A digital data acquisition system

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A DIGITAL DATA ACQUISITION SYSTEM

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ABSTRACT

A digital data acquisition system with punched paper tape output has been assembled; it consists of a digital voltmeter, digital clock, and typewriter and tape punch. An interface unit was designed and constructed and is described in detail. The maximum sample rate is about two per second, and accuracy about 0.1%. The system is used to record results of observations of the airglow surrounding the earth, as well as a time signal at the beginning of each set of readings.

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A DIGITAL DATA ACQUISITION SYSTEM

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INTRODUCTION

During the course of an experimental program which was initiated to observe the infrared spectrum of the airglow surrounding the earth it became apparent that a digital data acquisition system would be very useful. Digital records could improve both the speed and accuracy of analysis of the results as compared with analog records.

The type of digitizing system chosen was dependent upon several factors. First, since the rate at which information was retrieved by the optical systems was relatively slow, a maximum digitizing rate of two samples per second was adequate; secondly, a digitizing accuracy of 0.1% was sufficient. This meant that a simple perforated paper-tape system and moderate digital voltmeter would be suitable.

Since results of observations of the airglow spectrum obviously depend upon local time, owing to effects such as the scattered solar continuum, it was advisable to include some method for digitally recording the time. A simple electromechanical digital clock which registered hours and minutes was considered to be adequate.

It was advantageous to arrange that the digital system accept both voltage and time information asynchronously since the requirements for digitizing rate and recording of time varied with different types of experiments. The asynchronism feature made it necessary to incorporate a type of command which could be detected during the subsequent computer analysis as the end of a given set of information, since there would be an unknown number of samples in a given set. This command was to be initiated by the observing instrument at an appropriate time such as at the beginning or end of a spectral scan.

DESCRIPTION OF COMMERCIAL EQUIPMENT IN THE SYSTEM

The master unit in the system is a Hewlett-Packard Model 3440A digital voltmeter with a Model 3443A plug-in chassis. The voltmeter is used to initiate all the sampling commands with a continuously variable time between samples.

A paper-tape perforator included in a Teletype Model 33 ASR typewriter is used, which can operate at a maximum rate of ten characters per second. The typewriter simultaneously produces a printed copy of all information being recorded on paper tape. The keyboard

may be used to enter information on the paper tape. The unit also includes a paper-tape reader which may be used to verify previously perforated paper tape.

A Chrono-Log Model 2500-B electromechanical digital clock provides the time information in hours and minutes in binary coded decimal format.

The three units mentioned above have been made compatible by constructing an interface unit which performs the required functions.

SEQUENCE OF OPERATIONS

The operating sequence of the system is shown in Fig. 1. The function blocks contained within the dotted lines designate control circuitry located in the interface unit. This unit accepts information from the digital voltmeter, the digital clock, and the airglow observational equipment. It directs the appropriate information to the typewriter and controls the data output format.

When the system is in the signal recording mode the interface accepts PRINT commands from the voltmeter and transfers the voltmeter reading to the typewriter after performing the required modifications to the digital signal. After eight voltage readings of four digits each have been transferred, the interface generates RETURN and LINE FEED functions. The recording of the voltmeter readings continues until a command is received by the interface from the airglow observing instrument indicating that the end of a spectral scan has been reached. All subsequent groups of four characters are formed by the use of the numeral 8 exclusively until the RETURN and LINE FEED functions are generated by the interface. The first group of four characters on the next line is then accepted from the digital clock and directed to the output unit. After recording the time, the interface then resumes the recording of voltmeter readings. This line then has one time reading and seven voltmeter readings. All subsequent lines have eight voltmeter readings until the signal signifying the end of a spectral scan is again received by the interface, at which time the sequence is repeated from the recording of the numeral 8.

OPERATING INSTRUCTIONS

The voltmeter and digital clock are connected to the interface unit, and a suitable range is selected on the digital voltmeter before the power

to the interface is turned on and before the Teletype is connected to the interface. The voltmeter is then placed in the HOLD position so that no PRINT commands are generated until desired. The interface power is turned on and the RESET button on the interface front panel is depressed. The RETURN and LINE FEED functions are entered manually on the Teletype and the paper tape is advanced to provide a leader. The Teletype is connected to the interface unit and the system is then ready to record information as soon as the voltmeter is adjusted to produce PRINT commands. The recording rate is continuously variable but must be less than two readings per second.

The digital clock is set before a time reading is required. A contact closure must be supplied by the airglow observing instrument to the interface unit whenever the reading of time is required or when the end of a scan is to be indicated.

The recording may be stopped at any time by placing the voltmeter in the HOLD position. The recording rate may also be varied at any time.

DESCRIPTION OF CIRCUITRY

The detailed electronic circuitry contained in the function blocks located inside the dotted line in Fig. 1 is discussed below.

