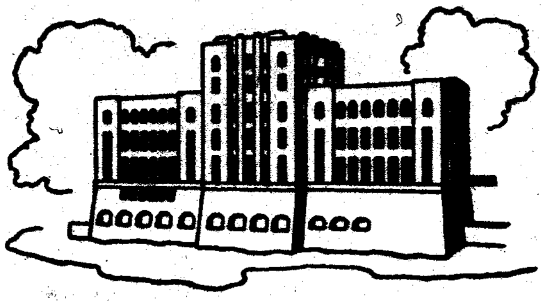
DIGITAL ACQUISITION OF MISSOURI RIVER BED PROFILES

by

John R. Glover

Sponsored by
U.S. Army Corps of Engineers
Missouri River Division, Omaha District
Contract DACW45-68-C-0055



IIHR Report No. 109

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ABSTRACT

A computerized data acquisition system for measuring bed profiles of the Missouri River is described. The system incorporates an IBM 1801 Digital Computer and Bludworth sounder which communicate via a magnetic tape recorder and various other components to provide punched cards with numbers representing the depth for each sounding. Accuracy and resolution are sufficient for determining the statistical properties of the bed profiles.

Digital Acquisition of Missouri River Bed Profiles

The problem of measuring bed profiles in alluvial channels has been approached many times with many different solutions, some having been simple and straightforward while others were more sophisticated. The system described in this report is in the latter category since it includes a combination of the latest available digital processing instruments with sonic depth-measuring equipment. Briefly, the goal was to design an instrumentation system capable of measuring bed profiles of the Missouri River with sufficient accuracy and resolution to permit meaningful computation by digital techniques of the statistical properties of the bed forms. Thus, the instrumentation system for this study became a combination of instruments which individually were adequate only for one phase of the problem. Because available equipment was used it was necessary to insert specially designed units to achieve compatibility within the system. Although explanations of these units constitute a large portion of this report, complete operation of the system will be explained.

The basic instrument for the measurement of bed profiles in alluvial channels utilizes the principle of sound navigation and ranging (SONAR). A sound wave which is generated by the appropriate transducer and electronic circuitry, transmitted toward the channel bottom, reflected and detected, serves as the medium for determining time intervals proportional to the distance between the transducer and the channel bottom. These time intervals may be processed by several different procedures depending on the information desired. If a continuous record or voltage is required, appropriate electronic techniques may be employed to convert the time intervals to voltage levels. The voltage, however, having been derived from samples, is really not continuous (although after effective filtering it may appear to be so) and contains no information not already contained in the sampled data. In fact, if the analyses to be performed are done in digital form, and thus require the data to be in digital form, the conversions from sampled data to continuous back to sampled data would only decrease the signal-to-noise ratio. Therefore, when the data are to be processed by digital techniques, it is advantageous to preserve them in sampled form. Also, by not having to convert the data to continuous form, more reliability and reduced weight and power requirements are realized for the field instruments.

Figure 1 is a schematic diagram of the complete system with the IBM 1801 serving as system controller. Because the digital processing could not be done in the field, it was necessary to record the output signals from the sounder on magnetic tape. The decision to process the time intervals directly required that an accurate oscillator with sufficient resolution be gated by the transmitted and echo signals; and in order to avoid the effect of possible time variations introduced by the tape recorder, the ungated oscillator signal was recorded simultaneously with the time interval markers from the sounder. In addition to recording these two signals, voice communications between the boat and an on-shore transit operator giving the position of the boat were recorded to provide correlation between boat position and bed-form measurements.

The gating of the oscillator signal, as is seen in Figure 1, was accomplished during playback; the circuitry for doing this was interfaced with a counter for totalizing the gated oscillator signal, and with the analog-to-digital converter. The sequence of operation started with the transmitted signal which opened the AND gate controlling the oscillator output. The counter totalized the pulses from the oscillator until the echo signal, which closed the AND gate, was received. At this point in time, the ADC was instructed by the interface circuitry to convert the sixteen channels of the multiplexer containing the binary-coded decimal information from the counter. The computer decoded the sixteen logic signals, stored the equivalent binary word for punching, reset the counter, and then returned control to the interface circuitry to wait for the next sounding or sample. After twelve samples had been taken they were punched on an IBM card with program execution such that punching caused no loss of samples.

The sounder was a Bludworth Depth Recorder, Model ES~~-1036~~ 1025, and the time markers were obtained from the output of the receiver amplifier. To attenuate the high-voltage output from the sounder to an acceptable level for the tape recorder, a non-linear network (Fig. 2) connected the output of the Bludworth to the recorder. The non-linearity was of such a nature so as to attenuate the high-level signals much more than the low-level signals. On occasion, the depth recorder would not have had sufficient gain to amplify weak echos to a suitable level for recording if linear attenuation had been employed; thus for better detection, the non-linear amplifier was incorporated.

