Loughborough University

This item is held in Loughborough University's Institutional Repository (https://dspace.lboro.ac.uk/) and was harvested from the British Library's EThOS service (http://www.ethos.bl.uk/). It is made available under the following Creative Commons Licence conditions.

creative commons

COMMONS DEED

Attribution-NonCommercial-NoDerivs 2.5

You are free:

- to copy, distribute, display, and perform the work

Under the following conditions:

Attribution. You must attribute the work in the manner specified by the author or licensor.

Noncommercial. You may not use this work for commercial purposes.

No Derivative Works. You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

Your fair use and other rights are in no way affected by the above.

This is a human-readable summary of the Legal Code (the full license).

Disclaimer

For the full text of this licence, please go to:
http://creativecommons.org/licenses/by-nc-nd/2.5/

THE ERGONOMICS OF VIDEO DISPLAY TERMINAL WORKPLACES IN INTERNATIONAL TELEPHONE EXCHANGES

By

T. G. MOORE

VOLUME 2 (of 2)

A DOCTORAL THESIS

Submitted in partial fulfilment
of the requirements for the award of
Doctor of Philosophy of the
Loughborough University of Technology.

FEBRUARY, 1981.

Supervisor: Professor N. S. Kirk
Department of Human Sciences.

© by T. G. Moore

DAMAGED

TEXT

IN

ORIGINAL

TEXT BOUND INTO

THE SPINE

BEST COPY

AVAILABLE

TEXT IN ORIGINAL IS
CLOSE TO THE EDGE OF
THE PAGE

Text cut off in original

REFERENCES

REFERENCES

ASTMS (1979) Guide to health hazards of visual display units. Policy Document from the Association of Scientific, Technical and Managerial Staffs, London.

BEDWELL, C.H. and STONE, P.T. (1976) Recommendations relating to viewing of the visual display unit and keyboard of ANE 403, Report to L.M. Ericsson, June.

BELL, R.A. (1970) CRT Phosphor Selection. Instruments and Control Systems, March.

BERGER, C. (1944) Stroke width, form and horizontal spacing of numerals. Jnl. Applied Psychol., 28, 208-231.

BOURNE, C.P. and FORD, D.F. (1960) A study of methods for systematically abbreviating English words and names. Jnl. Assn. Computing Machinery. 538-552.

BROWN, E.G. (1967) Low resolution television: subjective comparison of interlaced and non-interlaced pictures. Bell Systems Technical Journal, 46, 199-232.

BROWN, I.D., WASTELL, D.G., TREDRE, B., COPEMAN, A.K. and COLLINS, J. (1980) Some effects of task and workspace design trends on correlates of job satisfaction among telephone switchboard operators. 9th International Symposium on Human Factors in Telecommunication. Red Bank, New Jersey, Sept-Oct.

ELIAS, M.F., SNADOWSKY, A.M. and RIZY, E.F. (1965) Identification of televised symbols as a function of symbol resolution. Perceptual and Motor Skills, 21, 91-99.

GALITZ, W.O. (1965) CRT keyboard human factors evaluation. UNIVAC, Systems Application Engineering, Roseville DPD, March.

GIDDINGS, B.J. (1971) Contrast enhancement with CRT and other self luminous display devices. Displays Conference Proceedings, IEE Conference Publications 80.

GIDDINGS, B.J. (1972) Alphanumerics for Raster Displays. Ergonomics, 15, 65-72.

GOULD, J.D. (1968) Visual factors in the design of computer controlled CRT displays. Human Factors, 10, (4), 359-376.

GRAHAM, E.H. (1965) Discriminations that depend on wavelength. In Vision and Visual Perception (Ed. Graham, E.H.) Wiley, N.Y. pp. 350-370.

GRANDJEAN, E. and VIGLIANI, E. (Eds) (1980) Ergonomics aspects of visual display terminals. Taylor and Francis, London.

HABBERFIELD, V.J. (1971) Cordless switchboards. Post Office, THQ/SvD/Sv2, Internal Memo No. MDCT (71), June.

HARRIS, R.H., DUGGLEBY, R. and TURNHAM, L.K. (1975) Operating times for automanual switchboards. Post Office Telecommunications Management Services Dept., Report 340.

HAYMAN, E. (1969) Design criteria for CRT alphanumeric displays. IEEE Symposium Man-Machine Systems.

HEMINGWAY, J.C. and ERICKSON, R.A. (1969) Relative effects of raster scan lines and image subtense on symbol legibility on television. Human Factors, 11 (4), 331-338.

HILLIX, H.A. and COBURN, R. (1961) Human factors in keyset design. Research Report 1023, U.S. Navy Electronics Laboratory, San Diego, California.

HOPKINSON, R.G. and COLLINS, J.B. (1970) The Ergonomics of Lighting. MacDonald, London.

HOWELL, W.C. and KRAFT, C.L. (1959) Size, blur and contrast as variables affecting the legibility of alphanumeric symbols on radar-type displays. Wright Patterson Air Base Report, USAF: WADC TR 59-536.

HUDDLESTONE, H.F. (1974) A comparison of two 7x9 matrix alphanumeric designs for T.V. displays. Applied Ergonomics, 5, 81-83.

HULTGREN, G.V. and KNAVE, B. (1974) Discomfort glare and disturbances from light reflections in an office landscape with cathode ray tube terminals. Applied Ergonomics, 5, 2-8.

HYMAN, C.E. (1967) Anti-glare coatings for computer controlled CRT's IBM Technical Note TN 21.575-23, August.

I.E.S. Code (1973) Illuminating Engineering Society Code for Interior Lighting, I.E.S., London.

IVANOFF, A. (1952) Les aberrations de l'oeil. Revue d'Optique, Paris.

KELLEY, R.G. (1960) The effect of direction of contrast to (sic) TV legibility under varying ambient illumination. Performed at Dunlop and Associates, Stamford, Conn. (Shurtleff, 1967).

KINGHORN, J.R. (1975) Character rounding for alphanumeric video display. Mullard Technical Communications, No. 126 (April).

KINKEAD, R.D. and GONZALEZ, B.K. (1969) Human factors design recommendations for touch operated keyboards - final report. Document 12091-FR, Honeywell Inc., Minneapolic, March.

KNOWLES, W.B. and WULFECK, F.W. (1972) Visual performance with high contrast cathode ray tubes at high levels of ambient illumination. Human Factors, 14 (6), 521-532.

KUEHN, R.L. (1969) Display requirements assessment for command and control systems. NATO AGARD Proceedings, 23, 81-92.

LALLY, K P. (1969) Non linear optical filters for high contrast displays. Proc. 7th Natl. Symp. Soc. Info. Display, 47-55.

LAU, E. (1921) Neue untersuchungen über das Tiefen und Ebenenschen f. Psychol. u. Physiol. d. Sinnesorg. Abt. II, 53, pp.1-35.

LUNDERVOLD, A.J.S. (1957) Electromyographic investigations of position and manner of working in typewriting. Acta Physiologica Scandinavia. Supplement 84.

MACLEAN, M.V. (1965) Brightness contrast, colour contrast and legibility. Human Factors, 7, 521-526.

MALLETT, R.J.F. (1964) The investigation of heterophoria at near and a new fixation disparity technique. The Optician. December.

MARTIN, J. (1973) Design of Man-Computer Dialogues, Prentice-Hall.

MONETA, K.B. (1960) Optimum physical design of an alphanumeric keyboard. Part 1. Survey of the Literature. Post Office Research Report No. 20412, Part 1, November.

ÖSTBERG, O. (1974) Fatigue in clerical work with CRT display terminals. Göteborg Psychological Reports, 4, 19.

POOLE, H.H. (1960) Fundamentals of display systems. Spartan, Washington.

REMINGTON, R.J. and ROGERS, M. (1969) Keyboard Literature Survey, Phase I: Bibliography. IBM Technical Report, TR 29.0042.

REY, P. and REY, J.P., (1963) Ergonomics, 6, 393.

RICHE, C.V. and KINEEY, G.C., (1969) Studies in display legibility. NATO AGARD Proceedings, 23, 93-103.

SCALES, E.M. and CHAPANIS, A. The effect on performance of tilting and toll-operator's keyset. Journal of Applied Psychology, 38, 452-456.

SEGAL, J. (1950) Centre Scientifique et Technique du Batiment. Monograph 8 Note 84.

SEIBERT, W.F., KASTEN, D.F. and POTTER, J.R. (1959) A study of factors influencing the legibility of Televised Characters. Journal of the Society of Motion Picture and Television Engineers, 68, 467-472.

SHURTLEFF, D.A. (1967) Studies in TV legibility - a review of the literature, Information Display, Jan./Feb.

SOAR, R.S., (1955) Height-width, proportion and stroke width in numeral visibility. Journal of Applied Psychology, 39, 1, 43-46.

SOAR, R.S. (1958) Numeral form as a variable in numeral visibility. Journal of Applied Psychology, 42, 3, 158-162.

STEWART, T.F.M. (1974) Computer Terminal Ergonomics. Statskontoret, Sweden.

STOCKER, A.C. (1964) Displays, papers and lighting: the visual system in command centres. Information Display, Sept./Oct.

STOCKER, A.C. (1966) The size and contrast of hard-copy symbols. Information Display, July/August.

VARTABEDIAN, A.G. (1970) Human factors evaluation of several cursor forms for use on alphanumeric CRT displays. IEEE Trans. Man-Machine Systems, Vol. MMS-11, No.2, June.

VARTABEDIAN, A.G. (1971a) Legibility of symbols on CRT displays. Applied Ergonomics, 2, (3), 130-132.

VARTABEDIAN, A.G. (1971b) The effects of letter size, case, and generation method on CRT display search time. Human Factors, 13, (4), 363-368.

VARTABEDIAN, A.G. (1971c) A graphic set for ASCII using a 7x9 dot matrix. Information Display, Nov./Dec.

VARTABEDIAN, A.G. (1973) Developing a graphic set for cathode ray tube display using a 7x9 dot pattern. Applied Ergonomics, 4, (1) 11-16.

WELLS, B.W.P. (1965) Building Science, 1, 57.

FIGURES.

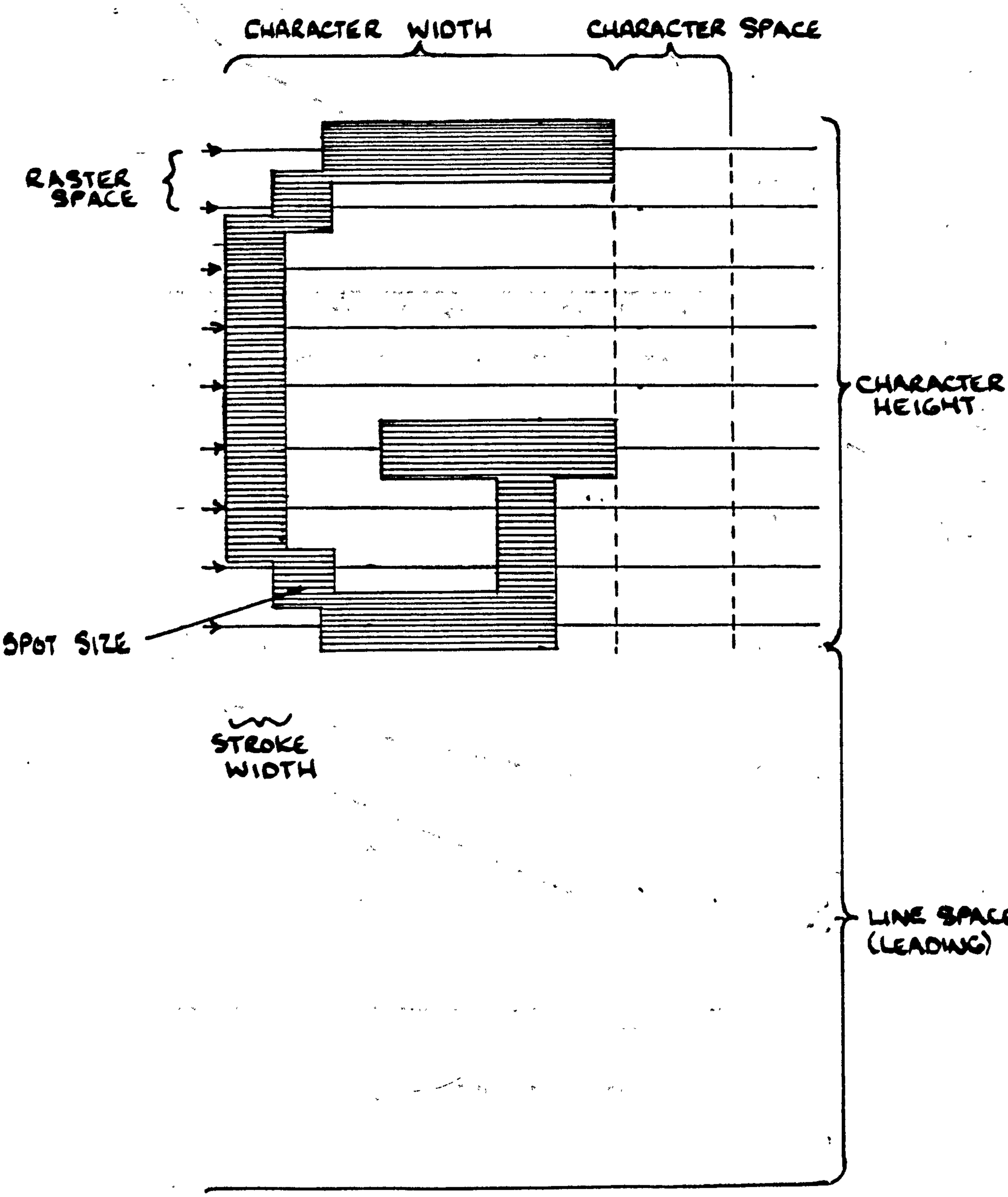
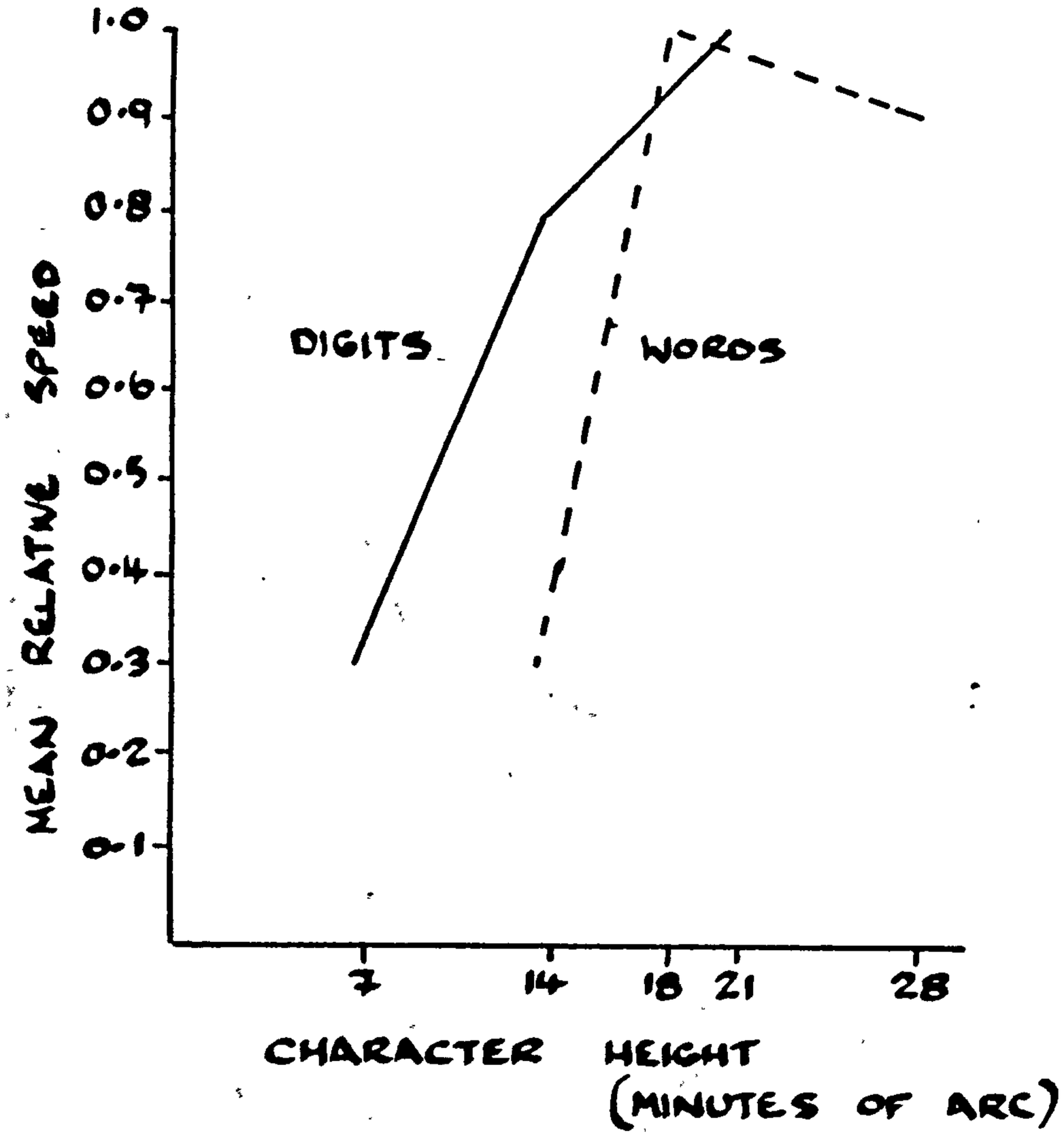


FIGURE 1 CHARACTER SIZES



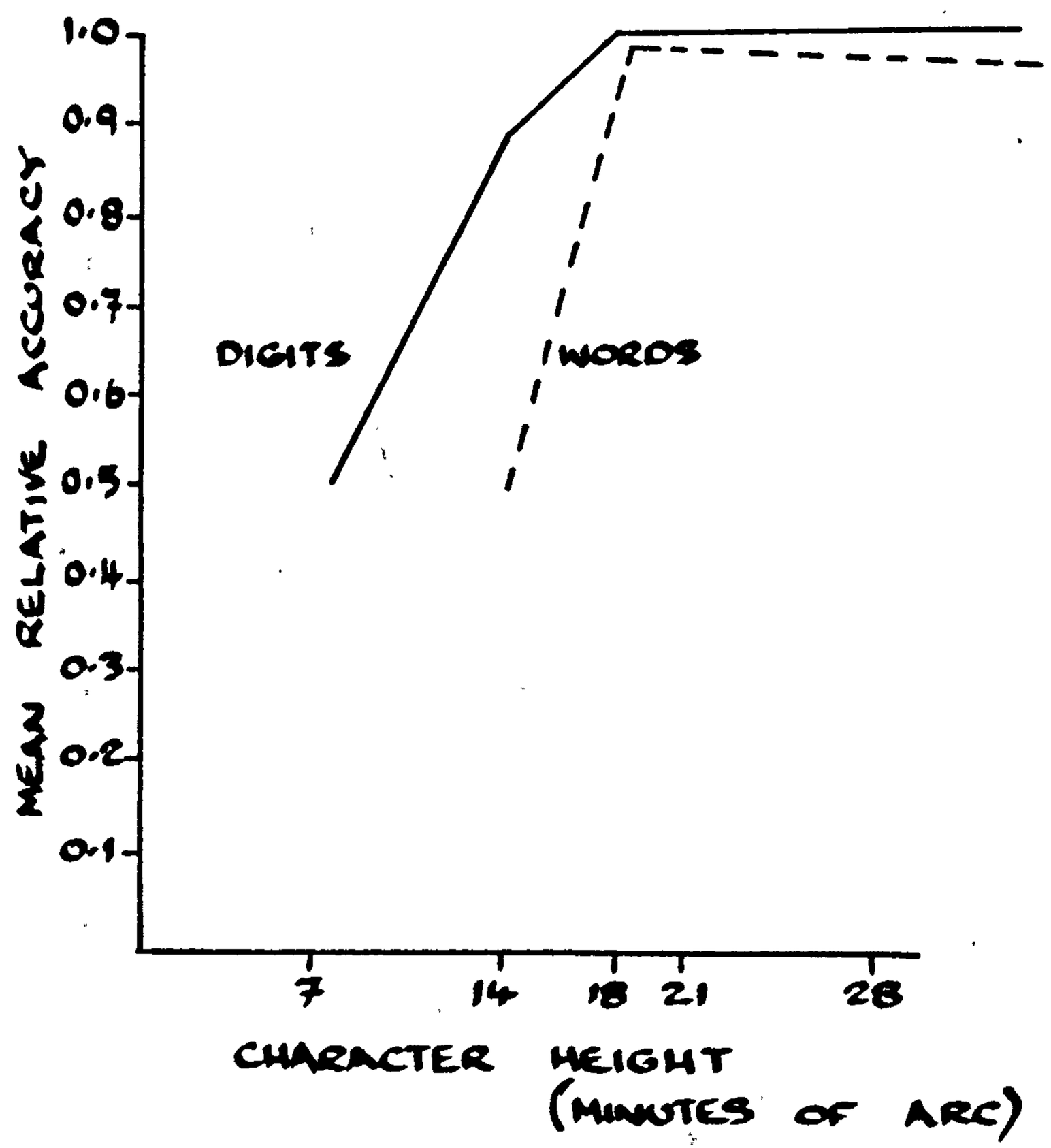
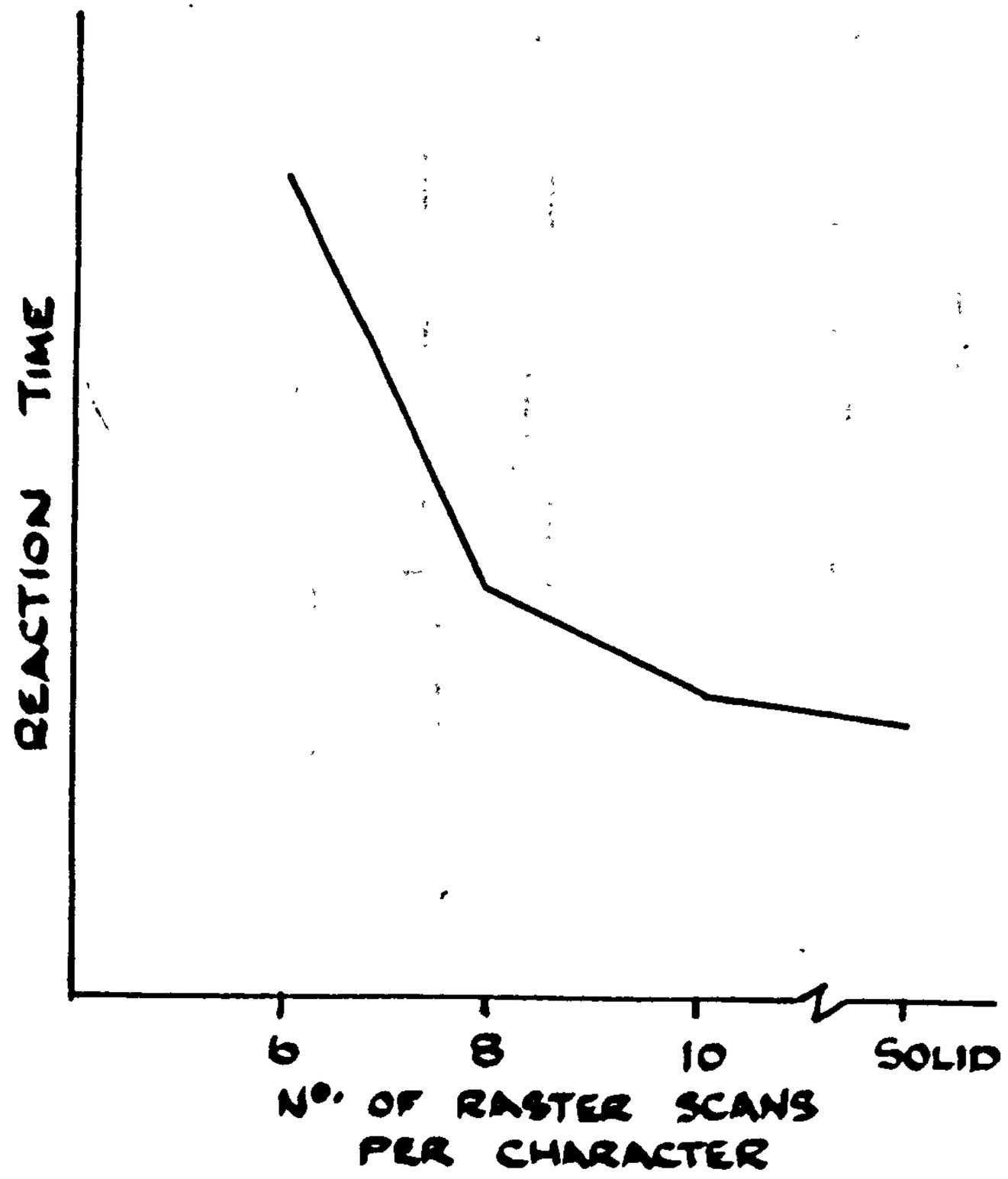


FIGURE 2 RELATIONSHIP BETWEEN HEIGHT AND PERFORMANCE
(GIDDINGS, 1972)



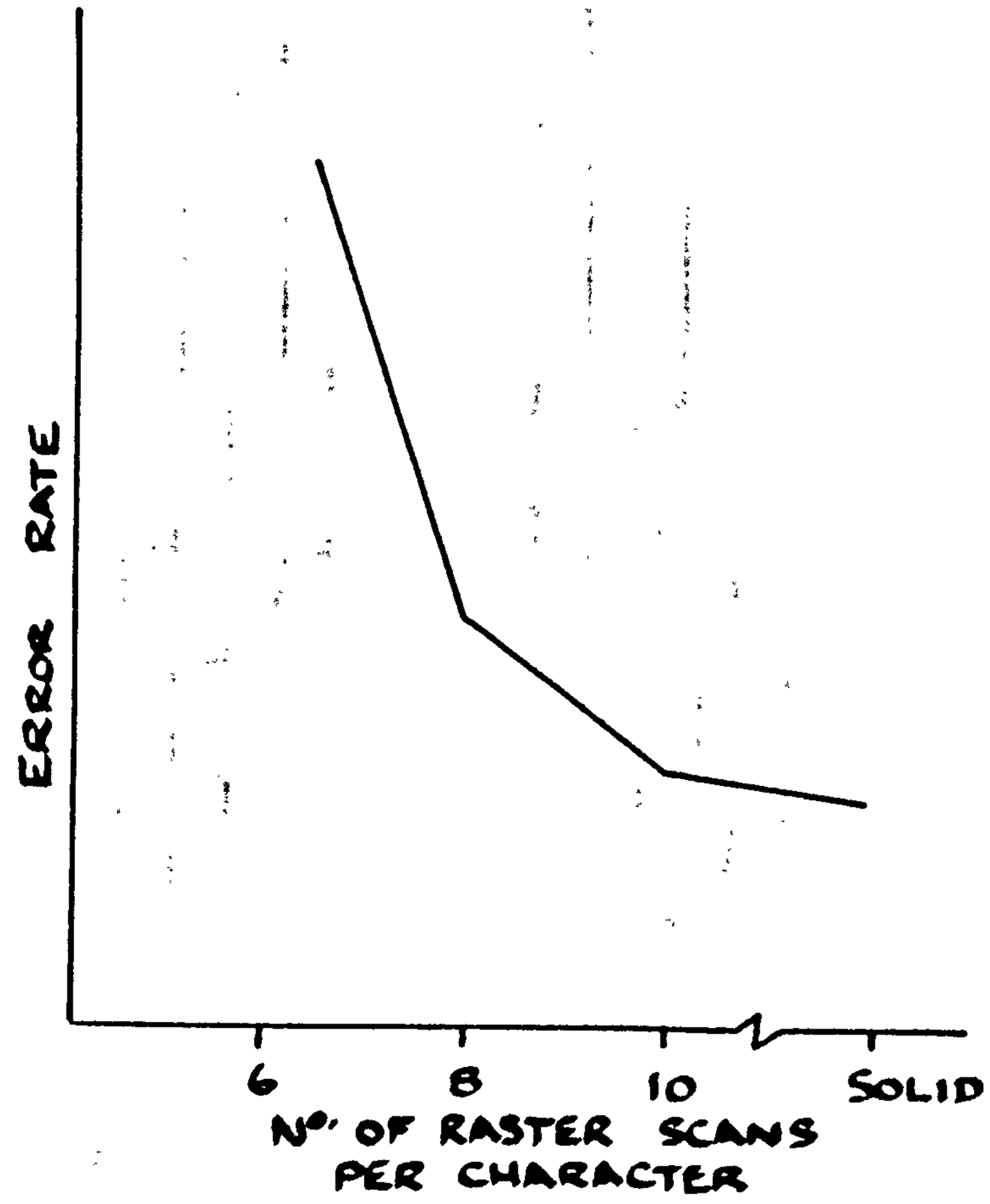
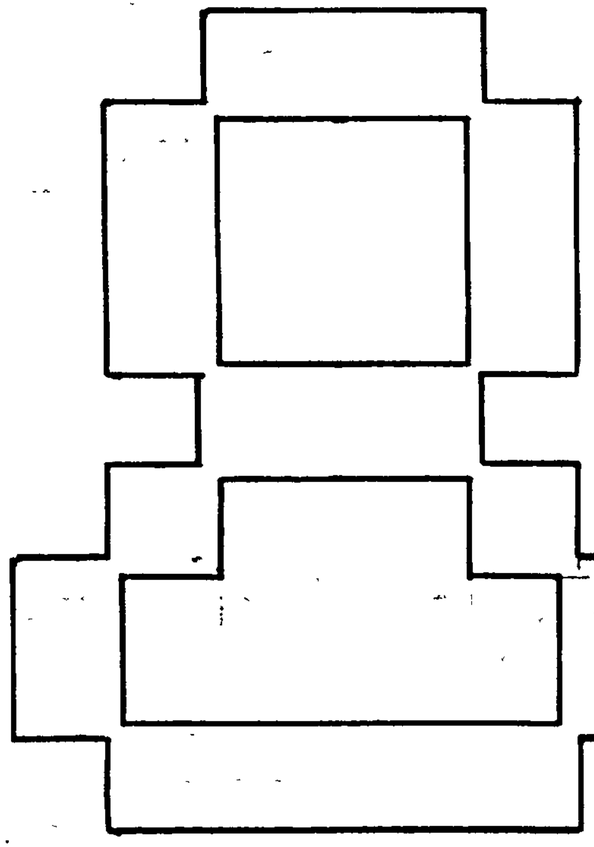


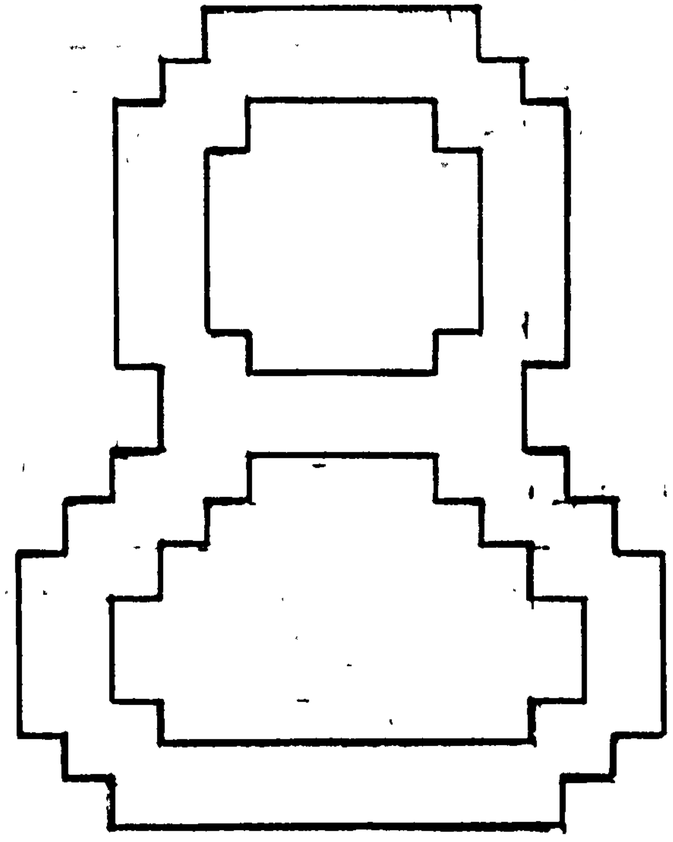
FIGURE 3 PERFORMANCE EFFECTS DUE TO NUMBER OF RASTER SCANS PER CHARACTER.
(SHURTLEFF (1967)

7x9 CHARACTER



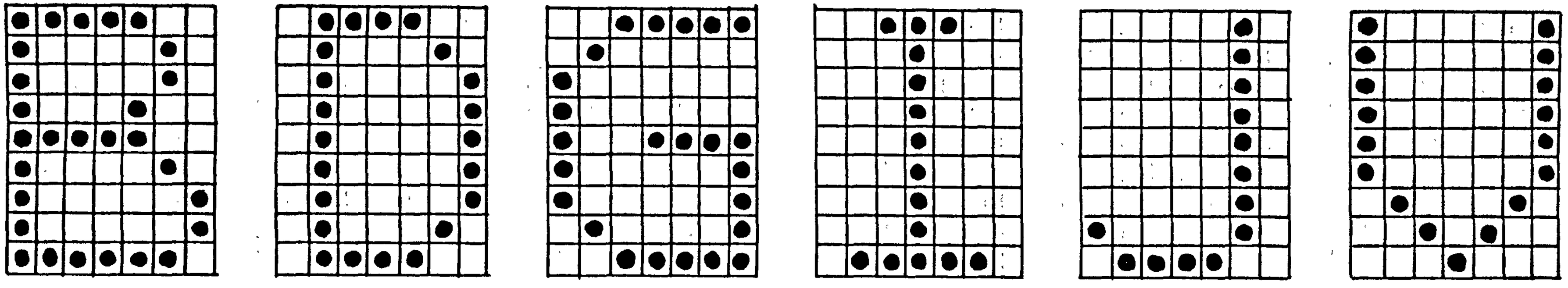
STROKE WIDTH = 1/7.5 x HEIGHT

7x9 CHARACTER (WITH ROUNDING)

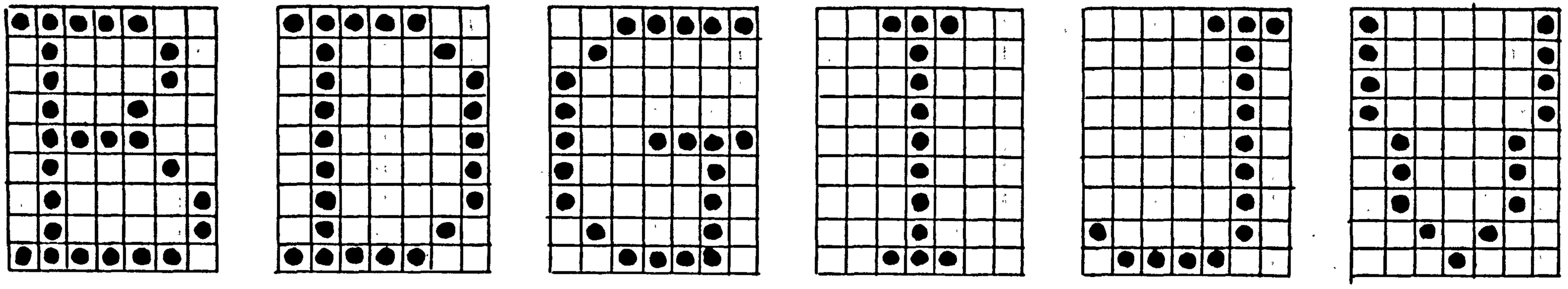


STROKE WIDTH = 1/10.5 HEIGHT

FIGURE 4 CHARACTER ROUNDING

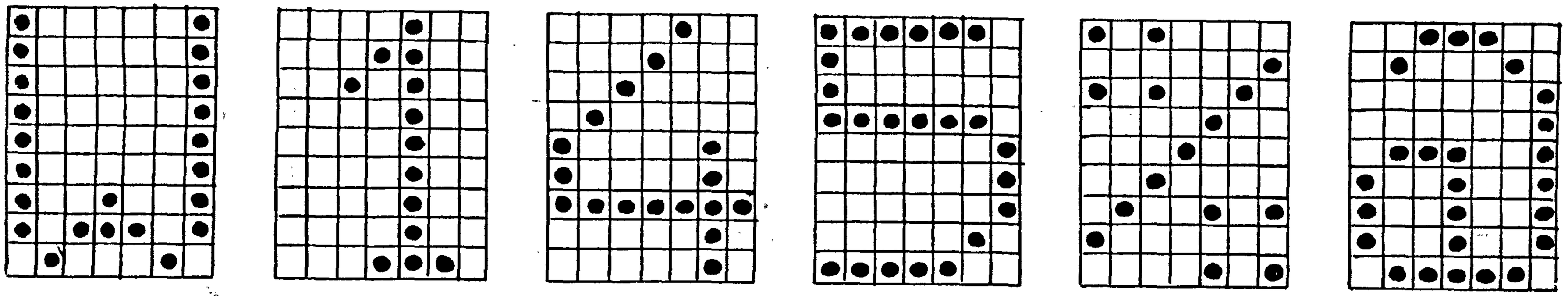


ORIGINAL



REDESIGNED

FIGURE 5A REDESIGNED 7x9 CHARACTERS.



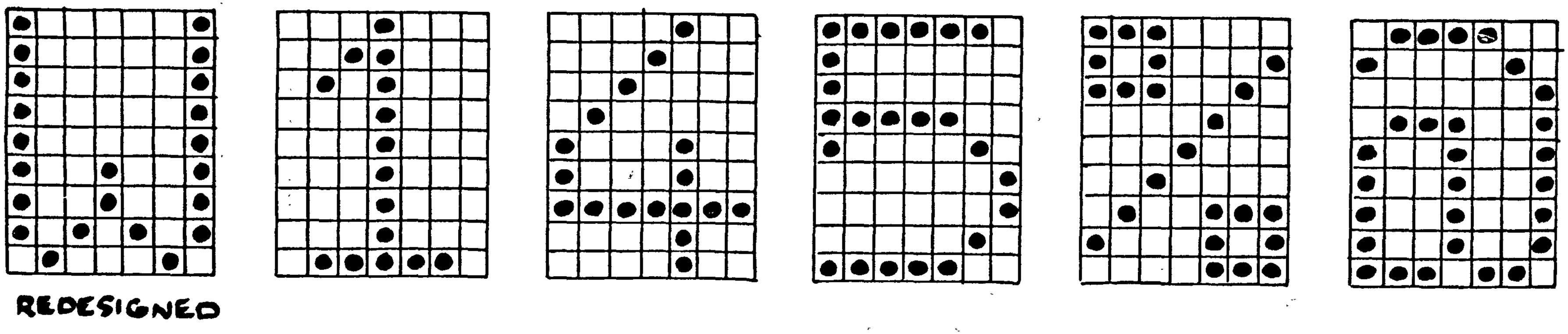


FIGURE 5B REDESIGNED 7x9 CHARACTERS.

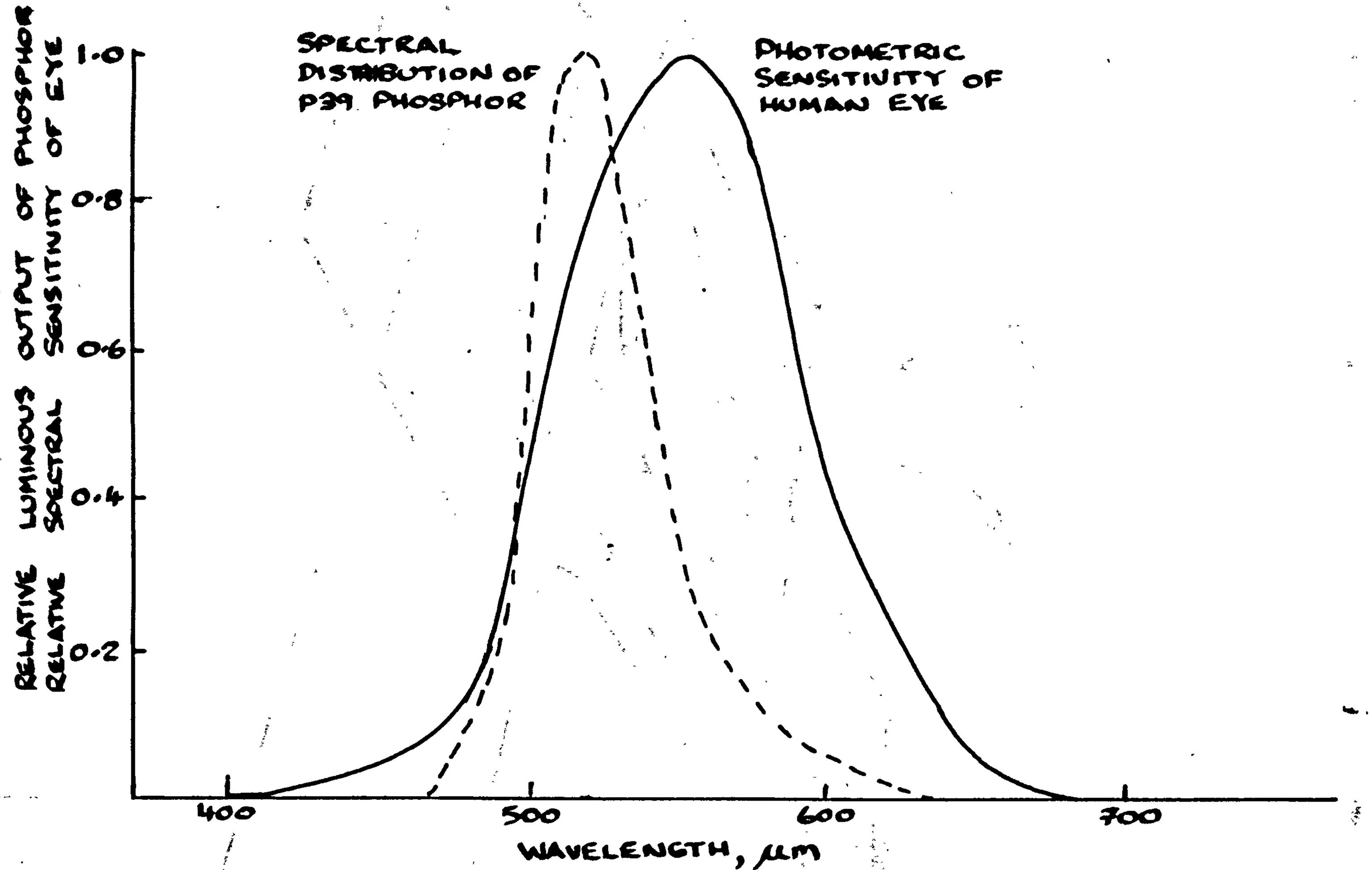


FIGURE 6 SPECTRAL DENSITY OF PHOSPHOR AND PHOTOMETRIC SENSITIVITY OF THE EYE
GRAHAM (1965)

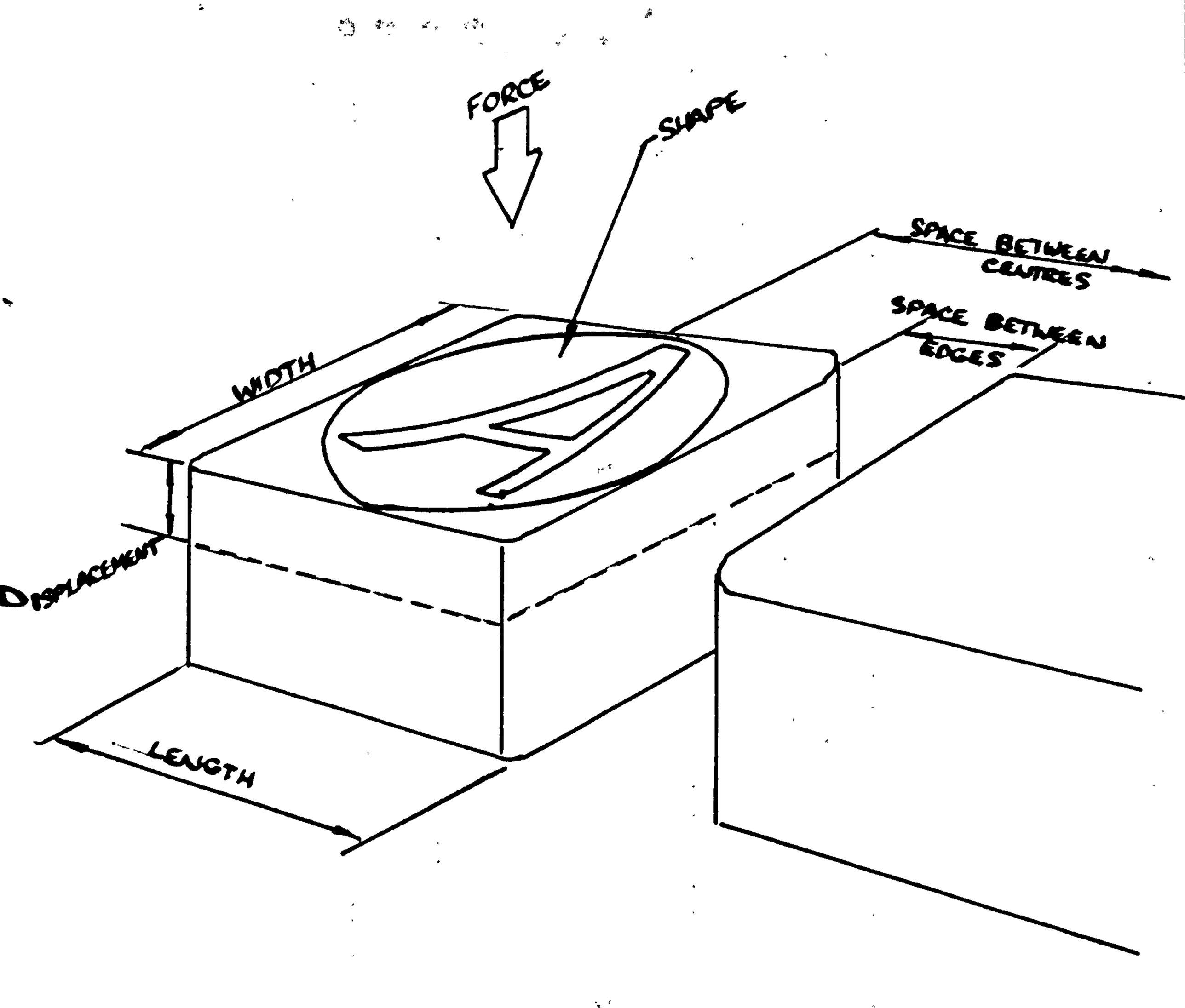


FIGURE 7 PHYSICAL CHARACTERISTICS OF KEYBOARDS

TYC IN .....