Some of the signal conditioning circuitry between the voltmeter output and typewriter input is shown in Fig. 2 (Board A). It includes gating facilities to change from the voltmeter output of 16 parallel lines representing 4 binary coded decimal digits to 4 parallel lines which present the 4 binary coded decimal digits in series as required by the typewriter. It also changes the weighting of the binary code from 1-2-4-2, as presented by the voltmeter, to 1-2-4-8, as required by the typewriter.

The circuits in Fig. 3 (Board B) contain gating functions to convert the fully parallel output of the digital clock to an output of 4 serial decimal digits with each digit presented in the parallel 1-2-4-8 binary code. A scale-of-8 counter which controls the number of readings per line of printed output is also contained on Board B. It is followed by a time delay circuit to allow time for the printing of the last 4-digit number in a line, before the RETURN and LINE FEED functions are generated.

The circuitry which generates the commands required to operate the parallel-to-serial gating functions is shown in Fig. 4 (Board C). The PRINT command from the voltmeter is used to condition two one-shot multivibrators which generate the 4 commands used to successively select the 4 decimal digits. For each PRINT command received, one pulse is directed to the scale-of-8 counter and 4 typewriter START signals are generated.

The reed relay circuits which provide the desired contact closures required by the typewriter are shown in Fig. 5 (Board D). Also on Board D are the circuits which generate the typewriter START, RETURN, and LINE FEED functions on command from other circuitry.

The circuitry which selects the source of the digital information to be recorded by the typewriter is shown in Fig. 6 (Board E). It selects the voltmeter or clock output, or it may generate the signals required to type the numeral 8 depending upon the current state in the sequence of operations as discussed previously. The external signals which control the operating sequence come from the observing instrument, the voltmeter PRINT command, the delayed output of the scale-of-8 counter, and the RESET switch on the interface front panel.

The circuit diagram of the power supply is shown in Fig. 7. The dynamic output impedance is sufficiently low so that no additional filtering is required in the circuitry.

The connections between the various boards and connectors along with wire colour codes are given in Table I.

TABLE I

Tabulation of circuit board interconnections

BOARD A		BOARD B		BOARD C		BOARD D		BOARD E	
+GND 1 B1 C1 D1 E1	Rd	1	Rd	1 +GND	Rd	1 +GND	Rd	+GND 1 A1 B1 C1 D1	Rd
-18V 2 B2 C2 D2 E2	Bk	2	Bk	2 -18V	Bk	2 -18V	Bk	-18V 2 A2 B2 C2 D2	Bk
3 F1	O	3 D19	O	3 F17 E10	Rd/W	3 B11 A23	Pk	3 J1	O
4 F2	Y	4 E5	Y	4 D20	V/W	4 B10 A24	Gy	4 J2	Pk
5 F3	Gn	5		5 B13	Gn	5 B9 A25	W	5 B4	Y
6 F4	LBu	6 E6	V	6 B18	Y/W	6 B8 E8 A26	Gn	6 B6	V
7 C12	Pu	7 C13	Gy	7 B23	Bn	7		7 B12	W
8 F5	Gy	8 D6 E8	Gn	8 B28	Bu	8		8 D6 B8	Gn
9 F6	W	9 D5	W	9 A22	Bu	9		9 A27	V
10 F7	V	10 D4	Gy	10 A17	Gy/W	10 HF	O	10 F17 C3	Rd/W
11 F8	Rd/W	11 D3	Pk	11 A12	Bk/W	11 Hd	Y	11	
12 C11	Bk/W	12 E7	W	12 A7	Pk	12 HZ	Gn	12	
13 F9	O/W	13 C5	Gn	13 B7	Gy	13 HL	Bu	13 A27 D21 E9	V
14 F10	Y/W	14 G1	Bu	14		14 HV	Pk	14 To push button	O/W
15 F11	Gn/W	15 G2	Rd/W	15		15 HR	Gy	15 i.e. reset flip-flop	
16 F12	Bu/W	16 G3	Bk/W	16		16 HJ HB	W		
17 C10	Gy/W	17 G4	O/W			17 HN	V	16	
18 F13	Bn/W	18 C6	Y/W			18 HT	Bn	17	
19 F14	V/W	19 G5	Gn/W			19 B3	O	18	
20 F15	O	20 G6	Bu/W			20 C4	V/W	19	
21 F16	Y	21 G7	Gy/W			21 A27 E13	V	20	
22 C9	Bu	22 G8	Bn/W			22 14V			
23 D3 B11	Pk	23 C7	Bn			23			
24 D4 B10	Gy	24 G9	V/W						
25 D5 B9	W	25 G10	O						
26 D6 B8 E8	Gn	26 G11	Y						
27 D21 E13	V	27 G12	Gn						
28		28 C8	Bu						
29		29 G13	Pk						
30		30 G14	Gy						
		31 G15	W						
		32 G16	V						

