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C4 RESPIRATOR FIELD OF VIEW STUDY. PART 2

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C4 Respirator Field of View Study, Part 2

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C4 RESPIRATOR FIELD OF VIEW STUDY, PART 2

1. Summary

1.1 Questions have been raised regarding how far soldiers can see to the edges of their visual horizontal plane using the C4 Canadian Forces respirator. Specifically, to what degree does the C4 impair peripheral vision in the horizontal plane? DCIEM commissioned a report on the issue of horizontal peripheral vision or field of view (FOV) and a comparison of ways of measuring the FOV (Barkow, 1995).

The 1995 report recommended pilot development of a test system using human observers rather than headform mannequins. The present report addresses that recommendation.

1.2 Three approaches to tests using human observers are covered in this report. These are: (1) the Kobrick/Natick apparatus, possibly with commercially available computer automation, (2) another commercial turn-key approach from MED Associates, and (3) test equipment drawn from medical settings.

1.3 Construction of a test apparatus modeled after that developed by Dr. John Kobrick of the U.S.D.O.D. Natick (Massachusetts) lab was explored. Due to proprietary considerations, the cooperation of Dr. Kobrick was constrained by his lab management. It was decided to use equipment available at a large eye clinic which could measure the same size of visual field.

1.4 Tests using two observers wearing the C4 were undertaken at a hospital eye clinic using a Goldmann Perimeter measurement device. Results show the test equipment was suitable for one observer but not for another. In other respects, the Goldmann device worked satisfactorily for charting a basic perimeter for cooperative observers.

1.5 In as much as there are two distinct functions of peripheral field testing, dividing measurement into two distinct approaches is the recommended course.

1.5.1 For testing the full extent of FOV (including with eyes free to move), it is recommended that DCIEM use a simple presence-absence test using a light source presented manually and conducted in a light-controlled test room, with a geometry permitting testing to ±135°.

1.5.2 Where more detailed examinations of peripheral vision are needed such as in relation to ambient pressure, sleep deprivation, g-forces, etc., a Goldmann Perimeter or Kobrick/Natick device be used, because it can provide more finely-grained information. In such work, the peripheral field may be narrowed to ±90° as a consequence of the variable under study.

2. Introduction and purpose

2.1. Results of the Part 1 report

In the Part 1 report, the significance of peripheral vision for military vocations was considered in relation to the C4 respirator. It was concluded that the C4 unit is an excellent design. But in light of criticism of the peripheral vision mediated by this respirator, closer examinations of peripheral vision of the C4 were deemed appropriate.

Without a respirator, the ordinary field of view (FOV) is about ±74° in the horizontal plane with foveal fixation maintained stationary and with eyes forward. Allowing for eye movements, only around ±35° of free visual angle would ordinarily be the design target for equipment, as stated in the DCIEM HFE Guide III. Yet, different tasks demanding different perceptual skills require different FOVs. It was concluded that a FOV ±70° would not result in a significant loss of skill for military tasks while wearing the C4 respirator. However, there still remains the question — whether of any functional importance or not — of restriction by the C4.

What is the sensible way to test FOV? Broadly speaking, two forms of testing were identified. These are (1) headforms or mannequin tests and (2) human observer tests. Comparing the benefits and limitations of these forms, it was concluded that headform tests are convenient and "objective," but headform-based tests are always open to criticism based on the design of the unit and fit of the respirator (that is to say, the matter of defining the precise location and fit of the respirator on the mute headform).

As no acceptable headform test could be identified, it was concluded that only tests using human observers would be suitable for present purposes.

FOV tests using human observers had been conducted successfully for some years by a military Psychologist, Dr. John Kobrick of the U.S.D.O.D. Natick (Massachusetts) lab. His automated test apparatus had been used in a variety of studies, such as for tests of the effect of oxygen restriction on peripheral vision, and seemed conformable to the present requirements.

It was concluded that DCIEM should next undertake a pilot test of the C4 using human observers with a Natick-type apparatus.