A-NR ..... SBO

A TOR

B-NR ..... SCO

B TOS

PER ..... TIM

CAT PA

ORD I ORD II ..... RET

REM CNR

MIS .....

.....

.....

.....

.....

INF

FIGURE 8 ORIGINAL TICKET.

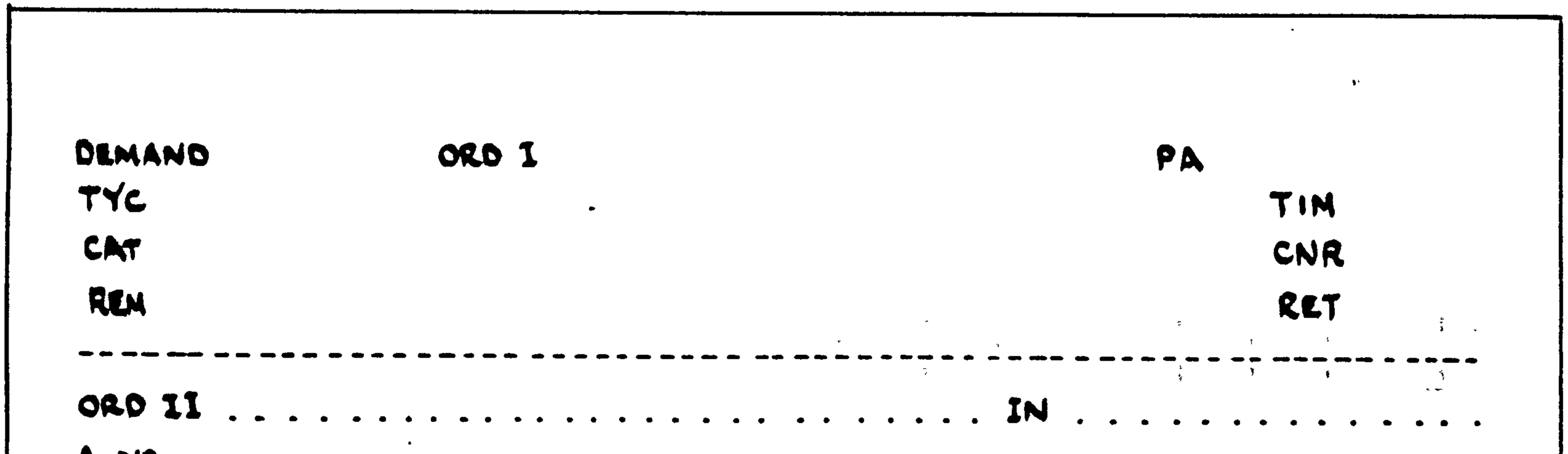


FIGURE 9 REDESIGNED TICKET.

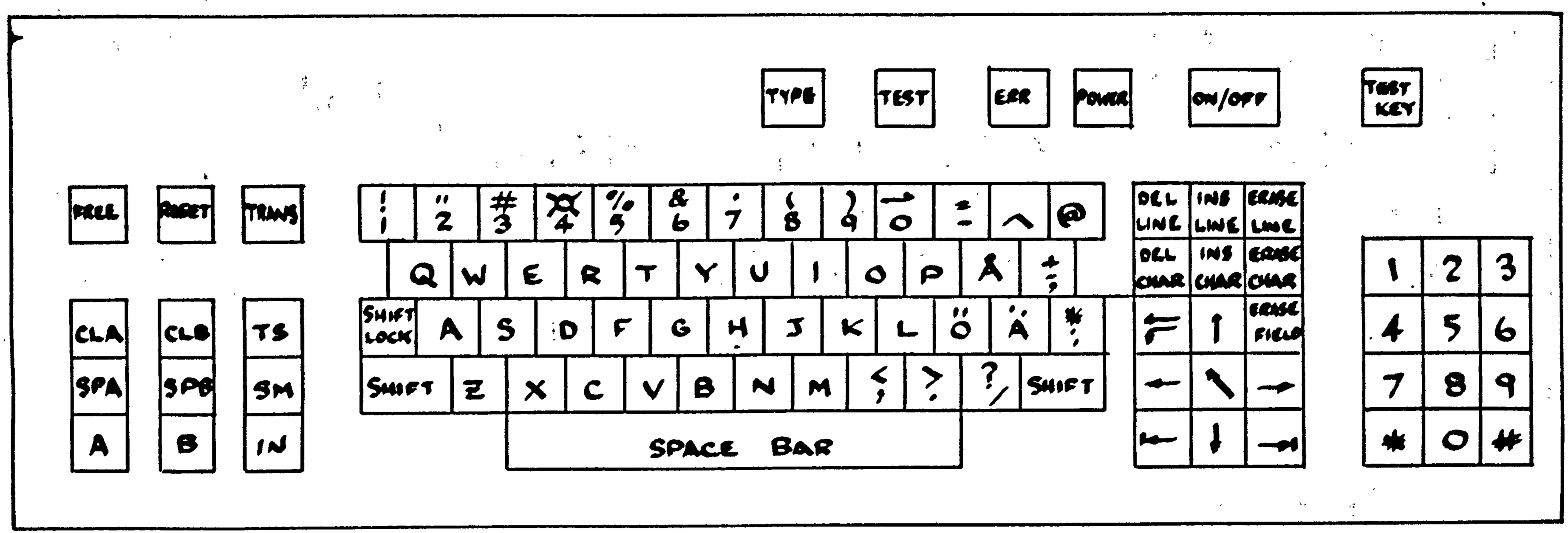
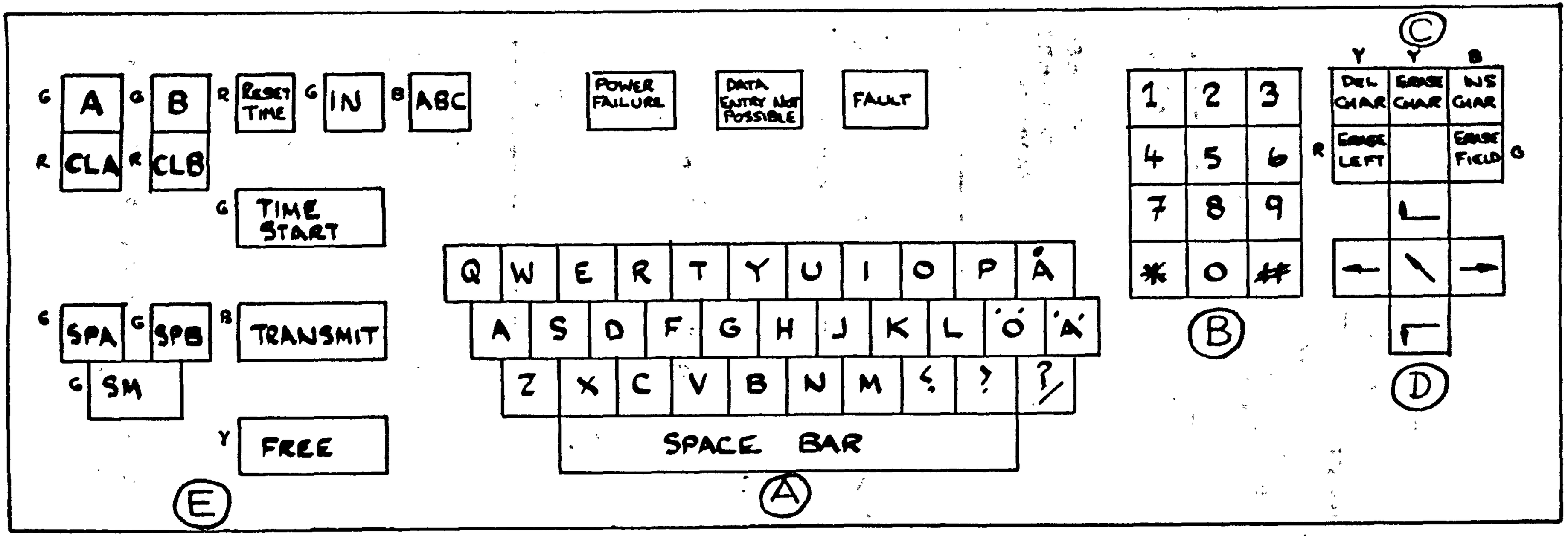


FIGURE 10 ORIGINAL KEYBOARD DESIGN.



COLOUR KEY

G	GREEN
B	BLUE
R	RED
Y	YELLOW

FIGURE 11 SUGGESTED KEYBOARD DESIGN

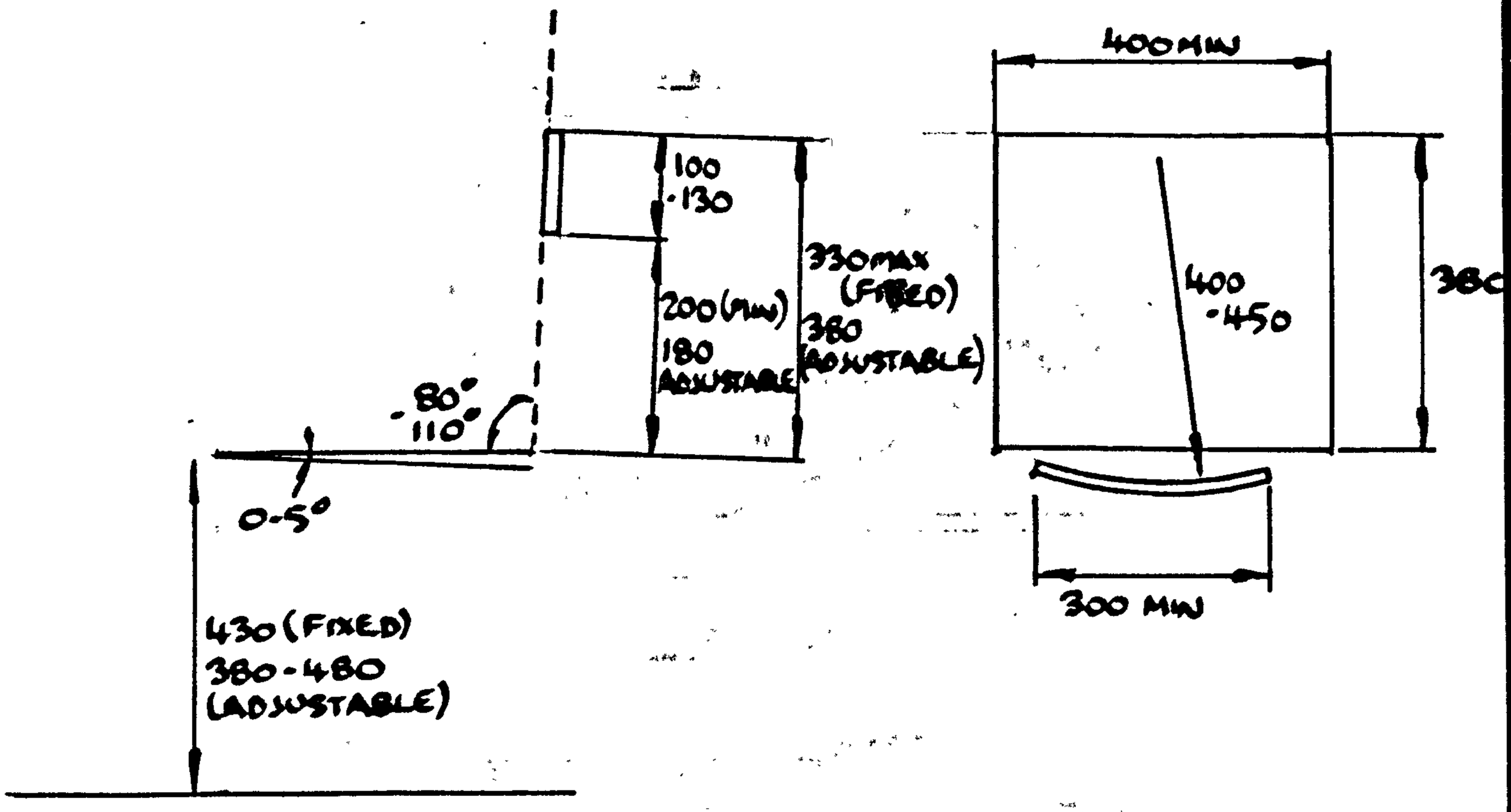


FIGURE 12A MINIMUM DIMENSIONS OF OFFICE CHAIR SPECIFIED BY BRITISH STANDARD BS 3893 (1965)

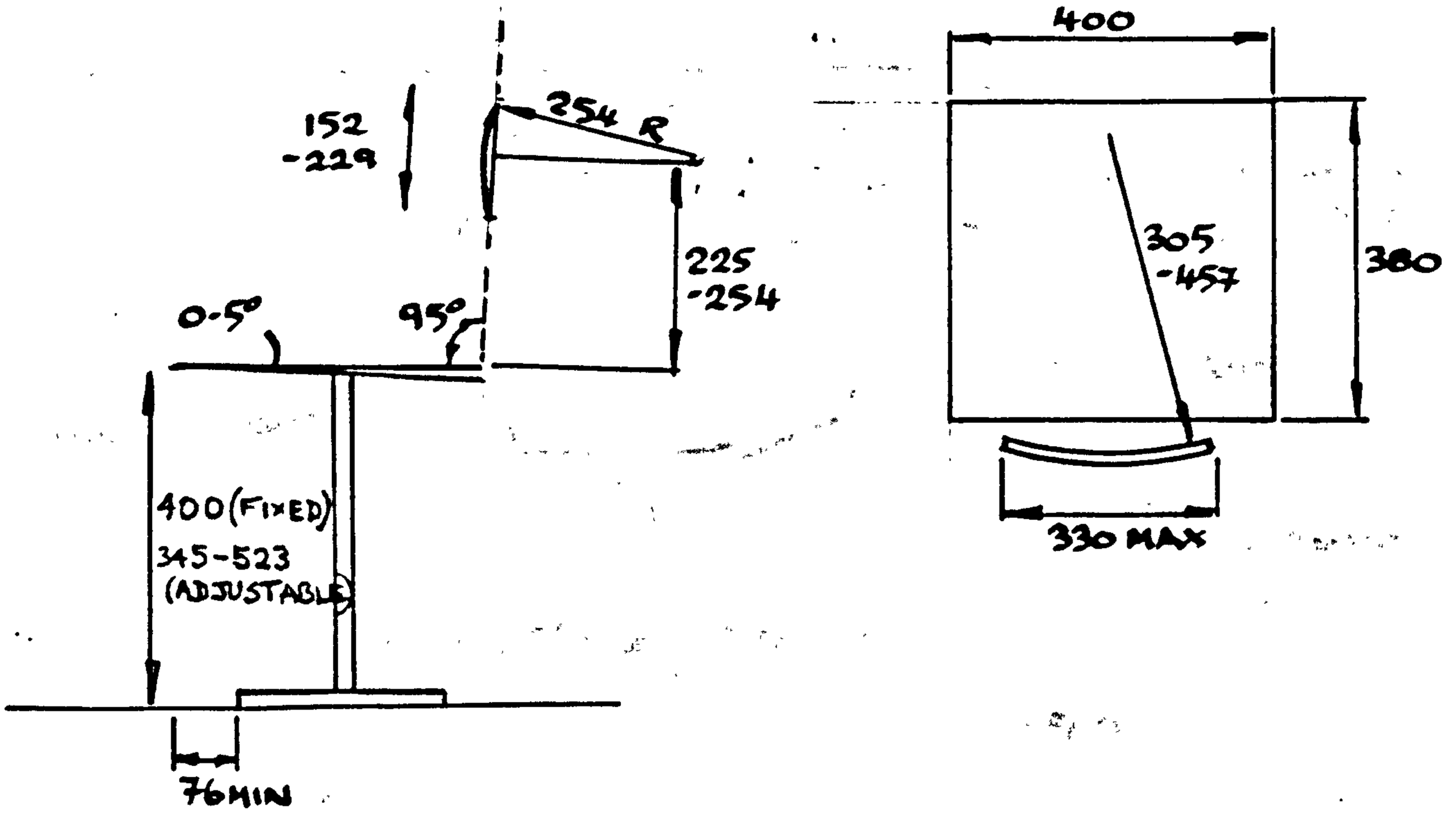


FIGURE 12B SUGGESTED DIMENSIONS OF OFFICE CHAIR (DIFFRIENT et al 1974)

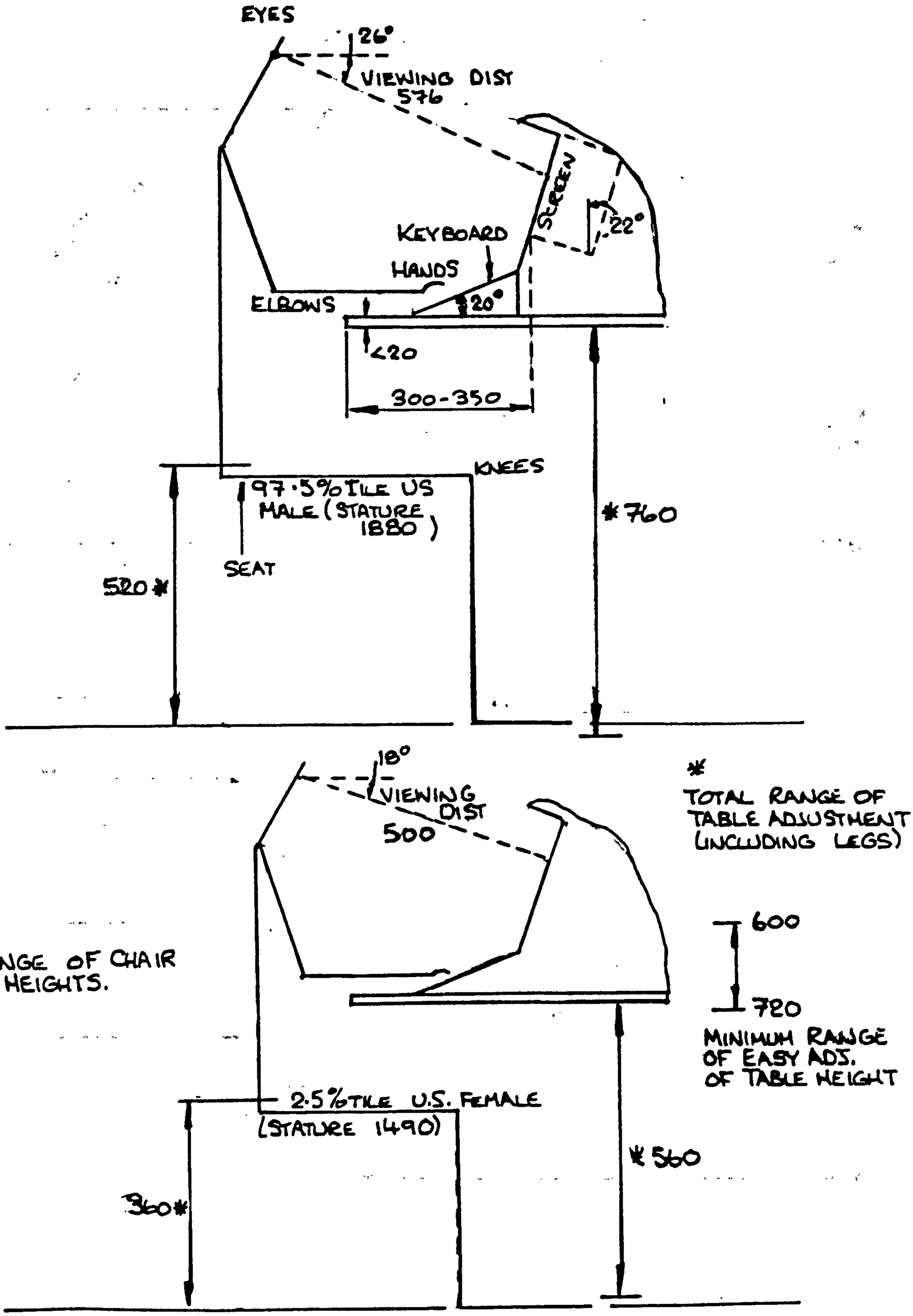


FIGURE 13a SIDE ELEVATION OF CONSOLE SUGGESTED

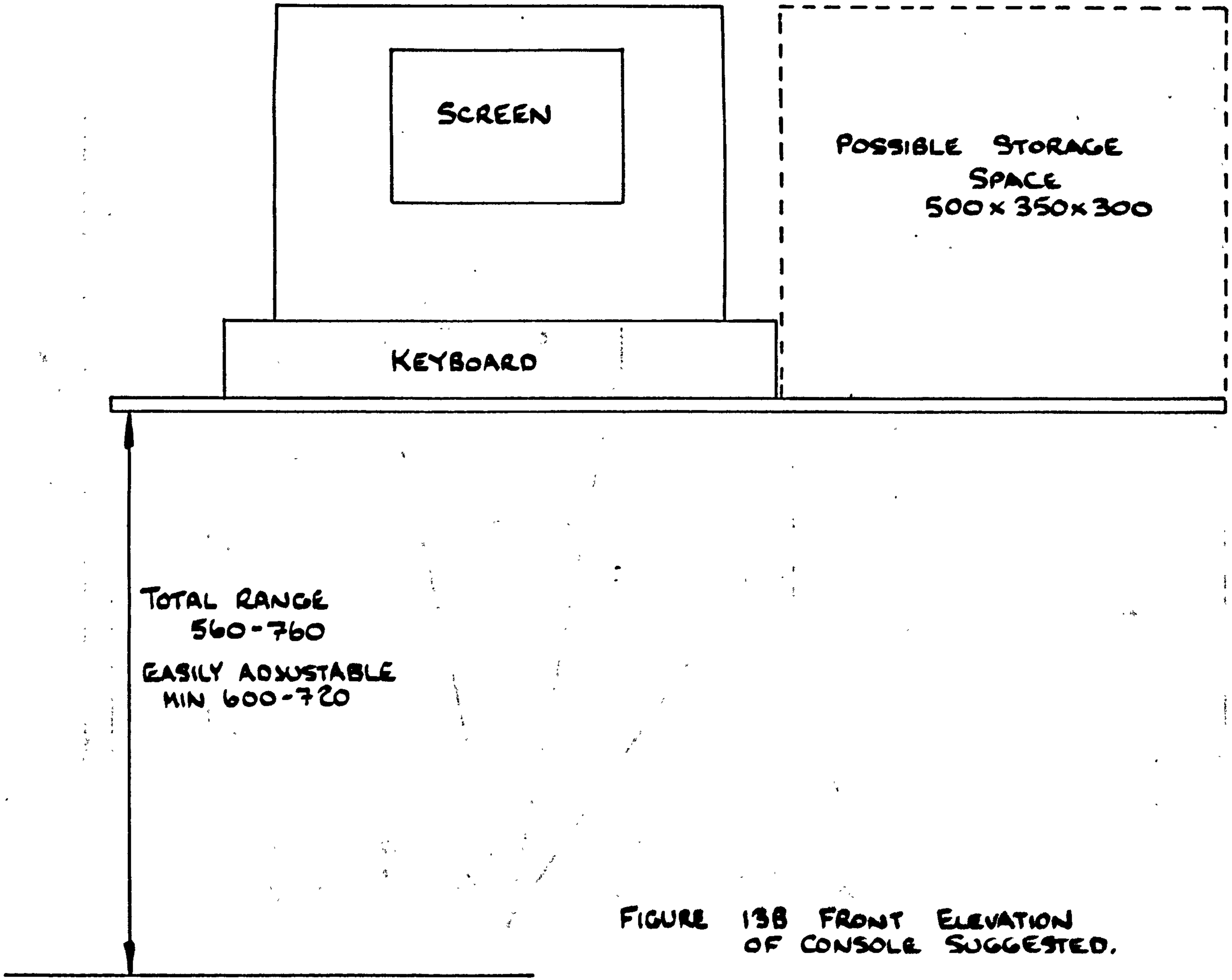


FIGURE 13B FRONT ELEVATION OF CONSOLE SUGGESTED.

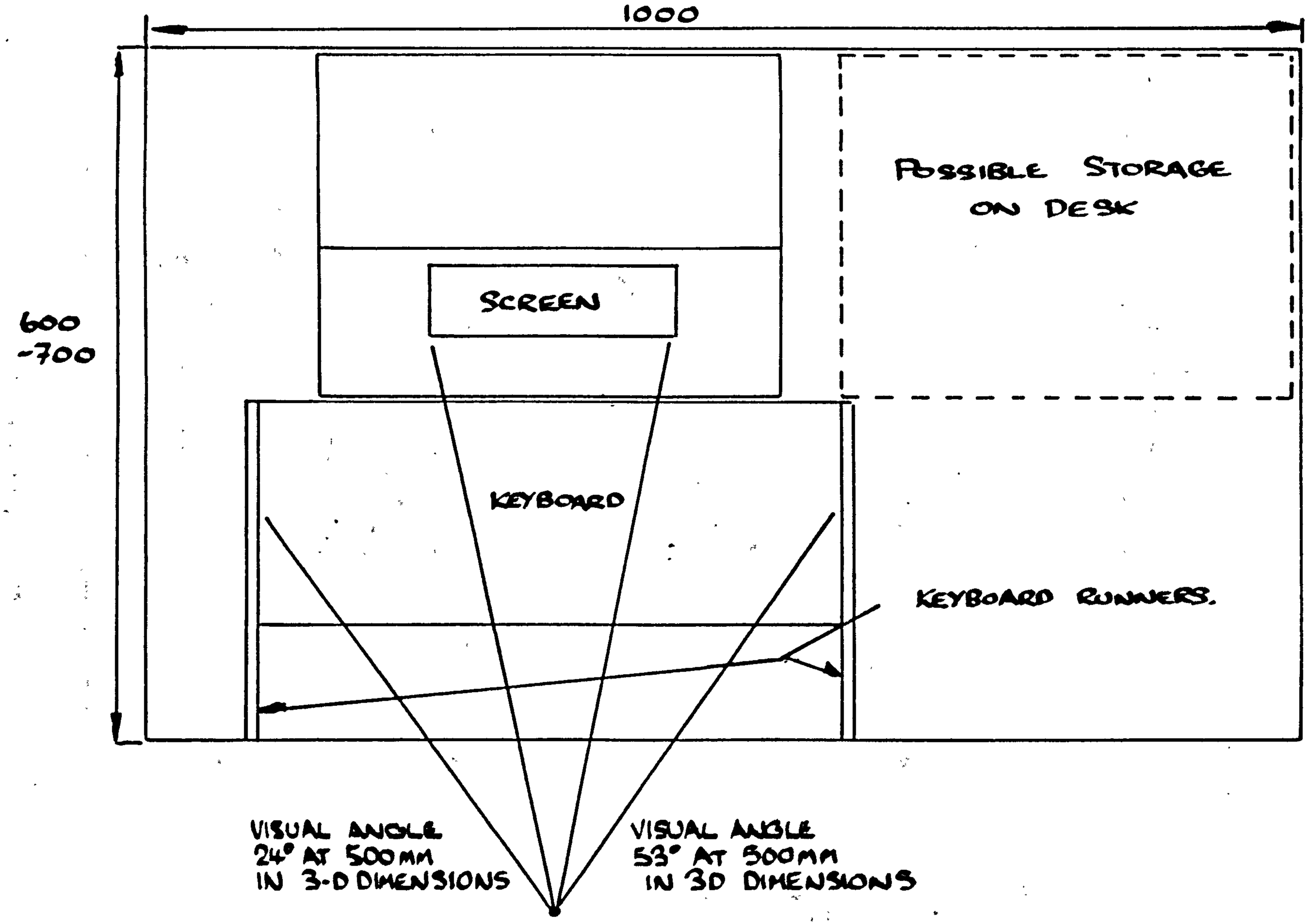


FIG 13C PLAN VIEW OF SUGGESTED CONSOLE.

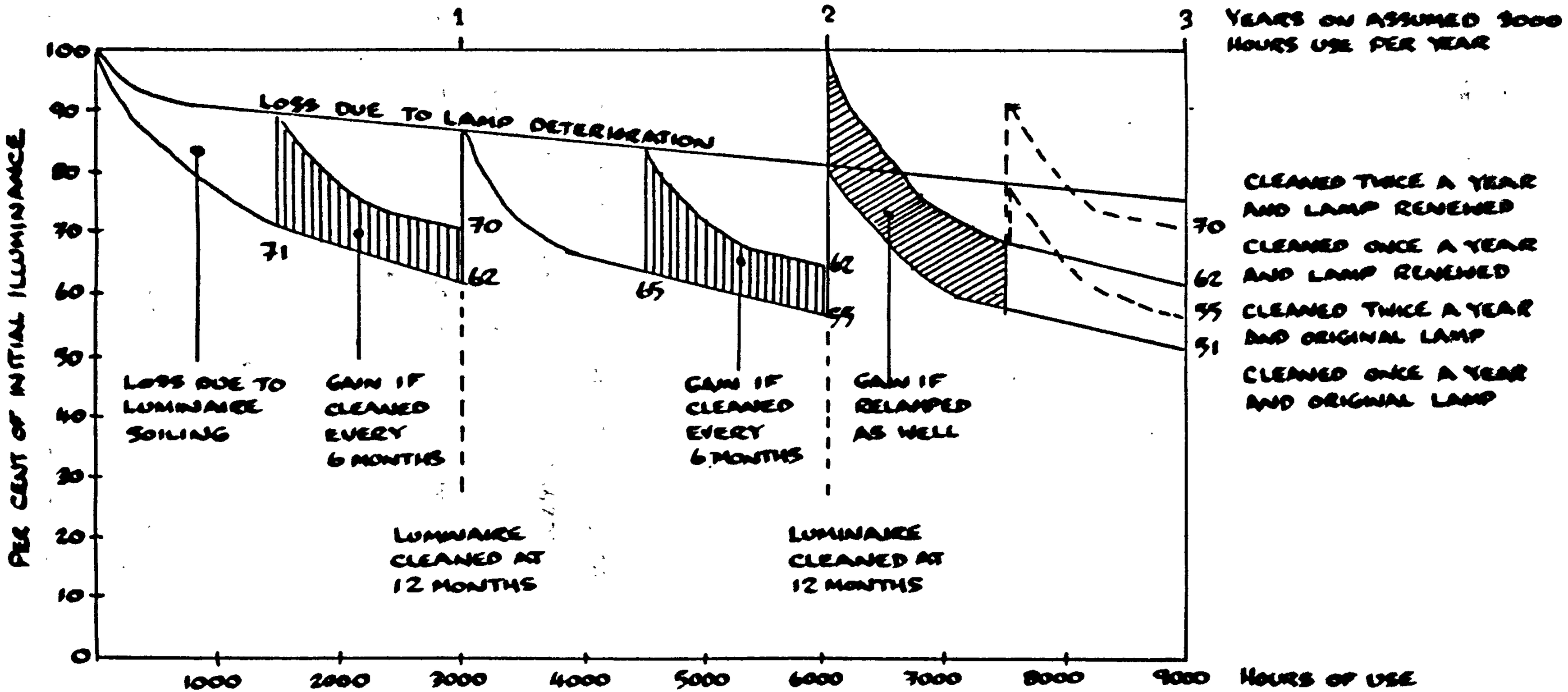


FIGURE 14 EFFECT OF MAINTENANCE AND REPLACEMENT REGIMES ON LIGHT INTENSITY (IES, 1973)

FIGURE 15 EXAMPLE OF TASK FORMAT

8104093004	8104093004
8810578868	8810578868
8900099485	8900099485
1000484089	1000484049
8481058884	8481058884
4845001158	4845001148
8999993884	8999993884
4845008968	4845008968
9680858008	9680858008
8049884899	8049884899
9484894009	9484894009
4840890058	4840890058
9489810005	9489810005
0448089138	0448089108

FIGURE 16 EXAMPLES OF TASK RESULTS PRINT OUT

```
TEST RESULT
**********

SUBJECT 13,EXPERIMENT 2V,FINVIDEO PLUS POLAROID,PERIOD 1

A=B   OK:          15    TIME:      105089      1133667389

A=B   NOT OK:       Ø    TIME:           Ø               Ø

A=/B  OK:          21    TIME:       94997       497004959

A=/B  NOT OK:       1    TIME:        5091        25918281


TEST RESULT
**********

S 13,E 2,FV POL,PERIOD 2

A=B   OK:          17    TIME:      113814       856581828

A=B   NOT OK:       Ø    TIME:           Ø               Ø

A=/B  OK:          19    TIME:       96985       596959455

A=/B  NOT OK:       Ø    TIME:           Ø               Ø
```

FIGURE 17. The position of the four datascreens in Experiment 1. Note that during the experiment screens not being judged were covered. The subjects' seat can be seen in the foreground.

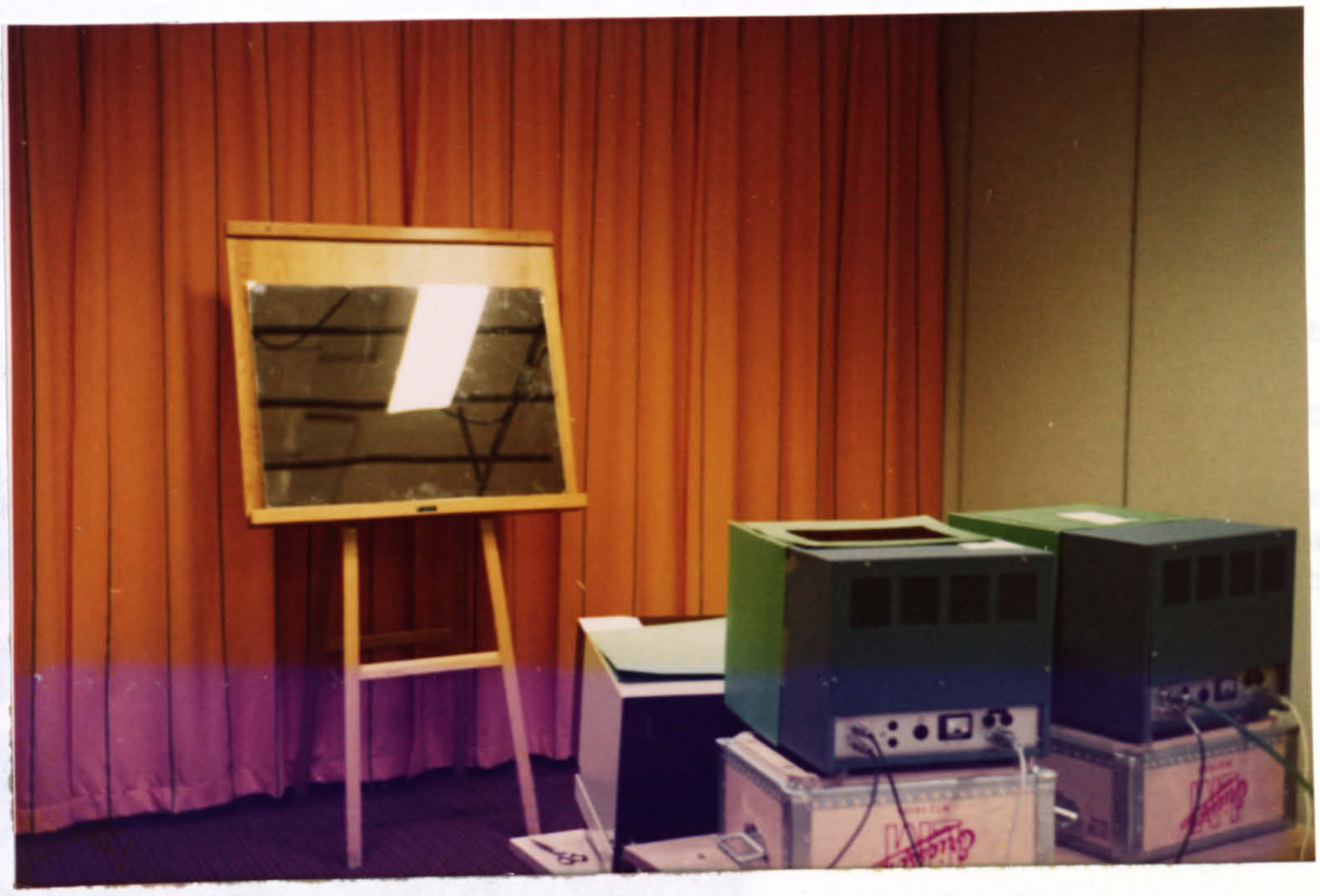


FIGURE 18. The position of the mirror used to reflect light from the luminaire over the subjects' shoulders and onto the datascreen. The rear of the four datascreens can be seen in the foreground.

FIGURE 19. A photograph taken from near the subjects' head position to give an impression of the reflections of the luminaires obtained from the screens.

