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Informal Report

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DESCRIPTION OF MODEL 73 TELEMETRY SYSTEM FOR REPORTING

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ABSTRACT

An electronic identification and temperature monitoring system is described. This system, designated Model 73, was designed and fabricated in 1973 to demonstrate the feasibility of implementing a technique which is based on a passive transponder which responds to interrogation by a transmitter operating in the L-band radar frequencies. The purpose of this report is to document the functional elements of this successful preprototype system.

I. INTRODUCTION

The design and construction of the passive biotelemetry system described in this report was carried out at the Los Alamos Scientific Laboratory (LASL) operated by the University of California under contract to the U. S. Atomic Energy Commission (currently the Energy Research and Development Administration). The work was jointly sponsored by the U. S. Department of Agriculture and the AEC. The first public showing of the system was in St. Louis, Missouri in September 1973.[1,2,3,4]

The technical characteristics of the system can be characterized as follows:

1. The system will read and display the temperature of the transponder in degrees Celsius and also display the identity of the transponder as three decimal digits.
2. The display is active only upon receipt of two consecutively identical identification words in order to minimize reading errors.
3. Multiple transponders will not produce errors. Only the strongest return is accepted for display.
4. The Model 73 unit operates at about 5 W and 1 GHz and has a range of about 3 m.
5. The rf source and receiving electronics is battery powered for portability.
6. The transponder is passive (no batteries). Its operating power is derived from the interrogating rf beam.

II. DESCRIPTION

Figure 1 shows the subsystem components of the Model 73 Interrogator-Receiver.

Figure 2 shows the electrical schematic for the hand-wired transponder with hybrid multivibrator. The voltage doubler has the dual role of converting the rf-induced antenna ac voltage into a dc voltage which supplies the transponder electronics and also to modulate the antenna. This action causes the antenna to have a varying backscatter cross section in synchronization with the multivibrator frequency. The purpose of the voltage regulator is to prevent excessive voltage excursions from affecting the multivibrator, whose frequency depends upon a thermistor, is actively trimmed at 39°C such that frequency will linearly track temperatures between 35°C and 45°C. The modulation switch and modulator approximates a short to the input voltage under control of

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the coding generator. The encoding scheme is derived from a form of pulse-width modulation in which a "0" is effected by allowing full amplitude for the first quarter of a bit period and modulating the amplitude by 50% (i.e., a short on the input voltage line) for the remainder of the bit period time. A "1" is effected by allowing full amplitude for the first half of the bit period. The transition from "short" to "open" at the beginning of each bit period allows for the detection of bit periods. The purpose for "shorting" the input voltage is to create a variable load impedance to the antenna such that the backscattered rf is a function of the AM-AM modulation.

Figure 3 is a block diagram illustrating the essential components of the rf subsystem. The oscillator and power amplifier provide the necessary rf power at a particular frequency. This hardware could be replaced by a commercial rf source. The circulator is a device which allows the use of a single antenna for both transmitting the rf carrier and receiving the modulated return signal. The purpose of the power splitters is to provide the appropriate signal to each of two mixers. The double-balanced mixers coherently detect the returned modulated rf signal with the local rf signal to produce the intermediate difference frequency, i.e., the modulation frequency. The operation is performed in two mixers, one of which has the local rf signal shifted 90° in order to negate nulling effects due to relative positioning between the rf antenna and the transponder antenna. The 90° phase shift guarantees that at least one of the mixers will have an output.

Figure 4 is a schematic of the first receiver board. The mixer outputs from the rf unit are amplified and passed through "all-pass" filters. The net 90° phase shift difference is to ensure that channel A and channel B can be summed to produce a signal whose amplitude is not a function of antenna position and a relative motion.

Figure 5 illustrates the bandpass filters centered at 15 kHz for the expected frequency (room temperature) range.

Figure 6 illustrates the automatic gain control (AGC) and amplifier circuitry. Since the coding format is produced by amplitude modulation, the AGC is required in order to preserve the modulation and to react to incoming signal variations due to transponder movements.

Figure 7 consists of a phase-locked loop (PLL) for acquisition of the modulation frequency (temperature) and a synchronous detector. The PLL has a binary divider in the reference signal to the comparator in order to cause the VCO output to multiply the input frequency by two. This provides the times-two scaling required since the transponder's multivibrator frequency is one-half the numerical value of temperature. The synchronous detector and the associated phase tracking circuitry at the bottom of the figure rectifies the PLL signal and tends to average out any noise in order to better discriminate between the high and low levels of the envelope.

Figure 8 shows the level detector circuitry which produces a high level for a "1" and a low level for a "0" as determined by the comparator set points. As previously mentioned in Fig. 2's discussion, a bit value of a "1" or "0" is determined by the presence or absence of a high level, respectively, during the second quarter of the bit period time. The "long" and "short" pulse test logic makes a decision as to whether or not the tentative high level has lasted too long or too short a time to be considered a valid "1." The "Beginning of Block" signal (BOB) detects when the data block or frame is starting for purposes of initialization. The "Data" signal is sent to the circuit in Fig. 10 to be loaded into the identification data register.

Figure 9 illustrates the logic which generates the identification data register shift pulse (clock) and which simultaneously clocks a 12-stage shift register for measuring the duration of 12 bits (3 digits) of identification data. The remaining logic will generate a "hold" (Q^1 output) and a "Flash" signal (the "hold" signal is only momentary if the "Flash" switch is closed) if the "long" and "short" tests passed and if the present word is equal to the previous word ("Code-Check-in" equals a "0" level).

Figures 10 and 11 consist of the present and previous word storage registers, a comparator for detecting equality of the two words, and the display drivers. If there is no equality, the "Blank" signal will come true until two consecutive words are equal.

Figure 12 shows the logic for counting the PLL VCO periods for 10 ms and the miscellaneous logic associated with the front panel controls and indicators.

Figure 13 shows the frequency counter, drivers, and temperature display.

III. CONCLUSION

The Model 73 telemetry system has been demonstrated to the USDA, the beef and dairy industries, and to other industries interested in remote identification and/or temperature monitoring problems. In consequence of these successful demonstrations, the USDA and the LASL have continued development of smaller and implantable transponders utilizing electronic hybrid technology. The improvements in the transponders and interrogator/receiver electronics and packaging will be presented in a later report.

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3. A. R. Koelle, S. W. Depp, and R. W. Freyman, "Short-Range Radio-Telemetry for Electronic Identification, Using Modulated RF Backscatter," Proceedings of the IEEE, August 1975.

4. Patent application, ERDA Docket No. S-47604, (continuation of SN501020).

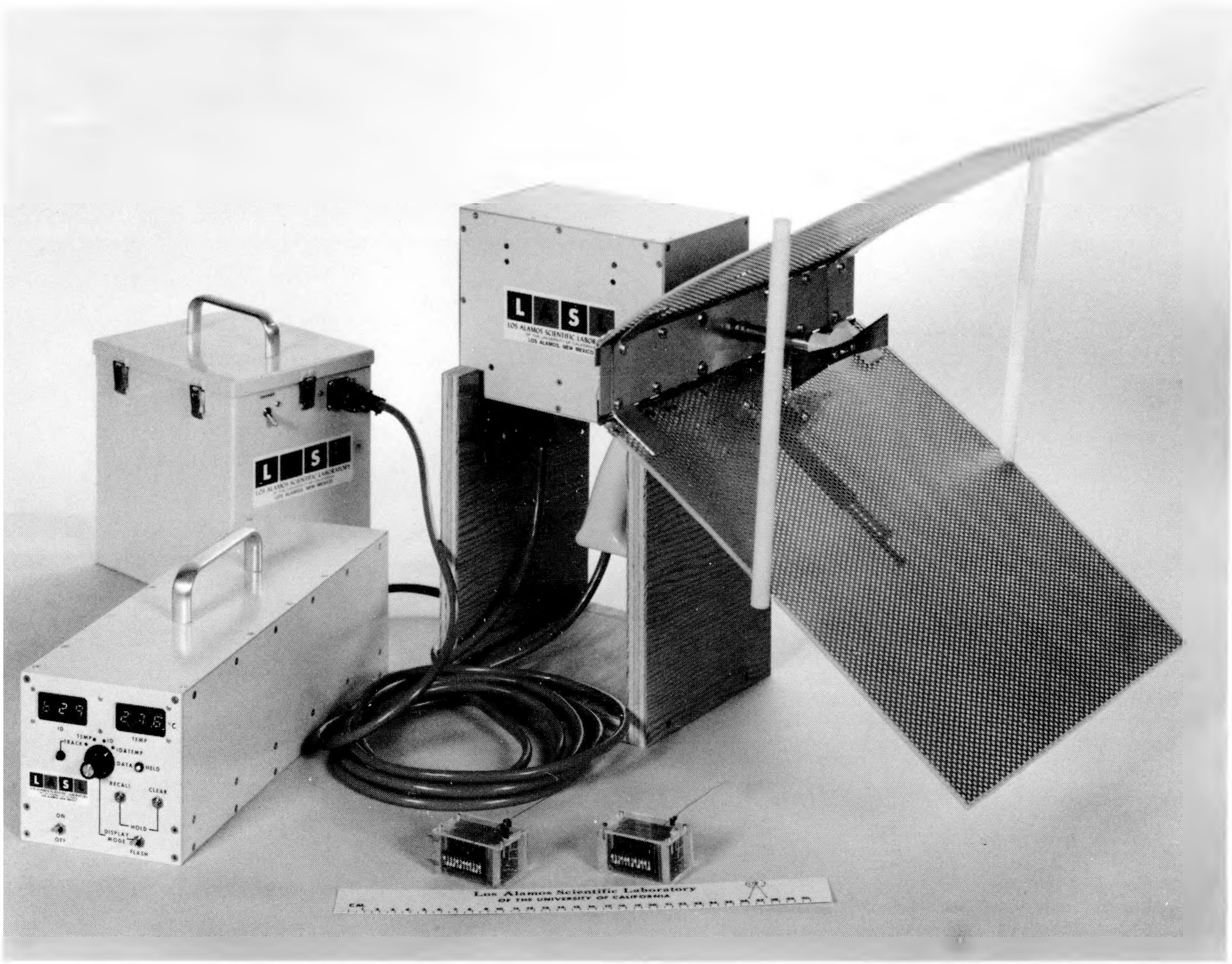

Fig. 1. System hardware.

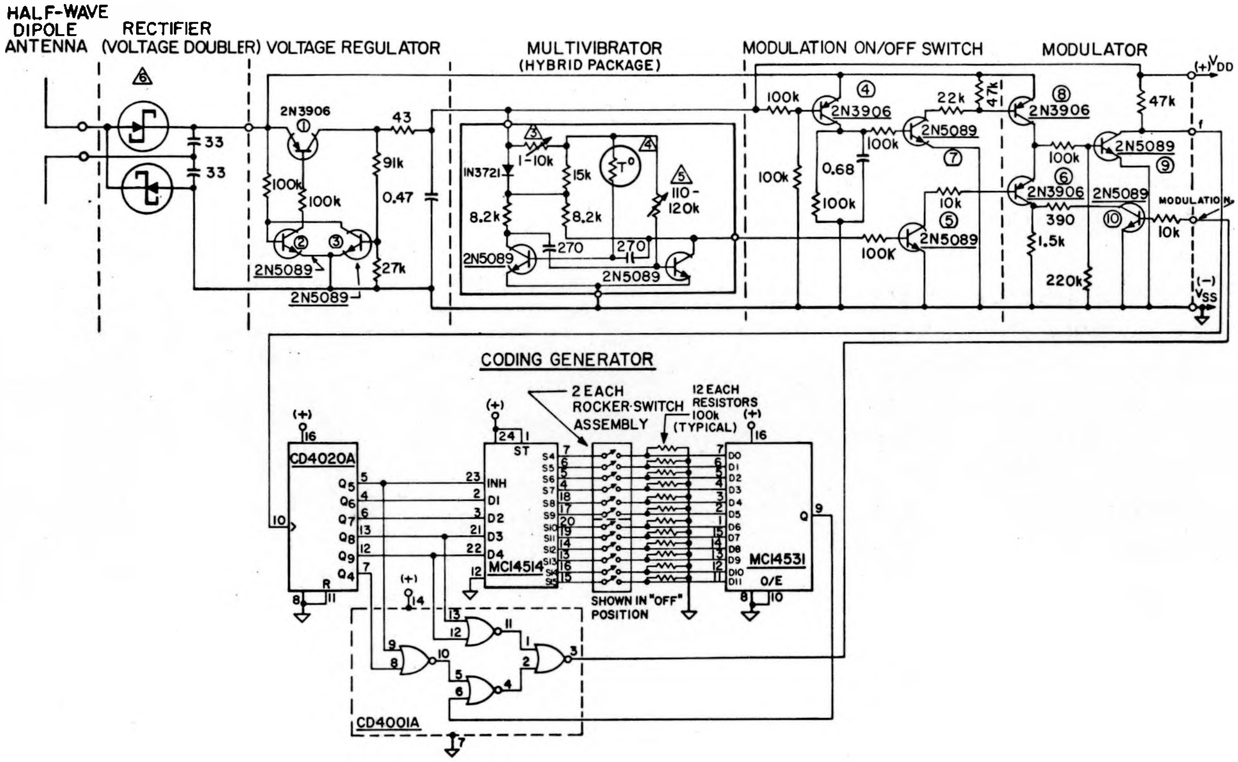

Fig. 2. Transponder.

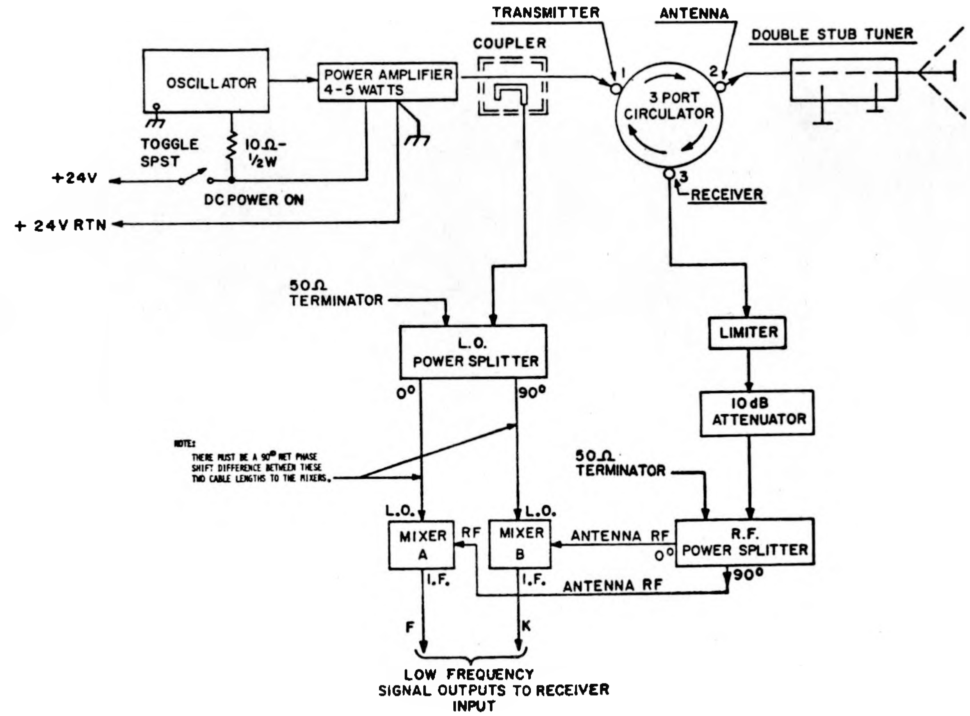

Fig. 3. RF unit block diagram.

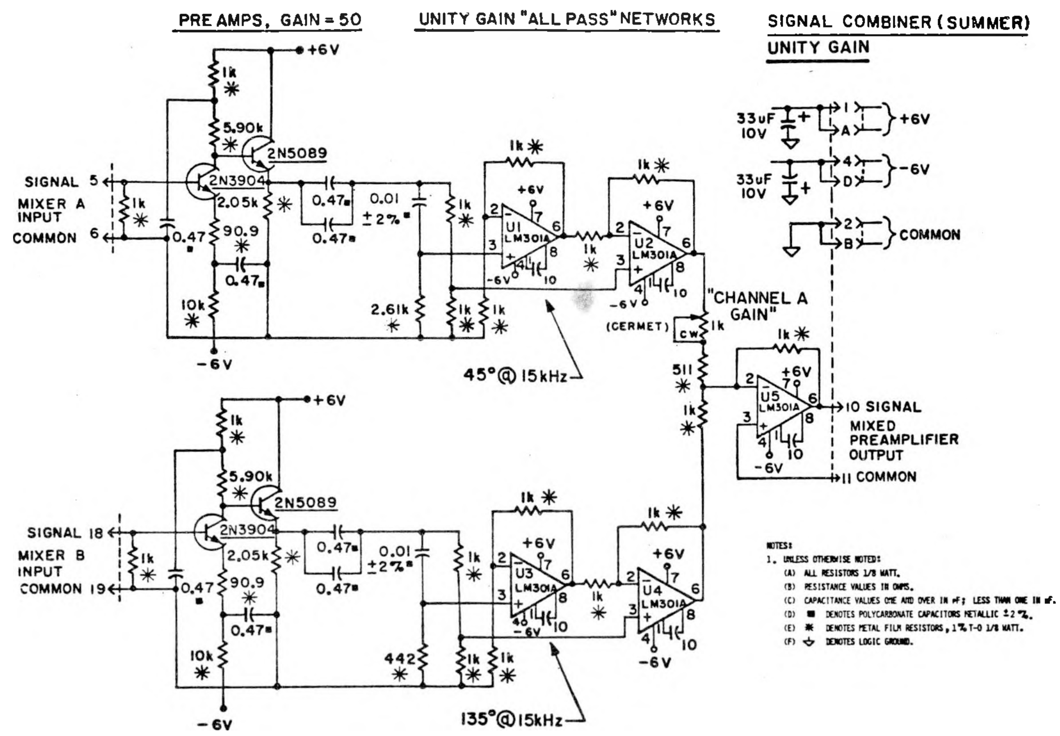

Fig. 4. Preamplifiers, phase shifters, signal combiner.

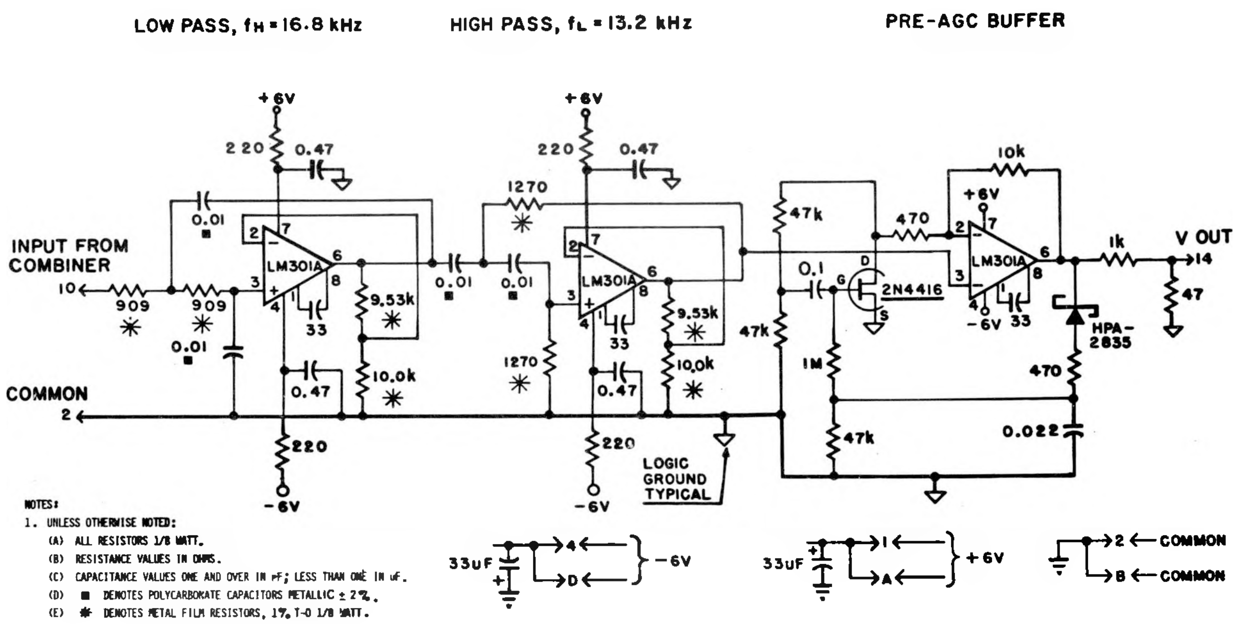

Fig. 5. Bandpass filter.

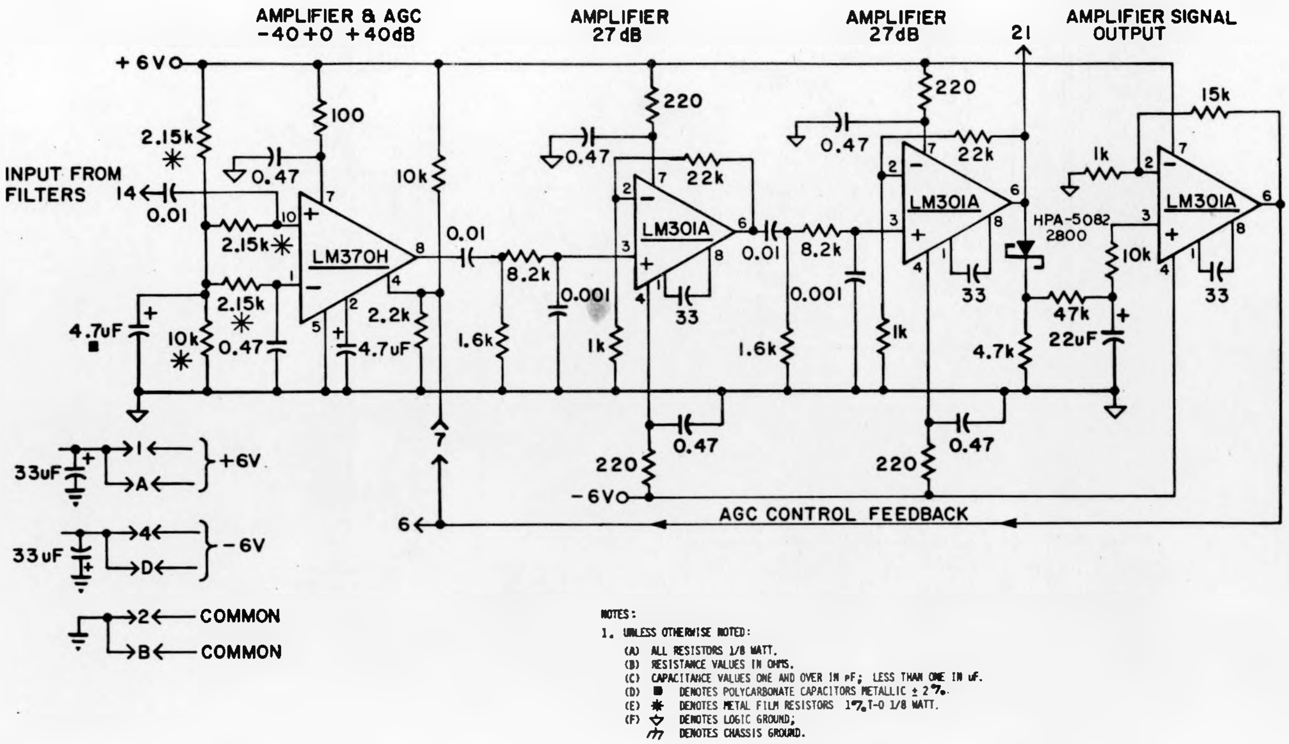

Fig. 6. AGC, main amplifier.

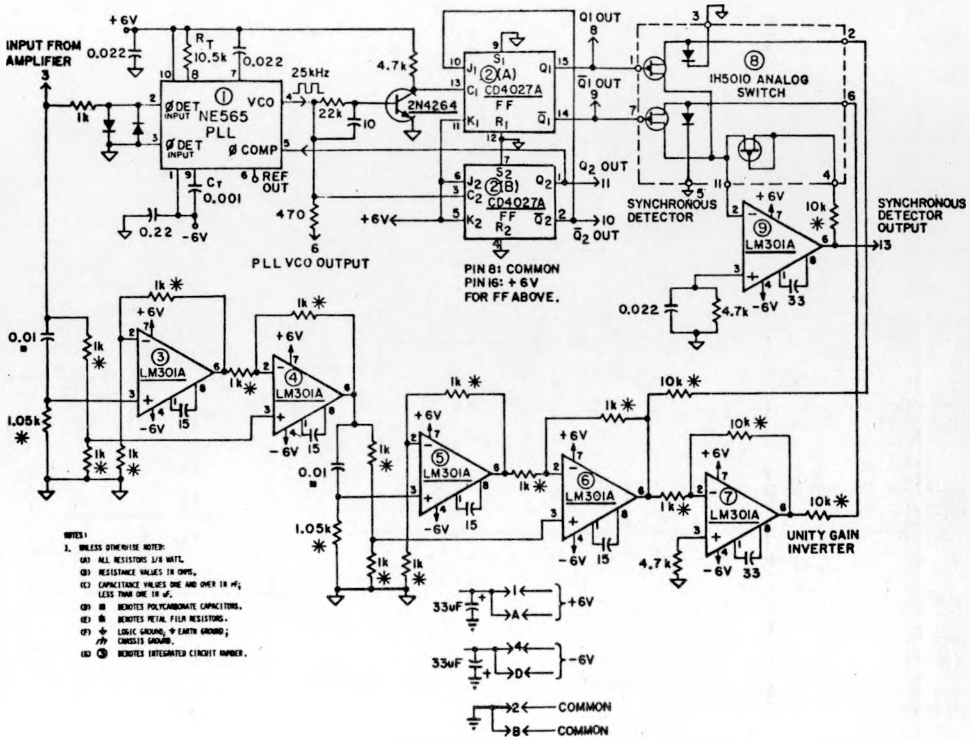

Fig. 7. Phase-locked loop and synchronous detector.

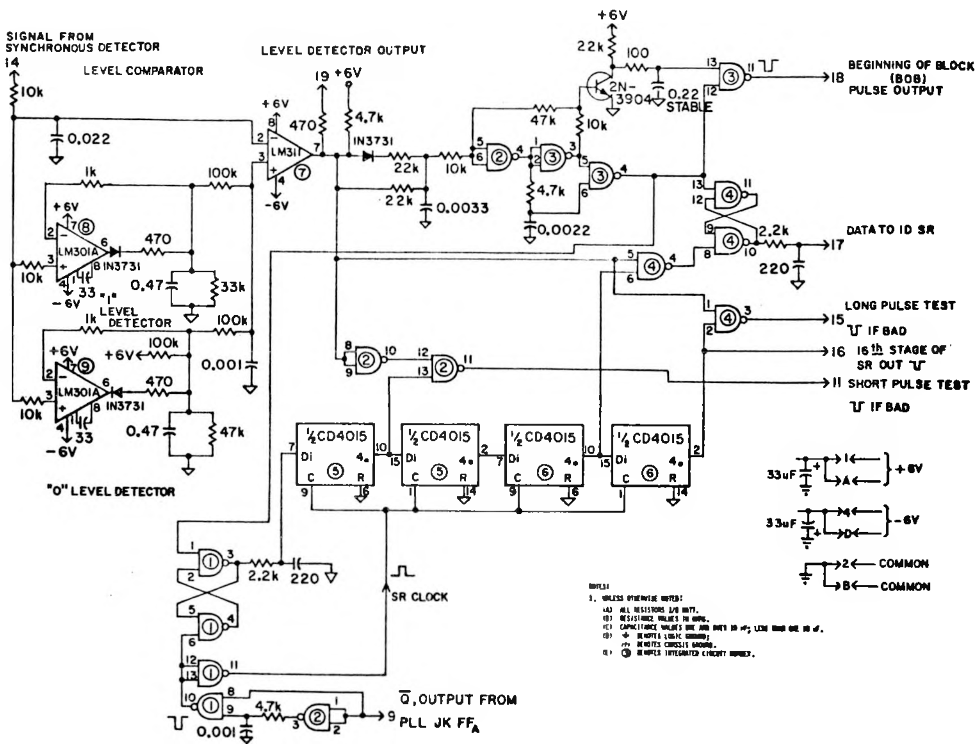

Fig. 8. Level detector, data strobe, pulse length tests.

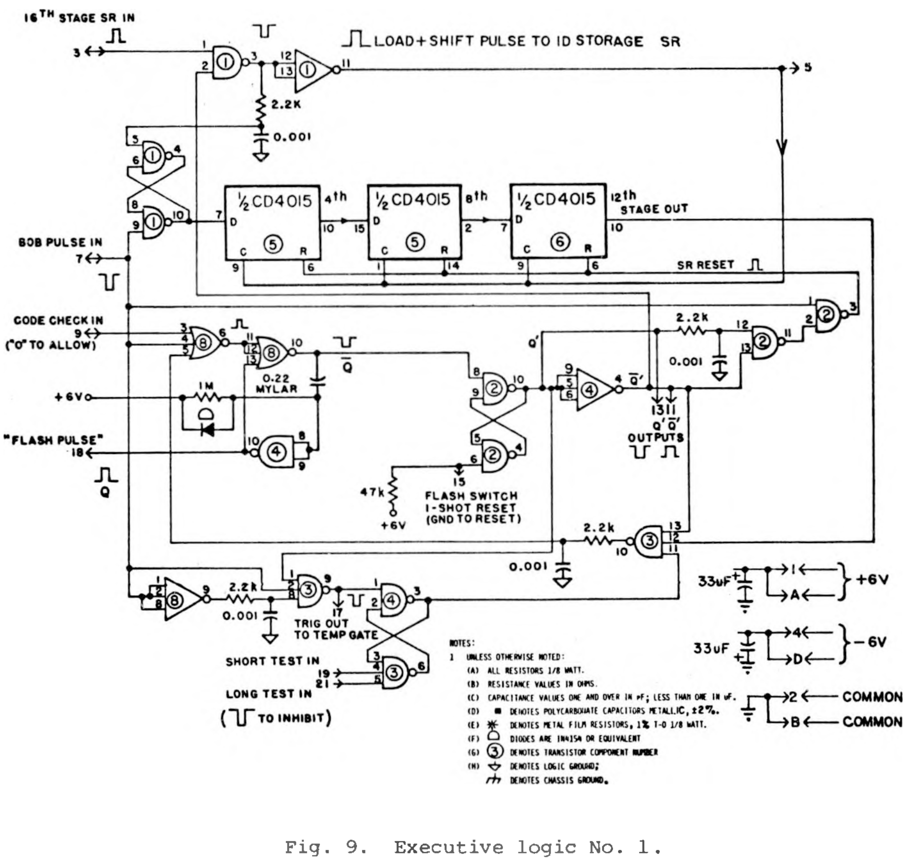

Fig. 9. Executive logic No. 1.

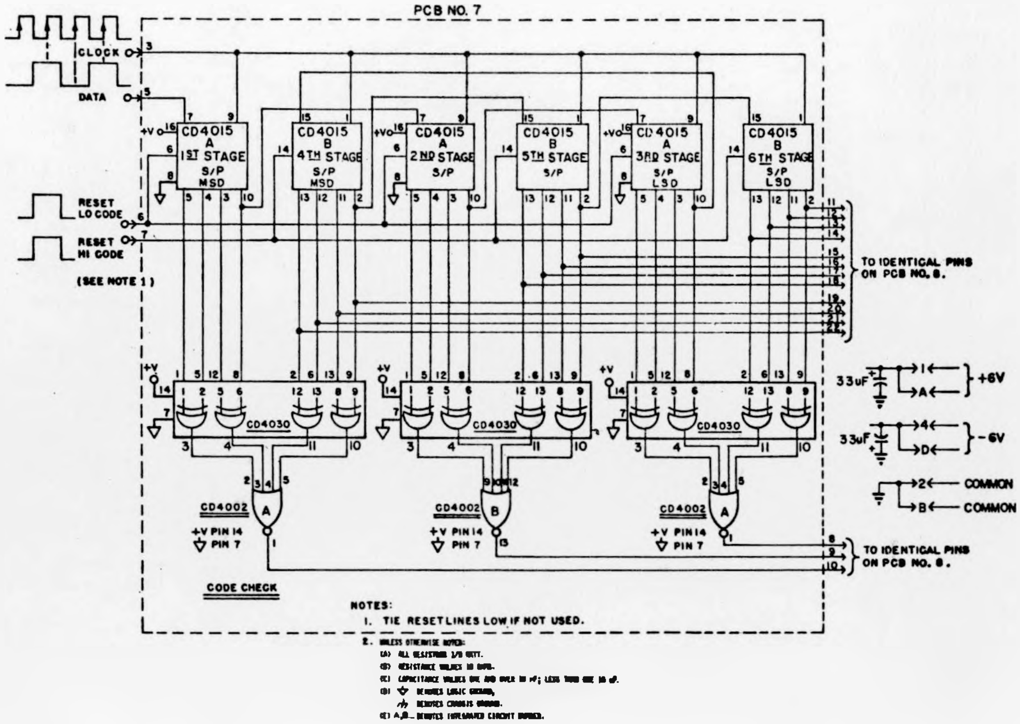

Fig. 10. ID code logics.

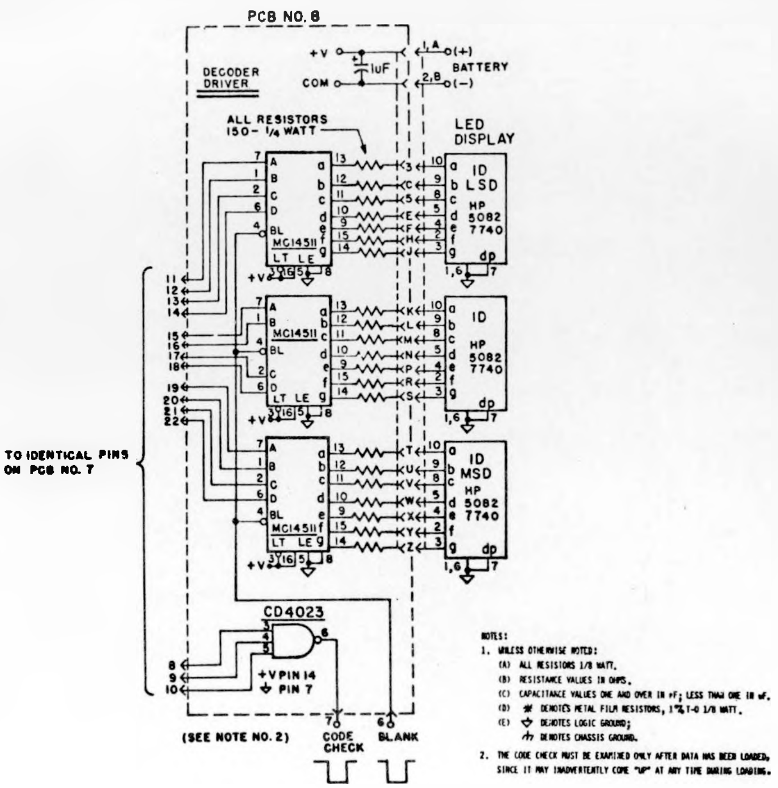

Fig. 11. ID code and display.

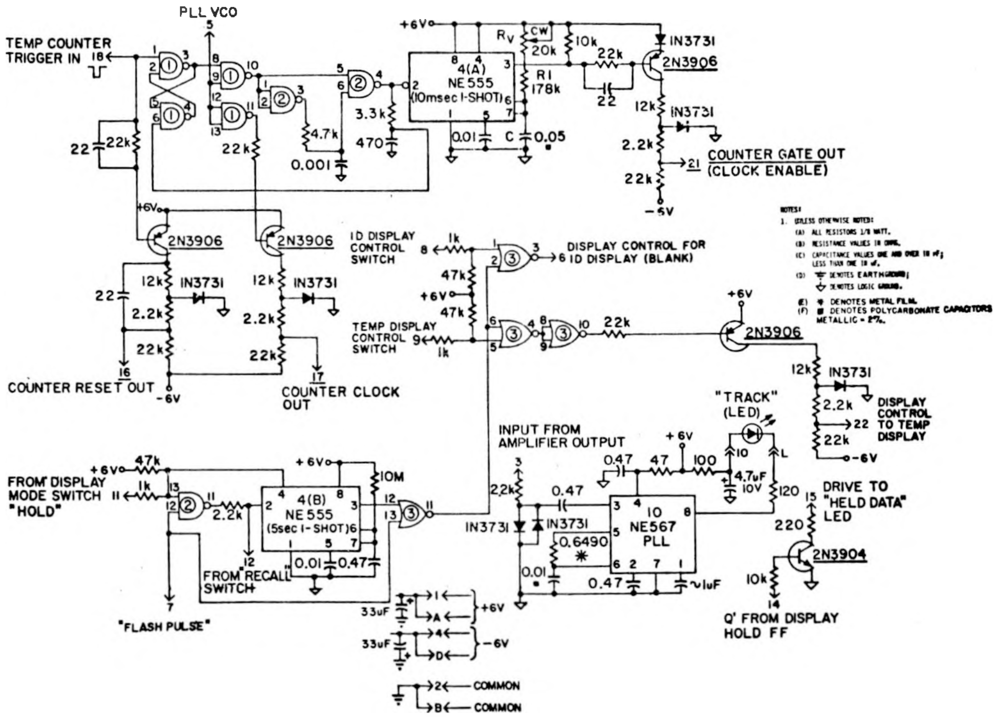

Fig. 12. Executive logics No. 2.

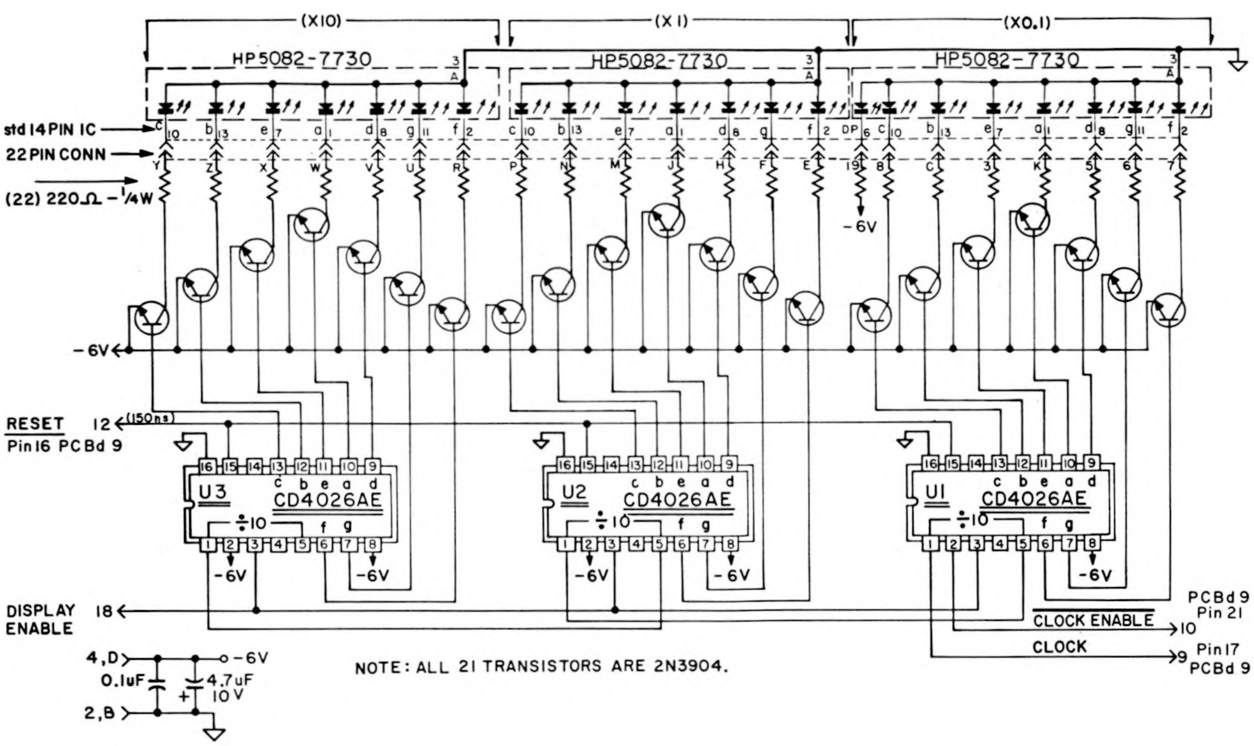

Fig. 13. Temperature counter and display.