The tape recorder used for collecting the field data was a Lockheed Model 417, and although it was a 7-track recorder, electronics for only two tracks of direct record-reproduce and one voice edge track were installed. The two data tracks recorded the sounding signal from the Bludworth and the 50 kHz oscillator signal, the latter being derived from a Model JB15-12Z crystal oscillator manufactured by Accutronics, Inc.

The problems associated with using the time markers from the ultrasonic equipment to gate the 50 kHz signal were many and varied. However, because in general the depth of the water was four feet or greater certain freedoms were taken which for shallower depths would not have been permitted. To aid in the understanding of the sequence of events for obtaining the data and of the reasons for including certain operations, reference will be made to Figure 3, which shows all pulses and time intervals of the various gates. The first and last traces are oscilloscope photographs of the recorded Bludworth signals and the gated oscillator signal which was fed to the electronic counter. Figure 4 is a block diagram of the interface circuitry, and Figures 5 through 10 are the detailed drawings.

In general, the recorded signal was at the proper amplitude, but on occasion it needed additional amplification for correct detection. It was, therefore, amplified and then rectified (Fig. 5) prior to triggering the amplitude level detector or Schmitt trigger (Fig. 6). The output from the Schmitt trigger set the binary divider which in turn opened the AND gate to pass the 50 kHz signal (Fig. 7). To eliminate the remaining pulses of the transmitted signal from influencing the binary divider, a two millisecond pulse (Fig. 8) initiated by the divider was fed back to the OR gate controlling the Schmitt trigger. By eliminating the remaining pulses in this manner, the filter for smoothing the rectified transmitted signal was also eliminated, and thus the time distortion it caused did not appear. Two milliseconds was sufficiently short that the Schmitt trigger could respond to the first echo signal and close the AND gate passing the 50 kHz signal. At times this interval was adjusted to different values to account for different time durations of the transmitted signal.

To remove the influence of the remaining pulses of the first and second echo signals, a pulse of thirty milliseconds (Fig. 9), initiated by the binary divider, and the complement of the divider controlled an AND gate, the output of which was one of two signals controlling the inverter driving the binary divider. This controlling feedback existed only while both signals were logically true because of the AND gate ahead of the OR gate feeding the inverter. Once the pulse of thirty milliseconds terminated, the Schmitt trigger was again effective in setting the binary divider. In addition to performing this function, the end of the pulse initiated a one millisecond pulse (Fig. 9) which reset the binary divider if an echo was not detected.

Synchronizing the computer so that it would read the BCD outputs from the counter at the proper time was accomplished by programming the ADC for external synchronization and by supplying the "sync" pulse after the first echo was detected. To avoid transient conditions in the counter, a one-millisecond interval was inserted prior to generating the "sync" pulse (ten microseconds in duration) which started the conversion.

Descriptions of the various elements in the block diagram (Fig. 4) of the system will not be presented herein, because they are classical in nature and are well documented (Refs. 1 & 2).

A flow chart of the Assembler computer program for processing the magnetic tapes is shown in Figure 11. It does not include all details of the program, but does represent its general operation and complete philosophy. A step-by-step explanation will not be given here, but several features will be discussed, because of their importance to the success of the program.

The program objectives were first to provide punched cards with data for twelve soundings per card, and second to determine the number of soundings between fixes so corrections for uneven spacing between samples could be made. Since each run or pass up a reach gave about 3000 soundings, storage of all points per run prior to punching them on cards was not possible, the limitation being inadequate computer memory. To break a run into two or more sections suitable in size for the punching operation would have created the problem of overlapping data, and thus was not practical. Hence, the decision was made to develop a program which could store the data from the tape recorder in lots of twelve and output them on cards without interrupting the input process. Initially, a punching program for a maximum of 160 soundings per second was developed, but was later discontinued in favor of a slower rate (24 soundings per second) to eliminate an intermediate card punching operation. The number of soundings between fixes was stored until the end of the run and then listed.

The analog-to-digital converter could be programmed with many different variations depending, of course, on the needs. Since program synchronization to an external device (i.e., external to the computer and its I/O devices) was desired, it was accomplished by using the external "sync" feature on the ADC. When operating in the external "sync" mode, the ADC would not convert a data word until the "sync" pulse had been received, even though it had been instructed to do so by the computer. By having a loop testing for ADC busy immediately following the ADC convert instructions, the program would not continue until the "sync" pulse was received or synchronization was realized. Once the "sync" pulse had been received, indicating that the first echo had been detected, the ADC converted terminal sixteen. After completing this conversion, it was programmed in the sequential mode of operation, internal "sync", for converting the remaining first fifteen terminals. Sounding rates were slow enough and the remaining program execution was fast enough so that the instructions to convert terminal sixteen were given well ahead of the point in time when needed.

