Dec. 25, 1945. J. C. MARSHALL ET AL 2,391,469

COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 1

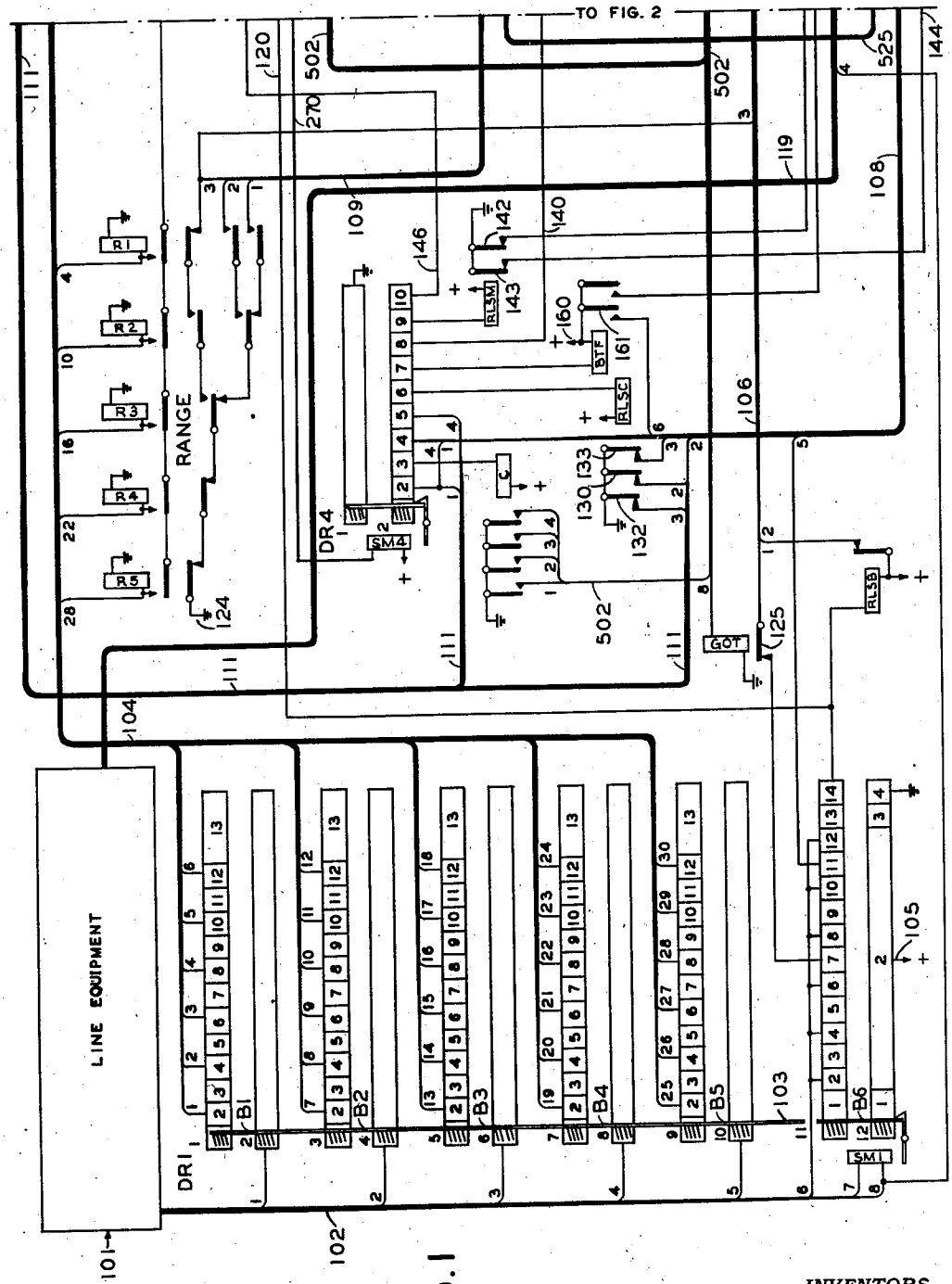

FIG. 1

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 2

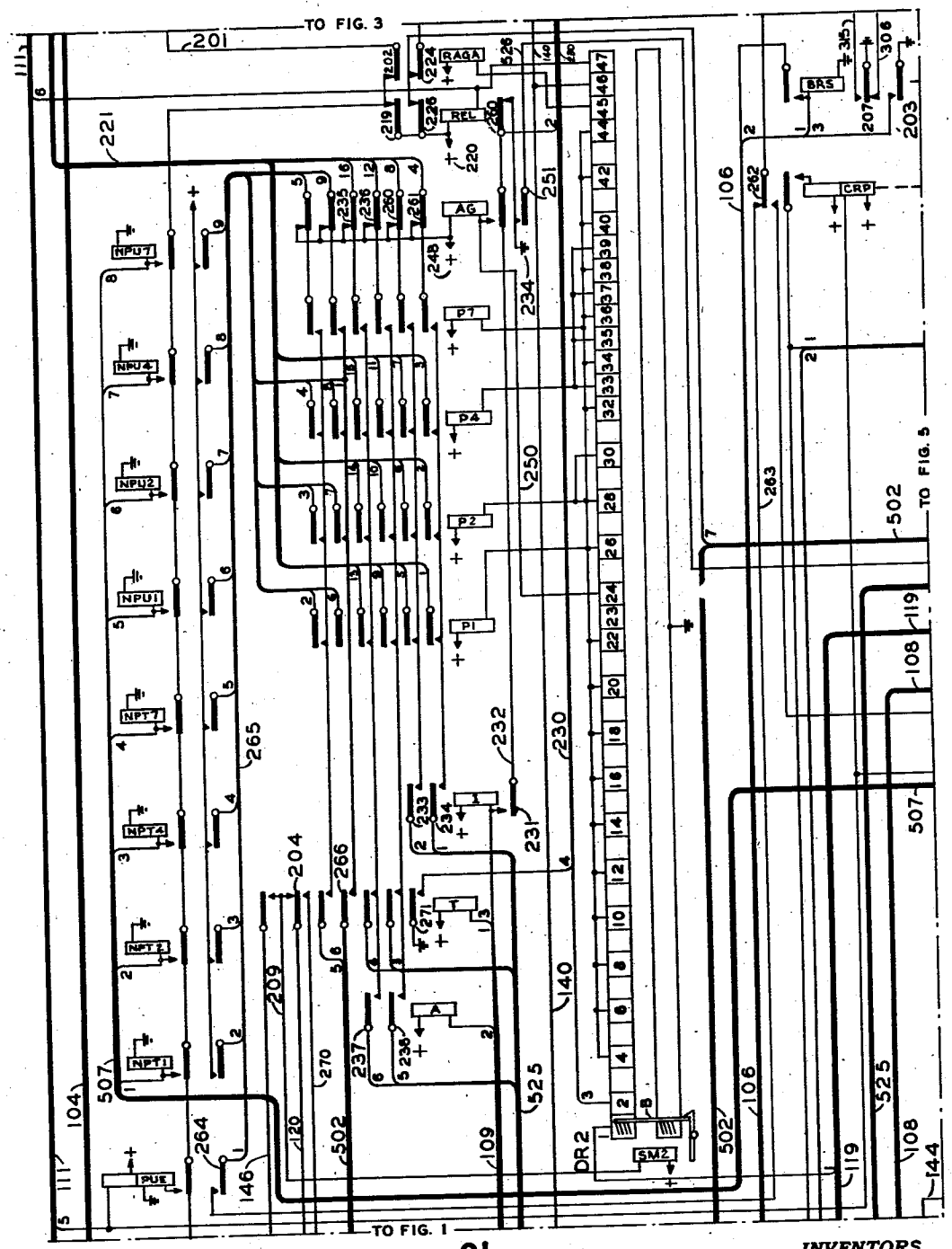

FIG. 2

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COMMUNICATION AND POSTING SYSTEM

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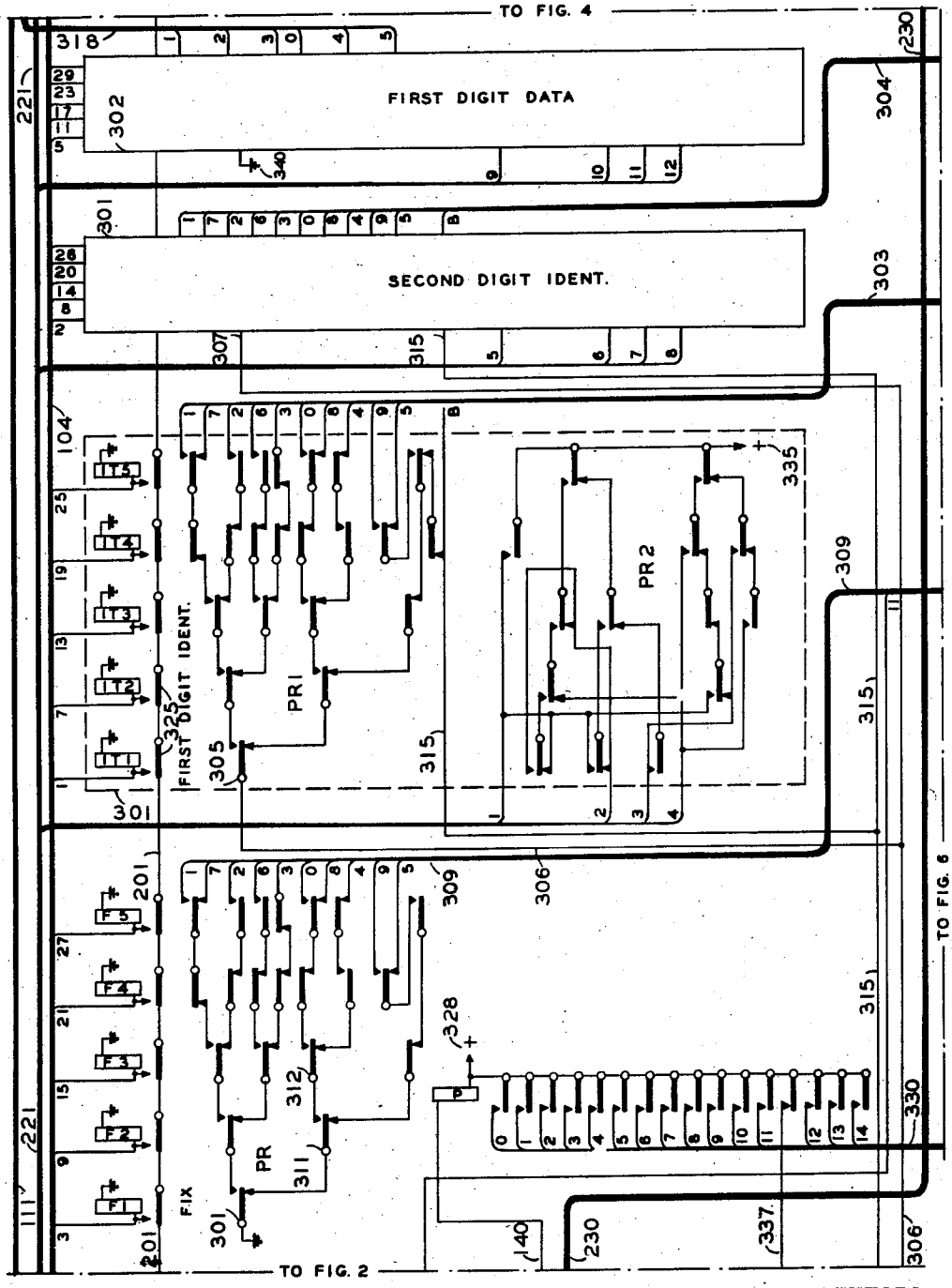

