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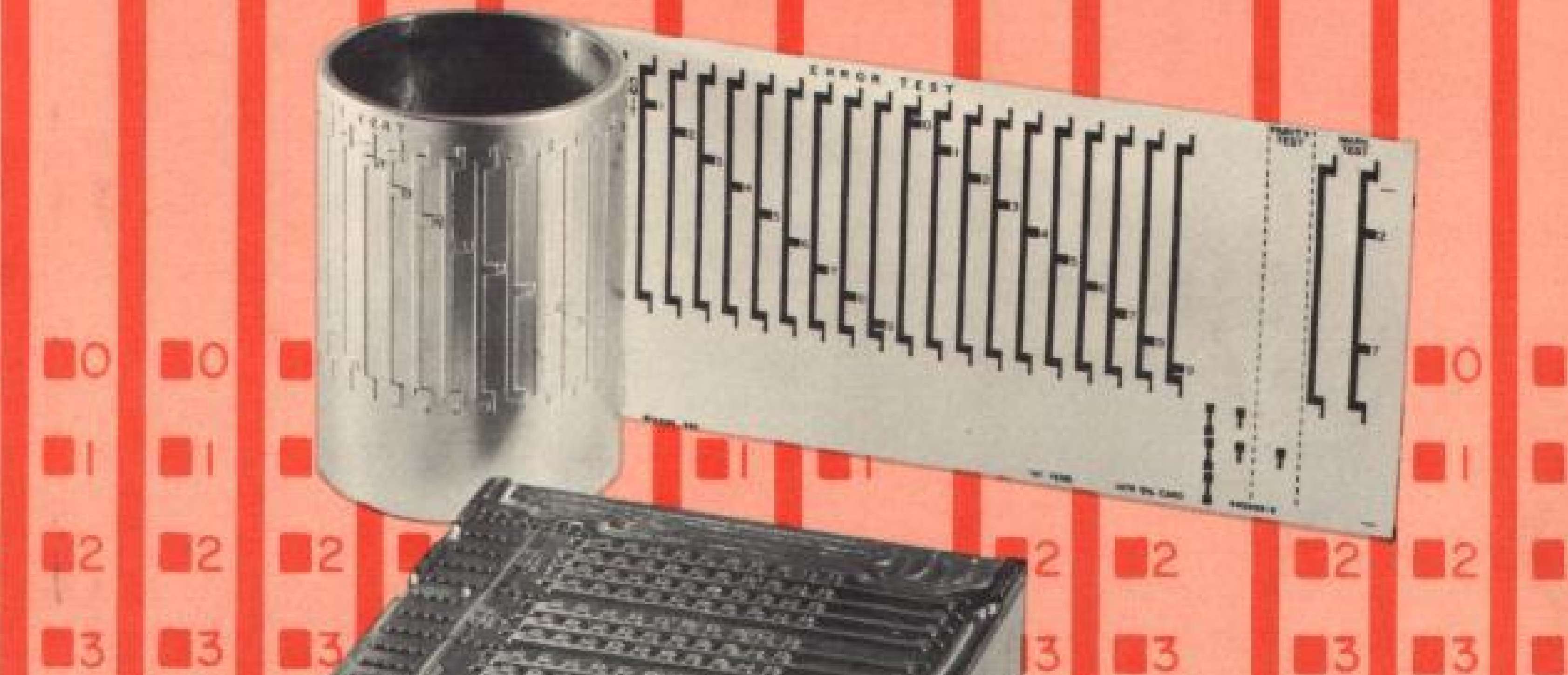
OCTOBER 1965



CONDUCTIVE PRINTING OF DATA CARDS

CONTROL UNIT OR EQUIP. NUMBER | STR. TYPE | PROG. NO. | FUNCTION

PAT. PEND. DATA W/U CARD 442015-C

THE WESTERN UNION TECHNICAL REVIEW

Cover: Plates and Art Work for Conductive Printing of Alpha Numeric and Numeric Only Data Cards

presents developments in Voice and Record Communications for the Western Union's Supervisory, Maintenance and Engineering Personnel.

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of

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Western Union Museum

Volume 19

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THE WESTERN UNION TELEGRAPH CO.

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WESTERN UNION

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Warren H. Fisher, and Frank J. Calderone, Senior Engineers, Inf. Systems & Servs. Dept.

Conductive Printing of Mark-Sense Data Cards

Introduction

Western Union's conductively-printed mark-sense data card is unique and different from most data cards. It has vast application in the automation of information collection at the data source. In conjunction with the Data Card Transmitter, the mark-sense data card, offers business firms a low-cost, simple, accurate means of collecting data at its source for telegraph transmission to a centralized data processing machine, without extra handling. The transmission is such that no hard copy is necessary, no involved keypunch, tape punch or tape reader is needed —just a simple pencil mark on a "customized" conductively-printed mark-sense data card, which has been specifically designed to meet customer requirements. Such cards are stacked in a Data Card Transmitter after they have been marked. The information is then automatically transmitted, from one card after the other, over a telegraph circuit.[1]

Principles of Card Design

The number of different card designs is unlimited but the basic principles of the design must be the same for proper operation of the Transmitter. The design layout for the numeric and alpha-numeric types of card is essentially the same, although the sizes of the cards differ. The term numeric or alpha-numeric, refers only to the kind of mark-sensing information to be transmitted.

The mark-sensing area, contains conductively-printed information on the upper portion of the card and consists of a number of vertical mark-sensing columns, as shown in Figure 1. The exact number of these columns and their relation to other information on the card, is determined by the customer's needs. Each column consists of a heavy, vertical bus bar with projections at the top and bottom of the bar. These projections, known as "control marks," activate the electronic circuits in the Data Card Transmitter and permit the cards to be fed through the unit at a predetermined speed.

Immediately to the left or right of each vertical bus bar is a column of printed boxes. To insert the variable information on the card, a standard No. 2 lead pencil is used to connect a particular box with its associated bus bar.

The "numeric-only" data card usually has eleven mark-sensing boxes in any one column (0 through 9, and an "omit" box); but it may have up to nineteen boxes for special applications. The "alpha-numeric" data card may have up to twenty-seven mark sensing boxes.

The fixed, or program data, area of the card always contains printed alpha-numeric information. The Western Union Conductive Mark-Sense Data Card may be con-

NOTE: A typical Mark-Sense Data Card manufactured by Western Union is inserted in the fold of this issue of the Technical Review, Oct. 1965. (Courtesy of Cities Service Oil Company, Lake Charles Div., Lake Charles, La.)

sidered as a paper electronic circuit board, which is disposable after use.

The fixed data is printed, with conductive ink, on the lower portion of the data card and uses a standard 5-unit telegraph code pattern with the addition of a parity check pulse. The fixed data may be either alpha or numeric. The parity check pulse is included for those combinations of the code which have an odd number of marking pulses. Thus, all characters in the fixed area have an even number of marking pulses. This "even" parity is registered in the electronic chassis, but the parity pulse itself is not transmitted to the telegraph line. When the parity check is found to be odd, further transmission of information on the card will be stopped automatically.

The fixed data area contains three possible "read" control marks which are located between pulses 1 and 2, 3 and 4, 5 and 0. These control marks, like those used in the mark-sense area, activate electronic circuits.

Size of Cards

The larger card contains alpha-numeric information; the smaller card contains only numeric data. While the card length may vary (from 4″ to 11-1/4″), the width must be held almost constant (4-1/16″ + .003″ − .000″) for alpha-numeric cards.

The smaller numeric-only data card is approximately 3-1/4″ wide by 7-3/8″ long. Both cards require a standard corner cut of 1/4″ × 30°, held to a tolerance of + .031″ − .000″ on the 1/4″ dimension.

The tabulating (tab) stock used for these cards is the standard seven-mil thickness.

Ink

The printing ink used is a special, black conductive ink consisting of a liquid base, or vehicle, containing suspended carbon particles. In order to remove the vehicle after printing, and leave only the carbon particles in intimate contact with each other, a moderate amount of forced heat drying is required. Several problems are involved in the drying process. The ink

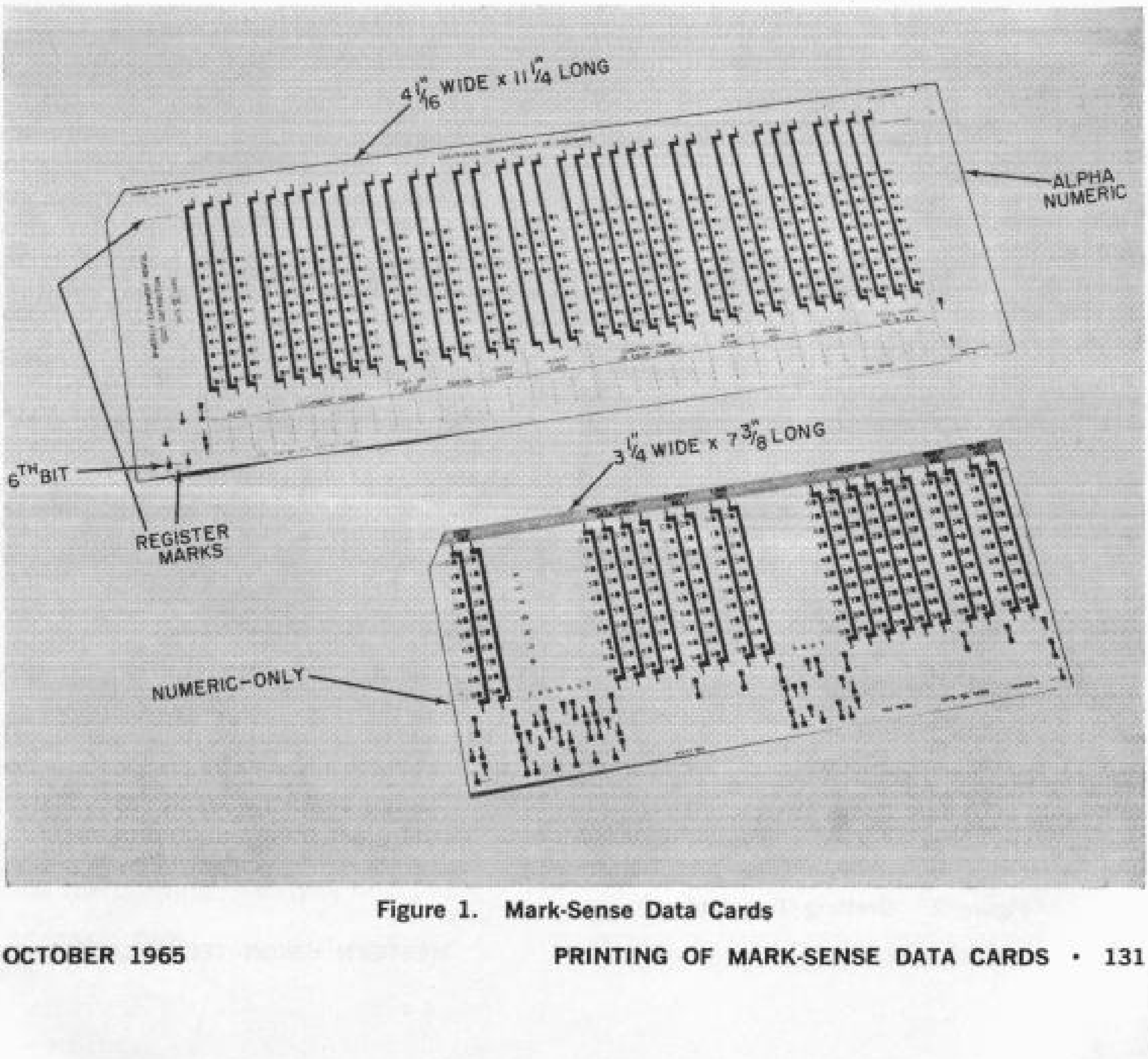

Figure 1. Mark-Sense Data Cards

vehicle, used in combination with the carbon black content, prevents rapid air-drying. A rapid drying tends to create problems such as, ink build-up on the press rollers and lower conductivity in the printing. Western Union, in conjunction with an ink manufacturer, Sinclair-Valentine, has developed a workable type of conductive ink for use in this particular printing process.

The ink formulation is complex. It contains physical and chemical properties which produce good electrical conductivity for printing on particular presses but cannot be considered applicable to all types of printing presses. As pointed out above, the drying rate of the ink depends on the vehicle used, which, in turn, requires different drive-off temperatures for its solvents. This affects the conductivity of the ink which must be maintained at 1.25 megohms resistance maximum, when dry. Conductivity for each card is measured between the extreme ends of the solid black bus bars, shown in the upper section of Figure 1.

Continual improvements are being made in the inks used for data card printing. Recently a varnish-type ink, which requires "very little" heat to completely dry the printed card, has been found most successful. The viscosity of the ink, in conjunction with the mechanical ink distribution of the press, must produce an even ink "lay" across the entire surface of the card thus, assuring a uniform resistance without ink trails, splatters, or opens.

