D-TDR-64-383

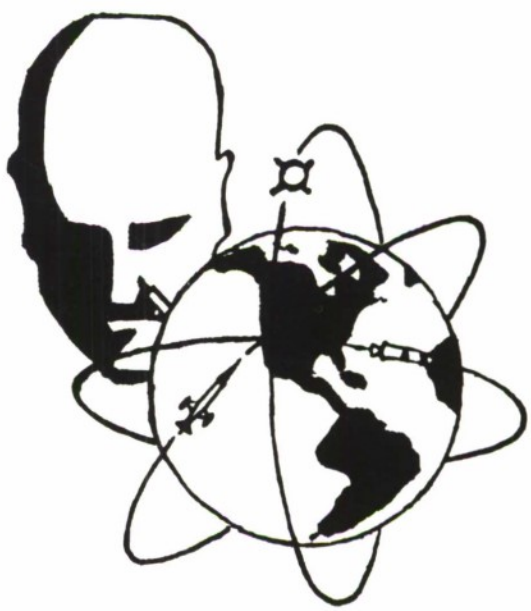
AN AUTOMATED FACILITY FOR FORCED - CHOICE SIGNAL DETECTION EXPERIMENTATION

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-383

APRIL 1964

William H. Watkins
Raymond S. Nickerson
John R. Schjelderup

DECISION SCIENCES LABORATORY
DEPUTY FOR ENGINEERING & TECHNOLOGY
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts



Project 7682

DDC AVAILABILITY NOTICES

Qualified requesters may obtain copies from Defense Documentation Center (DDC). Orders will be expedited if placed through the librarian or other person designated to request documents from DDC.

Copies available at Office of Technical Services, Department of Commerce.

ESD-TDR-64-383

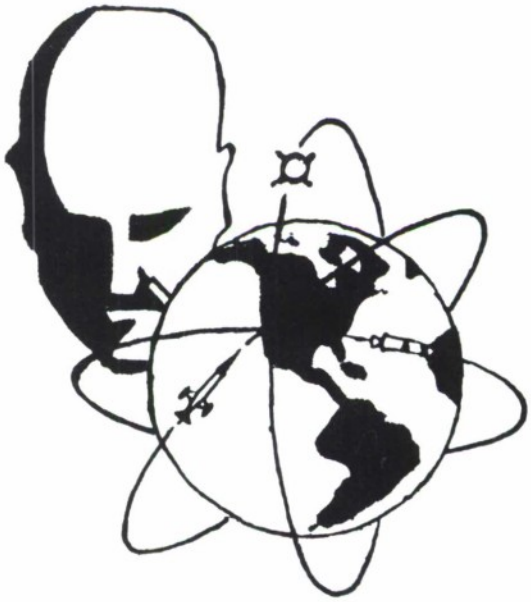
AN AUTOMATED FACILITY FOR FORCED - CHOICE SIGNAL DETECTION EXPERIMENTATION

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-383

APRIL 1964

William H. Watkins
Raymond S. Nickerson
John R. Schjelderup

DECISION SCIENCES LABORATORY
DEPUTY FOR ENGINEERING & TECHNOLOGY
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts



Project 7682

ESD-TDR-64- 383

AN AUTOMATED FACILITY FOR FORCED-CHOICE SIGNAL DETECTION EXPERIMENTATION

ABSTRACT

The facility described allows presentation of visual, auditory, or bisensory signals for the study of forced-choice signal detection. Means are provided for informing the observer, prior to each trial, of the signal mode he should expect on that trial. Considerable flexibility is provided for the scheduling of intermittent noise (aud. and/or vis.) within an observation interval. The facility includes an observer's station within an anechoic chamber and a control unit in a separate room. Data collection sessions are fully automated. The control system reads a paper tape input and produces a paper tape output. Input (stimulus scheduling) tapes are generated, and output (data) tapes are processed, by a PDP-1 computer.

PUBLICATION REVIEW AND APPROVAL

This Technical Documentary Report has been reviewed and is approved.

DONALD W. CONNOLLY
Chief, Display Division
Decision Sciences Laboratory

ROY MORGAN, Colonel, USAF
Director
Decision Sciences Laboratory

TABLE OF CONTENTS

KEY WORD LIST

1. HUMAN ENGINEERING
2. SENSORY MECHANISMS
3. HEARING
4. VISION
5. VISUAL SIGNALS
6. VISUAL ACUITY
7. BEHAVIOR
8. TESTS
9. EXPERIMENTAL DATA
10. COMPUTERS

AN AUTOMATED FACILITY FOR FORCED-CHOICE SIGNAL DETECTION EXPERIMENTATION[1]

William H. Watkins
Raymond S. Nickerson
John R. Schjelderup

This report describes an automated facility for the study of forced-choice signal detection (FCSD). The objectives are: (1) to furnish necessary information for potential users of the facility and (2) to provide a reference which will obviate repeating detailed descriptions of equipments in future research reports. For a discussion of the forced-choice method in signal detection experimentation, the reader is referred to Swets, Tanner and Birdsall (1961).

