

APOLLO

GUIDANCE AND NAVIGATION

Approved Milton B. Trageser Date 1/5/62
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved Roger B. Woodbury Date 1/8/62
ROGER B. WOODBURY, ASSOCIATE DIRECTOR
INSTRUMENTATION LABORATORY

~~GROUP 4
Downgraded at 5 Year Intervals;
Declassified after 15~~

(Unclassified Title)

REPORT E-1105

COMPUTER DISPLAYS

by

Eldon C. Hall

, January 1962

CLASSIFIED by NAS9-153
Subject to General Declassification Schedule of
Executive Order 11652 Automatically
Downgraded at Two Year Intervals.
DECLASSIFIED on 31 Dec 1973



INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

COPY # 373 OF 400 COPIES
THIS DOCUMENT CONTAINS 16 PAGES



ACKNOIYLEDGMENT

This report was prepared under the auspices of DSR Project 55-191, sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through Contract NAS9-153.

~~This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U. S. C., Sections 793 and 794, the transmission or the revelation of which in any manner to an unauthorized person is prohibited by law.~~

The publication of this report does not constitute approval by the National Aeronautics and Space Administration, of the findings or the conclusions contained therein. It is published only for the exchange and stimulation of ideas,

INTRODUCTION

The enclosed discussion of computer displays is taken from the minutes of a monthly progress meeting. This presentation is based on a very early iteration of the display problem. Substantial changes are expected to result from the overall display analysis which is underway.



~~CONFIDENTIAL~~

COMPUTER DISPLAYS

By: Eldon C. Hall

I will try to present a display concept that can be integrated easily into the computer that Dr. Alonso was discussing, and still provide sufficient flexibility to be modified in the future when the system and operational procedures have been more clearly defined. The fact that this display is quite flexible and compatible with the computer Dr. Alonso presented will become self-evident. In addition, for the amount of display being provided, it is inexpensive in program time, in power, in weight, and in the amount of equipment involved.

The technique employed will provide for up to 64 4-bit output registers, only part of which are required and used in the display proposed here. In addition to display, other outputs can be provided, such as operation of jets, staging signals, proportional control signals (or torquing signals for the platform) if desired, and rate signals for control of the sextant. Also, in the final version, telemetry could be provided, but for the R & D flights the telemetry will probably have to be handled by some other means.

In this first iteration, we provided for both manual or automatic control of the displays, whichever seems more desirable when the operational procedures are selected. The pilot can select display quantities, enter data into the computer, select programs that are already in the computer, and/or change programs such as from mid-course guidance to lunar landing.

~~CONFIDENTIAL~~

The illustration of a suggested display and control panel in Fig. 1 has various output displays, control buttons, mode selection switches, keyboard, and output discrete lights. For example, there is a discrete light labeled "idle", which, when lit, indicates that the computer is running at a very low rate. If the pilot sees any necessity for speeding up the computer, he must initiate the command to do so.

The output displays consist of meters, discrete lights, decimal number lights, and code number to identify the decimal number lights. The control panel incorporates the facility to enter data primarily through the keyboard but also, by proper command via the keyboard, data can be entered from the paper tape reader. The keyboard can be used to select modes of operation, such as IMU erection mode, sextant reading mode, or modes that do nothing more than interrogate various numbers in the computer and display them to the pilot. The discrete lights indicate the computer operating mode.

Consideration must be given to the indication of various malfunctions, some of which might be internal to the computer and some external. For example, if the computer has commanded a jet to operate for torquing the spacecraft and the jet is not functioning, there might be a light to indicate the jet is not operating, while a light on the computer indicates that the command has been given. The pilot would have to investigate the reason for the discrepancy in indication.