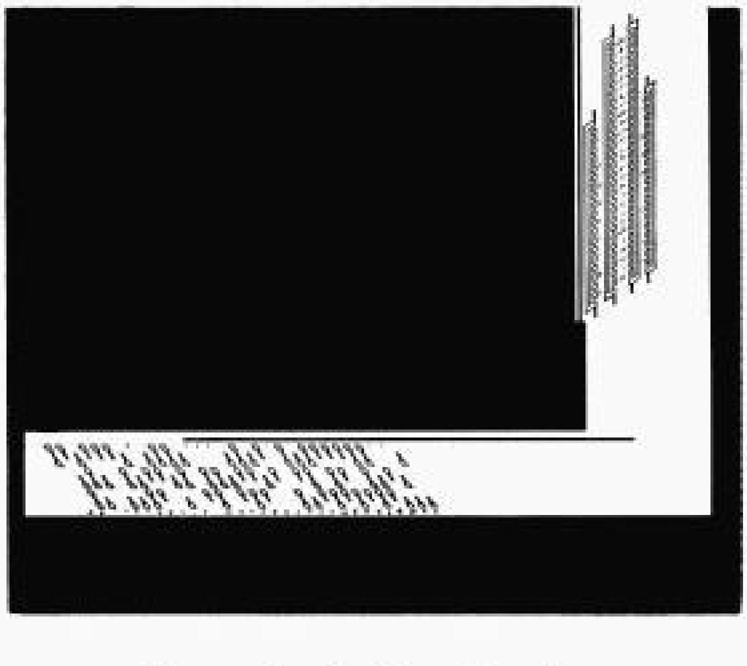

Figure 2. Drafting Template

Register

Another important consideration in the printing process is printing register. Register is defined as the ability of the printing technique to reproduce each card in a group, exactly the same with respect to a given guide. Register is measured from a reference point on the card stock to some designated printed character. In the case of the Data Card, the bottom edge of the card is used as the guide or reference point. The register marks are two, short, horizontal lines or marks, parallel to the bottom edge of the card, and located in the lower left and right corners of the card. These register marks are also lined up with the center of the sixth bit of the fixed information, as shown in Figure 1. The register marks should measure .125″ from the bottom edge of the card and be parallel with respect to the bottom edge over the entire length of the card. The allowable parallel deviation up or down from the .125″ measurement is $\pm$.005″. These tolerances are measured by means of a specially designed card gauge.

Art Work

In order to assure the printing accuracy required for data cards, the printing process requires an accurate master tracing called, "Art Work." The layout of a proposed card is drawn, double size, on mylar, using non-peeling ink. A special drafting template containing all the necessary characters and symbols needed for any Data Card is used. Figure 2 illustrates such a template. An example of the "Art Work" for a Data Card is shown in Figure 3.

The finished double size "Art Work" is photographically reduced fifty-percent by a Photoengraver. The resulting negative or positive is inspected, by means of a specially-designed gauge, for skew and correct photo reduction. Using an acceptable negative, the engraver will etch a plate in either zinc or copper. When an electrotype plate is desired, it is made of copper, since copper has less tendency to distort in size when released from a lead mold in the electrotype plate process.

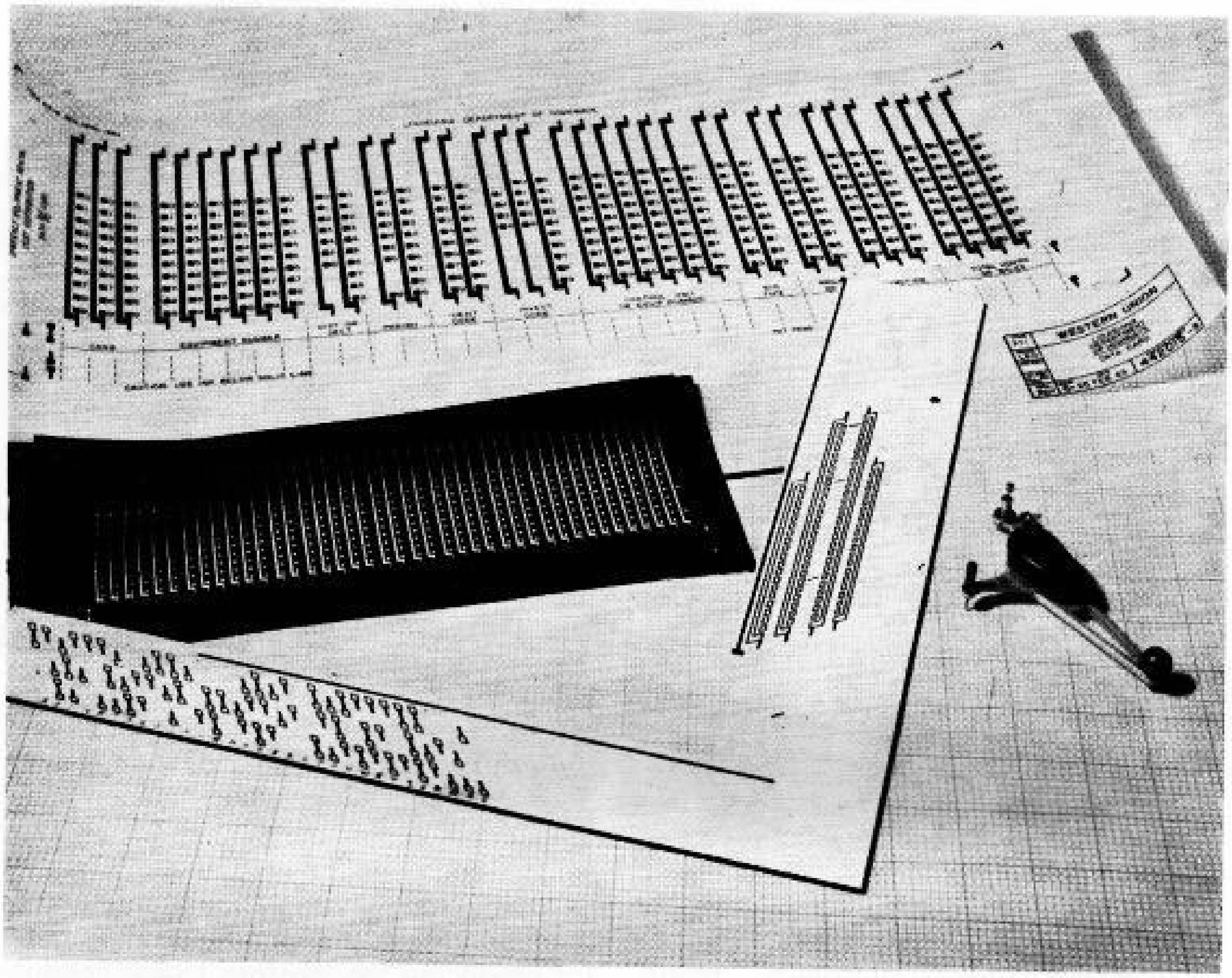

Figure 3. Art work and template

Plate Making

One plate-making process uses the original zinc plate as the final printing plate. The negative of the art work is transferred photographically to a zinc blank as shown in Figure 4. Then by a metal displacement process a deep etch of the art work is made removing as much of the unnecessary metal as necessary. This etched plate is chrome-plated before trimming its edge and then mounted to a non-warping board. When the original zinc plate is chromed for Data Card printing, where the tolerances for printing are more stingent than average, the life of the plate is increased, the plate is less distorted, and the printing fidelity is improved.

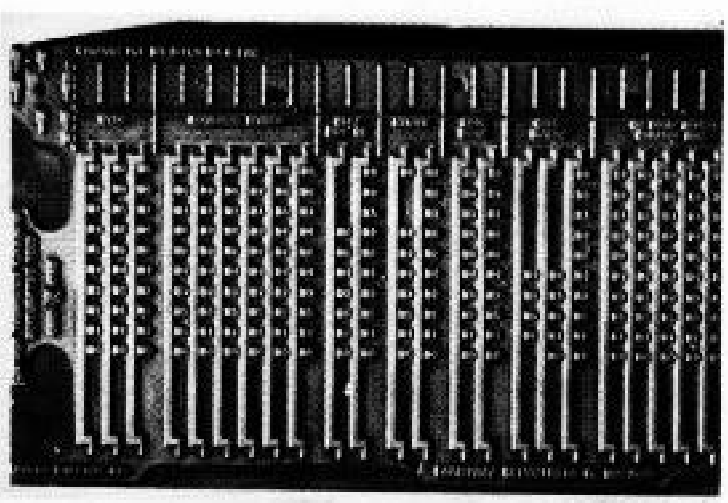

Figure 4. Portion of Typical Printing Plate Mounted on Board

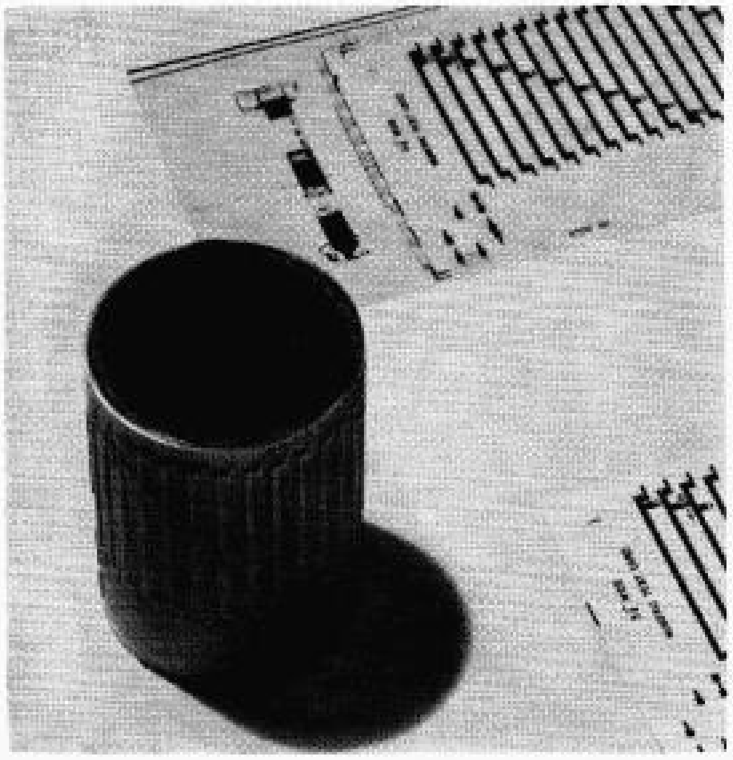

Figure 5. Hollow Cylinder Printing Plate

Dry-Offset Printing

The plate-making described above, has been used almost exclusively for letter-press printing of the data cards. However, another printing process for producing the smaller "Numeric-Only" card has recently been perfected which utilizes a "dry-offset," web-type Carroll Press. This press is similar to the type used to print the standard IBM punched cards. Since the "Numeric-Only" mark-sense data card is the same size as the standard punched card, this press has been adapted to use our conductive ink by the Business Supply Corporation of America.

The printing plate used in this process is a tapered-bore, hollow cylinder, as shown in Figure 5. It is prepared from the same kind of "Art Work" as previously described. Each cylinder blank is checked for concentricity, before it is etched, so that an even ink distribution can be obtained for each line of type, during the rotary-offset printing process. The plate, or "electrode" as it is called in the trade, is etched in magnesium and plated to increase its press life. As can be seen from Figure 5, the positive is marked to indicate its geometric center. This center is used to optically line-up a mechanical punch which inserts guide holes used to hold the negative in an accurately fixed position while the type images are photographed onto the blank cylinder. A metal displacement process follows resulting in a deep etch "electrode" right side up, not inverted as in a letter-press flat plate. Inspection is made with a hi-power magnifying glass so that foreign "type-hi" metal can be removed.

Whether the plate used for printing is the flat type or the cylindrical type described above, painstaking examination is made of the photographic positive before the plate is made, followed by a final plate inspection before it is considered useable for a given run of data cards. It is obvious that the operation of the Data Card Transmitter depends on the accuracy of the printed information on the data card. Unless the printing plate is perfect, errors may result. Hence, gauges are used to check the finished art work; other gauges are used to check the printing plate and the printed, dried data card, thus making good data cards a certainty.

Letter-Press Printing

As stated previously, this method of card printing was the first process used for producing the Western Union conductive mark-sense data card. "Letter-press" is the general term, there are many types of printing presses on the market which are letter-press in operation. Figure 6 illustrates the letter-press most frequently used by Western Union card suppliers, the platen type press, called The Heidelberg "Windmill." It is so named because the printing operation involves gripper arms which rotate during the printing cycle in a windmill fashion as they pick up the blank card stock, deliver it to the printing bed, remove the finished printed card and deposit it onto a moving conveyor belt while another gripper arm arranges to pickup a new blank to repeat the cycle. The card printing rate, when used with the required thermographic drying oven, is in the order of 2,000 cards per hour.

Another press used to a large extent in this program has been the Little Giant flat-bed letter-press. This press is a combination of flat-bed and rotary operation. The printing plate is inked on a horizontal bed with a combination of rollers performing

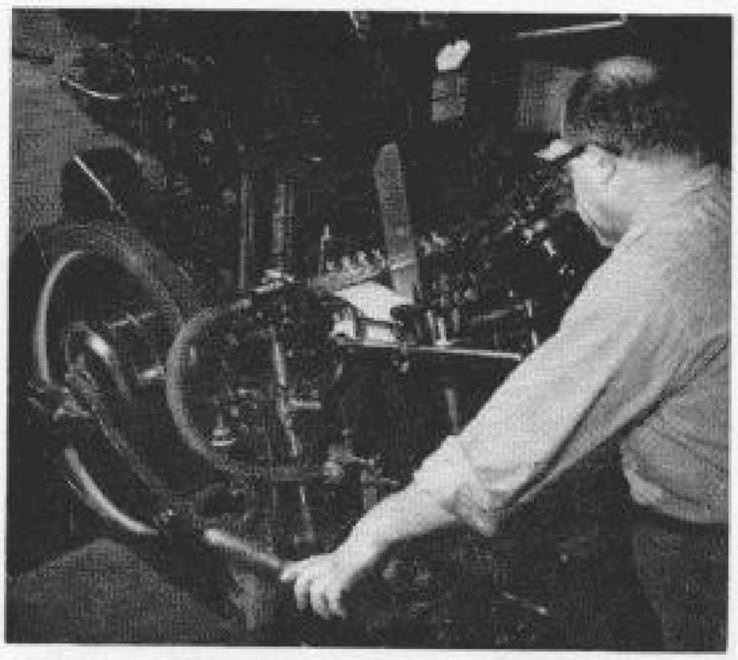

Figure 6. Plate Installed in Chase of Heidelberg Press

the inking function. The card stock is fed into the press automatically on a single card basis, and gripped by a rotary cylinder. As the card is wrapped around the cylinder, the printing plate is inked and moves horizontally under, and against the rotating cylinder containing the mounted card. Thus, the printing cycle is completed. As the grippers release, the printed card drops onto a moving conveyor belt and into a gas heated drying oven. The printing rate for this press is in the order of 6,000 cards per hour on a two-cards-at-a-time printing basis.

