DIGITAL RECORDING ON A STANDARD CASSETTE

by

JOSE E. VILARO, T. Engr. in E.E.

A THESIS

IN

ELECTRICAL ENGINEERING

Submitted to the Graduate Faculty
of Texas Tech University in
Partial Fulfillment of
the Degree of

MASTER OF SCIENCE

IN

ELECTRICAL ENGINEERING

Approved

Accepted

December, 1975

ACKNOWLEDGMENTS

I would like to thank Dr. W. M. Portnoy for his encouragement during the development of this device and for his understanding.

Special thanks to Dr. D. L. Vines for his cooperation in the writing of this thesis.

Finally, I would like to express my sincere appreciation to Dr. Dale Flowers for serving on my committee.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This thesis describes the implementation of design concepts which have been developed by the author over the past several years respecting a writing device for use by the blind. It is based not only on the literature, but also on direct experience obtained from discussions with the blind, observations of their problems, and existing devices.

Preliminary implementation was developed during four years of undergraduate study at the Escuela Industrial de Barcelona,[1] where the device, which was built, incorporated RTL circuits; later, TTL circuits were considered in order to improve the design. In the work described here, the basic design has remained essentially unaltered; however, the practical implementation has been considerably improved, and the device which has been constructed is not only a prototype on which to base the next and final stage of development, but is practical and useful in itself.

The purpose, therefore, of this work was to build a basic system for helping blind people to encode information written in Braille and to record it digitally on an inexpensive cassette recorder, and also to obtain any information stored in the cassette. The model constructed here was not necessarily the most economical or practical for the blind, but it provides a general purpose device which made it possible to study the different applications for the machine and to test any changes or improvements leading to more efficient operation.

One of the major problems of the blind is their writing system;

they require embossed patterns on paper, and the paper must be fairly thick. Each Braille character, which is made up of six dots, usually takes more space than the written character. A book written in Braille will consist of many more pages and will also cost much more than the same book in regular print. Considering libraries for the blind which must contain thousands of books written in Braille, it is obvious that the amount of space required would be enormous. One objective of this work was to design a system which would permit a much higher density of stored information. A convenient choice of a storage medium is a magnetic tape; by using sophisticated recording techniques, high storage densities can be obtained.

Although the result of this work provided a magnetic tape recording device, such a device was not the most important part of the work. The most significant result is the collection of techniques used for encoding and decoding of the information. Once information has been stored on magnetic tapes, it can be converted back to the original form employing the decoder, and then used as an input for an electric typewriter designed for the blind, which prints in Braille.

One important application of the result is in the production of metal plates used to print books in Braille. An operator, usually blind, with one hand reads what is to be printed, and with the other hand inputs information into six switches to be written. The problem with this technique is that it is not possible to activate all of the switches at the same time. A memory is built into the system which delays the output until all the information is entered; after this time, the information is punched into metal plates. The system is inefficient because it allows exactly the same time for switching one or all six input switches. Furthermore, a chain production is required, since, if too long delay occurs, the machine will write a blank. If a wrong entry is made, it is not possible to correct the error in the machine itself, since removal of the metal plate is required for correction. The error must be located, the wrong holes refined, and the correct letter repunched.

Using the encoding and decoding procedures developed here, these problems may be avoided. In the present encoding scheme, the encoder includes a timer which will allow a variable delay between entries. An error can be corrected by going back one location in memory and writing the correct letter, and in case of a mistake, corrections can be made before holes are punched in the metal. A normal output can be provided as a check for errors or format.

The following chapters discuss the encoder and decoder design, and describe the operation of the device and some results of its use.

Writing in Memory

This unit employs two different types of memories; one is in the encoder, and the other is in the decoder. For the encoder, the information comes in parallel from the eight momentary switches and is transferred directly to memory.(2)

Since the standard P2101 memory device has a 256 x 4 configuration, two of them are needed to make the eight inputs available. Since the capacity of this memory is 256 eight bit words, an eight bit counter is needed to address all of the locations.

To encode data, the device is set to the write mode and data on the input of the memory will be stored. Consequently there is no need for a write pulse. To read, one changes to the read mode and the data from the presently addressed locations will appear at the outputs.

The memory device for the decoder, a P2102, has a configuration of 1024 words of 1 bit. [3] This type of memory requires a write pulse and acts as a long shift register.

Since the encoder has a capacity of 256 x 8 bits, two of these P2102 memory devices will be needed, since to address this amount of information 2^{11} = 2048 bits are required. The last bits will be used to disable one of the memories in order to avoid writing the same thing on both memories. This second type of memory, the P2102, which is also very standard has the tri-state capabilities which simplifies the output connections.

Since the purpose of an encoding device is to record data from a input source that is very slow such as a person punching switches, two problems appear immediately:

1. Should the recorder be on all the time even when it is not recording?
2. Should the recorder start and stop for every single letter that is recorded?

Neither system is practical. The first one would not record a great amount of data, and the second would not start and stop as fast as the person writes. Even if it could do it, the recorder would breakdown in a very short period of time due to the excessive number of starts and stops.

The system used here to minimize the mechanical problems in storage is to write the data in memory. When sufficient data is accumulated, it is transferred to the recorder at a higher and constant speed.

To eliminate contact bounce and to temporarily store data, eight set-reset flip-flops are used as shown in Figure 1.[4] The device is to write data into the memory and then the retriggerable one-shot of Figure 1B will allow a small time delay before advancing the memory location and before clearing the RS FFs. As shown in Figure 1C the time delay will be constant.

A circuit is included in Figure 1E which will decrement the address. The SN74193 counter, which is required to select the memory locations, is a versatile up-down counter of four bits. It has a preset feature to load any address as shown in Figure 2A. The eight AND gates shown in Figure 2B are used to drive the LED display of the contents of the memory. In Figure 3 the system of multiplexing the data to be recorded is illustrated.[5]

The circuit shown in Figure 4 starts the recorder prior to transmission of data. A timer will be on long enough to allow all of the bits to be recorded.

The serial information must now be frequency modulated (FM) to be recorded on the cassette. The oscillator will run at one of two frequencies, corresponding to the 1's or 0's.

The oscillators are enabled as shown in Figure 5 when data is transmitted. Also there is the schematic of the voltage coupling with the recorder. Since the voltage level is too high for the recorder, it is divided with two resistors to the appropriate level, depending on the type of recorder.

Another feature is represented in Figure 6. It is an audible alarm, [6] which indicates when limit of the memory has been reached. Also, it will indicate when the encoder memory is completely transferred to the magnetic tapes.

The Code Detector

Since this system of recording lacks many of the characteristics of better and more expensive system, there is the possibility of having some noise in the area of tape on which nothing has been recorded; for example, between blocks of 2048 bits or space allowed for stopping and speeding up the tape. This space, because of the start and stop of the motor, creates some extra noise pulses. Also, since the amount of time which it is stopped on this space is fairly large while the recorder waits for the person to write, there are more possibilities of noise being written. [3]

Although there are systems that will help avoid some of these problems, they may not be as economical and as simple as this applications demands. The noise level does not have to be reduced greatly since it is more probable that the person writing will produce more errors than the device itself, making it unnecessary to have a very sophisticated system.

The system chosen here is a simple one. Initially a predetermined code can be written as the first letter. Then it is recorded and played back into the decoder. In this system, the code is 11011111.[8] Once this code is received by the decoder, see Figure 7, it is loaded into a shift register. The outputs of the shift register are connected to an eight input NAND gate. The third input has an inverter, which means that the output of the NAND gate will go low just when the code is received. Only then will the data be allowed to go to the memory (the code will not be written into memory). Therefore, this provides a system for skipping the noise before the code. The bits that appear before the code will go into the shift register but when the right code is received, these bits will be shifted out and lost. Note that this system does not correct the errors that can appear inside the string of 2048 bits. Since it may be impossible to wait for the code, there are two switches that allows one to choose between having or not having to wait for the code, as shown in Figure 7.

The Decoder

The decoder must reconstruct the digital information from the data stored on magnetic tape. The possible distortion is minimized by shaping the waveform with a one-shot multivibrator. The change in frequency due to changes in motor speed are negligible. Voltage levels can be adjusted to be TTL compatible by varying the potentiometer of volume on the cassette. [9]

When the pulse is reconstructed, it is stored into memory in a manner similar to the read operation. The only difference is that now the memory is two P2102's which are 1024 x 1 bits or 2048 bits, to store the 256 x 8 (2048 bits) from the encoder.

