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MATERIALS REPORT ON THE LOCKHEED ATC-1 TRANSPARENT, ELECTRICALLY CONDUCTING COATING FOR ACRYLIC PLASTIC

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FOREWORD

This report was prepared by the Analysis and Measurement Branch and was initiated under Research and Development Order No. 112-28(Y-A) "Suppression of Precipitation Static". The materials evaluation was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with L. H. Bullis acting as project engineer.

Acknowledgement is made to the Cornell Aeronautical Laboratory, the Lockheed Aircraft Corporation, and the Flight Test Division of WADC for their cooperation and assistance in this program.

ABSTRACT

Accelerated weathering tests, air and rain erosion tests, and flight tests were conducted on the Lockheed ATC-1 transparent, electrically conducting coating to determine its suitability for use on canopies of military aircraft for the reduction of precipitation static. The coating successfully retained the desired values of electrical conductivity, transmittance, and haze throughout most of the tests. On this basis it is recommended from the materials standpoint as a coating meeting the physical requirements established by the Communication and Navigation Laboratory, WADC.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

M. R. WHITMORE
Technical Director
Materials Laboratory
Directorate of Research

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I. INTRODUCTION

One of the problems associated with the operation of modern, high-speed jet aircraft is the formation of precipitation static, which is the name given to static produced as a result of the presence in the atmosphere of particles of dust, rain, snow or ice. When aircraft encounter regions of air containing particles such as these, the particles strike the aircraft and are often electrically charged by the force or friction of impact. The particles therefore rebound leaving a charge of equal magnitude but opposite sign upon the surface of the aircraft. Although such charges when formed upon electrically conducting areas of the aircraft are to a large extent dissipated by the jet exhaust and wick dischargers, charges formed on the non-conducting areas are not free to move and thus remain in the region of impact, gradually increasing in magnitude until voltages high enough to cause arcing to the aircraft frame are produced. This phenomenon, known as corona discharge, is one of the primary causes for the production of static in communication and navigation equipment, and under adverse conditions such static may be sufficient to completely mask radio signals or may cause the radio compass to fluctuate to such an extent that it becomes useless. Clearly, precipitation static is greatest when flying conditions are most unfavorable, or precisely when the affected equipment is most needed.

One promising means proposed for overcoming this difficulty is by coating non-conducting areas with a conducting coating, thereby allowing the charges to be conducted via the airframe to the wick dischargers and the exhaust. Since most of the non-conducting areas involved are transparent, i.e. glass or plastic, the conducting coating material must of necessity be highly transparent. This is but one of the many requirements established by the Communications and Navigation Laboratory, WADC for such a coating. Others include resistance to both air and rain erosion, negligible haze, and a surface resistance from one to ten megohms per square. Work toward the development of such a transparent, electrically-conducting coating has progressed under Air Force Contracts AF 33(038)-12240, AF 33 (038)-23319, and AF 33(616)-2027.*

Aided by information contained in reports under Contract AF 33(038)-23319, the Lockheed Aircraft Corporation** independently developed a coating which may serve as an emergency measure pending development of a more suitable coating. Emphasis in this case was placed upon ease of application rather than durability. Details concerning the coating and the procedure for applying it to acrylic plastic are given in Appendix I.

This report presents the results of the evaluation of the Lockheed ATC-1 coating from the materials standpoint.

* A summary and evaluation of this work will appear in a WADC Technical Report.

** See Lockheed Report No. 9319(August 13, 1953).

II. TEST PROCEDURE

The Lockheed ATC-1 coating was subjected to three general types of tests: accelerated weathering tests, air and rain erosion tests, and flight tests.

Accelerated weathering tests were performed on specimens taken from samples submitted for evaluation by Mr. F. W. Thomas of the Lockheed Aircraft Corporation. The tests were conducted in accordance with methods outlined in Specification L-P-406b and included the following: (a)sunlamp exposure, Method 6021, omitting the fog cycle; (b) sunlamp and fog exposure, Method 6021, and (c) carbon arc and water spray exposure, Method 6022. 'Results of the tests are given in Tables I-III. All tables listed are in Appendix III.

Air and rain erosion tests simulating flight at approximately 260mph were conducted at WADC, the specimens being eroded for periods up to two hours. Results of the tests are given in Table IV. More elaborate air and rain erosion tests simulating flight from 460-550 mph were conducted at the Cornell Aeronautical Laboratory, Buffalo, N. Y. Results of these tests are given in Tables V-VIII.

Flight tests were carried out by coating the canopy of an F-86 test aircraft and flying it in both clear and rainy weather. The aircraft was first flown in clear weather, surface resistivity readings being taken after each flight for a total flight period of almost ten hours. Results of this test are given in Table IX. The canopy was cleaned and recoated and flown again for approximately an hour and a half in rainy weather and six hours in clear weather for a total period of seven and one-half hours. The canopy was again cleaned and recoated and flown for approximately two and one-half hours in rain and one and one-half hours in clear weather for a total of four hours. The results of these tests are given in Table X.

Details concerning these tests are given in Appendix II.

III. DISCUSSION

Although the Lockheed ATC-1 coating is not suitable as a permanent coating on an aircraft canopy, it was considered desirable to subject it to the standard accelerated weathering tests, partly to determine whether it would suffer breakdown too quickly to make it useful even as a temporary measure, and partly to determine if any of its constituents would cause damage to a canopy upon exposure to heat and ultraviolet radiation. As shown in Tables I-III, however, the values of resistance, transmittance, and haze for various specimens did not in general undergo significant change during any of the accelerated weathering tests. In some instances there were marked decreases in resistance, but this was largely due to a reduction in contact resistance as the silver-paint electrodes became baked into the plastic by the heat of the tests.

