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BRIEF COMMUNICATION

Automated System for Acquisition and Reduction of Startle Response Data

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WEISS, G. T. AND M. DAVIS. *Automated system for acquisition and reduction of startle response data.* PHARMAC. BIOCHEM. BEHAV. 4(6) 713–720, 1976. – A system specifically designed for the acquisition and reduction of startle data is described. It is able to (1) sample startle responses from 5 animals simultaneously during a specific time band after the eliciting stimulus, (2) convert the analogue startle amplitudes into 2-digit numbers, (3) print the digital results of each startle in each animal; (4) add up the startle amplitudes for each rat over a preset number of stimuli and print the totals, (5) print the interstimulus interval and (6) code for up to six different types of trials A non-technical description and complete wiring diagrams are provided.

Startle response   Data acquisition   Data reduction

THE startle response in the rat is being increasingly used for the analysis of animal behavior. This reflex, which is typically elicited by a loud sound, has a short, reproducible latency and occurs in virtually every rat. Startle is extremely sensitive to a large number of variables which can be experimentally manipulated. Thus it can be altered by changes in the parameters of the eliciting stimulus, surrouding environmental stimuli or general state of the animal (see [3]). During repetitive stimulation, startle either habituates or sensitizes, depending on the exact parameters used, and has provided an excellent model system for the analysis of behavioral plasticity. In addition, startle is sensitive to various drugs and is currently being used to investigate the pharmacology of behavior.

To date, many different systems have been described for measuring startle. In all cases, startle is detected by movement of a cage which is translated into a voltage, suitably amplified, and then displayed, typically with some type of pen recorder. A variety of transducers such as accelerometers [6] magnets within coils [5] phonograph cartridges [2] strain gauges [7] or even purely mechanical systems [1] have been used. All of the systems produce comparable results, in the sense that startle is repeatedly shown to be dependent on stimulus intensity, interstimulus interval, background noise, etc.

A major problem in this area, however, is not so much in the measurement of startle, but what to do with the data once it is gathered. For example, to evaluate the effects of a given drug on startle properly, it is necessary to test many animals over substantial periods of time at several doses. This is the only way to get a stable estimate of startle amplitude over periods long enough to sample the full duration of the drug effect. Very quickly, the investigator is faced with literally thousands of startle amplitudes to quantify. The prospect of measuring each startle in mm of pen deflection is awsome and sometimes persuades the investigator to sample startle in a limited way, which may lead to erroneous conclusions.

In addition, when using a pen recording system, it is often difficult to discriminate stimulus-elicited movements (startle) from spontaneous movements that may be occuring at about the same time (e.g. after certain drugs). In fact, with certain drugs it is essentially impossible to make this discrimination unless one actually watches the record as it comes out, or runs the paper at very fast speeds.

For these reasons, we have developed a system which markedly improves the acquisition and reduction of startle data. It has the ability to (1) sample cage movement from 5 cages simultaneously during a specified time band after presentation of the startle-eliciting stimulus; (2) convert the analogue startle amplitudes into a 2-digit number, (3) print the digital results of each startle in each animal, and (4) add up the startle amplitudes for each rat over a preset number of stimuli and print the totals. In addition, the interval between stimulus presentations (ISI) or between the startle stimulus and a prior event (e.g. for pre-pulse inhibition experiments) and a code for 6 different types of trials are printed automatically alongside the startle scores.

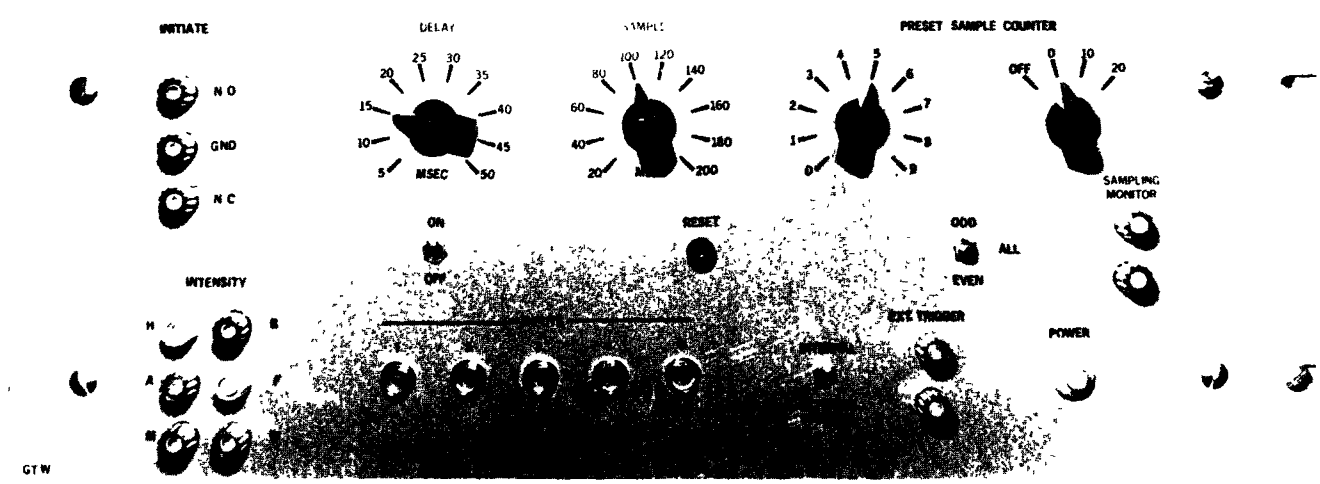

FIG. 1 Front panel of the Data Reduction Unit.

