AIRCRAFT TIME INFORMATION SYSTEM
8 Claims, 5 Drawing Figs.

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ABSTRACT: A multipurpose time information system which drives a plurality of digital clocks for respective members of the flight crew of a large airliner, and also provides time information to various remote systems on board, such as the AIDS, the flight recorder, the radio data link, the crash recorder, and the INS. The clocks include digital readout wheels which provide a visible display for the flight crew as well as the time information for the onboard systems, and also have inherent storage capabilities which are useful in case of brief power failures. These digit wheels are advanced by nearly identical drive modules, each having solenoid-operated ratchet mechanisms responsive to carry pulses derived from the preceding less significant digit module. But the least significant digit module is reverse-driven by a motor, requiring the ratchet mechanism to slip in the reverse direction, and also requiring the numerals on the least significant digit wheel to be arranged in the opposite direction relative to the more significant digit wheels.
AIRCRAFT TIME INFORMATION SYSTEM

FIELD OF THE INVENTION

This invention relates generally to aircraft instrumentation. It particularly concerns an integrated time information system which connects one of the clocks in the flight cabin to the various on board systems which require time information.

THE PRIOR ART

Modern airliners carry a number of electronic systems, for various flight control and recording functions, which require time information. For example, a fully equipped commercial airliner may have on board an AIDS (Aircraft Instrument Data System), a flight recorder, a radio data link, a crash recorder, and an INS (Instrument Navigation System), all of which require time information for the purpose of recording or reporting the time at which a significant event takes place. In addition, there are normally a number of clocks installed in the flight cabin for displaying the time to the flight crew. Typically, these are digital or number wheel clocks, rather than the circular dial type; and there is one such clock for the captain, another for the first officer, and a third for the navigator.

In the past, aircraft system designers have pursued the wasteful practice of providing a separate source of time information for each of the on board systems enumerated above. No attempt seems to have been made to integrate all systems which require and/or generate time information, so as to reduce overall cost, complexity and weight. In addition, the prior art has not provided any good system for temporary storage of time information for the benefit of the on board systems in the event of a brief power failure.

BRIEF SUMMARY OF THE INVENTION

The present invention deals with these problems by using one of the clocks in the flight cabin as a source of time information for each of the on board systems requiring such information. This approach has the advantage of providing mechanical storage of time information during brief power failures, since the time information is read electrically directly from the number wheels of the clock, which retain their positions during any inactive interval.

In reading time information from the number wheels, the system employs wiper contacts connected to separate electrical lines for each numerical value of each wheel. These lines go to a plurality of encoders, one for each decimal digit of the number wheels. The encoders convert the time information into digitally coded words, and pass the coded information along in bit parallel form to a sending shift register. Each of the on board time information utilization systems incorporates a receiving shift register; and a suitable time base circuit advances both shift registers at an identical bit rate so that the time information is unloaded from the sending shift register and entered into the receiving shift register in bit serial form. Thereafter the time information is unloaded from the receiving shift register, once again in bit parallel form, to a utilization device. The time base circuit may be incorporated into the utilization system, or in a preferred embodiment it may be the same time base circuit which governs the flight crew's clocks.

For ease and economy of manufacture, it is preferable that the number wheels of the clocks be driven by identical electromechanical drive modules, each comprising a ratcheted mechanism driven by a solenoid. The solenoid of each more significant digit module is energized by pulses derived from an electrical contact of the preceding less significant digit module. The ratchet drive mechanisms are of the unidirectional drive type, but they permit the number wheels to be driven in the reverse direction by an external drive source. This permits the least significant digit wheel to be continuously advanced by a synchronous motor, provided the numerals of the least significant digit wheel are arranged in a reverse fashion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B, with FIG. 1B on the right, together form a functional block diagram of a time information system in accordance with this invention, FIG. 1A showing the time information source apparatus, and FIG. 1B the time information utilizing apparatus of this system.

FIG. 2 is a perspective view of a conventional modular digital clock, of a type which is preferred for use in the apparatus of FIG. 1A.

