A BI-DIRECTIONAL COUNTER FOR OPERATION WITH MODEL OLD GOLD HOT-WIRE ANEMOMETER SYSTEMS

by

John R. Glover

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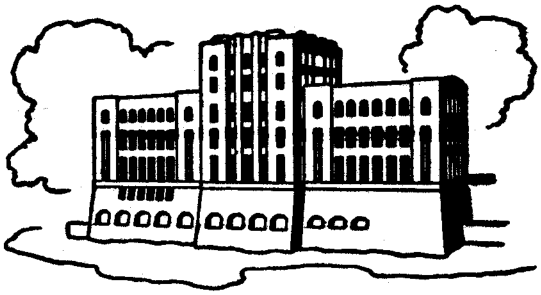
Department of the Navy
Contract Nonr-1611 (07)



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Iowa Institute of Hydraulic Research
The University of Iowa
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ABSTRACT

of

A BI-DIRECTIONAL COUNTER FOR OPERATION WITH MODEL OLD GOLD HOT-WIRE ANEMOMETER SYSTEMS

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The bi-directional counter described in this report was designed specifically for operation with a bi-polar analog-to-frequency converter which has two independent pulse trains. The counter will count in either direction, cross zero and change the sign, and reverse the count direction automatically. Seven-segment readouts are driven by memory circuits which are updated at the end of each gate-time interval. The time-base oscillator is a 100-Hz crystal oscillator, and its output is divided by factors of ten to give gate times of 1, 10, and 100 seconds. The frequencies of the input pulse trains are divided by 10 or 100 for gate times of 10 or 100 seconds respectively. Thus, the four-unit displayed is constant for all three gate times.

ACKNOWLEDGMENTS

Grateful acknowledgment is extended to Dr. John F. Kennedy, Director of the Institute, for his enthusiastic support of the continuing development of sophisticated electronic instruments, and to Mr. Ernest E. Schwab of the Institute Electronics Staff for instrument construction. Financial support for the design and construction of this unit was provided by the Department of the Navy, Office of Naval Research under Contract Nonr-1611 (07).

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A BI-DIRECTIONAL COUNTER FOR OPERATION WITH MODEL OLD GOLD HOT-WIRE ANEMOMETER SYSTEMS

I. INTRODUCTION

The Model Old Gold Type 2 Mean-Product Computer has been included as an integral part of the Type 4-2 Hot-Wire Anemometer System since the instrument was originally designed. This component of the integrated system has been continually improved by the incorporation of new and advanced products of the electronics industry. Specifically, advances in multipliers and the introduction of integrated circuit BCD up-down counters have now made it possible to provide a mean-product multiplier with a digital display of the product. The bi-directional feature of the counter permits direct computation of products that are either plus or minus, and hence eliminates the need for two separate readings corresponding to the plus product and the minus product. For example, the product can correspond to a shear-stress computation if a two-channel crossed-wire anemometer system is being used. Since average shear measurements are desired for analysis, the mean value of the product is computed by linearly converting the voltage representing the product to a frequency which is determined for some satisfactory time interval.

The counter described herein was designed specifically for operation with the bi-polar analog-to-frequency converter included with the Model Old Gold Anemometer System. The converter generates separate pulse trains which correspond to either a positive input voltage or negative input voltage. Of course, both pulse trains cannot exist simultaneously and this consideration was utilized in the design of the counter. The counter will count in either direction, cross zero, and change the sign and reverse the count direction automatically as a function of the two pulse trains. The count computed by the bi-directional counting modules is transferred to the four seven-segment displays at the end of the gate-time interval. The displayed count represents the difference between the two pulse trains and the polarity of the difference is indicated by a sign display.

The time-base oscillator is a 100-Hz crystal oscillator with its output divided by factors of ten to give gate times of 1, 10, and 100 seconds. The frequencies of the input pulse trains are also divided by 10 and 100 for gate times of 10 and 100 seconds respectively. The division of the pulse trains for the longer gate times makes the display independent of gate time. The four display units combined with the gate times limit the maximum frequency that can be displayed to 9,999 Hz. This upper limit is compatible with the analog-to-frequency converter which has a conversion coefficient of 1000 Hz per volt. It does not, however, represent the maximum counting frequency. This is limited by the recycle time and pulse width of the SN74121 modules used in the gating circuits. For the indicated values of the timing capacitor, the upper frequency limit is approximately 100 KHZ.

