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SPEED TESTS CONDUCTED IN CANADA DURING MUSKEG TRAFFICABILITY TEST PROGRAM, AUGUST 1962

MISCELLANEOUS PAPER NO. 4-621

July 1963

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

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I

26

...e of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

...E OR OFFICE SYMBOL	SUBJECT
...TR	Limitation on Loan of Technical Publications

W. G. Shockley
...ef, M&E Div

FROM Publications-Distribution DATE 19 Mar 71 CM...

The following reports have been restricted since publication. In accordance ...h instructions contained in AR 70-31, these reports should be reviewed again ... determine if they should be restricted for another 3 years.

MP 4-594, "Visit to University of Illinois to Discuss Tropical Soils Studies" August 1963. Statement 5 applied by M&E Div 3/5/68.

MP 4-602, "Study of the Characteristics of Rice Fields in the United States," October 1963. Statement 5 applied by M&E Div 3/5/68.

MP 4-621, "Speed Tests Conducted in Canada During Musket Trafficability Test Program, August 1962" July 1963. Statement 5 applied by M&E Div 3/5/68.

According to AR 70-31 all publications must have one of the two distribution ...tements listed in Change 3, a copy of which is attached. Please indicate which ...tement should be used for each of these reports.

...ncl

...SIV (19 Mar 71)

CHIEF, PUBL DISTR FROM CHIEF, M&E DIV DATE 12 May 71 CMT 2

...stribution statement A as given in Change 3, 15 Jan 71, to AR 70-31, may be used ...r the miscellaneous papers listed in CMT 1.

...ncl

SHOCKLEY

II

FORM ...2496 REPLACES DD FORM 96, EXISTING SUPPLIES OF WHICH WILL BE ...

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ARMY-MRC VICKSBURG, MISS.

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III

PREFACE

The study reported herein was conducted on 9 and 10 August 1962 under the joint U.S.-Canadian research program on the trafficability of muskeg in furtherance of DA Project 1-T-0-21701-A-046, "Trafficability and Mobility Research," Task 1-T-0-21701-A-046-02, "Surface Mobility," under the sponsorship of the R&D Directorate, U. S. Army Materiel Command. The data were collected by personnel of the Army Mobility Research Branch (AMRB), Mobility and Environmental Division, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., and of the Muskeg Laboratory of McMaster University, Hamilton, Ontario, Canada.

The study was performed under the general supervision of Messrs. W. J. Turnbull, Acting Chief, Mobility and Environmental Division; W. G. Shockley, Acting Assistant Chief, Mobility and Environmental Division; and S. J. Knight, Chief, AMRB; and under the direct supervision of Mr. E. S. Rush, Engineer, Acting Chief, Trafficability Section. Mr. B. G. Schreiner, Engineer, prepared this report.

Col. Alex G. Sutton, Jr., CE, was Director of the Waterways Experiment Station during this study and preparation of this report. Mr. J. B. Tiffany was Technical Director.

U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
CORPS OF ENGINEERS
OFFICE OF THE DIRECTOR
VICKSBURG, MISSISSIPPI

9 July 1963

REFER TO WESSR

MEMORANDUM FOR RECORD:

SUBJECT: Speed Tests Conducted in Canada During Muskeg Trafficability Test Program, August 1962

1. This memorandum supersedes a memorandum for record dated 23 October 1962, subject as above. The information contained herein is essentially the same as that in the previous memorandum; however, the format has been revised and photographs of the test course have been added.

Purpose and Scope of Tests

2. During the period 23 July to 24 August 1962, trafficability tests were conducted on confined muskeg in the vicinity of Parry Sound, Ontario, Canada, to develop suitable correlations between vehicle performance and characteristics of organic terrain (muskeg). The test program also included two special tests on 9 and 10 August 1962. These tests are the subject of this memorandum. One was conducted to determine the "maximum-safe" speed with which certain vehicles could traverse a specific test course, and the other to determine the "normal cross-country" speed over the same test course. Terrain and vegetation data in the test area, together with the results of the timed tests and observations of the performance of the vehicles during these tests, are presented herein.

Vehicles Tested

3. The vehicles tested were a Bombardier, an M29C weasel with 12-in. tracks, a Nodwell RN110, a Buffalo, an M29C weasel with 20-in. tracks, and a Dinah. Photographs of these vehicles are presented in inclosure 1 and pertinent vehicle characteristics are listed in inclosure 2.

Test Course

4. The test course, 1025 ft long and 40 ft wide, was laid out with a pocket transit and a Wye level about 15 miles north of Parry Sound and 75 yd west of Highway 69. An aerial view of the course is presented in inclosure 3. Representative photographs of the course are shown in inclosure 4, beginning at station 0+00 and continuing along the course to the end. Vegetation data are presented in inclosure 5.

5. The material of the test course consisted of gently rolling granite rock, typical of the Canadian Shield. The small rock knolls were usually bare of vegetation, and the shallow depressions between were usually covered with a very thin layer of moss. The knolls comprised approximately 40 percent of the area, the depressions about 60 percent. Small trees and shrubs grew in the rock crevices.

Test Procedures and Data

6. Traverse and profile data of the course are presented in inclosures 6 and 7, respectively. Microgeometry data were obtained at stations 2+50 and 5+01 on the test traverse. These two microgeometry sample cells characterize the surface roughness of the area. The top views of the sample cells and the profiles along the radii of each cell are presented in inclosure 8.

7. In the maximum-safe-speed test, test 1, the drivers were instructed to proceed, one at a time, as fast as possible through the test course at minimum risk of damage to vehicle and driver. The timer, who was located at the finish line with a stop watch, started the watch when he received a signal by radio as each moving vehicle crossed the starting line and stopped the watch at the instant the vehicle crossed the finish line. In the normal-speed test, test 2, the drivers were directed to proceed at a normal cross-country speed through the test course. Each driver kept his own beginning and ending time. After observations of the test operations and discussions with the drivers after completion of the tests, riding qualities and maneuverability were evaluated in qualitative terms of good, fair, and poor.

Analysis of Data

8. The following table shows the vehicle speeds and comparative ratings for quality of ride and maneuverability.

Vehicle	Load, lb	Driver	Time, min:sec	Speed, mph	Quality of Ride	Maneuver-ability
Maximum-Safe-Speed Test						
Bombardier	800	Vidito	1:21.0	8.63	Poor	Good
M29C (12-in. track)	700	Beasley	1:45.2	6.64	Fair	Fair
Nodwell RN110	2341	Larouche	1:50.1	6.32	Fair	Poor
Buffalo	0	Radforth	4:10.8	2.78	Fair	Poor
(Man trotted test course at 6.0 mph)						
Normal Cross-Country-Speed Test						
Bombardier	800	Vidito	2:49	4.13	Poor	Good
M29C (12-in. track)	700	Beasley	3:13	3.62	Fair	Fair
Nodwell RN110	2341	Larouche	3:38	3.21	Fair	Poor
Buffalo	0	Radforth	9:08	1.28	Fair	Poor
M29C (20-in. track)	700*	Shirley	3:23	3.46	Fair	Fair
Dinah	850*	Stevens	2:51	4.08	Good	Fair
(Man walked test course at 3.3 mph)						

* Estimated weight

Vehicle performance

9. The performances of the vehicles on the test course are discussed in the following paragraphs.

10. The Bombardier completed the test run faster than the other vehicles in both tests 1 and 2. The bombardier was able to maneuver and turn faster than the other vehicles; however, it was the roughest riding vehicle in both tests. The vehicle was apparently not damaged in either test although it later developed motor steering clutch trouble.

11. The M29C weasel with 12-in. tracks was the second fastest vehicle in test 1 and the third in test 2. It rode somewhat better than the Bombardier in both tests, but its maneuverability was not quite as good. The vehicle suffered a bent front idler, and its front pontoon was damaged in test 1; there was no damage in test 2.

12. The Nodwell RN110 finished third in test 1 and fifth in test 2. Its ride was smoother than the Bombardier's in these tests. Its maneuverability was poorer than that of the Bombardier, the two weasels,and the Dinah. Several bolts in the frame of the RN110 were shaken loose in test 1; there was no damage to the vehicle in test 2.

13. The Buffalo, slowest vehicle in both tests, traversed most of the test course in test 1 at its maximum available speed. Thus its speed was controlled by the low gear ratio of its transmission rather than by the microrelief of the test course. This vehicle's riding quality was about the same as that of the RN110, although its ride would probably have been rougher had the vehicle approached the speed of the other vehicles. It could not be maneuvered as fast as the Bombardier, the two weasels, or the Dinah. The Buffalo was not damaged in test 1 except that the spare battery turned over; the vehicle was not damaged in test 2.

14. The M29C weasel with 20-in. tracks was not tested in test 1. In test 2, this weasel finished fourth. The riding quality was about the same as that of the weasel with 12-in. tracks, but the weasel with 20-in. tracks had more trouble turning because of a worn steering clutch. The vehicle was not damaged in this test.

