NBS TECHNICAL NOTE

419

Accessory Equipment and Teletypewriter Modifications for Remote Computer Consoles

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

THE NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] provides measurement and technical information services essential to the efficiency and effectiveness of the work of the Nation's scientists and engineers. The Bureau serves also as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To accomplish this mission, the Bureau is organized into three institutes covering broad program areas of research and services:

THE INSTITUTE FOR BASIC STANDARDS . . . provides the central basis within the United States for a complete and consistent system of physical measurements, coordinates that system with the measurement systems of other nations, and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. This Institute comprises a series of divisions, each serving a classical subject matter area:

—Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic Physics—Physical Chemistry—Radiation Physics—Laboratory Astrophysics[2]—Radio Standards Laboratory,[2] which includes Radio Standards Physics and Radio Standards Engineering—Office of Standard Reference Data.

THE INSTITUTE FOR MATERIALS RESEARCH . . . conducts materials research and provides associated materials services including mainly reference materials and data on the properties of materials. Beyond its direct interest to the Nation's scientists and engineers, this Institute yields services which are essential to the advancement of technology in industry and commerce. This Institute is organized primarily by technical fields:

—Analytical Chemistry—Metallurgy—Reactor Radiations—Polymers—Inorganic Materials—Cryogenics[2]—Office of Standard Reference Materials.

THE INSTITUTE FOR APPLIED TECHNOLOGY. . . provides technical services to promote the use of available technology and to facilitate technological innovation in industry and government. The principal elements of this Institute are:

—Building Research—Electronic Instrumentation—Technical Analysis—Center for Computer Sciences and Technology—Textile and Apparel Technology Center—Office of Weights and Measures —Office of Engineering Standards Services—Office of Invention and Innovation—Office of Vehicle Systems Research—Clearinghouse for Federal Scientific and Technical Information[3]—Materials Evaluation Laboratory—NBS/GSA Testing Laboratory.

---

[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C., 20234.

[2] Located at Boulder, Colorado, 80302.

[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

UNITED STATES DEPARTMENT OF COMMERCE
Alexander B. Trowbridge, Secretary
NATIONAL BUREAU OF STANDARDS • A. V. Astin, Director

TECHNICAL NOTE 419

ISSUED FEBRUARY 1968

Accessory Equipment and Teletypewriter Modifications for Remote Computer Consoles

Charles H. Popenoe and Robert C. Thompson

Institute for Basic Standards
National Bureau of Standards
Washington, D.C. 20234

For sale by the Superintendent of Documents, Government Printing Office
Washington, D.C., 20402 - Price 20 cents

CONTENTS

Illustrations

Figures:

Accessory Equipment and Teletypewriter Modifications For Remote Computer Consoles

Charles H. Popenoe and Robert C. Thompson

Equipment auxiliary to, and simple modifications of a teletypewriter are described which enable it to be used more efficiently as a remote console of a computer. The descriptions and drawings are sufficiently detailed to enable one to duplicate the modifications or construct the auxiliary equipment with little or no design effort.

Among the items treated are: pushbutton word generators, providing automatic typing of often used programming instructions; and option switches for full or half-duplex operation, for inserting the sixth bit for lower case letters, and the eighth bit for parity compatibility.

Key words: Teletype, time-sharing, remote access.

1. Introduction

A number of laboratories in the Heat Division of the National Bureau of Standards have made considerable use in recent years of punched-paper tape for data recording and computer processing. This program has yielded much first-hand experience in the use of remote-access, time-shared computing systems, first at Dartmouth College and then at several commercial installations. These facilities have in common a simplified, convenient, user-oriented language called BASIC[1], and remote-access input-output terminals provided by a teletypewriter operated over commercial telephone lines. Experience gained during this use motivated the authors to make a number of modifications and improvements and to design auxiliary devices to increase the efficiency of the terminal when used in routine data editing or as computer consoles. In most cases, a simple mechanical or electrical modification to the machine has sufficed to provide increased facility in its use as a remote terminal. It has been found that considerable savings in time may be realized by the use of a word generator, which provides for the automatic typing of often used programming instructions and system commands. This type of accessory equipment is especially useful for the non-typist, speeding up the typing, and eliminating typing errors. In the BASIC computer language, it is necessary to number each line in increasing order. To aid in this task, a number sequence generator was constructed and found to be a real time saver. This report serves to document the accessory equipment and modifications found to be especially necessary or desirable when using a teletypewriter as a remote computer console.

---

1. J.G. Kemeny and T.E. Kurtz, "A Manual for BASIC," Dartmouth College, Dartmouth Computation Center, Dartmouth Bookstore, Hanover, N.H., (1965).

By way of illustration, the auxiliary equipment was connected to and the modifications were made on a Model 33 ASR Teletype (Teletype Corp. 5555 Touhy Ave., Skokie, Ill. 60078), which is one type of teletypewriter. In the drawings when a numbered lead or connector is referred to, the number corresponds to a component in the Model 33 Teletype. While this equipment was connected to a Teletype, it will be understood that only small changes would be necessary to use this equipment with other teletypewriters or data recorders. Inclusion in this report of specific parts or equipment in no way represents approval or disapproval of any manufacturer or product by the National Bureau of Standards.

2. Description of Modifications

2.1. Column Index

Early experience with the 4 row, 100 word per minute teletypewriter as a data input device pointed out the need for a carriage position indicator similar to the column index on a keypunch. This is readily implemented by a small sheet metal pointer (fig. 1) attached to the carriage as shown in figure 2 and allowed to protrude under the front edge of the platen cover through a 1/8 inch high slot filed in the bottom edge of the cover. A suitable scale may be affixed above the pointer. Perhaps the simplest such scale may be made by typing with the teletypewriter directly onto non-glossy transparent mending tape, covering with another layer of tape, and pressing onto the upper edge of the slot as shown in figure 3.

2.2. Tape Editing Switches

The editing of punched-paper tape either for errors, changes or systematic insertion of fiducial marks, is greatly facilitated by the ability to advance the tape one character at a time with or without printing or punching.

Two pushbutton switches may be added to the tape reader to facilitate tape editing (c.f. fig. 3). One switch advances the tape without printing, the other prints and punches one character at a time. The schematic diagram is shown in figure 4. The normally open contacts of the "tape advance" switch are connected to pins 3 and 9 of the reader power pack connector. The "tape print" modification connects to pins 14 and 15 of the tape reader connector (Connector 6) in parallel with the tape reader switch. The time constant of the capacitor network permits sufficient current to flow to trip the "tape read" solenoid, allowing the machine to print exactly one character, even if the operator has a heavy hand.

2.3. Transmit Mode Switch

A switch may be added to the teletypewriter to enable operation in either full-duplex or half-duplex transmission mode. Such a feature may be desirable if several facilities requiring different transmission modes are to be worked from a single teletypewriter. The connection is made as in figure 5, in which the switch is shown in the half-duplex position.

2.4. Code Modifying Switches

The bit configuration used by the existing 4 row, 100 word per minute teletypewriters conforms to the American Standard Code for Information Interchange (ASCII)[2]. A recent revision of this code has been proposed which provides for both upper and lower case alphabet. It is only necessary to add bit 6 to obtain the lower case configuration. The addition of two switches permits tapes to be cut on the older teletypewriters using the ASCII code that would be compatible with new machines having both upper and lower case alphabets. The schematic for the two switches is shown in figure 6. When the DPST toggle switch is in one position, bit 6 is added to every character. The normally closed pushbutton switch placed in the lower left-hand corner of the keyboard serves the same purpose as a shift key on an ordinary typewriter. It suppresses the 6th bit when punching capital letters. However, since the code configuration for the control functions and the horizontal and vertical arrows must not contain bit 6, it will be necessary to depress the shift button when typing these characters. The addition of bit 6 will cause a parity change resulting in parity errors if the teletypewriter has a parity check. This means this modification can be used only if there is no parity check.

Early model teletypewriters using the ASCII code punch bit 8 for all characters, whereas the latest models are provided with even parity, bit 8 being punched when necessary to make each character contain an even number of bits. An additional switch may be added as in figure 6 to optionally punch bit 8 on every character.

3. Description of Accessory Equipment

3.1. Word Generator

During program composition or machine conversation, considerable savings in time may be realized with a device for generating serial groups of characters at the touch of a single button. A relatively simple such device capable of generating some 32 often-used programming commands has been constructed and used in an exploratory manner with the 4 row, 100 word per minute teletypewriter.