The four principal parts of the bi-directional counter, which are discussed below, are: 1) time-base circuits; 2) count direction, sign, and storage circuits; 3) gating circuits; and 4) transfer and reset circuits.

II. TIME-BASE CIRCUITS

Figure 1 is a schematic of the time-base circuits and depicts the five decade modules for generating the time periods of 1, 10, and 100 seconds and the flip-flop (2-SN7474-2) which controls the gate passing the pulses to the counting modules. The SN7490 is an MSI-TTL high-speed binary-coded-decimal decade counter. The first two modules divide the 100-hertz signal from the reference oscillator to give 1-second pulses. Units 3, 4, or 5 produce a positive output pulse every 1, 10, or 100 seconds, respectively. The SN7474 is set by the first oscillator pulse in the gate-time interval and reset by the pulse from the decade module selected by the time-base switch. The $\overline{Q}$ output of the SN7474 is connected to the reset lines of the decade modules, and when the time interval has elapsed, the reset lines are taken to logical "one" and held there until the next positive pulse is generated by the oscillator. Since the SN7490 units are negative-edge triggered, they count the same pulse which clears the reset lines. Because the frequency of the crystal reference oscillator is so low, adequate time is provided to transfer the outputs from the counting modules to the memory circuits and reset the counting modules before the oscillator pulse occurs which clears the reset lines on the SN7490 modules.

Manual resetting is provided by the push-button switch shown in the figure, which when depressed connects the second set of reset lines on the SN7490 units to B plus. The second set of reset lines sets the SN7490 units to a binary-coded-decimal count of 9. Hence, automatic resetting initiates on the next oscillator pulse.

III. COUNT-DIRECTION, SIGN, AND STORAGE CIRCUITS

The truth table shown in figure 2 summarizes the relationships which exist between the two pulse trains (labeled plus input and minus input), zero, sign, and counter direction. A plus pulse train exists when the input to the converter is positive and the minus pulse train exists when the input is negative. Zero is indicated when all counting modules are at logical "zero," and the sign corresponds to either an accumulated positive input signal or an accumulated negative input signal. Counter direction corresponds to the mode of the bi-directional counters (i.e., either up or down). To understand the relationships between these five variables, consider the following sequence of events with all decade counting modules being at zero initially. If one assumes a positive pulse train, the sign must be positive or logical "one" and the direction must be up or logical "one." The termination of the positive pulse train and the starting of the negative pulse train sets the direction to the down mode or logical "zero." The sign does not change until all decade modules are at zero again. Continuation of the negative pulse train causes the sign to change to minus or logical "zero" and the direction to change to up or logical "one." These states exist until the minus pulse train terminates and the positive pulse train again starts. The direction then changes to down or logical "zero" and when all decade units reach zero the sign changes to plus or logical "one" and the direction changes to up or logical "one." Since the converter input cannot be instantaneously both positive and negative, simultaneous pulse trains are not possible and hence do not need to be considered. Figure 3 is a schematic of the logic circuits which satisfy the relationships shown in figure 2. Module 2-SN7474 is the memory element for the sign. The plus input and minus input pulses lead the pulses going to the SM193 counting units. This is necessary so that the mode (up, down) of the

SM193 may be established before counting the pulse.

Circuits for deriving the zero signal indicated in figure 3 are shown in figure 4. All six decades must be included even though two of them are not displayed, and as is easily verified, zero is at logical "one" when the outputs of all six counters are at logical "zero."

Figure 5 is a typical schematic of the storage and display circuits. A memory feature is included with the counter because of the automatic recycling of the time-base generator. At the end of each time interval (that is 1 second, 10 seconds, or 100 seconds) a transfer pulse is issued which via the transfer line activates the SN7475 latch so that information at its inputs is transferred to its outputs. The decoder, SN7447, decodes the output of the latch so that it is in suitable form for driving the seven-segment display. The storage unit for the sign display is 2-SN7474-1 and is shown in figure 3.

IV. GATING CIRCUITS

Figure 6 shows the circuits for gating the input frequencies. All modules are SN74121 and are one-shot monostable multivibrators. The first two units provide signals for the count-direction and sign circuits while the third sums and gates the two pulse trains. The fourth unit drives the SM193 units and is included to provide the delay necessary for making direction changes (up, down) prior to receiving the pulses for counting. The transistor input circuits are designed specifically for operation with the analog-to-frequency converter included with the Old Gold Hot-Wire Anemometer System. The voltage level necessary for activating the one-shot multivibrator is approximately one volt.

V. TRANSFER AND RESET CIRCUITS

The transfer and reset circuits are shown in figure 7 and consist of two monostable multivibrators. The transfer-pulse circuitry is activated by the time-base circuitry. The same pulse (the output of 2-SN7474-2) which closes the gate passing the pulses to the SM193 counting units also activates the transfer-pulse circuitry. The transfer pulse causes information at the inputs to the SN7475 latch circuits to be transferred to the outputs of the latch circuits. The trailing edge of the transfer pulse activates the reset-pulse circuit which, in turn, resets the SM193 units to logical "zero" in preparation for the next counting sequence. After the completion of this pulse, all units are at the proper logic levels for completing another bi-directional counting operation.

VI. OPERATING PROCEDURES

Operation of the bi-directional counter is very simple. The two input BNC connectors must be connected to the corresponding output BNC connectors on the analog-to-frequency converter in the Hot-Wire Anemometer System. The plus connector should be connected to the plus connector of the converter, and the minus to the minus. Once the power switch is turned on and the above connections made, the instrument will automatically operate after it completes the first time interval selected by the SUMMATION TIME switch. If the SUMMATION TIME switch is rotated to a new position, the display at the end of the first time interval will be incorrect. This incorrect first reading can be eliminated by pressing the RESET button. The RESET button is generally used only for the 10- and 100-second summation intervals. It is always good practice to correlate the display given by the counter with the deflection of the MONITOR on the Hot-Wire System in order to verify correct operation of the instruments.

VII. CONCLUSIONS

The major design objective initially defined for the bi-directional counter has, without question, been satisfied. That is, the counter will accept two pulse trains and automatically compute the difference between them during a specified, selectable, time interval. The objective to make the counter small enough to fit into existing space within a two-channel anemometer chassis was not met. This is because four discrete cards were required to contain the logic circuits, and there is adequate room for only three cards in the anemometer chassis. To be sure, the means by which the logic was satisfied could possibly be accomplished more efficiently, particularly in view of the new integrated circuits components which have been introduced since the design presented herein was adapted. Specifically, a different bi-directional counter could reduce the number of components for generating the zero signal, or inverters included in the NAND gate modules would eliminate the need for the external inverters. Another section that could be changed to reduce the number of components is the memory and display section. In any event, modifications can be readily made which will permit the inclusion of the bi-directional counter in the anemometer system because of the rapid advances of technology in the electronics industry.

