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Operational Evaluation of the Union Switch and Signal Limited Data Display and Transfer System

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OPERATIONAL EVALUATION OF THE UNION SWITCH AND SIGNAL LIMITED DATA DISPLAY AND TRANSFER SYSTEM

SUMMARY

This report describes the simulated environment tests of a device called the Limited Data Display and Transfer System (LDDT), manufactured by the Union Switch and Signal Co., to determine (1) if further operational testing is warranted, and (2) the feasibility of placing the equipment in the Boston air route and approach control facilities for operational testing.

The simulation tests indicated that the LDDT equipment is superior to the General Railway Signal Interlock System (GRSI) presently in use at Boston, Mass. Whereas the GRSI is dependent upon interphone communications requiring the attention of two operators and the manual writing and placement of flight data, one center operator using the LDDT can transfer data and cause the flight information to be displayed automatically at the approach control operating position. Only infrequent use of the interphone is necessary to supplement the transfer of data when using the LDDT equipment. The LDDT equipment provides the same means of data transfer between approach control and other tower operating positions, as opposed to the GRSI system which requires the use of interphone and the attention of two operators to accomplish each transfer of data.

It was the consensus of the Boston controller personnel participating in these tests that the controller workload using the LDDT system was much less than that using the GRSI system. It is recommended that the existing LDDT equipment be installed for operational testing.

INTRODUCTION

The LDDT system described in this report was manufactured for the Technical Development Center (TDC) by the Union Switch and Signal Co. The specifications were prepared by TDC and the program was sponsored by the Air Navigation Development Board. This equipment was designed to provide a means of displaying flight data and of transferring such data between displays located in two control facilities. With the present equipment configuration, and provided that the main relay is centrally located, the maximum distance over which the transfer of data can take place is 300 feet.

The Boston ARTC Center and approach control facilities are so arranged that the distance criteria are met. Since these facilities could be used for an in-service evaluation, in December 1957, TDC requested the assistance of the CAA First Regional Office in making arrangements for a preliminary dynamic simulation test of the LDDT in the Boston terminal area environment. TDC was furnished typical logs of daily traffic movements to and from Boston. Four controllers from the Boston ARTC Center and two controllers from Boston approach control assisted in the conduct of the tests. The simulation tests were begun on January 20, 1958. This report presents the results of the dynamic simulation tests of the LDDT equipment.

EQUIPMENT DESCRIPTION

The LDDT components consist of three mounting racks, Fig. 1, to accommodate the necessary relays and accessories, and ten control panels which include the data displays and the push-button switches and lamps necessary to operate the system. The mounting racks and the six different types of control panels are described in the following paragraphs.

Each data display indicator unit is an electromechanical device 1 3/4 inches high, 5/8-inch wide, and 10 3/4 inches deep. See Fig. 2. Each unit has a display window in one end, behind which any of 59 characters, including the alphabet, numerals, meteorological symbols, punctuation marks, and special symbols, may be presented one at a time. In addition, the displayed characters may be duplicated on another panel without disturbing the original display except when the transfer originates on either the PAR or local control panels.

Input Panel - Fig. 3A.

The system includes two input panels, each of which is 11 inches high, 12 inches wide, and 12 3/16 inches deep, and incorporates one row of nine data display indicators, in addition to the following controls and indicator lamps. Item numbers correspond to those in Fig. 3A.

1. ERASE Push-Button Switch. When this switch is depressed, the data displayed are removed from the system.

2. RELEASE Push-Button Switch. When this switch is depressed, the input operation is returned to the first display indicator in the row.

3. CENTER SELECTOR Push-Button Switches. When any one of these three switches is depressed, the associated center panel is selected to receive the displayed data. Note: Only two center panels are incorporated in the existing system.

4. ALTITUDE SELECTOR Push-Button Switches. When any one of these six switches is depressed, the displayed data are transferred to the center panel previously determined (see Item 3, above), and to the vacant altitude row represented by the selected switch.

5. KEYBOARD Push-Button Switches (Keys). When any one of these 38 switches (keys) is depressed, the character represented by that key is displayed on the data display indicator which is next in sequence. The sequence moves from left to right. By depressing the BLK (block) key, the next indicator in the sequence may be omitted and the succeeding indicator selected for input. The same action may be accomplished by depressing the SPC (space) key. The SPC key also performs the additional function of erasing data

already displayed on the indicator being omitted. In addition to omitting indicators from the sequence, these keys also permit the erasure or correction of data displayed on individual indicators.

6. KEYBOARD Indicator Lamp. When displaying a white steady light, this lamp indicates that an indicator is receiving data from the keyboard. When displaying a flashing light, it indicates that the power has been reapplied after a power failure.

7. CENTER Indicator Lamps. Each of the three amber center lamps displays a steady light when its associated center selector switch is depressed. If the selected center panel is active when the selector switch is operated, the associated lamp will display a flashing light.

8. ALTITUDE Indicator Lamps. When one or more of the six green lamps displays a steady light, the altitudes associated with the lighted lamps are vacant on the selected center panel.

9. PROGRESS Indicator Lamps. When one or more of the nine white lamps displays a steady light, the data display indicators associated with the lighted lamps are available to receive a character from the keyboard.

Center Panel - Fig. 3B.

The system includes two center panels, each of which is 14 3/8 inches high, 12 inches wide, and 12 3/16 inches deep, and incorporates six rows of nine data display indicators in each row, in addition to the following controls and indicator lamps. Item numbers correspond to those in Fig. 3B.

1. FROM-TO Push-Button Switches. When the FROM-TO switch associated with any one of the six rows of indicators is depressed, it designates the selected row as the transmitter of the data displayed in that row if the row is occupied, or as the receiver of the data displayed in the FROM row if the selected row is vacant.

2. ERASE Push-Button Switches. When the ERASE switch associated with any one of the six rows of indicators is depressed twice, the data displayed in the selected row are removed from the system.

3. CUTOUT Push-Pull Switches. When the CUTOUT switch associated with any one of the six rows of indicators is raised, the selected row is removed from service. When any switch is depressed, the associated row of indicators is returned to operation.

4. RELEASE Push-Button Switch. When the panel relay circuits have been disabled because an action stalled or an inappropriate switch was operated, the circuits may be restored by depressing this switch.

5. TRANSFER Push-Button Switches. When any of the three TRANSFER switches associated with the lower three rows of indicators are depressed, the transfer of jurisdiction of the data displayed in the selected row to the associated approach control panel is initiated.

6. ACTIVE Indicator Lamp. When this white lamp displays a steady dim light, it indicates that an action associated with the panel has ceased but was not completed. When it displays a bright steady light, it indicates that an action associated with the panel is in progress. When it displays a bright flashing light, it indicates that either a fault associated with that panel has been detected or that the power has been restored following a power failure.