This design in Figure 8 also provides the counter with the feature of counting up or down, this one can back up a few lines to observe data.

Another feature which is very convenient, see Figure 8, is a sound indicator that tells that the recording has been finished. If one is printing from this memory, it will indicate when the limit of the memory has been reached; for example, a certain amount of characters before the end. This certain amount can be set at will with the four input NAND gate. It is set by connecting each of the inputs of this gate to the outputs of a counter.. Only when this number is reached will the output of the NAND gate go low which will trigger the one-shot for a certain amount of time. This one-shot will enable the oscillator which will produce an audible frequency from a small speaker.

The oscillator is a very simple circuit which uses a Schmitt trigger with a feedback resistor and a capacitor.[10] Then the output is high, it charges the capacitor to a high level. Since this capacitor is connected to the input, the output will go low and the capacitor will discharge through the resistance. When the capacitor discharges, the input will go low and the output will be high again.

When the data is in the decoder memory, it is offered in parallel to the typing machine that will print on paper or metal. Therefore, there is a need for converting the serial configuration of the memory 2048 x 1 to 256 x 8. An eight bit shift register SN74164 is used to accumulate the eight bits but in order to load the shift register it has to be clocked eight times.[11] Consequently a circuit is used that will generate eight pulses as shown in Figure 9. Therefore, if the information is at the input of the shift register and it is clocked at the same time this increases the memory location, then the eight bits will be in parallel. These eight pulses may be sent at any speed but it would be preferable if this is done in less than ten milliseconds as shown in Figure 9.

Figure 10 shows a circuit that generates a narrow negative pulse used to clear flip-flops. [12]

The Front Panel

The front panel, see Figure 11, is the interface between man and the circuit. Essentially the left part of the front panel is the encoder, while the right half is for the decoder. The two speakers serve the dual purpose: to indicate the limit of the memory of the encoder, and secondly, to indicate the limit of the memory of the decoder. The bottom eight switches are used to load or to read information into the encoder memory at a chosen location. The decimal thumbwheel [13] switch determines the number of pulses that the oscillator will produce (eight in this case).

The eight central switches are used to input the information. The three potentiometers are used to minimize transmission rates to be able to match the speed of the person who is typing.

The lights on the upper left indicate the present memory encoder address, while the contents of the location is displayed below the address. The lights on the right side perform a similar function for the decoder.

The power is obtained from a 5 volt, 3 amperes regulated power supply. The circuits are mounted inside an aluminum case, which provides enough space for mounting a variety of boards. The boards are constructed in such a way that it allows for easy changes and for improvement of the design. Additional socket space has been put onto some of the boards for future modifications. The rest of the switches are the ones drawn in the different Figures. The order is of no significance.

CHAPTER II

ENCODING - DECODING AND RECORDING

TIMING DIAGRAM

The function of the encoding-decoding and recording is represented as a timing diagram in Figure 12. At line A, one can see the output from the frequency modulator if the data in its inputs has been 00101. As explained before, the normal output of the oscillator would be around four volts. This is normally too much to record on a tape recorder. The level of recording obviously will depend on the recorder and mainly on the frequency, since the response of this recorder goes down as the frequency goes up. If the frequency increases, the input voltage to the recorder will have to be increased. In this prototype, a value of 200 mV has been working properly, a representation of this signal is represented in line B.

Once it is recorded and played back, the shape of the output will depend primarily on the volume one wants to obtain from the recorder.[14] If this recorder were more sophisticated and had features like tone or fidelity control, this would also change the shape of the output. The frequency will not, however, change significantly.

The shape of the output is of no importance, but the peak voltage has to be TTL compatible and a value of 4 volts would be the most convenient. A typical shape from the recorder is represented in line C.

To make the signal TTL compatible, one must be able to get rid of the negative part of the wave. Since the power demands for the input of the one-shot are very small, just one diode in parallel with it will be enough to obtain the positive part, as shown in line D.

The output changes frequency, but this shape is not equal to the original. The waveform is applied to the input of a monostable multivibrator whose time constant is equal to the encoder oscillator. This will provide the original shape with just a small change in frequency due to the change of speed of the recorder. Note in the drawing, that line E should be shifted to the right to trigger at the correct level of the one-shot. For graphical purposes it was drawn as if it were the original shape.

After the original waveform is recovered, the decoding must be accomplished to store the data in memory. Observe that the difference between zeros and ones is just a difference in frequency. [15] The zeros were selected as the highest frequency because there will probably be more zeros than ones written. The way to distinguish between ones and zeros is by considering that after the original pulse goes down, the next pulse will come sooner if it was a zero, or later if it is a one.

Therefore, there is at the output of E, another one-shot that will trigger from the moment E goes low. The time constant of this new one-shot should be for better precision, the average time between zeros and ones. According to this, F will go low when E. is low for ones and high for zeros. To make this more logical, consider the complement of E and then F will go low when E is low for zeros and high for ones.

To write into memory, a narrow pulse of 1 millisecond is required as shown in line G.

Observe that if the value of E is input into the date line of the memory, and G which is the write pulse into the R/W of the memory, then the information stored will be correct.

The last step is, of course, to increment the address after the write pulse. This can be done by connecting F to the counter. Observe that F goes up after the write pulse, except in the first location.

CHAPTER III

START AND STOP OF THE RECORDER

The ideal conditions of recording would be to use every inch of tape, which would require either a huge amount of semiconductor memory to temporarily store data or a person that writes as fast as the recording speed. Since both are impossible, a compromise enables one to (1) store in semiconductor memory a predetermined number of bits, (2) start the recorder, (3) record data, and (4) stop the recorder.

For a cheap recorder, the time for starting and achieving the right speed would be approximately one second. The same amount of time, one second, can be expected for stopping.

Since two seconds are required to start-stop and just one second of data is recorded, then only 33 percent of the tape is used. To increase the percentage, more semiconductor memory which is fairly expensive is required. (16)

A good compromise would be to have enough semiconductor memory as to allow the person to write with very little interruption. For instance, the time to write may be at least 100 times longer than the time to record. Similarly the amount of recording on tape should be two or three times greater than the start-stop time to make good use of the tape. A representation of this distribution on tape is explained in Figure 13.

CHAPTER IV

CONCLUSIONS AND OBSERVATIONS

The needs for the blind are of enormous proportions, but in recent years, and due to the improvement in technology, some needs are being met, thanks mainly to medicine and electronics.

The result of this work is a device that already is usable to help the blind in writing, storing, and editing information. This device goes beyond this point, as it has been built so the engineering modifications can be introduced for improvement. Some of the features go beyond the need of the blind, but have been put there in order to simply development.

One fact that this research has brought to surface is that the approach taken to help the blind is a correct one. This device has been already used to input data into a computer. This experiment shows that the blind could get into the field of computer programming.

To improve this system the goal might be directed to several specific areas: (1) making the system more economical and reliable, (2) portable, and (3) interfaceable to calculators and to computers.