The above tests were promising enough to warrant preliminary rain erosion tests, as shown in Table IV. Specimens AM 335-1 and AM 335-2, initially with resistances of less than 1 megohm per square and haze values of less than 1%, increased to 100 megohms per square and 10% haze after only three minutes of test. Specimens AM 335-7 and 335-9, however, taken from the same sample, showed only slight increases after an hour of test. Further specimens were therefore tested for a period of three minutes, but in no case did the resistance fail to remain in the 1-10 megohms per square range. The resistance of specimens AM 336-5 and AM 336-6, which were eroded for two hours, rose considerably beyond this range, however, and in addition became hazy to an undesirable extent.

These results were surprising, nonetheless, in view of the fact that the ATC-1 coating could be easily wiped off any specimen with a soft cotton cloth, particularly if the cloth was wet. More elaborate air and rain erosion tests were therefore conducted, using the facilities of the Cornell Aeronautical Laboratory together with specially designed samples as described under Test Procedures, Appendix II. As can be seen from Table VI, specimens AM 1063 and AM 1064 both retained good conductivity (resistances in the range of 1-10 megohms per square) along the sides of the specimens(a,b,d, and e positions, see Figure 2, Appendix III), whereas the frontal or leading edge areas (c positions) quickly eroded, particularly along the high-speed ends(1, 2, and 3 positions). The best results for a leading edge position were obtained on 5c of Specimen AM 1064, which retained a measurable conductivity for somewhat more than one minute. This is in sharp contrast to position 4a of this specimen, which did not change throughout the test.

Comparison of these specimen areas emphasizes the extreme difference in erosion occurring on the leading edge of a specimen to that occurring along side areas. Erosion is so extreme along the leading edge that the specimen itself begins to erode after only 1/2 minute. After 1 minute, scattered pit marks appear along the high-speed end of the leading edge; after 5 minutes, the entire leading edge becomes pitted; after 10 minutes, the leading edge becomes heavily pitted; and after 15 minutes, pitting is so severe that scattered holes going completely through the 1/8 in. thick specimen appear. Obviously, no thin, conducting coating could be expected to last long under such conditions. It appears possible, however, that such a coating might last along the side areas for periods considerably in excess of the test time of 15 minutes, since most of these areas retained their conductivity throughout the test.

As can be seen from Table VII, the coating remained virtually unchanged on all areas of Specimens AM 1065 and AM 1066 after 1 1/2 hours of erosion in dry, dust-free air. This is even more correct when one takes into account the consideration that a large part of the variation in the results is due to (1) the difficulty of placing the probe in exactly the same spot for successive readings on any given specimen area, and (2) the variation in line voltage at the Cornell Aeronautical Laboratory, which made identical zeroing of the ohmmeter for each run impossible.

Comparison of the "c" values given in Table VIII with those given in Table VI demonstrates a tendency for coatings produced using thick coats of primer to erode less quickly than those produced with thin coats of primer. This is not of particular importance, however, in view of the fact that the thinnest primer coats produced coatings which did not erode along the sides of the specimens to any great extent and were at the same time optically better than the coatings prepared with thick coats of primer.

These tests at the Cornell Aeronautical Laboratory demonstrate that a coating such as the Lockheed ATC-1 will not remain on canopy areas, the normals of which make angles of 30° or less with the direction of flight, and will be eroded more quickly at higher speeds. A comparison of the Cornell tests with those conducted at WADC at much lower speeds, as shown in Table IV, bears this out, inasmuch as the latter tests were conducted with the water striking the specimens at right angles, similar to "c" positions on the Cornell specimens.

The most important feature of these tests was that although the ATC-1 coating has extremely poor resistance to abrasion by rubbing, the forces involved here are quite different from those encountered by a bombardment of the coating by atmospheric particles, as is the case encountered in actual practice. Thus, insofar as the life expectancy of the coating during operation is concerned, resistance to abrasion by rubbing is unimportant.

In view of these results, the ATC-1 coating was given flight tests to determine if the results of laboratory testing would be substantiated in actual practice. Data given in Tables IX and X show that this is indeed the case. The data obtained from flight tests indicated that within the time limits of the tests, the electrical resistance of the coating did not appreciably change. In those instances shown where the coating resistance became infinite, it was apparent from the appearance of the canopy that the coating had been rubbed off rather than eroded, usually by the pilot when using the canopy to maintain balance on entering and leaving the cockpit.

The flight tests described above have shown that the Lockheed ATC-1 coating can be expected to remain uneroded on an aircraft canopy for at least ten hours during flight through dry air and for at least three hours flight through rain. It is entirely likely that the coating will remain uneroded for periods considerably longer than these, since after tests of these durations the electrical resistance of the coating had not yet begun to change from the original values. It is therefore evident that the coating may be considered suitable for flights of ordinary duration under conditions normally encountered. The behavior of the coating under conditions of extremely heavy rainfall, i.e. several inches per hour, was not established in these tests, but there is no reason to believe that it would be removed even under conditions such as these provided the rain did not exert a strong frictional force on the canopy.

IV. CONCLUSIONS

The Lockheed ATC-1 transparent, electrically-conducting coating did not erode from an F-86 aircraft canopy during ten hour's flight through dry air and three hour's flight through rain.

APPENDIX I

Lockheed Aircraft Corporation Procedure for The Application of the ATC-1 Conductive Coating

The procedure which has been established for the application of the ATC-1 coating to an acrylic canopy is as follows:

1. Cleaning Procedure:

The acrylic canopy is first cleaned with ATC-1 cleaner. This cleaning operation may be performed on both the inside and outside surfaces of the canopy to provide maximum light transmission. Cleaning the inside surface frequently removes oil, grease, or stains contributing to haze. The ATC-1 cleaner is applied to the acrylic surface and is rubbed off with a new, clean, soft diaper-type cloth, specially supplied for this purpose. No subsequent cleaning action should immediately follow the use of the ATC-1 cleaner, since such action will cause irregular, or spotty application of the conducting material. The ATC-1 cleaner has been carefully evaluated for any crazing tendency. No crazing is observed under stresses of 3000 pounds per square inch.

