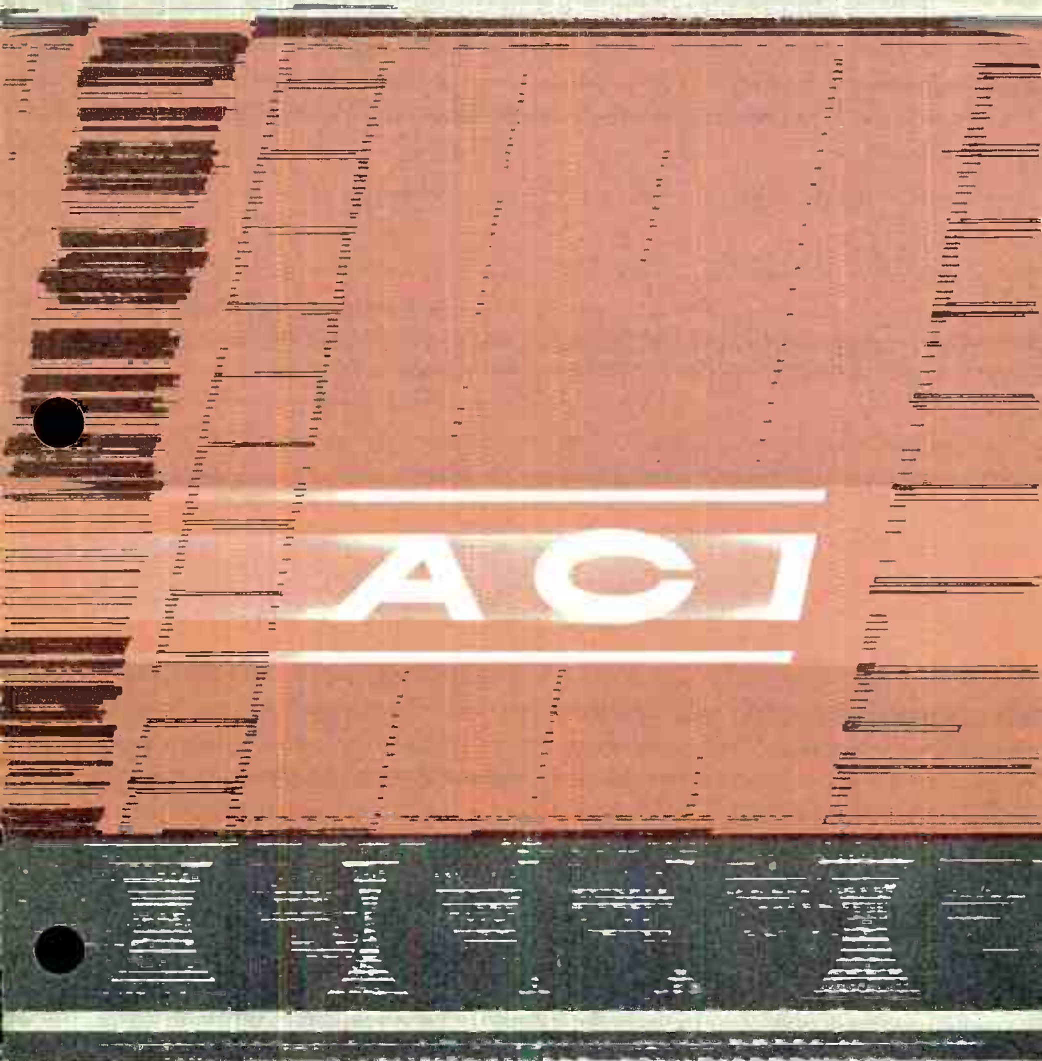
