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AN AUTOMATED SYSTEM TO ASSESS PILOT PERFORMANCE IN A LINK GAT-1 TRAINER

Peter H. Henry, et al

School of Aerospace Medicine
Brooks Air Force Base, Texas

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NOTICES

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The voluntary informed consent of the subjects used in this research was obtained in accordance with AFR 80-33.

This technical report has been reviewed and is approved for publication.

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A prototype control and scoring system has been developed around the Link GAT-1 trainer that permits laboratory assessment of pilot performance. This system automatically presents subjects with an hour-long series of maneuver requests providing a laboratory approximation of a cross-country flight on instruments in a single-engine light aircraft. Performance is scored electronically in terms of how closely subjects are able to stay within the tolerances prescribed for various flight instruments as they execute the series of maneuvers.

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20. Abstract (continued)

Major components of this non-computer based system are: (1) two Link GAT-1 trainers; (2) special display panels mounted in the cockpit of each trainer; (3) a central control station; (4) an assembly of special-purpose analog and digital logic for error detection and scoring; and (5) paper tape perforators for data logging. This report covers the basic design and circuitry details. Results of performance tests using this system are reported elsewhere.

PREFACE

The authors express their appreciation to Mr. George A. Rex and MSgt. Makely G. Salter of the Biomedical Electronics Branch of the USAF School of Aerospace Medicine, for their contributions to the design and documentation of the Error Detection Control Board.

CONTENTS

CONTENTS (continued)

ILLUSTRATIONS

CONTENTS (continued)

TABLES

AN AUTOMATED SYSTEM TO ASSESS PILOT PERFORMANCE IN A LINK GAT-1 TRAINER

INTRODUCTION AND BACKGROUND MATERIAL

To objectively assess pilot performance in the laboratory, a special-purpose control system was developed around the Singer Co. GAT-1 flight trainer. This system has already been described in general terms in previous reports detailing the results of tests at three alcohol dose levels using rated and nonrated subjects (1, 2, 3). A general review of earlier work using Link trainers to assess performance by other investigators has also been written (2). The purpose of this report is to provide sufficient additional details of the system organization and hardware to permit construction and employ of similar task systems. It should be emphasized that the prototype system was assembled primarily from readily available pieces of equipment and bench stock electronic items. The direct duplication of this prototype system using the same equipment is not recommended. Because we envision replacing the prototype control system with a mini-computer some time in the near future, this report will be summary in nature and we will not attempt full documentation of the type desirable for a service manual.

Link GAT-1 Trainer

Several years ago, the Singer Link Corporation began to market a low-cost flight trainer called the Link General Aviation Trainer, Model 1 (GAT-1). This trainer was designed to introduce and train students in the procedures involved in flying a single-engine light aircraft. Instruction and rating of the student's performance were intended to be accomplished by an instructor-rater seated behind and to the side of the trainee (Fig. 1). To conduct laboratory investigations of human "flying performance" as a function of physiologic and environmental stresses, the Psychobiology Function of the USAF School of Aerospace Medicine (SAM) acquired four of these trainers. A major shortcoming of the commercial version that precluded the trainer's immediate use, however, was the lack of any automated and objective performance measures.

Semiautomated Link Performance Test

Description--The first version of an electronically scored simulated flying performance test was developed at SAM in 1970. The test required subjects to fly a sequential series of climbs and dives to one of three altitude values (1000 ft, 1500 ft, and 2000 ft (±40 ft)) while maintaining a fixed heading (±5°), a fixed airspeed (±5 mph), and a vertical velocity not to exceed ±500 fpm. The performance measures were: (a) the number of 500-ft altitude changes completed during the session; (b) the

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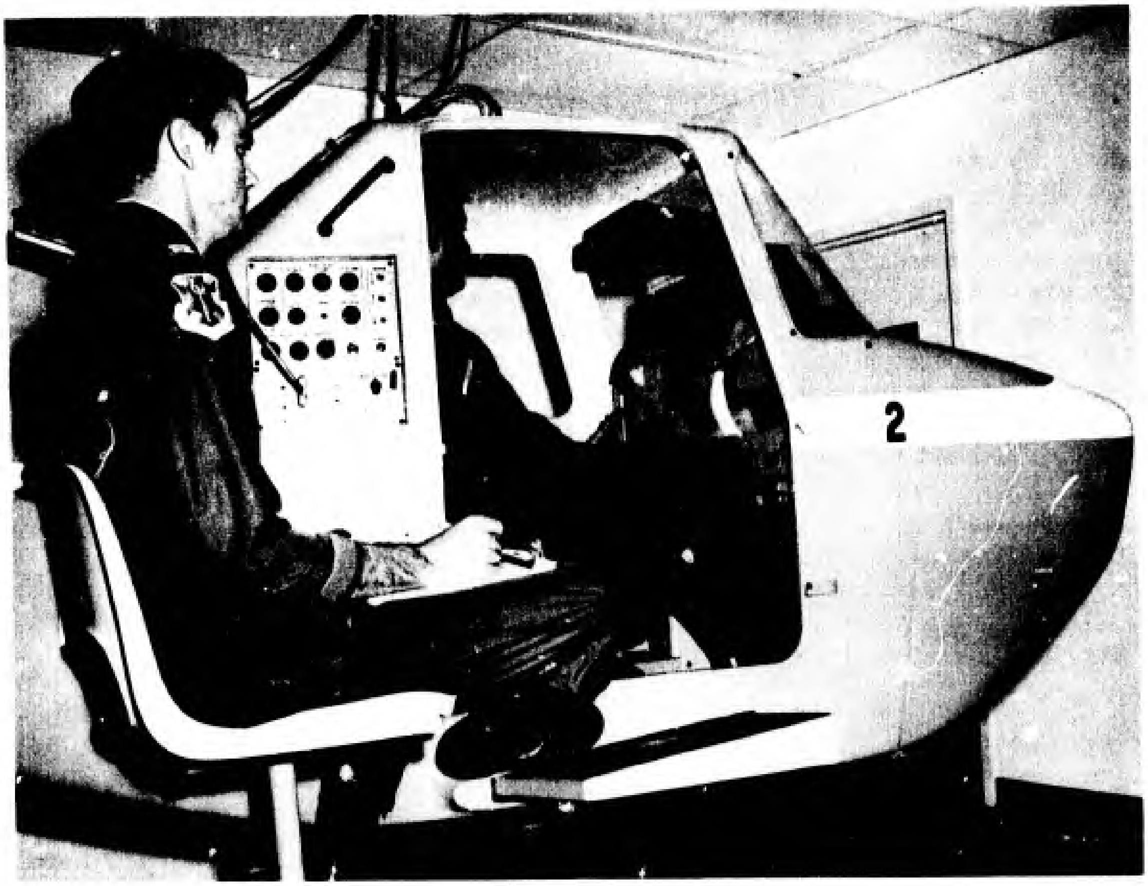

Figure 1. The Link GAT-1 trainer showing a flight examiner rating the performance of a subject.

total number of errorless altitude changes; (c) the total number of discrete errors for heading, airspeed, and vertical velocity; (d) the total time in error for each parameter; and (e) the total time when any parameter was scored in error.

A typical schematic for the control and scoring unit for this system is provided in Figure 2, which shows the altitude programming circuit designed to present a subject with the task (i.e., fly to 1000 ft, 1500 ft, or 2000 ft) and detect his arrival within the target altitude windows of ±40 ft. Similar detection circuits were used for scoring heading, airspeed, and vertical velocity.

Deficiencies--The primary deficiencies of this first GAT-1 test lay with its basic task simplicity and with its rudimentary data collection

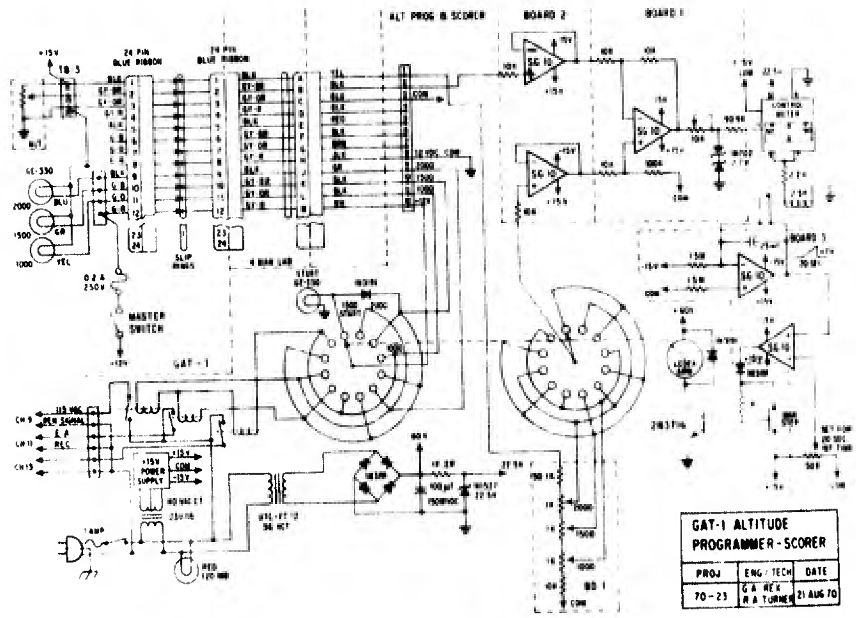

Figure 2. Wiring diagram of the programming unit for the semiautomated Link performance test.

apparatus. While a series of "vertical S" maneuvers is probably a reasonable task to request of subjects "flying" the GAT-1, the hard wired programming of this system precluded testing subjects on a wider range and variation of maneuvers. In addition, the subject-paced nature of the task prevented easy statistical comparison of the individual subject's scores. Some subjects would elect to make as many altitude changes as possible during the test session and accept a larger error score for staying within the error windows for heading, airspeed, and vertical velocity. Other subjects, however, would optimize their time in error scores at the cost of performing fewer altitude changes per unit time.

Error data from this system were entered on an Esterline Angus strip-chart event recorder and on digital counters. The number of errors and time in error for each parameter and various combinations, however, had to be visually interpreted from the strip chart by the experimenter and manually entered on a data sheet for further analysis. Electrical artifacts and spurious error indications left the reliability of the performance measures in doubt.

GENERAL DESCRIPTION OF THE PILOT PERFORMANCE EVALUATION SYSTEM

Introduction

Because of the difficulties encountered with the first version of the performance test for the Link GAT-1, this task was used for only one study. A second version, overcoming the liabilities, has been developed and tested over the past two years. The new prototype system has permitted far greater flexibility in the programming of maneuvers to be executed by the subjects; is an experimenter-paced task; has increased accuracy and reliability in the scoring circuitry; and generates a computer compatible perforated paper tape as the principal data record. We have called this system the Pilot Performance Evaluation System (PPES).[1]

The performance measurement system developed around the Link GAT-1 presents a series of maneuver requests, constituting the flight plan, to the subject via a special display panel. The type and number of maneuvers are under program control. While mission durations of 1 hour are typical, longer tests can easily be run.

Error scoring is based on detecting deviations of the flight instruments outside the fixed threshold error windows programmed for each maneuver. Feedback of errors to the subject is provided via a series of red and green lights on the pilot display panel. Data are recorded on digital counters and on perforated paper tape which can be processed by a computer. Additionally, analog voltage data can be recorded on 14-channel magnetic tape to permit more detailed analysis of performance such as integrated tracking errors and the subject's use of flight controls (elevator, rudder, ailerons, flaps, and throttle).

Maneuver Request Display

To present subjects with a sequence of instructions that result in a reproducible and thus statistically comparable series of maneuvers, a pilot display panel has been added to the GAT-1's conventional instrument panel (Fig. 3). This stimulus box permits the subject to select a radiofrequency and obtain information as to his distance to (inbound) or from (outbound) the selected station (a simulated tactical air navigation,

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[1]The PPES is a "prototype" system because it was designed and constructed to test the general principles involved and demonstrate the value of the concept. It was not intended for long-term laboratory use because a number of the components used to build the system are not noted for high reliability and long service life.

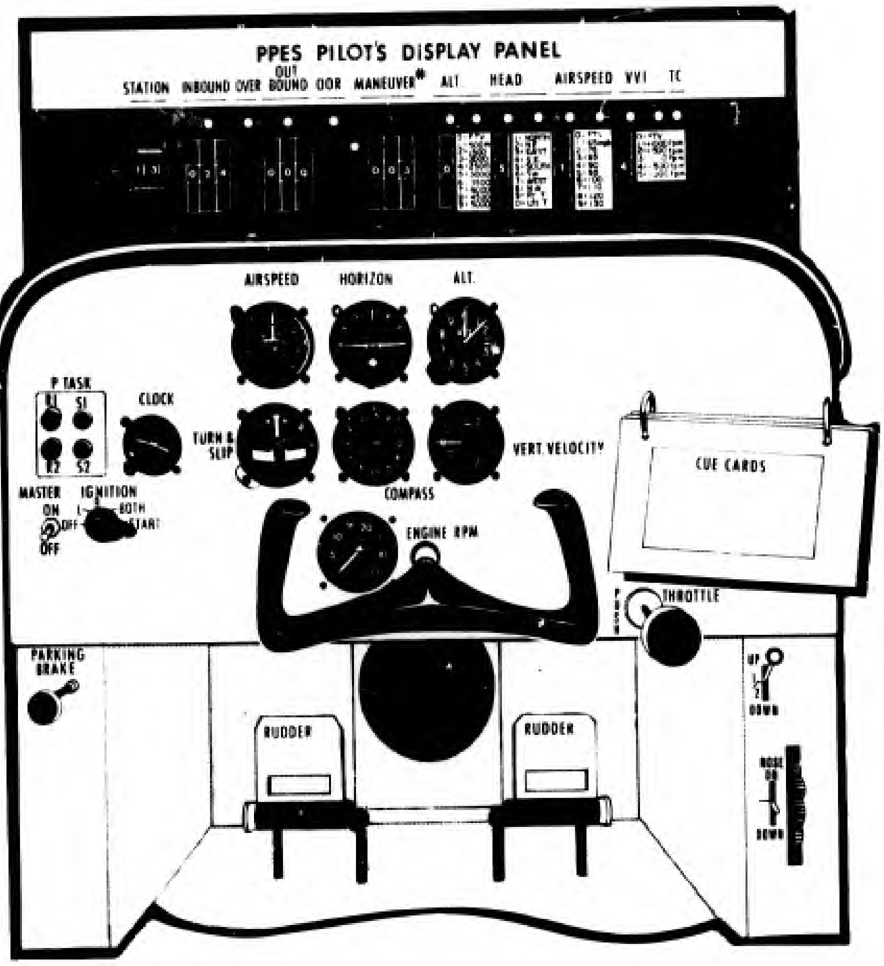

Figure 3. Task presentation to subjects in the Pilot Performance Evaluation System. The pilot display panel permits subjects to select a radio station and obtain information as to their distance to (inbound) or from (outbound) the station. A set of four task decade units indicate the proper altitude, heading or turn rate, airspeed, and vertical velocity for the maneuver. Red and green error feedback lights are located over the task decade units.

TACAN, station with distance measuring equipment, DME, readout). A further series of four 10-digit display units indicate (by a code known to the subject) what his altitude, heading, airspeed, and vertical velocity should be for the current maneuver which is also indexed by a digital counter. This display box and its attendant control system give the experimenter complete and programmed control as to nature and duration of all maneuvers to be executed by the subject.

Maneuver Codes

The code used in presenting subjects with maneuver requests is given in Table 1. The experimenter limits his choice to combinations of airspeed, altitude, and vertical velocity that can be achieved in normal flight. The code 3343, for example, translates as "fly at an altitude of 2000 ft, heading due east, airspeed of 90 mph, and vertical velocity of 0 fpm." During testing, the subject can be presented with a sequence of codes which he has to interpret and execute as a linked series of maneuvers (called a flight profile, mission, or flight plan). Alternatively, subjects can be given a set of "cue cards," one for each maneuver, which describe in detail what is to be accomplished during each maneuver (Fig. 4) and is used to supplement the information provided by the pilot display panel.

TABLE 1. STANDARD INSTRUMENT SETTINGS AND THEIR DIGITAL CODE USED TO INDICATE EXPERIMENTER-REQUESTED MANEUVERS

Altitude		Heading		Airspeed		Vertical velocity	
Code	Center value (ft)	Code	Center value	Code	Center value (mph)	Code	Center value (fpm)
0	FTV	1	North	0	FTV	0	FTV
1	500	2	North East	1	65	1	+1000
2	1500	3	East	2	75	2	+ 500
3	2000	4	South East	3	85	3	0
4	2500	5	South	4	90	4	- 500
5	3000	6	South West	5	95	5	-1000
6	3500	7	West	6	100		
7	4000	8	North West	7	110		
8	4500	9	Right std turn	8	120		
9	5000	0	Left std turn	9	130		

Note: A code of 0, free to vary (FTV), allows that parameter to assume any value and not be scored. During a climb of 500 fpm vertical velocity, for example, altitude is not scored.

Flight Plans

The 19-maneuver sequence called maneuvers flight-2 (MF-2) is typical of the hour-long series of maneuvers to be executed by subjects while performance is scored electronically (Fig. 5). In our previous tests with alcohol, this relatively simple sequence was made even more difficult

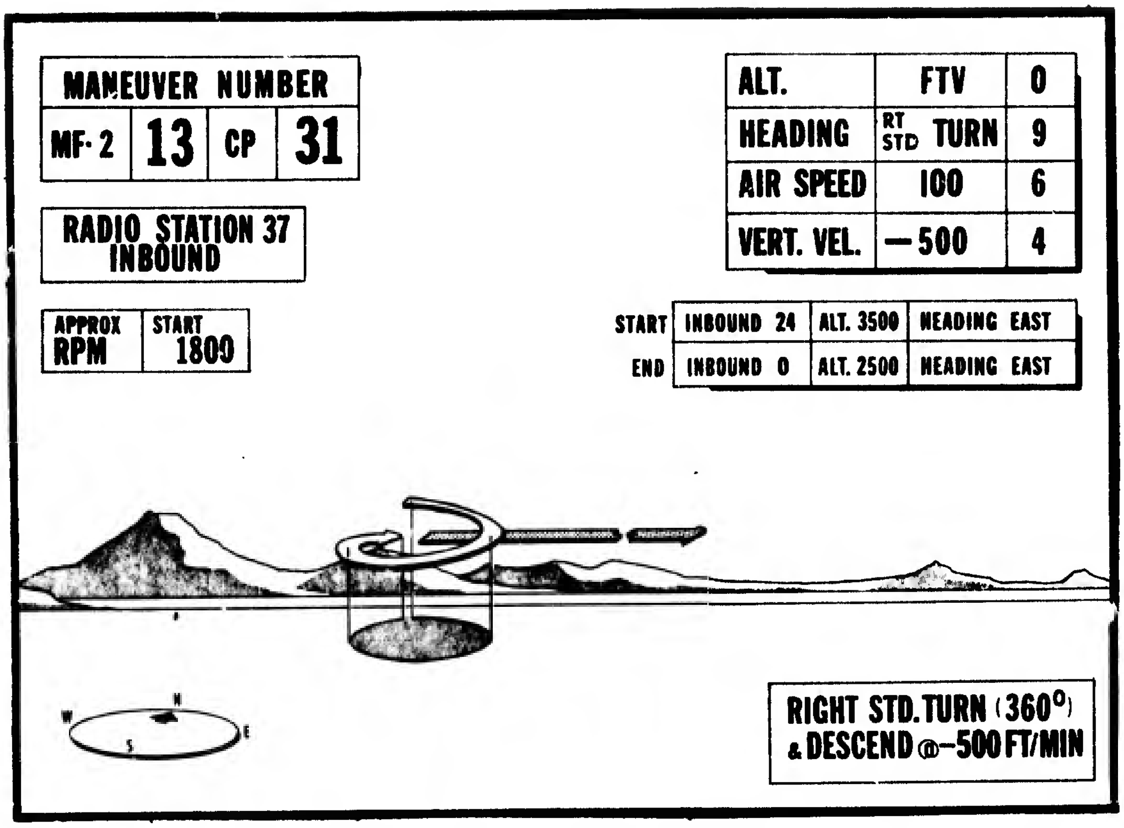

Figure 4. Example of a "cue card" for maneuver 13 of the maneuvers flight-2 (MF-2) flight plan. The subject is required to complete a descending 360° standard rate turn in 2 minutes. The code numbers 0964 will appear on the pilot display panel task indicator units and the inbound DME readout will start at 024 and down count to 000 during the 2 minutes required for the maneuver.

by replacing the long straight and level flight (leg 7) with a series of 19 maneuvers, segment B (Fig. 6) which were directed solely by the pilot display panel. No cue cards were provided for segment B. Appendix A contains a listing of the flight plans developed for use with the PPES.