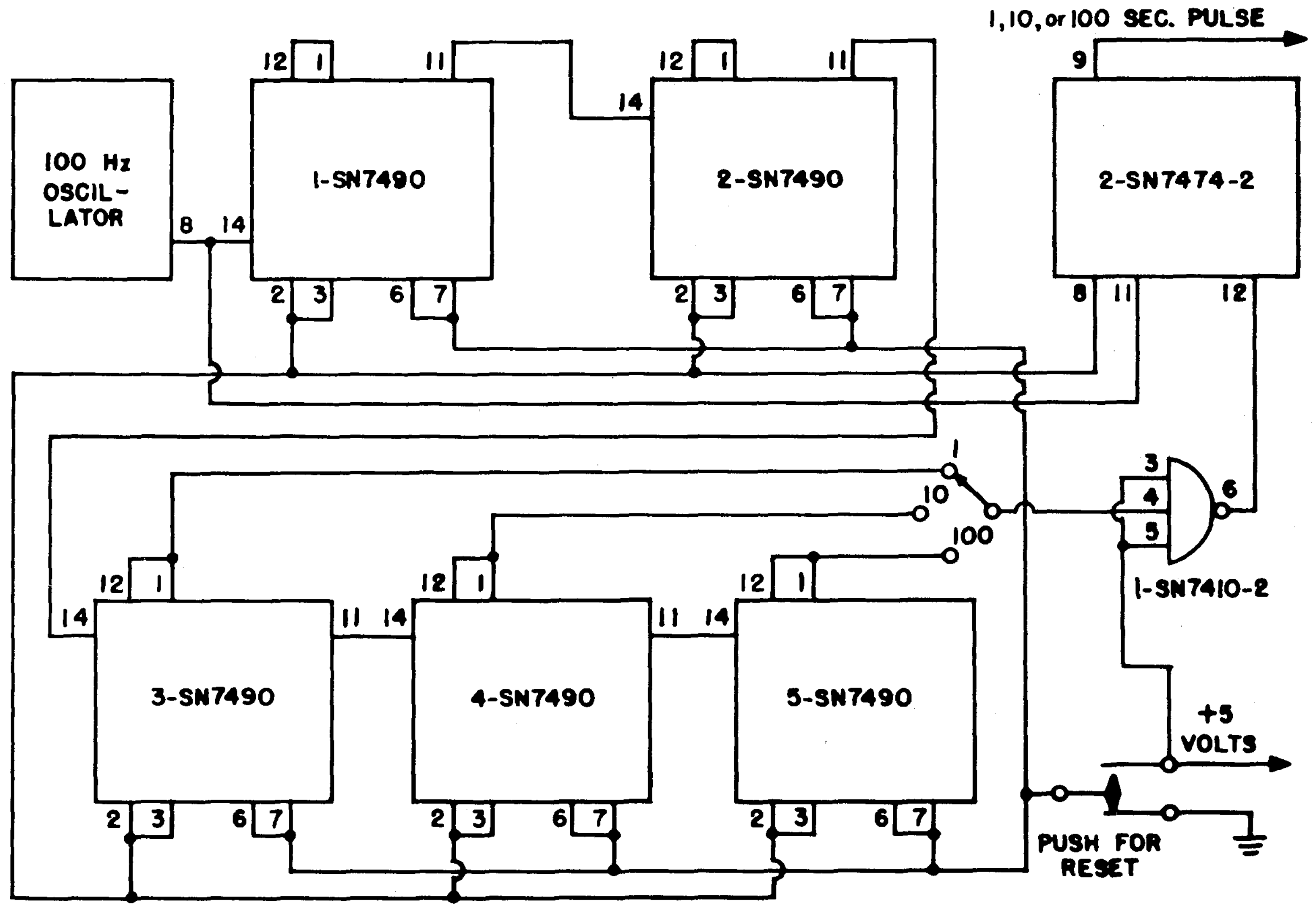

Figure 1. Time-Base Circuits.

SIGN	+ INPUT	− INPUT	ZERO	COUNTER DIRECTION
1	1	0	1	1
0	0	1	1	1
1	1	0	0	1
1	0	1	0	0
0	1	0	0	0
0	0	1	0	1

Figure 2. Truth Table for Establishing Counter Direction.