REFERENCES

1. L. Nashelsky, Teoria de las Calculadoras Numericas Automaticas, Editorial Alhambra, S.A., 1966.

2. National Corporation, Digital Handbook, National Corp., 1974.

3. Harris Corporation, Harris Intergrated Circuit Today, Harris Corporation, 1975.

4. Fairchild Corporation, Fairchild Data Catalog, Fairchild Corp., 1975.

5. RCA Corporation, RCA Digital Intergrated Circuits, RCA Corp., 1975.

6. Donald E. Lancaster, TTL Cookbook, Howard W. Sams and Co., 1974.

7. James Martin, Introduction to Teleprocessing, Prentice Hall Inc., 1972.

8. Frederick J. Hill, Gerlad R. Peterson, Digital Systems, Wiley , 1973.

9. Hans W. Geshwind, Edward J. McCluskey, Design of Digital Computers, Springer-Verlag, 1975.

10. Texas Instruments, TTL Book, Texas Instruments, 1972.

11. Signetics Corporation, Signetics Intergrated Circuits, 1975.

12. Zvi Kohavi, Switching and Finite Automata Theroy, McGraw-Hill, 1970.

13. Eugene R. Hnatek, A User's Handbook of Intergrated Circuits, Wiley, 1975.

14. Thomas R. Blakeslee, Digital Design, Wiley, 1975.

15. Burrough Corporation, Digital Computer Principles, 1969.

16. Douglas A. Carrell, Introduction to Computer-Aided Manufacturing in Electronics, Wiley-Fulerscience, 1972.

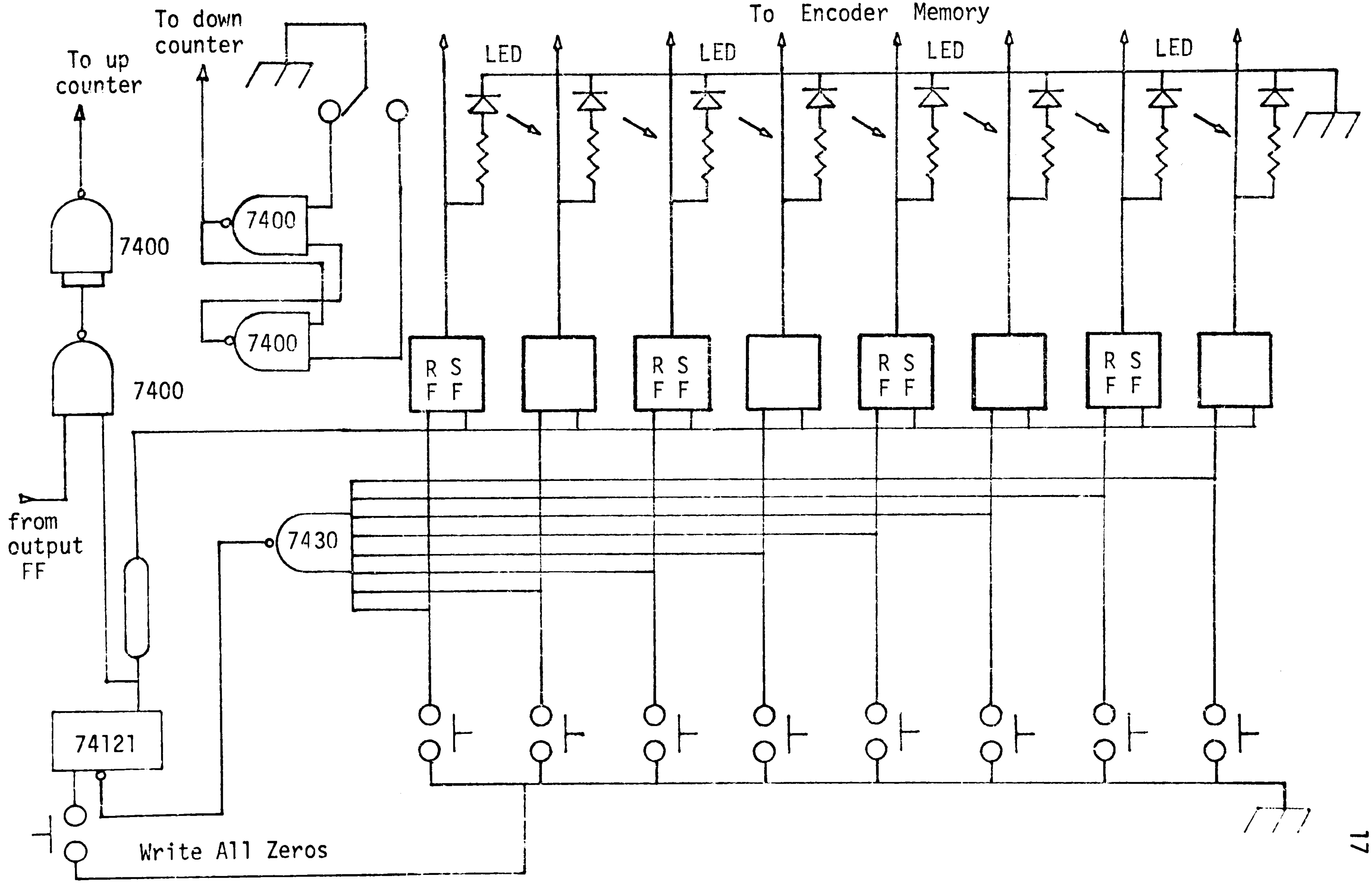

Figure 1. Data Input System.

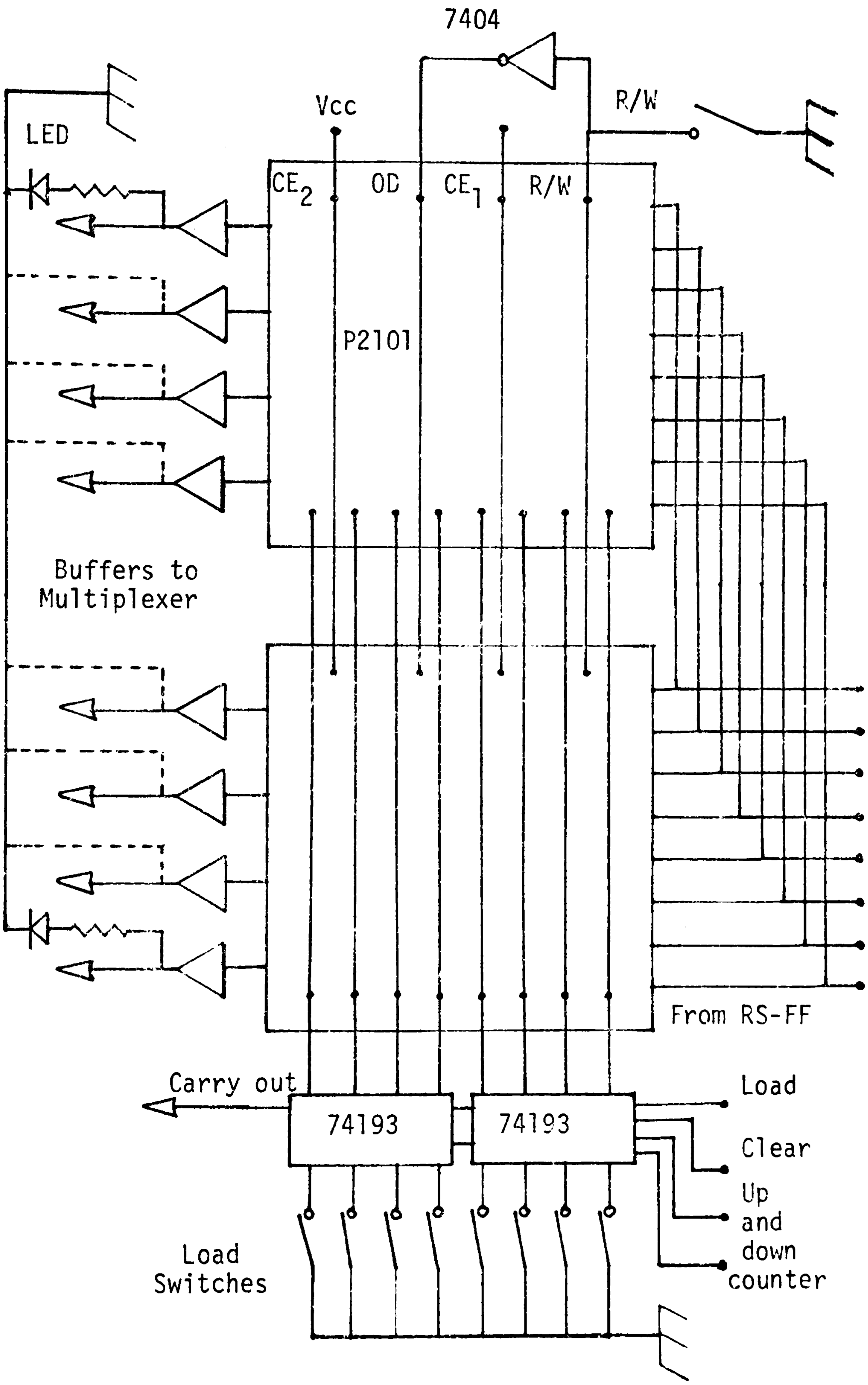

Figure 2. Encoder Memory System.

