of knitted stainless steel padding of the type used in commercial equipment for eliminating mist from gas.

Experimental brooms have been constructed using polypropylene, rubberized horse hair and pig hair, nylon mesh, and a perforated copper-bronze sheet used as an awning material and known as Kool Shade, but none of these materials has shown as good all-around results as the 8 lb. test monofilament nylon.

The stainless steel wire with the strands stuck together collected slightly more water than the nylon, but was not as effective as the nylon in the improvement of visibility. This was probably due to the greater fan action which brought fog from uncleared areas into the cleared area being measured by the photoelectric cell.

The same condition existed with the polypropylene, but in this case the greater fan action was caused by the increased cross-section of the strands. (.050" vs. .012 for the nylon)

The Kool Shade brooms also produced a fan action. Another disadvantage of these brooms lies in the fact that they would have to be constructed and mounted very strongly to prevent wind damage in outdoor installations.

The rubberized horse hair and pig hair were effective in improving the visibility, but they absorbed the water and it was not dropped into the collector. After they were soaked with water they were not as effective in visibility improvement. In addition, they had a very objectionable odor when wet.

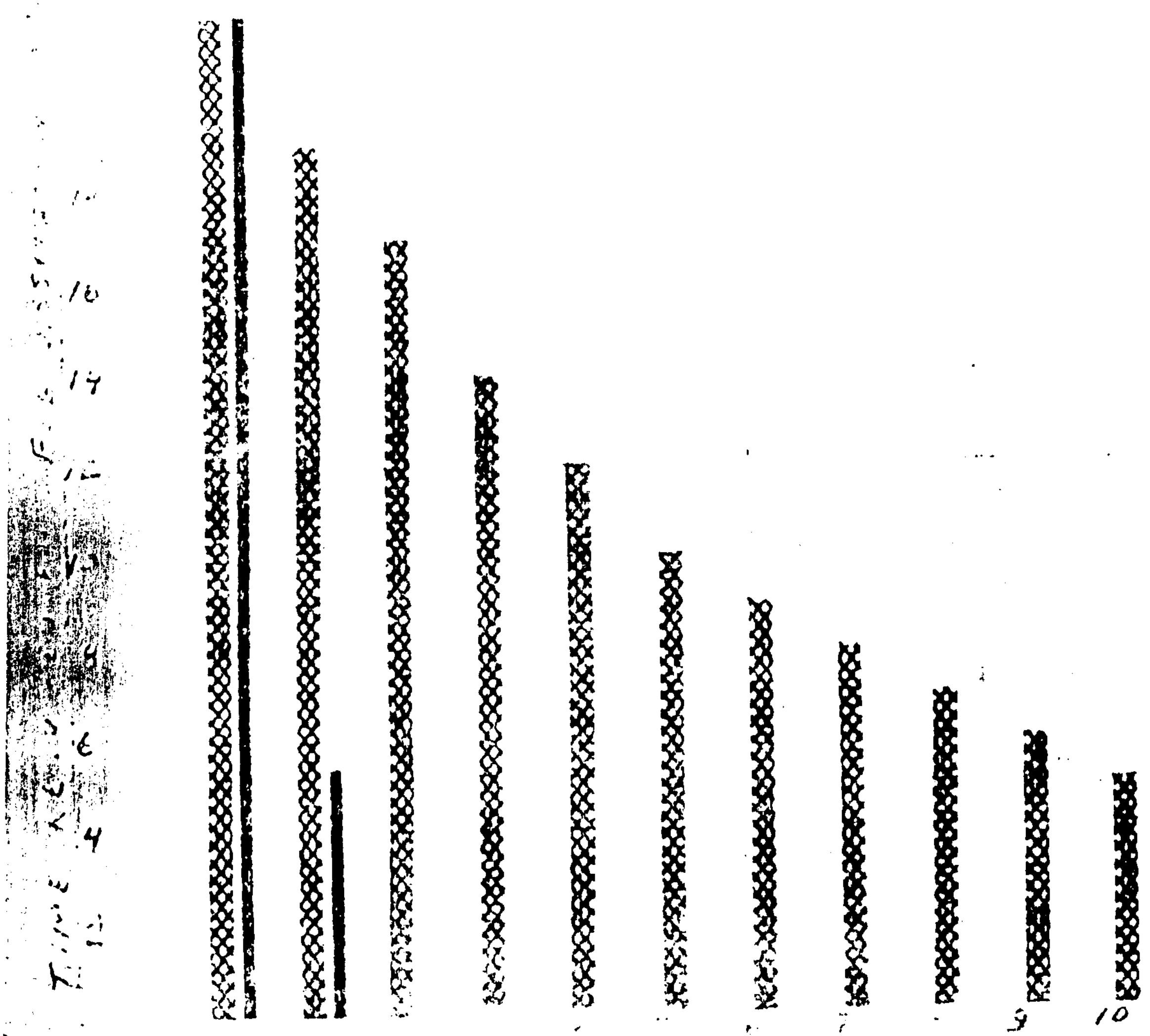

FIGURE 1

AVERAGE TIME REQUIRED FOR FOG TO DISSIPATE WITH VARIOUS NUMBERS OF FOG BROOMS IN OPERATION

(cross-hatched bar) INDICATES TIME IN LARGE FOG ROOM

(solid bar) INDICATES TIME IN SMALL FOG ROOM

TABLE I