The card punch being a relatively slow output device operated with the computer jointly on a "cycle steal" and interrupt basis. Although the card punching rate for this system was only one card per approximately two seconds, card feeds were injected between punch cycles by programming so that the punch would not have to wait for a new card after receiving instructions to punch. The reason for this was the card punch after being instructed needed only 160 microseconds of computer time to punch 80 columns, although approximately 500 milliseconds were required by the punch itself.

Because the 160 microseconds were consumed on a "cycle steal" basis, the computer could continue essentially undisturbed for the 500 milliseconds, or as in this situation, to process two or more soundings during the punching interval. The interrupt from the card punch occurred only at the end of the punching interval, but because it had a lower priority than the ADC, it did not interfere with the ADC while converting. Thus, it is seen that the two I/O devices (ADC and card punch) could operate simultaneously with the computer acting as buffer as well as control.

Although the system described in this report was developed for specific equipment, namely the IBM 1801 and the Bludworth sounder, it presents a concept which could have evolved in many different ways. However, it does represent the flexibility and adaptability of a general-purpose high-speed digital-data acquisition system, and thus provides another example of how research studies generating large amounts of data may be handled.

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This program of investigation was conceived jointly by and has been carried out under the general supervision of Mr. Donald C. Bondurant, Missouri River Division of the U.S. Army Corps of Engineers, and Drs. John F. Kennedy and Emmett M. O'Loughlin of the Institute of Hydraulic Research. Grateful acknowledgement is extended to Mr. Robert Livesey of the Corps of Engineers for the cooperation provided in obtaining the loan of the Lockheed Model 417 tape recorder and the Bludworth Sounder, and to Mr. Clifford Armstrong, whose assistance was invaluable in making the field system operational. Financial support was provided by the Corps of Engineers, Omaha District, under contract DACW45-68-C-0055.

REFERENCES

[1] L. Strauss, "Wave Generation and Shaping," McGraw-Hill Book Company, Inc., 1960.

[2] "Silicon Transistor Flip-Flop Circuits," *Application Note*, Texas Instruments Incorporated.

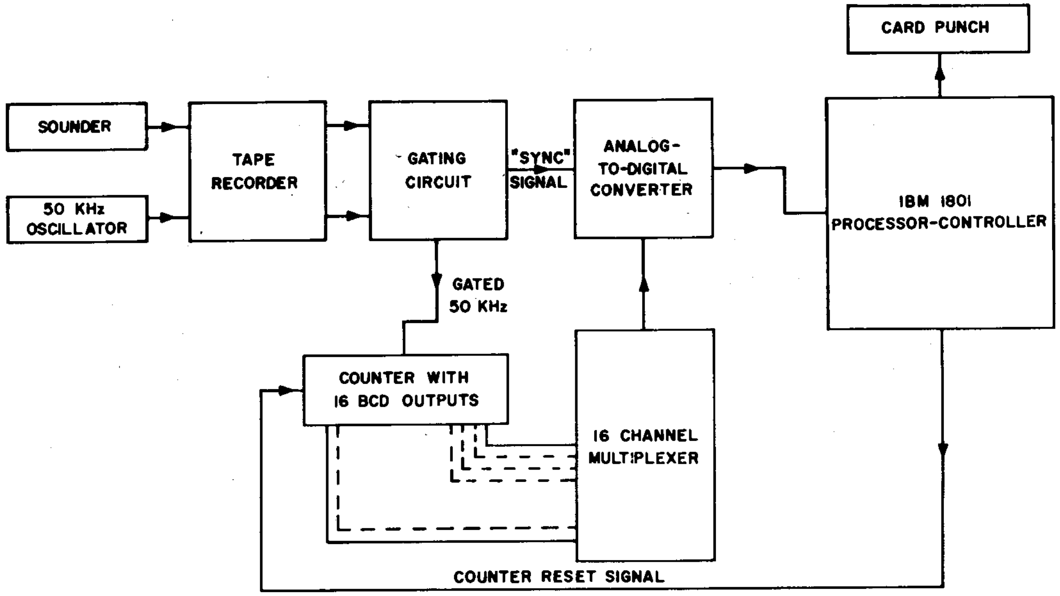

Figure 1. Block Diagram of System for Measuring Bed Profiles.

