

FINAL REPORT
CONTRACT NAS 9-12528

Modified and Improved Sleep Monitoring Display Console

Submitted by

James D. Frost, Jr., M.D.
Associate Chief, Neurophysiology Service
The Methodist Hospital
6516 Bertner Blvd.
Houston, Texas 77025

March 31, 1972

CONTENTS

Introduction	1
Prototype Display Console	1
Modified Display Console	2
Operation and Care of Display Console Units	5
Table I	6
Figures	7

In accordance with Exhibit C of this contract, we undertook to produce two sleep monitoring display consoles which would be capable of simultaneous display of these entities:

- a) visible indication of the current sleep stage of each subject,
- b) a cumulative, numerical display (in hours and minutes) of the total amount of time the subject spends in each stage, and
- c) a stepwise, graphic recording of subject sleep stage versus time.

The sleep monitoring display console as originally developed has been described in detail in the Final Report to Contract NAS 9-10747, Development and Testing of a Prototype Operational System for Automatic Monitoring of Sleep During Manned Space Flight, May 31, 1971. An improved unit has been built, and two of these improved units (serial numbers D-4 and D-5) have been delivered.

Prototype Display Console

This console, as specified in Exhibit C and described in the report cited above, was designed to be located at the remote monitoring site and to accept the seven-level voltage output from the M133 sleep monitoring system, providing the necessary three display modes.

Circuit Description. Fig. 1 shows the component arrangement for the prototype console, which operates as required in the statement of work for Exhibit C.

Modified Display Console

This unit is likewise located at the remote monitoring site and accepts a seven-level voltage input which is proportional to the state of sleep. The unit provides these simultaneous display modes:

1. a visible indication of the subject's current sleep stage,
2. a cumulative, numeric display (in hours and minutes) of the total amount of time spent in each sleep stage, and
3. a stepwise, graphic recording of the subject's sleep stage versus time.

Circuit Description. (See Fig. 2.) A voltage level, which is proportional to sleep stage (see Table I), enters the display console where it is presented to the common inputs of a series of seven comparator circuits, each corresponding to one of the pre-defined stages. The reference levels of each comparator are fixed such that the comparator will respond only if the input voltage is within a narrow range above or below the specified voltage value for the particular stage, as indicated in Table I.

The output of each comparator is normally held at a positive value. When the input voltage falls within the range of a particular comparator, its output is switched to zero, or ground, potential. Since the output of the sleep analyzer is restricted at all times to one of the seven specified levels, one comparator will always be switched "on" (zero volts output).

Each stage-detector comparator connects to a relay-driving circuit composed of two 2N3646 transistors and associated components, Q_1 and Q_2 (see Fig. 2). The first transistor of the pair, Q_1 is normally held in the "on" condition, since the positive output of the comparator circuit is connected to its base through a $1.2\text{ k}\Omega$ resistor. Since the second 2N3646, Q_2 , is driven from the collector of the first, it is normally held in the "off" condition, and consequently the relay in series with the collector of the Q_2 is normally inactivated.

When one of the stage comparators switches to the "on" condition, Q_1 is immediately switched "off." However, because of the $500\mu\text{F}$ capacitor located between the collector and ground of Q_1 , Q_2 does not switch "on" immediately but does so after a delay time (capacitor charge time) of approximately 0.5 sec. If the stage comparator reverts to the "off" condition, the relay is immediately inactivated, since Q_1 goes "on," immediately shorting the $500\mu\text{F}$

capacitor to ground, thereby turning Q_2 "off." This 0.5 sec on-time delay is necessary to compensate for the inertial "coasting" effect when the elapsed-time indicator is turned off.

Consequently, at any given time one of the delay circuits will be found "on," thus showing the current sleep stage indicated by the analyzer. When in the "on" condition, each double-pole relay activates its corresponding panel lamp (Drake 5131-072) to indicate the current stage of sleep and simultaneously turns on a cumulative-time indicator clock (Caslon 701). Each elapsed-time indicator thus keeps a cumulative record of the amount of time the corresponding panel lamp is illuminated, and this value is equivalent to the total amount of time occupied by that particular stage of sleep.

The input signal to the display console (since it is an analog voltage proportional to sleep stage) may also be utilized after suitable amplification to drive the vertical axis of a strip-chart recorder to obtain a graphic profile of sleep stage versus time. Initial amplification is provided by the Fairchild 741 operational amplifier and final amplification by the differential configuration consisting of one 2N1304, one 2N1374 and two 2N456 transistors. This circuit is sufficient to drive the pens of the M. F. E. model M-2 recorder, which runs at a speed of approximately 7 in. /hr.