The word generator is constructed of rotary stepping switches having 11 banks of 25 contacts each. The wiring diagram for one switch is shown in figure 7. One side of the switch stepping motor is connected to 110V DC. The other side is connected to the wiper on the "stable" bank and through the interrupter switch to the wiper on the "search" bank. When one of the pushbutton switches is actuated, all contacts of the "search" bank are grounded except the one connected to the normally closed contact of the switch. This causes the stepping motor to operate until the wipers are at a position where the contact on the "search" bank is not grounded. Simultaneously, one side of the protective relay coil is grounded. This opens the circuit to the "stable" and "print" banks while stepping to eliminate interference with the teletypewriter. When the pushbutton switch is released, a pulse from the teletypewriter actuates the "drive" relay, grounding the stepping motor via the "stable" bank and moving the wipers ahead one row. The "print" bank now completes a circuit causing the teletypewriter to read the eight bits that comprise a character from banks 1 through 8. The drive relay is again actuated, repeating the process until the wipers of the stepping switch come to an

2. Communications of the ACM 8, 207, (1965).

ungrounded contact on the "stable" relay at which the switch stops. The unlabeled switches shown closed are closed when the word generator is in use and open otherwise. The switch in the line to the "drive" relay is used in common with similar switches on the tape reader to select the desired input to the teletypewriter. The switch that connects the common lead from the teletypewriter to bank 8 is opened when the word generator is not in use to keep spurious signals from bit 8. This switch would not be needed if the stepping switch had 12 banks and one were used as the common lead. Banks 1 through 8 are wired to produce the desired character sequence in the ASCII code.

Additional stepping switches may be added in parallel to provide as many words as desired. To connect the word generator, an extension cable (fig. 8) is made up to connect between the tape reader cable connector and the teletypewriter connector. An additional connector for the word generator may be wired in parallel. It is necessary to connect pins 6 and 12 on the reader power pack to unused pins 12 and 13 on the word generator connector to operate the drive relay. The same extension cable may be used to connect the Code Translator Module to the teletypewriter to convert ASCII to IBM coding and vice versa.

3.2. Consecutive Number Generator

The consecutive number generator, used in conjunction with a 25-position word generator stepping switch, is used to facilitate data entry into a BASIC program. The BASIC format requires that each data line be preceded by a line number, the word DATA, and then the data quantities. This device performs the repetitive typing of consecutive 2-digit line numbers and the word DATA preceded and followed by a space at the press of a single button. It is constructed from two rotary stepping switches having 3 banks of 11 contacts each, 3 of 10 each, and an off-normal switch.

The wiring diagram is shown in figure 9. Bank "one" has all contacts except the first and last ones wired to a normally open switch labeled "reset units" (tens). When this switch is closed, the stepping motor moves the wipers to the home position. The last contact is connected to ground to step the wipers past the unused eleventh position. The "units" stepping switch is advanced one step each time the drive relay is actuated. The "tens" stepping switch is advanced one step when the drive relay is actuated and the "units" off normal switch is closed, which occurs only when the "units" stepping relay is in the "nine" position. Thus, when the "units" switch is advanced to the "zero" position, the "tens" switch is advanced one step. The common, 1,2,3,4 wipers on the "tens" relay are connected to the "tens" position on the 8, 1, 2, 3, 4 banks of the 25-contact rotary stepping switch. The wipers of the "units" stepping switch are connected in similar manner to the "units" position. The space, DATA, space are coded as described for the word generator. When the pushbutton labeled TUDATA is depressed, the number generator is advanced one digit and the 25-contact rotary stepping switch hunts for the ungrounded position. When the pushbutton is released, the 2-digit number and word DATA are printed out. The number generator also may be used to generate line numbers spaced 10 apart by connecting its output to another set of contacts on the stepping switch and coding the successive positions for zero followed by a space. The top and bottom views of a pushbutton generator combined with a consecutive number generator are shown in figures 10 and 11, respectively. Another module having 5 additional 25-position stepping switches is used to provide full word capability.

3.3. Single Character Generator

Characters not included on the teletypewriter or requiring actuation of a shift key may be conveniently generated by depressing a single key with the single-character generator. The same techniques are used for construction of remote keyboards or 10-key numeric keypads.

Eleven-pole coding switches are used to generate the characters as in figure 12. As the switch is operated, circuits A and L are made first, followed by the eight code levels (C, D, E. F, G, H, I, J) and last, circuit B, which energizes the drive relay causing the teletypewriter to print one character. The contacts of the drive relay are connected to the teletypewriter in the same manner as the "tape print" switch on the reader. The coding switches are connected in parallel by encoding strips which connect to the switches by wiring tabs. Coding is accomplished by breaking off unwanted tabs. The relay is necessary because of the low voltage rating of the coding switch contacts. The -20V voltage on the common contact is supplied by the dataset coupler. The other side of the relay coil is connected to the +20V side of this supply. These pushbuttons must be held down long enough for the bit configuration to be scanned by the teletypewriter (100 ms.) since the coding is lost when the switch is released. A single character generator with 24-character capability is shown mounted adjacent to the keyboard in figure 13.

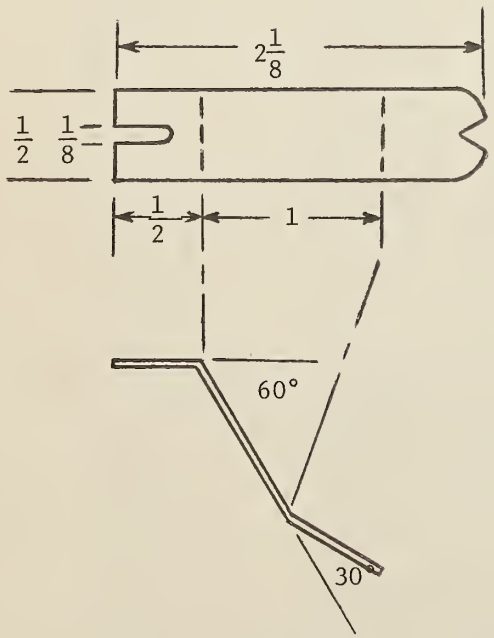
3.4. Remote Tape Reader

A remote tape reader may be added with tape spooling facilities for handling lengthy tapes. The reader, purchased as a replacement item, is mounted on a 9-inch panel (fig. 14) and is connected to teletypewriter by an additional cable. The wiring diagram for the remote reader is shown in figure 15 and the tape spooling circuitry in figure 16.

Tape handling is provided by two inexpensive 4-pole induction motors. Full line voltage is applied to the motors for fast forward or rewind, reduced line voltage for takeup tension, and dc for dynamic braking. Spring-loaded arms take up slack in the tape during spooling operations and provide buffer loops to prevent tape damage. This arrangement allows extremely fast tape transfer between reels with quick braking and is particularly uncomplicated, all tape control being accomplished electrically.

The tape reader cable may be connected to an unused connector at the rear of the teletypewriter. The reader to be operated is selected by the "local-remote reader" switch located on the control panel of the teletypewriter. This DPDT switch transfers the signals from the reader feed contacts and the tape read switch from one reader to the other.

COLUMN INDEX



Make from 52S aluminum 1/32 thick
All dimensions in inches

Figures 1 and 2. Construction and Mounting of Column Index Pointer.