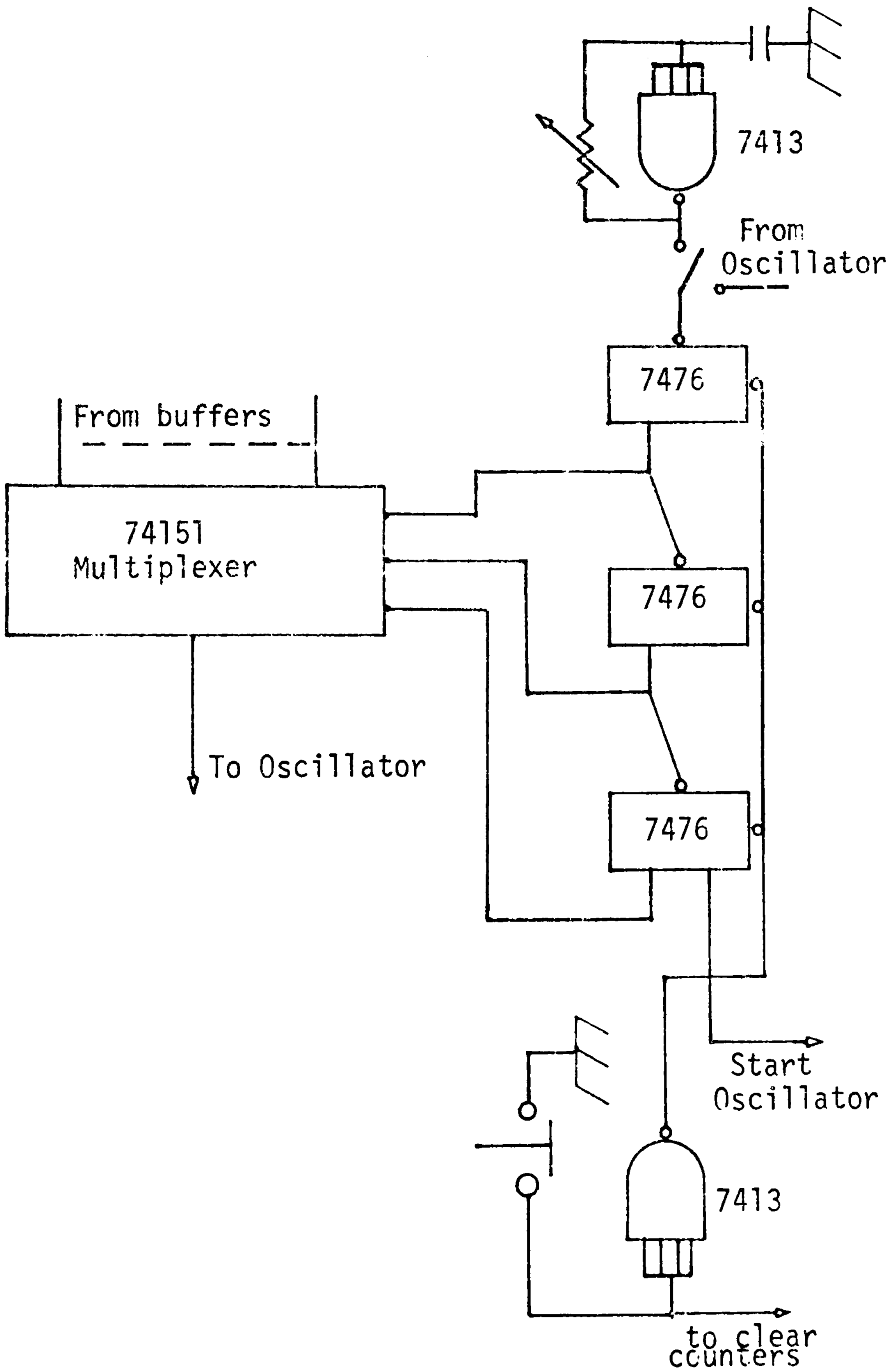

Figure 3. Memory Output Multiplexing.

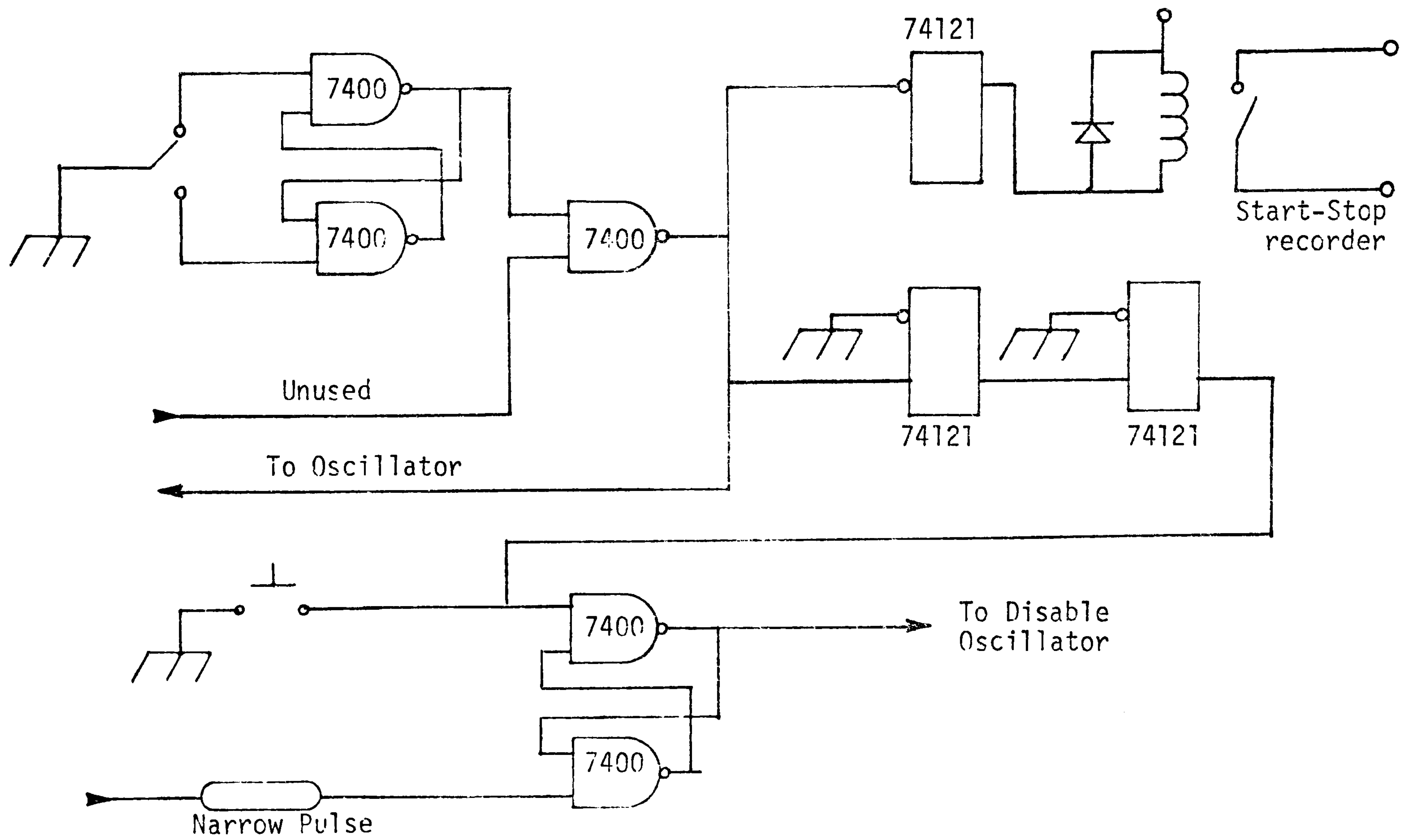

Figure 4. Recorder Controller.