F Cannon connector 19 pin, female, to digital voltmeter	G Cannon connector 19 pin, male, to digital clock	H 10 pin amp connector to Teletype	J Cannon connector 2 pin, female, to end-of-scan microswitch
1 J9 Bu A3	1 B14 CK8 Bu	F D10 O	1 E3 O
2 J10 V A4	2 B15 CK4 Rd/W	d D11 Y	2 E4 Pk
3 J35 V/W A5	3 B16 CK2 Bk/W	Z D12 Gn	
4 J34 Gn/W A6	4 B17 CK1 O/W	L D13 Bu	
5 J7 Y A8	5 B19	V D14 Pk	
6 J8 Gn A9	6 B20 CK14 Bu/W	R D15 Gy	
7 J33 Y/W A10	7 B21 CK12 Gy/W	B HJ D16 W	
8 J32 O/W A11	8 B22 CK11 Bn/W	J HB D16 W	
9 J5 Rd A13	9 B24 CK28 V/W	N D17 V	
10 J6 O A14	10 B25 CK24 O	T D18 Bn	
11 J31 Rd/W A15	11 B26 CK22 Y		
12 J30 Bk/W A16	12 B27 CK21 Gn		
13 J3 Bn A18	13 B29		
14 J4 Bk A19	14 B30		
15 J29 Pk A20	15 B31 CK32 W		
16 J28 W A21	16 B32 CK31 V		
17 J23 Gy GND	17 CK5 CK15 CK25 CK35		
18 Spare Bu/W	18		
19 Gy/W	19		

