# A remote control system for lighthouse equipment

Neal, G.; Wright, R. A.



**Publisher's version / Version de l'éditeur:**
https://doi.org/10.4224/21276066
*Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB), 1969-01*

ERB-809

UNCLASSIFIED



NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION



# A REMOTE CONTROL SYSTEM FOR LIGHTHOUSE EQUIPMENT

- G. NEAL AND R. A. WRIGHT -

OTTAWA

JANUARY 1969

# A REMOTE CONTROL SYSTEM FOR LIGHTHOUSE EQUIPMENT

G. Neal and R.A. Wright,
Radio and Electrical Engineering Division
National Research Council

CANADA.



## SUMMARY

This article describes a simple solid state low speed, 12-function remote control system suitable for use in maritime areas. In addition it features a communication and supervisory capability.

# A REMOTE CONTROL SYSTEM FOR LIGHTHOUSE EQUIPMENT

With the cooperation of the Department of Transport, a study was undertaken at the National Research Council to determine the requirements which must be met by a remote control system for lighthouse equipment operating in the Canadian climatic environment.

Since most navigational lights were already controlled automatically by photocell switches they were excluded from consideration.

The results of this study may be summarized by the following list of requirements:

(1) The maximum number of functions to be controlled is 12 (six "ON" and six "OFF").

(2) Standby power at the unattended end of the link should be kept to a minimum to permit long term operation on a battery supply.

(3) There must be a monitoring system built-in so the operator may know if his command has been obeyed.

(4) An alarm feature should be incorporated to alert the operator if there is any malfunction of the equipment at the remote site.

(5) The system must operate over a line-of-sight path up to 8 miles in length at temperatures of +120°F to -30°F.

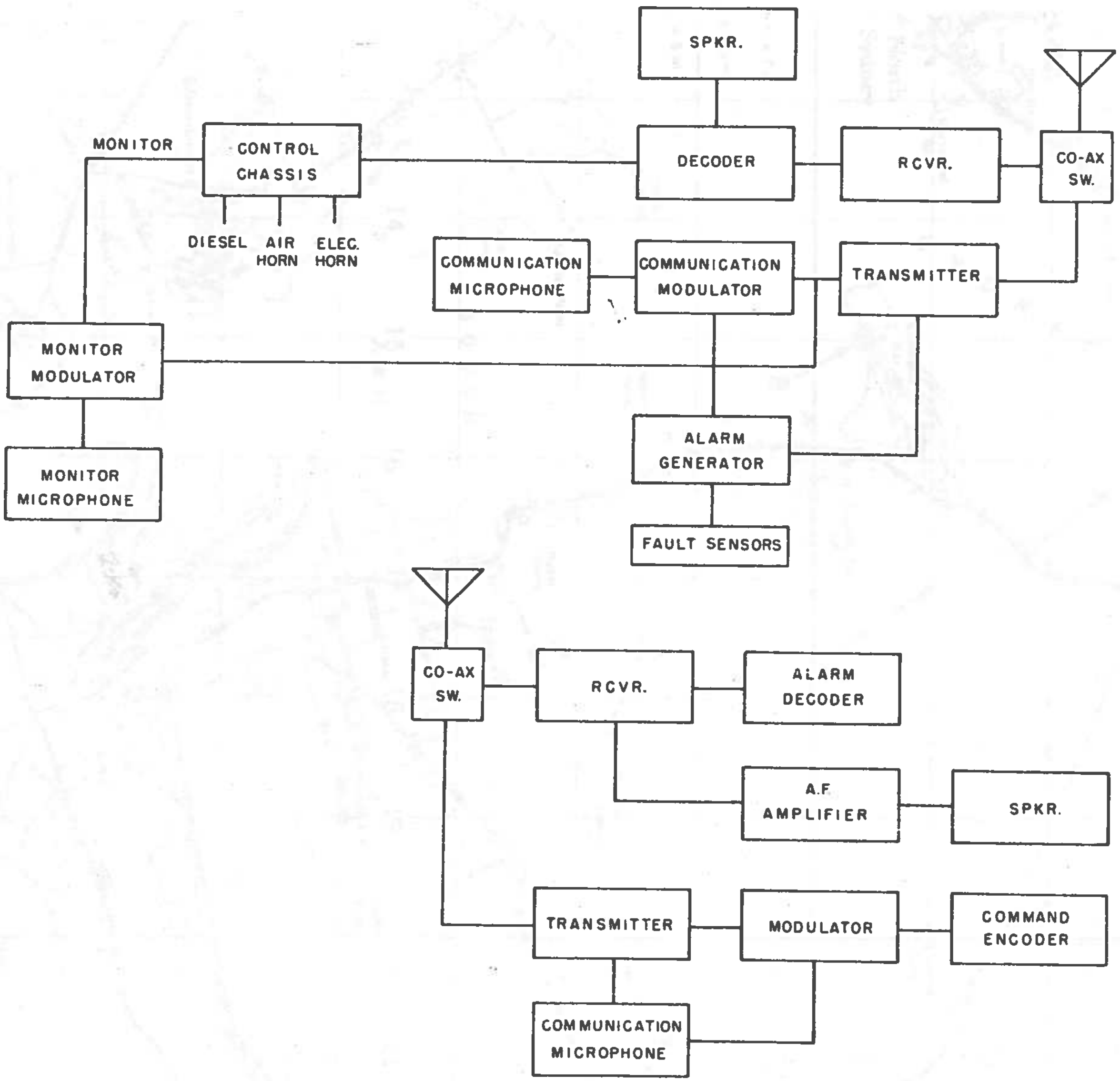



Figure 1. - Block Diagram of Remote Control System for Unattended Fog Horn and Auxiliary Equipment.

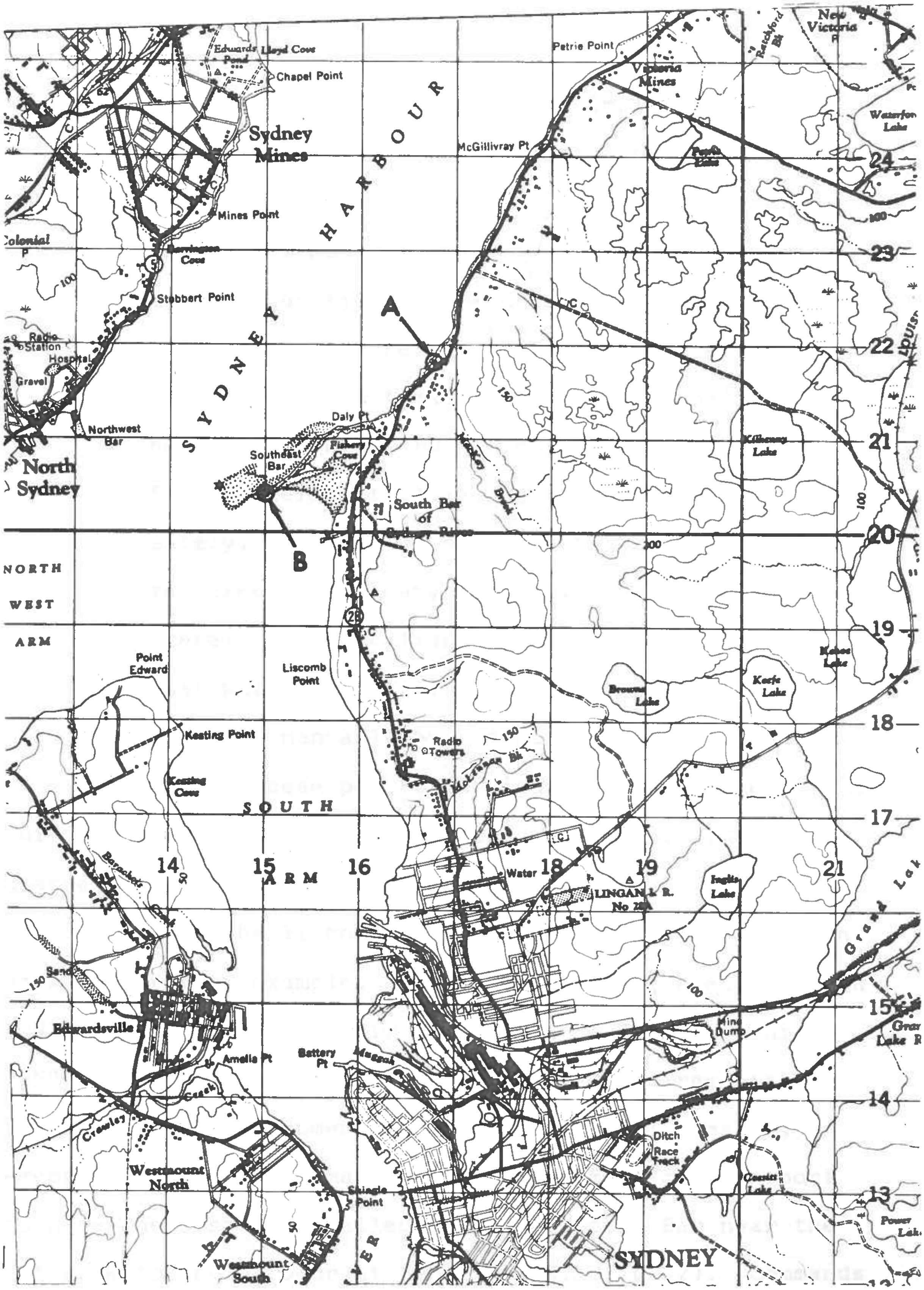



Figure 2. - Map of Harbour at Sydney, N.S., showing location of equipment at South Bar.

(6) The system should be kept as simple as possible in the interests of reliability and ease of maintenance.

(7) The system must be easily restored to emergency manual operation in the event of failure of the link to provide remote control of the apparatus.

(8) Slow speed data transmission may be used since no function needs to be performed quickly, in fact, a delay of 1/2-a-minute may be tolerated safely, between the start of transmission and the execution of any command.

(9) Overall system reliability must be as high as that which was obtained when the equipment was operated manually by resident personnel.

With all of these points in mind, the development of a suitable remote control system was undertaken. (See block diagram, Fig. 1).

Only 7 of the 12 control functions provided have been used so far (for example, diesel "ON", "OFF", electric horn "ON", "OFF", compressed air horn "ON", "OFF", and monitor "ON"), leaving five remaining for future requirements.

