The Lenkurt® Demodulator

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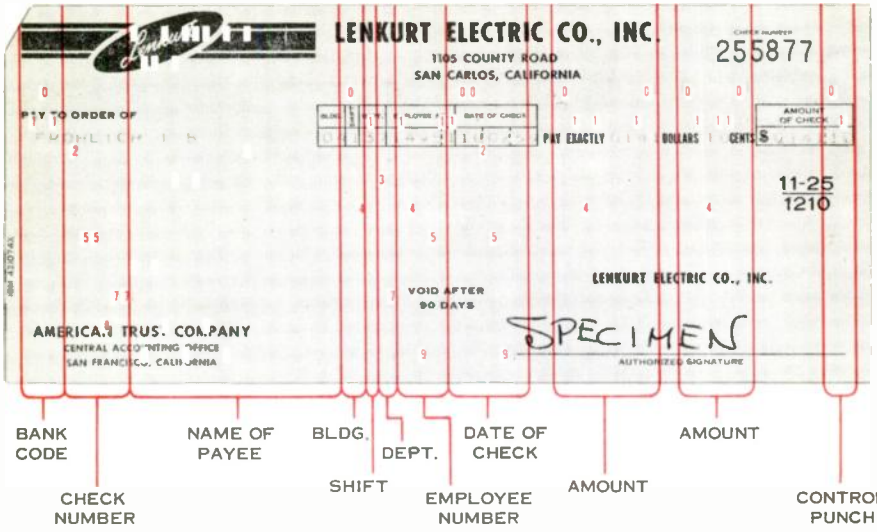
Why *so much* Data Transmission?

Telephone industry leaders recently declared that within ten years the telephone companies of America may be transmitting more business data than voice signals; that data transmission between business machines and computers could become the future's most widely used communication service. Revolutionary changes in business techniques since the war make such a change desirable, and new transmission capabilities now are making it possible. This article explores some of the background of this surge in data transmission, and discusses some of the possibilities for the near future.

Data, as used in communications, means numbers. Numbers are the life blood of industry, and comprise a common language understood by both men and machines. Just about any information necessary to a business operation can be converted into numbers. In this form, information can be rapidly transmitted and manipulated. Machines can perform wonderful gymnastic feats of calculation at speeds and accuracies that still seem fantastic. New techniques and equipment are revolutionizing business and showing the way to far more efficient and economical operation of many industries. As a result, the cost of goods is lowered and our national standard of living is raised.

It's surprising how many different types of transactions and operations can be expressed in purely numerical form. Most of us are familiar with punched-card bank checks. The small perforations state the numerical equivalent of everything appearing on the face of the check, except, perhaps, the signature. In fact, the holes usually provide much more information than is printed on the face of the check.

The fact that just about everything can be expressed in numbers, and that these numbers can be handled very ef-



Modern punched-card paycheck includes more information than most manually-written checks. Machine preparation of 1,500 payroll checks requires only about 1½ hours. Manually-written checks require two to three minutes each. Savings can be used for compiling more management data.

ficiently by machines, has given rise to a tremendous change in the way that our society conducts its business. Not very many years ago, business accounts were always tallied by hand. Bookkeepers, hunched over their ledgers, were indispensable to business activity. Today, the bookkeeper has been largely replaced—he may now sell some of the increased flow of goods resulting from more efficient business methods—or perhaps he works for the business machine company. Where there was once a building full of bookkeepers and accountants, today there is a relatively small space containing computers or tabulating machinery.

Companies which transport oil, gas, or water often find it economical to operate pumping stations automatically by remote control. A continuous flow of data concerning flow rate, pressure, fluid density, and similar factors is transmitted back to a control station for monitoring. In turn, the control station transmits operating instructions to the remote equipment. Although telemetered data may be in a different form than teletypewriter signals or the output of a computer, both may be applied directly to machines.

According to the Bank of America, an efficient bookkeeper with one year's experience can sort and post about 245 checks an hour. The bank is now converting to computers which can sort and post 33,000 accounts an hour—and much more accurately. The improved speed and accuracy, and the lower cost of this essential accounting activity obviously permits the bank to extend and improve its services.

In Boston, a wholesale distributor of automobile parts mechanized its order, billing, and inventory control operations in order to speed up order process-

ing. In addition to speeding up order processing, the company was able to make special studies of the seasonal sales pattern of each of the 20,000 parts stocked. As a result, the company was able to adjust its inventory to closely match the needs at various times of the year. Not only was inventory greatly reduced, but customers also were able to reduce their inventories drastically because of the much shortened delivery time made possible by this mechanized approach to business.