Intermaneuver Interval

Approximately 15 seconds of unscored time elapsed between each maneuver. This time was required by the system to reset the various programming elements to proper initial values for the start of the new leg. During this period subjects could prepare for the next maneuver and make any needed correction in course, altitude, or airspeed without penalty. All radio station changes were to be accomplished during this interval.

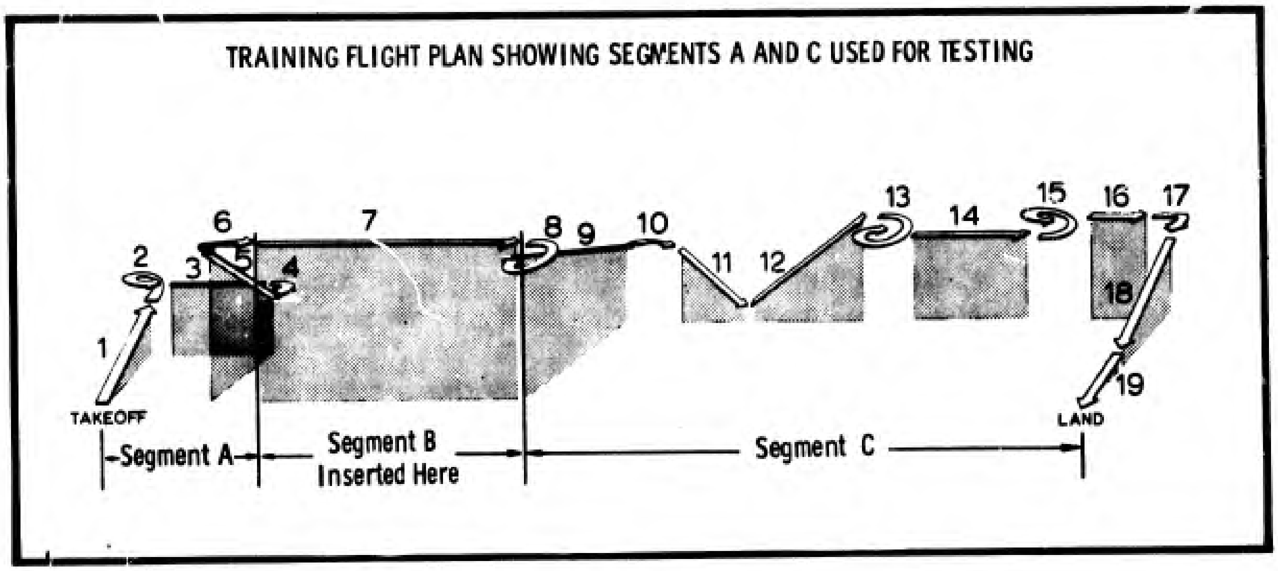

Figure 5. Training flight plan MF-2 consisting of 19 maneuvers. Segments A and C of this plan were also used for testing. The place for insertion of segment B for testing is shown.

Error Detection

A major component of the PPES is the error detection unit. This unit is provided with: (a) voltages for each parameter to be scored: altitude, heading, airspeed, vertical velocity, turn rate, and turn coordination; and (b) reference voltages from voltage divider networks where the selected reference value is equal to the required GAT-1 instrument setting. Voltage comparators detect the condition when the GAT-1 and the reference voltage for each parameter are approximately the same. Further electronic controls permit the precise adjustment of the upper and lower boundaries--defining correct and incorrect instrument settings. Table 2 indicates the approximate amount of deviation permitted on the various instruments before errors are detected electronically.

Error Feedback

The pilot display panel also contains a series of red and green lights to indicate when an error has been detected for any parameter. This error feedback is very useful during training, and subjects quickly learn to read the flight instruments and to make appropriate corrections before the red error lights come on. This feedback has also been used during nearly all testing thus far in the belief that the variance of subject scores would probably be reduced.

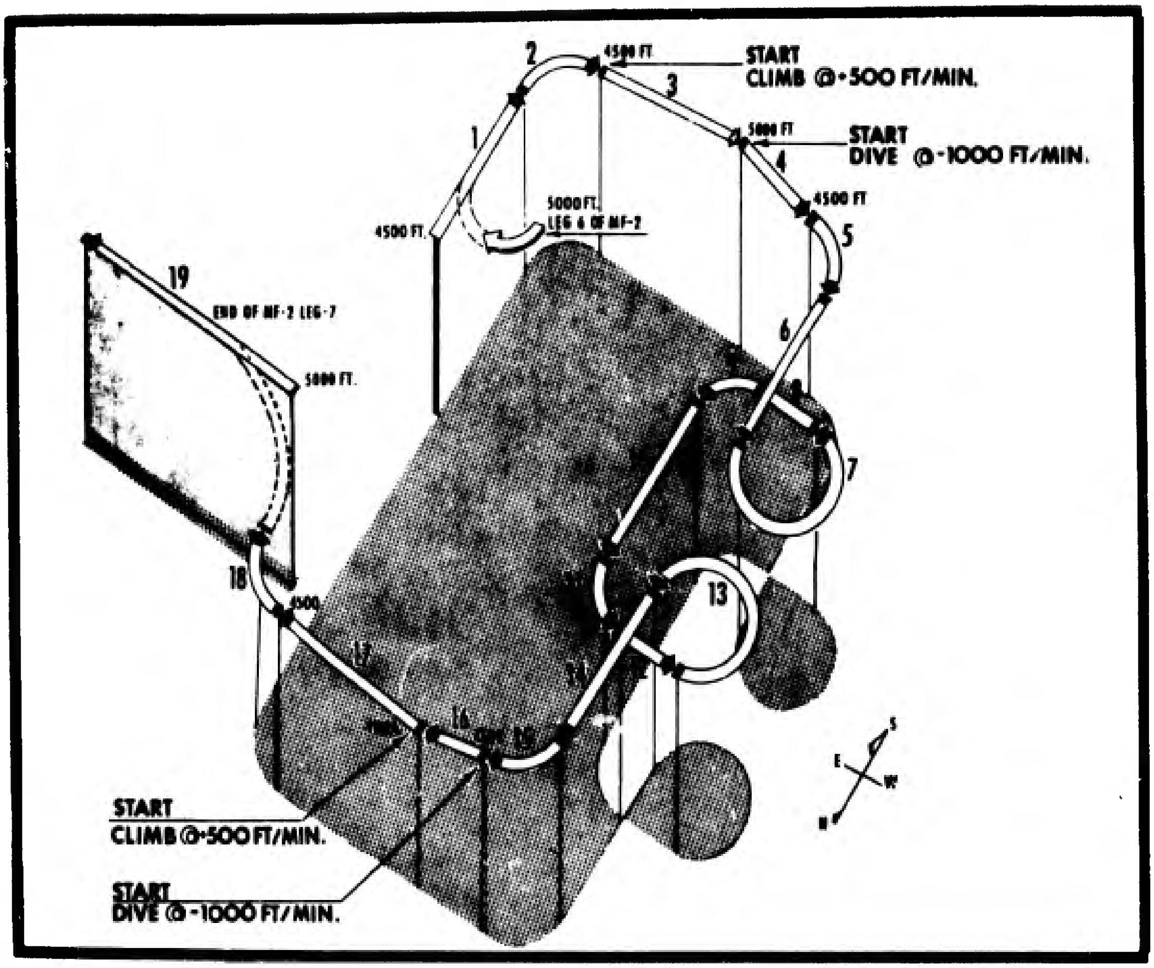

Figure 6. Segment B of the testing flight plans. This is one of two basic arrangements used for testing. The other basic arrangement started at leg 10 of this illustration. Both arrangements were flown clockwise or counterclockwise, thus producing four different orders of the same 19 maneuvers. These four orders when combined with segments A and C of MF-2 formed the testing flight plans CP-1, CP-2, CP-3, and CP-4.

TABLE 2. AMOUNT OF VARIATION PERMITTED ON LINK INSTRUMENT SETTINGS BEFORE ERRORS ARE SCORED

Link parameter	Windows in current use
Altitude	± 100 ft
Heading	± 2 1/2 degrees
Airspeed	± 2.5 mph
Vertical velocity	± 150 fpm
Turn rate	± 0.5°/sec
Ball angle	± 5° vertical

Performance Measures

Performance data are collected by the Link system in several ways: digital counters, 8-channel perforated paper tape, and 14-channel analog magnetic tape. Digital counters record the number and total duration of the errors made during each second of flight for each of the following parameters: altitude, heading, airspeed, vertical velocity, turn rate, ball angle, and radiofrequency selection errors. In addition, the summary statistics "combined total seconds of error" (CTSE) and "seconds of perfect flight" (SPF) are also recorded on line by digital counters (Table 3). The logic used to advance the digital counters also drives an 8-channel paper tape perforator giving a permanent record of the subject's performance for each second of the entire flight.

Analog Tape Record

In addition to the above data logging based on fixed threshold error scoring, a 14-channel analog tape recorder has been incorporated into the system. This permits study of the performance data at variable threshold levels and allows evaluation of absolute tracking errors. Control signals from elevator, rudder, aileron, throttle, and flaps are also recorded.

Data Processing

A number of computer programs have been developed for analyzing the perforated paper and analog magnetic data tapes produced by the PPES (4). Each test (plus the corresponding length of data tape) is uniquely identified by a 7-character identification code called a "run number." The paper tape record for a "run" can be analyzed to determine the number and total duration of periods when the subject exceeded the tolerances programmed for a given parameter. Figure 7 is an example of a printout of the results of a single hour-long test, run AC-035-72, based on analysis of the paper tape record.

TABLE 3. PARAMETERS RECORDED ON DIGITAL COUNTERS DURING PPES TESTS

Parameters

* 1.	Altitude TSE
* 2.	Heading TSE
* 3.	Airspeed TSE
* 4.	Vertical velocity TSE
* 5.	Turn coordination TSE
* 6.	Turn rate TSE
* 7.	Radio station match TSE
8.	Spare (time on target when employed)
9.	Seconds of perfect flight (SPF)
10.	Combined total seconds of error (CTSE)
*11.	Current maneuver (leg) No.
*12.	Total elapsed time (TET) in seconds

Note: *Parameters also recorded on paper tape

Definitions of summary statistics

1. TSE = Total seconds of error--The total sum of the seconds of error scored for any of the six flight parameters or radio station match for the entire flight or any subportion.

2. CTSE = Combined total seconds of error--The aggregate sum of the seconds of error scored for all six flight parameters for the entire flight or any subportion.

3. SPF = Seconds of perfect flight--The total time in seconds when all six flight parameters were scored as within tolerance.

RUN NUMBER: AC-035-72   NAME: GILBERT, ROBERT

DATE 720503   TIME 09:00   WINDOWS: ALT=W HEAD=B AIRSP=N VVI=N TC=N

TREATMENT: ALCOHOL STUDY; SUBJECT GIVEN 1 OZ. ETOH

FLIGHT PLAN: CP-2   PERIPHERAL TASK: R AND G, B-2

	ALT	HEAD	ASP	VVI	TC	TR	TPF	ENTIRE FLIGHT
FREQ	3	11	42	80	14	76	134	226
DUR E	67	77	367	494	91	211	2204	1307
TOTAL STATION ERROR		141						

TOTAL		AIRSPEED		TPF		SEGMENT
C	SEC	C	SEC	C	SEC	
34	96	5	19	27	618	MF-2 PART 1
109	820	22	270	46	481	RF PORTION
83	391	15	78	61	1105	MF-2 PART 2
117	487	20	97	88	1723	MF-2 TOTAL
26	159	7	56	14	233	STRAIGHT AND LEVEL
22	81	7	39	20	930	STRAIGHT AND CLIMB
36	223	8	41	25	459	STRAIGHT AND DIVE
79	415	12	123	38	241	TURN AND LEVEL
28	72	2	14	20	151	TURN AND CLIMB
21	103	3	16	13	134	TURN AND DIVE
14	254	3	78	4	56	STRAIGHT AND LEVEL DISC.

SUM BY PARTS AGREES

SUM BY MANEUVER AGREES

COUNT BY PARTS AGREES

COUNT BY MANEUVER AGREES

Figure 7. Typical printout of PPES results for a single test run based on the analysis of the paper tape record.

<u>Note</u>: FREQ = Number of errors.
DUR E = Total duration of errors in seconds.
TPF = Seconds of perfect flight (also SPF).
C = Number of errors.
SEC = Total duration of errors in seconds.
RF PORTION = Segment B of testing flight plan.
TOTAL = Total for the segment of the flight plan or types of maneuvers listed.

The analog tape records similarly can be processed to produce either window crossing data or integrated tracking error data. Figure 8 is an example of the printout of the results for the same run as Figure 7 but based on the analysis of the analog tape record. It provides the performance scores for integrated tracking error for various parameters.

RUN NUMBER: AC-035-72 NAME: GILBERT, ROBERT

DATE 720503 TIME 09:00 WINDOWS: ALT=N HEAD=N AIRSP=N VVI=N TC=N

TREATMENT: ALCOHOL STUDY; SUBJECT GIVEN 1 OZ. ETOH

FLIGHT PLAN: CP-2 PERIPHERAL TASK: R AND G, B-2

INTEGRATED TRACKING ERROR

CORRECT NUMBER OF LEGS 37

ALT	HDG	ASP	VVI	TC	TR	ELE	AIL	TOTAL	
1020	452	760	1628	1005	768	1679	1458	5633	ENTIRE FLIGHT
124	20	68	190	193	105	360	374	700	MF-2 PART 1
743	304	533	803	484	387	537	491	3254	RF PORTION
153	128	159	635	328	276	782	593	1679	MF-2 PART 2
277	148	227	825	521	381	1142	967	2379	MF-2 TOTAL
191	83	86	199	177	0	194	152	736	STRAIGHT AND LEVEL
96	56	119	254	72	0	504	525	597	STRAIGHT AND CLIMB
42	100	91	440	247	0	351	196	920	STRAIGHT AND DIVE
439	0	229	298	285	482	301	284	1733	TURN AND LEVEL
7	0	23	93	76	133	118	110	332	TURN AND CLIMB
28	0	29	102	54	153	127	99	366	TURN AND DIVE
217	213	183	242	94	0	84	92	949	STRAIGHT AND LEVEL DISC.

SUM BY PARTS AGREES
SUM BY MANEUVER AGREES

Figure 8. Typical printout of PPES results for a single test run based on the analysis of the analog tape record. The numbers are raw counts.

Note: ELE = elevator
AIL = aileron
TOTAL = The sum of the counts for altitude, heading, airspeed, vertical velocity, turn coordination, and turn rate.

Although the printouts illustrated in Figures 7 and 8 were of some value in the early stages of the development of the PPES, more useful formats have been developed to summarize the results for several subjects. The most recent programs developed include tests for statistical significance using either parametric or nonparametric statistics (3). In Figure 9, the results of tests for 12 subjects at three alcohol dose levels are listed for the summary statistic CTSE.

1 ENTIRE FLIGHT CTSE

	DATA						DECREMENT			% DECREMENT		
DOSE	0	0.3	0	0.6	0	0.9	0.3	0.6	0.9	0.3	0.6	0.9
ORDER T,C												
SUBJECT												
2	941	1394	707	4589	1083	7313	453	3882	6230	48.14	549.08	575.25
3	1317	1472	1167	2222	1137	3354	155	1055	2217	11.77	90.40	194.99
4	941	899	885	807	814	1582	-42	-78	768	-4.46	-8.81	94.35
8	2033	2230	2027	3726	1767	5949	197	1699	4182	9.69	83.82	236.67
9	1094	830	746	1695	626	3170	-264	949	2544	-24.13	127.21	406.39
11	757	843	757	854	757	1470	86	97	713	11.36	12.81	94.19
MEAN	1181	1278	1048	2316	1031	3806	98	1267	2776	8.73	142.42	266.97
ORDER C,T												
SUBJECT												
1	938	874	891	1943	1318	1740	-64	1052	422	-6.82	118.07	32.02
5	840	634	728	756	431	1366	-206	28	935	-24.52	3.85	216.94
6	1008	994	1359	941	804	1792	-14	-418	988	-1.39	-30.76	122.89
7	1131	1142	993	1340	1084	2248	11	347	1164	0.97	34.94	107.38
10	665	731	738	1308	657	1882	66	570	1225	9.92	77.24	186.45
12	1050	1011	673	1188	857	1317	-39	515	460	-3.71	76.52	53.68
MEAN	939	898	897	1246	859	1724	-41	349	866	-4.26	46.64	119.89
GR MN	1060.0	1088.0	972.5	1781.0	945.0	2765.0	28.5	808.0	1821.0	2.2	94.5	193.4
						SE	52.6	311.1	439.3	5.4	43.4	41.5
						P	0.300	0.013	0.001	0.343	0.027	0.000
						LOWER 95% CONFIDENCE LEVEL =	-66.9	244.2	1024.7	-7.5	15.8	118.3

T TEST FOR PAIRED OBSERVATIONS, ADJUSTED FOR ORDER, ONE TAIL

Figure 9. Listing of individual subject data for PPES measure CTSE for the entire flight. The decrements and results of significance testing are also shown. For alcohol dose levels: 0 = control; 0.3 = low alcohol dose; 0.6 = moderate alcohol dose; and 0.9 = high alcohol dose. "Order T,C" refers to the subgroup of subjects who were tested in the order Treatment first and then Control. "Order C,T" is the reverse order for remaining subgroup of subjects. "GR MN" is the grand mean; "SE" is the standard error; and "P" is the probability.

PPES ELECTRONICS AND HARDWARE

General Description

The preceding sections have outlined the general design rationale of the prototype Pilot Performance Evaluation System (PPES). The discussion will now focus on the hardware used to accomplish the task, beginning with an overall block diagram and then turning to an analysis of each component element of the system.

Figure 10 illustrates how the system controller is used to drive a pilot display panel in a Link GAT-1 trainer. The analog voltages from the flight trainer are fed to the Error Detection Control Board (EDCB) for error determination using programmable fixed threshold error windows. The state of the EDCB's error relays is indicated in the pilot display panel and is sampled once a second by the scoring logic which in turn

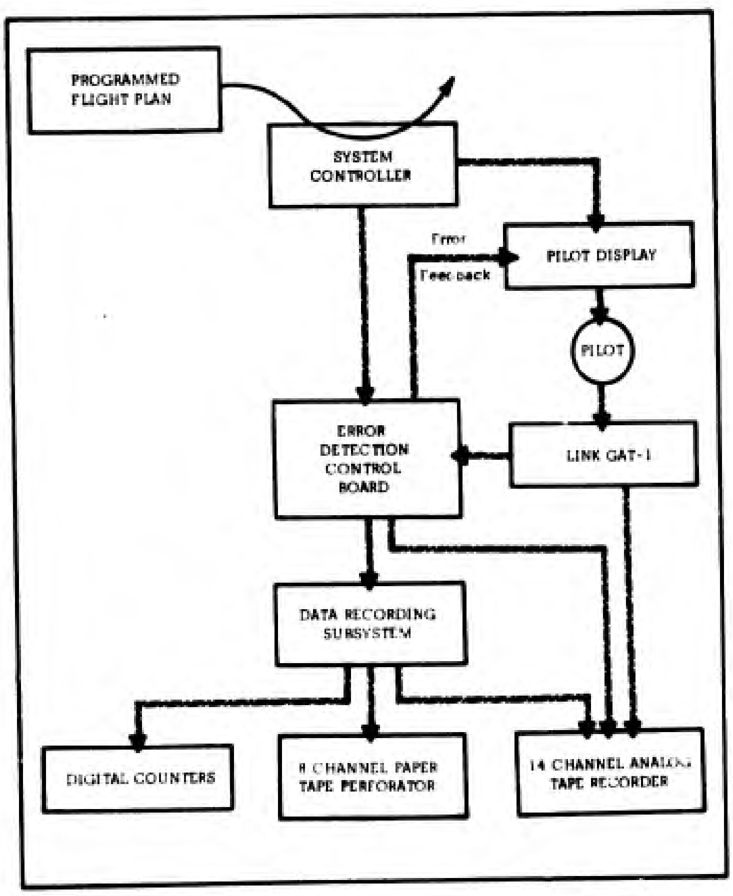

Figure 10. Block diagram of the PPES.

drives a set of digital counters (seconds of error) and a paper tape perforator. Connections to the EDCB and scoring logic are provided to enable analog recording of: (a) differential error signals (Link parameter voltage vs. reference value); (b) GAT-1 control elements (rudder, aileron, elevator, and throttle); and (c) secondary events and timing codes. While our initial experience with the PPES was obtained with a single GAT-1 trainer, the system also has been employed using two trainers simultaneously. For this configuration a second GAT-1, pilot display panel, EDCB, and data recording subsystem were added to the system controller which was used to control both trainers.