Before the equipment had been fully field tested, an emergency request was made by the Department of Transport to have the system installed at Sydney South Bar near the entrance to the harbour at Sydney, N.S. (Fig. 2). Commands are sent from the shore station (A) to the fog horn building (B).

The light in the nearby lighthouse was already operating automatically but a compressed air horn was used on the bar at (B) which required 110-volt, 60 Hz power to operate its compressor motor.

The control previously had been a switch mounted in a shelter on shore which fed commercial power to the motor in the horn building via a two-wire open line. A number of wooden poles, each mounted on rock-filled cribbing supported this power line from the shore-end of the sand bar to the horn building.

In the spring of 1966, high tides combined with an unusually large amount of drift ice to knock down most of the poles and put the system out of action.

Access to the horn building to employ the manual controls was difficult, even dangerous at high tide, so NRC was asked to install its radio control system as soon as possible. The installation was made and is still in operation (December 1968) having undergone some changes and modifications in the interim.

Let us now examine the remote control system as it is presently constituted.

Each command is transmitted by pressing a push-button on the encoder chassis at the shore station. This generates one of twelve possible 4-tone sequential codes which amplitude modulates a 20 mW transmitter operating on 219.4 MHz (Fig. 3). The amplifier containing $Q_{24-27}$ produces an audible signal in order that the operator may monitor the transmitted tones in the sequence as they are being sent. Resonant reed devices are used both to generate and decode these audio frequencies which are designated as follows:

Tone A - 634.5 Hz, Tone C - 746.8 Hz

Tone B - 688.3 Hz, Tone D - 810.2 Hz

Each tone is transmitted for 5 seconds as one of the many precautions taken against false triggering of equipment at the horn building. Yagi antennas are employed at each end of the system in combination with co-ax switches to transfer from the receive to the transmit mode. The standby current drain of the remote equipment from the 12-volt battery is approximately 100 mA.

Every three-tone command sequence made up of combinations of tones A, B, and C is preceded by a "keying" tone D. A pulse duration circuit checks to see if this keying tone is present for at least two seconds before applying voltage to the rest of the tone decoder circuits. It is removed automatically either after 20 seconds or at the completion of a sequence, whichever occurs first.

Let us examine how this pulse duration circuit works by looking closely at the decoding circuit for the keying tone "D". (See Fig. 4).

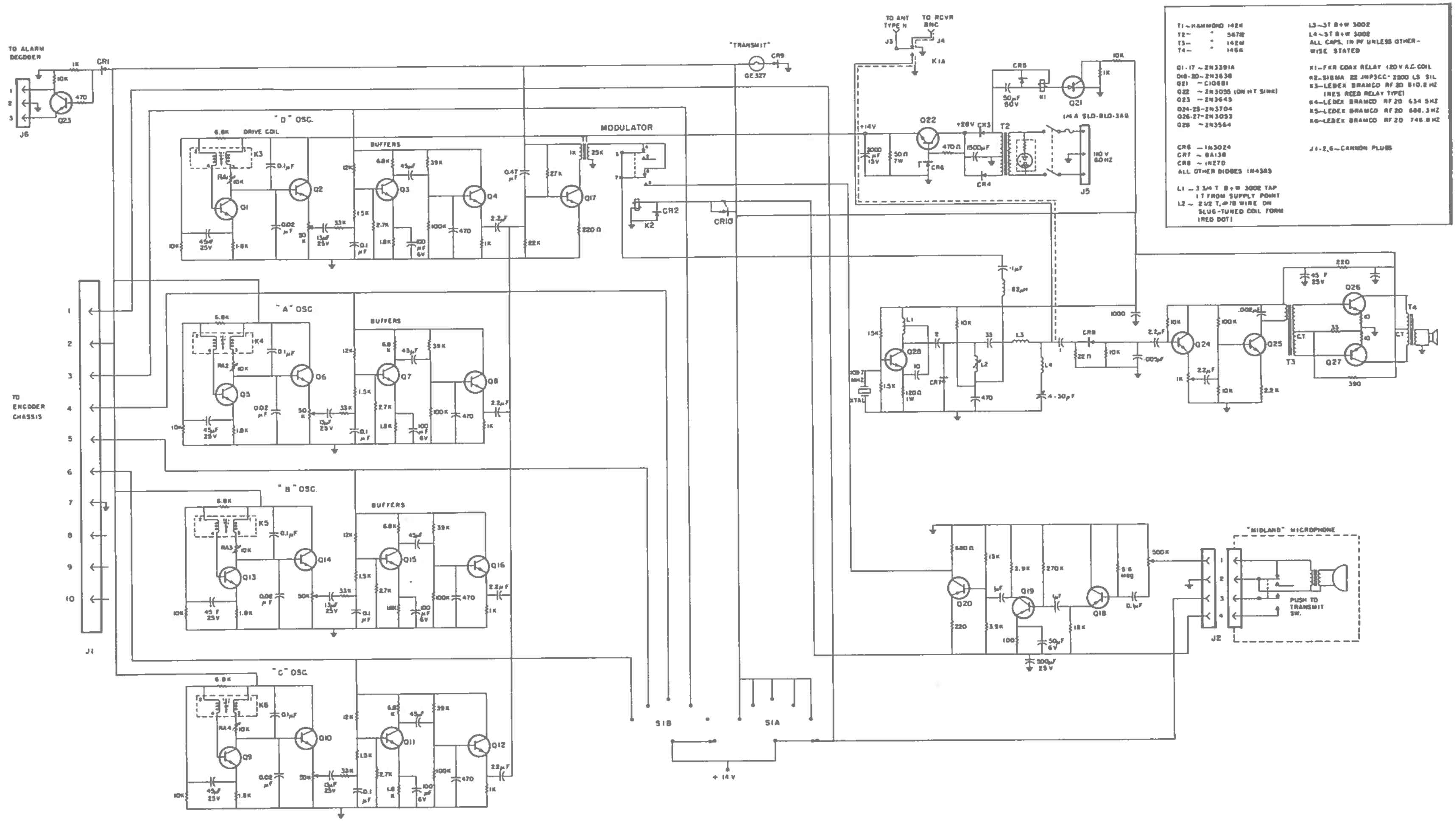



Figure 3. - Low Power Transmitter and Modulator circuit including tone generators

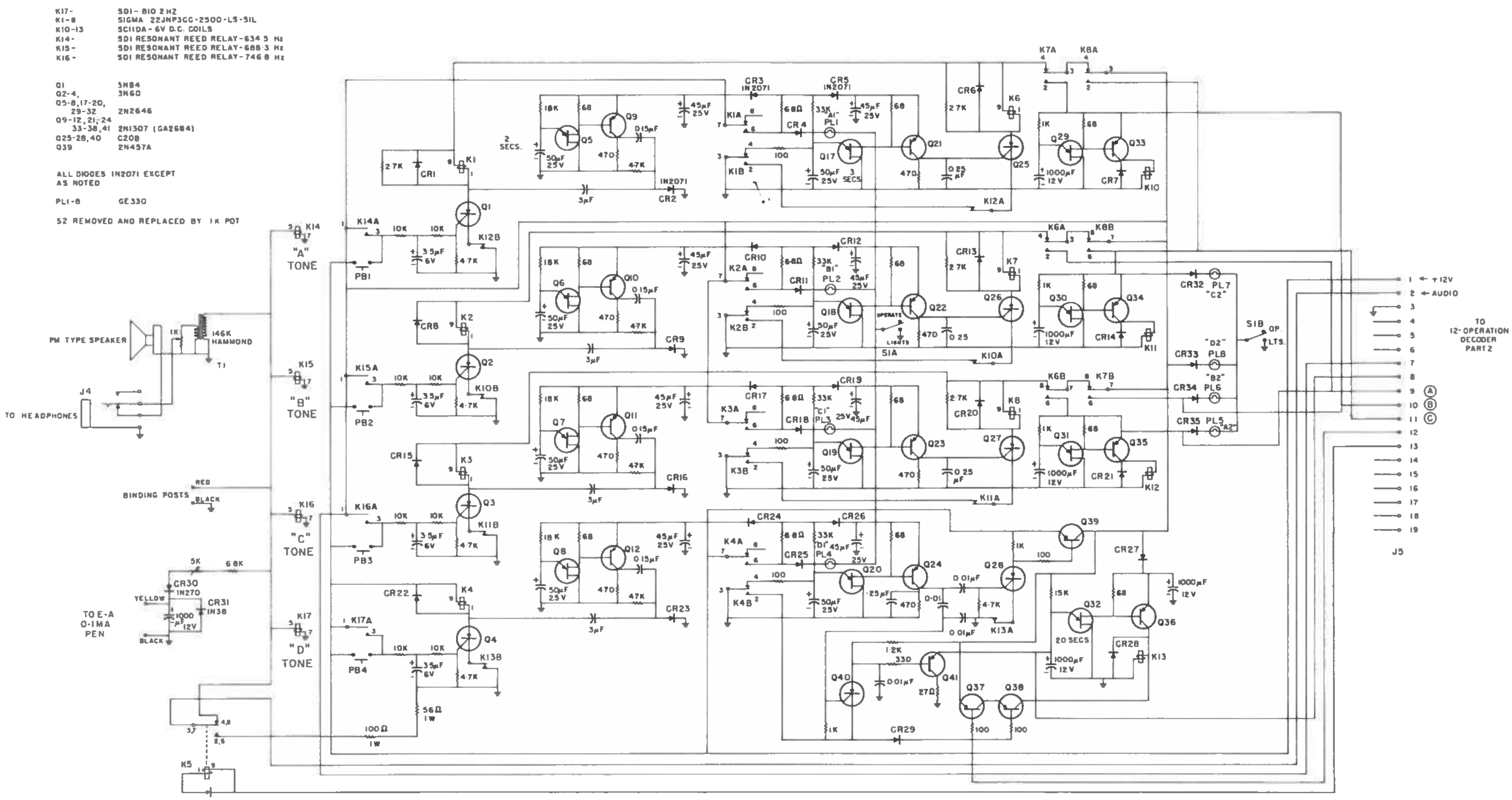



Figure 4. - 12-Operation Decoder Circuit, Part 1.