FIGURE 20. A subject seated before one of the datascreens evaluated in Experiment 2. Two keys on the keyboard were used to indicate the subjects' responses

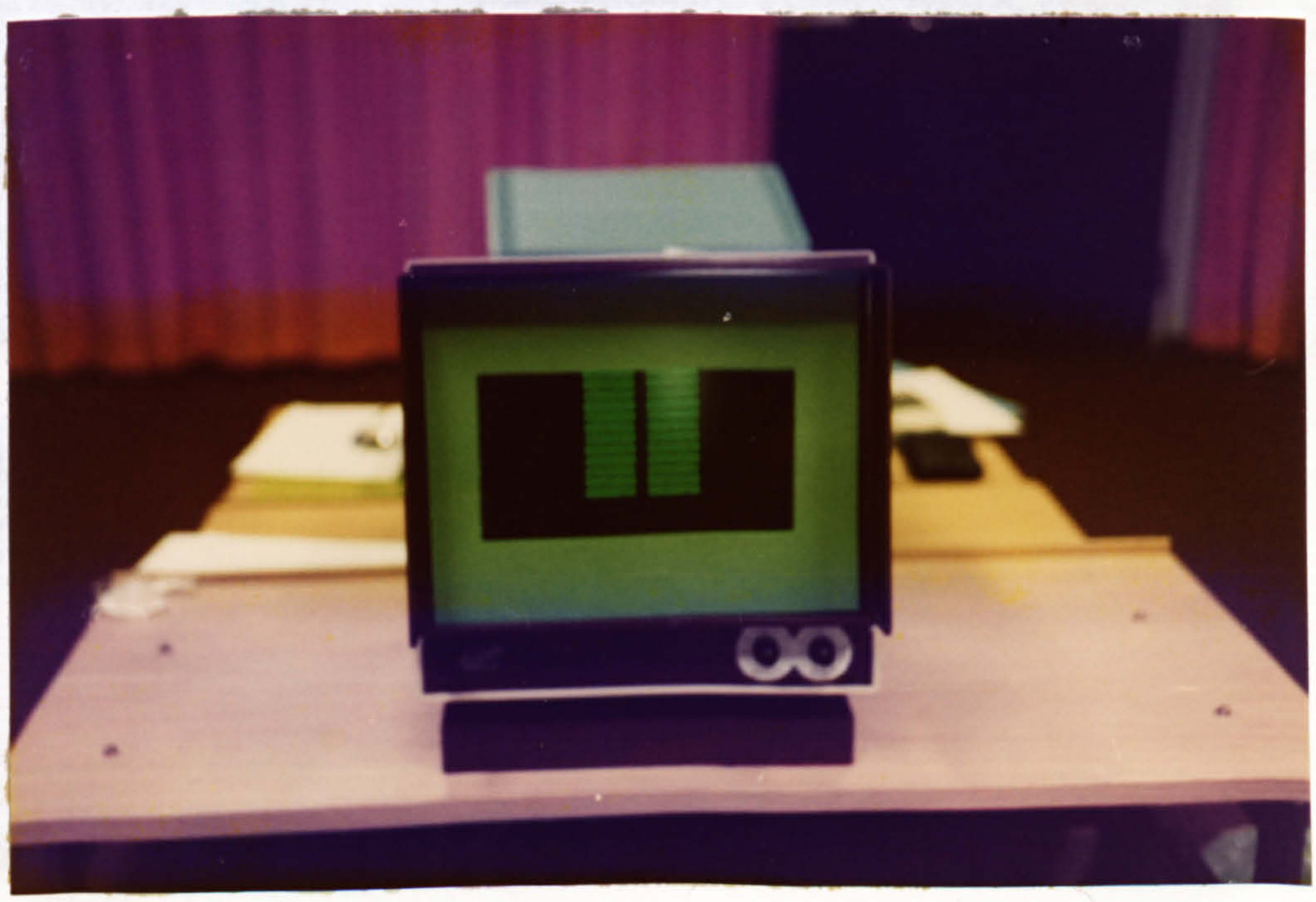
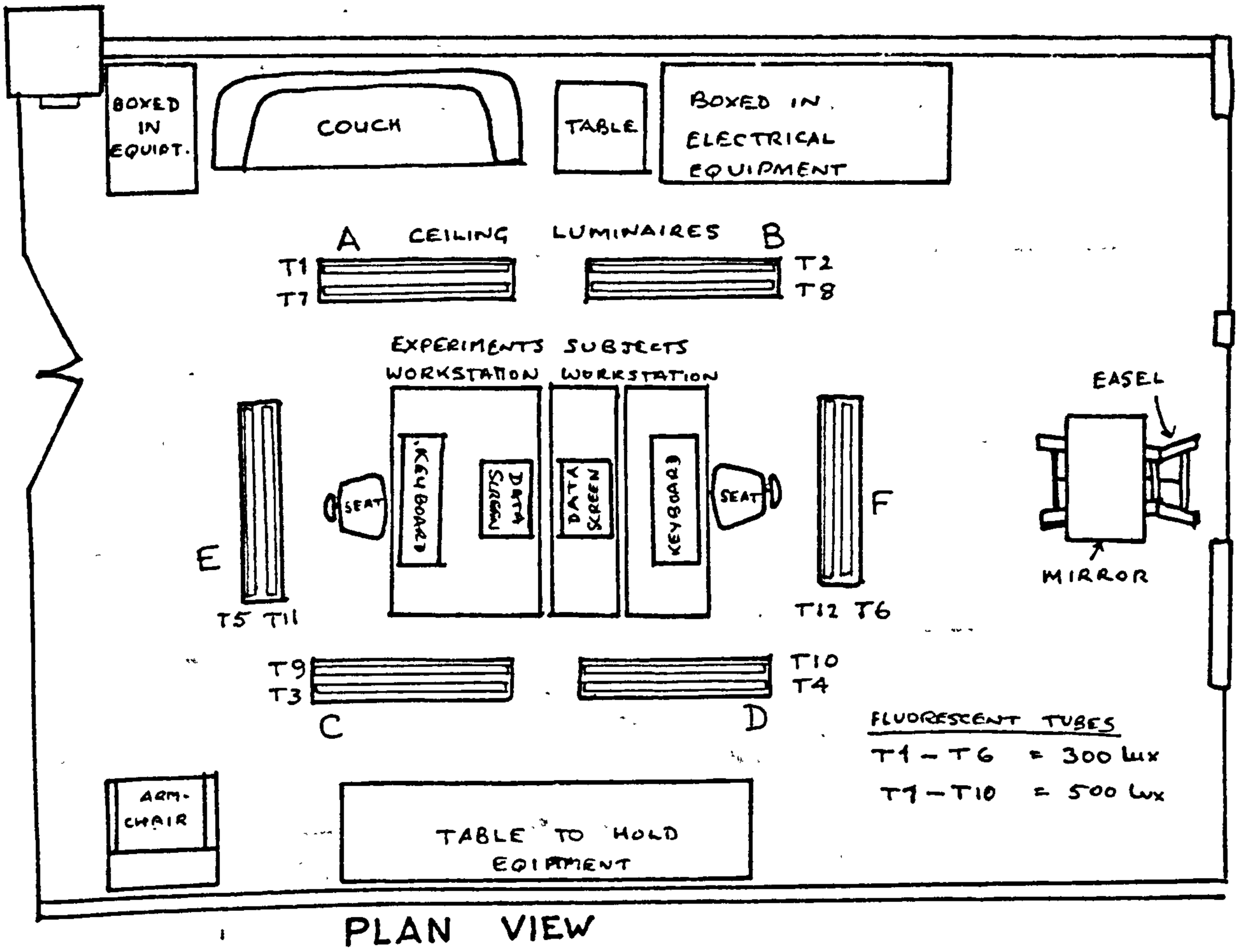


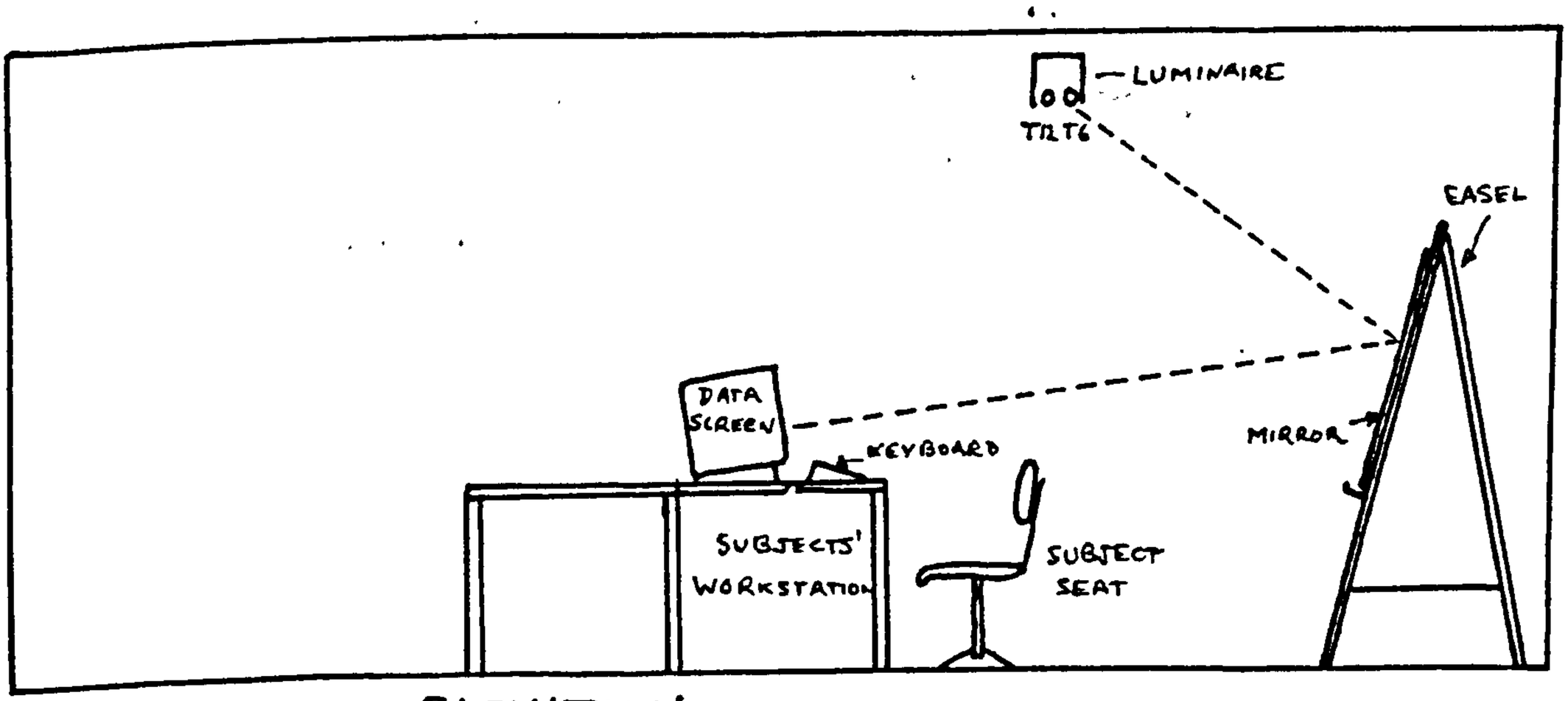
FIGURE 21. An example of the display on one of the datascreens. Twelve rows of 2 ten digit numbers can be seen displayed (The blurring is due to camera shake). The brightness and contrast adjustment knobs can be seen below and to the right of the screen.

FIGURE 22. The subjects' workstation can be seen in the foreground. The experimenter can be seen seated at a second workstation facing the subject.

FIGURE 23. An example of the information displayed to the experimenter on demand after the subject had completed a period working at the display. The format of the display is identical to that used for hard copy printout (see Figure 16).



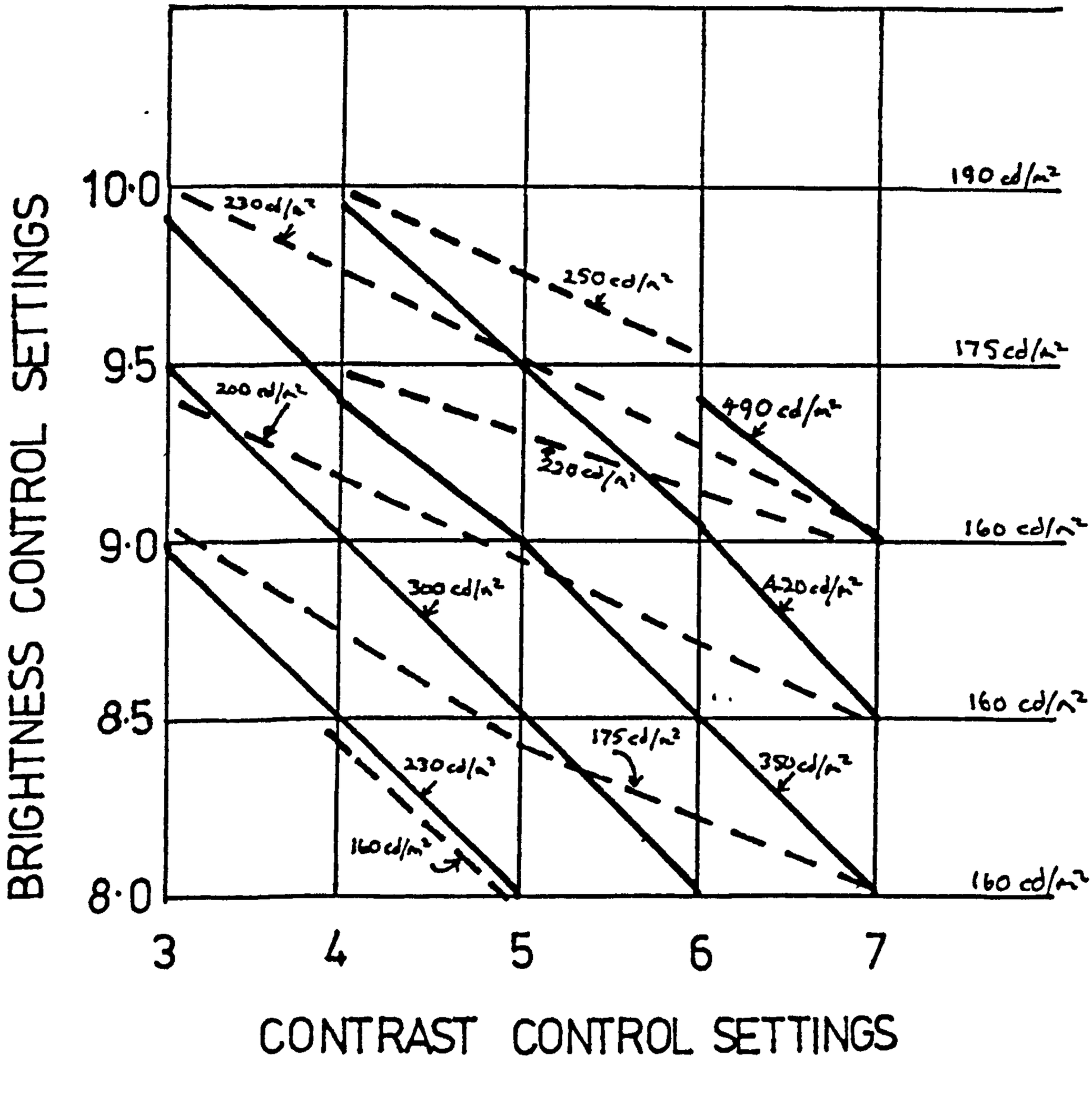
PLAN VIEW



ELEVATION

FIGURE 24. Configuration of lights, mirror and workstation in Experiment 2.

FIGURE 25. Luminance levels obtained on the B1 Datascreen at various settings of the brightness and contrast controls.



KEY

——— Luminances of brightest characters

– – – – Luminances of dullest characters

FIGURE 26 Prototype console.

FIGURE 27. Configuration of the Workstations in the experimental room

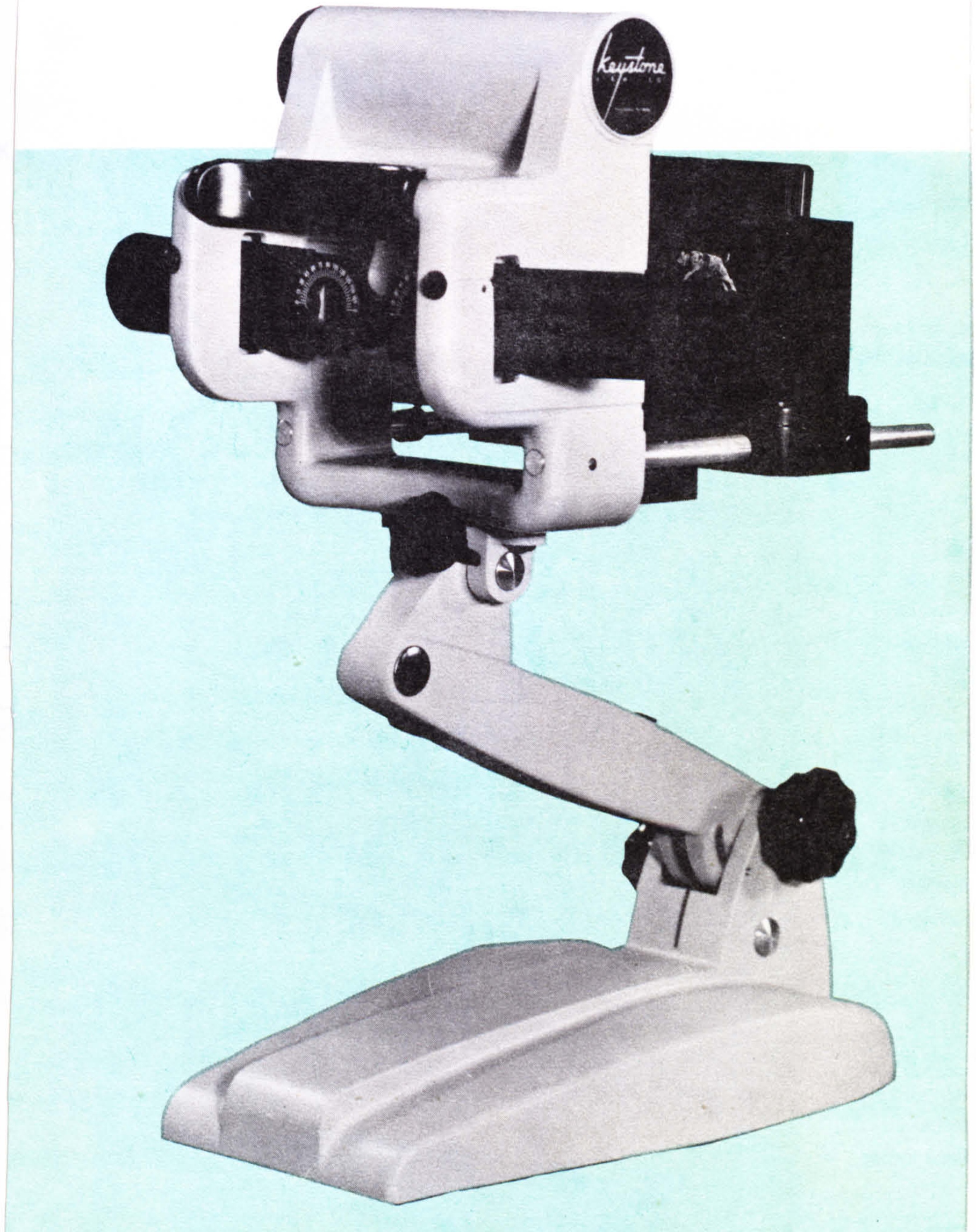
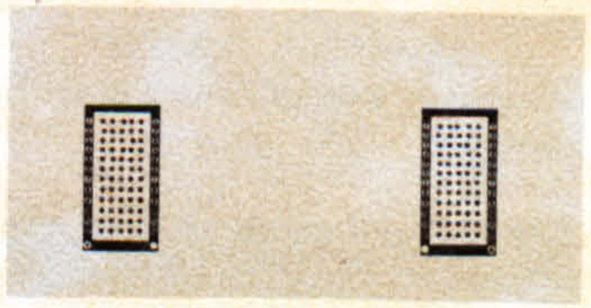


FIGURE 28a Keystone Ophthalmic Telebinocular

FIGURE 28b Cards comprising Visual Skills Test Set for the Keystone Apparatus.

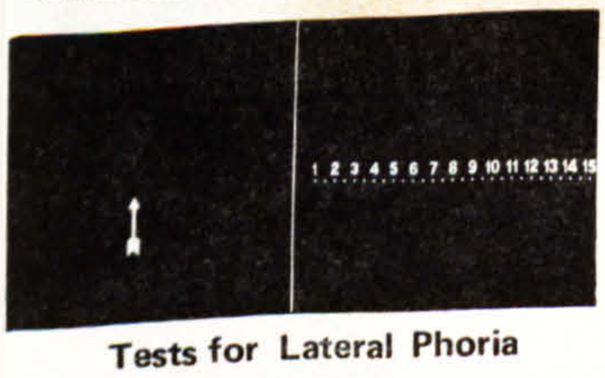
Simultaneous Perception — Test 1

Vertical Phoria — Test 2



Stereopsis — Test 7

Color Perception — Tests 8



Tests for Lateral Phoria

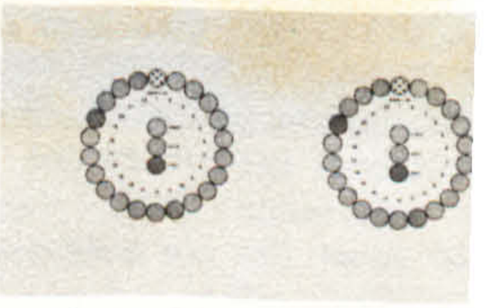
Test 3 — At far point (00)
Test 10 — At near point (16 in.)

Tests for Fusion Ability

Test 4 — At far point
Test 11 — At near point

Usable Vision at Far Point

Test 4-1/2 — Both eyes together
Test 5 — Right eye
Test 6 — Left eye



Usable Vision at Near Po

Test 12 — Both eyes toget
Test 13 — Right eye
Test 14 — Left eye

-272

KEYSTONE VISUAL SKILLS PROFILE

For Use with Keystone Ophthalmic Telebinocular

Doctor's Cumulative Profile Form No. 3A

Order No. 5506

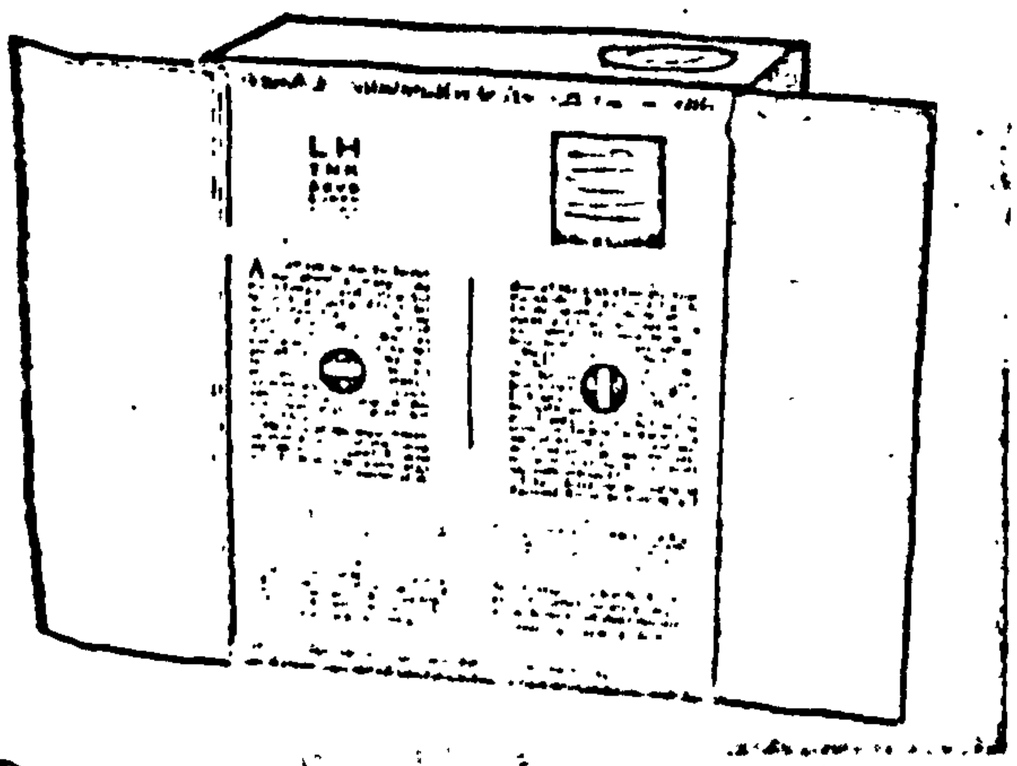
Name_____ Age_____ Date_____ Wearing Glasses: Yes_____ No_____

	Left Only	Right Only	Underconvergence Low Usable Vision				EXPECTED			Overconvergence High Usable Vision						
Set at Far Point																
Test 1 (DB-10A) Simultaneous Vision (Far Point)																
Test 2 (DB-8C) Vertical Posture (Far Point)	only	only														
Test 3 (DB-9) Lateral Posture (Far Point)	only	15-14-13 · · 3-2-1 Numbers Only	15	14	13	12	11	10½	10	9	8½	8	7	6	5	4	3	2	1
Test 4 (DB-4K) Fusion (Far Point)	only	only	Four, widely separated			Four, near each other		Four then three			Four, then three		Four, near each other			Four, widely separated			
Test 4½ (DB-1D) Usable Vision, Both Eyes (Far Point)			1 L 49%	2 B 70%	3 T 84%	4 L 88%	5 R 92%	6 T 96%		7 L 98%	8 B 100%		9 B 103%			10 R 105%			
Test 5 (DB-3D) Usable Vision, Right Eye (Far Point)		No Dots Seen Unless Left Eye Is Occluded	1 T 49%	2 R 70%	3 L 84%	4 T 88%	5 B 92%	6 B 96%		7 L 98%	8 R 100%		9 T 103%			10 R 105%			
Test 6 (DB-2D) Usable Vision, Left Eye (Far Point)	No Dots Seen Unless Right Eye Is Occluded		1 B 49%	2 L 70%	3 R 84%	4 R 88%	5 T 92%	6 L 96%		7 B 98%	8 L 100%		9 R 103%			10 T 105%			
Test 7 (DB-6D) Stereopsis (Far Point)	+ only	only ●	1 +	2 ○	3 ✳	4 ○	5 □	6 □	7 ♡	8 +	9 ✳		10 +	11 ♡	12 ○				
Test 8 (DB-13A) Color Perception (Far Point)	32		79				23	ALL CORRECT											
Test 9 (DB-14A) Color Perception (Far Point)	63		92				56	ALL CORRECT											
Move to Near Point																			
Test 10 (DB-9B) Lateral Posture (Near Point)	only	10-9 · · · · 4-3-2 Numbers Only	10	9	8	7	6½	6	5	4½	4	3	2						
Test 11 (DB-5K) Fusion (Near Point)	only	only	Four, widely separated			Four, near each other		Four, then three			Four, then three		Four, near each other			Four, widely separated			
Test 12 (DB-15) Usable Vision, Both Eyes (Near Point)	1 D 10%	2 L 20%	3 D 30%	4 D 40%	5 L 50%	6 D 50%	7 D 60%	8 L 60%	9 D 70%	10 D 70%	11 G 80%	12 L 80%	13 L 90%	14 D 90%	15 L 100%	16 D 100%	17 L 102%	18 D 102%	19 G 103%	20 D 103%	21 D 105%	22 L 105%
Test 13 (DB-16) Usable Vision, Right Eye (Near Point)	1 D 10%	2 D 20%	3 L 30%	4 D 40%	5 L 50%	6 D 50%	7 D 60%	8 L 60%	9 D 70%	10 L 70%	11 D 80%	12 G 80%	13 L 90%	14 L 90%	15 D 100%	16 D 100%	17 G 102%	18 D 102%	19 L 103%	20 D 103%	21 D 105%	22 L 105%
Test 14 (DB-17) Usable Vision, Left Eye (Near Point)	1 L 10%	2 D 20%	3 D 30%	4 D 40%	5 L 50%	6 D 50%	7 L 60%	8 D 60%	9 D 70%	10 D 70%	11 L 80%	12 L 80%	13 G 90%	14 D 90%	15 L 100%	16 D 100%	17 L 102%	18 D 102%	19 L 103%	20 G 103%	21 D 105%	22 L 105%

NOTES:

FIGURE 29. Test form for use with Keystone Apparatus and Visual skills profile.

Copyright, 1969, Keystone View, Davenport Iowa, Reproduction Positively Forbidden. Printed in U. S. A.



near vision instrument for the detection of fixation disparity

hough the body/chassis units
roofed to varying standards by
facturers, repeated corrosive atte
been found to produce hidden r
nd the protection can be even m
broken dow[illegible]e exposed ar
Laurin, o[illegible]dish automo
Motor, st[illegible] investigate
ct of rust p[illegible]ve treatmen
He evolved the "ML" meth
is now carried out on a l
ntage of the cars imported
en. Volvo and Saab incorpora
their production procedure.
ss has now been brought to
try and there are ML station

Fig. 1

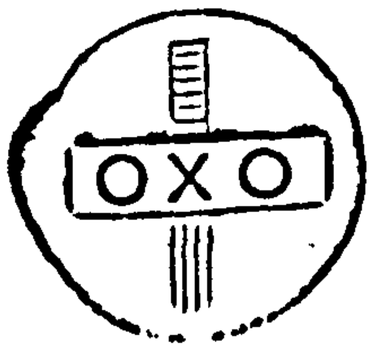
Chart for detecting lateral fixation disparity (actual size).

wn up by the road wheels
ides the painted underside of th
gradually exposes the bare r
ies and gravel can do as effici
as a sand-blasting machine.
eres to the ba[illegible]tal surface
ls moisture [illegible] the body
s have dried [illegible] one impo
on for clean[illegible] regularly
ced mud that accumulates u
h.
he unit construction of the m
incorporates box-sections
sed-steel profiles, and much c
mbly involves spot-welding.
itably occur, and it is through

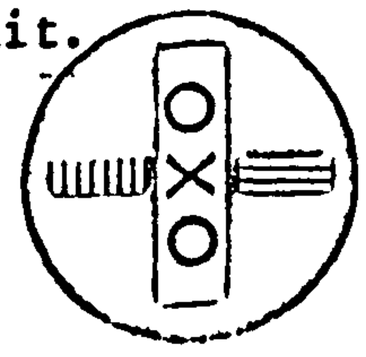
Fig. 2

Chart for detecting vertical fixation disparity (actual size).

FIGURE 30a Mallett fixation disparity unit.



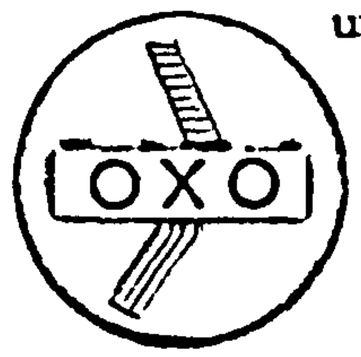
30c Orthophoria or compensated lateral heterophoria.



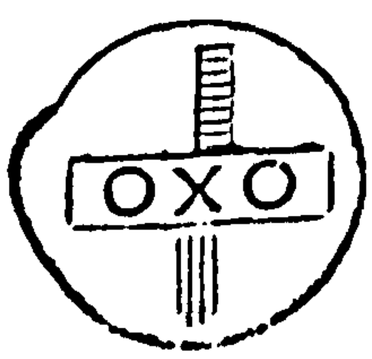
30d Orthophoria or compensated hyperphoria.

FIGURE 30b Targets in Mallett unit.

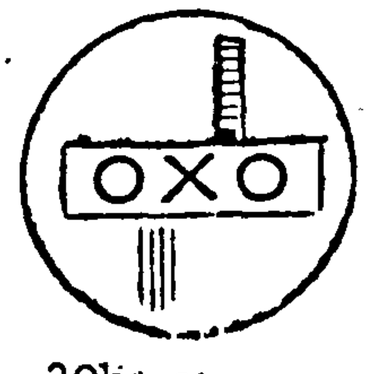
30e R. excyclophoria.



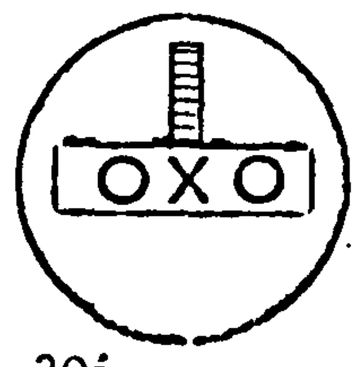
30f Bilateral incyclophoria.



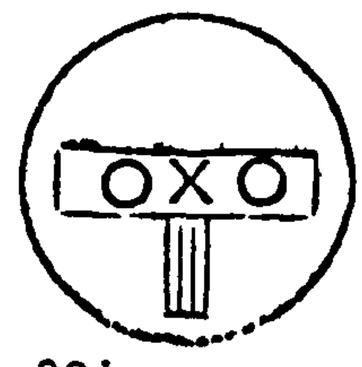
30g Uncompensated exophoria with slip in L.E.



30h Uncompensated exophoria with slip in both eyes.

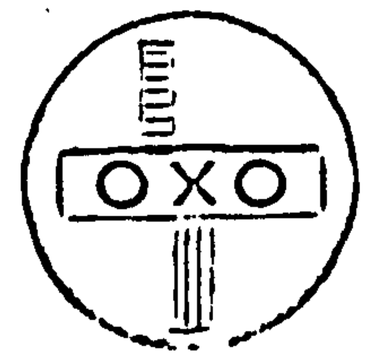


30i Deep central suppression R.E.



30j Deep central suppression L.E.

30k Uncompensated esophoria with slip in both eyes.

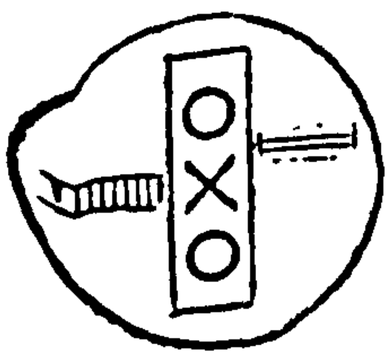


30l Uncompensated esophoria with slip in L.E.

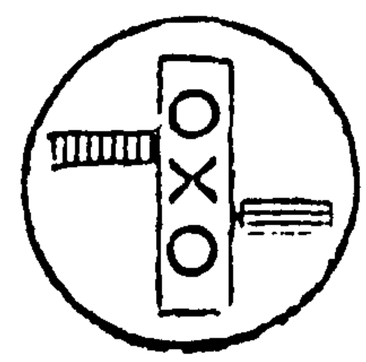
The polarised strips

(a) Seen by R.E.

(b) Seen by L.E.



30m Uncompensated R. hyperphoria with slip in L.E.



30n Uncompensated L. hyperphoria with slip in both eyes

FIGURES 30c-30n Possible subjective views of targets. (Mallett, 1964)

NAME

JOB

PRESENT SPECTACLES R L ADD

BIFO TRIFO SPEC · FAR NEAR

NEVER ALWAYS SELDOM AT WORK READING FOR DISTANCE

PURCHASE YEAR

FAR VISION - WITHOUT SPECTACLES R L
- WITH SPECTACLES R L
- WITH NEW SPECTACLES R L

500mm VISION - WITH PRESENT SPECTACLES J
- WITH NEW SPECTACLES J

500mm
NEW SPECTACLE PRESCRIPTION R L ADD

LATERAL PHORIA AT FAR - WITHOUT SPECTACLES
- WITH SPECTACLES
- WITH NEW SPECTACLES

VERTICAL PHORIA AT FAR - WITHOUT SPECTACLES
- WITH SPECTACLES
- WITH NEW SPECTACLES

LATERAL PHORIA AT NEAR - WITHOUT SPECTACLES
- WITH SPECTACLES
- WITH NEW SPECTACLES

VERTICAL PHORIA AT NEAR - WITHOUT SPECTACLES
- WITH SPECTACLES
- WITH NEW SPECTACLES

LATERAL DISPARITY AT 500mm - WITHOUT SPECTACLES
- WITH SPECTACLES
- WITH NEW SPECTACLES

VERTICAL DISPARITY AT 500mm - WITHOUT SPECTACLES
- WITH SPECTACLES
- WITH NEW SPECTACLES

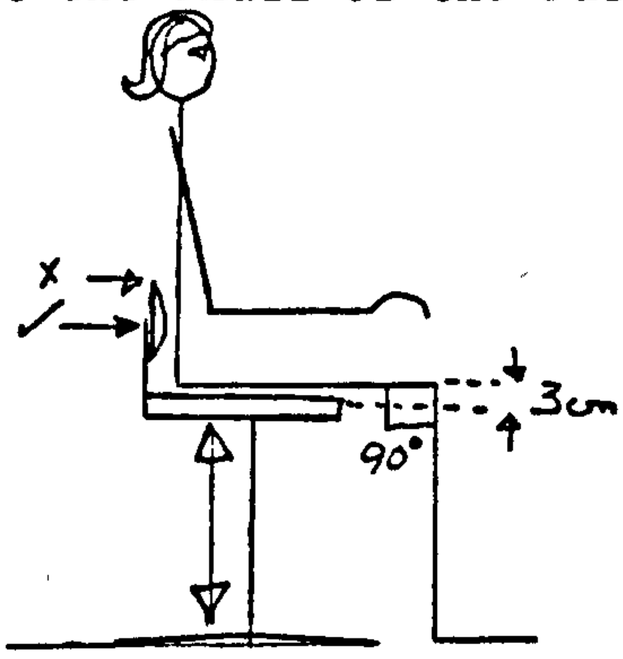
COMMENTS

FIGURE 31. Ophthalmic test result form (Translation)

FIGURE 32 Workstation adjustment instructions

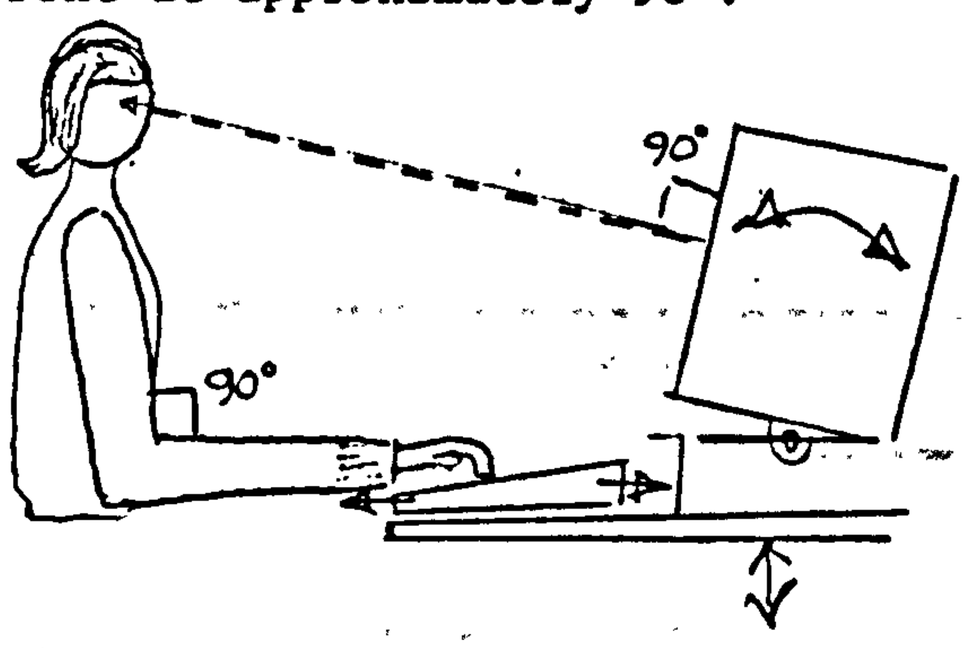
1. Adjust chair

Ideally the seat squab should be approximately 3cm below the back of the legs when bent at 90° into the seated position. The chair backrest should support the pelvis and not the small of the back.



2. Adjust the desk height

Ensure that the desk is adjusted such that with the hands on the centre of the keyboard the arms are bent at approximately 90°.



3. Adjust the angle of the datascreen

Adjust the angle of the datascreen until it is at right angles (ie 'normal') to the line of sight. If there are any annoying reflections tell the experimenter and then try to remove them by changing the angle. You will probably find that any reflections will be reduced by tilting the screen towards you.

4. Adjust the fore and aft position of the keyboard

Adjust the keyboard to its most comfortable position.

5. General position

Ensure that datascreen, keyboard and chair are in a straight line.

6. Adjust the brightness and contrast of the datascreen

Use the two knobs below the screen to adjust the brightness of the image and the difference in brightness between the image and the background

PUPIL NO 1 ZNAK INQUIRY .....

NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERRORS	NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERROR
1	10	1		117	1	9	1	1		104	1
2	8	3		141	7	10					
3	6	3		161	14	11					
4	4	3		31	0	12					
5	2	2		163	3	13					
6	9	2		245	10	14					
7	7	2		47	0	15					
8	5	2		112	1	16					

PUPIL NO 2 ZNAK INQUIRY .....

NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERRORS	NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERROR
1	10	1		999	3	9	3	1		326	1
2	8	1		387	3	10					
3	6	1		288	1	11					
4	4	1		65	0	12					
5	2	1		993	12	13					
6	9	1		385	7	14					
7	7	1		65	0	15					
8	5	1		365	1	16					

FIGURE 33 Sample of call handling statistics for 4 subjects over one twenty minute period

PUPIL NO 3 ZNAK INQUIRY .....

NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERRORS	NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERROR
1	10	3		380	2	9	3	2		126	0
2	8	3		110	0	10					
3	6	3		223	1	11					
4	4	3		30	0	12					
5	2	2		257	0	13					
6	9	2		120	1	14					
7	7	2		34	0	15					
8	5	2		336	4	16					

PUPIL NO 4 ZNAK INQUIRY .....

NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERRORS	NUMBER	BUFF NO	REP TMS	NOM TIME	AVER TIME	ERROR
1	10	4		228	13	9	3	3		89	2
2	8	4		84	2	10					
3	6	3		244	46	11					
4	4	3		32	0	12					
5	2	3		113	5	13					
6	9	3		132	10	14					
7	7	3		31	0	15					
8	5	3		257	62	16					

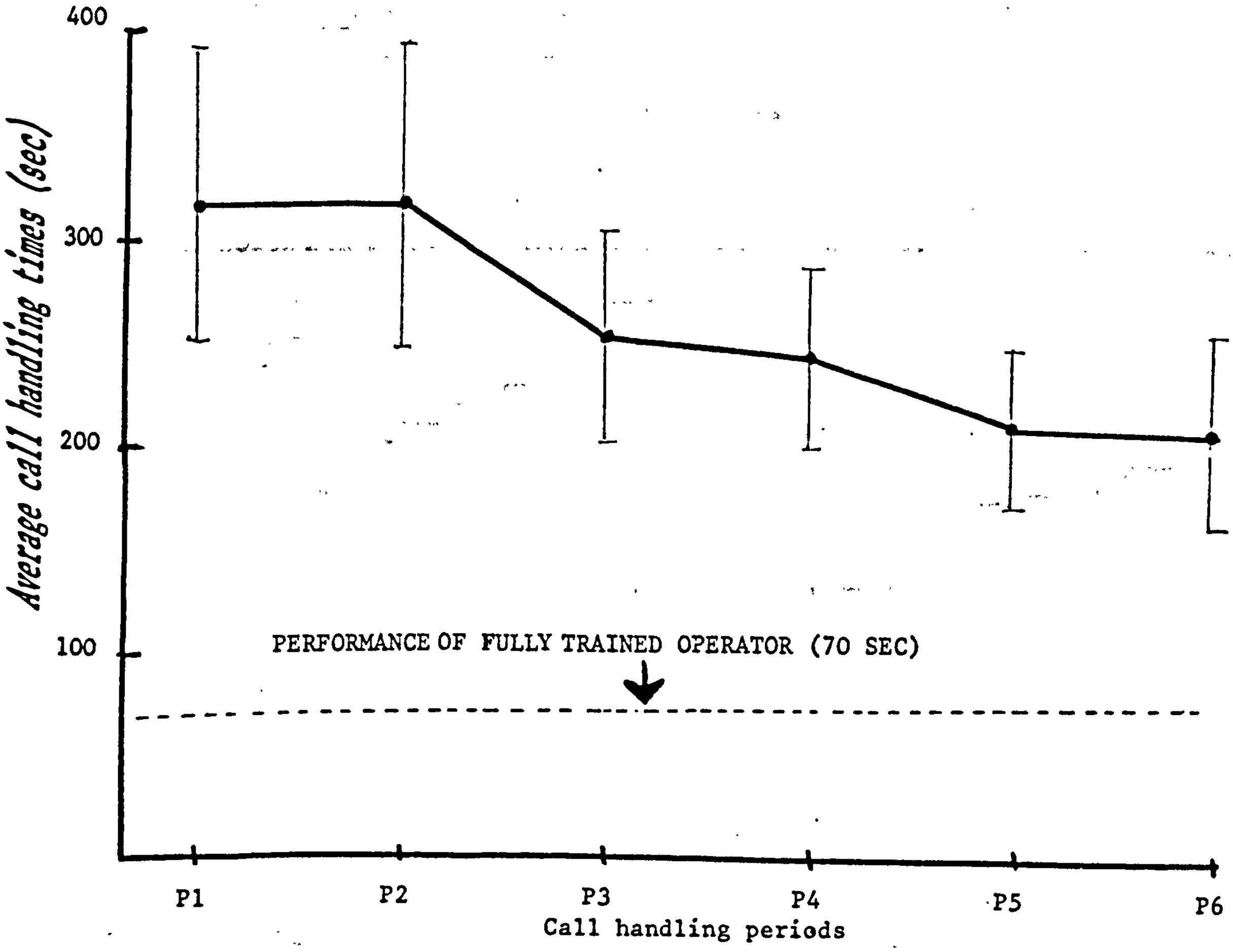


FIGURE 34 Average call handling rates during six successive call handling periods

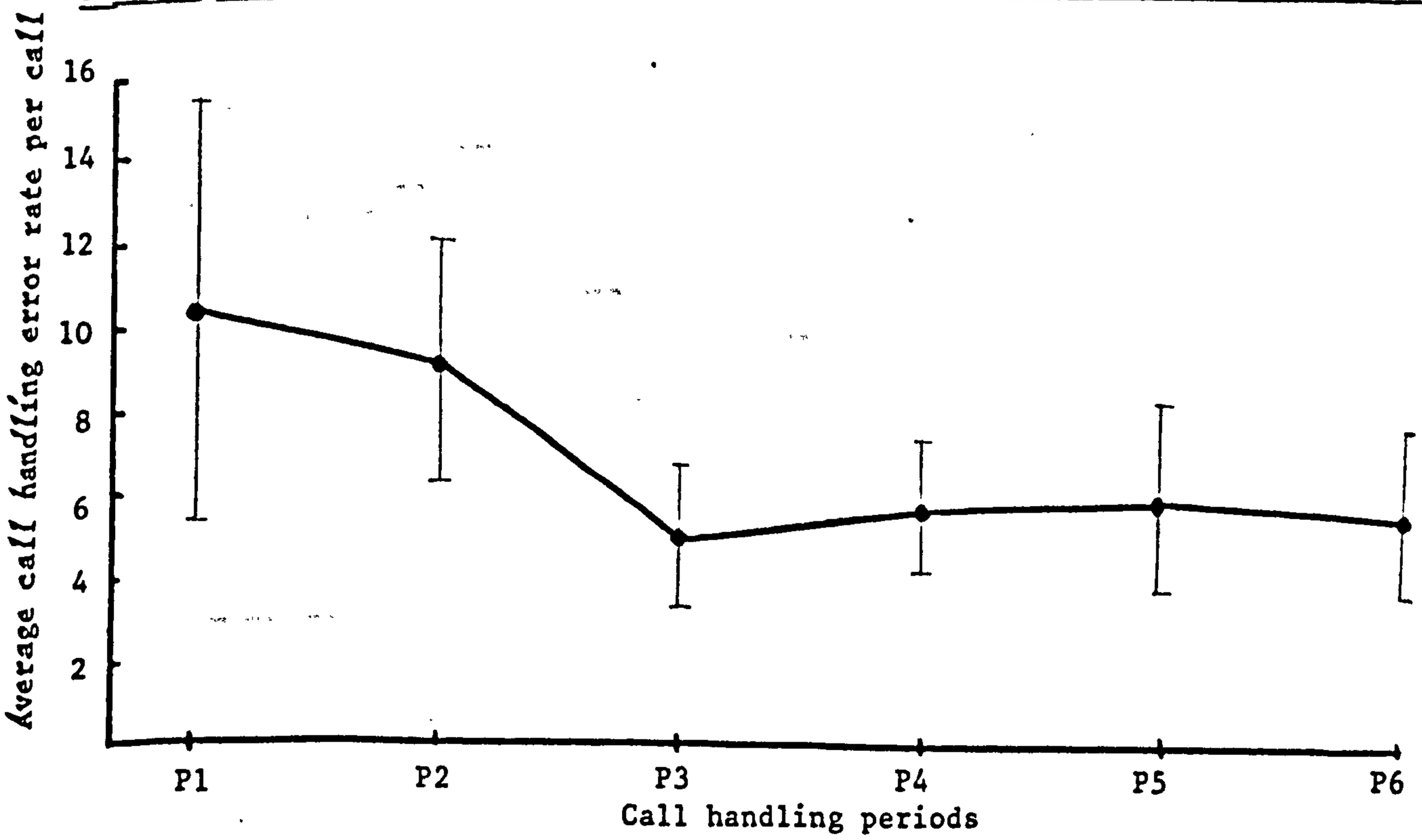


FIGURE 35 Average error rates during six successive call handling periods

FIGURE 36: Average call handling times by call type (call types ranked by increasing call handling time)

