

## FURTHER INVESTIGATION OF NIGHT VISION AMONG PERSONNEL OF AN A.A. UNIT.<sup>1</sup>

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FOLLOWING the conclusions reached in an investigation of night vision among personnel of an A.A. unit, the report on which was published in the *JOURNAL OF THE ROYAL ARMY MEDICAL CORPS* for January, 1942, endeavours were made to discover or devise a simple, practical and inexpensive test for night vision, suitable for use in the field and which could be operated by a responsible N.C.O. without prolonged special training.

### OUTDOOR TEST.

The first test tried out consisted of large black letters 15 inches square and 3 inches thick on a square white background. The letters used were those which could be placed in four different positions such as C, E, and K. The test was carried out at night in the open. Orderlies held the letters in front of the men being tested and moved 5 feet backwards for each test. Three letters were shown in each position. Those that could recognize the letters at the greatest distance had a better night visual standard than those that failed earlier. The eyes of those tested were fully dark adapted previously. The drawbacks to this test are that it is not a standard test as the conditions vary considerably with the weather and the phases of the moon and the test cannot be carried out satisfactorily in extremes of weather, i.e. fog and rain or bright moonlight. In summer too the time during which this test can be performed is limited and inconvenient.

### STANDARD CANDLE TEST.

It was therefore decided that an indoor test must be used. The first problem was to obtain a standard light source of low intensity. Having read of Bishop Harman's apparatus for testing night vision using a standard candle an attempt was made to obtain the apparatus but the manufacturers at that time were unable to supply it. A lantern was therefore constructed out of a four gallon petrol can and a pint soup tin. A night light was placed in the lantern using an inverted soup tin as a candlestick. The light was projected on to a screen of reversed balloon fabric, painted matt black, 6 feet square. In the centre of this hung a white card 4 inches square on which was a black

<sup>1</sup> An Army Night Vision Test, approved by the Night Vision Committee of the Medical Research Council, has now been standardized and is in use throughout the Army. It is entirely different from the test described in this article.—*Ed.*

letter (Snellen's Type 36 metres). This card could be replaced by others, or hung sideways or upside down. The lantern placed 5 metres from the card gave a reasonable illumination and the subject, starting level with the lantern, could move backwards or forwards depending on whether he recognized the letter in the first position or not. It was essential for the room housing the test to be completely dark. In Bishop Harman's test small white discs on a black background have to be counted but it was felt that perception of rays of white light may not necessarily be the same faculty as the ability to recognize a dark object against a lighter background, as in spotting aircraft at night, and a black letter on a white background was therefore used. The difference in contrast between the black letter and the white card varies with the distance of the person being tested from the card (intensity of light varies inversely as the square of the distance). It then became necessary to obtain a standard candle to replace the night light used in the development of this test but though several large manufacturing houses were approached no standard candles were obtainable. The National Physical Laboratories were consulted but were unable to help and strongly advised against the use of standard candles in such a test as these were not considered to be reliable.

The flame of the standard candle may not always be in the same position owing to combustion of the candle or to draughts, and its luminosity is therefore liable to vary.

#### ELECTRIC STANDARD TEST.

An electric light bulb was then calibrated to one candlepower with the object of using this as the standard light instead of a candle in the apparatus described above. If the apparatus remained stationary this would probably have been satisfactory but difficulties, owing to variations of current (A.C., D.C.) and voltage and the varieties of batteries available, limited its sphere of usefulness. It was considered important to be able to take the apparatus to the men rather than to have to bring the men to the apparatus, particularly in small, scattered detachments of A.A. troops in the line. To purchase a battery, variable resistance, ammeter, etc., in order to facilitate mobility, was considered to be too costly and elaborate so that this test was also discarded.