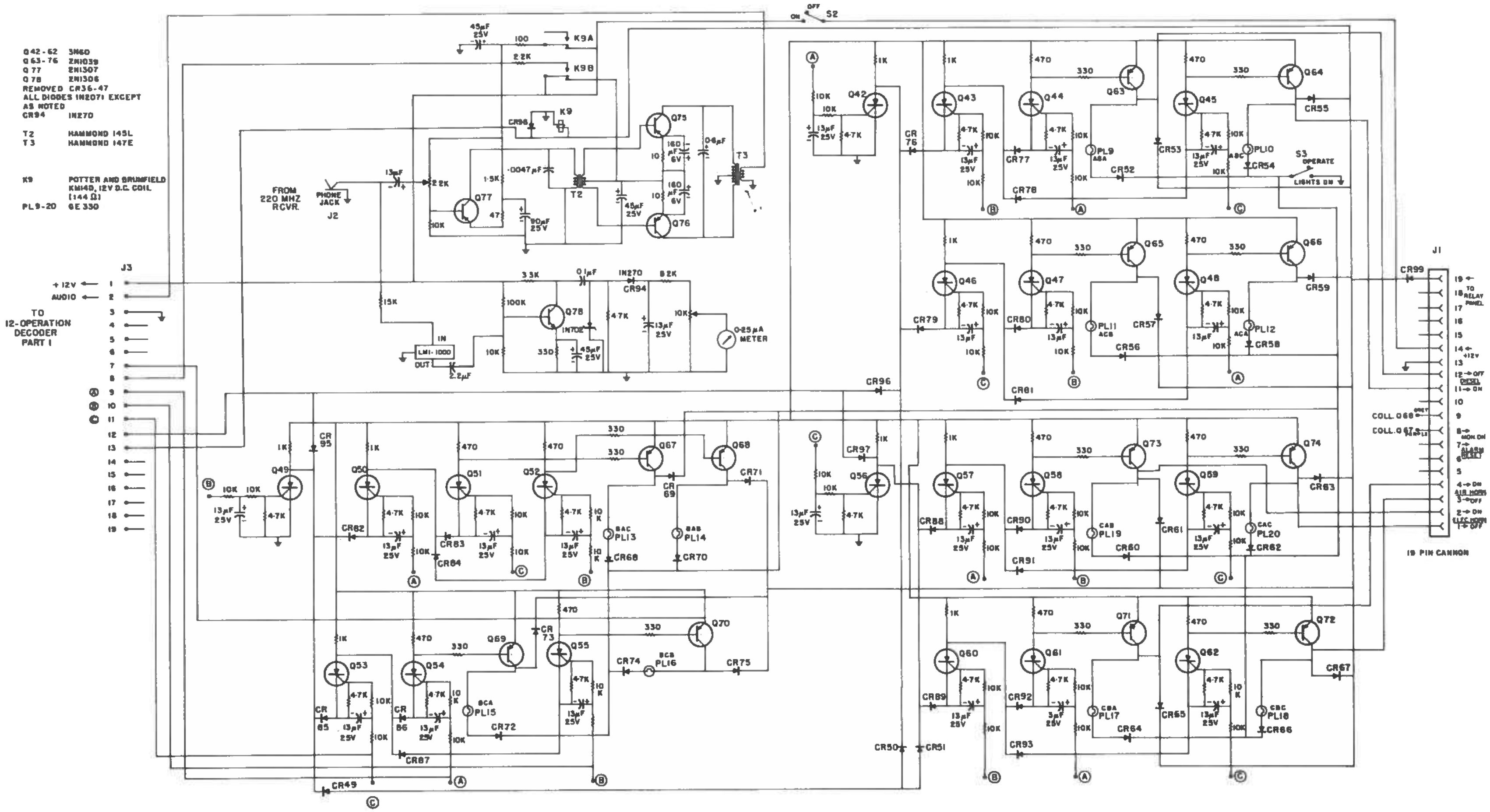



Figure 5. - 12-Operation Decoder Circuit,
Part 2.

Extensive use has been made of sensitive relays in this circuit rather than integrated logic circuits in order to keep standby power consumption down to a minimum.

The presence of tone "D" turns on $Q_4$ and thereby operates $K_4$. Its contacts supply power to two unijunction timing circuits containing $Q_8$, $Q_{12}$ and $Q_{20}$, $Q_{24}$ having periods of 2 seconds and 3 seconds respectively. At the end of 2 seconds the resulting pulse will turn off $Q_4$ through the 3 μf commutating capacitor connected to its anode and $K_4$ will then open its contacts. Voltages will be removed from $Q_{20}$ and $Q_{24}$ and no further action will occur except that the timing capacitor for $Q_{20}$ will be quickly discharged through $K_{4B}$ and so be ready for another signal.

If, however, tone "D" is still present when $Q_8$ "fires", $Q_4$ will turn off and then quickly turn back on again. This will mean that $Q_{20}$ will now "fire" after another second and apply the supply voltage to the rest of the decoder circuits and timing circuit $Q_{32}$, $Q_{36}$ via $Q_{28}$ and $Q_{39}$.

Twenty seconds later (period of $Q_{32}$, $Q_{36}$) $K_{13}$ will receive a pulse which will turn off $Q_4$ and $Q_{28}$ thereby removing the voltage from the other decoder circuits or in other words resetting the system. $Q_{40}$, $Q_{41}$ insure that the 20 second period for $Q_{32}$ does not start until tone "D" ceases to be received by maintaining a very low impedance across $Q_{32}$'s timing capacitor until $K_4$ goes to the "normally open" position.

Another method of dealing with the corruption of the signal by noise, is the use of logic circuits which will "reset" the decoder output if the keying tone is received again part way through a sequence. This provides protection against the situation where the key and one or more of the other tone decoder circuits has been turned on by noise just prior to the reception of a "true" command signal. $Q_{37-38}$ (see Fig. 4) act as an "AND" gate to operate $K_{13}$ and so cut-off the power supply, via $Q_{39}$, to the rest of the decoder circuits. In this way no false signal made up of a combination of noise and a"true"command will be accepted.

The other three tones are handled in a similar manner.

Each time a 4-tone sequence has been successfully received, a voltage is fed back to pulse $K_{13}$, resetting the system. This prevents more than one operation from being performed (under "noisy" conditions) for each command transmitted.

Since the original installation at Sydney, N.S. was completed, an electric horn has replaced the original compressed air unit which is now reserved for 'stand-by' purposes only. This has resulted in the diesel generator being turned on for several hours each day for battery charging. Complete remote control is provided for both horns as well as the diesel generator and monitor system.

A two-way voice communication channel has been added for purposes of conducting tests on the system. It may be used at any time except, of course, when a command or monitoring information is being transmitted.

The monitor portion of the system consists of a microphone mounted on the wall of the horn building located in such a way that it can pick up the sounds of the diesel engine and the fog horn.

Each received command activates this microphone and modulates a low power transmitter with it to provide the "monitor" signal which is heard at the shore station. At the end of approximately 45 seconds it is turned off automatically (Fig. 6).

In the case of the compressed air horn, the monitor is not turned on for about 5 minutes after the compressor is started. This delay is necessary to allow the air pressure to built up to the point where the horn will operate.

The "ON" period of the monitor is chosen to be long enough to transmit at least two blasts of the horn (if it is on) thus indicating correct operation.

The remote switching is arranged so that the horn compressor cannot be in the "ON" state unless the a.c. is present from the generator. This prevents damage to the motor generator set which would result if it tried to start under full load.

The monitor may be commanded "ON" at any other time by pressing the "MONITOR ON" button at the shore station.

At the "command" end of the link, a number of "status" lights have been provided on the panel, whose purpose it is to show which pieces of equipment should be "ON" and which should be "OFF" at the remote location.

An alarm feature has been built into the equipment so that if any command has been received but not obeyed by the remote equipment or if any unauthorized change of state has occurred, two audio tones (540.5, 570.4 Hz) will alternately modulate the monitor transmitter for a 30 seconds period, and turn on a flashing light together with a "Sonalert" device at the command center. These will both remain "ON" until cancelled by the operator who can then monitor the operations and decide what action must be taken (Figs. 7 and 8).

It was necessary to design some special circuits in order to start the diesel generator remotely.

Figure 9 shows the starting circuit for a typical diesel engine.

$S_1$ is a spring-loaded single pole, 3-position switch with center off while $S_2$ is a spring-loaded normally open push-button switch.

In order to start the engine, $S_1$ must be pushed to the "START" position and held there for a few seconds while