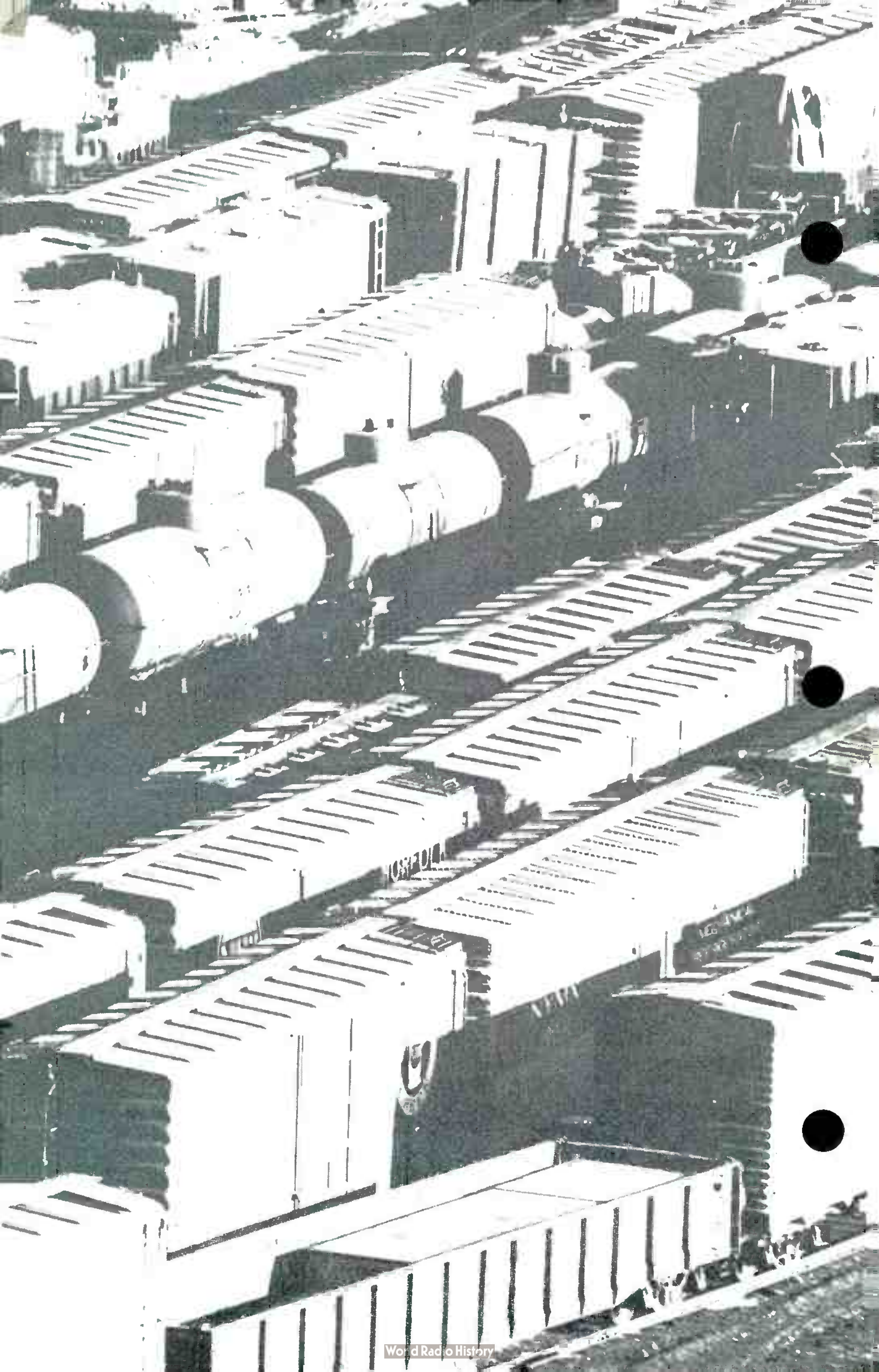
The Lenkurt DEMODULATOR