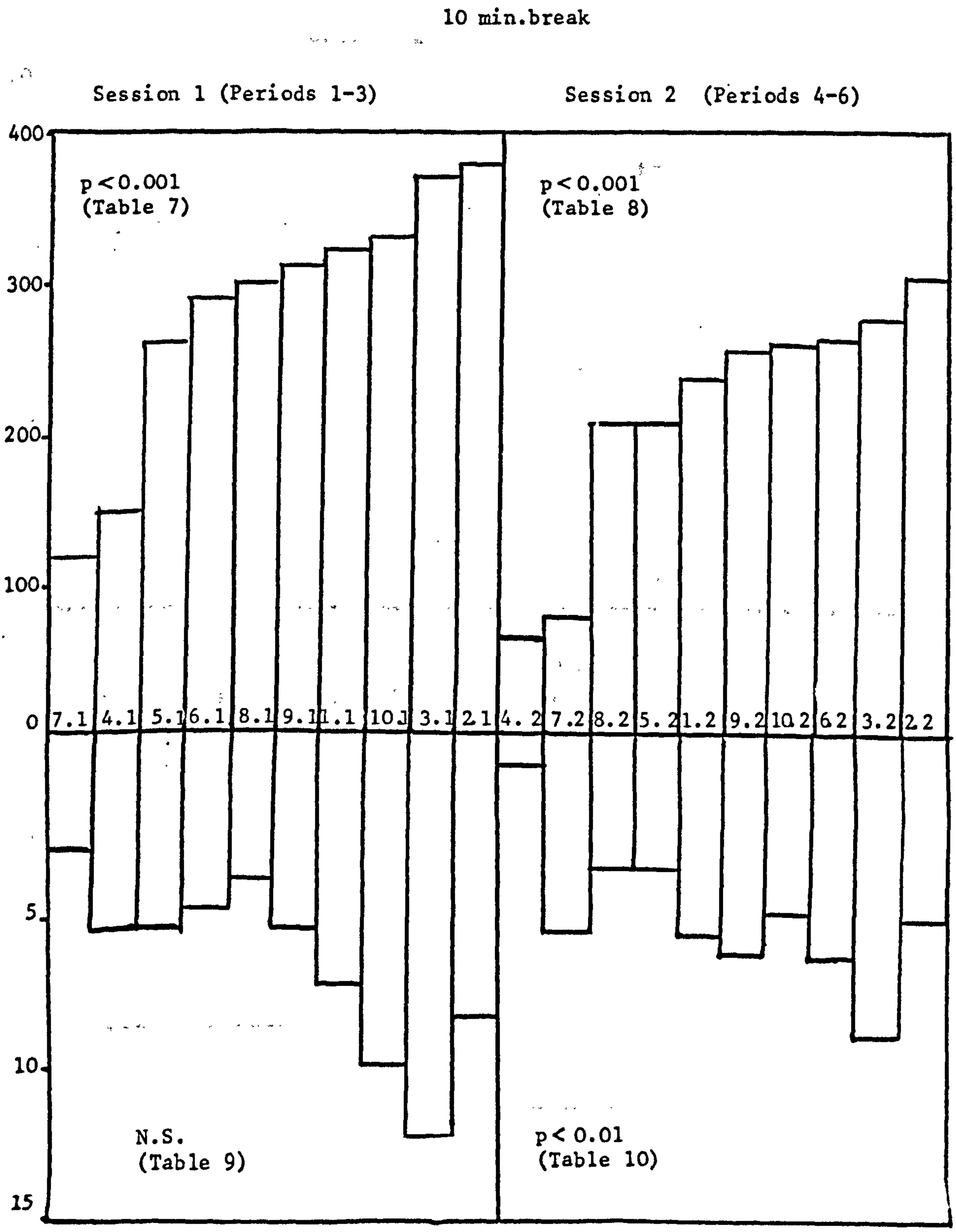


FIGURE -37: Average call handling error rate by call type (call types ranked by call handling time as in Figure 36)

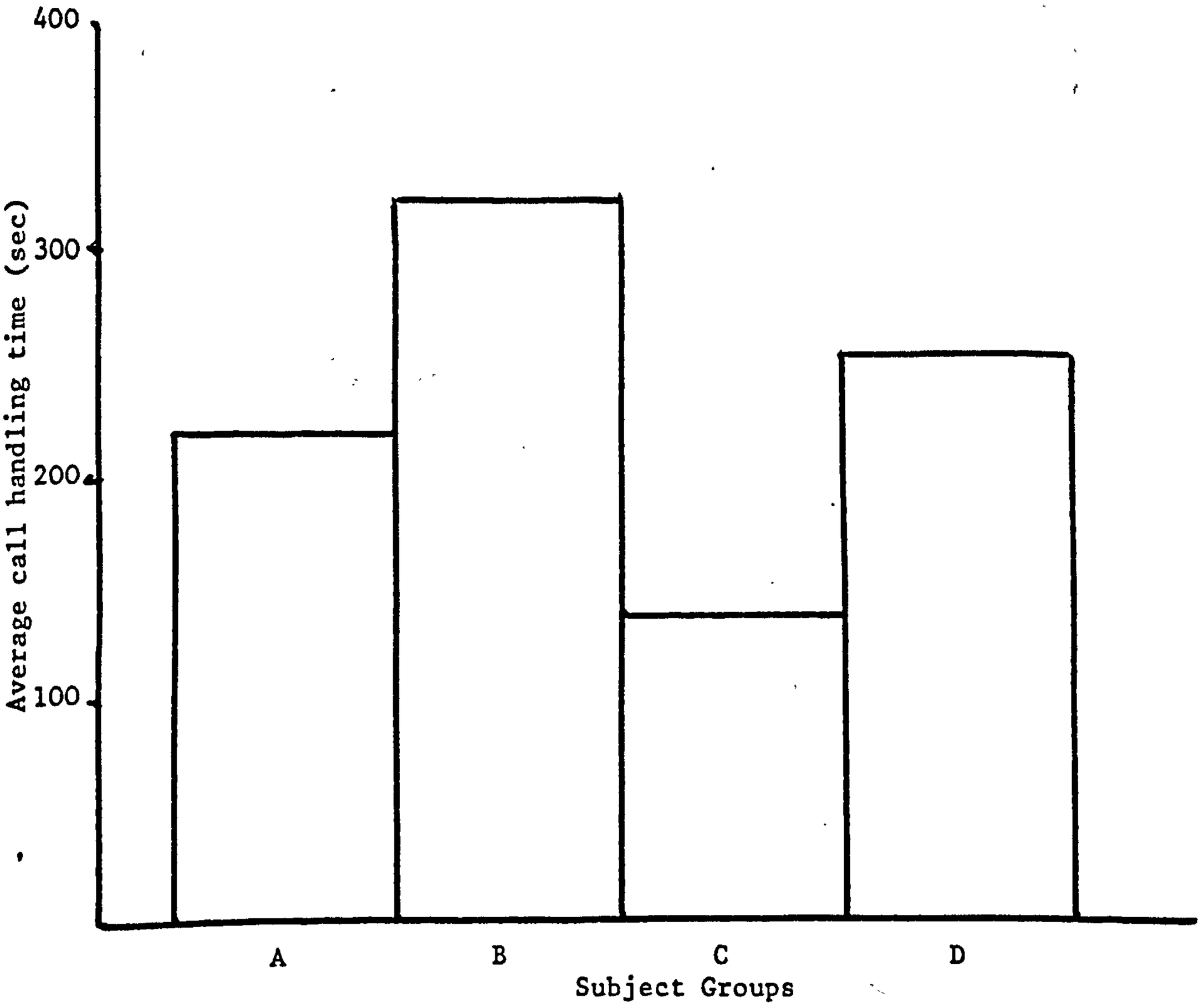


FIGURE 38: Average call handling times of subject groups

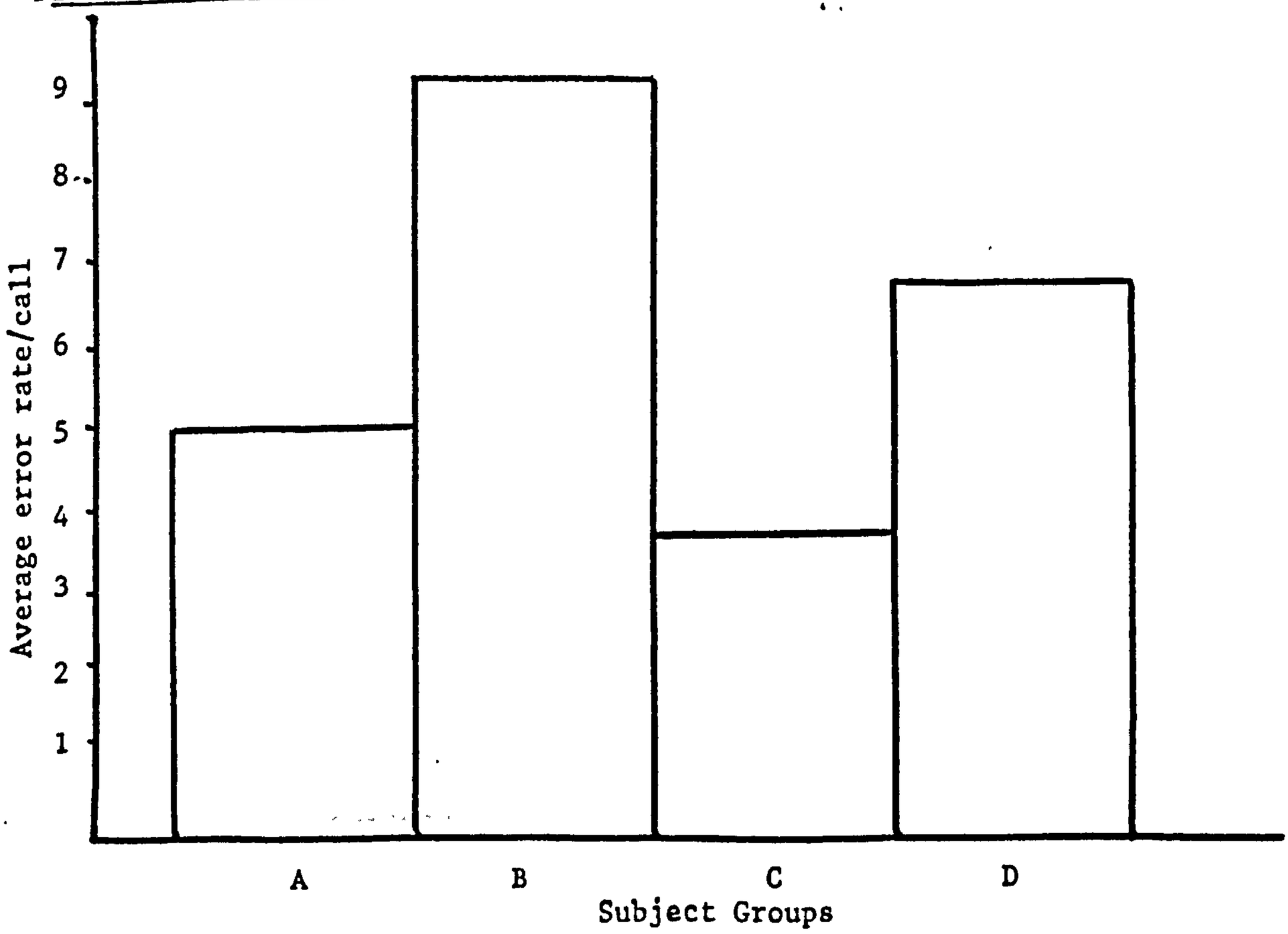


FIGURE 39: Average error rate per call of subject groups

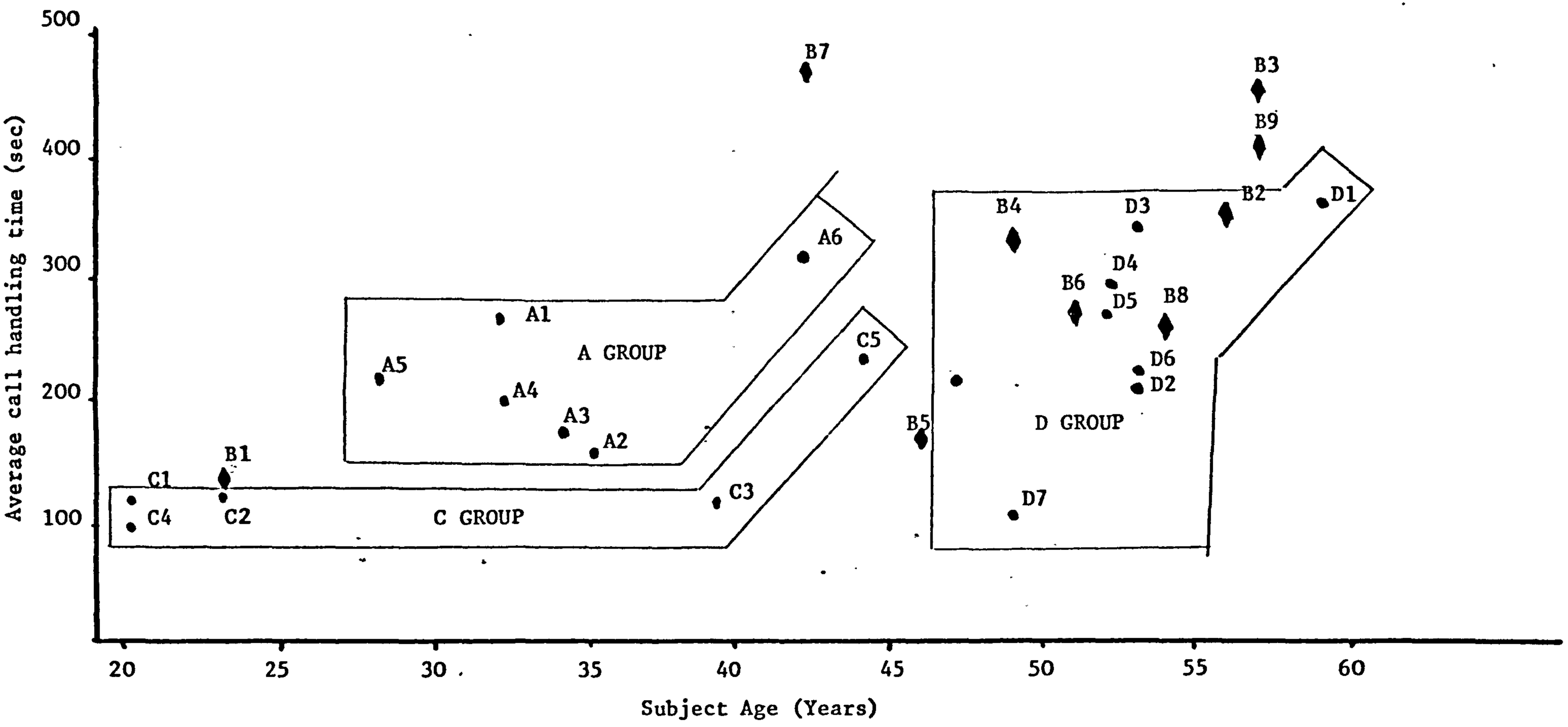


FIGURE 40: Relationship between subjects' age and average call handling time

FIGURE 41. ANE 403 Terminal and Console

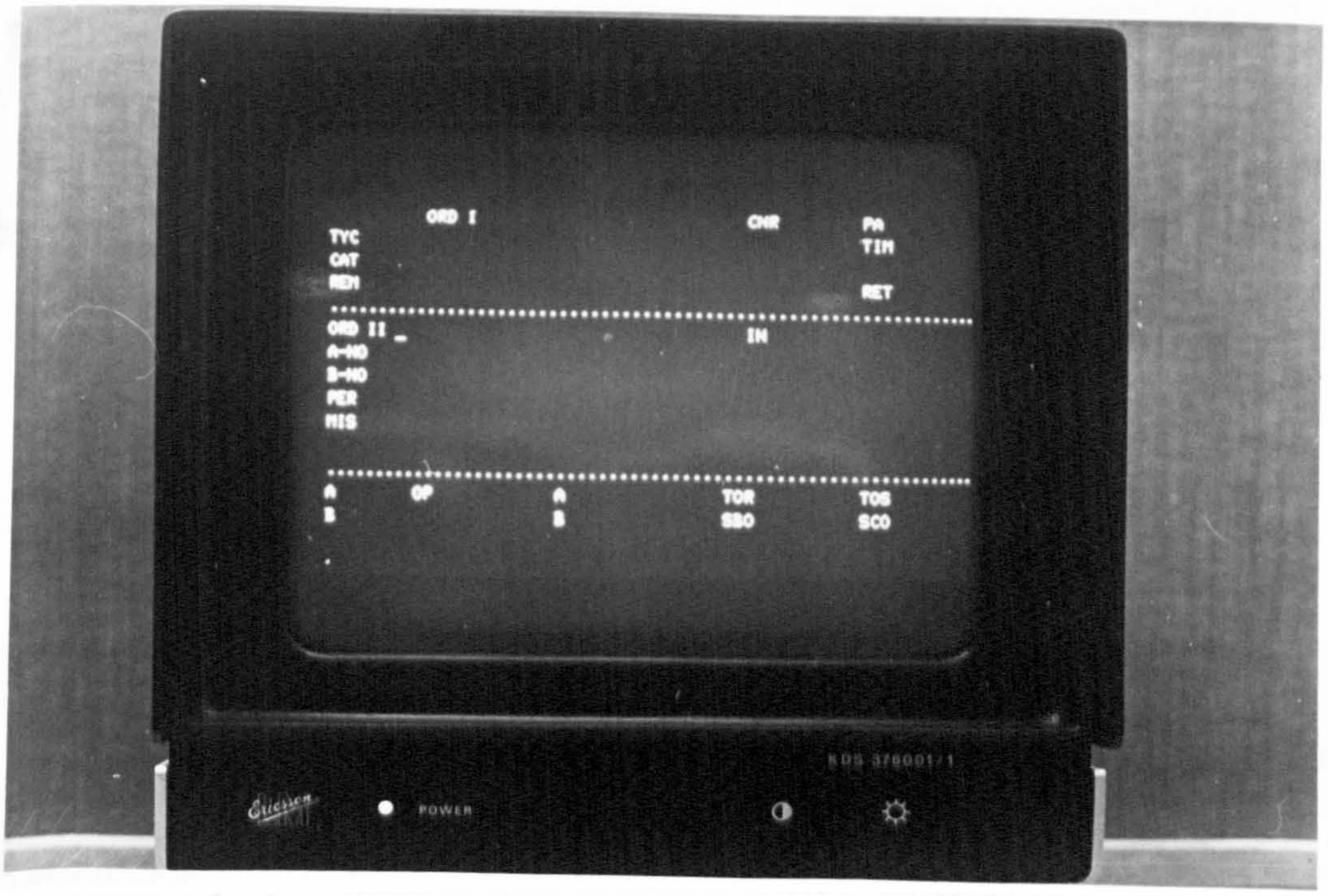


FIGURE 42. Close-up of datascreen with 'ticket' format.

FIGURE 43. Keyboard layout

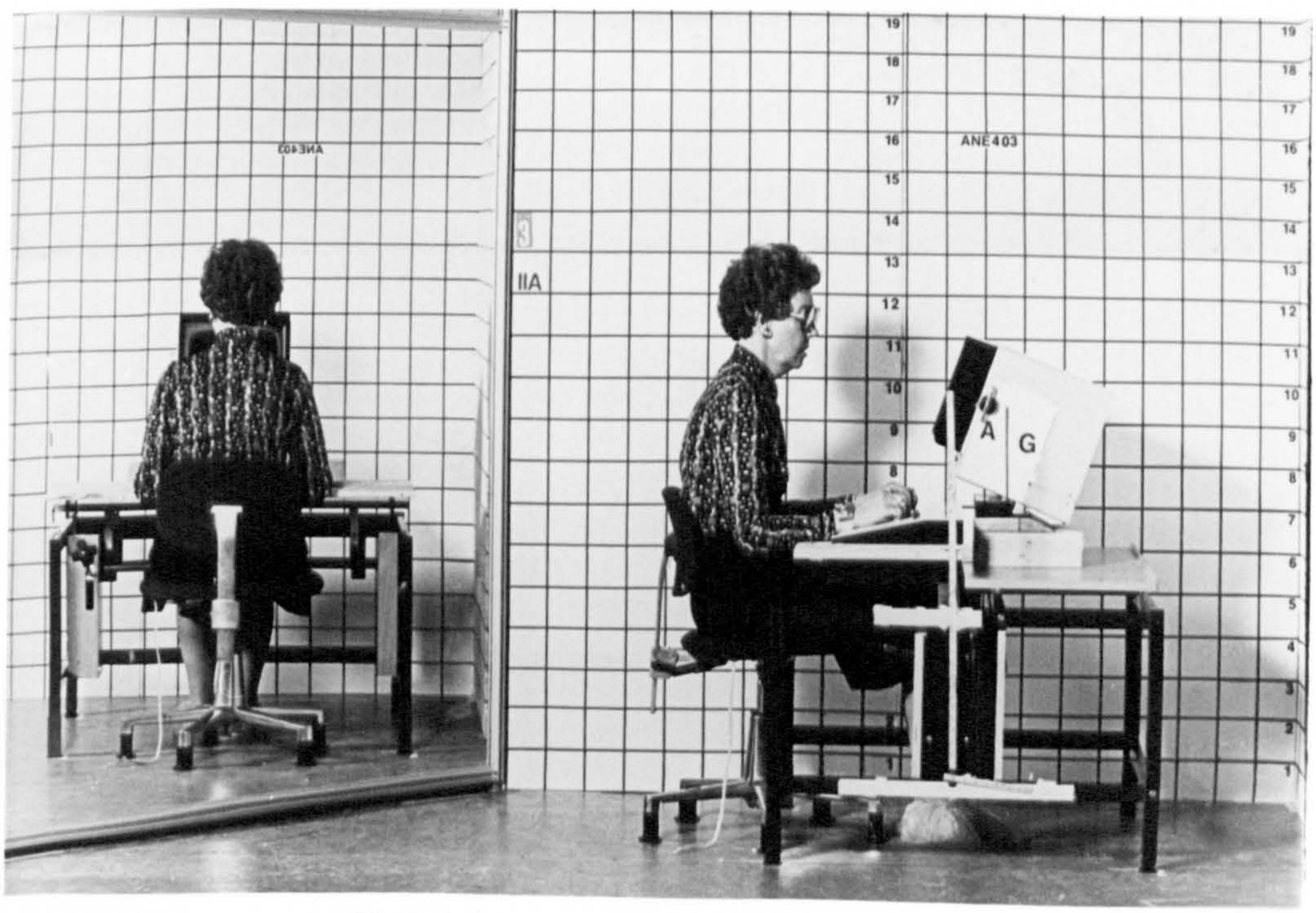


FIGURE 44. Console 'fitting' trials

FIGURE 45. General view of ANE 403 workstation.

FIGURE 46. Suggested room layout 1.

FIGURE 47. Suggested room layout 2.

TABLES

TABLE 1. Preferences in Paired Comparisons in Experiment 1 ‡

Screen Characteristics	Screen A0 P31 Phosphor with matt finish applied directly to the screen versus:-			Screen B0 P39 Phosphor with matt finish applied directly to the screen versus:-			Screen A0 P31 Phosphor + matt finish versus:-
	Screen A1 P31 Phosphor Plus Green Pol. Filter	Screen A2 P31 Phosphor Plus Neutral Pol. Filter	Screen A3 P31 Phosphor Plus 3M LCF Filter	Screen B1 P39 Phosphor Plus Green Pol. Filter	Screen B2 P39 Phosphor Plus Neutral Pol. Filter	Screen B3 P39 Phosphor Plus 3M LCF Filter	Screen B0 P39 Phosphor + matt finish
	A0 A1 =	A0 A2 =	A0 A3 =	B0 B1 =	B0 B2 =	B0 B3 =	A0 B0 =
Flicker	1 10 0 **	8 3 0	8 3 0	0 2 9	1 3 7	1 3 7	0 10 1 **
Character sharpness	1 7 3 *	7 2 2	7 3 1	0 3 8	0 1 10	0 2 9	9 2 0 *
Character wobble	3 8 0	5 6 0	5 6 0	1 9 1 *	2 8 1	2 8 1	1 8 2 *
Background stability	3 8 0	7 4 0	7 4 0	2 8 1	2 7 2	3 6 2	3 8 0
Reflector of lights	3 5 3	4 3 4	6 2 3	3 3 5	7 0 4 **	8 0 3 **	1 5 5
Reflectors of self	3 5 3	4 2 5	10 1 0 **	4 2 5	6 1 4	8 1 2 *	2 3 6
Colour	2 9 0 *	4 7 0	4 7 0	2 8 1	4 6 1	3 7 1	7 4 0
Overall	2 9 o *	6 5 0	6 5 0	2 8 1	3 6 2	3 7 1	6 5 0

** $p<0.01$)
* $p<0.05$) Binomial test

‡ The numbers in the body of the table indicate how the eleven subjects voted when indicating their preferences to each pair of screens on each of eight screen characteristics.

TABLE 2. Significant Difference in Paired Comparisons in Experiment 1 ‡

Screen Characteristics	Screen AO P31 Phosphor with matt finish applied directly to the screen versus			Screen BO P39 Phosphor with matt finish applied directly to the screen versus			Screen AO P31 Phosphor + matt finish versus
	Screen A1 P31 Phosphor Plus Green Pol. Filter	Screen A2 P31 Phosphor Plus Neutral Pol. Filter	Screen A3 P31 Phosphor Plus 3M LCF Filter	Screen B1 P39 Phosphor Plus Green Pol. Filter	Screen B2 P39 Phosphor Plus Neutral Pol. Filter	Screen B3 P39 Phosphor Plus 3M LCF Filter	Screen BO P39 Phosphor + matt finish
	Preference ‡	Preference ‡	Preference ‡	Preference ‡	Preference ‡	Preference ‡	Preference ‡
Flicker	A1 > AO **	-	-	-	-	-	BO > AO **
Character sharpness	A1 > AO *	-	-	-	-	-	AO > BO *
Character wobble	-	-	-	B1 > BO	-	-	BO > AO *
Background steadiness	-	-	-	-	-	-	-
Reflections of lights	-	-	-	-	BO > B2 *	BO > B3 *	-
Reflections of operator	-	-	AO > A3	-	-	BO > B3 *	-
Colour	A1 > AO *	-	-	-	-	-	-
Overall acceptability	A1 > AO *	-	-	-	-	-	-

** $p<0.01$) Binomial test (see Table 1)
* $p<0.05$)

‡ The symbol > is here used to mean "is significantly preferred to". For instance A1 > AO means that A1 is significantly preferred to AO on that characteristic.

TABLE 3. Average Ratings of Screens and Filters in Experiment 1.

Screen Characteristics	Screen A1 P31 Phosphor + matt green polaroid filter	Screen A2 P31 Phosphor + mattneutral polaroid filter	Screen A3 P31 Phosphor +1. matt green 3M LCF filter	Screen B1 P39 Phosphor + matt green polaroid filter	Screen B2 P39 Phosphor + mattneutral polaroid filter	Screen B3 P39 Phosphor +1.matt green 3M LCF filter	Significance *
Flicker	2.09	3.91	3.27	1.00	1.18	1.09	$p<0.001$
Character sharpness	1.91	2.55	1.55	1.91	4.09	1.91	$p<0.001$
Character wobble	2.00	4.18	4.00	1.09	1.27	1.09	$p<0.001$
Background steadiness	1.91	3.27	4.55	1.18	1.73	1.45	$p<0.001$
Reflections of lights	3.54	4.82	4.73	2.91	4.55	4.82	$p<0.01$
Reflections of operator	2.18	4.00	3.64	1.73	2.64	3.91	$p<0.01$
Colour	1.64	2.82	2.09	2.18	2.00	1.82	N.S
Overall acceptability	2.27	3.00	3.09	2.72	3.00	2.09	N.S

Note: A rating of 1 is ideal and 5 is very bad.

* Significance assessed by Kruskal-Wallis one-way analysis of variance with correction for ties. A separate analysis of variance across all six screen designs was carried out for each of the screen characteristics.

TABLE 4. Crude Comparison* of Screens Based on Significantly Different Ratings of Screen Characteristics given in Experiment 1.(See Table 3)

Screen Characteristics	Screen A1 P31 Phosphor + matt green polaroid filter	Screen A2 P31 Phosphor + matt neutral polaroid filter	Screen A3 P31 Phosphor 1, matt green 3M LCF filter	Screen B1 P39 Phosphor + matt green polaroid filter	Screen B2 P39 Phosphor + matt neutral polaroid filter	Screen B3 P39 Phosphor 1, matt green 3M LCF filter
Flicker	2	3	3	1	1	1
Character sharpness	1	2	1	1	4	1
Character wobble	2	4	4	1	1	1
Background stability	1	3	4	1	1	1
Reflections of lights	3	4	4	2	4	4
Reflections of operator	2	4	3	1	2	3

*Note: Score of 1 has average rating between 1 and 1.99. (Good performance)

Score of 2 has average rating between 2 and 2.99.

Score of 3 has average rating between 3 and 3.99.

Score of 4 has average rating between 4 and 4.99. (Poor performance)

It can be seen that screen B1 gained good ratings on five screen characteristics.

TABLE 4. Crude Comparison* of Screens Based on Significantly Different Ratings of Screen Characteristics given in Experiment 1.(See Table 3)

Screen Characteristics	Screen A1 P31 Phosphor + matt green polaroid filter	Screen A2 P31 Phosphor + matt neutral polaroid filter	Screen A3 P31 Phosphor 1, matt green 3M LCF filter	Screen B1 P39 Phosphor + matt green polaroid filter	Screen B2 P39 Phosphor + matt neutral polaroid filter	Screen B3 P39 Phosphor 1, matt green 3M LCF filter
Flicker	2	3	3	1	1	1
Character sharpness	1	2	1	1	4	1
Character wobble	2	4	4	1	1	1
Background stability	1	3	4	1	1	1
Reflections of lights	3	4	4	2	4	4
Reflections of operator	2	4	3	1	2	3

*Note: Score of 1 has average rating between 1 and 1.99. (Good performance)

Score of 2 has average rating between 2 and 2.99.

Score of 3 has average rating between 3 and 3.99.

Score of 4 has average rating between 4 and 4.99. (Poor performance)

It can be seen that screen B1 gained good ratings on five screen characteristics.

TABLE 5. Results of visual screening test prior to Experiment 2.

Test no.*	Description of test (see Appendix 3)	Subject Group 1 who used Screen A0 P31 Phosphor with matt finish	Subject Group 2 who used Screen B3 P39 Phosphor plus 3M LCF filter	Subject Group 3 who used Screen B1 P39 Phosphor plus Green Pol. filter	Subject Group 4 who used Screen A1 P39 Phosphor plus Green Pol. filter
1	Type of spectacles worn				
	Far	2	2	2	4
	Near	3	4	2	1
	Bifocal	4	3	0	0
	None	3	2	6	6
	Far vision problems ‡				
2	Vertical phoria	- -	2Y -	- -	- -
3	Lateral phoria	1Y -	1Y -	- -	1Y -
4	Acuity both	2Y -	2Y -	3Y -	1Y -
5	Acuity left	2Y -	1Y 2R	- 2R	1Y 1R
6	Acuity right	1Y -	1Y -	- -	- -
	TOTAL	6Y -	7Y 2R	3Y 2R	3Y 1R
	Near vision problems ‡				
7	Acuity both	3Y -	4Y -	2Y -	- -
8	Acuity right	3Y 1R	3Y 1R	- 2R	- -
9	Acuity left	2Y -	2Y 1R	- -	- -
10	Vertical phoria	- -	1Y -	- -	- -
11	Lateral phoria	1Y -	- -	2Y -	- -
	TOTAL	9Y 1R	10Y 2R	4Y 2R	- -

* See Appendix 3 for position on recording form of tests noted here.

‡ The numbers with 'Y' as suffix indicate the number of subjects in that group whose vision on that test is below the standard for clerical and administrative jobs as laid down by the Purdue University Standard for the visual screener. The numbers with an 'R' as suffix indicate seriously lowered visual skills for satisfactory job performance according to the same Purdue Standard.

TABLE 6. Results from pre-task questionnaire, subjects' eye condition before Experiment 2

Qu. Nos	For full details of question see Appendix 2.	Subject Group 1 who used Screen AO P31 Phosphor with matt finish	Subject Group 2 who used Screen B3 P39 Phosphor plus 3M LCF filter	Subject Group 3 who used Screen B1 P39 Phosphor plus Green Pol. filter	Subject Group 4 who used Screen A1 P39 Phosphor plus Green Pol. filter
	No. of subjects	10	9	10	10
A3	Average age (years)	45.0	45.0	35.0	32.8
B1	No. of eye complaints	1	1	3	3
B2	No. with use of one eye only	0	0	1	0
B3	Number colour blind	0	0	0	0
B4	No. with corrected vision:-				
	Spectacles	7	7	4	3
	Contact Lenses	0	0	0	1
C1	No. not wearing corrections regularly	1	1	1	0
C2	Average number of years since last visit to optician	1.71	1.71	1.75	1.83
C3	Time corrections worn:				
	0 - 4.9 yr.	1	2	1	0
	5 - 19.9 yr.	5	3	2	2
	20 + yrs.	1	2	1	1
C4a	Type of spectacles worn:				
	Single lens	3	4	4	3
	Bifocal	3	3	0	0
	Both	1	0	0	0
C4b	Type of contact lens worn:				
	Hard	0	0	0	1
	Soft	0	0	0	0
C5	Tinted correction:(% wearers)				
	a. Spectacles	6 (75%)	2 (28.6%)	2 (50%)	2 (66%)
	b. Contact lenses	0	0	0	0
C6	Can correction be worn for long periods of time?				
	Yes(% wearers)	5 (71.4%)	7 (100%)	1 (25%)	4 (100%)
	No	2 (28.6%)	0	3 (75%)	0
C7	Symptoms experienced when wearing corrections:(%wearers)				
	Tiredness	2 (28.6%)	1 (14.3%)	0	0
	Heaviness	0	0	0	0
	Irritation	0	0	0	0
	Increased light sensitivity	1 (14.3%)	1 (14.3%)	1 (25%)	0

TABLE 6. Results from pre-task questionnaire, subjects' eye condition before Experiment 2. (continued)

		Subject Group 1 who used Screen A0 P31 Phosphor with matt finish	Subject Group 2 who used Screen B3 P39 Phosphor plus 3M LCF filter	Subject Group 3 who used Screen B1 P39 Phosphor plus Green Pol. filter	Subject Group 4 who used Screen A1 P39 Phosphor plus Green Pol. filter
D1	Do you experience any of the following symptoms?				
a. Tiredness	Often or Seldom	8	8	10	9
	Never	2	0	0	1
b. Watering	Often or seldom	3	2	6	4
	Never	6	6	4	5
c. Dryness	Often or seldom	3	2	4	4
	Never	6	7	6	6
d. Soreness	Often or seldom	4	3	3	1
	Never	5	6	7	9
e. Itching	Often or seldom	4	2	3	5
	Never	5	7	7	5
f. Twitching	Often or seldom	4	4	5	6
	Never	5	5	5	4
g. Heaviness	Often or seldom	5	2	4	4
	Never	4	7	5	6
h. Eyestrain	Often or seldom	5	6	7	7
	Never	4	3	3	3
i. Excessive blinking	Often or seldom	1	1	0	1
	Never	8	8	10	9
j. Blurring of distant objects	Often or seldom	2	3	3	1
	Never	8	6	7	9
k. Blurring of print	Often or seldom	2	5	4	4
	Never	8	4	6	6
l. Double vision	Often or seldom	1	2	0	0
	Never	8	4	6	6

TABLE 6. Results from pre-task questionnaire, subjects' eye condition before Experiment 2 (continued)

		Subject Group 1 who used Screen A0 P31 Phosphor with matt finish	Subject Group 2 who used Screen B3 P39 Phosphor plus 3M LCF finish	Subject Group 3 who used Screen B1 P39 Phosphor plus Green Pol. filter	Subject Group 4 who used Screen A1 P39 Phosphor plus Green Pol. filter
D2	a. Do you get headaches?				
	Often	1	1	3	0
	Seldom	4	6	7	10
	Never	4	2	0	0
	b. If yes, can you attribute them to eyestrain?				
	Yes(% sufferers)	0	0	2(20%)	3(30%)
	No	3 (60%)	2 (28.6%)	1(10%)	4(40%)
	Don't know	2 (40%)	5(71.4%)	7(70%)	3(30%)
D3	Do you get pains when reading?				
	Head	0	0	0	1
	Neck	1	2	2	2
	Shoulders	0	0	1	2
	Back	0	2	1	0
	Elsewhere	0	0	0	0
D4	Do you experience eyestrain under any of these conditions?				
	a. Reading	3	3	2	3
	b. Watching T.V.	3	4	3	5
	c. Watching cinema	2	2	2	3
	Driving (% of drivers)	0%	0%	60%	0%
	Irritability of eyes:				
D5	To lights	5	3	7	7
D6	To cigarette smoke	6	4	8	6
D7	To dry air	0	1	3	1

TABLE 7a. Error Rate for Visual Task in Experiment 2.

	Screen A0 P31 Phosphor with matt finish (Subject Group 1)	Screen B3 P39 Phosphor Plus 3M LCF filter (Subject Group 2)	Screen B1 P39 Phosphor Plus Green Polaroid filter (Subject Group 3)	Screen A1 P31 Phosphor Plus Green Polaroid filter (Subject Group 4)
Average Error %	3.27	5.93	2.29	4.45

TABLE 7b. Analysis of Variance Summary Table for Means in Table 7a.

Source	S of S	df	MS	F	Significance
Treatment	69.75	3	23.25	1.25	N.S.
Error	650.03	35	18.57		
TOTAL	719.77	38			

TABLE 8a. Response Time (Correct and Incorrect Responses) for Visual Task in Experiment 2.

	Screen A0 P31 Phosphor with matt finish (Subject Group 1)	Screen B3 P39 Phosphor Plus 3M LCF filter (Subject Group 2)	Screen B1 P39 Phosphor Plus Green Polaroid filter (Subject Group 3)	Screen A1 P31 Phosphor Plus Green Polaroid filter (Subject Group 4)
Average response time (sec.)	5.58	4.72	5.64	4.85

TABLE 8b. Analysis of Variance Summary Table for Means in Table 8a.

Source	S of S	df	MS	F	Significance
Treatment	6.68	3	2.22	0.83	N.S.
Error	93.38	35	2.67		
TOTAL	100.06	38			

TABLE 9a. Response Time (Correct Responses) for Visual Task in Experiment 2.

	Screen A0 P31 Phosphor with matt finish (Subject Group 1)	Screen B3 P39 Phosphor Plus 3M LCF filter (Subject Group 2)	Screen B1 P39 Phosphor Plus Green Polaroid filter (Subject Group 3)	Screen A1 P31 Phosphor Plus Green Polaroid filter (Subject Group 4)
Average correct response time (sec.)	5.5	4.7	5.6	4.8

TABLE 9b. Analysis of Variance Summary Table for Means in Table 9a.

Source	S of S	df	MS	F	Significance
Treatment	6.54	3	2.18	0.81	N.S.
Error	93.65	35	2.68		
TOTAL	100.2	38			

TABLE 10a. Response Time (Incorrect Responses) for Visual Task in Experiment 2.

	Screen A0 P31 Phosphor with matt finish (Subject Group 1)	Screen B3 P39 Phosphor Plus 3M LCF filter (Subject Group 2)	Screen B1 P39 Phosphor Plus Green Polaroid filter (Subject Group 3)	Screen A1 P31 Phosphor Plus Green Polaroid filter (Subject Group 4)
Average incorrect response time (sec.)	6.52	4.96	5.62	4.74

TABLE 10b. Analysis of Variance Summary Table for Means in Table 10a.

Source	S of S	df	MS	F	Significance
Treatment	16.82	3	5.61	2.25	N.S.
Error	79.57	32	2.49		
TOTAL	96.39	35			

TABLE 11. Results from post-task questionnaire, after Completing the Visual Task in Experiment 2

Qu. Nos.	Brief description of question(see Appendix 5)	Screen A0 P31 Phosphor with matt finish Subject Group 1	Screen B3 P39 Phosphor Plus 3M LCF filter Subject Group 2	Screen B1 P39 Phosphor Plus Green Polaroid filter Subject Group 3	Screen A1 P31 Phosphor Plus Green Polaroid filter Subject Group 4
B1	Post-task eye condition:				
	a. Tired	4	2	6	5
	b. Heavy	2	2	0	2
	c. Sore	1	2	1	1
	d. Irritated	1	2	1	3
	e. Wet eyed	0	0	0	1
	f. Dry eyed	1	0	0	2
	g. Inflamed	0	0	0	0
	h. Blurred	3	0	2	3
B2	Change of colour vision				
	Little	0	0	0	3
	Much	0	0	0	0
	Not at all	10	9	10	7
B3	Frequency of headaches				
	Yes	0	1	1	1
	No	10	8	9	9
	Onset during task?(%)	0	1(100%)	0	1(100%)
B4	Aches due to task				
	Neck	4	0	0	1
	Shoulders	0	1	0	1
	Back	0	1	1	1
	Elsewhere	0	0	0	0
C1	Tiredness in the eyes				
	None	2	3	3	5
	Little	7	6	7	3
	Much	1	0	0	2
C2a	Would you have liked to pause?				
	No	3	3	2	4
	Yes	7	5	7	6
b	If yes, how often?				
	Every 10 mins.	2	3	2	4
	Every 20 mins.	1	0	1	1
	Every 30 mins.	2	0	1	1
	After 1 hour	1	1	1	0
	Not answered	1	1	2	0
C3	Was it easy to work with the screen for 30 mins?				
	Yes	6	7	6	6
	No	3	2	4	4
	Not answered	1	0	0	0

TABLE 12. Subjective judgements of screens* after Experiment 2

	Screen A0 P31 Phosphor with matt finish Subject Group 1	Screen B3 P39 Phosphor Plus 3M LCF filter Subject Group 2	Screen B1 P39 Phosphor Plus Green Pol. filter Subject Group 3	Screen A1 P31 Phosphor Plus Green Pol. filter Subject Group 4	Significance ‡
Flicker	2.20	1.44	1.22	2.50	$p < 0.05$
Character sharpness	2.00	2.33	1.50	2.30	N.S.
Character wobble	2.60	1.89	1.22	2.50	$p < 0.05$
Background steadiness	1.50	1.63	1.11	1.10	N.S.
Reflection of lights	1.90	4.11	3.89	3.30	$p < 0.05$
Reflection of self	1.80	3.11	1.44	2.00	N.S.
Colour	1.90	2.67	2.22	2.20	N.S.
Acceptability	2.60	2.00	2.20	2.10	N,S.