2.2. Purposes of Part 2 and terms

Moving forward to produce a pilot test of a Kobrick/Natick type apparatus, it was requested of the contractor to provide a small set of measurements to provide concrete evidence of how such an apparatus might work.

The terms for Part 2 also indicated an interest in "integrating" the STOLL measurements (as used in Holland to evaluate the C4) with the Natick approach. However, no information other than anecdotal reports have ever been accessed by DCIEM for the STOLL method and so, early in the project this component of the report was dropped.

2.3. Activities

This project had two phases.

Phase 1 - Information Gathering

In this phase, authorities and sources of information were consulted. Information was sought on FOV testing. In addition, sources of information on how to create automated testing systems and where to procure equipment were interviewed. Information gathering also took place after the Pilot Test phase.

Phase 2 - Pilot Test

Even though recommended in the Part 1 report, it was concluded that Dr. Kobrick's approach was not readily feasible for mounting of the pilot test without further inquiry. It was decided to conduct basic perimeter measurements on two individuals using a medium size C4 respirator. The testing was conducted by a trained medical specialist on a Goldmann perimeter measurement device at the Toronto Western Eye Clinic.

3. Systems of measurement

3.1. Introduction

While the Kobrick/Natick apparatus was identified as the first priority test system in the Part 1 report, a number of other approaches are possible. This section describes (1) Kobrick/Natick, (2) generic lab equipment, and (3) medical test equipment approaches.

3.2. Kobrick/Natick apparatus

Basic design

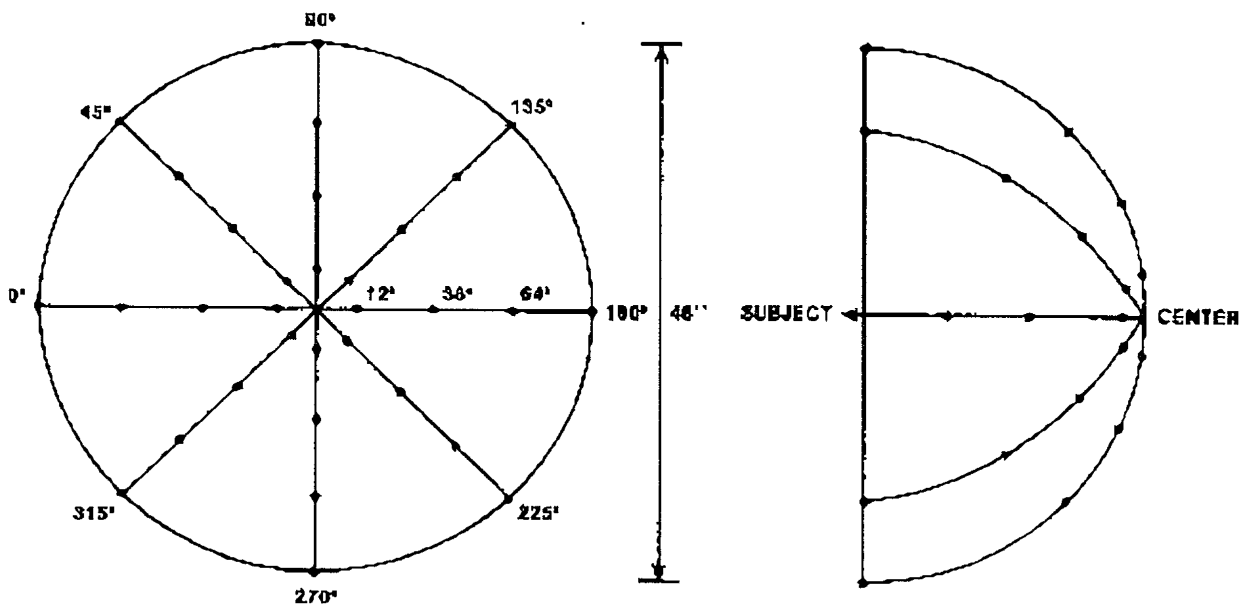
The Kobrick apparatus has been evolving for about 25 years. The basic stimulus presentation structure has been relatively unchanged for some time but an improved system for automatically presenting stimuli and recording reaction times has been the main target of development. Little development has taken place since 1985 although there is at present some interest in further efforts to refine the test device.