FIG. 3 is a schematic illustration of a conventional solenoid and ratchet drive mechanism for one of the number wheel modules in the clock of FIG. 2.

And FIG. 4 is a schematic diagram illustrating the manner in which a timing motor and the solenoid drive mechanisms of these modules are used in accordance with this invention to advance the least significant digit wheel and the more significant digit wheels respectively of the clock of FIG. 2.

The same reference characters refer to the same elements throughout the several views of the drawing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The time information system illustrated in FIG. 1 may be divided conveniently into a time information source and a time information sink, illustrated in FIGS. 1A and 1B respectively. Turning first to the time information source in FIG. 1A, the flight cabin of a large airliner normally comprises a plurality of clocks 10, 12 and 14 which are mounted on the instrument panel, and display the time of day in numerical, i.e., digital, form for the benefit of the captain, first officer and navigator respectively. These clocks are of identical construction, and are driven by respective synchronous motors 152, 160 and 162 and drive shafts 154, 161 and 163. The motors in turn are advanced at a timed rate by a timing pulse stream distributed over a common line 16 and three individual lines 17, 19 and 21 respectively. The source of the pulse stream on line 16 may be either a time base oscillator circuit 18 or another time base oscillator circuit, as will be discussed below in connection with FIG. 1B.

Since the clocks 10, 12 and 14 are identical, it suffices to discuss the detailed construction of only one clock, namely clock 10, which comprises a plurality of discrete number wheel modules 20.1 through 20.4. These modules are placed side-by-side, so that each one displays a different decimal digit in a multidigit number, e.g., 12:34, representing the time of day, be it local time, Greenwich Mean Time, or some other time zone upon request. The digit modules 20.1 through 20.4 have respective display windows 21.1 through 22.4 behind which are respective number wheels 24.1 through 24.4. These wheels have respective groups of characters 26.1 through 26.4 printed about the peripheries thereof; and each group consists of the 10 numerals zero through nine. When the wheels 24 are rotated about their horizontal axes, they display the characters 26 in numerical order through the respective windows 22. A semicolon 28 is printed on the face of the digital clock between the modules 20.2 and 20.3 to indicate the break between the hours and minutes digits.

In addition to providing a visible display to a member of the flight crew, one of the digital clocks, for example, clock 10, in accordance with this invention, also sends time information in electrical form to a number of systems on board the aircraft. As seen in FIG. 1B, these include a flight recorder 30, AIDS 32, INS 34, radio data link 36, crash recorder 38, and any other electronic system requiring time information, which the aircraft may carry. Each of these systems includes some type of utilization device for such information. In the data link 36 the time information goes to a radio transmitter, whereas in the other systems the time information may go to a printer,打卡机, 或者 other printing device, such as the printer 40 of flight recorder 30, which prints the received information upon a moving record such as a paper tape 42. The printer has four separate print modules 44.1 through 44.4 which print the four respective decimal digits of time information, e.g., 12:34.
We turn our attention next to the manner in which the time information is communicated from the source apparatus of FIG. 1A to the utilization systems 30 through 38 of FIG. 1B. Modules 20 are in actuality electronic counters of a conventional kind. Since they are nearly identical, it suffices to describe just one of them, module 20.1, in detail. Each of the rotating wheels 24 has, associated therewith in some manner, 10 electrical contacts 50 arranged in a circular pattern, and a single wiper contact 52 which makes contact with each of the contacts 50 in succession as the associated digit wheel 24 rotates through its time readout cycle. For present purposes it is of no importance whether the contacts 50 are mounted upon the digit wheel 24 and rotate with respect to a stationary contact 52, or vice versa. Each of the 10 contacts 50 corresponds to a respective one of the 10 numerals 26 printed about the periphery of the associated wheel 24, and the wiper contact 52 at any moment engages the particular one of the numeral contacts 50 which corresponds to the particular numeral 26 which is then being displayed through the window 22 by the digit wheel 24. In addition, each of the numeral contacts 50 has an individual one of ten electrical lead 54 connected thereto. Thus a selected one of the 10 electrical leads 54, corresponding to the currently displayed numeral 26, is always energized.