FIG. 3

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 4

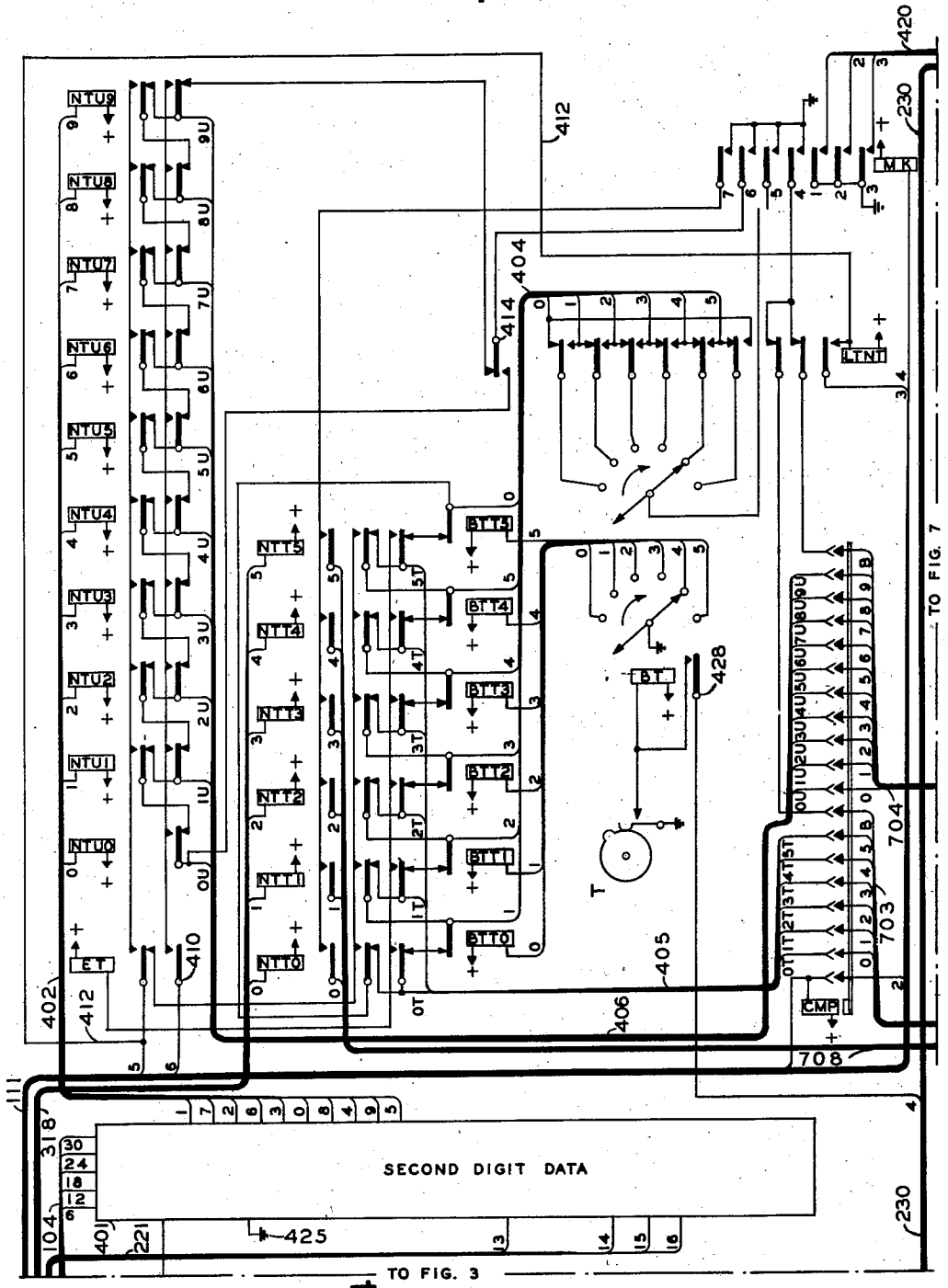

FIG. 4

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 5

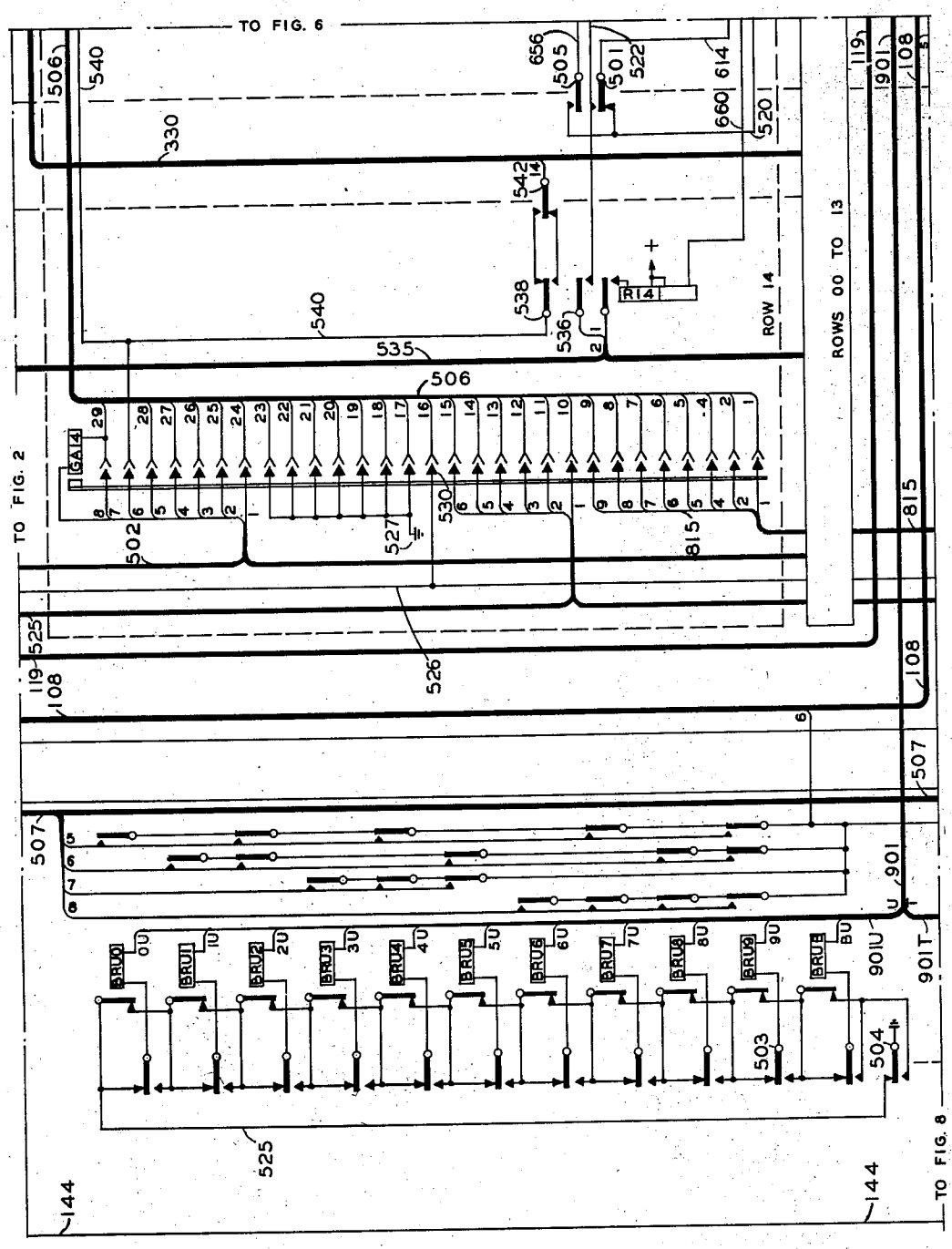

FIG. 5

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 6

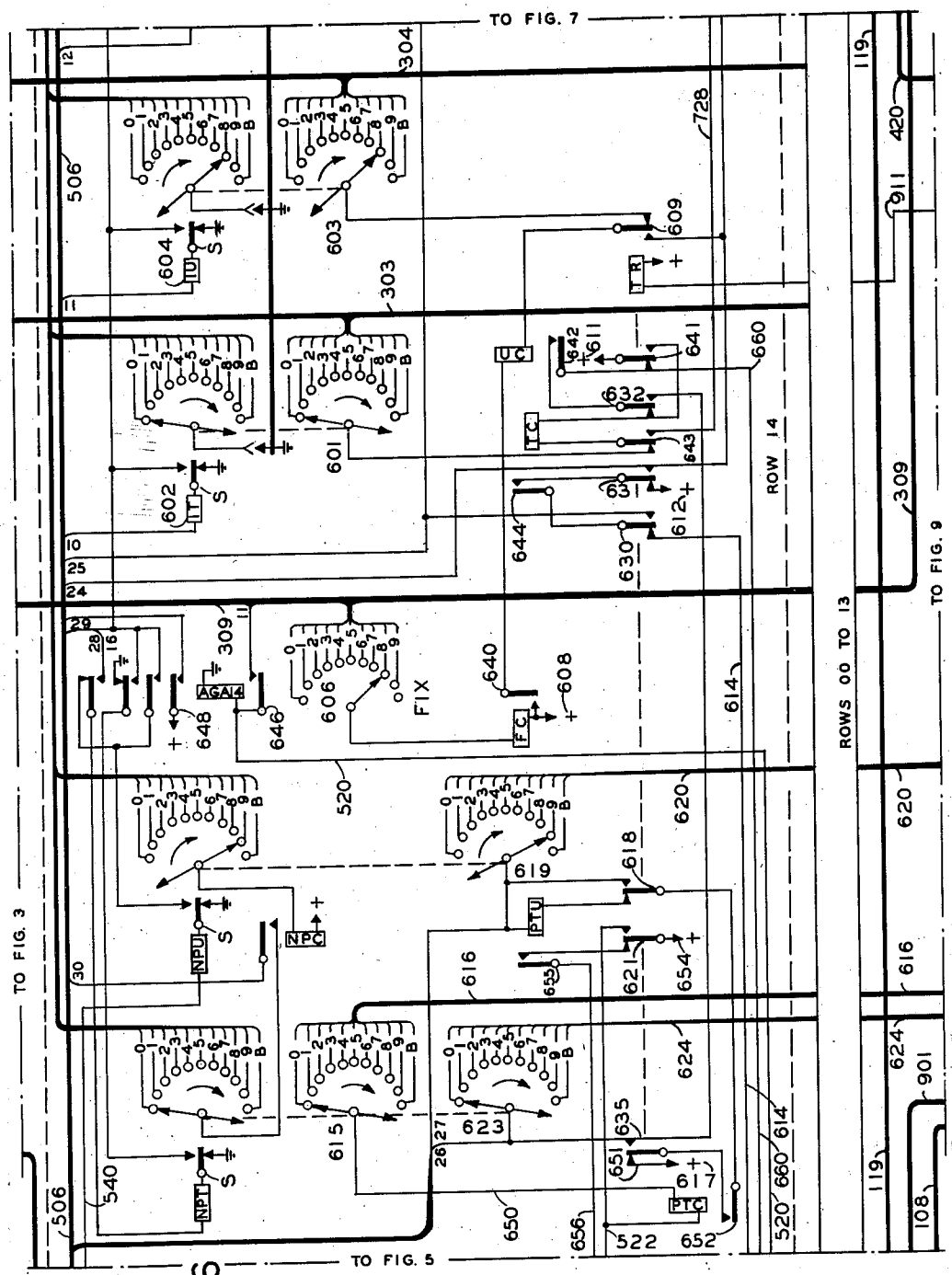

FIG. 6

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 7

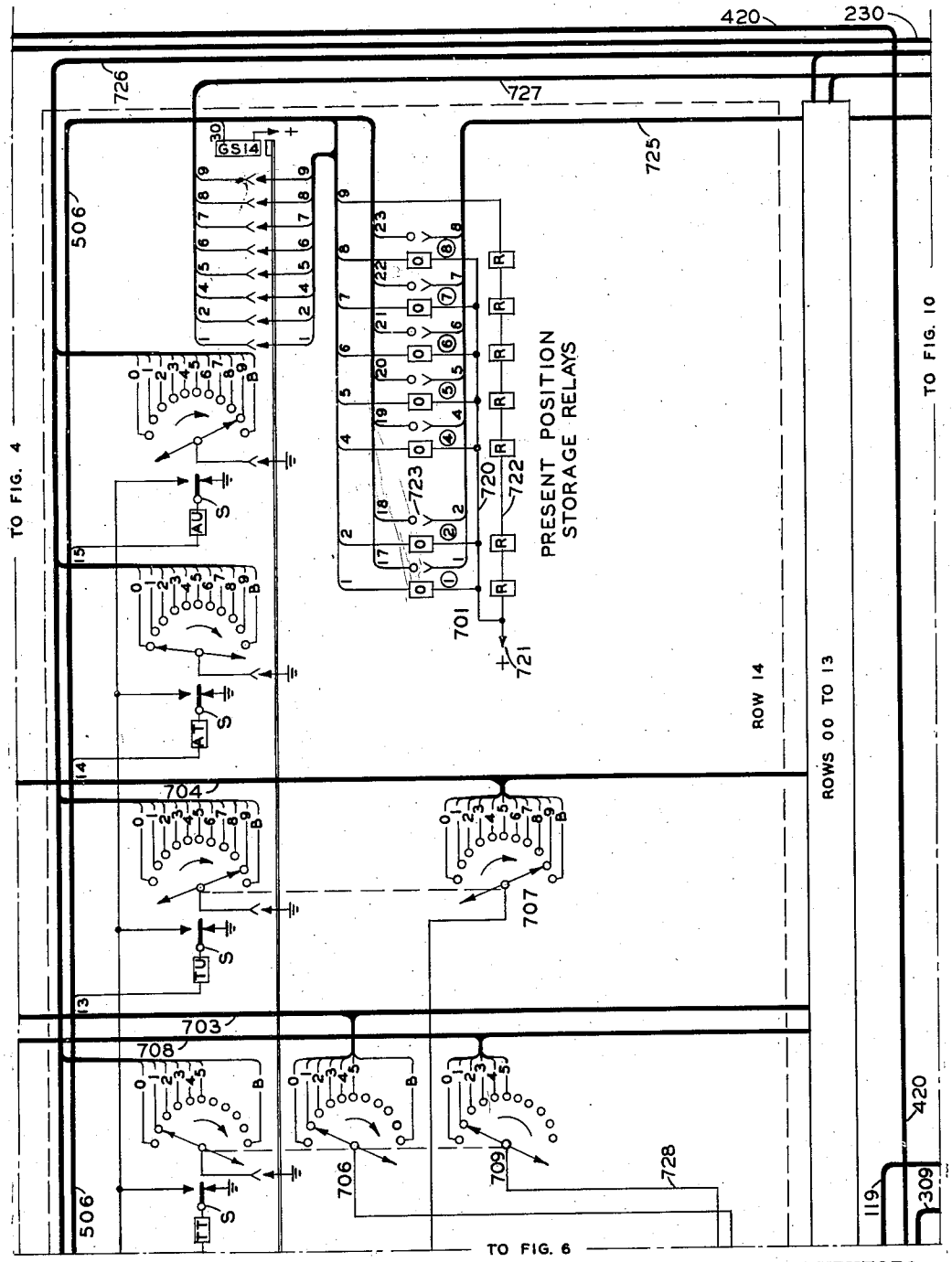

FIG. 7

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 8

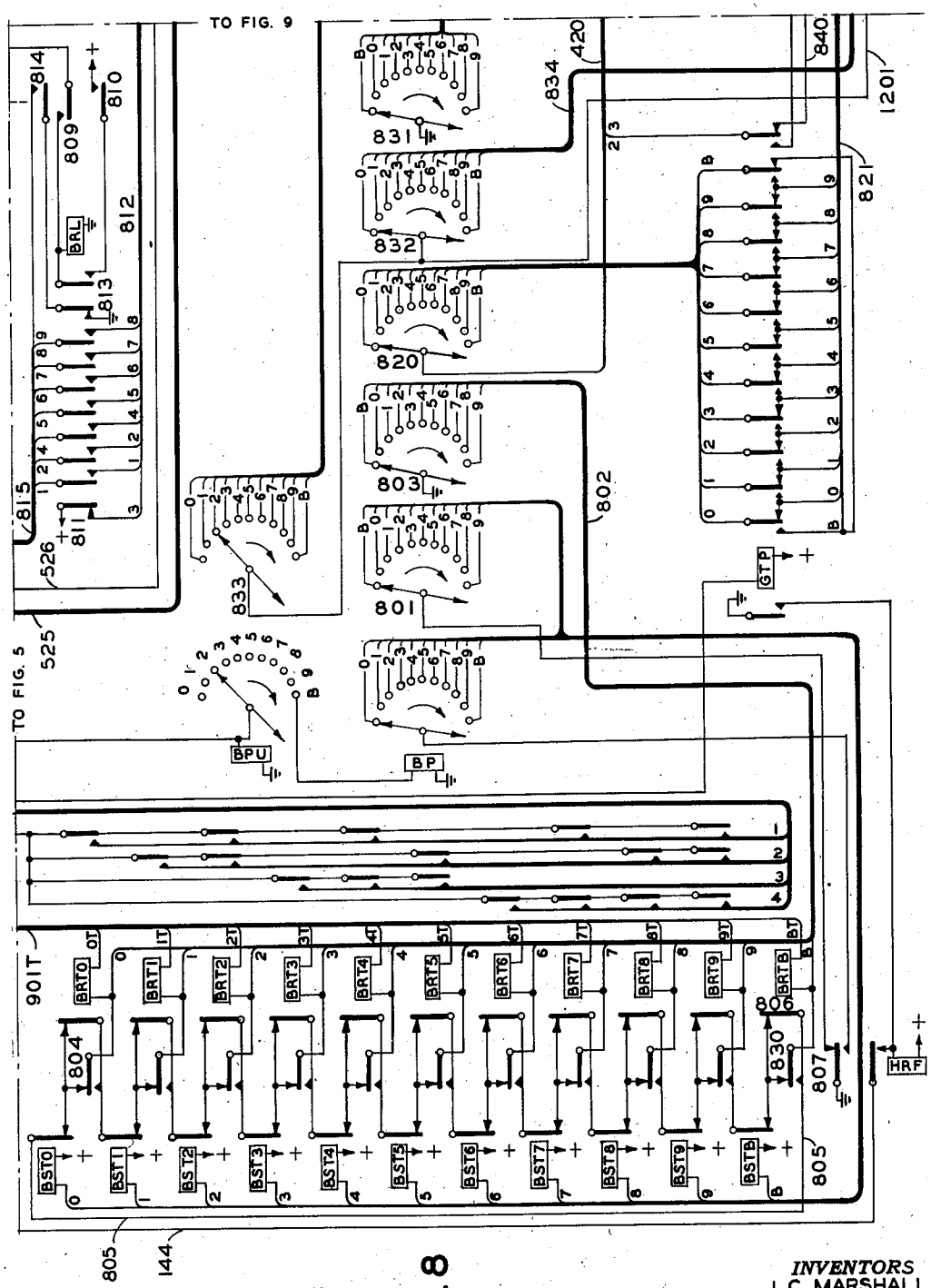

FIG. 8

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 9

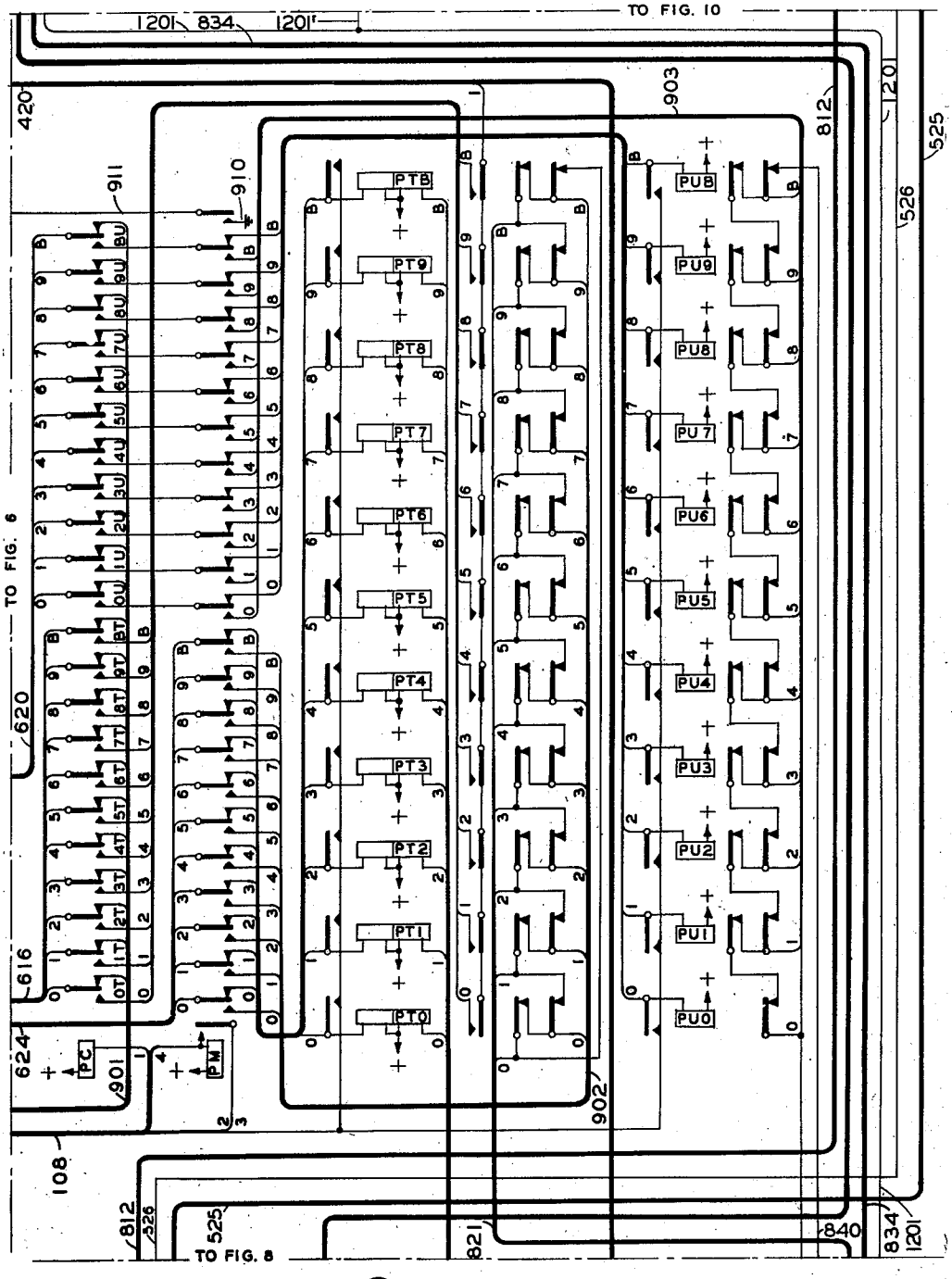

FIG. 9

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COMMUNICATION AND POSTING SYSTEM