#### DR. WRIGHT'S TEST.

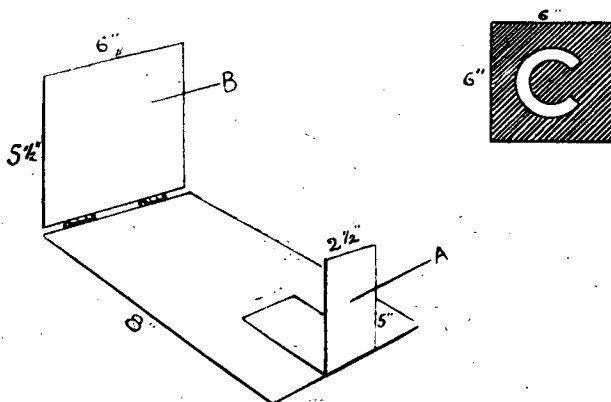
It was finally decided to make use of the test for night vision designed by Dr. W. D. Wright, A.R.C.S., D.Sc. and published by Messrs. Sir Isaac Pitman and Sons, Ltd. Dr. Wright's description of the apparatus is as follows—

“ The device consists of a wooden container which can be opened out as in the figure. In A a small disc of radium luminous compound provides a faint source of light which shines through a cellophane window on to B. Against B any one of nine cards can be placed, each card consisting of a broken circle printed in grey on a black background. One card differs from another in being a lighter or a darker grey, and the object of the test is to

discover which card can just be seen by the observer, the test being carried out in complete darkness except for the small light in A."

The whole apparatus is painted black.

The eyes of the person to be tested must be dark adapted and the test explained. He is then seated at a table in front of the test and the room is made completely dark. The flap A containing the radium luminous substance is then raised and the cards, held vertically against flap B, should be viewed from a distance of 12 inches. An endeavour is then made to perceive the position of the gap in the circles. A notch has been cut in each of the cards in order that the person operating the test can tell the position of the gap in the darkness. The flap A must not be raised until the room is in complete darkness as the radium luminous substance phosphoresces on exposure to light and its luminosity would be temporarily diminished. If the flap is inadvertently raised in light, the apparatus should not be used for some



Dr. Wright's test for night vision.

hours. The disc gradually diminishes in intensity, about 25 per cent in two years, and should then be replaced. The apparatus costs 25s., and the discs can be renewed for 5s.

On using this apparatus it was found that it was difficult in the dark to be certain that the subject was, in fact, 12 inches away from the card. A little over eagerness tended to reduce the distance and to give a better, but false, result.

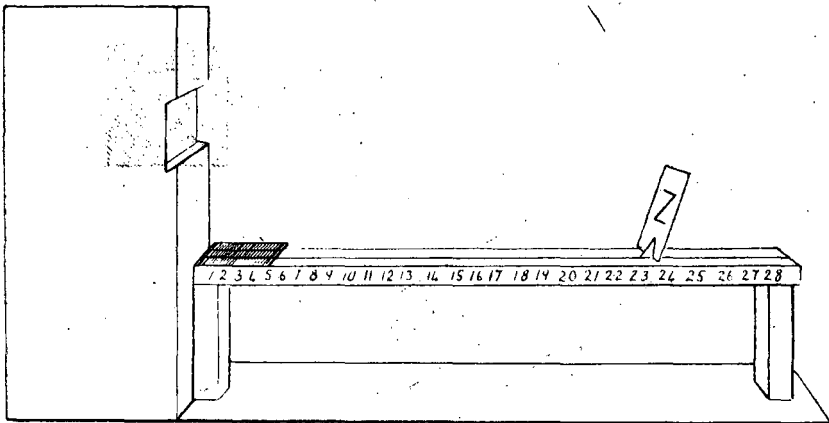
The apparatus itself is somewhat flimsy, and it was doubtful whether it would stand up to heavy and extensive use in the Services as it stood.

The test depended, as in Bishop Harman's test, on white light against a black background instead of the recognition of the reverse.

#### MODIFICATION OF DR. WRIGHT'S TEST.

The test was consequently modified in the following manner. A wooden box 20 by 10 by 7 inches was obtained from the ration stores and a slit was

cut in the bottom  $3\frac{1}{4}$  inches wide 5 inches from one end. The box was then mounted, on the end further from the slit, on a piece of three-ply  $38$  by  $10\frac{1}{2}$  inches. A sliding scale was made of a "bulldog" pattern paper clip, two battens of wood  $30$  by  $1\frac{1}{4}$  by  $\frac{3}{8}$  inches and an ordinary tape measure. Flap A of Wright's test, and that part of the wooden container approximating to it when lying flat, was sawn off and mounted on one end of the sliding scale. The whole was then attached to the three-ply in such a way that when flap A was raised it rested against the box with its upper border level with the lower border of the slit. The whole apparatus was then painted matt black including the inside of the box, except for the part of the paper clip directed towards the box which was painted matt white. Ten white cards  $5$  inches square were made, on each of which was a letter in  $36$  metre Snellen's type (*see* illustration below).



