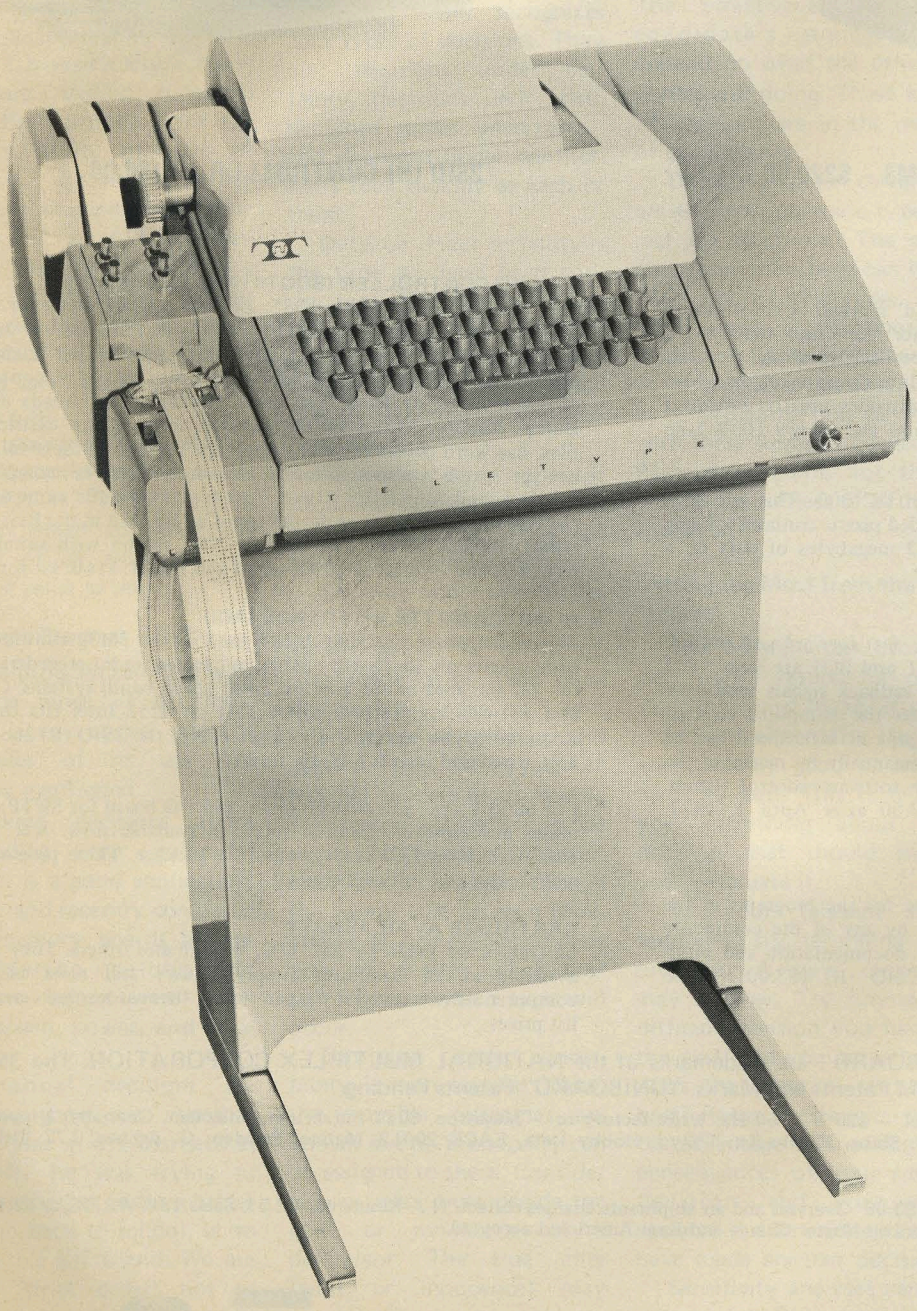
Inside the Amazing ASR 33

... checking out the most popular terminal



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If you have ever raised the cover of a Model 33 Teletype while it is operating, you might have pulled back involuntarily to avoid the shower of metal parts which seems about to erupt at any moment. Not only does it

keep right on typing, but most of them continue on for years as long as liberally supplied with lubricating oil. Service manuals have lengthy sections devoted to details of lubrication, but the common practice among many experienced service men seems to be to just squirt oil everywhere except on the ribbon.

If Henry Ford put America on wheels then certainly the Model 33 put America, and the world, in communication with computers. Since it was first introduced in 1962, more than 470,000 were produced thru 1976. By the end of this year over a half million of these machines will have been shipped, and this does not include its forerunner, the 5-level Model 32, or the "souped-up" Model 35. Like the VW Beetle, they have been virtually unchanged year after year, apparently on the same principle, that when you know you have something good, leave it alone.

A testimony to the quality of the Model 33 is the fact the ASR (Automatic Send-Receive) 3320, 3JA, the version most common for computer use, currently lists at $1070 new, yet old machines rebuilt by a number of companies, still bring approximately $900.