Operation and Care of Display Console Units D-4 and D-5

Specifications

Power Input:	110-120 V a. c., 60 Hz
Telemetry Signal Input:	+ .92 to +4.72 V d. c., seven discrete voltage levels as specified in Table 1.
Output:	Strip chart recorder; eight pilot lamps, one indicating total time, seven corresponding to stages of sleep. Eight digital clocks, one accumulating total time, remaining seven accumulating time for specific stages of sleep.

Operation

1. Place POWER and TIMER switches in the OFF position.
2. Plug POWER CORD into 110-120 V a. c., 60 Hz outlet.
3. Apply proper telemetry signal voltage to B.N.C. connector on the back of the unit (one of seven discrete levels).
4. Zero TIMERS by rotating the dial downward.

CAUTION Do not attempt to rotate the dial UP.
Do not touch the numbered flaps.

If at any time the numbered flap stops on the lower edge of the visual access hole, gently press inward on the SETTING DIAL.

5. Place POWER SWITCH in the ON position.
The chart recorder and indicator light are now operational.
6. Place TIMER SWITCH in the ON position.

UNIT IS NOW OPERATIONAL.

TABLE I
Voltage Values for Sleep Stages

Awake	=	0.929 V
Stage 1	=	1.561 V
REM	=	2.194 V
Stage 2	=	2.826 V
Stage 3	=	3.459 V
Stage 4	=	4.091 V
Stage 0	=	4.723 V