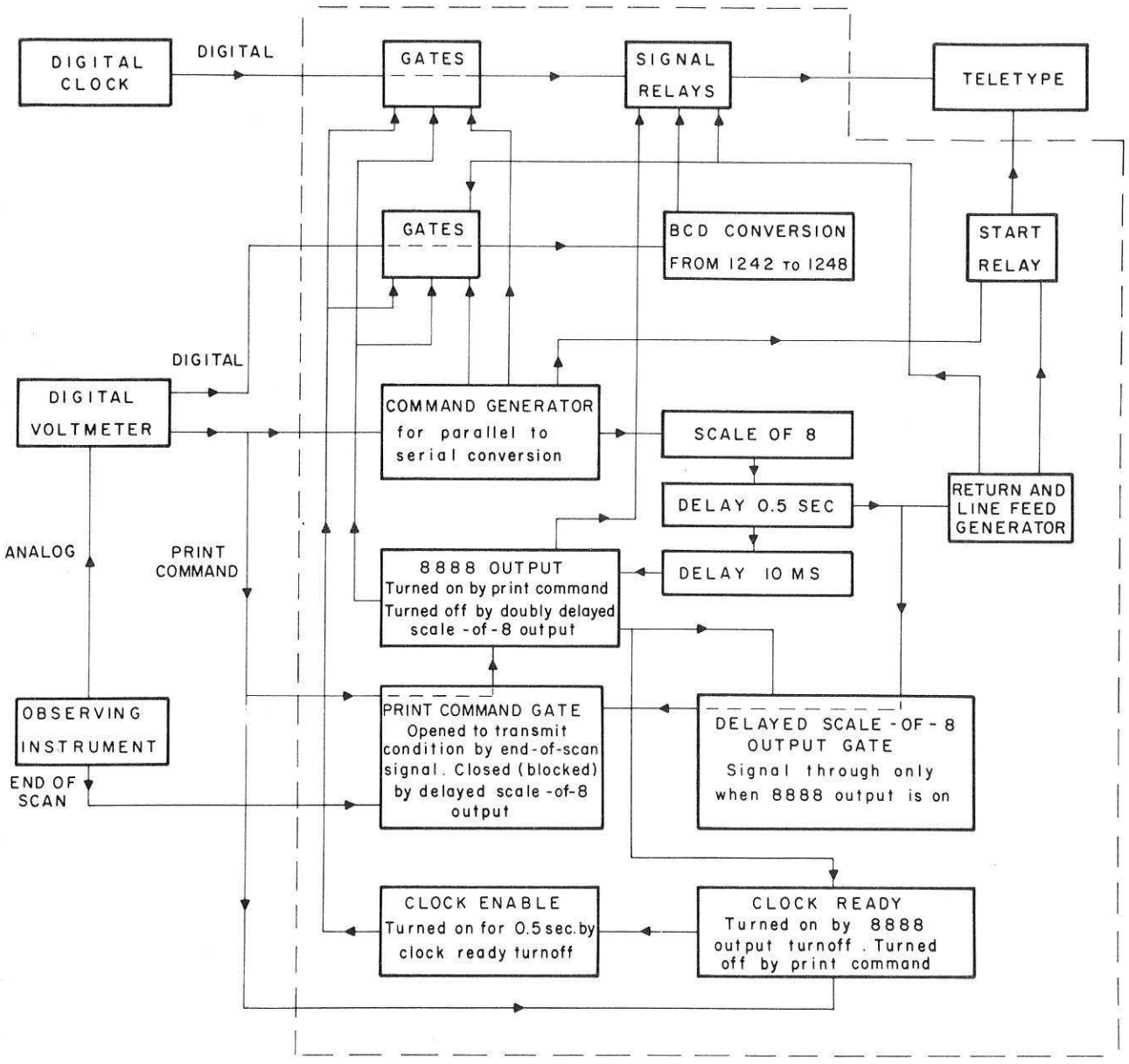

Fig. 1 Sequence of operations of the data handling system

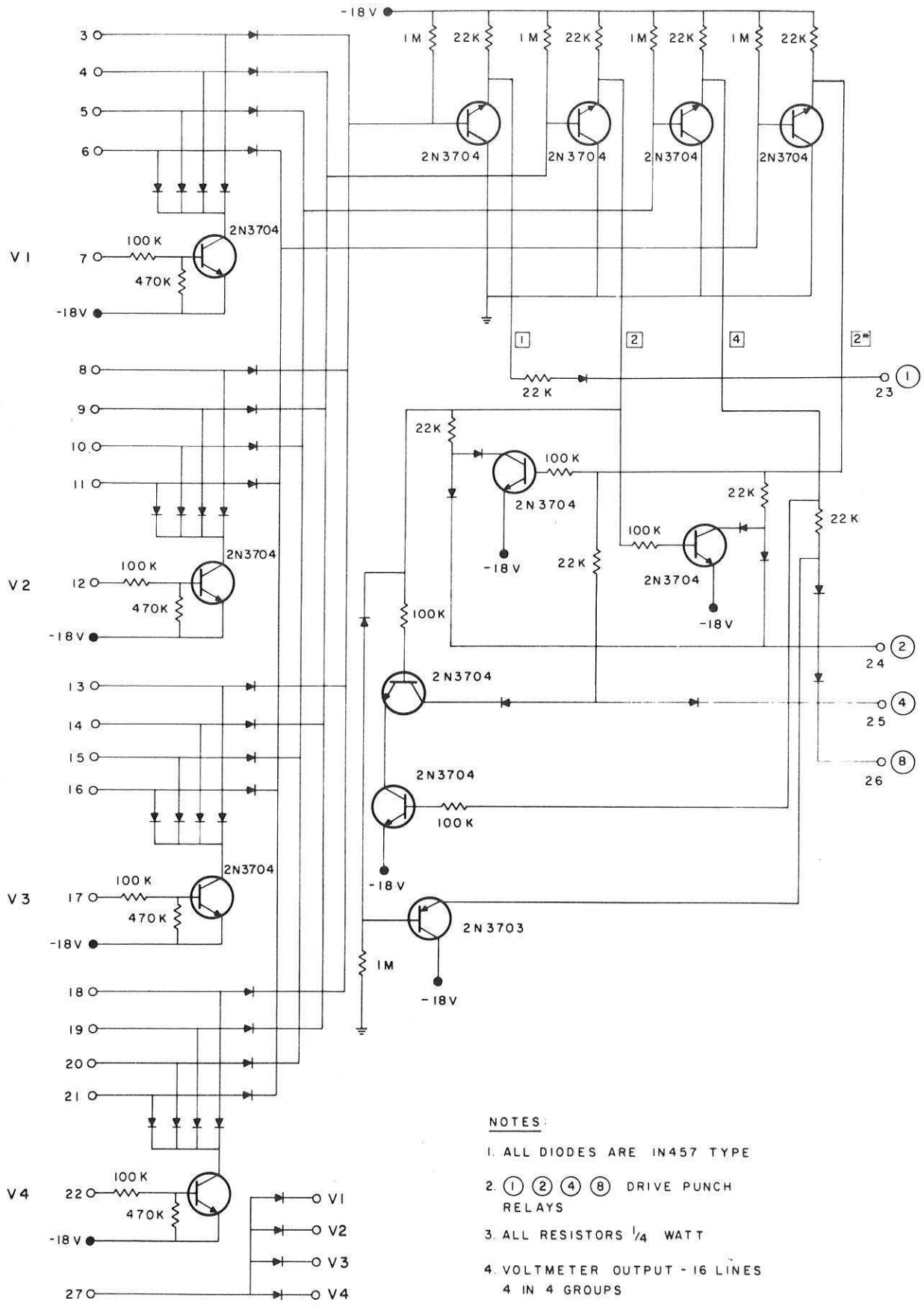

Fig. 2 Board A - Gating to convert voltmeter readings from four decimal digits in parallel (each in 1-2-4-2 binary code) to four decimal digits in series (each in 1-2-4-8 binary code)