The Kobrick test methodologies and apparatus can be reviewed in the following references:

Barkow, 1995.
Kobrick and Dusek, 1970.
Kobrick, Lussier, Mullen, and Witt, 1985.
Kobrick and Sleeper, 1986.
Kobrick and Sutton, 1970.

The basic test unit, see the illustration below, may be thought of as an umbrella frame with eight spars (without the axial handle member, of course). The spars or ribs form a hemisphere with a 53 cm (24 inch) radius and uniformly spread about the central axis, 45° apart. Yellow LED bulbs (or other colours may be used) are placed along the spars, in order to form visual angles with reference to a forward fixation of 12, 38, 64, and 90 degrees. With eight spars and four angles of observation on each, there are a total of 32 bulbs plus a fixation target, if needed. A simple chin rest is used to locate and stabilize the observer's head position.

Although this unit extends only to ±90°, there is no reason in principle why it could not extend further, at least in the horizontal plane. However, with the exception of the present DCIEM purpose (to examine if the C4 compromises FOV, with eye movement) there appears to be no research imperative to go beyond 90°. But phenomena of narrowing of the visual field under various bodily stresses and conditions can be observed well within a ±90° extent.



A listing of a program written in Basic to operate on a Hewlett-Packard computer, long since discontinued, is available. The apparatus and control systems are described in Kobrick, Lussier, Mullen, and Witt (1985).

A number of phone discussions were held with Dr. Kobrick in 1995 and 1996. As of the last contact, the DOD have not decided if they are interested in maintaining proprietary rights to the apparatus and control software. Therefore, while the code listing is published, other researchers, even DCIEM, are not able to get functional electronic versions of the software.

Cost

Developing a Kobrick apparatus was estimated in the Part 1 report at $2 500 for the basic physical unit. Some means of controlling light exposures is also needed. This can include the use of multi-pole switches and manual presentation, requiring minimal hardware expenditures of perhaps $300... and a clipboard.

It is assumed in this report that a suitable PC computer is available and no budget is here assigned to its procurement.

At the simplest level of automation assistance, control software and a hardware interface are needed, Purchasing a hardware interface between the a computer and the light sources would be $500 for a MED Associates *output* interface, model DIG-727A, 32 Output SuperPort (allowing some variation for dollar conversion to U.S. prices).

Other pieces of ancillary equipment, including cabinets, cables, power supplies, etc. can add up to about $700.

Software development varies appreciably depending on features, degree of automation, and the extent to which data is formatted and output. Software which only presents the stimuli and does not otherwise detect, measure, or record responses, would cost approximately $2 000 for development.

Outputting of data can be entirely manual and inexpensive, with the lab staff recording presence or absence of detection of the stimulus, as described above. At the other end of the range, a fully automated system can measure reaction time and prepare standard format ASCII tables or even attractive charts constructed from the data and showing separately the visual angle at which the stimuli were presented. This requires (1) an additional *input* hardware interface in order to input the observer's response and the timing of that response and (2) control software as simple or as elaborate as is required and tied to some means of display or output.

Input hardware is available from MED Associates for prices ranging from $500 for a simple input interface, to approximately $3 000 which includes software, site licence, and ancillary pieces.

What system might be satisfactory for initial installation at DCIEM? For a basic system which counts detections as well as reaction time and simply displays these on a screen, the hardware might be $1 500 and the software development cost might be in the range of $6 000 to $10 000.

3.3. Apparatus constructed from generic lab equipment sources

Basic design concepts

While the presentation apparatus used by Dr. Kobrick cannot be purchased as a stock unit, the command and control systems can be. While some familiar suppliers of perceptual lab equipment — such as Lafayette — have gone out of business in recent years some of their units and/or conceptual designs are available from successor firms.

MED Associates of St. Albans, Vermont, for example, provide timers, sequencers, and various lab gear which appear to similar to that formerly manufactured by Lafayette.

Gerbrands Corporation, Arlington, Massachusetts, who were respected for their tachistoscopes, may or may not have a successor organization.