Some of the Benefits

The Model 33 is supplied in three basic configurations: a receive only (RO), consisting only of a printer unit; a keyboard send-receive (KSR), which adds a keyboard to the printer: and an automatic send-receive (ASR), which adds a paper tape reader and punch. It is the latter version which is of the most interest to the small computer hobbyist and to many large commercial users as well. Hard copy is a must for anyone whose computer ambitions extend beyond playing games, and magnetic storage media simply lack the practicality of paper tape for the vast majority of small computer users. Paper tape operations with the Teletype are slow, to be sure, but when faced with the fact that most users have little need for high speed input or output, and the cost of a high speed reader-punch, it is not difficult to live with ten characters per second.

High cost of maintenance has often been stated as a drawback to personal ownership of a Model 33, but those making this statement have probably not studied the technical manuals supplied by Teletype. These manuals are models of what technical manuals should be and are so detailed and illustrated that most users can handle a major part of maintenance themselves. They are truly incredible documents. For example, a modern automobile has vastly more complicated wiring than a Teletype, yet a car wiring diagram usually covers one page of a shop manual. The Model 33 wiring diagram (Part No. VDP-0316, at $4.95 plus freight) consists of thirty-five 11" x 16" sheets. With such documentation almost anyone can soon become an expert. The mechanical side is equally well covered by three well filled loose leaf books, one for general operation, one for adjustments, and one for replacement parts. If any small screw, nut, or spring should fall from a Teletype, you can be certain to find it illustrated, numbered, and fully described.

The Model 33 is compatible with virtually all small computers made throughout the world, probably because the computer manufacturers realize that their product must be compatible, rather than the other way around. Connections to a computer are frequently as simple as connecting four wires, two for input and two for output, from the computer interface to a terminal strip at the back of the Teletype. The same connections are also available at a plug just above the terminal strip. If the Teletype has an automatic tape reader (Version 5JA), these four wires are all that is required, the reader being started and stopped under program control by simply transmitting the proper ASCII character, usually DC-1 (021 in 7-bit ASCII code) to start the reader and DC-3 (ASCII 023) to stop the reader.

Some manufacturers of small computers do not use this method of reader control, but instead use the manual reader (Version 3JA) with an added relay circuit, wired with two extra wires to their interface. The automatic reader (5JA) will work with their computers, but will not respond to their software or firmware. A standard manual reader Teletype is easily converted to their mode of operation by installation of a small printed circuit relay board. These boards have recently been quoted at prices ranging from $50 by a used teletypewriter dealer to $150 by a large and well-known computer manufacturer. Examination of this board, along with a catalog from an electronics supply house, reveals that the total material costs are approximately $4.29 in production quantities.

The Theory Behind the Clankety-Clunk

The basic operation of the Model 33 consists of sending or receiving a series of current pulses, a logic 1 being represented by a flow of current and a logic 0 by no flow. The current levels are 20 or 60 mA, the 20 mA level being most common for computer use. This option, as well as a choice between half duplex or full duplex mode of operation, can be implemented in a few minutes with only a screwdriver. Full duplex, meaning the ability to transmit and receive simultaneously, is the normal computer mode. Factory wiring is for 60 mA current loop and half duplex, consequently the changes must be made on new machines.

Fig. 1 illustrates the

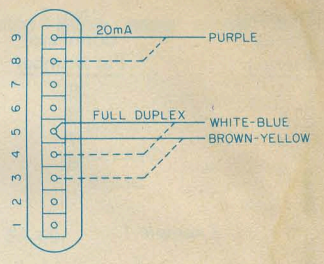

Fig. 1.

changes required to convert from the factory configuration to 20 mA current loop and full duplex.

Data transmission to and from the Teletype is a serial stream of current pulses at a 110 baud rate. Each character transmitted consists of eleven pulses, or more correctly, eleven time units defined in the send mode by the mechanical speed of the distributor rotor and in the receive mode by the clocking in the computer interface. The computer interface, therefore, must be capable of sending pulses at a 110 baud rate. With eleven pulses per character (8 data bits plus one start and two stop bits) this results in a rate of ten characters per second. The eight data bits, in the case of keyboard operation, are a seven-bit ASCII code and an even parity bit. (Don't forget the parity bit in programming ASCII masks.) The tape reader transmits whatever is on the eight levels of the tape, regardless of whether it is in ASCII code, binary, or just plain holes.

Transmission of a character starts with a parallel presentation of the eight data bits to the data contacts on the distributor disk. It is a parallel operation because all eight feeler pins in the reader rise at the same time, and the stroke of a key sets all of the code bars at the same time. Transmission in parallel would be faster, but would require a separate line for each bit, cumbersome for a computer and impossible in the case of a telephone line. When the code is ready at the distributor contacts, the distributor rotor makes one

Terminal Strip Contact	No. 2 Connector Pin Number
3	5
4	6
6	7
7	8

Example 1.

revolution, wiping a carbon brush across the ten contacts (a *start* segment and eight *data* segments of equal length, and a *stop* segment of double length, for a total of eleven time units). Depending upon the code presented to the data segments, each time interval is either *marking*, meaning that current is flowing or logical 1, or *spacing*, meaning no current flow or logical 0. With this system the importance of the baud rate setting of the interface becomes obvious. At any setting other that approximately 110 baud, the stream of pulses becomes jibberish.