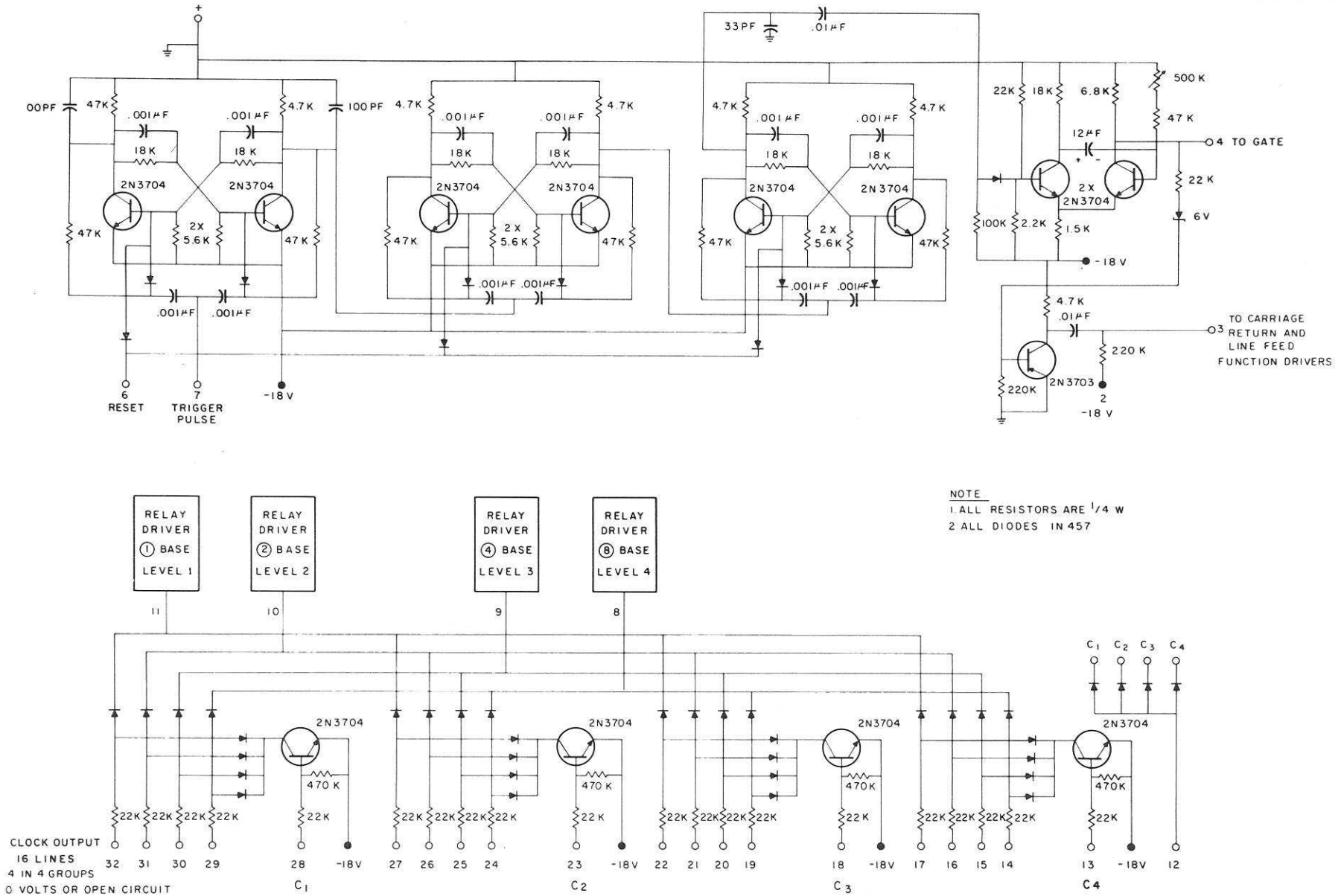

Fig. 3 Board B - Gating to convert time readings from four decimal digits in parallel to four decimal digits in series (all in 1-2-4-8 code). Scale-of-8 counter and time delay