2. Application of ATC-1 Primer:

An ATC-1 primer solution may be sprayed or rubbed on the acrylic surface. The primer film is optically transparent, haze-free, and serves only to retain the conducting film. Application of the ATC-1 primer must be such that a uniform film is obtained. Such uniformity is readily attained by wiping the acrylic surface with a clean cloth, or Kleenex saturated with the primer. An oscillatory motion of the hand usually produces a more uniform film than a strictly linear motion. Standard spray equipment using a fine mist-like spray is also satisfactory. The ATC-1 primer dries immediately on application, and requires no external source of heat for cure. After the primer has been applied it may be lightly rubbed with a soft cloth, or Kleenex to insure a uniform film.

3. Application of ATC-1 Conducting Film:

A conductive material has been selected for optimum electrical and optical properties. This material is designated as ATC-1 conductive coating compound. The compound is applied as a dry powder to a velvet glove, which retains the material and serves as the applicator pad. The velvet glove with the applied ATC-1 conductive coating compound is applied to the primed acrylic surface by a light oscillatory motion, transferring the conductive powder to the acrylic surface to produce a uniform conductive film having desirable electrical and optical properties. The conductivity of the coating is a minimum as first applied. In fact, it may show no conductivity at all; however, a light buffing action with the velvet pad soon brings the resistance to the required level. The conductivity of the film may be readily measured by any of the standard methods noted in the literature. Approximately 30 minutes are required to process a canopy as a field test operation.

4. Maintenance:

The coating can be readily and safely stripped, or removed from the canopy with ATC-1 cleaner and a new clean diaper-type cloth. The durability of the coating during normal flight, under conditions exclusive of rain or snow, has been found to be good. If it is necessary to clean the canopy because of grease, oil, dirt, etc., such cleaning operation may increase the resistance of the film beyond the allowable limit, in which case the ATC-1 coating material may be re-applied to the surface by means of the velvet mitt. If the primer has been removed during cleaning it will be necessary to re-process the canopy as previously described.

APPENDIX II

DETAILED TEST PROCEDURE

Tests conducted on the Lockheed ATC-1 coating can be conveniently grouped into the following: (a)accelerated weathering tests, (b)air and rain erosion tests, and (c)flight tests.

A. Accelerated Weathering Tests

Accelerated weathering tests were performed on samples of 6x6x1/16 in. flat acrylic sheet having approximately the desired properties of 80% transmittance, 1% haze, and a surface resistance of 1-10 megohms per square. The samples, submitted by Mr. F. W. Thomas of the Lockheed Aircraft Corporation, were identified as 10, 5, and 1/2 and were assigned Analysis and Measurement Branch Serial Numbers AM 334 through 337, respectively.

Each sample was cut into nine 2x2x1/16 inch specimens and the resistance transmittance, and haze of each specimen were obtained before and after each test. Resistance measurements were obtained with an RCA VoltOhmyst ohmmeter using silver paint electrodes. Transmittance measurements were obtained using a General Electric Recording Spectrophotometer. A typical curve is given in Figure 1. All figures and tables are given in Appendix III. Since the curves were fairly flat with constant slope, variations of the weighted values below 555 mu from the average essentially cancelled out the variations of value above 555; therefore the value at 555 mu, the wavelength to which the human eye is most sensitive, was recorded. The values obtained for resistance, transmittance, and haze are given as R_0, T_0, and H_0 in the appropriate tables.

Specimens AM 337-1 through AM 337-6, respectively, were assigned to sunlamp exposure for 500 hours using a Type S-1 lamp for 150 hours and a Type S-4 lamp for 350 hours. The test was conducted as outlined in Method 6021, Specification L-P-406b, omitting the fog cycle. The results of this test are given in Table I.

Specimens AM 337-7 through AM 337-9, respectively, were subjected to sunlamp and fog exposure for 240 hours as specified in Method 6021, Specification L-P-406b. The results of this test are given in Table II.

Specimens AM 334-1 through 334-9, respectively, were subjected to carbon arc and water spray exposure for 100 hours as specified in Method 6022, Specification L-P-406b. Since the apparatus available for this test was not connected to a distilled water supply, the specimens became coated with impurities, and useful measurements of transmittance and haze could not be made following the test. The results of this test are given in Table III.

B. Air and Rain Erosion Tests

Specimens AM 335–1 through 335–7 and AM 335–9, respectively, were subjected to a rain erosion test under conditions roughly simulating flight through rain at 260 mph for periods up to one hour, the water being incident normally upon the specimens. The results of this test are given in the upper half of Table IV. Since these results were inconsistent, a further series of tests was therefore made using Specimens AM 336–1 through 336–6, respectively. The results of this test are given in the bottom half of Table IV.

More elaborate erosion tests than those reported above were conducted at the Cornell Aeronautical Laboratory, Inc., Buffalo, New York. The specimens used were the standard methyl–methacrylate specimens (Lucite and Plexiglas) made by the plastics group of the Cornell Laboratory and designed to fit their rain erosion tester. The specimens were approximately 5x2-3/4 x 1/8 inch, formed into the shape of a symmetrical air foil having a leading edge radius of curvature of approximately 1/8 inch as shown in Figure 2. The specimens were assigned Analysis and Measurement Branch Serial Numbers 1063–1070, and were coated as described in Appendix I. Specimens were given one to three coats of primer material and were eroded in both rain and dry air, as shown in Table V.

The apparatus used was the Cornell rain erosion tester, which consists of an 1800 rpm motor geared to a double–bladed metal propeller so as to rotate the latter at 3600 rpm. One specimen can be mounted on the leading edge near the extremity of each blade, the specimens being held in place by metal clips. The distances from propeller center to the inner edge, center, and outer edge of each specimen are respectively 21.5, 23.5, and 25.8 inches. The corresponding linear velocities of these portions of the specimens are therefore 460, 503, and 551 mph with other portions varying linearly between the two extremes. Water is ejected under pressure from a spray–type nozzle located sufficiently high above the propeller to allow the drops of water to attain free–fall before striking the blades, the pressure being controlled so as to allow a simulated rain of approximately one inch per hour.