7. TRANSFER Indicator Lamps. When any of the amber lamps associated with the lower three rows of data indicators are lighted, they indicate that the transfer of jurisdiction of the data displayed in the associated rows to the approach control panel and the transfer of control of the aircraft represented by the data have been initiated from the en route controller to the approach controller.

8. ACCEPT Indicator Lamps. When any of the green lamps associated with the lower three rows of indicators are lighted, they indicate that the approach controller accepts jurisdiction of the associated data on the approach control panel, and accepts control of the aircraft represented by the data.

Approach Control Panel - Fig. 4A. Item numbers correspond to those in Fig. 4A.

The system includes two approach control panels, each of which is 14 3/8 inches high, 12 inches wide, and 12 3/16 inches deep, and incorporates six rows of ten data display indicators in each row, in addition to the following controls and indicator lamps:

1. FROM-TO Push-Button Switches. The function of these six switches is the same as for Item 1 in the description of the center panel.

2. ERASE Push-Button Switches. The function of these six switches is the same as for Item 2 in the description of the center panel.

3. CUTOUT Push-Button Switches. The function of these six switches is the same as for Item 3 in the description of the center panel.

4 RELEASE Push-Button Switch. The function of this switch is the same as for Item 4 in the description of the center panel.

5. ACCEPT Push-Button Switches. When any of the three ACCEPT switches associated with the upper three rows of data indicators are depressed, the green accept lamp associated with the corresponding data on the center panel is lighted. This action serves the purpose described for the center panel, Item 8.

6. OUTER MARKER TIME (OMT) Push-Button Switches. When any of the six OMT switches are depressed, numerals representing an outer marker time are displayed in the last data indicator of the associated row. Note: This procedure is used in the automatic transfer of data to the PAR panel, and the necessary computer components are not installed in the existing equipment.

7. PRECISION APPROACH RADAR (PAR) Push-Button Switches. When any of the three PAR switches associated with the lower three rows of data indicators are depressed, the nonautomatic transfer of jurisdiction of the data displayed in the selected row to the PAR panel is initiated.

8. APPROACH CONTROL FIX (ACF) Push-Button Switch. When this switch is depressed on one of the approach control panels after a FROM-TO switch has been depressed on the same panel and the same actions have been accomplished on the other approach control panel, the data in an occupied row selected on one panel are transferred to the vacant row selected on the other.

9. PAR 1 - PAR 2 Toggle Switch. The data selected on Items 6 and 7, above, will be transferred to the PAR panel selected by this switch. Note: Only one PAR panel is incorporated in the present system.

10. ACTIVE Indicator Lamp. The function of this indicator lamp is the same as described for the center panel, Item 6.

11. TRANSFER (AMBER) Indicator. When any of the amber lamps associated with the upper three rows of data indicators are lighted, they indicate that the action described for the center panel, Item 5, has taken place.

12. ACCEPT (GREEN) Indicator Lamps. When any of the green lamps associated with the upper three rows of data indicators are lighted, they indicate that the actions described for the center panel, Items 5 and 8, have taken place.

13. TRANSFER (RED) Indicator Lamps. When any of red lamps associated with the lower three rows of data indicators are lighted, they indicate that the action described in Item 7 is in progress.

14. ACCEPT (WHITE) Indicator Lamps. When any of the white lamps associated with the lower three rows of data indicators are lighted, they indicate that the action described in Item 7 has been completed.

Missed-Approach Panel - Fig. 4B.

The system includes two missed-approach panels, each of which is 6 1/2 inches high, 12 inches wide, and 12 3/16 inches deep, and incorporates two rows of seven data display indicators in each row, in addition to the following controls and indicator lamps:

1. APPROACH CONTROL FIX (ACF) Push-Button Switches. When either of the two ACF switches associated with the two rows of data indicators is depressed, and the FROM-TO switch adjacent to a vacant row of data indicators on the associated approach control panel also is depressed, data displayed in the selected row of indicators on the missed-approach panel are transferred to the approach control panel.

2. ERASE Push-Button Switches. The function of these two switches is the same as described for the center panel, Item 2.

3. CUTOUT Push-Pull Switches. The function of these two switches is the same as described for the center panel, Item 3.

4. RELEASE Push-Button Switches. The function of this switch is the same as described for the center panel, Item 4.

5. ACTIVE Indicator Lamp. The function of this indicator lamp is the same as described for the center panel, Item 6.

Precision Approach Radar Panel - Fig. 5A.

This panel is 11 inches high, 10 1/2 inches wide, and 12 3/16 inches deep, and incorporates four rows of data display indicators with seven indicators in each row, in addition to the following controls and indicator lamps:

1. MISSED APPROACH PANEL (MAP) Push-Button Switches. When the MAP switch associated with any one of the four rows of indicators is depressed, the data displayed in the selected row will be transferred to the missed-approach panel.

2. CUTOUT Push-Pull Switches. The function of these four switches is the same as described for the center panel, Item 3.

3. LOCAL CONTROL Push-Button Switch. When this switch is depressed, data displayed in the lowest row of indicators is transferred to the local control panel.

4. RELEASE Push-Button Switch. The function of this switch is the same as described for the center panel, Item 4.

5. MAP A-B Toggle Switch. The data selected in Item 1, above, will be transferred to the missed-approach panel selected by this switch.

6. MAP FULL Indicator Lamp. When this lamp displays a steady bright light, it indicates that the missed-approach panel selected by the MAP A-B switch is fully occupied. When it displays a flashing bright light, it indicates that an attempt has been made to transfer data to a fully occupied missed-approach panel.

7. ACTIVE Indicator Lamp. The function of this lamp is the same as described for the center panel, Item 6.

Local Control Panel - Fig. 5B.

This panel is 11 inches high, 10 1/2 inches wide, and 12 3/16 inches deep, and incorporates four rows of data display indicators with seven indicators in each row, in addition to the following controls and indicator lamps:

1. MISSED APPROACH PANEL (MAP) Push-Button Switches. The function of these four switches is the same as described for the PAR panel, Item 1.

2. CUTOUT Push-Pull Switches. The function of these four switches is the same as described for the center panel, Item 3.

3 ERASE Push-Button Switches. When the ERASE switch associated with a row of indicators is depressed, the data displayed in that row is transferred to storage and the indicators are cleared

4. RELEASE Push-Button Switch. The function of this switch is the same as described for the center panel, Item 4.

5. MAP A-B Toggle Switch. The function of this switch is the same as described for the PAR panel, Item 5.

6. MAP FULL Indicator Lamp. The function of this lamp is the same as described for the PAR panel, Item 6.

7. ACTIVE Indicator Lamp. The function of this lamp is the same as described for the center panel, Item 6.

SYSTEM OPERATION

The general interrelationship of the control panels of the LDDT is shown in Fig. 6. The panels illustrated by solid lines represent the existing system, which can be expanded to include the eight additional components illustrated by broken lines. The following detailed descriptions of the components of the existing system also are applicable when components of the same type are added.