Finally, a number of firms (for example, "Z-World") manufacture controllers which connect to PCs in order to control real-world functions. Controllers can be sophisticated I/O boards or external, separately powered units. These range from $200 and upwards in price for single channel units.

Costs

As previously discussed, the presentation apparatus cannot be procured from stock but must be fabricated for approximately $2 500.

An entire system of control for basic presentation as well as recording of responses has been quoted by MED Associates (Quotation MW-1830, 1996 October 2) at US$2 090, exclusive of taxes, transportation, certain software coding, and the computer on which it would operate. This includes non-custom software which operates the equipment, known as "MED-PC Version 2."

Tachistoscope equipment from Gerbrands could have been purchased as individual elements when the firm was in active business in 1991. As best as can be judged from catalog listings, Gerband's prices are higher than MED Associates, but they offered a greater range of components.

On first inspection, this "turn key" solution appears economical compared to developing a Kobrick/Natick system for DCIEM which uses stock interface units and locally developed software. However, at this point in time it can not be accurately estimated as to what degree this solution would approximate DCIEM needs or the amount of custom code that would be required to bring it within serviceability for DCIEM.

3.4. Medical test equipment

A few instruments represent the standard systems used for testing visual fields and therefore the peripheral extent of these fields in ophthalmology settings.

Goldmann Perimeter

The older, mechanically complex, manually operated unit is the Goldmann Perimeter. The subject rests their head on a chin cup and forehead bar. The subject's head is at the centre of a hemisphere, about 1 m in diameter. The operator introduces a bright light source into the perimeter of the field while the person fixates ahead. When the target is detected, the patient presses a switch which alerts the technician to mark a sheet mimicking the visual field. The technician then connects the points, tracing the visual field as tested.

The Goldmann Perimeter device was chosen for pilot test to be described below. It was found that an unaltered C4 could, with a slight degree of awkwardness, be tested without alteration to the head location mechanism. With a modest degree of mechanical ingenuity, a headrest fully suitable for the C4 (and the person within it) could be produced.

The test strategy of the Goldmann Perimeter is not sophisticated. As it is ordinarily used, the observer merely notes when he or she "sees" the incandescent white lamp spot enter their field of view, albeit at somewhat randomly chosen locations. This may be contrasted with a Kobrick/Natick set-up where flashes are randomly presented anywhere in the field and reaction time to flashes can also be recorded. Persons with inclination to cheat (for example, where they have a motivation to perform well) are less hindered by the Goldmann and indeed, well-meaning observers may sense light reflecting from parts of the C4 lens, although not truly visible within their FOV.

The Goldmann Perimeter is sold by Innova Ophthalmic who are themselves uncertain if it is still being made. If available, its cost is about $20 000.

Humphreys Field Analyzer

The newer instrument, now replacing the Goldmann mechanical device in most settings is the Humphreys Field Analyzer. This unit is computer driven and requires little attention from an operator once the person is located in the head stabilizing apparatus. Again, the person is at the centre of a hemisphere, although one much smaller than the Goldmann globe.

Two models are available. Model One, available presently only second-hand and refurbished has a field extent of ±75° and sells for $10 000 to $20 000. Model Two has a field which is ±90° and sells for around $40 000.

Both Humphreys units have the drawback that a respirator would have to be carefully trimmed close to a human head size in order to fit within the apparatus. The trimming might upset the structural integrity of the C4 and make goodness of fit moot. The Part 1 report pointed out that the quality of fit of the C4 with mechanical headforms was a serious drawback of the headform measurement approach.

Interzeag Octopus 101

A newer, device along the same lines as the Goldmann (but operated automatically like the Humphreys) is the Octopus 101. Again a sphere is used but bulbs of fixed location are flashed from the outside of the globe. It is larger than a Humphreys but smaller than a Goldmann. It can be set up to cover angles greater than 90° although just how this is done is not obvious from the description of the unit. The cost is about $25 000 and a PC with Windows is also needed.