In addition to standard signal parameters, e.g., intensity and frequency, the facility provides E with control over the following variables:

1) Number of observation intervals. The defining property of a FCSD experiment is O's task of specifying the one of several observation intervals during which the signal occurred. In this facility, a trial may have either two or four observation intervals.

2) Signal mode. The signal may be either visual or auditory, or visual and auditory combined. Whichever it is, it is delivered during one, and only one, of the observation intervals. However, signals of different types may occur within the same experimental session.

---

[1] The generous assistance of John B. Goodenough in refining the PDP-1 programs is gratefully acknowledged. David Nadroski performed a large portion of the apparatus construction and assembly work.

3) Mode cue. The facility provides E the option of informing O, prior to each trial, of the type of signal which will occur, or of leaving signal mode unspecified.

4) Observer's report. O may be required to report the signal type (Sound, light, or Combination) as well as the signal interval. If the type-response requirement is not imposed, a standard entry is automatically supplied for each trial, on the data record.

5) Auxiliary sound. Sounds of various kinds may be presented in visual detection experiments for investigation of inhibition/facilitation phenomena.

The major components of the physical system are an observer station, an assemblage of control equipment, and a set of PDP-1 computer programs. The control apparatus includes a paper tape reader for stimulus scheduling, and a paper tape punch for data recording. The computer is used to produce stimulus-sequencing paper tapes and to process data. Each of these components is described more fully below.

OBSERVER STATION

Located inside an anechoic chamber, and arranged as shown in Figure 1, the components of the observer station are a visual display, an auditory display, and an observer's chair.

Visual Display

The central component of the visual display is an approximately cubical plywood box with a 1/8 in. thick, 31 3/4 x 31 3/4 in. frosted plexiglas front. The inside of the box has been painted white, and measures 30 1/2 inches