There are four such groups of electrical leads 54.1 through 54.4 issuing from the respective digit modules 20.1 through 20.4 and leading to respective encoder circuits 56.1 through 56.4. Each of the encoders 56 responds to the input appearing on the energized one of its input leads 54, and produces a 4-bit digitally encoded output word representing the numeral currently displayed by the associated number wheel 24. These encoded words appear in bit parallel format as groups of 4-bit output lines 58.1 through 58.4 issuing from the encoders 56.1 through 56.4 respectively.

The 16 bits of time information on the output lines 58 go to a circuit 60 comprising 16 individual bit gates simultaneously enabled by a LOAD instruction appearing on a lead 62. When enabled, the gates 60 pass the 16 bits of time information over respective groups of four output leads 62.1 through 62.4 in bit parallel form for loading into the respective stages of a 16-bit shift register 64. Thus, each time a LOAD command appears on lead 62, 16 bits of time information, representing the current time to the latest minute, are entered into the shift register 64.

The shift register 64 is the sending shift register, from which the encoded time information is transmitted over a communication line 65 each time it is required by one of the utilization systems 30 through 38. Taking the flight recorder 30 as a representative utilization system, we see that the communication line 65 is connected to the first stage of another 16-bit shift register 66, referred to as the receiving register. The encoded time information stored in the sending register 64 is sent over communication line 65 in bit serial form and entered into the receiving register 66, by advancing, i.e., shifting, both registers at the same bit rate. A series of advancing pulses is continuously applied to the sending register 64 by means of a lead 68. A similar series of advancing pulses is applied to the receiving register 66 over a lead 70 whenever a control gate 72 is enabled by an appropriate signal applied to a gate control lead 74. The purpose of the gate 72 and the enabling signal on lead 74 is to determine when the flight recorder 30 will receive time information.

In order to synchronize the shift registers 64 and 66, their respective lead 68, and a lead 80 which is connected to the input of the gate 72, are tied together by a lead 67 for connection to a common pulse source, which may be either of the time base oscillator circuits 18 or 82.

The equipment illustrated in FIG. 1A and that illustrated in FIG. 1B are normally provided by different manufacturers of aircraft instrumentation, a situation which lends itself to a lack of design coordination, resulting in some amount of system redundancy. Specifically, the equipment of FIG. 1A may have its own oscillator 18 for driving the digital display clocks 10, 12 and 14, while each of the time information utilization systems in FIG. 1B may have its own oscillator 82, or one oscillator 82 may be common to all the systems 30 through 38. In this event, the oscillator 18 associated with the source system of FIG. 1A or an oscillator circuit 82 associated with one or more of the utilization systems in FIG. 1B may be used to drive both shift registers 64 and 66. In the first instance, a stream of timing pulses from the oscillator circuit 18 passes over leads 84, 88 and 67 to the respective register advancing leads 68 and 80, while in the second instance the oscillator circuit 82 provides a stream of advancing pulses which travels over leads 86 and 67 to the advancing leads 68 and 80. Any design approach which advances registers 64 and 66 at the same bit rate is acceptable. Preferably, the overall system design should be coordinated in advance, and then only one of the oscillators 18 or 82 would be needed to drive the digital clocks 10, 12 and 14 at a timed rate and to advance the shift registers 64 and 66 at an identical bit rate when time information is transferred.

After a full 16 bits of time information has been transferred from register 64 to register 66, they are unloaded over 16 output lines divided into four equal groups 92.1 through 92.4. When an UNLOAD command pulse appears on a lead 94, all 16 individual bit gates in a circuit 90 are enabled simultaneously to pass the time information bit parallel over groups of leads 96.1 through 96.4. The four bits on each such group of leads comprise respective encoded words representing the first through fourth decimal digits of time information, and are used to control the print modules 44.1 through 44.4 respectively. Thus, in the specific example discussed above, print modules 44.1 through 44.4 print out the respective numerals of the time of indication "12:34:56:17."