AUGUST 1968





ACI

. . . . Automatic Car Identification aids the railroads in computerized traffic control

There are more than two million railroad cars in North America – boxcars, tankers, reefers, flatcars, cattle cars, gondolas and cars carrying trucks "piggyback". These millions of cars are owned by 130 different railroads and are scattered over 255,000 miles of track.

Simply accounting for all this rolling stock is a monumental task for a single line. The problem is compounded by the number of companies in any one area and further by long-standing agreements among the various carriers. Traditionally, railroads have comparatively free access to each others' cars for hauling freight. When making up a train in the marshalling yards, one railroad is likely to use cars belonging to any number of other lines. For some idea of the complexity and magnitude of the accounting problems involved it is only necessary to watch a passing freight train and count the number of different labels on the cars. For accounting and billing purposes, all these cars must be counted, identified, and have their destinations and cargoes noted.

All of this information is usually marked on the sides of the cars in some form of numeric code. Heretofore, the information was read and processed in the yards by men using pencils and tally sheets. The data was then carried to an office for computation and forwarding – by mail or telegraph – to the various companies

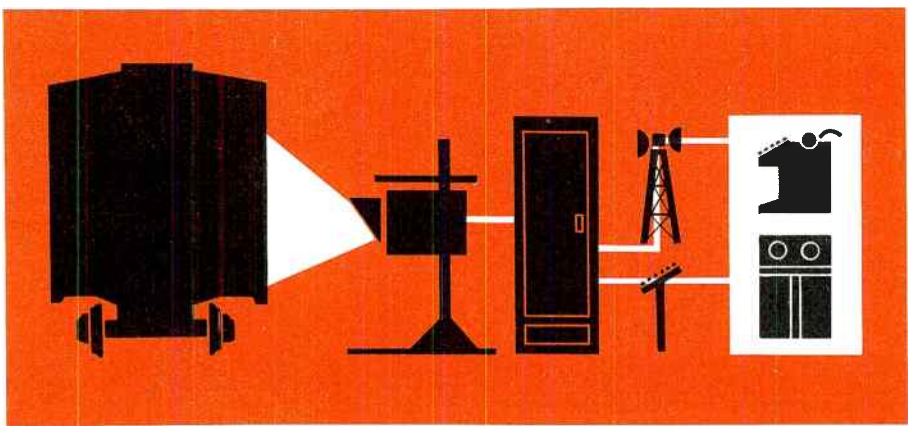


Figure 1. The basic ACI system consists of three components – the label (on the car), the scanner and the decoder. Optional equipment can be added to meet requirements for higher levels of system sophistication.

involved. This all added up to an extremely slow, inaccurate and expensive process.

Obviously, a fast, accurate and universal method of identification – probably electronic – was needed. To this end, the Association of American Railroads (AAR) turned to the electronics industry for some means of automatic car identification. Sylvania Electronics developed and manufactured an ACI system and gave it the trade name Kartrak (see Figure 1). The system has recently been adopted by the AAR as the industry standard.

Working in conjunction with computers and data communications modems, the Kartrak system is able to identify a passing railroad car and transmit the information to a computer center while the train is moving – at speeds up to 80 mph. Cars are counted, identified as to owner, type and serial number and the information forwarded – all automatically. Optional equipment for recording cargo, destination and direction of travel is also available.

The basic system consists of three components: label, scanner and decoder. The label is on the car itself and contains the pertinent data; the scanner reads the passing labels, and the decoder processes the information and feeds it to a communications system.

Retroreflective Labels

All of a car's identification data is encoded and condensed into a single multi-colored label. The car labels,