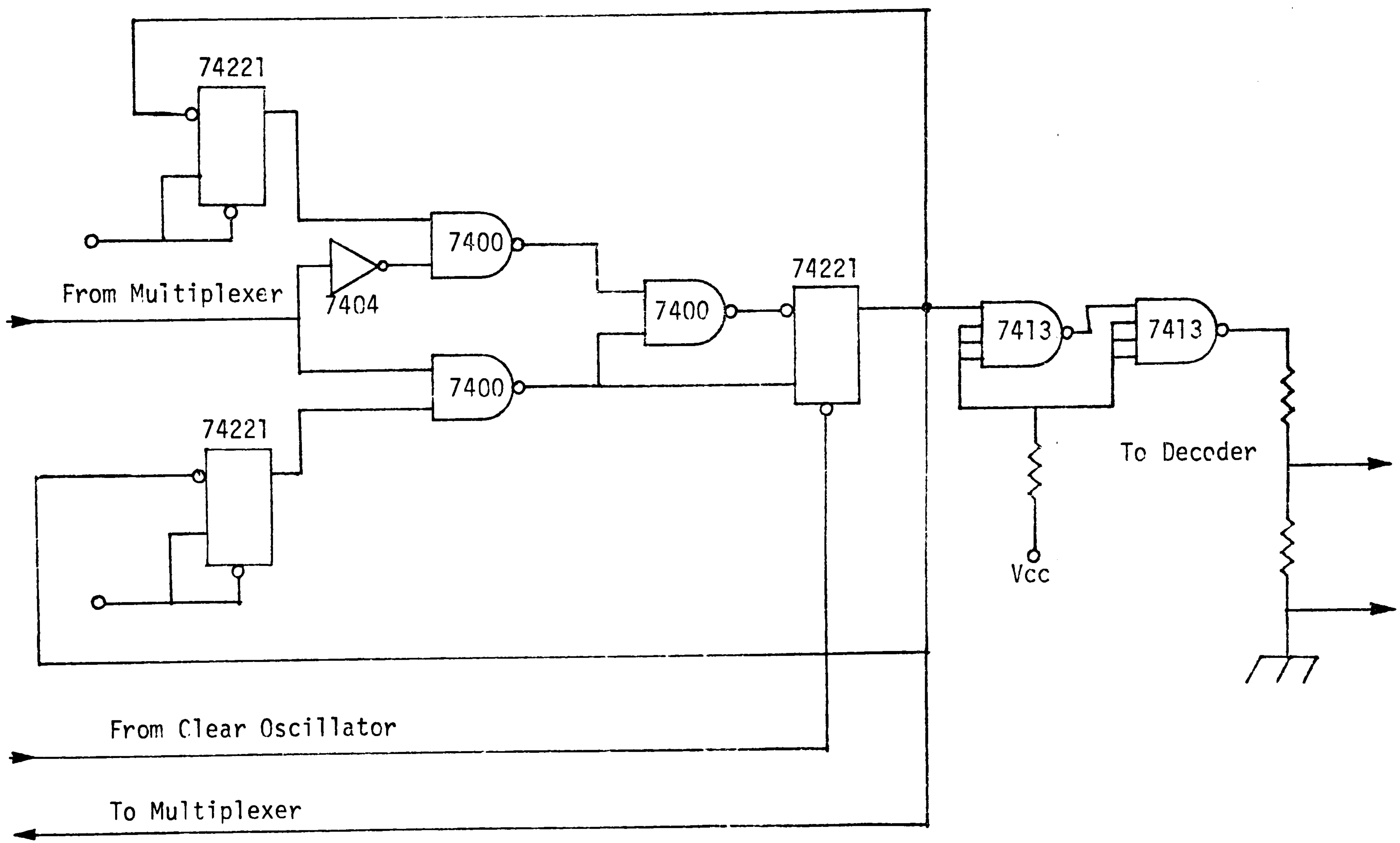

Figure 5. Oscillator and Recorder Interfacing.

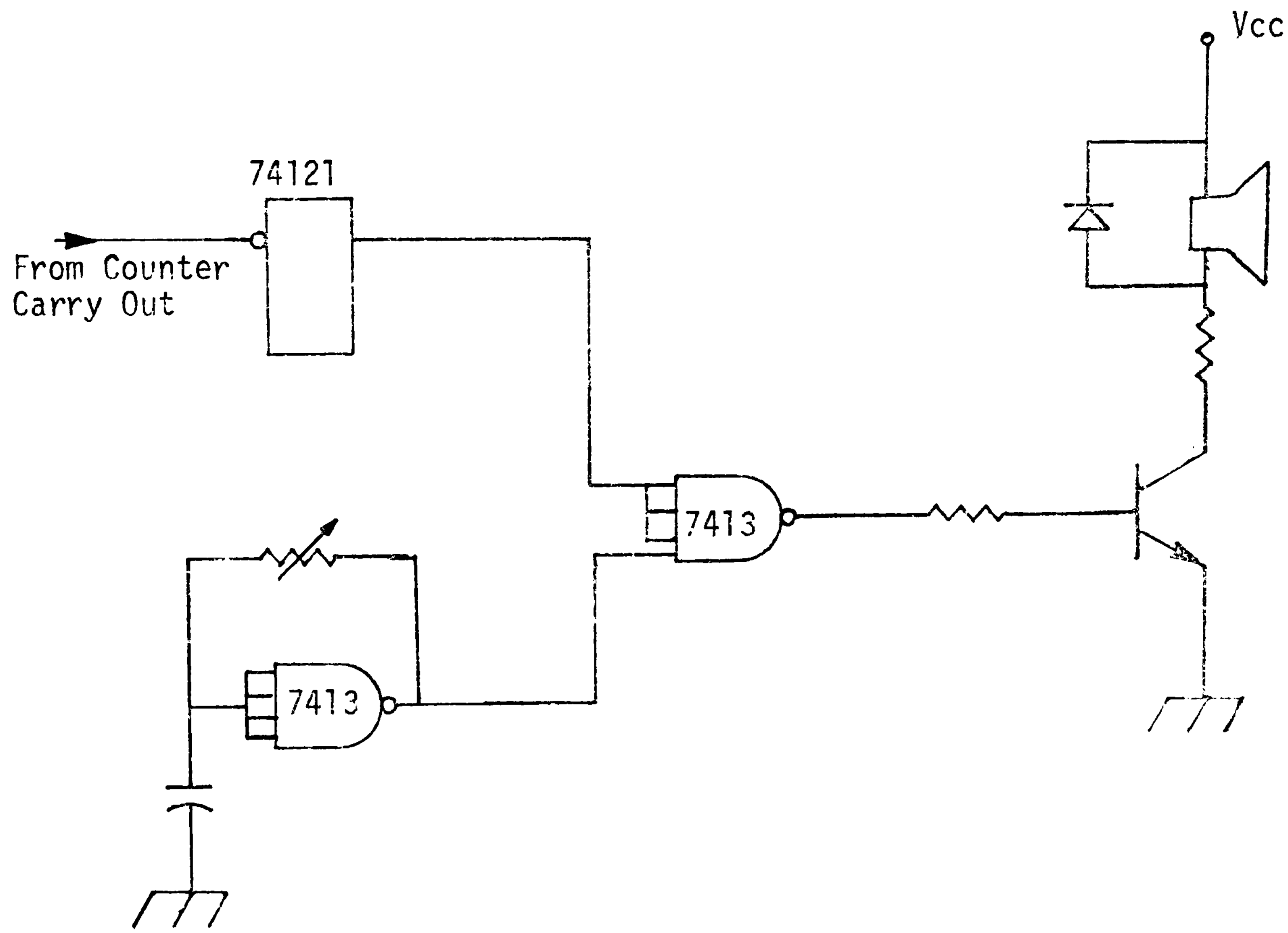

Figure 6. Sound Indicator for the Recorder.