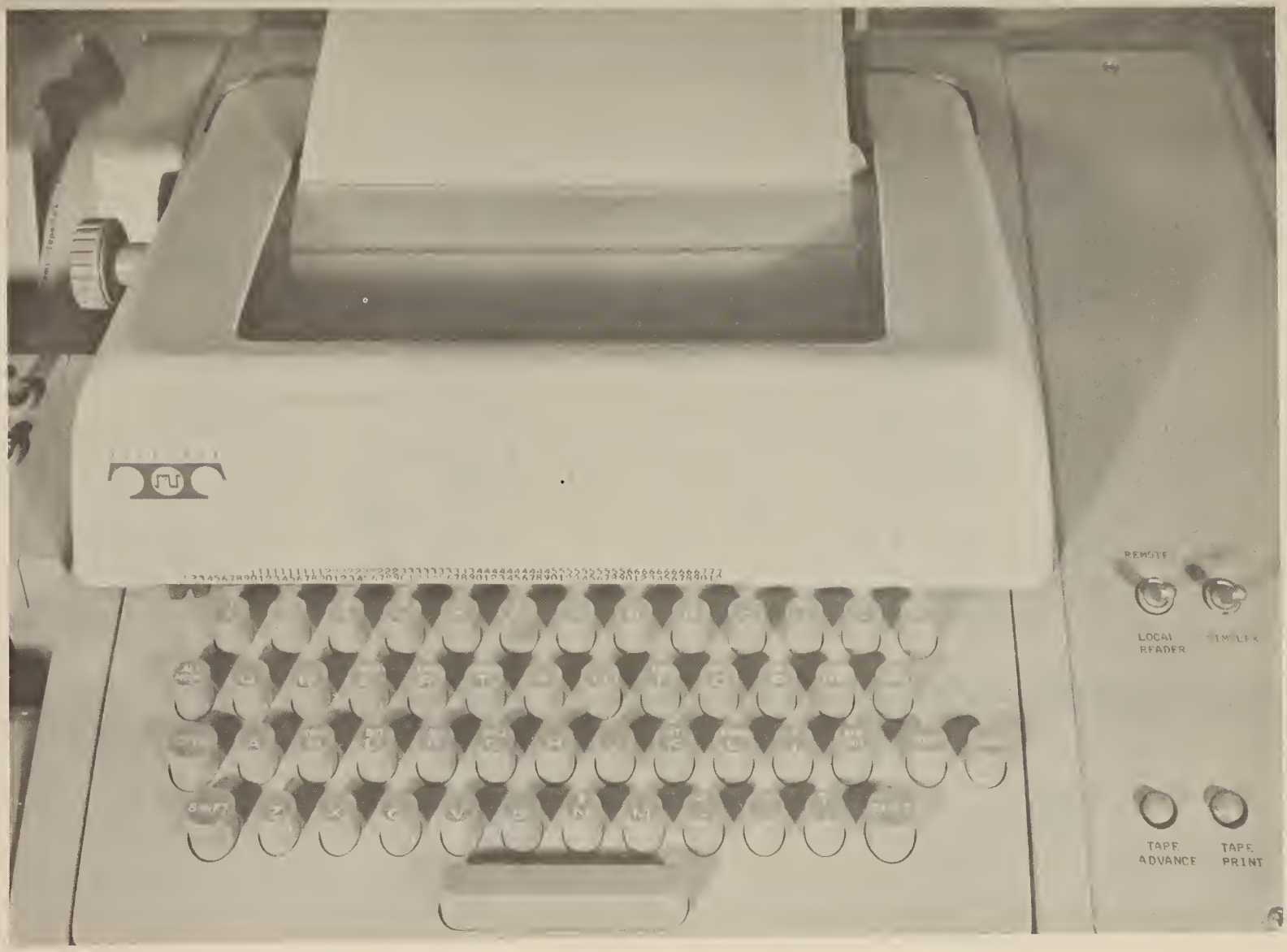
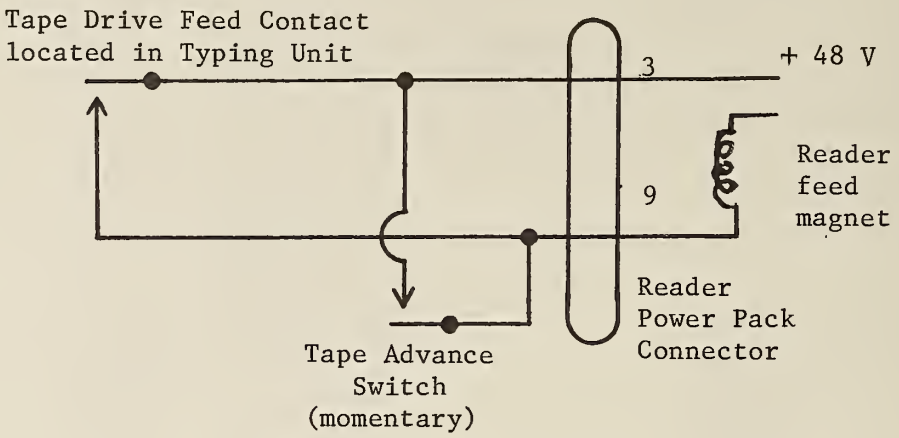


Figure 3. Teletype Keyboard with Column Index



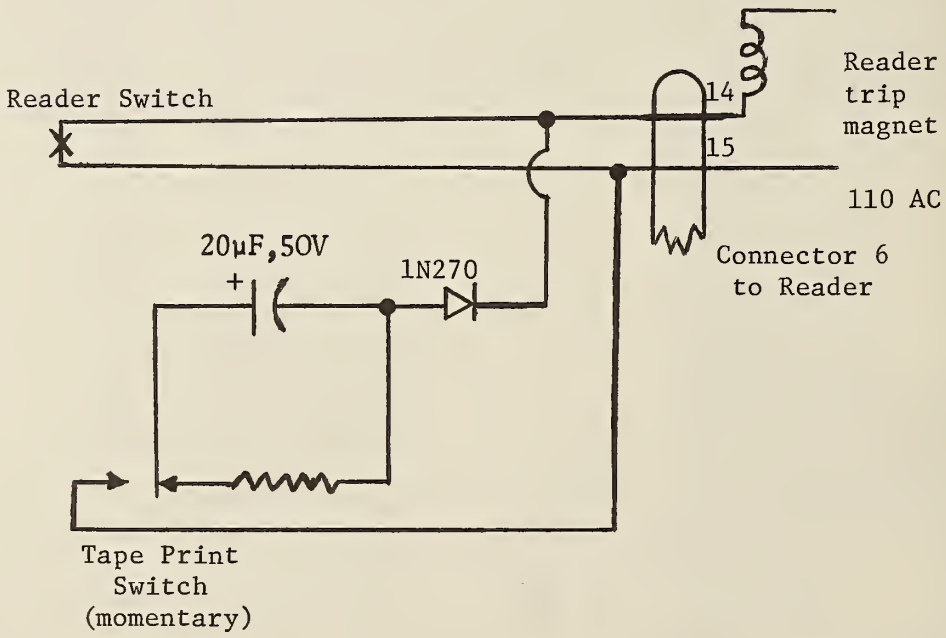


Figure 4. Tape Editing Modifications.

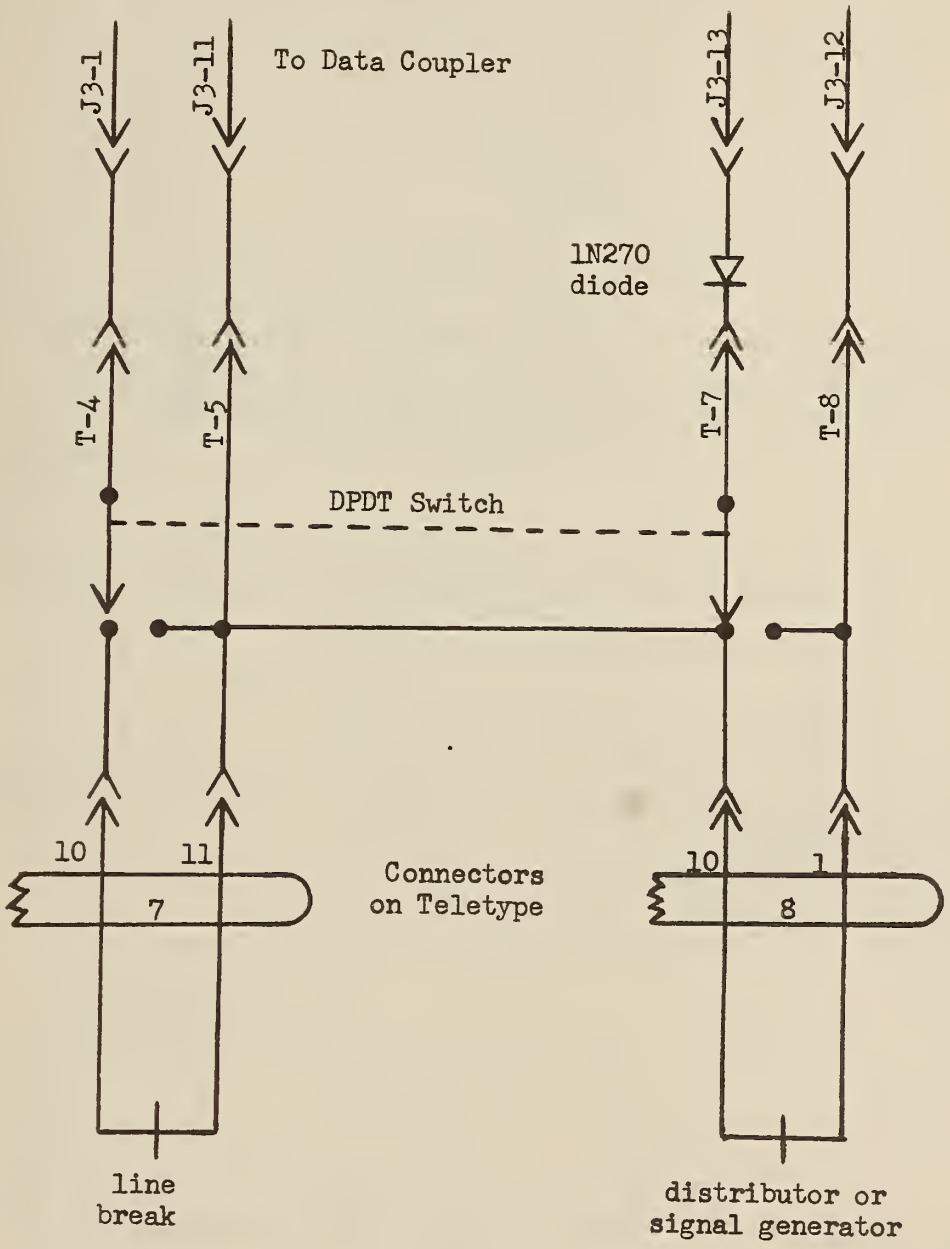


Figure 5. Transmit Mode Switch.