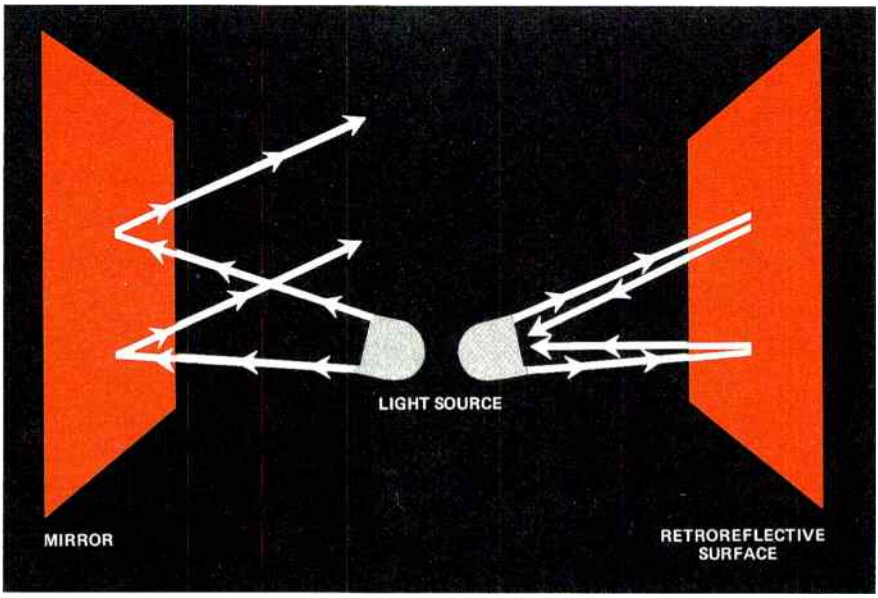


Figure 2. Retroreflection differs from ordinary mirror reflection in that light is reflected directly back to the source regardless of its incoming angle, or of any slanting of the surface.

LABEL MODULE CODE STRUCTURE

NUMBER	FIRST PART RED	FIRST PART BLUE	SECOND PART RED	SECOND PART BLUE
0	0	X	X	X
1	X	X	X	X
2	X	X	X	0
3	X	0	0	0
4	X	0	X	0
5	0	X	0	0
6	X	X	0	X
7	X	0	X	X
8	X	X	0	0
9	0	X	0	X
STOP 10	0	X	X	0
START	X	0	0	X

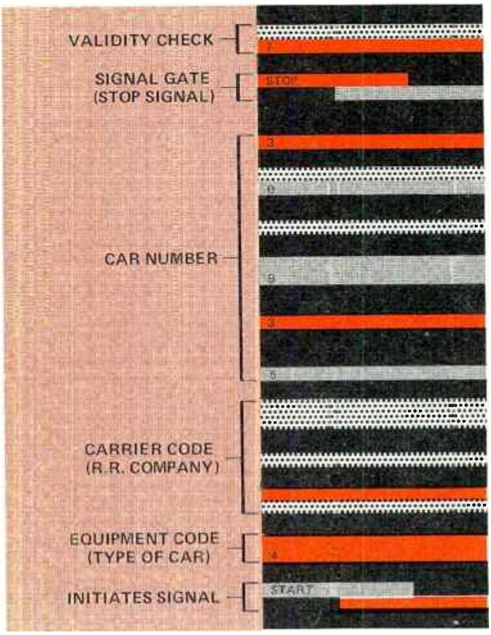


Figure 3. An ACI label has 13 parts, each divided into two strips. As the scanner reads the label from the bottom to the top, combinations of the colors red, blue and white are set in coded pairs to represent the numerical values in the accompanying chart. For example, the START symbol is represented by a red strip in the first part, and by a blue strip in the second. These are indicated by the x's in the Code Structure Chart. Reflected light from a white (checkered) strip triggers both the red and the blue sensors in the scanner and is represented in the chart by x's in both columns. (Note: The label strips appearing as grey in the illustration are bright blue in an actual ACI label.)

affixed to both sides of the car, are made from adhesive-backed, retroreflective sheeting very similar to that seen on automobile bumper strips and highway warning signs. Light striking such material is reflected back to its source along the same path it followed when transmitted. As illustrated in Figure 2, retroreflection is different from mirror reflection where light is reflected at an angle opposite to that from which it came, or away from its source; unless of course the mirror and the light source are perpendicularly opposed. A retroreflective surface, on the other hand, reflects light back to its source regardless of the light's incoming angle — in much the same manner as a corner reflector antenna works.