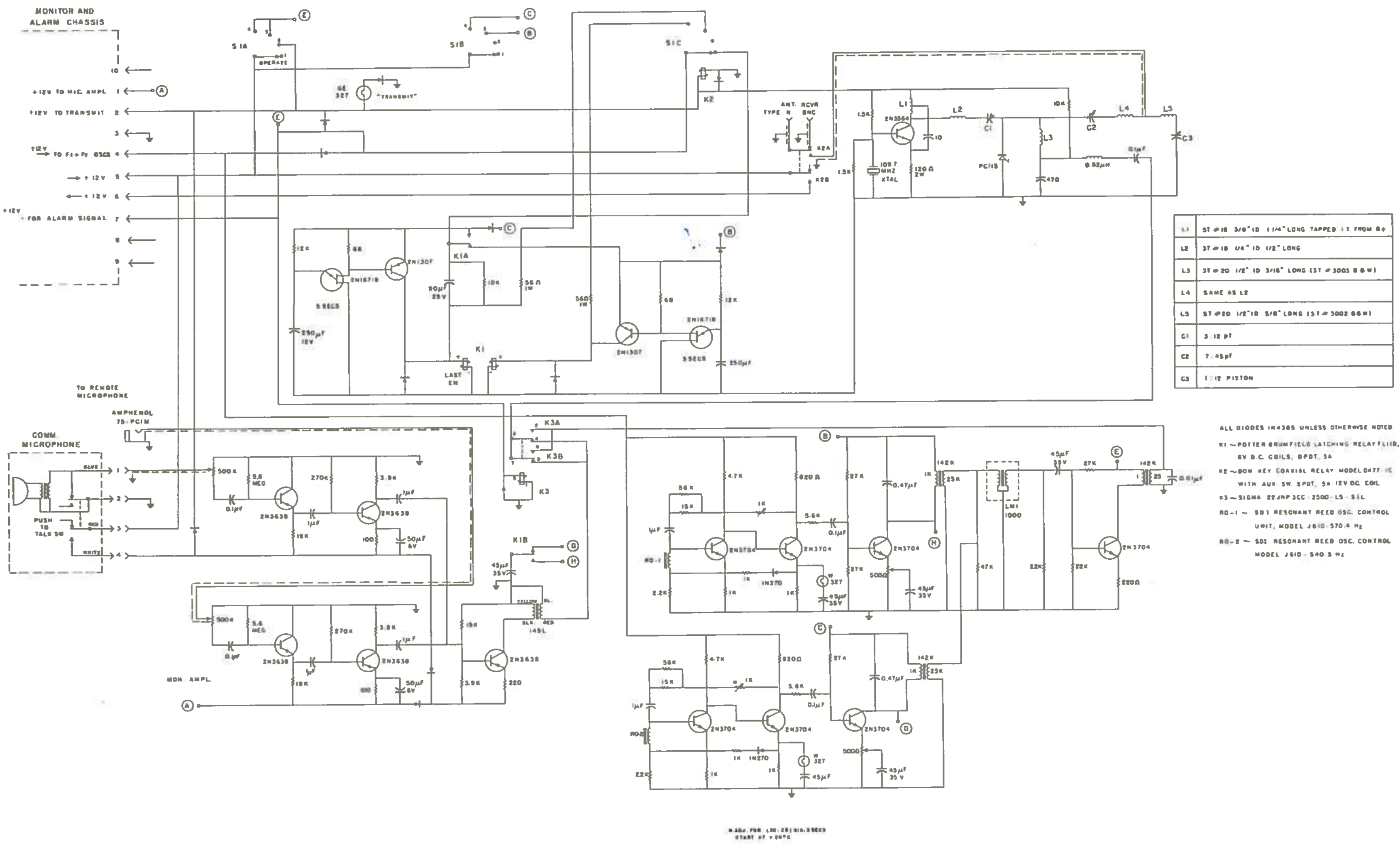



Figure 6. - Remote Control Monitor Modulator and Transmitter Circuit.

| | |
|---|---|
| K8, 9, 17 | PB FL11D, 6V DC COIL, 3PDT, 3A |
| K10, 14 | DIALTRON THERMAL DELAY PR-60S-NO-12 |
| K11 | HAYDON RECYCLING TIMER, ADJ. 2-15 MINS. |
| K12 | KRP14A, 115V 60~ COIL, 3PDT AT 10A |
| K13 | KRP11AN, 230V 60~ COIL, DPDT AT 10A |
| K16 | FL11D, 6V DC COIL, DPDT, 3A |
| K18 | KRP14DG, 24V DC COIL, 3PDT, 5A |

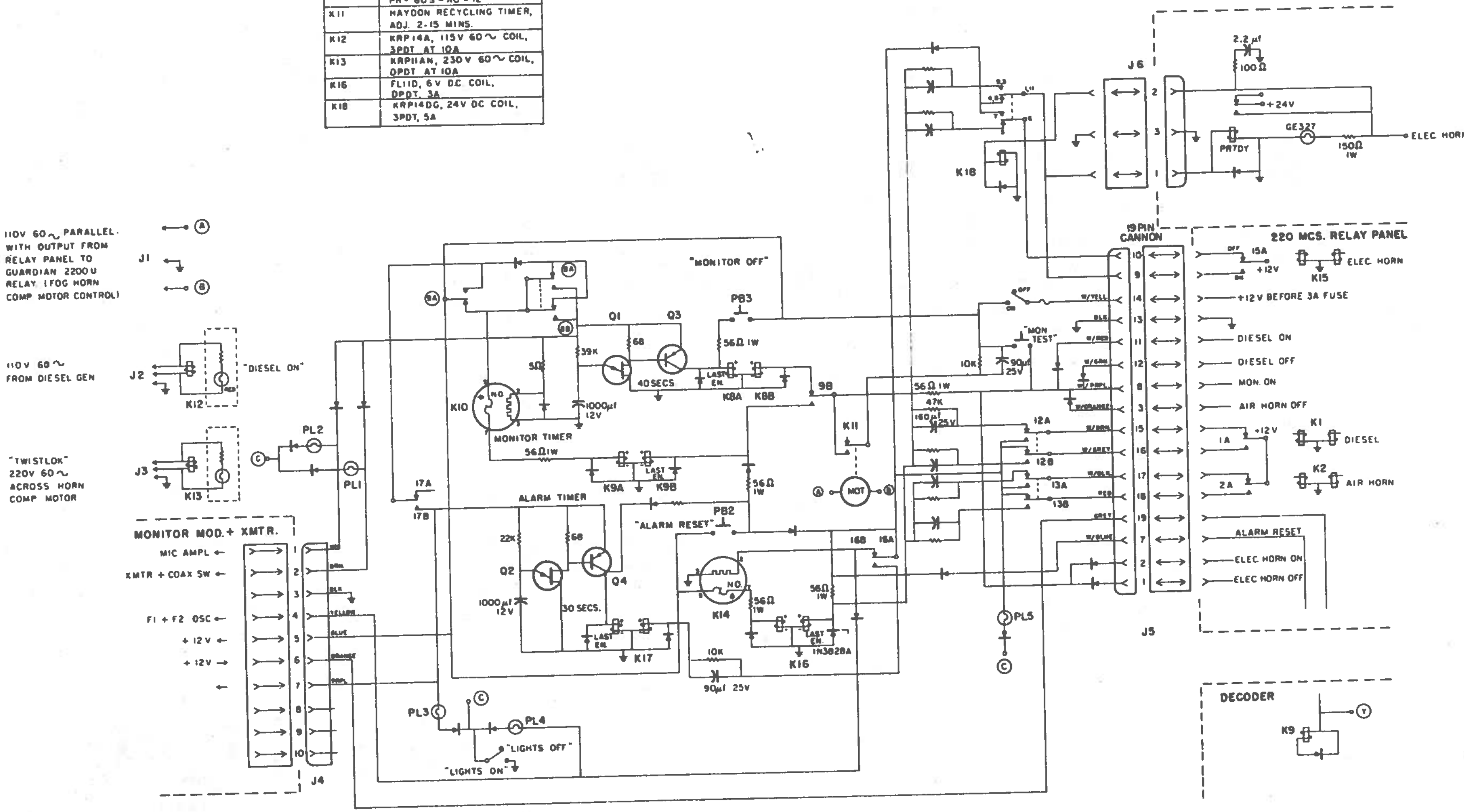



Figure 7. - Monitor and Alarm Control Circuit.

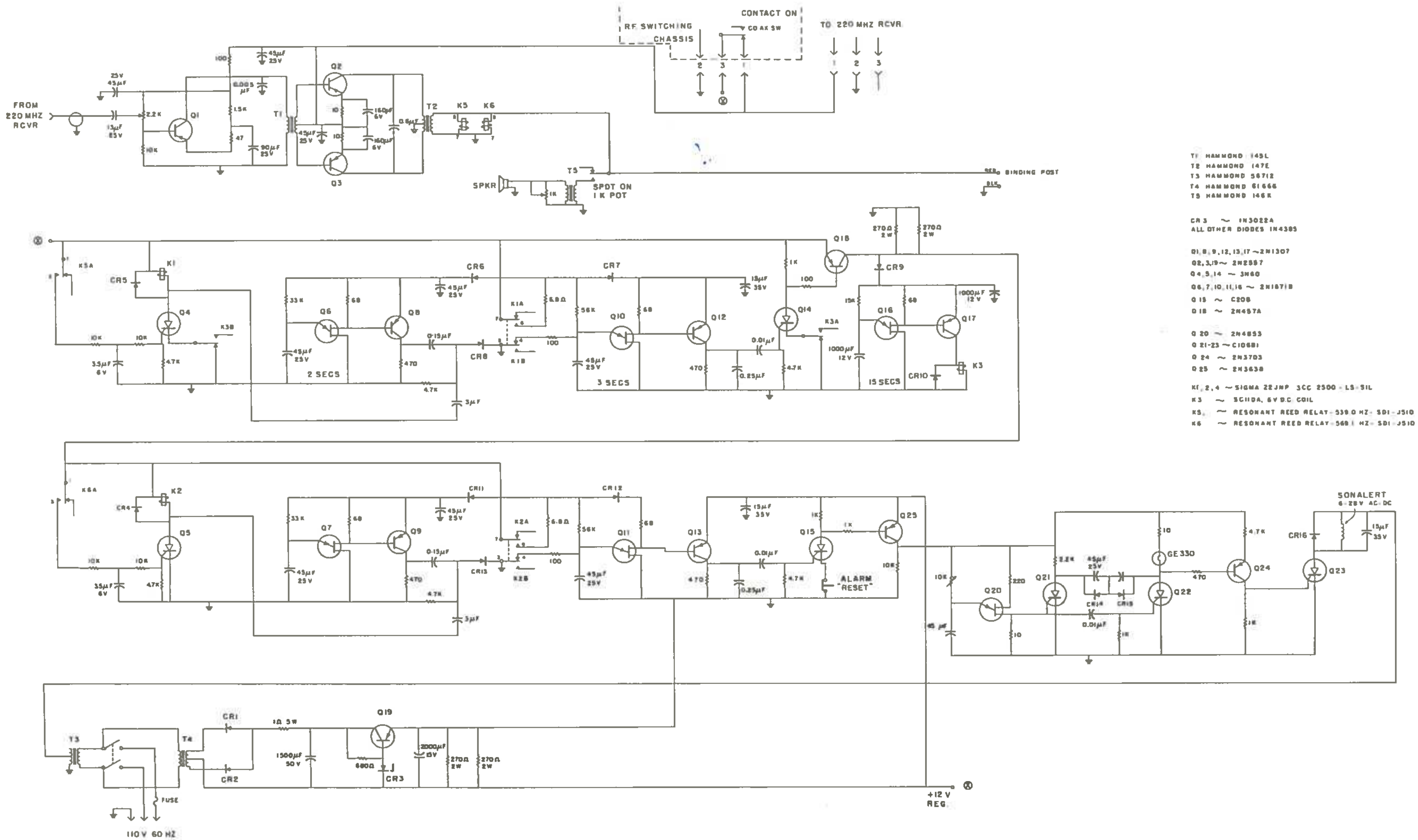



Figure 8. - Alarm Decoder Circuit.