15. The Dinah, an articulated vehicle, was not tested in test 1; however, it finished second in test 2. This vehicle's maneuverability was probably about the same as that of the weasel with 12-in. tracks. Its riding quality was the best of the vehicles tested. The Dinah did not suffer damage in this test; however, the front track guides were damaged on similar terrain when the Dinah was climbing sharp slopes.

Factors affecting tests

16. The major factor that affected the speed of the vehicles in the two tests, except for the Buffalo, was microrelief. A second factor, directly related to the microrelief, that must be considered is drivers' judgment of maximum safe speed and normal cross-country speed. It was not possible to evaluate this factor in these tests. Soil strength and vegetation were not factors in these tests, since the test course was laid out over rock, and avoided all vegetation that might have had an effect on vehicle performance.

17. Microgeometry. Examination of the top views of the microgeometry sample cells and their profile plots (inclosure 8) reveals elongated features in the area that generally lie in a north-south direction, which is approximately at right angles to the direction of the test course. One such feature, crossed by the 0° radius line in the microgeometry sample cell at station 2+50 had a 13-in. vertical rise on one side and an 11-in. fall on the other side within a horizontal distance of 14 ft. The drivers decreased their vehicle speed when they crossed features such as this.

18. The frequency of occurrence of slopes along the length of the test course in percent is shown as a histogram in inclosure 9; the data for this plot are presented in inclosure 10. The histogram shows that the predominant slopes lie between 0 and 0.5 percent.

19. Driver judgment. From the data collected there is no way of knowing what the maximum safe speed and the normal cross-country speed of the vehicles are except through individual driver judgment. The M29C weasel with 12-in. tracks suffered major damage while traversing the test course in test 1 (see paragraph 11); hence, in this test, driver judgment of maximum safe speed was too optimistic. This would indicate that driver judgment of maximum safe speed would not necessarily be the vehicle's maximum safe speed. The normal cross-country speed of the vehicle is an elusive value which quite naturally will vary among drivers. However, as can be seen from the data in paragraph 8, the vehicle speeds in the normal cross-country test are about half the vehicle speeds in the maximum-safe-speed test on this test course. This is significant in that it shows a common mathematical relation between drivers' judgments of maximum safe speed and normal cross-country speed.

Conclusions and Recommendations

Conclusions

20. From data collected and observations made during these tests, the following conclusions are drawn:

a. If more data of vehicle speed versus microgeometry were available, relations might be shown to exist between frequency of occurrence of a particular slope interval and vehicle speed.

b. Deviations in drivers' judgment of speed may or may not be a problem of considerable importance. At the present time, data are not available upon which to base a full analysis of the effects of drivers' judgment on vehicle speed in cross-country movement.

c. The articulated system of the Dinah, no doubt, is an asset to the vehicle's good riding qualities and maneuverability.

d. The Bombardier completed the test course in the least time in both tests; however, it was the roughest riding vehicle tested. It also had the best maneuverability. The Dinah and the Buffalo proved to have the best riding qualities.

e. On this test course, the speeds recorded for the normal vehicle cross-country speed test were about half the speeds recorded for the maximum-safe-speed test.

Recommendations

21. It is recommended that:

a. Traffic tests of this type be conducted to qualify the relation of microgeometry to vehicle speed.

b. Instruments and techniques be developed to measure what effects deviation in drivers' judgment have on cross-country movement of vehicles.

c. In lieu of qualitative evaluations of riding quality, critical vehicle components be instrumented with accelerometers and strain indicators to measure shock and strain of vehicle components. These measurements could also be used in establishing vehicle maximum safe speed and normal cross-country speed.

d. Further investigation be made of articulated vehicles in cross-country movement.

e. A controlled test be developed that would encompass all factors affecting cross-country movement. Methods of measuring these factors should also be investigated.

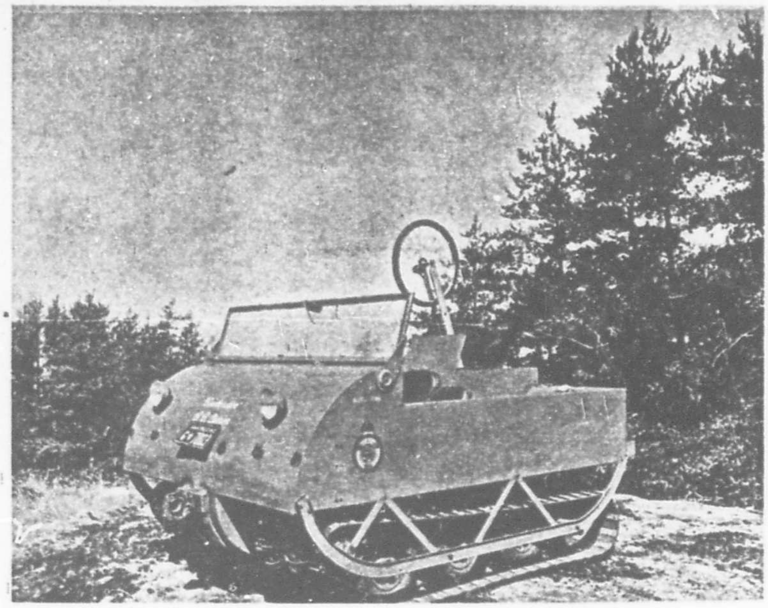
Barton G. Schreiner

10 Incl
as

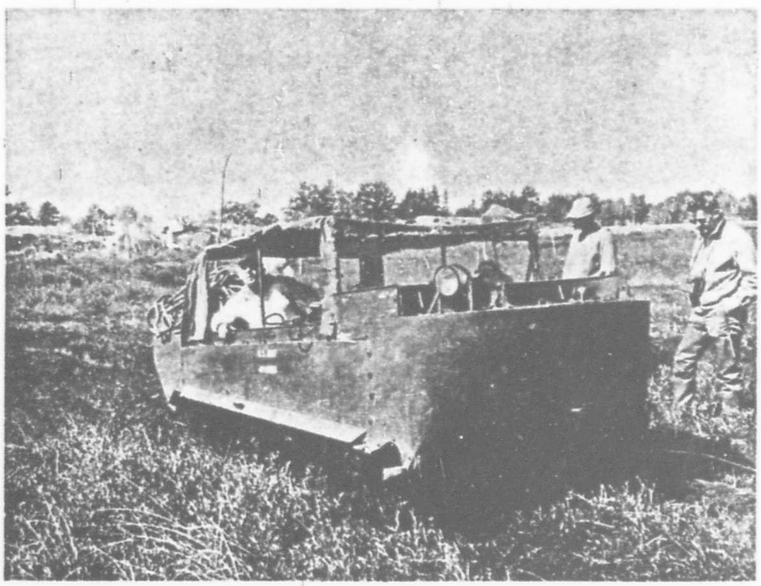
BARTON G. SCHREINER
Engineer
Trafficability Section