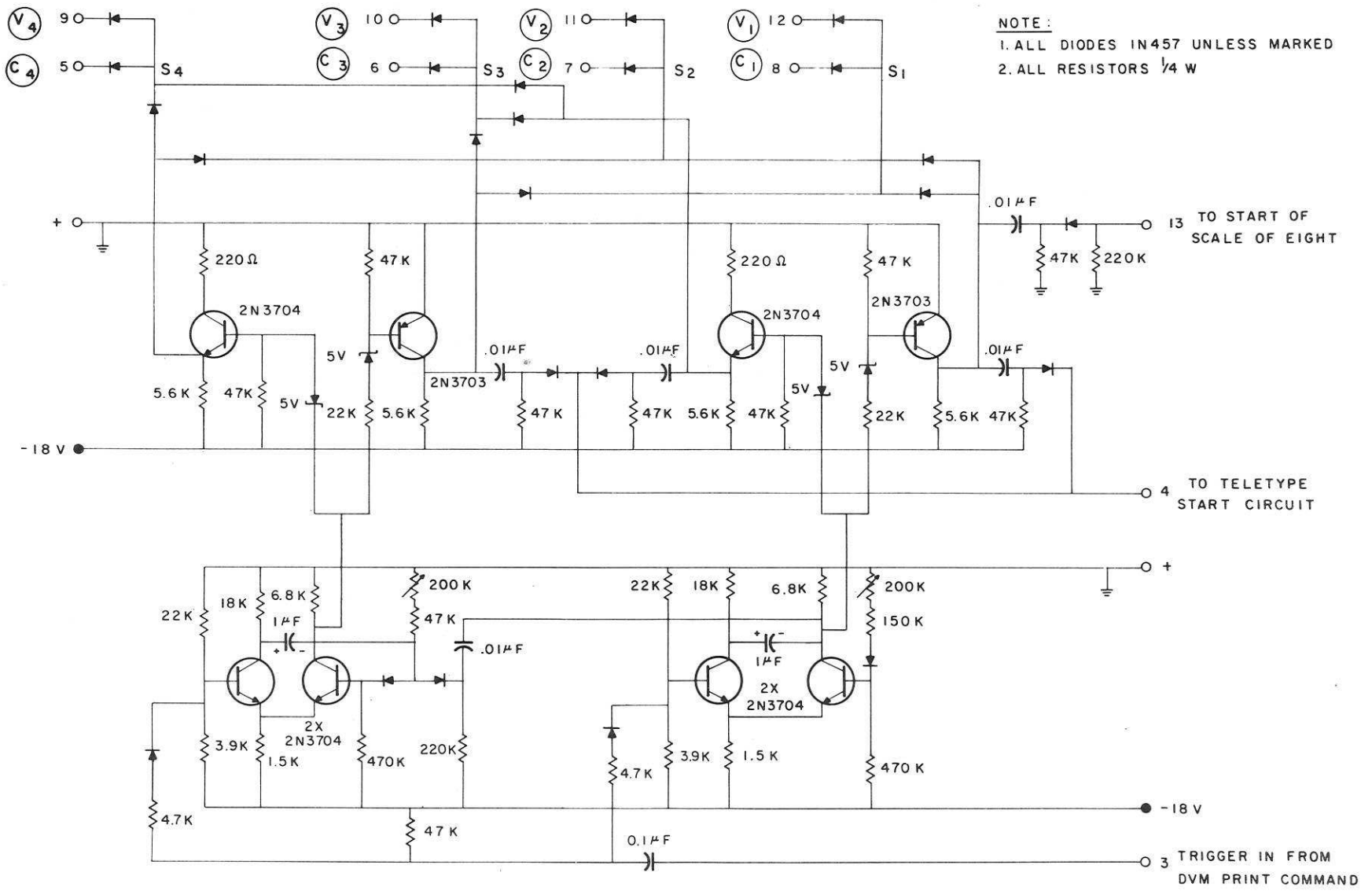

Fig. 4 Board C - Command generator to operate parallel-to-serial gating functions