* The body of the Table contains the mean ratings given by the subjects in each group to the datascreens they used on each of eight characteristics. The lower the rating the better the score.

‡ Kruskal-Wallis one-way analysis of variance used to determine the statistical significance of the differences in the mean ratings given to the screens on each of the eight characteristics.

TABLE 13. Results of visual screening test prior to Experiment 3

Test No.*	Description of test (see Appendix 3)	Subject Group 3 who used Screen B1 under 300 lux**	Subject Group 5 who used Screen B1 under 500 lux
1	Type of spectacles worn		
	Far	2	2
	Near	2	0
	Bifocal	0	0
	None	6	8
	Far vision problems ‡		
2	Vertical phoria	- -	- -
3	Lateral phoria	- -	- -
4	Acuity both	3Y -	- -
5	Acuity right	- 2R	1Y -
6	Acuity left	- -	- -
	TOTAL	3Y 2R	1Y -
	Near vision problems ‡		
7	Acuity both	2Y -	- -
8	Acuity right	- 2R	1Y -
9	Acuity left	- -	- -
10	Vertical phoria	- -	1Y -
11	Lateral phoria	2Y -	- -
	TOTAL	4Y 2R	2Y -

* See Appendix 3 for position on recording form of tests noted here.

** These results were obtained from the subject group who used Screen B1 in Experiment 2

‡ The numbers with 'Y' as suffix indicate the number of subjects in that group whose vision on that test is below the standard for clerical and administrative jobs as laid down by the Purdue University Standard for the visual screener. The numbers with an 'R' as suffix indicate seriously lowered visual skills for satisfactory job performance according to the same Purdue Standard.

TABLE 14. Results from pre-task questionnaire, subjects' eye condition before Experiment 3.

Qu. Nos.	For full details of questions see Appendix 2.	Subject Group 3 who used Screen B1 under 300 lux*	Subject Group 5 who used Screen B1 under 500 lux
	No. of subjects	10	10
A3	Average age (years)	35.0	26.4
B1	Number of eye complaints reported	3	1
B2	Number with use of one eye only	1	0
B3	Number of colour blind	0	0
B4	Number with corrected vision:		
	Spectacles	4	2
	Contact lenses	0	0
C1	Number not wearing corrections regularly	1	0
C2	Average number of years since last visit to optician	1.75	3.00
C3	Time corrections worn:		
	0 - 4.9 years	1	1
	5 - 19.9 years	2	1
	20 + years	1	0
	Average time worn (years)	10.5	3.25
C4a	Type of spectacles worn:		
	Single lens	4	2
	Bifocal	0	0
	Both	0	0
C4b	Type of contact lens worn:		
	Hard	0	0
	Soft	0	0
C5	Tinted correction: (% wearers)		
	Spectacles	2 (50%)	2 (100%)
	Contact lenses	0	0
C6	Can correction be worn for long periods of time? (% wearers)		
	Yes	1 (25%)	0 (0%)
	No	3 (75%)	2 (100%)
C7	Symptoms experienced when wearing corrections: (% wearers)		
	Tiredness	0	0
	Heaviness	0	0
	Irritation	0	0
	Increased light sensitivity	1 (25%)	0

* These answers were obtained from subjects who used screen B1 in Experiment 2.

TABLE 14. Results from pre-task questionnaire, subjects' eye condition before Experiment 3 (continued)

			Subject Group 3 who used Screen B1 under 300 lux*	Subject Group 5 who used Screen B1 under 500 lux
D1	Tiredness	Often/Seldom	10	10
		Never	0	0
	Watering	Often/Seldom	6	4
		Never	4	6
	Dryness	Often/Seldom	4	0
		Never	6	10
	Soreness	Often/Seldom	3	3
		Never	7	7
	Itching	Often/Seldom	3	3
		Never	7	7
	Twitching	Often/Seldom	5	3
		Never	5	7
	Heaviness	Often/Seldom	4	4
		Never	5	6
	Eyestrain	Often/Seldom	7	8
		Never	3	2
	Excessive blinking	Often/Seldom	0	3
		Never	10	7
	Blurring of distant objects	Often/Seldom	3	4
		Never	7	6
	Blurring of Print	Often/Seldom	4	4
		Never	6	6
	Double vision	Often/Seldom	0	1
		Never	10	9

* Subject group from Experiment 2.

TABLE 15a. Error Rate for Visual Task in Experiment 3.

	Screen B1 under 300 lux Subject Group 3 *	Screen B1 under 500 lux subject Group 5
Average error rate (%)	2.29	4.39

TABLE 15b. Analysis of Variance Summary Table for Means in Table 7a.

Source	S of S	df	MS	F	Significance
Treatment	22.05	1	22.05	2.30	N.S.
Error	172.40	18	9.58		
Total	194.45	19			

TABLE 16a. Response Time (Correct and Incorrect Responses) for Visual Task in Experiment 3.

	Screen B1 under 300 lux Subject Group 3*	Screen B1 under 500 lux subject Group 5
Average response time (secs.)	5.64	4.77

* Results obtained in Experiment 2

TABLE 16b. Analysis of Variance Summary Table for Means in Table 16a.

Source	S of S	df	MS	F	Significance
Treatment	3.77	1	3.77	1.23	N.S.
Error	55.32	18	3.07		
Total	59.09	19			

TABLE 17a. Response Time (Correct Response) for Visual Task in Experiment 3.

	Screen B1 under 300 lux Subject * Group 3	Screen B1 under 500 lux subject Group 5
Average response time (secs.)	5.63	4.75

TABLE 17b. Analysis of Variance Summary Table for Means in Table 17a.

Source	S of S	df	MS	F	Significance
Treatment	3.78	1	3.78	1.22	N.S.
Error	55.81	18	3.10		
Total	59.59	19			

* Results obtained in Experiment 2.

TABLE 18a. Response Time (Incorrect Responses) for Visual Task in Experiment 3.

	Screen B1 under 300 lux Subject* Group 3	Screen B1 under 500 lux subject Group 5
Average response time (seconds)	5.06	5.45

*
Results obtained in Experiment 2.

TABLE 18b. Analysis of Variance Summary Table for Means in Table 18a.

Source	S of S	df	MS	F	Significance
Treatment	0.14	1	0.14	0.05	N.S.
Error	48.90	18	2.72		
Total	49.04	19			

TABLE 19. Results from post-task questionnaire, after Experiment 3.

Qu. Nos.	Brief description of question (see Appendix 5)	Screen B1 under 300 lux subject * Group 3	Screen B1 under 500 lux subject Group 5
B1	Post-task eye condition:		
	1. Tired	6	5
	2. Heavy	0	1
	3. Sore	1	0
	4 Irritated	1	1
	5. Wet eyed	0	1
	6. Dry eyed	0	0
	7. Inflamed	0	0
	8. Blurred	2	2
B2	Change of colour vision		
	Little	0	0
	Much	0	0
	Not at all (or no answer)	10	10
B3	Frequency of headaches		
	Yes	1	0
	No	9	10
	Onset during task? (%)	0	0
B4	Aches due to task		
	Neck	0	1
	Shoulders	0	1
	Back	1	0
	Elsewhere	0	0
C1	Tiredness in the eyes		
	None	3	2
	Little	7	8
	Much	0	0
C2a	Would you have liked to pause?		
	No	2	3
	Yes	7	7
C2b	If yes, how often?		
	Every 10 minutes	2	4
	Every 20 minutes	1	1
	Every 30 minutes	1	1
	After 1 hour	1	0
	Not answered	2	1
C3	Could you work with the screen for 30 minutes?		
	Yes	6	8
	No	4	2
	Not answered	0	0

* Results obtained from Experiment 2.

TABLE 21 . Settings of Brightness Control at Fixed Contrast Level Settings *

(Experiment 3)

Light level	Contrast setting	Subject number 51	52	53	54	55	56	57	58	59	60	Average
300 lux	3	9.5	9.5	9.5	10.0	9.0	9.0	9.5	9.5	9.5	9.5	9.45
	4	9.5	9.0	9.0	9.5	9.5	9.0	9.5	10.0	9.0	9.5	9.35
	5	9.0	9.5	8.5	9.0	9.5	9.0	9.5	10.0	8.5	9.5	9.20
	6	9.0	9.0	9.0	9.0	10.0	9.0	9.0	10.0	9.0	9.5	9.25
500 lux	3	10.0	9.5	9.0	10.0	9.0	9.0	9.0	8.5	9.0	9.5	9.25
	4	9.5	9.0	8.5	10.0	9.5	9.5	9.0	9.0	9.0	9.5	9.25
	5	9.0	9.0	9.0	9.0	9.0	9.5	9.5	9.0	9.0	9.5	9.15
	6	9.0	9.0	9.0	9.5	9.0	9.0	9.5	8.0	9.0	9.0	9.00

* These settings were marked around the controls of the monitor used in this experiment.

TABLE 22 . Preferences for Control Settings at 300 Lux and 500 Lux (Experiment 3)

Light level	Control	Settings*										Average
300 lux	Contrast	5.0	4.5	3.0	5.0	4.0	4.5	6.0	5.0	5.0	4.5	4.65
	Brightness	9.0	9.5	9.5	9.0	9.5	9.5	9.0	9.0	9.0	9.5	9.25
500 lux	Contrast	4.5	4.0	5.5	5.0	3.5	5.0	6.0	4.5	4.0	4.0	4.60
	Brightness	9.0	9.0	8.5	9.5	9.5	9.0	9.5	9.0	9.0	9.0	9.10

* These settings were marked around the controls of the monitor used in this experiment.

TABLE 23.. Brightness and Contrast of Characters at Various Control Settings

(Experiment 3)

Brightness control setting	Contrast control setting 3		4		5		6		7	
10.0	370 230 190	1.95 1.21	430 250 190	2.26 1.32						
9.5	300 200 175	1.71 1.14	380 220 175	2.17 1.25	420 230 175	2.40 1.31	525 240 175	3.00 1.37		
9.0	230 170 160	1.44 1.06	300 190 160	1.88 1.19	350 200 160	2.19 1.25	410 210 160	2.56 1.31	490 220 160	3.06 1.38
8.5			230 160 160	1.44 1.00	290 180 160	1.81 1.13	350 190 160	2.19 1.19	420 200 160	2.63 1.25
8.0					230 166 160	1.43 1.00	300 170 160	1.88 1.06	350 175 160	2.19 1.09

Acceptable brightness range

Acceptable contrast range

KEY

AAA	D.DD
BBB	E.EE
CCC	

For each box:-

AAA = Brightness of brightest characters

BBB = Brightness of dullest characters

CCC = Brightness of background

D.DD = Contrast of brightest characters

E.EE = Contrast of dullest characters

Hatched area was acceptable to subjects

TABLE 24. Results of visual screening test prior to Experiment 4

Test No.*	Description of test (see Appendix 3)	Subject Group 5 who used Screen B1 ** under poor conditions	Subject Group 6 who used Screen B1 under better conditions
1	Type of spectacles worn		
	Far	2	3
	Near	0	4
	Bifocal	0	1
	None	8	3
	Far vision problems ‡		
2	Vertical phoria	- -	1Y -
3	Lateral phoria	- -	- -
4	Acuity both	- -	3Y -
5	Acuity right	1Y -	1Y -
6	Acuity left	- -	2Y -
	TOTAL	1Y -	7Y -
	Near vision problems ‡		
7	Acuity both	- -	1Y -
8	Acuity right	1Y -	2Y -
9	Acuity left	- -	- -
10	Vertical phoria	1Y -	- -
11	Lateral phoria	- -	1Y -
	TOTAL	2Y -	4Y -

* See Appendix 3 for position on recording form of tests noted here.

** Results obtained from Subject Group 5 in Experiment 3.

‡ The numbers with 'Y' as suffix indicate the number of subjects in that group whose vision on that test is below the standard for clerical and administrative jobs as laid down by the Purdue University Standard for the visual screener. The numbers with an 'R' as suffix indicate seriously lowered visual skills for satisfactory job performance according to the same Purdue Standard.

TABLE 25. Results from pre-task questionnaire, subjects' eye condition before Experiment 4

Qu. Nos.	For full details of questions see Appendix 2	Subject Group 5 who used Screen B1 under poor* conditions	Subject Group 6 who used Screen B1 under better conditions
	No. of Subjects	10	10
A3	Average age (years)	26.4	39.9
B1	No. of eye complaints reported	1	3
B2	No. with use of one eye only	0	0
B3	Number of colour blind	0	0
B4	No. with corrected vision:-		
	Spectacles	2	6
	Contact lenses	0	1
C1	No. not wearing corrections regularly	0	1
C2	Average number of years since last visit to optician	3.00	1.50
C3	Time corrections worn:		
	0 - 4.9 yr.	1	1
	5 - 19.9 yr.	1	2
	20 + years.	0	3
	Average time worn (years)	3.25	20.67
C4a	Type of spectacles worn:		
	Single lens	2	5
	Bifocal	0	1
	Both	0	0
C4b	Type of contact lens worn:		
	Hard	0	0
	Soft	0	0
C5	Tinted correction:(% wearers)		
	Spectacles	2 (100%)	1 (16.7%)
	Contact lenses	0	0
C6	Can correction be worn for long periods of time?(% wearers)		
	Yes	0 (0%)	5 (83.3%)
	No	2 (100%)	1 (16.7%)
C7	Symptoms experienced when wearing corrections: (% wearers)		
	Tiredness	1 (50%)	0
	Heaviness	0	0
	Irritation	0	0
	Increased light sensitivity	0	0

* Results obtained from Subject Group 5 in Experiment 3.

TABLE 25. Results from pre-task questionnaire, subjects' eye condition before Experiment 4 (continued)

			Subject Group 5 who used Screen B1 * under poor conditions	Subject Group 6 who used Screen B1 under better conditions
D1	Do you experience any of the following symptoms?			
	Tiredness	Often/Seldom	10	9
		Never	0	1
	Watering	Often/Seldom	4	7
		Never	6	3
	Dryness	Often/Seldom	0	6
		Never	10	4
	Soreness	Often/Seldom	3	4
		Never	7	6
	Itching	Often/Seldom	3	3
		Never	7	7
	Twitching	Often/Seldom	3	5
		Never	7	5
	Heaviness	Often/Seldom	4	3
		Never	6	6
	Eyestrain	Often/Seldom	8	7
		Never	2	3
	Excessive blinking	Often/Seldom	3	1
		Never	7	9
	Blurring of distant objects	Often/Seldom	4	1
		Never	6	9
	Blurring of print	Often/Seldom	4	4
		Never	6	6
	Double vision	Often/Seldom	1	1
		Never	9	8

* Results obtained from Subject Group 5 in Experiment 3.

TABLE 25. Results from pre-task questionnaire, subjects' eye condition before Experiment 4 (continued)

		Subject Group 5 who used Screen B1 under poor* conditions	Subject Group 6 who used Screen B1 under better conditions
D2a	Do you get headaches?		
	Often	0	1
	Seldom	9	7
	Never	1	2
b	If yes, can you attribute them to eyestrain? (% sufferers)		
	Yes	0	0
	No	4 (44.4%)	2 (25%)
	Dont' know or not answered	5 (55.5%)	6 (75%)
D3	Do you get pain when reading?		
	Head	0	0
	Neck	2	0
	Shoulders	1	0
	Back	0	1
	Elsewhere	0	0
D4	Do you experience eyestrain under any of these conditions?		
	Reading	1	3
	Watching T.V.	2	3
	Watching cinema	1	2
	Driving (% of drivers)	40%	0%
	Irritability of eyes		
D5	To lights	5	6
D6	To cigarette smoke	1	6
D7	To dry air	1	2

* Results obtained from Subject Group 5 in Experiment 3.

TABLE 26a. Error Rate for Visual Task in Experiment 4.

	Task Periods			
	Period 1	Period 2	Period 3	Period 4
Average % Error Rates	3.6	2.9	3.1	2.1

TABLE 26b. Analysis of Variance Summary Table for Means in Table 26a.

Source	S of S	df	MS	F	Significance
Subjects	209.6	9	23.28	10.3	$p < 0.001$
Period	11.5	3	3.83	1.7	N.S.
Error	61.0	27	2.26		
Total	282.1	39			

TABLE 27a. Response Time (Correct and Incorrect Responses) for Visual Task in Experiment 4.

	Task Periods			
	Period 1	Period 2	Period 3	Period 4
Average Reaction Times	4.9	4.8	4.7	4.7

TABLE 27b. Analysis of Variance Summary Table for Means in Table 26b.

Source	S of S	df	MS	F	Significance
Subjects	35.1	9	3.9	48.8	$p < 0.001$
Period	0.24	3	0.08	1.0	N.S.
Error	2.26	27	0.08		
Total	37.6				

TABLE 28a. Response Time (Correct Responses) for Visual Task in Experiment 4.

	Task Periods			
	Period 1	Period 2	Period 3	Period 4
Average Correct Response Time	4.9	4.8	4.7	4.7

TABLE 28b. Analysis of Variance Summary Table for Means in Table 28a.

Source	S of S	df	MS	F	Significance
Subjects	34.2	9	3.8	47.5	$p < 0.001$
Periods	0.16	3	0.05	0.63	N.S.
Error	2.24	27	0.08		
Total	36.6	39			

TABLE 29a. Response Time (Incorrect Responses) for Visual Task in Experiment 4.

	Task Periods			
	Period 1	Period 2	Period 3	Period 4
Average Incorrect Response Times	4.9	4.9	4.5	5.1

TABLE 29b. Analysis of Variance Summary Table for Means in Table 29a.

Source	S of S	df	MS	F	Significance
Subjects	52.9	7	7.56	18.44	$p < 0.001$
Periods	4.1	3	1.37	3.34	N.S.
Error	8.6	21	0.41		
Total	65.6	31			

TABLE 30. Results from Post-task questionnaire after Experiment 4

Qu. Nos.	Brief description of question (see Appendix 5)	Screen B1 viewed in poor conditions* (Subject Group 5)	Screen B1 viewed in better conditions (Subject Group 6)
B1	Post-task eye condition:		
	1. Tired	5	6
	2. Heavy	1	2
	3. Sore	0	1
	4. Irritated	1	1
	5. Wet eyed	1	0
	6. Dry eyed	0	0
	7. Inflamed	0	0
	8. Blurred	2	1
B2	Change of colour vision		
	Little	0	0
	Much	0	0
	Not at all	10	10
B3	Frequency of headaches		
	Yes	0	1
	No	10	9
	Onset during task (%)	0	1(100%)
B4	Aches due to task		
	Neck	1	0
	Shoulders	1	0
	Back	0	1
	Elsewhere	0	2
C1	Tiredness in the eyes		
	None	2	4
	Little	8	4
	Much	0	2
C2a	Would you have liked to pause?		
	No	3	3
	Yes	7	6
C2b	If yes, how often?		
	Every 10 mins.	4	2
	Every 20 mins.	1	2
	Every 30 mins.	1	2
	After 1 hour	0	0
	Not answered	1	3
C3	Could you work with the screen for 80 minutes?		
	Yes	8	7
	No	0	3
	Not answered	2	0

* Results obtained from Subject Group 5 in Experiment 3.

TABLE 31. Subjective Judgements of Screens in Experiment 4.

Screen characteristic judged	Screen B1 viewed in poor conditions‡ (Subject Group 5)	Screen B1 viewed in better conditions (Subject Group 6)	Significance*
Flicker	1.60	1.20	N.S.
Character sharpness	1.80	1.50	N.S.
Character wobble	1.30	1.10	N.S.
Background steadiness	1.30	1.20	N.S.
Reflection of lights	3.60	1.10	$p<0.01$
Reflection of self	2.00	1.90	N.S.
Colour	2.20	2.20	N.S.
Acceptability	1.90	2.20	N.S.

* By Kruskal-Wallis one-way analysis of variance applied to the ratings obtained under the two conditions for each of the screen characteristics.

‡ Results obtained from Subject Group 5 in Experiment 3.

TABLE 32

Results of ophthalmic eye screening and Mallett fixation disparity tests before and after Experiment 5

Subject Group and Subject Number	Company (LM/TV*)	Age (Years)	Type of eyesight	Type of spectacles worn during experiment⋕	Type and extent of θ Heterophorias (Dioptres)			Type of Fixation Disparity Before θ	Type of Fixation Disparity After θ
					Lateral	Vertical	Cyclical		
A1	LM	32	'Normal'	None	4 EXO	-	-	-	-
A2	LM	35	"	"	3 ESO	-	-	-	-
A3	LM	34	"	"	2 ESO	2 HYP	-	-	-
A4	LM	32	"	"	1 EXO	-	-	-	-
A5	TV	28	"	"	-	-	-	-	-
A6	LM	42	"	"	-	-	-	-	-
	Average 33.8								
B1	TV	23	Hypermetrope	None	1 EXO	-	-	-	-
B2	LM	56	"	R	10 EXO	-	-	-	-
B3	TV	57	"	R	5 EXO	-	-	EXO	EXO
B4	LM	49	"	R	6 EXO	-	-	EXO	EXO
B5	LM	46	"	None	3 EXO	-	-	-	-
B6	LM	51	"	R	4 EXO	-	-	-	-
B7	TV	42	"	None	6 EXO	-	-	EXO	EXO
B8	TV	54	"	R	-	-	-	-	SUP
B9	LM	57	"	None	5 EXO	-	-	-	EXO
	Average 47.6								
C1	LM	20	Myope	CL	-	2 HYP	-	-	HYP
C2	TV	23	"	D	-	-	-	-	SUP
C3	LM	39	"	D	4 EXO	5 HYP	-	-	HYP
C4	TV	20	"	D	5 EXO	-	-	EXO	EXO
C5	TV	44	"	None	5 EXO	-	-	-	EXO
	Average 29.2								
D1	TV	59	Presbyope	B	3 EXO	-	-	-	EXO
D2	TV	53	"	R	8 EXO	-	-	-	SUP
D3	TV	53	"	B	2 ESO	-	-	-	-
D4	LM	52	"	B	7 EXO	-	-	-	-
D5	LM	52	"	R	2 EXO	-	-	-	-
D6	LM	53	"	B	9 EXO	-	-	-	-
D7	LM	49	"	B	14 EXO	-	-	EXO	EXO
D8	TV	47	"	R	3 EXO	-	-	-	-
	Average 52.3								

Overall average age = 43. ⋕ R = Reading spectacles, D = Distance spectacles, B = Bifocal spectacles, CL = Contact le-
θ EXO = exophoria, ESO = esophoria, HYP = Hyperphoria, SUP = Central. * LM = L.M.Ericsson, TV = Televerket

TABLE 33

Results from pre-task questionnaire, subjects eye condition before Experiment 5

For full details of questions see Appendix 8.	Group A		Group B		Group C		Group D	
Number in Group	6		9		5		8	
B. VISUAL CONDITION	Yes	No	Yes	No	Yes	No	Yes	No
B1 Do you suffer from any eye problems?	2	4	4	5	4	1	6	2
B2 Can you see with both eyes?	6	0	8	1	5	0	8	0
B3 Are you colour blind?	-	6	0	9	0	5	0	8
B4 Do you or should you use spectacles or contact lenses?	-	6	9	0	5	0	8	0
C. FOR SPECTACLE OR CONTACT LENS USERS	Not Applicable							
C1 Do you always use them?	"		5	4	5	0	8	0
C2 When did you last visit an optician? (months)	"		26.1		11.6		24.8	
C3a How long have you worn the spectacles? (months)	"		33.3		18.5		33.0	
C3b How long have you worn contact lenses? (months)	"		-		4.0		-	
C4a What sort do you have?								
Reading	"		9		-		6	
Distance	"		-		5		3	
Bifocal	"		-		-		7	
Trifocal	"		-		-		-	
Other	"		-		-		-	
C4b What sort of contact lenses do you wear?								
Hard	"		-		-		-	
Soft	"		-		1		-	
Other	"		-		-		-	
C5a Are the spectacles tinted?	"		6	3	3	2	6	2
C5b Are the lenses tinted	"		-	-	0	1	-	-

Cont.

TABLE 33 : Results from pre-task questionnaire, subjects eye condition before Experiment 5 (continued).

	Group A	Group B	Group C	Group D
Number in group	6	9	5	8
	Yes No	Yes No	Yes No	Yes No
C6a Can you wear your spectacles for long periods?	Not applicable	7 2	4 1	7 1
C6b Can you wear your lenses for long periods	"	- -	1 0	- -
C7a Do your spectacles make your eyes				
Tired?	"	1 8	1 4	2 6
Dry?	"	0 9	0 5	0 8
Irritated?	"	1 8	1 4	1 7
More sensitive to light	"	0 9	0 5	3 4
C7b Do your lenses make your eyes				
Tired?	"	- -	1 0	- -
Dry?	"	- -	0 0	- -
Irritated?	"	- -	0 0	- -
More sensitive to light	"	- -	0 0	- -
D GENERAL EYE CONDITION	N S O A*	N S O A	N S O A	N S O A
D1 Indicate following symptoms				
a Tiredness	6 5 1 0	0 7 2 0	0 4 1 0	0 5 3 0
b Watering eyes	6 5 1 0	4 4 1 0	3 2 0 0	6 2 0 0
c Dryness	2 3 1 0	6 3 0 0	5 0 0 0	8 0 0 0
d Sore tender eyes	3 3 0 0	5 3 1 0	3 1 1 0	5 0 3 0
e Itching around eyes	4 1 1 0	3 5 1 0	4 1 0 0	7 1 0 0
f Twitching of eyelids	2 4 0 0	5 4 0 0	2 3 0 0	5 3 0 0
g Heaviness	3 3 0 0	6 3 0 0	3 1 1 0	5 2 1 0
h General eyestrain	1 4 1 0	2 6 1 0	1 4 0 0	5 1 2 0
i Excessive blinking	4 2 0 0	6 2 1 0	4 1 0 0	7 1 0 0
j Distant objects blurred	4 2 0 0	5 2 1 1	3 1 1 0	5 3 0 0
k Written text blurred	3 2 1 0	5 4 0 0	2 3 0 0	3 4 1 0
l Double vision	4 2 0 0	8 1 0 0	5 0 0 0	7 1 0 0
D2 Do you get headaches?	N S O	N S O	N S O	N S O
	0 6 0	3 5 1	0 4 1	2 2 4
D2a Is it possible that these symptoms are connected with eyestrain?	Y N D≠	Y N D	Y N D	Y N D
	1 2 3	- 2 4	2 3 0	0 0 6
D3 If you have headaches where do they usually occur?				
Neck	1	0	0	1
Back of head	0	2	0	0
Top of head	2	4	3	4
Forehead	1	1	1	1
Behind eyes	2	0	2	2
All over	0	0	0	0

* N = never, S = seldom, O = Often, A = Always

≠ Y = yes, N = no, D = Don't know.

Cont.

TABLE 33 : Results from pre-task questionnaire subjects eye condition before Experiment 5 (continued).

	Group A	Group B	Group C	Group D
Number in group	6	9	5	8
D4 When you read do you often suffer from pain in the:				
Head?	1	0	0	1
Neck?	2	0	0	3
Shoulders?	0	2	0	2
Back?	0	0	0	1
Elsewhere	0	0	0	0
	A S N D*	A S N D*	A S N D	A S N D*
D5 Do you suffer from eye strain when you				
Read?	0 2 4 0	0 5 3 1	0 1 4 0	0 5 3 0
Look at TV?	2 0 4 0	0 1 7 1	0 3 2 0	0 7 1 0
Go to films?	2 1 3 0	0 2 6 1	0 1 4 0	0 3 5 0
Drive a car?	0 0 2 4	0 0 5 4	0 2 0 3	0 2 2 4
	Yes No	Yes No	Yes No	Yes No
D6 Do you suffer undue eyestrain under other conditions?	2 4	0 9	0 5	1 7
D7 Do you suffer discomfort from strong light?	5 1	5 4	3 2	4 4
	A S N*	A S N*	A S N*	A S N*
D8 Do you suffer discomfort from:				
Flicker?				
Lights?	0 5 1	3 2 4	1 4 0	2 5 1
Television?	0 3 3	1 4 4	0 5 0	2 4 2
	V M L N≠	V M L N≠	V M L N≠	V M L N≠
D9 Do your eyes become irritated by cigarette smoke in a room?	0 2 4 0	0 1 8 0	0 2 1 2	0 1 6 1
D10 Do your eyes feel especially dry in a room with dry air or when it is dry outside?	0 2 1 3	0 0 5 4	0 0 0 5	0 0 1 7

* A = always, S = seldom, N = never, D = Don't drive

≠ V = very much, M = moderately, L = a little, N = never

TABLE 34

Average call handling time for all subjects during each twenty minute call handling period

	Experimental periods					
	P1	P2	P3	P4	P5	P6
Average call handling time for all subjects (sec)	319	320	252	243	210	208
Standard deviation	184.9	186.5	134.4	115.0	100.8	118.1
Dispersion+	$\bar{X} \pm 71.6$	$\bar{X} \pm 72.2$	$\bar{X} \pm 51.0$	$\bar{X} \pm 44.5$	$\bar{X} \pm 39$	$\bar{X} \pm 45.7$

$\pm$ Standard Error x t
where Standard error = $S.D./\sqrt{N}$
and t = 2.048 (for df = 28 and Confidence limit = 95%)

TABLE 35

Average call handling error rate for all subjects during each twenty minute call handling period

	Experimental periods					
Average call handling error rate for all subjects (E/N)	10.4	9.2	5.0	5.7	6.0	5.7
Standard deviation	13.35	23.77	4.42	4.03	6.07	5.24
Dispersion	$\bar{X} \pm 5.17$	$\bar{X} \pm 2.92$	$\bar{X} \pm 1.71$	$\bar{X} \pm 1.56$	$\bar{X} \pm 2.35$	$\bar{X} \pm 2.03$

TABLE 36

Call handling performance by call type

Calls handled during Periods 1-3

Call type	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1
Time	319	378	368	146	259	284	115	296	309	328
Error rate	8.4	8.7	13.3	6.3	6.4	5.3	3.9	4.8	6.4	11.0

Calls handled during Periods 4-6

Call type	1.2	2.2	3.2	4.2	5.2	6.2	7.2	8.2	9.2	10.2
Time	234	306	279	60	209	261	72	206	253	260
Error rate	6.7	6.3	10.0	1.0	4.4	7.4	6.5	4.3	7.3	5.8

TABLE 37

Summary Table for Analysis of Variance of call handling times during Session 1 (Periods 1-3)

Source	Sum of Squares	df	Mean Square	F-Ratio	Significance
Call types	2271844	9	252427	18.0	$p < 0.001$
Subjects	4135966	27	153184	11.0	$p < 0.001$
Error	3398914	243	13987		
Total	9806724	279			

TABLE 38

Summary Table for Analysis of Variance of call handling times during Session 2 (Periods 4-6)

Source	Sum of Squares	df	Mean Square	F-Ratio	Significance
Call types	1763855	9	195984	21.5	$p < 0.001$
Subjects	2430757	27	90028	9.9	$p < 0.001$
Error	2220064	243	9136		
Total	6414676	279			

TABLE 39

Summary Table for Analysis of Variance of call handling error rates during Session 1 (Periods 1-3)

Source	Sum of Squares	df	Mean Square	F-Ratio	Significance
Call types	2065	9	229	1.8	N.S.
Subjects	12047	27	446	3.5	$p < 0.001$
Error	30841	243	127		
Total	44953	279			

TABLE 40

Summary Table of Analysis of Variance of call handling error rates during Session 2 (Periods 4-6)

Source	Sum of Squares	df	Mean Square	F-ratio	Significance
Call types	1825	9	203	2.9	$p < 0.01$
Subjects	5027	27	186	2.7	$p < 0.001$
Error	16887	243	69		
Total	23739	279			

TABLE 41

Average call handling performance of subject groups across all call types

	Group A	Group B	Group C	Group D	Significance*
Average call handling time	220	321	136	254	$p < 0.001$
Average error rate per call	5.0	9.2	3.6	6.7	$p < 0.05$

* By single factor one way analysis of variance on times and on errors

TABLE 42

Summary Table: Analysis of variance of Subject group average call handling times over all call types

Source	Sum of Squares	df	Mean Square	F-ratio	Significance
Groups	2304709	3	768236	14.6	$p < 0.001$
Error	14530232	276	52646	-	
Total	16834942	279			

TABLE 43

Summary Table: Analysis of Variance of subject group average error rate per call over all call types

Source	Sum of Squares	df	Mean Square	F-ratio	Significance
Groups	2425	3	808	3.33	$p < 0.05$
Error	66848	276	242		
Total	69274	279			

TABLE 44

Numbers of subjects reported increases, decreases, or no change in ratings of eye fatigue symptoms during Experiment 5 (Questionnaire 4 question B1-6

Total number reporting only increases in fatigue in one or more symptom	14
Total number reporting increases in fatigue in some symptoms and decreases in others	8
Total number reporting no change in symptoms	5
Total number reporting only decreases in fatigue in one or more symptom	1
Total number of subjects	28

TABLE 45

Frequency with which subjects reported changes in individual fatigue symptoms in Experiment 5.

Question Number	Symptom	Number of subjects reporting changes in fatigue ratings		
		Increase	No Change	Decrease
B1	Tiredness	13	15	0
B2	Heaviness	9	18	1
B3	Soreness	4	24	0
B4	Watery/dry*	5	20	3
B5	Blurred vision	9	16	3
B6	irritated eye-lids	4	21	3

* Movements from the centre towards either end of the scale very watery - very dry were counted as increases in fatigue symptoms. Movements towards the centre were counted as decreases.

TABLE 46

Proportion of subjects in each subject group reporting increases, decreases or no changes in fatigue symptoms in Experiment 5.

Subject Group	Percentage reporting only increases (number)	Percentage reporting increases and decreases (number)	Percentage reporting no changes (number)	Percentage reporting only decreases (number)
A	50% (3)	-	50% (3)	-
B	44% (4)	44% (4)	11% (1)	-
C	60% (3)	40% (2)	-	-
D	50% (4)	25% (2)	12.5% (1)	12.5% (1)

TABLE 47

Proportion of each subject group reporting increases in each eye fatigue symptoms in Experiment 5.

Fatigue symptoms	Net proportion of subjects reporting an increase of symptoms*			
	Group A	Group B	Group C	Group D
Tiredness	0.166	0.55	0.8	0.375
Heaviness	0.33	0.33	0.6	0.125
Soreness	0.166	0.11	0.2	0.125
Dryness	0	0.22	0.2	0.25
Blurring	0.33	0.33	0.6	0.125
Irritation	0.33	0.22	0	0

* This ignores the size of the shifts reported

TABLE 48

Comparison between sume subjects' reports of eye fatigue during Experiment 5 and during a 'normal' day at a manual switchboard

	During Experiment 5	During a normal working day
Total number reporting only increases in fatigue in one or more symptoms	7	5
Total number reporting increases in fatigue in some symptoms and decreases in others	2	4
Total number reporting no change in any symptoms	4	4
Total number reporting only decreases in fatigue in one or more symptoms	0	0
Total number of subjects providing both experimental and control results	13	

TABLE 49

Comparison between subjects in fatigue response categories during Experiment 5 and during a normal working day.

		Responses during Experiment 5			
	Response* categories	I	I/D	-	TOTAL
Responses during a normal working day	I	3 **	1	1	5
	I/D	2	0 **	2	4
	-	2	1	1 **	4
	TOTAL	7	2	4	

* I = Number of subjects reporting only increases in fatigue in one or more symptoms

I/D = Number reporting increases in fatigue in some symptoms and decreases in others

\- = Number reporting no change in any symptoms

** = The numbers on the cells along the dotted diagonal line indicate the number of subjects who showed some degree of fatigue under the experiment and on a normal day

TABLE 50

Comparison between some subjects' reports of increases in specific eye fatigue symptoms during Experiment 5 and during a 'normal' day at a manual switchboard

Questions from Questionnaire 4 (see Appendix 10).		Number of subjects, from a total of 13, reporting an increase in each eye fatigue symptom (percentage of total number of 13 subjects who acted as their own control)	
Question Number	Symptom	During Experiment 5	During a normal working day
B1	Tiredness	5 (38%)	8 (62%)
B2	Heaviness	1 (8%)	4 (31%)
B3	Soreness	1 (8%)	2 (15%)
B4	Watery/Dry*	1 (8%)	1 (8%)
B5	Blurred vision	6 (46%)	5 (38%)
B6	Irritated Eyelids	8 (62%)	11 (85%)

* Movements from the centre towards either end of the scale "very watery - very dry" were counted as increases in this fatigue symptom. Movements towards the centre of the scale were counted as decreases in the symptom.

TABLE 5.1. Division of subjects into four groups according to average call handling times and reported increase in visual fatigue during Experiment 5.

	Average call handling times	
	Short (<150s/call)	Long (>150s/call)
High visual fatigue (only increases in visual fatigue symptoms reported)	11	13
Low visual fatigue (no changes or some decreases in visual fatigue symptoms)	5	9

APPENDICES

APPENDIX 1 - ABBREVIATIONS FOR SCREEN TICKET

Present field Label	Meaning*	Suggested Label
TYC	Type of Call	TYPE
CAT	Category of Call	CATEG
REM	Remarks	REMARK
ORD I	Order from System	ACTION
PA	Price Advice	PRICE
TIM	Time Duration	DURATN
CNR	Call Reference Number	REF.NO
RET	Recall Time	RECALL
ORD II	Order to System	ORDER
A-NR	"A" subscriber Number	A-NO.
B-NR	"B" subscriber Number	B-NO.
PER	Persons name	PERSON
MIS	Miscellaneous	MISC.
A	"A" subscriber status	A-STAT
B	"B" subscriber status	B-STAT
TOR	Time of Order	BOOKED
TOS	Time of Start	BEGIN
SBO	Signature of Booking Operator	SIGN 1
SCO	Signature of Completing Operator	SIGN 2
INF	Information	INFO

---

* The letters used to construct the original abbreviations have been underlined.

APPENDIX 2. QUESTIONNAIRE 1 PRE-TASK QUESTIONNAIRE FOR PHASE II

INTRODUCTION

We are investigating the effectiveness of different designs of datascreens which might be used in L.M.E.'s products. We have invited you to participate in some experiments with these devices. The purpose of this questionnaire is to determine the sharpness of your vision and to get to know if you have any (other) visual problems.

The information requested in this questionnaire will be treated in a highly confidential manner by the researchers and will not be passed on to anyone else, either within or outside L. M. Ericsson, without your express agreement. The experimental data will be published in a composite form so that particular individuals cannot be identified.

If you do not completely understand a question, or if for some reason you cannot answer a question in a suitable manner, ask for help. If for some reason you do not wish to answer a question, strike that question through with a line and you will not be asked that question again.

Finally I would like to take the opportunity of thanking you for your help.

Tim Moore.

APPENDIX 2. QUESTIONNAIRE 1. PRE-TASK QUESTIONNAIRE FOR PHASE II (continued)

A. GENERAL INFORMATION

A1. Name: . . . . . .

A2.

A3. Age: . . . . . .

A4. What do you do in L.M.E.? . . . . . .

. . . . . .

B. VISUAL CONDITION

B1. Do you suffer from any problems with your eyes?

Yes ☐ If yes, briefly describe the problems: . . . . . .

. . . . . .

. . . . . .

No ☐

B2. Can you see with both eyes?

No ☐ If no, which eye can you use? Left ☐

Right ☐

Yes ☐

B3. Are you colour blind?

Yes ☐ If yes, is your colour blindness: Light? ☐

Moderate? ☐

Severe? ☐

No ☐

B4. Do you use, or should you use, spectacles or contact lenses?

Yes ☐ If yes, continue on the next sheet

No ☐ If no, go directly to Section D and skip over Section C of the questionnaire.

C. FOR SPECTACLE OR CONTACT LENS USERS

C1. Do you always use spectacles and/or contact lenses when you should?

No If no, give the reason(s): . . . . . .

. . . . . .

Yes

C2. When was the last time you visited an optician? (Ignore the visit to the Company optician in connection with this research).

. . . . . .

Instruction: If you wear spectacles fill in the left-hand section below.
If you wear contact lenses fill in the right hand section.
If you wear both spectacles and contact lenses fill in both sections.

FOR SPECTACLE WEARERS

C3a. How long have you worn spectacles?

. . . . . .

C4a. What sort of spectacles have you?

Ordinary
Bifocal
Trifocal
Other

If your answer falls in the last category, what sort of spectacles do you have?

. . . . . .

C5a Are the spectacles tinted?

Yes
No

C6a. Can you wear your spectacles for long periods at a time?

Yes
No

C7a. Do your spectacles make your eyes:

Tired
Dry
Irritated
More sensitive to light

FOR CONTACT LENS WEARERS

C3b. How long have your worn contact lenses? . . . . . .

C4b. What sort of contact lenses have you?

Hard lenses
Soft lenses
Other

If your answer falls in the last category, what sort of lenses do you have?

. . . . . .

C5b. Are the contact lenses tinted?

Yes
No

C6b. Can you wear your contact lenses for long periods at a time?

Yes
No

C7b. Do your contact lenses make your eyes:

Tired
Dry
Irritated
More sensitive to light

TO BE FILLED IN BY EVERYBODY

D. GENERAL CONDITION OF THE EYES

D1. Put a cross to indicate how often you experience the following symptoms:

	Never	Seldom	Often
Tiredness in the eyes (eye fatigue)	☐	☐	☐
Watering eyes	☐	☐	☐
Dryness in the eyes (dry eyes)	☐	☐	☐
Sore (tender) eyes	☐	☐	☐
Itching round the eyes	☐	☐	☐
Twitching of the eyelids	☐	☐	☐
Heaviness in the eyes	☐	☐	☐
General feeling of eyestrain	☐	☐	☐
Excessive blinking	☐	☐	☐
Objects a long way away become blurred	☐	☐	☐
Written text becomes blurred	☐	☐	☐
Double vision	☐	☐	☐

D2. Do you get headaches?

Often ☐
Seldom ☐
Never ☐

Is it possible that these symptoms are tied up with eye-strain?

Yes ☐
No ☐
Don't know ☐

D3. When you read, do you suffer from pain in the:

Head? ☐
Neck? ☐
Shoulders? ☐
Back? ☐
Some other place? ☐

If your answer falls in the last category, indicate when the pain occurs.

. . . . . .

. . . . . .

D4. Do you suffer from some sort of eye-strain when you:

Read?	Yes ☐	No ☐	
Look at television?	Yes ☐	No ☐	
Go to the films?	Yes ☐	No ☐	
Drive a car?	Yes ☐	No ☐	I don't drive a car ☐

D5. Do you suffer discomfort from strong light?

Yes ☐
No ☐

D6. Do your eyes become irritated by cigarette smoke in a room?

Yes ☐
No ☐

D7. Do your eyes feel especially dry in a room with dry air or when it is dry outside?

Yes ☐
No ☐

APPENDIX 3. VISUAL SCREENING TEST RESULTS FORM FOR PHASE II (SWEDISH)

Arbetets art

Avdelning

Datum

Undersökare/bitrade

RESULTAT AV SYNTEST

	Avstånd																
PHORIA	Vertikal	x	1	2	3	4	5	6	7	8	9						
	Lateral	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ACUITY	Bada	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Höger	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Vänster	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Djup	0	1	2	3	4	5	6	7	8	9	10	11	12			
	Färg	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Nära																
ACUITY	Bada	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Höger	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Vänster	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHORIA	Vertikal	x	1	2	3	4	5	6	7	8	9						
	Lateral	x	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

(1)

(2)

(3) ☐ Aldrig ☐ Oregelb ☐ Alltid

Glasögon

☐ Avstånd ☐ Nära

Jæger

(4) ☐ Bifokal ☐ Speciella arb glas ☐ Hardat glas

(5) Synskärpa med glas

H: V:

Synskärpa utan glas

H. V:

(6) Synskärpa + 1

H: V:

Färgsinne

Tidigare glasstyrka

Sign

H. V:

Nuvarande refraktion

Sign

(7)

H: V:

(8) Upplysning

(9)

(10)

(11)

Arbetets art

Avdelning

Datum

Undersökare/biträde

RESULTAT AV SYNTEST

	Avstand																
PHORIA	Vertikal	x	1	2	3	4	5	6	7	8	9						
	Lateral	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ACUITY	Båda	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Höger	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Vänster	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Djup	0	1	2	3	4	5	6	7	8	9	10	11	12			
	Färg	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Nära																
ACUITY	Bada	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Höger	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Vänster	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHORIA	Vertikal	x	1	2	3	4	5	6	7	8	9						
	Lateral	x	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Glasögon

☐ Aldrig ☐ Oregelb ☐ Alltid ☐ Avstånd ☐ Nära

Jæger

☐ Bifokal ☐ Speciella arb glas ☐ Härdat glas

Synskärpa med glas

H: V:

Synskärpa utan glas

H: V:

Synskärpa + 1

H. V:

Färgsinne

Tidigare glasstyrka

Sign

H. V:

Nuvarande refraktion

Sign

H V:

Upplysning

APPENDIX 3. VISUAL SCREENING TEST RESULTS FORM FOR PHASE II (ENGLISH)

Nature of work		Patient	
Department			
Far	RESULT OF EYETEST	Date	Examiner/Assistant
Phoria Vertical	(2)	Spectacles (1)	
Phoria Lateral	(3)	☐ Never ☐ Seldom ☐ Always	☐ Far ☐ Near
Acuity Both	(4)	☐ Bifocal ☐ Specially Worked Glass ☐ Hardened Glass	Jaeger
Acuity Right	(5)		
Acuity Left	(6)		
Depth		Vision with spectacles R: L:	Vision without spectacles R: L:
Colour		Visual Acuity R: L:	Colour sense
Near		Strength of previous glasses R: L:	Signature
Acuity Both	(7)	New prescription R: L:	Signature
Acuity Right	(8)		
Acuity Left	(9)		
Phoria Vertical	(10)	Comments:	
Phoria Lateral	(11)	. . . . .	
		. . . . .	
		. . . . .	
		. . . . .	

No flicker						Unacceptable flicker
Clear characters						Blurred characters
Characters wobble						Steady characters
Steady background						Moving background
Reflections from the lighting can be seen						No reflections from the lighting can be seen
No reflections of you can be seen						Reflections of you can be seen
Dislike the colour of the characters						Like the colour of the characters
The screen is very acceptable						The screen is unacceptable

APPENDIX 4. RATING SCALES FOR SUBJECTIVE ASSESSMENT OF SCREENS DURING PHASE II

APPENDIX 5 QUESTIONNAIRE 2. POST-TASK QUESTIONNAIRE FOR PHASE II

INTRODUCTION

Now you have finished this part of the investigation I would like you to fill in another questionnaire. The objective of the questionnaire is to get to know your impressions of the screen and your experience of it after having used it for a short time.

QUESTIONNAIRE 2. AFTER THE INVESTIGATION

A. General information

A1. Name: . . . . . .

A2.

B. Feelings in your eyes

B1. Do your eyes feel: Tired? ☐
Heavy? ☐
Tender (sore)? ☐
Irritated? ☐
Watery? ☐
Dry? ☐
Inflamed? ☐
Seeing blurred? ☐

Put a cross against as many alternatives as apply.

B2. Has your perception (experience) of colours changed?

Changed a bit ☐
Changed a lot ☐

If change has taken place, describe the change: . . . . . .

No change ☐

B3. Have you a headache now?

Yes ☐ If yes, did you have it before the investigation?
Yes ☐
No ☐

No ☐

B4. Have you any pains which have appeared since the experiment began?

In the neck ☐
In the shoulders ☐
In the back ☐
Anywhere else ☐

In the last case, where?
. . . . . .
. . . . . .

QUESTIONNAIRE 2. POST-TASK QUESTIONNAIRE FOR PHASE II (continued)

C. Feelings in your eyes during the experiment

C1. While you worked on the screen, did you experience any visual fatigue? (put a cross against the reply which applies to you)

No fatigue ☐ Little bit ☐ Much ☐

C2. Did you feel it necessary to take a pause to rest your eyes?

Yes ☐ If yes, how often? Every 10 min. ☐
Every 20 min. ☐
Every 30 min. ☐
After 1 hour ☐

No ☐

C3. Was the screen easy to work with for 50 minutes?

No ☐ If no, Why? . . . . . .
. . . . . .

Yes ☐

C4. Did you notice any of the following things on the screen?

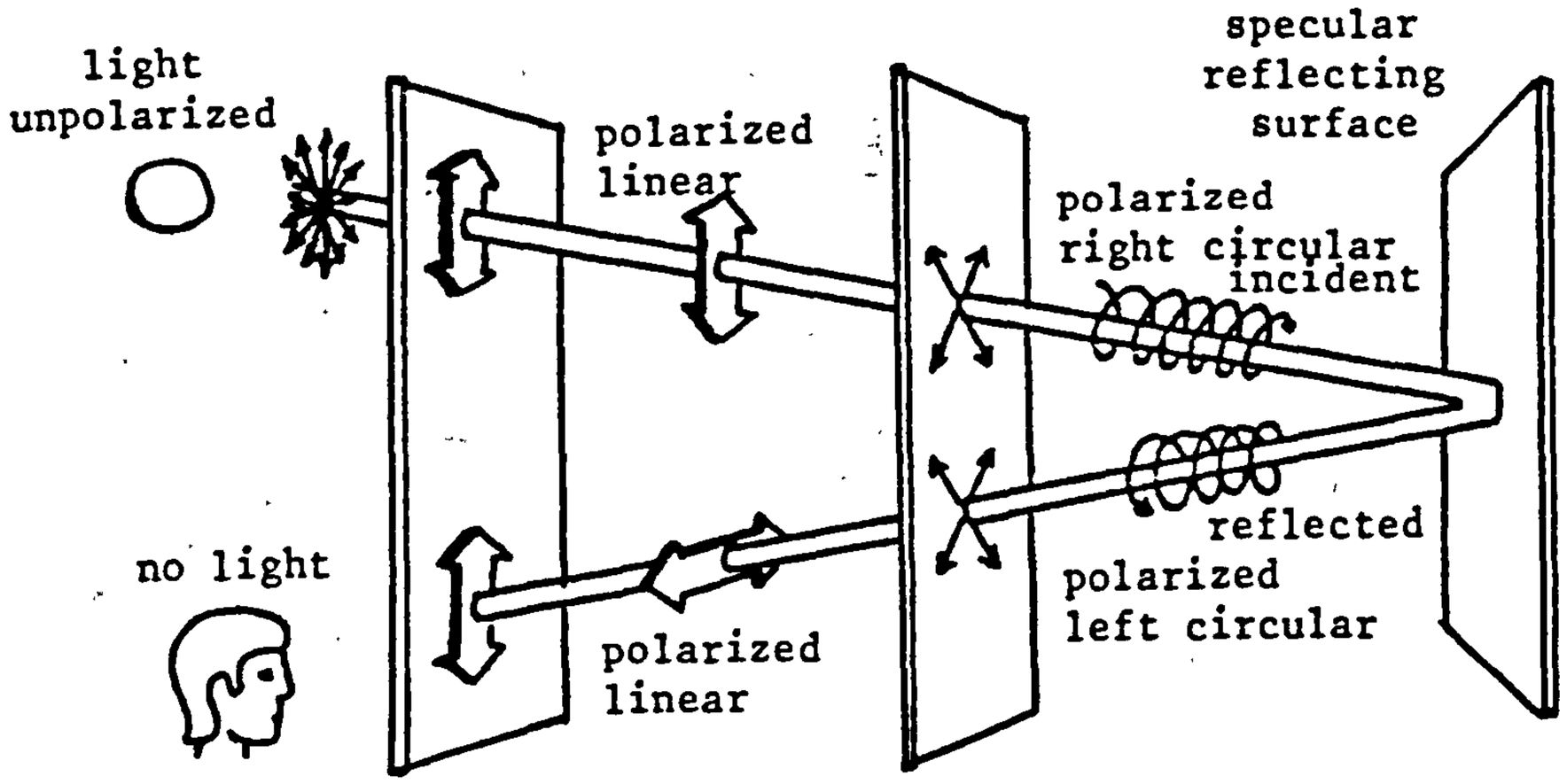
Characters became blurred ☐
Characters jumped ☐
Screen flickered ☐
Background rolled ☐
Reflections from lighting on ceiling ☐
Reflections from you ☐
Something else ☐

In which case, what?
. . . . . .
. . . . . .
. . . . . .

C5. Is there anything about the screen which you think should be changed?

Yes ☐ In this case, what?
. . . . . .
. . . . . .
. . . . . .

No ☐



Linear polarizer + Quarter wave plate = Circular polarizer

WHAT IS A CIRCULAR POLARIZER?
HOW DOES IT WORK?

A circular polarizer (CP) consists of a linearly polarizing filter and a $\frac{1}{4}$ wave retarding element whose slow and fast axes are at 45 to the axis of the polarizing filter. When a ray of unpolarized light passes through the linearly polarizing filter, it becomes linearly polarized at 45 to the respective axis of the retarder. The action of the linearly polarized light ray upon entering and passing through the $\frac{1}{4}$ wave retarder may be described as the passage of two equal but oppositely polarized components one retarded with respect to the other by a $\frac{1}{4}$ of a wave lenth. This combination of wave fronts results in a circularly polarized light ray of either left or right hand rotation—similar to a left or right threaded screw—depending upon the initial orientation of the linear and $\frac{1}{4}$ wave elements.

When a circularly polarized light ray is reflected from a specular surface, the sense of rotation reverses with the reflection of the ray. The change in both direction and sense of rotation of the light ray results, on re-entry through the quarter-wave component, in an additional quarter-wave phase shift. The total change in phase of the light ray entering and exiting the quarter-wave component is therefore, one-half of a wave length which transforms the circularly polarized ray back into a light ray that is linearly polarized in a plane 90 to its original entrance plane. Thus the back reflected light is absorbed by the linearly polarized component of the circular polarizer.

WHY USE CIRCULAR POLARIZERS FOR CONTRAST IMPROVEMENT?

At any given point on a CRT screen (or similar instrument) the luminance perceived by a viewer can be considered to be the sum of two contributions: a perceived luminance, S, due to the action of the CRT (signal), and a perceived luminance, N, that is due to the external illumination (noise). If we consider the ratio of S & N under two different conditions—with no filter (nf) and with a circular polarizer (Cp)—we can define a contrast improvement ratio of

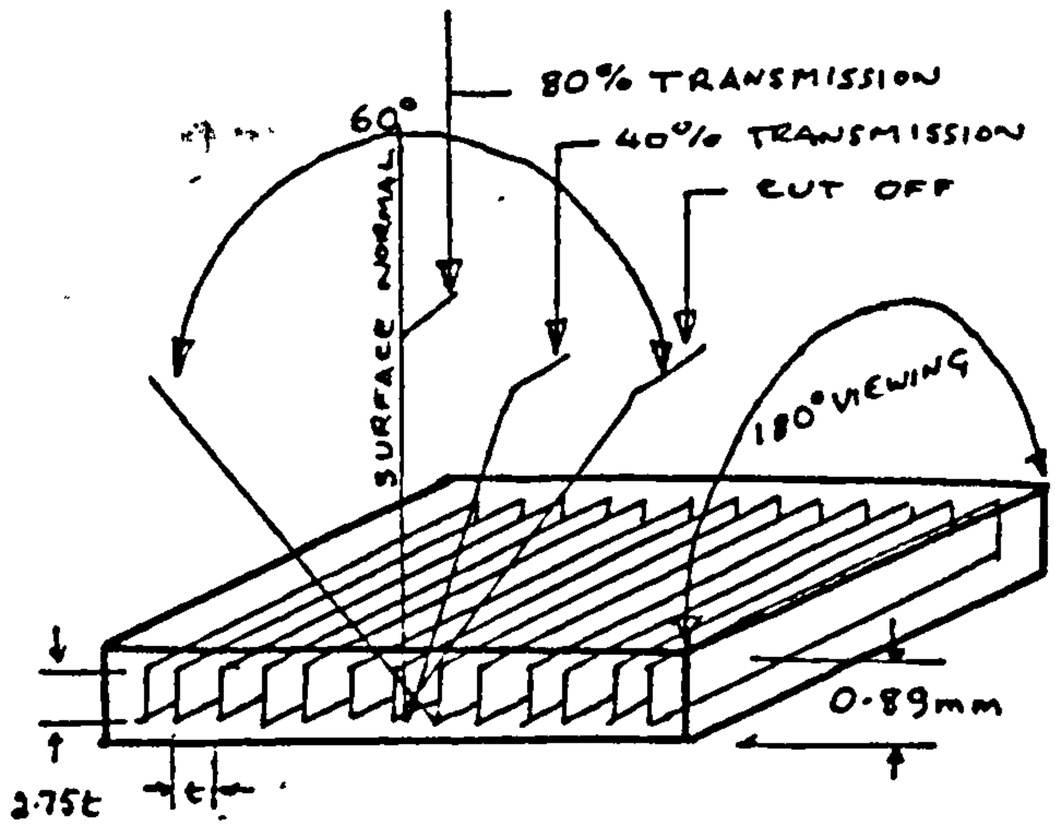
$$CIR = \frac{(S/N)\ Cp}{(S/N)\ nf}$$

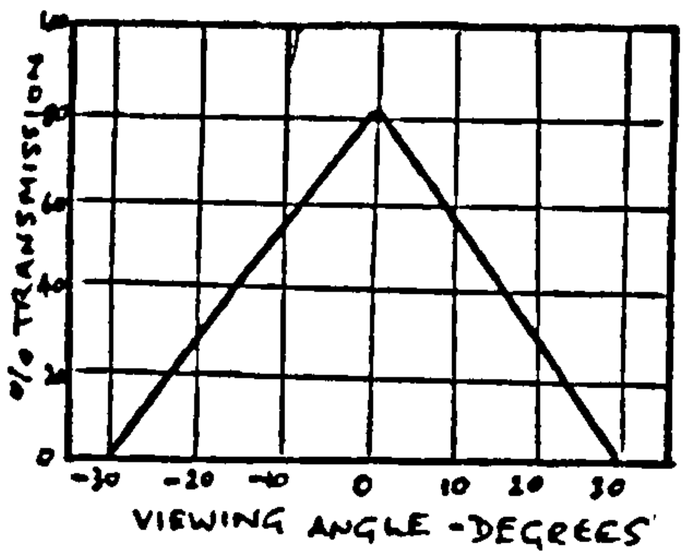
By the use of CIR values, we can now compare the contrast improvement effectiveness of a circular polarizer to that obtained with conventional isotropic coloured or neutral filters.

Filter Transmittance	*CIR value of typical neutral isotropic filter relative to no filter*	*CIR value of typical neutral circular polarizer relative to no filter*	
40%	2.5 to 1	100 to 1	(3 to 1)
30%	3.3 to 1	130 to 1	(4 to 1)
20%	5 to 1	200 to 1	(6 to 1)

The CIR values in parentheses are representative of ratios obtained from non - specular - depolarizing - surfaces. Since the surfaces of most CRT phosphors are not completedepolarizers—retention of polarized light varies from 15% to 35% typically—the parenthetical values represent minimums for nonspecular surfaces. Considering that reflections from CRTs and/or similar devices are generally both specular and non-specular, it is apparent from above CIR values that circular polarizers are overall far more effective in improving contrast than comparable neutral or coloured isotropic filters. Furthermore, the higher efficiency of the circular polarizer makes it possible to operate at a higher filter transmittance thus avoiding an unnecessary reduction of signal intensity.

APPENDIX 6. THE OPERATION OF A CIRCULAR POLARIZING FILTER





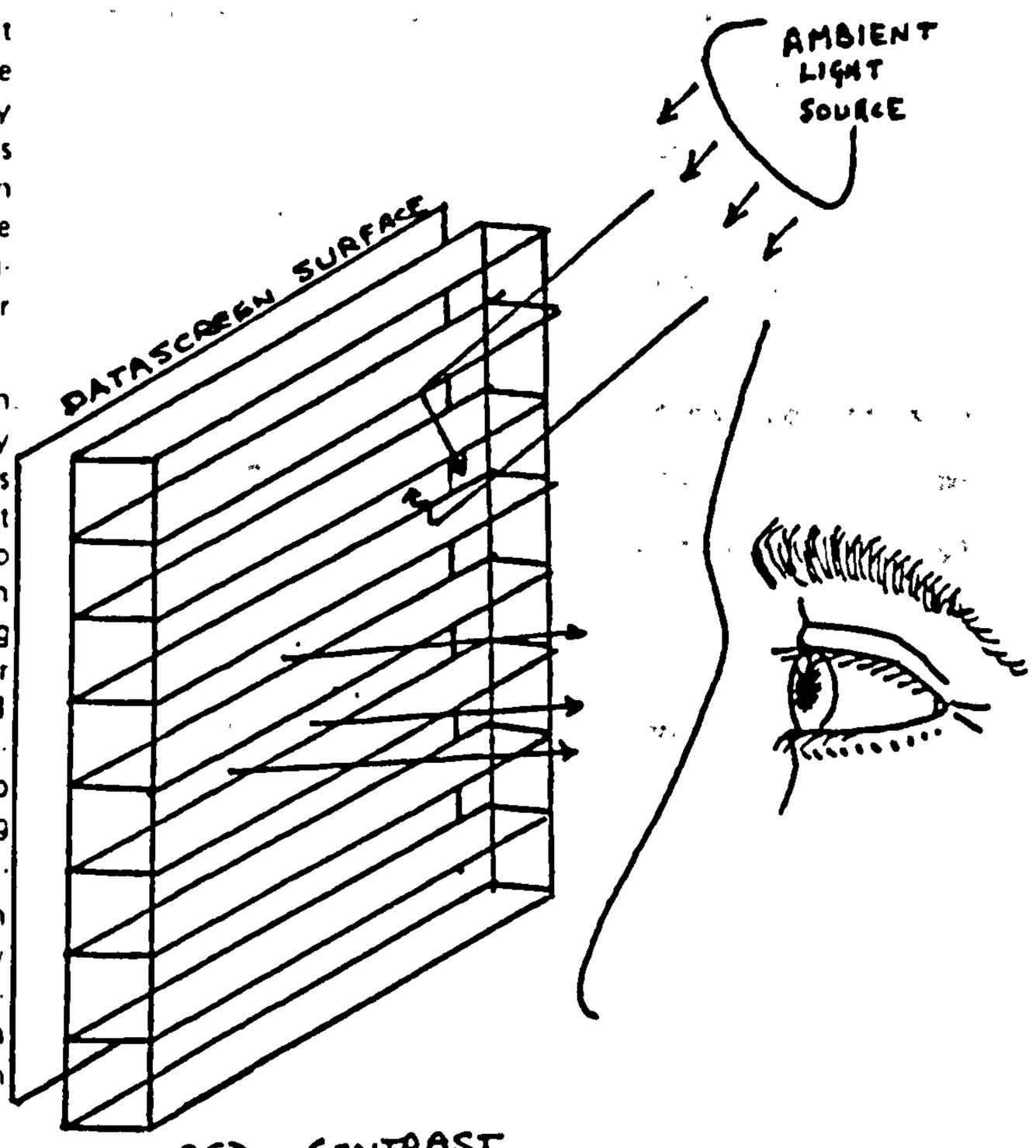
Louvered Filters

Louvered filters are very effective in reducing the amount of bright artificial light or daylight reflected from the face of a display, without a substantial reduction in display emitted light. The construction of a louvered filter is diagrammed in Figure 11. Inside a plastic sheet are thin parallel louvers which may be oriented at a specific angle with respect to the surface normal. The zero degree louvered filter has the louvers perpendicular to the filter surface.

The operation of a louvered filter is similar to a venetian blind as shown in Figure 12. Light from the LED display passes between the parallel louvers to the viewer. Off-axis ambient light is blocked by the louvers and therefore is not able to reach the face of the display to be reflected back to the viewer. This results in a very high contrast ratio with minimal loss of display emitted light at the On-axis viewing angle. The trade-off is a restricted viewing angle. For example, the zero degree louvered filter shown in Figure 11 has a horizontal viewing angle of 180°, however, the vertical viewing included angle is 60°. The louver aspect ratio (louver depth/distance between louvers) determines viewing angle. A list of louver option possibilities is given in Table 1.

Some applications require a louver orientation other than zero degrees. For example, an 18 degree louvered filter may be used on the sloping top surface of a point of sale terminal. A second, is the use of a 45 degree louvered filter on overhead instrumentation to block out ambient light from ceiling mounted lighting fixtures.

Louvered filters are effective filters for enhancing the viewing of LED displays installed in equipment operating under daylight ambient conditions. In bright sunlight, the most effective filter is the crosshatch louvered filter. This is essentially two zero degree neutral density louvered filters oriented at 90 degrees to each other. Red, yellow and green digits may be mounted side by side in the same display. Using only the crosshatch filter, all digits will be clearly visible and easily read in bright sunlight as long as the sun light is not parallel to the viewing axis. The trade-off is restricted vertical and horizontal viewing The effective viewing cone is an included angle of 40° degrees (for a filter aspect ratio of 2.75 1).



Neutral density louvered filters are effective by themselves in most bright ambient lighting conditions without the aid of a secondary wavelength filter. However, colored louvered filters may be used for additional wavelength filtering at the expense of display emitted light.

APPENDIX 7. THE OPERATION OF A LOUVRED FILTER.

APPENDIX 8. QUESTIONNAIRE 3. EYE CONDITION QUESTIONNAIRE FOR PHASE III

INTRODUCTION

We have invited you to participate in some experiments. The purpose of this questionnaire is to determine the sharpness of your vision and to get to know if you have any (other) visual problems.

The information requested in this questionnaire will be treated in a highly confidential manner by the researchers and will not be passed on to anyone else, either within or outside L.M.Ericsson, without your express agreement. The experimental data will be published in a composite form so that particular individuals cannot be identified.

If you do not completely understand a question, or if for some reason you cannot answer a question in a suitable manner, ask for help. If for some reason you do not wish to answer a question, strike that question through with a line and you will not be asked that question again.

Finally, I would like to take the opportunity of thanking you for your help.

Tim Moore.

APPENDIX 8. QUESTIONNAIRE 3. EYE CONDITION QUESTIONNAIRE FOR PHASE III (contd.)

The answers from all the subjects in Experiment 5 are shown in italics. For a breakdown of answers by subject groups see Table 2.

A. GENERAL INFORMATION

A1. Name . . . . . .

A2. Birthdate. *Average age of all subjects 42.7 years* * . . . . . .

A3. Where do you work. *16 from LME 12 from Televerket* . . . . . .

A4. What do you work with? *All telephone operators* . . . . . .

. . . . . .

* The italic typewriting throughout this questionnaire indicates some of the answers given.

APPENDIX 8. QUESTIONNAIRE 3. EYE CONDITION QUESTIONNAIRE FOR PHASE III (contd.)

B. VISUAL CONDITION

B1. Do you suffer from any problems with your eyes?

Yes [16] If yes, briefly describe the problems . . . . . .

. . . . . .

No [12]

B2. Can you see with both eyes?

No [1] If no, which eye can you use? Left [ ]

Right [1]

Yes [27]

B3. Are you colour blind?

Yes [ ] If yes, is your colour blindness: Light [ ]

Moderate [ ]

No [28] Severe [ ]

B4. Do you use, or should you use, spectacles or contact lenses?

Yes [22] If yes, continue on the next sheet

No [6] If no, go directly to Section D and skip over Section C of the questionnaire.

C. FOR SPECTACLE OR CONTACT LENS USERS *(22 subjects)*

C1. Do you always use spectacles and/or contact lenses when you should?

No [4] If no, give the reason(s) . . . . . .

. . . . . .

Yes [18]

C2. When was the last time you visited an optician? (Ignore the visit to the Company optician in connection with this research). *22.3 months*

Instruction: If you wear spectacles fill in the left-hand section below.

If you wear contact lenses fill in the right hand section.

If you wear both spectactles and contact lenses fill in both sections.

FOR SPECTACLE WEARERS

C3a. How long have you worn your present spectacles? . *29.8 months* . . . . .

C4a. What sort of spectacles have you?

Reading spectacles	15
Distance spectacles	8
Bifocal	7
Trifocal	-
Other	-

If your answer falls in the last category, what sort of spectacles do you have? . . . . . .

C5a. Are the spectacles tinted?

Yes	15
No	7

C6a. Can you wear your spectacles for long periods at a time?

Yes	18
No	4

C7a. Do your spectacles make your eyes:

Tired	4
Dry	-
Irritated	3
More sensitive to light	3

FOR CONTACT LENS WEARERS

C3b. How long have you worn your present contact lenses? *4 months (1 subject)* . . . . . .

C4b. What sort of contact lenses have you?

Hard lenses	-
Soft lenses	1
Other	-

If your answer falls in the last category, what sort of lenses do you have? . . . . . .

C5b. Are your contact lenses tinted?

Yes	-
No	1

C6b. Can you wear your contact lenses for long periods at a time?

Yes	1
No	-

C7b. Do your contact lenses make your eyes:

Tired	1
Dry	-
Irritated	-
More sensitive to light	-

APPENDIX 8. QUESTIONNAIRE 3. EYE CONDITION QUESTIONNAIRE FOR PHASE III (contd.)

TO BE FILLED IN BY EVERYBODY

D. GENERAL CONDITION OF THE EYES

D1. Put a cross to indicate how often you experience the following symptoms:

	Never	Seldom	Often	Always
Tiredness in the eyes (eye fatigue)		21	7	
Watering eyes	13	13	2	
Dryness in the eyes (dry eyes)	21	6	1	
Sore (tender) eyes	16	7	5	
Itching round the eyes	18	8	2	
Twitching of the eyelids	14	14		
Heaviness in the eyes	17	9	2	
General feeling of eyestrain	9	15	4	
Excessive blinking	21	6	1	
Objects a long way away become blurred	17	8	2	
Written text becomes blurred	13	13	2	
Double vision	24	4		

D2. Do you get headaches?

Never	5
Often	6
Seldom	17

Is it possible that these symptoms are connected with eye-strain? *of 23*

Yes	3
No	7
Don't know	13

D3. If you have headaches where do they generally occur?

Neck or Back of head *	2
Top of head	2
Forehead	13
Behind eyes	4
All over	6

* *The Swedish word "bakhuvudet" makes no clear distinction.*

D4. When you read, do you often suffer from pain in the:

Head	2
Neck	5
Shoulders	3
Back	
Some other place	

If your answer falls in the last category, indicate where the pain occurs . . . . . .

D5. Do you suffer from some sort of eye-strain when you:

	Always	Sometimes	Never
Read		13	14
Look at television	2	11	14
Go to the films	2	7	18
Drive a car		4	9

I don't drive a car 15

D6. Do you suffer undue eyestrain under any other conditions?

Yes 5 No

If so what conditions . . . . . .

D7. Do you suffer discomfort from strong light?

Yes 17 No

D8. Do you suffer discomfort from flicker

	Always	Sometimes	Never
from lights	6	16	6
from television	3	16	9

D9. Do your eyes become irritated by cigarette smoke in a room?

Very much	Moderately	A little	Never
	6	19	3

D10. Do your eyes feel especially dry in a room with dry air or when it is dry outside?

Very much	Moderately	A little	Never
	2	7	18

D4. When you read, do you often suffer from pain in the:

Head	2
Neck	5
Shoulders	3
Back	
Some other place	

If your answer falls in the last category, indicate where the pain occurs . . . . . .

D5. Do you suffer from some sort of eye-strain when you:

	Always	Sometimes	Never
Read		13	14
Look at television	2	11	14
Go to the films	2	7	18
Drive a car		4	9

I don't drive a car 15

D6. Do you suffer undue eyestrain under any other conditions?

Yes 5 No

If so what conditions . . . . . .

D7. Do you suffer discomfort from strong light?

Yes 17 No

D8. Do you suffer discomfort from flicker

	Always	Sometimes	Never
from lights	6	16	6
from television	3	16	9

D9. Do your eyes become irritated by cigarette smoke in a room?

Very much	Moderately	A little	Never
	6	19	3

D10. Do your eyes feel especially dry in a room with dry air or when it is dry outside?

Very much Moderately A little Never

APPENDIX 9. TRAFFIC HANDLING CASES USED IN EXPERIMENT 5

Call type	Description
1	DEMAND CALL - B-ANSWER DEMAND CALL - NOTIFICATION OF END OF PERIOD
2	DEMAND CALL - NO B-ANSWER, CANCEL DEMAND CALL - NO B-ANSWER, BOOKING OF DELAY CALL
3	DEMAND CALL - B-BUSY, BOOKING OF DELAY CALL DEMAND CALL - B-BUSY, CANCEL
4	DELAY CALL - B-ANSWER DELAY CALL - END OF PERIOD NOTIFICATION
5	DELAY CALL - NO B-ANSWER, CANCEL DELAY CALL - NO B-ANSWER, BOOKING OF NEW TIME
6	DEMAND CALL - PRICE ADVICE AFTER CALL DEMAND CALL - PRICE INFORMATION BEFORE CALL
7	PRICE ADVICE AFTER CALL LIMITED DURATION
8	DEMAND CALL - LIMITED DURATION DEMAND CALL - B-ANSWER
9	DEMAND CALL - SEARCH COLLECT CALL
10	DEMAND CALL - PERSONAL BOOKING OF DELAY CALL

APPENDIX 10. QUESTIONNAIRE 4. VISUAL FATIGUE QUESTIONNAIRE FOR PHASE III

(The italic numbers to the top left of the answer boxes indicate the frequency with which these answers were given before Experiment 5 and those in the bottom right indicate the frequency with which these answers were given at the end of Experiment 5).

APPENDIX 10. QUESTIONNAIRE 4: VISUAL FATIGUE QUESTIONNAIRE FOR PHASE III (cont

A. GENERAL INFORMATION

A1. Name . . . . . .

A2. Time of day . . . . . .

B. CONDITION OF EYES NOW

B1. Not at all tired	21 12	3 4	2 7	0 1	2 4	Very tired
B2. Not at all heavy	24 18	2 6	1 2	0 0	1 2	Very heavy
B3. Not at all sore	28 24	0 3	0 0	0 1	0 0	Very sore
B4. Very watery	14 14	0 2	10 8	4 3	0 1	Very dry
B5. Very clear vision	16 13	8 9	4 4	0 1	0 1	Very blurred vision
B6. Eyelids comfortable	24 22	2 1	0 2	0 1	2 2	Eyelids irritated

*

C. HEADACHES

C1. Have you a headache now? Yes [3 5] No [25 23]

C2. If so, how bad is it?

Very mild	1 3
Mild	2 2
Moderate	
Severe	
Very severe	

C3. Where is it primarily located? ‡

Neck	
Crown of head	1
Forehead	2 2
Behind eyes	1 1
General	1 2

*Top left corner number of subjects giving ranks before experiment
Bottom right corner number of subjects giving ranks before experiment

‡Does not sum to number of headaches (i.e. C1 above) due to double entry by one subject.

D. PAINS

D1. Have you any pains elsewhere?

Neck	2 2
Shoulders	1 2
Back	3 3

Elsewhere [1 1] If so where? . . . . . .

D2. Can you attribute these feelings to any event or to any medical condition?

Yes [4 2] No [1 4]

If so, please describe it . . . . . .

. . . . . .

APPENDIX 11. QUESTIONNAIRE 5

ASSESSMENT OF CALL HANDLING EQUIPMENT AND PROCEDURE QUESTIONNAIRE FOR PHASE III

(Italic numbers is the answer boxes indicate the total frequency with which those answers were given)

APPENDIX 11. QUESTIONNAIRE 5. ASSESSMENT OF CALL HANDLING EQUIPMENT AND PROCEDURE. PHASE III (WITH ANSWER FREQUENCIES ADDED).

The purpose of this questionnaire is to collect your opinions of the adequacy of the equipment and the operating procedures used in call handling. Please ring the number corresponding to your answer. Cancel errors with a large cross.

A. DATA SCREEN

Rate the data screen on the following scales (please ring appropriate numbers).

a.	Screen size	Screen much too large			26	2		Screen much too small
b.	Letter size	Letters much too large		1	25	2		Letters much too small
c.	Legibility of letters	Very legibile	13	1	12	2		Totally illegible
d.	Brightness of letters	Letters much too bright		3	25			Letters much too dim
e.	Contrast level	Too much contrast		4	24			Too little contrast
f.	Flicker	No flicker	16	3	8	1		Unacceptable level of flicker
g.	Steadiness of image	Very steady image	17	4	6	1		Image very unsteady
h.	Reflections of lights	No reflections of lights	16	3	7	2		Unacceptable reflections of lights
i.	Reflections of self	No reflections of self	15	4	6	2	1	Unacceptable reflections of self
j.	Colour	Very good colour	14	6	8			Unacceptable colour

k. Other features of the screen on which you wish to comment

. . . . . .

. . . . . .

B. TICKET FORMAT

The call handling 'ticket' is composed of fields, each identified by a name (eg ORDER) and containing information (contents) entered either by the operator, via the keyboard or by the computer. The cursor is the flashing underline symbol indicating where the information entered on the keyboard will appear.

Please answer the following questions relating to the format.

B1. How easy was it to learn the positions of the fields?

Very easy	Easy	Difficult	Very difficult
4	14	8	2

B2. How easy was it to learn the orders which had to be entered into the computer?

Very easy	Easy	Difficult	Very difficult
0	15	12	1

B3. How easy was it to enter information into the order field?

Very easy	Easy	Difficult	Very difficult
3	15	10	0

B4. How often do you think that you made mistakes when writing orders which you corrected before transmitting them?

Never	Seldom	Often	Very often
	7	13	8

B5. How often do you think that you misread or misinterpreted orders or information on the data screen?

Never	Seldom	Often	Very often
	14	12	2

B6. Was it easy to enter A and B numbers onto the data screen?

Very easy	Easy	Difficult	Very difficult
6	22	[illegible]	

B7. How easy was it to find the cursor on the screen?

Very easy	Easy	Difficult	Very difficult
11	15	2	

B8. Was the cursor distracting?

Never distracting	Seldom distracting	Often distracting	Always distracting
21	6	1	

B9. How easy was it to appreciate the state of the subscribers? (eg Engaged)

Very easy	Easy	Difficult	Very difficult
11	16	1	

B10. How easy was it to appreciate the connection between the operator and the subscribers? (eg Speak to A)

Very easy	Easy	Difficult	Very difficult
5	15	7	1

B11. Are there any further points you wish to make regarding the format of the data scale (if yes, describe them below)

Yes [5] No [23]

. . . . . .

. . . . . .

C. KEYBOARD

C1. Key dimensions

Please rate the keys on the following scales

a.	Key size	much too small	2		24	2		Much too large
b.	Key spacing	much too close	2	4	20	2		much too wide apart
c.	Operating force	Much too little	4	2	21	1		Much too great
d.	Labels	Very legible	13	3	12			Very illegible
e.	Key travel	Much too little	1	5	20	1	1	Much too great

C2. Keyboard slope

Please rate the slope of the keyboard

Much too little slope	2		24	2		Much too much slope

C3. Keyboard layout

How convenient did you find the layout of the separate keyboard sections?

Very convenient	9	2	18			Very inconvenient

How convenient did you find the layout of the following keyboard sections?

	Very convenient				Very inconvenient
a. Exchange controls	8	4	16		
b. Alphabetic keyboard	6	6	15	1	
c. Numeric keyboard	12	2	12		2
d. Editing keys	4	4	19	1	
e. Cursor control keys	10	5	11	4	1

If any scores are 4 or 5 please elaborate your answer.

. . . . . .

D. CONSOLE

D1. Seating

Rate the seats on the following factors:

	very good				very bad
a. Range of seat heights available	22	2	4		
b. Ease of height adjustment	22	4	2		
c. Amount of back support	20	3	5		
d. Adjustment of back support	19	4	4	1	
e. General comfort	20	4	4		

D2. Desk

Rate the desk on the following factors:

a.	Distance of screen from eyes	Much too far away	1		25	2		much too near
b.	Height of screen	Much to high	1	1	25	1		much too low
c.	Height of keyboard	Much to high	2		26			much too low
d.	Knee clearance	Much too much	1	2	24	1		much too littl
e.	Ease of entering and leaving	Very easy	11	3	13	1		very difficult
f.	Ease of adjustment of screen tilt	Very easy	10	1	14	2	1	very difficult
g.	Ease of adjustment of screen height	Very easy	9	2	14	2	1	very difficult
h.	Desk space	Much too much		2	18	4	4	much too little
i.	Room for personal belongings	Totally satisfactory	2	3	8	11	4	total un-satisfactory
j.	General appearance	Very acceptable	7	9	10	2		Very un-acceptable

E. ENVIRONMENT

E1. Lighting

Rate the lighting in the room:

a.	Brightness	much too dark	1		20	5	2	much too bright
b.	Colour	totally acceptable	7	7	11	3		totally unacceptable
c.	Position of lights	totally acceptable	6	4	14	8	1	totally unacceptable
d.	Flicker	no flicker from lights	21	1	5		1	unacceptable flicker from lights
e.	General appearance	totally acceptable	12	3	10	3		totally unacceptable

E2. Acoustics

Rate the acoustics of the room:

a.	Noise level	too noisy	2		25	1		too quiet
b.	Resonance	too 'dead'	3	4	21			too resonant
c.	General acceptability	totally acceptable	10	7	11			totally unacceptable
d.	How distracted were you by the sounds of other operators	not distracted at all	25		2	1		very distracted

E3. Thermal

Rate the thermal environment:

a.		much too warm	4	6	17	1		much too cool
b.		much too dry		4	24			much too humid

F. OPERATING PROCEDURES - Demand Calls

F1. Initial ticket and call acceptance

a. How easy was it to appreciate that the call was a demand call?

very easy | 10 | 7 | 7 | 2 | 2 | very difficult

b. Did you like the use of the announcing machine?

liked it a lot | 5 | 2 | 10 | 6 | 5 | disliked it very much

c. Would you prefer to have to make the announcement yourself?

Yes [12] No [7] would prefer to be able to select mode [9]

d. Did you prefer to have control over accepting the call or would you prefer this to be automatic?

accept control always [9] automatic acceptance always [7] would prefer choice [12]

F2. Entry of call details

a. How easy was it to enter the A and B Numbers into the appropriate fields?

very easy | 10 | 6 | 10 | 2 | | very difficult

b. How easy was it to carry out an A Number check?

very easy | 7 | 6 | 14 | 1 | | very difficult

c. Hose useful do you think is the facility to provide Country and/or area code numbers automatically from the name?

very useful | 16 | 3 | 7 | 2 | | of very little use

F. OPERATING PROCEEDINGS- Demand Calls (continued)

F3. Special Services

How easy was it to use the following special services?

a.	Specify call priority	very easy	*							very difficult
b.	Collect call	very easy	8	6	11	2	1			very difficult
c.	Booking a personal call	very easy	8	6	11	2	1			very difficult
d.	Booking a limited duration call - automatic	very easy	6	6	12	3	1			very difficult
e.	Booking price advice after call	very easy	7	7	10	3	1			very difficult
f.	Booking a notification of end period -	very easy	7	6	11	3	1			very difficult

g. How easy was it to provide price advice in advance of a call?

		very easy	8	8	6	4	2			very difficult

F4. Setting up call

a.	How easy is it to ring towards a B-subscriber	very easy	6	9	12	1				very difficult
b.	How easy is it to appreciate the state of the B-subscriber	very easy	4	7	14	3				very difficult
		very easy	4	7	15	2				very difficult
c.	How easy is it to speak to A-subscriber	very easy	4	5	16	3				very difficult
d.	How easy is it to start timing manually	very easy	11	4	12	1				very difficult

Audio

Visual

* *Call type not used subjects instructed not to complete this scale*

F4. Setting up call (continued)

e.	How easy is it to make a new attempt on an unsuccessful call	very easy					very difficult
f.	How easy is it to cancel a call	very easy	7	5	10	4	2	very difficult
g.	How easy is it to book a delay call	very easy	8	2	15	2	1	very difficult
h.	How easy is it to check speech connection	very easy	8	8	8	2	2	very difficult

F5. Release of call

	How easy is it to free the operators position	very easy	8	3	13	4		very difficult

* *Question ambiguous and consequently misunderstood by some subjects. Answers not reliable and therefore not used.*

G. OPERATING PROCEDURES - DELAY AND RECALL CALLS

a. How easy is it to handle the following types of calls

1.	Delay call	very easy	2	10	13	3	very difficult
2.	Limited duration call operator contacted	very easy	3	11	11	3	very difficult
3.	Recalled for price advice	very easy	7	6	13	2	very difficult
4.	Notification of end period operator contacted	very easy	8	5	13	2	very difficult

b. How easy was it to search for a specified delay ticket

very easy | 5 | 8 | 13 | 2 | very difficult

H. OPERATORS JOB

Rate the job of call handling on the new equipment against your present job.

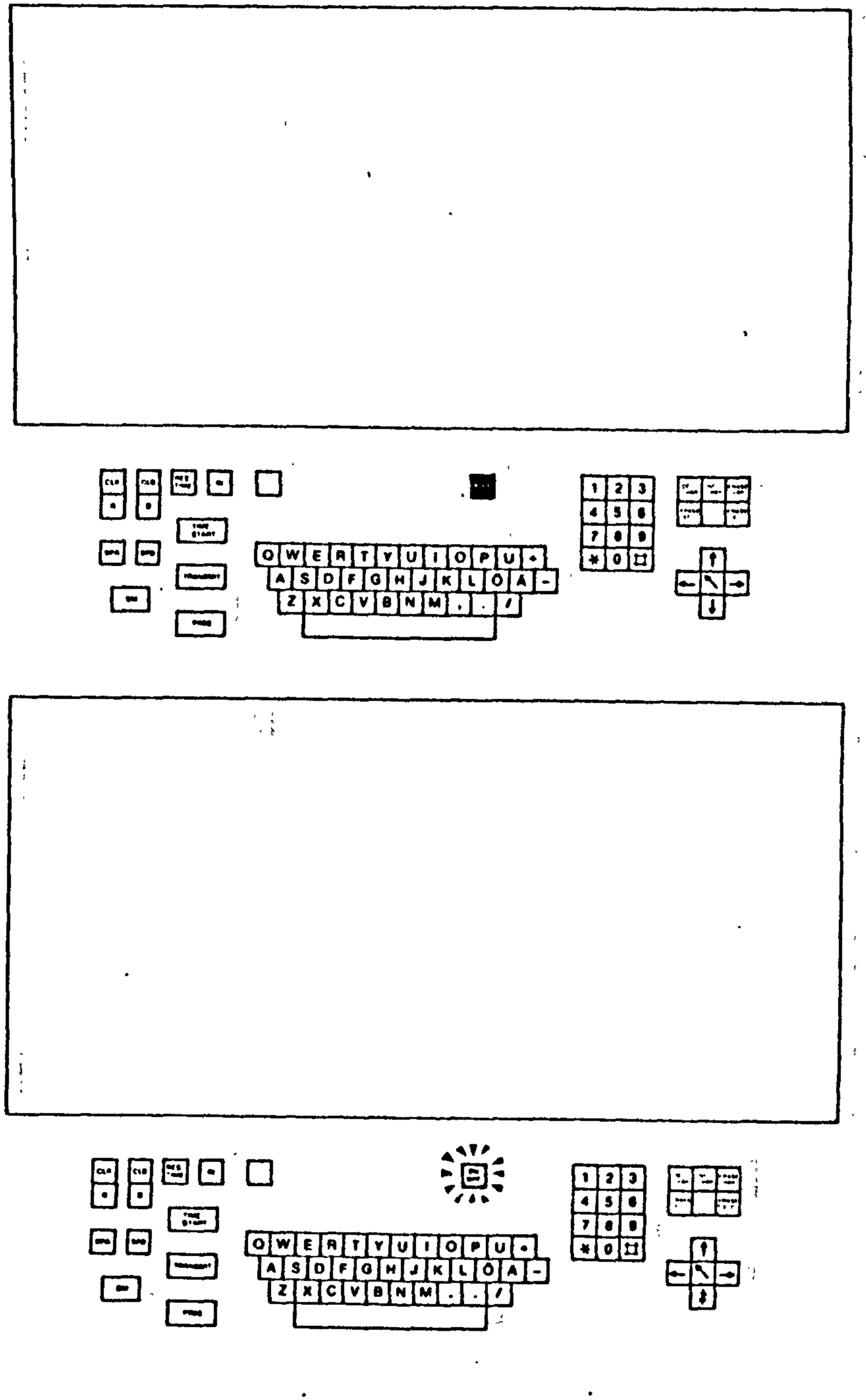
a.	Much more boring		4	11	7	6	Much more interesting
b.	Much more repetitive	2	1	15	6	4	Much less repetitive
c.	Much more mentally demanding	5	3	15	3	2	Much less mentally demanding
d.	Much more generally tiring	3	6	15	3	1	Much less generally tiring
e.	Much more eye fatigue	4	8	14	1	1	Much less visual fatigue
f.	Much more postural fatigue	3	7	16	1	1	Much less postural fatigue
g.	Much more prestigious		3	13	6	6	Much less prestigious
h.	Much less pleasant environment	2	4	14	7	1	Much more pleasant environment

APPENDIX 12. DETAILED CALL HANDLING PROCEDURE FOR SUCCESSFUL DEMAND CALL

3 OCCUPATION

3.1 Power on

ACTION	Switch on the power by pressing ON/OFF
ACKNOWLEDGEMENT	The lamp in the key is lit
	The position cannot be occupied if the text BLOCKED is shown on the display. Switch off the power and try another position.

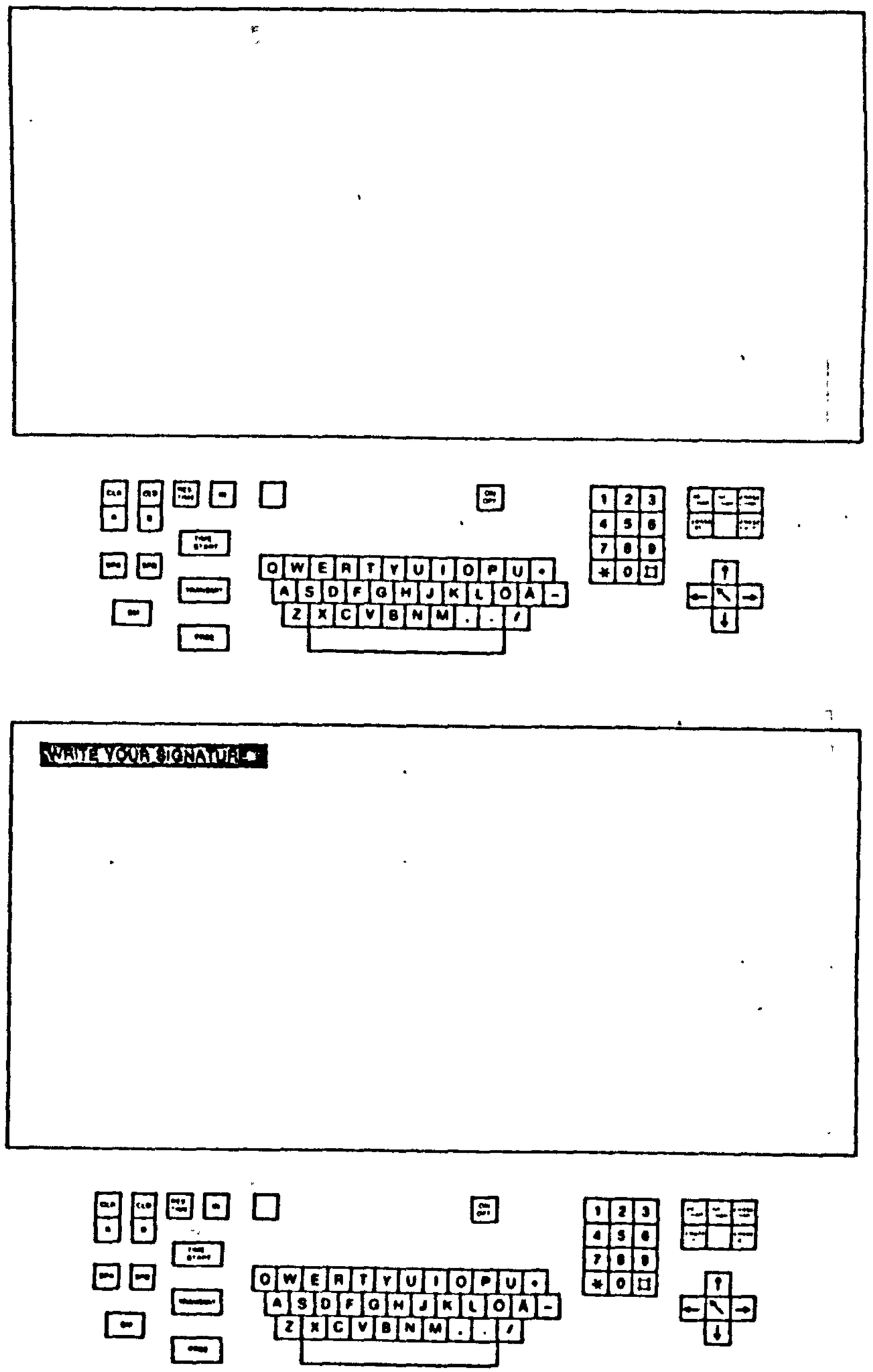


APPENDIX 12. (cont'd) DETAILED CALL HANDLING PROCEDURE FOR SUCCESSFUL DEMAND CALL.

3.2 Connection of headset

ACTION Insert the headset plug

ACKNOWLEDGEMENT WRITE YOUR SIGNATURE



3.3 Writing of signature

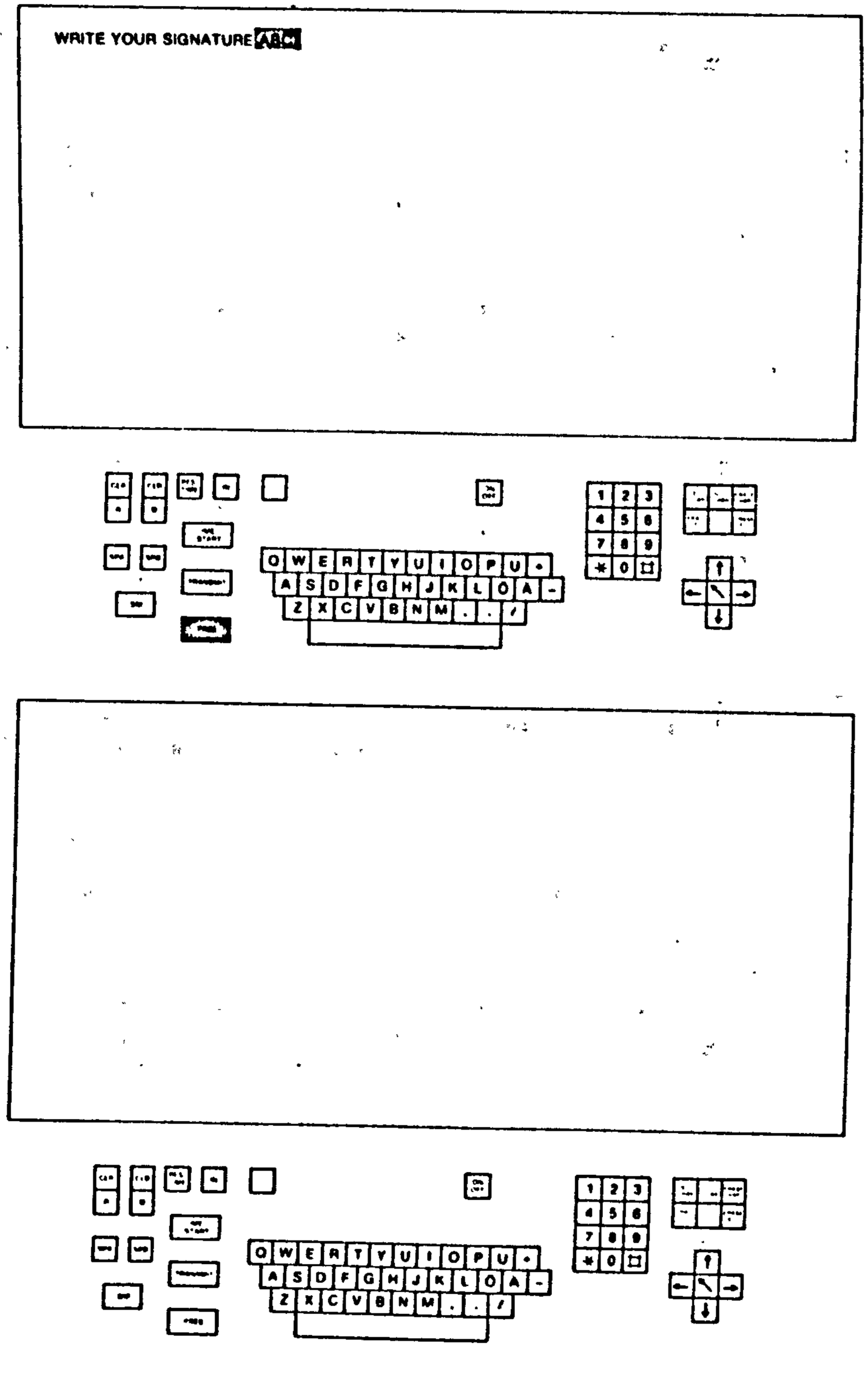
ACTION: Write the signature and press FREE

ACKNOWLEDGEMENT: The display goes out

If the signature is not accepted, the text WRONG SIGNATURE will be shown on the display. Check the signature and try again.

The signature analysis is temporarily out of order if the text TRY AGAIN is shown on the display. Wait a couple of minutes and try again.

The position is now occupied and ready for traffic handling.



4 DEMAND OPERATION

4.1 Incoming call, no direct access

EVENT

A ticket is set up on the display with the following information filled in:

DEMAND	incoming call from a subscriber or operator in another exchange
TYC	call type
ACAT	The A subscriber's category
A ANSWER	the A subscriber in answer position
TOR	time of booking (day hour.min)
SBO	own signature

ACTION

Press [SM] to answer the call. The call must be answered within 30 s.

ACKNOWLEDGEMENT

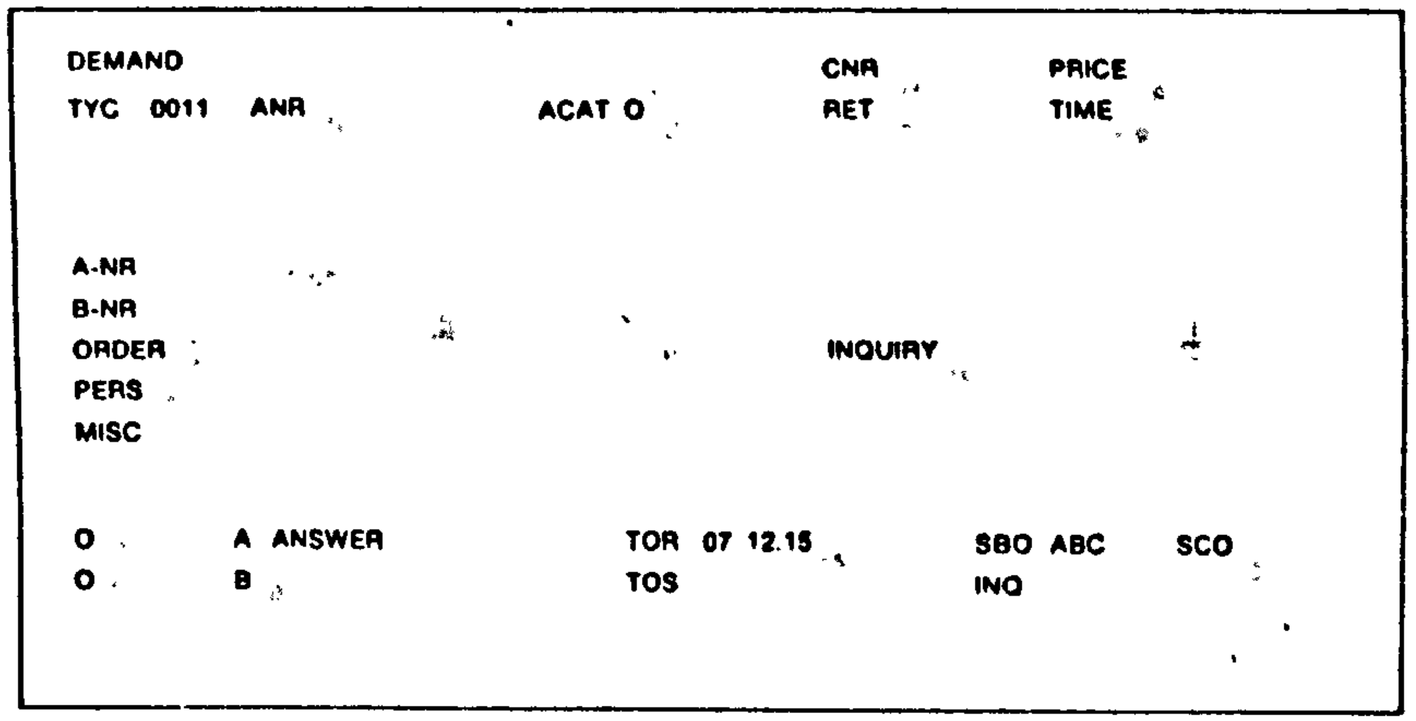
O======>A speech connection
O======>B to the A and B sides

The announcing machine answer is heard. When the announcing machine answer ends, speech connection is established to the A subscriber.

If a tone pulse is heard instead of the announcing machine answer, the answer should be read out by the operator.

4.2 Incoming call, direct access

The procedure is the same as in the case of no direct access, except that the call is not answered by pressing SM. The announcing machine answer thus comes directly when the ticket is set up.



4.3 Reception of bookings

ACTION

Write the A subscriber number in the A-NR field. If there is automatic transmission of the A number, the A number is already specified in the A-NR field on the ticket.

If there is not automatic A number transfer, a check of the A number given by the subscriber can be made according to 15.1 - 15.11 page 87

Write the B number desired in the B-NR field. As regards different ways of writing the B number see 2.20 page 17

If the A subscriber wishes special services, such as call priority, personal call, limited duration, price advice etc., these are noted in the ORDER field according to 8.1 - 8.14 page 56

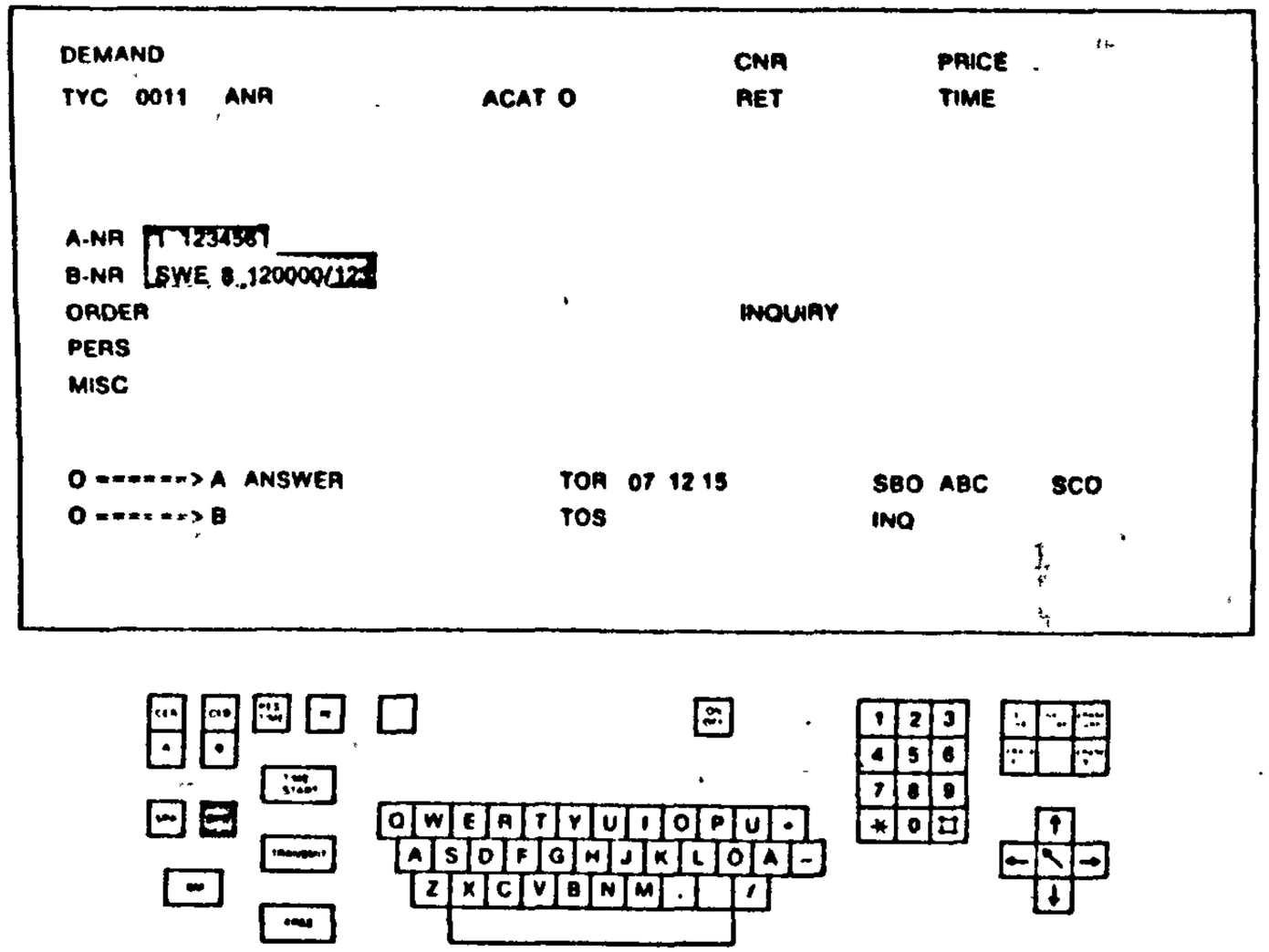
If the A subscriber wants to order delay service, the procedure is according to 6.2 page 47

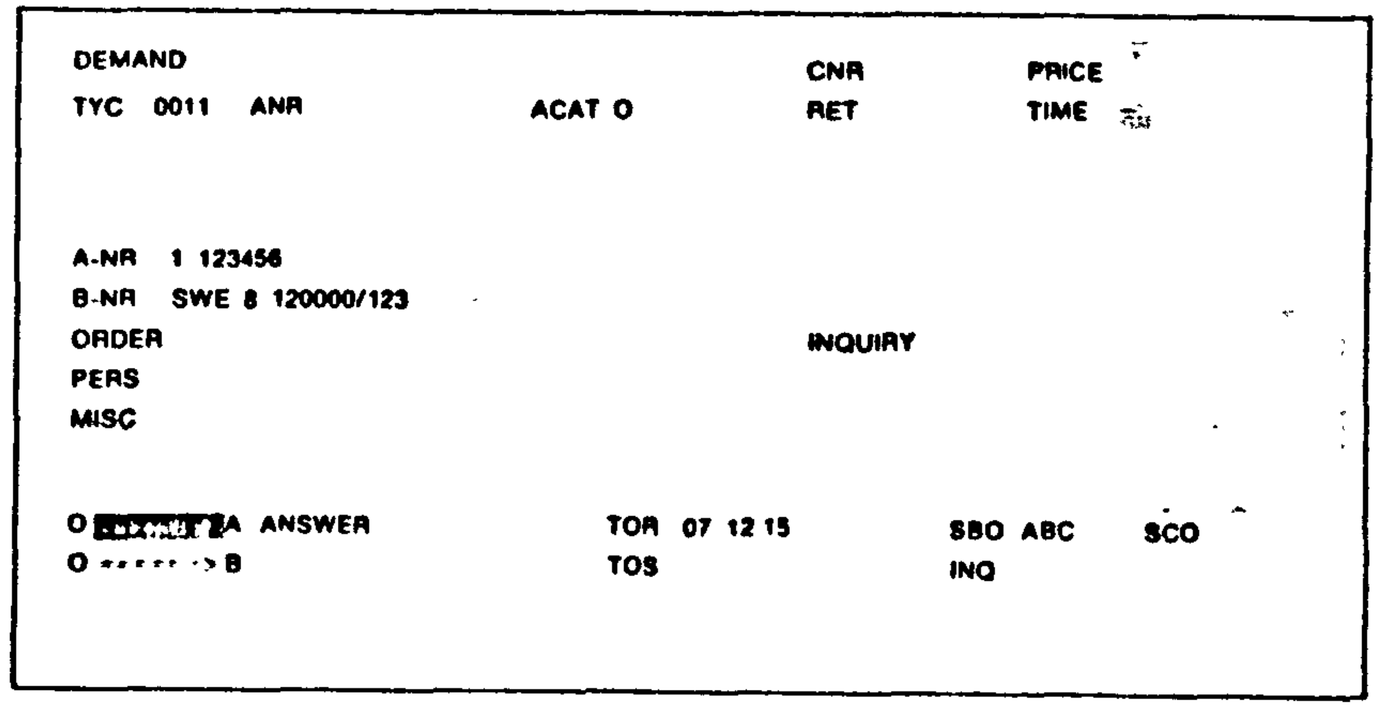
If the call set-up is to be over an open circuit, set the call up to the B subscriber according to 4.4 next page

If the call set-up is not to be over an open circuit

ACTION Press [SPB] to split the connection

ACKNOWLEDGEMENT 0 A the speech connection with the A subscriber is broken





4.4 Calling the B subscriber

ACTION

Press [B] to set up a call to the B subscriber.

ACKNOWLEDGEMENT

The light intensity is dimmed on the information written in. The analysed B number is set up in the B-NR field.

While call set-up is in progress B condition CALLING is shown. When the call is established the condition is changed to RINGING and a ringing tone is heard, if the B subscriber is free.

In the event of congestion the B condition CONGESTION is shown.

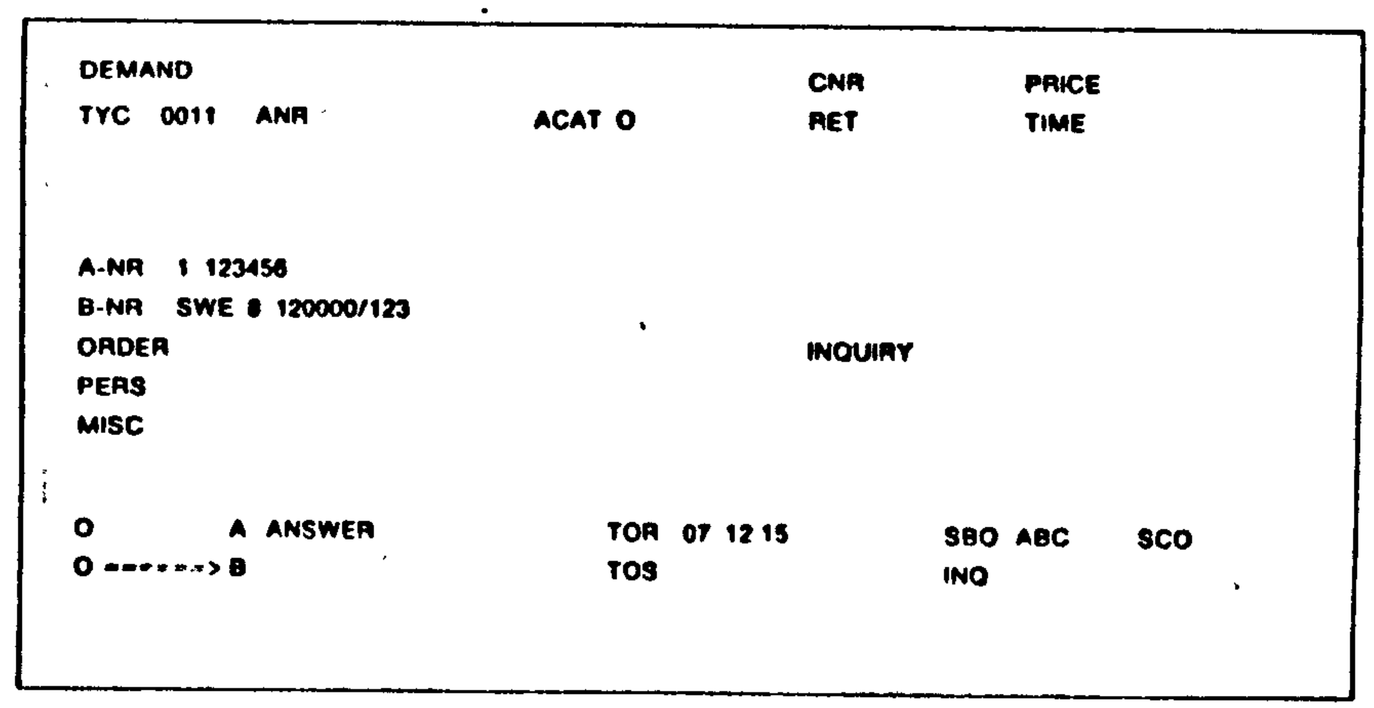
If the B subscriber is busy a busy tone is heard and the B condition BUSY is shown. In certain cases the busy tone is heard at the same time as the B condition RINGING is shown. The B subscriber is busy in this case also and the text BBUSY shall be written in the ORDER field and [TRANSMIT] pressed.

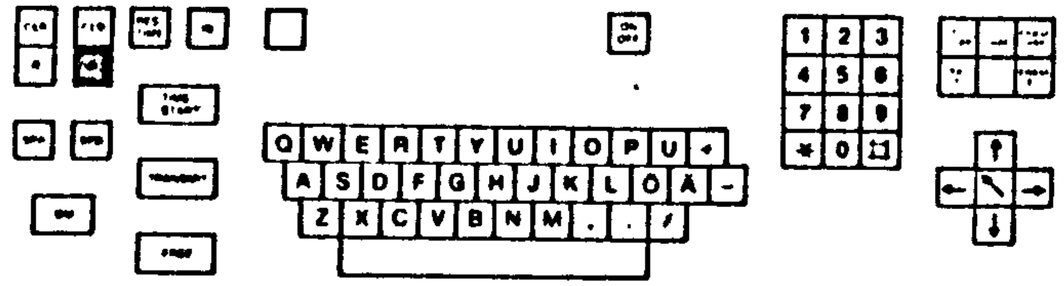
The call is then handled in the case of congestion or busy according to 4.9 page 37

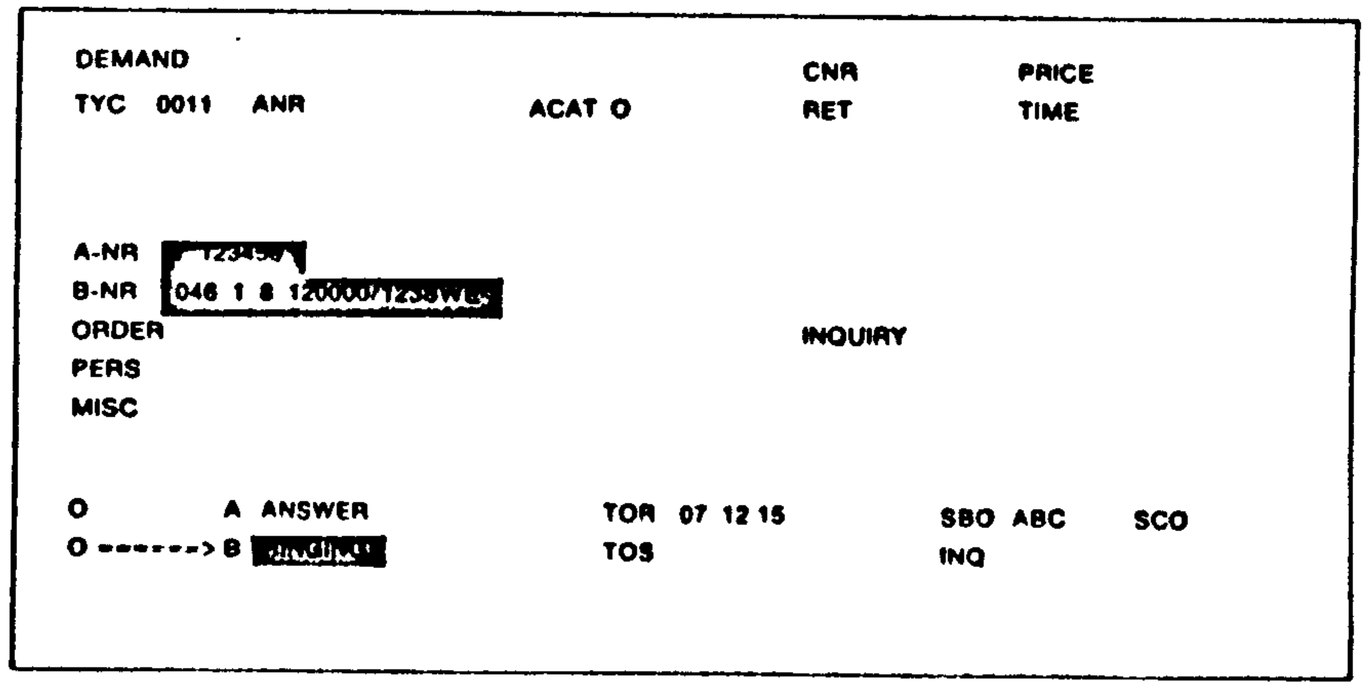
Trunk offering to a busy B subscriber inside the country is performed according to 5.1 - 5.5 page 42

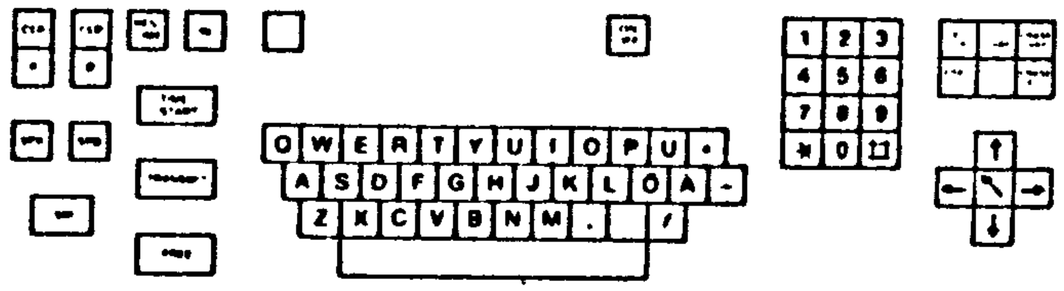
The operator may release the position before B answer.

If the B subscriber does not answer BNOANS is to be written in the ORDER field and [TRANSMIT] is pressed. Continue the procedure according to 4.9 page 37









APPENDIX 12. (Cont'd) DETAILED CALL HANDLING PROCEDURE FOR SUCCESSFUL DEMAND CALL.

4.5 The B subscriber answers

EVENT — The B subscriber answers. The B condition is changed to ANSWER

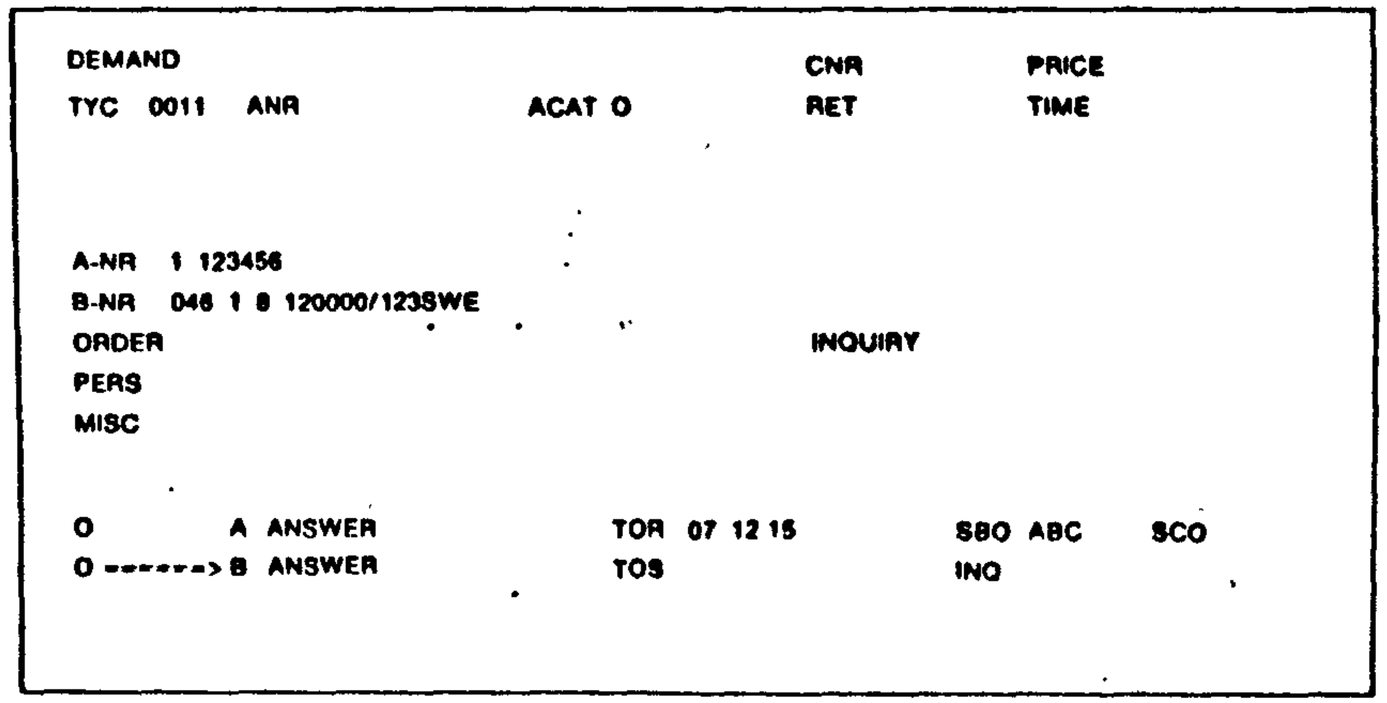
ACTION — Announce the call

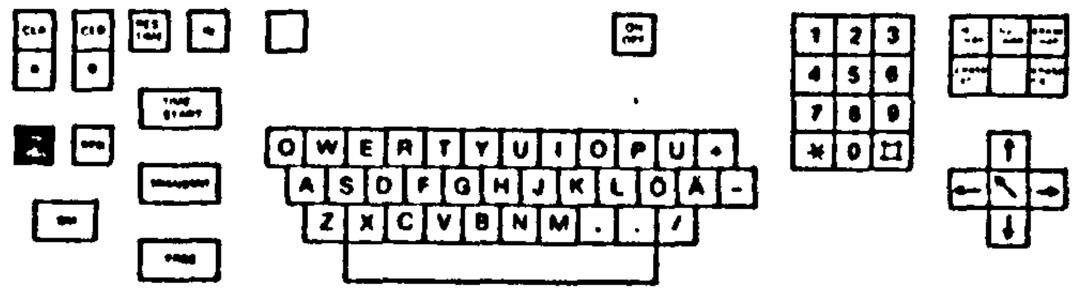
If the call establishment is over an open circuit — next page

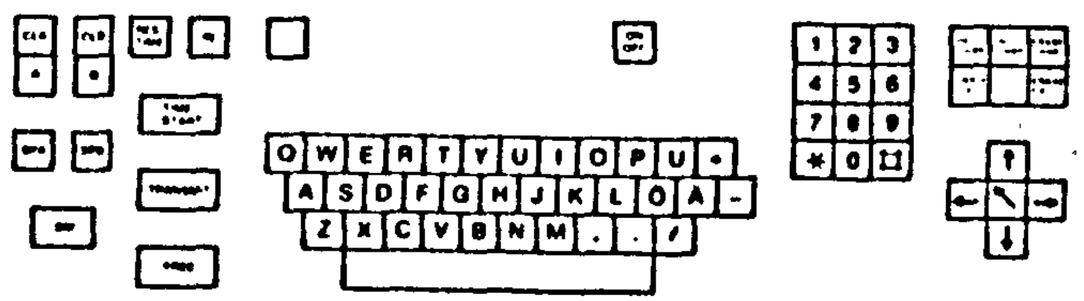
If the call establishment is over a split circuit

ACTION — Press SPA to establish speech connection to the A subscriber and disconnect the B subscriber.

ACKNOWLEDGEMENT — 0======>A speech connection with
0 B the A subscriber instead of with the B subscriber





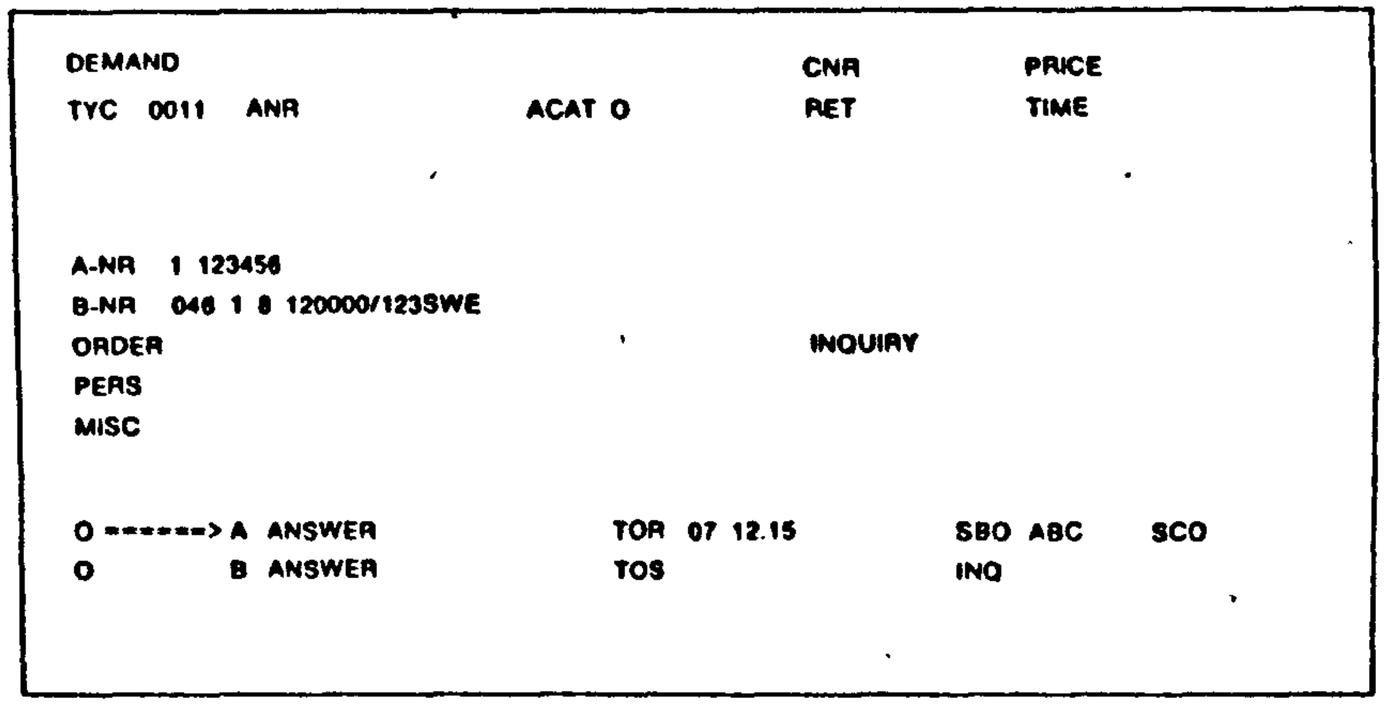


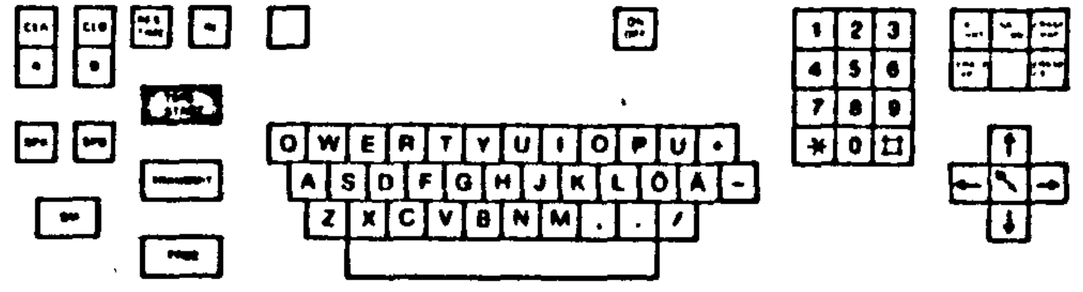
4.6 The call establishment ready

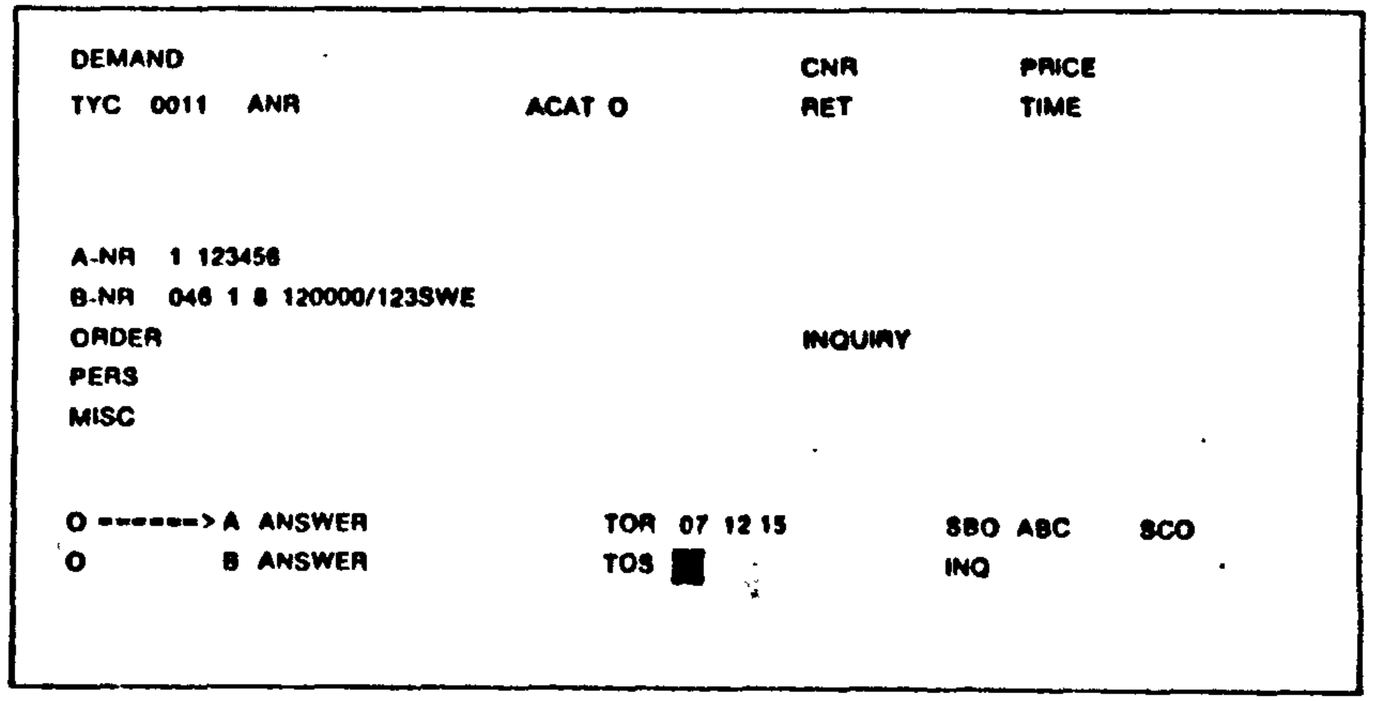
ACTION Inform the A subscriber that the call establishment is ready.