4. Pilot testing

4.1. Preliminary efforts and limitations of the pilot test

Discussions were started with Dr. Kobrick at the onset of this contract for the purpose of availing the project with his software which could then be applied to a mock-up construction of his presentation device.

For most of a year, Dr. Kobrick was unable to commit to assisting us while the management of the Natick lab considered the value of deeming his work proprietary to the U.S.D.O.D. At the end of their deliberations in the summer of 1996, it was determined to take a conservative approach and to ask Dr. Kobrick to withdraw from free cooperation with the contractor. In as much as this Natick management policy change took place in the course of the contract and could not be foreseen or controlled, no general lesson may be drawn from the experience for pilot testing in the future except to recognize the value of always having a "Plan B."

At the same time, discussions took place with visual test authorities, principally Dr. Martin Steinbach who is associated with the Sick Kids and Toronto West Hospital eye clinics as well as faculty at York University. It was Dr. Steinbach's recommendation to use existing medical-related eye test equipment. He suggested the use of a Humphreys Field Analyzer or Goldmann Perimeter test device.

All matters considered, it was deemed expedient to use a Goldmann test. The Toronto Western Hospital, which has the largest eye clinic in Canada, provided staff with testing experience, at least in a medical context. Moreover, by renting the equipment and personnel, it was possible to produce reliable plots using standardized equipment, an achievement not possible with mock-up gear or developmental designs.

4.2. Pilot test using a Goldmann Perimeter

Two observers, using a medium size C4 were tested by an experienced operator on the Goldmann Perimeter at the Toronto Western Hospital Eye Clinic. All components which could be readily removed from the basic C4 shell without material damage to the unit were absent in these tests.

As a reasonable compromise, it was decided not to damage a C4 even though positioning of the respirator as worn by the observers in the Goldmann head holder was not as well controlled or as correctly oriented as might be desired for more formal testing. It appears to superficial inspection that the Goldmann head positioning mechanism could be modified to provide stable positioning to the C4. But this would require some machining of parts although of a simple, straightforward sort. (Such modifications appear, to superficial observation, to be harder to bring about on a Humphreys device.)

The plots of peripheral vision are reproduced below in the Appendix.

It can be seen that observer #1 while wearing the C4 has peripheral vision which exceeds the ±90° capacity of the Goldmann. But peripheral vision of observer #2 does not exceed the Goldmann's capability. Observer #2 has a FOV in the C4 which is ±85°.

In addition to restriction of horizontal plane FOV, some restriction is apparent at the bottom (and possibly the top) of the field.

It may be noted that with eyes forward, the C4 was not the limiting condition of vision for observer #2. However, if eyes were not required to be fixated ahead, the C4 would have constrained the observer's FOV but this constraint would have been outside the range of measurement of the Goldmann Perimeter.

5. Conclusions/Recommendations

5.1. Introduction

As with many aspects of research, it may be hard to develop an apparatus which can meet all requirements. Rather, it may be productive to divide FOV testing requirements into two classes, (1) the original purpose of this exercise, to establish to what extent the C4 compromises peripheral vision and (2) experiments with stressors which influence peripheral vision.

5.2. C4 Field of View

None of the devices examined provides measurements beyond 90°. With eyes fixated forward, that is an adequate range for any purposes but not enough to settle the basic question of restriction when eye movements are permitted. Using eye fixation is an arbitrary and unrealistic way to consider military vision in operational circumstances.

Testing of FOV of the C4 need not be elaborate or highly automated provided that it is undertaken infrequently. If so, it may be suitable to rig a light-tight room with a mechanism to fix the observer's head and some means of presenting visual targets at known angular distances.

However, this custom test suite may not meet squarely enough the criticism from NATO. That is because it is not a standard or reproducible test system. Committed critics of the C4 may require evidence from a system of which can be better documented or which is a standard of practice, such as the Humphreys system. Moreover, for many purposes a simple "Can you see the light?" test is insufficiently psychologically sophisticated in the sense of not being securely resistant to observer dissembling (Webb, Campbell, Schwartz, and Sechrest, 1969).

