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COMPACT DISPLAY ALARM SYSTEM

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Abstract

During the past years, the trend has been to increase the amount of information displayed to the pilot: a situation of 50 ÷ 60 caution indications is not unusual. At the same time, the cockpit space available for a Caution Panel is decreasing for different reasons.

This paper concerns the philosophy of a compact display system associated to a caution and warning system.

The differences with a conventional dedicated system are illustrated.

The main characteristics of the "Compact" System are:

- Presentation reduced to a few lines.
- Logic of operation similar to that of the conventional solution.
- Reduced cockpit occupation.
- Presentation of true alarms only.
- Avoidance of untimely alarms.

The above features are obtained by the use of a four line display and a decision making routine.

1. Foreword

This paper concerns the philosophy of a Central Warning System, composed of a group of sensors, a processing unit and a display unit.
The system here described has been called "compact" as a consequence of the few lines of presentation of the display unit, compared with the many messages presented at the same time by a "traditional" system.
The description focuses on the operational criteria, assuming that common aeronautical criteria about reliability, redundancy and self test of electronic circuits are followed.

1.1 Background of the subject

The task of a Central Warning System is the timely information to the pilot of an impending dangerous condition, as detected by dedicated discrete sensors.
To achieve this goal, in the traditional system a Master light is placed in the principal cone of vision of the pilot.
When the Master light goes on, the pilot is informed that a failure has occurred somewhere. To determine the actual failure, he looks at a display unit where some legends are lighted, associated to the dedicated sensors.
A typical traditional display unit is shown in Fig. 1

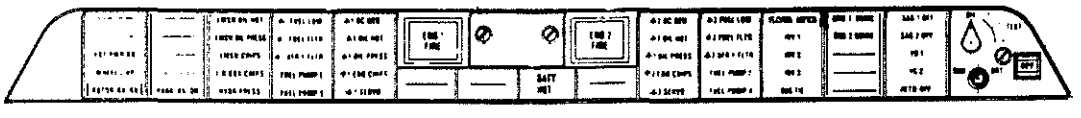


Fig. 1 TRADITIONAL DISPLAY UNIT

To acknowledge this, and make the Master ready to inform about the arrival of a new failure, a reset action is performed by the pilot on the memories of the system, turning off the Master.

Weak points of the above system are:
- Large space allocated on the cockpit, due to the large number of possible different messages.
  (The present trend is 50 messages and more)
- Difficulty to identify the most recent message (even with flashing techniques).
- Presence of distracting messages, in the case where a situation detected by a sensor can have different meanings and implications.
- Lack of flexibility. Any modification to the number of channels, their category or their effect implies a modification of parts.
- Untimely alarms, when a short duration fault condition turns on the Master temporarily, without being identified.

1.2 Aim of the "Compact" System

The Compact system described in this paper, while still satisfying the requirement to be able to present all the messages to the pilot, gives a contribution to reduce the space occupation of the cockpit, to inform about the most recent message, and to reduce non-relevant and untimely alarms.
In the opinion of the author, the effort to define such a system is worthwhile, as notwithstanding the extensive use of general purpose (CRT) displays, where all the different situations and parameters needed for the flight can be displayed, a stand alone unit, carrying the information related to the safety of the aircraft, is still needed.

2. Technical Summary

Refer to Fig. 2 for the Block Diagram of the system.