Copies furnished:
AMC (AMCRD-RS-ES-E) w/o incl
Dr. N. W. Radforth

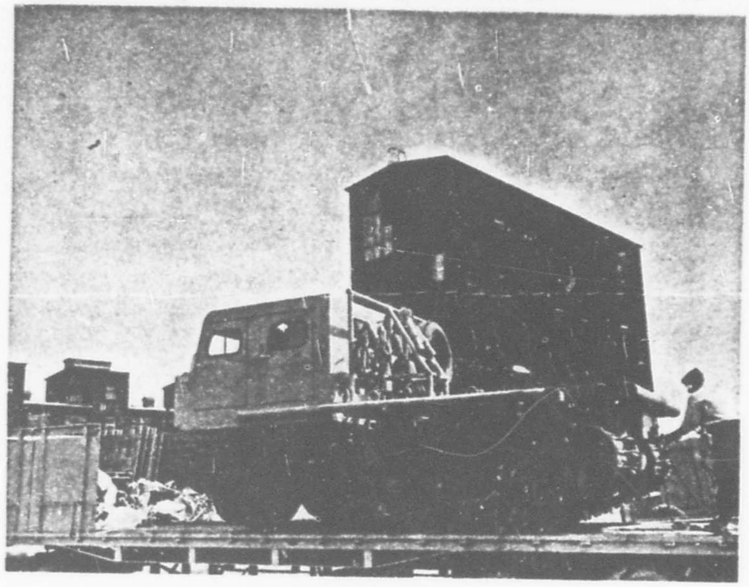
38908



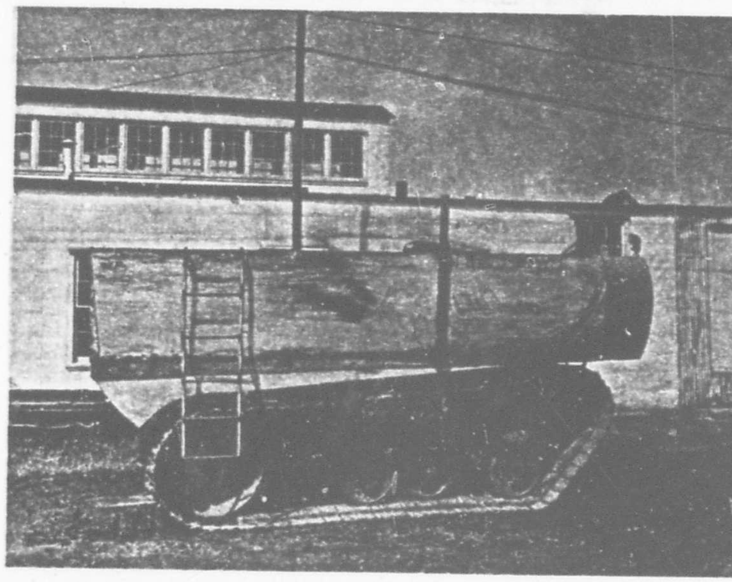
Bombardier



M29C weasel with 12-in. tracks

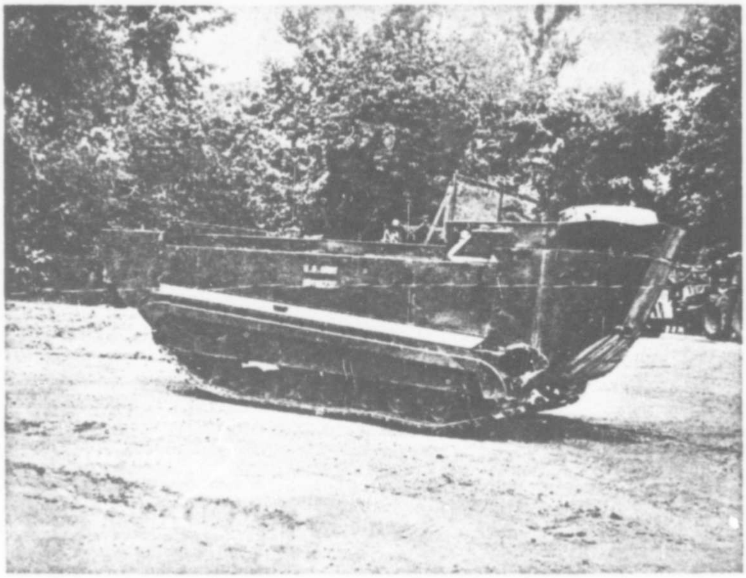


Nodwell RN110

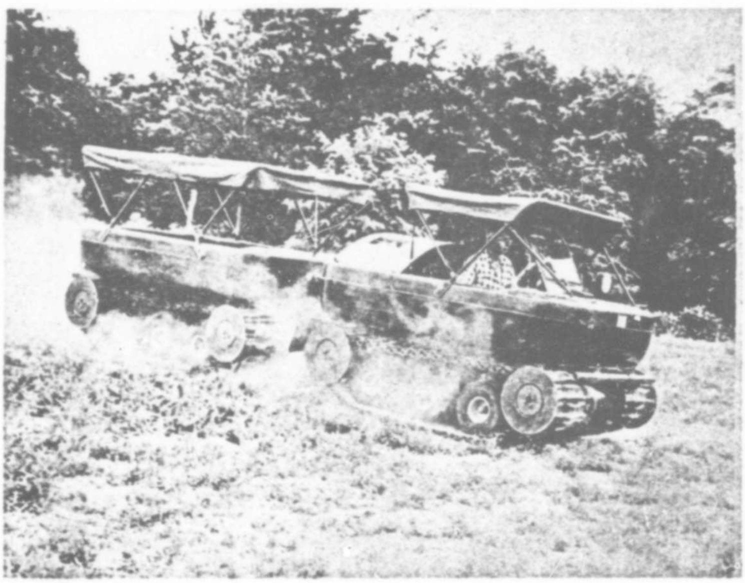


Buffalo

Incl 1 (sheet 2)



M29C weasel with 20-in. tracks

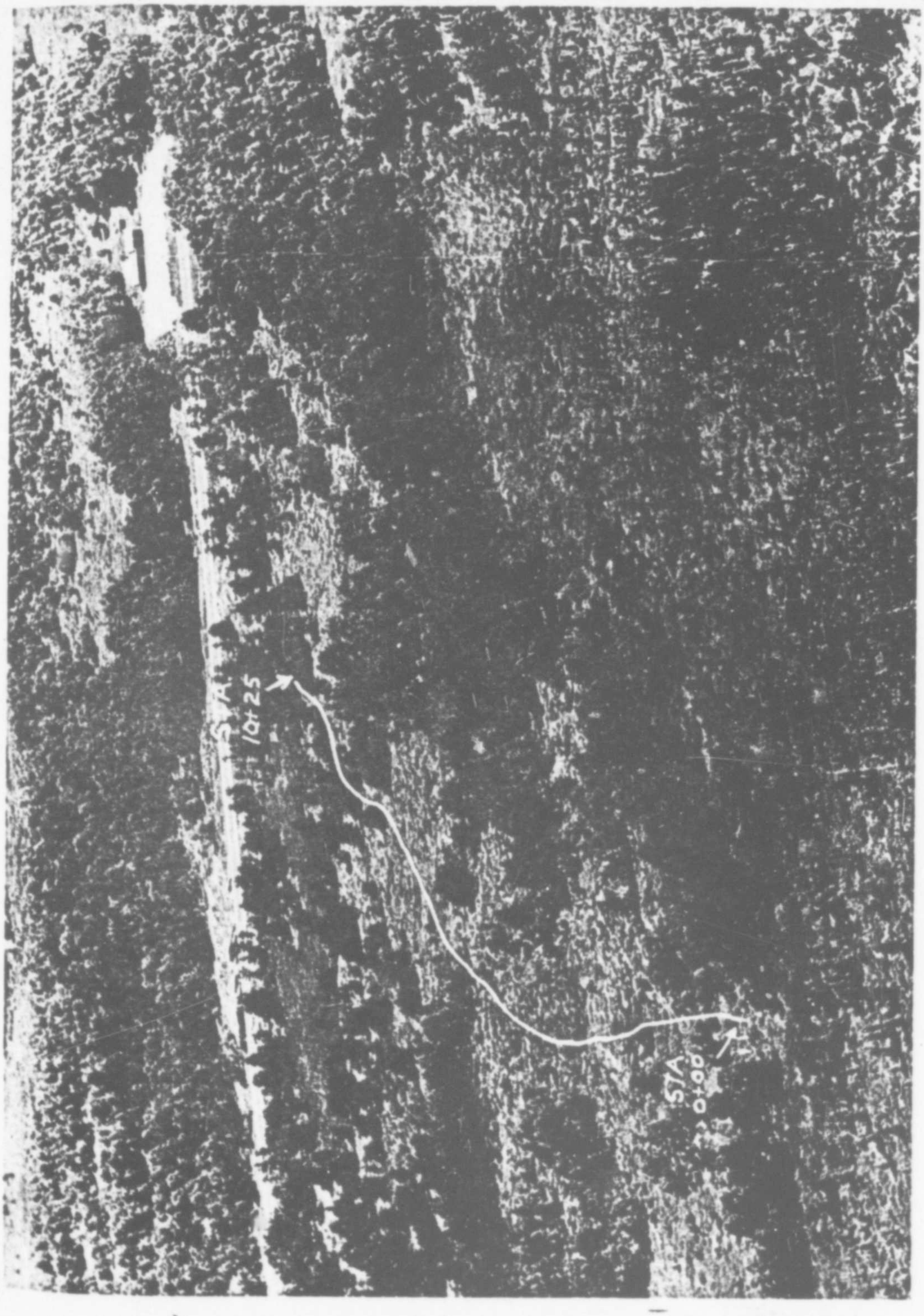


Dinah

VEHICLE CHARACTERISTICS

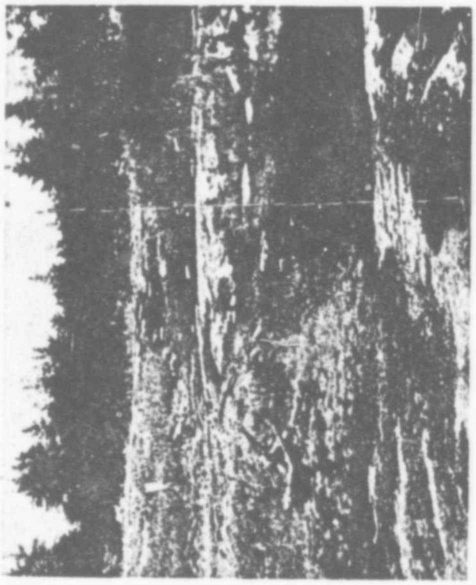
Vehicle	Gross Wt, lb	Track Width, in.	Bogies on Ground Per Side	Clearance, in.	Engine Type, hp	Transmission Type	Minimum Turning Radius, ft
Bombardier	2,960	26	4	9.00	gasoline, 57	mechanical	--
M29C weasel	5,478	12	8	12.00	gasoline, 65	mechanical	--
Nodwell RN110	12,350	[illegible]	4	16.00	gasoline, 185	mechanical	8.5
Buffalo	31,000	48	5	16.00	diesel, 70	mechanical	--
M29C weasel	5,478	20	8	12.00	gasoline, 65	mechanical	12.0
Dinah	4,400	20	6	10.5	gasoline, 42	mechanical	19.5