Input Panel.

The input panel is the primary unit of the system and is used for entry of the data pertaining to each flight. The data displayed on the data indicators on this panel are transferred to a center panel, and must then be erased from the input panel in order to prepare it for a new flight data entry. These actions are accomplished as follows:

1. The panel is prepared for the insertion of data by depressing the RELEASE switch.

2. Data then are inserted into the system by means of the keyboard

3. The center panel to which the displayed data will be transferred is selected by depressing the CENTER switch which represents the desired panel.

4. Vacant altitudes on the selected center panel are represented by lighted green altitude lamps, and by depressing an associated ALTITUDE switch, the displayed data are transferred to the corresponding altitude position on the center panel.

5. The displayed data are erased by depressing the ERASE switch.

Center Panel.

Each row of data display indicators on the center panel represents an altitude, and is labeled accordingly. Data displayed in the lower three altitudes are duplicated automatically in the upper three rows of indicators on the associated approach control panel; any sequencing or erasing action by the center controller which involves these altitudes is duplicated automatically on the approach control panel. Flight data displayed in the upper three altitudes of the center panel must be sequenced into one of the lower three altitudes in order that the data appear on the approach control panel. The center controller retains jurisdiction over all displayed data until he depresses a TRANSFER switch. The actions required in the use of the center panel are as follows:

1. Until the TRANSFER switch is depressed, the displayed data are sequenced by depressing the FROM-TO switch associated with an occupied altitude and depressing the FROM-TO switch associated with a vacant altitude.

2. When flight data have been sequenced to another altitude, the duplicate data still displayed at the altitude from which the transfer was made are erased by twice depressing the ERASE switch associated with the original altitude.

3. The transfer of jurisdiction over data displayed in any of the lower three altitudes is initiated by depressing the TRANSFER switch associated with the desired altitude. This action causes the associated amber transfer lamp to be lighted on both the central panel and the approach control panel.

4. Until the approach controller accepts jurisdiction, the center controller may regain jurisdiction over flights on which the transfer action has been initiated by depressing the RELEASE switch.

Approach Control Panel.

Each row of data display indicators on the approach control panel represents an altitude, and is labeled accordingly. The three upper altitudes duplicate the data displayed in the three lower altitudes of the center panel. Only data displayed in the three lower altitudes can be transferred to the PAR panel. The actions required in the use of the approach control panel are as follows:

1. After the center controller has initiated the transfer of jurisdiction, the approach controller accepts jurisdiction over a flight by depressing the ACCEPT switch associated with the altitude at which the data appear. This action causes the associated green accept lamp to be lighted on both the approach control panel and the center panel, and causes the corresponding amber transfer lamps to go out.

2. The displayed data over which the approach controller has assumed jurisdiction are sequenced by depressing the FROM-TO switch

associated with an occupied altitude and by depressing the FROM-TO switch associated with a vacant altitude. While the data being sequenced remain in the three upper altitudes, the green accept lamp will follow the associated data on both the approach control panel and the center panel.

3. Data displayed in any of the three lower altitudes are transferred to the lowest vacant altitude on the PAR panel by depressing the associated PAR switch.

4. Immediately after data have been transferred to the PAR panel, the white indicator lamp associated with the PAR switch will be lighted, and the transferred data then may be erased by twice depressing the associated ERASE switch.

Precision Approach Radar Panel.

Each row of data display indicators on the PAR panel represents an altitude and is labeled accordingly. The data or flight information transferred to the panel are displayed automatically in the row representing the lowest vacant altitude, and are sequenced downward automatically as the data displayed in the lowest altitude are transferred to the local control panel. The actions required in the use of the PAR panel are as follows:

1. Data displayed at the lowest altitude are transferred to the lowest vacant altitude on the local control panel by depressing the LOCAL CONTROL switch. If data are displayed at more than one altitude, the lowest row will be transferred to the local control panel and the data displayed at the other altitudes will be sequenced downward automatically. During this sequencing process, as the data are displayed at a new altitude, the flight information is erased automatically at the altitude from which it was transferred.

2. If aircraft represented in the display must execute missed approaches while under the jurisdiction of the PAR controller, a missed-approach panel is selected by operating the MAP A-B switch to the A or B position and by noting the availability of the missed-approach panels as indicated by the map-full lamp.

3. When a missed-approach panel has been selected by depressing the associated MISSED APPROACH PANEL switch, the appropriate data are transferred to the lowest available altitude on that panel. The subsequent sequencing and erasing operations correspond to those following the transfer of data to the local control panel described in Item 1.

Local Control Panel.

Each row of data display indicators on the local control panel represents an altitude and is labeled accordingly. Data transferred to the panel are displayed automatically in the row representing the lowest vacant altitude, and are sequenced downward automatically as the data displayed at any altitude are transferred to the missed-approach panel or storage. The actions required in the use of the local control panel are as follows:

1. When displayed data are no longer required in the system, the flight information is removed by depressing the associated ERASE switch. If data are displayed at other altitudes in addition to the one erased (stored), the data displayed at the other altitudes will be sequenced downward automatically following the erasing operation. During this sequencing process, as the data are displayed in the new altitude, the flight information is erased automatically at the altitude from which it was transferred.

2. If aircraft represented on the display must execute missed approaches while under the jurisdiction of the local controller, a missed-approach panel is selected by operating the MAP A-B switch to the A or B position and noting the availability of the missed-approach panels as indicated by the map-full lamp.

3. After a missed-approach panel has been selected, by depressing the associated MISSED APPROACH PANEL switch, the appropriate data are transferred to the lowest available altitude on that panel. The subsequent sequencing and erasing operations correspond to those following the erasing operation described in Item 1.

Missed-Approach Panel.

Data can be transferred from any altitude on either the PAR panel or the local control panel to either of the missed-approach panels. The transferred data will be displayed on the lower row of data display indicators if both rows were vacant previously; however, if either row already is occupied at the time the transfer is made, the new data will be displayed in the other row regardless of whether it is the upper or lower row. No sequencing of data is possible on this panel. Data displayed on the missed-approach panel can be transferred only to the approach control panel, and the actions are as follows:

1. The displayed data are transferred by depressing the APPROACH CONTROL FIX switch associated with the selected row, depressing the FROM-TO switch associated with the selected row, and then depressing the FROM-TO switch associated with the vacant altitude to which the data will be transferred on the approach control panel.