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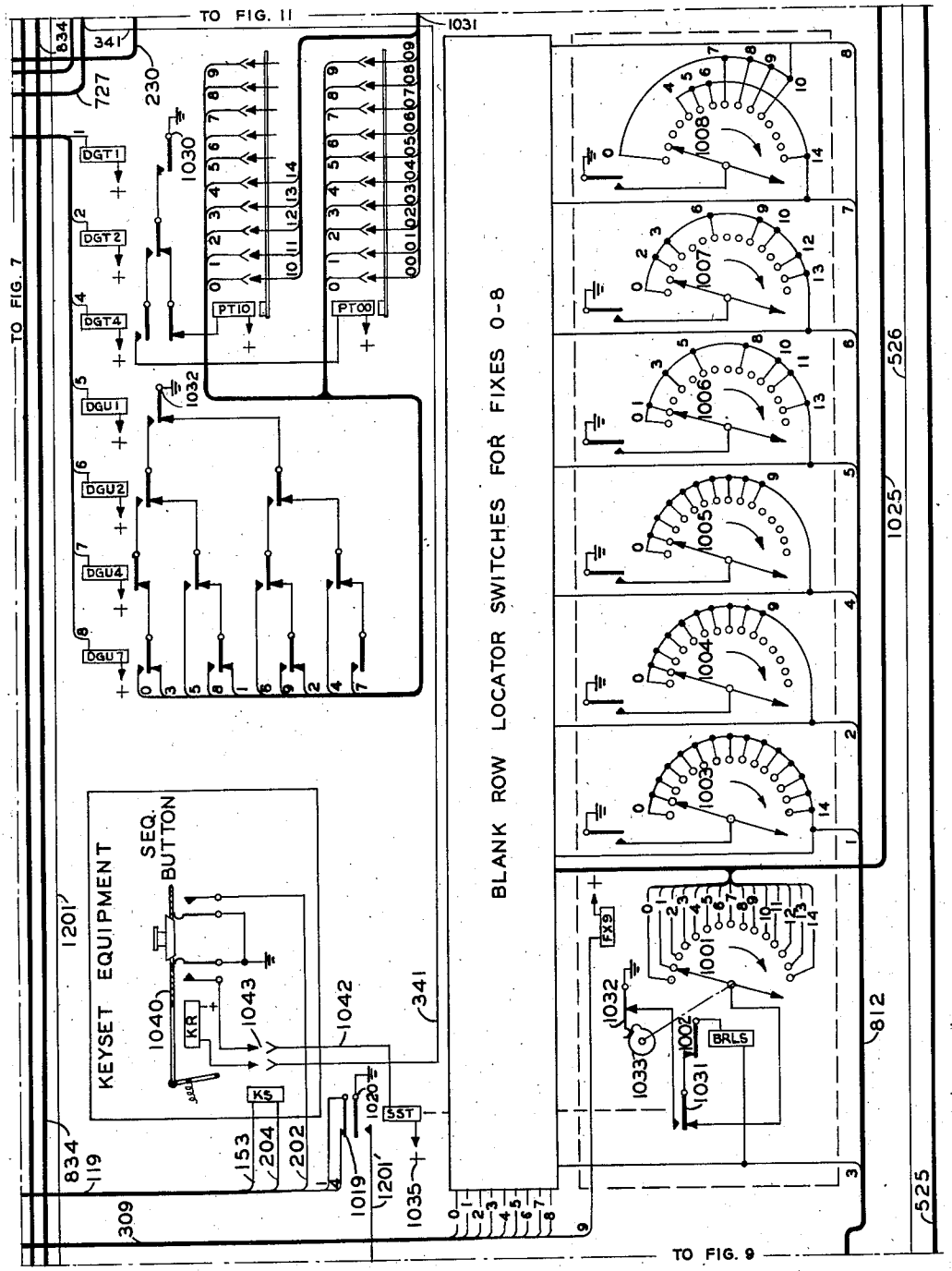

FIG. 10

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COMMUNICATION AND POSTING SYSTEM

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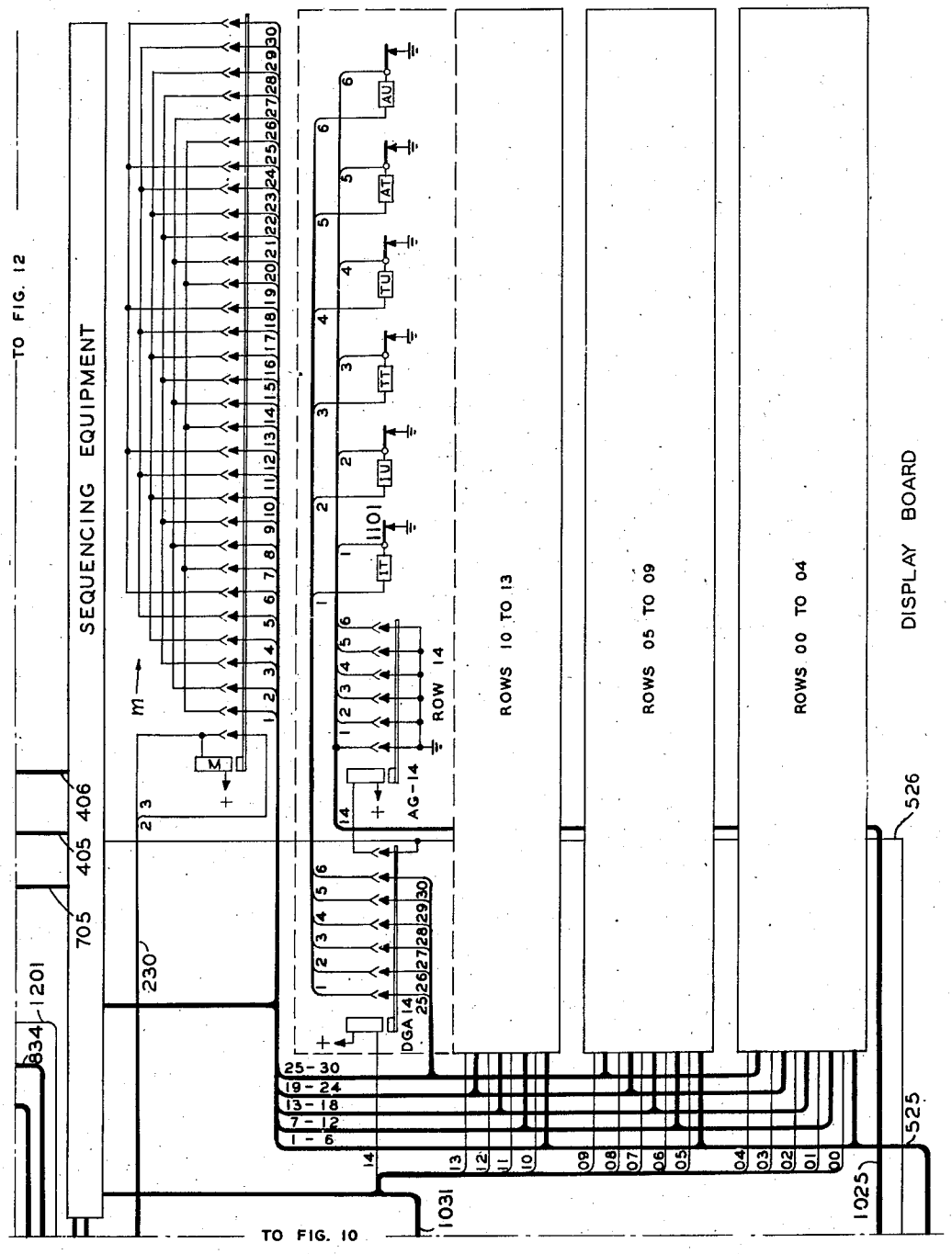

FIG. 11

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 12

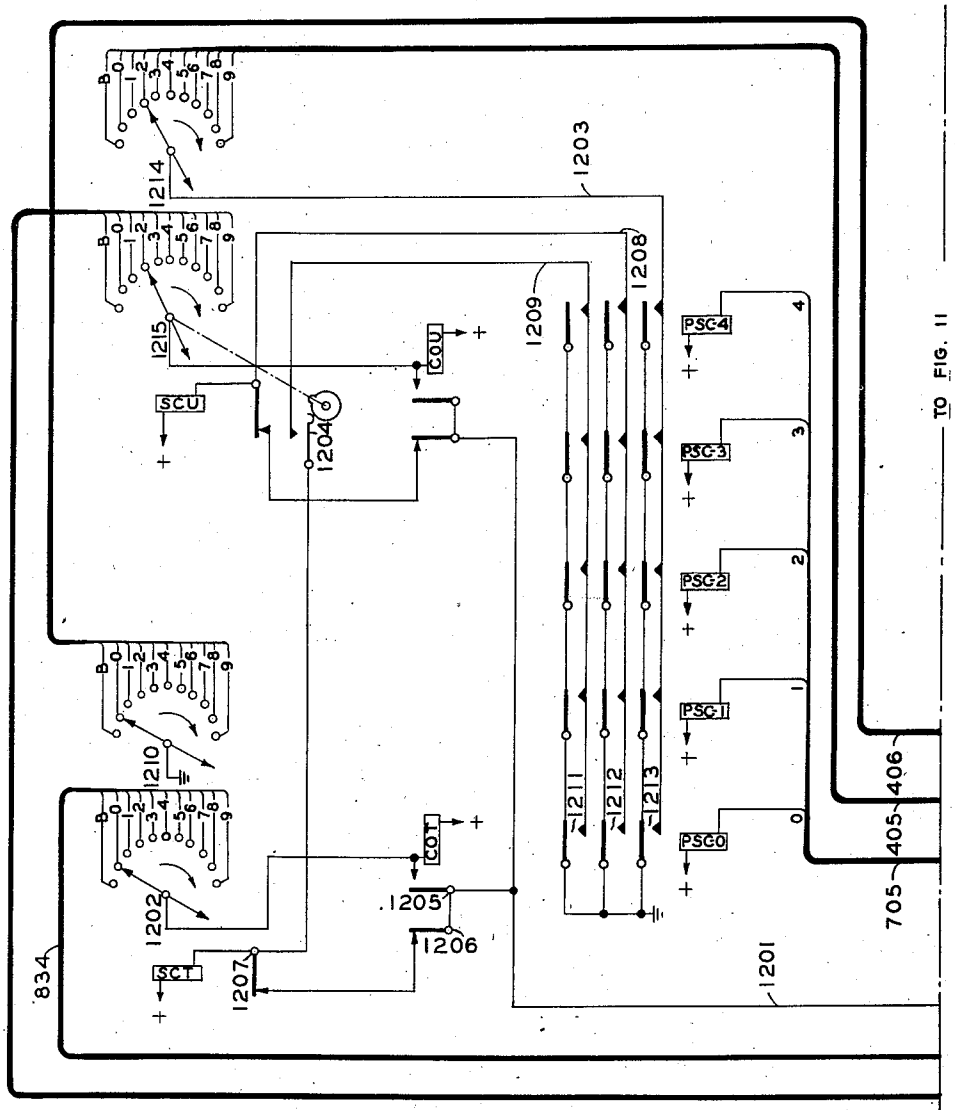

FIG. 12

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COMMUNICATION AND POSTING SYSTEM

Filed Sept. 2, 1944 13 Sheets-Sheet 13

FIG. 13

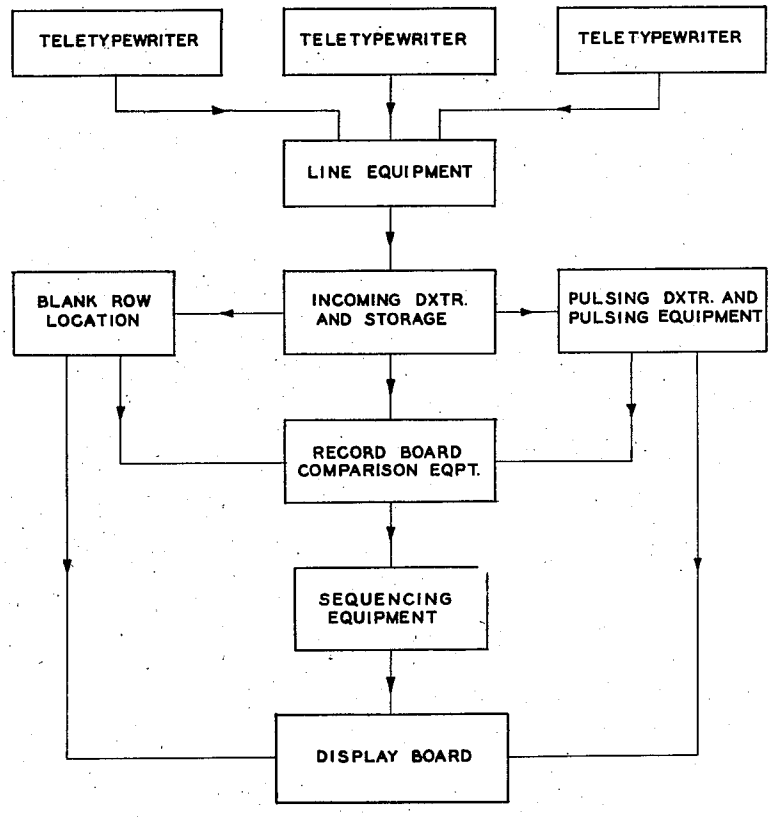

FIG. 14

FIG. 1	FIG. 2	FIG. 3	FIG. 4	
	FIG. 5	FIG. 6	FIG. 7	FIG. 12
	FIG. 8	FIG. 9	FIG. 10	FIG. 11

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Patented Dec. 25, 1945

2,391,469

UNITED STATES PATENT OFFICE

2,391,469

COMMUNICATION AND POSTING SYSTEM

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Application September 2, 1944, Serial No. 552,428

20 Claims. (Cl. 177—353)

This invention relates generally to communication and posting systems for displaying on announcing boards information or data in regard to a number of different items by means of groups or rows of indicators which are automatically and selectively actuatable or settable in response to incoming signals to display information or current changes in information in regard to the items posted. The invention is particularly adapted, although not limited, to a system for the transmission, recordation and posting of data on announcement or bulletin boards relating to air traffic control information in which the signals representing the information thus posted may be transmitted either from a local transmitter or from wire or radio transmitters remotely situated with respect to the receiving posting and recording apparatus, and in which the remote transmitters may be located either at ground stations or within aircraft in flight.

The system disclosed herein is an improvement over the communication and posting systems disclosed in the Marshall et al. Patent No. 2,246,449, issued June 17, 1941, and in our copending application Serial No. 518,370, filed January 15, 1944, now Patent No. 2,386,743, issued October 9, 1945. In order to simplify the present disclosure and to set forth more clearly the improvement represented by the instant invention, certain of the apparatus and equipment in the aforesaid prior cases is diagrammatically represented in the drawings of the instant case by labeled rectangles, the disclosures of the prior cases being incorporated herein by reference.

In systems for recording or posting flight plans and flight progress reports of aircraft and other messages relative to the control of aircraft, the information thus posted on the bulletin or announcing board usually relates to numerous flights which may be identified by numbers, and the indicators on which the items are posted usually are arranged in display groups according to the various "marker" or "Fix" classifications and preferably are arranged within each Fix group in accordance with the expected or estimated time of passage or arrival of the aircraft at the various recording or marker points en route and at the airport. The flight data posted may have to be changed from time to time during the progress of the flights as the result of conditions affecting the progress of aircraft, such as poor visibility, ice, changes in the direction and velocity of the wind, the necessity of blind landings, and other emergency conditions.

The information posted may comprise numerous data such as the flight designation numbers, followed by a section number, if any; information as to the direction of the various flights; the estimated time when the aircraft will pass over or land at certain marker points on the flight route; the time at which the aircraft actually passes over or lands at specific marker points; the expected approach time when the pilot may receive instructions to start his approach to a landing field; the proposed altitude at which the clearance has been issued to cross each marker or flight path; the altitude at which the aircraft actually crosses the various markers or flight paths, and the landing sequence number assigned to landings under instrument conditions. In addition to the foregoing, other information may be posted on the flight progress display boards, such as an indication that a clearance through a marker or Fix has been issued, an indication of a flight over the airport, an indication of a stop en route, and an indication that an aircraft has been cleared to the airport control tower or range station so that there will be no delay in landing.

As set forth in the foregoing patents, local communication facilities comprising known telephone or telegraph wire or radio equipment may be employed to establish communication between the air line company's dispatch offices and the various aircraft, airport control towers, the local communications operator in the airway traffic control, government regulating bureaus, military operations offices, if any, and other airports. In our Patent No. 2,386,743 a record board is provided having electrical signal storage rotatable indicators on which information in regard to the various flights is stored, in random order on the board, and a display board having a plurality of rotatable indicating devices for displaying information in regard to the flights with sequencing apparatus controlled by the signal storage devices of the record board for obtaining information therefrom and automatically selecting and energizing the indicators on the display board to cause them to display in a predetermined serial order the items of information stored on the record board. The order in which the items were to be written or rewritten on the display board was determined by the settings of new position storage devices manually set by an attendant who determined the desired serial arrangement or order of the items to be displayed or rewritten on the display board, and who assigned corresponding position numbers to the items on the record board.

In accordance with one feature of the present invention, the new position storage devices are automatically set by the incoming flight signals to indicate or produce a desired serial order of items when the display board is rewritten, in accordance with the relative values of data con-

cerning the items, which data, for example, may be proposed altitude or time information. This is accomplished by causing such data in a received message to be automatically compared with the same kind of data displayed in currently posted items, and the existing new position data stored on the new position storage devices corrected, if necessary, the comparison also determining what position numbers to assign to the new items of information.

Preferably, and as disclosed in the illustrative embodiment herein, the new position storage devices embody visual indicating means whereby numbers or other indicia are automatically posted on such devices which indicate a desired serial order in which the items should be displaced. From these indicia, which in this case are one or two digit numbers representing the relative positions in which the items should be posted on the display board, the control personnel may manually reset the indicators in the display board, as by means of a key set or otherwise, although preferably the resetting of the display indicators is automatically controlled by the new position storage devices, the only manual operation required being that of initiating an automatic sequencing operation. If desired, the display board could automatically be rewritten at predetermined intervals by switch means periodically controlled by clockwork or other suitable mechanism, although ordinarily the rewriting operation of the board is left to the discretion of the controller or other member of the operating personnel. Also, from the new position numbers displayed by the new position storage indicators, the personnel may selectively pick out and transmit in a predetermined order certain of the stored items to auxiliary posting boards or other apparatus.

In our aforesaid patent it was also necessary to manually select and control the operation of indicators in order to store on the record board any flight or other item appearing for the first time, so that additional information or changes in information in incoming messages would find its way automatically to the proper storage devices through the medium of a flight or item locator which searched for an identification number associated with each flight or other item. This identification number, which precedes each incoming message, was not available to the flight or item locator until the first posting of the identification number was made by means of a keyset.

In accordance with another feature of the present invention, blank row locator apparatus is provided which functions when the flight locator fails to find an existing posted flight identification corresponding to the flight identification in an incoming message. When no existing posted identification is found, the blank row locator selects an available row of indicators in the display board and also in the record board, which preferably although not necessarily, is the lowest blank row in the display board and is the first blank row above existing postings in the record board. In these selected blank rows, the new item of information including the flight identification indicia, which usually is a number, is posted without the need for manual control.

The blank row locator apparatus functions when the flight locator fails to find an item with an identification number identical to that contained in the incoming message. The time comparator apparatus functions whenever an incoming report or message contains time. If neither of the foregoing conditions occurs when a flight message is received, neither the blank row locator nor the time comparator circuit is required to function, and the received information is posted on the groups of indicators in the record and display boards where information in regard to the flight is currently posted.

One of the objects of the invention is a system for automatically receiving, storing and posting data in regard to various items, particularly aircraft and other vehicles, which system has means responsive to incoming signals for automatically comparing certain data in incoming messages with the same kind of data in the prior messages posted and for storing signals and/or posting indicia representative of a predetermined serial order in which said items should be posted.

Another object is a posting or announcing system which utilizes two boards having indicators carrying substantially the same information, or on which certain information is duplicated, one of which boards is a record board on which the information regarding various flights or other items may be stored in more or less random order and the other a display board on which the various flights or other items may be displayed in a particular serial order or sequence which is automatically determined from the relative values of certain data in the messages thus posted.

Still another object is the provision of means for rewriting the information on the display board in a predetermined serial order or sequence which automatically is determined in accordance with the relative values of certain data in the messages posted, and in which a multiplicity of rows of indicating devices in the display board may simultaneously or concurrently be rewritten by multiple row sequencing operations.

An additional object is an arrangement whereby the order in which the flights or other items are displayed on the display board may be changed to display the items in chronological order as determined automatically by certain time data in said items.

Another object is a system in which the relative positions of the flights or other items displayed on the display board are determined by the settings of new position storage units which are automatically set and/or reset in accordance with the relative values of certain data contained in the incoming messages with respect to similar data currently posted in regard to the flights or other items.

Still another object is a system and apparatus for automatically effecting a comparison between a certain datum contained in an incoming message and the same kind of data posted on the board with regard to other items and for indicating or relocating the relative posting position or positions of the incoming item or of the currently posted items, or both, in accordance with the new datum.

A further object is apparatus for determining from the item designation in an incoming message whether information in regard to the item is currently posted, and if not, for finding an available blank row of posting devices for entering the information in regard to the new item.

A still further object is apparatus for entering a new item in an available blank row of posting devices and then comparing the relative values of the data in the new item with the same kind

of data previously posted in other devices to determine the serial order in which the items should be displayed.

Various other objects, advantages and improvements will be apparent from the following detailed description of an illustrative embodiment of the invention, taken in connection with the accompanying drawings, in which:

Fig. 1 is a view, partly in diagrammatic form, of incoming telegraph line equipment, together with a receiving distributor for applying the incoming signals to certain storage relays, and another distributor associated with the time comparator circuit;

Fig. 2 shows a pulsing distributor and associated pulsing and control relays;

Fig. 3 shows certain Fix, flight identification and data storage and decoding relays;

Fig. 4 shows a time comparator circuit with "new time" relays, and a base time switch and associated relay equipment;

Fig. 5 illustrates certain blank row selection relays and record board gang relays;

Fig. 6 shows new position storage indicators, flight identification storage indicators and gang relay auxiliary equipment;

Fig. 7 shows time and altitude storage indicators and present position storage relays;

Fig. 8 shows certain blank row selection relays and base position rotary switches;

Fig. 9 is a view of various time comparator relays;

Fig. 10 shows blank row locator rotary switch equipment;

Fig. 11 represents diagrammatically a plurality of rows of indicators in the display board and gang relays associated therewith, and shows in diagrammatic form sequencing equipment for rewriting the display board;

Fig. 12 shows certain other sequencing equipment for rewriting the display board;

Fig. 13 is a diagram showing various units of the system and their relation with respect to each other; and

Fig. 14 is a diagram showing the arrangement of the various sheets of drawings illustrative of the system.

In the specific embodiment of the invention illustrated herein, data in regard to the movements of a number of aircraft within a given area of a terminal or other flight control zone are recorded, and preferably are visually posted, on a record board, Figs. 6 and 7 of the drawings, and are displayed in predetermined order on the display board shown in Fig. 11. Rotatable indicators IT, IU, TT, TU, AT and AU, which are arranged in horizontal rows designated **00** to **14**, in Figs. 6, 7 and 11, preferably are employed as the recording and display devices. Each row of indicators, when identified with a certain flight, is adapted to display the flight identification number and the flight information or data, for example, the estimated and actual times at which the aircraft reaches or passes a particular location or Fix, or the proposed and actual altitudes of the aircraft at the various points, and also any additional information that may be desired.

While the flights may be recorded or stored in the record board in random order, it is highly desirable that in the flight progress display board of Fig. 11 the flights and information in regard thereto be displayed in a predetermined order corresponding to the relative values of either the altitude or time data, the indicators also being arranged in groups corresponding to the different Fix points to which they relate, such as Fix **1**, Fix **2**, Fix **3**, etc. Both the record board and the flight progress display board may be located at the same place, such as an air traffic control center or airport, where the flights terminate or traverse a predetermined area associated with or controlled by the airport, and are posted on the display board by means of the indicators so as to be visible at all times to the airway traffic personnel or others interested in the progress of the flights thus posted.

General description of comparator circuits

In our aforesaid patent two types of comparisons were effected, namely, flight location and position location, the latter occurring during the sequencing operation. These comparisons were made by energizing one conductor of a multiple which was connected to the banks of all indicators in the same column of the record board. For example, to locate a flight bearing the identification number 24, the No. 2 lead in the multiple connected to the tens identification column and the No. 4 lead in the units identification column would be energized. Within the horizontal row of indicators assigned to flight **24** these energized leads functioned to operate a gang relay which connects the indicator units of the row to the pulsing equipment. This type of comparison, which may be called an equality comparison, results in the selection of the one row in which the settings of the flight identification indicators exactly match the combination of energized multiple conductors.

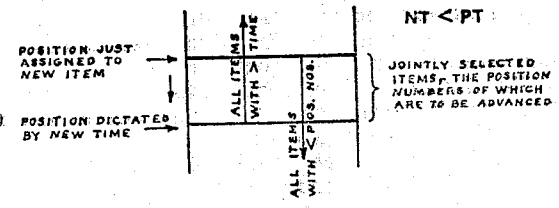
Other types of comparison, in addition to an equality comparison, are employed in the system of the present invention. One of these is used to select all horizontal rows bearing position numbers higher than that of a certain row. Let us assign, for example the number 35 as the position number of a certain row of indicators. As hereinafter explained in greater detail, one of the necessary steps is to select all rows having position numbers greater than 35. If the comparison could be confined to a single denominational column or decimal position, the procedure would be to energize all multiple leads above a certain number. For example, to select all rows with unit numbers greater than five, it would only be necessary to energize leads **6**, **7**, **8**, **9** and blank, and indicators setting on any of these positions would be selected.

When we wish to accomplish a similar result in two denominational columns, a different situation is encountered because a single column comparison does not identify those items which are greater in the units column but equal in the tens column, for example, 36, 37, 38, etc. It is necessary in making a multi-column comparison to initiate an "equality" comparison and a "greater than" comparison in all columns except the last or lowest decimal column. Where an indicator in the highest decimal position is connected to a "greater-than" lead, that postion number is immediately deemed greater. If the same indicator receives an indication of equality, the function of comparison is extended to the indicator in the next lower decimal position, where a similar comparison is repeated. If no indication of either equality or greater-than is received, the position number is deemed lower. In order to distinguish between equality and greater-than indications, a separate multiple and contact bank is assigned for each type of indication. By the same arrangement, it is possible to select all items bearing

position numbers lower than a particular position number.

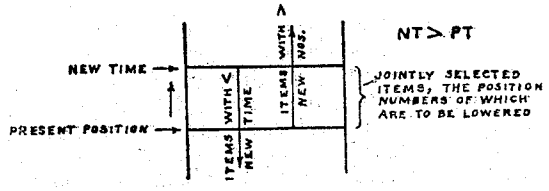
Types of indicators employed.—In the decimal system of counting, the digit 0 precedes the digit 1 and represents the absence of a quantity in that denominational position in which it appears. Rotatable step-by-step indicators of the type having eleven settable positions comprising ten digit display positions and a blank position preferably, although not necessarily, are employed; in such indicators the digit 1 ordinarily follows the blank position on the indicator drum in order that the number of stepping pulses necessary to actuate the indicator to any digit position will be equal to the value of the digit displayed. Therefore, if it is desired to use a uniform type of step-by-step indicator throughout the system both for counting (as in the case of new position storage indicators) and for display purposes and in which such eleven-position indicators are used, the digit 0 should follow the blank position on the indicator drum. In this case the number of stepping pulses necessary to advance the indicator drum from its blank position to any digit will be one greater than the value of the digit, and the pulse generating and transmitting equipment employed in this case is designed to generate one pulse more than the number represented by the digit posted. It is, of course, possible to utilize two different types of step-by-step indicators; one type may have the digit 1 following the blank position, whereas the other type used for the new position indicators may have the digit 0 following the blank position.

Position numbering.—At this time it will be helpful to understand how position numbers are assigned and changed to maintain a desired sequence of items. As mentioned before, the sequence may be based upon the time, which is part of the information in each item, and for purposes of illustration herein it will be assumed that a chronological sequence is desired. The item also contains such information as a flight identification number, the altitude of the plane and often other data pertinent to the control of air traffic. The item (on the record board only) also bears a position number, of one or two digits, which corresponds to its proper relative location on the display board. Physical location is random on the record board, the position number taking the place of the actual physical ordering on the display board. Time may be displayed either as two digits, representing minutes, or as four digits, representing hours and minutes. For simplicity the system illustrated herein displays the time in minutes. In the initial condition of the board, even when no items are actually posted, the position numbers of the rows are posted. When the first item is posted, the row bearing the lowest position number is chosen. When the next item is received, it is posted in the row bearing the next lowest position number. This selection of rows is accomplished by the blank row locator. If, however, time is included in the information, an additional comparison takes place to change the position numbers if necessary. In any time comparisons, blank time is considered greater than any specific time to insure that all items including time data will be segregated at the bottom of their respective Fixes. If a new item of information containing time is received, a blank row is assigned and then the time is compared with that displayed by all items already posted, since the new item should be inserted below all items with higher posted times. It is arbitrarily planned to insert the item above all items having the same time posted. To insert an item at any place it is necessary to move up, or actually increase, the position numbers of all items whose posted time data are greater than that of the new item. As the new item has been assigned to a blank row, it is only necessary to increase the position numbers of those rows up to the blank row just assigned. This ceiling on the number of rows is determined by selecting only those rows with posted times greater than the new time and position numbers lower than the position number just assigned. The diagram below shows this principle of selection.



If the new information received pertains to an item already on the record board, the flight locator finds the existing item instead of the blank row locator assigning a row. Otherwise the same comparison as described above occurs. The selected rows have their position numbers advanced one step, and the original position number of the lowest selected row is rewritten in the row where the new information is to be posted.

Under certain conditions new information will require changing an item to show a later time than that previously posted. This will generally require the position number of that item to be increased. In this case the rows between the old and new position numbers will require a reduction in position number. These rows are selected by the combined requirements of having posted times lower than the new time received and position numbers greater than the present position number of the item being changed. The following diagram shows how these requirements determine and select the rows to be changed.



Base position scheme.—It is not feasible to drive the step-by-step indicators backward, and therefore a different method of lowering the position numbers of the selected rows is employed. In this method the position numbers of all rows except the selected rows are raised; this lowers the position numbers of the selected rows relatively. As a result any number may be assigned to the lowest numbered row in the board. Eventually the lowest item in order of posting will bear a number near the maximum and the highest item will bear a lower number because the numbering cycle has passed through zero. For example, if the base position number is 95 when the lowest numbered row is —5 (— represents blank which follows 9) and the highest is 08, we have a contradiction to the normal order of counting.

In order to correct this situation it is necessary to introduce a base position number, which is a means of keeping a record of the lowest numbered item on the record board. The position

numbers recorded for the individual items are not the actual row numbers which the item should occupy but are merely a relative indication which is referred to a changeable base position to determine the true display board row. Consequently, when it is necessary to lower the position numbers of selected items, the position numbers of all other items are raised and also the base position number is raised. It should be noted that a base position recorder is required because of the repeating nature of the position numbers.

Base time scheme.—When making comparisons of time, a problem similar to that of the position comparator is encountered. Time, being cyclical, repeats itself every twenty-four hours when hours and minutes are employed, and in the present disclosure time repeats every sixty minutes, since only two indicators are used. The question arises as to which time is greater when, for example, one time is 2:50 and the other 3:10. In order to ensure correct comparisons, it is necessary to provide base time indicating equipment to record the lowest time. In the example above the base time indicated might be :40. Referred to this standard it is evident that :50 is lower than :10. The base time equipment indicates the zero point in the time cycle, just as the base position indicating equipment indicates the zero point in the position cycle.

Circuit description

The incoming signals for posting on the record board and the display board may be of any suitable type. Usually, and in accordance with conventional telegraph practice, permutation code signals, for example, five-unit code signals, are employed, and these signals may be initiated at various keyboard printer or other transmitting stations and transmitted by wire to the receiving line equipment 101, Fig. 1, or the signals may be transmitted by radio transmitting apparatus situated in the aircraft while in flight, and thereby transmit signals which are received by radio apparatus. Various means of transmitting and receiving both types of signals are known in the art, some of which are disclosed in the aforesaid Marshall et al. patent and our patent. The line equipment 101 contains receiving distributors for applying incoming signals to tape reperforators of known types, for example, as disclosed in Hoover Patent 2,252,852 and Dirkes et al. Patent 2,193,809. The perforated tape is fed through conventional tape transmitters whereby the stored signals are repeated and applied to a distributor such as DR1 shown in Fig. 1.

In the illustrative embodiment disclosed herein each flight information message comprises numerical, alphabetical and functional characters. The first two characters or digits of the message represent the flight identification number, and the third character a digit which represents a particular Fix; the fourth character is a range or selecting signal, which usually is an alphabetical character, for the data posting indicators, for example, Time, in which case the fifth and sixth characters are the tens and units digits respectively of the Time, and are followed by two spacing signals which are interposed between the first and second parts of the message when both Time and Altitude information data are transmitted. The first two characters following the second space signal again represent the flight identification number, the third character the Fix number; the four character is the range or selecting signal for the Altitude posting indicators, and the following two characters are the thousands and hundreds digits of the Altitude, and are followed by the end-of-message signal, which is usually transmitted by the key L of the printer keyboard. As above stated, each complete message received by the receiving distributors in the line equipment is followed by an end-of-message signal which is stored in a group of relays and which causes seeker mechanism in the line equipment to function and start an associated tape transmitter into operation to transmit the received message during a revolution of the distributor DR1 of Fig. 1, which is set into operation by the seeker relay associated with the operated group of end-of-message relays when the seeker mechanism has come to rest in a position associated with the operated seeker relay, as described in detail in the Marshall et al. patent and our aforesaid patent. The operation of a transmitter-connecting relay in the line equipment connects, at the proper times, the transmitting tongues of the tape transmitter, through conductors 1 to 5 of cable 102, Fig. 1, to the five solid rings 2, 4, 6, 8 and 10 of the rotary distributor DR1. Conductor 6 is connected to the even numbered segments 2, 4, 6, 8, 10 and 12 of the segmented ring 11 of distributor DR1 for stepping the tape transmitter.

Operation of distributor DR1

The start magnet SM1 operates in series with the transmitter-connecting relay in the line equipment, by means of conductor 7 in cable 102, conductor 4 in cable 119 to the break contact and armature 1019 of a sequence start relay SST, Fig. 10, and thence by way of conductor 1 in cable 119 to the stop segment 1 of rotary distributor DR2, Fig. 2, and through the brush B and the solid ring 2 to ground. Operation of SM1 releases the rotatable brush arm of distributor DR1 thereby setting the distributor in operation. The engagement of brushes B1 to B5 of the distributor with their corresponding segments 2, closes the circuits from the tongues of the tape transmitter in the line equipment, through conductors 1 to 5 of cable 102 and conductors 1, 7, 13, 19 and 25 of cable 104 to the grounded windings of the first digit identification storage and decoding relays IT1 to IT5, Fig. 3. Assume, for example, that the first digit of the identification number of the aircraft or other source from which a report or message is being received is the digit 1. The five-unit permutation code pulses for digit 1 are marking, marking, marking, spacing, marking, and when the row of tape perforations representing digit 1 passes through the tape transmitter of the line equipment, conductors 1, 2, 3 and 5 of cable 102 will be energized with battery from the marking bus of the tape transmitter. Since battery is supplied only to conductors 1, 2, 3 and 5 of cable 102, only relays IT1, IT2, IT3 and IT5 will be operated. These relays operate and lock over a circuit from ground at their windings, through their make contacts and armatures 325 to holding battery 220 furnished over conductor 201 through normally closed contact and armature 202 of relay RAGA, Fig. 2, and normally closed contact and armature 219 of release relay REL. The arrangement of relays and armatures for the second digit identification storage relay group of Fig. 3 is the same as that of the first digit identification group shown.

The brush B6 of distributor DR1 next contacts segment 2 of ring 11 and completes a circuit

from grounded battery 105 on segment 2 of ring 12, through the brush and segment 2 of ring 11 to conductor 6 of cable 102, and thence to the tape stepping magnet of the tape transmitter in the line equipment 101, thereby stepping the tape in the transmitter in known manner. As the distributor DR1 rotates, the brushes B1 to B5 thereof close circuits to segments 4 of rings 1, 3, 5, 7 and 9, connecting the second digit identification storage and decoding relays shown in Fig. 3, to the tongues of the tape transmitter in a manner similar to that of the preceding character, thereby actuating and locking the relays in the second identification group in accordance with the code for the second digit, for example, the digit 4.

Similarly, as the tape is advanced through the tape transmitter, the remaining characters are transmitted by segments 6, 8, 10 and 12 of rings 1, 3, 5, 7 and 9 of DR1, and successively are stored in the Fix relay group, Fig. 3, the range relay group, Fig. 1, the first digit data group, Fig. 3, and the second digit data relay group, Fig. 4.

When the brush B6 of distributor DR1 reaches segment 12 of ring 11, this completes a circuit from grounded battery on segment 2 of ring 12, through the brush, segment 12, and conductor 6 of cable 102, to the tape stepping magnet of the tape transmitter in the line equipment. Stepping of the tape transmitter advances the next character under the sensing pins which is a "space" signal.

When the brush B5 of distributor DR1 reaches segment 14 of segmented ring 11, ground is applied from segment 4 of ring 12, through the brush, segment 14, conductor 120, armature 204 and break contact of relay T, Fig. 2, conductor 209, start magnet SM2 of distributor DR2, and thence to grounded battery, actuating the start magnet and releasing the brush B of the distributor for rotation. As the distributor brush of DR2 leaves its rest position, the circuit from segment 1 of ring 1 is opened, thereby deenergizing start magnet SM1 of distributor DR1, and distributor DR1 then comes to rest with its brushes on its stop segment 1. The distributor waits until distributor DR2 has completed its cycle of transmission hereinafter described, before continuing to take the remainder or second half of the message from the tape transmitter.

Blank row locator

In order to provide the blank row locating feature, the distributor DR1 has been modified to include circuits which originate from segments 7 and 11 of ring 11, the purpose of which will be explained below under "Blank row selection." In our aforesaid patent, following the completion of an operating cycle of distributor DR1, the flight identification number stored on the identification relays was used to locate the flight on the display board. In general, this operation involves energizing one conductor in each of the storage indicator multiples of the Identification and Fix indicators in the display board. These multiples in the instant disclosure are identified by reference numerals 303, 304 and 309 and are shown in Figs. 3 and 6. It will be seen that the apex of the relay pyramid PR1 associated with the first digit identification relays IT1 to IT5 is supplied with ground at armature 305 of relay IT1, over conductor 306 and normally closed contact and grounded armature 207 of blank row selector relay BRS, Fig. 2. Similarly, the apex of the pyramid of the second digit identification relays shown schematically by the rectangle 301 in Fig. 3, and which are like the first digit identification relays, obtains ground from the normally closed contact and armature 207 of relay BRS over conductors 306 and 307. When the code combinations representing the digits of the identification number have been stored, one of the conductors 0 to 9 of cable 303, and one of the conductors 0 to 9 of cable 304 will be energized with ground from the armature 207 of relay BRS. The multiple cable 303 is connected to corresponding banks 601 of the first digit identification storage indicator 602, Fig. 6, in each of the horizontal rows of storage indicators of the record board. Fifteen of such rows of indicators are shown in the drawings, the lower fourteen rows 00–13 being indicated diagrammatically in Fig. 7, and the upper row No. 14 being shown in detail in this figure. It will be understood that in practice a great many more rows than those indicated will be employed in the record board; in an average size installation there may be 2500 or more rows of such indicators.

Each horizontal row of the record board contains storage or recording units NPT, NPU, F, IT, IU, TT, TU, AT and AU, the upper row 14 of which is shown in Figs. 6 and 7, these recording units respectively storing digits representative of the new position tens, new position units, Fix, identification tens, identification units, time tens, time units, altitude tens and altitude units. With the exception of the Fix storage units which are switches with manually rotatable switch arms, the recording units preferably are step-by-step indicators of the type disclosed in Haselton et al. Patent 2,155,825, issued April 25, 1939. Such indicators are provided with a set of equally spaced contacts corresponding in number to the number of positions to which the indicator drums may be rotated by electromagnetic pawl and ratchet structure, the contacts being arranged in a continuous series. The wiper arm is attached to the indicator drum assembly and engages the contacts of the indicator in accordance with the instant setting of the drum; for example, if the drum is set to display the digit 1, the wiper will be engaged by the contact 1; similarly, if the indicator is set for its blank position, the associated wiper will be in engagement with its blank contact B. The contact assemblies herein referred to are illustrated schematically in arcuate form in the drawings to show more clearly the circuits connected thereto, it being understood that the wipers take settings in accordance with the flight identification and information digits or symbols posted by the indicators. As each of the indicators reaches its blank or home position, during the transmission to the indicator of restoration pulses, the restoration circuit to ground is opened and an actuation or resetting circuit is closed by a switch element, such as indicated at *s* in the indicators of Figs. 6 and 7, thereby to cause the indicator to stop when it reaches its home position and its actuating coil switched to an actuation circuit, as disclosed in the patents to Haselton 2,049,499, issued August 4, 1936, and Hicks et al. 2,189,581, issued February 6, 1940. The subsequent application of the resetting or actuation pulses to the indicator causes the switch member *s* to be restored to its former position when the indicator leaves its blank position during the resetting operation.

Cable 304 is multipled to banks 603 of the second digit identification storage indicator 604 in

every row of the record board. The Fix storage relays F1 to F5, Fig. 3, function in a manner similar to the identification storage relays, but the cable multiple 309 from the Fix pyramid is connected to the banks of a manually settable tap switch 606, Fig. 6, in each row of the record board. The Fix character, while not actually a part of the flight identification number, represents the section of the record board which is assigned to all flights passing over a certain geographical zone, and the same flight identification number may appear in several places of the record board under different Fixes.

It will be seen that the settings of the brushes on the Fix and Identification banks 606, 601 and 603 of row 14 are in positions representing Fix 8, Flight 08. Assuming that the incoming message contains this information, corresponding conductors of cables 309, 303 and 304 will be energized by the pyramids of the Fix and identification relays, and a path for operating an auxiliary gang relay AGA14, Fig. 6, will be completed. The circuit for operating this relay may be traced from ground on armature 310 of the Fix relay F1, Fig. 3, through its normally closed contact to armature 311 of relay F2 which is now operated in accordance with the character 8 which in permutation code has the signal elements 2 and 3 marking in character and which is stored on the Fix storage relays. This ground is extended through the make contact associated with armature 311, relay F2, armature 312 and make contact of energized relay F3, and normally closed contacts of relays F4 and F5 to conductor 8 in cable 309. Since the brush of the Fix switch 606 in row 14, Fig. 6, is resting on terminal 8 of the switch bank, a path to a relay FC is established from battery 608, and FC operates. This relay connects battery from 608 through its armature 640 and make contact to the winding of a units comparator relay UC, the circuit continuing through armature 609 and break contact of a transfer relay TR, to the brush of bank 603 of the IU indicator, and then through bank terminal 8 and conductor 8 in cable 304 to the second digit identification pyramid PR1 in the relay group 301, Fig. 3. Since this pyramid has stored in it the digit 8, a circuit is completed over conductors 307 and 306 to the grounded armature 206 of relay BRS, Fig. 2.

Relay UC, Fig. 6, operates and connects battery 611 through armature 641 and break contact of the transfer relay TR, armature 642 and make contact of operated relay UC, armature 632 and break contact of the relay TR, to the winding of the relay TC. The circuit from this winding continues through armature 643 and break contact of relay TR, to the brush of contact bank 601 of the IT storage indicator in row 14. Since this brush is resting on bank terminal 0, the circuit is extended over lead 0 in cable 303 to the first digit identification pyramid, Fig. 3. Stored in this pyramid is the digit 0, the permutation code signal for which has code elements 2, 3 and 5 marking, and the circuit of conductor 0 in cable 303 is extended to armature 305 of relay IT1 to ground on armature 207 of relay BRS, Fig. 2. Relay TC, Fig. 6, operates and connects battery 612 through normally closed break contacts 631 of relay TR, through armature 644 and make contact of operated relay TC, normally closed contacts 630 of relay TR, conductor 614, armature 501 and break contact of relay BRS, Fig. 5, and conductor 520 to the winding of auxiliary gang relay AGA14, Fig. 6, and thence to ground.

Relay AGA14 operates and locks up over its armature 646 and make contact, conductor 11 in cable 309, through armature 224 and break contact of relay RAGA, Fig. 2, and armature 226 and break contact of release relay REL, to battery 220. The operation of relay AGA14 applies battery, through its armature 648 and make contact, to conductor 29 in cable 506, and thence to the winding of gang relay GA14, Fig. 5. The circuit continues from the winding of this relay, over conductor 8 in cable 502, and through the winding of relay GOT, Fig. 1, to ground. Thus, the operation of relay GA14 required the successive operation of relays FC, UC and TC, indicating an agreement in the Fix, second digit identification and first digit identification characters. When GA14 or any other similar gang relay operates, relay GOT operates in series with it.

Blank row selection.—If no row of storage indicators in the record board carries the Fix and Identification numbers stored in the storage and decoding relays, Fig. 3, none of the GA gang relays will operate, and relay GOT, Fig. 1, will be unoperated, thus indicating that the incoming message has not been previously posted. When brush B6 of the distributor DR1 reaches segment 7 of ring 11, battery 105 will be fed through the brush, segment 7, armature 125 and break contact of relay GOT, and thence over conductor 1 in cable 106, and through the winding of the blank row selector relay BRS in Fig. 2, to ground. This relay has an armature and contact 501, Fig. 5, in each row in the record board, which serves to change the selection circuits in each row to select a blank row. To accomplish this the blank conductors B from the first and second digit Identification pyramids PR1, Fig. 3, must be energized since any blank row will have its Identification indicators setting in the blank positions. The blank leads are energized by means of armature 207 and associated make contact of relay BRS, Fig. 2, which applies ground to conductor 315 connected to the B (blank) leads in cables 303 and 304, Fig. 4. Any storage indicators IT or IU which are in their blank positions will have their associated tens and units comparator relays TC and UC, Fig. 6, operated provided their Fix comparator relay FC has been operated previously. However, there may be a plurality of blank rows in each Fix and only one, the lowest numbered, should be selected. The operation of relay BRS has added this requirement by opening the normal gang relay path through its armature and break contact 501, Fig. 5.

When conductor 614, connected to armature 501, is energized in the several blank rows through the combined operation of their FC, UC and TC relays, battery 612 (in all blank rows) is connected over conductor 614, armature 501 and make contact of relay BRS and conductor 522 to the winding of the position tens comparator relay PTC, Fig. 6. The circuit continues over conductor 650 to the brush and bank 615 of the new position tens storage indicator NPT, Fig. 6, and thence through one of the bank terminals to a conductor in cable 616 which is multiplied to a corresponding bank of the NPT storage indicator in each of the rows 00–14. If, for example, we assume that row 14 is a blank row, the conductor 0 in cable 616 will be energized through the winding of the PTC relay from the battery 612, Fig. 6. The conductors of cable 616 are connected through normally closed contacts of a position comparator PC relay, Fig. 9, and thence through conductors OT to BT of cable 901 which termi-

nates on the windings of relays BRTO to BRTB, Fig. 8.

Since the NPT indicators, Fig. 6, in the blank rows may be resting on different bank terminals, several of the BRT (blank row tens) relays in Fig. 8 will attempt to operate. The circuit of the other side of each BRT relay winding passes through a transfer armature and contact 804 on the HRF (highest row finder) relay to a contact on either the next higher or lower BRT relay. With the HRF relay unoperated, which is the condition for finding the lowest numbered blank row, the operation of any BRT relay, at its armature and break contact, will open the operating path for any higher numbered BRT relay. This insures that only the lowest numbered BRT relay can operate and consequently that only the PTC relays in those rows bearing the lowest tens position number can operate, this being in accordance with the scheme of base position numbering hereinbefore explained. It will be evident that it cannot be stated definitely which is the lowest numbered BRT relay. Depending on the base position in existence at any time, one BRT relay will be deemed lowest in any comparison operations. The setting of the base position rotary switch BP, Fig. 8, determines which BRT relay is lowest by supplying the operating coil of that relay direct with ground which is fed from bank 803 of switch BP. With the switch in the position shown in Fig. 8 this bank feeds ground over conductor B to the winding of BRTB. Relay BRTB is able to operate regardless of any other BRT relay and so is effectively the lowest numbered BRT relay. To open the endless chain circuit below the BRTB relay, the adjacent BSTB relay is operated from bank 801 of the BP (base position) switch.

With the circuit arrangement just described, the lowest numbered position tens comparator relay PTC will operate in all such rows which have the same tens digit of the new position number, but only one BRT relay will operate. Assuming that row 14 bearing new position number 09 is blank and that no other rows are blank, the path for operating the PTC relay is over the brush and bank 615 of the NPT storage indicator, Fig. 6, conductor 0 in cable 616, normally closed contacts of relay PC, Fig. 9, conductor OT in cable 901, winding of relay BRTO, Fig. 8, normally closed contact 804 of relay HRF, normally closed contact of relay BSTO, conductor 805, normally closed contact 806 of relay BRTB, normally closed contact 830 of relay HRF, conductor B in cable 802 and bank 803 and wiper of switch BP, to ground. The operation of the position tens comparator relay PTC connects battery 617 from normally closed contact and armature 651 of relay TR, through armature 652 and make contact of operated relay PTC, and thence through armature 618 and break contact of relay TR, to the winding of PTU relay. The other side of the PTU winding is connected through the wiper and bank 619 of the NPU storage indicator to conductor 9 in cable 620, and thence through normally closed contact 9 of relay PC, Fig. 9, and conductor 9U of cable 901 to the winding of blank row units relay BRU9 in Fig. 5. The relays BRU0 to BRU8 are wired for mutually exclusive operation in a manner similar to the BRT relays except that no base position is involved, and relay BRU0 is the lowest numbered relay in any case. Continuing the circuit of relay PTU through the winding of relay BRU9, the circuit may be traced through normally closed contact 503, Fig. 5, of relay HRF, normally closed contacts of BRU8, BRU7, BRU6, BRU5, BRU4, BRU3, BRU2, BRU1, BRU0 and conductor 525, to ground at the normally closed contact 504 of relay HRF. Relays PTU and BRU9 operate in series. The operation of PTU connects battery 654, Fig. 6, through the normally closed contact 621 of relay TR, through the armature 655 and make contact of PTU, conductor 656, armature and make contact 505 of blank row selector relay BRS, conductor 520, to the winding of relay AGA14, Fig. 6, operating this relay. As before, relay AGA14 at its armature 648 operates gang relay GA14, Fig. 5.

The operation of gang relay GA14 connects the indicators in that row to the pulsing multiples 502 and 525, so that the information in the incoming message can be stored on the indicators. Recording indicator units NPT, NPU, IT, IU, TT, TU, AT and AU of row 14 are thereby connected so as to be controlled by range relays A, T and I, and pulsing relays P1, P2, P4 and P7, Fig. 2. The operation of relay GA14 also connects ground at 527 over conductors 17, 23 in cable 506 to contacts of the group of present position storage relays 701 of row 14, Fig. 7. The purpose of these relays is to control the selection of the particular row of indicators in the display board where the flight concerning which the information is currently being received is at present displayed. The present position relays, seven in number, are of the mechanical-latching, electrical-reset type, and store in permutation code a two-digit number corresponding to the row number in the display board, Fig. 11, where the flight is posted. If, for example, the data recorded in row 14 of the record board was displayed in row 06 of the display board, the group of relays 701 would store the number 06 in permutation code. Upon operation of gang relay GA14, the contacts of the relays 701 would be energized and through the permutation code stored in them would effect the selection of row 06 in the display board, and the indicator units in both boards would then be pulsed in parallel to display the information contained in the incoming message, as described in greater detail in our said prior application. While any suitable form of mechanical-latching or electrical-locking type of relay may be employed, various of which are known in the art, the mechanical-latching type preferably is employed, one of which types is disclosed in detail in our prior application. In such an arrangement, as seen in Fig. 7, operating windings 0 of the relays are connected in multiple through a conductor 720 to a source of grounded battery 721. All the reset windings R are connected in series, by means of a conductor 722, to the battery 721. When the operating winding of any of the relays is energized, it attracts its armature and closes a circuit through its make contacts 723 diagrammatically illustrated in the drawings, from certain conductors 1 to 9 of cable 506, to certain conductors in cable 725. As the relay armatures move towards their make contacts, each releases a pivotally mounted mechanical latch which drops down behind the armature and keeps it locked in circuit closing position until the reset winding B is energized. Energization of the reset winding attracts its armature and raises the latch, whereby the armature returns to its open position, either under the influence of a spring or by gravity.

The ground from 527, Fig. 5, is applied selectively through the closed contacts of those present position relays which are operated, and through

certain conductors of cable 725 to the windings of relays DGT and DGU of Fig. 10. The relays DGT and DGU operate in combination in accordance with the permutation codes stored on a present position storage relay and serve to select and apply ground 1032 to one of ten leads 0 to 9 in cable 1031 through the conventional pyramidal arrangement of armatures and contacts associated with the relays DGT and DGU, to the winding of one of the display board gang relays DGA, Fig. 11, to battery, operating the gang relay. The indicator units of the record and display board will then be pulsed in parallel to display the information contained in the incoming message.

If the flight had not been previously posted, however, as in the present example, a blank row in the display board must also be selected before pulsing can begin. This blank row is selected through the operation of the blank row locator switch BRLS, Fig. 10. A terminal of bank 1001 of this switch is wired, through a cable 1025, to the contact end of the identification tens indicator 17, Fig. 11, in each row of the display board. A typical connection is shown from bank terminal 14 which is connected, by means of cable 1025, to the IT indicator in row 14. If the row is blank, the IT indicator will be in its blank position and its off normal contact 1101 open. If anything is displayed in the row, the off normal contact of the IT indicator will be closed, thereby grounding the hunting bank 1001 of terminal switch BRLS. This switch, by means of a self-interrupting stepping circuit comprising its bank terminals and wiper 1001, break contact and armature 1031 of a sequence start relay SST, interrupter spring 1002, winding of BRLS, lead 3 in cable 812, armature and break contact 811 of relay BRL, Fig. 8, to battery, hunts for a blank row and normally rests on a blank row terminal. In order to cause BRLS to locate the lowest blank row in the display board, following a sequencing operation, the switch is buzzed to its home position 0 during each sequencing operation. This circuit is from ground through the off normal break contacts 1032, the armature and make contact 1031 of relay SST (which is operated during a sequencing operation), through interrupter springs 1002 and winding of BRLS, over lead 3 in cable 812 to break contact and armature 811 of relay BRL, Fig. 8, to battery. The off normal contacts are opened when switch BRLS reaches its 0 position, by the lobe on a cam 1033 which is driven by the switch in synchronism with its wiper arms.

Since several Fixes may be included in one bay of the display board, a blank row locator switch BRLS is provided for each Fix, although only one of these switches is illustrated in detail in Fig. 10. On any one switch a group of rows which are assigned to a different Fix will be made permanently busy by ground strapping their corresponding terminals on the bank 1001 of such a switch. Such terminals are permanently busy on such a switch since they are assigned to another Fix and the corresponding rows are only available on another BRLS switch. The proper BRLS switch is chosen to mark the conductors of cable 812 through the operation of the Fix relay such as FX9 in Fig. 10. The BRLS switch illustrated is energized by relay FX9. When a message for Fix 9 is received, the FX9 relay is operated through the Fix pyramid contacts of Fig. 3 over cable 309.

Referring again to the previous example, when relay BRS, Fig. 2, operated from segment 7 of ring 11 of the distributor DR1, its armature 809 and make contact, Fig. 8, partially completed a path for operating the relay BRL. When brush B6 of distributor DR1 reached segment 11, battery 105 was extended over conductor 5 of cable 108, through armature 809 and make contact of relay BRS, Fig. 8, to the winding of relay BRL which operates and locks to armature 810 and make contact of relay BRS. The operation of BRL removed battery supplied through its normally closed contact 811 and conductor 3 of cable 812 to the winding of switch BRLS, Fig. 10, thereby preventing it from stepping until the pulsing of the indicators is completed. When BRL operates, it closes through leads from banks 1003 to 1008 on the blank row locator switch BRLS to the contacts of the gang relays. These leads carry a permutation code representing the number of the blank display board row. If gang GA14 is to be operated, for example, these leads are extended as conductors 1 to 8 in cable 506 to the operated windings of the present position storage relays shown in Fig. 7, these relays being operated in permutation code combination in accordance with the setting of switch BRLS. Any previous setting was erased by the energization of the reset coils R of these relays before relay BRL of Fig. 8 operated, the resetting circuit being closed when relay BRS operated. Ground through normally closed contact 813 of BRL was extended through contact 814 of relay BRS, by means of conductor 9 in cables 815 and 506, and through the reset coils R of the present position storage relays, to battery. When relay BRL operated, this circuit was opened.

When the present position storage relays operate, they close through ground on contacts 17 to 23 of the gang relay in permutation code combinations, through cables 506 and 725, to the tens and units display gang selection relays DGT 1, 2, 4 and DGU 1, 2, 4, 7, Fig. 10. These relays operate to select the display board gang relay, the method of final selection being a straight decimal selection scheme. Assuming that relay DGA14 in row 14 of Fig. 11 is to be operated, the DGT1 relay, Fig. 10, is operated, the remaining DGT relays being unoperated. The operation of DGT1 through its armature and make contact, connects ground 1030 through the lower unoperated armatures and contacts of relays DGT2 and DGT4, and through the winding of relay PT10, operating the latter relay. The armature of this relay connects conductors 10 to 14 of cable 1031, which conductors respectively are connected to the operating windings of DGA relays 10 to 14, and thus connect these to the pyramid of relays DGU 1, 2, 4 and 7. DGU4 relay has operated, thus applying ground 1032 through the unoperated armatures of relays DGU1 and DGU2, the lower operated armature and make contact of DGU4 to energize conductor 4, thereby causing DGA14 relay to operate and connect the indicators IT to AU of row 14 in the display board to the pulsing multiple.

A blank row has now automatically been selected for posting a new flight, and a gang relay in the record board belonging to the lowest numbered blank row has been operated. Also, a blank row in the display board has been selected and its position recorded in the selected row of the record board, and the display board gang relay of this row has been operated. We are now in a position to pulse the indicators in these selected rows, provided that no information in the incoming message pertains to time, i. e., the range re-

corded in the incoming message is not time (T). Let us assume that the selected range was the altitude (A) and that the code for this is 1 and 2 marking. When this code was received in the range relays R1 to R5 of Fig. 1, relays R1 and R2 operated and conductor 2 in cable 109 had ground 124 applied thereto by the pyramidal selection, and Altitude range relay A in Fig. 2 will be operated.

When relay BRS operated, as hereinbefore described, ground was supplied from an armature 203 of relay BRS over conductor 3 of cable 106, conductor 3, Fig. 1, of cable 109, to operate relay I in Fig. 2. This relay locks up through conductor 232 and armature 260 and break contact of relay REL, and cuts through at its armatures 233 and 234 and make contacts the pulsing control leads from the contacts of pulsing relays P1, P2, P4 and P7 which, when operated, connect through conductors 1 to 8 in cable 221 from the first and second digit identification pyramids PR2, Fig. 3, to insure that the flight identification contained in the message is posted. If relay BRS had not operated, thus indicating that the flight identification number had been posted previously, it would not have been necessary to operate relay I. In other words, when the flight identification has previously been posted, there is no point in reoperating the flight identification indicators, either in the record or display boards, and consequently the flight identification numbers of the message are employed only for locating the previously posted flight. If, however, the aviator or other person transmitting the message should inadvertently transmit an incorrect flight number, which causes the blank row locator to post the message in a blank row, it is possible for him to correct the flight number thus posted, by transmitting a succeeding message in which the range character I is inserted and the correct flight identification number is inserted in the data portion of the message, but instead of beginning the message with the correct flight identification number he will again begin the message with the incorrect flight number previously transmitted, thereby to select the row which had been assigned by the blank row locator. Since range relay I will operate under these circumstances, the correct flight number will go into the data information storage relays, but instead of being applied to either the altitude or time storage indicators when the indicators are pulsed, the stored identification signals will be applied to the identification indicators.

When brush B6 of distributor DR1 reaches segment 14 of ring 11, relay RLSB is operated, releasing relay BRS, Fig. 2, and the release of the latter relay releases at its armature 899 and break contact, Fig. 8, the relay BRL. Segment 14 of ring 11 of DR1 also closes a path over conductor 120, armature 204 and break contact of Time range relay T, Fig. 2, and conductor 209 for operating the start magnet SM2 of distributor DR2.

Operation of distributor DR2

The distributor generates pulses for pulsing indicators in accordance with the information stored in the pyramids PR2 of the identification and data relay groups of Figs. 3 and 4. The first operation accomplished by distributor DR2 as its brush arm B leaves its rest position is to apply ground from ring 2 to segment 2 of ring 1, and thence over conductor 8 in cable 230 to the winding of the M relay, Fig. 11, to grounded battery, and M operates. Through its innermost make contact, a locking path for relay M is maintained over conductor 2 of cable 230 to the lower armature 260 and break contact of release relay REL, to ground 234. The relay M is arranged to tie together the pulsing multiples of the various rows in the display board. As referred to later under "Sequencing" it is desirable to utilize five separate pulsing multiples, seen at the left hand portion of Fig. 11, in the display board. However, for the purpose of posting a single flight, these multiples must be connected to the individual range relays A, T and I and the pulsing relays P1 to P7 shown in Fig. 2. When relay M is operated, the corresponding leads of the pulsing multiples are tied together by means of the multiple connections *m* on the contacts of relay M. Relay M remains locked up until the REL relay is operated from segment 47 of distributor DR2 at the end of the cycle of the distributor.

The brush B of DR2 next closes a circuit from segment 4 of ring 1 of DR2. It will be noted that the ten even-numbered segments 4 to 22, inclusive, are connected together and furnish an operating path for the pulsing relay P7, Fig. 2. Each time that relay P7 operates, battery 248 through break contacts and armatures 235 and 236 of relay AG is supplied, through the armatures 237 and 238 and associated make contacts of operated range relay A to leads 5 and 6 in pulsing multiple 525. Since relay I is operated, relay P7 also supplies battery 248 from armatures 260 and 261 of relay AG, through armatures 233 and 234 of relay I to leads 1 and 2 in pulsing multiple 525. The ten restoration pulses generated in passing over segments 4 to 22 on ring 1 of distributor DR2 would have restored the selected identification and altitude indicators in the display board and record board to their blank positions if a blank row had not been selected. During a restoration operation, each indicator as it reaches its blank position, has the restoration circuit to ground automatically opened by the indicator switch member such as *s* in Fig. 6 and 1101 in Fig. 11, thereby stopping the indicator in this position. In a blank row, it will be understood that the restoration circuit is open at the time the restoration pulses were generated.

When the brush arm of distributor DR2 reaches segment 24, ground from ring 2 is fed to the brush over conductor 250 to the winding of relay AG and thence to grounded battery 248, causing AG to operate. The operation of AG removes the restoration pulsing battery 248 formerly supplied through its break contacts and armatures to the armatures of the pulsing relays P1 to P7, and also supplies ground through its lower outer armature 251 and make contact over conductor 526, through contact 530 of relay GA14, Fig. 2, to the actuation ground feeder 16 in cable 506 for the indicators in row 14, Figs. 6 and 7, of the record board. The ground over conductor 526 is also extended through the outer right hand contact of operated relay DGA14, Fig. 11, and the winding of relay AG14 to grounded battery. Relay AG14 operates and connects ground through its contacts 1 to 6 to one end of the windings of the indicators IT to AU in row 14 of the display board. The indicators in the record and display boards are now in position to move from their blank positions when actuation or resetting pulses are sent over the pulsing multiple.

As the brush arm B of distributor DR2 passes over segment 26 of ring 1, the pulse relay P1 is operated once, and when the brush arm passes over segments 28 and 30, which are strapped to-

gether, the pulse relay P2 is operated twice. When the brush arm passes the seven even-numbered segments 32 to 44, inclusive, the pulse relay P1 is operated seven times, and when the brush arm passes over the four odd-numbered segments 33 to 39, inclusive, the pulse relay P4 is operated four times. It will be seen that the combination of one, two, four and seven pulses forms an additive permutation code which enables any number of pulses from one to ten to be produced in accordance with the circuits set up by the pyramids PR2 of the first and second digit Identification and Data storage relay groups in Figs. 3 and 4. The pyramidal arrangement PR2 of armatures and contacts, which is embodied in each group of these relays, is such that the introduction of the five-unit permutation code into the windings of the relays of each group causes pulsing battery 335, Fig. 3, to be applied to a combination of four outgoing leads in cable 221, there being one group of such leads for each of the four storage relay groups. The leads selectively are connected to armatures of relays P1, P2, P4 and AG so that the number of resetting or actuation pulses transmitted to the indicators will correspond to the data stored in the groups of storage relays.

At the end of the pulsing cycle the brush of distributor DR2 reaches segment 35, thereby operating relay RAGA which at its armature 224 and break contact removes locking battery 220, which was applied over conductor 11 in cable 309, from the AGA14 relay, Fig. 6, releasing the latter relay. At its armature 202 and break contact, the deenergization of relay RAGA releases the locked-up pyramid relays F1 to F5, IT1 to IT5, and the corresponding relays in the second digit identification, first digit data and second digit groups. When the brush of the distributor reaches segment 46, relay P in Fig. 3 is operated, over conductor 149, for the purpose of generating an extra pulse required in certain comparison operations hereinafter described under the heading "Time comparison."

When the brush reaches segment 47, a circuit is closed from ground through the winding of the REL relay which operates, and releases at its lower armature 260 and break contact, the locked-up AG and I relays. The released armature 226 and break contact of relay REL releases locked-up gang relay GA14, Fig. 5. Release of the gang relay deenergizes the contacts of the present position storage relays in row 14, Fig. 7, and in turn releases the DGT and DGU selection relays in Fig. 10, which relays release the display board gang relay DGA14.

Time comparison and operation of distributor DR4

In the example mentioned the incoming message did not include the Time range, and consequently the operation of distributor DR1 was immediately followed by the operation of distributor DR2. If the T (time) range relay of Fig. 2 had been operated instead of the A (altitude) range relay, the armature 204 and associated make contact of relay T would have transferred the circuit 120 of segment 14, ring 11 of distributor DR1, from the start magnet SM2 of distributor DR2 to a conductor 270, and hence the start magnet SM4 of distributor DR4, Fig. 1, which distributor controls any time comparisons. Let us assume that the message to be posted includes time as the data portion of the message. Distributor DR1 will function as usual to store the incoming message on the various range, Fix, identification and data pyramids by means of their associated relays of Figs. 1 to 4. If the flight identification number is already posted on the record board, the blank row selection operation need not be invoked, but the operation of time comparison can also occur in posting a message which must be assigned to a blank row. We will, therefore, assume that the posting operation has reached a stage where a gang relay GA14 in the record board and a corresponding gang relay DGA14 in the display board have operated. The brush B6 of distributor DR1 has contacted segment 14 of ring 11, but the reception of the T range by relays R1 to R5, Fig. 1, has operated the T range relay, Fig. 2, and the circuit of segment 14 has been transferred from the start magnet of DR2 to the start magnet of DR4, Fig. 1. Distributor DR4 begins the time comparison cycle by connecting ground through segment 2 to conductor 1 in cable 111 and also to conductor 1 in cable 108. This causes operation of the comparator relay CMP, Fig. 4, over a circuit comprising conductor 1 of cable 111, and the relay locks through its innermost contacts over conductor 2 of cable 111 to the armature 130 and break contact of relay RLSC, Fig. 1. It also operates relay PC, Fig. 9, which is connected in parallel with relay CMP over conductor 1 of cable 108, and relay PC consequently locks to the grounded armature 130 and break contact of the RLSC relay.

The operation of relay PC, Fig. 9, connects, through its armatures and make contacts, the multiple cables 616 and 620 to the relays PTO to PTB and PUO to PUB, Fig. 9. The other end of cable 616 is multipled to bank 615 of the NPT storage indicator, Fig. 6, in each row of the record board, while cable 620 is multipled to bank 619, Fig. 6, of each NPU storage indicator, this connection being required for later comparisons. The operation of relay CMP, Fig. 4, connects multiple cables 703 and 704 from banks 706 and 707 of the TT and TU storage indicators, Fig. 7, to cables 405 and 406 connected to comparator relays NTT0 to NTT5 and NTU0 to NTU9, Fig. 4, which connection will be used to compare the present time stored on the indicators with the new time stored on the data relay pyramids. A comparison will be made to determine whether the new time is greater than, less than, or equal to the present time stored on the indicators in accordance with the principle of comparison hereinbefore described.

The brush of distributor DR4 next connects ground to segment 3 and causes operation of the C relay, Fig. 1. The C relay applies ground momentarily to conductors 1, 2, 3 and 4 of cable 502, which through contacts of gang relay GA14 applies ground to conductors 24, 25, 26 and 27 in cable 506, Fig. 5, thus grounding the wipers 623, 619, 706 and 707 of storage indicators NPT, NPU, TT and TU, respectively. Grounding the wiper 623 of the NPT indicator, Fig. 6, applies ground to conductor 0 in cable 624 for the setting shown in row 14, thus operating, through contacts of operated relay PC, the relay PTO, Fig. 9. Grounding the wiper 619 of the NPU storage indicator applies ground to conductor 9 in cable 620 and through contacts of operated relay PC operates the PU9 relay, Fig. 9. Relays PT0 and PU9 lock up over their upper armatures and make contacts and conductor 3 in cable 108 to a normally closed contact 132 of relay RLSC, Fig. 1. Grounding the wiper 706 of the TT indicator in Fig. 7 connects ground over conductor 1 of cable

703 through closed contacts of operated relay CMP and cable 405 to the armature 1T of relay NTT1 in Fig. 4. Ground on wiper 707 of the TU storage indicator connects ground over conductor 9 of cable 704, through closed contacts of relay CMP and cable 406 to the armature 9U of relay NTU9.

Both the first and second data relay groups 302 and 401 have pyramids like PR1 and PR2 in the first and second digit identification relay groups, except that the apex 305 of the pyramids PR1 in the first and second data groups respectively are connected directly to ground 340, Fig. 3, and 425, Fig. 4. Since the storage relays of the first and second relay groups are set in permutation code combination in accordance with the data signals stored therein, this causes the pyramid PR1 of each group to apply ground to one of the outgoing leads 0 to 5 in cable 318 and 0 to 9 in cable 402. A blank lead B is not required in these relay pyramids, and when comparison is made for Time, the first digits data group which stores the tens value of time requires only five outgoing leads 0 to 5 from the pyramid PR1. If it were desired to compare altitude or some other item of information in which all of the digits 0 to 9 were required, the number of leads from the first digit data would correspond in number to the leads 0 to 9 of the second digit data group. The operation of the pyramids PR1 of the first and second data relay groups 302 and 401 has resulted in applying ground to one lead each in cables 318 and 402, representing the tens and units of time in the incoming message.

Let us assume that the time in the incoming message is :19 and that this is the same as the time stored in the record board, row 14. This will result in relays NTT1 and NTU9 being operated. Since time is a repeating function, a base time recorder switch BT, Fig. 4, is employed to establish a base time in the manner hereinbefore referred to. The wiper of the BT switch is stepped at definite intervals of time, for example, each ten minutes, by a clock operated contact T, Fig. 4.

Since switch BT, Fig. 4, is stepped from a clock operated contact T, Fig. 4, its action is independent of the other elements of the circuit. In order to prevent switch BT from stepping while the circuits through its bank contacts are in use, a locking circuit is provided for switch BT so that, if BT winding should be energized while the comparison circuits through its bank contacts are in use, the stepping of switch BT will be delayed until after the data comparisons have been completed. The circuit may be traced from battery on the winding of switch BT, Fig. 4, coil of switch BT, locking contacts 428 of switch BT, lead 4 in cable 230, armature and make contact 271 of relay T, Fig. 2, to ground.

In the present example the wiper of switch BT is resting upon the terminal 4. This causes the operation of relay DTT4, which splits the chain circuit of relays NTT0 to NTT5 and establishes relay NTT4 as the upper end of the time scale and relay NTT5 at the lower end in time comparison. In other words, the base time (4) is lower than any other time, even new time 4 in an incoming message. The circuit from TT bank 706, terminal 1, Fig. 7, may be traced through conductor 1 of cable 703, contacts 1 of comparator relay CMP, conductor 1P in cable 405, to the operated armature 1T of relay NTT1, and thence through the winding of the ET (equal tens) relay. A corresponding path is established from TU indicator bank 707, through conductor 9 in cable 704, contact 9 of relay CMP, conductor 9U of cable 406, to the operated armature 9U of cable NTU9, armature 410 and make contact of operated relay ET, and thence through conductor 6 in cable 111 to the winding of release relay REL, Fig. 2, causing the latter relay to operate. The operation of REL opens the locking circuit for the storage relays, thereby releasing them, and also releases relay AGA, Fig. 6, and the gang relay GA14, Fig. 5. Release of the storage relays releases the range relay T. Release of relay GA14 releases the DGT and DGU relays, Fig. 10, thereby releasing the display board gang relay DGA14. The distributor DR4 comes to rest without starting distributor DR2.

If the present time recorded on the TT and TU indicators was not equal to the new time contained in the incoming message, the comparison operation would continue. Assume, as before, that time :19 is the present time, but that the new time stored by the data relays is :17. The circuit from bank 706 of the TT indicator is the same as before, since the tens digit is the same as for the equal time comparison above referred to, and relay ET operates. In the units comparison a different circuit is set up, comprising conductor 9 in cable 704, contacts of comparator relay CMP, armature 9U of relay NTU9, through series contacts on relay NTU1. No complete circuit is found, which indicates that the present time is greater than the new time.

If the reverse condition existed as, for example, time :17 recorded in row 14 of the record board and time :19 stored in the data relays, the circuit would have been through conductor 7 of cable 704, contacts of relay CMP, armature 7U of relay NTU7, series contacts on relays NTU7, NTU8, inner make contact of operated relay NTU9, inner make contact of relay ET, conductor 412, and winding of relay LTNT, Fig. 4. Through conductor 5 in cable 111 the circuit is also extended through the winding of relays PUE and CRP, Fig. 2, to the winding of relay GTP, Fig. 8. The operation of these relays indicates that the new time is greater than present posted time, and their operation generally reverses or shifts groups of leads by one step to effect the opposite type of comparison from that required when the new time is less than the present posted time. To simplify the description, one type of unequal comparison will be explained, that is, the condition where new time :17 is less than present time :19.

Referring back to the distributor DR4, the comparison just described determined whether the new time was equal, greater than, or less than the present posted time and also recorded in the PT0 and PU9 relays the present position number of row 14. The next step of the brush of distributor DR4 grounds segment 4 and conductor 4 of cable 108, thereby operating relay PM, Fig. 9, which relay locks through its innermost armature and make contact, and conductor 2 in cable 108 to the grounded armature 130 and break contact of relay RLSC, Fig. 1. This operation transfers the multiple leads of cables 624 and 620 from the PT and PU armatures and contacts for further comparison. In addition, the operation of relay PM applied ground 910, through its outer armature and make contact, to conductor 911, thereby operating relay TR, Fig. 6, in each row of the record board. The operation of the TR relay transfers the TC, UC, PTU and PTC relay

circuits, Fig. 6, from the positions used for row selection.

We are now ready to mark all rows with time greater than new time (17) and position numbers less than the position number of the selected row. It will be recalled that the position number of row 14 is 09, which is stored on the NPT and NPU indicators, the marking operation being referred to hereinbefore under "Position numbering." The brush of distributor DR4 next applies ground to segment 5, which through conductor 4 of cable 111 causes the operation of marking relay MK, Fig. 4. The operation of relay MK applies ground through its upper make contact and armature 7, to armature 1 of operated relay NTT1, which grounds conductor 1 in cable 708. Any row with the tens digit of time 1 (stored on indicator TT) will have its TC relay operated. The circuit may be traced from ground on conductor 1 in cable 708 as described above, through bank contact 1 and wiper 709 of indicator TT, Fig. 7, lead 728, armature and make contact 643 of operated relay TR, Fig. 6, winding of relay TC, armature and make contact 641 of operated relay TR, to battery 611. This includes any rows bearing posted times greater than :17 as, for example, 18 and 19. Relay MK applies ground from its contact 5, switch terminal 4, normal contact of relay LTNT, conductor 4 in cable 404, and thence through the chain circuit contacts of relays NTT4, BTT3, NTT3, BTT2, NTT2 and BTT1 to open contact at operated relay NTT1. The chain circuit is opened in the opposite direction by the operated relay BTT4. This results in grounding conductors 4T, 3T and 2T in cable 703, the only tens digits greater than 1. Rows with the tens digit of time corresponding to 2, 3 or 4 will have their UC relays operated if their FC relays have been previously operated during row selection. Operation of the UC relay immediately indicates a time greater than the time :17.

If, however, only relay TC operated, a further comparison with the units digit must be made. This is accomplished by the MK relay, Fig. 4, applying ground from armature and make contact 6, upper armature 414 and break contact of relay LTNT, the chain contacts of relays NTU9 and NTU8 to open circuit at operated relay NTU7. This grounds conductors 8U and 9U of cable 406, and conductors 8 and 9 of cable 704. Any rows with units digits of time 8 or 9 will have their UC relays operated, provided relay TC has been operated by the times comparison; the circuit comprises bank 707, armature 630 and make contact of relay TR, Fig. 6, armature 644 and make contact of relay TC, armature 631 and make contact of relay TR, armature 609 and make contact of TR, and the winding of relay UC. In this manner the rows with time greater than :17 have their UC relays operated.

At the same time, rows with position numbers lower than 09 are being selected as follows. The switch bank 831 of base position switch BP, Fig. 8, has operated relay PTB, Fig. 9, while relay PTO was operated and locked by the operation of relay C previously described. Relay MK at its armature 1 and make contact applies ground over conductor 1 of cable 420, through "equals" contacts of operated relays PT0 and PTB, Fig. 9, and make contacts of relay PC, to the 0 and B leads in cable 616.

All rows with new position tens (NPT) on 0 will have circuits completed through their banks 615, conductor 650, winding of relay PTC, and armature 621 and break contact of relay TR to battery 654, thereby operating their PTC relays. No rows will have new positions tens indicators in the B (blank) position because the cycle of base position numbers is chosen at least one tens digit longer than the number of new position numbers needed, i. e., the number of rows. In the illustrative embodiment the number of rows shown is fifteen, while the base position switch representing only the tens digit of base position includes eleven steps 0–B. If the units of the base position were counted on a non-decimal eleven-step cycle, the total number of base positions represented would be 11×11, or 121 base positions. Therefore, with a base position of, for example, —3 (— representing blank), the fifteen rows would be encompassed by the range of positions 03–16, inclusive, in a non-decimal system and no NPT indicators would be in the B position. Consequently, energizing the B, or blank, equals lead in addition to the 0 equals lead will produce no false operation of a PTC relay. The grounded armature 2 and associated make contact of relay MK, Fig. 4, applies ground to conductor 2 in cable 420 and thence to bank 820 of switch BP, Fig. 8, contact 0 of the bank, innermost armature and break contact of relay GTP, and conductor 0 in cable 821. In Fig. 9, conductor 0 of cable 821 finds an open circuit at locked-up relays PTO and PTB, which indicates that there are no tens digits of present positions which are less than 0 with B as a base position.

In rows where the position tens comparator relay PTC, Fig. 6, has been operated, indicating equality in the tens digit, an additional comparison must be made in the units position to mark rows which are lower than 09. This marking operation originates at the grounded armature 3 and make contact of relay MK, Fig. 4, and is applied to conductor 3 of cable 420, through the outermost armature and break contact of relay GTP, Fig. 8, and conductor 840 to the chain circuit starting on relay PUB, Fig. 9, and thence through chain contacts of PUB to open chain contacts on operated relay PU9. Conductor B in cable 903 is thus energized, the circuit continuing through armatures and make contacts of relays PM and PC to conductor B in cable 620. In those rows where the NPU storage indicator rests on terminal bank B and where relays PTC and UC have operated, a circuit will be established from bank 619 of indicator NPU, make contact and armature 618 of operated relay TR, armature 652 and make contact of operated relay PTC, make contact 635 and armature of relay TR, make contact and armature 632 of relay TR, make contact and armature 642 of relay UC, and conductor 660, to the operated winding of an R relay, such as R14 in Fig. 5, and thence to battery.

In each case the operation of the R relay, such as R14, indicated those rows within the correct Fix whose time was greater than the new time in the incoming message and whose position number was less than that of the selected row. It will be recalled that the time stored in row 14 was greater than the new time in the incoming message, and therefore the time in row 14 is to be lowered and consequently its position number will be subject to downward revision. The position numbers of the rows marked by the operation of relay MK of Fig. 4 will each be increased by 1 in order to free a position number for row 14. The operation of the R relay, corresponding to R14, prepares a circuit for advancing the NPT

and NPU indicators in these rows in a manner hereinafter described.

The next position of the brush of distributor DR4 applies ground to segment 6 and operates a release comparison relay RLSC, Fig. 1. This relay operates and removes locking ground, at its break contact and armature 133, from conductor 3 of cable 108, and hence from the PT and PU relays of Fig. 9, releasing them. At its break contact and armature 130, the relay RLSC removes locking ground from conductor 2 in cables 108 and 111, thereby releasing relay PM, Fig. 9, and relay CMP, Fig. 4. When relay PM releases, it disconnects ground 910 from conductor 911 and releases relay TR of Fig. 6. When comparator relay CMP, Fig. 4, releases, relay PC, Fig. 9, which is connected in multiple with it, also releases. This disconnects the various time and position multiples from the comparison relays of Figs. 4 and 9. Relay PC, Fig. 9, in releasing reconnects multiples 616 and 620 to the BRU and BRT relays, Figs. 5 and 8. These relays will now be used to determine the position number to be assigned to row 14. This number is evidently the lowest number of any row marked by the operation of relay MK and whose R relay, such as R14, is now operated. The operated R relays lock, through their inner armatures and make contacts, over conductor 1 in cable 535, to the outer grounded armature and break contact of relay RLSM, Fig. 1.

The next step of the distributor brush DR4 operates relay BTF from segment 7. Operation of this relay connects battery through its outer armature and make contact, and conductor 2 in cable 535, through an armature 536 and make contact of each operated R relay corresponding to R14 in Fig. 5, and thence over conductor 522 and through the winding of relay PTC, conductor 650, bank 615, armatures and break contacts of relay PC, Fig. 9, to the windings of the BRT relays, Fig. 8. As described under "Blank row selection," only the lowest BRT relay can operate, and consequently only those PTC relays, Fig. 6, in rows with the lowest tens digit will operate. The operation of PTC, Fig. 6, extends battery 617 through the winding of switch PTU, the wiper and bank 619, operated armatures and make contacts of relay PC to the BRU relays, Fig. 5. As before, only the lowest BRU relay can operate, and thus a BRT and a BRU relay are operated to record the number of the lowest row where an R relay is operated. Each BRT and BRU relay is equipped with additional armatures and contacts arranged in an additive permutation code. When the BRT and BRU relays operate, battery 160 is supplied to a combination of leads in cable 507 which causes operation of corresponding NPT and NPU relays in Fig. 2, through a circuit comprising armature 161 and make contact of operated relay BTF, lead 6 in cable 108, through the permutation code make contacts of the operated one of the BRU and BRT relays, Figs. 5 and 8, and two of the leads in cable 507 to the windings of the corresponding NPT and NPU relays, Fig. 2, to ground. These NPT and NPU relays lock up in the same manner as the other pyramid relays, and during the pulsing cycle will control the number of pulses to be sent to the NPT and NPU indicators in row 14. It will be noted that the chain circuits of the BRT and BRU relays are through armatures and contacts of the HRF relay, Fig. 8. When relay HRF is operated, the highest row will be selected.

When the brush of distributor DR4 reaches segment 8, ground is applied through conductor 140 to an extra pulse relay P, Fig. 3, to grounded battery 328, causing this relay to operate. The operation of P closes a pulsing circuit to every row in the record board, but only in those rows in which a relay R (corresponding to relay R14) is operated will the path be completed. This path is from the battery 328, armatures and make contacts of relay P, cable 330, armature 542 and break contact, Fig. 5, of relay CRP, make contact and armature 538 of operated relay R, conductor 540 and winding of the NPU storage indicator to ground at the commutator contact *s* of NPU. When NPU reaches its blank position, its switching contact *s* rests on the actuating side, i. e., the upper contact as viewed in the figure, and the pulsing circuit is completed through the upper outer break contact and armature of relay AGA14 and thence through the winding of NPT. In this way a carry-over operation is secured between the two indicators, and both NPT and NPU will be advanced one step. The pulsing circuit from relay P was through the armature 14 and break contact of unoperated relay CRP, with the R relay operated. The position numbers of all rows marked by the operation of MK have now been raised to permit row 14 to be inserted below the raised rows when the display board is rewritten.

On the other hand, if the original comparison had indicated that the new time was greater than the present time, relay CRP would have been operated and the pulsing path would have been through its armature 542 and make contact, and break contact and armature 538 of unoperated relay R. In other words, all rows except those marked by the operation of relay MK would have been advanced.

The brush of distributor DR4 next applies ground to segment 9, thus operating relay RLSM, which at its outer armature 142 and break contact and conductor 1 in cable 535 releases the locked-up R relays. Also, at its inner armature 143 and break contact, the operation of RLSM disconnects ground from conductor 144 and releases highest row finder relay HRF of Fig. 8, in the event that this relay had been operated to select the highest, rather than the lowest, numbered R relay.

The brush of distributor DR4 next applies ground to segment 10 and thence to conductor 146, which through armature 250 and make contact of relay P, Fig. 2, and conductor 209 operates start magnet SM2 of distributor DR2. The operation of pulsing the indicators in the selected row 14 by distributor DR2 has been described hereinbefore, but in addition the new position indicators NPT and NPU are reset under control of relays NPU and NPT of Fig. 2. Also, within the selected row the auxiliary gang relay AGA has been operated over a circuit hereinbefore described. The AGA relay opens the carry-over circuits between indicators NPT and NPU and connects them in the same manner as the other indicators in the row so that they may be blanked out and reset.

If the time in the incoming message (new time) had been greater than the present time in the selected row, relay PUE (position units extra) would have been operated by the comparison circuits of Fig. 4, over lead 5 in cable 111 to the winding of PUE to ground. The position units indicator would then have been advanced one step above the number of the highest row marked by the operation of relay MK, the reason for which is explained below. It will be recalled that near the end of the pulsing cycle of distributor DR2,

relay RAGA was operated from segment 45 to release the AGA relay, such as AGA14 in Fig. 6. Following the release of relay AGA, the distributor brush next contacted segment 46, operating the P relay to generate an extra pulse, the path for which is through conductor 337, break contact 262 on relay CRP, conductor 263, make contact and armature 264 on relay PUE (if operated), conductor 1 in cable 265, armature 266 and make contact of operated relay T, conductor 6 in cable 502, contacts of the operated GA relay, conductor 540, and the winding of NPU to ground, to pulse the position units indicator NPU in the selected row one extra pulse. If the NPU indicator is in its blank position, both NPU and NPT would have been advanced by the carry-over circuit above referred to. Following the operation of relay P, the distributor brush reaches segment 47, operating the REL relay which, as before, releases the locked-up storage relays and the gang relay.

Referring back to the need for the extra pulse from relay P, if the new time had been greater than the present time in the selected row, the position number of the selected row would have to be raised. All rows with time less than the new time, and position numbers greater than that of the selected row, would have their R relays operated by the operation of relay MK. These rows would have to have their position numbers lowered to free a position for the selected row. Since the numbers cannot actually be lowered, the position numbers of all other rows would be raised. However, when the position number of the highest marked row is recorded on the BRT and BRU relays, this number will be one lower than actually should be assigned to the selected row. It is, therefore, necessary to add 1 to this number after pulsing the NPT and NPU relays. In order that the carry-over circuits can function, the AGA relay is released before generating the extra pulse by the P relay.

Sequencing

In our aforesaid patent, a keyset is provided in order that the operator may cause to be displayed in predetermined positions on the record board and display board the identification numbers relative to the various flights concerning which information is to be transmitted so that, upon the reception of incoming signals relating thereto, the data will be posted in the previously assigned rows in the record and display boards. In accordance with the present invention this keyset operation is not necessary, since an incoming message relating to an item not previously posted will automatically be directed to an available blank row of indicators. Also, in our aforesaid patent, it was necessary for the operator manually to control by the keyset the settings of the "New position" storage indicators, whereas in accordance with the instant invention the new position storage indicators are automatically set by the comparison circuit, in accordance with Time or other data contained in the messages. In the present disclosure, if an operator desires to initially post a proposed flight plan in regard to any particular flight, this may readily be done by perforating a tape with such information and passing the tape through one of the tape transmitters contained in the line equipment of Fig. 1, and the blank row locator equipment will function to post such information in an available blank row of indicators. However, a keyboard may be used to accomplish this, if desired, in the manner of our aforesaid patent.

Whenever the control personnel desires to have the flights posted on the display board of Fig. 11 rewritten in accordance with changed information received on the record board so that the items on the display board will be arranged in desired order, for example, chronological order, this may be effected by depressing a sequencing button SEQ, Fig. 10, to secure access to the line equipment by means of the operation of the keyset selecting relay KS and its associated circuits, in the manner described in detail in our aforesaid application. The push button SEQ preferably is of the mechanical locking type, as indicated by the slidable locking bar 1040, and the key preferably is held depressed by the locking bar until it is released by a key release magnet KR which, when energized by an armature and make contact of relay REL, Fig. 2, over conductor 341 in cable 119, moves the locking bar and releases the key.

The circuit equipment for effecting sequencing of the indicator units in the display board is described in detail in our aforesaid patent. To simplify the present disclosure, this equipment is diagrammatically indicated by the rectangle bearing the legend "Sequencing equipment," shown in Fig. 11, except that there are disclosed herein additional circuit arrangements and elements correlating the sequencing operation with the blank row locator and comparator of the instant disclosure. In the record board ground is applied to the wipers of the upper contact banks on the storage indicator units IT, IU, TT, TU, AT and AU by the operation of a GS relay, such as GS14 in Fig. 7, which transfers the settings of the indicators to translating and storing relay groups in the sequencing equipment in the manner of our aforesaid patent, this equipment also including a sequence control distributor and associated translating, switching and pulsing circuits for posting the display board. The operation of sequencing the circuits shown in the instant case is the same with the exception of the order of selection of new position digits, which is described below. In our aforesaid patent, in order to display the flight information in a desired sequence, the keyset operator by means of the local keyset reset the "New position" storage indicators NPT and NPU of the associated row in the record board, and upon operation of the SEQ key the sequencing circuit then functioned to rearrange the flights on the display board in the desired order. By means of the data comparison feature in the instant disclosure, the new position indicators are automatically set to the proper position.

The general operation of the Base Position scheme, which allows any number to be assigned as the lowest numbered row in the board, has hereinbefore been described. Rotary switches BPU and BP of Fig. 8 are used to record the existing base position, which in turn establishes the existing new position number for the lowest row of the display board. It will, therefore, be apparent that in sequencing with the time comparison feature of the present disclosure, it is necessary to determine the starting point with reference to the base position, that is, in place of the fixed initial selection of new position number 00 as in our aforesaid application, a variable starting point is introduced which is always determined by the position of the base position switches at the time the sequencing operation is initiated. Because of this, the sequence collection switch SCS and associated relays RC and RP in our aforesaid patent are replaced by equipment shown in Fig. 12

of the instant disclosure. The cables 405, 406 and 705 which terminate in the sequence collection switch circuit of our aforesaid patent terminate in the instant disclosure in the equipment of Fig. 12 therein, the operation of which is explained below.

Description of circuit for linking base position with sequencing circuit

As explained previously, the new position number associated with the lowest row of the display board is dependent on the existing base position and will be ten steps in advance of that position. Thus, with the base position switches BP and BRU of Fig. 8 set to the B2 position shown in the drawings, the established lowest row or starting point for the sequencing circuit would have its new position indicators set to the 02 position.

When the key SEQ is depressed, the sequence start relay SST, Fig. 10, operates over a circuit from battery 1035 through conductor 1042 and closed contacts 1043 of the keyset relay KS, to the left hand make contacts of the sequencing push button SEQ to ground. The armatures and contacts 1019, 1020 and 1031 of relay SST, shown in Fig. 10, are in addition to other armatures and contacts of this relay disclosed in our aforesaid patent, which relay is embodied in the sequencing equipment diagrammatically depicted in Fig. 11 of the present disclosure. The added armatures and contacts of SST are required due to the automatic data comparison and blank row locating features disclosed herein. Relay SST, at its armature 1020 and make contact, applies ground over conductors 1201' and 1201 to wiper 832 of switch BP, Fig. 8. The same SST contact also furnishes ground over lead 1201 through the armature 1206 and break contact of cut-off tens relay COT, Fig. 12, through interrupter contact 1207 of rotary sequence control tens switch SCT and the operating coil of this switch to grounded battery. Switch SCT is stepped through self-interrupted pulses from the battery at its coil over the circuit just described until the stepping circuit is opened at contact 1206 of relay COT. As wiper 1202 of switch SCT contacts bank contact 0, a circuit is completed over conductor 0 in cable 834, through bank contact 0 and wiper 832 of switch BP, Fig. 8, which has been grounded by the armature and contact 1020 of sequence start relay SST, causing relay COT to operate and lock over its armature 1205 and make contact, to ground from relay SST. Thus, the operation of relay COT has stopped switch SCT at the correct tens digit for the lowest numbered row as determined by rotary switch BP of Fig. 8. In a similar manner, the wiper arms 1214 and 1215 of switch SCU, Fig. 12, are positioned under control of base position units switch BPU of Fig. 8, to bank contact 2, which is the correct units digit of the lowest new position number with the existing base position B2.

Position sequence control relays PSC0 to PSC4, Fig. 12, have been connected to operate from leads 0 to 4 of cable 705 which, in the sequencing equipment diagrammatically indicated in Fig. 11, and as disclosed in our aforesaid patent, originate from segments of a ring of the distributor which pulses the display board, these conductors being connected to ground successively by the operation of the distributor and serving to successively select the five lowest numbered GS relays during the sequencing operation cycle. As hereinbefore stated, to enable sequencing circuits to function with the time comparison feature of the present disclosure, the sequence collection switch SCS and associated relays RP and RS of our aforesaid patent have been replaced by the elements shown in Fig. 12 of the present disclosure, the remainder of the sequencing elements as disclosed in our aforesaid patent remaining the same.

Conductor 0 in cable 705, Figs. 11 and 12, is connected to ground, as disclosed in detail in our aforesaid patent, by the action of a distributor in the sequencing equipment indicated in Fig. 11. The added relay PSC0, Fig. 12, is operated. The grounded armature 1213 and make contact of relay PSC0 supplies ground over conductor 1203 to the wiper 1214 of a rotary switch SCU through bank terminal contact 2 to the conductor 2 in cable 405, and thence to the sequencing equipment. A wiper 1210 of rotary switch SCT supplies ground over bank contact 0 and conductor 0 of cable 406 to the sequencing equipment. Thus, tens 0 and units 2 new position number is chosen as the lowest numbered row of the display board. The sequencing circuit operation from energized conductors in cables 405 and 406 is in accordance with that described in our aforesaid patent.

Operation relay PSC0, through its armature 1212 and make contact and conductor 1208, has connected ground to the coil of rotary switch SCU, which is thereby energized from battery connected to its operating winding. Switch SCU is, therefore, prepared to advance one step when the operating coil of the switch is deenergized by the release of relay PSC0, since conductor 0 in cable 705 has ground removed therefrom by the sequencing distributor in the sequencing equipment. Thus, as relay PSC1 operates over conductor 1 of cable 705 following the release of relay PSC0, switch SCU has been stepped to bank position 3 and the second lowest row of the display board is selectively associated with the new position number 03. This action continues with successive operation of relays PSC0 to PSC5, advancing the switch SCU and selecting new position numbers 04 to 0B in order. As switch SCU is stepped to the B position, off-normal contact 1204 is closed by the lobe of a rotary cam driven by the switch in synchronism with the wiper arm 1215. The following operation of any PSC relay will advance switch SCT one step, which circuit may be traced from ground on make contact 1211 of relay PSC0 over conductor 1209 through cam contacts 1204, which are closed when the cam is in the B position, and thence to the winding of switch SCT. Thus, a carry-over pulse is applied to the sequence control tens switch SCT as the sequence control units switch SCU is stepped from its B position. At the conclusion of the display board sequencing operation, button SEQ is released by the operation of relay KR from lead 341 in cable 727, this lead being grounded through a display gang selection switch in the sequencing equipment of Fig. 11. Release of button SEQ in turn releases the sequence start relay SST, Fig. 10, removing ground from conductors 1201 and 1201', whereupon the locked up relays COT and COU, Fig. 12, are released and the circuit restored to normal.

Various modifications of the circuit arrangements and apparatus shown, and the various equivalents or substitutes for the devices illustrated, will readily occur to those versed in the art without departing from the spirit and scope of the present invention. The disclosure, therefore, is for the purpose of illustrating the principles of the invention which is not to be regarded

as limited except as indicated by the scope of the appended claims.

What is claimed is:

1. A system for posting information regarding a plurality of items, comprising posting board apparatus embodying a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said items, and actuatable to different settings for storing data in regard thereto, a source of incoming messages comprising item designation and data signals, means responsive to said signals for automatically comparing the incoming data with certain data currently stored in said groups of storage devices, and means controlled by said comparing means for determining the serial order in which the items should be displayed in accordance with the relative values represented by the compared data.

2. A system for posting information regarding a plurality of items, comprising posting board apparatus embodying a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said items, and actuatable to different settings for storing data in regard thereto, new position posting devices respectively associated with said groups of signal storage devices and actuatable selectively to display different indicia, a source of incoming messages comprising item designation and data signals, means responsive to said signals for automatically comparing the incoming data with certain data currently stored in said groups of signal storage devices, and means controlled by said comparing means for actuating certain of said new position posting devices to cause them to display indicia representative of the serial order in which the items should be displayed in accordance with the relative values represented by the compared data.

3. A system for posting information regarding a plurality of items, comprising posting board apparatus embodying a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said items, and actuatable to different settings for storing data in regard thereto, new position signal storage devices respectively associated with said groups of storage devices and actuatable to different settings to establish different electrical circuit conditions, a source of incoming messages comprising item designation and data signals, means responsive to said signals for automatically comparing the incoming data with certain data currently stored in said groups of storage devices, means controlled by said comparing means for actuating certain of said new position storage devices to cause them to establish electrical circuit conditions representative of the serial order in which the items should be displayed in accordance with the relative values represented by the compared data.

4. A system for posting information regarding a plurality of items, comprising posting board apparatus embodying a plurality of groups of electro-responsive storage indicators, assignable to different ones of said items, and rotatable to different settings for storing signals and displaying data in regard thereto, each of the groups including at least one of said indicators for storing and displaying an item posting position number, a source of incoming messages comprising item designation and data signals, means including relay circuits responsive to said signals for automatically comparing the incoming data with certain data currently stored in said groups of indicators, and means controlled by said comparing means for rotating certain of said position number indicators to cause them to store signals and display numbers representative of the serial order in which the items should be displayed in accordance with the relative values represented by the compared data.

5. A system for posting information regarding a plurality of items, comprising posting board apparatus embodying a plurality of groups of electro-responsive signal storage devices assignable to different ones of said items and actuatable to different settings for storing data in regard thereto, a source of incoming messages comprising item designation and time data signals, means responsive to said signals for automatically comparing the incoming time data with the time data currently stored in said groups of storage devices, and means controlled by said comparing means for determining the positions in which the items should be displayed to produce a chronological order in accordance with the relative values represented by the compared time data.

6. A system for posting information regarding a plurality of items, comprising posting board apparatus embodying a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said items, and actuatable to different settings for storing the designations of the items and data in regard thereto, a source of incoming messages comprising item designation and data signals, means responsive to said signals for automatically comparing the incoming item designation and data with the item designations and certain data currently stored in said groups of storage devices, and means controlled by said comparing means for determining the relative positions in which the items should be displayed in accordance with the item designations and the relative values represented by the compared data.

7. A system for posting information regarding the movements of aircraft, comprising posting board apparatus embodying a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said aircraft, and actuatable to different settings for storing the aircraft identification indicia and data in regard thereto, a source of incoming flight messages comprising aircraft identification and data signals, means responsive to said signals for automatically comparing the incoming aircraft identification and data signals with the identification indicia and certain data currently stored in said groups of storage devices, and means controlled by said comparing means for determining the relative positions in which the flights should be displayed in accordance with the aircraft identification indicia and the relative values represented by the compared data.

8. A system for posting information regarding the movements of aircraft, comprising posting board apparatus embodying a plurality of groups of electrical signal storage devices, assignable to different ones of said aircraft and different Fix designations, and actuatable to different settings for storing the aircraft identification indicia, Fix designation and data in regard thereto, a source of incoming flight messages comprising aircraft identification, Fix designation and data signals, means responsive to said signals for automatically comparing the incoming aircraft identification, Fix designation and data signals with the identification in-

dicia, Fix designations and certain data currently stored in said groups of storage devices, and means controlled by said comparing means for determining the relative positions in which the flights should be displayed in accordance with the Fix designations and the relative values represented by the compared data.

9. A system for posting information regarding a plurality of different items, comprising a record board having electrical signal storage devices on which data in regard to the items may be stored in random order on the board, a display board having a plurality of indicating devices assignable to different ones of said items for displaying said data, a source of incoming messages comprising item designation and data signals, means responsive to said signals for automatically comparing the incoming data with certain of said data currently stored in said signal storage devices, means controlled by said comparing means for storing electrical circuit control conditions representative of the serial order in which the items should be displayed on the display board in accordance with the relative values of the compared data, and sequencing apparatus controlled by the last named storage means for obtaining said data from the signal storage devices of the record board and automatically selecting and actuating the indicating devices of the display board to cause them to display in said serial order the data stored on the signal storage devices of the record board.

10. A system for posting information regarding a plurality of different items, comprising a record board having electrical signal storage devices on which item designations and data in regard to the items may be stored in random order on the board, a display board having a plurality of indicating devices assignable to different ones of said items for displaying said item designations and data, a source of incoming messages comprising item designation and data signals, means responsive to said signals for automatically comparing the incoming item designation and data with the item designations and data currently stored in said signal storage devices, means controlled by said comparing means for storing electrical control conditions representative of the serial order in which the items should be displayed on the display board in accordance with the item designations and the relative values of the compared data, and sequencing apparatus controlled by the last named storage means for obtaining said item designations and data from the signal storage devices of the record board and automatically selecting and actuating the indicating devices of the display board to cause them to display in said serial order the item designations and data stored on the signal storage devices of the record board.

11. A system for posting information regarding the movements of aircraft, comprising a record board having electrical signal storage devices on which flight identification indicia, Fix designations and other flight data may be stored in random order on the board, a display board having a plurality of indicating devices assignable to different ones of said flights and different Fix designations for displaying information in regard thereto, a source of incoming messages comprising flight identification, Fix designation and other flight data signals, means responsive to said signals for automatically comparing the incoming flight identification, Fix designation and data signals with the flight identification, Fix designation and certain data currently stored in said signal storage devices, means controlled by said comparing means for storing electrical control conditions representative of the relative positions in which the flights should be displayed on the display board in accordance with the Fix designations and the relative values of the compared data, and sequencing apparatus controlled by the last named storage means for obtaining the aforesaid information from the signal storage devices of the record board and automatically selecting and actuating the indicating devices in the proper Fix designations of the display board to cause them to display in said relative positions the flight identification indicia and data stored on the signal storage devices of the record board.

12. A system for posting information regarding a plurality of items, comprising a posting board having a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said items, and actuatable to different settings for storing the designations of the items and data in regard thereto, a source of incoming messages comprising item designation and data signals, item locator means responsive to the incoming item designation signals and operative to locate an available idle group of said storage devices when there is no existing posted item designation in said storage devices corresponding to the designation in the incoming message, and means controlled by the item locator for posting item designation and data in the incoming message in said idle group of storage devices.

13. A system for posting information regarding a plurality of items, comprising a posting board having a plurality of adjacent electro-responsive signal storage devices, assignable to different ones of said items and arranged in display groups in which certain ones of said items may be posted concurrently in a plurality of such display groups, and actuatable to different settings for storing the designations of the items and data in regard thereto, a source of incoming messages comprising item designation, display group selection, and data signals, item locator means responsive to the incoming item designation and display group selection signals and operative when there is no existing posted item designation in said storage devices in the selected display group corresponding to the item designation in the incoming message for locating an idle storage device adjacent to the groups having existing postings in the selected display group, and means controlled by the item locator for posting the incoming message in said idle storage device.

14. A system for posting information regarding a plurality of items, comprising a posting board having a vertical column of rows of electro-responsive signal storage indicators, assignable to different ones of said items, and actuatable to different settings for posting the designations of the items and data in regard thereto, a source of incoming messages comprising item designation and data signals, item locator means responsive to the incoming item designation signals and operative when there is no existing posted item designation in said storage indicators corresponding to the designation in the incoming message for locating an available blank row of said storage indicators above the rows having existing postings, and means controlled by the item locator for posting the incoming message in said blank row of storage indicators.

15. A system for posting information regard-

ing a plurality of items, comprising a record board having a plurality of groups of electro-responsive signal storage devices, assignable to different ones of said items, and actuatable to different settings for storing the designations of the items and data in regard thereto, a source of incoming messages comprising item designation and data signals, item locator means responsive to the incoming item designation signals and operative to locate an available idle group of said storage devices when there is no existing posted item designation in said storage devices corresponding to the item designation in the incoming message, means controlled by the item locator for posting the item designation and data in the incoming message in said idle group of storage devices, a display board having a plurality of indicating devices assignable to different ones of said items for displaying information in regard thereto, means for automatically comparing certain data in the newly posted item in said idle group of storage devices with the existing posted data in the other storage devices, and means controlled by said comparing means for determining the serial order in which the items including the newly posted item should be displayed on the display board in accordance with the relative values represented by the compared data.

16. A system for posting information regarding a plurality of different items, comprising a record board having a plurality of groups of electro-responsive signal storage devices respectively for storing data representative of certain characteristics of the items, another group of signal storage devices responsive to incoming signals for storing for comparison purposes item data representative of said certain characteristics which are employed as a basis of comparison of the incoming item, circuit connections including switching means for selecting the particular item characteristics to be compared, means for selecting the type of comparison to be made between each of said characteristics to determine whether the particular item characteristic selected is greater, equal to, or less than the corresponding characteristic employed as a basis of comparison, circuit means for effecting the simultaneous comparison of said like characteristics of the items stored in all of said first named storage groups with the selected characteristic of the item stored in said another group of storage devices, and circuit means for selecting a plurality of the first named groups of storage devices in accordance with the result of said comparison.

17. A system for posting information regarding a plurality of different items, comprising a record board having a plurality of groups of electro-responsive signal storage devices respectively for storing data representative of a plurality of the characteristics of the items, circuit connections including switching means for selecting the particular characteristic of each of the items to be compared with the other items, circuit means for selecting the type of comparison to be made between the selected characteristic of each of the various items to determine which one of the items is the highest or lowest with respect to said characteristic, and circuit means for effecting the simultaneous comparison of said like characteristics of all of the items to indicate which of the items is the highest or lowest depending upon the type of comparison selected.

18. A system for posting information regarding a plurality of different items, comprising record board apparatus embodying a plurality of groups of electro-responsive signal storage devices actuatable to different settings for storing information to be displayed in regard to the items, each of said groups of signal storage devices being adapted to store a display position number and a datum pertaining to one of said items, a source of incoming message signals comprising an item designation and a datum relating to the item, means responsive to said signals for comparing the item designation contained in the incoming signals with the designations of the items currently stored in said groups of storage devices, means controlled by said designation comparing means for selecting a group of storage devices having an item designation corresponding to the item designation in the incoming message signals and ascertaining the existing display position number of the item, means for comparing the datum in the incoming message with the datum stored in the group of storage devices selected by the incoming message, means controlled by the result of said datum comparison for comparing both the display position number of the item and the datum in the incoming message with the display position numbers and data stored in the other storage devices, and means controlled by said last named comparison means for selecting those items having lesser values of data and higher display position numbers or greater values of data and lower display position numbers depending upon the result of said first-named datum comparison.

19. A system for posting information regarding a plurality of different items, comprising record board apparatus embodying a plurality of groups of electro-responsive signal storage devices actuatable to different settings for storing information to be displayed in regard to the items, each of said groups of signal storage devices being adapted to store a display position number and a time datum pertaining to one of said items, a source of incoming message signals comprising an item designation and a time datum relating to the item, means responsive to said signals for comparing the item designation contained in the incoming signals with the designations of the items currently stored in said groups of storage devices, means controlled by said designation comparing means for selecting a group of storage devices having an item designation corresponding to the designation of the incoming signals and determining the existing display position number of the incoming item, means for comparing the time datum in the incoming message with the time datum stored in the group of storage devices selected by the incoming message, means controlled by the result of said time comparison for comparing both the display position number of the item and the time datum in the incoming message with the display position numbers and time data stored in the other storage devices, and means controlled by said last named comparison means for selecting those items having earlier times and higher position numbers or later times and lower position numbers depending upon the result of said first-named time comparison.

20. In a posting system for electrically comparing a plurality of items embodying numerical information stored on electro-responsive signal storage devices which are settable to different positions in accordance with a cyclic numbering system having $(b+1)^n$ permutations for comparing b^n items, where b represents the base of

the numbering system and n represents the number of decimal columns employed in the system, electro-responsive means for storing electrical signals representative of a given number to be compared, a comparator circuit comprising means for determining whether the various numbers stored on the first named storage devices are greater, equal to or less than said given number, said comparator means comprising an electro-responsive device for storing electrical signals representative of a changeable base position number and means controlled thereby to condition electrically the comparator circuit to determine the beginning of the counting cycle and thereby establish the relative comparison values represented by the settings of the first named storage devices.

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