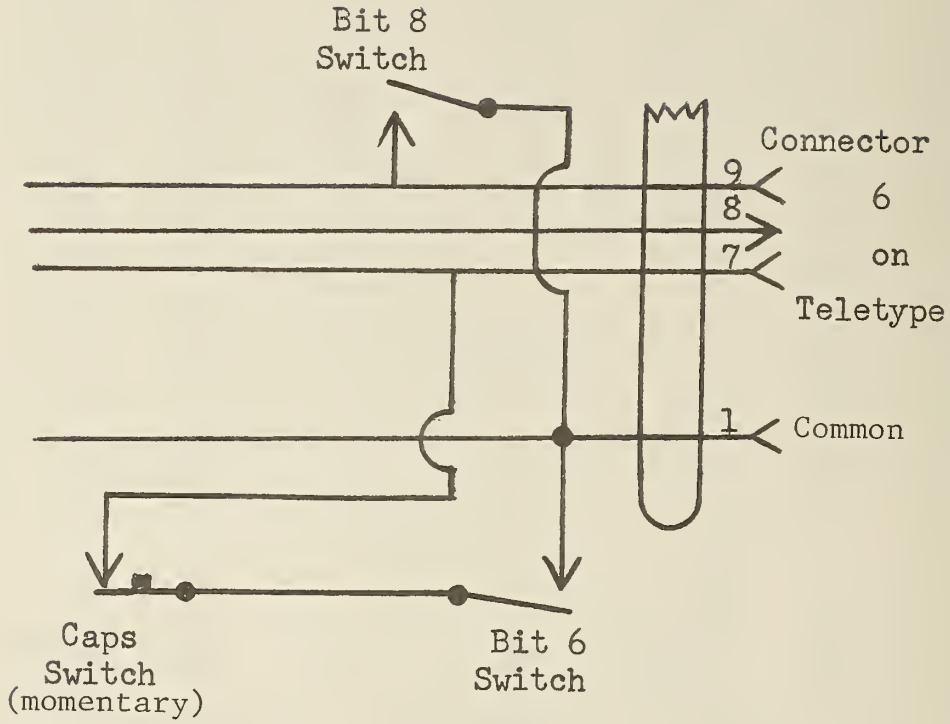


Figure 6. Code Modifying Switches.