Letter-press printing has a great future in the printing of the larger "Alpha-Numeric" card. However, the smaller "Numeric-Only" card will likely require the Carroll, Dry-Offset, Rotary Web Press.

Plate Insertion in Press

The letter-press process for printing conductive mark-sense data card requires art work followed by plate manufacture, as previously described. The finished plate is then installed in the chase of the letter-press, as shown in Figure 6 and vertically locked in place. It is imperative that the printing plate is aligned as near as possible to the required printing register on the first try. The fine alignment is made by moving the printing guides, which accept and balance the card stock during the printing. It is this ability of the press to accept and hold printing register that makes one press better than another.

Inking the Press

Once the plate is adjusted for printing register, proper distribution of ink across the entire card is of major concern. In the flat plate vertical operation of printing, the entire plate is printed at one time. Therefore, "impression" is very important. The pressman must make many fine adjustments to gain a light touch. The lighter the touch the better the impressions with the type of ink used for Western Union data cards. After adjustment of "impression," the press is ready to run.

Card Loading

The feeder of the press is loaded with pre-cut, blank data cards and the ink well of the press is filled with the black, electro-conductive ink. This well is equipped with an agitator, so that the desired physical properties and flow rate is maintained at all times during the run. When the press is started, one card is picked off at a time from the feeder by the card grippers; it is pushed against the flat printing plate which has been inked prior to card pickup; the printed card is then deposited on a moving conveyor belt and transported to the drying oven.

Ink Drying

After leaving the drying oven, where the ink has been dried by exposure to gas-flame heat, the card passes beneath final jets of air and into the collecting bin, as shown in Figure 7. The correct rate of

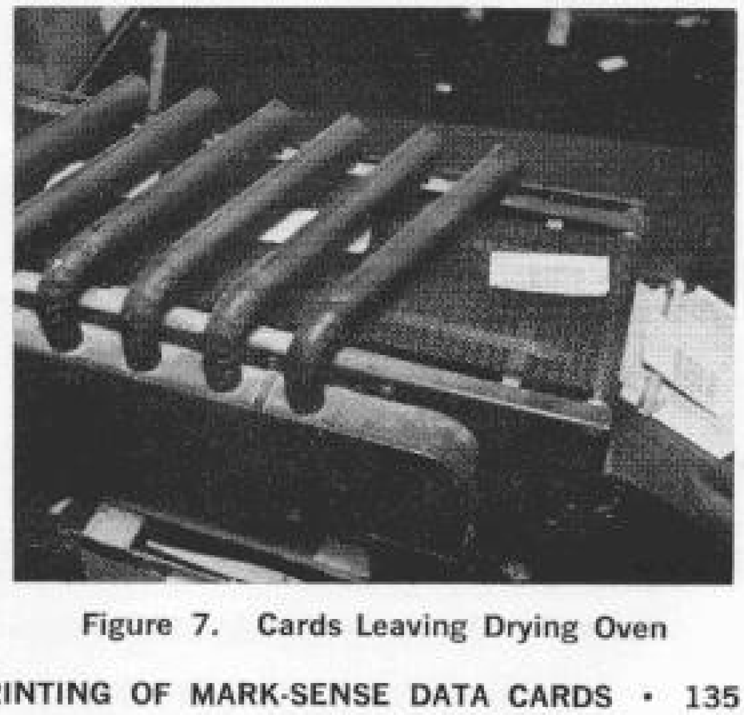

Figure 7. Cards Leaving Drying Oven

forced drying is most important to completely dry the printed matter so that it is conductive. Excess heat will cause undue shrinkage to the pre-cut blank card. To compensate for this shrinkage and also to add rigidity to the card length, the card stock is slit from large mill rolls along the paper grain and to a predetermined oversize width to allow for the precalculated shrinkage. There is little or no shrinkage experienced in the card length. Consideration was given to reverse the card grain to widthwise resulting in a short grain card. This would minimize the shrinkage problem affecting printing register and transmitter card clearances. However, the application of short grain card resulted in problems of wavy cards affecting the card feed mechanism of the transmitter and increased considerably the cost of fabricating the card stock.

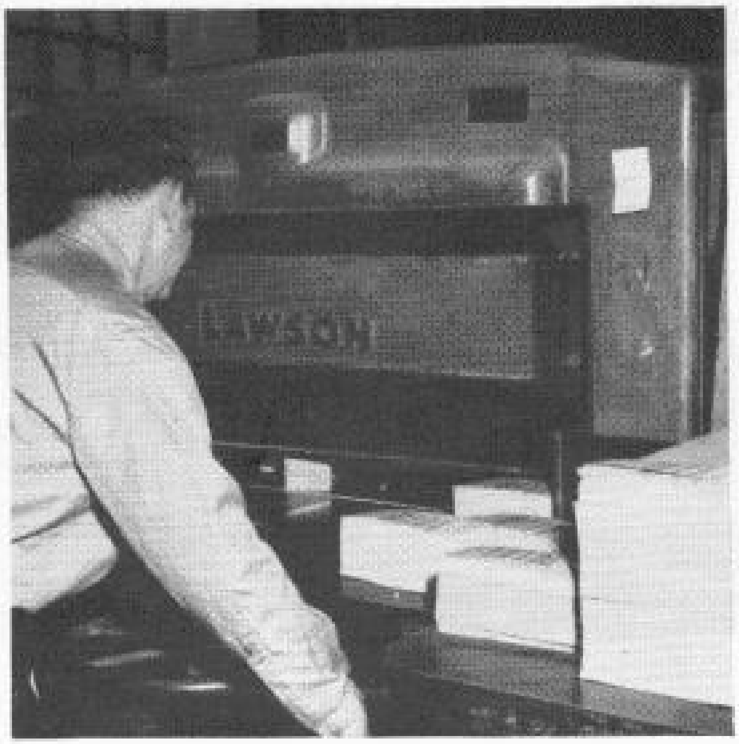

Figure 9. Acceptable cards at the shear for corner cutting

Quality Control

Quality Control of the conductive mark-sense data cards is carried out all during the printing operation. Figure 8 shows a typical quality control inspection being made on a run of cards. A visual inspection of a card, using a high-powered magnifying glass, checks for improper ink coverage, such as skips, or splatters, which cause circuit failures. After this examination, the finished card is inserted into the gauge to determine proper printing register, by matching the register marks printed on the card with corresponding reference marks on the gauge. Register, of course, is a measure of proper plate location in the chase of the printing press, and can also indicate certain malfunctions in press operation. If the card fails to pass the inspection, it is rejected, with a sufficient number of other cards, printed during that same time interval. A second inspector examines the card, for conductance, for the maximum resistance of 1.25 megohms. Those cards having a higher resistance will be rejected.

Figure 8. Quality Control Inspection

Figure 9 shows a quantity of acceptable cards at the shear for corner-cutting. After corner-cutting, they are carefully packaged in moisture-proof wrappings and sturdy inner containers, 500-cards to a package. As many as eight inner containers will then be packed in a sturdy outer container, with a sample card affixed to the outside for final inspection.

Before final packaging a number of cards, from each batch of 500, is pulled at random from the containers, at regular intervals, by a Western Union inspector at the printer's premises. These are carefully checked with respect to printing register, conductivity, offset, splatters, trails, scratches, holes and fidelity, using special gauges designed for this purpose by Western Union. If more than one percent of the inspected cards, from any lot of 500, is found unsatisfactory, the entire lot of 500 cards is rejected. Western Union insists upon top quality in printing our data cards.

Carroll Rotary Web Press

The dry-offset printing process used in the production of the "Numeric-Only" data cards, has been proposed by the Business Supplies Corporation of America in Princeton, New Jersey. The success recently achieved in the use of the Carroll Rotary Web Press for the printing of the mark-sense cards is due, in large measure, to the new Sinclair-Valentine Astro black conductive ink, a varnish base ink. While a slower drying rate for the ink is tolerable on the slower letter-press operation, the high speed of the Carroll Rotary Web Press is not economical for printing at a reduced rate.

Advantages of Dry-Offset Press

With the development of the faster drying ink and the addition of special heat lamps to the dry-offset Carroll Rotary, Web Press, the mark-sense Numeric-Only data cards are being successfully mass-produced at a rate several times that is possible on a letter-press.

As may be seen from Figure 10, this

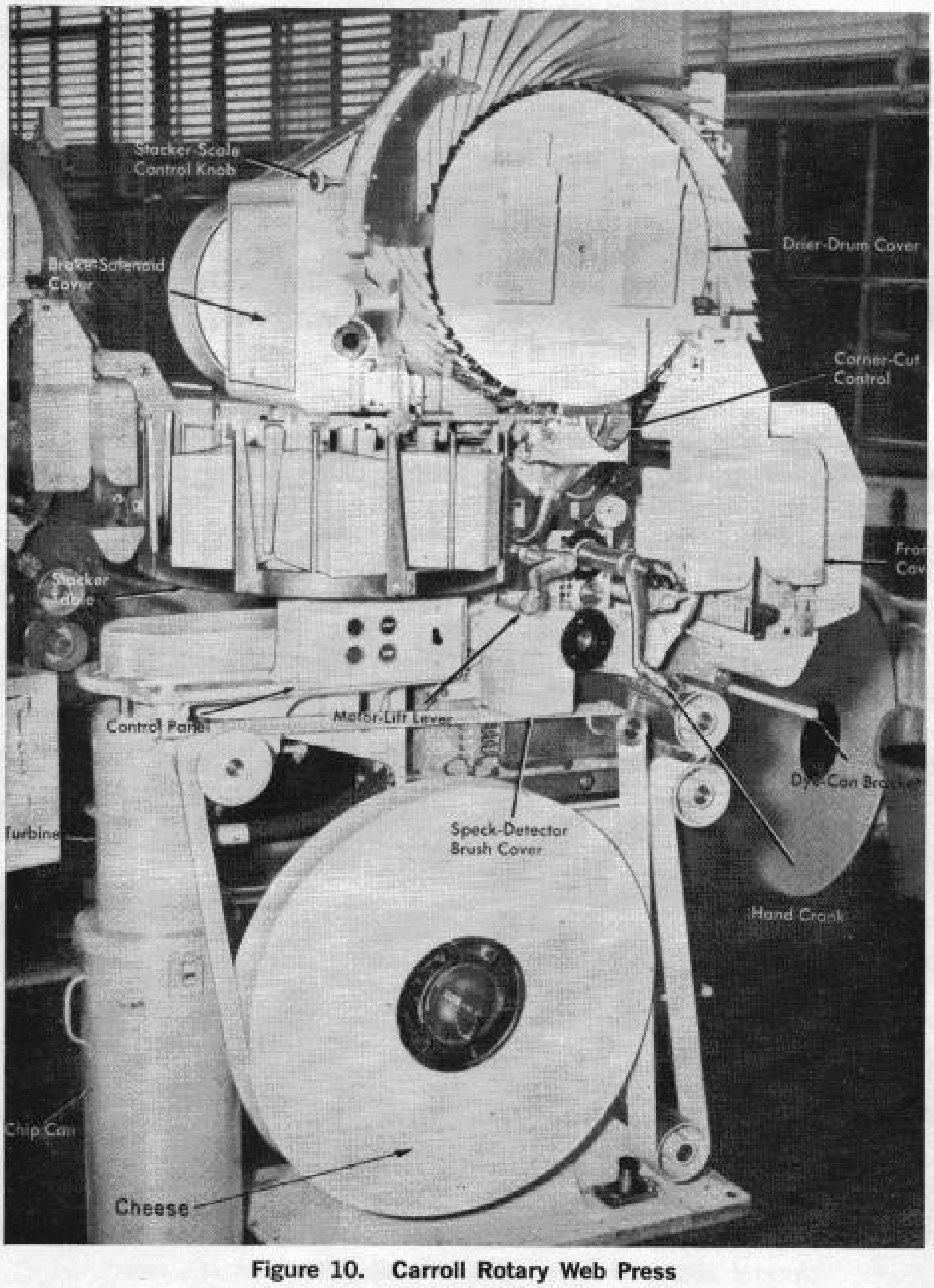

Figure 10. Carroll Rotary Web Press

unique machine is loaded with a cheese-like roll of tab stock which has been made by slitting a large mill-roll of tab stock into many wafers of the precise card width. The "web" formed by threading the paper from the "cheese" into the press, is continuous through the print stage. The oscillating main ink roller picks up a quantity of ink from the ink well only at certain tangent points. This quantity of ink is evenly distributed to several other ink rollers of smaller diameter. This insures an even ink distribution to the printing plate. This technique is commonly used on most presses. The ink plate, or "electrode," prints a reversed image onto a "mat" from which it is transferred on contact to the card stock, right side up. Immediately after the printing operation (which is actually dry-offset printing) the web is precisely cut to form the correct size mark-sense card. The cards, thus cut, are held by grippers around the drier drum and under a cover which houses the drying lamps. As soon as the drum has made a complete revolution, the cards are dry. Then, they are dropped from the grippers on the drum corner-cut, and then placed into collecting hoppers where they are accumulated in stacks of 1,000 cards. The cards, thus accumulated, are continuously quality-controlled by the printing firm, in the same manner as the letter-press printing operation previously described. The cards of proven good-quality are then packaged as before and final inspection called for.