The physical appearance of the PPES control station for two Link GAT-1's is illustrated in Figure 11. The double rack in the center contains the system controller and EDCB for one GAT-1 and a TV monitor for that trainer's instrument panel. The double rack on the right contains the digital scoring logic, counters, and paper tape perforators for recording the performance from two subjects. The two racks on the left are a 14-channel analog tape recorder and a second EDCB, reference decades box, and TV monitor for the second GAT-1 employed.

Figure 11. The PPES Central Control Station which permits presentation of a series of maneuver requests to two Link GAT-1 trainers and scores the performance of subjects executing the flight plan. Data are recorded on digital counters, perforated paper tape, and analog magnetic tape. Closed circuit TV monitors allow verification of scoring accuracy.

System Controller

Introduction--The system controller is the basic programming and control unit of the PPES. Three functions are performed by this unit:

1. Reading blocks of the program tape (programmable memory) and setting the reference, distance, and peripheral task steppers to appropriate values for the start of each maneuver.

2. Automatic switching of the status of the system between a "reading program tape" mode when steppers are set to initial values, and a "collecting data" mode where performance is scored and where timing pulses drive the simulated distance measuring equipment (DME) display to clock the duration of each maneuver.

3. Automatic cycling of the status of the direction stepper among the four modes: "inbound," "over," "outbound," and "out of range." A block diagram of the system controller is given in Figure 12.

The system starts by a manually entered pulse to the paper tape reader which initiates the reading of the first block of the program tape. The characters of the paper tape are decoded as they are read; and after an initial reset of all steppers, pulses are delivered to set: (a) either the inbound DME or the out of range DME counters: (b) the reference steppers; and (c) the peripheral task steppers.[2] The final character of the block, when read and decoded, changes the system status to the collect data mode and the direction status to inbound or outbound. Performance is then scored by the EDCB which provides error indications to the pilot display panel, scoring logic, and central control.

During the maneuver, a clock delivers a pulse to the inbound or outbound DME display once every 5 seconds. When the inbound display reaches a value of 000 (down counting from its programmed initial value) or the outbound display value equals the out of range value (counting positively from zero), a control pulse is generated. This pulse signals the end of the maneuver; the distance status stepper advances to "over" or "out of range," and the system status advances to "reading paper tape

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[2] Extensive use of the Durant Unipulser II® decade steppers has been made in the design of the PPES. This unit features a visual display of the digits 0 through 9 on an electromechanically driven drum and an electrical readout through a single pole 10-position rotary switch. Both positively and negatively counting units have been used to create 2- and 3-digit counters that increment either positively or negatively. A 24-volt DC pulse is used to step these units and a 36-volt AC half wave is used to reset positively counting units to zero and negatively counting units to 9.

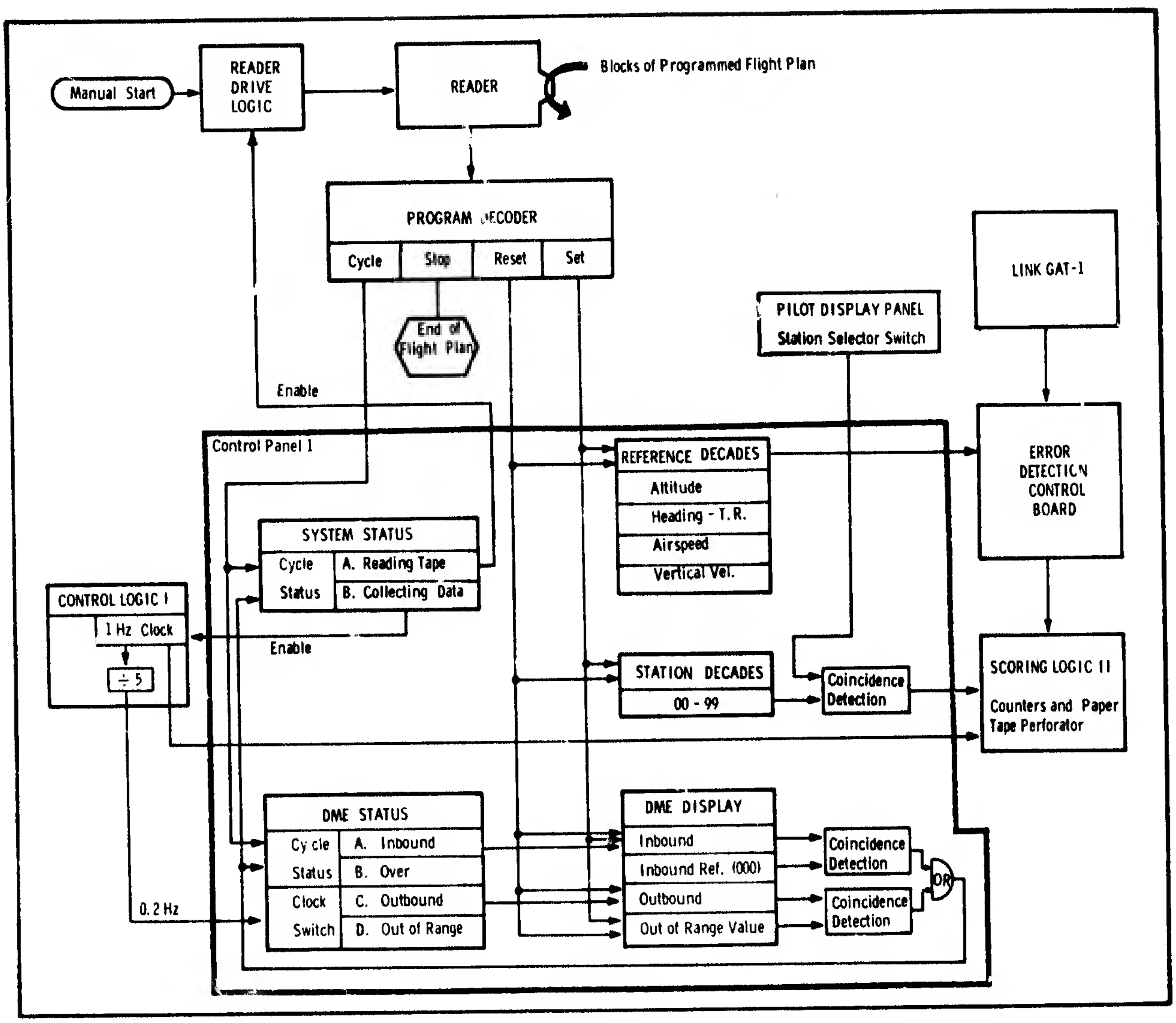

Figure 12. Block diagram of the system controller.

and setting decades."[3] The reader then automatically advances through the next block on the program tape. The first three characters of the block reset all the distance, reference, and peripheral task steppers to zero, or 999 in the case of the inbound steppers. The subsequent string of characters sets each stepper to its appropriate value for that maneuver. The final character of the block advances the system status stepper to "collecting data" and the direction status stepper to "inbound" or "outbound." This sequence of events continues until a "system stop" code is read from the program tape indicating the end of the flight plan. Further explanation of the program tape format and decoding action is provided in Appendix B.

Program Tape Recorder--A surplus 6-channel, Friden Model SP-2, paper tape reader was used to read blocks of program tape. A slow reading rate of 3 characters/second was used primarily due to the unreliability of the relay decoder. Thus approximately 15 seconds were required to read one block of program tape. The maximum stepping rate of the reader itself, however, is approximately 15 to 20 characters/second.

A 24-volt pulse is delivered to the reader's clutch escapement relay which results in a single character being read. The state of each of the 6 channels is indicated by a brief contact closure if a hole is sensed. Since one side of each data channel's switch contact pair has been connected to 24 VDC, a 24-volt pulse results when a hole is sensed. A diagram of the logic used to control the reader is provided in Appendix B.

Program Decoder--The program tape decoder was the first element of the PPES to be constructed and has been the most troublesome of the entire system. The logic has been constructed from surplus 24-VDC 2 to 12PDT relays and 4PDT latching relays. These are connected such that the appropriate number of pulses from the program tape reader are delivered to the inbound and out of range DME displays, reference value decade units, and radio station decade units. In addition, this relay logic permits the automatic resetting of all decades at the start of each leg, recognizes the end of a program tape block, and shuts down at the end of the program tape.

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[3]The normal sequence of the DME display is to start maneuver number 1 as "inbound," and at the end of the maneuver, the direction status stepper advances to "over" (the station) while the next block of tape is read and decoded. The start of maneuver number 2 is signaled by the direction status stepper's advance to "outbound." When the "out of range" value is reached, the maneuver ends and the direction status stepper advances to "out of range" while all the steppers are reset for maneuver number 3. This 4-step cycle is completed when maneuver number 3 begins as the direction status stepper advances to "inbound" once again. The choice of a 5-second pulse to drive the DME display is purely arbitrary and for certain situations could be made variable and in direct relation to true ground speed, or "computed" distance to or from the station.

Because a complete redesign of this unit is desirable, further discussion of this unit is not warranted. See Appendix B for further notes on the present system.

Central Control Unit--Within the functional unit called the system controller, the central control panel: (a) houses the decade units for distance displays, reference value selection, and radio station; (b) provides the system operator with a display of the state of the error relays;[4] and (c) contains the steppers for determining the status of the system and the direction status of the DME display. Figure 13 shows the front panel from which a number of the features of this unit can already be surmised. A schematic of the central control unit is presented in Figure 14. The basic inputs to this unit are: (a) trains of pulses from the decoder logic which are used to set the DME display decades, reference decades, and radio station decades; (b) a pulse every 5 seconds from a precision clock which is used to step the DME display (when enabled); (c) -24 volt signal inputs from the error detection control board which are used to drive the indicator lights; and (d) a contact closure when a "#6 input character latching relay" is in the "1" state. The basic outputs from this unit are: (a) a single pulse once every 5 seconds to the inbound or outbound DME display while the system is in the "collect data" mode; (b) the selection of a single reference value for each of the four reference decades; (c) a relay contact closure when the radiofrequency selector switch of the pilot display panel and station decades are mismatched; and (d) a momentary contact closure at the end of a maneuver.

Within the control unit, one stepper is employed to advance the system status through the cycle: (a) "waiting for step;"[5] (b) reading the program tape; and (c) collecting data. A second stepper is used to advance the direction status through the cycle: (a) inbound; (b) over; (c) outbound; and (d) out of range. The system status stepper advances: (a) when the inbound DME display reaches zero or the outbound decades equals the out of range value; (b) when the automatic or pilot step contacts are closed; (c) when the #6 input character latching relay closes; and (d) when any of the homing contacts are closed.

The direction status stepper will advance once as the system status stepper is homing to its "wait for step" position. This leaves the DME display in the "over" or "out of range" state at the end of each leg. At the start of each leg a -24 volt pulse from the #6 character input pulse relay of the decoder advances the direction status stepper to inbound

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[4]With the addition of a second GAT-1, a reference decade box was added to the system which contained a set of error feedback lights and decade steppers for reference voltage and radio station value selection.

[5]A provision was made for allowing the subject time to prepare for the next maneuver and to "step" on to the next maneuver when he keyed a switch on his DME display panel. This option, thus far, has not been employed in performance testing.

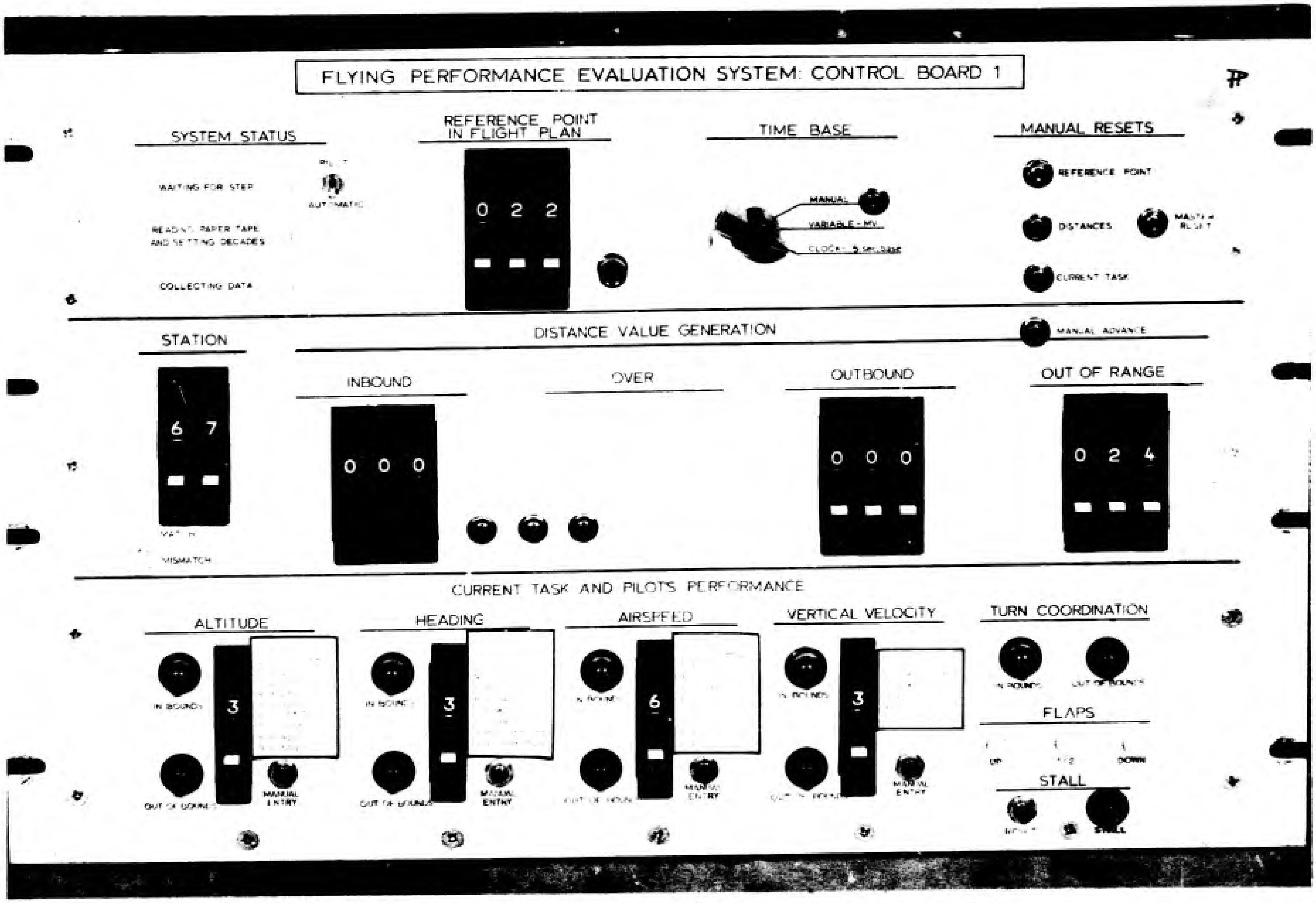

Figure 13. Front panel of the central control unit.

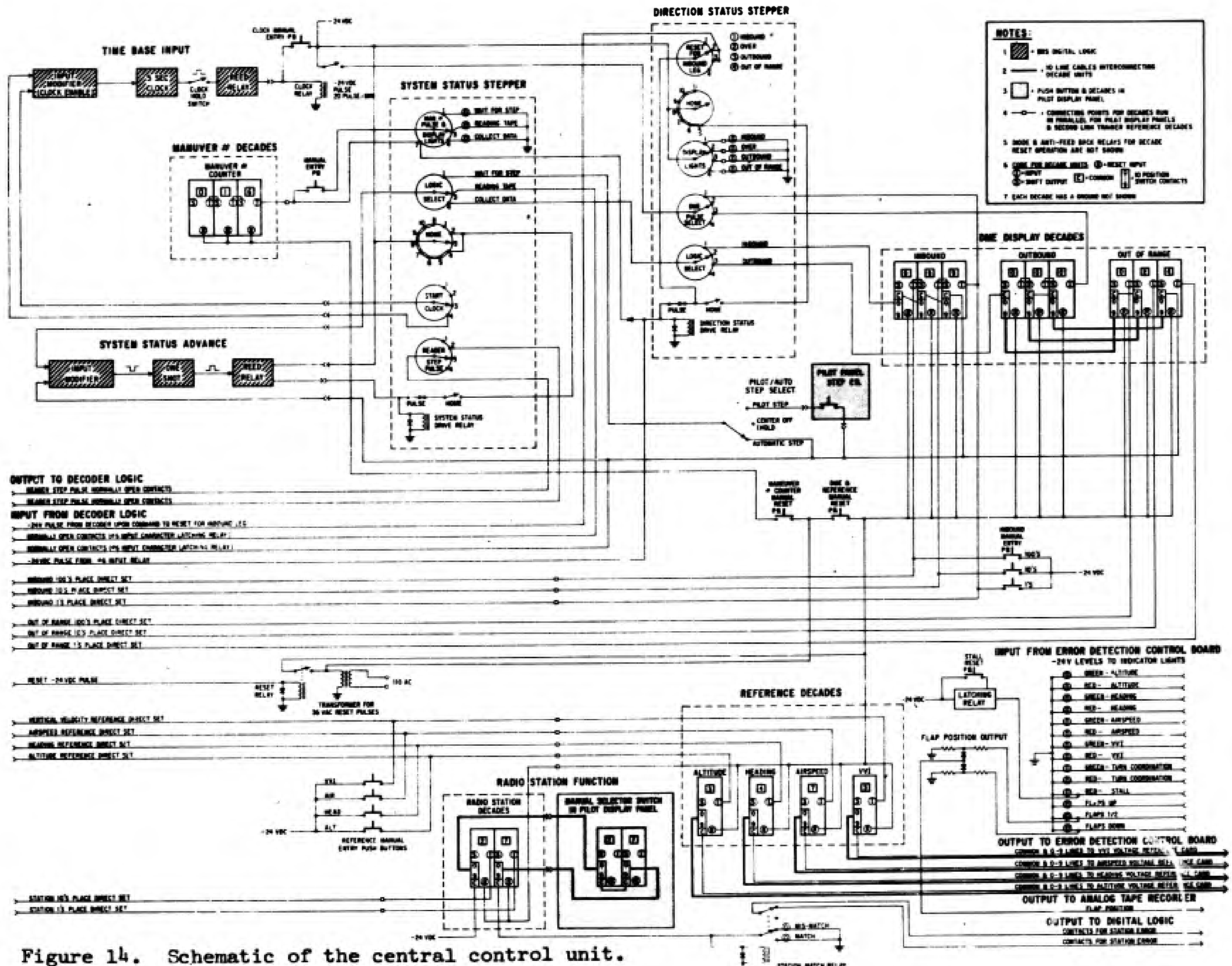

Figure 14. Schematic of the central control unit.

or outbound. A set of homing contacts are used to advance the stepper to the out of range position upon command from the decoder. This last option permits repetitive inbound legs to be programmed without having to cycle through the outbound DME display function.

To simplify the central control unit schematic, the maneuver number, DME display, and reference decades of the pilot display panel are not shown. Basically, these remote units are wired in parallel to the decades illustrated.

Error Detection Control Board

Introduction--The EDCB is designed to compare the input voltages from six GAT-1 flight parameters with six reference voltages and make relay closures when the differential voltages (GAT-1 voltage minus reference voltage) are within tolerance, indicating that pilot performance for that parameter is within accepted limits.