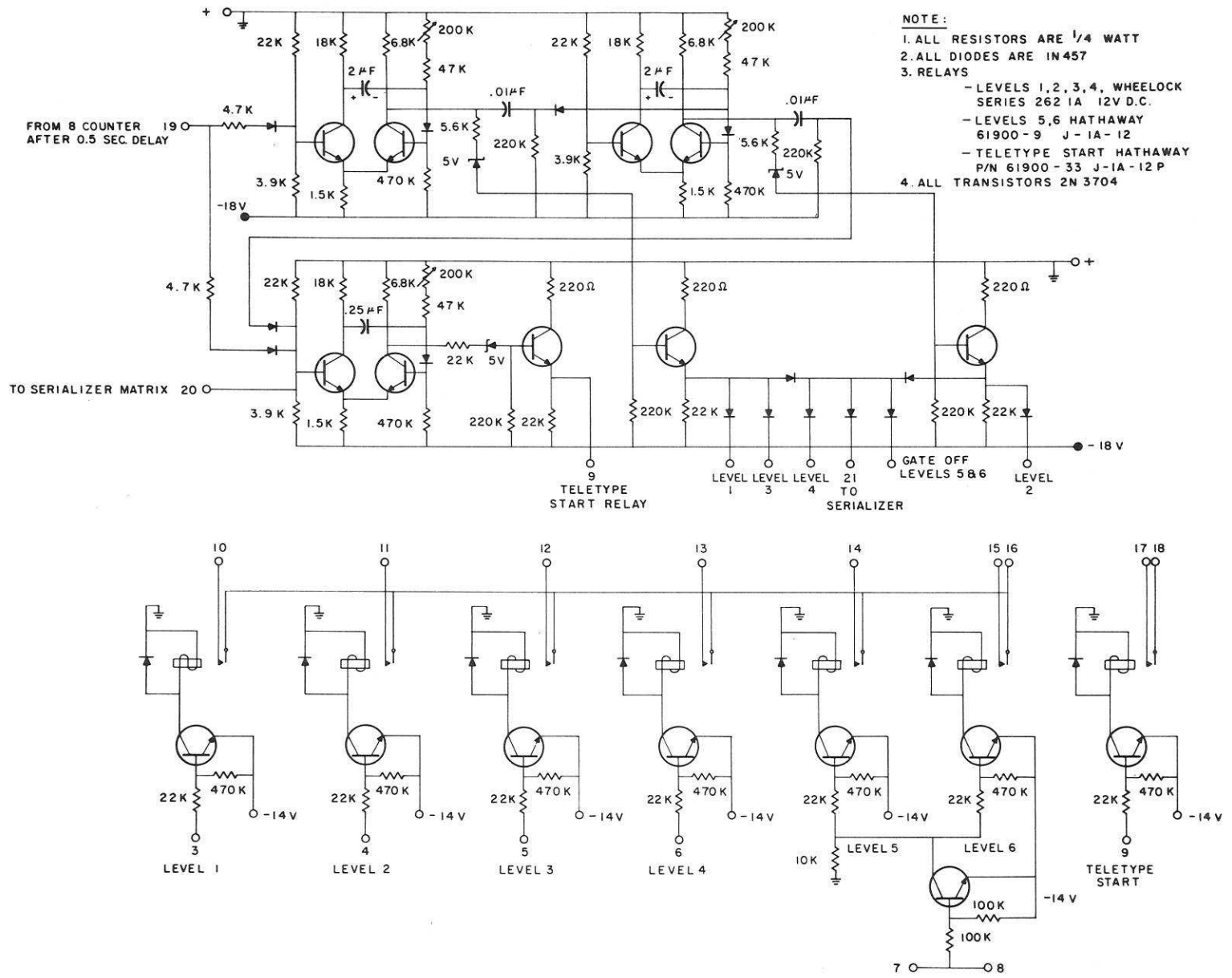

Fig. 5 Board D - RETURN, LINE-FEED, and START function generators, plus reed relays which provide contact closures required by typewriter