Study of the flow chart, shown in Figure 11, will clearly indicate the order of events from the first contact with the customer to the final delivery of specific, custom-tailored data cards to his facility. Form 605, referred to by dotted line, is the sales representative's pictorial representation of the customers needs and card definition. It is available throughout Western Union to all sales representatives. This form is the first step, and probably the single, most-important phase, of the implementation of the Data Card Program. All the steps on the chart have been described in technical detail in this article. Thus, it is possible to see the procedure sales and engineering efforts take in the design of a data card from conception to implementation. The success which has been achieved with this new Western Union Data Card is most gratifying and rewarding.

Printing Rate

The main difference between the production printing of the two sizes of mark-sense cards is the difference in printing rate.

It is likely that small orders of cards, for trial by a customer, will continue to be made by the slower letter-press operation,

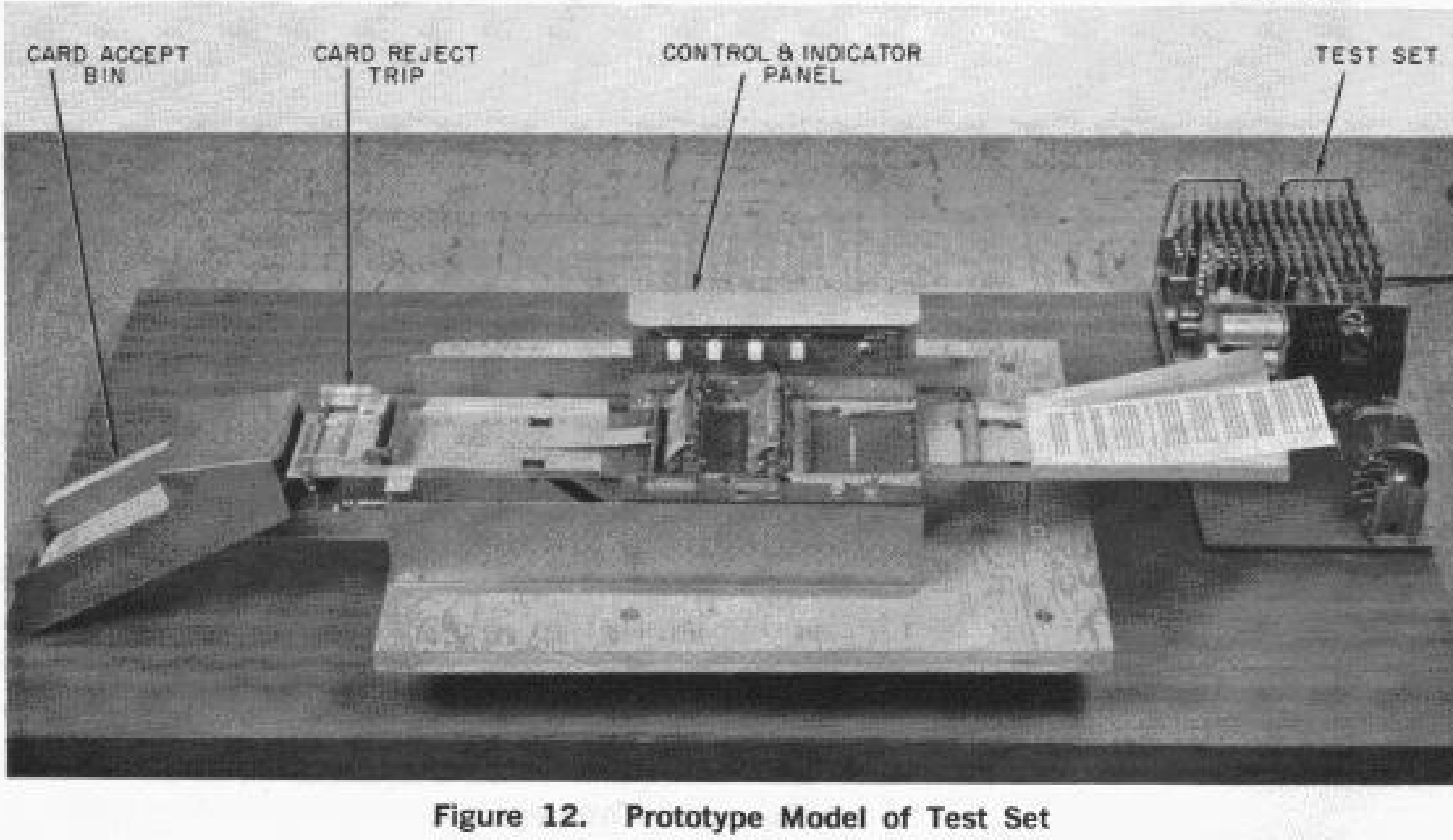

Figure 12. Prototype Model of Test Set

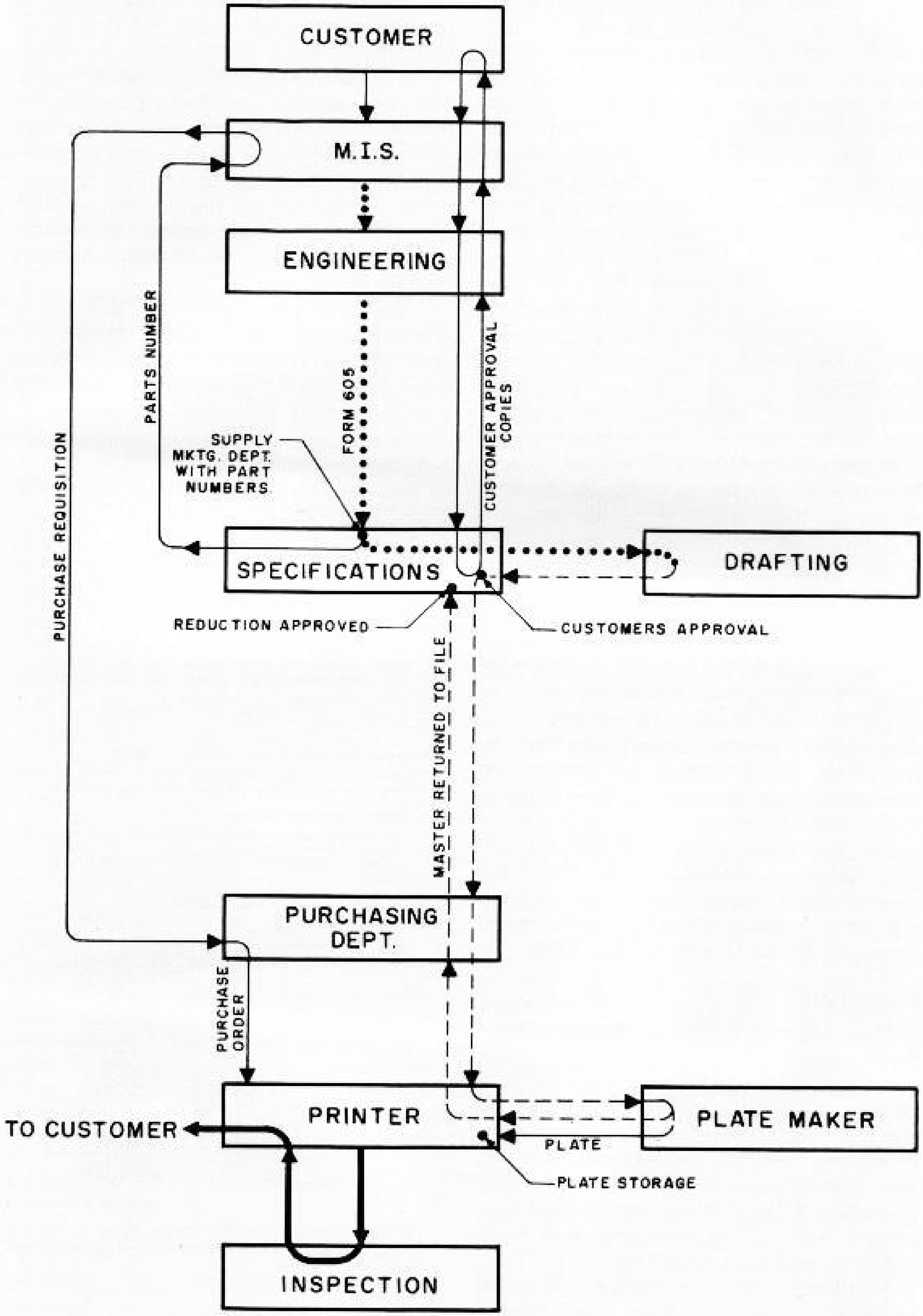

Figure 11. Flow Chart-Implementation of Data Card Program

since economy cannot be derived by small volume on a high speed press. Further, since the quality by either process is equally good, and since the achievable rate is no disadvantage from a sales standpoint, high speed production is not of major importance. However, the day is not too far off, when our card manufacturing ability will be as rapid, and as flexible as that for the simpler punched hole card used so much in industry today.

New Solid-State Card Test Set

A continuous effort is being made to reduce the number of man-hours required for quality control and inspection without sacrificing W.U. standards of quality. A fully-automatic, solid-state, card inspection device has been developed by our engineers which checks for ink resistance, the presence of open or short circuits anywhere on the card, and proper printing register. This prototype model is illustrated in Figure 12. When the cards drop from the heater conveyor belt into the guide chute they are carried through the test cycle by motor driven rollers, and are either accepted at the left end, as shown, or automatically dumped below the receiving bin into a reject-bin. The reason for a rejection is indicated on lamps on the control panel. Some further refinements are presently being considered. Obviously, a certain amount of manual surveillance will always be required in data card production, but machine automation will make for greater profits to Western Union and the customer, because of the more economical operation of the Quality Control effort.

Conclusion

The custom-tailored, conductive, Mark-Sense Data Cards are used with the Western Union Data Card Transmitter for data processing applications. The success of the Transmitter is dependent upon the use of well-marked, reliably printed data cards. The development of the design for the Mark-Sense Data Cards has proven that such a card can be mass-produced, without error and with repetition.

Problems were encountered in many areas. Choosing the proper paper for the card required much research. The paper had to have stability to withstand heat and moisture absorption, to retain but not to soak up the ink used, and had to be capable of transport and use by salesmen in many types of businesses and environs. The ink selected had to contain the inherent conductivity required of the end product and reading device, yet had to be useable on the most economical printing device. Selection of the proper printing process required our engineers to become knowledgeable of the printing industry techniques.

Thus, after two years of developing printing techniques, Western Union can now offer a truly versatile, Mark-Sense Data Card, the only one available for use with a low-cost data card transmitter.

Acknowledgements:

The authors wish to acknowledge the contributions of the following individuals to the success of the Data Card Program in general and the Mark-Sense Data Cards in particular:

Bob Steeneck, Data Systems Engr.—For his original concept & counseling during development.

P. F. Recca, Senior Proj. Engr., Telegraph Equipment Division

For his many novel and original ideas for the manufacture of both the Transmitter and the Data Card itself. The concept of both is, in large measure, his own.

D. P. Roddin, Senior Proj. Engr., Physical and Chemical Division.
J. A. Falkenberg, Project Engr., Physical and Chemical Division.

For their untiring efforts in quest of the proper qualities of paper and conductive ink for use in the manufacture of the Data Cards.

J. H. LaCas, Assistant General Purchasing Agent

For his patience and unrelenting search for the proper Printing Firm and process for mass-producing the Data Card.

W. E. Muller, Materials Engineer

For the wisdom and guidance afforded the program by him and members of his Inspections Dept. in determining the proper and necessary criteria of Quality-Control and Final Inspection.

Outside Companies

In addition, the following business firms are hereby cited for their contributions to the state-of-the-art in our behalf:

Sinclair-Valentine & Co., New York City—Ink research and supply.

Link Paper Co., Englewood, N. J.—Paper research and supply.

Wilkata Folding Box Co., Kearny, N. J.—Early trials of printing techniques.

Stanley Impressions Inc., New York City—Successful printing applications.

American Business Card Co., New York City—Successful printing applications.

Business Supplies Corp. of America, Princeton, N. J.—Successful original & Novel Printing Techniques.

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1. **P. F. Recca**—Data Card Transmitter, Western Union TECHNICAL REVIEW Vol. 17, No. 1 Jan. 1963.

MR. WARREN H. FISHER, Head of the Telegraph Equipment Division of the Information Systems and Services Department, guided the development of the mark-sense Data Card Transmitter, the new Punched Card Transmitter and the High Speed Tape Reader for the AUTODIN Project.

In 1957 Mr. Fisher was placed in charge of electromechanical design for Plans 57 (U.S. Steel) and 59 (F.A.A.). He participated in the engineering for the Telex Program, and was responsible for the packaging of such PMS Systems as Plans 36, 39, and 40.

He is a 1943 graduate of Stevens Institute of Technology and joined the Western Union Telegraph Company in March of 1946. He served as an Engineer successively on the staffs of the Central Office Engineer, the Apparatus Engineer, the Specifications Engineer and the Patrons Systems Engineer with work on such projects as Plans 20, 21, Baltimore Telecar Program for the PMS and Plans 51, 54 and 55 for the PWS.