DATA ACQUISITION

Five stabilimeter devices are used to record the amplitude of the startle response. Each stabilimeter consists of an 8 × 15 × 15 cm Plexiglas and wire mesh cage suspended within a 25 × 20 × 20 cm steel frame. Within this frame the cage is rigidly sandwiched between 4 compression springs above, and a 5 × 5 cm rubber cylinder, below. An accelerometer (M. B. Electronics Type 302), with a sensitivity of 40–60 mV/g, is located between the bottom of the cage and the top of the rubber cylinder. Cage movement results in a slight and imperceptible displacement of the accelerometer. The resultant voltage is fed to a matched accelerometer amplifier (M. B Electronics Model N504), the output of which is proportionate to the velocity of accelerometer displacement. Measuring velocity (i.e. amplifier on the Integrate position) rather than acceleration proved to be more sensitive and eliminated artifacts during presentation of the eliciting tone. Since the cage is rigidly held in place and no mechanical adjustments are required, the system has remained very stable over several years.

DATA REDUCTION

Figure 1 shows the front panel of the Data Reduction Unit. Five independent BNC input connectors accept the outputs of the 5 accelerometer amplifiers. The useful range of input voltages extends from 0.1–9.9 volts, which ultimately correspond to startle amplitudes from 1–99. Although we happen to use the startle cages described above, the unit can be used with any of the types of startle cages in current use, by adjusting their outputs to be within the 0.1 – 10 volt range.

The unit was designed to be interfaced with electromechanical programming equipment with appropriate safeguards for relay bounce and electrical artifacts. The NO, C and NC studs of a conventional double throw relay are connected to the NO, C and NC Initiate jacks. When the relay is operated a complete cycle of the unit begins. Upon initiation, the analogue output of the startle cage is sampled for a specified time band. This time band can be varied from 20–200 msec in 20 msec steps by the Sample dial. The beginning of the sample period can be delayed from 5–50 msec after the initiate pulse by the Delay dial. This

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99. 81. 19. 33. 21.   150. H
97. 95. 20. 19. 37.   150. A
88. 98. 38. 31. 08.   150. M
40. 97. 24. 23. 16.   150. B
99. 94. 36. 39. 22.   150. F
00. 00. 04. 09. 00.   150. W
04. 03. 05. 01. 00.   150. W
94. 77. 24. 23. 31.   150. F
98. 99. 61. 43. 97.   150. B
45. 65. 34. 65. 35.   150. M
42. 78. 25. 17. 24.   150. A
58. 81. 31. 23. 30.   150. H

591.600.334.212.319.  105. M
 47. 77. 30. 23. 27.  105. M
 64. 72. 35. 35. 57.  105. M
 48. 66. 28. 25. 52.  105. M
 61. 69. 32. 25. 44.  105. M
 40. 99. 09. 15. 08.  105. M
 51. 65. 68. 19. 18.  105. M
 75. 47. 37. 13. 29.  105. M
 57. 47. 30. 17. 26.  105. M
 49. 20. 26. 07. 16.  105. M
 99. 38. 39. 33. 42.> 536. M
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FIG. 2. Photograph of a sample printout.