The unloading of the contents of the receiving shift register 66 to the printout device 40 terminates one cycle of time information transmission. Simultaneously, a LOAD command pulse should appear on the lead 62 so that the next batch of encoded time information available from the encoders 56 is loaded through gates 60 into the sending register 64 while the preceding batch is unloaded. For this purpose, both the LOAD command lead 62 and the UNLOAD command lead 64 are connected to a common drive line 100, which in turn is connected to the output of a one shot or monostable multivibrator circuit 102. The latter circuit functions as a pulse stretcher. It produces a single pulse output, of sufficient duration to keep the gates 60 and 90 enabled during the passage of encoded information, in response to a shorter trigger pulse arriving over a lead 104. This trigger is the output of a modulus 16 pulse counter circuit 106, which is connected by a lead 108 to count the stream of register-advancing time base oscillator pulses appearing on lead 67. The counter 106 thus counts up the 16 pulse time interval required to transfer the entire 16-bit contents of register 64 to transfer the entire 16-bit contents of register 64 to register 66, and at the end of that time it triggers the one shot circuit 102, causing it to issue a gate command pulse on the lead 100 so that one batch of time information is then unloaded from the register 66 and the succeeding batch is simultaneously loaded into the register 64.

The time information source equipment of FIG. 1A sends time information to a particular utilization system, e.g., flight recorder 30, during the entire time that an enabling command appears on its gate enabling lead 74. When the enabling signal on lead 74 terminates, the flight recorder 30 no longer accepts the time information which is available on the lead 65. Similarly, the other time information utilization systems 32 through 38 accept the time information available on lead 65 only when appropriate signals appear on their respective enabling leads 76 through 79. During the time that any one of the systems 32 through 38 is enabled, time information is accepted over respective leads 80 going to each system, and gate control signals are received on the leads 100 connected thereto.

FIG. 2 shows that the four counter modules 20.1 through 20.4 of clock 10 are thin, rectangular packages which can be
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Counter modules of the kind preferred for this system are commercially available, for example from the Presin Company of Shelton, Conn. Thus the counter modules 20 in themselves are entirely conventional, but they have certain operating characteristics which enable them to be used in a unique fashion in accordance with the present invention.

FIG. 3 shows the solenoid and ratchet drive mechanism for rotating the number wheel 24 of any module 20. The number wheel is mounted upon a shaft 110 for rotation about a horizontal axis. Coupled to the wheel for rotation therewith is a toothed wheel 112, characterized by a plurality of peripheral teeth 114. A two-pronged drive ratchet 116 includes an upper tooth 118 which normally engages the teeth 114 above the center of rotation, and a lower tooth 120 engaged the teeth below the center of rotation when the ratchet member 116 is actuated. Member 116 is fixed upon a horizontal shaft 122 for rotation therewith. Also fixed to that shaft is a rocker crank 124 having a crank arm 126 and a drive handle 128 at the end of the arm. The handle is substantially circular in configuration and is rotatably embraced by the drive collar 130 formed at the end of a drive link 132, which reciprocates freely in the horizontal direction between a pair of fixed guide pins 134 and 136.

The link 132 is driven through this reciprocating motion by means of a solenoid comprising a coil 138 wound on a U-shaped iron core 140. When the coil is energized, the core exerts a horizontal attraction upon an armature 142 which is affixed to the drive link 132. The armature 142 has a guiding pin 144 which passes through a suitable opening in a fixed guide member 146. A biasing spring is coiled about the guide pin 144, and is compressed between the armature 142 and guide member 146 when the armature is attracted to the core 140.

In operation the number wheel 24 is advanced one numerical step for each electrical drive pulse applied to the coil 138. At the start of such a pulse, the coil is energized, the core 140 attracts the armature 142, pulling the link 132 to the left relative to FIG. 3, and causing the drive collar 130 to rotate the crank 124 through a small angle in the counterclockwise direction. This similarly rotates the two-pronged ratchet 116 about the axis of shaft 122, causing the lower ratchet tooth 120 to move upwardly into engagement with the teeth 114 in the region below the shaft 110. At this time the tooth 120 cams against one of the sloping teeth surfaces in such a manner that it advances the tooth wheel 112 and number wheel 24 half a numeral step in the angular direction indicated below arrow 150.