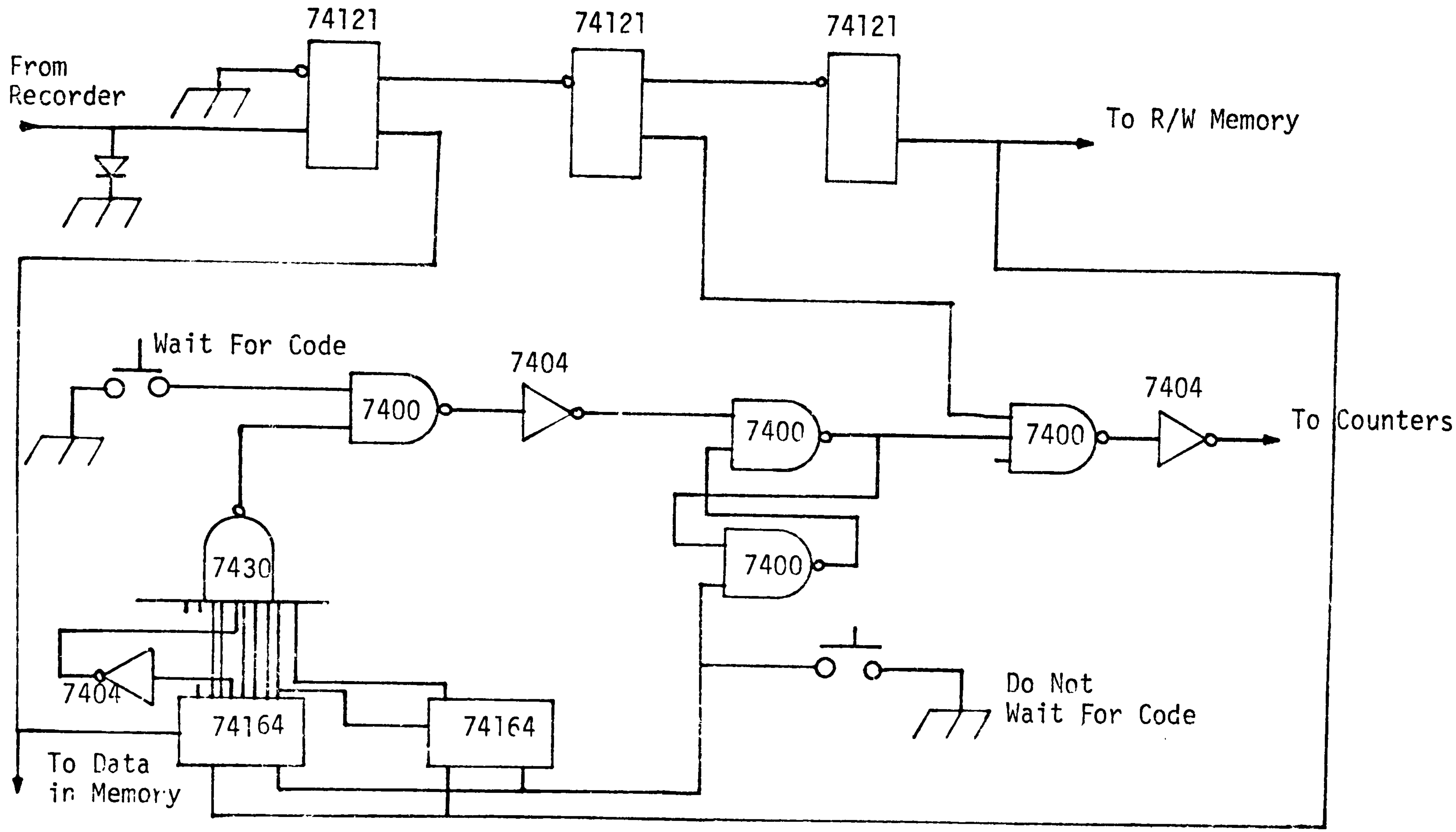

Figure 7. Data Decoding and Code Selector.

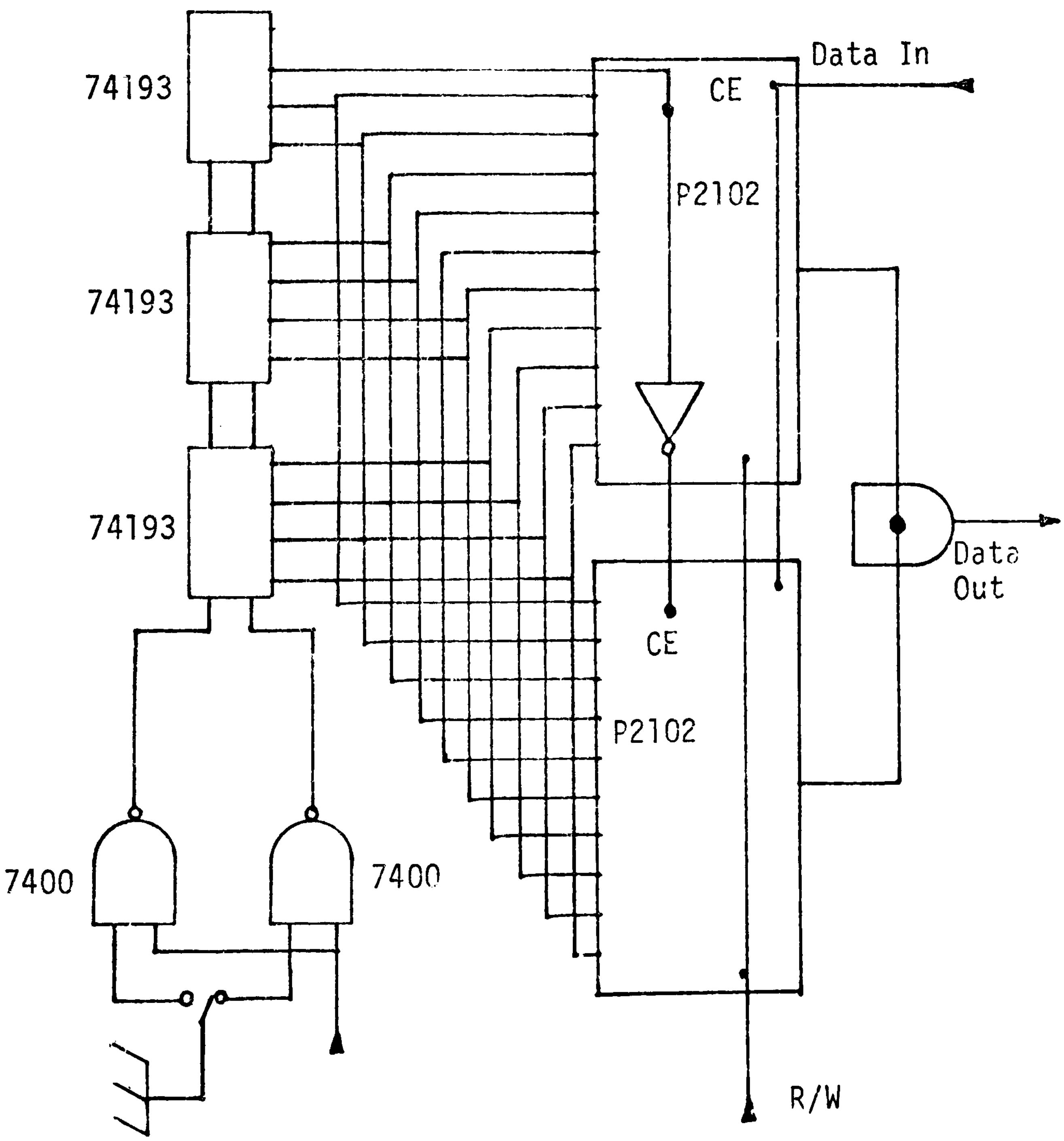

Figure 8. Decode Memory Systems.