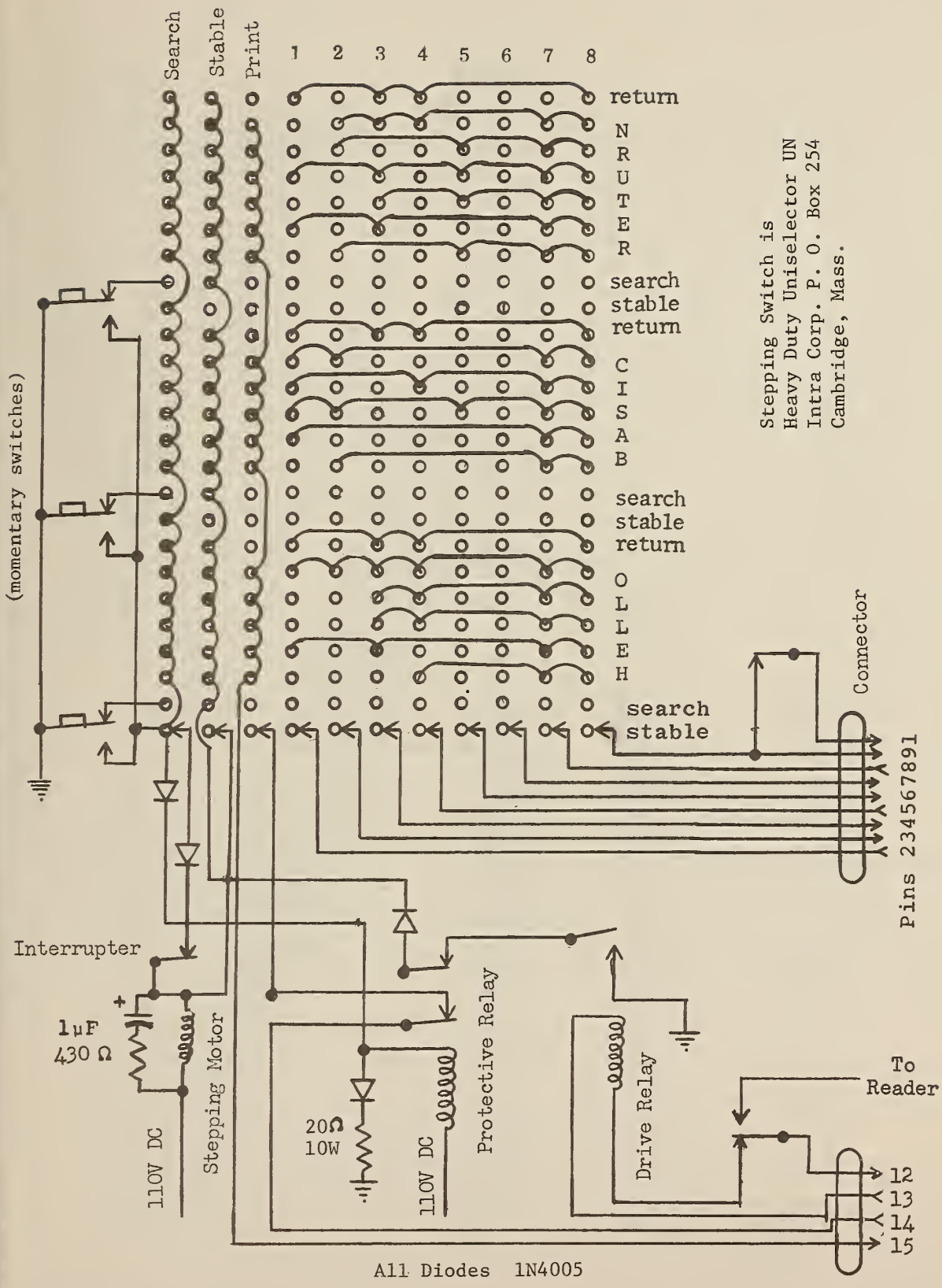


Figure 7. Wiring Diagram for the Word Generator

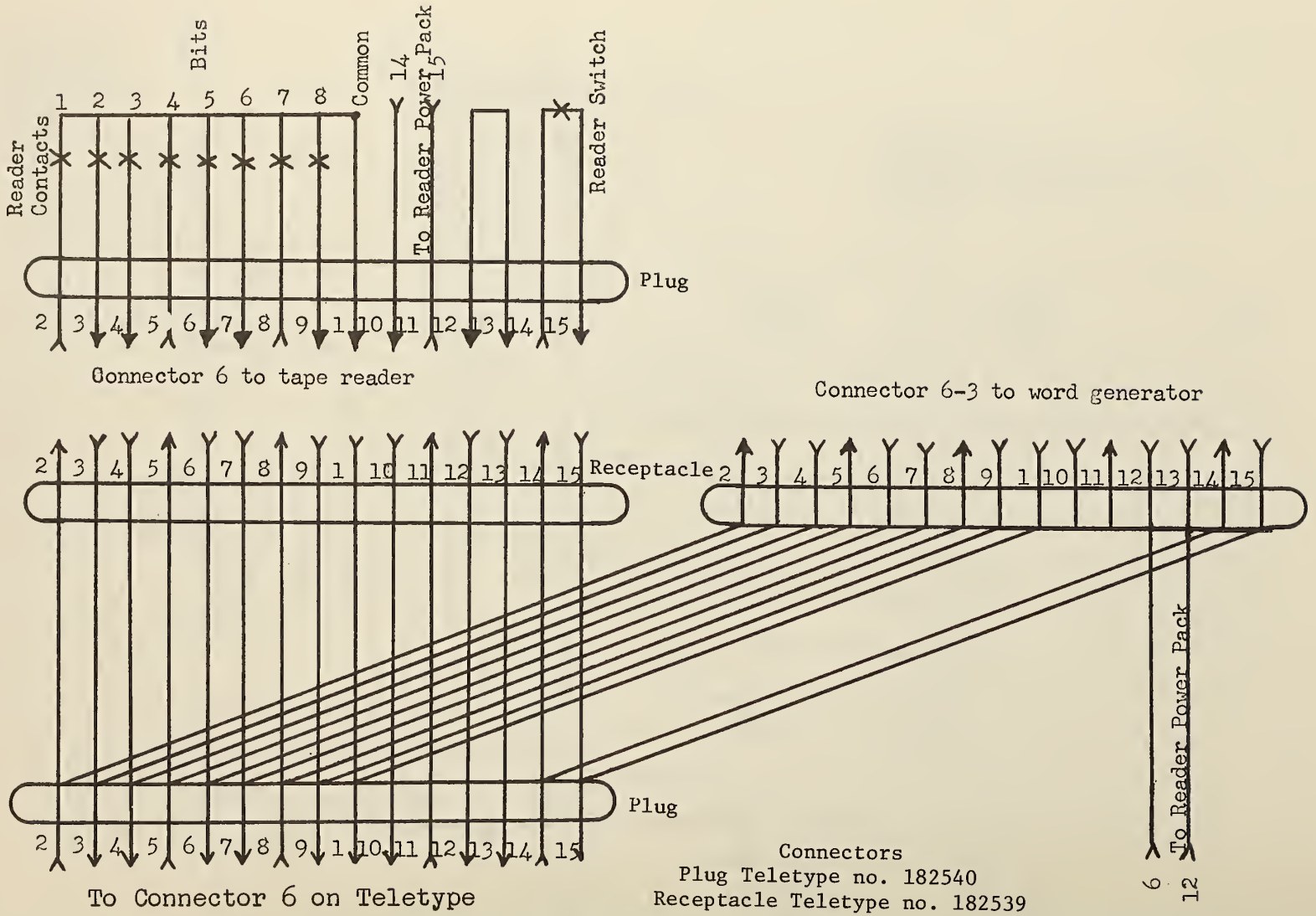
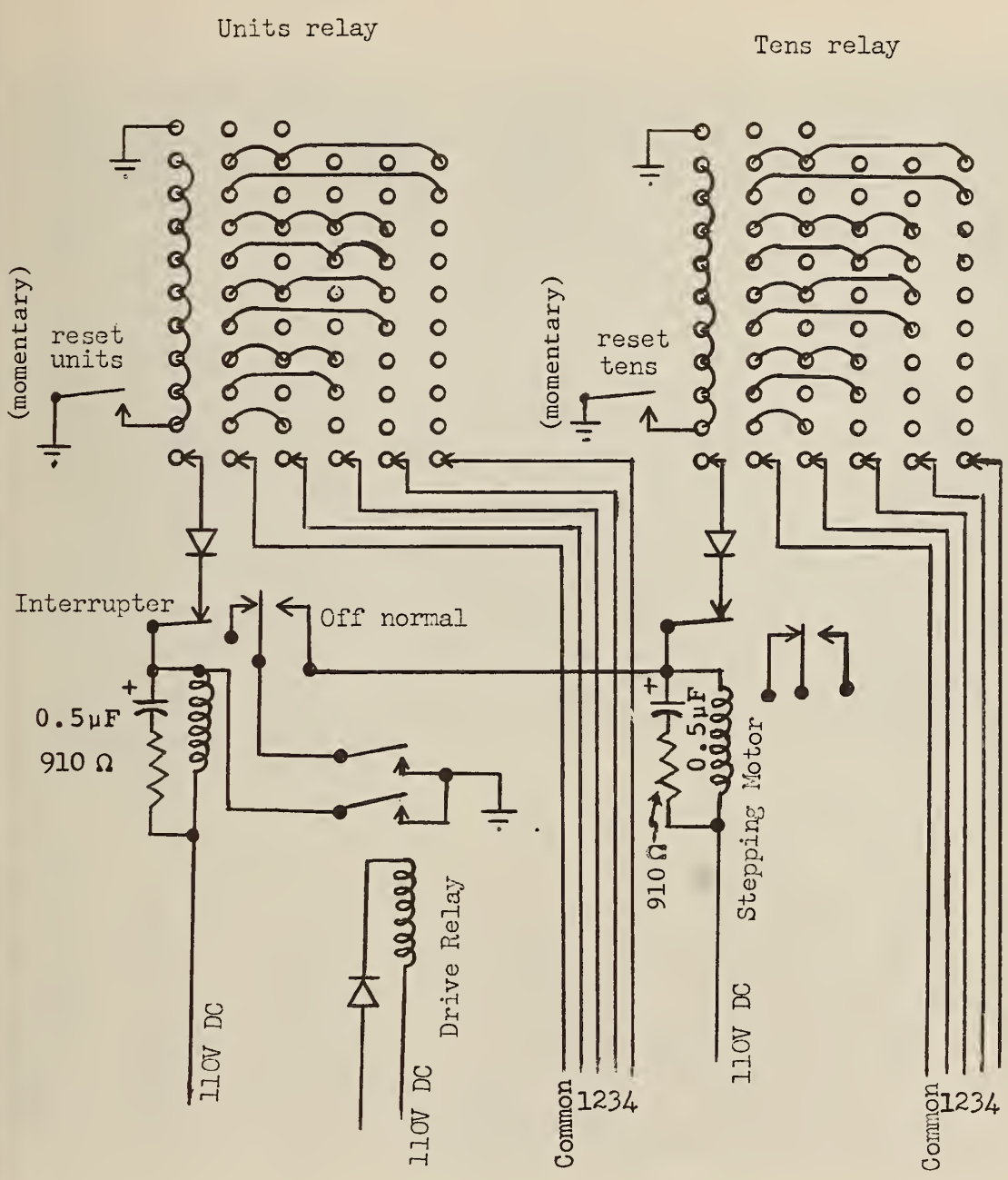


Figure 8. Extension Cable.



All Diodes 1N4005

Type 40 Rotary Stepping Switches
Automatic Electric Co.
1120 Conn. Ave., N.W.
Washington, D. C.