Figure 15 shows the basic input/output relationships. For each parameter, the GAT-1 voltage is compared to the corresponding reference voltage by a differential amplifier. The differential output voltage from this amplifier is then fed directly to a comparator and after an inverter stage to a second comparator. These two comparators determine if the absolute value of the differential error signal has exceeded tolerance values (i.e., for airspeed, the equivalent of ±2.5 mph). The outputs from the two comparators are then fed into a two-legged, negated input, NAND gate which provides a signal output only when the differential error signal is within positive and negative tolerance limits. The output from the NAND gate is then used to drive a relay to provide display light voltages and to provide a contact closure for digital logic. A tape recorder output is also provided to enable recording of the differential error signals.

Typical Circuit for Error Detection--A representative diagram of the circuit used for error detection is given in Figure 16. The program stepping switch is used to select a single reference voltage from the voltage divider. Each of the potentiometers of the chain can be adjusted to provide the exact voltage corresponding to a given indication of the flight instrument. Note that in the "0" position, the stepping switch ties the GAT-1 input voltage to reference value input; this results in an automatic "within bounds" condition.

A meter is provided for each parameter to monitor Link and reference voltages. These meters, as well as the error feedback lights, are disabled during the transition time when the program stepping switches are being set by the program tape decoder.

The GAT-1 and reference voltages are fed to a unity gain differential amplifier, A1, whose output is the difference between the reference and

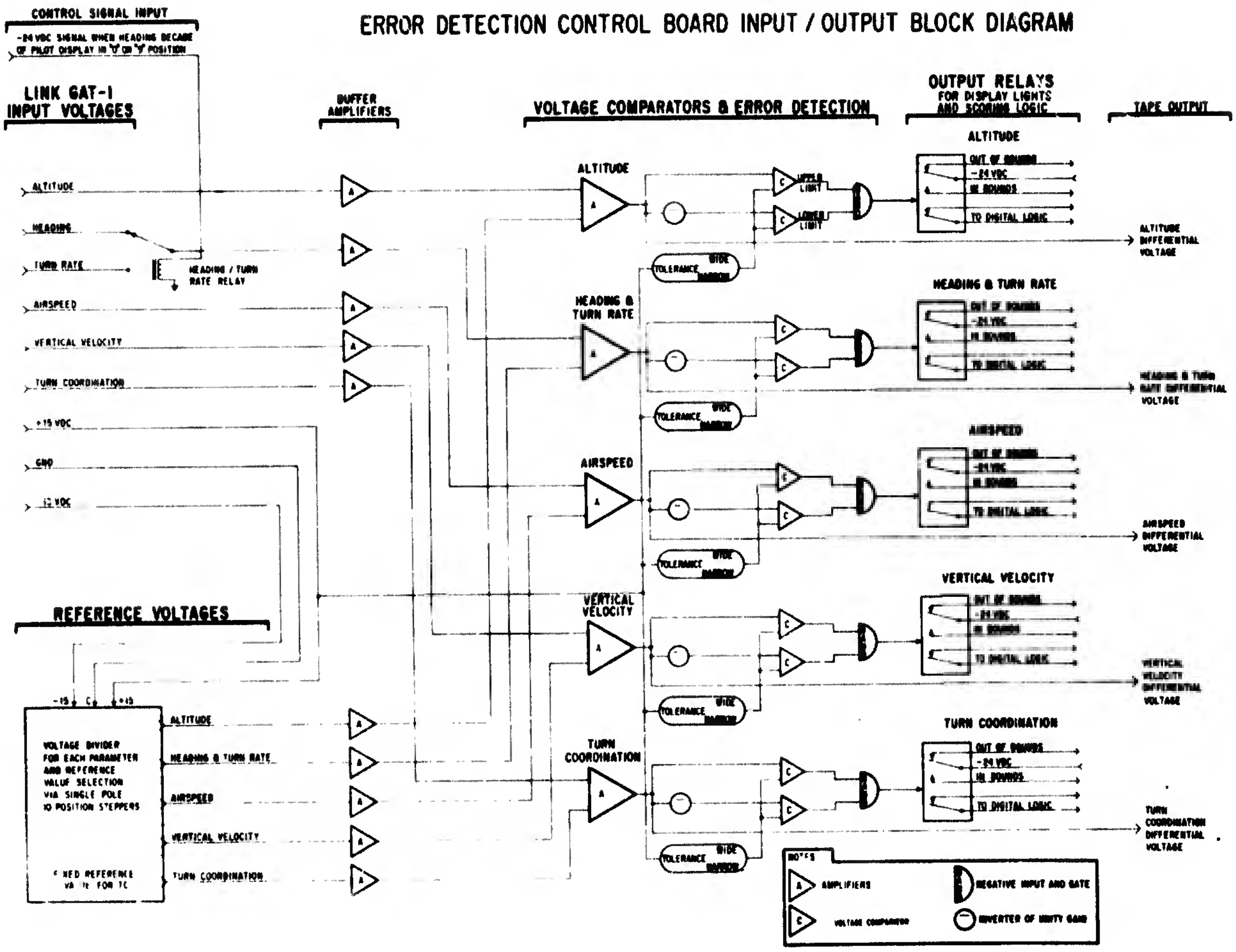

Figure 15. Block diagram of the input/output relationships of the Error Detection Control Board.

GAT-1 voltages. A balance pot is provided on A1 to zero the output when the inputs are tied together as in the "0" position of the stepping switch. The difference signal from A1 is amplified by A2 and a gain control is provided to scale the difference signal to the range of the tolerance adjustments. The absolute value of the difference signal is then compared to reference tolerance values in comparator A4 and, after being inverted by a unity gain inverter A3, in comparator A5. The size of the window defining correct performance is adjusted by varying the "wide" and "narrow" tolerance potentiometers. The tolerance reference voltage selected, either wide or narrow, is fed to both comparators A4 and A5.

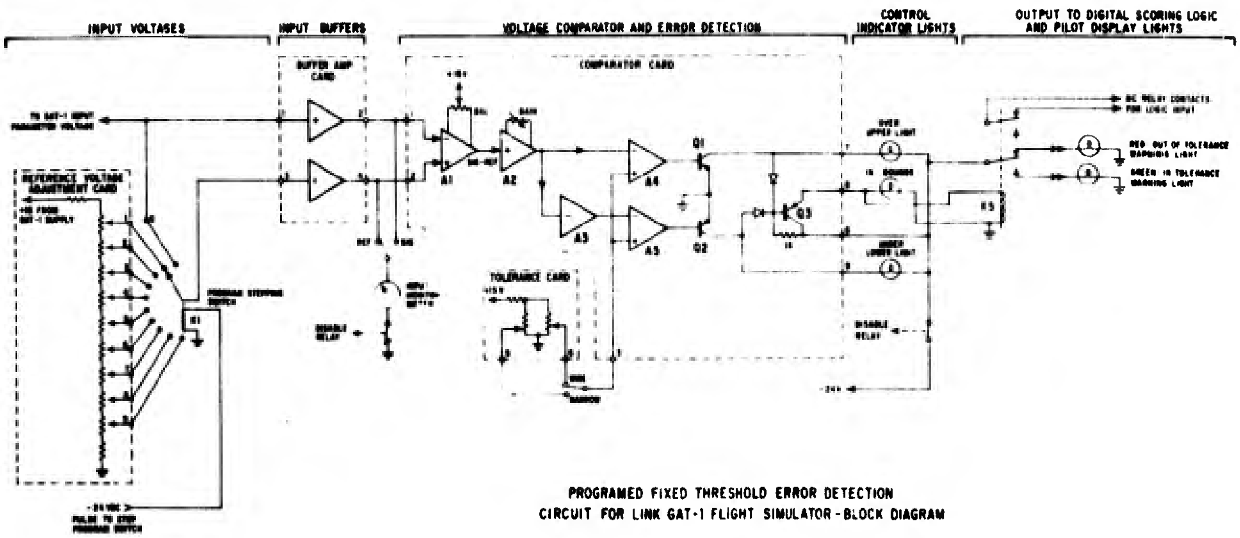

Figure 16. Typical scoring circuit used on the EDCB.

If the GAT-1 signal exceeds the limit above the reference level, the output of A4 goes negative and switches Q3 off. If the tolerance is exceeded on the lower side, Q2 is similarly turned on and it also turns off Q3. Within tolerance, the outputs of the comparators A4 and A5 are at or near ground. Q1 and Q2 are both off and Q3 is biased on, which lights the "in bounds" indicator light and keeps relay K5 energized.

The final outputs to the scoring digital logic and pilot display panel lights are provided by the contacts of relay K5. A normally closed set of contacts open only when performance is within limits, and a second set of SPDT contacts are used to energize red and green error feedback lights.[6]

EDCB Complete Circuit Diagram--The complete circuit diagram for the EDCB is given in Figure 17. The layout of components of the EDCB is illustrated in Figures 18 and 19, showing front and rear views of the unit. A meter is provided for each of the four programmable parameters to monitor Link or reference voltages selected by the meter input switches. The "monitor jacks" (below the meter input switches) can be connected to a digital voltmeter or oscilloscope to provide higher resolution voltage measurements or for examination of AC noise levels on the input lines. The window tolerance selector switches are located just beneath the monitor jack for each parameter.

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[6]In the actual EDCB circuit a SPDT relay represented in Figure 16 as K5 is used to drive a 24-volt 4PDT relay which provided the actual contact closures for 24-volt and logic level signals.

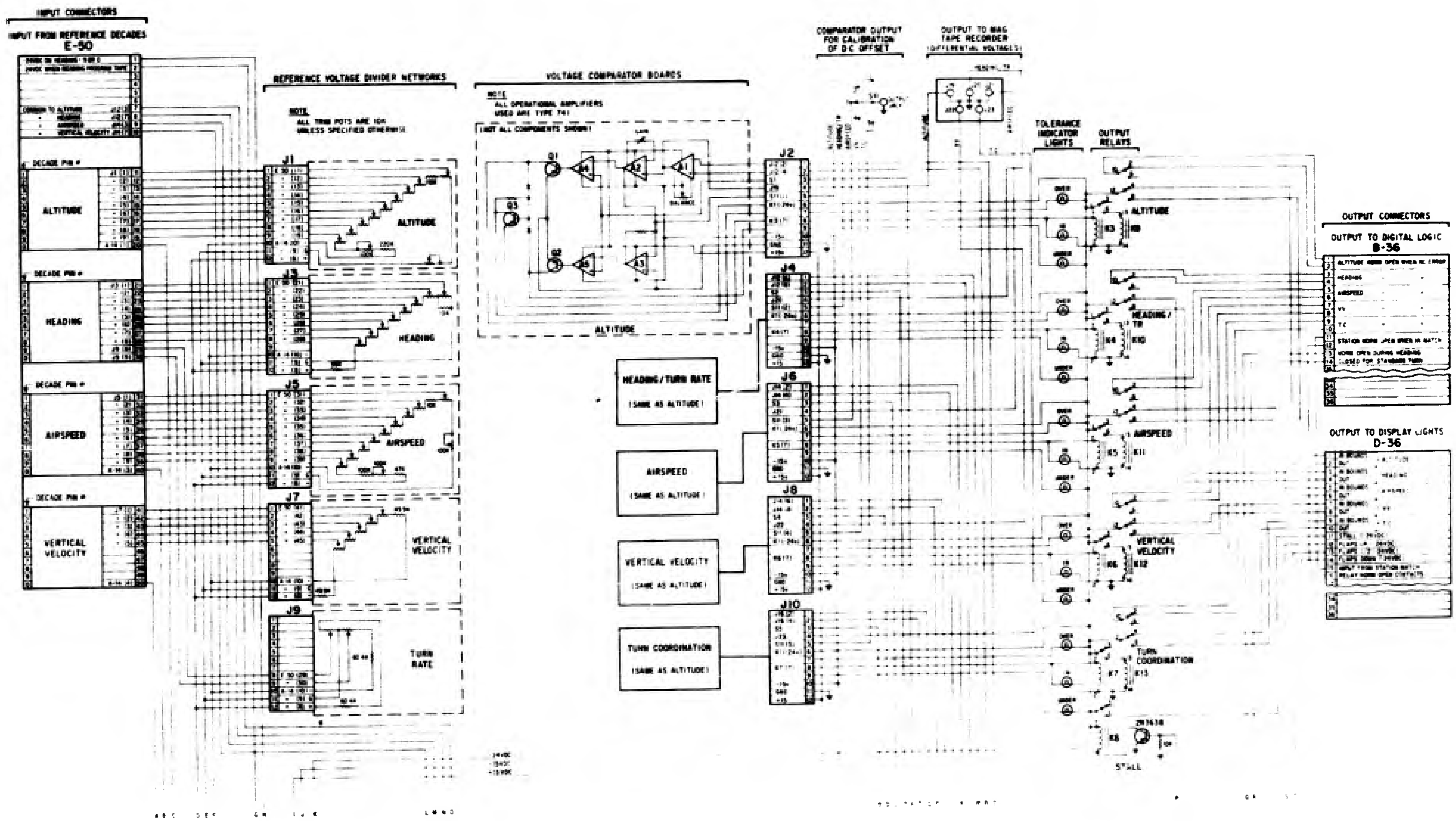

Figure 17. Error detection control board circuit diagram.

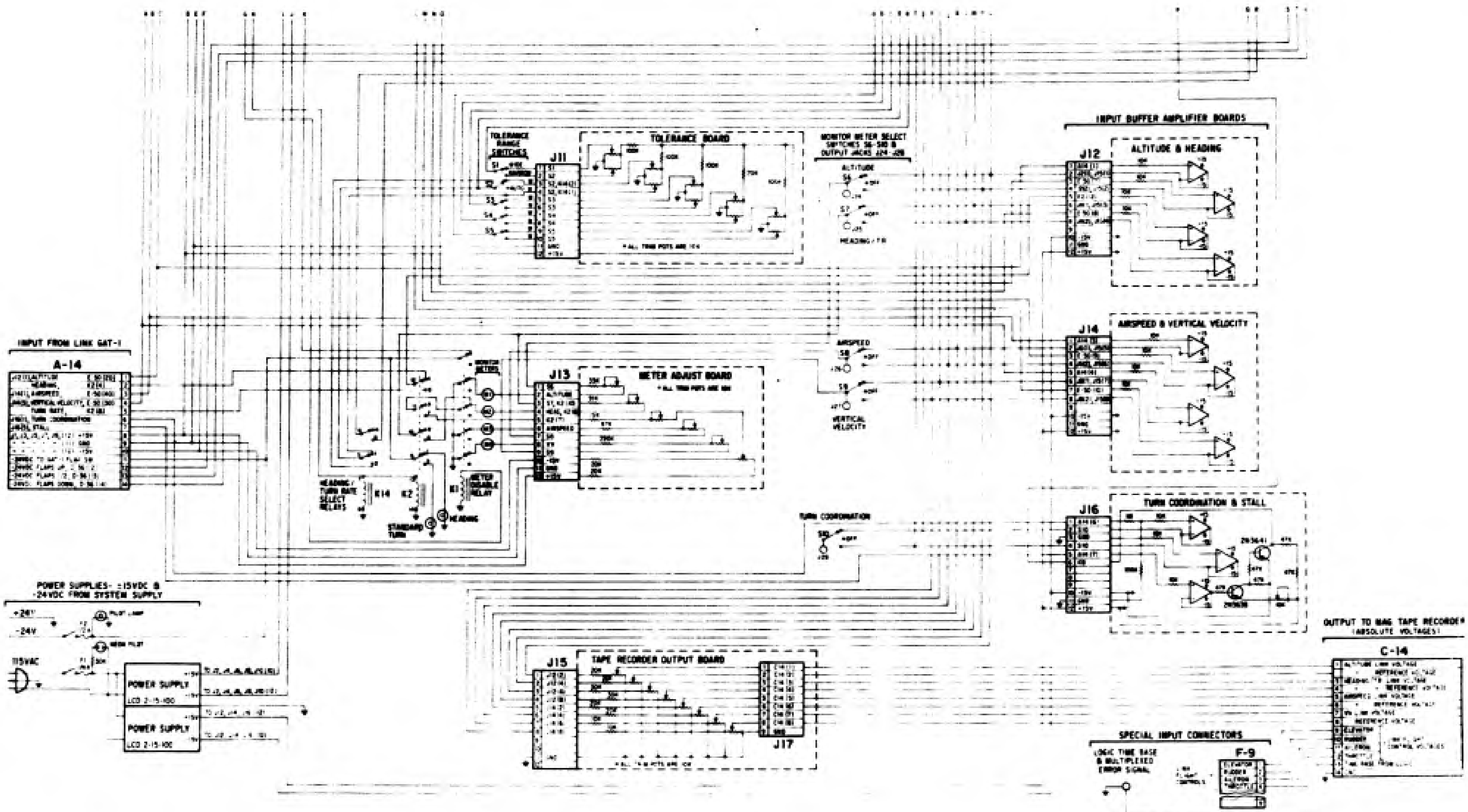

Figure 17 (continued)

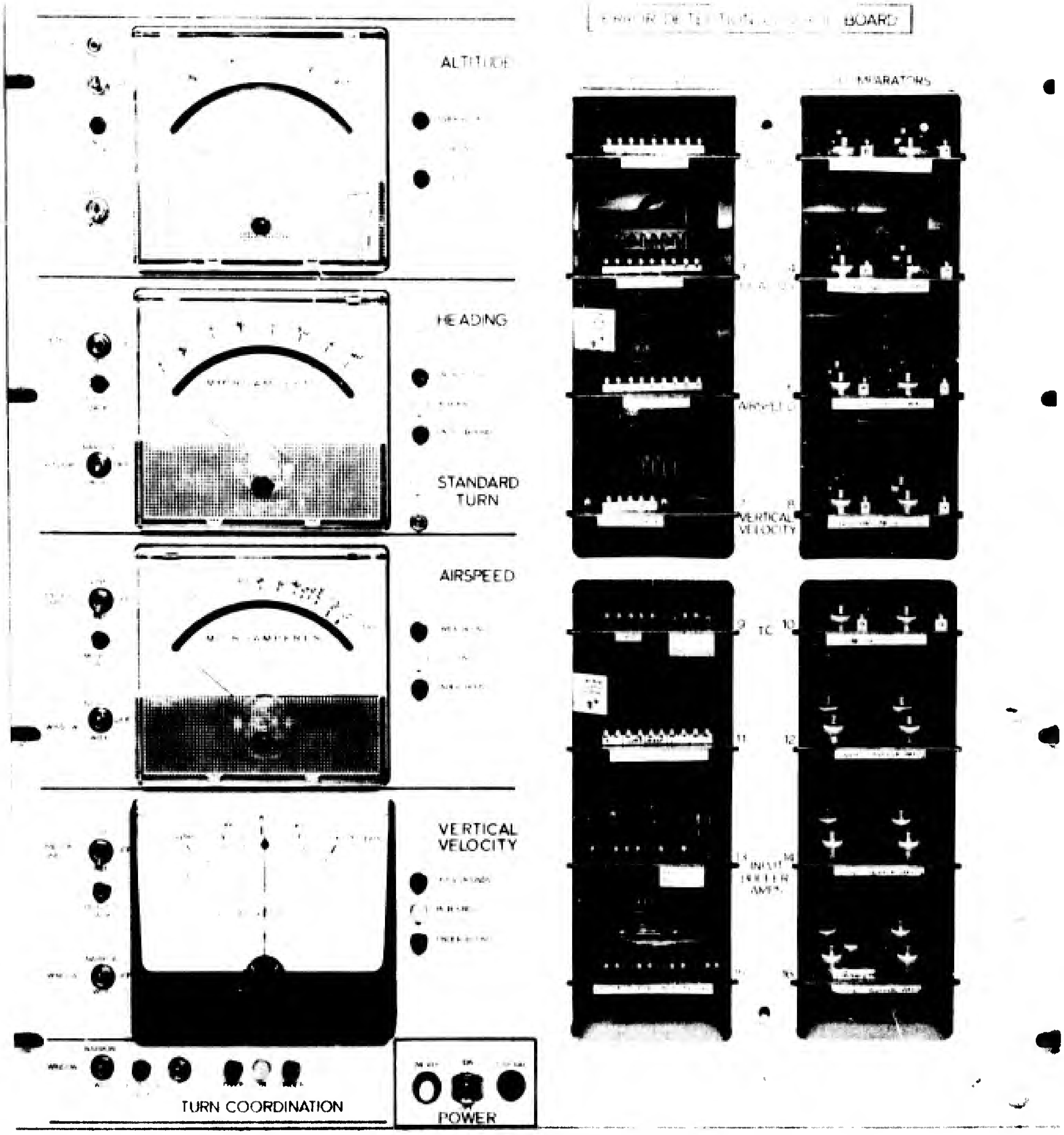

Figure 18. Front view of the EDCB.