Mr. Fisher has since directed the engineering of such projects as modernization of the American Stock Exchange Transmission Plant, participated in the PMS Economic Improvement Program.

MR. F. J. CALDERONE, Senior Engineer in the Division of the Telegraph Equipment Engineer in the Information Systems and Services Department, is Engineer-in-Charge of production of mark-sense Data Cards. Many of the successes achieved in this project are attributable to his tenacity and inherent technical ability.

He joined the Western Union Telegraph Company in November of 1945 after four and one-half years of military service as a Senior Non-Commissioned Officer in the U.S. Marine Corps Reserves. He received his BS Degree in 1953 at Fordham University.

Mr. Calderone has spent his entire career at Western Union in the engineering of Public Message Systems and has been directly associated with the design, development and testing of small office reperforation. He has participated in the engineering for many items of new electro-mechanical apparatus, most important of which is the mark-sense Data Card Transmitter.

J. A. Sinnaeve, Senior Engineer—Information Systems & Services Department

Broadband Switching Centers for Broadband Exchange Service

The initial phase of the Broadband Exchange Service has been operational since late 1964. This service is provided in twenty-two different cities across the United States. The network for the Broadband Exchange Service has the capability of interconnecting any two or more subscribers by using various types of transmission channels. It provides all subscribers with a high-grade nationwide record-voice communication service on a call-up basis.[1]

Broadband Exchange Network

The initial network consists of seven Primary Switching Centers and twelve Concentrator Locations. These 19 locations service twenty-two cities, as shown in Figure 1. The Concentrators are parasitic units attached to the Switching Centers to extend the line terminations from the Primary Switching Center.

Primary centers perform the switching, ringing, routing, addressing forward, intercepting, and all other functions associated with a normal automatic voice-data transmission switching system. Since the subscriber may request more than one type of transmission channel at any time, the Center must be able to intercept this request.

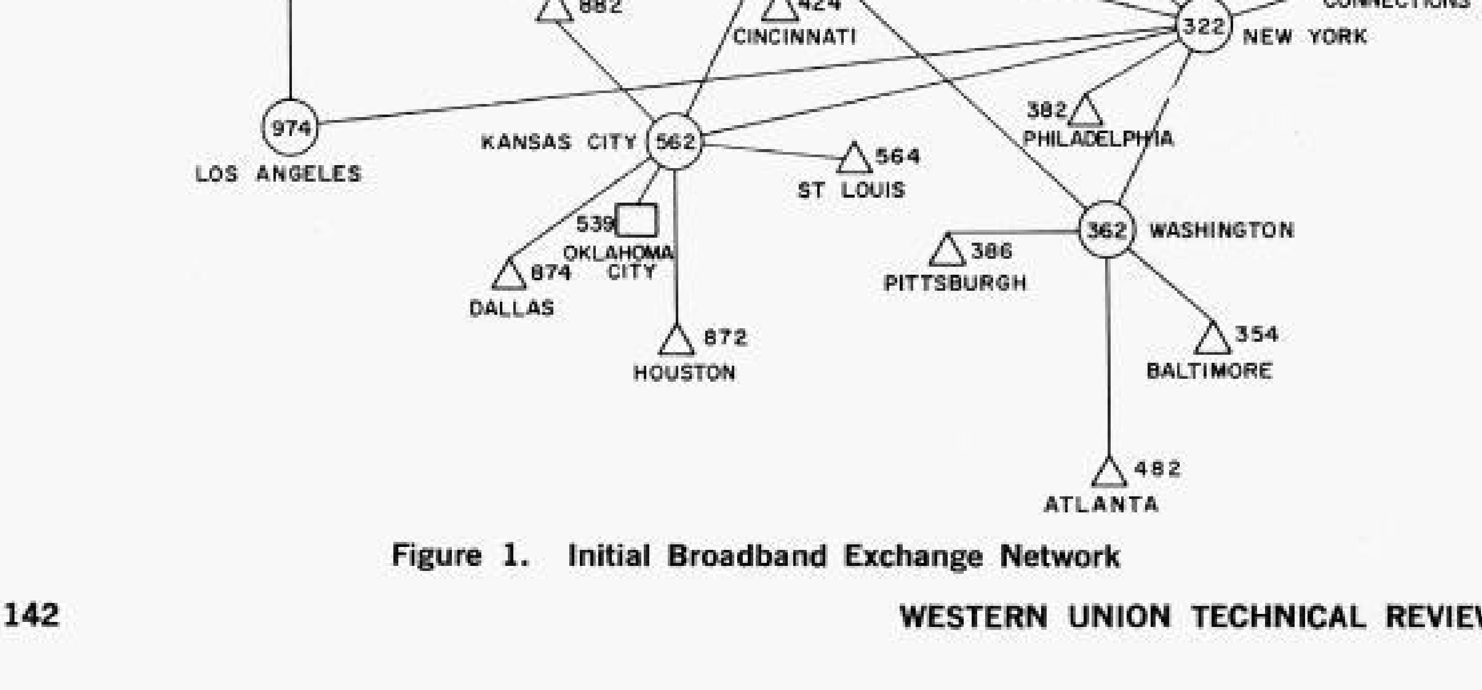


Figure 1. Initial Broadband Exchange Network

Bandwidth Rating

When a subscriber subscribes to this service, he is given a bandwidth rating of 2-, 4-, 8-, 16-, 4/48-, 8/48- or 16/48 kilocycles per second. The subscriber may originate a call at this particular rating or at a lesser rating. If he should originate a call greater than his rating, an intercept recording will inform him of the error. The fourth digit or the digit following the office code of the called number determines the requested bandwidth of the call. The called number of one subscriber may vary depending on the requested bandwidth of the connection.

The subscriber's local loop facilities, functioning to provide the link between the subscriber location and the system, will be conditioned in regard to amplitude and delay distortion. The extent of conditioning will comprehend the highest bandwidth rating of the subscriber.

Figure 2 is a table of the designated 10 digits in the address information. The first three digits (YYY) are used to designate the area code of the foreign system compatable with the Broadband Exchange Service. The next three digits are those assigned to the Broadband Switching Center. The next digit is the dialed number of the requested bandwidth. The following three digits are those of the called subscriber.

When the addressing information is received by the switching center, the call is routed over the proper bandwidth to the addressee. Automatic alternate routes are used to complete the call if the primary choice routes are fully engaged.

Table I

10-digit Address → YYY	YYY	X		XXX
Foreign System Area Code	**Broadband Office Code**	**Bandwidth**		**Called Subscriber Designation**
		Dial Number	**Band**	
YYY	YYY	0	Restricted	XXX
		1	not used	
		2	VF	
		3	not used	
		4	" "	
		5	" "	
		6	2 Kc	
		7	8 Kc	
		8	16 Kc	
		9	48 Kc	

YYY—designated code, limited in use, by foreign systems
XXX—any digit, 0 to 9

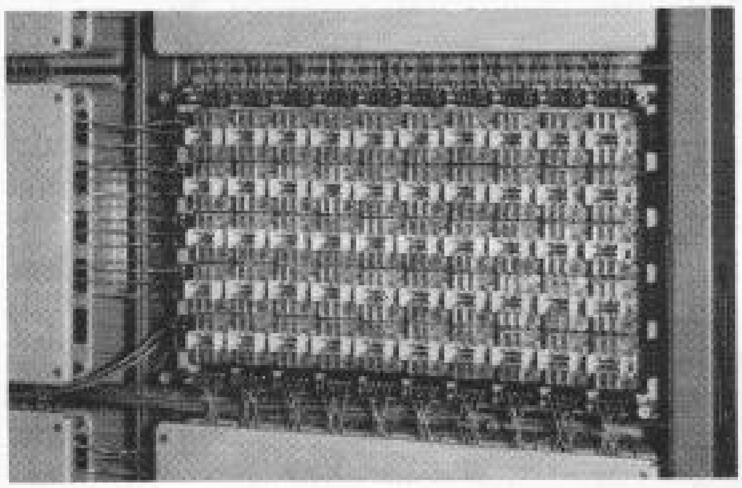
Figure 2. Table Showing Format of Ten Digits used in Address Information

How a Call Is Made

When a subscriber requests service by lifting the handset of the subset, equipment in the switching center is seized and it then functions to identify the calling line.

A register is assigned to the incoming call and the identifying line equipment number is passed on to the register for storage. Address signals (either dial pulses or multifrequency tones) are received and stored by the register. The register presents the calling line identity number and called address digits to the translator for analysis.

The translator converts the address digits into the appropriate routing number which, in turn, is passed to the terminating marker. The terminating marker examines the called circuit (or in the case of an inter-office call, the outgoing trunks) to determine its busy or idle condition. If the called circuit is idle, the marker establishes a connection, the incoming line circuit to the intermediate matrix module shown below to the called circuit (or outgoing trunk).



When the connection has been completely set up, through one or more switching centers, as required, the connector link in the terminating office applies a signaling (ringing) tone toward the called station and monitors it for "answer."

When the called station answers, the connector removes signaling current from the line. Answer supervision is returned to the ticketer causing it to connect momentarily to the chronographer to record and store the time of answer and the rate that is in effect.

The calling and called parties now converse and exchange data.

Objectives of BB Exchange Service

The first objective of the Broadband Exchange Service is to connect one party of the network with any other party of his choice, using a specific type of facility. The second objective, and the one which becomes the critical factor in the design of the system, is to interconnect the subscribers with a facility, on an "'end-to-end" basis, with the best possible performance characteristics for the transmission of data signals. The initial contact on the system is usually voice for the subsequent co-ordination of the data transmission to follow.

The voice transmission is affected little or not at all by such things as frequency delay distortion, amplitude distortion, harmonic distortion, impulse noise, and longitudinal balance. In planning a system for data transmission these items assume major importance and must be given primary consideration.

Specifications of the Centers

The new Microwave Radio System recently constructed by Western Union is used to provide the major portion of the channels used for the network of the Broadband Exchange Service. This microwave system was designed to accomodate data transmission, therefore considerations were given to the characteristics necessary for data circuit facilities.

In planning the switching centers a full set of requirements were specified. Obviously the centers were required to function and operate somewhat like a normal telephone switching center. However, the unique requirements were those related to quality analog or digital data transmission through the center. Some of the more important requirements were:

- Absolute Delay
- Delay Distortion
- Amplitude Distortion
- Total Harmonic Distortion
- Intermodulation Distortion
- Impulse Noise
- Idle Channel Noise and Crosstalk
- Longitudinal Balance
- Supervisory Signalling on Trunks

Special Features of the Centers

Various techniques were employed to meet these specifications. Some of these are:

1. All **circuit** transmission **pairs** are **individually shielded.** This has the tendency to minimize crosstalk and noise from control circuits in transmission paths. Extreme care was taken in selecting points to ground the shields, since introduction of unbalanced "ground loops" on a shielded pair will actually introduce noise into a transmission path rather than protect it.

2. **Send** and **receive pairs** are run in **separate cables.** This minimizes crosstalk due to differences in power levels normally encountered between the send and receive transmission pairs.

3. Each **line** and **trunk circuit** is **isolated** and **matched** to the Switching Center by a specially designed transformer. This provides a constant impedance of 150 ohms to the internal switching matrix, excludes direct current voltages from reaching the switch matrix points, and matches the incoming facility impedance.

4. The **physical layout** of the switching **center** is **divided** into **two sections,** the **transmission** section and the **control** section. By the physical separation of path selection, line and trunk control relays, translation trees, ticketing and timing equipment, and other direct current-pulsed apparatus from the transmission paths, the major source of channel noise and especially impulse noise is minimized. Even in the intra-office cabling the control cables are run on separate runways or separated on the same runway as much as possible.

5. The **supervisory signal** used has thus far been found to be **unsimulatable** by human speech and present data signals. The transmitter sends a frequency of 1688 cps at a power level of —14 dbm. This frequency is phase shifted, three times, 180°, every 10 milliseconds separated by 20 milliseconds. Then the code cycle is repeated continuously. The receiver monitoring the line detects the signal and outputs the supervisory signals only, on receipt of a full cycle of coded 1688 cps signal. The signal amplitude is illustrated in Figure 3.

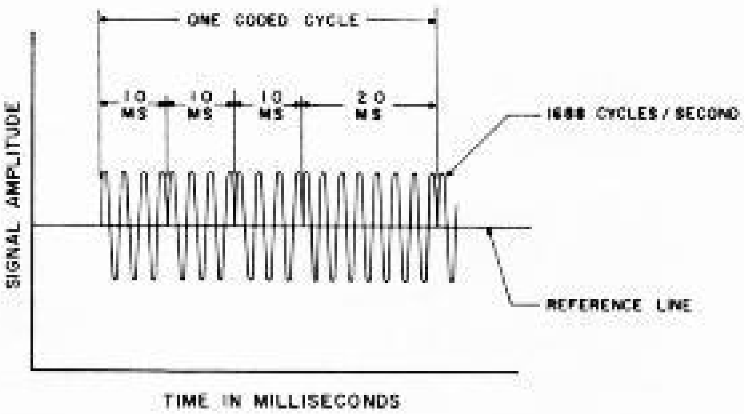


Figure 3. Signal Amplitude

Capabilities of Centers

Interconnection with Other Systems

The center is equipped with universal register senders and receivers. They will accept or send dial pulse address information, send or receive up to eleven (10) digits, perform prefixing, suffixing or code conversion. This capability tends to allow interconnection with other systems of somewhat different numbering patterns.

Flexibility

The Switching Center equipment is very flexible and will allow the make-up of the center to consist of any desired ratio of lines to trunks. This allows a center to function as a tandem when the system layout and traffic flow require it to do so.