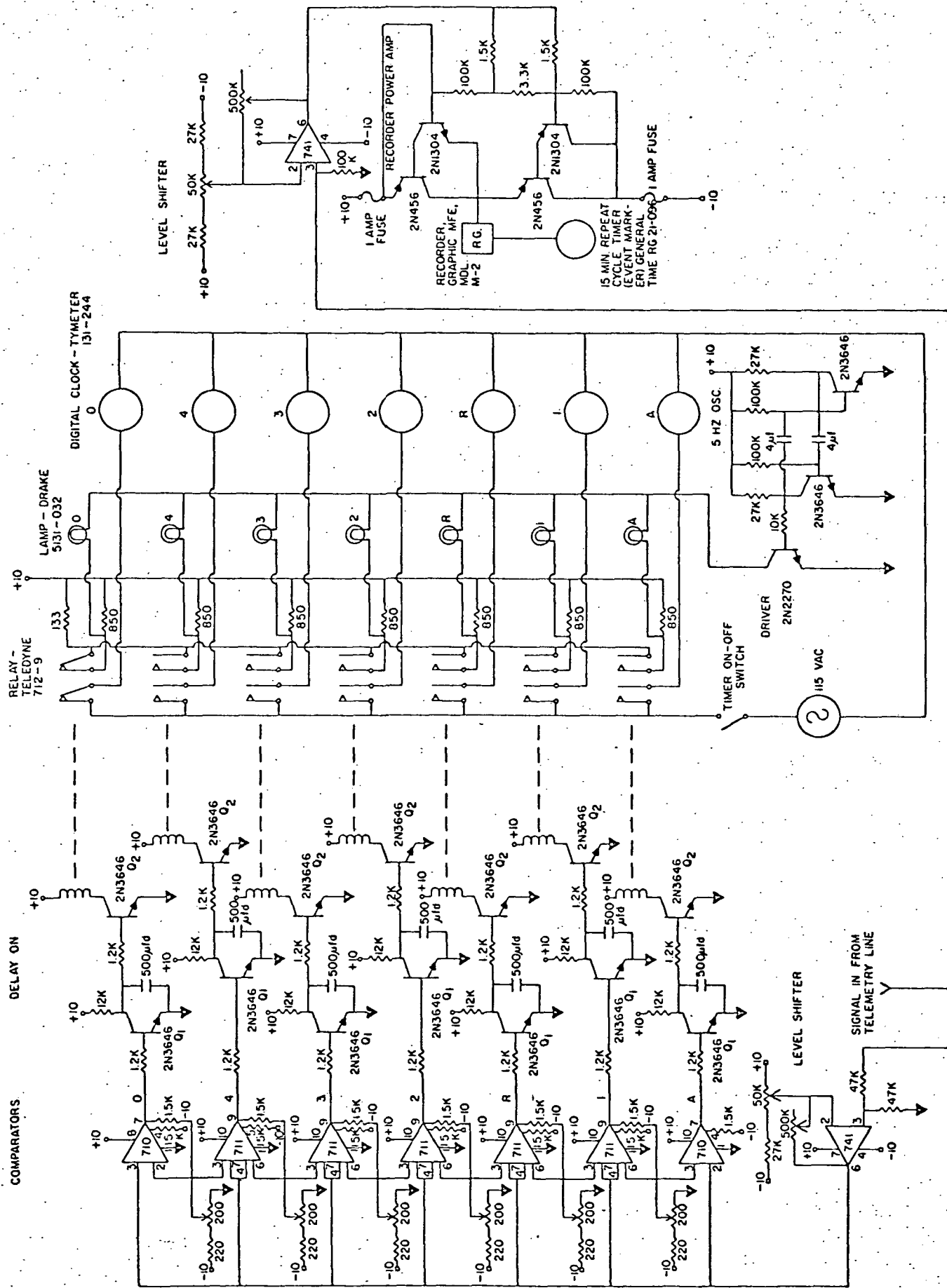


Fig. 1 Prototype Display Console

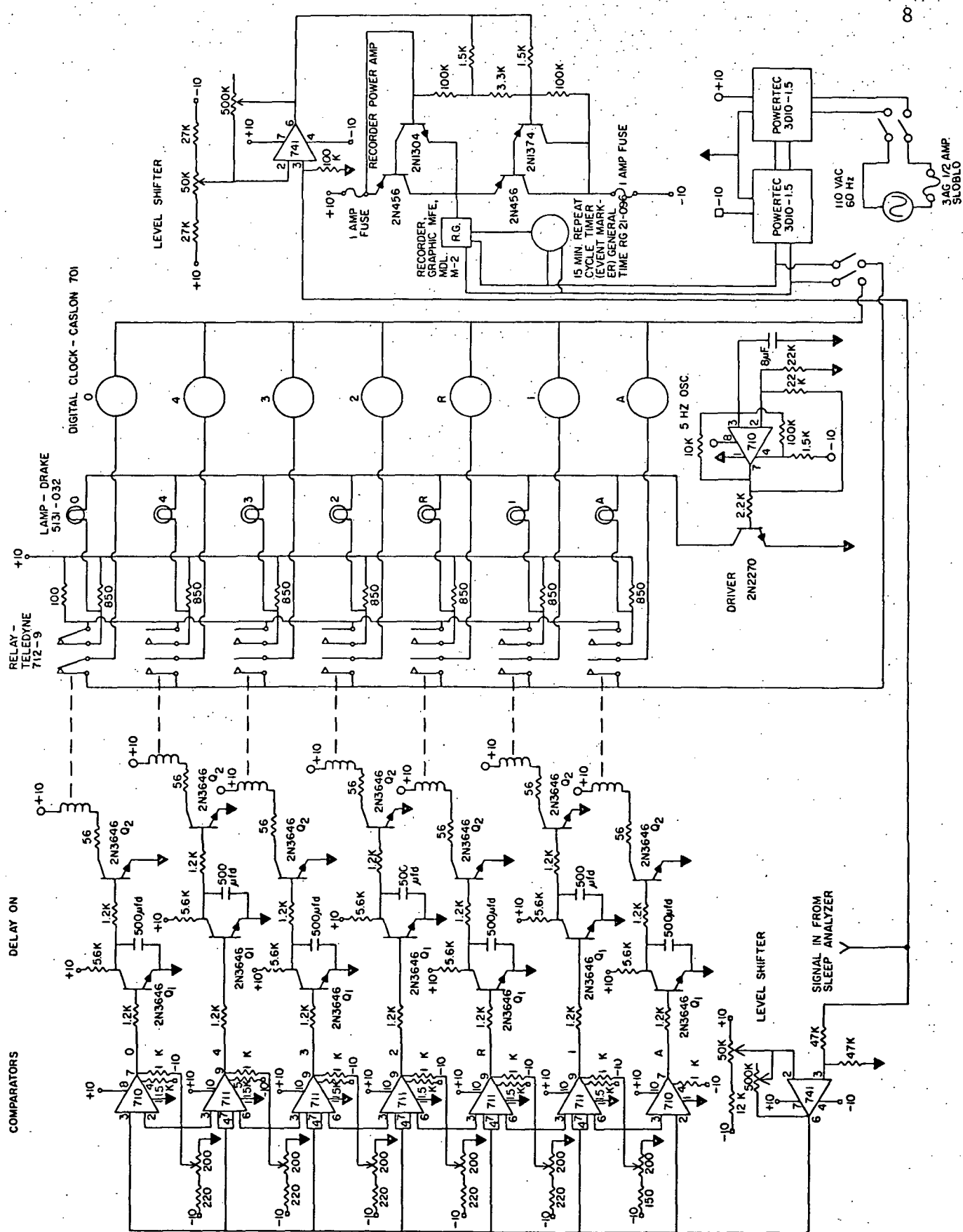


Fig. 2. Schematic for Display Consoles D-4 and D-5