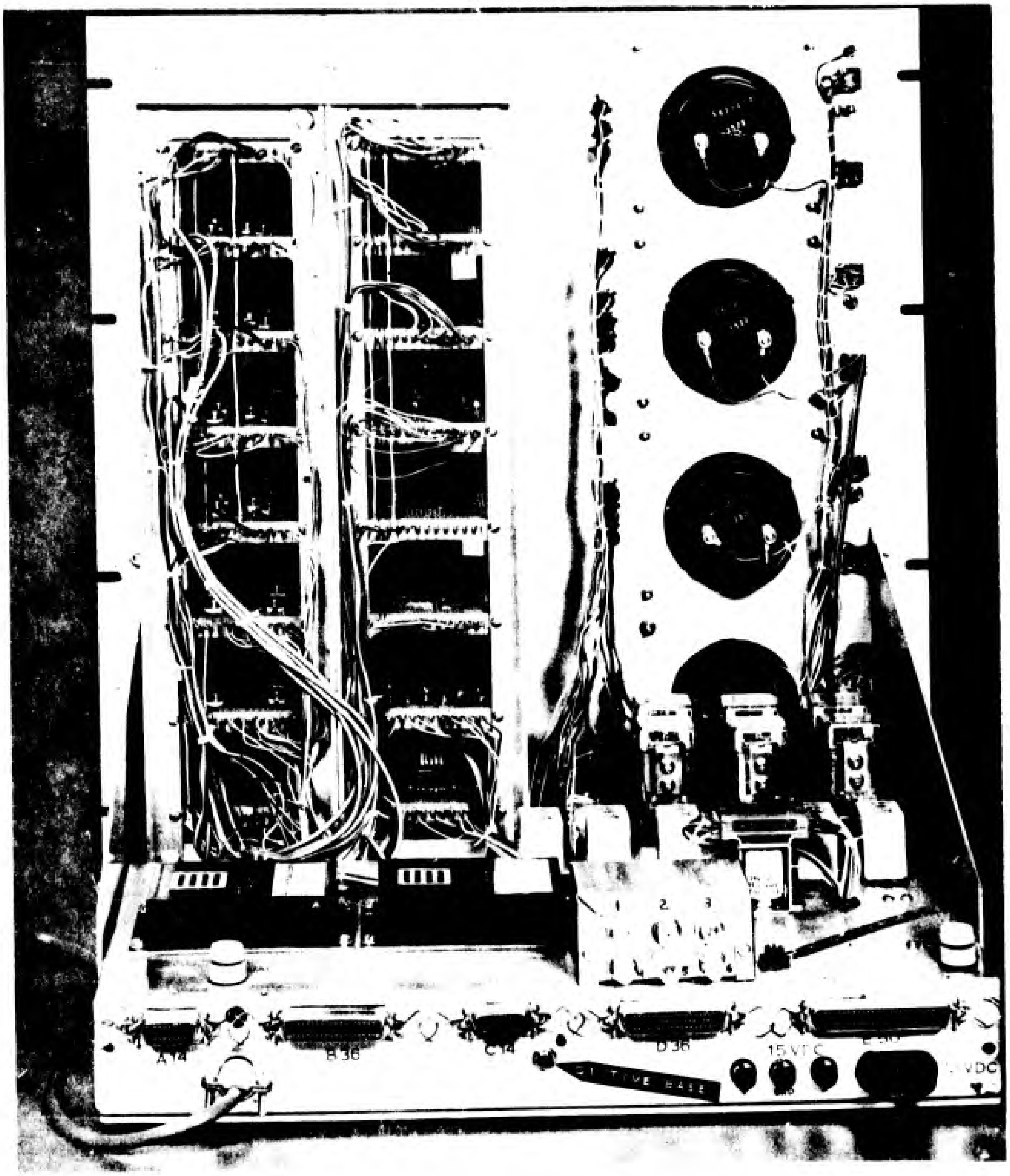

Figure 19. Rear view of the EDCB.

The card file contains 5 comparator cards, 5 voltage reference cards, 3 input buffer amplifier cards, 1 tolerance window card, 1 panel meter adjustment card, and 1 tape output voltage adjustment card. Figure 20 provides the complete schematic for the voltage comparator board. Amplifiers A1 to A5 are type 741 operational amplifiers.

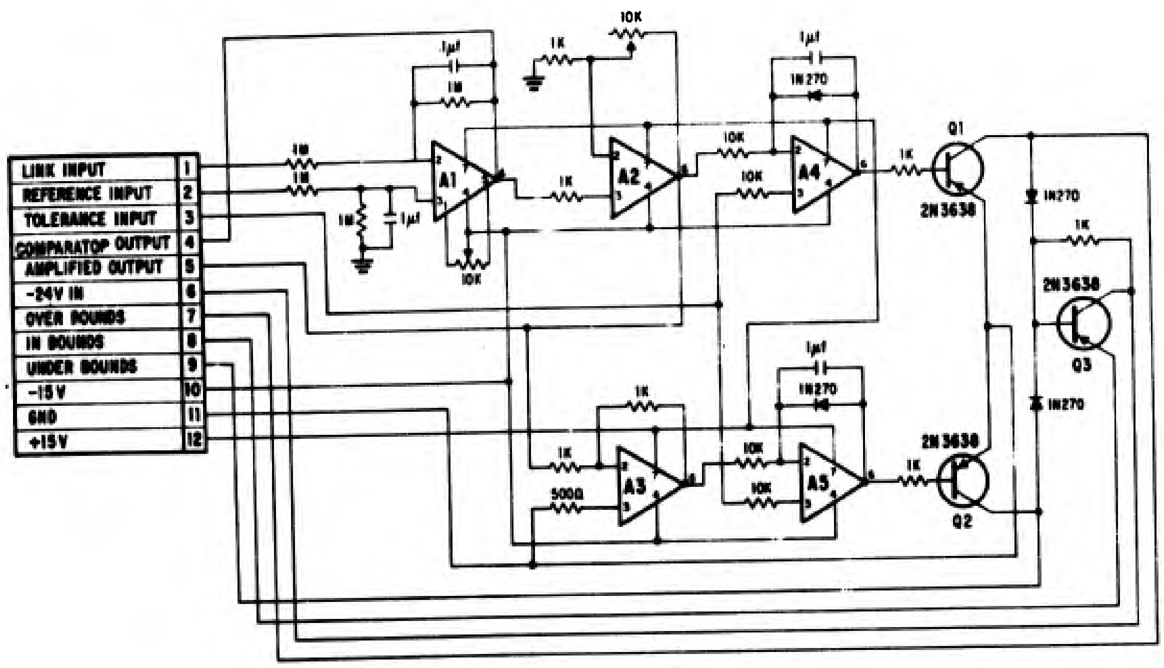

Figure 20. EDCB voltage comparator board circuit.

<u>Calibration procedures for EDCB</u>--Because the PPES uses programmable fixed threshold error tolerance levels, precise calibration of the Link instrument settings in relation to reference voltage levels is essential for consistent performance measurement.

The general steps taken for calibration of the PPES are the following: (a) assure that the Link GAT-1 is operating properly; (b) for each parameter, obtain the corresponding GAT-1 voltages with the instrument needle at the specified values; (c) set the reference voltage for each step level to the corresponding GAT-1 voltage; (d) balance the differential amplifier output to zero with the GAT-1 and reference inputs tied together; (e) set the narrow and wide tolerance levels to the desired window width; (f) verify proper system operation with test flights stepping through all the reference values for each parameter.

When a tape recorder is to be used to record the differential error voltages, an additional amplification stage is necessary to provide sufficient gain. The amplifiers used for this stage must also be balanced and scaled to provide a standard voltage level for a given magnitude of differential voltage (i.e., for altitude, a 1-volt differential voltage level can be scaled to represent a deviation of 100 ft from the requested value).

Although many visual checks on the performance of the PPES have been done through test flights and subject testing, no careful study has been made, to date, of the accuracy and reproducibility of the error detection circuitry. In the ideal system, the error feedback lights should change state at the precise moment that the needle indication crosses a given hash mark on the meter face. In the present system, DC voltage levels are used as indicators of the needle positions and hash marks and because of various sources of error will only approach the ideal system.

Sources of error include: (a) parallax sighting error of needle position due to observer's head position; (b) electromechanical play in meter movements of the GAT-1 instrumentation (especially apparent in the motor-driven altimeter with back lash of approximately ±10 ft of indicated altitude); (c) errors in setting the reference voltage divider potentiometers to the required values; (d) fluctuation of ±15 volt supply used in the GAT-1 and for the EDCB reference voltage dividers; (e) noise and artifact of GAT-1 and reference input lines; (f) errors in setting the DC balance potentiometers (resulting in asymmetric thresholds about the center value); (g) errors in setting the tolerance reference voltage dividers; (h) nonlinearities in GAT-1 indicator voltages resulting in variations in error window widths over the range of values employed.

The complexity of this calibration problem and the difficulty in measuring and recording exact thresholds for error detection at each target value suggest that a special computer program should be written to analyze the differential error signals and determine the precise voltage at which switching occurs. This approach would provide a record of the thresholds used for performance measurement for each EDCB; would permit verification of their stability; and would assure that each EDCB was adjusted to very nearly the same values.

Pilot Display Panel

General Description--The pilot display panel provides subjects flying the GAT-1 with the following information: (a) the number of the maneuver in the flight plan currently being scored; (b) the altitude, heading or turn rate, airspeed, and vertical velocity required for the maneuver; (c) the time remaining in the maneuver via the DME display; and (d) performance feedback consisting of green lights whenever the above parameters are scored as being "in bounds" and red lights whenever the above parameters and/or turn coordination are scored as being "out of bounds."

Subject input via the display panel consists of setting a 2-digit "radio station frequency" selector switch to the appropriate value programmed for each maneuver. A pilot "step" button was intended for use in subject-paced sequencing of maneuvers but has not been used in testing thus far (this pushbutton and lines could be used for other peripheral tasks).

Figures 21 and 22 show front and rear views of the pilot display panel. The switch mounted in the left rear portion of the panel (Fig. 22) is used to extinguish all error feedback lights and may be reached through a port in the sheetmetal cover.

Circuit Diagram of the Pilot Display Panel--The circuit diagram for the pilot display panel is illustrated in Figure 23. Input/output is of three major groups: (a) -24 VDC pulses for setting the decades to appropriate values, stepping, and resetting; (b) input to display lights; and (c) connection of the radio station selector switches with their corresponding elements in the central control panels. Relay K1 is used to extinguish the error feedback lights between maneuvers. Relay K2 is used to open the input lines to the decades during reset to prevent unwanted feedback to other decades connected in parallel which otherwise results in incomplete resets.

A modification is proposed for the station selector switch in Figure 24 which will allow a considerable reduction in the 20 lines currently used for this function. By locating two decade steppers behind the thumbwheel switch in the pilot display panel all interconnections between the command and slave selector switches can be made within the panel housing. An input to the "1" and "10's" place decades will be required and output to a "station match" relay will need a third line. The remaining ground, reset, and K2 relay contacts are available. This modification would simplify transmission line requirements to the control station.

Link GAT-1 Trainer

Introduction--The Link GAT-1 trainers used in the PPES were purchased with the standard instrument package: no radio navigation aids or ground track plotters were included. The current purchase price for a GAT-1 in

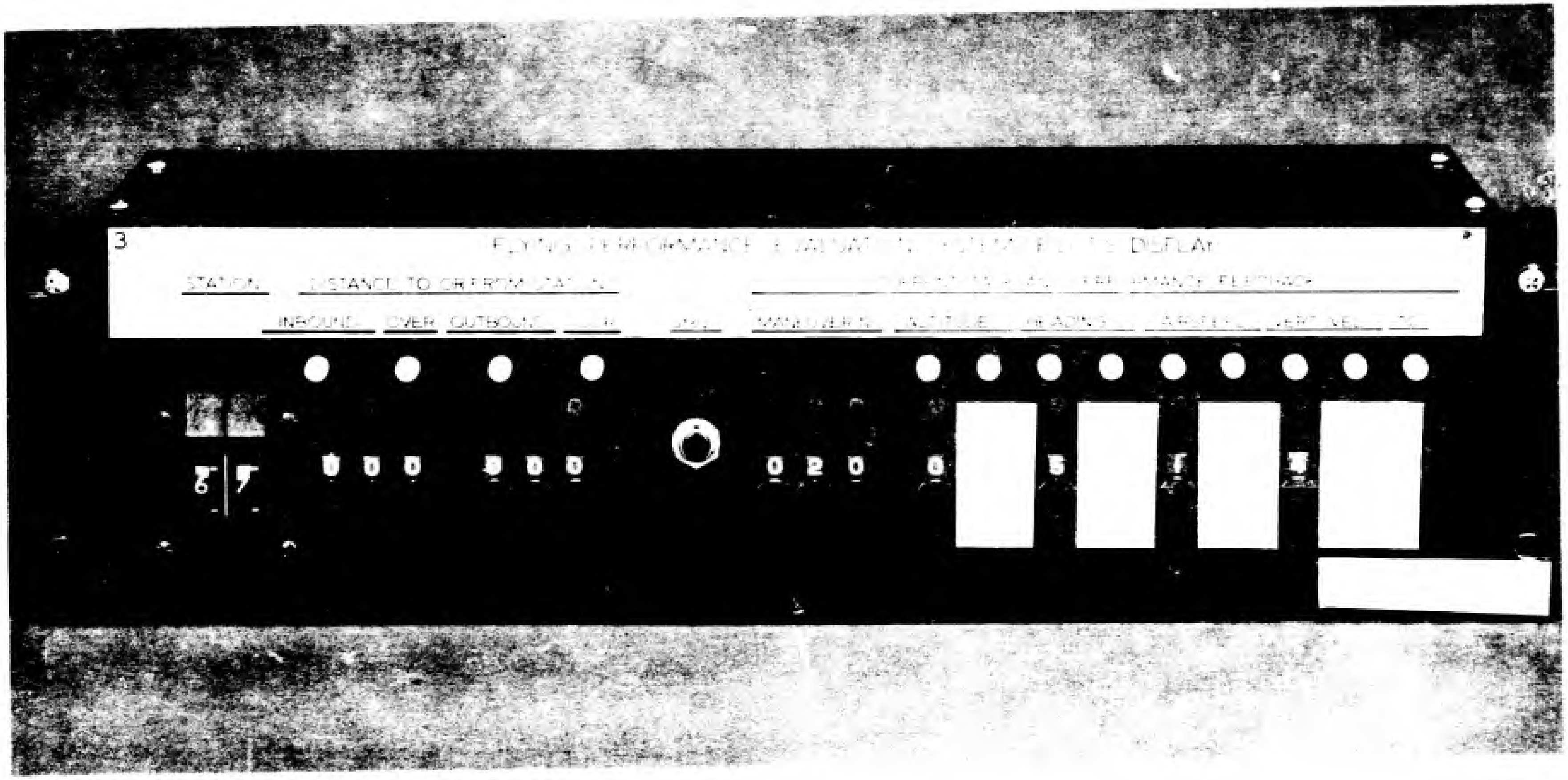

Figure 21. Front view of the pilot display panel.

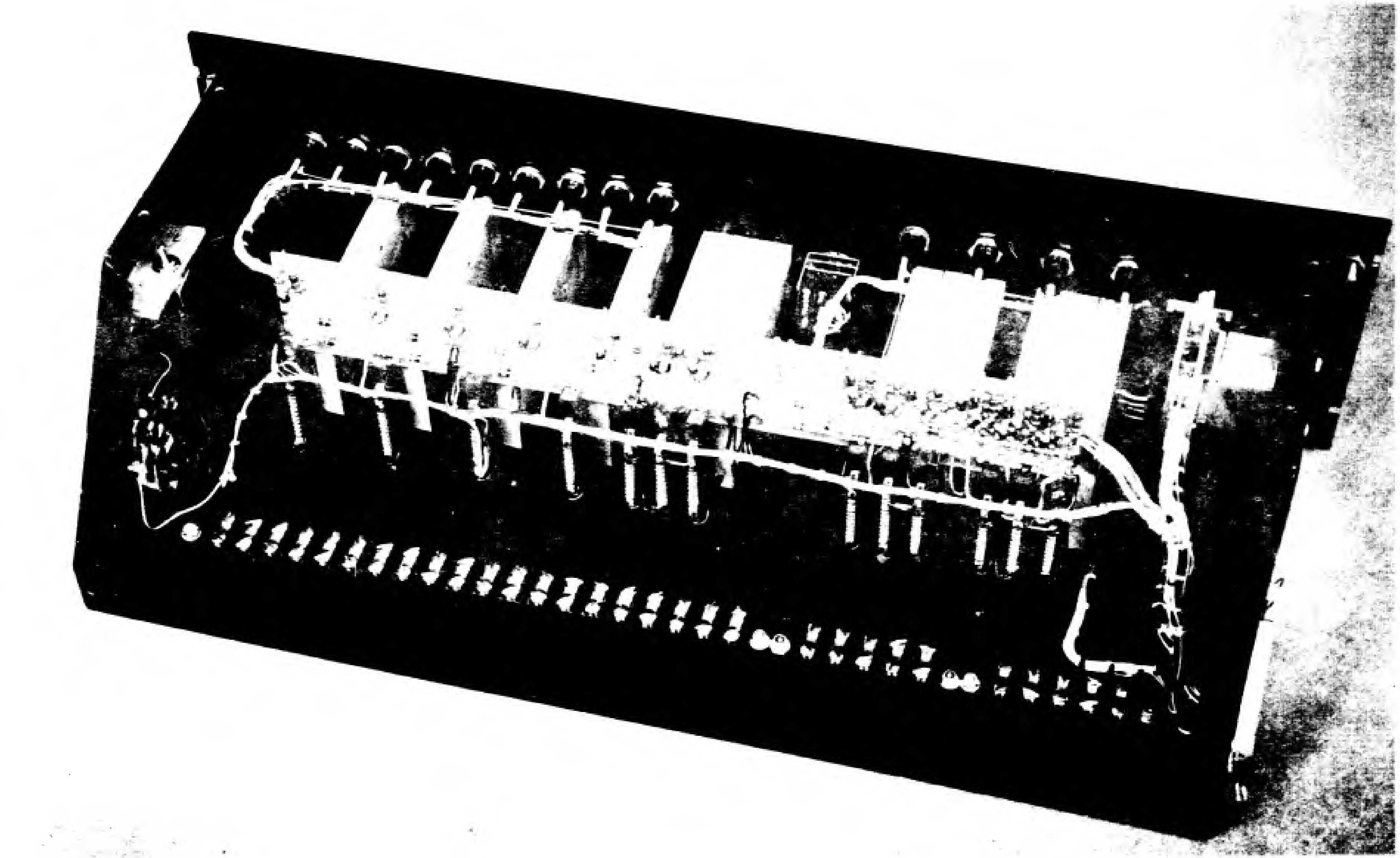

Figure 22. Rear view of the pilot display panel.