The label surface, developed by 3M Company, is coated with tiny glass beads — about 90,000 of them per square inch — each of which is its own

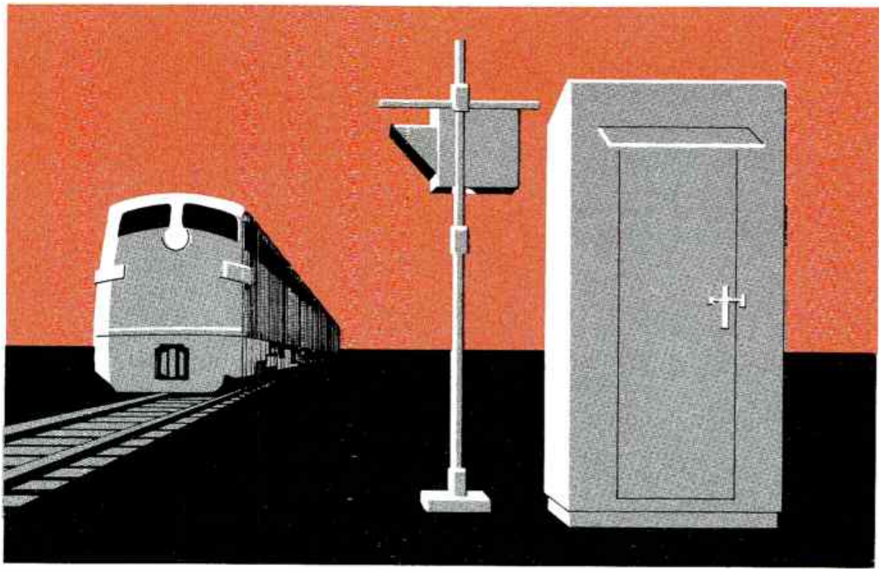


Figure 4. Mounted at trackside so as to provide maximum view of the passing trains, the scanner covers a vertical area of just under nine feet. Its protective housing allows the scanner to operate at temperatures ranging from -50^{o} to 150^{o} Fahrenheit.

optical system. En masse, the beads reflect light back to the wayside scanner – light that is 200 times more intense than normal reflected light from a colored object.

Each car label is made up of thirteen 1 x 6 inch colored strips of sheeting. The strips are arranged one atop the other in a color coded sequence and stuck to the side of the car. The color code consists of some combination of red, blue, black or white (Figure 3). Each strip is divided into two parts whose colors represent discrete numbers to the trackside scanner.

It's All Done With Mirrors

The heart of the system is the scanner. Its primary function is to read the labels from the passing cars – in fact, it reads each label up to four times as the train passes.

As illustrated in Figure 4, the scanning equipment is mounted at trackside in a weatherproof steel housing. Its mounting position permits the scanner to cover an area reaching from 16 inches to 9.5 feet above track level. This allows the scanner to pick up every passing label regardless of the type of car it is on or its location on the car.

The schematic diagram in Figure 5, shows the various operating components of the scanner. A 9,000 watt xenon lamp is the system's light source. The light is first routed through the system by a series of mirrors to the multifaceted scanning wheel, each facet of which is also a mirror. As the wheel spins at a high speed, it causes the light beam to move from the bottom of the scan to the top at the same high rate.

The light is projected at the label and then follows the same path back to the partially silvered mirror. From here, the light is focused through the lens to create an image of the label. This image is then transmitted through the slit plate. Due to the rapid rotation of the scanning wheel and the narrow aperture in the plate, only a small portion of the label's image passes through the plate at any one instant. Hence, a time sequential pulse train of light is created. This light train is analogous to the car label – that is, composed of bands of red, blue or white light. At this point, the light is optically filtered into two broad spectra defined as red and blue. Here, photomultipliers change the optical signals into electrical pulses for input to the decoder.

Decoder

Interpretation of the data from the scanner is the primary function of the decoder. It is basically a digital device composed of analog to digital (A/D) conversion circuits, digital logic and output circuitry. The A/D conversion circuitry changes the electrical input from the scanner into meaningful digital values for transmission as data. Logic circuits analyze incoming signals