Resistance measurements were made on twenty–five areas of each specimen during these tests. The measurements were made using a probe constructed of aluminum foil mounted on sponge rubber strips such that each placement of the probe on the specimen measured an area of approximately 1/8 square inch. One edge of each specimen was numbered from one to five at equal intervals, the number one being placed on the high–speed edge as shown in Figure 2. This served to locate points along the axis or length of the specimen. Points along the width of the specimen were located by the letters a through e, the letters a and e corresponding to the actual specimen edges and the letter c corresponding to the leading edge, or high–curvature frontal region. The probe was connected directly to an RCA VoltOhmyst ohmmeter which was operated on the Xmeg scale for all readings.

Specimens AM 1063 and AM 1064 were rain eroded first. Resistance readings were taken after 0, 0.5, 1, 5, and 15 minutes without removing the specimens from the propeller blades, since adequate drying of the specimens took place during the time required for the blades to come to rest. Readings could not be taken on positions 1b, 1c, and 1d after the specimens were mounted because they were shielded by the metal clips holding the specimens to the blade. Results of the test are given in Table VI.

Specimens AM 1065 and AM 1066 were eroded in air alone, partly to determine if any erosion took place during the period required for the blades to attain maximum velocity, and partly to correlate the results being obtained from flight tests through dry air being conducted at WADC(see Part C below). The results of this test are given in Table VII.

Tests given Specimens AM 1063 and AM 1064 so severely pitted the specimens along the leading edges that attempts were made to prevent this from occurring with future specimens by coating the leading edges with 3M No. EC 847 rubber-base cement. Specimens AM 1067 and AM 1068 were treated in this manner, the coating being reapplied to the leading edges every three minutes. In spite of these precautions the specimens still became pitted during the test, so that rain erosion was limited to 15 minutes at most due to danger of the pitted edges cracking and allowing the specimens to be shattered. No results for these specimens are reported.

Finally, Specimens AM 1069 and AM 1070, each of which had been given three coats of ATC-1 Primer, were rain-eroded exactly as were Specimens AM 1063 and AM 1064, with the exception that the test time was limited to 10 instead of 15 minutes in order to prevent specimen rupture due to pitting. Results are given in Table VIII.

C. Flight Tests

Erosion of the ATC-1 coating under actual service conditions was carried out by coating the canopy of an F-86 test aircraft and flying it both in clear and in rainy weather. The coating was applied according to the procedure given in Appendix I, and measurements of surface resistivity were made using a Superior Model 610B megohm meter and a probe constructed from aluminum foil mounted on sponge rubber strips such that each placement of the probe on the canopy measured an area of approximately one square inch. Readings of resistance were taken at nineteen locations on the canopy, the locations being numbered on the underside of the canopy so that approximately the same area was measured each time. Locations 1 through 12 were on the forward third of the canopy, location 1 being on the pilot's right, 2 over his head, and 3 on his left. Numbers 4, 5, 6 represent locations about two inches back along the canopy, 4 being behind 1, 5 behind 2, etc. Locations 7, 8, 9 and 10, 11, 12 were similarly located toward the rear of the canopy, thereby dividing the forward third of the canopy into two-inch zones. Likewise, locations 13, 14, 15 were approximately half way toward the back, 16, 17, 18 two-thirds of the way back, and 19 on the extreme end.

The aircraft was first flown in clear weather, readings being taken after each flight for a total flight period of nine hours fifty minutes. Results of this test are given in Table IX.

The canopy was cleaned and recoated and flown again for one hour twenty minutes in rain and six hours ten minutes in clear weather, for a total of seven hours thirty minutes. The results of this test are given in the left half of Table X. The canopy was again cleaned and recoated and flown for two hours forty minutes in rain and for one hour thirty-five minutes in clear weather, for a total of four hours fifteen minutes. The results of this test are given in the right half of Table X.

APPENDIX III

TABLES AND FIGURES

Table I

Accelerated Weathering of ATC-1 Coating by Sunlamp Exposure (500 hrs)

Identification of Specimen	Before Test			After Test		
	R_o*	T_o(%)	H_o(%)	R*	T(%)	H(%)
AM 337-1	2.7	79	1.5	2.6	78	1.4
" -2	4.3	80	2.0	3.1	80	1.9
" -3	1.2	77	1.5	1.0	76	1.0
" -4	4.9	79	0.5	8.5	78	0.5
" -5	8.4	80	2.5	5.7	78	2.5
" -6	1.6	80	1.0	1.5	79	1.5
Control 1	—	92	0.1	—	92	0.5

* Megohms per square

Table II

Accelerated Weathering of ATC-1 Coating by Sunlamp and Fog Exposure (240 hrs)

Identification of Specimen	Before Test			After Test		
	R_o*	T_o(%)	H_o(%)	R*	T%	H%
AM 337-7	1.4	77	0.7	1.2	76	1.4
" -8	2.1	77	0.5	1.5	78	0.5
" -9	0.8	82	0.5	0.8	81	0.5
Control 2	—	92	0.1	—	92	0.2

* Megohms per square

Table III

Accelerated Weathering of ATC-1 Coating by Carbon Arc with Water Spray (100 hrs)

Identification of Specimen	Before Test R_o*	T(%)	H(%)	After Test R*
AM 334-1	4.0	81	0.4	3.1
" -2	130	82	0.3	38
" -3	7.0	81	0.3	5.1
" -4	15	82	0.4	11
" -5	2.5	80	0.4	1.7
" -6	2.0	80	0.5	1.3
" -7	6.5	81	0.3	2.8
" -8	3.1	80	0.4	2.6
" -9	3.8	82	0.3	3.3