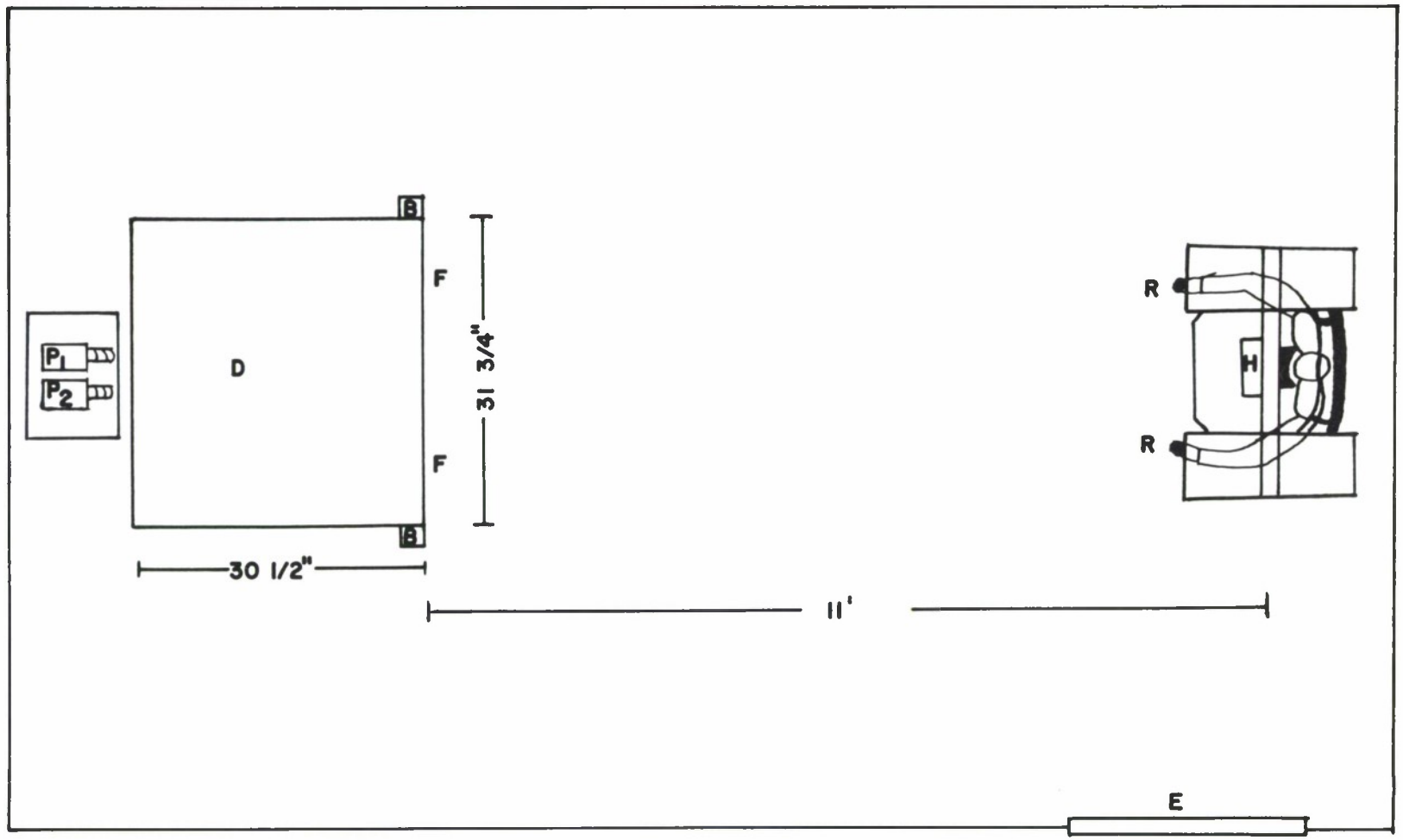


Figure 1. Floor plan of anechoic testing room. B: cue boxes. D: main display box. E: entrance (insulated door). F: front surface of visual display. H: viewing hood. P: projectors. R: response switches.

front to back. The box is mounted so that its center is approximately 47 in. above floor level, corresponding to the average "seated" eye level of prospective Os. A rack and pinion arrangement at the rear makes it possible, by tilting, to adjust the display surface to a plane perpendicular to a specific O's line of vision.

The plexiglas surface is illuminated from the rear by four standard 115 v. incandescent lamps, mounted at the four corners of the inside of the back of the display box. The back is hinged to permit easy replacement of bulbs. The function of these lamps is to maintain the background illumination of the display surface at a constant level. In signal detection terminology, these lamps may be considered a source of external visual noise.

The visual signal itself consists of a brief intensification of a light spot centered upon the back surface of the plexiglas sheet which forms the front of the visual display. The beam emanates from a 300 w. "2 x 2" slide projector, which rests on a platform at the back of the box. A hole in the back allows projection of light onto the center of the back of the plexiglas. Intensity of the visual signal is controlled by manipulation of the projector lamp current flow, as discussed below. Manual adjustments of position, shape, and spectral parameters by means of projector relocation, and use of masks and filters, provide opportunities for study of detection as a function of a variety of visual signal characteristics.

The visual display surface is shown in Figure 2. The two small (5/8 in. diameter) lights, spaced 3 1/2 in. apart at the top of the display are "ready" and "vote" indicators, left and right respectively. The ready indicator is white, and the vote, red. At each of the four corners of the