Figure 9. Wiring Diagram for the Consecutive Number Generator

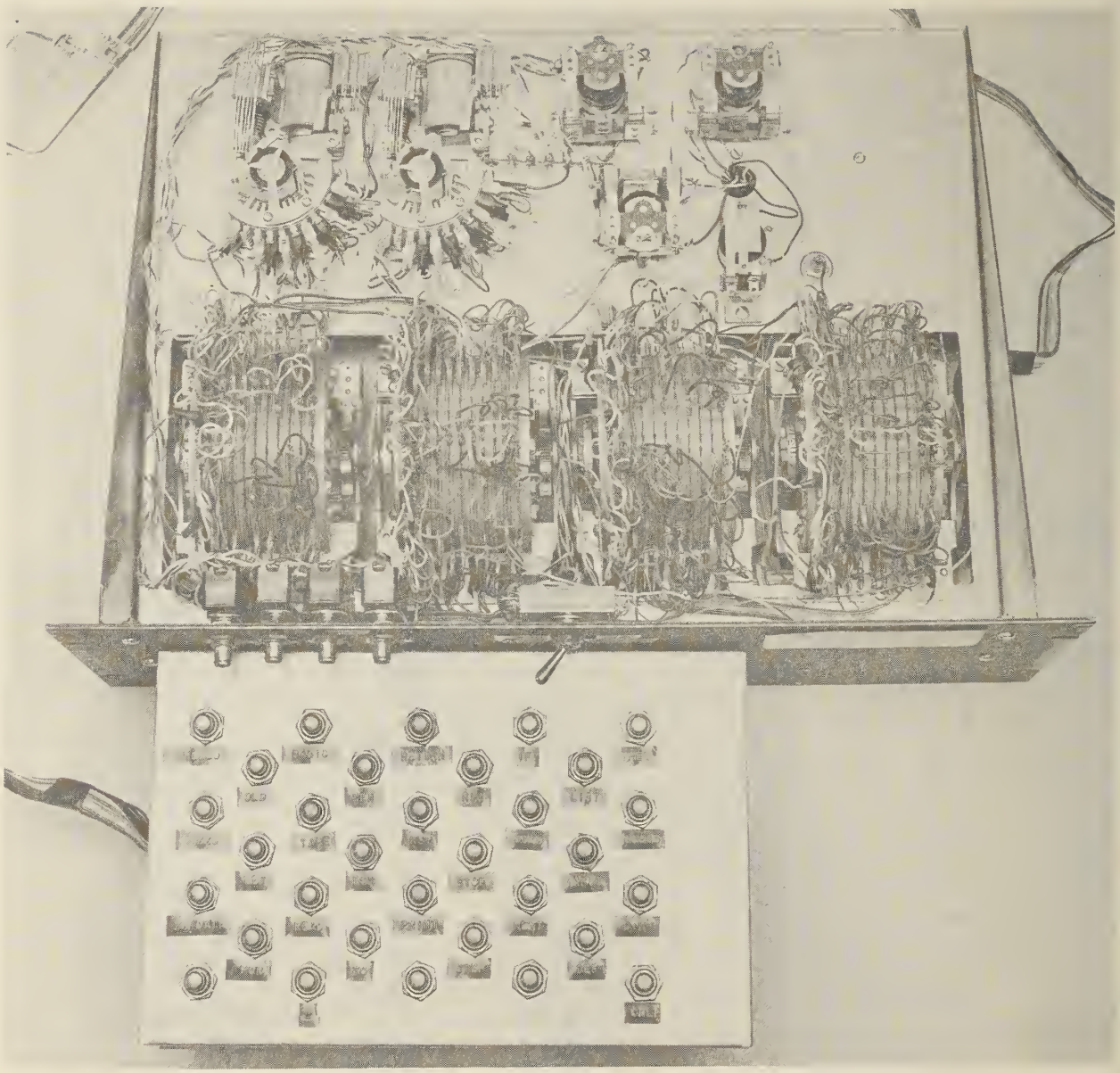


Figure 10. Pushbutton Word Generator, Top View

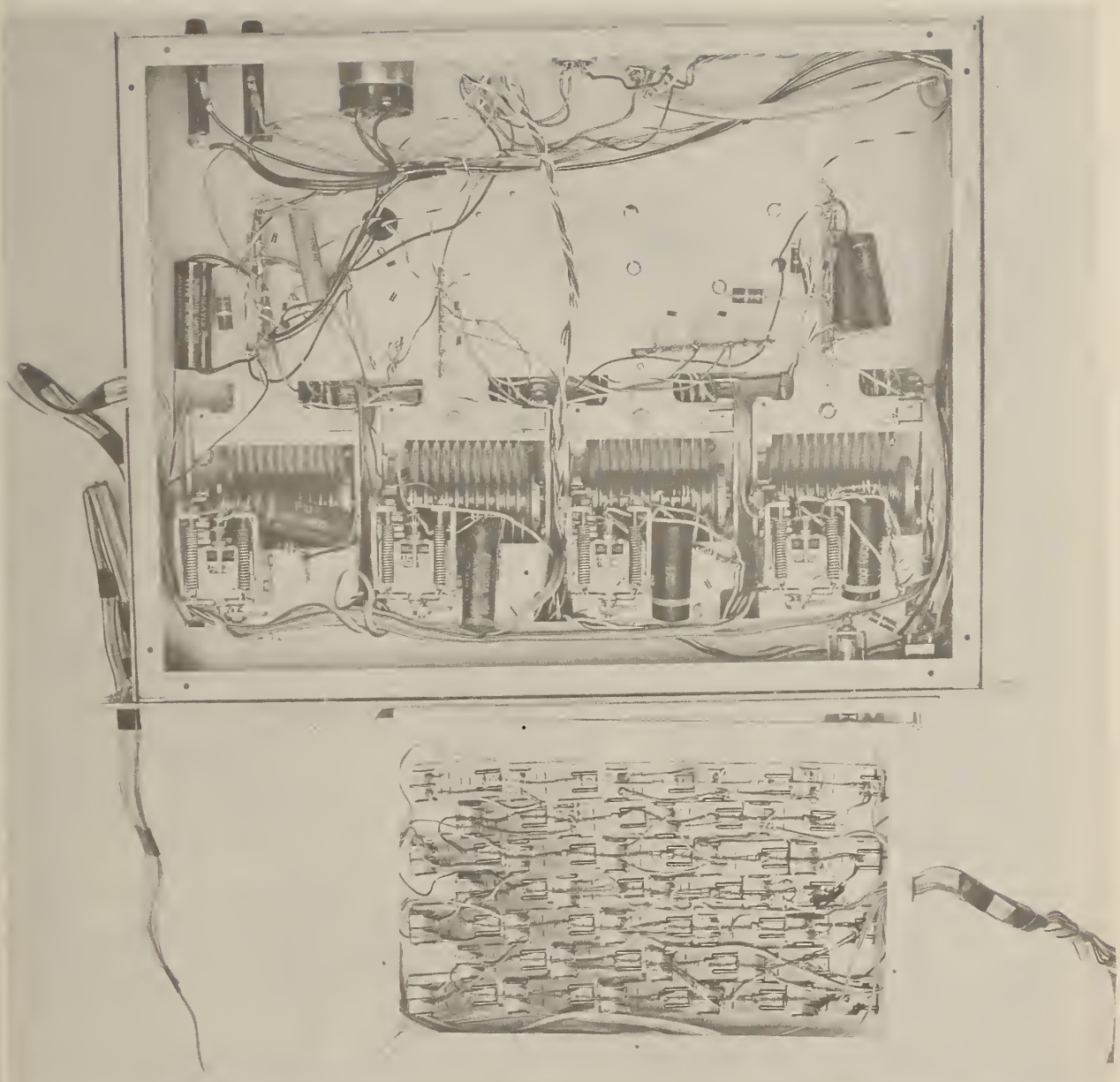
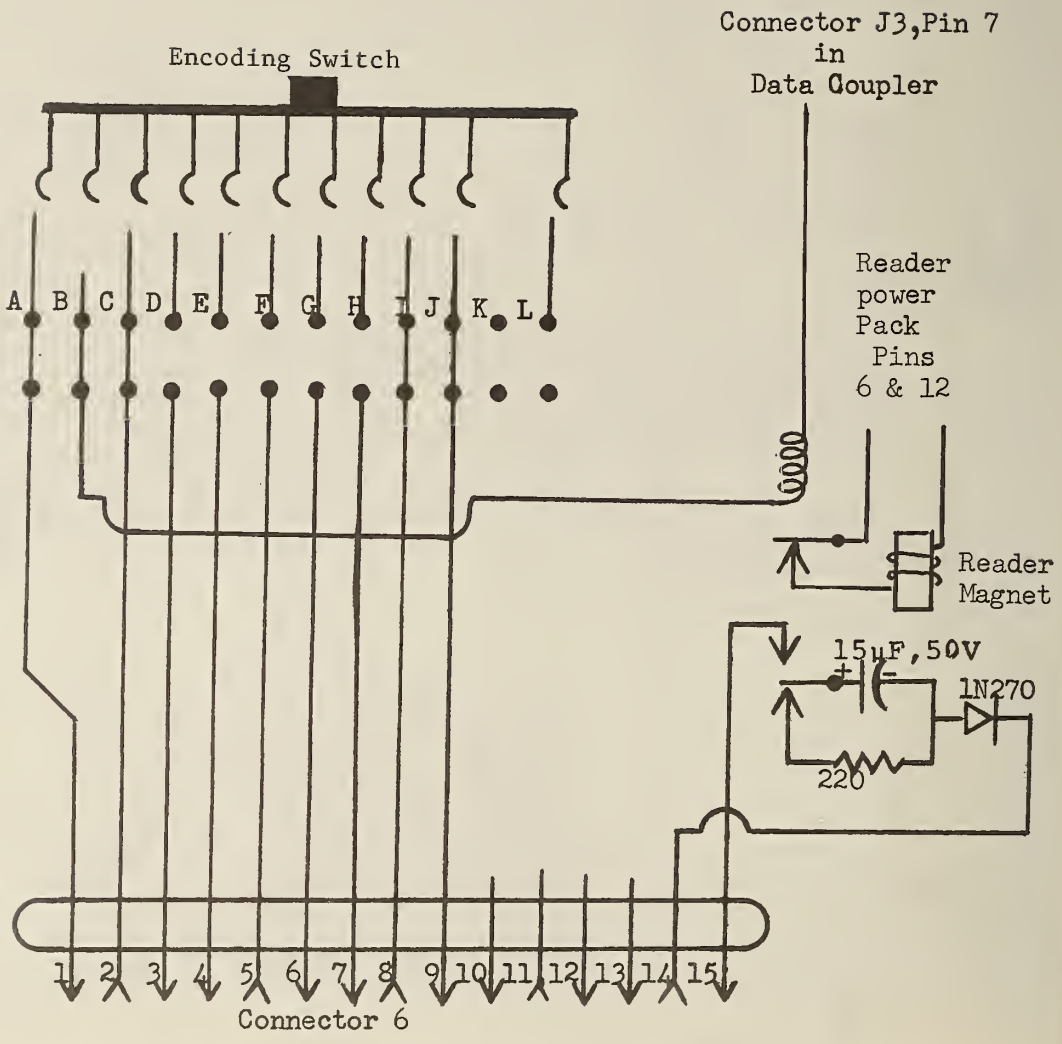


Figure 11. Pushbutton Word Generator, Bottom View.