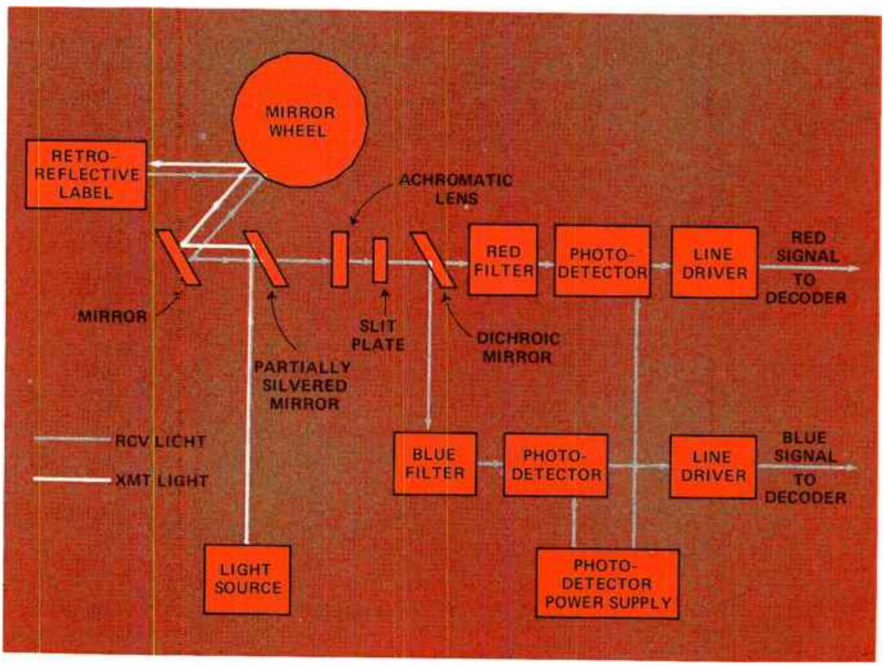


Figure 5. The scanner, represented schematically here, reads the passing labels, separates the color signals and relays them to the decoder.

and "decide" whether a proper label has been scanned and accuracy requirements have been met.

As outlined in Figure 6, the basic elements of the decoder's logic are the label data register, validity check circuitry, a bad label designator, and an unlabeled car detector. The output circuitry is separate.

The decoder also has a storage function sufficient to store the data from one label. As the incoming data is stored in the label data register, the validity check circuitry makes the necessary arithmetic calculations and stores the result. While this is going on, another part of the validity check circuitry monitors the input for the presence of Start and Stop digits (see Figure 3). Thus, the circuitry is able to indicate the presence of label data which meets the predetermined criteria for validity. Normally, the pattern is a Start indication followed by ten digits of information which is in turn followed by the Stop indicator. The thirteenth digit is derived from a mathematical calculation for determining the validity of the color code.

Positive and negative checks indicate that the information received in the label data register is correct or incorrect. When a positive comparison is indicated, the information is transmitted directly to the output circuitry. But, if a negative comparison occurs, the information in the label data register is transferred to the bad label

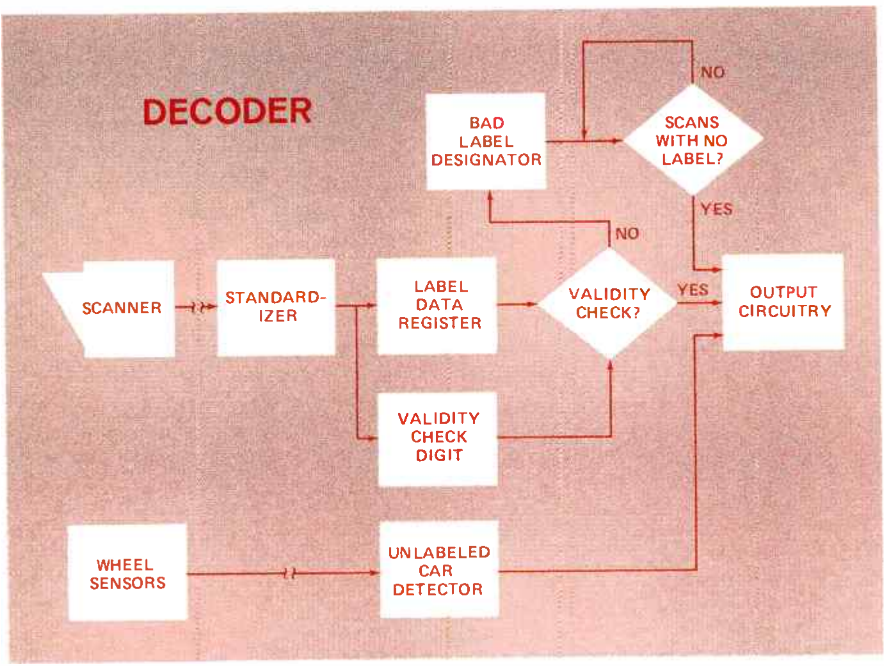


Figure 6. Primarily, the decoder's job is to receive the color signals and convert them into meaningful electrical impulses for transmission as data.