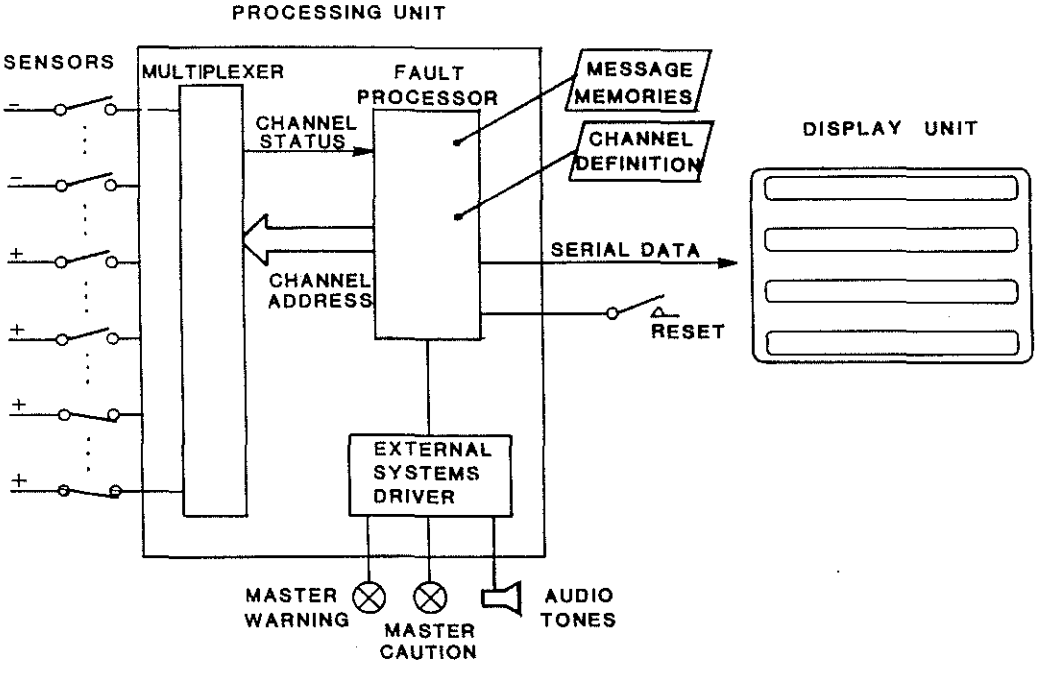


Fig. 2 BLOCK DIAGRAM

2.1 System philosophy

- Space occupation not proportional to the number of monitored channels, by the reduction of messages presented at the same time (limited to four in the following description).

- No new controls, just the "Reset" switch, to avoid additional workload on the pilot.

- Only "true" messages are displayed, by inhibiting the presentation of alarms invalid with engines off (as detected by engine speed sensor).

- No hidden faults, that is, the pilot must be able to read all the messages, by applying the normal sequence of Master,Caption, Reset.
  This is obtained by considering the priority of the "Non reset" message over the "Reset" one, and the "Last" over the "preceeding".

- Avoidance of untimely alarms, by considering an input channel in the fault status only after an appropriate number of scanning cycles.

2.2 Input Specification

The typical input sensors are of the discrete ON-OFF type, meaning they have two logic electrical conditions, one with the meaning of "Normal", the other with the meaning of "Fault".
The three following main categories have been considered:

CATEGORY	NORMAL STATE	FAULT STATE
Negative (NEG)	open line	ground
Positive (POS)	open line	pos. voltage
Null (NULL)	positive voltage	open line

In addition to the electrical category, the class distinction between Warning and Caution is considered, where Warning is associated to a situation which requires immediate corrective action on the part of the pilot.

2.3 Processing Unit

The input sensors are sequentially scanned by means of the digital input multiplexer of the processing unit.
A logic level conditioner detects a fault condition by means of the comparison with the content of a table of declaration of category (software defined).
The time relationship of the arrival of faults is stored, together with the information of their reset or non reset condition.
By following a decision making routine, the channels to be displayed are identified and sent to the display unit.
By the application of the following two basic rules of priority:

"Reset"	priority over	"Non reset"
"Last"	priority over	"preceeding"

the faults are arranged in the appropriate sequence in each of the two classes, Warning and Caution.
In addition to the above rules, there is a category of faults which are not valid when engines are off and for this reason they are ignored.
A message memory contains the alphanumerical message associated to each channel.
Two lines of the display are dedicated to the warnings and two lines to the cautions.
To avoid an untimely alarm of the pilot, the inputs are scanned more than once before been considered as faults.
Only after "n" consecutive times (with "n" software defined) an input is considered to be in the failure state.
The choice of the number of times is a trade off between high immunity and delay of the information.
Two levels of delay are advisable: the standard one as compared with the long one, where the choice is affected by physical performance (for ex.: low level of fuel quantity or chips).

As a result of the above procedure, the arrival of a fault deplaces the existing information on the display unit, presenting the newly arrived, non reset faults and turning ON the relevant Master (one for Caution and one for Warning).
By applying momentarily a Reset signal, acknowledging by this action the information of the display unit, the presentation is altered following the basic rules, and the Master goes off only if no "non reset" fault exists.
The Reset function is implemented by the standard Reset switch associated to the Master, to which the pilot is accustomed.
This important feature has the purpose of avoiding changes in the routine used traditionally by the pilot to acknowledge the fault.