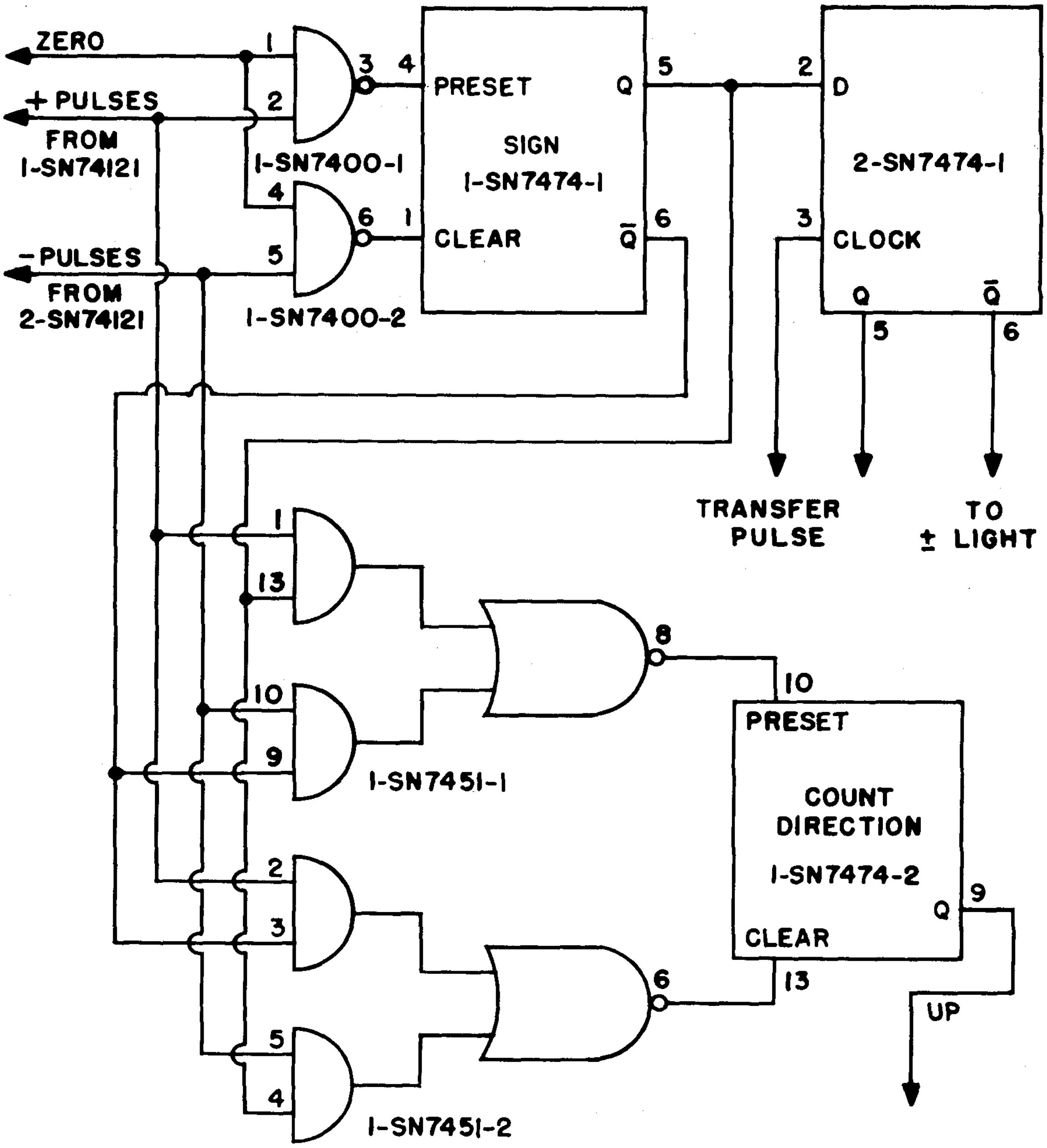

Figure 3. Logic Circuits for the Determination of Counter Direction.