The modified apparatus.

#### METHOD OF TESTING.

The A.A. troops to be tested were quartered in huts which were not light-proof. It was therefore more convenient to carry out the test at night and in the following manner. The apparatus is placed on a table covered by a dark grey army blanket and the edge of the box is held firmly, level with the edge of the table, by means of an ordinary screw clamp. If a blanket were not used a noticeable glare was reflected from the table and the clamp prevented the apparatus from being upset in the darkness. All those tested, whether by night or by day, wore pre-adaptation goggles (R.A.F. pattern) for at least forty-five minutes, followed by ten minutes in complete darkness, as it was considered that the increase in retinal sensitivity that occurs after one hour is not appreciable. Those who were tested at night and had been exposed for some time to artificial light were already partially dark adapted but error is less if the time of dark adaptation tends to be long rather than short.

The test was explained to the subject seated at the table in front of the test with the hut in darkness. If spectacles were normally worn they were worn for the test. A card was placed in the clip at about the middle of the scale by the observer, sitting in front and to the right of the subject, and the flap raised. With his head in the box, the subject endeavoured to recognize the letter on the card through the slit. If the letter could be recognized it was moved further away, and vice versa until the furthest point at which the letter could be recognized was reached. This was checked by placing two other cards in the clip and adjusting if necessary. There was a tendency to eye fatigue if the subject strained for too long to see the letter and the letter could only then be read much nearer. If other candidates were in the room, the distance on the scale was read by means of an extremely dim and well-screened torch after closing the flap; otherwise the light could be turned on. The difficulty in making a hut light-proof during the day was overcome by placing a table, folding, flat, on a table, barrack, trestle, six foot. The apparatus slid comfortably under the smaller table, over which an army blanket was draped and allowed to hang down in the form of a tent. The blackout shutters of the hut were placed in position and the door closed. The inside of the "tent" was then completely dark and the test was carried out as before.

The technique of this test does not conform to the strictly scientific and accurate precepts of Mandelbaum who in measuring the sensitivity of the dark adapted retina exposes each subject to the same source of light for a fixed time, dark adapts each subject for a fixed time, exposes the object for a fixed time, and arranges by means of apparatus that the size of the pupils is constant. But it does appear to be a reasonably standard and simple test suitable for use in the field. Instead of using white cards with black letters, Dr. Wright's cards can be used, with advantage, on the modified apparatus if so desired. A difficulty arising from the use of the white cards is to keep them clean.

#### THE TEST.

Three apparatus as described above were constructed and used to test the night vision of the personnel of an A.A. unit. Three responsible N.C.O.s were instructed in the use of the test and 1,027 men were tested in a little more than five weeks despite frequent interruptions by air co-operation and other duties. The N.C.O.s were also instructed in testing visual acuity with a Snellen's type sight card and the visual acuity of every man, with, and without, spectacles if worn, was tested prior to the night vision test except in the case of those men who had had respirator spectacles issued recently, in which case the visual acuity with, and without, spectacles was taken from the A.B.64. The colour vision of more than three hundred of those taking part was tested by means of pseudo-isochromatic plates (made by American Optical Co. and supplied by Messrs. Theo. Hamblin, Ltd.) in an endeavour to discover the relationship, if any, between colour blindness and night vision.

Other data collected are shown on the proforma below which was filled in for each man. "1st Test" and "2nd Test" on the bottom line refers to the Livingston Rotating Hexagon Test for night vision with which a number of the men had been tested previously.

Name .....	Date.....	194
Rank .....	Number .....	Colour of Eyes .....
Regt. ....	Battery .....	Troop.....
Duty .....	Visual Acuity	Without Spectacles .....
Age .....	Length of Service .....	With Spectacles .....
Civilian Occupation .....	Visual Standard .....	Colour Vision .....
Town or Country Dweller .....	Night Vision .....	1st Test .....
Whether Tested on Livingston Hexagon ? .....	2nd Test.....	

#### COMPARISON OF THE APPARATUS.

All three radium luminous discs used were purchased at the same time and each bore the manufacturers warning "Renew before September 1942." In order to test that there was no marked difference between the luminosity of the discs a subject who had a very high night visual standard checked all three apparatus on the same night. Letters were recognized at 27 inches on two apparatus and 26 $\frac{3}{4}$  inches on the third. An attempt was made to compare the luminosity of the discs by means of a grease spot photometer but even after being dark adapted for several hours the intensity of illumination was too low to obtain an accurate result. The results obtained on the three apparatus only varied within reasonable limits.

#### ANALYSIS OF THE RESULTS.

Those tested were divided into the following age-groups—under 20, 20-29, 30-39, 40 and over. These were further sub-divided into the six visual standards laid down in A.C.I. 1428 of 1941 which are briefly as follows—

- Visual Standard 1. Unaided vision is not less than 6/6 in one eye and 6/9 in the other.
- Visual Standard 2. Unaided vision is less than V.S.1 but not less than 6/12 6/12 or 6/6 (R.) 6/36 (L.).
- Visual Standard 3. Unaided vision is less than V.S.2 but can be corrected to at least V.S.2.
- Visual Standard 4. Unaided vision is less than V.S.2 cannot be corrected to V.S.2 but can be corrected to at least 6/12 6/36.
- Visual Standard 5. V.S.1-4 cannot be attained but can be corrected to at least 6/24 6/24.
- Visual Standard 6. Vision with or without glasses is *not* less than 6/12 in one eye but is less than 6/36 in the other.

Visual Standard 4 precludes a man from shooting and V.S. 5 and 6 from both shooting and driving. These standards exclude far more from driving motor vehicles than does the civilian test which only requires the reading of a motor car number plate with or without spectacles at a distance of 25 yards.

The card in the sliding clip could be moved from 5½ to 29 inches from the luminous disc, and the furthest distance at which the card could be seen by each person was recorded. The recordings in the two largest groups are shown below, ignoring fractions of an inch (i.e. 18¾ taken as 18) :—

	V.S.1	Age 20-29		V.S.1	Age 30-39
		%			%
29	1	0.2		1	0.4
28	0	0.0		0	0.0
27	2	0.5		1	0.4
26	3	0.7		3	1.3
25	6	1.5		3	1.3
24	7	1.7		7	3.0
23	17	4.1		4	1.7
22	14	3.4		8	3.4
21	31	7.5		15	6.4
20	35	8.5		14	6.0
19	41	9.9		16	6.9
18	59	14.3		23	9.9
17	47	11.4		31	13.3
16	38	9.2		24	10.3
15	32	7.7		16	6.9
14	19	4.6		16	6.9
13	23	5.6		19	8.2
12	6	1.5		14	6.0
11	13	3.1		7	3.0
10	6	1.5		2	0.9
9	6	1.5		3	1.3
8	4	1.0		3	1.3
7	3	0.7		2	0.9
6	0	0.0		1	0.4
5	0	0.0		0	0.0
0	1	0.2		3	1.3
	<hr/>	<hr/>		<hr/>	<hr/>
	414	100%		236	100%

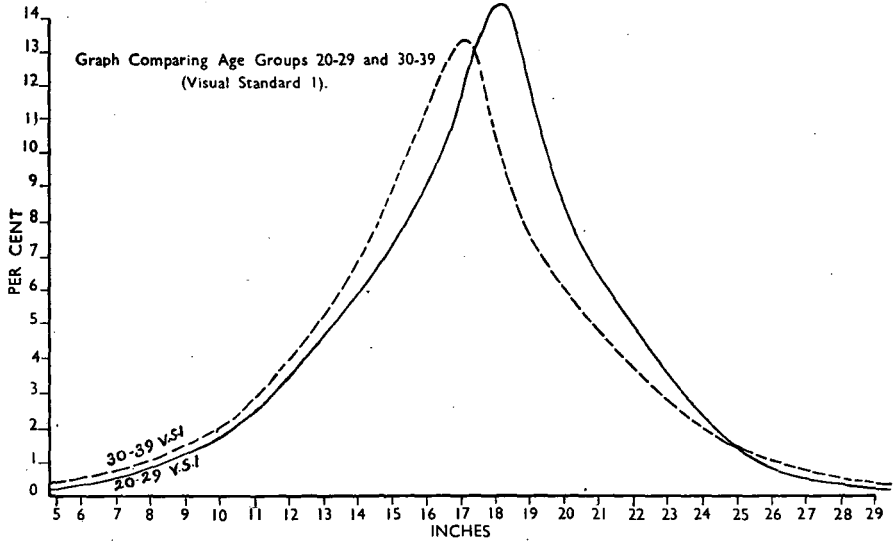
The advisability of placing these results in groups comparable to those in use in the R.A.F. was first considered, in which case the grouping would be as follows :—

	V.S.1	Age 20-29	V.S.1	Age 30-39
		%		%
Exceptional	(24-29)	4.7		6.4
Above average	(20-23)	23.3		16.3
Average	(16-19)	44.7		40.2
Below average	(12-15)	19.3		27.9
Poor	( 0-11)	8.0		9.1

As the exceptional group was small there appeared to be no value in

separating this from the group below and the final grouping decided upon was as follows:—

	V.S.1	Age 20-29 %	V.S.1	Age 30-39 %
Night Visual Standard 1 (20-29)		28.0		22.7
Night Visual Standard 2 (16-19)		44.7		40.2
Night Visual Standard 3 (12-15)		19.3		27.9
Night Visual Standard 4 ( 0-11)		8.0		9.1



These night visual standards were recorded on the training card of each man. The object was to choose "spotters" from N.V.S.1 and night drivers from N.V.S.1 and 2. If really necessary, night drivers could be drawn from N.V.S.3 but it was considered that those in N.V.S.4 should not drive at night.

The complete analysis of the tests in the various Age, Visual Standard, and Night Visual Standard Groups is tabulated below. Nine hundred and thirty of the men tested were in the six groups covered by V.S.1, 2, and 3, and aged 20-29 and 30-39. Only these groups are of any value in comparison, as the other groups are too small.

From the above table it appears that those aged between 20 and 29 in V.S.1 have better night vision than the others. This agrees with Bishop Harman's observations although Mandelbaum has not found this to be the case. Those in V.S.2 are definitely not as good as those in V.S.1 in either age-group. Although those in V.S.3 in the 20-29 group have a high percentage in N.V.S.1 there is also a high percentage in N.V.S.4. On the whole those in V.S.3 (who have had their vision corrected) have a better night visual standard than those in V.S.2.



Visual Standard	Night Visual Standard	Age groups				Total			
		19 & below	20-29	%	30-39	%	40+	No.	%
V.S.1 6/6 6/9	N.V.S.1	4	116	28.0	53	22.7	2	175	25.5
	N.V.S.2	13	185	44.7	94	40.2	5	297	43.3
	N.V.S.3	4	80	19.3	65	27.9	7	156	22.7
	N.V.S.4	2	33	8.0	21	9.1	2	58	8.5
<b>Total</b>		<b>23</b>	<b>414</b>	<b>100.0</b>	<b>233</b>	<b>100.0</b>	<b>16</b>	<b>686</b>	<b>100.0</b>
V.S.2 6/12 6/12 or 6/6 6/36	N.V.S.1	1	17	18.1	5	8.1	0	23	13.5
	N.V.S.2	2	30	31.9	29	46.8	2	63	37.1
	N.V.S.3	3	34	36.2	18	29.0	2	57	33.5
	N.V.S.4	2	13	13.8	10	16.1	2	27	15.9
<b>Total</b>		<b>8</b>	<b>94</b>	<b>100.0</b>	<b>62</b>	<b>100.0</b>	<b>6</b>	<b>170</b>	<b>100.0</b>
V.S.3c spectacles 6/12 6/12 or 6/6 6/36	N.V.S.1	0	19	27.1	3	5.3	0	22	16.1
	N.V.S.2	0	23	32.9	30	52.6	2	55	40.1
	N.V.S.3	1	16	22.9	16	28.1	3	36	26.3
	N.V.S.4	0	12	17.1	8	14.0	4	24	17.5
<b>Total</b>		<b>1</b>	<b>70</b>	<b>100.0</b>	<b>57</b>	<b>100.0</b>	<b>9</b>	<b>137</b>	<b>100.0</b>
V.S.4c spectacles 6/12 6/36	N.V.S.1	0	0		1		0	1	
	N.V.S.2	0	1		0		0	1	
	N.V.S.3	0	4		2		0	6	
	N.V.S.4	0	0		0		0	0	
<b>Total</b>		<b>0</b>	<b>5</b>		<b>3</b>		<b>0</b>	<b>8</b>	
V.S.5c spectacles 6/24 6/24	N.V.S.1	0	0		0		0	0	
	N.V.S.2	0	1		0		0	1	
	N.V.S.3	0	1		0		0	1	
	N.V.S.4	0	0		1		1	2	
<b>Total</b>		<b>0</b>	<b>2</b>		<b>1</b>		<b>1</b>	<b>4</b>	
V.S.6c spectacles 6/12 6/60	N.V.S.1	0	1		1		0	2	
	N.V.S.2	0	7		1		0	8	
	N.V.S.3	1	3		3		0	7	
	N.V.S.4	0	3		2		0	5	
<b>Total</b>		<b>1</b>	<b>14</b>		<b>7</b>		<b>0</b>	<b>22</b>	
<b>V.S.1-6</b>		<b>Total</b>	<b>33</b>	<b>599</b>		<b>363</b>		<b>32</b>	<b>1,027</b>