designator for storage. The data remains here during the several subsequent scans until either a positive check is obtained and the data can be forwarded or no positive check is received and special handling instructions are sent with the bad label designation. Such a designation is received at the computer terminal as a question mark.

Another device, the unlabeled car detector, works in conjunction with electronic wheel sensors on the track. The wheel sensor counts the passing cars, and relays a signal for each car to the unlabeled car detector. If this signal is not cancelled by the indication from the label data register that a label has been read, the unlabeled car detector generates a series of zeros to the output circuitry indicating that an unlabeled car has passed.

Output from the basic system is in either 5-level Baudot or ASCII code. The output circuitry interfaces with teletype equipment locally or with data modems for transmission of the data to some distant point. Lenkurt's new data set, the 25B, will handle ACI data as well as telegraph and telemetry traffic.

The output circuitry has the additional function of transforming data into a selected output code and data rate for either direct printout or further processing.

Optional Equipment

When railroad traffic density or train speeds dictate system sophistication beyond that of the basic ACI system, certain optional equipment may be implemented to meet these requirements.

Since time is an all-important factor in railroad traffic control, it is normally desirable to have times and dates recorded along with the other ACI information. The optional device for this function is a calendar clock which is incorporated into the decoder assembly. The calendar clock generates a total of seven characters of information. The first three indicate the date while the four following digits indicate time on a 24 hour basis. Hence, 927 1440 would be translated as Sept. 27 at 2:40 p.m. However, the calendar clock cannot be used alone. Another unit, called a message generator, must work with it.

Most data messages are in three parts – prefix, body and suffix. In this case the ACI data, generated by the scanner, is the body of the message. The prefix and suffix are added by the message generator. These may include such information as address group, time and date, control characters, direction of train approach or any other configuration of the 64 available alpha-numeric characters that a user might dictate.

Buffers

Sixteen characters of information are generated by each labeled car that passes a scanner. Normally, depending on the code structure, this is represented by about 150 binary digits. Given an average car length of 44 feet and a train speed of 80 mph, this comes to about 300 b/s as a required signaling speed. Calculation is further complicated by carriers bearing more than one label – such as piggyback cars. By AAR specification, labels on multiple carriers must be at least six feet apart. In this case, the peak signaling speed can reach 2400 b/s.

Obviously, if a 2400 b/s data system such as the Lenkurt 26C is in service, there is no transmission problem. But, if the existing railroad signaling equipment is not capable of such speed, some sort of buffering or