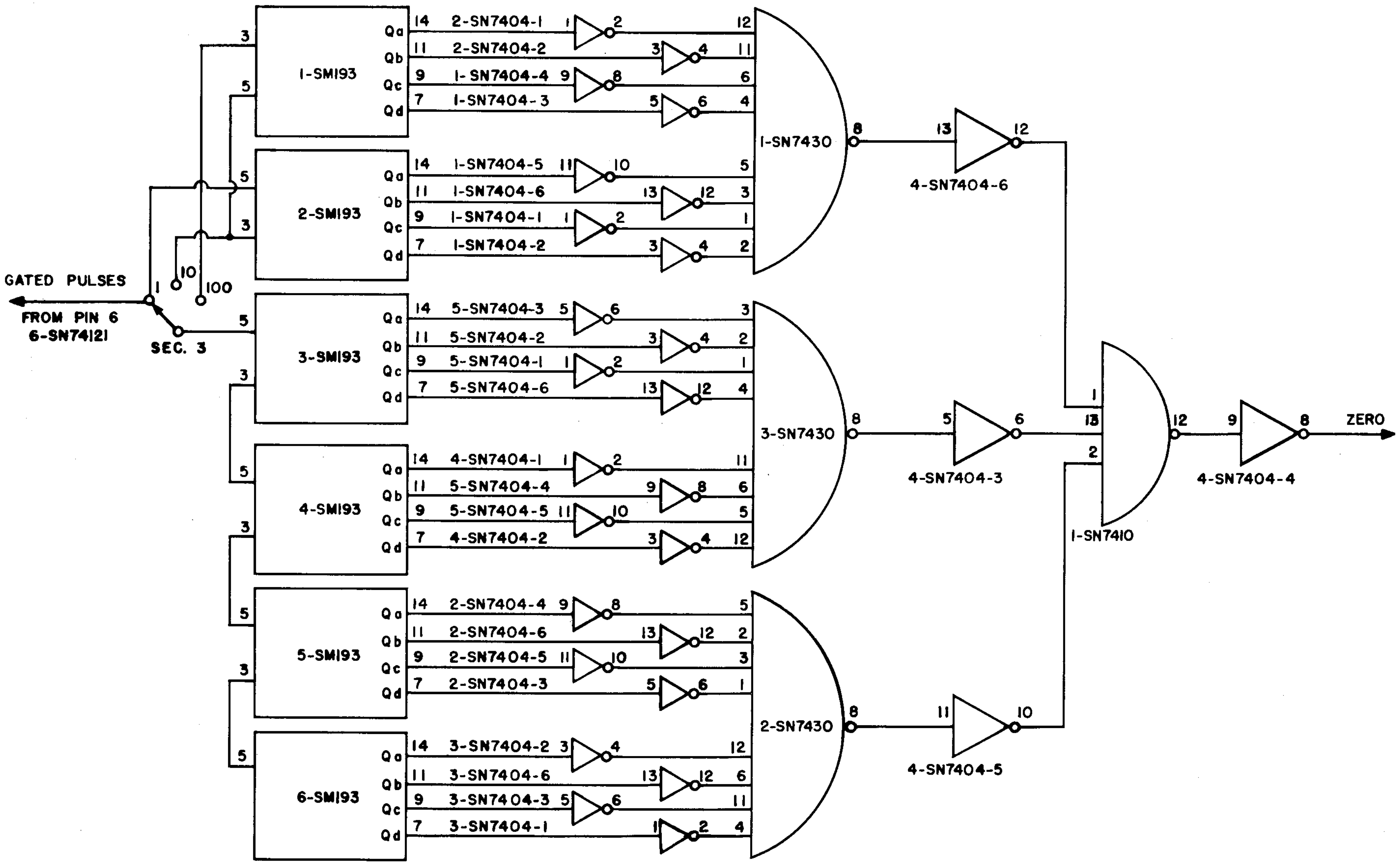

Figure 4. Logic Circuits for Determination of Zero.