* Megohms per square

Table IV

Weathering of ATC-1 Coating by Rain Erosion

Identification of Specimen	Before Test R_o*	Before Test T_o(%)	Before Test H_o(%)	Time (min)	After Test R*	After Test T(%)	After Test H(%)
AM 335-1	0.4	75	1.0	3	100	78	10
" -2	0.6	75	1.0	3	100	78	10
" 5	1.5	78	1.1	10	8.2	77	2.0
" 6	0.5	76	1.0	10	0.9	76	2.3
" 3	0.2	75	1.0	30	0.2	75	1.5
" 4	0.6	77	1.7	30	0.9	77	1.5
" 7	0.8	76	1.4	60	2.1	78	10
" 9	0.2	71	1.0	60	0.3	72	1.7
AM 336-1	0.6	77	0.5	3	1.2	78	1.6
" -2	1.8	78	1.5	3	4.8	78	2.0
" -3	0.6	76	1.5	3	1.1	77	2.5
" -4	1.2	80	0.5	3	1.8	79	1.5
" -5	0.8	77	1.4	120	98	78	2.5
" -6	0.3	75	1.2	120	20	78	3.0

* Megohms per square

Table V
Identification of Test Specimens Tested at Cornell Aeronautical Laboratory, Inc.

AM Number	Cornell Number	Primer Coats	Type of Erosion	Base Material
1063	817A	1	Rain	Plexiglas
1064	818A	1	Rain	Plexiglas
1065	819A	1	Air	Plexiglas
1066	820A	1	Air	Lucite
1067	821A	2	—	Lucite
1068	822A	2	—	Lucite
1069	817B	3	Rain	Plexiglas
1070	819B	3	Rain	Plexiglas

Table VI

Rain Erosion of ATC-1 Coating(One Primer Coat)

Location on Specimen	Specimen AM 1063 Resistance(in megohms per square) after time indicated(in minutes)					Specimen AM 1064 Resistance(in megohms per square) after time indicated(in minutes)				
	0	.5	.1	5	15	0	.5	1	5	15
1a	1.5	3.5	2.6	3.7	12	.3	.7	.6	1.0	5.5
b	.8	—	—	—	—	.2	—	—	—	—
c	1.0	—	—	—	—	.2	—	—	—	—
d	1.0	—	—	—	—	37	—	—	—	—
e	2.1	3.5	3.6	3.1	400	2.8	.1	1.5	11	
2a	.5	.9	1.0	1.1	1.1	.1	.4	.5	.5	.7
b	.3	1.2	1.6	4.5	2.0	.1	.6	.7	1.2	.5
c	.6	500	∞	∞	∞	.1	500	∞	∞	∞
d	.5	1.0	1.0	1.6	1.9	1.4	3.0	4.0	1.7	2.8
e	1.0	1.0	1.5	1.9	2.3	.7	1.0	15	1.2	1.4
3a	.6	.7	.7	.8	.8	.1	.1	.1	.2	.1
b	.4	.9	1.3	1.6	1.9	.1	.1	.2	.3	.2
c	.4	600	∞	∞	∞	.1	200	∞	∞	∞
d	.5	.8	1.3	1.5	1.9	.4	.5	.5	.3	.5
e	1.3	1.3	1.2	1.8	1.1	.2	.3	.3	.1	.3
4a	1.3	1.3	1.5	2.3	2.6	.1	.1	.1	.1	.1
b	.5	1.2	2.0	3.8	4.3	.1	.1	.1	.3	.2
c	.3	400	∞	∞	∞	.1	150	∞	∞	∞
d	.6	1.0	1.0	1.9	2.4	.2	.3	.3	.5	.7
e	3.4	1.7	3.0	5.6	7.0	.3	.1	.1	.1	1.6
5a	7.0	4.6	4.8	7.5	14	.2	.1	.1	.1	.7
b	10	9.0	13	18	22	.2	.1	.1	.6	.7
c	.9	50	∞	∞	∞	.5	110	500	∞	∞
d	3.0	1.5	2.6	4.7	40	2.2	.9	1.5	3.0	55
e	40	3.0	10	30	500	15	.8	1.9	.2	300

Table VII

Erosion of ATC-1 Coating in Dry, Dust-free Air(One Primer Coat)

Location on Specimen	Specimen AM 1065 — Resistance(in megohms per square) after time indicated(in minutes)						Specimen AM 1066 — Resistance(in megohms per square) after time indicated(in minutes)					
	0	5	20	40	60	90	0	5	20	40	60	90
1a	.6	.7	.9	.7	2.1	.8	9.0	3.5	2.7	8.0	9.0	1.6
b	.8	—	—	—	—	—	.3	—	—	—	—	—
c	.4	—	—	—	—	—	.5	—	—	—	—	—
d	.4	—	—	—	—	—	.2	—	—	—	—	—
e	2.0	.1	1.7	.5	2.0	1.7	1.2	.5	.2	1.2	2.4	1.2
2a	2.0	2.1	4.2	1.9	8.5	5.8	.3	.2	.2	.3	.8	.4
b	.1	.3	.3	.5	1.2	1.0	.1	.1	.1	.1	.4	.1
c	.1	.1	.2	.4	1.0	.8	.2	.1	.4	.6	1.0	.9
d	.1	.1	1.0	.8	3.0	7.0	.1	.2	.1	.1	.4	.2
e	.3	.1	.3	.3	.7	.6	.9	.2	.8	.6	1.7	1.2
3a	.6	1.0	1.1	1.1	1.5	1.2	.2	.1	.1	.1	.5	.1
b	.1	.1	.1	.1	.3	.2	.1	.1	.1	.1	.3	.1
c	.1	.1	.3	.3	1.0	.6	.4	.2	.3	.5	1.2	.8
d	.3	.1	.1	.1	.4	.5	.9	.5	.6	1.0	1.7	1.5
e	.3	.1	.1	.2	.5	.3	3.5	.2	2.2	2.0	7.0	6.0
4a	.6	.5	.5	.5	1.3	1.1	.2	.1	.1	.1	.6	.1
b	.2	.1	.1	.3	.6	.4	.1	.1	.1	.1	.4	.2
c	.5	.2	.4	.6	1.6	1.2	.4	.4	.5	.9	1.7	1.6
d	.6	.2	.2	.3	.8	.9	1.2	.9	2.3	3.3	6.0	4.5
e	3.3	.2	.3	.7	.8	.6	3.0	1.0	3.5	6.7	11	9.5
5a	3.6	2.9	3.1	3.5	6.0	5.4	2.7	.7	.8	.5	1.5	1.2
b	1.9	.8	1.1	1.7	3.2	3.2	1.0	.2	.4	.4	1.4	1.0
c	2.2	1.4	1.3	3.0	5.0	4.8	4.6	.9	1.0	3.2	4.5	4.2
d	1.2	.4	.4	.5	1.7	1.4	4.1	.6	5.7	10	17	11
e	5.0	.8	2.4	8.3	7.0	4.2	2.2	.8	2.2	6.8	5.8	4.5

Table VIII

Rain Erosion of ATC-1 Coating (Three Primer Coats)

Location on Specimen	Specimen AM 1069 Resistance (in megohms per square) after time indicated (in minutes)					Specimen AM 1070 Resistance (in megohms per square) after time indicated (in minutes)				
	0	.5	1	5	10	0	.5	1	5	10
1a	7.5	1.3	1.7	20	10	6.5	8.5	18	29	200
b	5.2	—	—	—	—	8.0	—	—	—	—
c	.3	—	—	—	—	.4	—	—	—	—
d	2.6	—	—	—	—	.4	—	—	—	—
e	.9	.7	.6	.3	4.8	1.3	.8	4.5	2.6	70
2a	.4	.7	.8	.9	.8	.2	.3	.4	.5	.6
b	.2	.5	.9	2.2	1.6	.4	1.0	1.4	1.6	1.3
c	.1	150	∞	∞	∞	.1	100	∞	∞	∞
d	.1	.4	1.1	.9	1.1	.1	.4	1.5	.7	.6
e	.2	.3	.3	.5	.5	.3	.6	.6	.7	.9
3a	.2	.2	.4	.6	.5	.1	.1	.1	.2	.2
b	.1	.2	.4	1.0	1.6	.2	.2	.4	1.2	.7
c	.1	100	400	∞	∞	.1	45	∞	∞	∞
d	.1	.1	.2	.3	.4	.1	.2	.2	.4	.4
e	.1	.1	.1	.2	.3	.2	.1	.2	.3	.5
4a	.1	.2	.2	.5	.5	.1	.1	.2	.3	.4
b	.1	.1	.3	.9	.4	.5	.3	.3	.6	.4
c	.1	60	150	∞	∞	.3	60	400	∞	∞
d	.1	.1	.2	.3	.3	.2	.2	.2	.7	.3
e	.1	.1	.1	.2	.4	.5	.3	.7	.8	.9
5a	.4	.4	.6	.7	1.1	.5	.5	.6	.8	3.5
b	.4	.6	1.0	1.3	1.5	1.1	.9	2.5	1.1	2.1
c	.2	50	200	∞	∞	.5	50	400	∞	∞
d	.2	.4	.4	.6	1.1	.5	1.2	1.7	2.7	8.0
e	.3	.4	1.2	.9	2.3	3.0	2.0	4.0	2.5	50

Table IX

Erosion of ATC-1 Coating During Flight in Clear Weather

Position	Resistance (in megohms per square) after flight time indicated (in hrs and min.) 0	1:20	2:45	4:25	5:30	6:50	8:10	9:50
1	2	1	1	3	2	4	7	∞
2	3	9	∞	∞	45	100	∞	∞
3	2	2	3	10	5	2	4	∞
4	2	2	2	1	6	7	6	10
5	4	4	3	2	6	6	5	∞
6	2	2	2	3	4	2	2	3
7	2	1	2	3	3	6	4	7
8	4	4	4	4	6	7	4	5
9	2	3	2	3	4	2	2	2
10	1	2	2	2	3	4	4	6
11	2	4	3	3	5	5	4	5
12	3	3	2	4	3	2	2	2
13	6	4	5	7	8	7	7	3
14	2	2	4	3	2	3	4	5
15	3	4	3	3	5	2	2	3
16	2	1	2	2	2	2	2	3
17	2	2	2	2	1	2	2	3
18	3	3	3	4	5	2	2	3
19	2	2	3	3	3	4	3	4

TABLE X

Erosion of ATC-1 Coating During Flight in Clear Weather and Through Rain

Position	Resistance (in megohms per square) after time indicated (in hrs and min.) 0	1:20 Rain	7:30 Dry	0	4:15 (Rain 2:40 Dry 1:35)
1	0.5	0.6	3.5	1.8	1.8
2	1.0	∞	∞	0.8	0.4
3	3.L	1.0	1.0	0.8	10.0
4	0.5	1.0	1.0	1.5	0.8
5	0.5	1.2	1.5	0.6	0.3
6	0.5	0.9	1.0	5.0	5.0
7	0.5	0.5	0.9	2.3	2.0
8	1.0	2.0	2.5	1.3	0.6
9	1.0	1.5	2.5	4.0	3.0
10	0.5	0.7	1.0	2.0	1.0
11	1.0	2.0	2.5	0.8	0.3
12	0.5	0.7	0.9	1.8	2.5
13	0.5	0.7	0.4	1.3	0.5
14	1.5	2.5	3.0	3.0	2.5
15	0.5	0.7	1.0	1.5	1.5
16	0.5	0.2	0.2	0.7	0.3
17	0.5	0.2	0.2	3.5	1.3
18	0.5	0.5	0.5	1.8	1.5
19	1.0	0.3	0.6	0.7	0.3

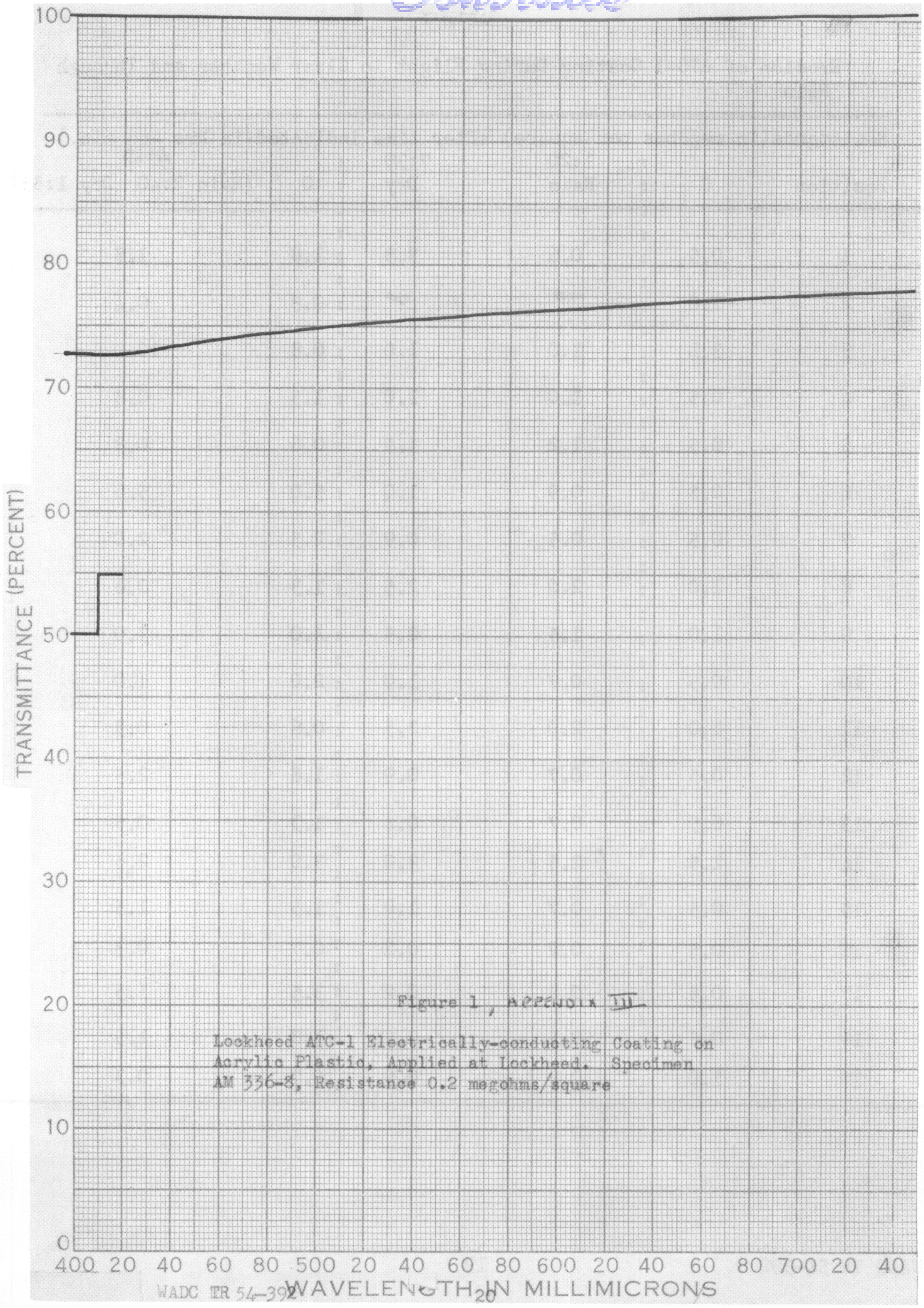

Figure 1, Appendix III

Lockheed ATC-1 Electrically-conducting Coating on Acrylic Plastic, Applied at Lockheed. Specimen AM 336-8, Resistance 0.2 megohms/square

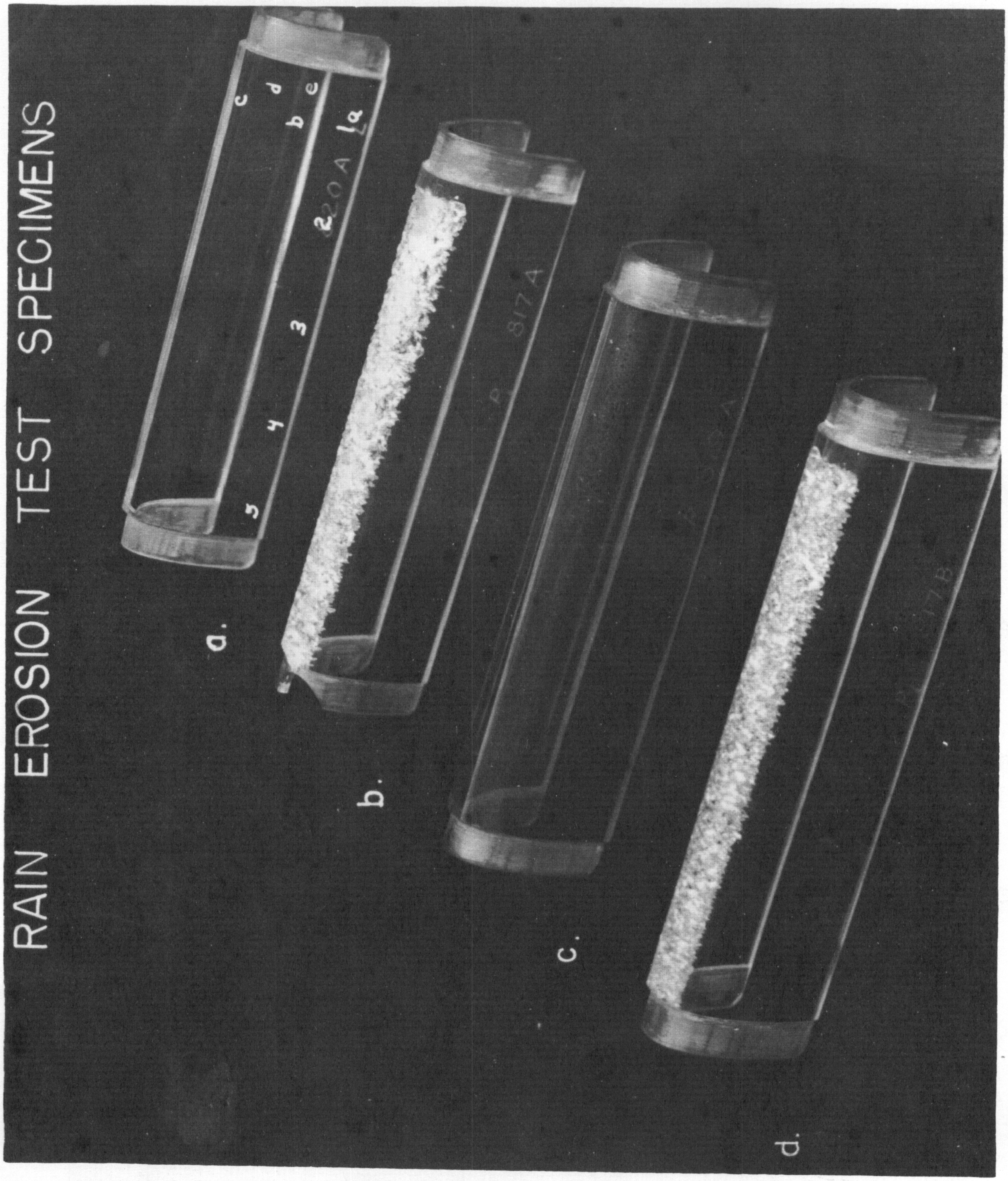

Figure 2

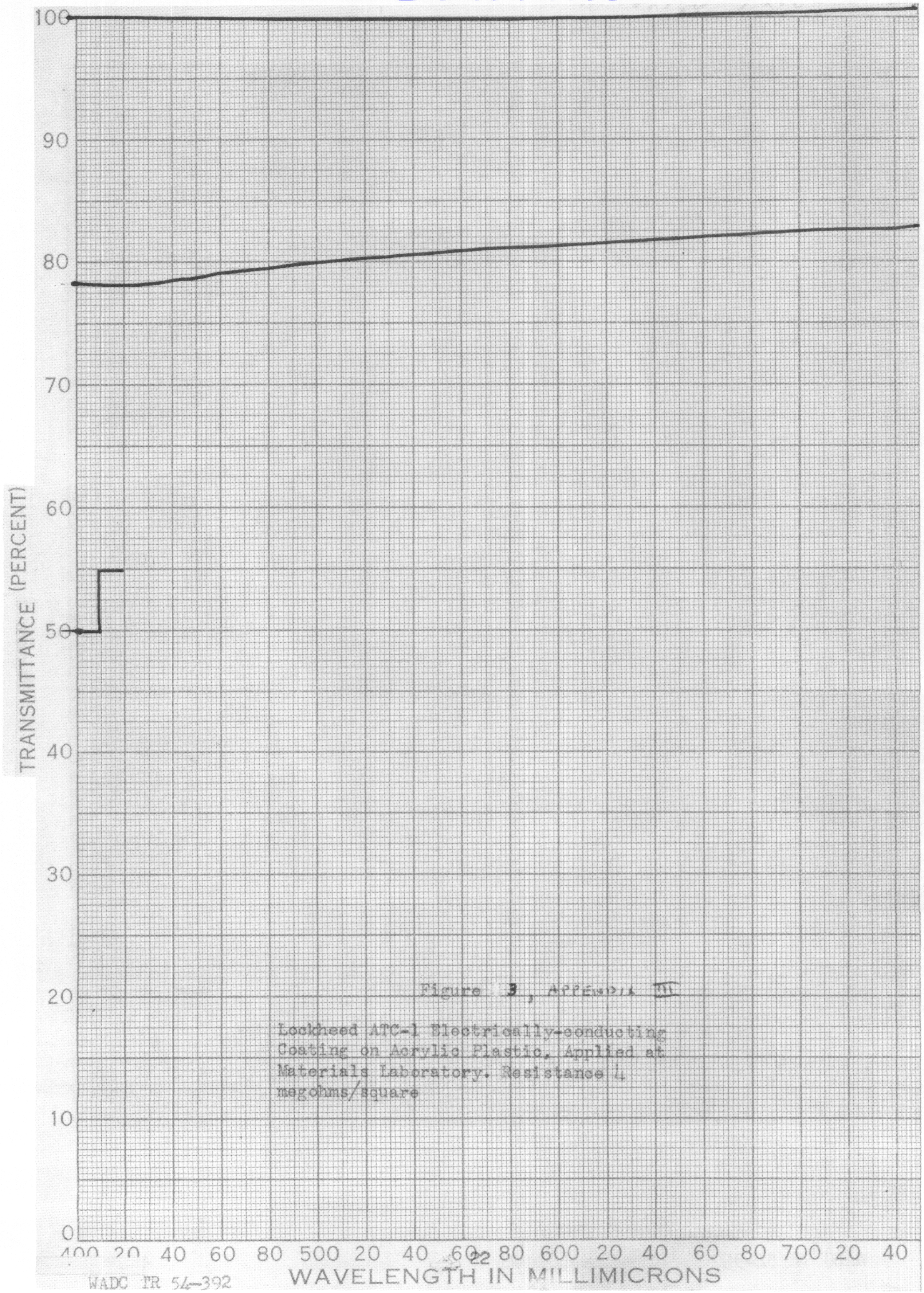

Figure 3, APPENDIX III

Lockheed ATC-1 Electrically-conducting Coating on Acrylic Plastic, Applied at Materials Laboratory. Resistance 4 megohms/square