Availability of Terminal Units

Special units of equipment are available to terminate subscriber lines located at any distance.

Abbreviated Number Addressing

The switching centers are capable of offering abbreviated number addressing and conference call facilities.

Data Apparatus

Optional items of equipment for use at the subscriber's station to facilitate the flexibility of operation of the data apparatus is anticipated. These items may be: indicator panels, auxiliary ringers and alarms, and control panels made to adapt to unique customer requirements.

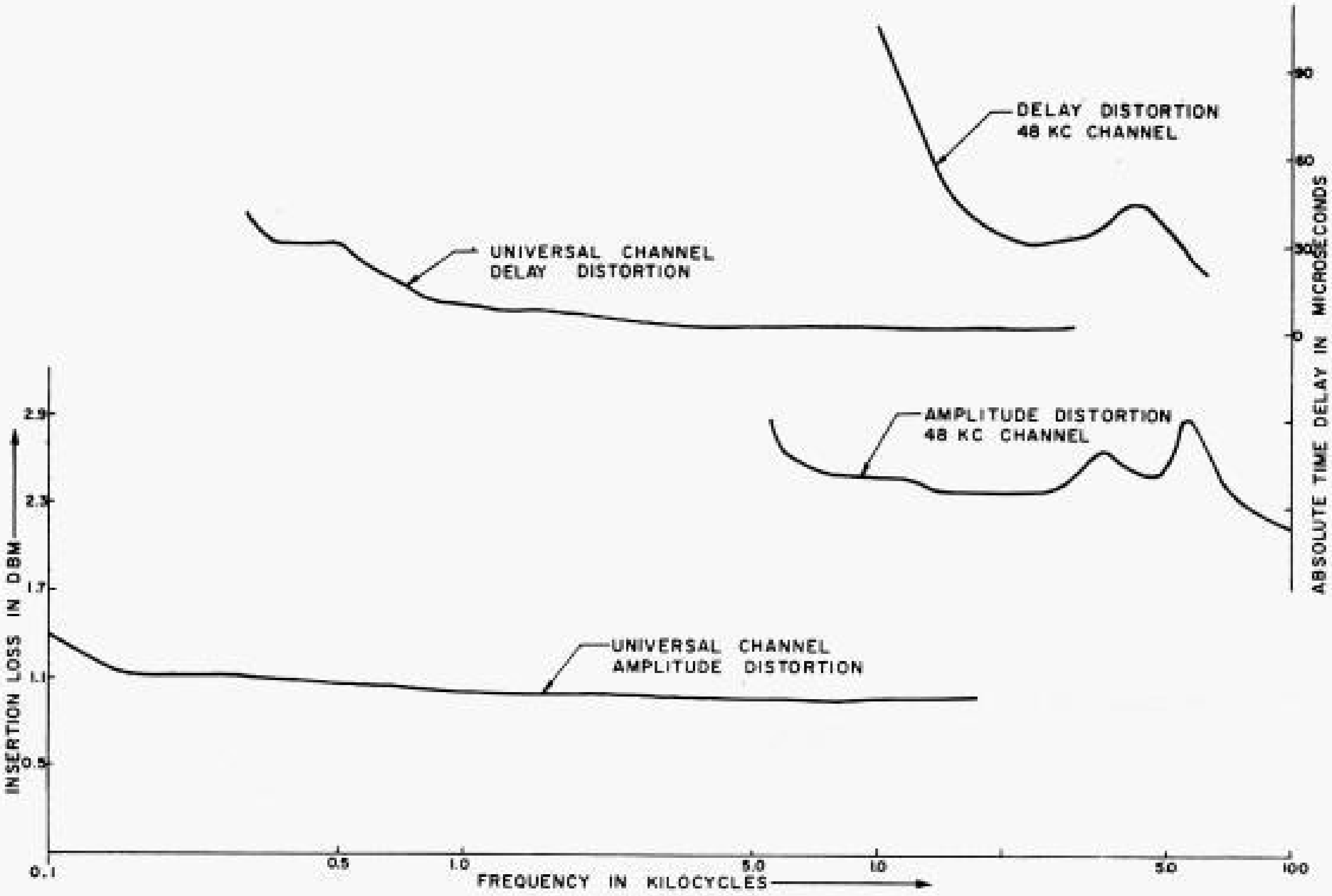


Figure 4. Frequency Delay and Amplitude Distortion vs. Frequency

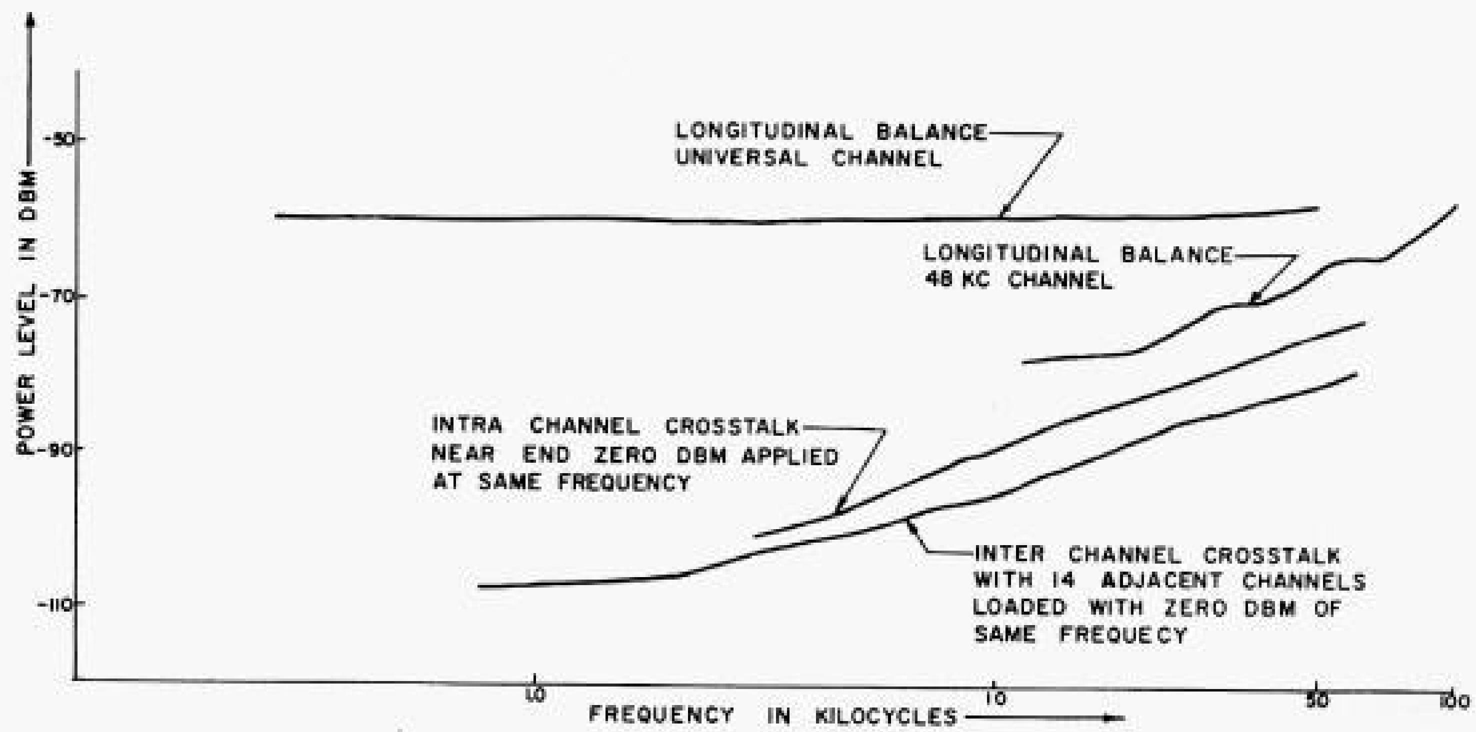


Figure 5. Crosstalk and Longitudinal Balance vs. Frequency

Test Results

Tests were performed on an actual installed operational switching center before it was turned over to traffic. The results of these tests indicate the system design criteria were met and in some cases exceeded. Some examples of the more critical quality are as follows:

a. Frequency Delay and Amplitude Distortion as shown in Figure 4.

b. Crosstalk and Longitudinal Balance. as shown in Figure 5.

c. Harmonic Distortion
   Injection Frequency-13,600 cps.
   Signal Power Level-0 DBM.
   1st Harmonic-Measurable at minus 85.7 DBM.
   No other harmonic levels measured above minus 100 DBM.

d. Intermodulation Distortion
   Injection Frequencies-13,350 cps and 14,221 cps.
   Signal Power Level of each frequency-0 DBM.
   Modulation Products measured:
   820 cps at minus 72 DBM.
   12,475 cps at minus 78 DBM.
   15,108 cps at minus 76 DBM.
   No other modulation products measured above minus 100 DBM.

Future Expansion

Automatic Answering Unit 11774-A is now available. An automatic calling unit is under development.

Local switching arrangements to operate more than one data terminal apparatus per station is available.

As shown on Figure 1, New York and San Franscisco function as "gateway" points for connection of calls to overseas locations via the international carriers.

Interconnection with the Canadian System for extending the Broadband Exchange Service is in progress and it is anticipated that this interconnection will be operational early in 1966.

The equipment used is easily adaptable to expansion as the system grows and is presently in the initial phases of expansion. With the advent of the computer and automation age the volume of generated data is multiplying. The Broadband Exchange Service is the communication vehicle to effectively accomodate this data and can expand to meet the growing need of the computer age.

* * * *

References

[1] **A. F. Connery**—Introduction to Broadband Switching, Western Union TECHNICAL REVIEW, Vol. 16, No. 3, July 1962

MR. J. A. SINNAEVE, Project Engineer in the Information Systems and Services Dept. is responsible for the implementation of the network for the Broadband Exchange Service into the Western Union operating plant. In 1961 he was assigned to the development of a requirement specification for a Broadband Switching System. Proposals from equipment manufacturers resulting from the requirement specification were evaluated both technically and economically and a supplier recommended.

He assisted in the design, development and documentation of a Technical Control Facility used at Fuchu, Japan and Croughton, England for the Plan 55 Air Force message switching system.

Mr. Sinnaeve received his B.S. degree in Electrical Engineering from Michigan Technological University in June 1953 and a B.S. in Engineering Administration from the same university in 1956.

He joined Western Union in 1956 as a Field Engineer and has been concerned with various private wire services and plans for special customer requirements.

C. R. Deibert and F. T. Turner, Senior Engineers—Information Systems & Services Dept.

Optical Character Reader

The Model 220 Optical Character Reader has been designed by Western Union for application in Private Wire Services and Data Processing System.

Recently it has been tested in an overseas service where the live traffic was read and punched into paper tape as it was received. An entire file of messages was transmitted over a high speed digital circuit.

The Reader has application also in the publishing field, where abstracts of various published articles may be filed in digital form and stored in a computer for use in publications.

Computers, data processors and communication systems all have one common problem—the transcribing of documentary information into a medium the machine or system can use. The manual process of punching tape or cards, in proper form, is not only expensive and time consuming but is also far from error free. Much effort has been expended in developing methods for automating the data preparation process.

Optical reading machines, which are capable of translating printed information directly into punched tape and punched card media, have been the subject of much research because of the many ways in which machines can be used to reduce the punching operation. As solid-state technology advanced, particularly with respect to the miniaturization of photocells, Western Union recognized the need for a comparatively low-speed optical reader which would solve some of the input problems of communications systems more economically than those available.

High Speed vs. Low Speed Readers

In the field of optical character reader research emphasis has largely been placed upon the development of high-speed readers capable of handling large quantities of information to match the input requirements of data processing and computer systems. These machines are expensive and in order to economically justify their cost, the purchaser must have an extremely high volume of input. In many cases where these character readers match the input requirements of the data system to which they are interfaced, the time during which they are used is a very small percentage of the total time available. High speed equipment of this type does not fit the requirements of the telegraph system very well because load concentrations are rarely such as to permit operation at more than a small fraction of capacity. Even in the few large cities where peak-load demands could match high-speed reader capacity, other factors would make low-cost low-speed readers more desirable. "Back-up" equipment is necessary to assure a continuity of service. If a high-speed reader is used, one spare reader represents 100% of capacity and 100% of original cost. If 10 low-cost slow-speed readers are used, one spare reader representing 10%

of capacity and original cost might well be adequate. The low-speed equipment also more nearly matches the speed of conventional telegraph circuits and introduces no interface problems.

W. U. Development Program

Western Union recognized the potential value to the telegraph industry of a low-speed, low-cost character recognition device and instituted a development program to produce such a device in 1962. This project has culminated in the production of the Western Union Model 220 Optical Character Reader. In Figure 1, the cabinet on the right houses the Model 220 Character Reader, and the auxiliary paper handling mechanism including the punch, reader-transmitter, and storage facilities are housed in the cabinet to the left.

The Model 220 Optical Character Reader was initially designed to read messages typewritten on a standard Western Union "Telegram Received by Telephone" blank and to convert this information into standard punched paper tape in the 5-level Baudot code, at 172 words per minute. In this machine, the high speed capability was sacrificed for machine simplicity, reliability and low cost. This unit was developed by Western Union specifically for "in-house" use. However, the basic design has many features which can be used advantageously in other applications. This machine can be redesigned to:

a. Process other paper sizes (8½" x 11" and 8½" x 14")
b. Recognize other type fonts
c. Produce a variety of outputs to paper tape, magnetic tape or other output devices.