2.4 Display Unit

The display considered in this description has a standard enclosure per MIL-C-6781, 5.75" wide and 3.375 " high, DZUS mounted.
It contains four, 16 character, alphanumeric lines.
What, at the present time, is thought to be suitable to the purpose, is a Liquid Crystal Display, of the dichroic type.
This type of display exhibits very good performances, expecially in direct sunlight illumination, where the messages are perfectly readable.
The characters are white on a black background, have a wide viewing angle, and, when not energized, remain completely dark.
An additional advantage is the low power consumption.
As LCD are not emissive, backlighting for night operation must be provided.

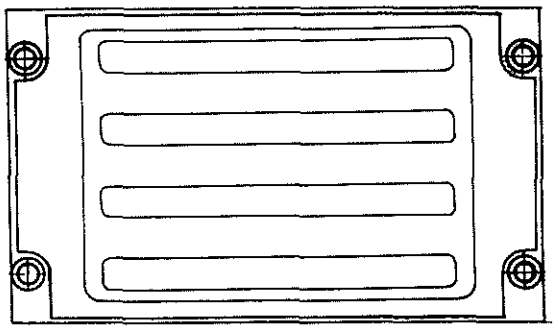


Fig. 3 Compact Display Unit

The right most characters of the upper display line of each class are reserved to a fault totalizer display.
Two dedicated totalizers, one dedicated to warnings and one dedicated to cautions are provided.
Each totalizer shows the number of failed channels.

3. Operation

This section gives a detailed description of management concepts, giving examples of sequences of arrivals and disappearances of failures.
As the number of possible simultaneous messages is limited to four (which seems a good trade-off between limited cockpit occupation, probability of occurrence of simultaneous arrival of messages and completeness of information) the effort is directed by inhibition and timing routines, to the presentation of "true" alarms, so as to leave the display blank until a dangerous condition is detected.

3.1 Fault Management

Flux diagram of Fig. 4 shows the logical operations performed on faults, immediately after their arrival.
This diagram is the result of the application of the following priority criteria, shown in decreasing order of priority:

a) "non reset" faults are more important than "reset" faults, as reset faults are already acknowledged by the pilot.
b) "more recent" fault in each class are more important the "less recent" faults in the same class.

A main feature is the inhibition of the reset for the faults that are not displayed. As the Masters are not turned off until every fault is acknowledged and reset, this feature avoids the possibility that non displayed faults may be ignored by the pilot.
An additional criteria is the division of the faults in two groups:

- normal channels
- channels inhibited when engines are off.

The latter group applies to the channels in which the sensor fault signals represent a dangerous situation when in flight, but are indicating just a normal operation condition on the ground (for ex; DC GEN, LOW OIL P, ...).

Apart from the avoidance of unnecessary operations on the part of the pilot, the above conditioning, gives the advantage of suppressing ground operation time for the display.

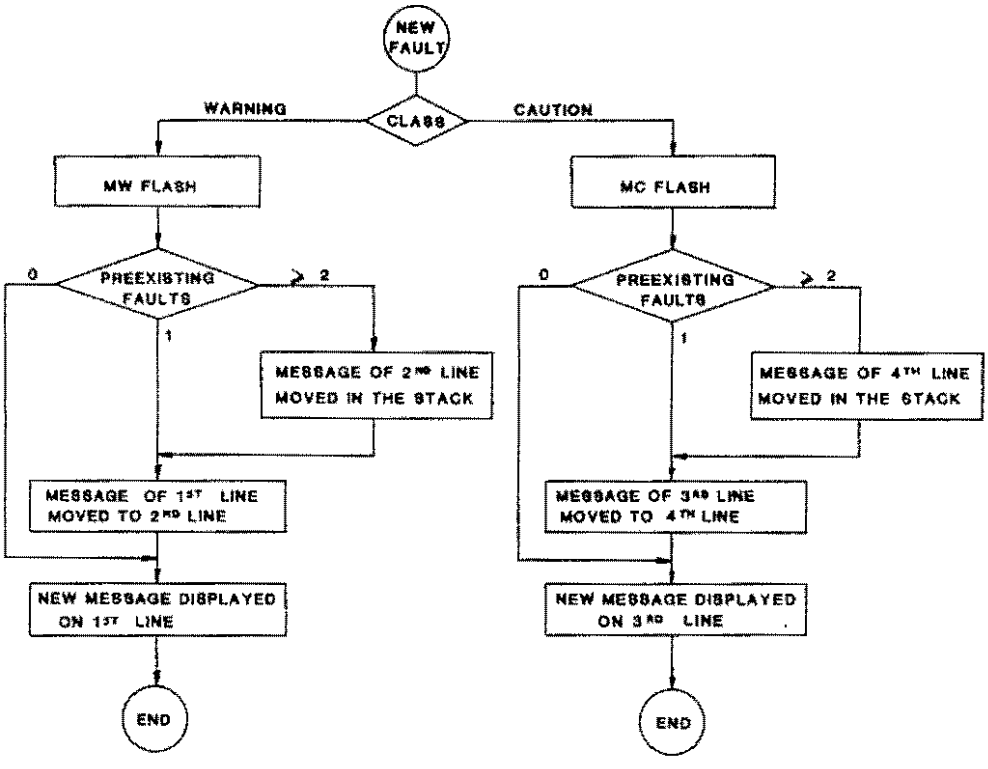
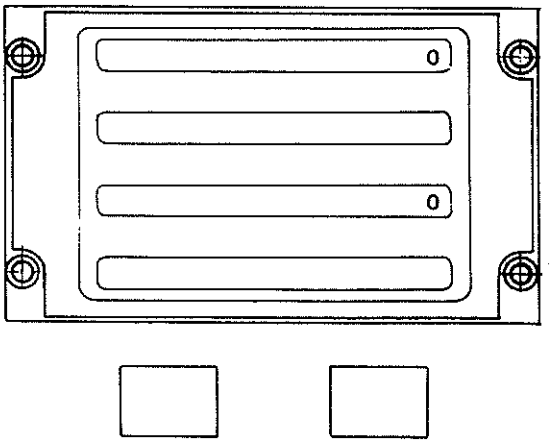