Business documents such as checks and stock records can be produced, sorted, totaled, posted, tallied, and any other desired operation performed at tremendous savings compared to hand operations. The speed and ease with which management can collect vital statistics about company operations is, in turn, promoting ever wider use of elec-

Personal checks also are being automated. Imprinted magnetic characters enable each check to be identified, sorted, posted by machine. Amount of check is added (lower right) when check is received at the bank. This machine sorts and posts 33,000 checks an hour compared to 245 an hour for a skilled clerk. Data transmission may be used for reconciling balances between branch banks or banking centers.

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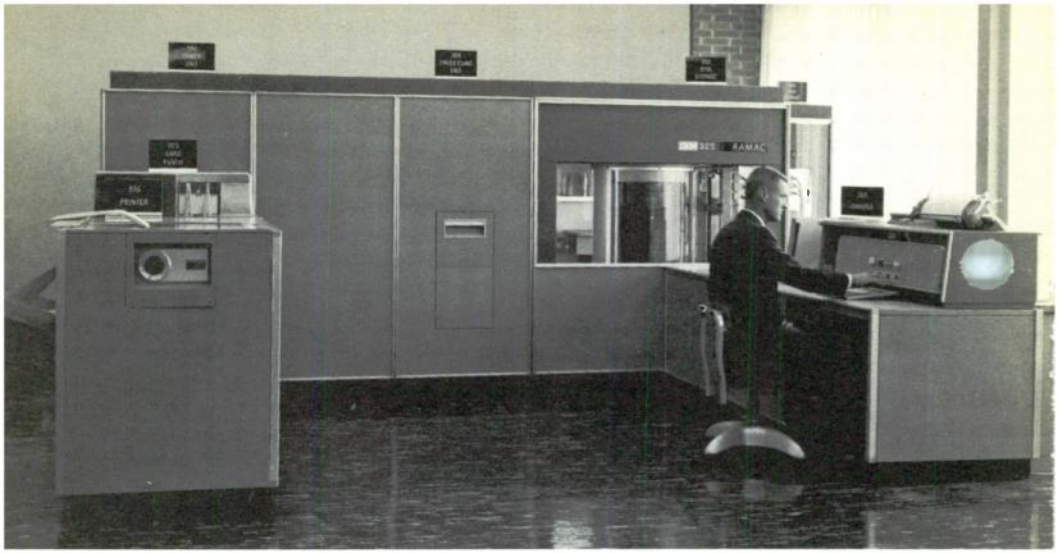
ABA NUMBER — BRANCH — ACCOUNT — TYPE OF TRANSACTION — AMOUNT



INTERNATIONAL BUSINESS MACHINE

A modern high-speed business-type computer designed for accounting, inventory control, airline reservation control and similar business applications. Magnetic disk storage unit visible through window has a capacity of 5,000,000 digits. Machine provides either punched-card or printed output.

tronic and mechanical means of handling business operations.

United Airlines and other large airlines have always had a problem of reserving space on flights. Unlike trains, which can add or remove coaches, aircraft are relatively inflexible. Underbooking of space loses money, while overbooking causes customer anger and eventual loss of business. United now uses a centrally-located computer system for booking space on their various flights. Reservation offices throughout the country are connected directly to the computer, located in Denver, by means of long-distance data transmission circuits. A reservation clerk in San Francisco, for instance, can determine in seconds just how much space, if any, is available on any given future flight. The computer is kept up-to-date on seat availability from instant to instant. The moment a seat is sold, the computer is notified so that it will not be sold again. If a reservation is cancelled, the space is instantly made available throughout the country.

The nation's railroads have some of the most demanding needs of all for data. Tens of thousands of railroad cars of all types shuttle back and forth and around the nation each day. These cars carry countless varieties of goods, some perishable, some durable. The cars themselves experience great variety in the demands made upon them. Some cars keep on the go, others find themselves spending a lot of time on sidings, which complicates their maintenance. Just keeping track of all this rolling stock and the cargos is a tremendous problem.

Making sure that cattle loaded in Texas or New Mexico have adequate feed all the way to Chicago, or that the meat loaded in Chicago is kept properly iced on its way to the East coast, requires careful organization and impeccable communications. In addition, railroaders themselves are often on the

move, working here today, there tomorrow. Keeping up with the administrative chores of such widespread activity is a communication problem of no small importance in its own right. Scheduling, coordinating, proper handling of a perishable load, particularly when it is handled by several railroads in succession, has provided a fine challenge to railroad communications.