Encoding switch is KB encoding switch 7A 1AA
Microswitch, Div. of Honeywell
Freeport, Ill.

Figure 12. Schematic Diagram for the Single Character Generator

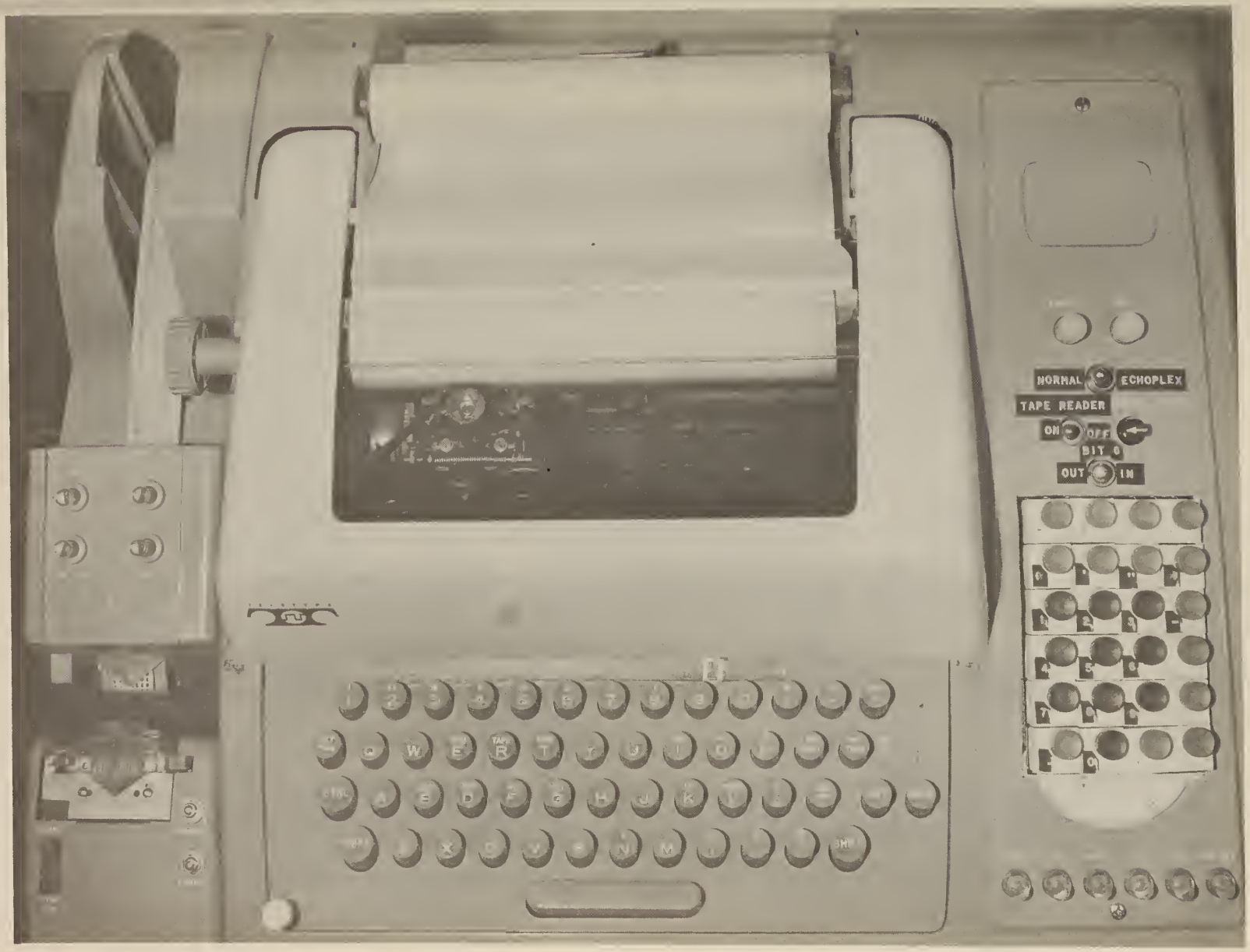


Figure 13. Layout of the Modifications on a Model 33 ASR Machine

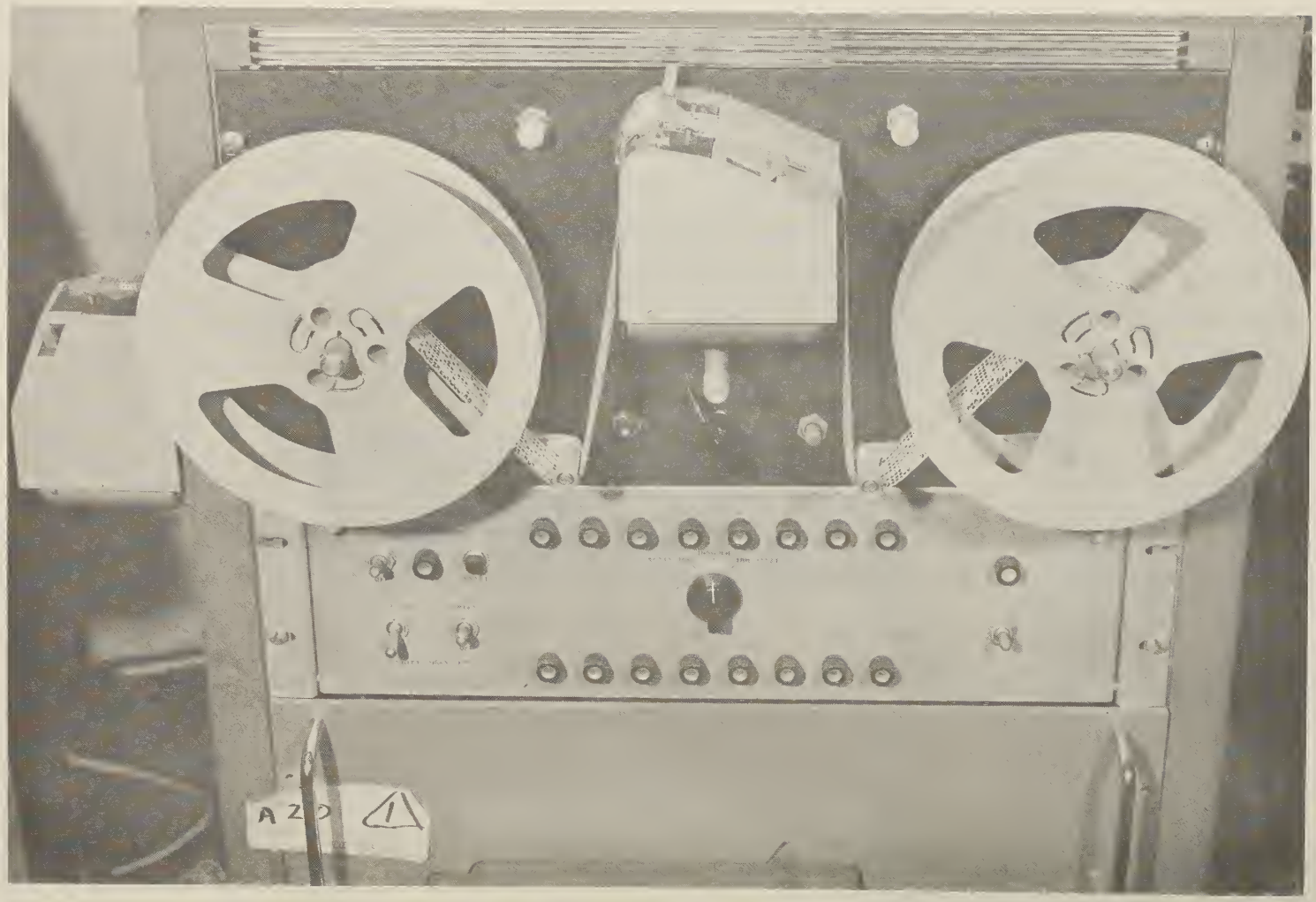


Figure 14. Remote Tape Reader Assembly

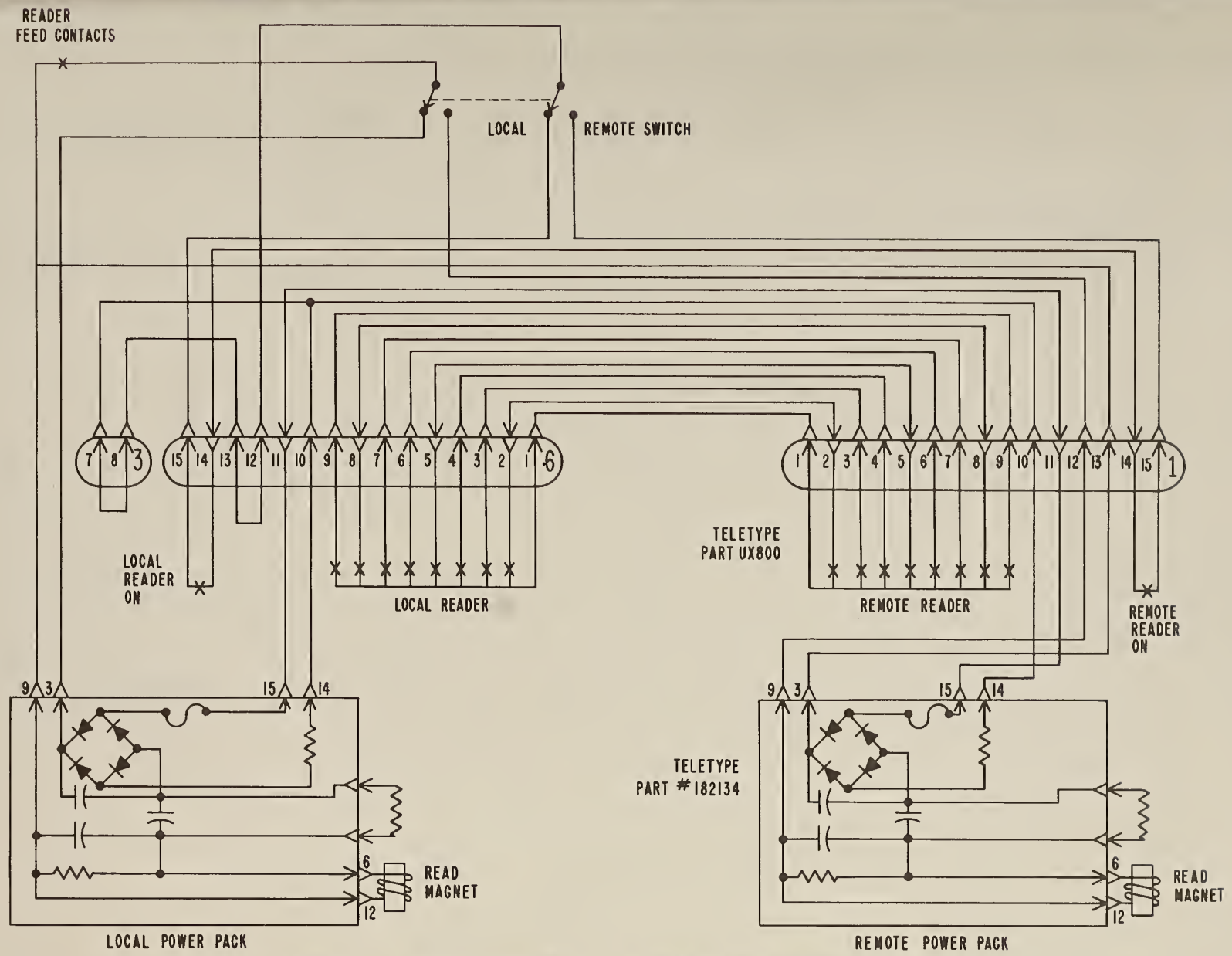


Figure 15. Wiring Diagram for the Remote Tape Reader

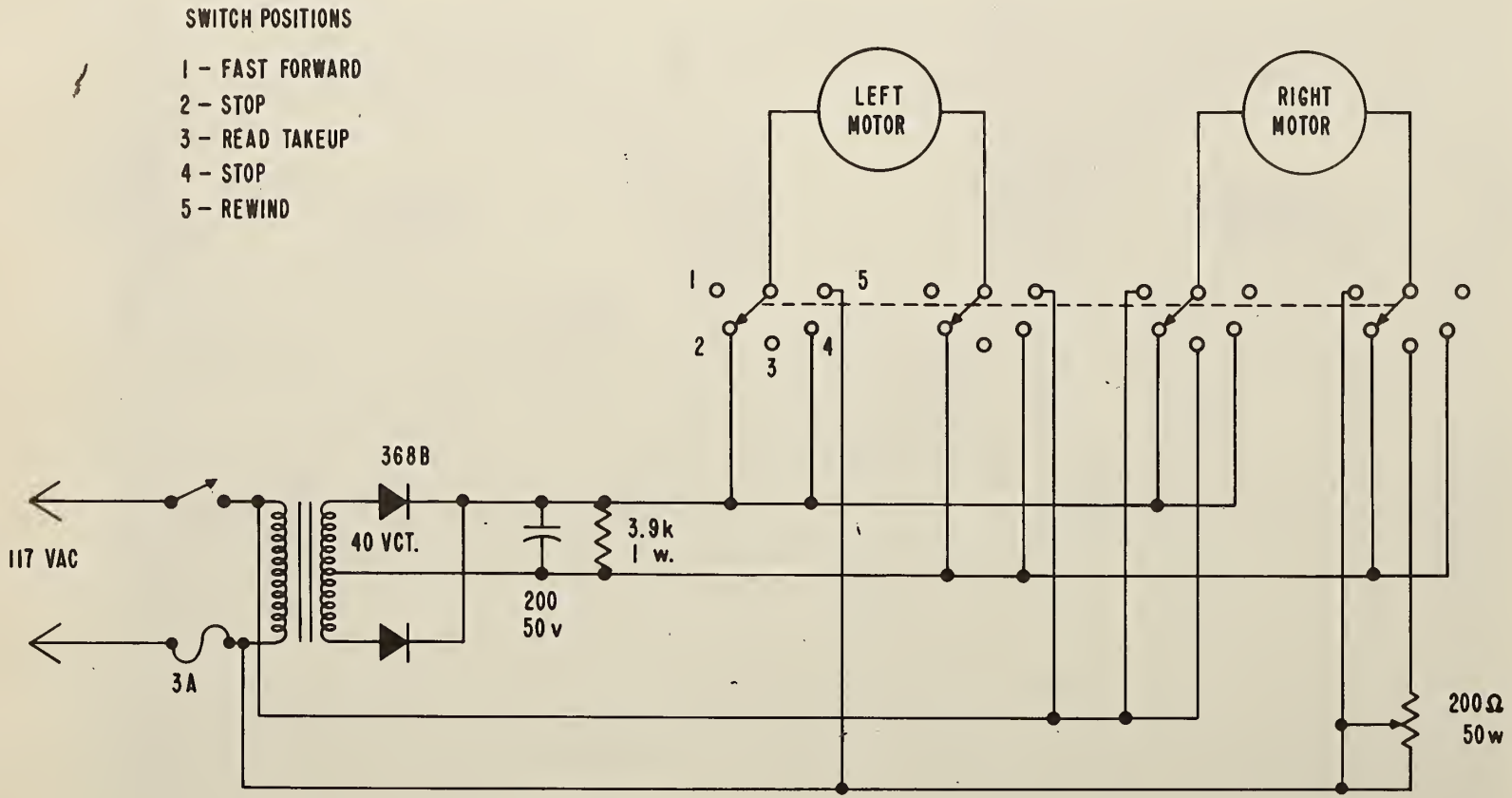


Figure 16. Tape Spooler Wiring Diagram

* U.S. GOVERNMENT PRINTING OFFICE : 1968—301-023/76

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

• Physics and Chemistry

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $5.00; foreign, $6.00*.

• Mathematics and Mathematical Physics

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75*.

• Engineering and Instrumentation

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50*.

TECHNICAL NEWS BULLETIN

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company executives.* Annual subscription: Domestic, $1.50; foreign, $2.25*.

*Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test methods, and performance criteria of building materials, components, systems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Miscellaneous Publications. Charts, administrative pamphlets, Annual reports of the Bureau, conference reports, bibliographies, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

CLEARINGHOUSE

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write:

Clearinghouse
U.S. Department of Commerce
Springfield, Virginia 22151

Order NBS publications from:
Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

U.S. DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20230

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE