Graduated Dynamic End Point System 'GRADEPS' for Assessment of Visual Field Contraction during +Gz Acceleration

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In the determination of tolerance to +Gz acceleration fixed angle peripheral light loss (PLL) is used as an end point, which only indicates whether or not the angle of vision of the subject is less than a certain value. A new dynamic system with multiple lights has been developed and incorporated into the human centrifuge for quantifying the extent of reduction in the angle of vision. It provides a better assessment of progressive narrowing of the visual field and helps in the study of role of the compensatory mechanism of the cardiovascular system. The present communication describes the details of this system using eight light emitting diodes subtending angles of 64°, 60°, 56° and 52° and presenting the visual stimulus. A brief description of the control circuitry developed using integrated circuits of the TTL family is presented. Details of its operation and results obtained during different rates of onset of acceleration are discussed.

GREY out or peripheral light loss (PLL) of various grades has been utilized as an end point to determine the tolerance of Gz stress in most of the laboratories. For the last 15 years PLL at 53° has been used as the end point in the human centrifuge which is available at the Institute of Aviation Medicine (IAM), Bangalore. But during the trials with this system it was observed that the occurrence of PLL cannot be predicted and the tests have to be repeated to obtain the exact +Gz threshold value. Therefore it was felt that a set of lights subtending different angles and indicating a progressive narrowing of the visual field may be more convenient and useful for measuring PLL. Thus it would be easier to establish the threshold values by giving less number of trial runs. Moreover the improvement in PLL threshold during a run due to cardiovascular compensatory mechanisms can also be evaluated properly with this system of multiple lights. Gillingham and Mcnaughton[2] have reported the use of a multiple light system in their study of effect of seat back angles on g tolerance.

A dynamic system with multiple lights for presenting visual stimulus at graduated angles and for measuring the response of the subject to this stimulus has been developed and incorporated into the human centrifuge at IAM. A display system of eight lights is mounted in the gondola for presenting the stimulus. An electronic sub system selects the correct pair of lights and, when the subject responds, another subsystem switches the lights off and controls the stimulus repetition and random switching circuits. Additional subsystems have been added for discretized recording of the angle of vision on a polygraph. These subsystems are described and the result of the trials on human subjects under different rates of g onset are presented.

The GRADEPS

Eight light emitting diodes (LED) mounted symmetrically on an arc of radius 30" such that LED pairs subtending angles of 64°, 60°, 56° and 52° at the level of the eye of the subject (Fig. 1) constitute the display

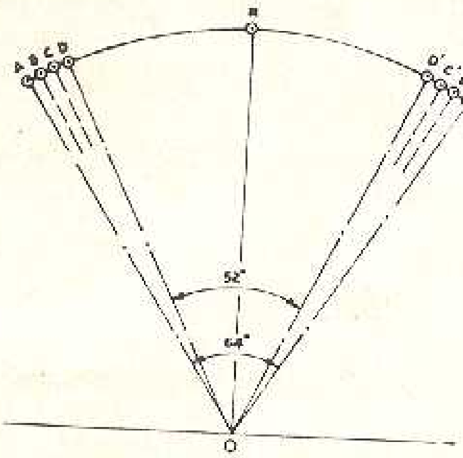


Fig. 1 — Display system of the GRADEPS for presenting visual stimulus to the subject. A to D and D' to A' are light emitting diodes fitted such that the pair A—A', B—B', C–C' and D–D' subtend angles of 64, 60, 56 and 52° respectively.

unit of the graduated dynamic end point system (GRADEPS). The LEDs are interconnected such that only one of the pairs (A and A', B and B', C and C', or D and D') can glow at a time to present a light stimulus for the measurement of angle of vision of the subject. When the light stimulus is presented at a particular angle, say 64°, if the glowing LED pair, viz., A-A' is within the field of vision of the subject he responds by pressing a microswitch (PTT button) mounted on the mock control column. This button is referred to as 'RESPONSE' key in the following description. The details of the GRADEPS is outlined in the block diagram of Fig. 2. A controlled clock generates the

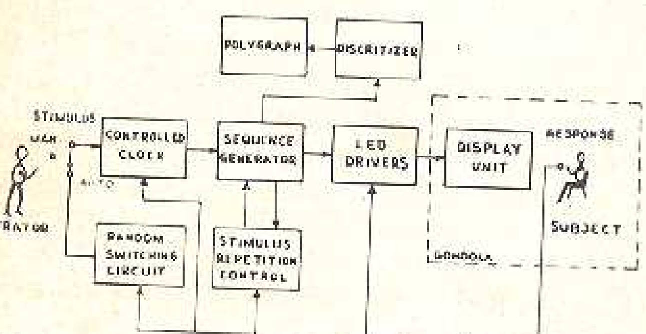


Fig. 2 — Functional block diagram of the graduated dynamic end point system, GRADEPS.

pulses of desired duration to drive the sequence generator. Output of this generator is given to the LED drivers which energize the selected pair of LEDs of the display unit. When the subject responds, LEDs are switched off, and the stimulus repetition control and random switching circuit are triggered for the next stimulus to be presented after a random delay. The output of the sequence generator is discretized to obtain a four level recording on the polygraph. The system can be operated in the manual or automatic mode. It has been designed using TTL integrated circuits[3] (ICs) and discrete components. Each of the subsystems is described in detail in the following paragraphs. The ICs used to realise each of them are also indicated.

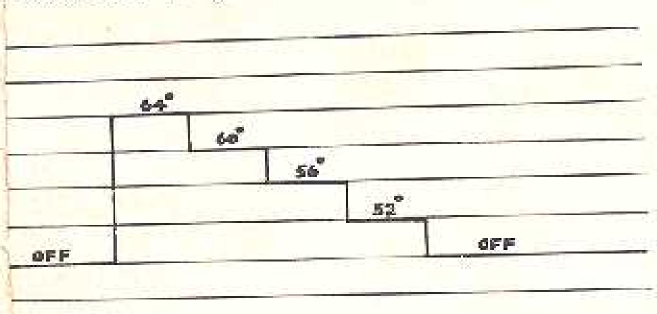
Controlled Clock. The controlled clock can be selected to genarate pulses of variable duration (Tc) equal to one and a half times the response time of the subject at rest. The clock is started by the STIMULUS control (Fig.2) activated by the controller or a random switching circuit and stopped by the RESPONSE key operated by the test subject. A timer (NE 555) used as an astable mulivibrator, a flipflop (SN 7473) and an AND gate (SN 7408) constitute the controlled clock.

Sequence Generator. Driven by the pulses of the controlled clock, the sequence generator provides control voltages for the LED drivers which in turn drive the corresponding LED pair. The sequence of light stimuli starts with the glow of the pair of LEDs A-A' which stays ON for the duration Tc. If the subject responds within the time Tc indicating that the lights are within the field of his vision, the lights are switched off and the clock is stopped. The next stimulus starts with the same pair of LEDs and the above process repeats if he keeps responding within the period Tc. However, if he fails to respond within that period indicating loss of vision at that angle, the sequence generator activates the drivers of the next inner pair of LEDs namely B-B' (60°) which may still be visible to him. If so, he responds, the lights are switched off and the next stimulus is repeated at 60° (B-B'). In case there is no response within time Tc the LED pair C-C' corresponding to next lower angle of 56° is turned on and this shift to lower angles continues till subject responds. Four flipflops (SN 7473) connected as ripple counters and eight AND gates (1/4 SN 7408) as decoders constitute this subsystem.

LED Drivers. LEDs require current in the range of 10-20 mA for a distinct and bright display. Drivers provide this current for the selected LED pair and the intensity control can be set to provide the desired brightness of the LEDs. It is also required that the lights are switched off as soon as the subject responds. This function is achieved by a gating switch common to all the drivers. Transistors AC 127 driven by the outputs of the decoders of the sequence generator are the drivers.

Stimulus Repetition Control. As long as the subject keeps responding within the period Tc, the stimulus at the maximum angle (A-A') is repeated by the sequence generator. However, when the stimulus is at the angle corresponding to B-B' or lower, it is necessary to verify the measurement by repeating the stimulus twice or thrice at the same angle. It is desirable to restart the stimulus from a higher angle to establish if there is any improvement in the field of his vision due to compensatory mechanisms of the body. The stimulus repetition control (SRC) counts the number of responded stimuli at angles corresponding to B-B', C-C' or D-D' and resets the sequence generator after three such stimuli so that the fourth stimulus ɩuld be from A-A'. The complete sequence given ɔve is repeated. Two flipflops (SN 7473), an AND te (1/4 SN 7408) and transistor 2N 2207 constitute ɜ SRC.