2. After the transfer is completed, the original data are removed by twice depressing the ERASE switch associated with the row from which the transfer was made.

Alarms.

The system has three types of alarm or warning devices. These alarms and the conditions under which they will be activated are as follows:

1. A buzzer will sound when the power is interrupted momentarily.

2. A buzzer will sound when an attempt is made to transfer data from the approach control panel to the PAR panel when it already is completely occupied.

3. A flashing active lamp on any panel indicates either a momentary interruption of power to that panel, or a stalled condition occurring during an action initiated at that panel.

The following corrective actions are numbered to correspond to the above malfunctions:

1. When the power-off alarm sounds, (a) the buzzer is silenced by depressing the RELEASE switch on any panel except the input panel; (b) the controls are reactivated by depressing the RELEASE switch on each panel; and (c) the corresponding relays are restored to their normal operating condition by depressing the ERASE switch associated with each vacant row of data display indicators on all panels.

2. To silence this alarm, a row of data must be transferred from the PAR panel to either the missed-approach panel or the local control panel.

3. The affected panel is restored to a normal operating condition by depressing the RELEASE switch on that panel.

TEST OBJECTIVES

The GRSI system in the Boston Center and approach control facilities is used in conjunction with interphone equipment for transferring flight data and control jurisdiction from the Center to approach control. Since the LDDT equipment, in addition to its normal utilization, also can be operated so as to simulate the GRSI system, a comparison of the operational characteristics of the two methods was feasible. The objectives of the test were to:

1. Compare by simulation the relative effort required of controllers in utilizing the LDDT and GRSI equipments.

2. Compare the respective efficiencies of the two methods as reflected in the delays imposed upon the aircraft being controlled.

3. Determine the practicability of using the LDDT in the ATC environment.

TEST ENVIRONMENT

The TDC dynamic simulator was utilized in performing the tests. Two input panels and two center panels of the LDDT were set up in the Center in conjunction with two tabular display flight progress boards to simulate two Center sectors, and two approach control panels were set up in the tower in conjunction with two radar scopes to simulate two approach control sectors. The tower configuration also included one PAR panel, one local control panel, and two missed-approach panels; however, these were not used in the tests.

In order to examine the operation of each of these systems in a center radar and approach control radar environment, one scan-converted radar (SPANRAD) was used as the center radar display, and two direct-view scopes were used as approach control radar displays.

TEST PROCEDURES

Because the GRSI and LDDT systems were designed to be used in the control of arriving aircraft, the test problems consisted of four traffic samples of aircraft landing at Logan Airport at Boston. Each sample had a different aircraft distribution, an average traffic density of 24 aircraft per hour, and comparable control difficulty. The traffic samples were alternated, and the controller personnel were rotated through operating positions, so that no controller dealt with the same traffic situation more than once.

The four traffic samples, each having a run duration of 30 minutes, were tested once in each of the following modes

Mode	Facility	Equipment (GRSI Simulated by LDDT)
1	Center	Flight progress boards and GRSI.
	Approach Control	Flight progress boards, radar, and GRSI.
2	Center	Flight progress boards and LDDT.
	Approach Control	Flight progress boards, radar, and LDDT.
3	Center	Flight progress boards, radar, and GRSI.
	Approach Control	Flight progress boards, radar, and GRSI.
4	Center	Flight progress boards, radar, and LDDT.
	Approach Control	Flight progress boards, radar, and LDDT.

During all runs, automatic counters measured the frequency and duration of all air/ground and ground/air communications on each channel, the frequency and duration of each interphone contact which involved center personnel, and each contact which involved approach control personnel. In addition, observers with stop watches recorded the frequency and duration of the data-entry activities required by the LDDT system. Because the actions required in the operation of the GRSI approach control component and the LDDT approach control panel are so nearly the same, it was not necessary to make time measurements for comparison.

Although tests were made with the PAR panel, the local control panel, and the missed-approach panels in order to determine the operating relationships of these components with each other, measurements were not made. There were three reasons for this, namely:

1. The GRSI system contains no comparable components or functions.

2. The air traffic control system normally does not include precision approach radar.

3. Although the PAR panel can be combined with the local control panel, local variations in tower configurations and approach control and tower procedures obviate standard installations and procedures.

The sum of the communications data from the two center sectors represented the total center communications effort. The score for each run was represented by the sums of the number and of the duration of the communications appropriate to the system involved. The center communications effort for the GRSI was taken to be indicated by the number and duration of interphone contacts involving center personnel. In the use of the LDDT system, the center communications effort was taken to be the sum of the time required to enter the flight data on the center panel plus the sums of the number and duration of interphone contacts necessary to supplement the system.

TEST RESULTS

Equipment.

The operation of the LDDT equipment is not difficult and does not require appreciable typing skill or special techniques for the programming or transferring of data. When the time for programming data was measured, it was found that the average time required for the insertion and transfer of data to the center panel was 27 seconds. The minimum equipment response rate to the programming action was found to vary from 9 to 12 seconds, depending upon the alpha-numeric combinations required.

The amount of data which can be displayed varies from nine characters on the center and approach control panels to seven on the PAR, local control, and missed-approach panels. Since the display of aircraft identification frequently requires the use of six characters, this leaves only three characters in the one case and one in the other which can be used to display other pertinent data such as type, transfer point, direction of flight, and so forth.

The center and approach control panels have three altitudes in common, and data can be exchanged between them to a limited extent, inasmuch as any action involving data appearing in these three rows on one panel is duplicated on the other. This makes it possible for data to be transferred back to the center panel by returning the flight information to one of the three common altitudes on the approach control panel.

There is no direct manner in which data can be mutually exchanged between the approach control, PAR, and local control panels, although a partial exchange of data is possible through the use of the missed-approach procedure. This does not permit complete duplication of the original flight data, since some of the panels have nine data indicators per row while the rest have only seven. This indirect method is comparatively time-consuming and is difficult to achieve if the panels are not adjacent.

The loss of flight data and the impossibility of entering new data anywhere except on the center panel limit the usefulness of the LDDT equipment. In the event of inadvertent erasure of flight data on the center panel, the original flight progress strips are available and the data may be entered into the system again. If this situation occurs on any other panel, there is no practicable method of reentering the data. Similarly, no provision has been made for entering data on controlled VFR, low-altitude, or "pop-up" flights which come immediately into the system under approach control jurisdiction.

The difficulty or in some cases, impossibility, of correcting or up-dating flight data also limits the applications of the LDDT equipment. If a change is required in the center environment data, the original data must be erased, and the revised flight data must be reentered via the input panel. In the approach control environment, a change of transfer point can be indicated by transferring the complete flight data to the approach control panel representing the revised transfer point. It is not possible to revise either the displayed transfer point designator or any other information contained in the transferred data. This does not preclude the altitude revisions accomplished by the sequencing process described elsewhere in this report.