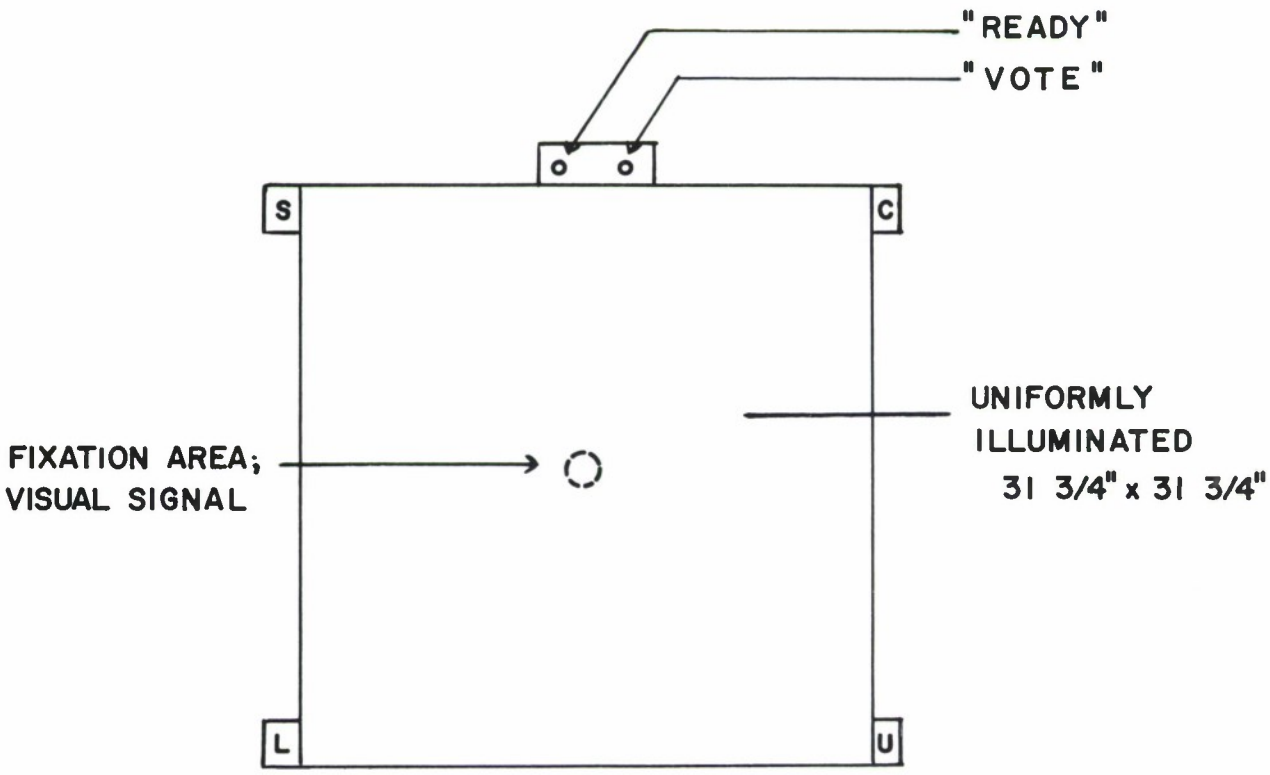


Figure 2. Front view of visual display. Main panel and the four cue boxes are transluminated, frosted plexiglas.

display is a "cue" box with a rear-illuminated 2 1/2 in. x 3 1/4 in. frosted plexiglas front. The cue boxes serve the dual function of specifying signal mode and marking off the several observation intervals of each trial. The letters S, L, C and U stand for sound, light, combination and unspecified. On each trial of an experiment, the observation intervals are marked off by only the appropriate one of these cues. For example, if the signal mode is to be "unspecified", the box marked U will be briefly illuminated just prior to the beginning of each observation interval. The specific temporal properties of the mode cue - interval marker and its relationship to the other events of a single trial of a four interval experiment are shown in the phasing diagram, Figure 3. The cue boxes may be turned entirely off at a single switch.

A second projector, positioned next to the one described above, is focused and masked to supply a spot of light which completely includes the spot produced by the first projector.[2] This second spot is available to flash on during each possible signal appearance period. (The four times are "N's" on figure 3.) Operating in this fashion, the display presents four intensifications of the fixation spot per trial, with the visual signal imbedded in one of them.

Note that if the second projector is turned on, all possible signal times are precisely defined by the presence of this additional, concentric spot. Cue boxes are normally turned off when the second projector in in use.

---

[2] The second spot was suggested by Charles Brown.

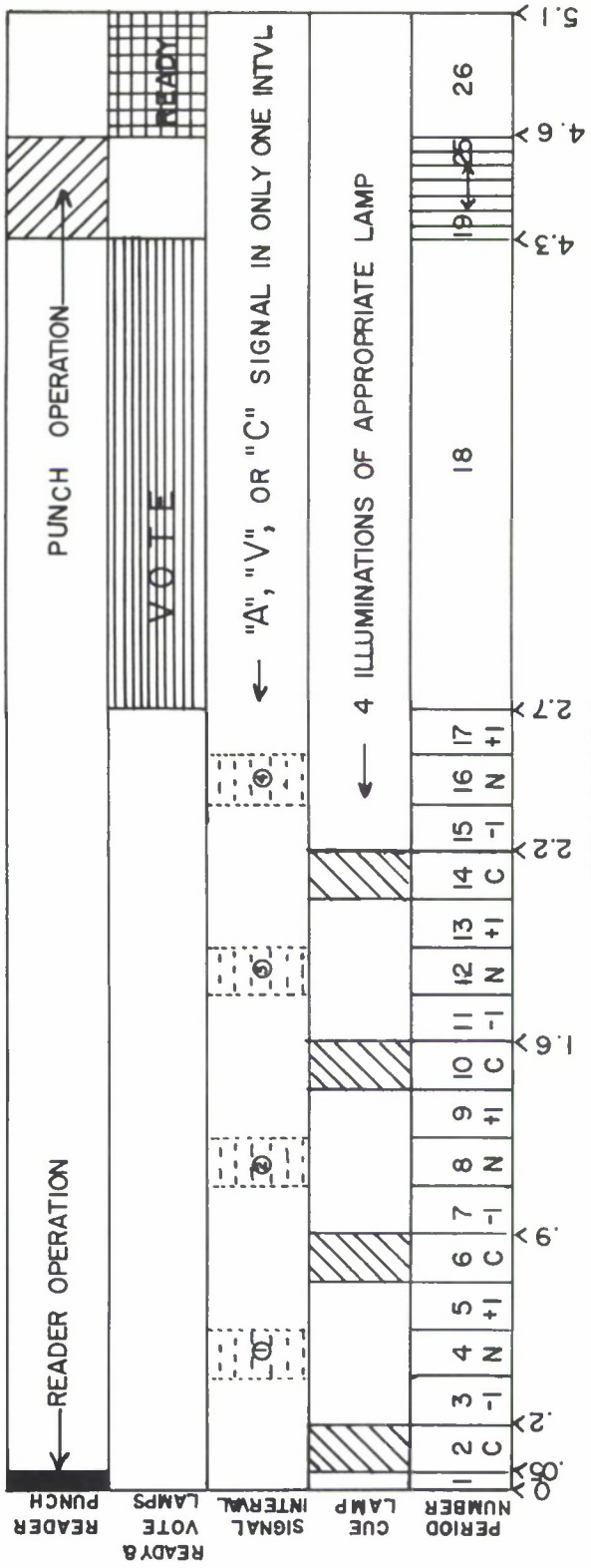


Figure 3. Phasing diagram. Numbers 1 through 26 in the period number channel refer to positions along the stepping switch in the control unit.

Auditory Display

The acoustic input consists of random noise filtered to a band 100-6800 cps and/or a pure tone signal. Both noise and signal are delivered to O binaurally through rubber-capped Grason Stadler HD 30 earphones. The noise and tone generators are located in a control rack outside the anechoic chamber and are described below as control equipment. The amplitude and frequency of the tone, as well as the amplitude of the noise, are easily manipulated by E. In addition, brief intensifications (bursts) or attenuations (interruptions) of noise and/or tone in any or all of the component time segments of four observation intervals, may be presented. There are four successive segments in each observation interval; identified as C, -1, N and +1: (see Fig. 3).

C. The normal time for illumination of the lamp in one of the cue boxes.

-1. The period immediately following C and preceding N.

N. The period during which the signal can be presented.

+1. The period between N and the beginning of the succeeding C for intervals ONE through THREE, and in the case of FOUR, the period between N and the start of the VOTE period.

Both magnitude and duration of intensifications (or attenuations) may be used as experimental variables, but are not varied within a single experimental run.

Observer's chair

The observer's chair is equipped with a viewing hood, two sets of response switches, and a "start experiment" switch.

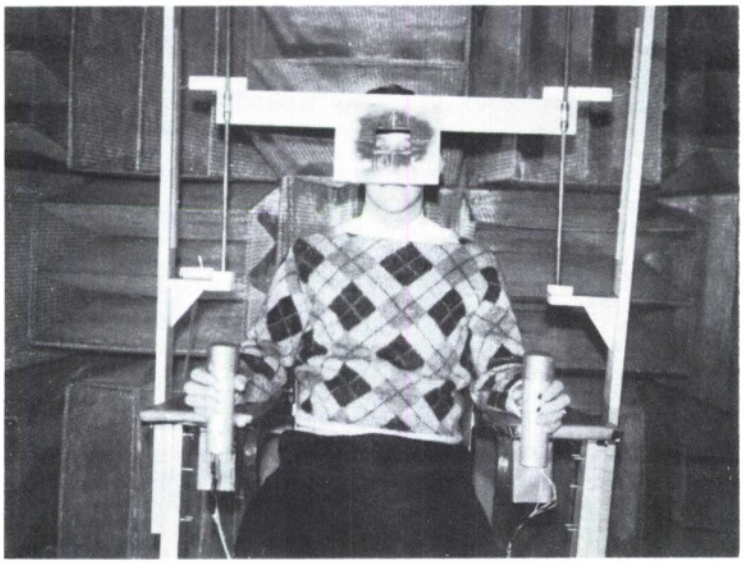


Figure 4. Observer seated in detection-response position. Earphones are worn for all testing, but are not visible due to viewing hood.

The viewing hood is vertically adjustable to accomodate individual differences in eye level. Its purpose is to restrict the observer's field of view to the area of the visual display. Similar in design to a stereopticon hood, the front is contoured to a shape approximating that of the face around the eyes, and is padded with rubber. At the end of the hood, about 5 1/2 inches from the eyes of a properly positioned observer, is a mask blocking all but a central, rectangular opening approximately 2.7" x 1.7", through which the visual display is viewed.

A set of response switches is housed in a cylindrical tube mounted at the front of each arm rest on the chair. The tubes are 2 inches in diameter and easily grasped when the forearms are resting on the arms of the chair. (See Figure 4). Each tube contains a set of vertically arranged push-button switches, which make an obvious tactual snap at the moment of circuit closure. The four switches on the observer's right correspond to the 4 observation intervals (1-4 from top to bottom). The two on his left usually correspond to the two possible signal modes (top for sound, bottom for light, both for combination). (At E's option, these two switches may be used instead for expression of confidence, or to supply other response data.)

The "start experiment" switch is a "spring back" toggle switch located in easy reach of O's right hand. This allows O to begin the experimental run when he is ready. The switch releases a "hold" in the control system, provided the system has been activated in all other respects.

CONTROL SYSTEM

The control system consists of a specially designed coding/decoding and timing unit used in conjunction with punched paper tapes; tape reader;

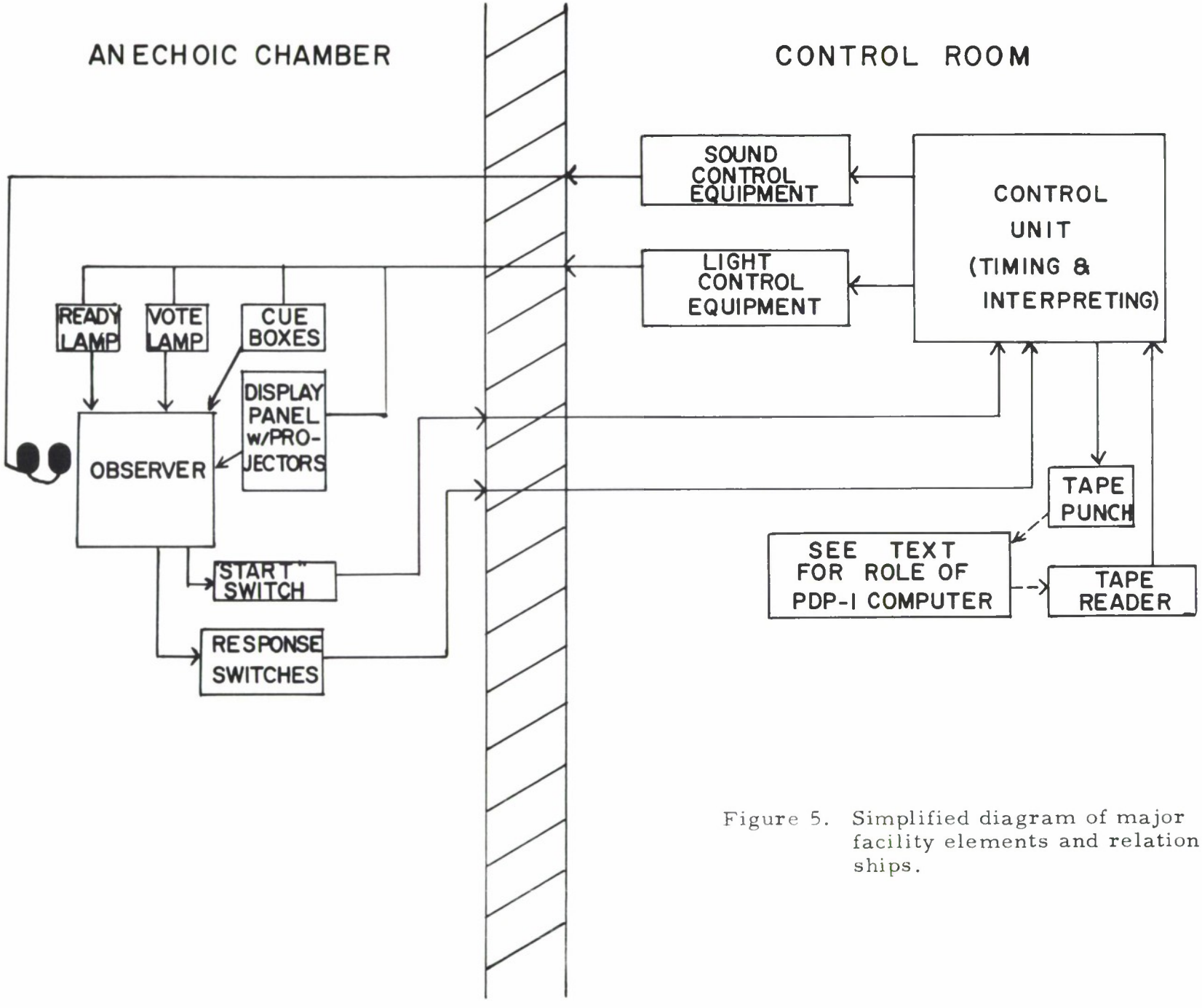


Figure 5. Simplified diagram of major facility elements and relationships.

tape punch and signal and noise generating apparatus. Figure 5 is a block diagram of the configuration of equipments. The system performs the following functions.

a. Translates the information contained on a punched paper tape input into circuit closures at times determined by constants and adjustments in the circuitry. The tape is read by an 8-hole paper tape reader. The input tape is coded by the computer programs described below. One line (6 bits) specifies signal mode, signal interval and cue type in accordance with the key shown in Figure 6.

b. Encodes and records on 3-line (18-bit) blocks of output tape, the following information pertaining to each experimental trial:

1) Type signal delivered

2) Type cue displayed

3) Interval in which signal delivered

4) Signal interval voted by O

5) Signal type voted by O (when O is required to specify signal type)

6) Whether O voted; end of run.

c. Halts the run on any trial in which O fails to vote during the "vote" period. Such a halt causes an alarm lamp on the control unit to light. Belated voting by O does not restart the equipment; restarting can be effected only by manual depression of a release push button on the control unit.