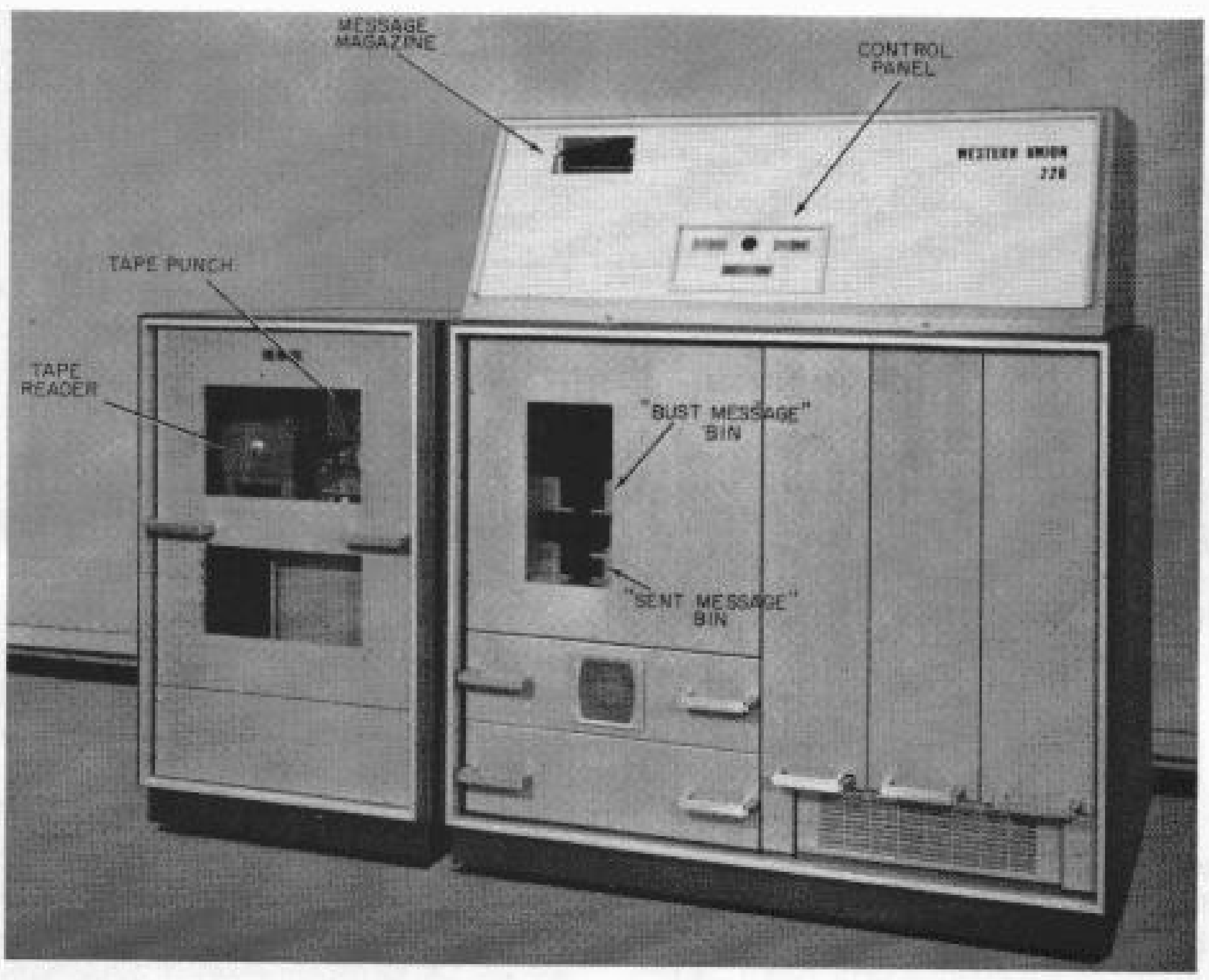


Figure 1. Western Union Model 220 Optical Character Reader and Auxiliary Cabinet

Principle of Operation

An operational flow chart is shown in Fig. 2. The physical path of the message is indicated by the dotted line on the left of the diagram. The message is transferred from the message magazine to the scanning mechanism. After scanning a normally read message is time stamped and deposited in the "Sent Message Bin." If for any reason a character is not read, that message is immediately discharged into the "Cancelled or Bust Message Bin." The error detector and the message detector do the sorting.

The information flow path is indicated by the heavy line. The information is transferred from the "scanning mechanism" to the "photocell matrix" in the form of an optically projected image. The photocell matrix dissects the image into 88 discrete bits of information. These bits are used to determine what character is being read. The recognized character by means of an encoding matrix transforms the signal into the appropriate telegraph code signal. This signal in turn operates a tape punch which prepares a paper tape. The tape may be read and transmitted to the telegraph circuit by an appropriate tape transmitter. The tape could also be accumulated for later transmission.

The interdependence of the various components is indicated by the control and error detector signals.

Loading

Messages to be read are placed in the box or message magazine, at the upper left of the unit in Figure 1. The messages must be put in the box on end, with their faces out, and the right margin down. They are loaded so that the message in the back of the box, or bottom of the pile, is the first read.

When the "start" button on the control panel is pressed, the top edge of the message sheet at the back of the message box is drawn, by vacuum, against the roller. As the roller turns, the sheet is first bent away and separated from the adjacent message and then drawn up, out of the box, over the roller and down the loading chute onto the scanning drum, as shown in Figure 3.

A lamp and photocell arrangement on the chute monitors the light transmitted

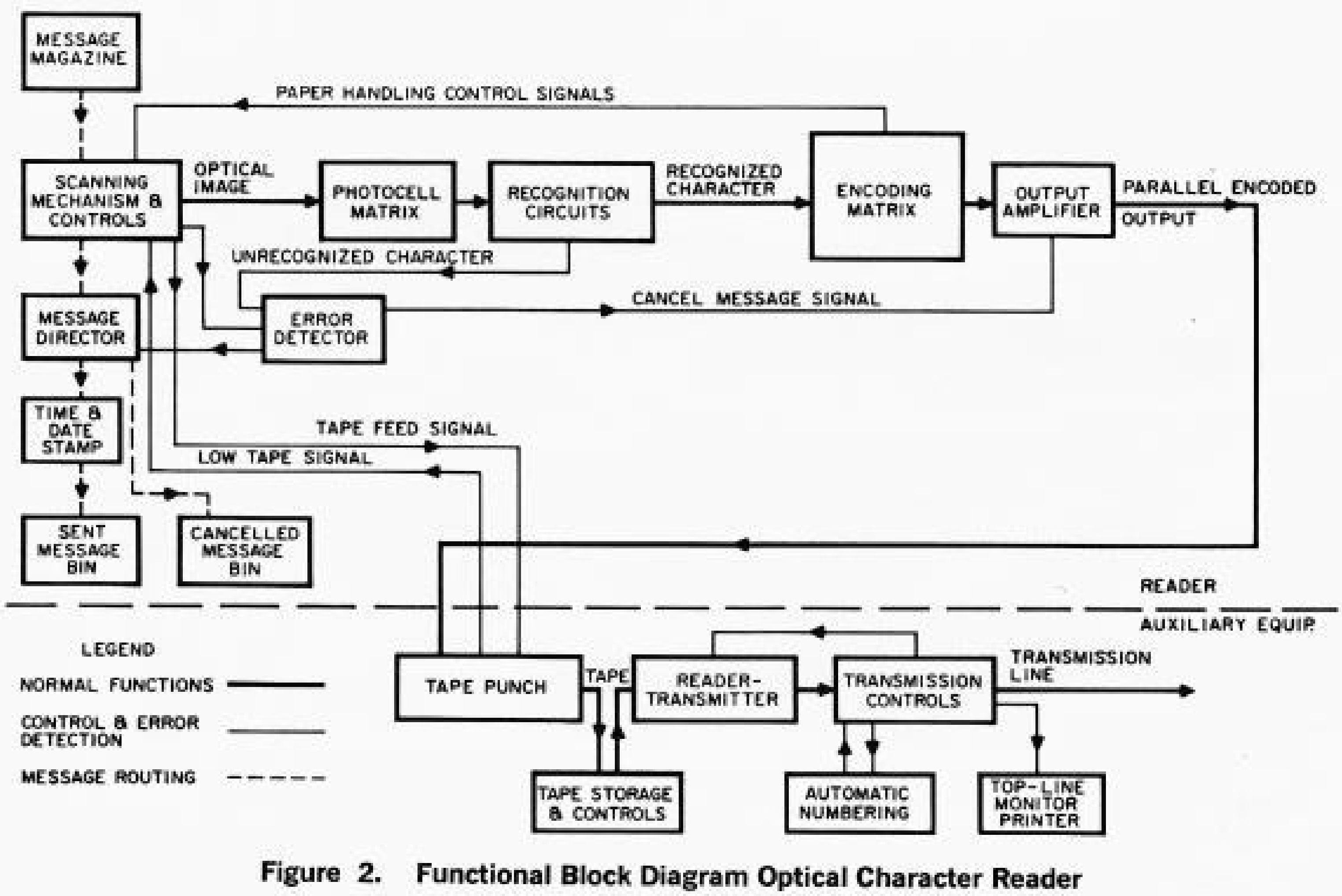


Figure 2. Functional Block Diagram Optical Character Reader

through the sheet in order to guard against the possibility of more than one message being loaded at a time.

The message box holds up to 25 standard (5¾″ x 8½″) message sheets. More may be added at the front as the rear sheets are automatically withdrawn, loaded and read. When an empty message box is detected, the reader shuts off automatically.

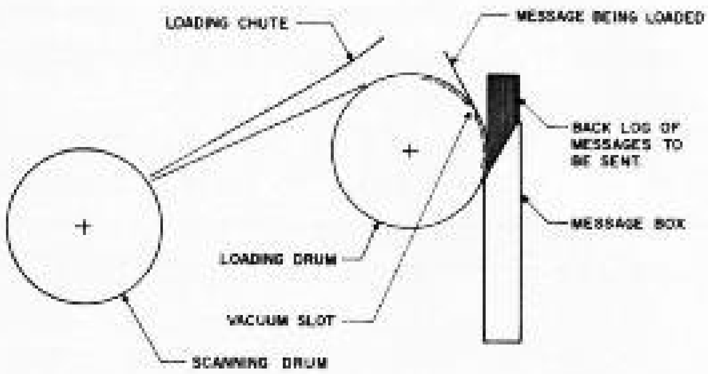


Figure 3. Message Loading

Scanning

A message sheet from the loading chute is automatically attached to the scanning drum and wrapped around it in such a manner that the message faces out and the lines of typewritten copy run around the circumference of the drum as shown in Figure 4.

The drum revolves at a uniform speed of 12 rpm as the copy is scanned. It is positioned along its axis so as to bring each typewritten line of copy sequentially into the focal plane of the projection lens. Since the area being read is brilliantly flood-lighted by two 100-watt quartz-iodine lamps, enlarged images of the characters under the lens are projected onto a photocell matrix. These characters are magnified 25 times to a height of about 2½ inches.

The first revolution of the drum scans the top line of the message. The drum is then moved along its axis so as to scan the second line and then another line on each subsequent revolution. If there is a short line, the machine scans the blank portion of the line at five times normal speed.

A total of 170 low-cost cadmium selenide photoresistive-type photocells are used in the machine. Their speed of response is comparatively slow, but adequate for the transmission of 17.2 characters per second. Their sensitivity, however, is very high, being of the order of amperes per lumen, the equivalent of a photo-multiplier tube. Each cell is individually mounted in a sealed TO-18 metal case which is cylindrical in form (about two-tenths of an inch in diameter and fifteen-hundredths of an inch high) with a window on the end. The reading cells are arranged in a compact rectangular 8 cell x 11 cell matrix. The reading matrix is surrounded, on the top and bottom, by long horizontal rows of Vertical Centering Cells and on each side by vertical columns of Margin Cells. The complete photocell matrix is shown in Figure 4.

The action of the drum, the lens and the centering mirror combine to produce an enlarged and reversed image of the character on the photocell matrix. During reading the letter image moves across the matrix at a uniform speed. It is held in the correct vertical position, balanced between the upper and lower rows of Vertical Centering Cells, through their control of the inclination of the centering mirror.

Letters on the copy, read by the machine, are spaced to produce a clear margin on either side. When the moving image of a character covers the Reading Cells only, both rows of Margin Cells are clear of any character image. Power is applied to the Reading Cells during this period only. When the image is centered on the Reading Matrix, certain cells are covered by the dark image of the character. Therefore, their resistance will be high. The resistance of the other cells which remain uncovered will be low. The division of the cells into these two groups of "Covered" and "Not Covered" cells is unique for each different character and is the basis of the recognition system used in the reader.

Photocell Selection

The selection of the photocells to be used for the recognition of each character is a most interesting one, and the techniques used are applicable in many fields other than character recognition. This problem of recognition is very common in information retrieval (library search), in medical diagnosis, and even in our own personal lives, to name but a few examples.