The issue of dissembling, ranging from unconscious desire to oblige the experimenter to purposive lying motivated by self-interest, can always be raised by committed critics. It may be the case that all perceptual methodologies involving subjective reactions are potentially subject to this criticism, conditioned by the experimental logic such as double-blind methods, etc. Thus the Goldmann Perimeter would not be suitable as part of a test battery to select, say, pilots, in which occupation good vision was deemed important. In the present instance, the benefits to the individual are insufficiently motivating to result in much influence.

If DCIEM (1) wish to develop a capability to do peripheral vision experimentation or (2) if DCIEM feel that a better documented system is warranted, then a Kobrick/Natick device can be developed, as recommended below, which extends to ±135°, but the final 45° should permit variable location of the LED, not fixed, as in the ±90° central range.

5.3. Peripheral Vision Experimentation

Various stressors found in military operations — including aircraft piloting — influence peripheral vision. DCIEM might wish to have available a test system in order to experiment with these influences. Various studies of this sort have been reviewed (Barkow, 1995) and the phenomena in question can be studied within a field of ±90°, often within ±70°.

To develop an in-house capability for such studies, it is recommended that DCIEM construct a Kobrick/Natick type apparatus and procure a commercial computer system to drive it, with customization of the software as needed.

6. References

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Kobrick, J. L. and L. A. Sleeper: Effect of wearing chemical protective clothing in the field in the heat on signal detection over the visual field. *Aviation, Space, and Environmental Medicine,* 1986.

Kobrick, J. L. and William R. Sutton: Device for measuring voluntary response time to peripherally placed stimuli. *Perceptual and Motor Skills,* 1970.

Webb, Eugene J., Donald T. Campbell, Richard D. Schwartz, and Lee Sechrest: *Unobtrusive Measures: Nonreactive research in the social sciences.* Chicago: Rand McNally & Co., 1969.

7. Appendix

7.1. : Sources of Information

Individuals

Vern E. Davidson - MED Associates, St. Albans, Vermont and MED-West Office, Lafayette, Indiana

Dr. Moshe Eisenman - Toronto Western Hospital Eye Clinic

Paul Fabris - interface specialist at Elm Street Computer

Dr. John Flanagan - Toronto Western Hospital Eye Clinic and Waterloo University

Dr. John L. Kobrick - research scientist, Natick Lab, U.S.D.O.D.

Brian Mitchell - software developer for hardware interfaces

Charlene Mueller - Administrative Director, Toronto Western Hospital Eye Clinic

Dr. Martin Steinbach - Hospital for Sick Children (vision research lab) and York University

Organizations

Humphreys Instruments, San Leandro, California (Katy Washburton, 510-895-9110)

Innova Ophthalmics, Downsview (Goldmann and Octopus 101; Jim Washbrook, 416-398-3306)

Toronto Western Hospital Eye Clinic (Wendy, Goldmann operator)

Z-World, Davis, California

Carl Zeiss, Toronto (Brenda Connoy, 416-429-3309)