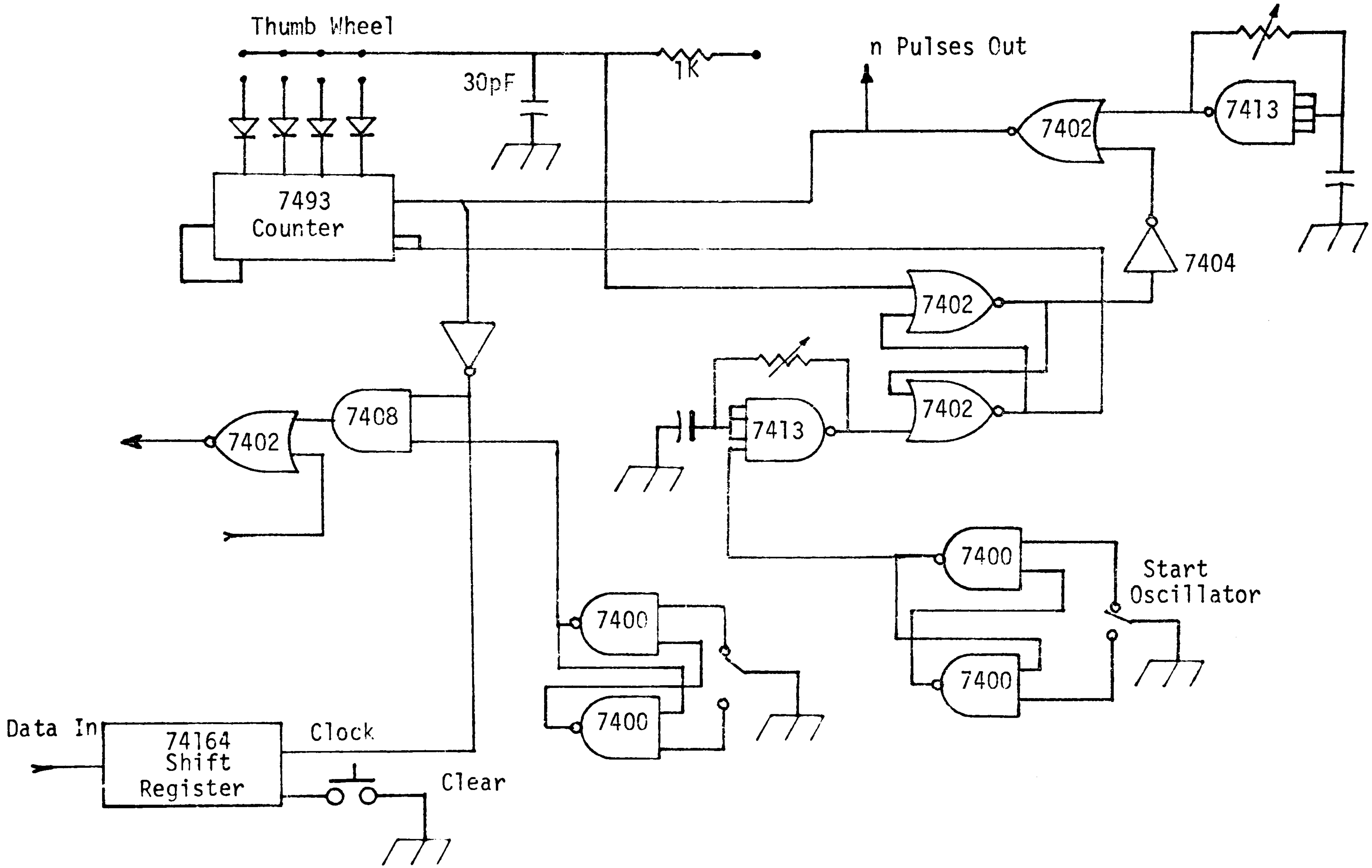

Figure 9. Pulse Oscillator.

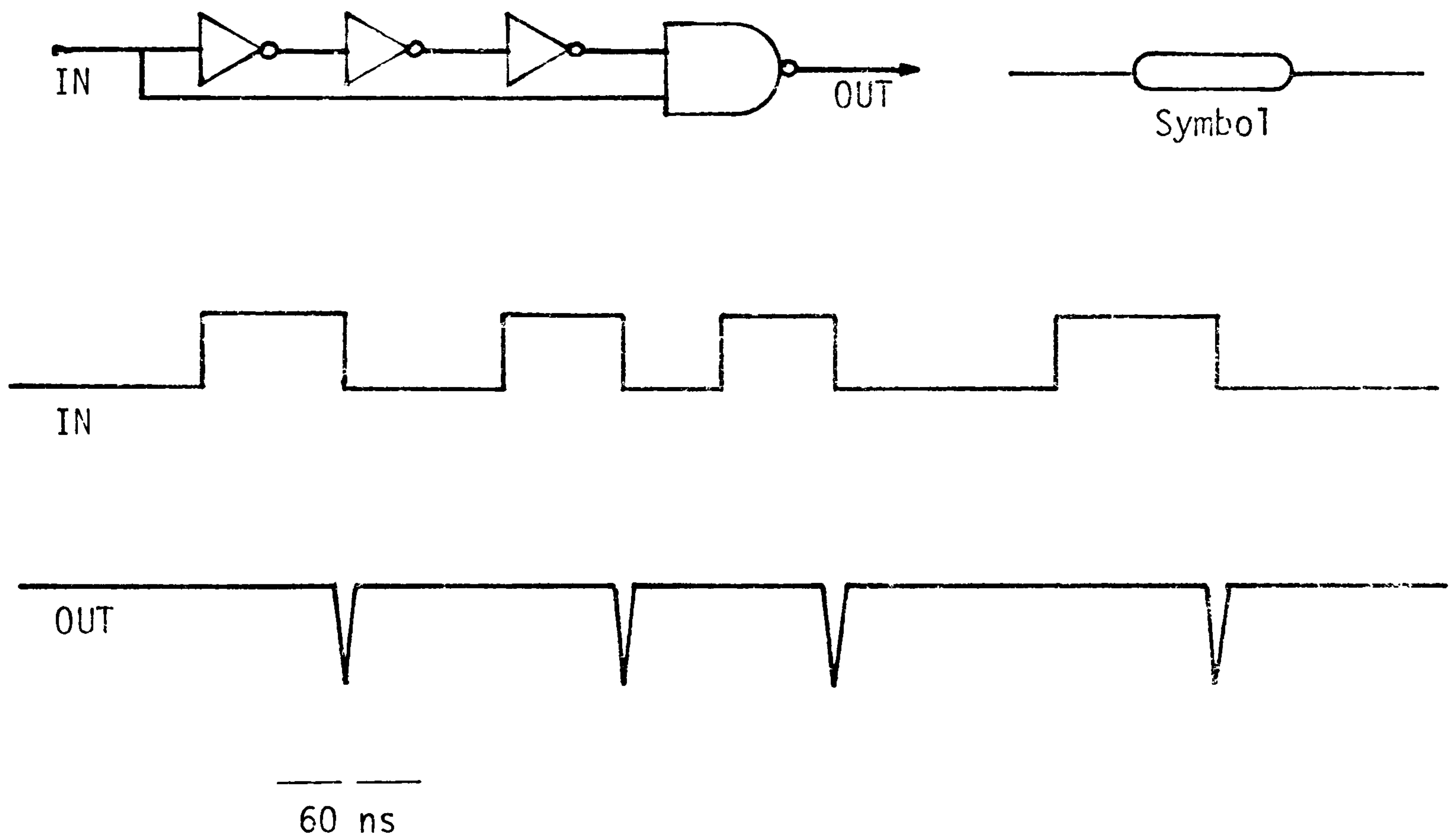

Figure 10. Narrow Low Pulse.