AVERAGES OF TEST RESULTS OBTAINED WITH SINGLE BROOM OPERATING IN 6000 CU. FT. OF FOG

Broom Design No.	Winding Direction, Material & Spacing	Time Required to Produce a 17 Micro-Amp Increase on Visibility Meter	Water Collected Per Minute of Operation
3	Vertical .050 Polypropylene (14/inch)	21 min.	5[illegible] c.c.
6	Vertical Dacron (16/inch)	21-1/2 min.	4.[illegible] c.c.
7	Vertical 8 lb. nylon (20/inch)	19 min.	5.8 c.c.
	" " (rotated horizontally)	21-1/2 min.	-
8	Diagonal 8 lb. nylon (20/inch)	20 min.	-
9	Horizontal 8 lb. nylon (20/inch)	21 min.	-
11	Rubberized Hair Mat (30" x 26")	-	4.2 c.c.
12	Rubberized Hair Mat (24" x 48")	-	1.0 c.c.
13	Vertical Kool Shade	-	5.6 c.c.
14	Horizontal Kool Shade	-	-
15	Rubberized Hair 12 hinged pieces (4"x15")	-	-
16	Nylon Mesh 144 openings/sq. in.	-	-
17	Stainless Steel Wire (20 per inch) vertical	-	-

TABLE II

AVERAGES OF TEST RESULTS OBTAINED WITH SINGLE BROOM OPERATING IN THE CURTAINED ROOM CONTAINING 1200 CU. FT. OF FOG

Broom Design No.	Winding Direction, Material & Spacing	Time Required to Produce a 17 Micro-Amp Increase on Visibility Meter	Water Collected Per Minute of Operation
3	Vertical .050 Polypropylene (14/inch)	5.7 min.	6.9 c.c.
6	Vertical Dacron (16/inch)	-	-
7	Vertical 8 lb. nylon (20-inch)	5.4 min.	6.6 c.c.
			-
8	Diagonal 8 lb. nylon (20/inch)	-	-
9	Horizontal 8 lb. nylon (20/inch)	-	-
11	Rubberized Hair Mat (30" x 26")	-	-
12	Rubberized Hair Mat (24" x 48')	-	-
13	Vertical Kool Shade	6.2 min.	7.2 c.c.
14	Horizontal Kool Shade	6.5 min.	7.1 c.c.
15	Rubberized Hair 12 hinged pieces (4"x15")	5.5 min.	3.0 c.c.
16	Nylon Mesh 144 openings/sq. in.	6.1 min.	5.0 c.c.
17	Stainless Steel Wire (20 per inch) vertical	7.3 min.	7.1 c.c.