The auditory equipment includes a Model 456 Grason Stadler random noise generator and a Model 200 AB Hewlett Packard audio oscillator. The output of the noise generator is normally passed to the earphones

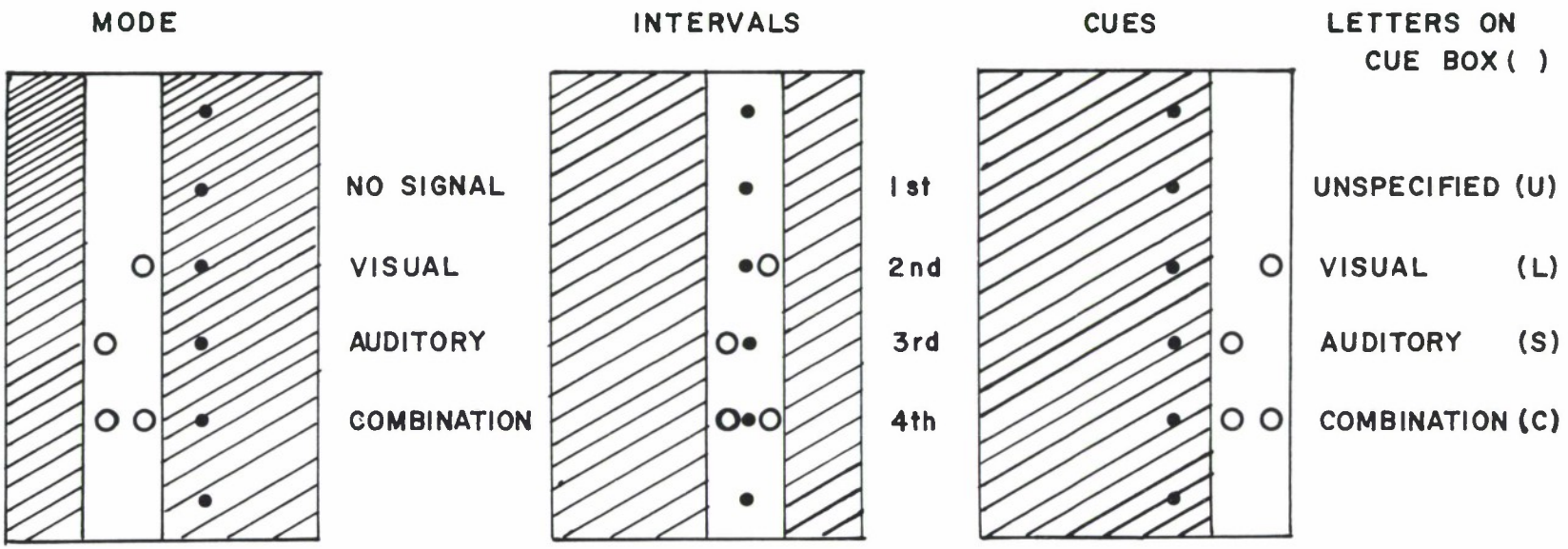


Figure 6. Code key for punched paper tape input to control unit. Six channels on one line of eight-channel tape are used to encode one trial. Channel allocation and interpretation are depicted above, with each trial being a combination of one of the Mode codes (channels 5 & 6), one of the Interval codes (channels 3 & 4), and one of the Cue codes (channels 1 & 2).