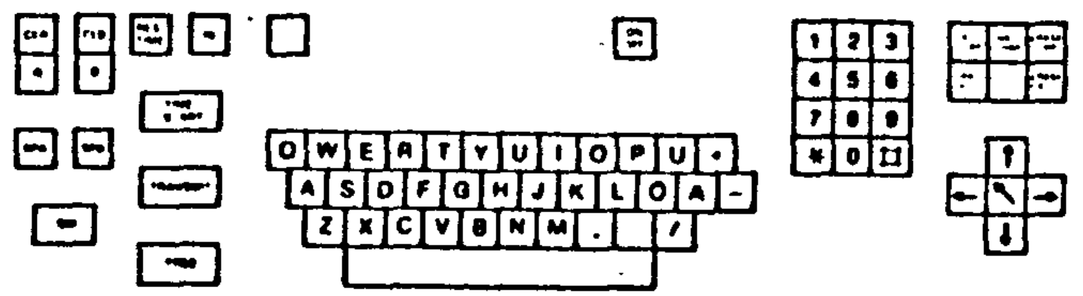
Press [TIME START] to prepare the start of charging. Time metering does not start until through-connection (SM pressed)

ACKNOWLEDGEMENT TOS *









4.7 Through-connection

ACTION Press [SM] to connect the subscribers and start call-duration metering. The operator passes to monitoring position.

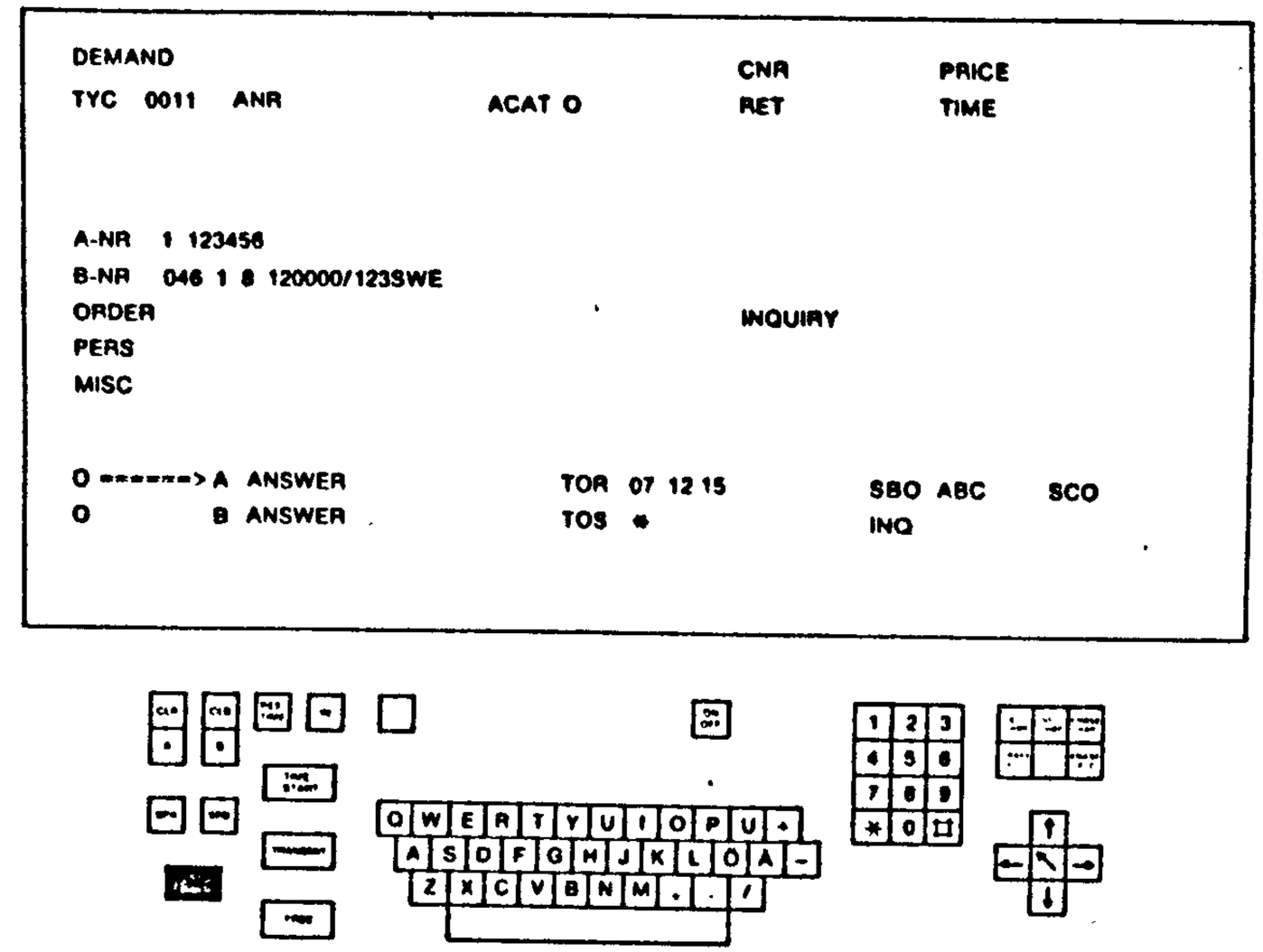
ACKNOWLEDGEMENT

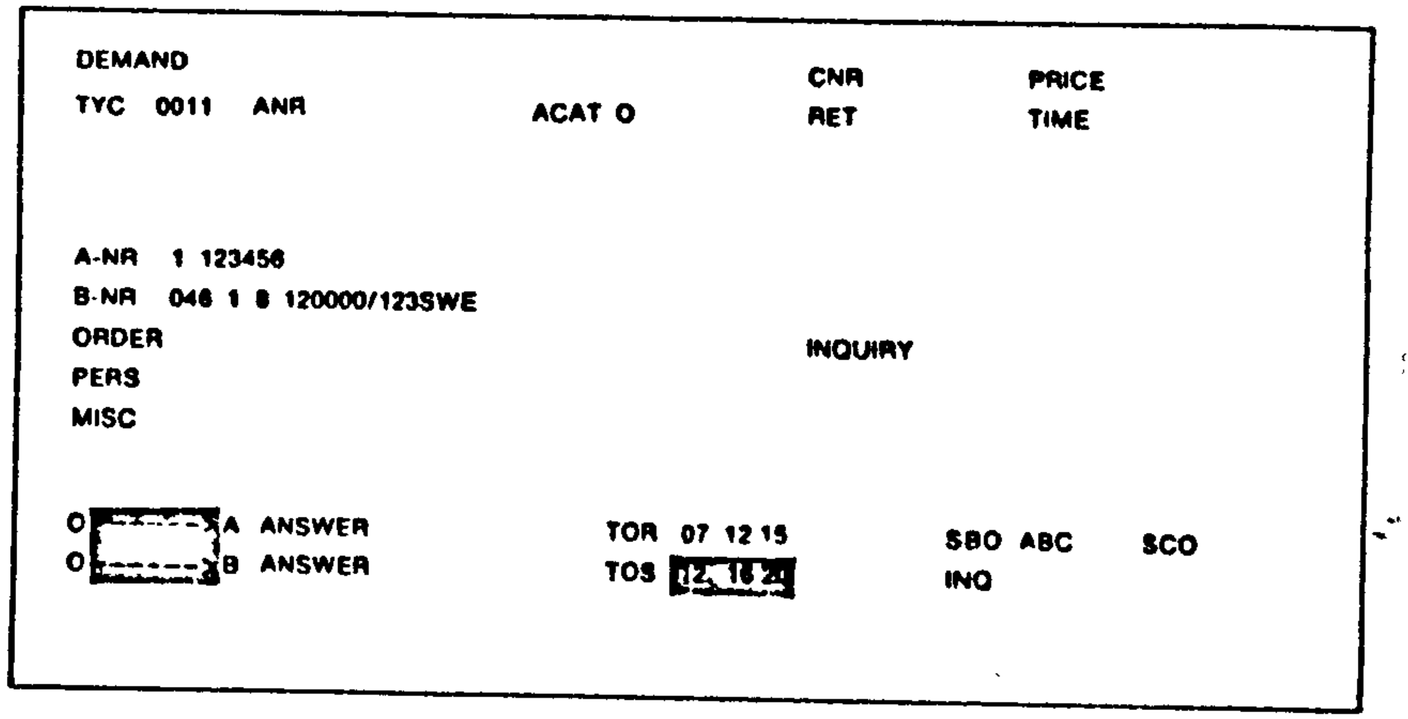
O------>A monitoring position
O------>B to the A and B side.

TOS time of start of call (hour.min.sec)

If the call does not get under way time metering can be stopped by pressing [TIME START] again. The time metered is then set to zero with [RES TIME] .

The operator can change to monitoring position before pressing [TIME START] in which case the time metering of the call does not start until the call has commenced and [TIME START] is pressed. The acknowledgements will be the same as the above except that * is omitted in the TOS field.



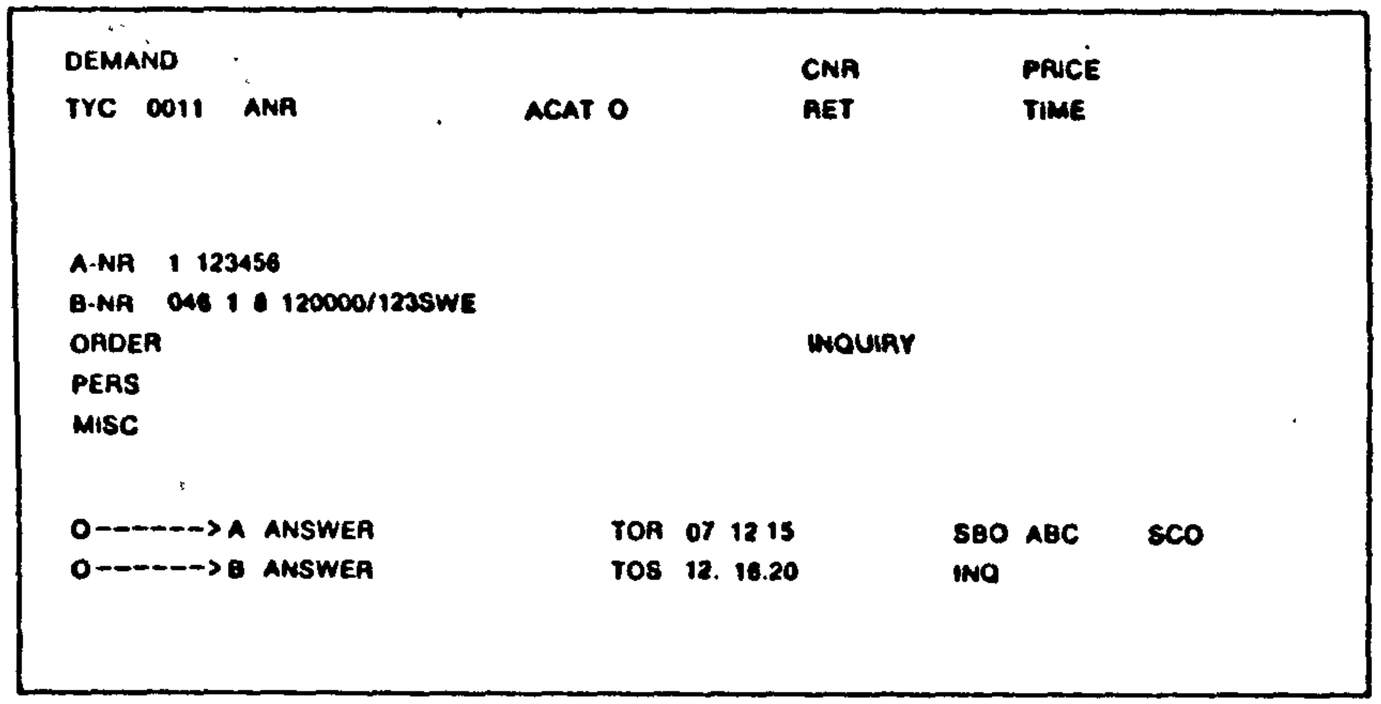


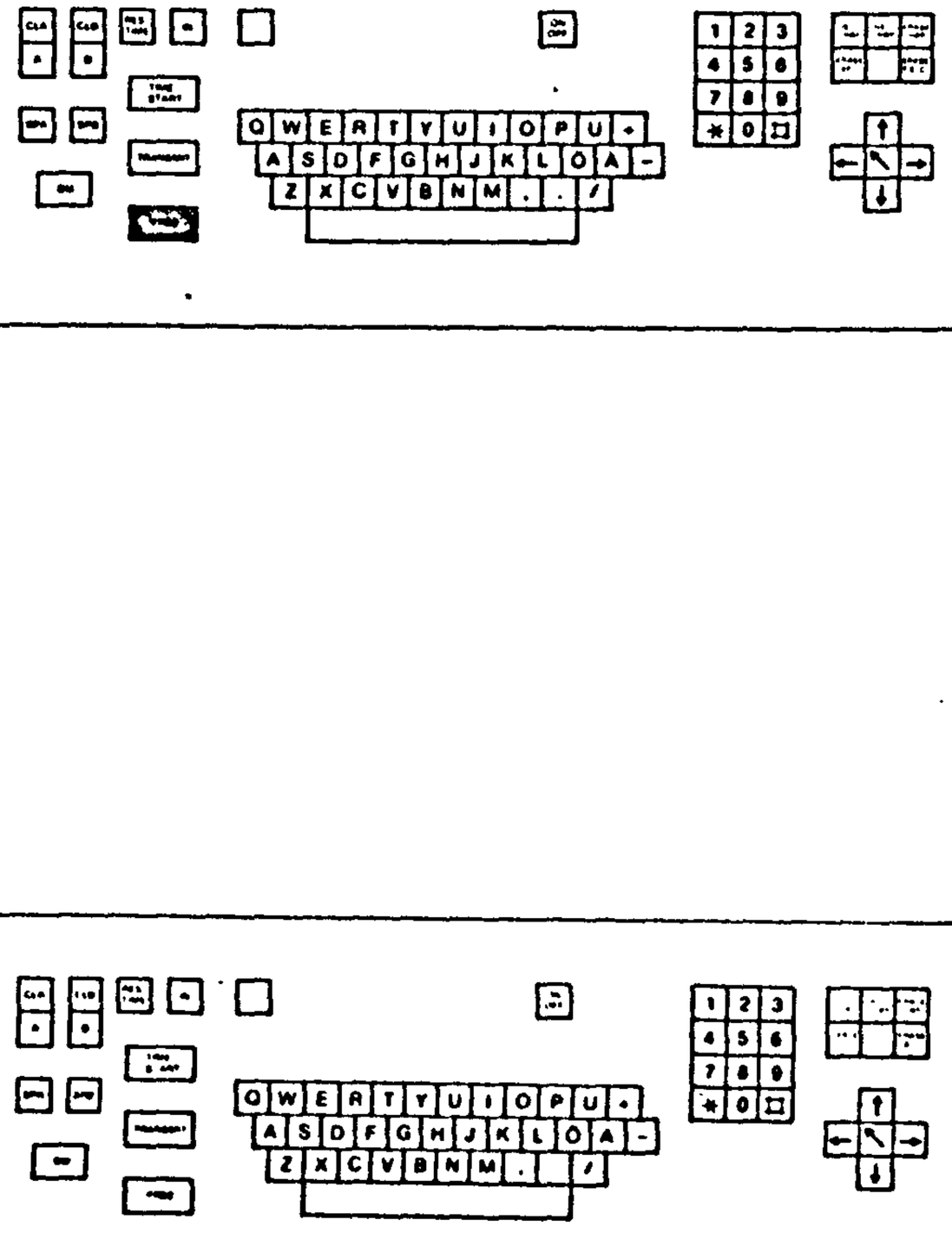
4.8 Release

ACTION If the call between the subscribers is under way without disturbances the operator can leave the call by pressing [FREE] .

ACKNOWLEDGEMENT The ticket disappears from the display.

The position is now free for a new call.



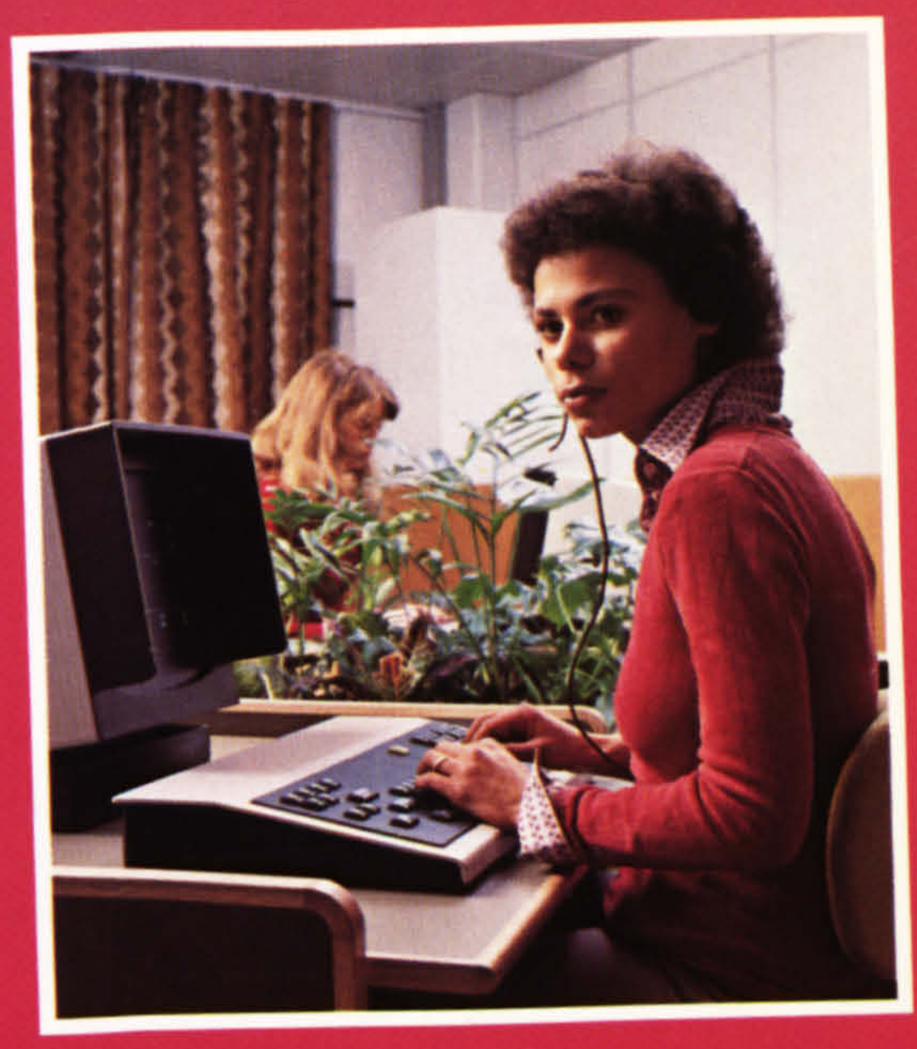


APPENDIX 13.

PUBLICITY MATERIAL FOR THE

ANE 403 SYSTEM

Operator system ANE 40



X/Yg 115 801 Ue

Operator system ANE 40

Contents

Introduction
Design and features
Ergonomics
Examples of traffic cases
Supervisor positions
Mechanical structure
Power supply
Operation and maintenance
Training

The contents of this book are subject to revision without notice due to continued progress in design and manufacture.

Introduction

Operator assisted traffic is not an obsolete technique. Even if the percentage of calls that need operator assistance decreases, a considerable amount of calls, depending on the general increase of telephone traffic, will still need operator assistance.

Furthermore, some services e.g. personal calls, collect calls, charging on a third party, will always or at least in the foreseeable future require the assistance of an operator.

In order to reduce or slow down the rise in costs of handling operator assisted traffic, when costs for wages and training are rising, a modern operator system must be both flexible and efficient. However, the designer of an operator system must always be aware that he is designing a man-machine communication system and take into account the ergonomic aspects.

To meet these demands LM Ericsson has designed ANE 40, a new operator system to be used with Ericsson's SPC-systems AXE and AKE

Design and features

The design is based, as in previous manual systems, on the concept that the operator fills in a ticket with the information that is required to establish and charge the call. However, for efficient communication with a processor in an SPC-exchange the paper ticket has been replaced by a data screen.

In order to meet the requirements of a modern work station, thorough studies and experiments concerning the ergonomic factors have been performed. One of the main considerations has been the selection of a data screen that does not cause strain and fatigue to the eyes of the operators. The design of the operator position desk and chair as well as colours and lighting are factors which have been included in the studies and experiments.

The modular design of the system permits changing parts of the system without affecting other parts. This is of great importance to enable adaptation of future technologies in the system, e.g. in the man-machine communications field.

Queues to the operators, delay call ticket handling, timing and charging are automatically handled by the system.

The design of the operators position desk and chair permits quick and easy adjustment to suit each individual operator. This is especially important as an operator can use any free position.

The operator position can either be located close to the exchange or in a remote location connected via a data link. This feature enables the administration to place the operator positions in localities others than in the exchange building and also perhaps in another city where operator staff is more available.

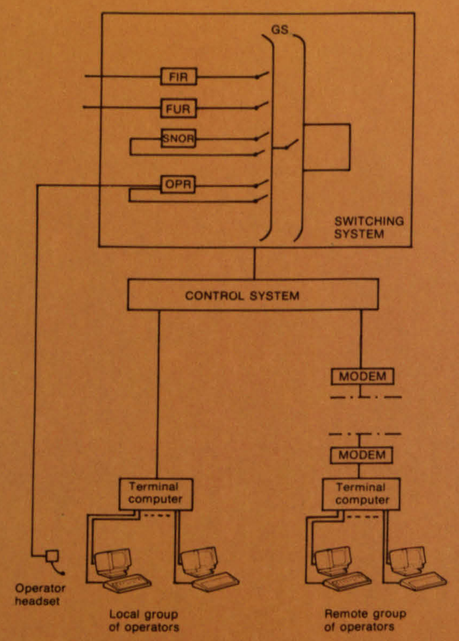
Each operator is assigned to an operator group handling one or more types of traffic. This means that each individual operator handles the traffic he/she has the knowledge of languages and training for. When an operator has signed on, which ever position he/she is sitting at, the type of traffic he/she is prepared to handle is automatically directed to that position.

The assignments of operators to groups and types of traffic to groups can, in order to adjust the organization to the traffic situation, be changed by commands from the chief operator.

The lay-out of the "ticket" and the call handling procedures are within limits up to each administration to decide upon. As a result of the ergonomic experiments certain recommendations are available.

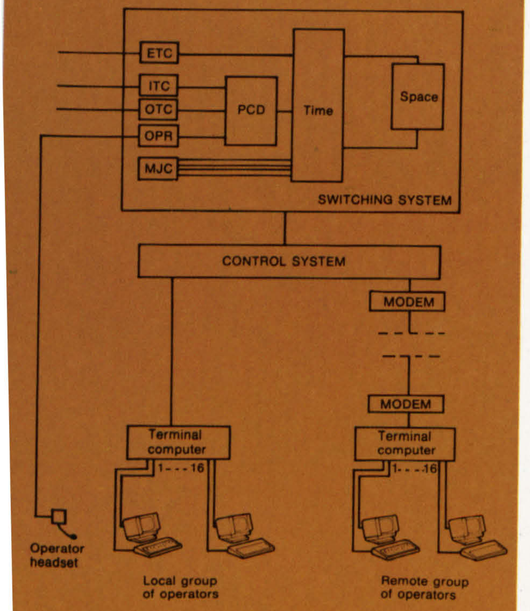
A separate training system is available where the operators can practice with simulated traffic.

ANE 40 in AKE 13



FIR Incoming trunk circuit
FUR Outgoing trunk circuit
GS Group switch
OPR Operator circuit
SNOR Cord circuit

ANE 40 in AXE 10



ETC Exchange terminal circuit
ITC Incoming trunk circuit
MJC Multi-junctor circuit
OPR Operator circuit
OTC Outgoing trunk circuit
PCD PCM terminal

Some of the most important features are:

- Introduction of data screens which eliminates the need to write tickets.
- Automatic storage of the call data for bookings and delay traffic.
- Automatic charging and storage of the charging information.
- Universal operator positions that can handle all types of services.
- Much shorter call handling times because of the automatization of routine work.
- Better service for the subscribers because of faster set up of the calls and the provision of more sophisticated services.
- Possibility of connecting different types of computers to which the operators may have access, e.g. directory enquiry service, centralized interception service etc.
- Flexible queuing system for calls to the operators. Modular increases in the number of operator positions.
- Possibility of remote location of the operator positions.

Ergonomics

The strenuous and exacting work of switchboard operators places strict requirements on their working environment. The environment must be quiet to allow concentration, but at the same time be stimulating and thus prevent fatigue.

The extensive architectural and psychological studies of the environmental problems are directly applicable to operators' rooms.

This applies also to Operator System ANE 40, which permits optional location of switchboards and optional future refurnishing thanks to the design of the operator's position and the simple cable terminations.

The design of the operator's position is the result of careful ergonomic studies and experiments. Both the chair and desk can be quickly and easily adjusted for each individual operator. The cathode ray tube has a green phosphorus screen which does not flicker and has a matt finish in order not to give disturbing reflections. The colours of the desk and the data screen hood have been selected so that they do not cause disturbing contrasts between the picture and the surrounding areas.

Examples of traffic cases

Types of calls

The following are examples of calls that can be received at an operator's position.

- Calls from domestic subscribers.
- Calls from operators abroad.
- Calls from operators within the country and from operators within the same exchange.
- Calls initiated by ANE 40.

When a call arrives at the operator's position a "ticket" indicating the type of call is displayed on the data screen. Calls from a subscriber or from another operator are given an appropriate message from an announcing machine. The message, which indicates the type of service, the name of the telephone exchange etc, is heard by both the calling party and the operator. The call is acknowledged by the operator pressing a key. If the call is not acknowledged within a certain period of time, the call is automatically transferred to another operator.

Call types and operator groups

All calls are assigned a certain call type depending on the service language to be used, whether it is a national, international, incoming or outgoing call etc. Each call type can be handled by one or more operator groups and an operator is always selected in the operator group with the lowest traffic level.

Each operator can have its own signature which defines the operator group he/she belongs to. Thus an operator can use any position.

A call will be allowed to wait in the call queue for a certain time if no free operator is available. Whenever an operator becomes free the call queue is always examined for waiting calls before any new calls will be accepted. There is one queue for each call type.

Reception of information

In the "ticket" on the screen the operator enters the verbal information received from the calling subscriber or operator. In the normal case he/she writes e.g. the following information.

- The calling subscriber's number.
- B-number, i.e. country code (if any), trunk code and directory number.
- The category of the call.
- Whether the subscriber wants a personal call.
- The party to be charged.

Identification of the A-number

If facilities are provided for automatic transfer of the A-number, the A-number is indicated on the "ticket" in connection with the call. In cases where there are no facilities for automatic transfer, the A-number could be checked by trunk offering towards the booking subscriber by the operator setting up a new connection to the calling subscriber.

Calling of B-subscriber

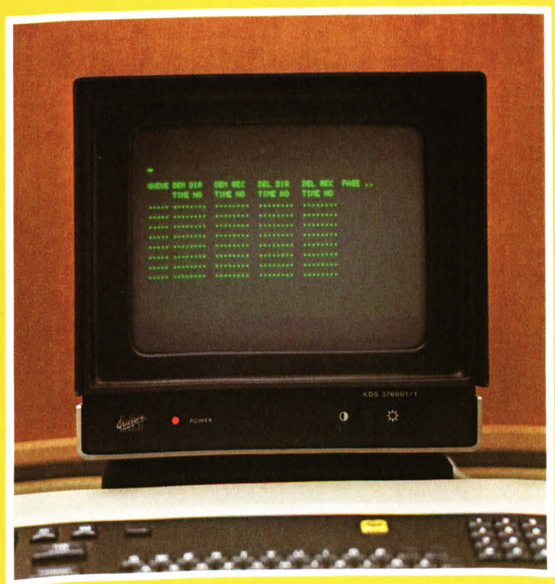
The selection and connection of a path to the B-subscriber is initiated by pressing a key on the operator's keyboard. When the connection is established the B-subscriber's state is indicated on the screen (free, busy or inaccessible due to congestion).

Start of charging

After the establishment of a connection between the A- and B-subscribers the operator orders start of recording of the conversation time.

Booking of delay calls

When a direct setting-up operation cannot be completed and the subscriber wants to make the call later on, the operator completes the direct setting-up operation by ordering a delay call before he/she releases the position.



Trunk offering and supervision

Trunk offering and supervision can be performed towards a busy subscriber. The call handling rules issued by the administration should state the situations and subscribers which may be subject to trunk offering.

ANE 40 is able to take over the supervision towards a busy subscriber and – when he becomes free – call a free operator.

Searching

Searching means that an operator can order the display of a "ticket" on the screen. This is done by writing a search order and the parameters necessary to find the "ticket".

The searching facility may be utilized in connection with traffic handling, e.g. in the following cases:

- When a subscriber, who has booked a call for later handling, wants to change the priority, the hour of handling, the type of call, or cancel the booking, etc.
- When the person wanted calls the operator for a personal call or a messenger call.
- When an operator in another exchange reports that a transfer booking is completed.
- When an operator requests the duration of a finished call.

Supervision of a call in progress

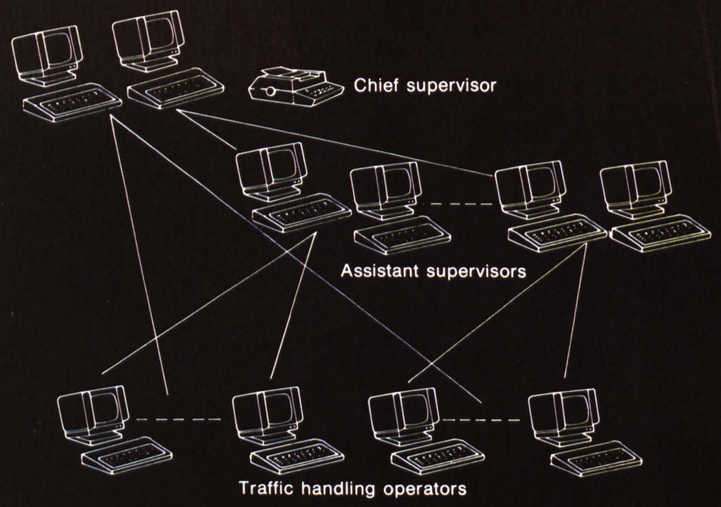
For some calls in progress monitoring of the connection must take place at regular intervals.

The type of call to be monitored – as well as the interval of monitoring – is determined automatically by the system during the setting-up of the connection. Monitoring can also be ordered by the operator.

Supervisor positions

Introduction

There are two hierarchic levels of supervisors in the ANE 40 system viz, assistant supervisors and the chief supervisor.



Assistant supervisor

The assistant supervisor position has two data screens. One is used for traffic handling and for answering internal inquiry calls, the other for supervision only.

The supervisor can obtain information about the number of occupied positions in the supervised group. For this purpose there is a special form which is set up on the supervision data screen by request of the supervisor.

The supervisor can connect his/her position to any position in the supervised group. He/she will then get a "copy" of the "ticket" at the supervised position on the traffic handling data screen. There is also an audio connection to the supervised position by which it is possible to listen or talk to the operator.

Chief supervisor

The chief supervisor position has two data screens and a typewriter. The typewriter is used for transcription of special tickets from the traffic handling operators and for orders to the system from the chief supervisor.

Some examples of these orders to the system are:

- to change the distribution of types of calls to the operator groups
- to block some types of incoming traffic
- to change the alarm level (the longest waiting time) on incoming queues

The two data screens are used partly as for the assistant supervisor position partly as described below. The chief supervisor gets information on the supervision data screen about the occupation condition of the operators, the queues, the routes and the operator groups.

The chief supervisor can get the occupation condition for all operators in the system and can supervise all of them, one at a time.

Some special functions

The chief supervisor can order the display of a maximum of 64 queues on the supervision data screen. For every queue the queue identification, longest waiting time and number of waiting subscribers in the queue will be displayed.

When the longest waiting time alarm level is exceeded this will be indicated by flashing this information on the screen.

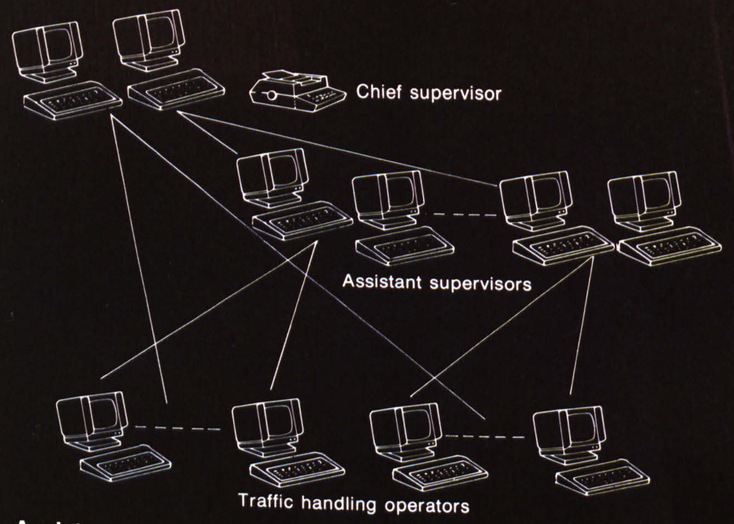
There is also a special form to indicate the route conditions. The form is set up by pressing a special function key for routes. The system will show the identity of the route when the alarm level has been exceeded for a certain time.

On the supervision data screen there is a special field to indicate alarms. This field is constantly displayed irrespective of which "ticket" there is on the data screen at the moment.

Supervisor positions

Introduction

There are two hierarchic levels of supervisors in the ANE 40 system viz, assistant supervisors and the chief supervisor.



Assistant supervisor

The assistant supervisor position has two data screens. One is used for traffic handling and for answering internal inquiry calls, the other for supervision only.

The supervisor can obtain information about the number of occupied positions in the supervised group. For this purpose there is a special form which is set up on the supervision data screen by request of the supervisor.

The supervisor can connect his/her position to any position in the supervised group. He/she will then get a "copy" of the "ticket" at the supervised position on the traffic handling data screen. There is also an audio connection to the supervised position by which it is possible to listen or talk to the operator.

Chief supervisor

The chief supervisor position has two data screens and a typewriter. The typewriter is used for transcription of special tickets from the traffic handling operators and for orders to the system from the chief supervisor.

Some examples of these orders to the system are:

- to change the distribution of types of calls to the operator groups
- to block some types of incoming traffic
- to change the alarm level (the longest waiting time) on incoming queues

The two data screens are used partly as for the assistant supervisor position partly as described below. The chief supervisor gets information on the supervision data screen about the occupation condition of the operators, the queues, the routes and the operator groups.

The chief supervisor can get the occupation condition for all operators in the system and can supervise all of them, one at a time.

Some special functions

The chief supervisor can order the display of a maximum of 64 queues on the supervision data screen. For every queue the queue identification, longest waiting time and number of waiting subscribers in the queue will be displayed.

When the longest waiting time alarm level is exceeded this will be indicated by flashing this information on the screen.

There is also a special form to indicate the route conditions. The form is set up by pressing a special function key for routes. The system will show the identity of the route when the alarm level has been exceeded for a certain time.

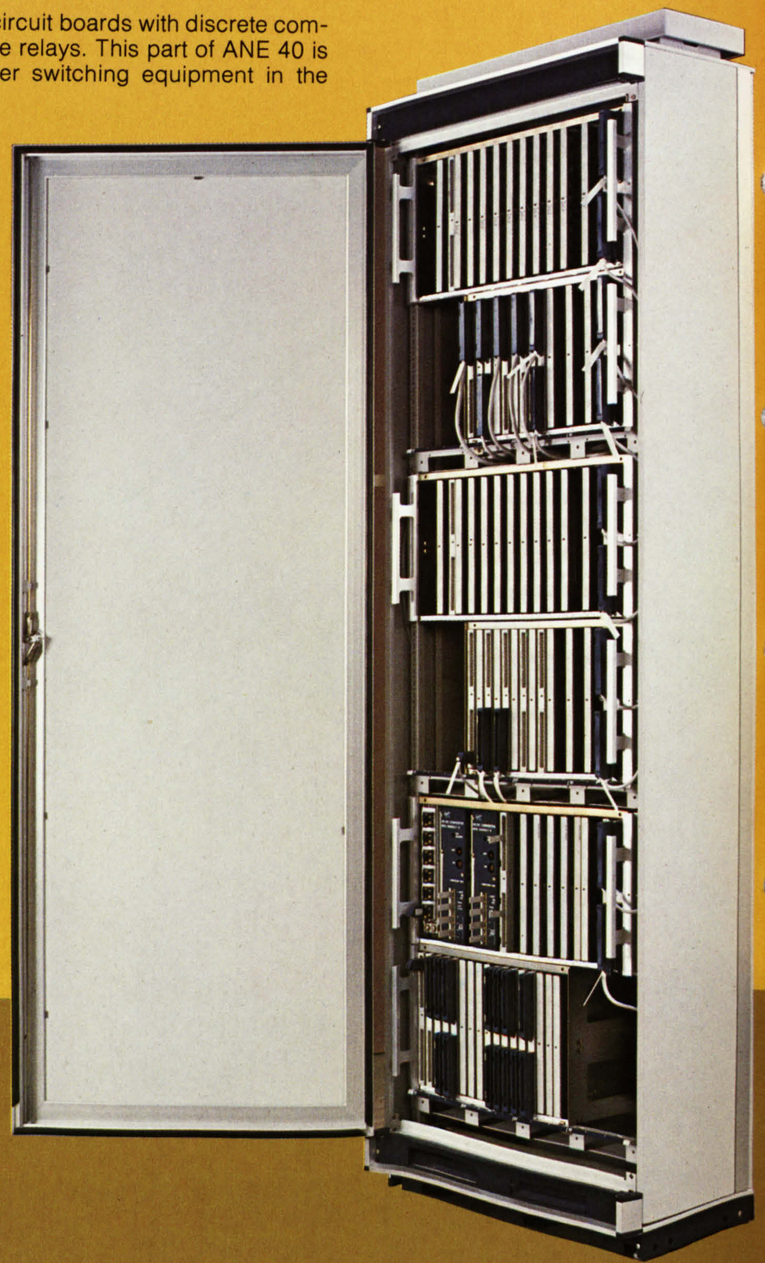
On the supervision data screen there is a special field to indicate alarms. This field is constantly displayed irrespective of which "ticket" there is on the data screen at the moment.

Mechanical structure

The packaging structure in which the operator system is built is partly determined by the telephone exchange system, to which the operator system is connected. When connected to an AXE exchange the packaging structure BYB is applied for both the switching and terminal part. When the connection is made to an AKE exchange the packaging structure BDH is used for the switching part and the packaging structure BYB for the terminal part.

The switching part

The switching part is built up on printed circuit boards with discrete components, integrated circuits and miniature relays. This part of ANE 40 is intended to be collocated with the other switching equipment in the switchroom.



The terminal part

The terminal part is always placed in the packaging structure BYB.

The terminal part is divided into an adjacent part and a remote part. The adjacent part is a unit handling the interwork towards the controlling telephone exchange. The unit is based on an Ericsson minicomputer of type APN 163. The control unit includes interface circuits toward the data links and software functions for the communication procedures on the links.

The remote part is also based on the minicomputer of type APN 163 and includes control units for keyboard and data screen, DC/DC converters and various connecting boards.

The units are built up on printed circuit boards and inserted in a number of magazines. The adaptation units for the headset are also placed in the remote part. The entire equipment in the remote part is housed in two BYB cabinets which, when desired, can be placed in the switchroom. When the remote part is located more than one kilometre from the adjacent part modems are required for the data transfer.

Power supply

Each computerized telephone exchange system has a separate power plant. This power source is also utilized by the Operator System ANE 40.

All the racks and cabinets are fed with –48 V. The racks or cabinets requiring logic voltage, i.e. 5 V and 12 V, are equipped with DC/DC converters.

The data screens are fed with –48 V. When the operator positions are remote-connected, i.e. they are located, so that supply from the exchange power is impractical, a separate power plant is used.

Operation and maintenance

The operation and maintenance functions for the Operator System ANE 40 are designed according to the LM Ericsson maintenance philosophy Controlled Corrective Maintenance (CCM). In brief, this implies the following:

- continuous fault supervision or automatic routine tests detect faults in the system.
- detected faults are analyzed so that only a disturbing fault state or fault level is reported to the maintenance staff, usually by means of an alarm system.
- automatic fault indication or fault diagnosis is made as far as possible, and is supplemented with documented routines for manual fault localization and repairs etc.
- collection of statistics to plan (dimension) exchanges and the network.

The ANE 40 system also includes traffic supervision functions comprising supervision of queues, recording of utilization of operator service etc. The chief operators and supervision operators handle this supervision.

The administrative functions are divided with respect to their handling between exchange maintenance and operator staff. The maintenance staff handles blockings, exchange data modifications, traffic recording etc. The chief and supervision operator handle changes in queue priorities, organizational changes etc.

Alarms, fault printouts, commands for blocking/deblocking, etc. which primarily are associated with the maintenance of the equipment, are included in the normal operation and maintenance organization of the exchange.

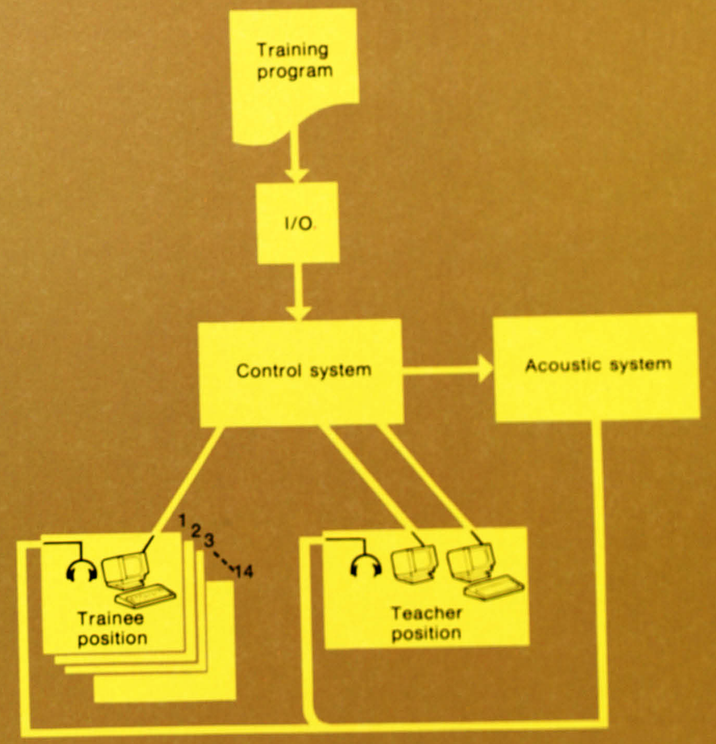
The traffic supervision and commands to modify queue priorities, organization, traffic handling etc. are included in the operator organization. These functions are handled by the chief operator by means of a supervision terminal and a typewriter.

Traffic recording

All calls to the operator system are distributed on different call types. The respective call types are then forwarded to operator groups. Each operator group consists of a number of operators for a certain traffic category.

Recordings of the traffic to the operator groups are mainly used for supervision of the traffic load. However more detailed recordings can be made on the call types, since all queues are oriented to the call type.

Training system



Within the Operator System ANE 40 there is a training system which is used for training of operators. This system can also be used for evaluation and development of call handling procedures.

From a trainee position different traffic cases can be practised (with or without assistance from the teacher). Any handling procedure used in the real operator system can be simulated in the training system. The equipment at the trainee position is the same as at a normal operator position and the information to and from the positions is the same as when handling normal calls.

The system can be installed as a completely separate system or by connecting ordinary positions to training positions, be incorporated in the operator system.

The traffic cases are prepared and fed into the control processor. The terminals for the teacher and the trainees are connected. The execution of the traffic cases is handled by the control processor. In the data is specified what the control processor shall write on the trainee data screen and what the trainee shall write on the data screen and which functional keys to operate.

The training system consists of a teacher position and a maximum of 14 trainee positions. Any position can with a command from the teacher be connected to the teacher position. From the teacher position it is possible to monitor the work at a trainee position both on the data screen and acoustically.