Fig. 4 LOGIC FLUX DIAGRAM

3.2 Example

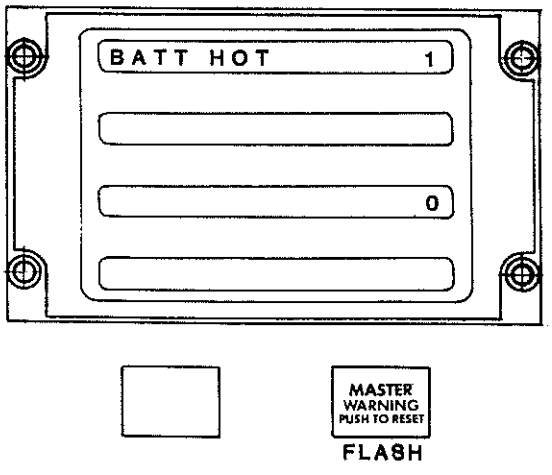
In four lines display units, the two upper lines are dedicated to warnings, the two lower lines to cautions. When no fault is present, the display is blank and the Masters are off.



3.2.1 First alarm

When a fault is detected the following events take place sequentially:

- alarm class (W or C) is detected from stored data
- the appropriate master is energized (in flashing mode)
- The associated message is sent to the display line dedicated to the alarm class
- the appropriate alarm counter is sent to 1.



Next to the acknowledgment on the part of the pilot by operation of the reset switch:

- the reset event is associated to the channel number
- the master is de-energized.

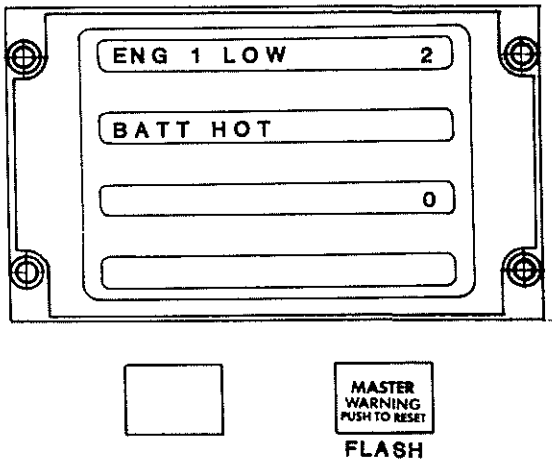
If later on the fault condition reverts to a normal one, the system returns toi the start condition.

3.2.2 Second alarm

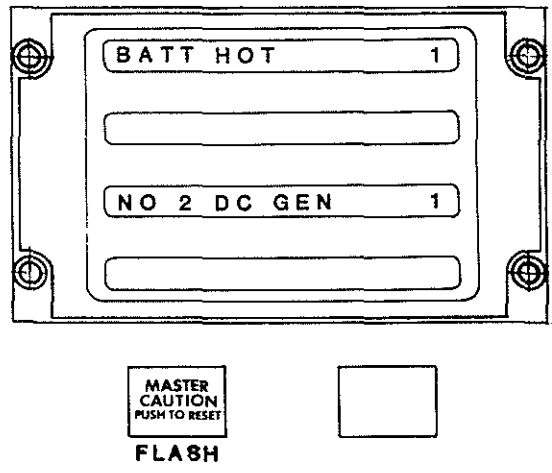
If a second fault is detected, while the first is still present and acknowledged by the pilot, the sequence of events is the following:

- the appropiate master is energized (in flashing mode)
- the new alarm is displayed on the dedicated line.