Another potential difficulty was found to exist if the local control and the missed-approach panels are used. Data can be transferred to either of the missed-approach panels from any altitude on the PAR or local control panels. The missed-approach panels contain only two rows of data indicators on each panel, and the transferred data will appear in the lowest vacant row on the selected panel without regard to sequence or altitude. Either row of either panel can be transferred to any vacant altitude of the associated approach control panel. In this procedure it is possible that the approach controller will not know which of the two aircraft displayed in the missed-approach panel is first in sequence or which altitudes the aircraft are occupying. It is probable that some of these problems could be solved procedurally by the use of discrete missed-approach altitudes or by other means.

If the local control panel is used and the flight data on each aircraft are processed through the entire system, it is possible to transfer the flight data displayed on the local control panel to storage, which may consist of a teletypewriter. At this point the number of data indicators contained in each row has been reduced to seven, and the only elements of the flight data remaining are the identification and type. The stored data, therefore, essentially are a record of only the individual aircraft which have passed through the system.

When the PAR panel and the local control panel are utilized, either as separate operating positions or combined into a local control position, it is possible to lose data by forcing them out of the system. This situation is introduced when an attempt is made to transfer data from the approach control panel to a fully occupied PAR panel. Such action causes an alarm to sound, and in order to silence the alarm, a row of flight data must be transferred from the PAR panel to either the local control panel or to the missed-approach panel. Since more than two aircraft normally are not released to approach control at a given time, this situation would not likely arise if the personnel follow an efficient system of equipment operation.

If the transfer is initiated at the local control panel, which also is fully occupied, the following will occur:

1. The data displayed on the lowest row of the local control panel will be forced out of the system automatically and transferred to storage if storage is incorporated in the system.

2. The remaining data will be sequenced downward automatically on the local control panel, leaving the top row vacant.

3. The data displayed in the lowest row of the PAR panel will be transferred automatically to the top row of the local control panel.

4. The remaining data will be sequenced downward automatically on the PAR panel, leaving the top row vacant.

5. The data which were to be transferred from the approach control panel then will be displayed automatically in the vacant top row of the PAR panel, and may be erased from the approach control panel.

Analysis.

The average number of center and tower interphone contacts per run and the average total number of seconds of interphone operation per run in each of the four modes described in the test procedures are shown in Table I. It should be noted that when the LDDT is used, a significant decrease occurs in both the number of contacts and the number of seconds. It also should be noted that the use of center radar had no significant effect upon interphone communications when either the GRSI or the LDDT systems were used.

TABLE I

INTERPHONE COMMUNICATIONS AVERAGES

	Center		Tower	
Mode	Frequency of Contacts (avg.)	Duration (sec.)	Frequency of Contacts (avg.)	Duration (sec.)
1	13	234	22	389
2	3	36	6	68
3	10	226	23	296
4	2	17	2	31

A formal analysis of the automatic measurements of air/ground and ground/air communications was not made, since scanning the data confirmed the belief that there would be no difference between the GRSI and LDDT systems. The frequency and duration of delays incurred by aircraft during the runs were measured and summed. It was found that the delays which occurred were not dependent upon the system used because they were a result of control requirements and had no relationship to the equipment in use. For this reason, no analysis of aircraft delays is included in this report.

CONCLUSIONS

The frequency and duration of interphone contacts between the center and tower are greatly reduced through the use of the LDDT.

The LDDT requires the close attention of operating personnel in order to preclude incorrect transfer actions, the inadvertent loss of pertinent flight data by accidental erasure, or the loss of flight data through forced storage.

The LDDT system is more compatible with a radar environment than is the GRSI. The use of the interphone is required in connection with the GRSI system in order to correct or up-date data or to resequence data displayed in the tower but which still is under the jurisdiction of the center. In the LDDT system under the same circumstances, the center can up-date, correct, or resequence the data at any time until jurisdiction has been accepted at the approach control panel, and these actions normally can be accomplished without recourse to a supplementary means of communication.

As indicated by its name, the LDDT inherently is limited in its applications and capabilities. In the present equipment configuration, the most critical limitation is the lack of input or data-entry capabilities at the approach control position. The existing equipment can serve only two facilities, which must meet restrictive distance criteria. It is less flexible than interphone for intrafacility coordination or for interfacility transfer of control jurisdiction.

RECOMMENDATIONS

It is recommended that the LDDT not be considered for general introduction into the air traffic control system because of its limitations and restrictive siting criteria.

It is further recommended that the LDDT system be installed at Boston for further in-service testing to determine its applicability to that location or any other location which can meet the distance criteria and which will not be adversely affected by the system limitations.

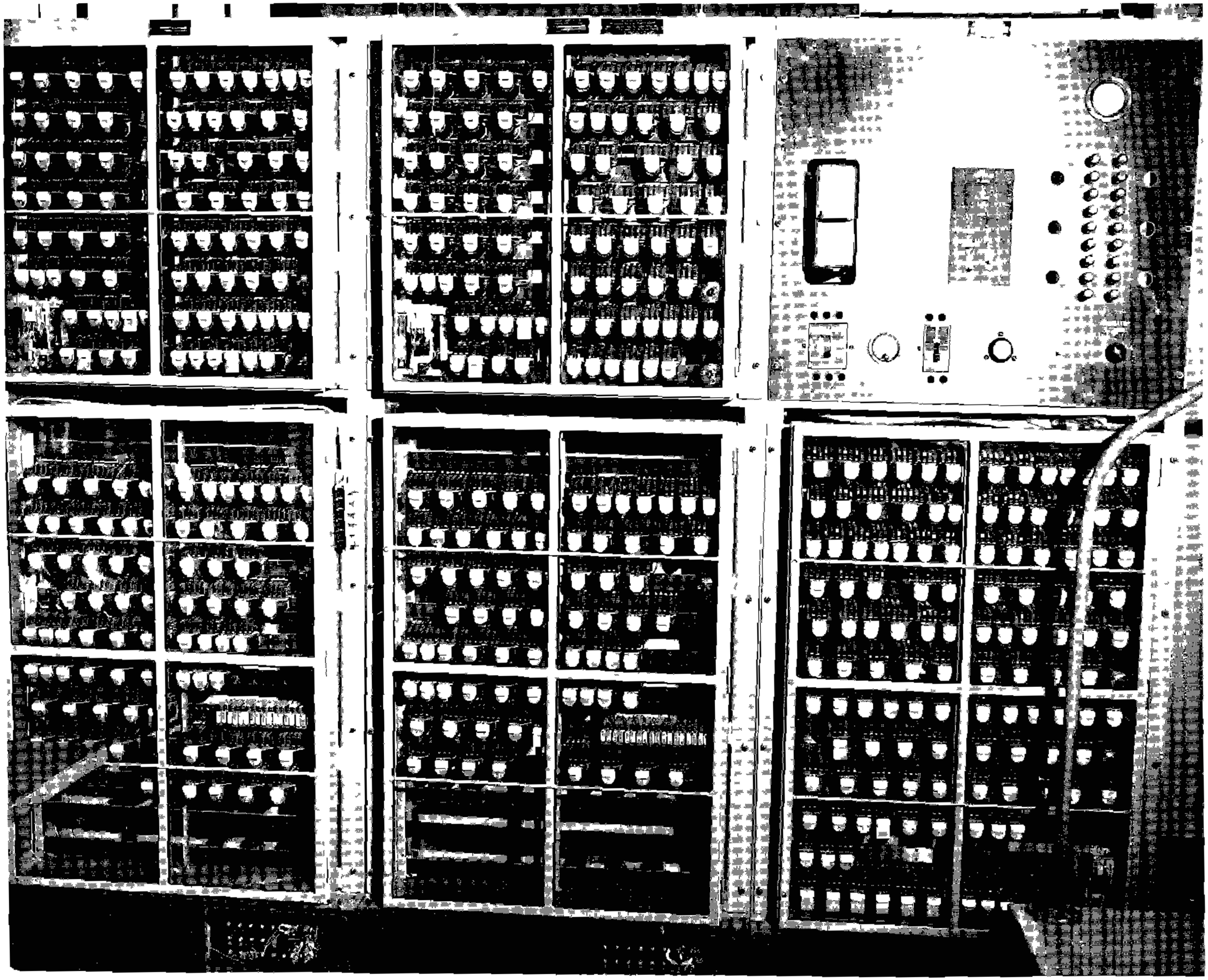

FIG. 1 RELAY MOUNTING RACKS

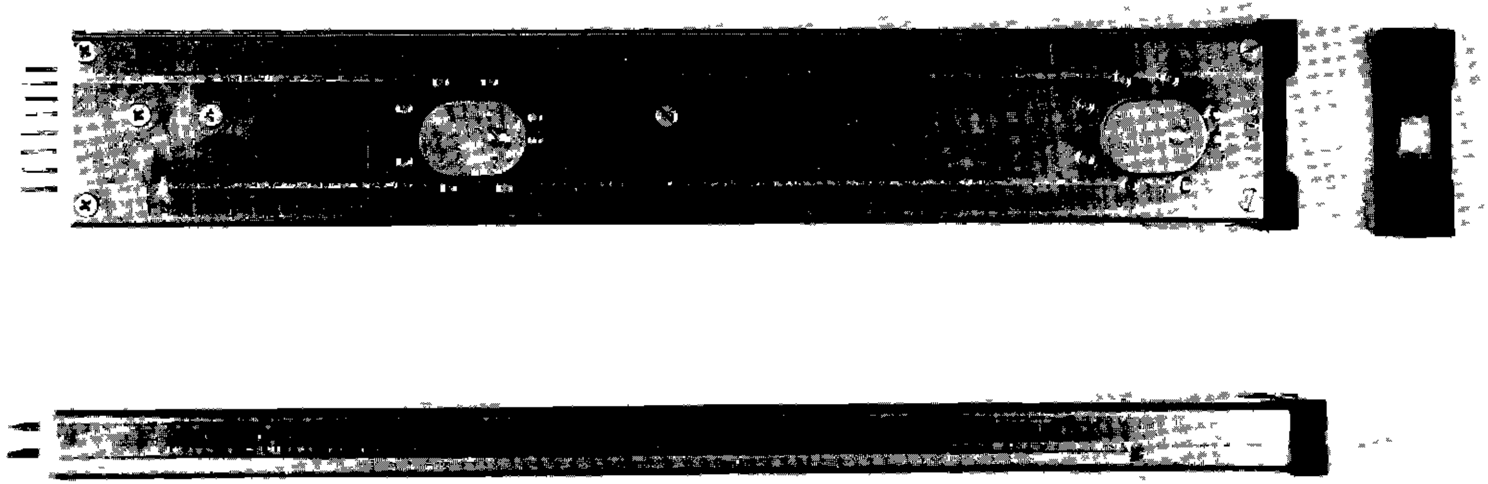

FIG. 2 INDICATOR UNIT

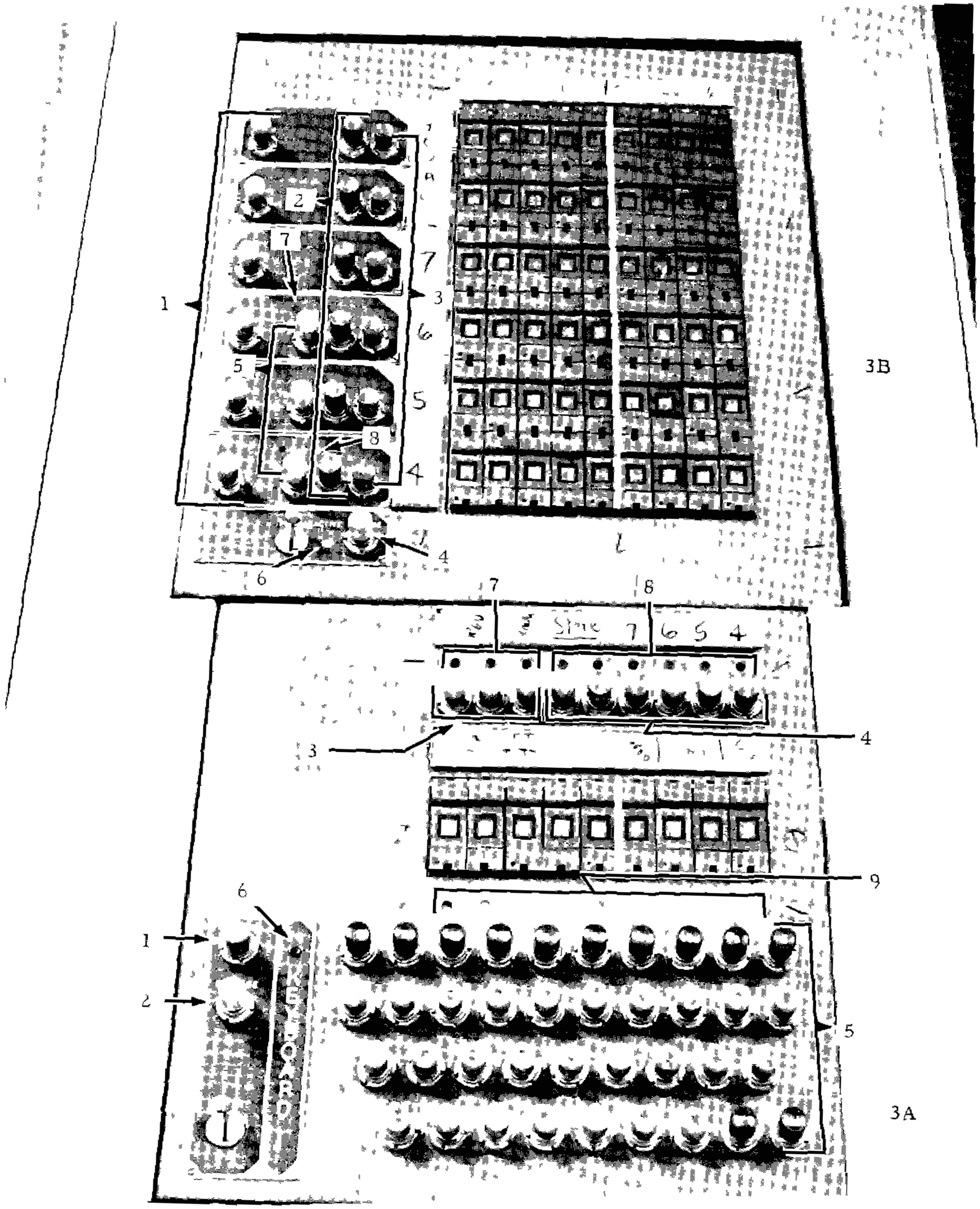

FIG 3A INPUT DEVICE, FIG. 3B CENTER PANEL

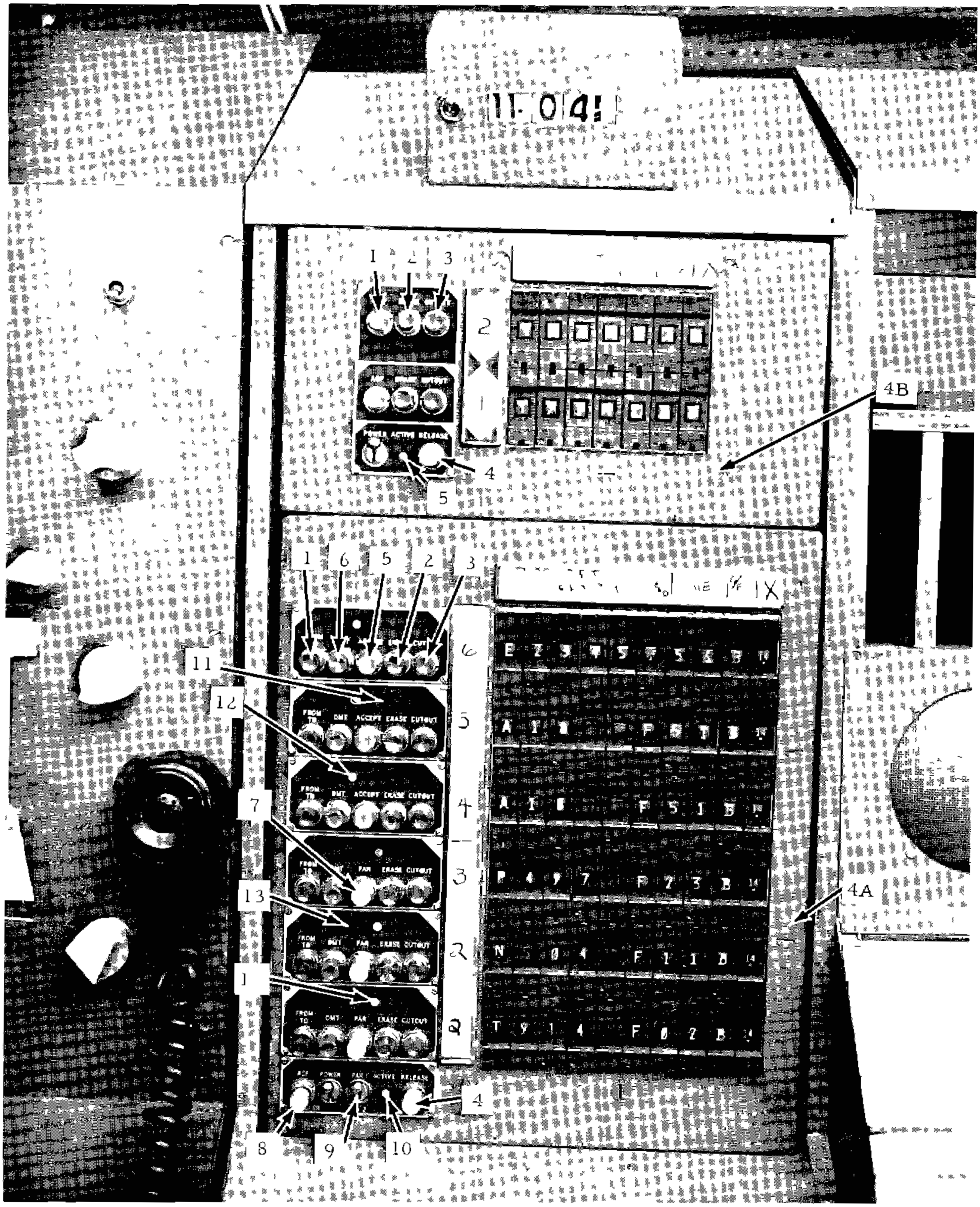

FIG 4A APPROACH CONTROL PANEL, FIG. 4B MISSED-APPROACH PANEL

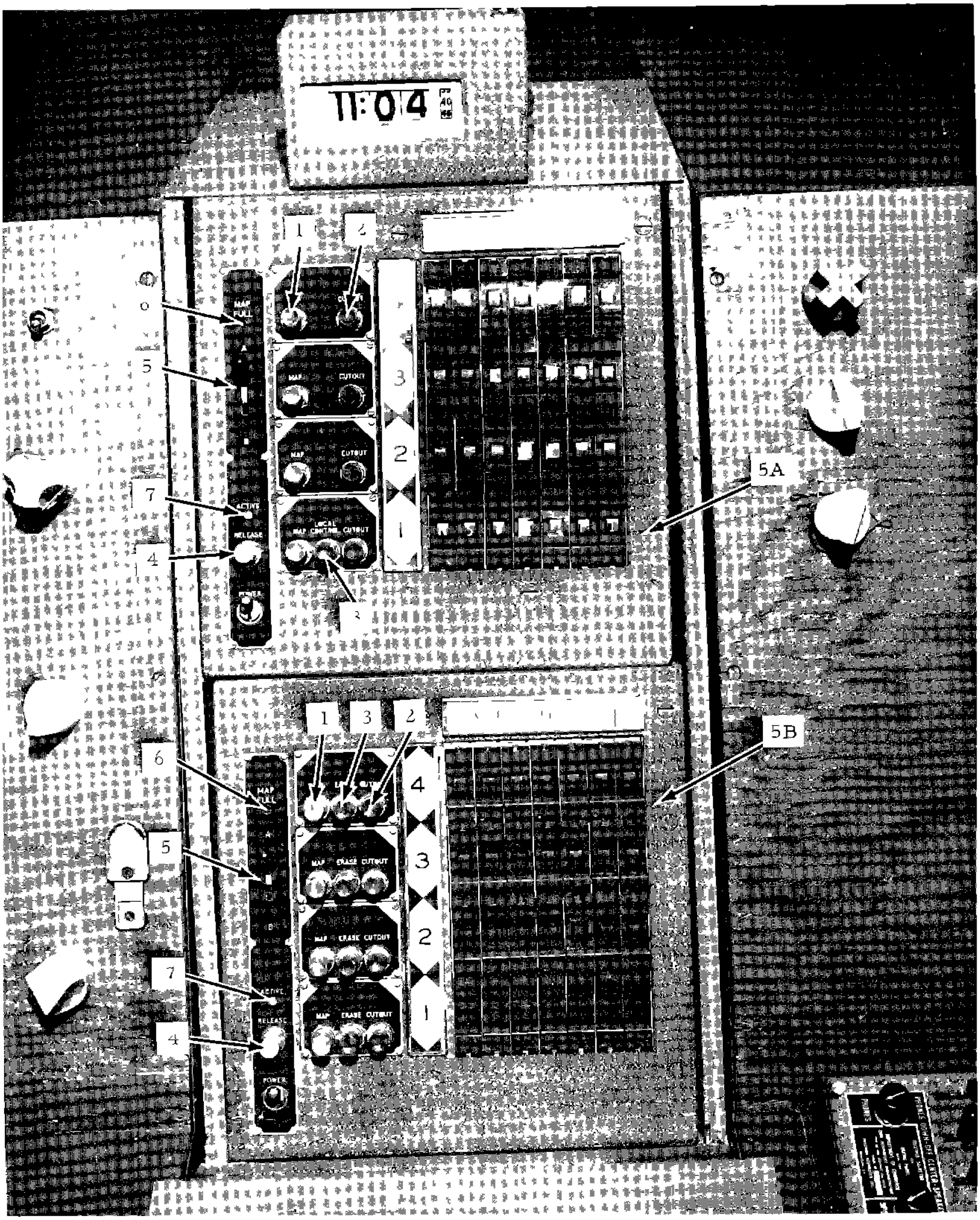