When the pulse energizing the coil terminates, the core 140 releases the armature 142, allowing the biasing spring 148 to return the armature to the right relative to FIG. 3. This results in return movement of the link 132, which rotates the crank 124 and the ratchet member 116 in the clockwise direction back to their original positions. At this time upper ratchet tooth 118 descends into reengagement with the wheel teeth 114, camming against one of the slopes of the teeth to advance the wheels 112 and 24 another half numeral step in the same angular direction (arrow 150). Thus, for each electrical pulse, the number wheel 24 is advanced one full numeral step, to change the time indication.

Between pulses applied to the coil 138, the upper ratchet tooth 118 remains in engagement with the wheel teeth 114, conveniently holding the numeral wheel 24 in a stable position. As a result, the clock 10 mechanically retains an indication of the correct time. As a result, the clock 10 serves as a memory for preserving a record of the most recent time indication during a power failure when temporarily disables the time information system. Instead of losing all count of the time. As completely electronic clock systems do when deprived of power, the time system of this invention is able to start from its last time-indication when power is restored. The resulting error time is much less than the error involved in starting all over from time zero.

Another important feature of these counter modules 20 resides in the fact that the geometry of the interengaging teeth 118 and 114 permits the number wheel 24 of any module to be driven by an external motor in the angular direction opposite to the direction of operation by the solenoid and ratchet mechanism of FIG. 3. When the number wheel 24 is reverse driven in this manner, the upper ratchet tooth 118 is able to slip over the passing wheel teeth 114.

FIG. 4 illustrates the manner in which this feature is used so that the clocks 10, 12 and 14 provide a continuously changing time indication instead of being advanced only at 1-minute intervals. The stream of oscillator pulses appearing on the input line 17 is applied to a synchronized timing motor 152, which consequently advances at a timed rate. The motor is connected by means of a drive shaft 154, schematically illustrated, to rotate the least significant digit wheel 24.4 in the angular direction indicated by arrow 156, which is opposite to the direction of normal number wheel advance (arrows 150) produced by the solenoid and ratchet mechanism.

The reverse direction of movement requires the numerals 26.4 to be arranged in the reverse order about the periphery of the number wheel 24.4. Therefore, as seen in FIG. 4 the numerals 26.4 are topcycling on the wheel 24.4, i.e. successively greater numerals zero through nine come over the top of the number wheel 24.4 and descend to the position of visibility through the associated readout window 22 (FIGS. 2 and 2'). The solenoid coil 138.4 of the least significant digit module 20.4 is not used at all, nor is its associated ratchet drive mechanism 116, 112, etc. The upper ratchet tooth 118 thereof simply slips over the wheel teeth 114 as the number wheel 24.4 is driven in the reverse direction by the timing motor 152. In all other respects the least significant digit module 20.4 is identical with the other digit modules 20.1 through 20.3.

The advantage of this modification is that the units of minutes digit in the time display is advanced continuously, instead of becoming up to 1 minute slow while waiting for incremental advances 1 full minute apart. As seen in FIG. 1A, the least significant digit modules of clocks 12 and 14 are also driven by synchronous timing motors 160 and 162 and schematically illustrated drive shafts 161 and 163 respectively, to obtain the advantage of continuous rotation of the units of minutes wheel thereof.

As shown in FIG. 4, once for each revolution of the least significant digit wheel 24.4, its associated wiper contact 52.4 closes a circuit to a contact 50.4 which is associated with the numeral zero in the least significant digit place. This closes a circuit to the advancing solenoid of the next more significant digit module 20.3, resulting in a carry to the next more significant digit module 20.3. Similarly, successive incremental numeral advances of the wheel 24.3 eventually bring its wiper contact 52.3 into engagement with a numeral contact 50.3, which pulses the advancing solenoid 138.2 of the next more significant digit module 20.2, and the same process is repeated in connection with the associated contacts 52.2 and 50.2 for the purpose of pulsing the solenoid coil 138.1 of the most significant digit module 20.1. Contacts 52.1 and 50.1 of the most significant digit module are unused.