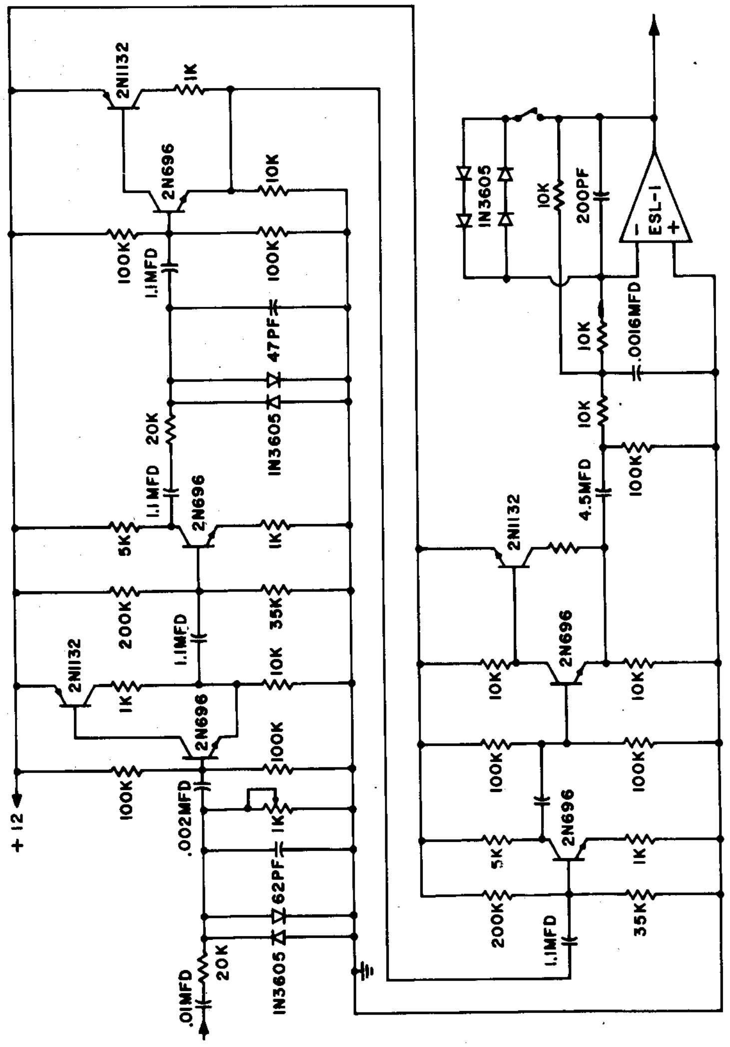

Figure 2. Bludworth Signal-Conditioning Network.