Receiving functions of the Teletype are largely independent of the sending functions, which makes full duplex operation possible. The stream of serial pulses arrives at the selector magnet driver that drives selector cams, which set the desired ASCII code in a series of code bars. The position of these bars determines how the typewheel will be set, vertically and rotationally. When set, a hammer strikes the typewheel driving it forward into the ribbon and paper.

ASCII code is not just one of a number of codes that a Teletype can receive, but is basic in the entire design of the machine, even to the design of the typewheel. For example, if the no. 4 pulse of the seven-bit ASCII code is marking (logic 1), the typewheel will turn counterclockwise from its null position to find the desired character, and if it is spacing (logic 0), it will turn clockwise and find the desired character on the other half of the typewheel. Pulses 1, 2, and 3 determine how far the typewheel should rotate, (there are eight characters around half of the wheel) and pulses no. 5 and 7 determine which of the four vertical levels of the typewheel will be selected. If pulses no. 6 and 7 are spacing, no selection is made, which means that the code was for a nonprinting function. A check of the ASCII code will reveal that all nonprinting functions have a code below 040, space, 040, being considered a printing function.

Buyer's Guide

The hobbyist who can locate a used ASR-33 in good mechanical condition can be reasonably sure that it can be interfaced to his computer, usually at no additional cost and very little work. The first check to be made is whether it is equipped for current loop operation. This can be determined by removing the cover from the machine and examining the selector magnet driver, a printed circuit board mounted at the right side toward the rear in the call control unit. The board should be labelled, ''.020A .060A NEU 181821". The side of this board that can be seen if only the small cover over the call control unit is removed will show only the bare board number, 181823.

Depending upon the provenence of the machine, there is a fair probability that it will already be in the 20 mA and full duplex configuration, but these options can be checked.

The 20 mA current loop mode: Check the large flat resistor mounted on the base of the call control unit, about in the center of the area. The four contacts extending toward the rear of the machine are numbered from right to left (looking from the operators position). If the blue wire is on contact no. 3 and contact no. 4 is vacant, slip the wire off no. 3 and push it onto no. 4. Remove the fiber cover from the terminal strip located at the lower rear of the call control unit. Several of the 15-pin plugs can be removed for easier access to the terminal strip. Viewed from the rear, the nine contacts on the strip are numbered from left to right. If the purple wire is on contact no. 8, move it to contact no. 9.

Half or full duplex mode: This requires two checks on the same terminal strip as above. If the brown and yellow wire is on contact no. 3, move it to contact no. 5. If this move was necessary, a white and blue wire will be found on contact no. 4. Move it also to contact no. 5. This completes the checking, or conversion, for 20 mA and full duplex operation.

The signal leads from the computer interface are also connected to this terminal strip. The input signal to the Teletype (printer-punch) will go to contact no. 6 for the negative line and to contact no. 7 for the positive line. Output from the Teletype (keyboard-reader) which is not polarity sensitive, will go to contacts no. 3 and 4.

If a plug-in connection is desired, rather than using the terminal strip, the 15-pin connector no. 2, in the battery of eight located over the terminal strip, is wired in parallel as shown in Example 1.

Programmed control of the tape reader is possibly the only area where some difficulty, and perhaps a small expense, might arise. If a Teletype is acquired equipped with an automatic tape reader, the reader switch should have four labelled positions, *auto*, *start*, *stop*, and *free*, instead of the usual three positions. Also, the reader power pack, usually located in the stand, will have a relay mounted on the circuit board of the power pack. Some hobbyists might prefer to leave it alone, controlling the reader by programmed transmission of DC1 and DC3 as mentioned before. If the hobbyist is concerned only with controlling the reader via his own programming, he can simply program for the automatic reader; but when using other software, or firmware, troubles could arise. For computer systems that use two extra wires from the interface for reader control, the modified manual reader is probably easier to implement for most users, than making both mechanical and electrical changes on the automatic reader. Installation of an additional relay is required in either case, since the existing relay in the automatic reader is not designed for the signal level of most computers, but operates on 48 volts ac.

Many ASR-33 machines will be equipped with *function contacts* which provide a convenient means of program control of external equipment. These switches, located just behind the typing unit, are single pole, double throw, momentary contact, and are rated at 115 volts ac or dc at 100 mA. With the addition of an inexpensive DPDT relay with a coil drawing less than 100 mA, almost anything can be turned on or off under program control by simply transmitting the appropriate ASCII code, such as 004 (EOT), 005 (ENQ), 013 (VT), 021 (DC1), or 023 (DC3). If the automatic tape reader feature is being used, DC1 and DC3 will not be available for other use.

Parting Points

In summary, a hobbyist who can find a good ASR-33 at a price he can afford to pay should not settle for anything less. Particularly when a teletypewriter such as the Digital Equipment Corporation LA36, although operating at three times the printing speed, has no paper tape input or output and costs more than twice as much as a new ASR-33. ■

Note: The word *teletypewriter* is a generic term meaning any communications typewriter, while *Teletype* is a copyrighted name owned by Teletype Corporation.