Incl 2



Incl 3

11



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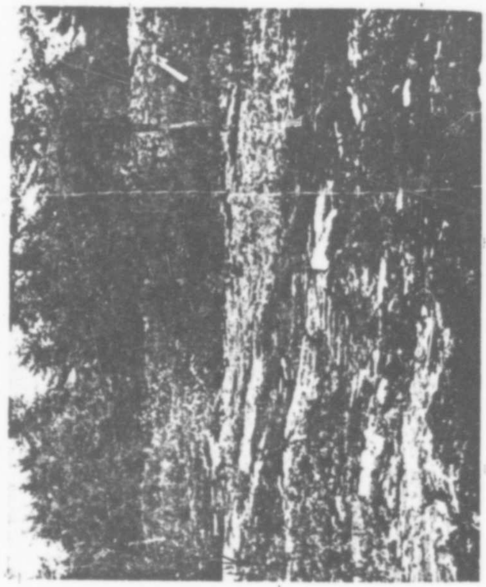

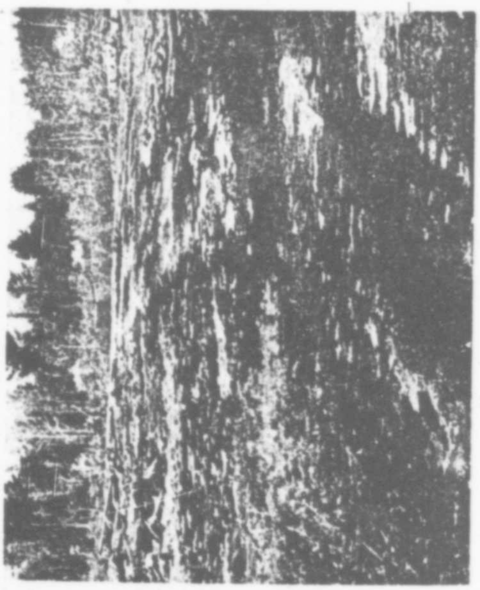

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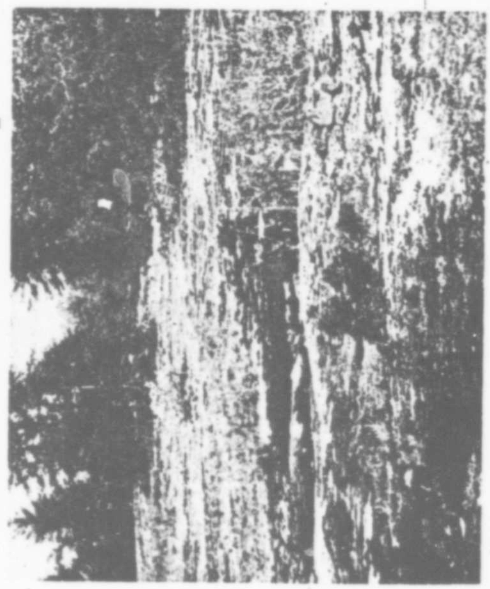
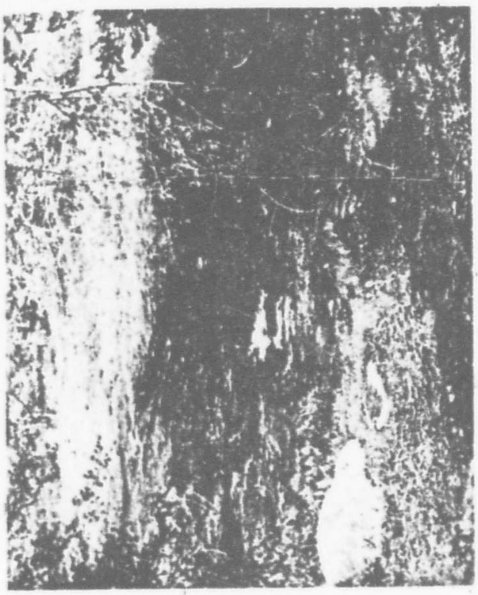


3

Incl 4 (sheet 1)

4

3



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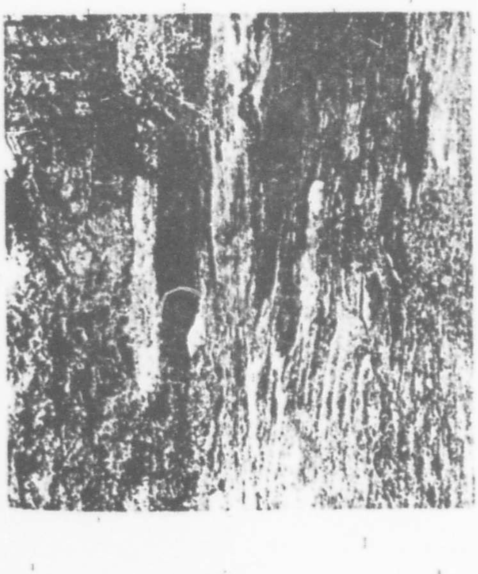

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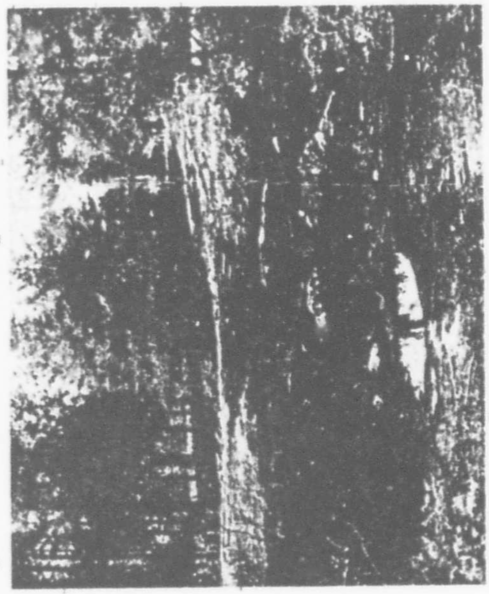


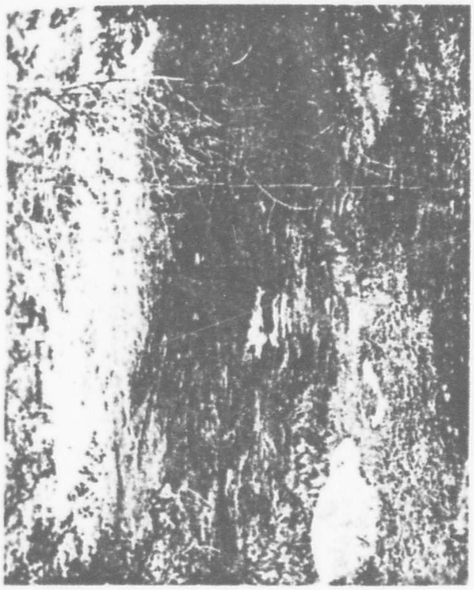
8

7

12

4

3



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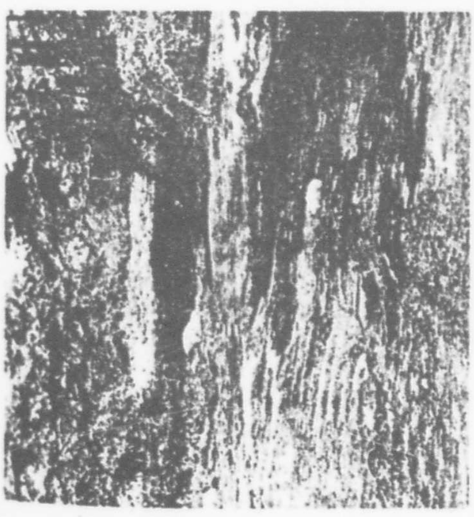

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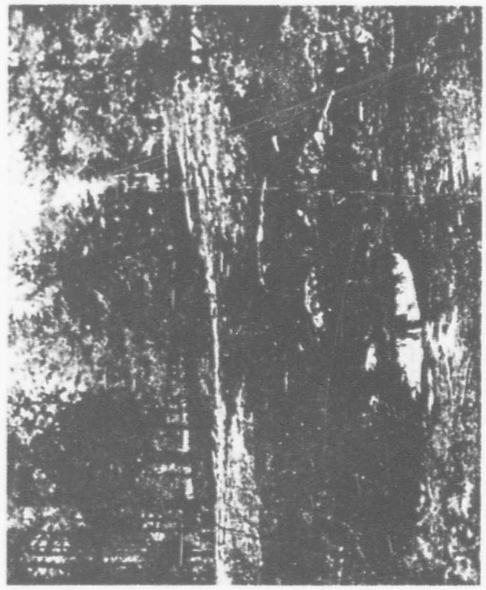

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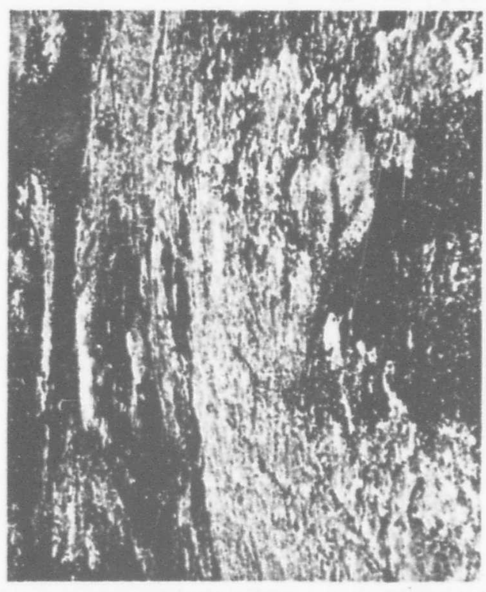
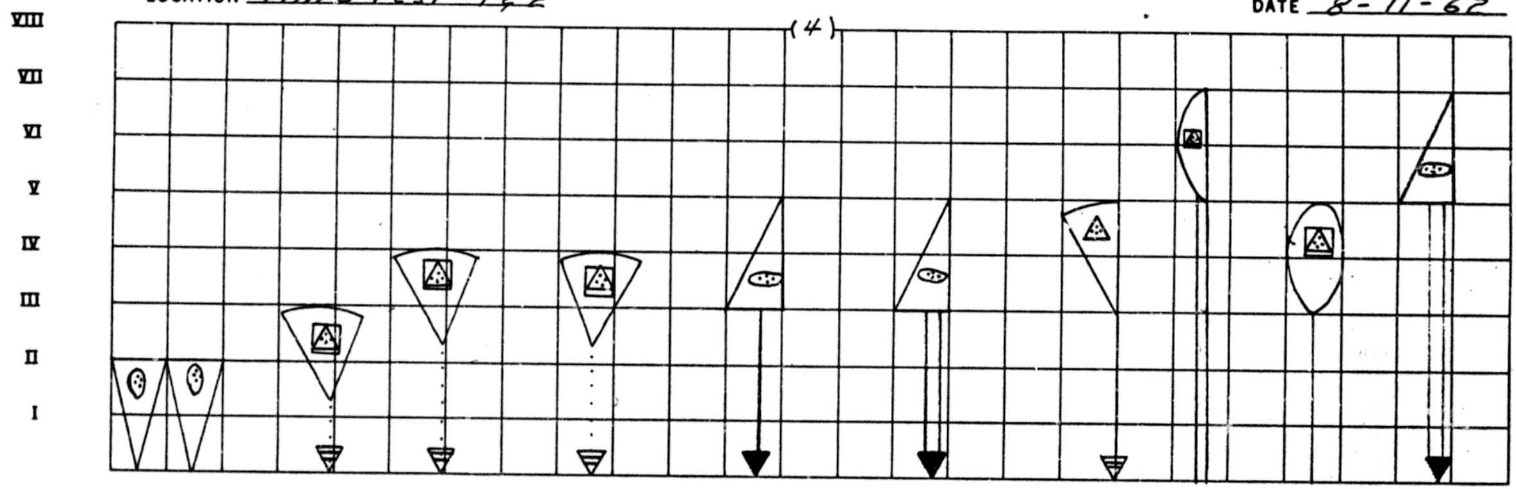


7

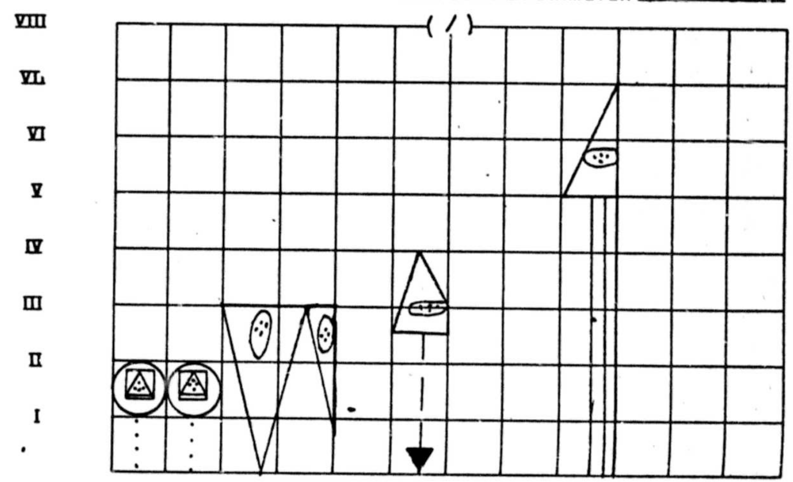
Incl 4 (sheet 2)

VEGETATION STRUCTURAL DIAGRAM

LOCATION *Time Test 1 & 2* DATE *8-11-62*



SAMPLE AREA DIAMETER *200'*

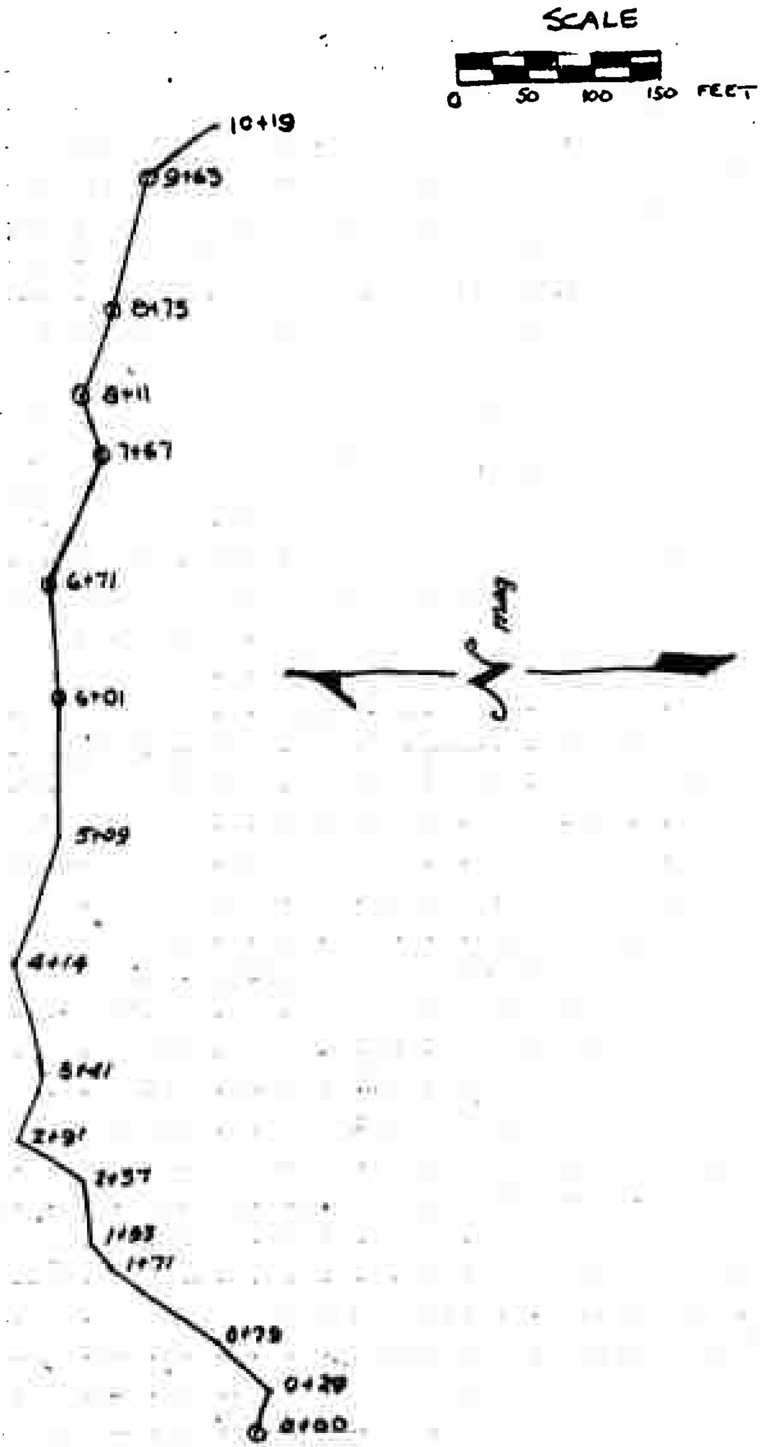


1. 2" To 3" of Living moss over 60% of the Area.
2. Leaves present and green at time of observation.

Incl 5

SPEED TEST

TRAVERSE



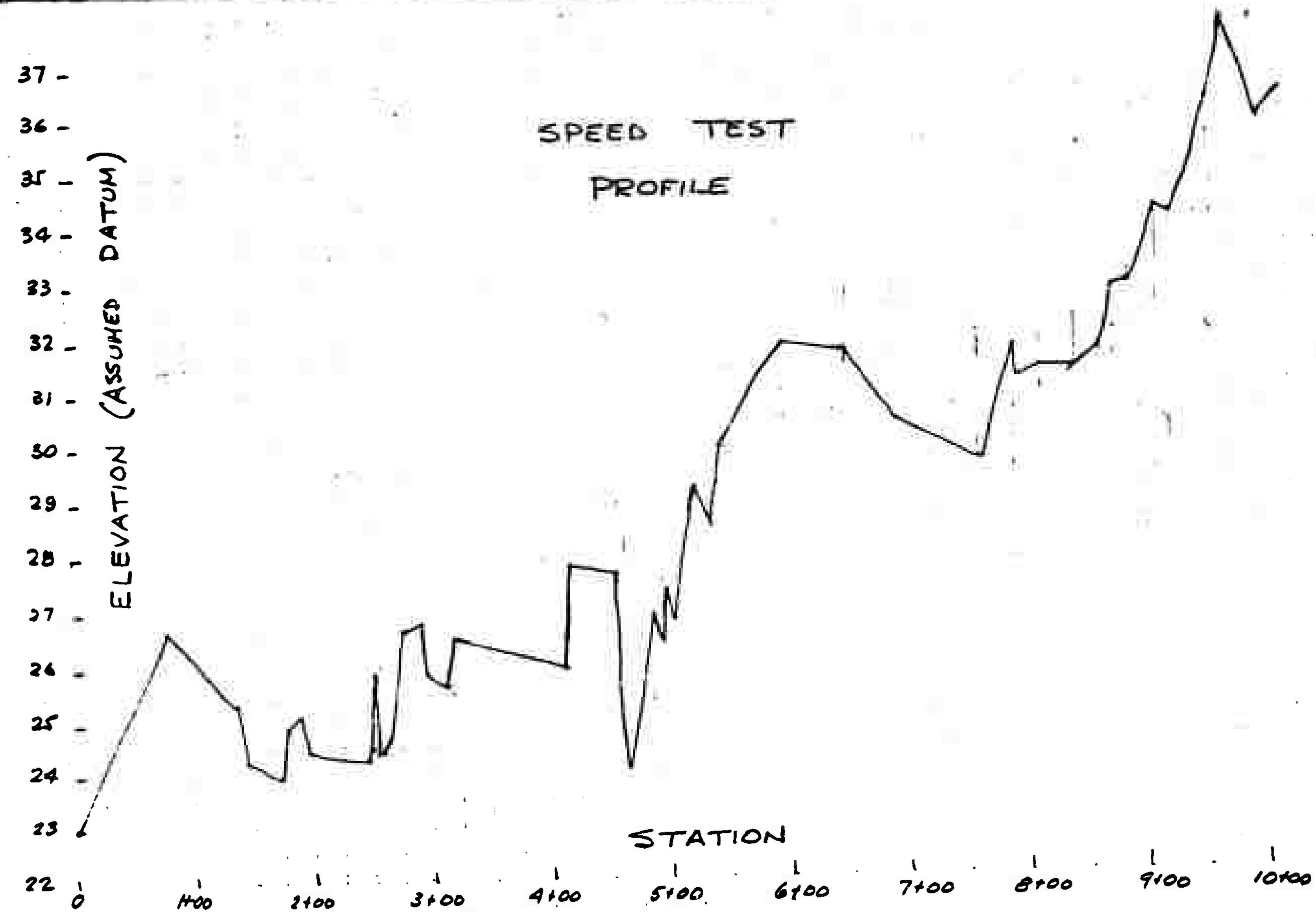
SPEED TEST

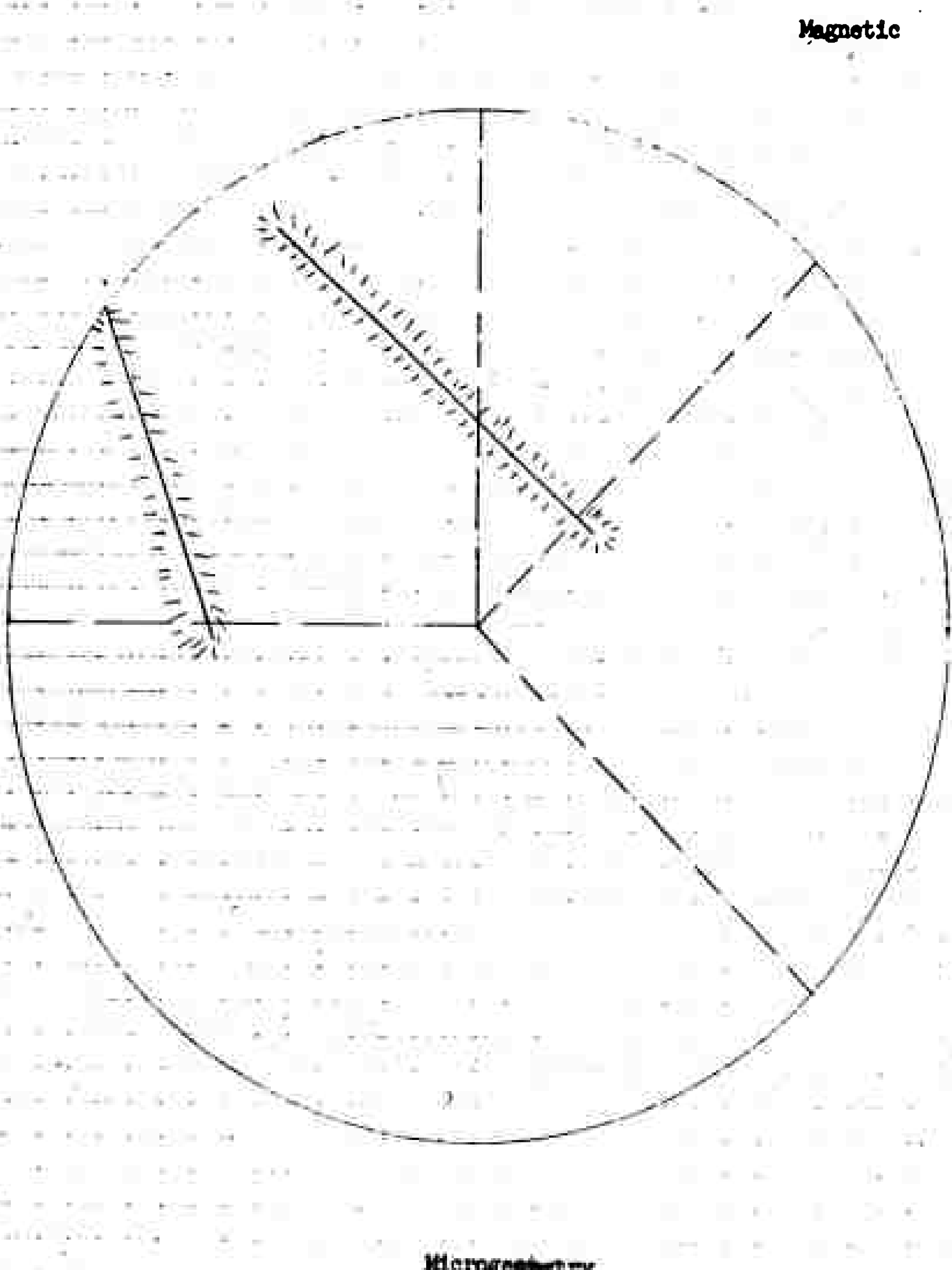
Elevations

Station	Elev.	Station	Elev.
0+00	23.00	5+09	26.76
0+79	25.61	5+25	29.14
1+36	25.36	5+37	28.49
1+43	24.20	5+45	29.93
1+71	23.95	6+01	31.82
1+78	24.92	6+53	31.66
1+89	25.08	6+71	30.44
1+97	23.92	7+62	29.64
2+47	24.30	7+67	29.57
2+52	25.83	7+93	31.72
2+57	24.41	7+97	31.15
2+66	24.61	8+17	31.34
2+76	26.59	8+46	31.33
2+91	26.34	8+66	31.67
2+95	25.39	8+77	32.75
3+32	25.68	8+85	32.83
3+41	26.95	8+93	33.57
4+14	25.94	9+14	34.13
4+21	27.75	9+28	34.02
4+59	27.58	9+61	36.16
4+64	24.02	9+78	37.73
4+87	26.88	10+04	35.65
4+93	26.34	10+25	36.30
5+00	27.31		

Traverse

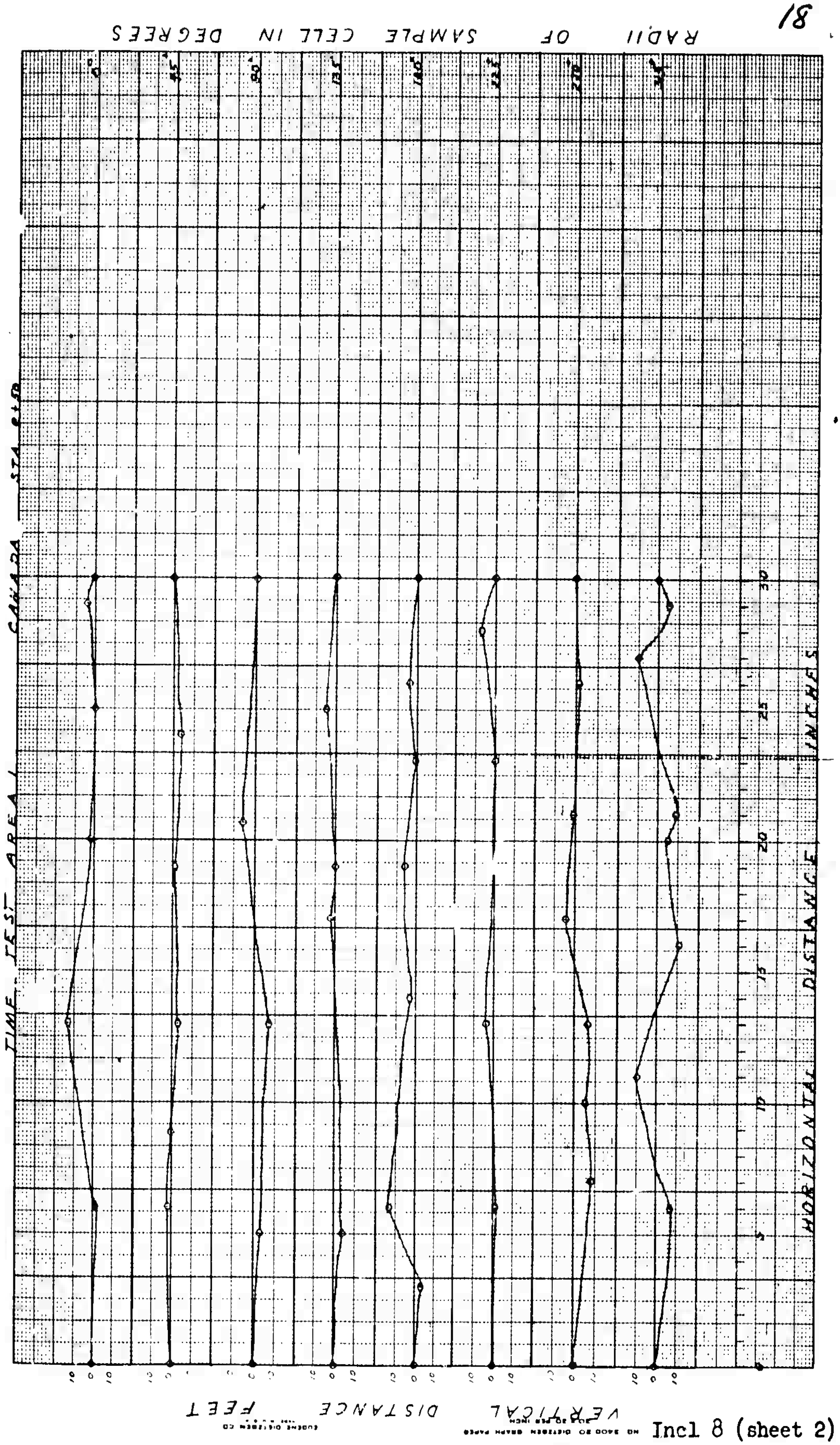
Station	to Station	Dist	Azimuth (North = 0
0+00	0+29	29	105°
0+29	0+79	50	40°
0+79	1+71	92	35°
1+71	1+93	22	46°
1+93	2+37	44	82°
2+37	2+91	54	32°
2+91	3+41	50	110°
3+41	4+14	73	74°
4+14	5+09	95	111°
5+09	6+01	92	90°
6+01	6+71	70	84°
6+71	7+67	96	114°
7+67	8+11	44	65°
8+11	8+73	62	112°
8+73	9+63	90	105°
9+63	10+19	56	144°


SPEED TEST
PROFILE
ELEVATION (ASSUMED DATUM)
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
STATION
0
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00



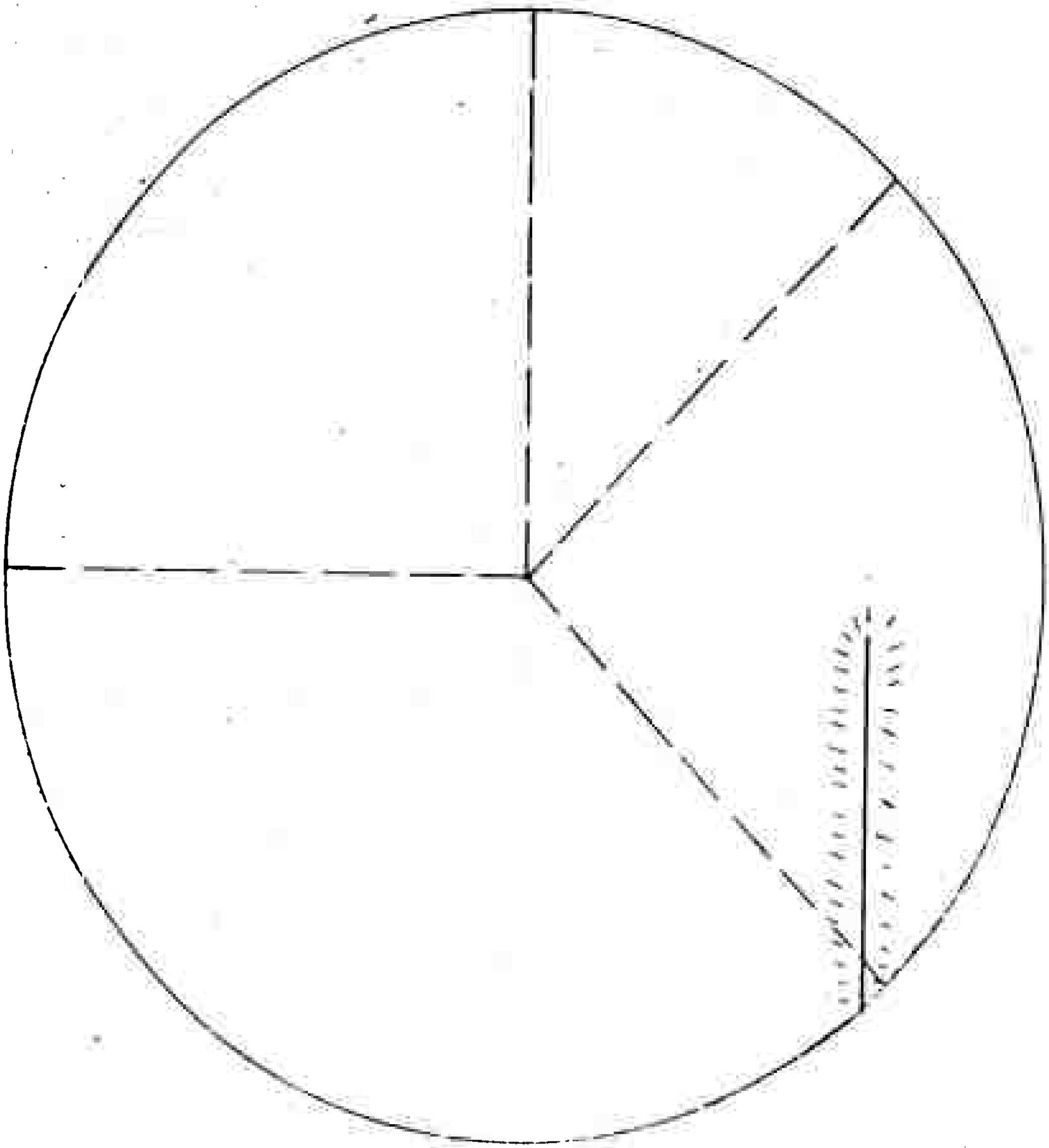
Time tests 1 and 2, sta 2+50
11 Ap 5 1962
Scale: 1 in. = 10 ft