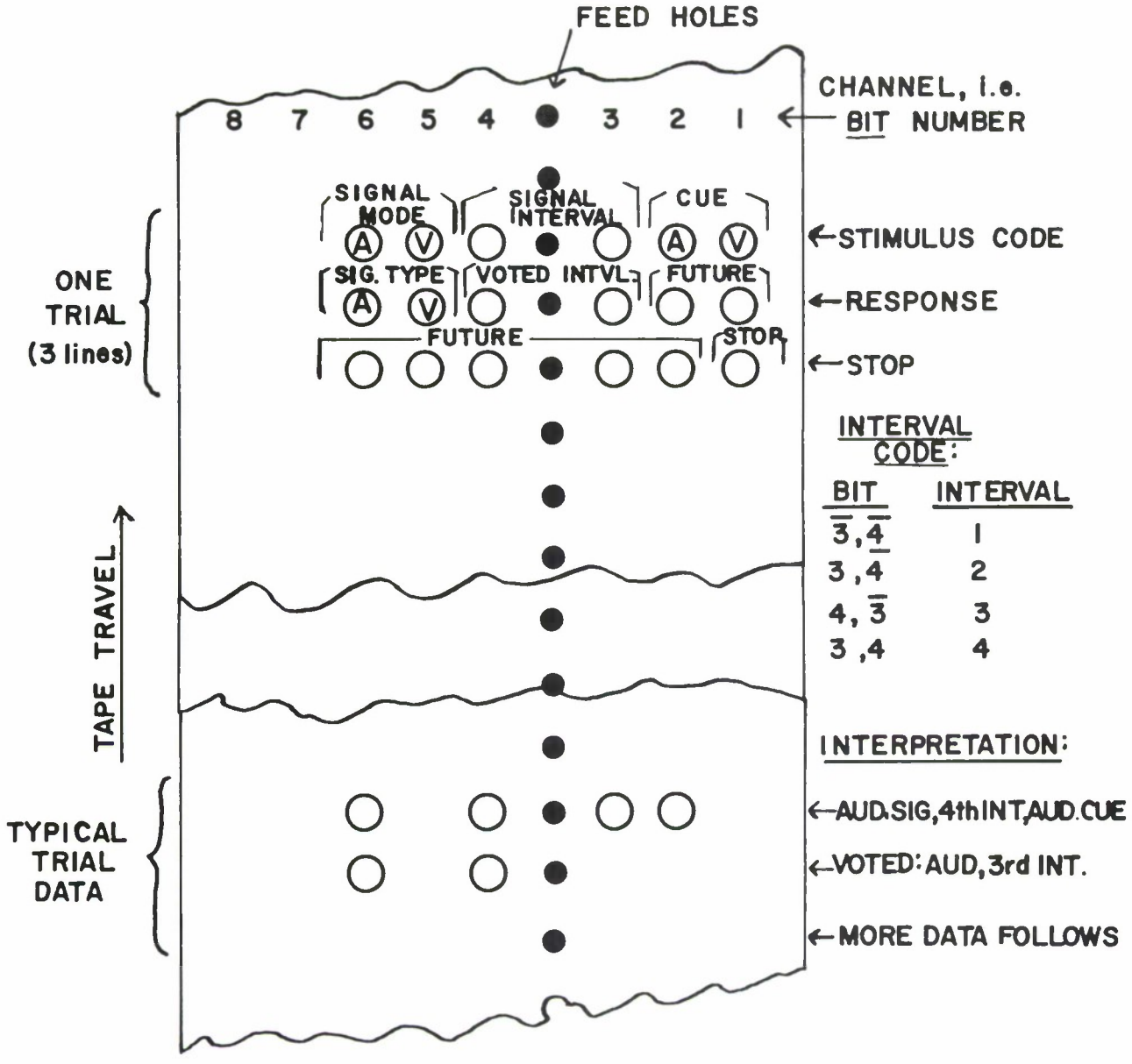


Figure 7. Data tape interpretation and explanation. Six channels of 8 channel tape are "used" per line. There are no open lines between the records of successive trials.

binaurally through a 100-6800 cps filter, its amplitude controlled by a Model 350A Hewlett-Packard 5 watt attenuator. The oscillator is capable of providing any desired frequency within the audible range. Its output is fed to the mixing input of the noise generator, where amplitude adjustments for the tone are made independently of those of the noise.

Visual equipment housed with the control system are a General Radio "Variac" (a variable transformer) and a set of filament transformers. The secondaries of the latter are wired in series with the normal projector lamp circuit. The primaries are wired to the Variac. If the input to the Variac is not energized by the control unit (i.e., if a visual stimulus is not present) only the normal projection lamp current flows - a "warming" current. When a visual stimulus is to occur, the control unit energizes the Variac and hence the transformer secondaries thus causing additional current to flow in the projection lamp circuit. By having the "warming" current always flowing, a faster onset of the visual stimulus is achieved.

In addition to actual control equipment, the control unit contains a configuration of monitor lights and a pair of digital counters. The monitor provides E with a trial-by-trial account of the progress of the experiment, displaying for each trial, as it occurs, the stimulus type, stimulus interval and O's vote with respect to both mode and interval. The counters accumulate the number of correct and incorrect responses, with respect to signal interval, thus providing a coarse indication of level of performance at the end of each run.

ROLE OF THE COMPUTER

The PDP-1 computer is used to generate "stimulus" tapes which are the input for the control unit, and to analyze "data" tapes output from the control unit.

It should be noted that programs may be written to generate any sequence of stimulus configurations within the capability of the equipment. The use of the computer to generate stimulus schedules allows E to acquire readily any desired number of schedules, all different with respect to the particular sequences, but the same with respect to certain specified statistical properties, such as: the relative frequency of occurrence of a particular stimulus event within some specified number of events, or sequential contingencies within some series of events.

A set of stimulus tape producing programs has been developed to satisfy immediate specific research objectives. These include programs to produce schedules with mixed mode signals (auditory, visual, combined) fixed mode signals (one type only), specified mode (cue corresponding to signal mode), unspecified mode ("unspecified cue) and inappropriate cue ("combined" cue, unimodal signal, and vice versa).

The advantages that the computer affords in the analysis of "data" tapes are obvious. It should be noted that the data tapes contain all the information including sequential, which is obtained in the experimental session. To date programs have been written to do only relatively simple summary type analyses, to reflect detection performance as a function of the primary independent variables under investigation.

REFERENCES

BLACKWELL, H. R., PRITCHARD, B. S., & OHMART, T. G. Automatic apparatus for stimulus presentation and recording in visual threshold experiments. J. Opt. Soc. Amer., 1954, 44, 322-326.

EGAN, J. P. & CLARKE, F. R. Psychophysics and Signal Detection. ESD-TDR-62-305. Bloomington, Ind. 1962.

SWETS, J. A. & GREEN, D. M. Signal Detection by Human Observers. ESD-TDR-64-174. Cambridge, Mass. 1964.

SWETS, J. A., TANNER, W. P. & BIRDSALL, T. G. Decision Processes in perception. Psychol. Rev., 1961, 68, 301-340.

WATKINS, W. H. Effects of certain noises upon detection of visual signals. J. exp. Psychol., 1964, 67, 72-75.