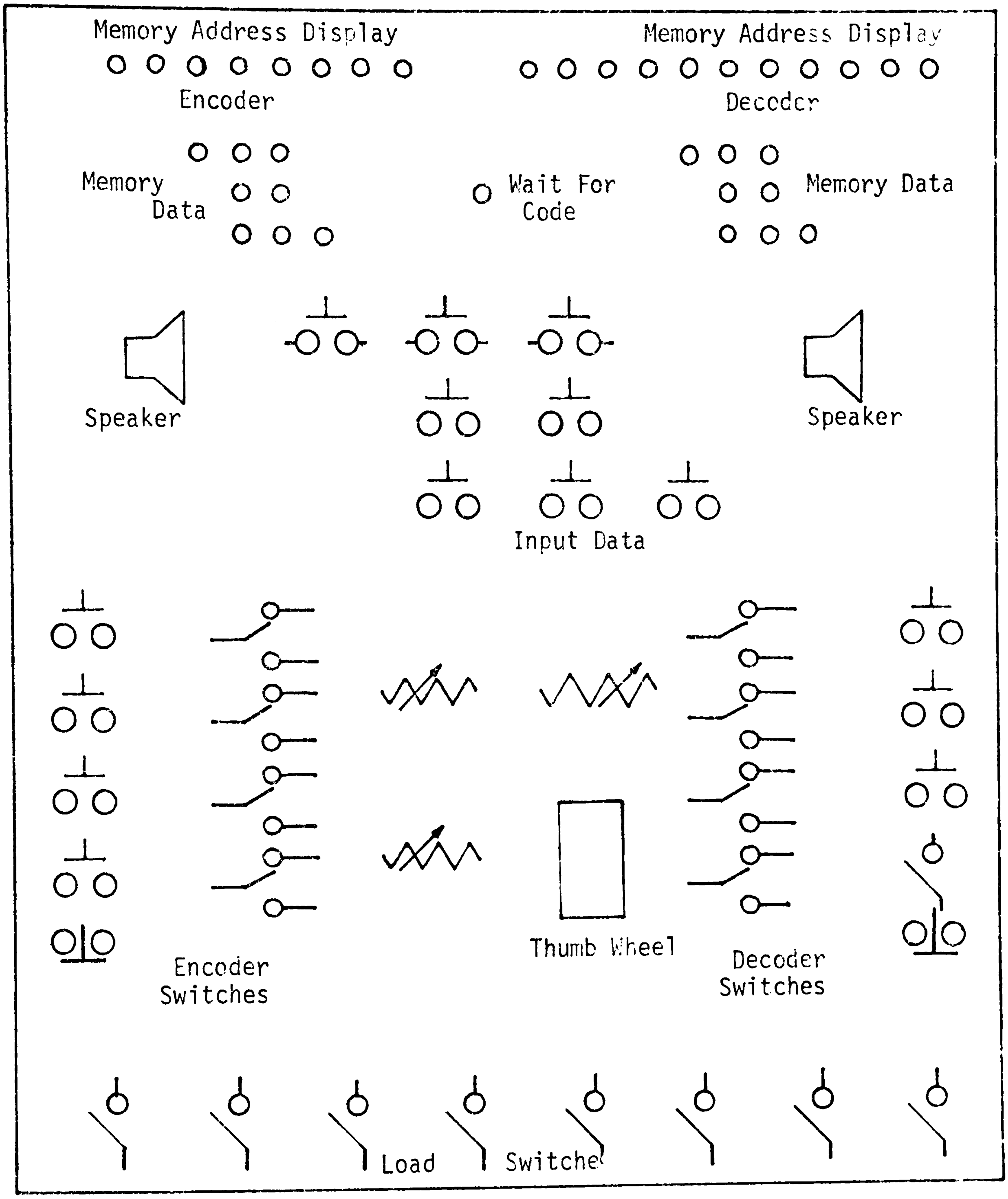

Figure 11. Front Panel.

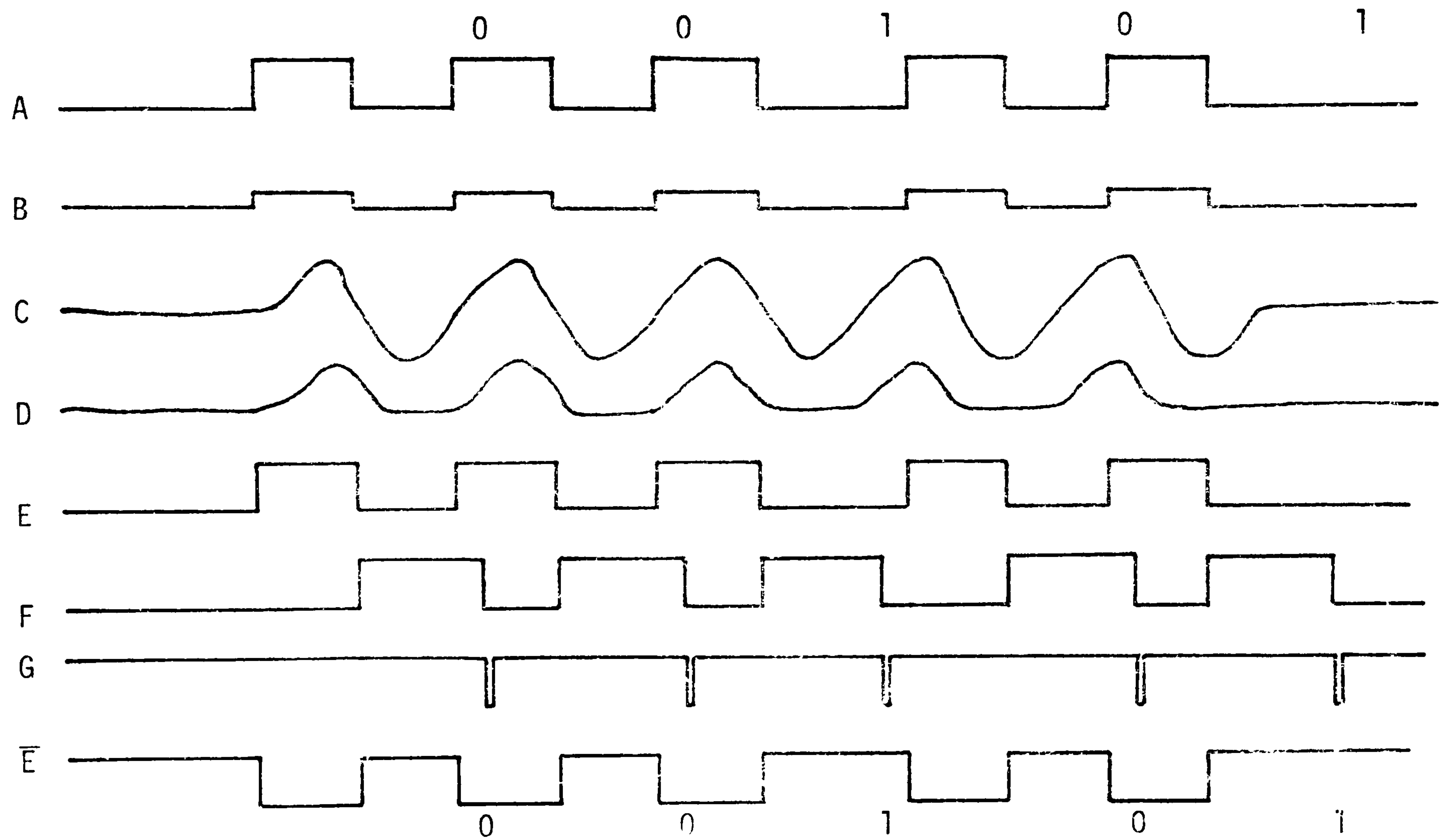

Figure 12. Timing Diagram.

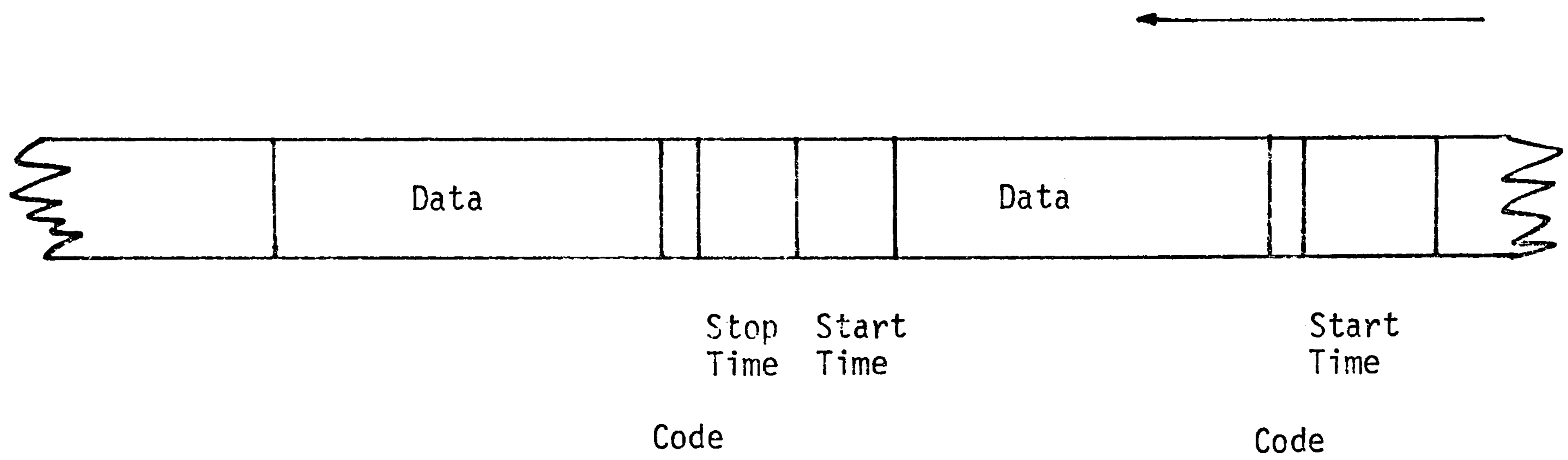

Figure 13. Start and Stop of the Tape.