To cope with these problems, many railroads are installing elaborate communications networks to link various parts of their systems. Computers and punched-card machinery act as the brains of the system to keep the railroad coordinated and functioning swiftly and efficiently.

Some forms of data are transmitted by facsimile or by telemetered signals. At least one railroad is using facsimile to transmit waybills which control what happens to each car in a train. These facsimile copies are excellent photo-quality reproductions of the original document, and can be used immediately on receipt, rather than undergoing further processing by office data equipment. Transmission of such reproductions, however, requires very great transmission bandwidth, which costs more.

The Future for Data

Data processing by industry and business has grown at an explosive rate in the past ten years. Despite today's widespread use of computers in business and industry, there was not one general purpose electronic digital computer as recently as ten years ago! Fifteen years ago there were not even designs for such machines. The next ten years will probably show much greater growth as we learn how to make these machines smaller, cheaper, and more efficient.

In many cases, a high-speed data processing system is still limited by human operations at its input or output —much the same as a modern super highway that can be reached only by a single-lane mud road! One of the important characteristics of modern data systems is that they can be designed for use with one another without requiring intermediate human operations. Only now are completely integrated systems beginning to appear. Many of the mechanized systems used today are probably only crude forerunners of much more highly integrated and sophisticated systems of the future.

Imagine a distributor with many widespread warehouses, all coordinated through a single computer installation. Orders might be fed directly to the computer, which would automatically cause shipments from the appropriate warehouses. Stock in each warehouse would automatically adjust with such precision that there would be no inventory shortages, but also no costly over-stocking of slow-moving items. The computer would automatically issue invoices, shipping papers, and management reports on its operation.

Banks might link individual tellers in many branches directly to a giant central accounting computer so that each individual transaction could be instantly recorded, and an up-to-the-second balance made available. Hand operations, still required before processing checks with computers, might be eliminated, perhaps by applying techniques that are now being developed for sorting mail electronically.

Data transmission may be expected to grow astronomically in response to these new techniques. Since most data of the sort described above is generated and transmitted in the form of pulses, new pulse techniques in the transmission and switching field may be expected to further increase the widespread transmission of data.

alternating current VOLTMETERS

The most important single measuring instrument used in communications is the alternating current voltmeter. The a-c voltmeter is most often used to measure signal voltages and power levels. In addition, it may be used for adjusting line and filament voltages. When used with a signal generator or other test-tone source, the a-c voltmeter permits the critical adjustment of virtually all circuits in a carrier system.

Three basic types of a-c voltmeter are commonly used in carrier and radio communications. These are the rectifier meter, the a-c vacuum tube voltmeter, and the frequency-selective voltmeter. The latter will be discussed in a separate article.

The rectifier meter consists of a moving-coil meter connected in series with a rectifier circuit. Usually, a full-wave bridge rectifier, such as diagrammed in Figure 1, is used. The full-wave configuration has greater sensitivity than a half-wave circuit, and provides a more accurate voltage indication for non-sinusoidal a-c waves. Because of its relatively low sensitivity, the rectifier meter is usually a general purpose meter, primarily used for measuring line and filament voltages.

The vacuum tube voltmeter employs one or more stages of amplification to increase meter sensitivity. Since the circuit being measured provides only a control voltage on the grid of an amplifier instead of energy to deflect the meter movement, a vacuum tube voltmeter is able to use an extremely high input resistance, and therefore provides no significant load to the circuit being measured.

The sensitivity of most voltmeters, both a-c and d-c, is rated in *ohms-per-volt*. This refers to the total resistance of the meter at the maximum voltage on each scale. Thus, when a 1,000 ohms-per-volt meter is used on the 30-volt scale, total meter resistance is 30,000 ohms. The more sensitive the meter movement used, the less current is required, thus permitting a higher series resistance to be used. When measuring the voltage appearing across a high resistance, the indication may be wrong due to the loading or shunting effect of the meter itself. This is particularly true in the case of low-sensitivity meters, which must have a low series resistance.

