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ABSTRACT
                A study was devised to develop a method for
describing a continuous, complex perceptual-motor task in descrete
categories by which subjects could be pretrained through the use of
static, programed, audiovisual techniques; to construct an
audiovisual training device to provide realistic, programed practice
in the stimulus-response events selected for pretraining; and to
conduct an experimental study to determine the relative levels of
transfer-or-training between three pretraining treatments and a
transfer task. Subjects were 45 males who were randomly assigned to
one of three groups: one group was pretrained by presenting
categories in a natural task sequence, a second group was pretrained
on categories presented in random order, and a baseline group
received no category pretraining. Significant positive transfer was
found for both the sequenced and random forms of pretraining relative
to the baseline group, although these two experimental groups did not
differ from each other. (Author/SH)

# Transfer from Audiovisual Pretraining
# To a Continuous Perceptual-Motor Task[1]

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A technique was developed for providing transfer-of-training from a form of audiovisual pretraining to an instrument flight task. The continuous flight task was broken into discrete "categories of flight." Each category combined an instrument configuration with a return-to-criterion aircraft control response. Three methods of sequencing categories during pretraining were compared: (1) one group was pretrained by presenting categories in a natural task sequence, (2) a second group was pretrained on categories presented in random order; while (3) a baseline group received no category pretraining. Significant positive transfer was found for both the sequenced and random forms of pretraining relative to the baseline group. Transfer percentages ranged from seven to 48 per cent throughout transfer practice.

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One distinctive human characteristic is the ability to
perform a continuous, complex perceptual-motor task with
precision and reliability. Traditionally, perceptual-motor
tasks are taught using apprenticeship instruction. During
instruction, emphasis is placed on the use of the actual
vehicle and task. Three recent developments have led to a
need for more efficient techniques for developing perceptual-
motor skill.

First, the dollar cost associated with the purchase and
maintenance of criterion devices such as airplanes and
automobiles continue to increase. Secondly, the air or ground
space needed for initial practice of the criterion task is
often not available or is easily polluted. Thirdly, as the
general complexity of many perceptual-motor tasks increases,
fewer criterion practice situations are available which provide
an acceptable learning environment for the novice.

To reduce some of these problems, modern instructional

technology provides a number of training techniques to
facilitate motor skills instruction. For example, the train-
ing effectiveness of simulators and part-task trainers has
been clearly demonstrated. However, these devices are
becoming so sophisticated and costly that efforts must be made
to define least-cost training techniques which can precede,
augment or replace existing forms of simulator or part-task
instruction.

Research regarding (1) the strong conceptual nature of
the perceptual-motor task, and (2) techniques for providing
stimulus pretraining seem particularly promising as sources
for new least-cost training techniques. Recent work by Posner
and Keele (1971) highlights the notion of conceptual "motor
programs" which serve to drive complex motor behavior.
Similar constructs are offered by Attneave (1957) and
Oldfield (1954) under the general rubric of conceptual
"schema." In the area of stimulus pretraining, significant
transfer-of-training has been shown when stimulus pretraining
was used for discrete, discrimination-type motor tasks. The
research in this area, including studies on stimulus predif-
ferentiation, sensory preconditioning, and acquired distinc-
tiveness of cues, leads one to believe that these principles
could be used to train Ss in the cognitive "motor programs"
or "schema" which direct subsequent motor behavior. The
efficient use of this general approach has not been generally
employed in perceptual-motor training.

The objectives of this study were: (1) to develop a
method for describing a continuous, complex perceptual-motor

task in discrete cognitive terms by which $\underline{S}$s could be pretrained through use of static, programmed, audiovisual techniques; (?) to construct an audiovisual training device to provide realistic, programmed practice in the stimulus-response events selected for pretraining; and (3) to conduct a comparative experimental study to determine the relative levels of transfer-of-training between three pretraining treatments and the transfer task.

### METHOD

Forty-five male volunteer $\underline{S}$s were randomly assigned to one of three groups of 15 $\underline{S}$s. All $\underline{S}$s were adult males between the ages of 18 and ?8, and had no previous piloting experience.

Figure one shows the light airplane instrument trainer with simulated motion (i.e., the Link GAT-1), used to provide the training environment for the transfer task. The GAT-1 was operated only in the pitch dimension, thus restricting the instrument flight task to straight ahead variations in pitch and altitude only. A random "rough air" perturbation was used as a forcing function, while $\underline{S}$ error in pitch and altitude was integrated over time (i.e., absolute integrated error) through use of an analog computer. Temporal measures of trial and intertrial interval, time to level-off, and level flight time were recorded through use of interval and clock counters.

Figure two shows the Audiovisual Cockpit Trainer (ACT) constructed to provide pretraining sequences. The ACT was
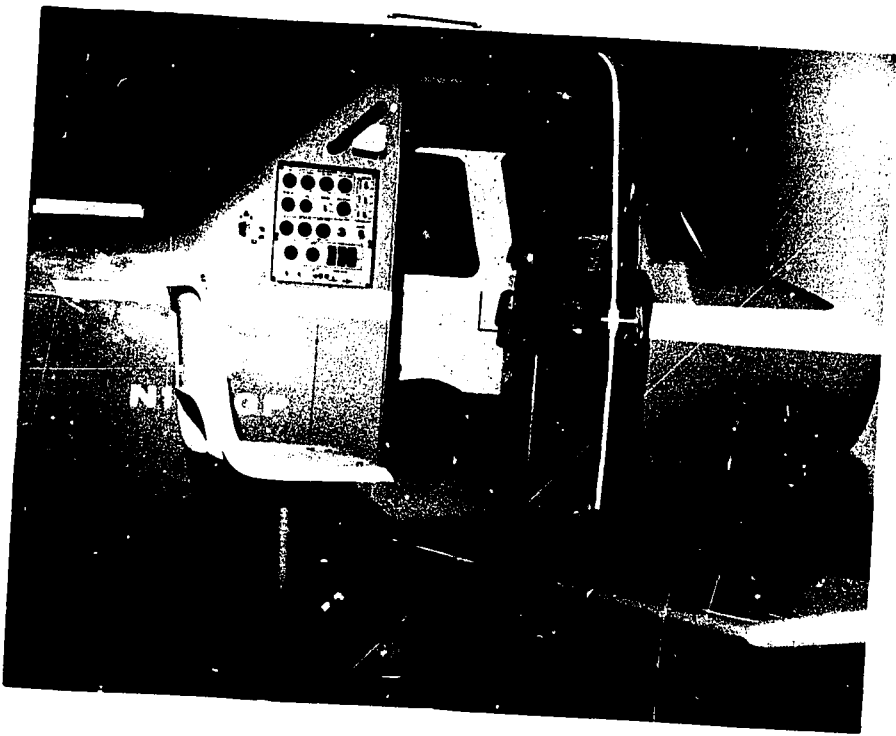
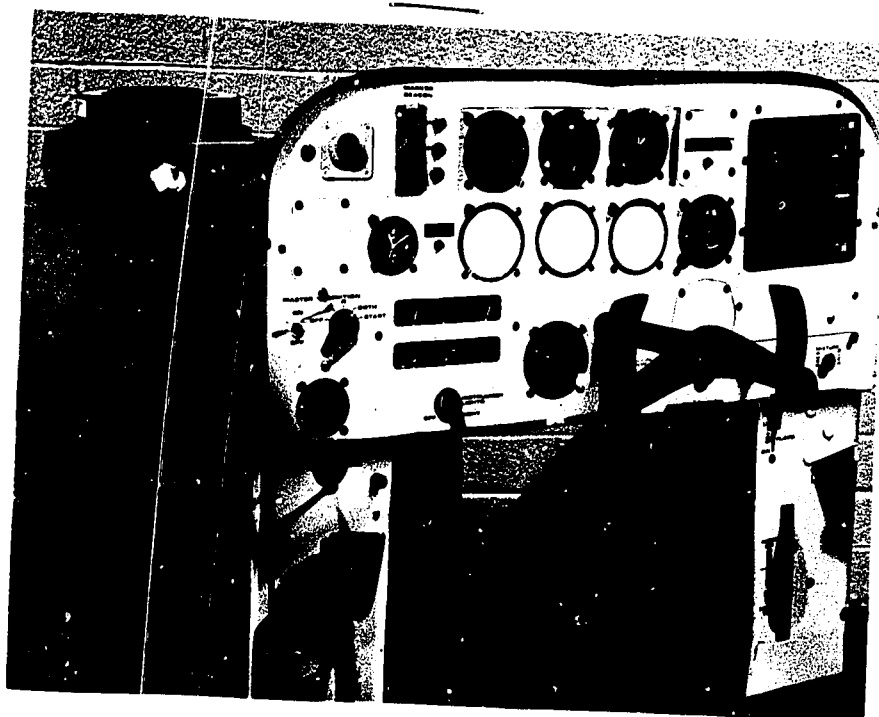Fig. 1. Link General Aviation Trainer (GAT-1).

Fig. 2.   Audiovisual Cockpit Trainer (ACT).

designed to represent the GAT-1 cockpit and provided: (1) wheel control; (?) a rear projection screen which represented the "instrument panel" of the GAT-1; and (3) a series of three lights which were used for feedback purposes. All dimensions and spatial relationships of the GAT-1 were preserved in the ACT. To provide open-loop wheel (pitch) responses to various instrument configurations, 35mm slides were displayed on the ACT "panel" by means of rear projection. Slide sequencing and audio instruction were provided by a cassette loaded tape programmer. Micro-switches positioned on the wheel assembly provided indications of $\underline{S}$ response for performance measurement and the display of knowledge-of-results. Accuracy and latency of response measures were obtained for all criterion test events. See Appendix I.

The following procedure was used for representing the instrument flight task in discrete terms for pretraining purposes: (1) the specific instruments involved in the criterion task were identified; (2) only three states were allowed for each instrument, i.e., greater than, equal to, or below a stated criterion; (3) all combinations of the selected instruments across three states were calculated; and (4) only those instrument combinations likely to be encountered in transfer performance were selected for pretraining purposes. See Appendix II for details.

Having selected a set of instrument "categories" appropriate for pretraining use, a pitch response was selected for each flight category which would initiate a

simulated return to the criterion flight condition. For example, the category "pitch high, altitude high" would require a wheel forward response to initiate a return to altitude. The category "pitch low, altitude low" would require a wheel back response to initiate a return to altitude. Inherent in this procedure is the definition of a set of mutually exclusive instrument configurations which represent the criterion task, but which can be manipulated in a number of different ways for pretraining purposes. It also provides a set of instrument-response categories which, taken singly or together, provide a general strategy for moving from a state of error to a "correct" criterion condition.

In terms of the present study, two variations in instructional sequence were explored. One group of 15 Ss received pretraining in flight categories which were sequenced in a natural task order, while a second group of 15 Ss were trained in the same flight categories presented randomly. A third, or baseline group of 15 Ss received no pretraining on flight categories, but did receive a form of pretraining which acquainted Ss with single-instrument reading skills only.

As shown in Figure 3, the experimental design required two experimental sessions presented on two consecutive days. On the first day, all Ss were given a simple reaction time test, and were required to read a simple "air to ground" message of the kind used for time sharing during the last six trials of transfer performance. Following a short audiovisual
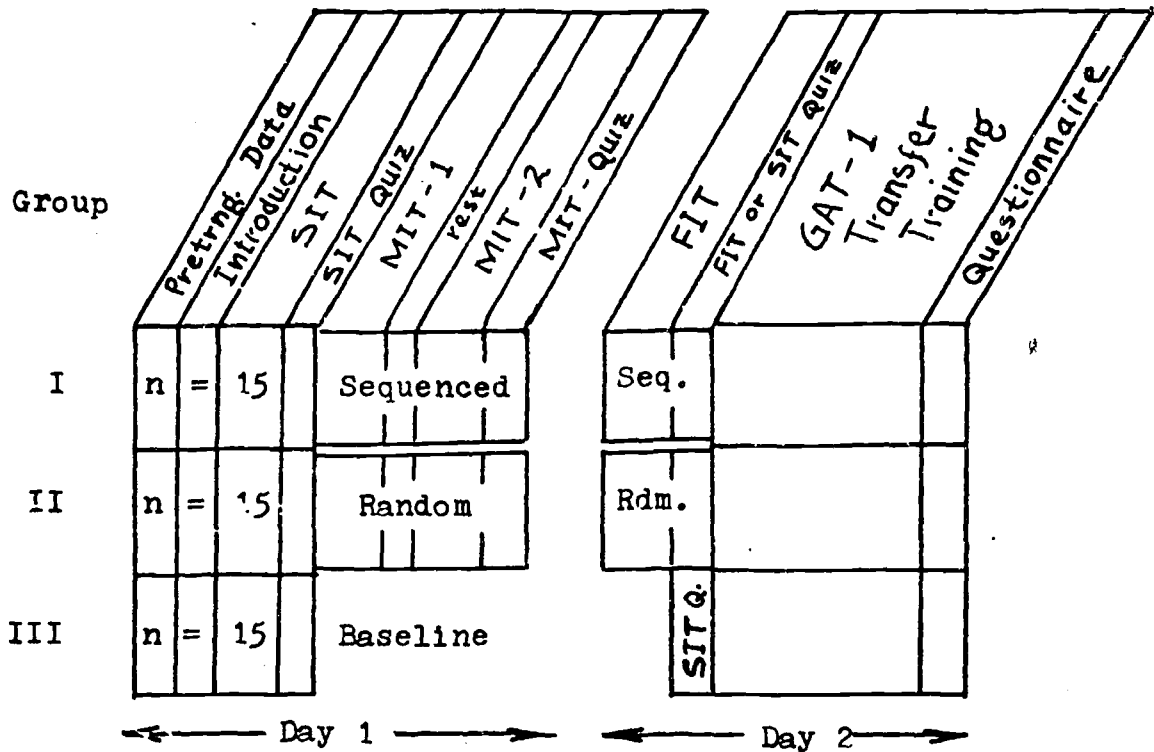
Fig. 3 Block diagram of experimental design showing temporal sequence of training events. Simple reaction time and message reading data were obtained under the heading Pretraining Data. Other abbreviations are as follows: SIT=Single Instrument Training; MIT=Multiple Instrument Training; and FIT=Final Instrument Training.

"introduction" program, all Ss received a linear, programmed
sequence on how to read pitch or altitude instruments when
presented singly. During this instruction, Ss used switches
located on the ACT panel to make identification responses to
questions presented on 35mm slides. A criterion test was
administered after single instrument training. Following
completion of this phase of instruction, the two experimental
groups were given either sequenced or random pretraining on
selected flight categories (i.e., multiple instrument train-
ing). Wheel responses were made during this phase of
instruction, with linear programming techniques being used to
guide Ss through a total of 18 exposures to each flight
category. A criterion test which required responses to
flight categories presented in both a sequenced and random
fashion were given after this training.

On the second day, baseline Ss were re-examined in single
instrument reading skills, and then given practice in the
transfer GAT-1 task. Experimental Ss received brief pre-
training sequences of either a sequenced or random nature,
followed by a "final practice" criterion test and practice on
the transfer task.

The transfer task is shown schematically in Fig. 4. Ss
were required to: (1) make a controlled climb or descent of
200 feet to an altitude of 3000 feet; (2) maintain level
flight at 3000 feet for 40 seconds; and (3) establish a
controlled climb or descent until the termination of a trial.
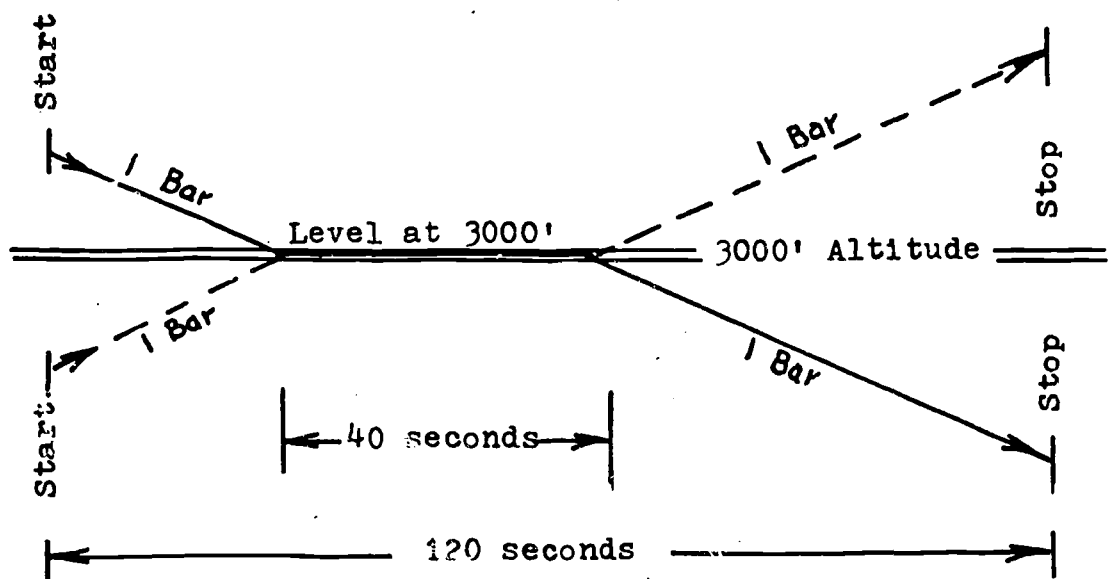Twelve two-minute trials were presented, followed by an

Fig. 4. Flight profile (i.e., ideal) of transfer task.

additional six trials in which $\underline{S}$s were required to read a
message while performing the level-flight portion of the
task. Trials were blocked by pairs of two for statistical
analysis.

## RESULTS AND DISCUSSION

A first measure of transfer performance in the GAT-1 was
time-to-level-off. To obtain this measure, $\underline{S}$s were timed as
they climbed or descended through 200 feet altitude at a 500
fpm rate. At 500 fpm, 24 seconds were required to move
through 200 feet of altitude. Variations from this 24 second
ideal were used as the time-to-level-off error measure. A
natural log transform was applied to the raw data to reduce
positive skew (Winer 1962). Figure 5 shows these data.

Based on a repeated measure analysis of variance
(Lindquist Type I), significant between $\underline{S}$ differences were
found, $F(2, 42)=11.1355$, $p<.0003$. Post hoc analysis of
simple main effects showed significantly less error for
sequenced trained $\underline{S}$s relative to baseline $\underline{S}$ during trials
7-8, $p<001$, and trials 13-14, $p<.05$. Significant simple
main effects were also found between baseline and random
trained $\underline{S}$s at trials 15-16, $p<.01$, and trials 17-18, $p<.05$.
The reliability coefficient, as estimated by Hoyt's (1941)
analysis of variance procedure, yields $r=.606$.

To more clearly display the direction and amount of
transfer, Fig. 6 shows the time-to-level-off data in terms of
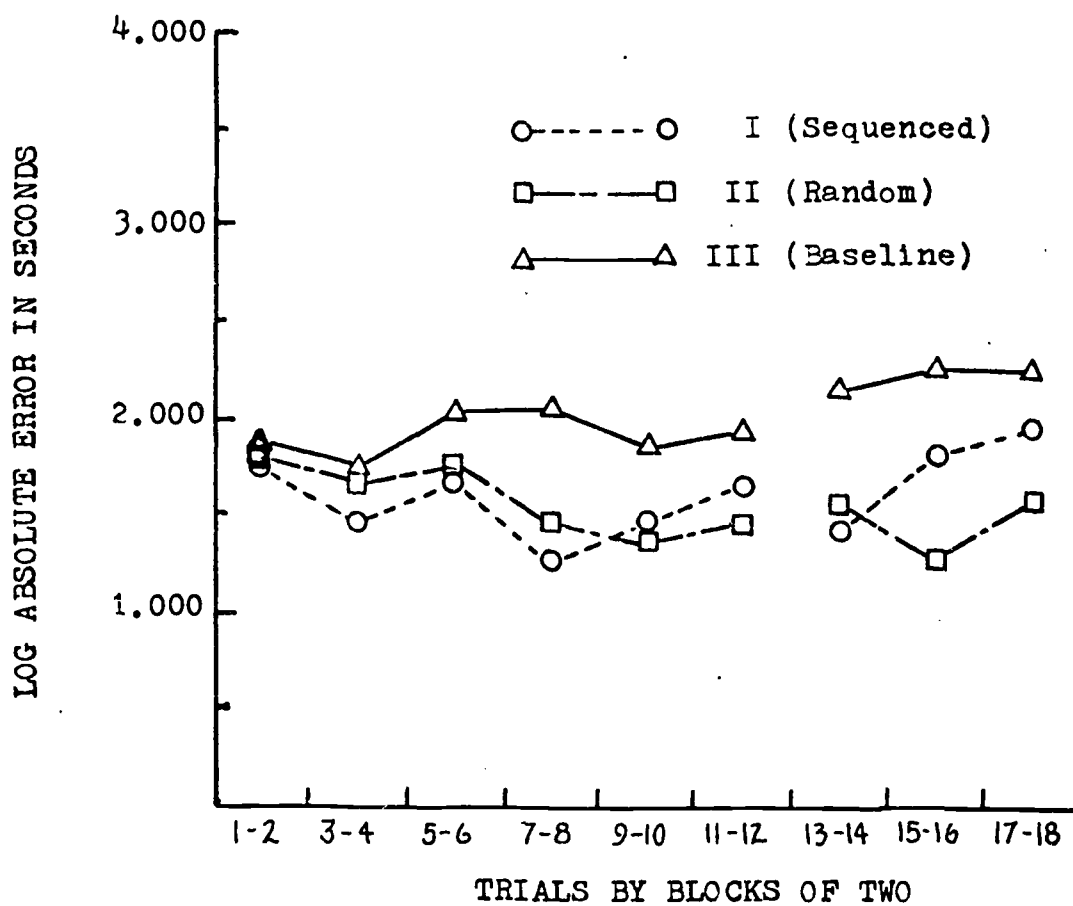per cent transfer. The Murdock (1957) formula was used where

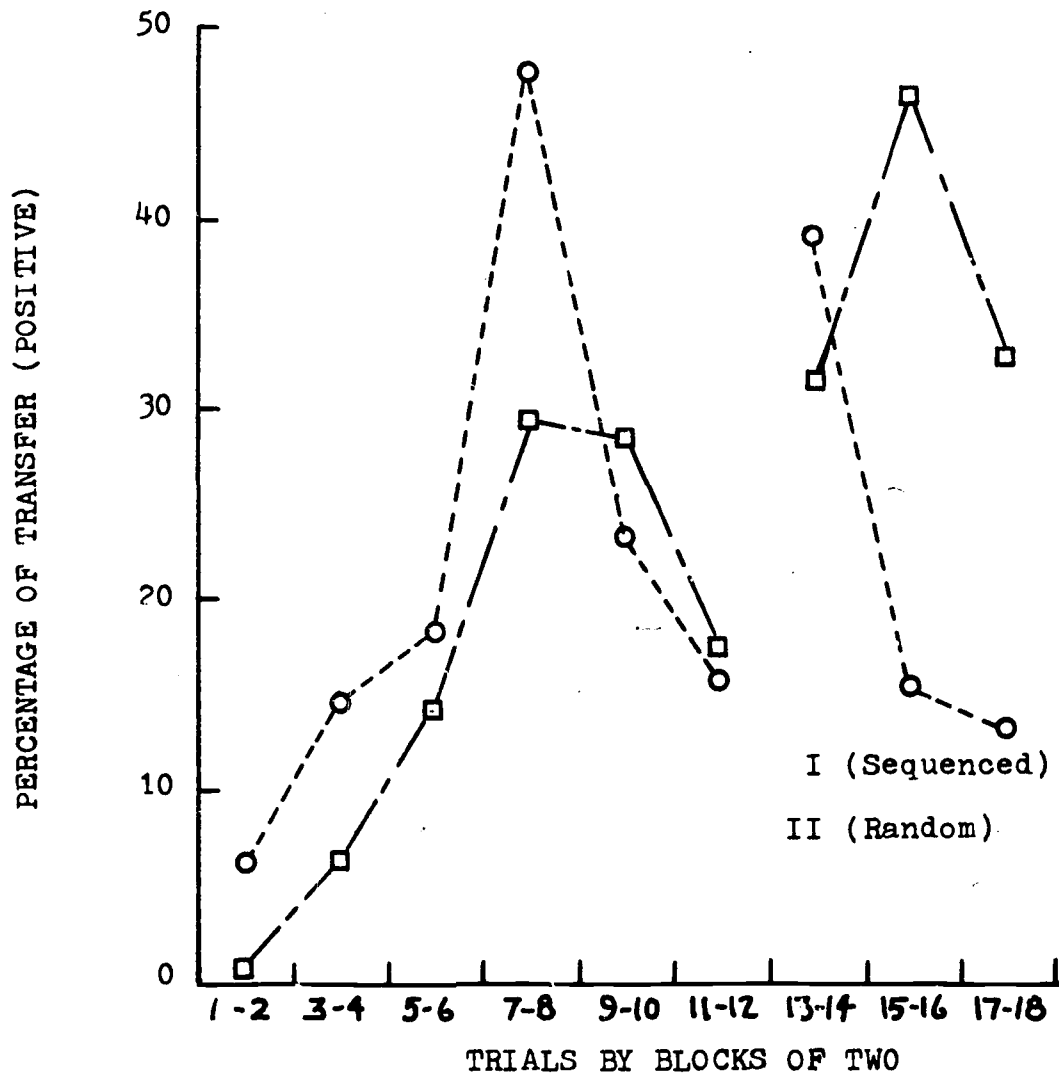Fig. 5. Mean absolute time-to-level-off error relative to 24-second-ideal.

Fig. 6.  Percentage of transfer for Time-To-Level-Off measure.

$$\text{Percentage of transfer} = \frac{\text{Experimental Score-Control Score}}{\text{Experimental Score+Control Score}} \times 100.$$

Log transform scores were squared prior to use in this formula to provide a best compromise between raw and log transformed data (Myers, 1966).

The profiles of Fig. 6 show transfer effects increasing with practice. During trials 15 through 18, random trained Ss show sustained transfer effects around the 40 per cent level.

A second transfer measure was a combination of two absolute integrated pitch error scores, i.e., pitch error obtained before level off plus pitch error obtained after termination of level flight. Figure 7 shows these data. To reduce positive skew, data were again transformed to natural logs. A Type I ANOVA showed significant between Ss effects, $F(2, 42)=3,446$, $p<.04$. Post hoc analysis of simple main effects showed early differences between baseline and experimental groups. Sequenced trained Ss were significantly better than baseline during trials 1-2, $p<.01$ trials 3-4, $p<.05$, and trials 5-6, $p<.05$. Random trained Ss showed significant gains during trials 1-2, $p<.01$, and trials 5-6, $p<.05$. Test reliability, as estimated by Hoyt's (1941) procedure, gives $r=.758$.

Figure 8 shows the approach plus departure pitch data as per cent transfer. The Murdock (1957) formula and squared log scores (Myers, 1966) were again employed. Relative to this measure, lesser amounts of transfer occur. Only early
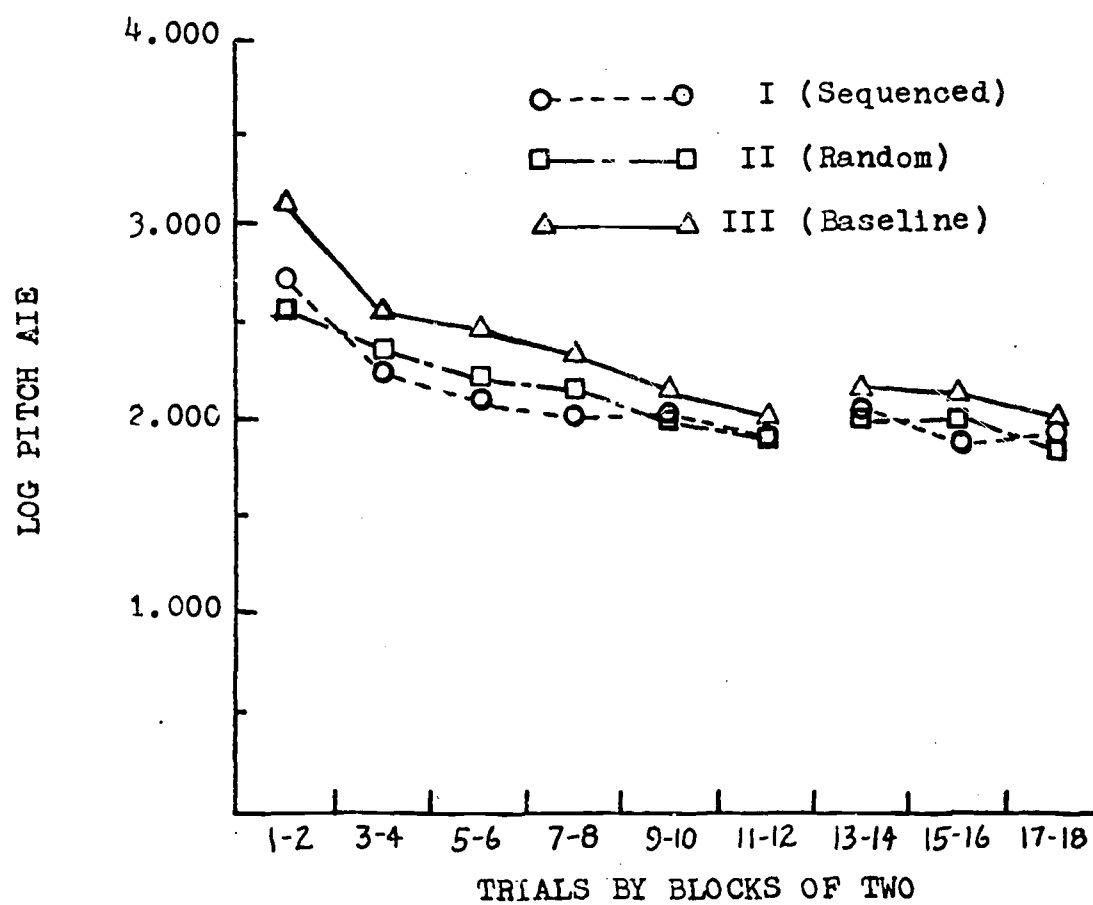
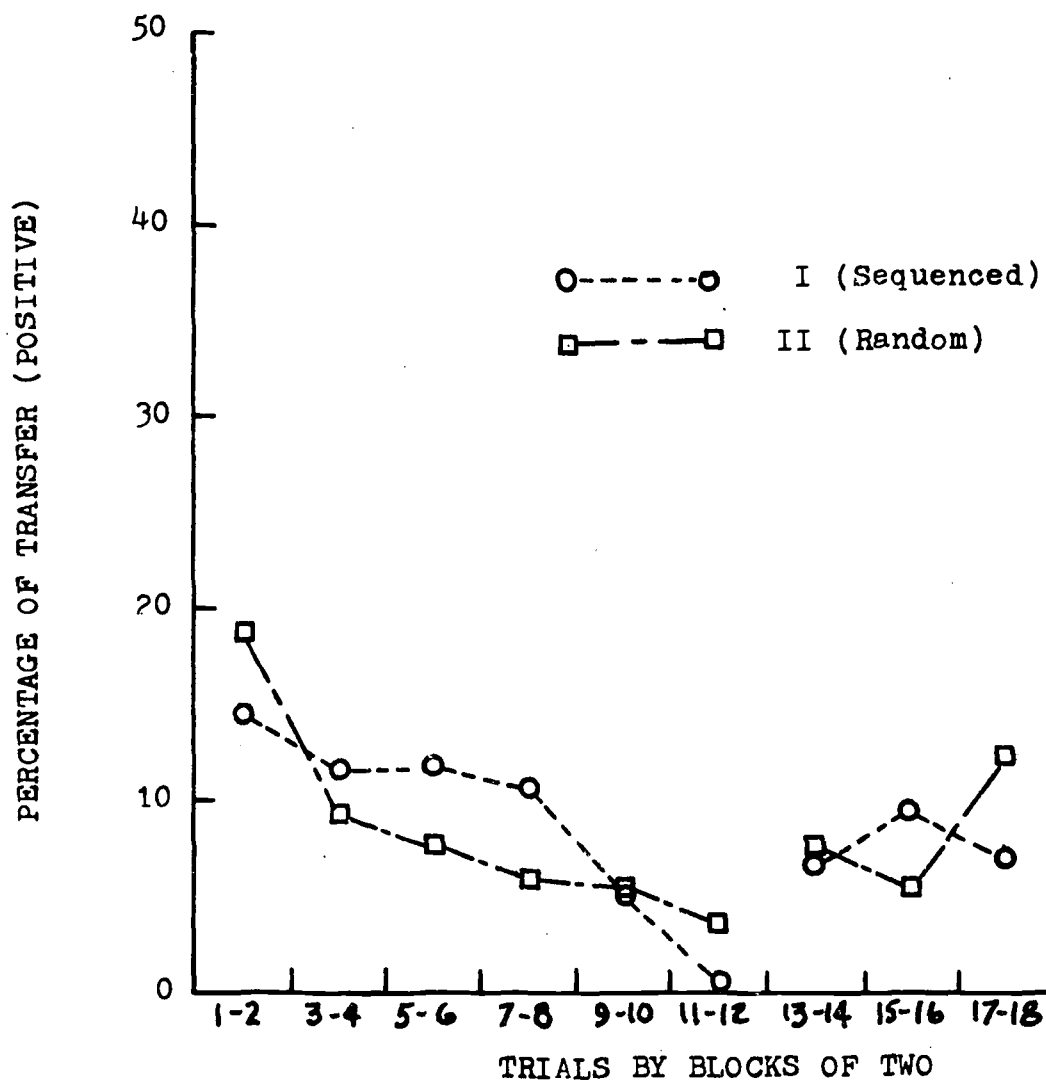Fig. 7. Mean Approach-Plus-Departure-Pitch error (Log AIE) as a function of transfer practice.

Fig. 8. Percentage of transfer for Approach-Plus-Departure-Pitch measure.

significant effects are apparent, i.e., trials 1 through 6,
with per cent transfer ranging from 18 per cent to 7 per cent.

A final set of measures reflect performance during the
level flight portion of transfer practice. Figure 9 shows
these data. Absolute Integrated Error was obtained for both
pitch and altitude. Natural log transforms were used to
reduce positive skew. Type I ANOVA showed no significant
differences for the pitch error measure. However, significant
findings were observed for altitude error, $F(2, 42)=4.057$,
$p<.0239$. Post hoc analysis of simple main effects showed
significantly less error for sequenced trained $\underline{S}$s relative
to baseline $\underline{S}$s during trials 1-2, $p<.05$, trials 3-4, $p<.05$,
and trials 17-18, $p<.05$. Similar significant results were
shown for random $\underline{S}$s relative to baseline during trials 11-1?,
$p<.01$, and trials 17-18, $p<.05$. Test reliability, as estimated
by Hoyt's (1941) procedure, gives $r=.839$.

By squaring the log scores (Myers, 1966) for use in the
Murdock (1957) per cent transfer formula, the data of Fig. 10
is generated. In the altitude control task, both forms of
pretraining provide transfer percentages that range from 16
to 24 per cent. Transfer effects also appear to persist
throughout all 18 transfer trials.

Considering the transfer data, several useful conclusions
can be drawn. Of primary importance was the finding that a
complex, continuous, perceptual-motor task can be pretrained
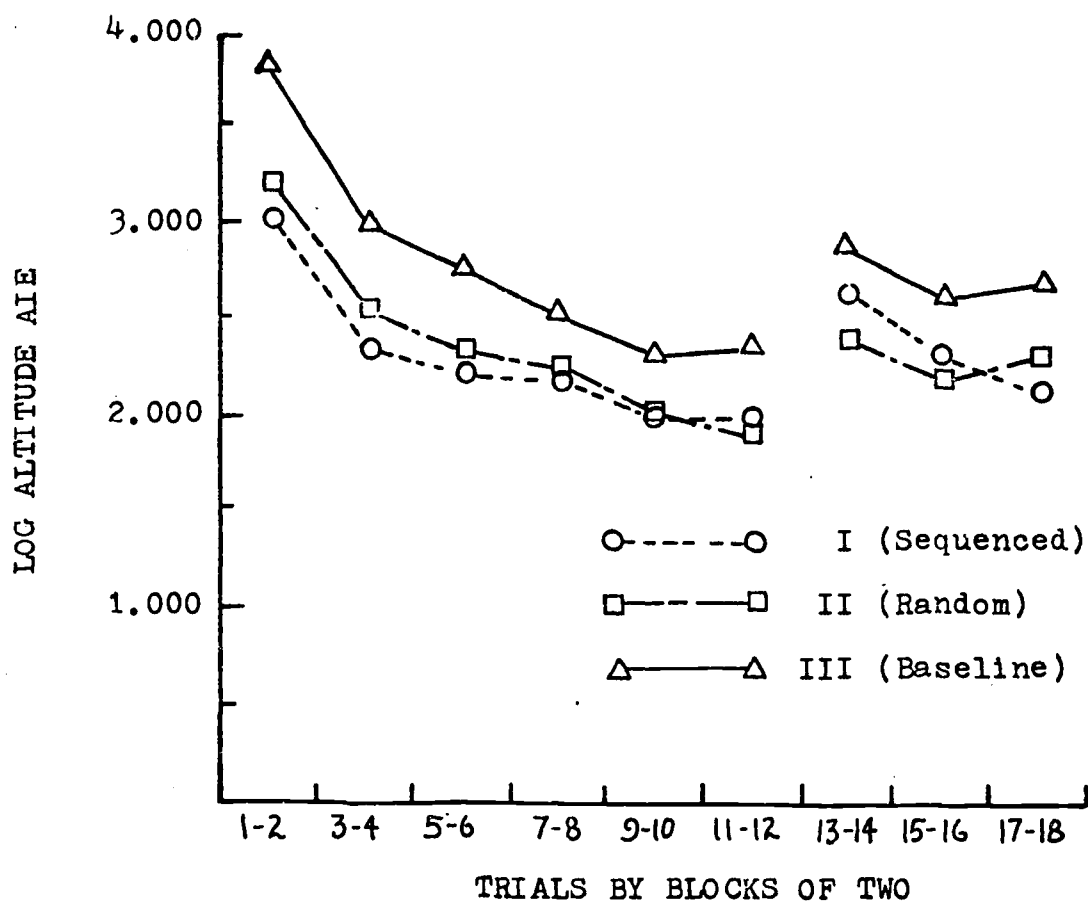using programmed, sound-slide techniques. Transfer

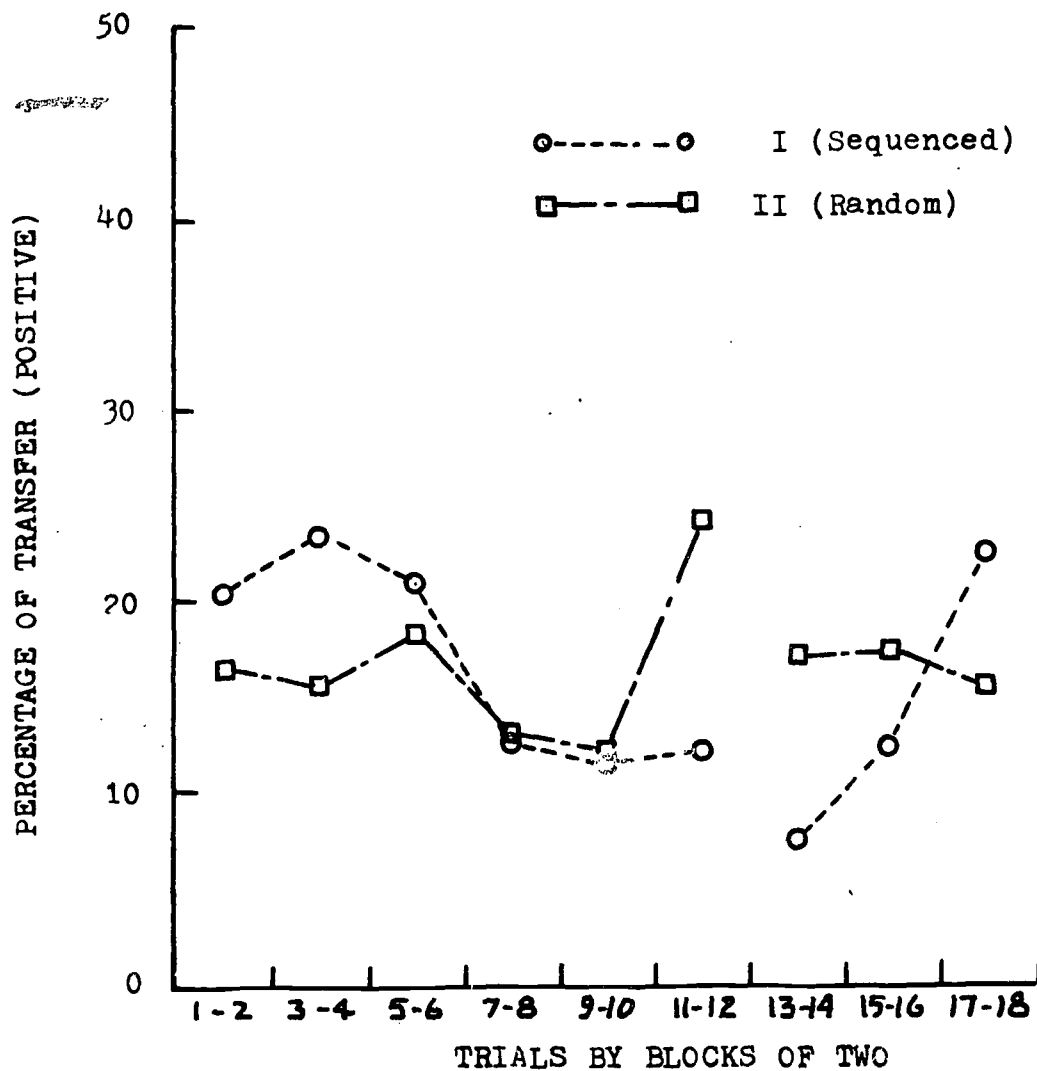Fig. 9. Mean altitude error during level flight (Log AI E) as a function of transfer practice.

Fig. 10. Percentage of transfer for Altitude-During-Level-Flight measure.

percentages ranging from seven to 48 per cent throughout

transfer practice suggest a pretraining technique of definite

practical potential. The immediate and sustained indication

of positive transfer during transfer practice provides clear

support for a relevant stimulus, relevant response form of

pretraining. Support is also given to the category method of

separating a continuous task into discrete parts, and the

notion of training $\underline{S}$s in error correction strategies rather

than a specific representation of the maneuver, (e.g., main-

taining level flight when return to level flight was the only

task pretrained). The results of this study also reduce

concern over pretraining characteristics which could have

provided negative transfer effects. The open-loop nature of

practice, lack of control "feel," fixed aircraft control

excursions, and no instrument movement represents factors of

this nature.

A lack of significant differences between random and

sequenced pretraining does not support the existence of major

differences between these treatments. A tendency for random

pretraining to provide a more sustained effect relative to

baseline is seen in the last four trials of time-to-level-

off. Random trained $\underline{S}$s also show sustained transfer effects

during trials 11-12 and 17-18 of the altitude-during-level-

flight measure. Considering the weak nature of these

findings, however, real differences between sequenced and

random pretraining are only suggested. It may be that future

research will show advantages for a random form of training

not determined in this study. For example, in the present
study it must be assumed that random trained $\underline{Ss}$ learned the
sequential dependency of the criterion task by their own
methods. This learning could occur during pretraining
through $\underline{S}$ logic, and/or during transfer practice. If $\underline{S}$ can
quickly learn the sequential aspects of a task in this way, a
well constructed random pretraining sequence could provide $\underline{S}$
with successful pretraining in the basic stimulus-response
elements of a large class of maneuvers. Should this occur,
the flying training student would have opportunity to
practice the task elements of flight much as the musician
practices the "scales" of music to better subsequent
performance.

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APPENDIX I

Functional diagrams of GAT-1 and ACT circuitries.
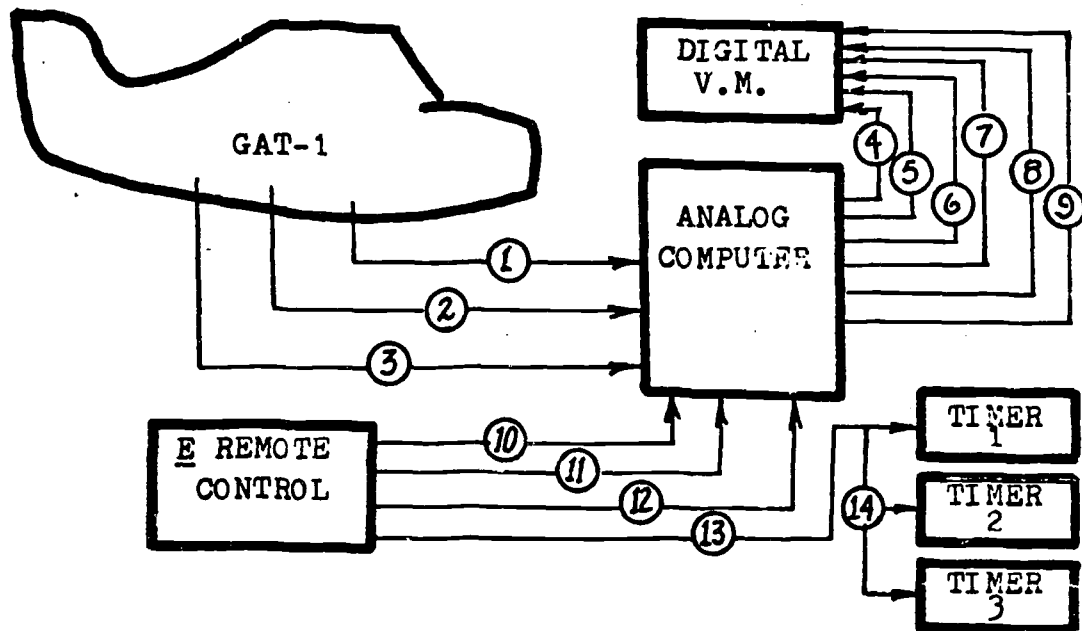
| GAT-Output | E Remote Control |
|---|---|
| 1. D.D. pitch error | 10. Analog reset |
| 2. D.C. altitude error | 11. Pitch climb/level/dive bias |
| 3. D.D. forcing function | 12. Pitch/altitude selector |
| | 13. Trial start |
| Analog to Digital VM | 14. Timing circuitry |
| 4. Pitch AIE | Timers |
| 5. Altitude AIE | |
| 6. VSI | 1. Trial interval timer |
| 7. Altimeter | 2. Pitch clock counter |
| 8. Forcing function | 3. Level flight clock counter |
| 9. Reference voltage | |

Functional circuit diagram of transfer equipments.
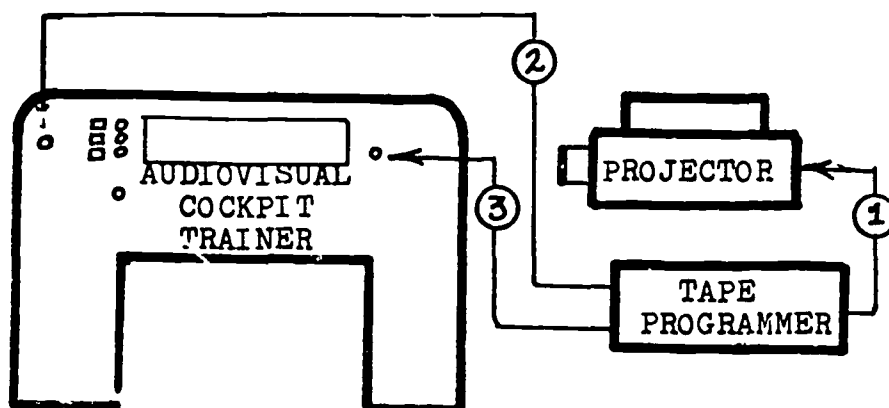
1. Slide synchronizer cord
2. Audio out for headphones
3. Tape programmer restart

Functional diagram of external ACT components.
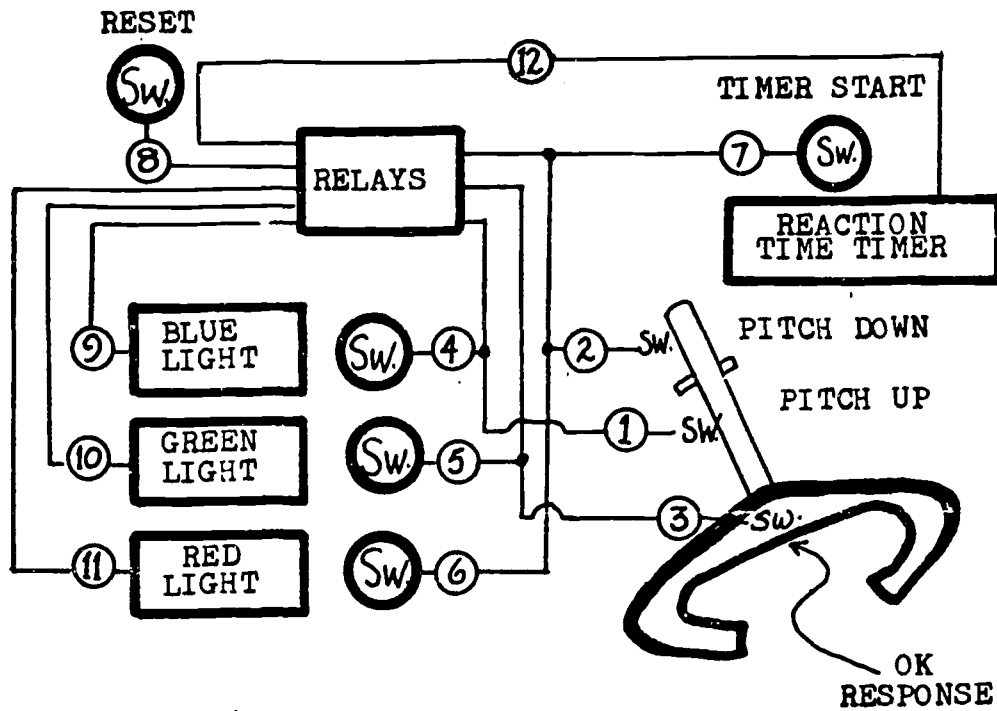
## Switched Inputs

1. Pitch up (wheel back)
2. Pitch down (wheel forward)
3. "OK" pitch response
4. Above response
5. Equal response
6. Below response
7. Reaction time start

## Reset

8. Reset switch

## Relay Out

9. Blue light
10. Green light
11. Red light
12. Reaction time stop

Functional diagram of ACT response and feedback circuits.

APPENDIX II

RULES FOR FORMING FLIGHT CATEGORIES

1.  Select instruments needed for performance of the task.  In the present study, only the altimeter and the pitch indicator of the artificial horizon was used.

2.  Select the flight criterion (criterions) which represent desired performance.  Level flight at 3000 feet was selected as the criterion task.

3.  Allow only three states to exist for any given instrument, i.e., greater than, equal to, and less than criterion.  Equivalent states for an altimeter would be high, OK, low.  States for pitch wuld be up, level, and down.

4.  Plot all possible combinations by instruments and states.  The nine combinations for altitude and pitch are shown below.  The maximum number of combinations equals the number raised to a power equal to the number of instruments, thus $3^n = 3^2 = 9$ categories.

| Category | Altitude | Pitch |
|----------|----------|-------|
| 1 | High | Up |
| 2 | High | Level |
| 3 | High | Down |
| 4 | OK | Up |

| Category | Altitude | Pitch |
|----------|----------|-------|
| 5 | OK | Level |
| 6 | OK | Down |
| 7 | Low | Down |
| 8 | Low | Level |
| 9 | Low | UP |

5. <u>Select those categories of flight likely to be encountered during practice, or those which are to be manipulated for experimental purposes.</u> In the present study, emphasis was placed upon error correction strategies, i.e., training Ss to return to 3000 feet. Because the middle three categories represent flight at 3000 feet, they were not included in the pretraining regime.

6. <u>Assign appropriate responses to the categories selected for use.</u> The assignment of responses for this study is as follows:

| Category | Altitude | Pitch | Wheel Response |
|----------|----------|-------|----------------|
| 1 | High | Up | Wheel forward |
| 2 | High | Level | Wheel forward |
| 3 | High | Down | OK |
| 4 | Low | Down | Wheel back |
| 5 | Low | Level | Wheel back |
| 6 | Low | Up | OK |

7. **Subdivide a given category with corollary response rules if required.** The present study required training of one-bar descents and level-offs for categories three and six. The final flight categories, with limiting instrument conditions, are:

| Category | Altitude | Pitch | Condition | Wheel Response |
|----------|----------|-------|-----------|----------------|
| 1 | High | Up | Any | Forward |
| 2 | High | Level | Any | Forward |
| 3a | High | Down | 1 bar | OK |
| 3b | High | Down | >1 bar | Back |
| 3c | High | Down | >40 feet | Back |
| 4 | Low | Down | Any | Back |
| 5 | Low | Level | Any | Back |
| 6a | Low | Up | 1 bar | OK |
| 6b | Low | Up | >1 bar | Forward |
| 6c | Low | Up | >40 feet | Forward |