Each of the contacts 50 is associated with the numeral zero of its associated number wheel 24, but in order to make sure that a proper carry occurs every 60 minutes, and every 12 or 24 hours, circuitry of a well-known kind, not illustrated here, is employed to make the 10's of hours module 20.3 advance rapidly to numeral zero immediately upon attaining the numeral six, to make the units of hour module 20.1 advance rapidly to numeral zero immediately upon attaining the numeral two or four, depending upon whether 12- or 24-hour time is used, and to step the most insignificant digit module 20.1 to zero upon attaining a total count of 13 or 24 hours.

It will now be fully appreciated that the present system provides a visible time display, at several different times of the flight cabin, which is continuously updated instead of being corrected only at 1-minute intervals, and which also provides electronically coded time reports to severs on board systems, with the additional feature of mechanically retaining a recol-
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lection of the last correct time report during an interval when the system is unable to operate because of a power failure.

While the time information source illustrated in FIG. 1A is shown to include only a meridional time display such as, for example, a Greenwich Mean Time display, it will be obvious that this meridional time display can be combined with other desirable time displays such as a short term and a long term elapsed time display, both of which are actuated by the time base oscillator 18 or 82 in the manner of U.S. Pat. application Ser. No. 840,729 filed on July 10, 1969 by Geoffrey H. 10 Hedrick, Frank H. Hawkins and William Van Os for Aircraft Time Indicator, which application has been assigned to the assignee hereof.

While I have herein shown and described the preferred form of the present invention and have suggested modifications thereof, other modifications may be made within the scope of the appended claims without departing from the spirit and scope of this invention.

What I claim is:

1. A time information system comprising:
at least one clock which displays time in digital form;
said clock including respective number wheels for each time digit so displayed, and means for rotating said number wheels as a function of time;
each of said number wheels having a plurality of legible numerals distributed thereabout, whereby to be displayed in said display, said number wheels rotate;
respective electrical circuits representing respective ones of said numerals;
respective switching means responsive to respective ones of said number wheels, and each arranged to energize the one of said electrical circuits which represents the particular numeral which its associated number wheel is currently displaying.

2. A time information system as in claim 1, further comprising:
a plurality of said utilization systems, all connected to said communication link and said advancing means to obtain time information from said sending shift register.

3. A time information system as in claim 2, further comprising:
a vehicle having a cabin for an operating crew;
said clock being installed in said cabin and readable by at least one of said operating crew;
said plurality of utilization systems being installed at respective locations on said vehicle remote from said cabin.

4. A time information system as in claim 1, further comprising:
respective drive modules for respective ones of said number wheels;
each said drive module including a solenoid and a mechanism responsive to said solenoid for advancing the number wheel of said module in one angular direction only, but permitting said number wheel to be driven in the opposite angular direction by an external drive means;
the solenoid of each drive module of each more significant digit number wheel being connected to one of said electrical circuits representing a selected one of the numerals on the immediately preceding less significant digit number wheel, whereby to effect a carry to each more significant digit number wheel in turn when a selected count modulus of the less significant digit number wheel is satisfied;
and a timing motor connected to drive said least significant digit number wheel at a time rate in said opposite angular direction.

the numerals on said least significant digit number wheel being arranged with their numerical order direction opposite to the numerical order direction of the numerals of the more significant digit number wheels, so that each of said number wheels is rotated in the direction of increasing numerical order of its numerals.

5. A time information system as in claim 7, wherein:
a toothed wheel is coupled with each of said number wheels; and said mechanism responsive to said solenoid includes pawl means engageable with said toothed wheel for rotating said toothed wheel and its associated number wheel.