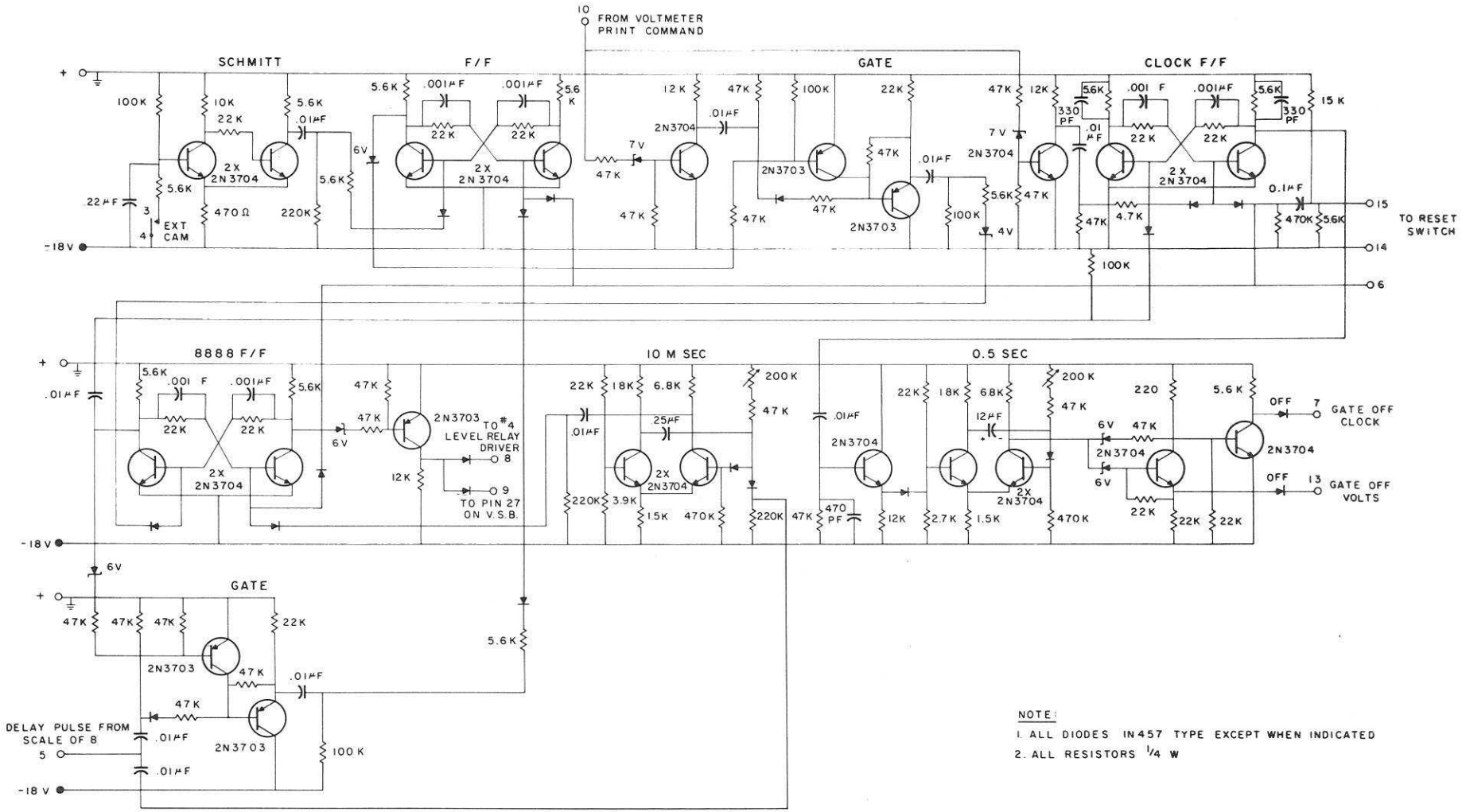

Fig. 6 Board E - Control circuits to select voltmeter or clock input or produce numeral 8 output

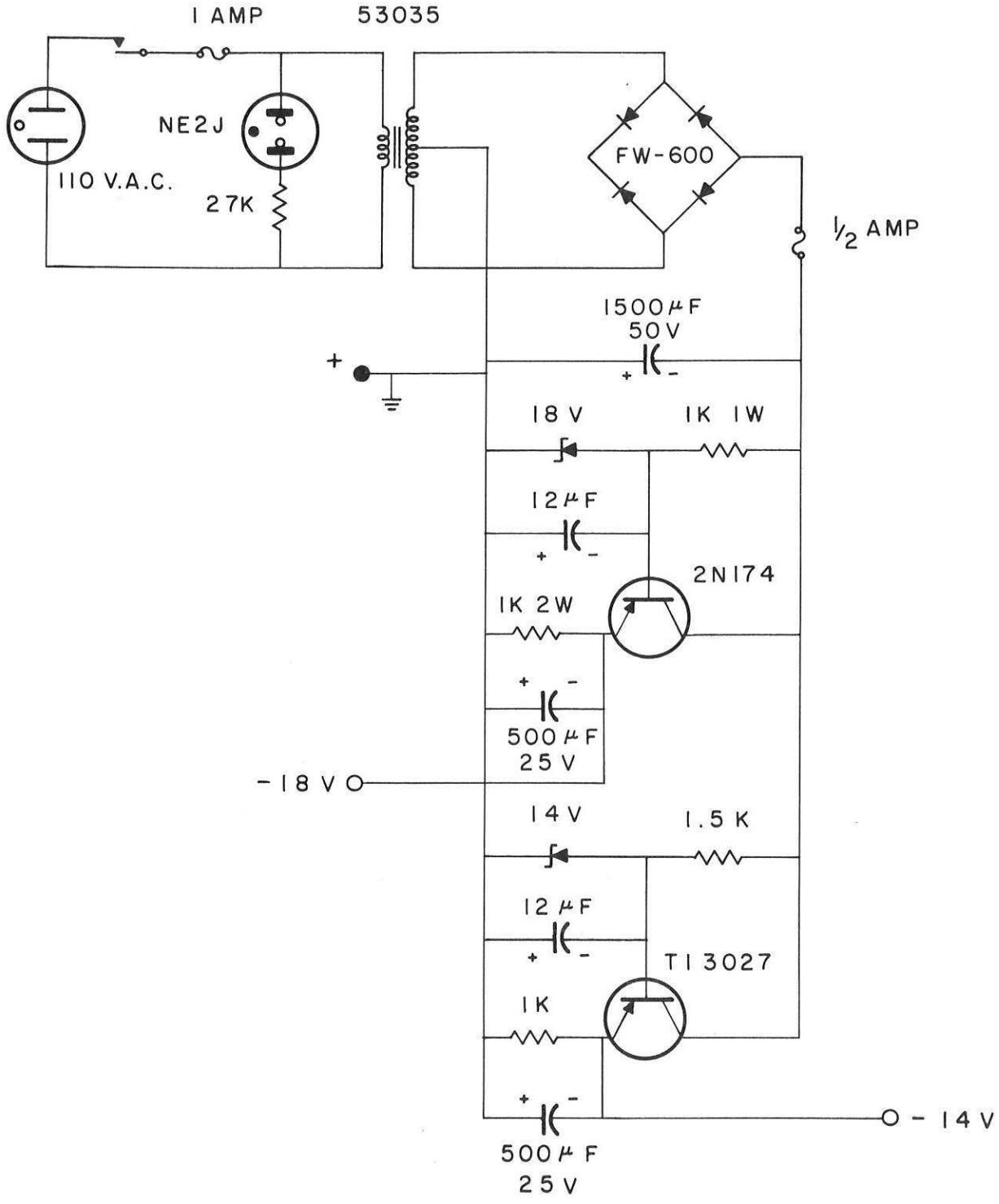

Fig. 7 Regulated power supply