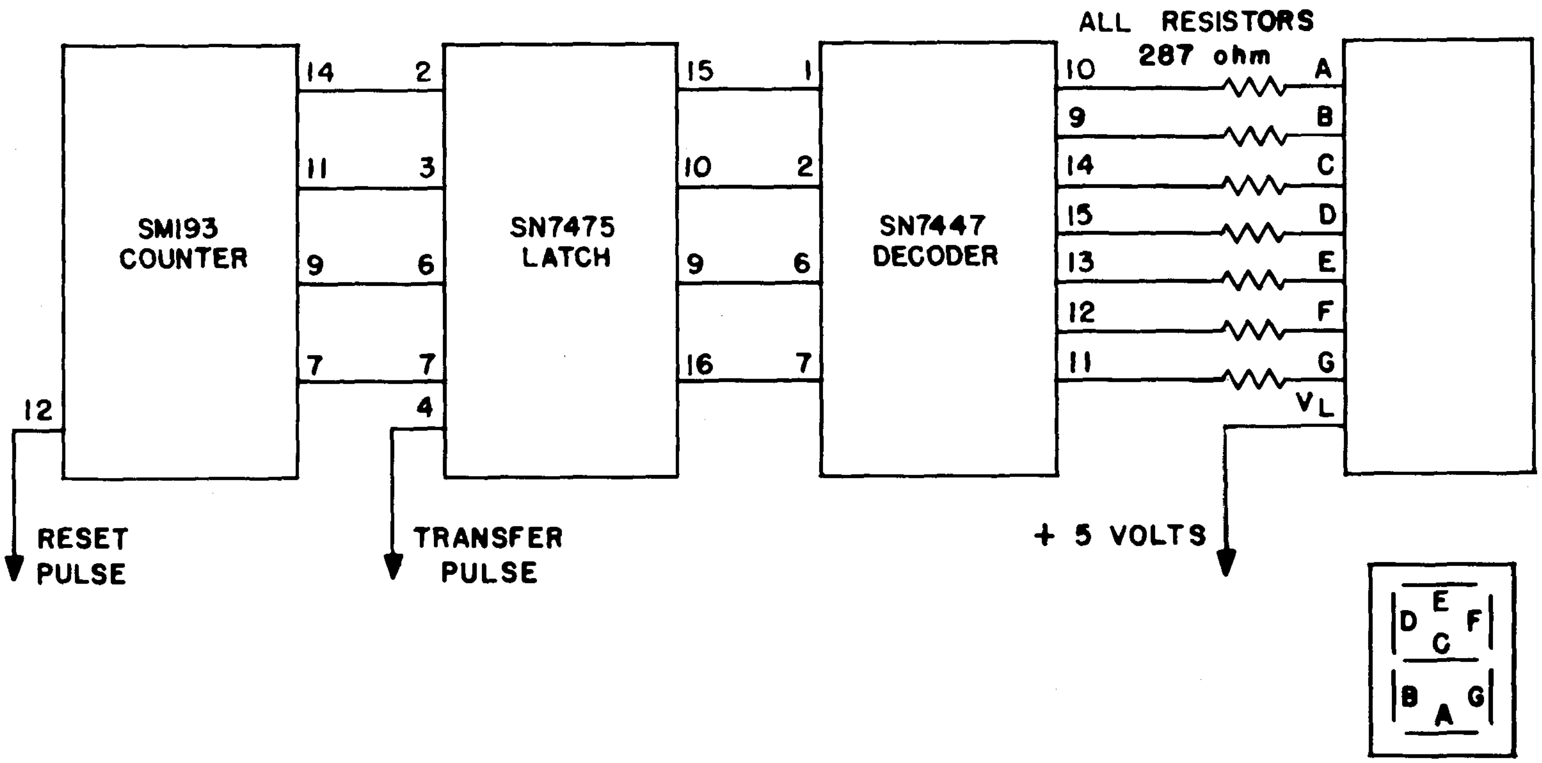

Figure 5. Typical Schematic of Storage and Display Circuits.

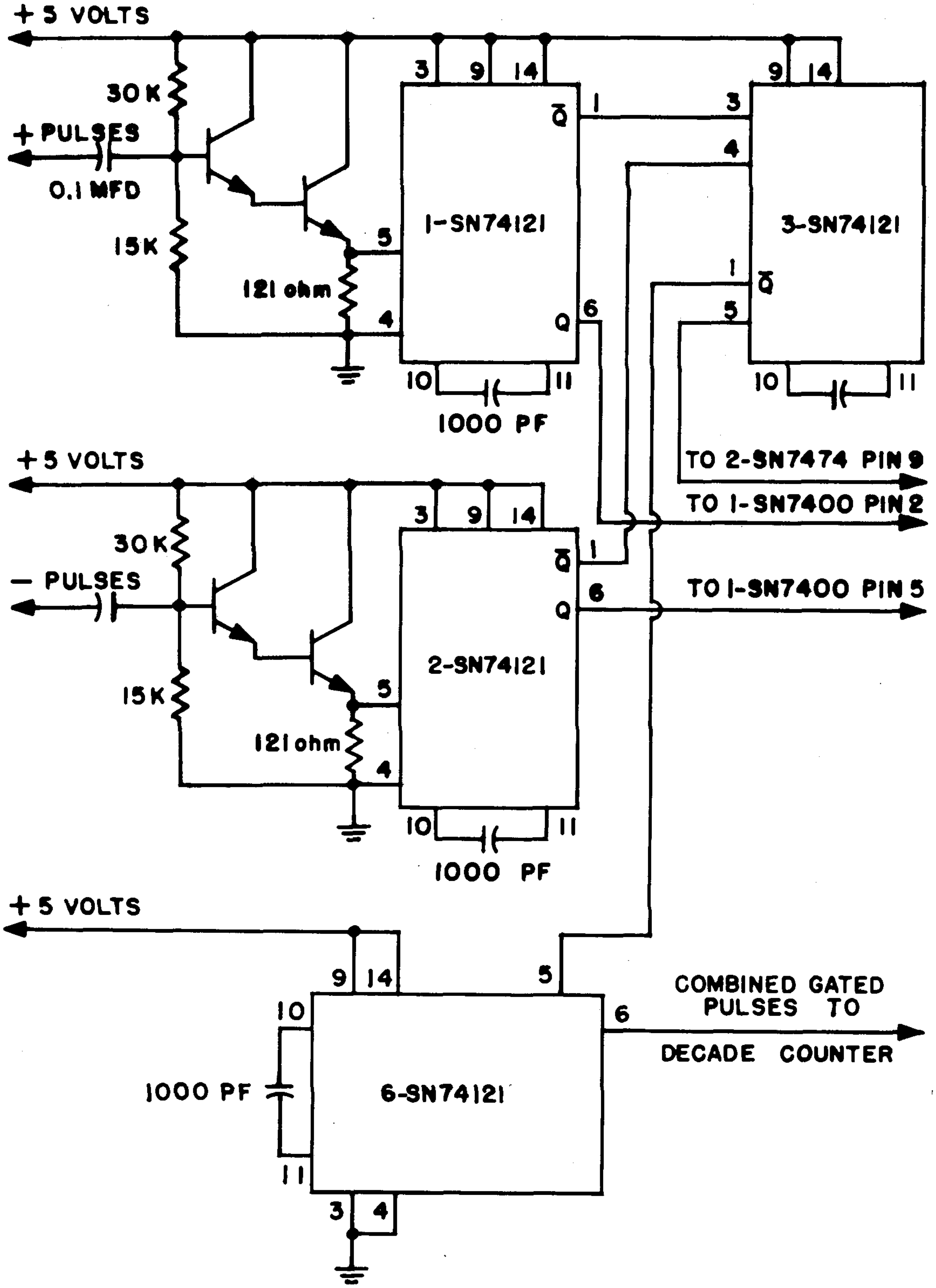

Figure 6. Pulse Shaping and Gating Circuits.