Incl 8 (sheet 1)



Incl 8 (sheet 2)

Magnetic



Microgeometry

Time tests 1 and 2, sta 5+01
11 Aug 1962
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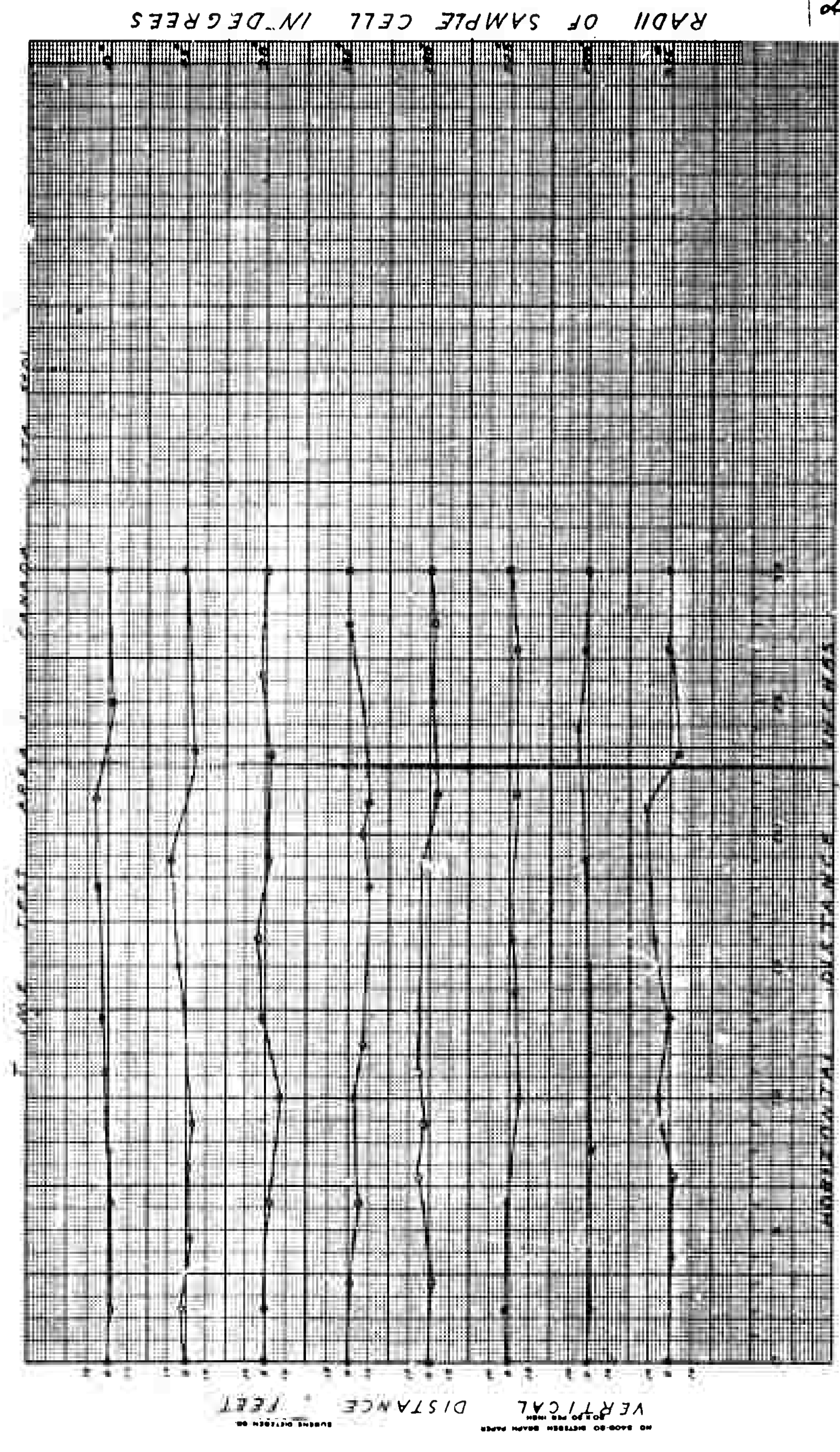
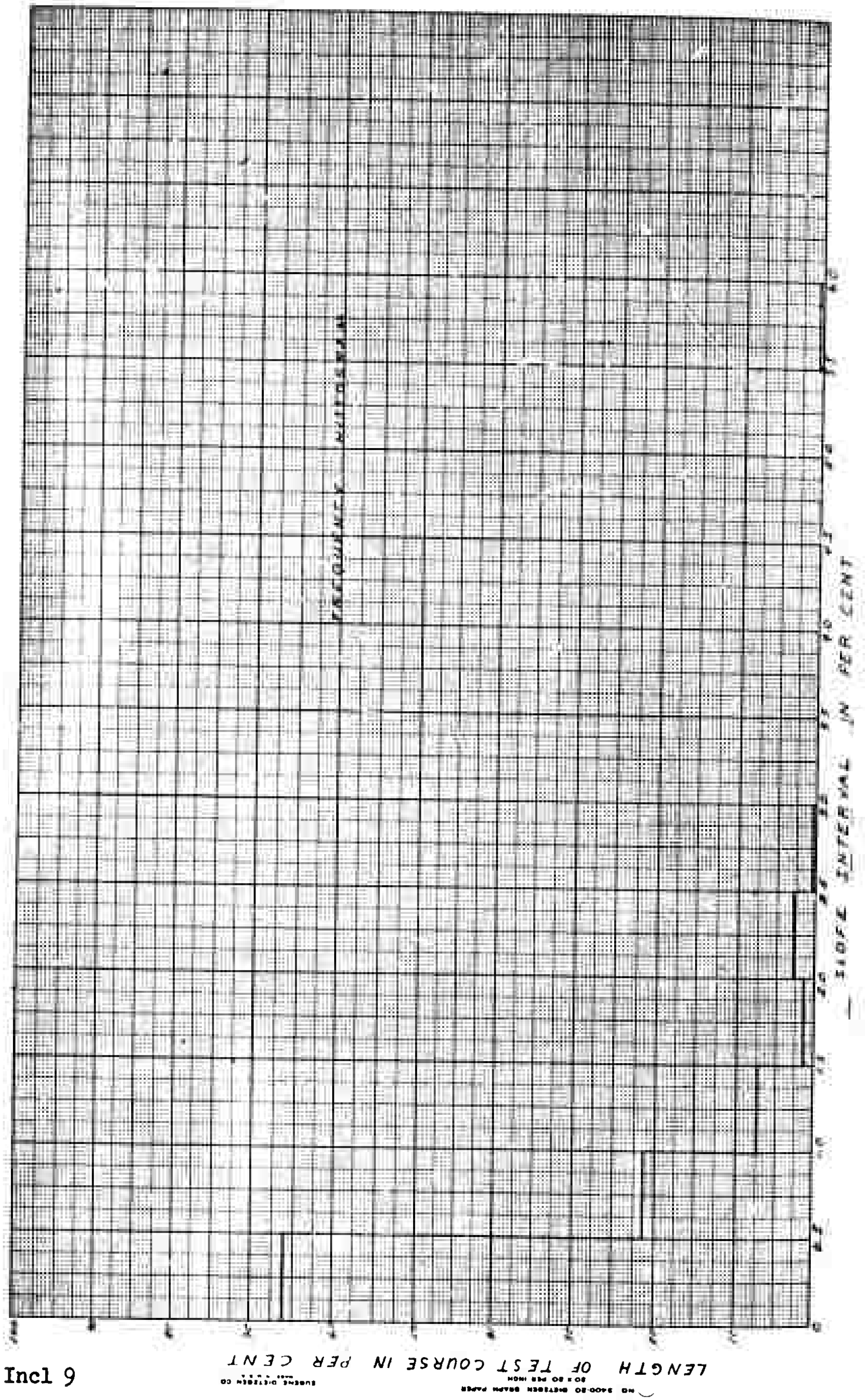

RADII OF SAMPLE CELL IN DEGREES
HORIZONTAL DISTANCE INCHES
VERTICAL DISTANCE FEET

21


FREQUENCY HISTOGRAM
SLOPE INTERVAL IN PER CENT
LENGTH OF TEST COURSE IN PER CENT

Incl 9

Slope Interval in percent	Percent Coverage	Distance in ft
0.0 - 0.5	66.14	678
0.5 - 1.0	21.40	219
1.0 - 1.5	7.40	76
1.5 - 2.0	1.36	14
2.0 - 2.5	2.74	28
2.5 - 3.0	0.48	5
3.0 - 3.5	0.00	0
3.5 - 4.0	0.00	0
4.0 - 4.5	0.00	0
4.5 - 5.0	0.00	0
5.0 - 5.5	0.00	0
5.5 - 6.0	0.48	5