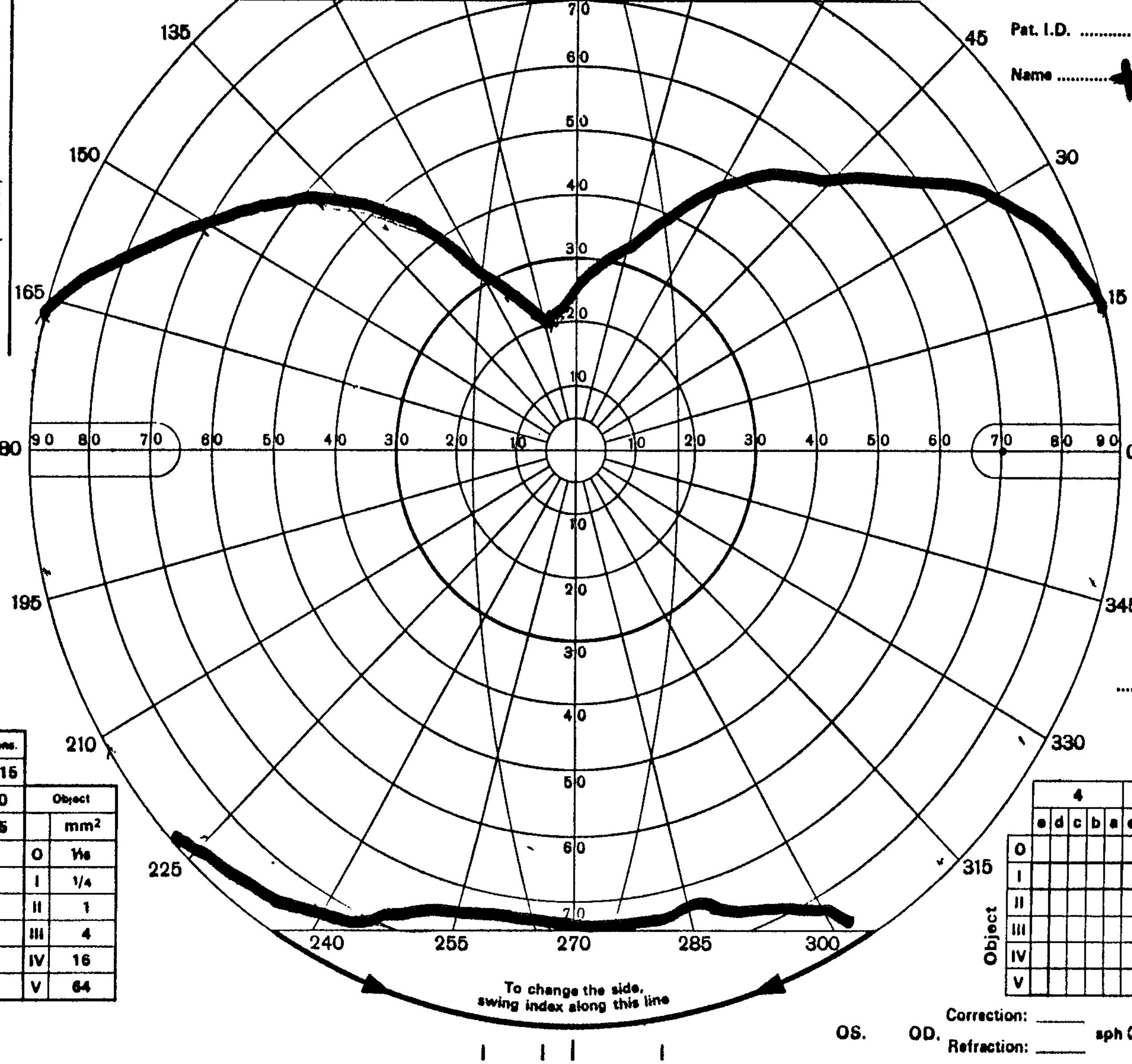
7.2. : Two Goldmann plots

GOLDMANN PERIMETER CHART
Form 2443 (Rev. 5/93)

Pat. I.D. ....

Name ......#1 ....

III4e
A.



.... mm Pupil size

Rel. Intens.	Object	mm²
0,0315		
0,100		
0,315		
1,00	O	1/16
0,40	I	1/4
0,50	II	1
0,63	III	4
0,80	IV	16
1,00	V	64

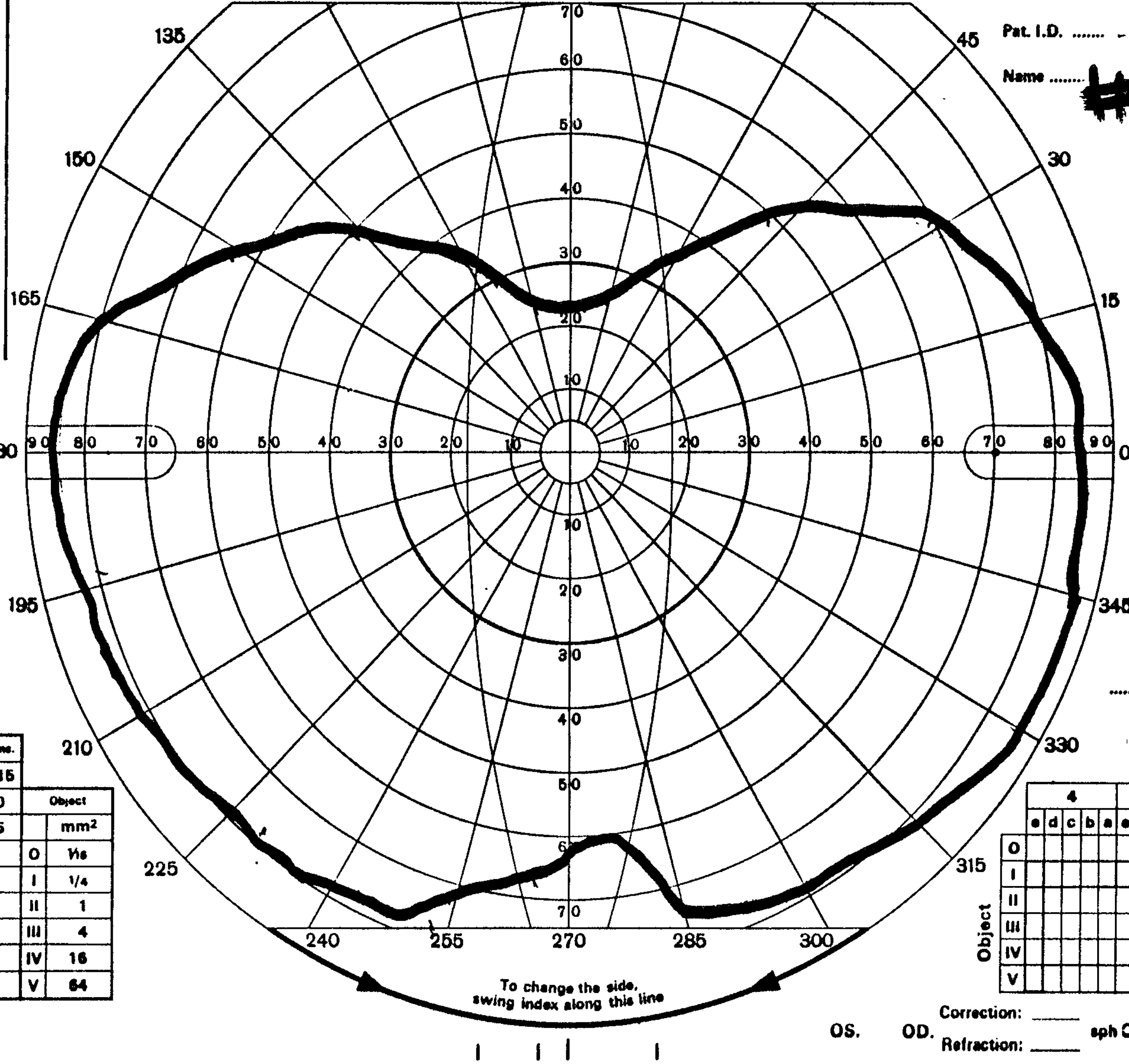
Relative Intensity

Object	4					3					2					1				
	e	d	c	b	a	e	d	c	b	a	e	d	c	b	a	e	d	c	d	a
O																				
I																				
II																				
III																				
IV																				
V																				

OS. OD. Correction: ____ sph ○ ____ cyl ____ • Vision:
Refraction: ____ ____ ____ • ____

GOLDMANN PERIMETER CHART
Form 2443 (Rev. 5/93)

Pat. I.D. ....
Name .... #2



Rel. Intens.		Object
0,0315		
0,100		
0,315		mm²
1,00	O	1/16
0,40	I	1/4
0,50	II	1
0,63	III	4
0,80	IV	16
1,00	V	64

.... mm Pupil size

Relative Intensity

Object	4					3					2					1			
	e	d	c	b	a	e	d	c	b	a	e	d	c	b	a	e	d	c	d	a
O																				
I																				
II																				
III																				
IV																				
V																				

OS. OD. Correction: ____ ____ ____ • Vision:
Refraction: ____ sph ○ ____ cyl ____ • ____

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