For analog data display, there are three meters as indicated in Fig. 1. Each meter has an associated mode switch which defines the output displayed on that meter. This switch programs the computer to

CONFIDENTIAL

CONFIDENTIAL

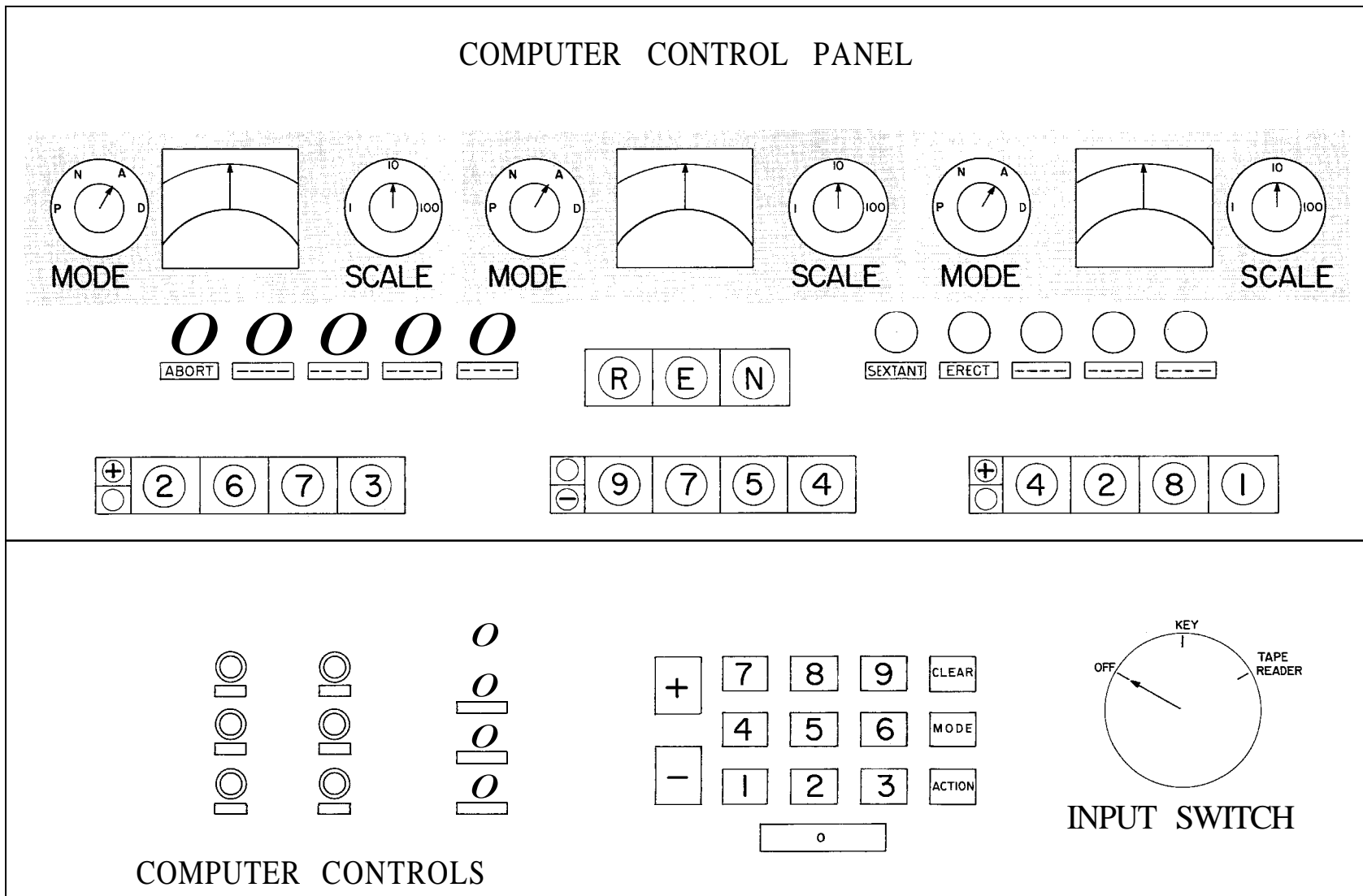


Fig. 1 Computer control panel

read the appropriate number into the meter. There is also a scale switch for use, if necessary, to program the computer to scale the output to the meter. The simplest presentation to the meter will provide one part in sixteen, since there are four bits in the output register, or approximately 7% of full scale. However, by adding another register to each meter, accuracy of about 1/2% can be obtained. If there is any reason to increase or decrease this accuracy, such increase or decrease is possible.