In our example, if the new alarm is another warning, it is sent to the first line of the display, and superimposes itself to the preceeding message.

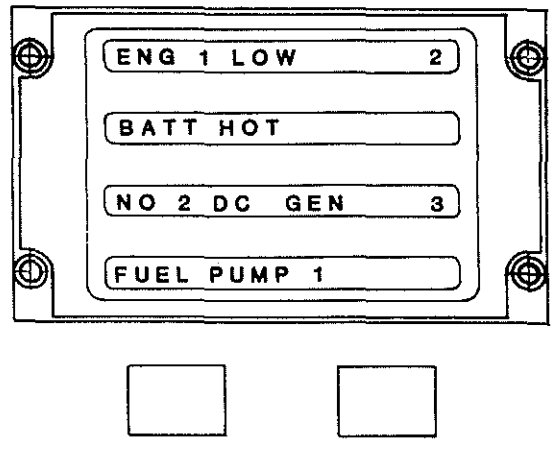


If the new alarm is a caution, on the contrary, it is sent to the third display line.•

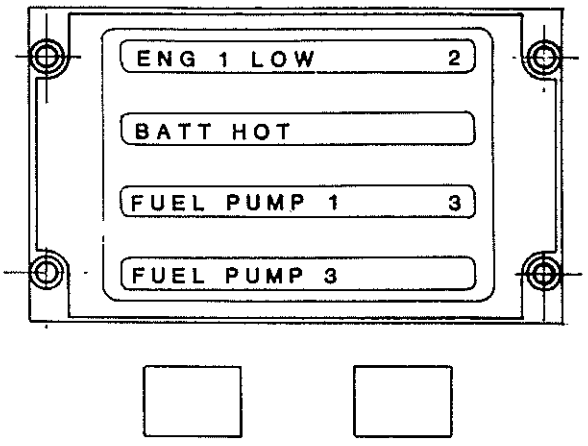


3.2.3 Nth alarm

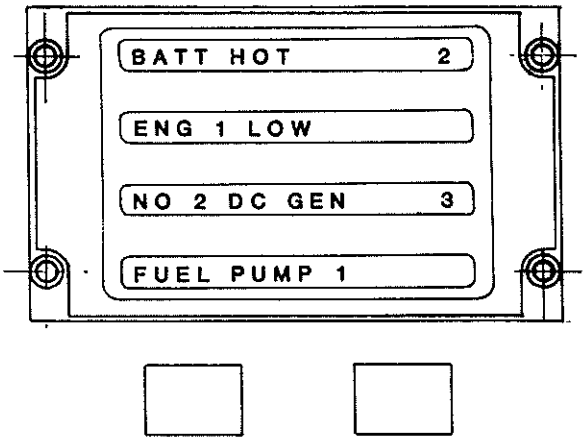
The display shows the two most recent warnings and cautions.
Alarms form two independent stacks, the pilot can review the total situation operating the reset switch; at each situation the two stacks of messages are moved up one line and displayed on the dedicated lines.
This enables the pilot to review the total situation.
This is the only control available to the pilot, so its use is very simple and the workload is kept to a minimum.
If the situation is



After operating the Master Cautionn Reset Switch, the display becomes:



The scroll of the warnings, on the contrary, gives:



4. Advantages

- Flexibility. No hardware modifications as a function of the different categories of input sensors.

- Reduction of untimely alarms. Channels are scanned more than once to determine whether they are in the fault status.

- Limited cockpit occupation. Surface of display unit is not proportional to number of channels.

- Presentation of true alarms.
  Alarms which do not represent a dangerous condition are inhibited.

- Easy identification of most recent message obtained by use of a "last on top" technique.

5. Conclusions

Due to limited space availability in the cockpit area, new solutions are needed to present to the pilot the alphanumerical informations associated to a Caution and Warning System.
The importance of this safety related information prevents the use of general purpose display and requires a dedicated unit.
The approach shown in this paper solves this problem by the use of a four line alphanumeric display and the choice of a suitable logic of management of information, which organizes the information about the status of the input channels, their time relationship and whether they are reset, to determine which channels are to be displayed to the pilot.