Because the vacuum tube voltmeter has a very high input resistance, usually 10 megohms or more, it will always indicate a higher voltage than a rectifier meter when measuring voltage in a high resistance circuit. For this reason, it is

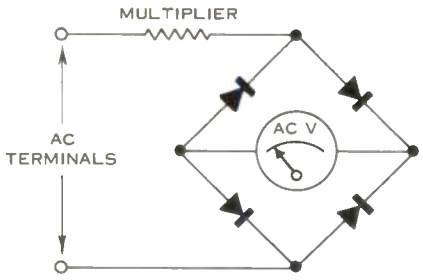


Fig. 1. Typical basic circuit for rectifier-type A-C voltmeter. Full wave bridge rectifier provides greatest sensitivity, improves accuracy when measuring non-sinusoidal waveshapes.

very important to follow the manufacturer's instructions regarding the type or sensitivity of meters used for adjusting carrier or radio equipment.

Figure 2 shows voltage readings obtained by using two different types of a-c voltmeter.

All a-c voltmeters are calibrated in terms of *effective* or *root-mean-square* (rms) voltage, rather than in peak or average voltage. The effective or rms value represents the voltage of a direct current that would produce the same amount of heat or work as the alternating current. For sine waves, this effective value is .707 times the peak voltage. Thus, an alternating current having a peak value of ten volts is equal in effect to a direct current of 7.07 volts.

Average-reading meters are usually those that apply a rectified voltage directly to the meter. In peak-reading meters, the rectified voltage is used to charge a capacitor, and the charge on the capacitor determines the meter indication. Both types of meter are calibrated in sine-wave rms values.

Most rms voltmeters are accurate only when measuring sine waves. Some types of voltage-regulating line transformers provide an output wave shape that is not a true sine wave. In such cases, the indicated voltage may be wrong, the degree of error depending on the wave shape. This error will be greater in meters which sense average, rather than peak voltage.

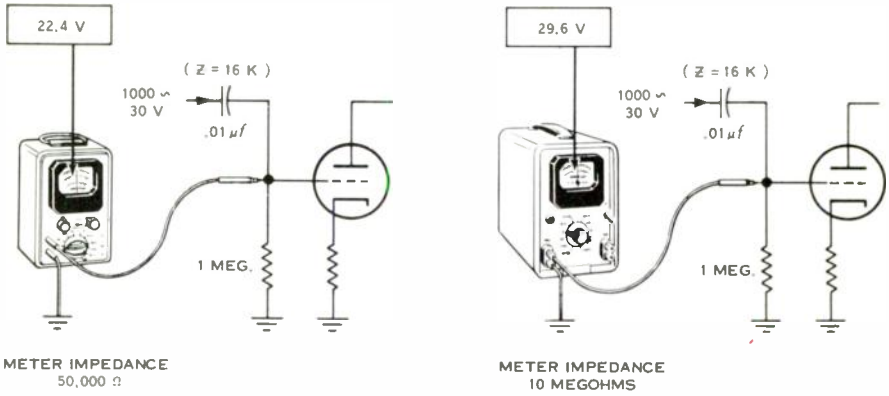


Fig. 2. Low impedance voltmeters may provide wrong indication when measuring voltage in high impedance circuits. Always use the type of voltmeter specified by equipment manufacturer.

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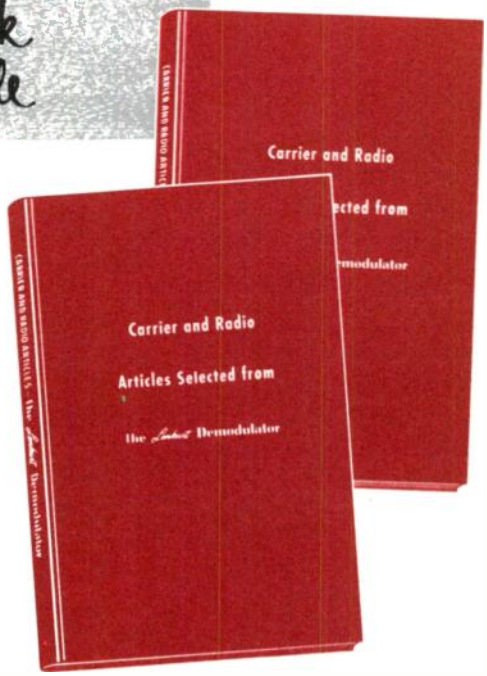

The 32 most-requested articles from the first seven years of *The Lenkurt Demodulator* have been compiled into book form.

The attractive, cloth-bound book is titled CARRIER AND RADIO ARTICLES SELECTED FROM THE LENKURT DEMODULATOR, and costs $2.50, postpaid. Address all orders to *Editor, The Lenkurt Demodulator, San Carlos, California.* Please send check or money order payable to Lenkurt Electric Co., with your order.