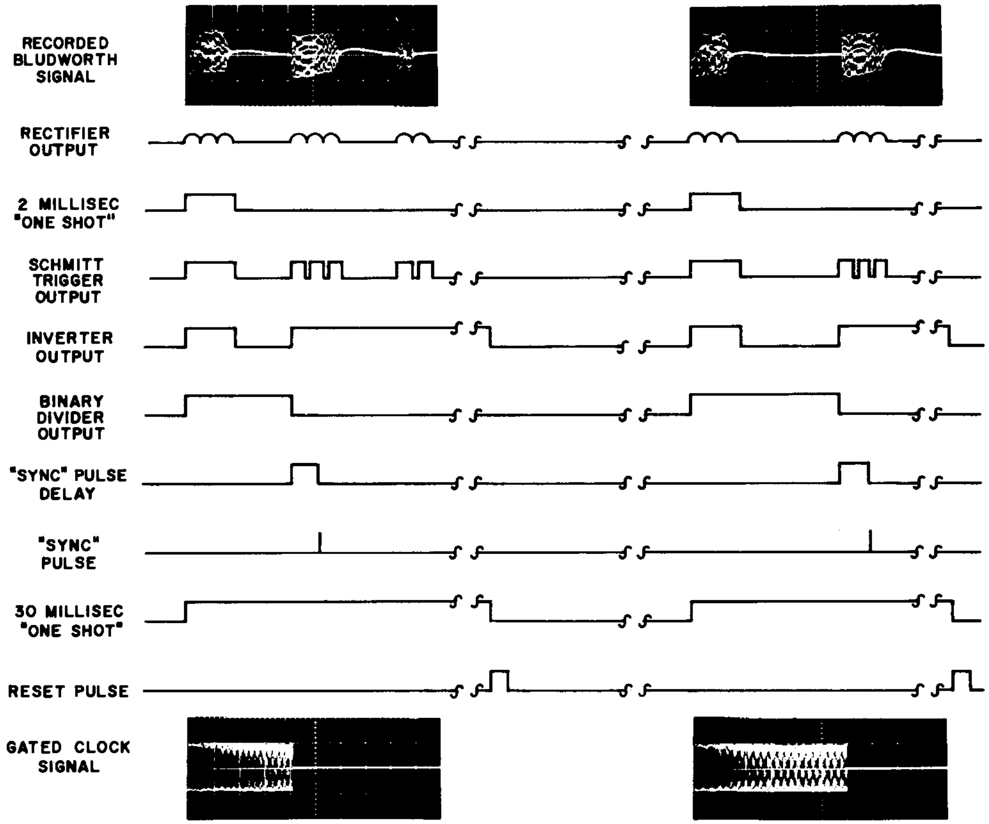

Figure 3. Response and Time Intervals of Components in the Gating Circuit.

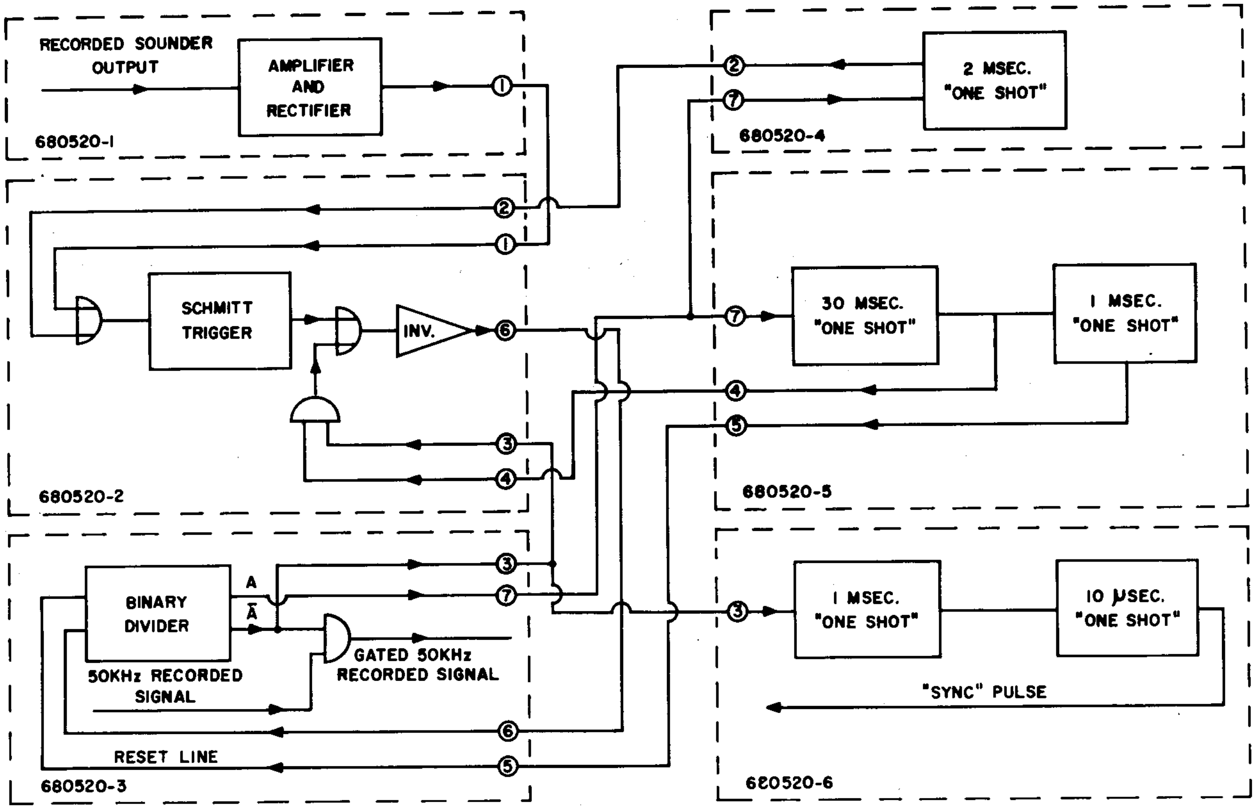

Figure 4. Block Diagram of Interface Circuitry.

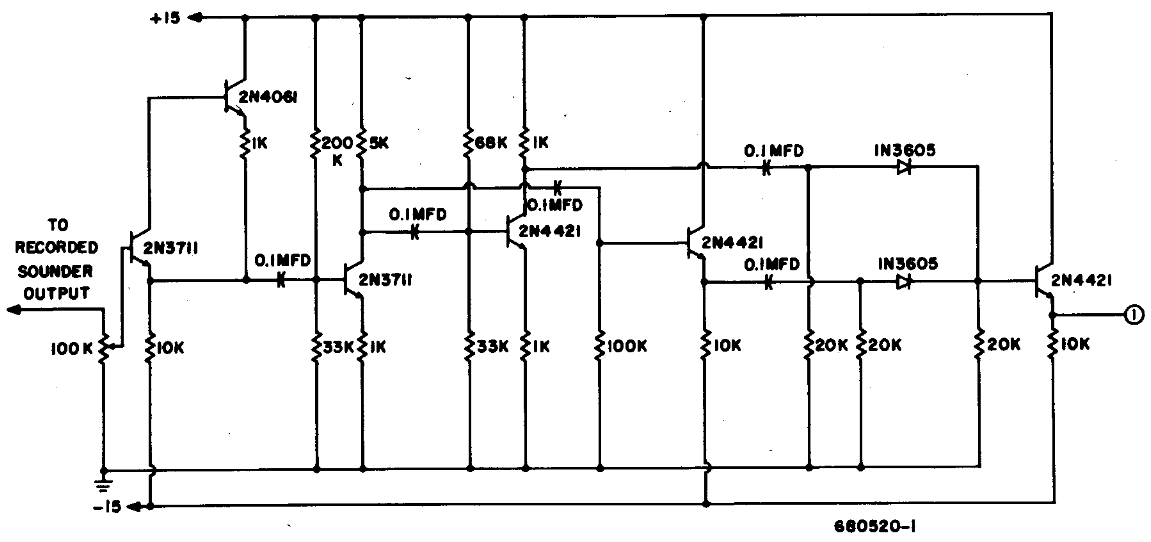

Figure 5. Amplifier and Rectifier.

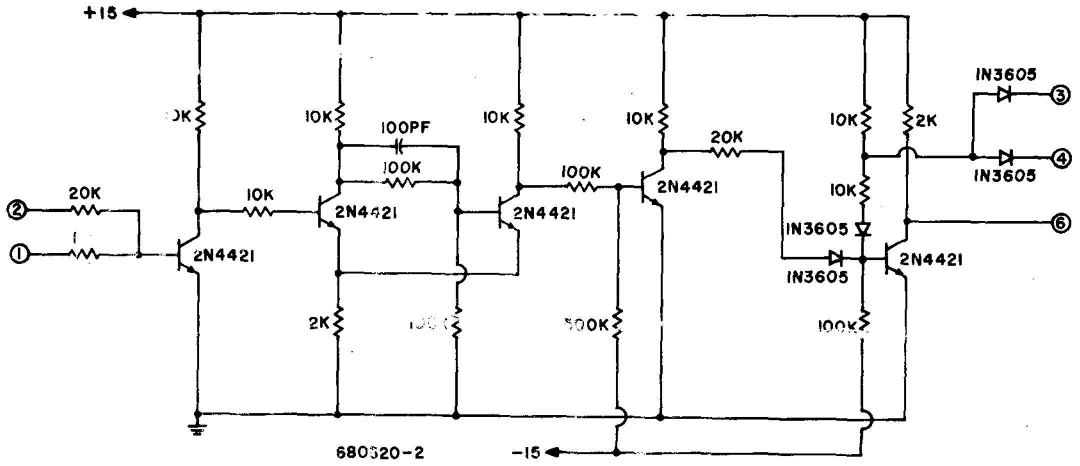

Figure 6. Schmitt Trigger and Inverter.

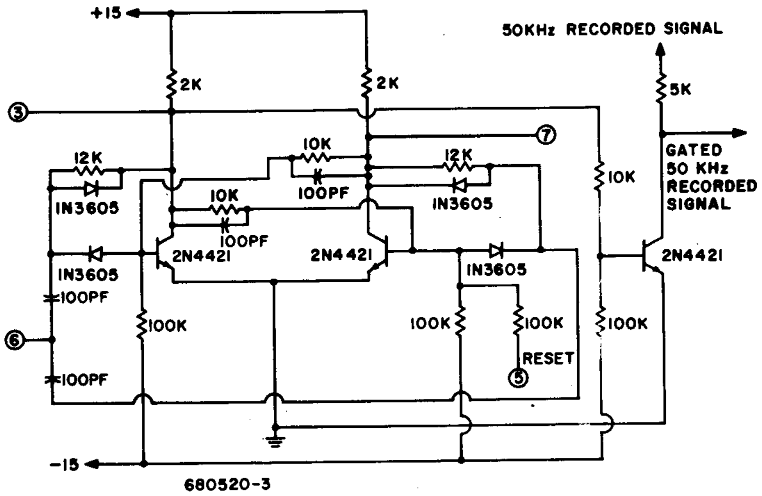

Figure 7. Binary Divider and 50 kHz Gate.

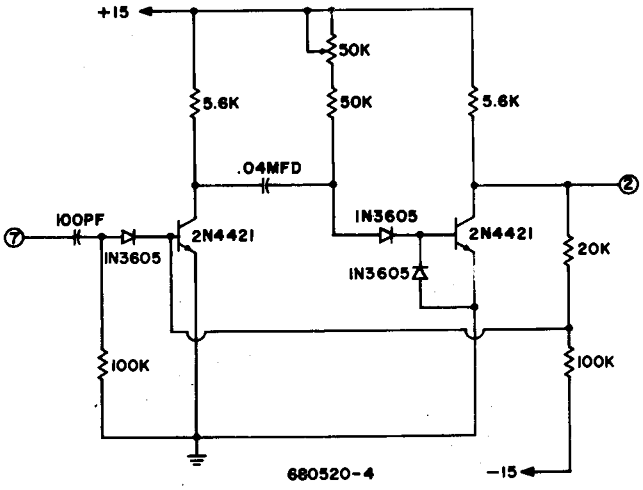

Figure 8. Two-Millisecond "One-Shot" Multivibrator.

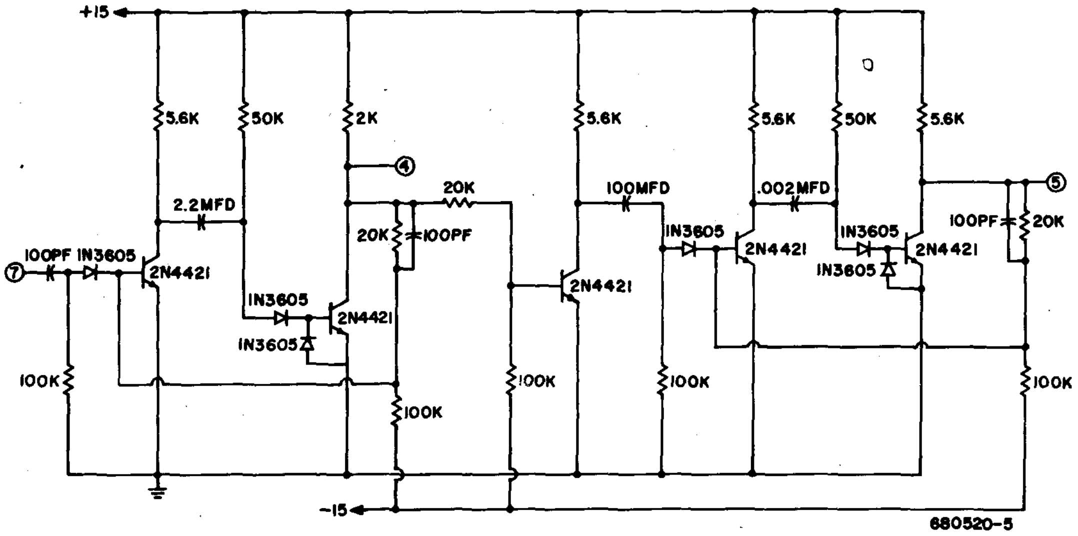

Figure 9. Thirty-Millisecond and One-Millisecond "One-Shot" Multivibrators.

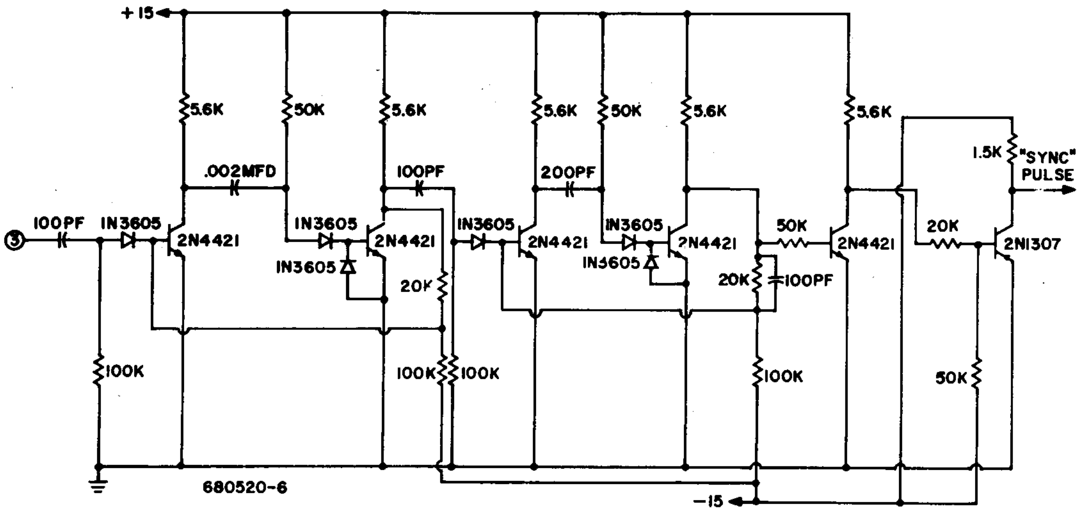

Figure 10. One-Millisecond and Ten-Microsecond "One-Shot" Multivibrators.

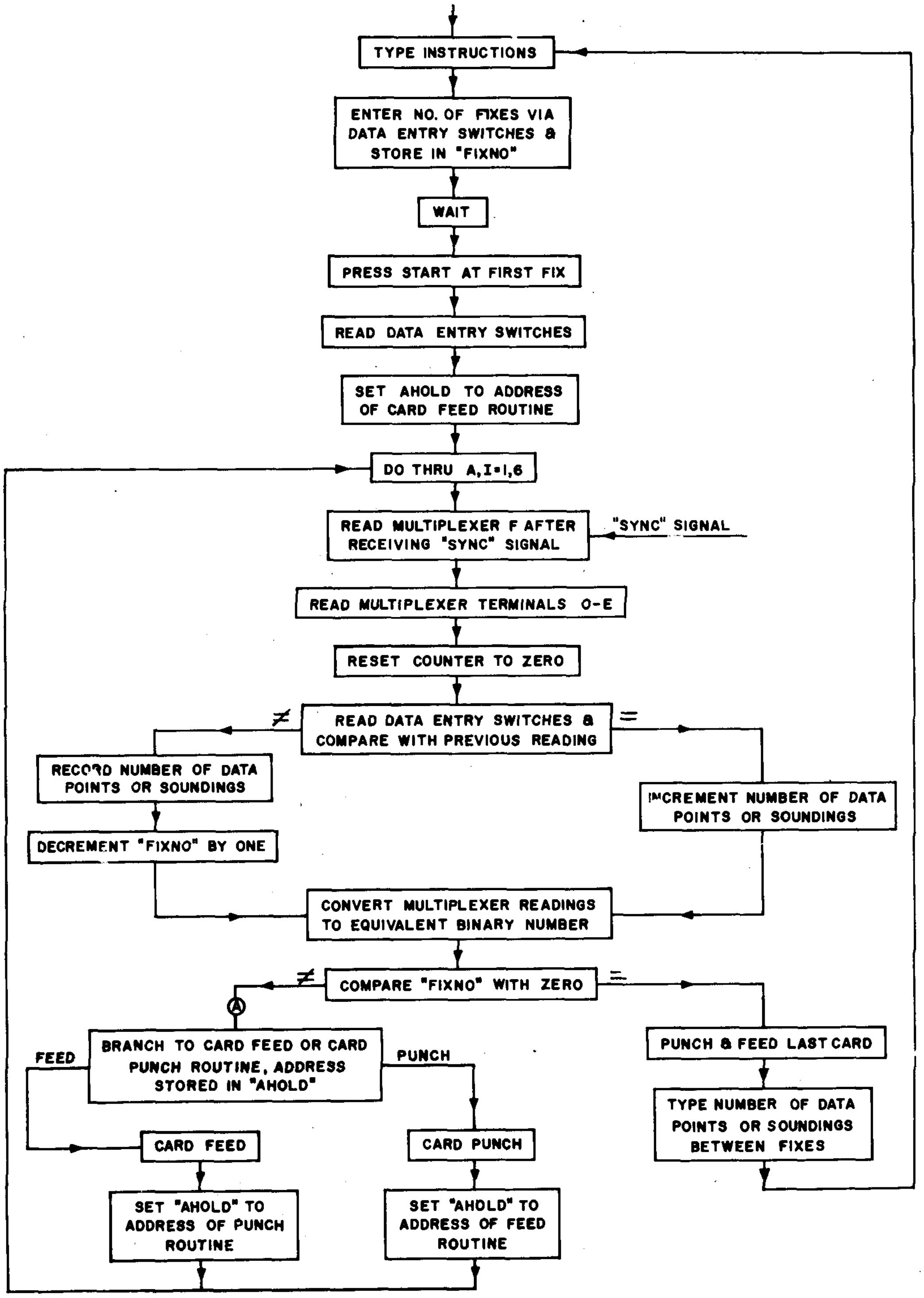

Figure 11. Flow Chart for the Assembler Program.

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