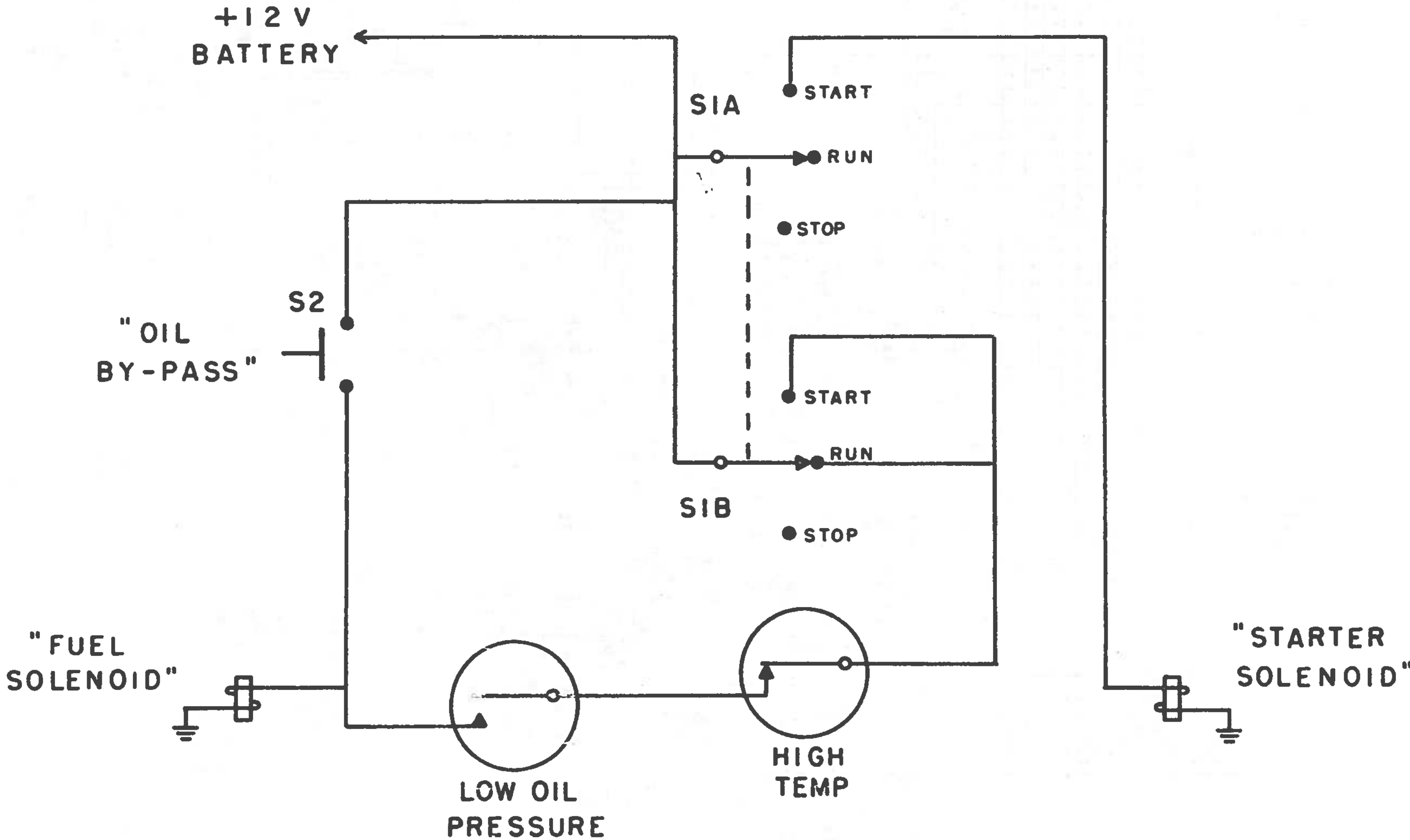



Figure 9. - Manual Starting Circuit for a typical Diesel Engine.

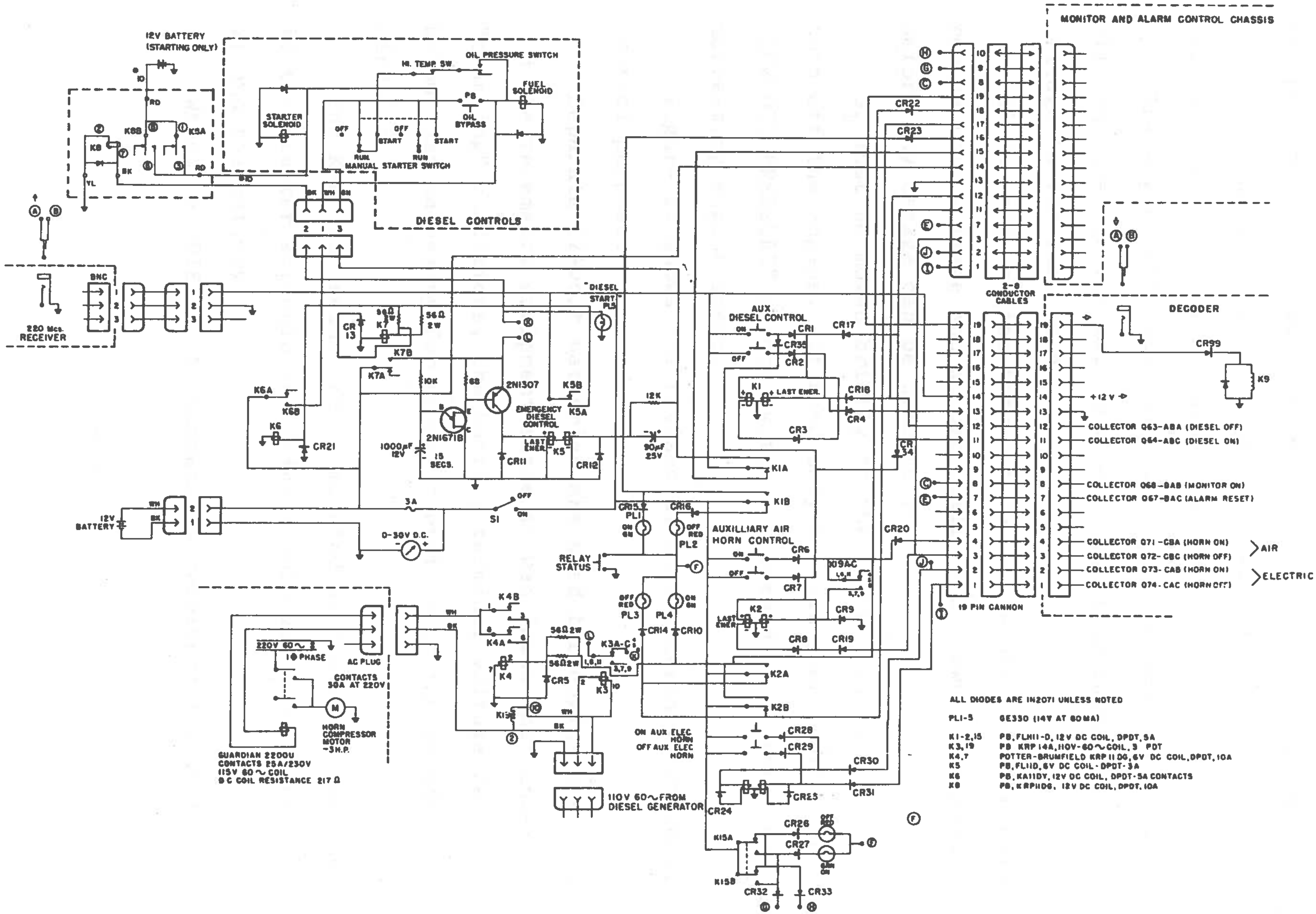



Figure 10. - Automatic Diesel Starting Circuit
as used at Sydney South Bar, N.S.

at the same time $S_2$ must be held closed for the same period.

When the motor is running both switches must be released so that they are as shown in Fig. 9.

The engine will now continue to run because the "low oil pressure" switch will now be closed thus supplying voltage to the fuel solenoid.

Either high engine temperature or low oil pressure will remove this voltage and automatically shut down the diesel before any damage can be done to it.

$S_1$ must be moved briefly to the "STOP" position to turn off the engine. It need only be held there until the "LOW OIL PRESSURE" safety switch has opened as a result of decreasing engine speed.

Figure 10 shows the revised circuit necessary for remote control purposes.

Separate 12-volt batteries are used for engine starting and the telemetry equipment since it was found that under "cranking" conditions, the battery terminal voltage fell below that necessary for proper operation of the decoder circuits.

The KRP 11DG relay, K8 is mounted as close as possible to the starter solenoid to minimize voltage drops between it and the battery.

When the "DIESEL ON" command is received; +12 volts is present for a maximum period of 15 seconds on pins 1 and 2 of the 3-pin connector shown on the "RELAY CONTROL PANEL". These voltages are provided through latching relay K5 and a UJT timing circuit. As soon as the 110-volt, 60 Hz is developed by the generator, relay K3 removes the cranking voltage from the starting motor to prevent damage to the ring gear on the diesel. Battery voltage still applied to pin 3 through K1A keeps the engine running. The "DIESEL OFF" signal removes all voltages from this plug by resetting $K_1$ and stops the engine by interrupting its fuel supply.

In the original design, a mechanical stepping switch was used to provide the four tone sequential signal generated when each control push-button was pushed. One of the improvements made to the system was the replacement of this stepping switch by a number of integrated digital circuits, (Figures 11, 12 and 13), thus eliminating all the mechanical problems inherent in this type of switch.

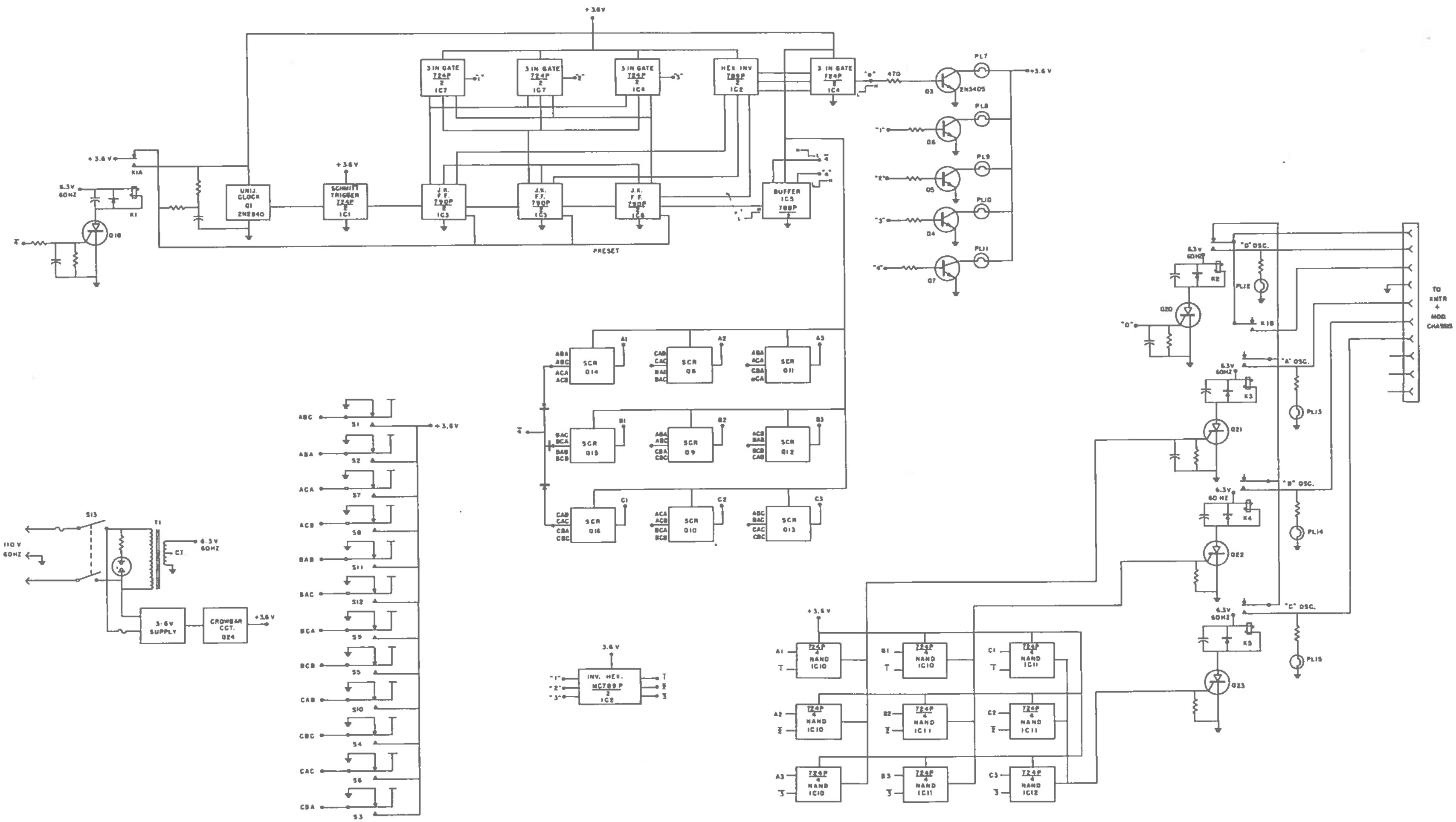
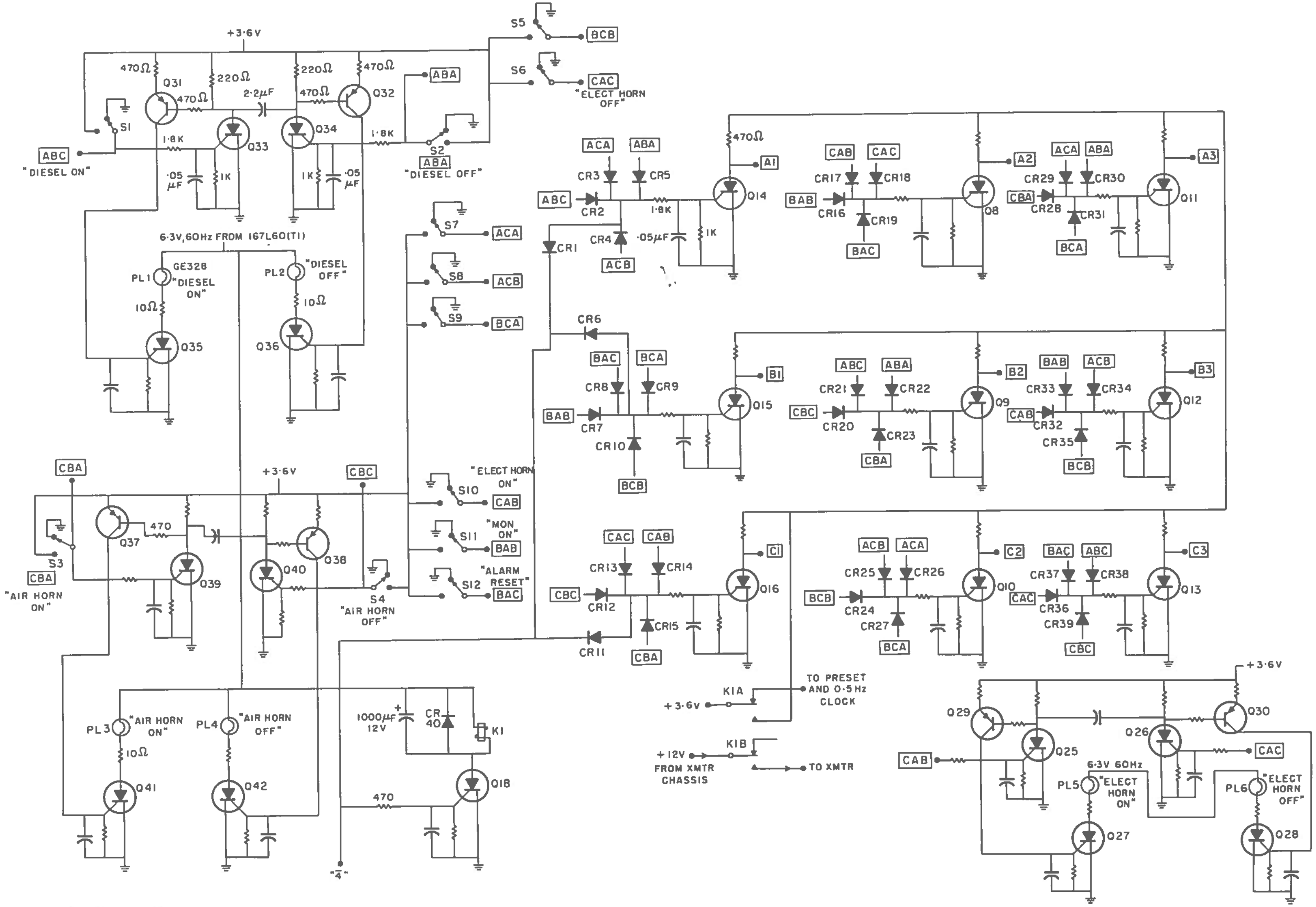


Figure 11. - Simplified Circuit of 12-Function Solid State Remote Control Encoder.




PL1-6 — GE328
Q8-16, 18, 25-28, 33-36, 39-42 — C106B1
Q29-32, 37-38 — 2N3638
ALL DIODES 1N4385 UNLESS
OTHERWISE STATED

Figure 12. - 12-Function Solid State Remote
Control Encoder Circuit - Part 1.

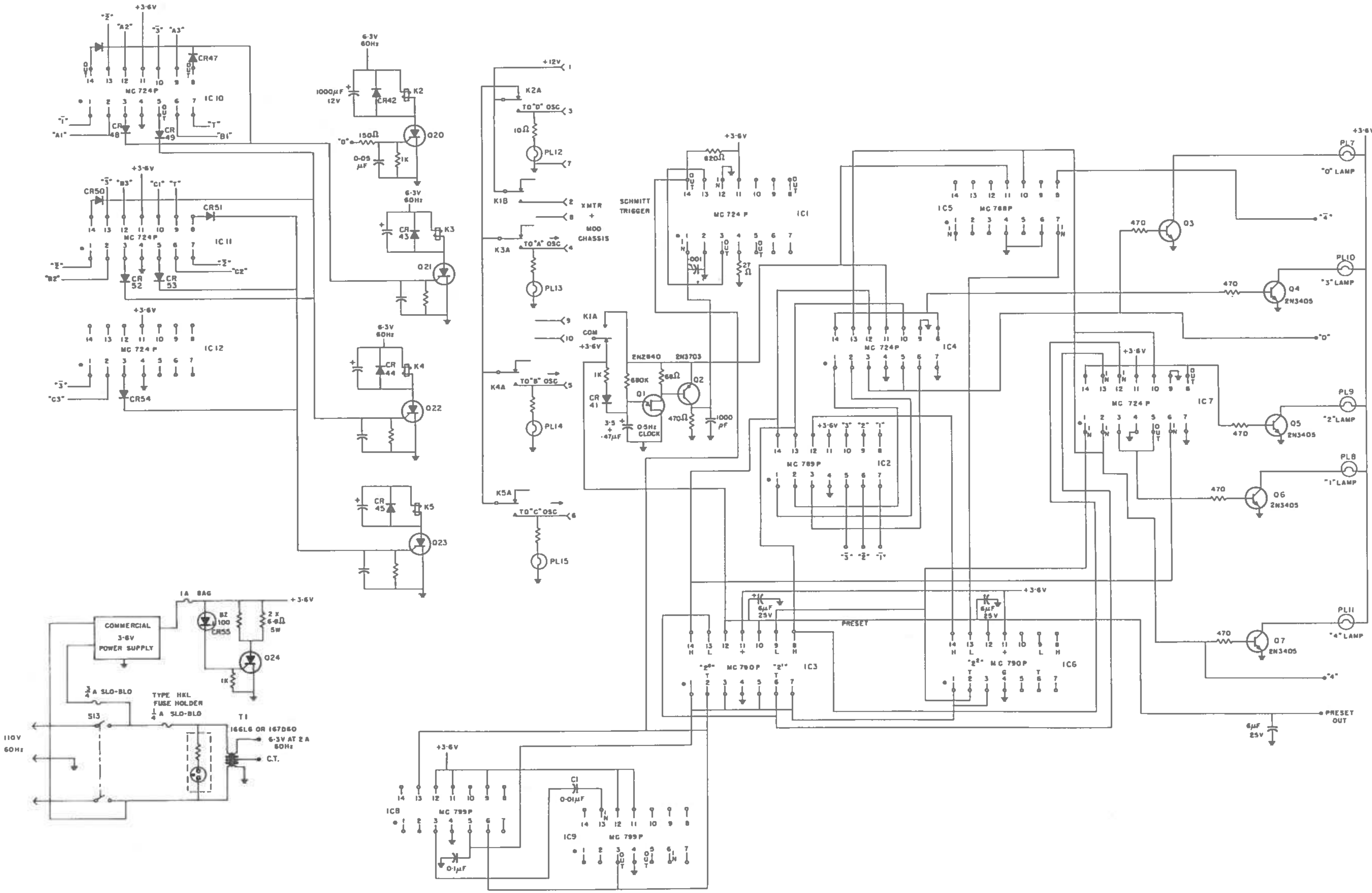


Figure 13. - 12-Function Solid State Remote Control Encoder Circuit - Part 2.