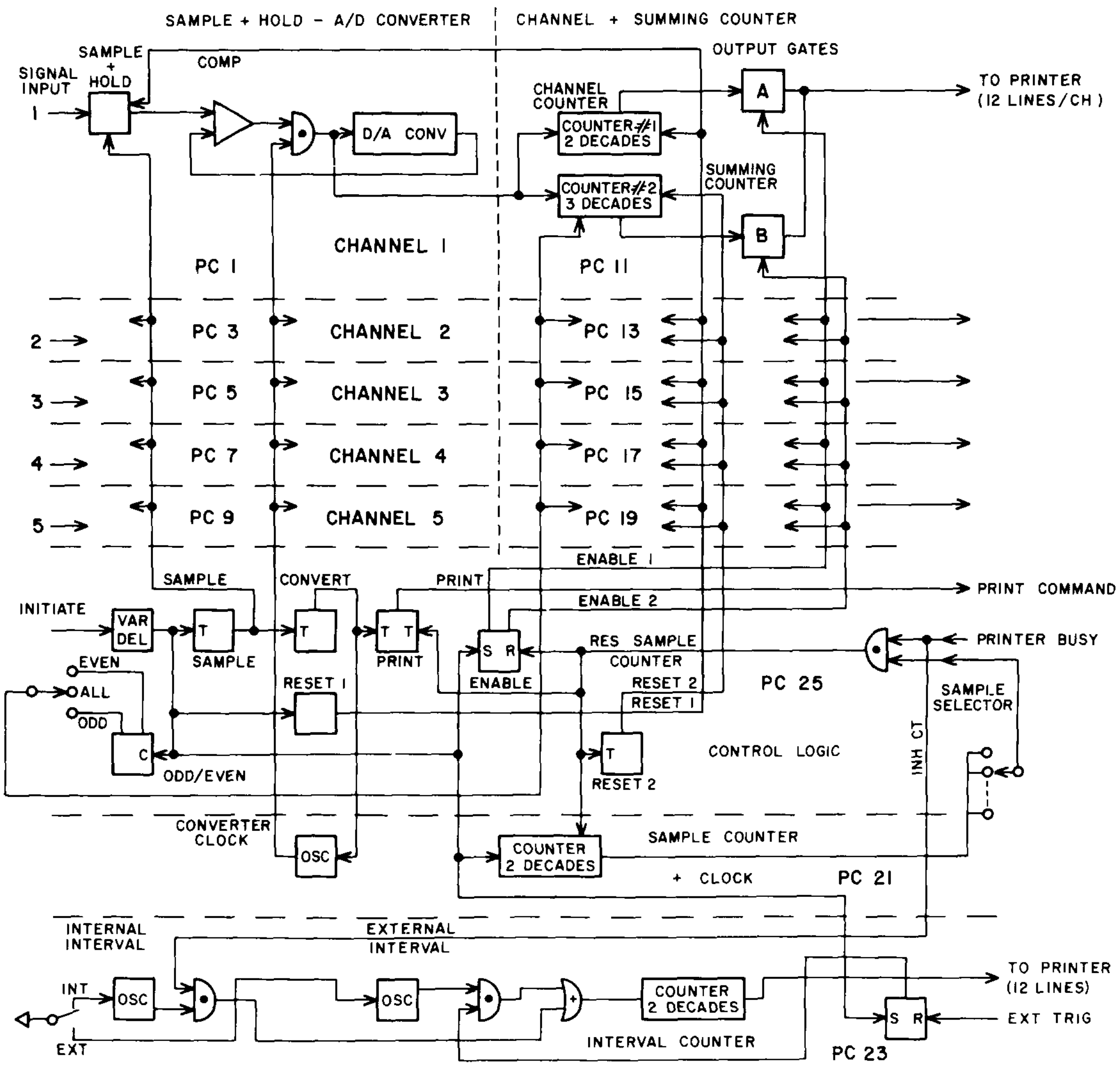

FIG. 3. Block diagram of the overall action of the Data Reduction System

was included to compensate for relay delays in electromechanical equipment when different relays are used to initiate the unit and to deliver the startle stimulus.

The Preset Sample Counter dials are used to determine the number of trials over which the startle scores are added. A total of 29 trials are possible. Depending on the location of the 3-position toggle switch below these dials, the summing counter will either sum over all trials (All) or every other trial (Odd-Even). This feature was included for the following reasons. As mentioned earlier, in evaluating the effects of certain drugs on startle, it is often the case that these drugs greatly increase activity. Since increased activity results in increased cage movement, part of the voltage sampled during the sample period, and considered as startle, may actually result from drug-induced increases in activity, rather than drug-induced increases in startle. To determine the contribution of this activity in contaminating the measures of startle, dummy trials can be included in which the initiate pulse is given in the absence of a startle-eliciting stimulus. In this way, cage movement can be compared to cage movement shortly following the startle stimulus over identical sample time bands If the real trials and dummy trials are alternated, the sample counter can still sum over the real trials, leaving only the dummy trials to sum by hand. This technique has been very successful in discriminating amphetamine-induced increases in startle from increases in activity [4] and is an important control in any drug study on startle. In other situations where different types of trials are alternated, such as two stimulus intensities, the odd-even switch allows half the trials to be summated, leaving the other half to do by hand.

The Intensity jacks allow 6 types of trials to be identified on the paper print out. This is accomplished by applying ground during the trial to one of the six jacks. This is helpful when complicated, balanced schedules of different trial types are used, and insures that the exact identification is permanently affixed next to the startle values for future reference.