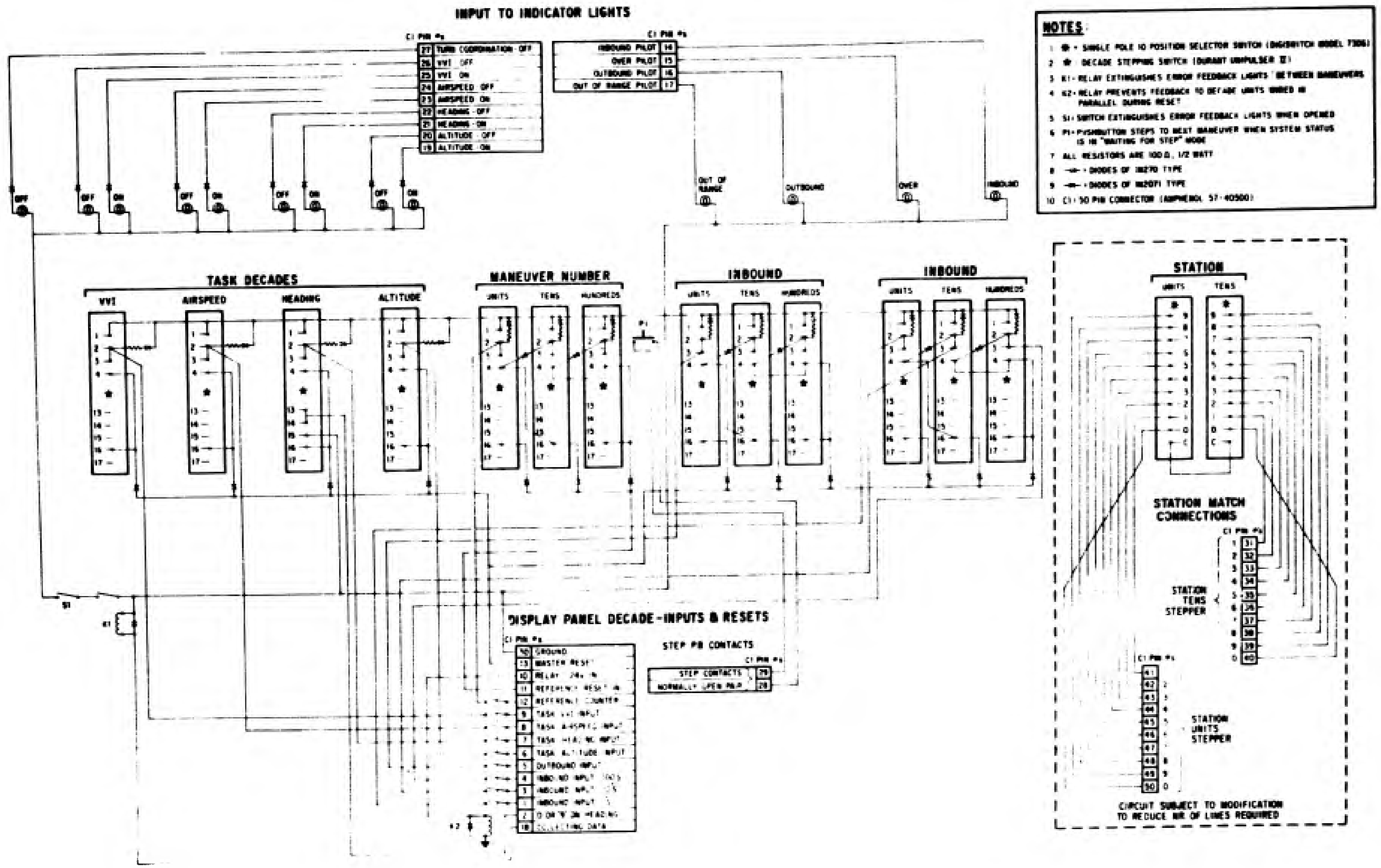

Figure 23. Circuit diagram of the pilot display panel.

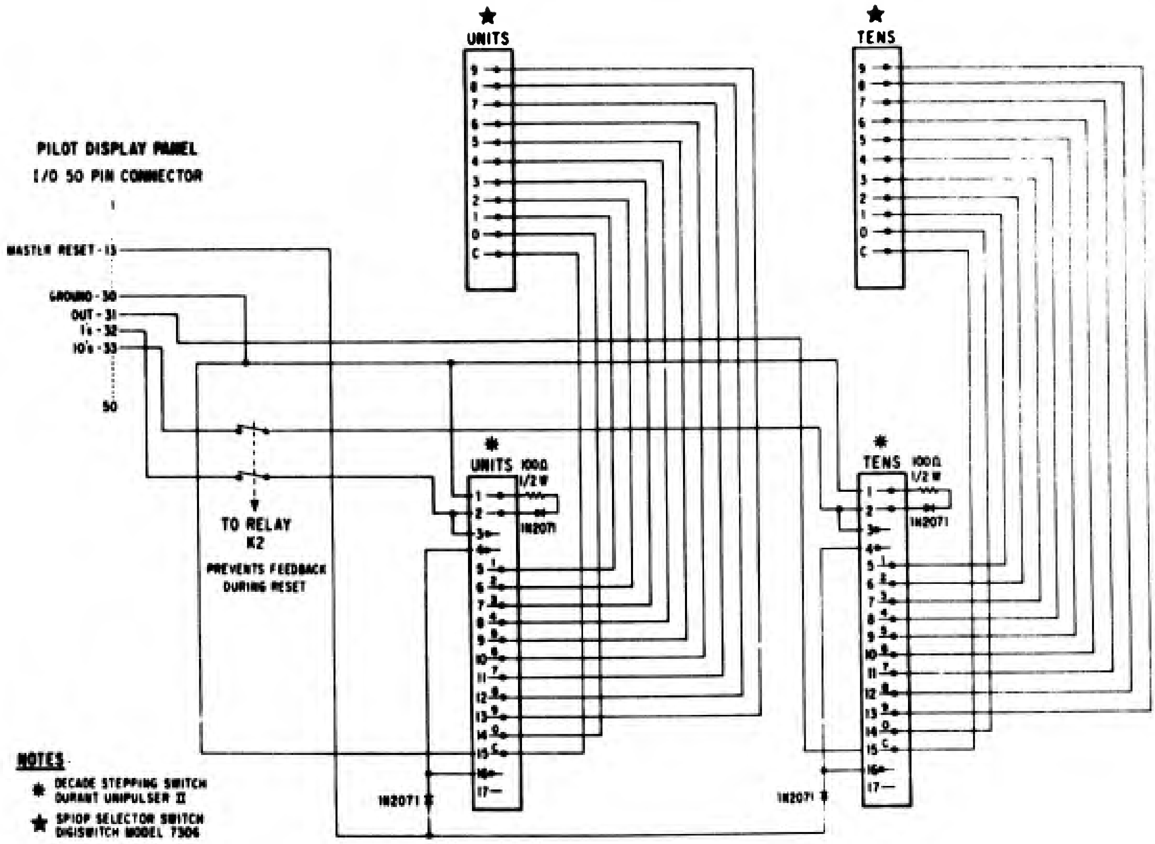

Figure 24. Modified circuit diagram for station match function of pilot display panel.

this configuration is approximately $14,000. The principal modifications necessary for interfacing the GAT-1 with the control system included: (a) derivation of Link GAT-1 instrument voltages (Table 4); (b) addition of overhead slip rings and/or rewiring of GAT-1 slip rings; (c) addition of a voice intercom; (d) externalization of the altitude hold switch and altitude add and subtract pushbuttons; and (e) installation of a pilot display panel.

<u>Input/Output Wiring</u>--When the first GAT-1 was incorporated in the PPES, a high quality 67-channel slip ring was available and all the input/output wiring between the GAT-1 and control station was directed through this slip ring. For the second GAT-1, overhead cables were used that had sufficient slack to permit two 360° turns before the cable had to be twisted in the opposite direction.

TABLE 4. SOURCE OF GAT-1 INSTRUMENT AND CONTROL VOLTAGES FOR CONNECTION TO THE PPES

Parameter	Connection on mother board	
	Plug No.	Pin design
Altitude	J20	18
Turn rate	J22	35
Airspeed	J20	24
Vertical velocity	J19	T
Engine RPM	J18	W
Ball angle	J12	J

Note: Heading was derived from the wiper arm of a 5K linear potentiometer installed in the place of the SIN/COS heading potentiometer. Voltages for control element positions were tapped directly off the corresponding potentiometers for aileron, elevator, rudder, and throttle. Flap position was remoted by employing an unused segment of the (3P3P) flap switch.

The flight plans were designed with this restriction in mind, and thus far no subject has lost control of the trainer to the point where the cable was endangered from overtwisting. Another alternative was to use the 30-channel slip ring of the GAT-1 motion base assembly, at least for some functions. The number (50) of channels required for the pilot display panel precluded this approach.

Intercom--Because the trainers were located in separate rooms, a voice intercommunication system had to be provided. Although we originally used a modified GAT-1 communication card for this purpose, we now use a standard intercom system.[7]

Altitude Hold Function--Located on the altitude card of the GAT-1 is a hold switch which will freeze the altitude indicated by the altimeter. In addition, altitude "add" and "subtract" pushbuttons are present which permit the experimenter to preposition the simulator at any given altitude. By using free terminals on the altitude board and receptacle and connecting three similar switches in parallel, these functions were externalized to the instructor station control panel.

GAT-1 Schematics--A complete set of GAT-1 blueprints was purchased to assist us in modifying and servicing the trainer. What we found lacking, however, was a level of documentation somewhere between the detailed blueprints and generalities of the GAT-1 Operation and Maintenance Manual. Thus it took some time before we had labeled the system

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[7]A model K-ML-5 master and K-LR-3 substations were employed, Talk-A-Phone Co. Chicago, Ill.

blueprints so that we could, for example, find the appropriate trim pots to adjust rates of turn and climb and be reasonably certain of system interconnections. In our view, the decision to provide one's own maintenance and modification is a serious one and well-trained support personnel are needed.

Data Recording Subsystem--The data recording subsystem performs the primary function of sampling the state of the EDCB output relays once every second and logging appropriate error counts on digital counters and on perforated paper tape (Table 3). BRS Foringer, Digi-Bit 200 series logic, counters, and paper tape punches were used. A diagram of the circuit used is given in Figure 25.

The format used to record the data on 8-channel perforated paper tape was as follows: On channels 1, 2, 3, 4, 5, and 6 a hole-punched corresponded to a second of error for altitude, heading or turn rate, airspeed, vertical velocity, turn coordination, and station respectively. The seventh channel represented the clock and was punched once each second at the time the EDCB relays were strobed. The eighth channel was used to indicate the first second of a new maneuver. A code of three characters of all holes punched signified the end of a run. This simple format permitted ready verification of proper operation of the equipment by the experimenters.

DISCUSSION

The Pilot Performance Evaluation System is both complex and costly. In our series of studies using ethyl alcohol as a known stress to degrade the performance of subjects we have seen that simpler psychomotor tasks (2) and a less complex Link trainer task (3) have fully comparable sensitivity to the PPES in terms of detecting the degrading effects of alcohol. It is important to ask, therefore, if development beyond the prototype PPES is warranted.

The strongest case for continued use of the PPES comes from the evaluation of a panel of 16 experienced pilots who were asked to rate the PPES (also referred to as the primary Link task) in comparison to a less complex Link task (3). They also provided their own estimates as to how well they felt the task was assessing what could be called "pilot performance." It was concluded that the PPES assessed pilot performance "moderately well" (Fig. 26).

Even more important, this panel of USAF instructor pilots and flight examiners were able to achieve some consensus on interpreting the practical significance of the performance measuring scale of CTSE. CTSE decrement scores (for the CP-1, CP-2, CP-3, and CP-4 flight plans) of less than 1000 units were judged to be of "mild or of no operational concern." CTSE decrement scores of 1000 to 2000 units were judged to be of "increasing operational concern." CTSE decrements above 2000 were

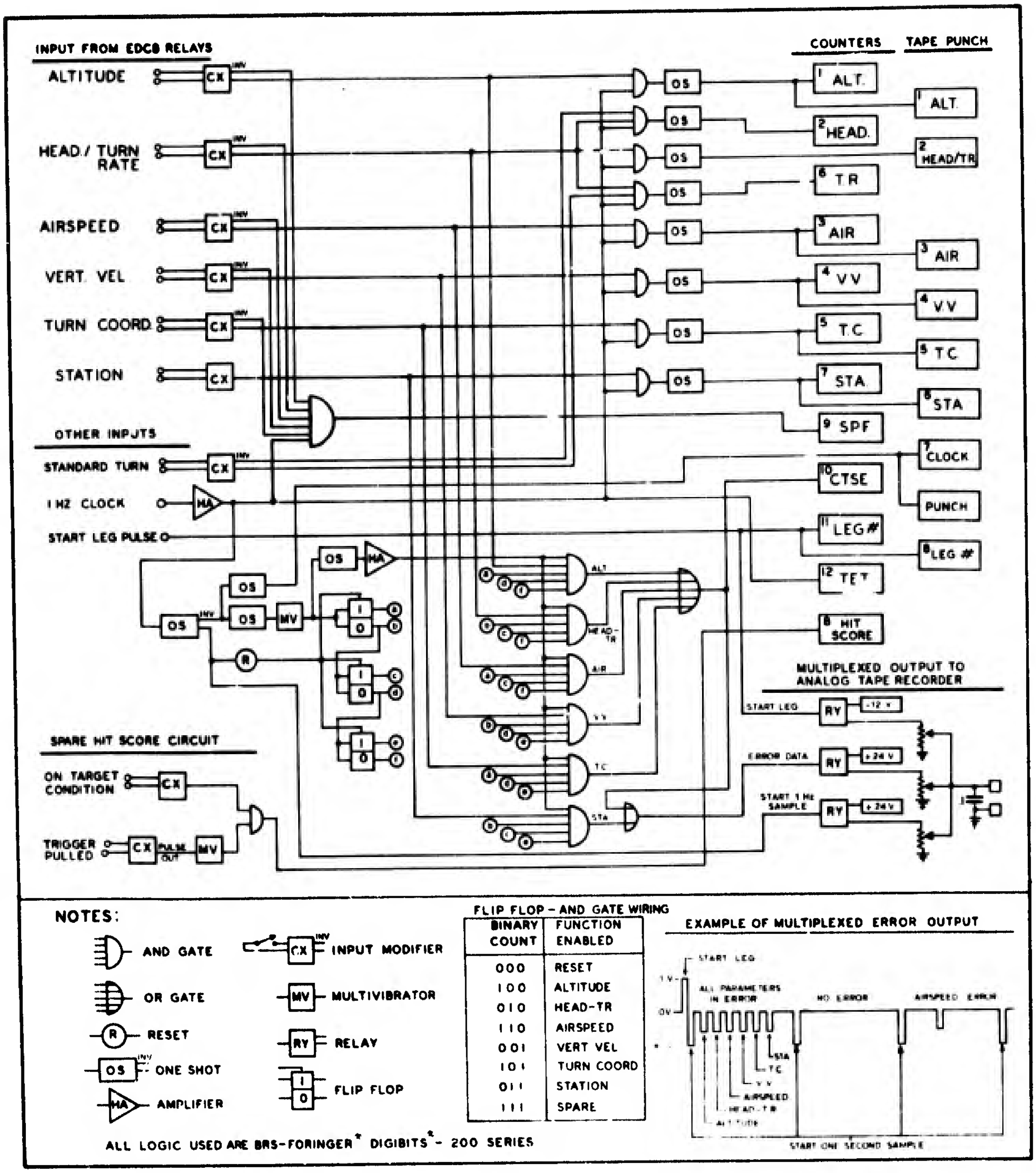
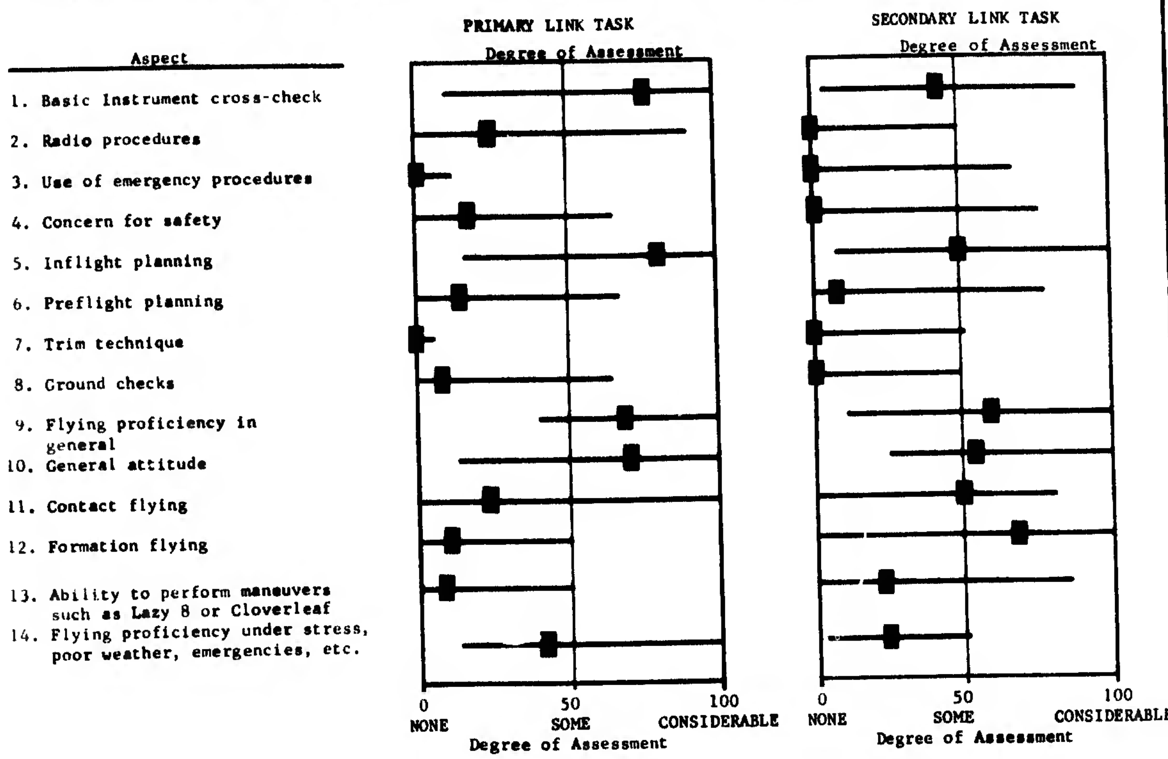


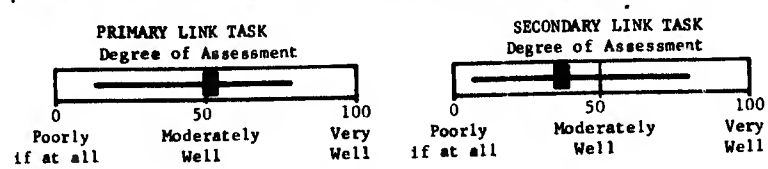
Figure 25. Logic for control of counters and paper tape perforator for scoring one GAT-1.

In the form of a questionnaire, each pilot was presented with a list of some "important aspects" of the overall job of flying training missions in T-37 or T-38 aircraft. The pilots were asked to rate how well they thought the primary and secondary Link tasks measured each aspect in the laboratory. Responses were made by making a vertical mark on a 2.5 inch horizontal scale.

In the figure below, each aspect has been listed and the group median response is denoted by the heavy vertical bar and the range from highest to lowest rating by the horizontal line.



The final question was to take all of the above into consideration and to rate how well the two tasks assessed what could be called "pilot performance" in the context of flying T-37 or T-38 aircraft on training missions.



Note: Flight examiners A and B did not participate in the evaluation of the secondary Link task as they had no formal training on this task.

Figure 26. An evaluation of the PPES (primary Link task) and a less complex Link task by a panel of 16 experienced pilots.

judged to constitute "significant operational concern," and by inference subjects demonstrating comparable degrees of performance decrement should not be flying. This type of information is essential if the experimenters are to go beyond issues of statistical significance and to estimate the probable operational impact that a given drug might have on pilot performance.

In summary, the PPES, although it permits only crude simulation of actual flying, is sufficiently effective so that experienced pilots: (a) show comparable performance decrements to nonpilot subjects; and (b) can relate sufficiently to the task to make some professional judgment as to the practical significance of the performance scores.

If the research conducted using the prototype PPES is to serve as a reference for future drug evaluations, then many of the following design features of this system should be retained:

1. Pilot Display Panel -- legibility of the numbers and code format.

2. Testing Flight Plans -- the duration, type, and sequence of maneuvers.

3. Scoring Criteria -- use of error tolerance windows and the statistic CTSE.

4. Intermaneuver Interval -- the 15-second free period between maneuvers.

Beyond these restrictions, however, it should be quite feasible to replace the present system controller, analog scoring logic, and data logging units by a more reliable digital computer system. A small general purpose digital computer with appropriate peripherals such as A/D conversion units, magnetic tape drives, and special purpose task display for the pilot, would probably be adequate. On the basis of the material contained in this report, such a system can be designed with relative ease. Given a clear picture of the desired end product, the accuracy of cost estimates should be high. From this standpoint alone, the prototype PPES has served a useful purpose.

REFERENCES

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3. Henry, P. H., et al. Evaluation of two Link GAT-1 trainer tasks by experienced pilots at three alcohol dose levels. SAM-TR-74-53 (in preparation).