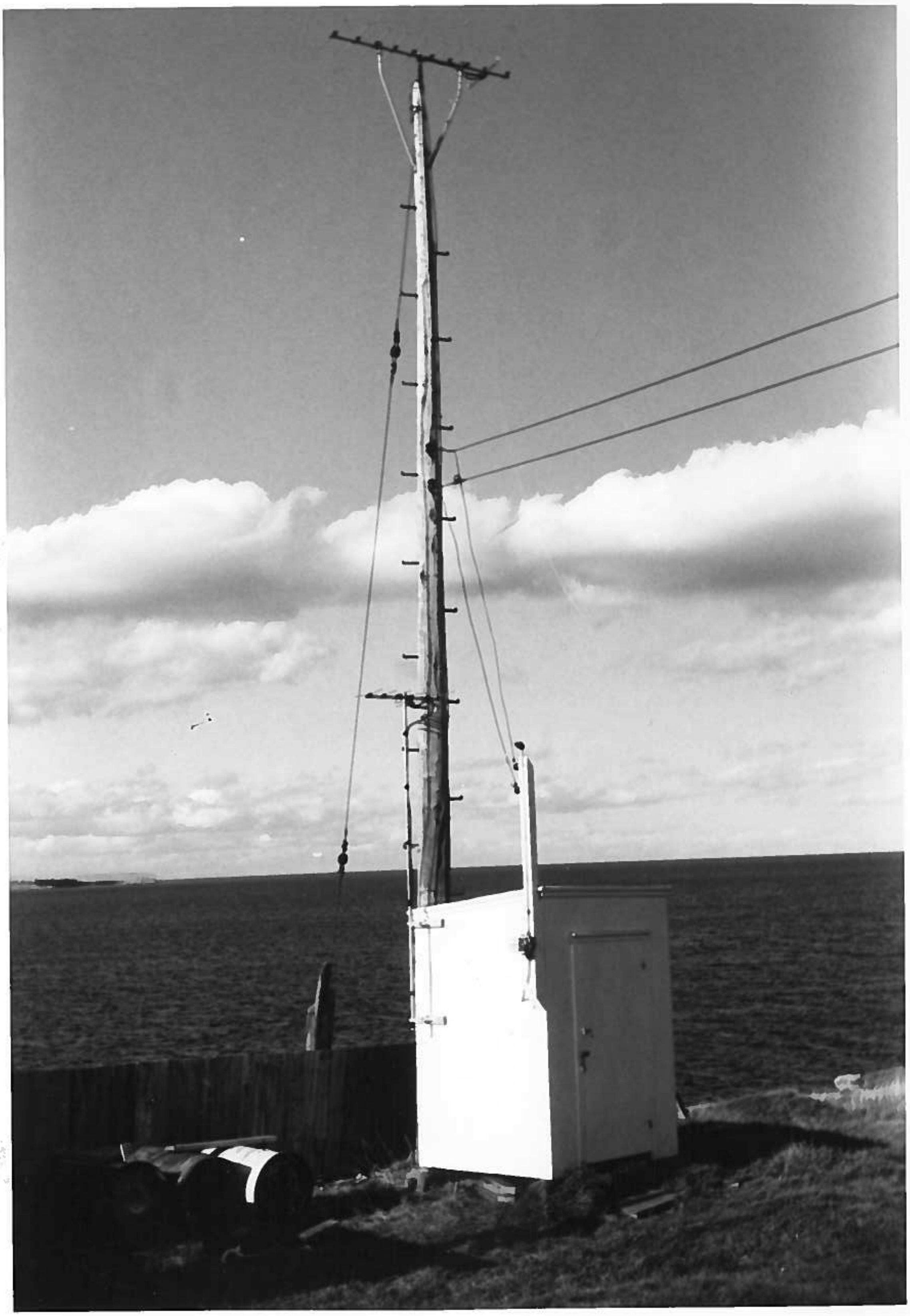


Figure 14. - Shore Station Installation of Remote Control System at Sydney, N.S., (Point A), looking out to sea.

Figure 15. - Shore Station Installation of
Remote Control System at Sydney,
N.S., looking toward Fog Horn
building on South Bar.

Figure 16. - Fog Horn building (Point B) on Sydney Bar showing Lighthouse in background.

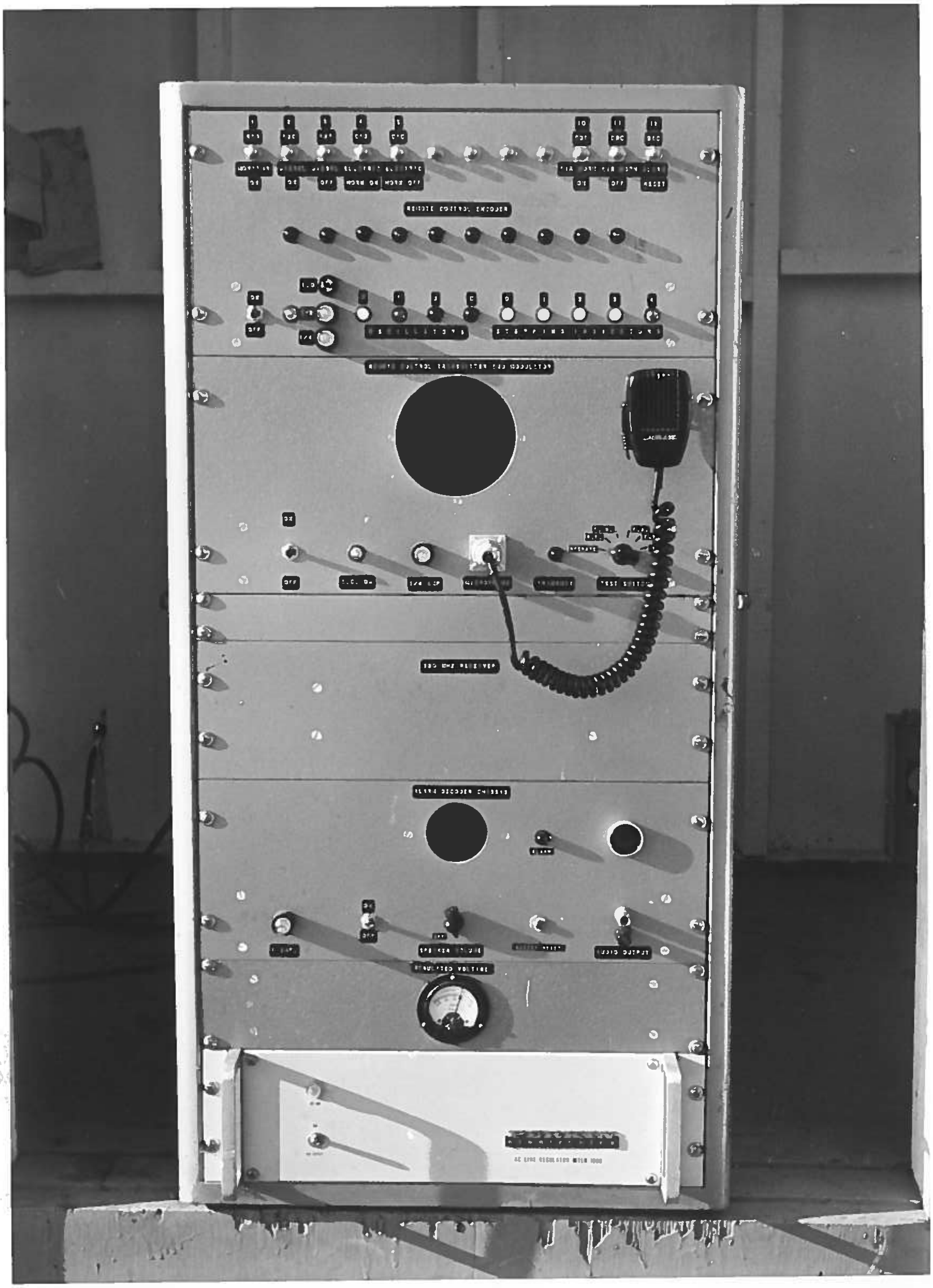


Figure 17. - Front View of Shore Station Equipment Rack.