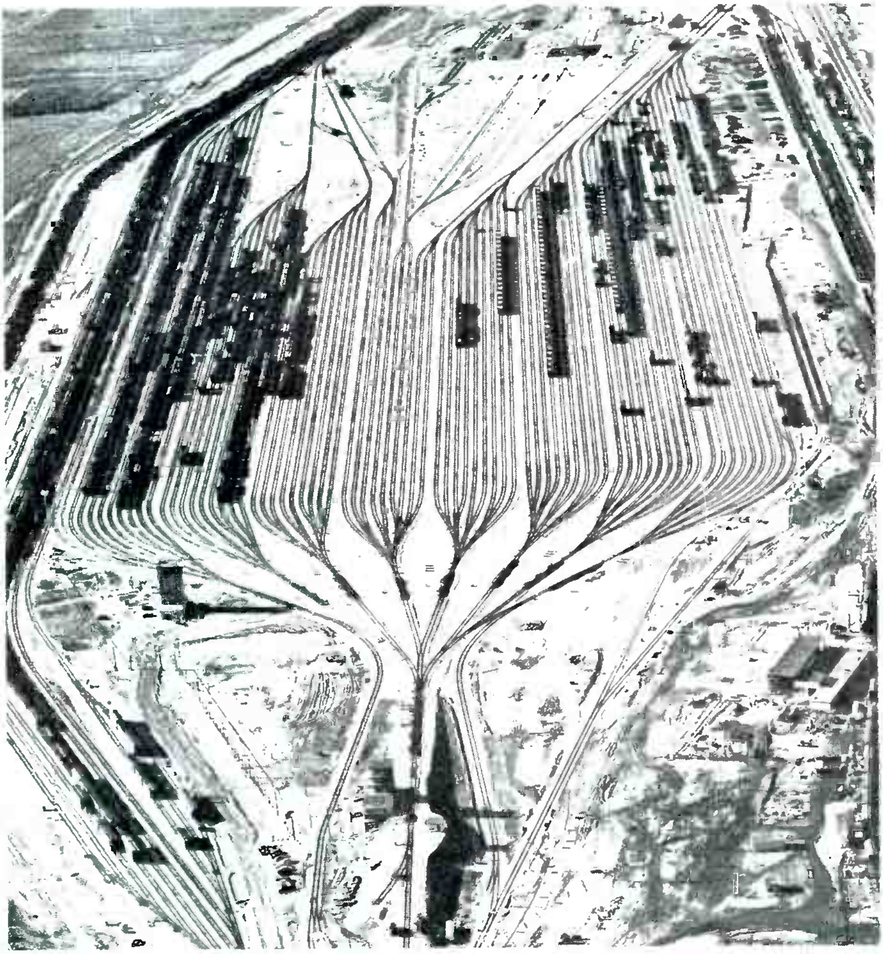


Figure 7. The complexity of marshalling yards such as this one illustrates the need for automatic car identification.

store-and-forward system becomes necessary.

The Kartrak ACI system has two kinds of buffer storage – magnetic tape or core storage. The magnetic tape buffer is an endless loop of recording tape which can store label data from as many as ten 200-car trains. Playback is on command, and if another train approaches while the buffer is operating in playback mode, label data from the new train will still be stored simultaneously.

Functionally, the core buffer is identical to the magnetic tape device. Their capacities, however, are different. Nominally, the core buffer can store data from only 500 labels: with optional attachments capacity can be increased to 1,000.

Other additional options increase the system's capabilities so that piggyback, stacked-container and other special cars can be read and recorded.

Communications Interface

For data communications, most railroads use one of three transmission systems – point-to-point teletype, multipoint teletype or the IBM 1050 multipoint data communications system. In the teletype arrangements, telegraph wires are normally the transmission media, but dedicated, voice grade circuits can also be used. In the case of high speed data though, voice circuits are the rule.

In order that ACI can be used in conjunction with existing data communications systems – particularly the teletype arrangements – it is necessary to employ some method of control compatible with these common systems. Using a teleprinter control unit, a buffered ACI system is able to operate point-to-point over dedicated circuits. Stored data is transmitted from the buffers to centrally located teleprinter units. Codes for these units are either 5-level Baudot or ASCII. Output hardware can be either off/on keying units for driving a standard telegraph loop, or a regular EIA interface for use with data modems. The Lenkurt 25B data set is designed for use with either telegraph or data, or both.

Again, where the IBM 1050 or other computerized systems are used, access to the telephone network is via medium or high-speed data sets. Four Kartrak systems are scheduled for installation on a freight line in the Midwest. They will use Lenkurt 26C data transmission sets for communication with a Sylvania TCS-50 computer over dedicated lines. The 26C's bit rate of 2400 b/s enables the system to operate without buffer storage. Communication between ACI system and computer is direct and on a real-time basis.

Instant Location

By 1970, all the nation's railroads should have a functioning ACI system. A traffic controller will be able to find any car on his line anywhere in the country, instantaneously. Computers will sort out all the complex billing and usage information and accounts will be credited and debited automatically.

Interestingly enough though, the really crucial and exacting job must be done manually. Somebody – some man – has to put all those labels on all those cars.

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