4. Keiser, H. N., and P H. Henry. PDP-12 processing of Link flight simulator data. DECUS Proceedings Fall 1972, pp. 3-7. Digital Equipment Computer Users Society, Maynard, Mass., 1973.

APPENDIX A

FLIGHT PLANS DEVELOPED FOR THE PPES

Of the following series of eight flight plans, the flight plans MF-2, RF-1, CP-5, and CP-6 have been used for training. Flight plans CP-1, CP-2, CP-3, and CP-4 have been used exclusively for testing performance of subjects under the influence of alcohol.

DESCRIPTION OF FLIGHT PLAN MF-2

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210		042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Lft Std Turn
3	300	300	060		4 3 7 3	13	Straight & Level
4	30	600		006	4 9 7 3	13	Rt Std Turn
5	300	630	060		0 5 4 2	17	Climb
6	30	930		006	9 0 4 3	17	Lft Std Turn
7	560	960	112		9 3 7 3	20	Straight & Level
8	90	1520		018	0 9 6 4	20	Dive & Rt Std Turn
9	210	1610	042		0 1 6 4	23	Dive
10	30	1820		006	4 9 7 3	23	Rt Std Turn
11	120	1850	024		0 3 8 5	32	Dive
12	360	1970		072	0 3 3 2	32	Climb
13	120	2330	024		0 9 6 4	37	Dive & Rt Std Turn
14	120	2450		024	4 3 7 3	37	Straight & Level
15	120	2570	024		0 0 4 2	42	Climb & Lft Std Turn
16	60	2690		012	6 3 6 3	42	Straight & Level
17	30	2750	006		6 9 6 3	43	Rt Std Turn
18	180	2780		036	0 5 3 5	43	Dive
19	60	2960	012		0 5 1 4	67	Dive & Land
		TET 3020					

DESCRIPTION OF FLIGHT PLAN RF-1

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	240	0	048		0 1 4 2	01	Take Off & Climb
2	90	240		018	3 0 6 3	80	Left Std Turn
3	105	330	021		3 3 7 3	11	Straight & Level
4	45	435		009	3 9 7 3	70	Right Std Turn
5	120	480	024		0 6 5 2	02	Climb
6	120	600		024	6 1 3 3	20	Straight & Level Disc
7	30	720	006		6 0 4 3	03	Left Std Turn
8	120	750		024	0 7 8 5	50	Dive
9	210	870	042		3 4 6 3	22	Straight & Level Disc
10	240	1080		048	0 1 2 4	20	Dive & Land
11	60	1320	012		0 1 5 2	03	Take Off & Climb
12	120	1380		024	0 9 5 2	40	Right Std Turn
13	240	1500	048		3 5 7 3	13	Straight & Level Disc
14	45	1740		009	3 0 7 3	10	Left Std Turn
15	60	1785	012		0 2 4 2	07	Climb
16	90	1845		018	0 9 6 4	20	Right Std Turn
17	30	1935	006		0 8 7 4	19	Dive
18	105	1965		021	2 0 6 3	21	Left Std Turn
19	180	2070	036		1 1 3 3	08	Straight & Level Disc
20	60	2250		012	0 1 2 4	60	Dive & Land
21	180	2310	036		0 1 1 2	04	Take Off & Climb
22	30	2490		006	2 9 2 3	10	Right Std Turn
23	120	2520	024		3 7 6 3	12	Straight & Level Disc
24	60	2640		012	3 0 6 3	31	Left Std Turn
25	60	2700	012		0 0 5 2	03	Left Std Turn
26	50	2760		010	4 7 7 3	40	Straight & Level
27	60	2810	012		0 9 8 4	08	Right Std Turn
28	150	2870		030	1 6 8 3	30	Straight & Level Disc
29	45	3020	009		1 0 4 3	27	Left Std Turn
30	60	3065		012	0 1 1 4	13	Dive & Land
		TET 3125					

DESCRIPTION OF FLIGHT PLAN CP-5

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210	0	042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Lft Std Turn
3	30	300	006		4 3 7 3	13	Straight & Level
4	30	330		006	4 9 7 3	13	Right Std Turn
5	300	360	060		0 5 4 2	17	Climb
6	30	660		006	9 0 4 3	17	Left Std Turn
7	90	690	018		8 1 6 3	03	Straight & Level Disc
8	30	780		006	8 9 6 3	10	Right Std Turn
9	30	810	006		8 0 7 3	32	Left Std Turn
10	30	840		006	8 1 6 3	41	Straight & Level
11	60	870	012		8 9 5 3	07	Right Std Turn
12	60	930		012	8 0 7 3	30	Left Std Turn
13	30	990	006		0 1 6 2	08	Climb
14	30	1020		006	0 0 5 2	40	Climb & Left Std Turn
15	35	1050	007		9 7 6 3	17	Straight & Level
16	30	1085		006	9 9 7 3	16	Right Std Turn
17	60	1115	012		9 0 5 3	07	Left Std Turn
18	30	1175		006	9 9 6 3	17	Right Std Turn
19	35	1205	007		9 7 6 3	31	Straight & Level
20	30	1240		006	0 9 3 4	21	Dive & Rt Std Turn
21	30	1270	006		0 1 4 4	20	Dive
22	60	1300		012	8 0 4 3	32	Left Std Turn
23	60	1360	012		8 9 6 3	08	Right Std Turn
24	90	1420		018	8 1 7 3	24	Straight & Level
25	90	1510	018		9 3 7 3	20	Straight & Level Disc
26	90	1600		018	0 9 6 4	20	Dive & Rt Std Turn
27	210	1690	042		0 1 6 4	23	Dive
28	30	1900		006	4 9 7 3	23	Right Std Turn
29	120	1930	024		0 3 8 5	32	Dive
30	360	2050		072	0 3 3 2	32	Climb
31	120	2410	024		0 9 6 4	37	Dive & Rt Std Turn
32	40	2530		008	4 3 7 3	37	Straight & Level
33	120	2570	024		0 0 4 2	42	Climb & Lft Std Turn
34	60	2690		012	6 3 6 3	42	Straight & Level
35	30	2750	006		6 9 6 3	43	Right Std Turn
36	180	2780		036	0 5 3 5	43	Dive
37	60	2960	012		0 5 1 4	67	Dive & Land
	TET	3020					

DESCRIPTION OF FLIGHT PLAN CP-6

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210	0	042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Left Std Turn
3	30	300	006		4 3 7 3	13	Straight & Level
4	30	330		006	4 9 7 3	13	Right Std Turn
5	300	360	060		0 0 4 2	17	Climb
6	30	660		006	9 0 4 3	17	Left Std Turn
7	90	690	018		8 5 6 3	03	Straight & Level Disc
8	30	780		006	8 0 6 3	10	Left Std Turn
9	30	810	006		8 9 7 3	32	Right Std Turn
10	30	840		006	8 5 6 3	41	Straight & Level
11	60	870	012		8 9 5 3	07	Right Std Turn
12	60	930		012	8 0 7 3	30	Left Std Turn
13	30	990	006		0 5 6 2	08	Climb
14	30	1020		006	0 9 5 2	40	Climb & Rt Std Turn
15	35	1050	007		9 7 6 3	17	Straight & Level
16	30	1085		006	9 0 7 3	16	Left Std Turn
17	60	1115	012		9 9 5 3	07	Right Std Turn
18	30	1175		006	9 0 6 3	17	Left Std Turn
19	35	1205	007		9 7 6 3	31	Straight & Level
20	30	1240		006	0 0 3 4	21	Dive & Left Std Turn
21	30	1270	006		0 5 4 4	20	Dive
22	60	1300		012	8 0 4 3	32	Left Std Turn
23	60	1360	012		8 9 6 3	08	Right Std Turn
24	90	1420		018	8 5 7 3	24	Straight & Level
25	90	1510	018		9 3 7 3	20	Straight & Level Disc
26	90	1600		018	0 9 6 4	20	Dive & Rt Std Turn
27	210	1690	042		0 1 6 4	23	Dive
28	30	1900		006	4 9 7 3	23	Right Std Turn
29	120	1930	024		0 3 8 5	32	Dive
30	360	2050		072	0 3 3 2	32	Climb
31	120	2410	024		0 9 6 4	37	Dive & Rt Std Turn
32	40	2530		008	4 3 7 3	37	Straight & Level
33	120	2570	024		0 0 4 2	42	Climb & Lft Std Turn
34	60	2690		012	6 3 6 3	42	Straight & Level
35	30	2750	006		6 9 6 3	43	Right Std Turn
36	180	2780		036	0 5 3 5	43	Dive
37	60	2960	012		0 5 1 4	67	Dive & Land
		TET 3020					

DESCRIPTION OF FLIGHT PLAN CP-1

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210		042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Lft Std Turn
3	30	300	006		4 3 7 3	13	Straight & Level
4	30	330		006	4 9 7 3	13	Right Std Turn
5	300	360	060		0 5 4 2	17	Climb
6	30	660		006	9 0 4 3	17	Left Std Turn
7	60	690	012		8 5 7 3	03	Straight & Level Disc
8	30	750		006	8 9 7 3	10	Right Std Turn
9	60	780	012		0 7 4 2	32	Climb
10	30	840		006	0 7 8 5	41	Dive
11	30	870	006		8 9 6 3	07	Right Std Turn
12	60	900		012	8 1 7 3	30	Straight & Level
13	90	960	018		8 0 6 3	08	Left Std Turn
14	20	1050		004	8 3 6 3	40	Straight & Level
15	30	1070	006		8 0 7 3	17	Left Std Turn
16	60	1100		012	8 1 7 3	16	Straight & Level
17	30	1160	006		8 0 6 3	07	Left Std Turn
18	20	1190		004	8 7 6 3	17	Straight & Level
19	90	1210	018		8 0 7 3	31	Left Std Turn
20	60	1300		012	8 1 6 3	21	Straight & Level
21	30	1360	006		8 9 6 3	20	Right Std Turn
22	30	1390		006	0 3 4 5	32	Dive
23	60	1420	012		0 3 3 2	08	Climb
24	30	1480		006	8 9 5 3	24	Right Std Turn
25	90	1510	018		9 3 7 3	20	Straight & Level Disc
26	90	1600		018	0 9 6 4	20	Dive & Rt Std Turn
27	210	1690	042		0 1 6 4	23	Dive
28	30	1900		006	4 9 7 3	23	Right Std Turn
29	120	1930	024		0 3 8 5	32	Dive
30	360	2050		072	0 3 3 2	32	Climb
31	120	2410	024		0 9 6 4	37	Dive & Rt Std Turn
32	40	2530		008	4 3 7 3	37	Straight & Level
33	120	2570	024		0 0 4 2	42	Climb & Left Std Turn
34	60	2690		012	6 3 6 3	42	Straight & Level
35	30	2750	006		6 9 6 3	43	Right Std Turn
36	180	2780		036	0 5 3 5	43	Dive
37	60	2960	012		0 5 1 4	67	Dive & Land
		TET 3020					

DESCRIPTION OF FLIGHT PLAN CP-2

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210	0	042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Lft Std Turn
3	30	300	006		4 3 7 3	13	Straight & Level
4	30	330		006	4 9 7 3	13	Right Std Turn
5	300	360	060		0 5 4 2	17	Climb
6	30	660		006	9 0 4 3	17	Left Std Turn
7	60	690	012		8 1 7 3	03	Straight & Level Disc
8	30	750		006	8 0 5 3	10	Left Std Turn
9	60	780	012		0 7 3 2	32	Climb
10	30	840		006	0 7 4 5	41	Dive
11	30	870	006		8 0 6 3	07	Left Std Turn
12	60	900		012	8 5 6 3	30	Straight & Level
13	90	960	018		8 9 7 3	08	Right Std Turn
14	20	1050		004	8 3 6 3	40	Straight & Level
15	30	1070	006		8 9 6 3	17	Right Std Turn
16	60	1100		012	8 5 7 3	16	Straight & Level
17	30	1160	006		8 9 7 3	07	Right Std Turn
18	20	1190		004	8 7 6 3	17	Straight & Level
19	90	1210	018		8 9 6 3	31	Right Std Turn
20	60	1300		012	8 5 7 3	21	Straight & Level
21	30	1360	006		8 0 6 3	20	Left Std Turn
22	30	1390		006	0 3 8 5	32	Dive
23	60	1420	012		0 3 4 2	08	Climb
24	30	1480		006	8 0 7 3	24	Left Std Turn
25	90	1510	018		9 3 7 3	20	Straight & Level Disc
26	90	1600		018	0 9 6 4	20	Dive & Right Std Turn
27	210	1690	042		0 1 6 4	23	Dive
28	30	1900		006	4 9 7 3	23	Right Std Turn
29	120	1930	024		0 3 8 5	32	Dive
30	360	2050		072	0 3 3 2	32	Climb
31	120	2410	024		0 9 6 4	37	Dive & Rt Std Turn
32	40	2530		008	4 3 7 3	37	Straight & Level
33	120	2570	024		0 0 4 2	42	Climb & Left Std Turn
34	60	2690		012	6 3 6 3	42	Straight & Level
35	30	2750	006		6 9 6 3	43	Right Std Turn
36	180	2780		036	0 5 3 5	43	Dive
37	60	2960	012		0 5 1 4	67	Dive & Land
		TET 3020					

DESCRIPTION OF FLIGHT PLAN CP-3

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210	0	042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Left Std Turn
3	30	300	006		4 3 7 3	13	Straight & Level
4	30	330		006	4 9 7 3	13	Right Std Turn
5	300	360	060		0 5 4 2	17	Climb
6	30	660		006	9 0 4 3	17	Left Std Turn
7	60	690	012		8 1 7 3	03	Straight & Level Disc
8	30	750		006	8 0 6 3	10	Left Std Turn
9	20	780	004		8 7 6 3	32	Straight & Level
10	90	800		018	8 0 7 3	41	Left Std Turn
11	60	890	012		8 1 6 3	07	Straight & Level
12	30	950		006	8 9 6 3	30	Right Std Turn
13	30	980	006		0 3 4 5	08	Dive
14	60	1010		012	0 3 3 2	40	Climb
15	30	1070	006		8 9 5 3	17	Right Std Turn
16	60	1100		012	8 5 7 3	16	Straight & Level
17	30	1160	006		8 9 7 3	07	Right Std Turn
18	60	1190		012	0 7 4 2	17	Climb
19	30	1250	006		0 7 8 5	31	Dive
20	30	1280		006	8 9 6 3	21	Right Std Turn
21	60	1310	012		8 1 7 3	20	Straight & Level
22	90	1370		018	8 0 6 3	32	Left Std Turn
23	20	1460	004		8 5 6 3	08	Straight & Level
24	30	1480		006	8 0 7 3	24	Left Std Turn
25	90	1510	018		9 3 7 3	20	Straight & Level Disc
26	90	1600		018	0 9 6 4	20	Dive & Right Std Turn
27	210	1690	042		0 1 6 4	23	Dive
28	30	1900		006	4 9 7 3	23	Right Std Turn
29	120	1930	024		0 3 8 5	32	Dive
30	360	2050		072	0 3 3 2	32	Climb
31	120	2410	024		0 9 6 4	37	Dive & Right Std Turn
32	40	2530		008	4 3 7 3	37	Straight & Level
33	120	2570	024		0 0 4 2	42	Climb & Left Std Turn
34	60	2690		012	6 3 6 3	42	Straight & Level
35	30	2750	006		6 9 6 3	43	Right Std Turn
36	180	2780		036	0 5 3 5	43	Dive
37	60	2960	012		0 5 1 4	67	Dive & Land
	TET	3020					

DESCRIPTION OF FLIGHT PLAN CP-4

Maneuver Number	Leg Dur Sec	TET Leg Start	Inbound	Outbound	Task Code	Radio Station	Maneuver Type
1	210	0	042		0 1 4 2	10	Take Off & Climb
2	90	210		018	0 0 4 2	10	Climb & Lft Std Turn
3	30	300	006		4 3 7 3	13	Straight & Level
4	30	330		006	4 9 7 3	13	Right Std Turn
5	300	360	060		0 5 4 2	17	Climb
6	30	660		006	9 0 4 3	17	Left Std Turn
7	60	690	012		8 5 7 3	03	Straight & Level Disc
8	30	750		006	8 9 7 3	10	Right Std Turn
9	20	780	004		8 7 6 3	32	Straight & Level
10	90	800		018	8 9 6 3	41	Right Std Turn
11	60	890	012		8 5 7 3	07	Straight & Level
12	30	950		006	8 0 6 3	30	Left Std Turn
13	30	980	006		0 3 8 5	08	Dive
14	60	1010		012	0 3 4 2	40	Climb
15	30	1070	006		8 0 7 3	17	Left Std Turn
16	60	1100		012	8 1 7 3	16	Straight & Level
17	30	1160	006		8 0 5 3	07	Left Std Turn
18	60	1190		012	0 7 3 2	17	Climb
19	30	1250	006		0 7 4 5	31	Dive
20	30	1280		006	8 0 6 3	21	Left Std Turn
21	60	1310	012		8 5 6 3	20	Straight & Level
22	90	1370		018	8 9 7 3	32	Right Std Turn
23	20	1460	004		8 3 6 3	08	Straight & Level
24	30	1480		006	8 9 6 3	24	Right Std Turn
25	90	1510	018		9 3 7 3	20	Straight & Level Disc
26	90	1600		018	0 9 6 4	20	Dive & Rt Std Turn
27	210	1690	042		0 1 6 4	23	Dive
28	30	1900		006	4 9 7 3	23	Right Std Turn
29	120	1930	024		0 3 8 5	32	Dive
30	360	2050		072	0 3 3 2	32	Climb
31	120	2410	024		0 9 6 4	37	Dive & Right Std Turn
32	40	2530		008	4 3 7 3	37	Straight & Level
33	120	2570	024		0 0 4 2	42	Climb & Left Std Turn
34	60	2690		012	6 3 6 3	42	Straight & Level
35	30	2750	006		6 9 6 3	43	Right Std Turn
36	180	2780		036	0 5 3 5	43	Dive
37	60	2960	012		0 5 1 4	67	Dive & Land
		TET 3020					

APPENDIX B

FLIGHT PLAN PROGRAM TAPE FORMAT AND DECODER NOTES

PHYSICAL APPEARANCE OF THE PROGRAM DECODER

The front panel of the program decoder is shown in Figure B-1. The illustration shows the position of the reader, the manual controls (reset, step, auto, and system stop reset), the manual entry pushbuttons, and three columns of indicator lights. The input character column indicates the last 6-bit character read by the reader (in this case 245 which is the system stop code). The next column indicates which code latching relays are in the "1" or on state. The third column, "pulse output," indicates when pulses are being delivered to the inbound, outbound (out of range), or reference decades. The cable on the right of Figure B-1 is to the 6-channel paper tape punch and is used for program tape duplication.

MF-2 AS AN EXAMPLE OF A PROGRAMMED FLIGHT PLAN

The program tape "maneuvers flight No. 2" (MF-2) is an example of a 19-maneuver sequence that has been used as a performance test with the PPES. The flight plan has been listed in Appendix A. A code has been devised for 6-channel paper tape to permit the setting of the radio station stepper, inbound or out of range stepper, and reference value steppers for each maneuver of the flight plan.

The sequence of characters comprising the first two blocks (or maneuvers) of the flight plan program tape for MF-2 is given in Table B-1. For maneuver 1, a master reset of all decade stepping switches is followed by setting the inbound DME decades to the value 042, station decades to the value 10, and reference decades to the value 0142. For maneuver 2, the master reset is followed by setting the out of range value decades to 018, the station decades to the value 10, and the reference decades to the value 0042.

PROGRAM DECODER

The paper tape reader decode logic is a series of relays and latching relays connected in such a way that the appropriate number of pulses are delivered to the inbound and out of range[B-1] DME steppers, station stepper, and reference value steppers. In addition, this relay logic permits the resetting of all decades, recognition of an end of block code, and a system stop code.

[B-1] Although "outbound" is used on the panel face, "out of range" would be more accurate since after a reset to zero the outbound steppers are not incremented--only the "out of range" steppers are set to the appropriate value.