The two largest groups were then added together and subdivided into other groups: visual acuity 6/6 6/6 and 6/6 6/9; town dwellers and country dwellers; light coloured eyes and dark eyes. The results tabulated below showed little of value.

Night Visual Standard	V.S.1 20-29 %	V.S.1 30-39 %	V.S.1 20-39 %	6/6 6/6 20-39 %	6/6 6/9 20-39 %	Town Dweller	Country Dweller	Blue Grey Eyes	Brown Hazel Eyes	
						20-39 %	20-39 %	20-39 %	20-39 %	
N.V.S.1	28.0	22.7	25.3	25.5	25.8	25.4	26.2	26.1	23.9	
N.V.S.2	44.7	40.2	42.4	43.0	36.2	41.7	45.7	40.2	46.4	
N.V.S.3	19.3	27.9	23.6	22.8	31.0	24.3	20.4	25.8	20.4	
N.V.S.4	8.0	9.1	8.6	8.7	6.9	8.6	7.6	7.8	9.2	
<b>Total in Group</b>		<b>414</b>	<b>233</b>	<b>647</b>	<b>589</b>	<b>58</b>	<b>535</b>	<b>112</b>	<b>390</b>	<b>250</b>

An analysis into occupations proved too complicated to carry out and

its value was also doubtful. The man who obtained the best result and could recognize letters beyond the end of the machine was aged 28, and was a Forestry Warrener in civilian life.

Of the three hundred or so whose colour vision was tested twelve were found to suffer from colour blindness. The distances recorded varied from 8 to 24 inches and the number in each N.V.S. group was as follows:—

N.V.S.1	3	25.0%
N.V.S.2	5	45.6%
N.V.S.3	2	16.7%
N.V.S.4	2	16.7%

Only one set of colour test cards was available and the test should be carried out in daylight. In view of this, and that the above results did not indicate that any significant conclusions were likely to be drawn by further testing with pseudo-isochromatic plates, this test was discontinued.

Eighteen officers were tested and, as in the case of fifteen officers tested on the Livingston Rotating Hexagon, their results were considerably better than the men's results although, of course, the number tested was small.

Officers	No.	%	
N.V.S.1	8	44.4	(7 in V.S.1, 1 in V.S.2.)
N.V.S.2	7	38.9	(5 in V.S.1, 1 in V.S.2, 1 in V.S.3.)
N.V.S.3	2	11.1	(2 in V.S.1.)
N.V.S.4	1	5.6	(1 in V.S.3.)

Only three of this group were tested on the Livingston Hexagon.

#### COMPARISON WITH LIVINGSTON HEXAGON TEST RESULTS.

Some difficulty was experienced in correlating the results obtained on the modified Wright apparatus and those obtained on the Livingston test. 106 men had been tested on both machines, and of these 83 had been tested twice on the Livingston Hexagon. The methods of marking are very different and the Livingston test depends to a certain extent on mental alertness and intelligence.

#### CONCLUSION.

A modification of Dr. Wright's apparatus having been used for testing the night vision of 1,027 men, it is considered that the objects enunciated at the beginning of this report have been achieved.

I am again indebted to Lieutenant-Colonel B. Chichester Cooke, R.A., Commanding Officer, 33rd S.L. Regt. R.A., whose full co-operation made this investigation possible.

My thanks are also due to the National Physical Laboratory for much advice.

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