Discretizer. It is required to record on the polyıph the angles of vision measured by the GRADEPS. ɜ discretizer assigns different weights for the out-



.3 — Four-level output of the discretizer for recording the angle of vision on the polygraph.

s of the sequence generator corresponding to diffnt angles and produces a four-level recording ɟ. 3) on one of the channels of the polygraph so (angle of vision at any stage of acceleration can be directly read off. Four potential divider networks, four diodes and two transistors (AC 127) form the discretizer.

Random Switching Circuit. When trials are repeated there is a possibility of the subject getting used to the rhythm of the medical controller and pressing the RESPONSE key even when he cannot see the glowing pair of lights. This leads to erroneous results

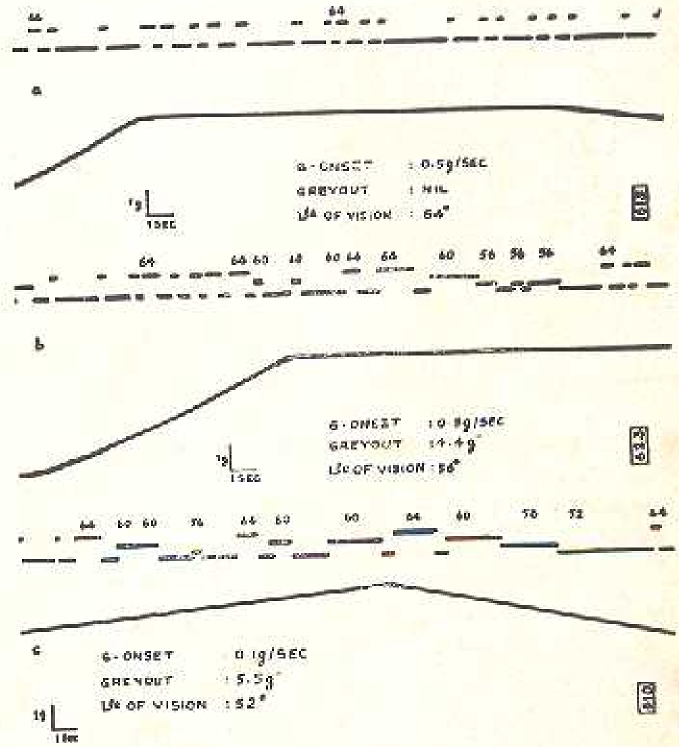


Fig. 4 — A typical record of the measurement of angle of vision using GRADEPS. Lower tracking in each of the above records is the g profile and the upper tracing is the angle of vision as measured using GRADEPS.

a) Rapid onset rate (ROR) of 0.5 g sec and a peak acceleration load of 4g No greyout is seen

b) ROR of 0.5 g/sec and a peak load of 4.5 g Grey out is at 4.4 g and minimum angle of vision 56°. Improvement in the angle of vision can be seen towards the end.

c) Gradual onset rate (GOR) of 0.1 g/sec and a peak load of 6.4 g. Grey out is at 5.5 g and minimum angle of vision is 52°.

in measuring his g tolerance. To avoid this a random switching circuit (RSC) has been designed and incorporated into this system. It also relieves the medical controller for monitoring subject's physiological parameters and his response. RSC is activated by taking the system into automatic mode. It triggers the controlled clock after a random delay from the start of the run or from the moment the subject responded to the previous stimulus. The maximum and minimum values of this delay are 0.1 and 0.6 sec. This circuit is realized using a timer (NE 555) as an astable multivibrator, four filpflops (SN 7473) as a ripple counter, eight AND gates (SN 7420) as a logical adder and two flipflops (SN 7473) as bistable multivibrators. The output of this system drives a reed relay which triggers the controlled clock into operation.

Results

GRADEPS has been used on more than one hundred subjects for establishing g threshold at PLL at different rates of onset, viz., gradual onset rate (GO 0.1g/sec) and rapid onset rate (ROR : 0.5g sec (Fig 4). The results show better accuracy in predic ting the g threshold of subjects. Medical controlle could pay more attention towards observation of th subject and his responses. Results of some of thes experiments have been compiled in a separate report

Conclusion

A graduated dynamic end point system has bee developed for measuring visual field contraction unde +Gz stress and incorporated into the human centri fuge. The results of the experiments on the system are found to be advantageous. It is now in routine use for establishing the +Gz tolerance.

References

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