The specific display uses of these meters are not clearly defined in this first iteration, but can include fuel supply or amount of velocity correction still available to the pilot, range and range rate to the lunar surface, etc. Any quantity in the computer erasable memory can be programed to be displayed on the meters.

In the decimal number readouts three 4-digit numbers are provided with a sign digit and a set of 3 code digits to identify the numbers. Each of the three 4-digit numbers will provide an accuracy of one part in 10,000, or by command of the pilot through the keyboard all twelve digits may be used to display one number to very high accuracy. The twelve digit display is more than necessary to display a double precision number contained in the computer. During normal operation the computer can be programed to display a set of quantities automatically. The pilot can command the display of any quantities contained in the erasable memory of the computer by proper code punched into the keyboard. For example, during checkout or possibly during some operational modes the data displayed in the meters may be required to more accuracy than 7%. By selection through the keyboard these numbers may be displayed on the decimal number readout.

Another data display that can easily be incorporated is a tape printer which is not shown in Fig. 1. A printer would be desirable since it could provide a permanent record of computational data. In case of failure a record of this type could be used to assist in manual navigation. No printer was shown at this time because it is felt there is no adequate printer available now. If one is developed it could be integrated into the display at a later time.

To control the computer operation and enter data into the computer there is a keyboard, a punched tape reader, six command buttons and the meter control switches already mentioned. When using the keyboard to enter information into the computer, the pilot would move the input switch to the "key" position to energize the keyboard. He then selects the data entry mode from the keyboard and enters the data and its code to identify the data. The data and its code would be read back to the pilot via the number display for verification before the computer accepts it as valid data to be used in computation. In addition to the keyboard there are six other command buttons provided which could be used to select modes, energize the display panel to check for malfunctions, change the computer operating speed, etc.

The tape reader can be used as a bulk data storage device for constants, computer checkout problems, initial conditions, etc. The data can be entered by command of the pilot or in a fully automatic mode the computer would interrogate the tape reader to get the data as needed.

The pilot can command the various modes in the computer through command buttons or by code through the keyboard. Examples of modes that could be commanded are erection, sextant, rendezvous, midcourse guidance, landing, etc. The modes used most frequently could be controlled via the command buttons, the others would be controlled by code through the keyboard. The buttons that are programmed to control spacecraft functions of various types may be manually operated by the pilot and easily accessible to him. Examples of controls of this type are those required for maneuvering the spacecraft during landing on the moon or earth re-entry,

In checkout mode of operation complete computer checkout and many guidance system checkout programs may be run. Test problems and system exercises may be stored on paper tape and in the fixed memory which would exercise the computer, the display, and other guidance equipment. The existence of a malfunction would be displayed to the pilot.

The computer and display hardware required for these functions (see Fig. 2) is one output register which has a total of 15 bits, seven of which provide the address of the display device. For example, one of the 64 combinations of the seven bit word will address one meter, one will address one of the decimal digits, etc. Associated with each address are four latching relays which are activated by the address. The remaining 8 bits of the 15 bit output registers is used to set the coils of the latching to the "1" or "0" side. The relay contacts provide the signal to activate the display quantity. In the case of a meter a