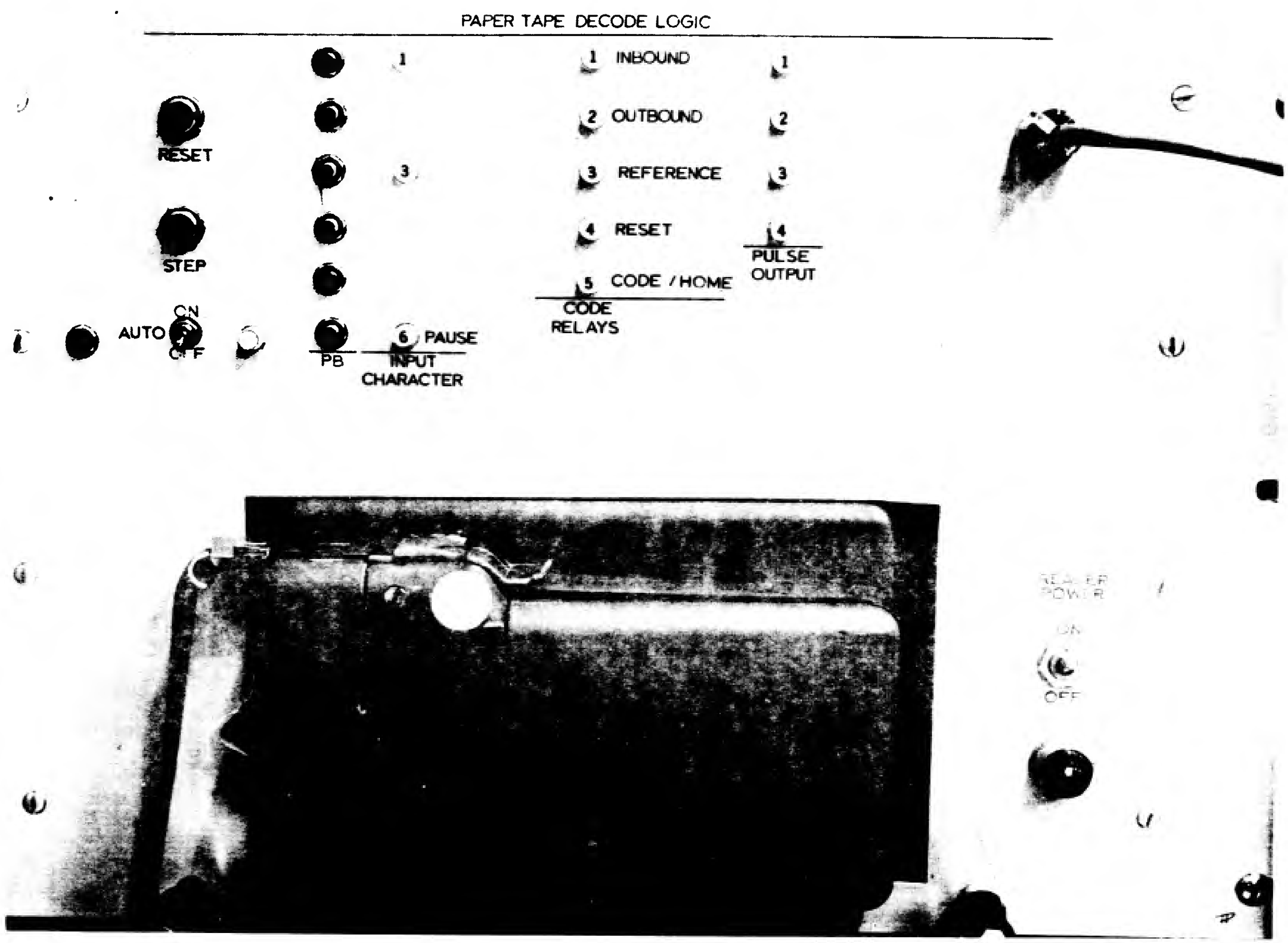

Figure B-1. Front panel of the program tape reader and decoder.

TABLE B-1. CODE SEQUENCE FOR MANEUVERS 1 AND 2
OF PROGRAM TAPE FOR MF-2

Maneuver 1

Channels punched	Interpretation
1 2 3 4 5 6	
5	set code latching relay
3 4 5	master reset of all decades
5	set code latching relay
1	set inbound latch relay
4	code reset
1 2 3	
1 2 3	957 = 042 INBOUND
1 2 3	
1 2 3	no 4's = station 1's = 0
1 2 3	
1 3	
1 3	
1	
1	
5	set code latching relay
1 4	inbound reset
5	set code latching relay
2	set outbound latching relay
4	code reset
4	station 10's = 1
5	set code latching relay
2 4	outbound reset
5	set code latching relay
3	set reference latching relay
4	code reset
3 4	reference task = 0142
3	
3	
5	set code latching relay
3 4	reference reset
space	
space	
space	8 spaces to equalize
space	read-in time for all
space	maneuvers
space	
space	
space	
6	pause (end of block)

Maneuver 2

Channels punched	Interpretation
1 2 3 4 5 6	
5	set code latching relay
3 4 5	master reset of all decades
5	set code latching relay
2	set outbound latch relay
4	code reset
2 3 4	
3	Outbound = 018
3	station 10's = 1
3	therefore station = 10
3	
3	
3	
3	
5	set code latching relay
2 4	outbound reset
5	set code latching relay
3	set reference latching relay
4	code reset
3 4	
3 4	reference task = 0042
3	
3	
5	set code latching relay
3 4	reference reset
space	
space	
space	
space	
space	
space	
space	15 spaces for equalization
space	
space	
space	
space	
space	
space	
space	
space	
6	pause (end of block)

The brief 24-volt pulses from the reader sense contacts are converted into 24-volt steady state logic level signals by the "character latching relays." This permits a reading of the paper tape, character by character, to verify operation and correct initial punching of the program tape. A set of manual entry buttons is also provided to enable testing of the decode logic.

The basic circuitry routes pulses from channels 1 to 4 of the reader to either the code latching relays (CLR's) or to the pulse output depending on whether or not the #5 code latching relay is in the "1" or "0" position. If the #5 code latching relay is in the "1" position, the #5 code relay lamp is lit, and a 4PDT code relay routes any pulses from channel 1 to the inbound CLR, channel 2 to the outbound CLR, channel 3 to the reference CLR, and channel 4 to the reset CLR. If the #5 CLR is in the "0" position, however, the "5 code relay lamp is off, and the 4PDT code relay routes any pulses from channels 1 to 4 through one of the 4PDT output relays (inbound, outbound, reference, or reset) which has been turned on by its corresponding CLR.

CODE SUMMARY

A summary of the codes used to program flight plans on paper tape is given in Table B-2. The list of "special codes" is a series of unique characters which have special control functions. The first three codes are automatically executed whenever the character is read. The remaining three codes must be preceded by the setting of the #5 CLR as a prior step for execution.

DIGITAL LOGIC USED IN THE PROGRAM DECODER

A number of BRS of digital logic modules have been used to control the decode logic and paper tape reader: Figure B-2 gives a block diagram of the circuitry. As long as the #6 input character latching relay is in the "0" state, and the "AUTO" switch is closed, the two one-shots act as a multivibrator and deliver alternate pulses to the reset relay K2 and clutch relay K2. When a hole in channel 6 is sensed, however, the #6 input character latching relay goes to the "1" state (pause) and blocks further pulsing of relays K1 and K2 by disabling the AND gate.

After the maneuver has timed out, a logic level pulse is delivered to the two-legged OR gate over the manual step input lines initiating a reset of the input character latching relays to the "0" state. This is followed by a "read next character" signal to the clutch relay K2. The reading action continues until the next "6" is read. Note that the "AUTO" switch can be opened manually at any time and will stop the read process. The "manual step" pushbutton can then be used to advance one character at a time. A "manual reset" pushbutton (not shown in figure B-2) directly resets the input character code latching relays and is intended for use with the manual entry input pushbuttons of the decoder. This reset push-button does not have to be used when reading one character at a time with the manual step.

TABLE B-2. SUMMARY OF CODES USED TO PROGRAM FLIGHT PLANS

Character		Purpose or function performed
6	"Pause"	= Stops reader until a start reading command is given. Provides the signal to "collect data."
5	"Code"	= Engages the code latching relay and the 12 PDT code relay. Reader pulses on channels 1 to 4 are then routed to code latching relays.
4	"Reset"	= When the #5 code latching relay is in the "1" state, a "4" pulse resets the code latching relay to the "0" state and leaves the 12 PDT code relay off so that subsequent pulses on channels 1 to 4 from the reader are routed through the 12 PDT output relays to the appropriate steppers.
4		When the #5 code latching relay is in the "0" state, a channel "4" reader pulse will be: a. routed to station 1's place if the inbound CLR is set to "1". b. routed to station 10's place if the outbound CLR is set to "1." c. Routed to the 4th reference decade (VVI) if the reference CLR is set to "1."
3		When #5 CLR is in "1" state, a channel 3 reader pulse will set the reference CLR.
3		When #5 CLR is in "0" state, a channel 3 reader pulse will be delivered to: a. inbound decades 100's place if the inbound CLR is set to "1." b. out of range decades 100's place if the outbound CLR is set to "1." c. third reference decade (airspeed) if the reference CLR is set to "1."

Character	Purpose or function performed
2	When the #5 CLR is in the "1" state, a channel 2 reader pulse will set the outbound CLR.
2	When the #5 CLR is in the "0" state, a channel 2 reader pulse will be delivered to: a. inbound decades 10's place if the inbound CLR is set to "1." b. outbound decades 10's place if the outbound CLR is set to "1." c. second reference decade (heading) if the reference CLR is set to "1."
1	When the #5 CLR is in the "1" state, a channel 1 reader pulse will set the inbound CLR.
1	When the #5 CLR is in the "0" state, a channel 1 reader pulse will be delivered to: a. inbound decades 1's place if the inbound CLR is set to "1." b. outbound decades 1's place if the outbound CLR is set to "1." c. first reference decade (altitude) if the reference CLR is set to 1.

SPECIAL CODES

	2		4	5	system stop
		3	4	5	master reset - all decades to zero (inbound to 999)
1			4	5	advance cycle direction status stepper to out of range
				5	followed by:
1			4		inbound CLR reset
	2		4		outbound CLR reset
		3	4		reference CLR reset

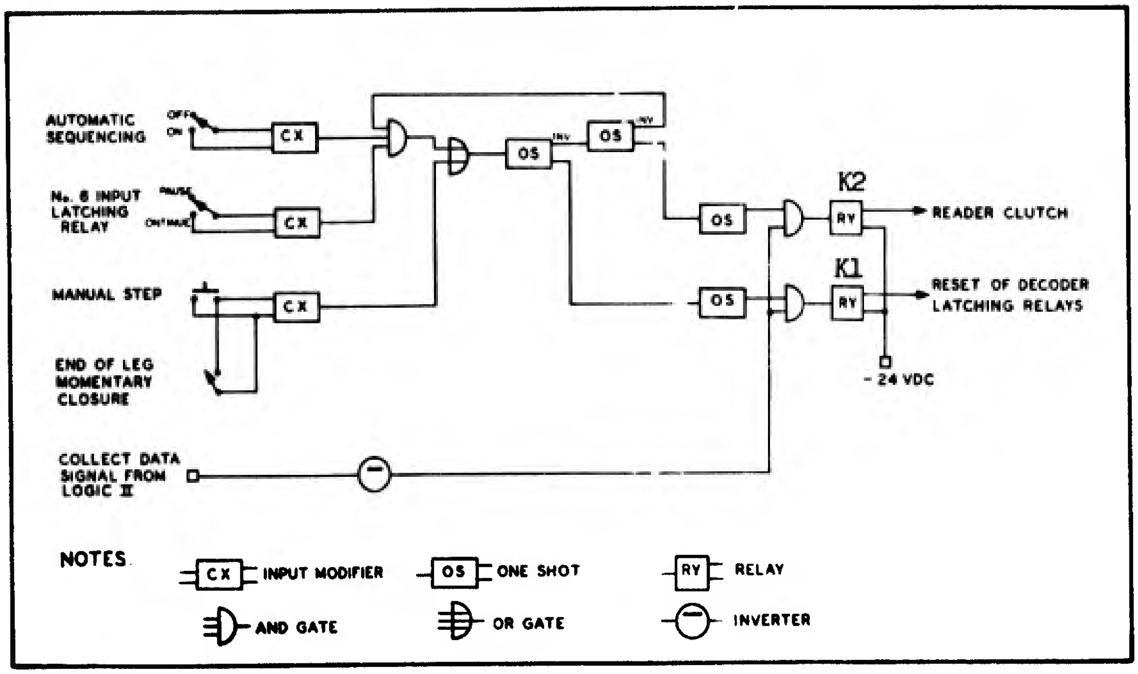

Figure B-2. Logic for paper tape reader drive.

APPENDIX C

OPERATING SEQUENCE CHECKLIST AND DATA RECORDING SHEET

The following checklist covers the sequence of operations required to set up the PPES and start a test session. This is followed by a copy of the standard form used to record subject data for the PPES.

Step — PPES Operator Checklist

1. Verify that the EDCB window select switches are set as follows: altitude on "wide window"; heading/turn rate on "center off" (switching between wide window for rate of turn and narrow window for heading is automatic); airspeed, vertical velocity, and turn coordination on "narrow window."

2. Check the number of the program flight plan loaded on the reader.

3. Verify that the program tape is positioned under the reader head with approximately two inches of blank tape prior to the punched characters which begin the program.

4. Switch the AUTO switch of the reader to the OFF position.

5. Turn the main power ON for both racks in the event that it is off.

6. Check that the 12-volt supply is ON and showing 12-14 volts.

7. Check that the 24-volt supply is ON and showing 24-26 volts.

8. Turn the reader power and tape spooler power to ON.

9. Clear all yellow indicator lights on the reader decode logic.

10. If the blue OFF light of the reader is lit, then push the black reset button next to it to reset the "stop reader" latching relay.

11. Push the SYSTEM STATUS ADVANCE button (Logic Panel 1) until the system status lights of the master control panel indicate "READING PAPER TAPE" status and the red "OUT OF RANGE" lamp is lit.

12. Push the REFERENCE POINT and MASTER RESET red buttons concurrently for 2 to 3 seconds to reset ALL decade counters on panel and in the GAT-1.

13. Enter a value of "001" in the REFERENCE POINT counter using the red button adjacent to the counter. (Repeat step 12 if error is made.)

14. Set the SYSTEM STEPPING MODE to "Pilot" or "Automatic" as called for in the flight plan and make sure it is not left in the center off position.

15. Set the TIME BASE selector switch to Clock 5 sec.

16. Reset all 24 of the digital counters.

17. Make sure that three characters of skip code have been punched in the data tape from the preceding run.

18. Advance the paper tape on the punch unit using the white over-ride button and record on the tape with pen, the run number, date, time, flight plan #, and subject's name.

19. Advance the paper tape THREE feet to provide a leader.

20. Write on paper tape "START" and list run number.

21. Check with subject and verify that he is ready to begin run.

22. Ask subject: "Are all three axes power switches ON?"

23. Ask subject: "Is your altitude set to the proper value?"

24. Ask subject: "Is your altitude hold switch set to NORMAL?

25. Ask subject: "Does your Maneuver Number Counter show 001?"

26. Start first leg by switching the reader AUTO switch to ON.

27. Reader should enter first problem and switch to the COLLECTING DATA mode. Error lights should light as appropriate on the EDCB and CP/1, and holes should be punched in the data tape indicating each second of error. Channel 7 of the data punch should be a continuous series of punches indicating seconds of elapsed time. Look at TV screen to verify that electronics and GAT-1 are in agreement.

28. At the end of the run advance the tape 2-3 inches and enter three consecutive characters of all holes punched. Write on the tape end of run and fill in correct run number. Advance tape 3-4 ft.

29. Record values from digital counters on data card and/or sheet.

LINK TEST PARAMETERS AND SUBJECT DATA RECORDING SHEET

SSAN	NAME (Last, First, MI)			RUN NUMBER

DATE			GRADE	AGE	OTHER
YEAR	MONTH	DAY			

LINK PARAMETERS

INSTRUCTOR, PANEL AND PILOT INSTRUMENT PANEL SETTINGS

CENTER OF GRAVITY:	%MAC	GROSS WEIGHT:	LBS.	OUTSIDE AIR TEMP:	°C
ROUGH AIR:		BAROMETRIC PRESSURE:	mm Hg	LINK NO.	
				SYSTEM NO.	

DOES ALTIMETER SHOW 0 FT ALTITUDE WITH LINK POWER ON BEFORE TAKEOFF? ☐ YES ☐ NO

IF NOT, ADJUST BARO PRESS KNOB TO INDICATE TRAINER ON THE GROUND IS AT SEA LEVEL.

ELEVATOR TRIM POSITION: NOSE DOWN / NOSE UP

(Show Position of Indicator)

ENGINE SOUND:

	OUT	MID	IN
CARB HEAT:			
MIXTURE:			

FLIGHT PLAN PARAMETERS

FLIGHT PLAN NUMBER:		STARTING TIME:		STOPPING TIME:	
PILOT DISPLAY PANEL TYPE:		PERIPHERAL TASK USED:		PERIPHERAL TASK TYPE:	

MODE OF PROGRAM STEPPING ☐ PILOT ☐ AUTOMATIC — AVERAGE DURATION OF PAUSE BETWEEN MANEUVERS ____ SEC.

TREATMENT OR EXPERIMENTAL MANIPULATION

LINK TRAINER LOCATED IN: ☐ LABORATORY ☐ CHAMBER

IF LOCATED IN CHAMBER:	ALTITUDE	HUMIDITY	TEMPERATURE

NATURE OF TREATMENT OR EXPERIMENTAL MANIPULATION:	TIME TREATMENT BEGAN

IF DRUGS GIVEN:	NAME OF AGENT	DOSE LEVEL	BLOOD LEVEL AT START OF FLIGHT	BLOOD LEVEL AT END OF FLIGHT

TIME SINCE LAST MEAL	AMOUNT SLEEP IN PAST 6 HOURS	AMOUNT SLEEP IN PAST 24 HOURS

COMMENTS

ON LINE SCORED PERFORMANCE IN SECONDS

1	2	3	4	5	6	7	8	9	10	11	12
ALTITUDE	HEADING	AIRSPEED	VERTICAL VELOCITY	TURN COORD	TURN RATE	STATION	TIME IN TARGET	PERFECT FLIGHT	TOTAL ERROR	LEG NUMBER	TOTAL TIME

SAM FORM 315 DEC 72 PREVIOUS EDITION IS OBSOLETE

SSAN	NAME (Last, First, MI)	RUN NUMBER

PREVIOUS FLYING EXPERIENCE

[ ] RATED	ESTIMATE OF THE NUMBER OF HOURS FLOWN IN SINGLE ENGINE LIGHT PLANES IN THE LAST SIX MONTHS	
[ ] INSTRUMENT RATED [ ] NON-RATED	ESTIMATE OF THE NUMBER OF HOURS FLOWN IN MORE ADVANCED AIRCRAFT IN THE PAST YEAR	

PREVIOUS FLIGHT SIMULATOR EXPERIENCE

ESTIMATE OF THE NUMBER OF HOURS FLOWN IN THE LINK GAT-1 FLIGHT SIMULATOR IN THE PAST SIX MONTHS	
ESTIMATE OF THE NUMBER OF HOURS FLOWN IN MORE ADVANCED FLIGHT SIMULATORS IN THE PAST YEAR	

PREVIOUS TEST EXPERIENCE

HAS THE SUBJECT'S FLYING PERFORMANCE BEEN TESTED WITH THIS SYSTEM PREVIOUSLY?	[ ] YES [ ] NO

OTHER SUBJECT DATA

IS THE SUBJECT AWARE OF THE EXPERIMENTAL DESIGN OF THE TEST OR STUDY AND THE CONDITIONS BEING RUN?	[ ] YES [ ] NO [ ] PARTIALLY
WHAT IS THE SUBJECT'S BELIEF AS TO THE NATURE OF THIS TEST OR STUDY AND THE IMPORTANCE OF THE OUTCOME?	
HAS THE SUBJECT BEEN GIVEN THE STANDARD BRIEFING AS TO THE NATURE OF THE TEST AND THE IMPORTANCE OF DOING HIS BEST UNDER ALL CONDITIONS?	[ ] YES [ ] NO
HAS SUBJECT SIGNED A RELEASE FORM AS A HUMAN VOLUNTEER?	[ ] YES [ ] NO
COMMENTS	