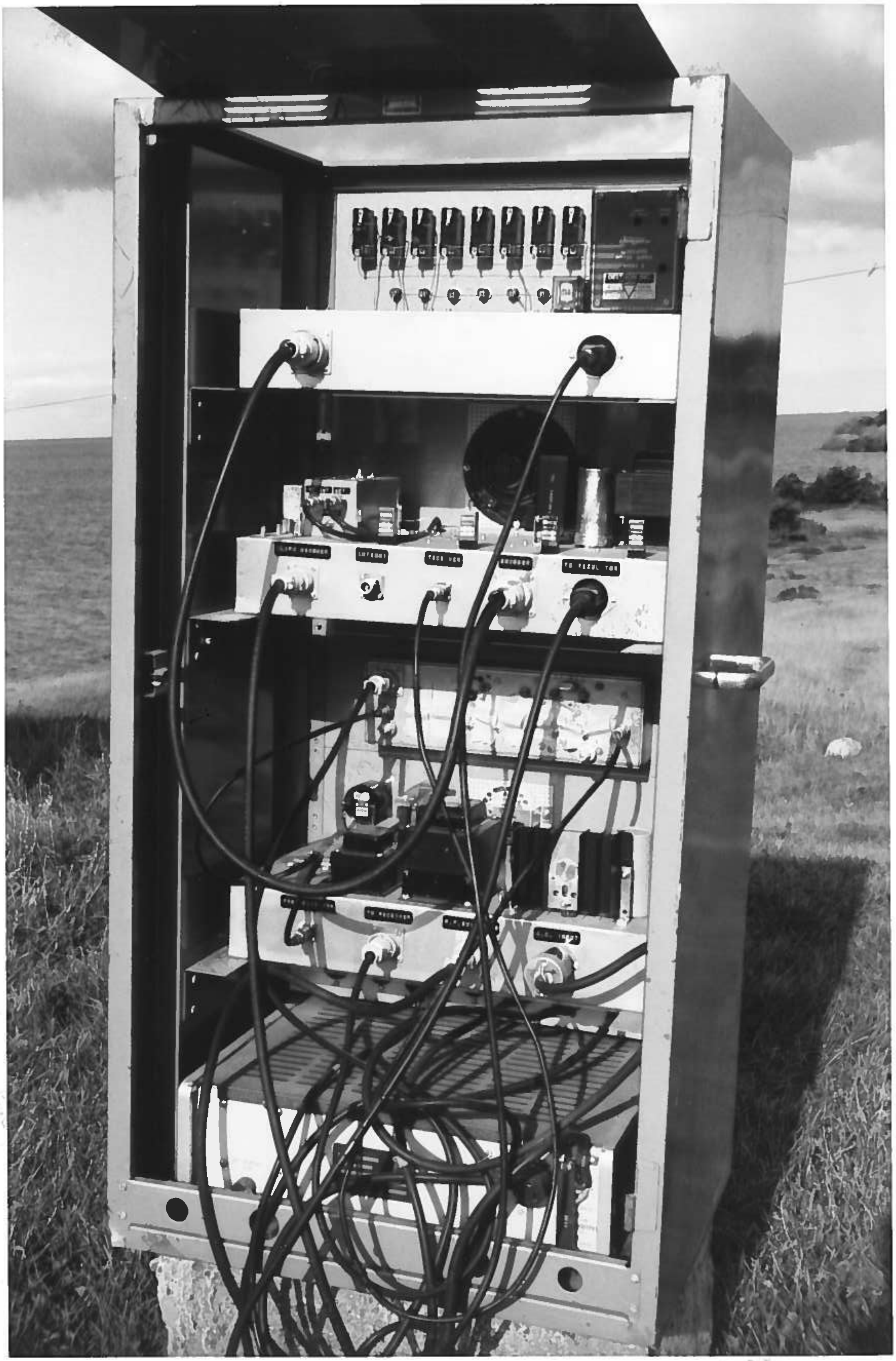


Figure 18. - Rear View of Shore Station
Equipment Rack.

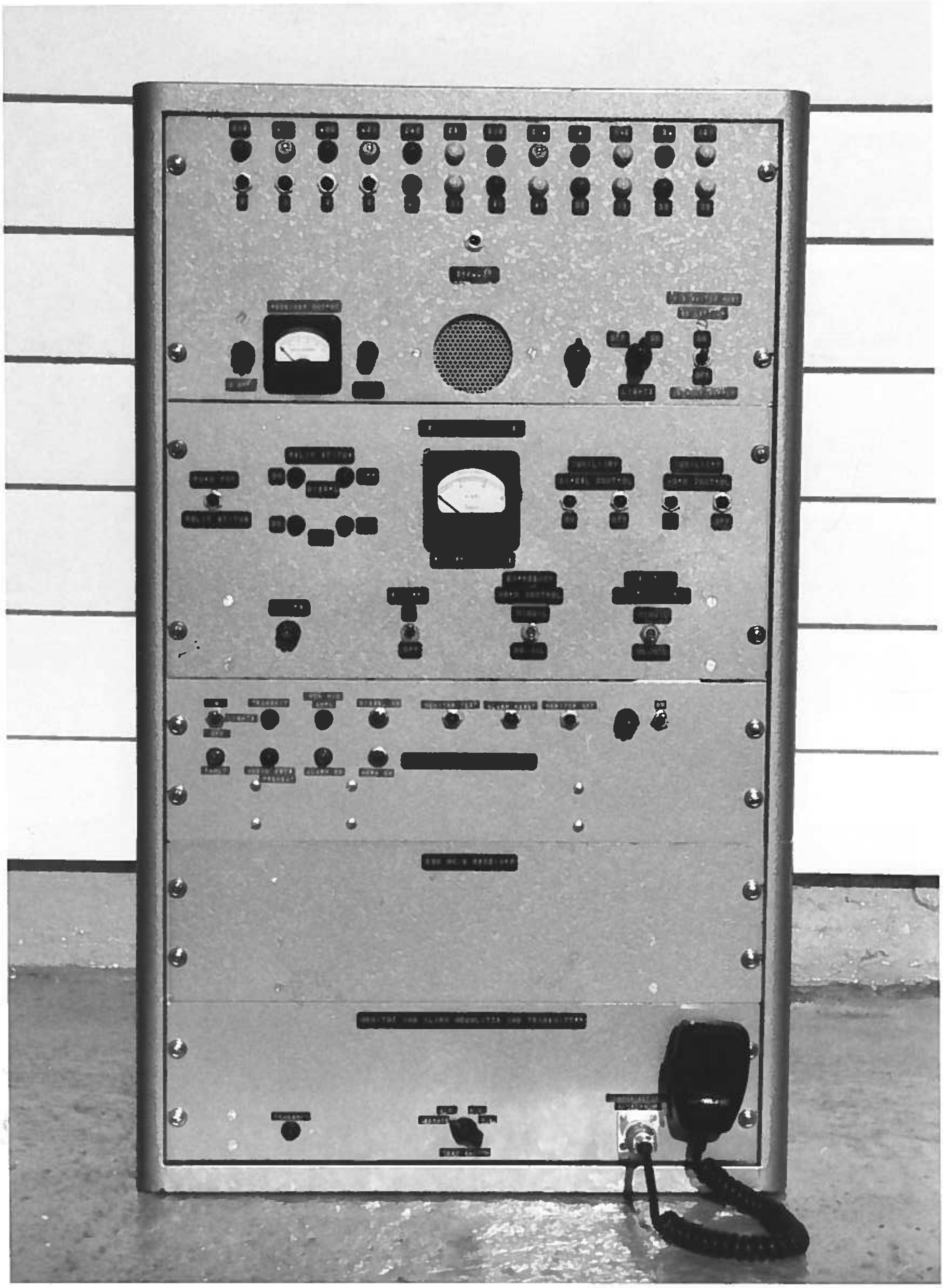


Figure 19. - Front View of Fog Horn building equipment rack.

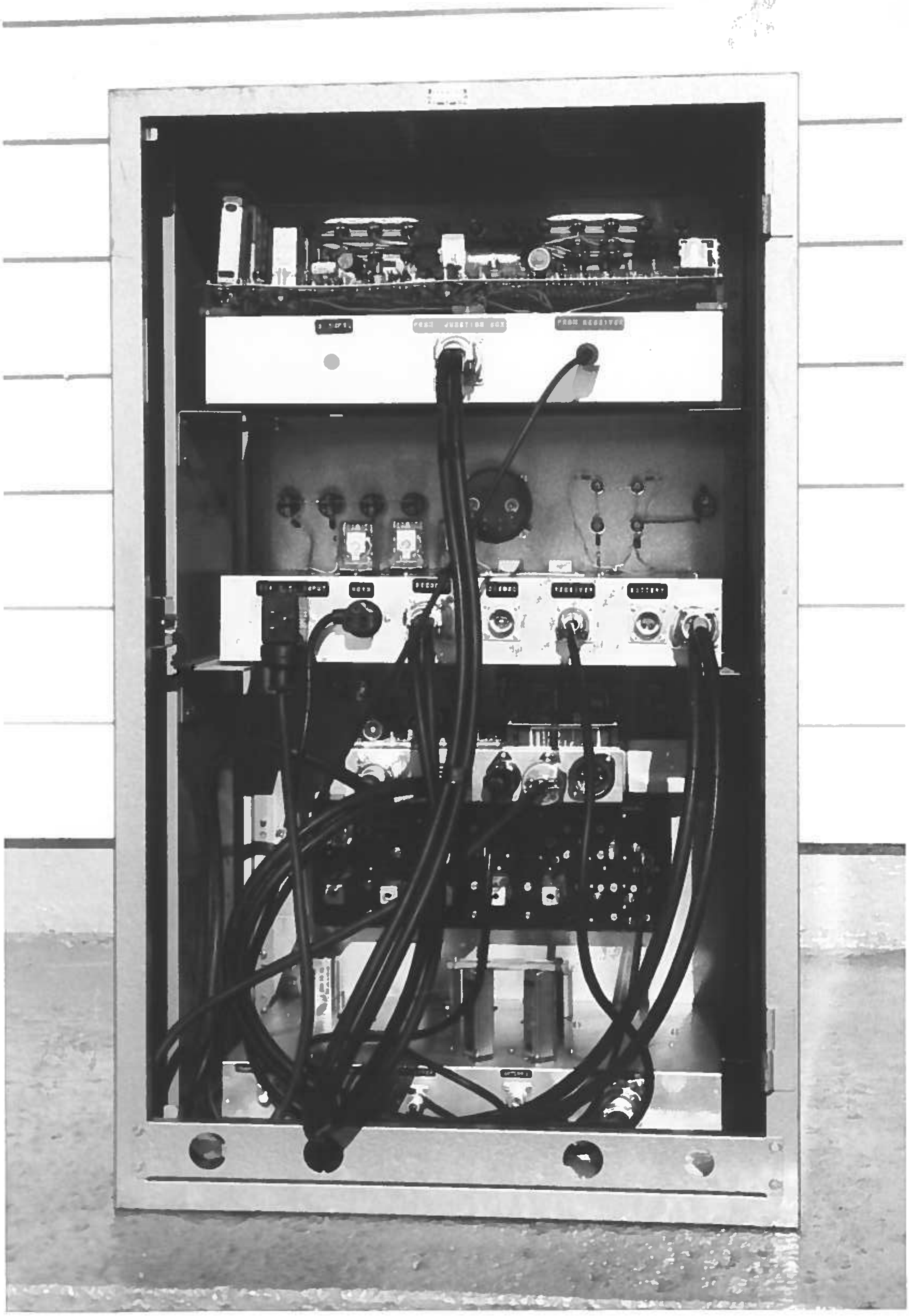


Figure 20. - Rear View of Fog Horn building equipment rack.