FIG 5A PRECISION APPROACH PANEL, FIG 5B LOCAL CONTROL PANEL

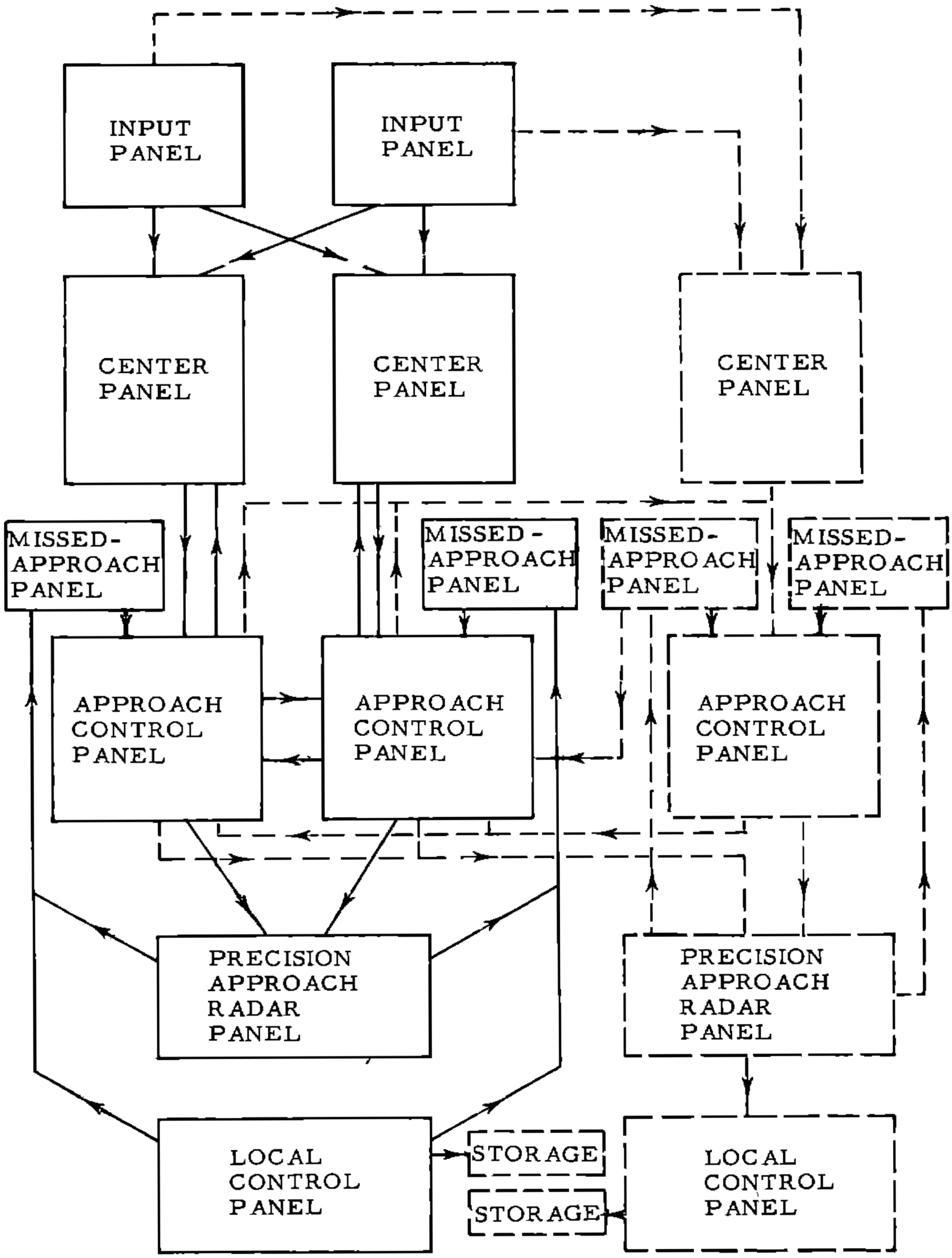

FIG. 6 FUNCTIONAL DIAGRAM LIMITED DATA DISPLAY AND TRANSFER SYSTEM