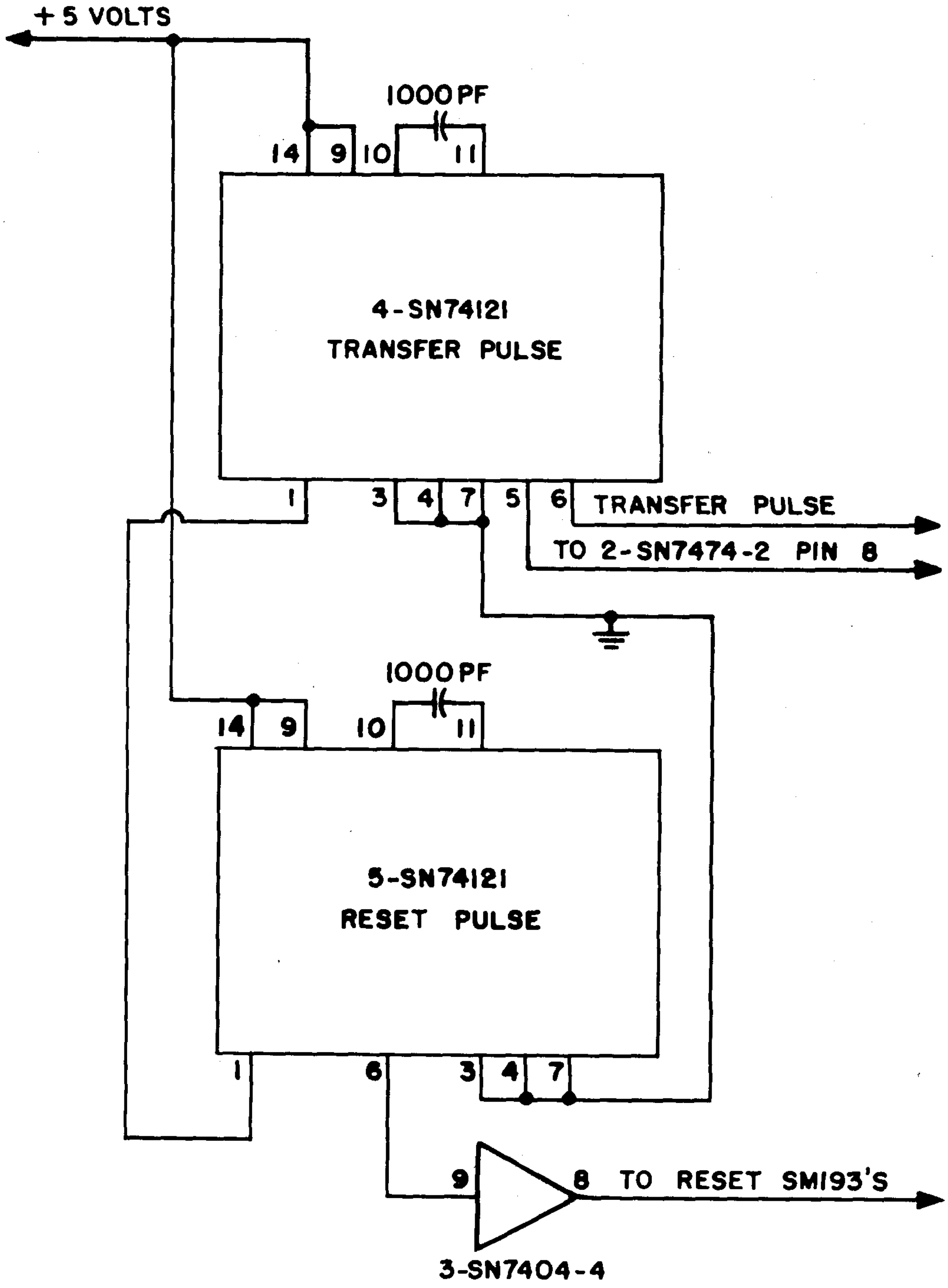

Figure 7. Transfer and Reset Circuits.