The Internal-External trigger jacks and switch relate to the measurement of inter-event intervals. In the Internal position, the interval between print cycles (up to 99.9 sec) is automatically printed and used to monitor inter-stimulus

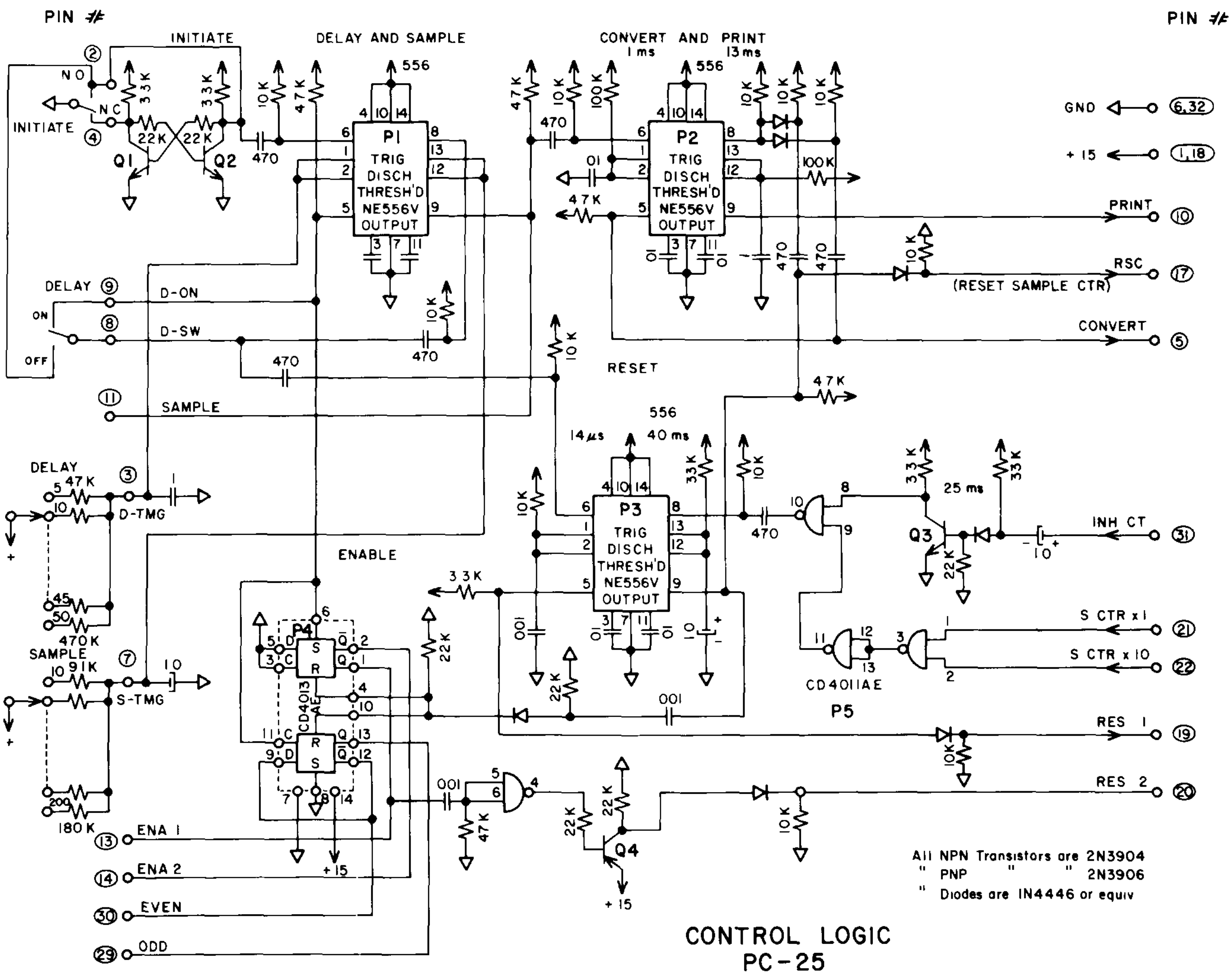

FIG 4 Overall circuit diagram of the control logic

interval. If intervals greater than 99.9 sec are used, a > sign is printed to the left. In the External position, the interval between a ground pulse to the External Trigger jack and the Initiate signal is measured. In this case the range is up to 999 msec and can be used when very short pre-pulse inhibitory effects are being studied.

Finally, the Sample Monitor jacks are provided to give a −15 volt DC signal during the Sample time band for calibration on an oscilloscope. When this is displayed alongside the actual anlogue output of the startle cage, it is easy to determine exactly what components of cage movement are being sampled.

Figure 2 shows an example of the actual printout which is read from bottom to top. The 5, 2-digit numbers on the left correspond to the individual startle amplitudes of the 5 rats. After 10 trials in this sample the separate startles of each rat are summed and printed out in red as 5, 3-digit numbers (separated by periods) in the left 15 columns. Column 21 is used for the trial code which was initially M on each trial and then varied as shown. Columns 17–19 correspond to the ISIs, which were initially all 10.5 sec, but then 15.0 sec.

The block diagram of Fig. 3 gives a general view of the logic structure of the instrument.

The control logic circuit (Fig. 4) generates the necessary signals in the proper sequence for the sampling, conversion, and print functions. The timing diagram (Fig. 5) indicates the sequence of the various control signals.

The Sample and Hold-A/D converter circuit (Fig. 6) samples and transforms the analog signal together with the Channel and Summing Counter (Fig. 7) into a digital number which can be recorded by a printer. The Summing Counter section adds all or alternate (odd or even) numbers received from the A/D converter after a preselected number of trials.

The Sample Counter and Clock Circuit board (Fig. 8) contains a presettable counter to choose the number of trials to be added. The oscillator which provides the pulses for the analog to digital conversion is also located on this board.

The Interval Counter (Fig. 9) provides the data for the printer to record the time interval between samples in tenths of seconds The timing pulses are generated by a 10 Hz multivibrator. The interval counter may also be used to

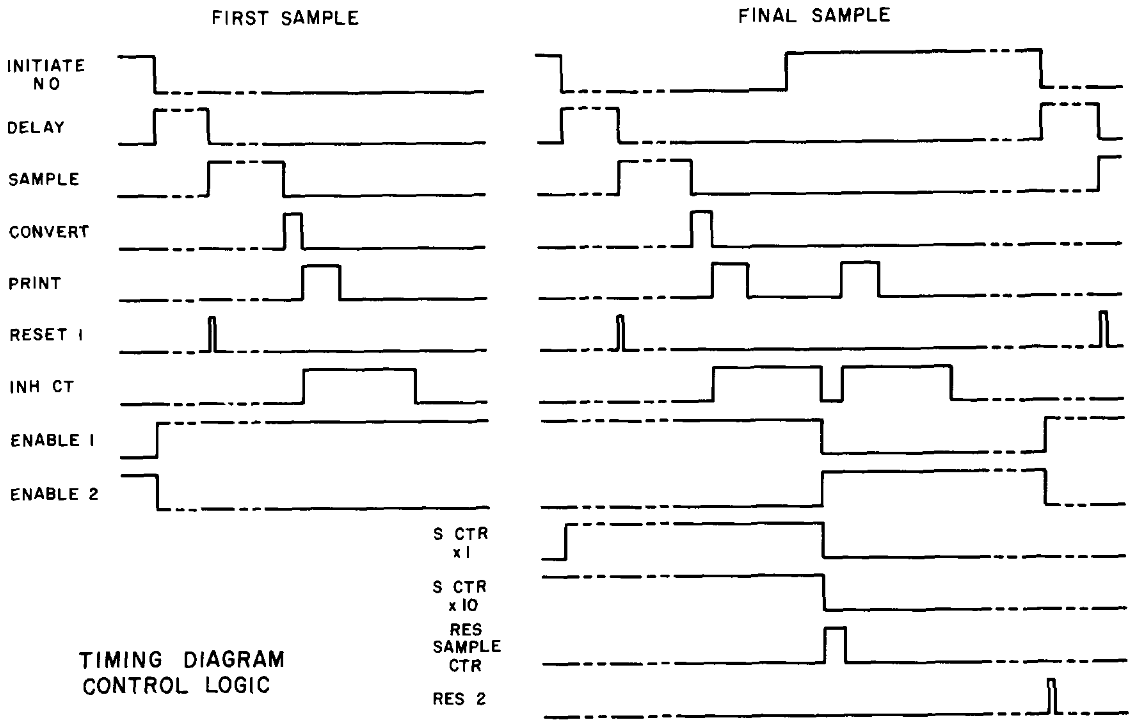

FIG 5 Overall timing diagram of the control logic

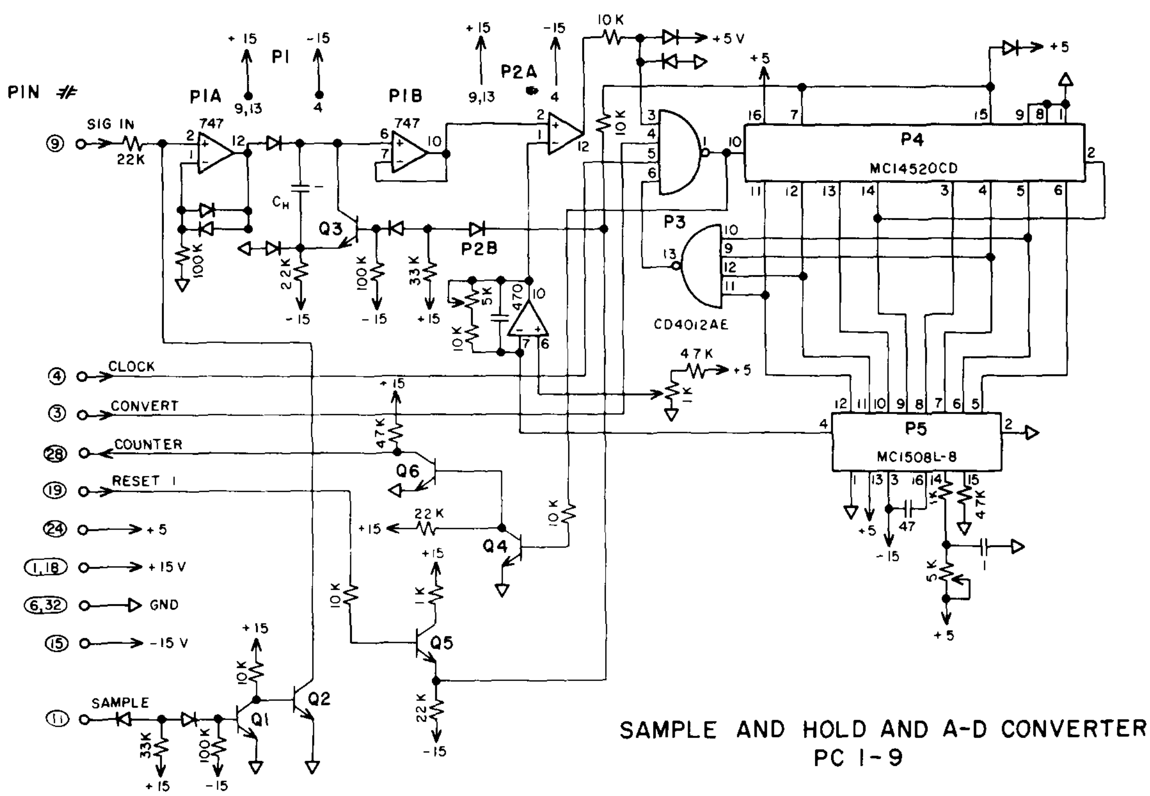

FIG 6. Circuit diagram of the Sample and Hold and A-D Converter.

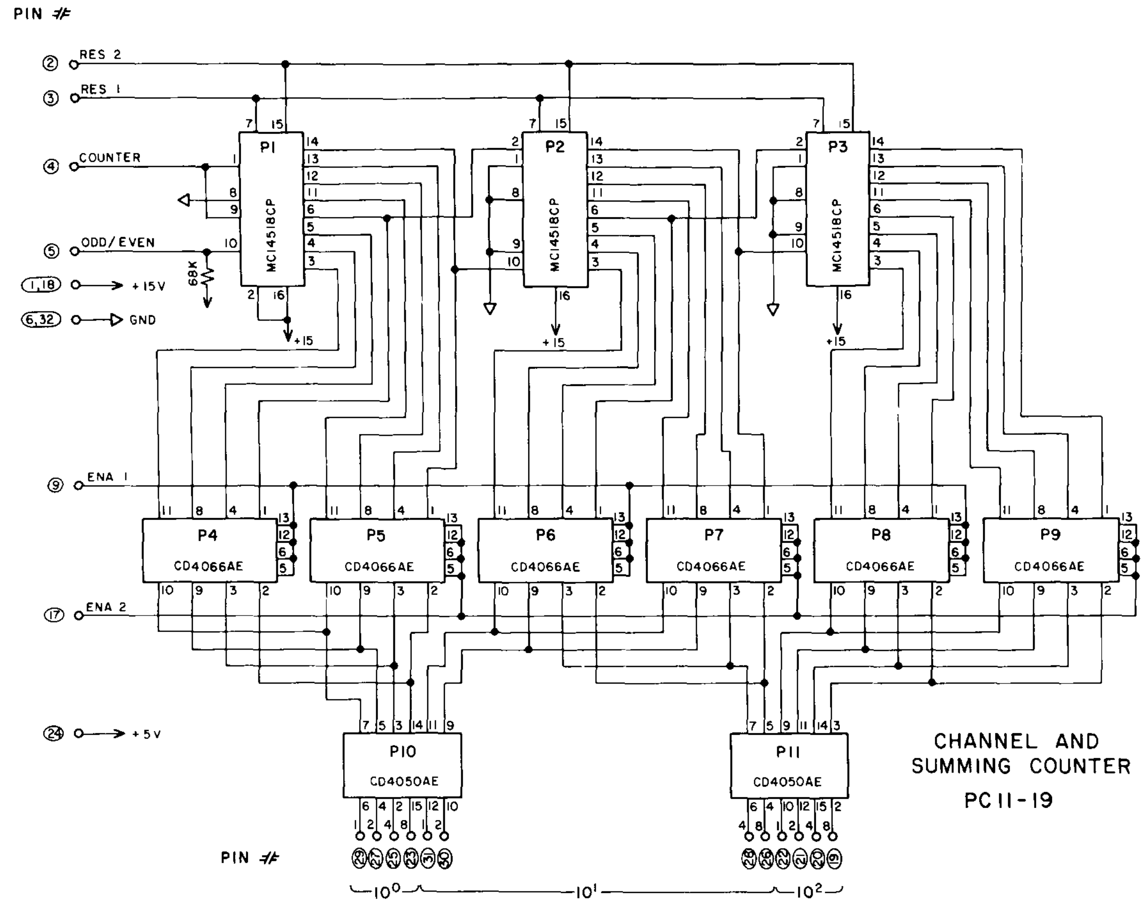

FIG. 7 Circuit diagram of the Channel and Summing Counter.

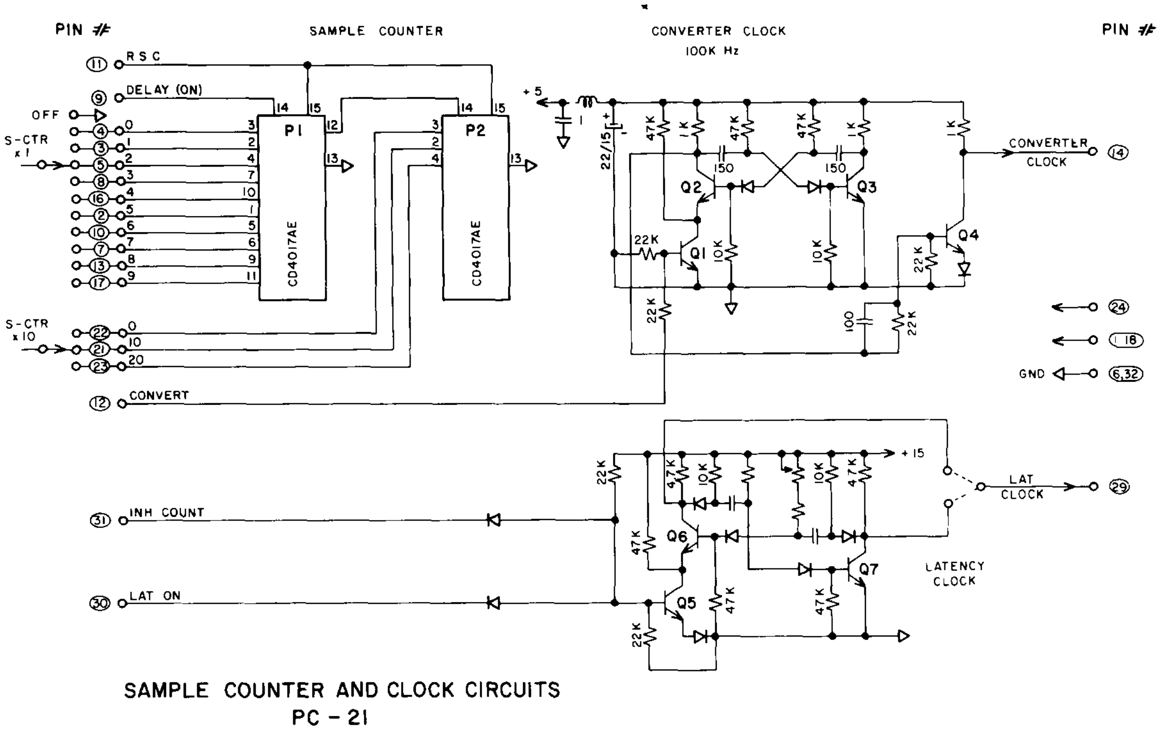

FIG 8 Circuit diagram of the Sample Counter and Clock.

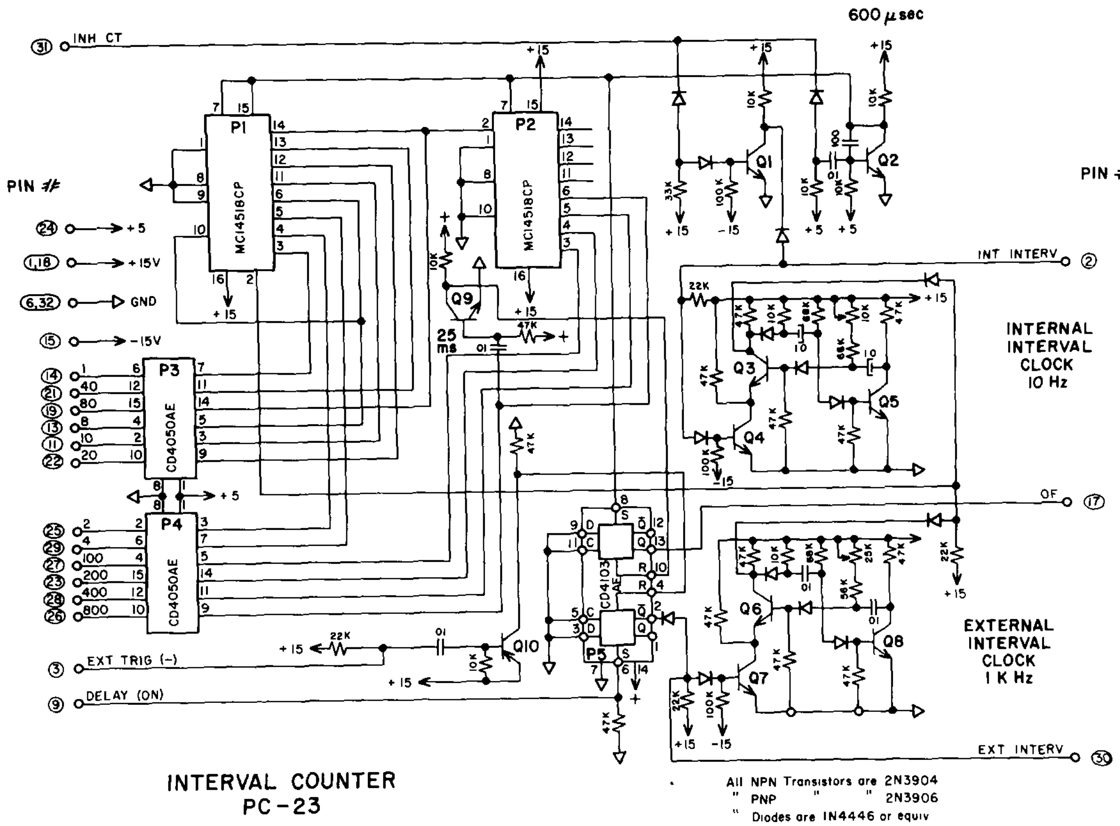

FIG 9. Circuit diagram of the Interval Counter

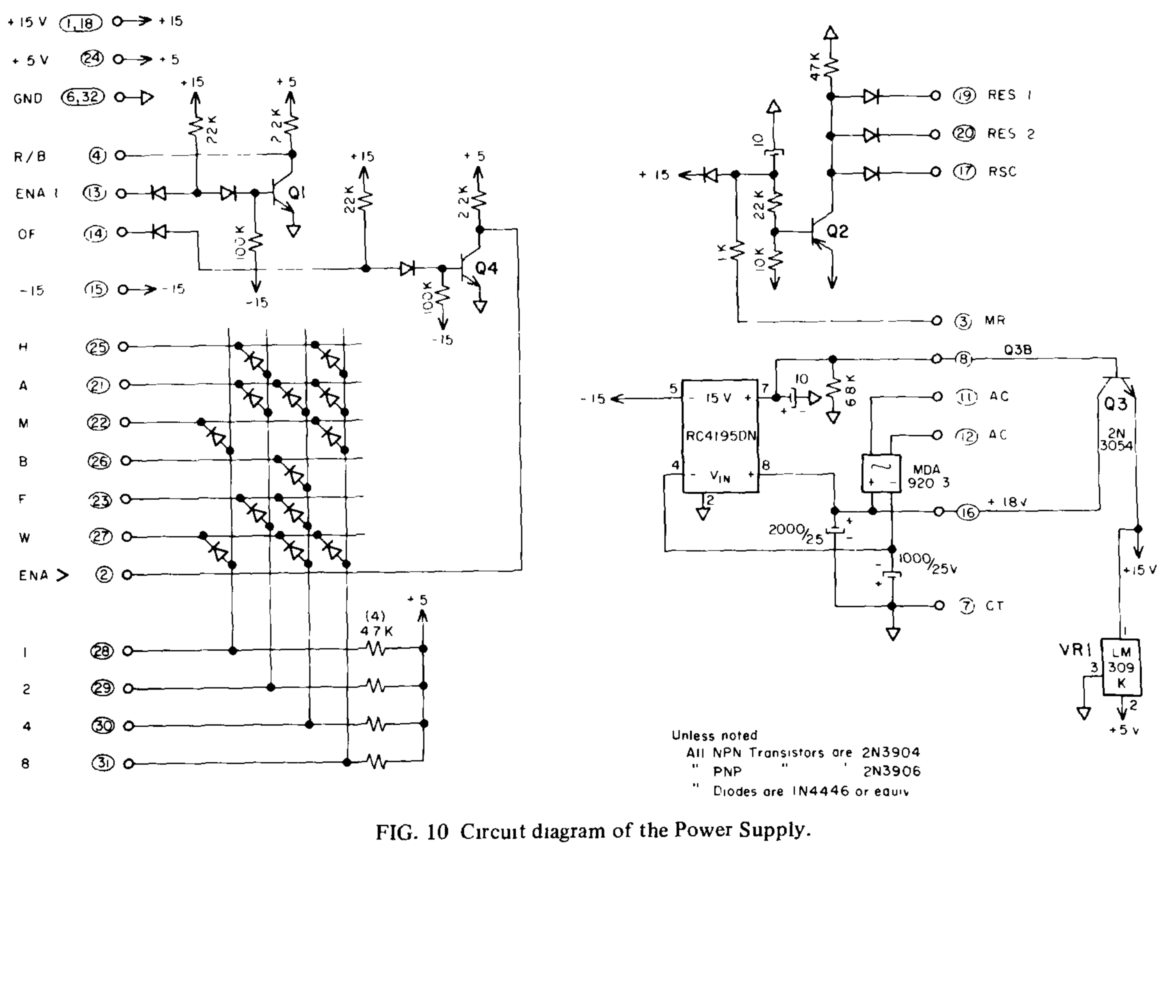

FIG. 10 Circuit diagram of the Power Supply.

measure other time intervals which are externally determined. Another oscillator is activated in this case, which provided timing pulses at a rate of 100 pps.

The Power Supply (Fig. 10) provides all required voltages for the operation of the instrument. The automatic and manual reset and the trial code circuits are also located on this board as well as the black and red printing logic and the circuit for the > symbol.

The printer used with this instrument was a Model 800 Digital Data Printer made by Newport Laboratories.

ACKNOWLEDGEMENTS

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