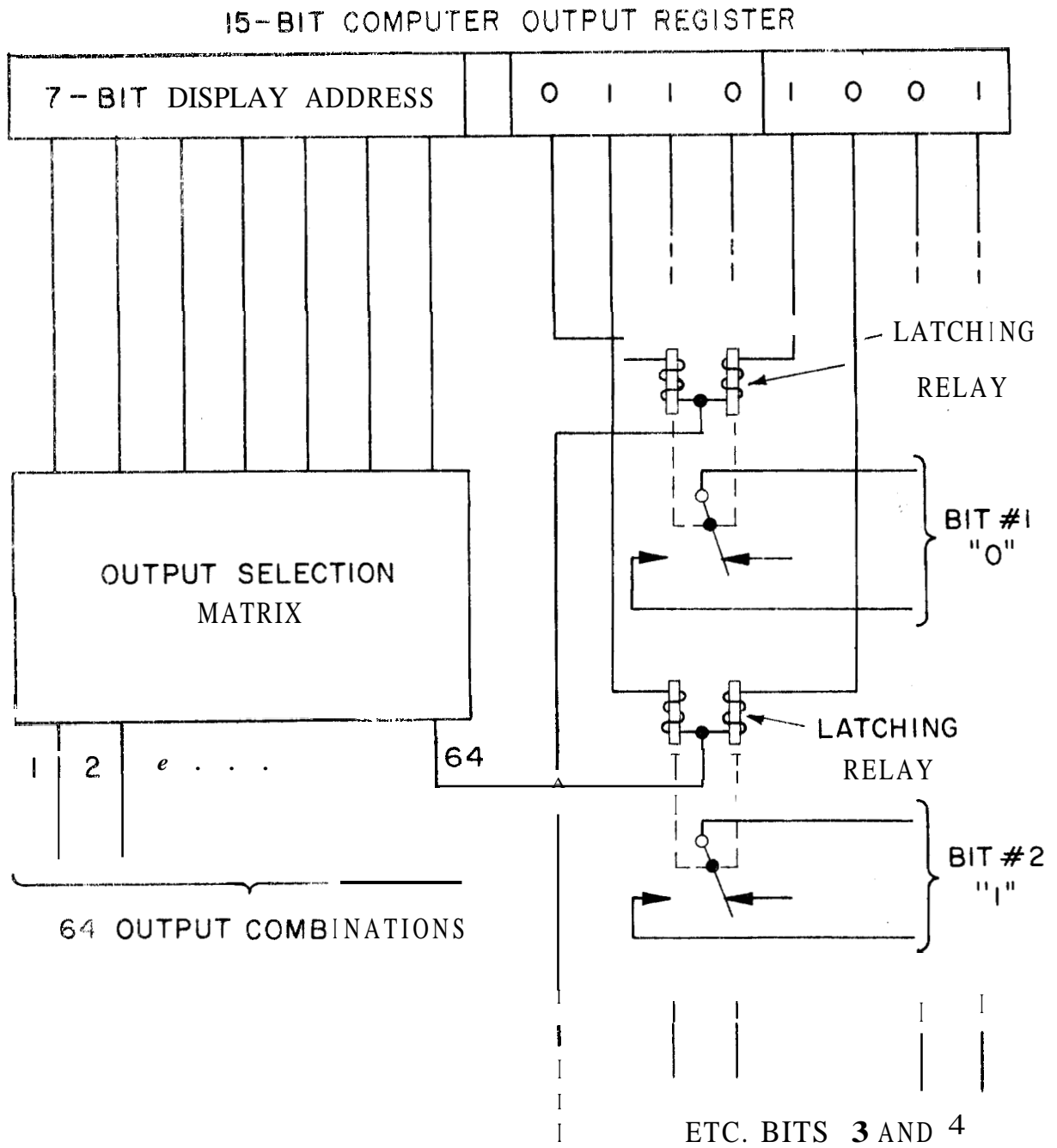
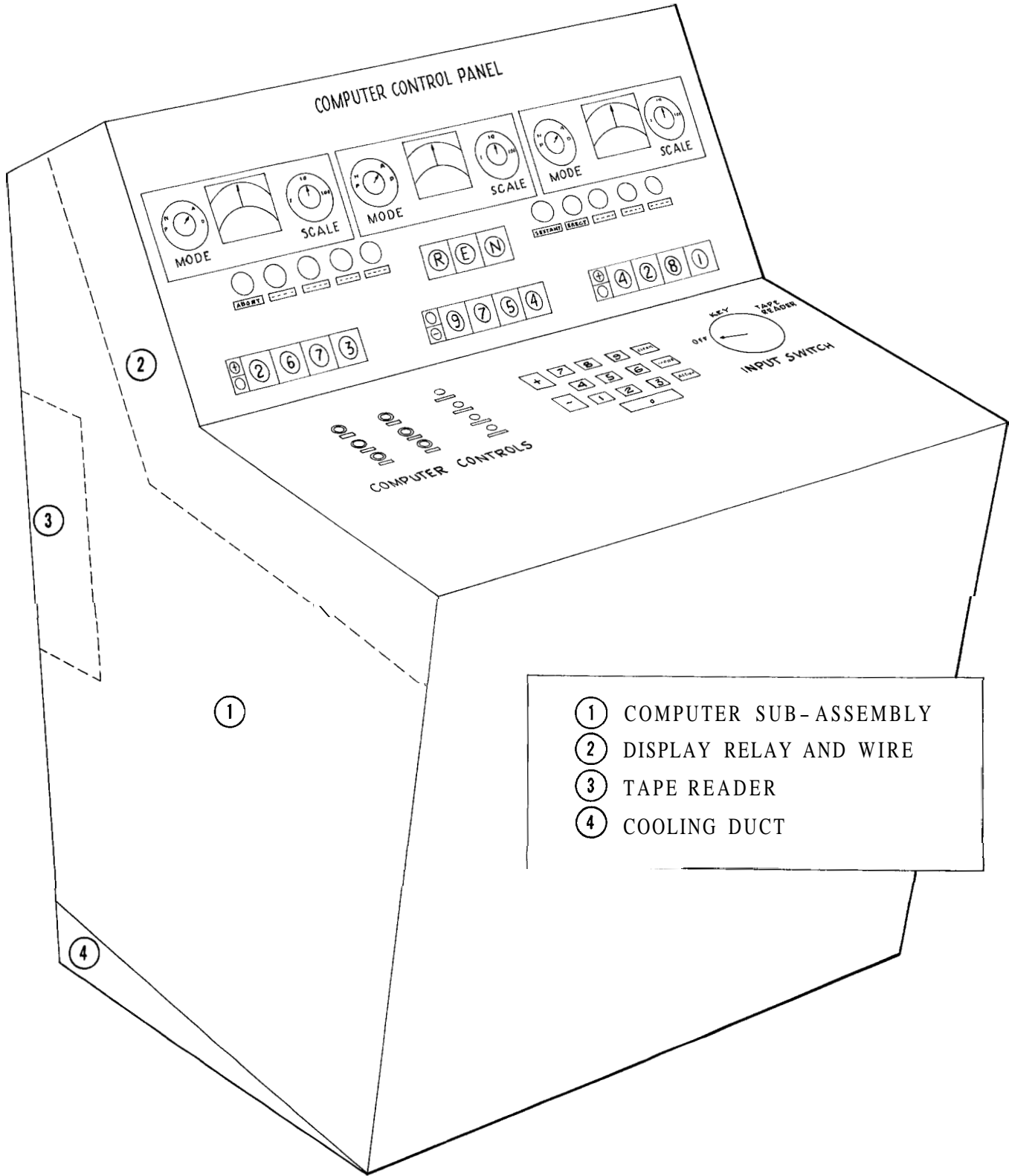


Fig. 2 15-Bit computer output register



- ① COMPUTER SUB-ASSEMBLY
- ② DISPLAY RELAY AND WIRE
- ③ TAPE READER
- ④ COOLING DUCT

Fig. 3 Artist's concept of computer display and control unit

in the computer program. The design of the final computer will, therefore, not be inhibited by any requirements of the other parts of the system as they are developed. More or less display can be provided at any time, the quantities displayed can be changed as readily as the computer can be programmed, etc. Also other types of outputs may be provided such as signals to operate jets, command the autopilot, communications outputs, etc. These outputs can be represented by binary numbers from 1 bit for discrete signals to as many bits as required for proportional type signals of high accuracy.