In the latter case of personal recognition, we do not resort to formal analysis of the problem; but we do unconsciously use some of the same techniques none the less. Since all humans have two eyes, a nose, and a mouth, we do not use these facts in distinguishing one from another. However, when one person has brown eyes this distinguishing factor may be most significant. We soon learn to rely, for recognition, on the most significant features

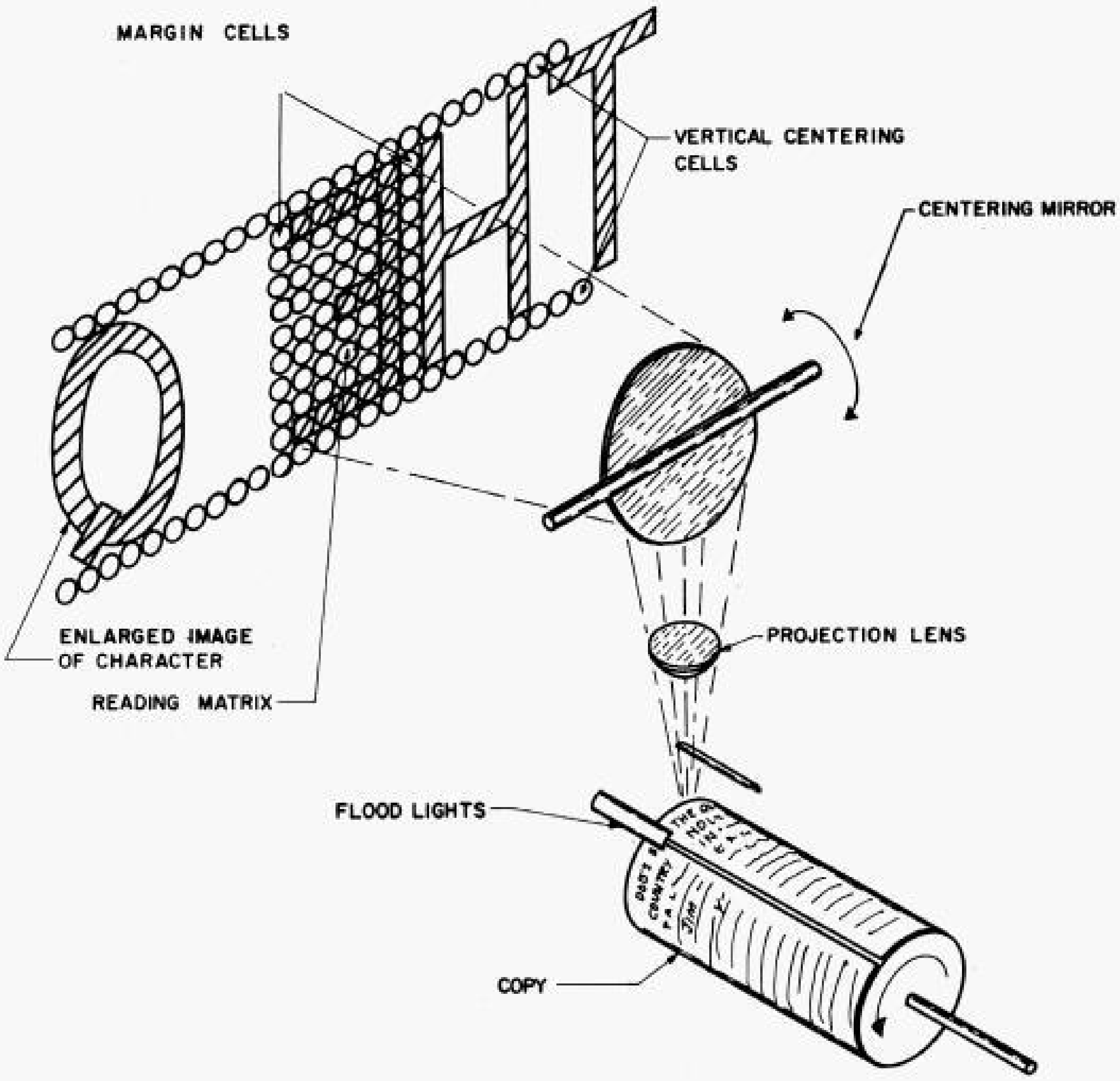


Figure 4. Operational Diagram of Lens System

without being consciously aware of what these may be.

So it is with character recognition, the problem is simplified and the recognition made much more reliable when we discover just which are the most significant features of each letter. For example, many letters such as B,D,E,F,H,M, etc. have a vertical line at the left side of the character. Obviously the presence of this line is of no value in distinguishing among the members of this group, and in the selection of cells for these letters we do not make much use of those lying in this portion of the character.

The selection of the cells actually used is a complex problem aptly suitable to solution by modern computer techniques.

The IBM 650 computer was used in the selection of "Covered" and "Not Covered" cells for each character.[1]

Recognition

A simplified schematic of a Reading-Photocell circuit is shown in Figure 5. The cell is connected so that one terminal is fed positive battery and the other terminal negative battery through a pair of resistors. The junction of the cell and the resistor going to positive battery is termed the "Covered" connection point. Its potential-to-ground is strongly positive, when the cell is covered by the black portion of the image and approaches zero when the cell is not covered by the image. The other cell terminal, called the "Not Covered" connection point, has a low negative potential-to-ground when the cell is not covered and a high negative potential when the cell is covered.

The reader has a printed circuit "Resistive Combining" card for each different character to be recognized. The cards are identical. The output point on each is connected, through twelve separate resistors, to the "Covered" connection point of each of 12 specifically selected cells in the "Covered" group and to 12 other specifically selected cells from the "Not Covered" group for the character to which the card is assigned. It has been found that twelve cells of each kind give sufficient information for positive recognition. If the cell selection is made properly, the output voltage of a given card will be a maximum,

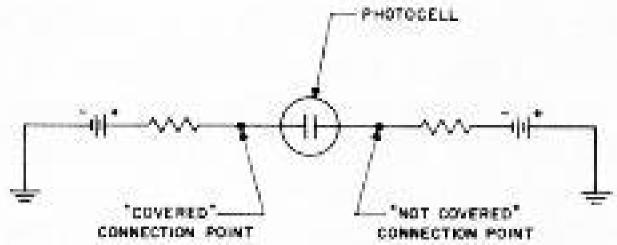


Figure 5. Schematic Diagram of Photo Cell Circuit

when the image of its assigned character is centered on the reading matrix. Any other character produces an output which is substantially less on this card but a maximum on its own card. The voltage margin above the interference level from other character cards varies from character to character, but averages several volts. The card, whose high output indicates that its character is the one on the matrix, triggers an associated circuit which in turn, through an encoding matrix, causes the tape punch to punch the digital code for that particular character. The encoding matrix determines the type of output. The reader presently produces a 5-level punched tape.

Auxiliary Functions

A "space" in the message being read is indicated and punched into the tape when the margin cells on the entering side of the reading cell matrix fail to detect the passage of a character across them at the end of the proper time interval. Three or more spaces, in sequence, are recognized as the end of a line. The machine scans the remainder of the line at high speed and advances to read the next line. The machine can be set to cancel this type of signal, if the spatial distribution of the original intelligence must be preserved as is the case when columnar data or encoded copy is being read.

A "letters" or "figures" shift is automatically inserted into the punched tape by the machine when needed. "Carriage return" and "line feed" are punched in the tape when symbols assigned to them appear in the copy being read or—on reading the first space after and arbitrarily selected character count indicating end-of-line has been reached. Special characters may be included in copy to instruct the reader to perform specific functions. The reader can be programmed to delete text between certain special characters or on the other hand, it can be instructed to pause, while information is introduced from an external source as an insert to be added to the copy being read. If it is wished to delete, or in effect erase any data, this can be done by simply lining through the unwanted portion of the copy. The machine will automatically close up the lined-out area.

An unreadable character is indicated when the entering margin cells detect a character and none of the "Resistive Combining" cards operate the punch. In this case, "Bust This" can be automatically punched into the tape, the message is unloaded from the drum and deposited in a special file, and an alarm given to alert an operator who will process the message manually. Alternately, this feature can be cancelled and the machine can be set to print a "special" character to indicate an "unread" character.

A message that has been read completely is unloaded, time stamped and deposited in the "sent" message file. The photograph Fig. 1 shows the "sent message" bin and the "bust message" bin at the lower left.

The present machine is equipped with 60 "Resistive Combining" cards and can recognize the total of 60 capital letters, figures, punctuation and other symbols of one particular type font. Additional characters can be read by adding one "Resistive Combining" card for each new character. Fig. 6 shows the Farrington type font which the machine recognizes. The machine can be programmed to read other type fonts by making new cell selections.

Accuracy

Accuracy tests, thus far, are very favorable. The accuracy of the reader is dependent on the quality of the typewritten copy fed into it. The well aligned, uniform-density, clean copy produced by a good typewriter and a good typist is read and transcribed by the machine with an error rate of the order of one in 10,000 or about one-tenth the national average error rate for manual transcription. Recent tests indicate an error rate of 1 in 100,000 characters may be possible. A series of consecutive runs of 170 pages of copy, totalling 335,000 characters, were made with only one reading error, a repeat of a semi-colon. Initially, it will be recommended that copy to be read be prepared on good quality white bond paper, using electric typewriters with one-time plastic ribbon, with Farrington type so as to produce the highest quality copy. Reduction in copy quality can be tolerated where machine accuracy requirements can be reduced.

```
TEST IXA001 PD=NEW YORK NY 17 1030A EDT]=

JOHN DOE]=

123 MAIN STREET

NEW YORK NY]=

THIS IS A SAMPLE MESSAGE PREPARED FOR THE WESTERN UNION

220 OPTICAL CHARACTER READER.]= THE FARRINGTON TYPE FONT

USED INCLUDES THE FOLLOWING CHARACTERS]= ABCDE FGHIJ KLMNO

PQRST UVWXY Z1234 56789 0DΔ?Γ ⊢-/.$ ,(")' :;&#? ¶]=

SIGNED MARY DOE ]]
```

Figure 6. Farrington Type Font

Mr. Clarence R. Deibert, Senior Engineer, is in charge of the Electronic Engineering group in the Product Planning and Engineering operation of the Information and Services Department. In this capacity he is responsible for developments in connection with Optical Character Recognition.

He was also responsible for the development of the 210-A Bomb Alarm System and presently serves as technical consultant in connection with its operation. He was responsible for the development of the high-speed Facsimile Terminal and Telegraph Terminal AN/FGC-29 for the Signal Corps. He participated in research to determine the feasibility of using "light" energy as a communication medium, developed prototype equipments for the armed services and was co-inventor of the concentrated arc-lamp, a by-product of this research.

Mr. Deibert received his BS in Electrical Engineering from Northeastern University. His experience before joining Western Union included service with the General Radio Company and the nuclear physics laboratories at MIT. He holds 7 patents and is the author of a number of technical papers and articles in the TECHNICAL REVIEW. He is a member of the IEEE.

Mr. Frank T. Turner, a Senior Engineer in the Electronics Engineering group of the Project Planning and Engineering Operation, Information Systems and Services Department, is the Project Supervisor now directing the development of the Optical Character Reader and is responsible for much of the basic logic used in the machine. He has been active in the development of facsimile equipment, a transistorized radio teletype converter, the Plan 37 Switching System, and the 210-A Bomb Alarm System. He entered the employ of Western Union in March 1946, having previously gained wide experience in the field of facsimile. In World War II he spent 18 months in Europe in the Air Force supervising installation, operation and maintenance of facsimile networks and equipment. His work in this field contributed to the present national Weather Map Facsimile network.

Mr. Turner was a member of the IRE Technical Committee on Facsimile. He is a member of the IEEE and the Society for Industrial and Applied Mathematics. He is also a member of American Standards Association subcommittee on Optical Character Recognition.

The Place of Western Union in the Information Revolution

Editor's Note: The following is extracted from an address by Russell W. McFall, President of Western Union, to the Columbia Graduate School of Business, Columbia University in New York City on September 8, 1965.

Significant changes are taking place in education, just as they are in the processes of business enterprise and government. . . . . .

. . . . . . It is certain that you . . . . . . will find the remaining years of this century a period of vast technological change, economic growth and social progress . . . . . .

. . . . . . As future business leaders you are going to be increasingly concerned with, and involved in, the information revolution that has also been termed an "explosion."

. . . .

. . . . . . World historian Arnold Toynbee, who holds the view that the well-being of a civilization lies in its ability to respond successfully to human and environmental challenges, has voiced deep concern about the problems of exploding information.

Says Toynbee: "In the modern age the gulf of ignorance has been rapidly widening—not because the human mind's capacity for acquiring knowledge has diminished, but because the quantity of things to be known has increased—and increased enormously."

Then Toynbee asks: "Can this rapidly widening gulf of ignorance be bridged by a rapidly improving technology? Can computing machines come to the rescue of human minds that are in danger of being drowned in an ocean of information?

. . . . . . These are questions not only on Toynbee's mind but are shared by many. Basically we are facing a communications problem. One great impetus behind the mounting wave of data has come from the development of high-speed electronic communications and data processing. When electro-mechanical communications reached their limits of speed, science pressed on to apply electronic techniques such as radio waves, video scanning, and automatic sensing, which permitted the storage of still more facts faster than ever before. The computer has come to the rescue. . . . . . .

. . . . . . You are living in the midst of a revolution—not only a knowledge revolution but a communications and automation revolution. . . . . . .

. . . . . . In the area of technology, there is no question that research and development activities in the United States are in a state of explosive growth and there are no signs that this boom is tapering off. Well over $12 billion annually is being spent for research and development and estimates are that by 1970 it could be $28 billion a year. . . . . . .

. . . . . . The information crisis is part of our continued economic growth which has surpassed anything experienced anywhere before. While it is true that we are being overwhelmed with information—and more is on the way—there is less panic when we view the problem in its true perspective. The basic questions are: What data are really needed and—who really needs the data?

The massive amounts of information washing over us can be separated into two classes. One of these is the river of "perishable" data which is useful only if obtained and processed within a fixed length of time. The time may be microseconds or hours. Thus the sending devices of automation produce continuous streams of perishable data which are processed and fed back to the machine in order to control the machine's work. . . . . . .

. . . . . . Western Union is playing a key role in the information revolution. To meet tomorrow's communication needs today, the company has been carrying out a record modernization and expansion program involving expenditures of about $500,000,000 for the 1960-65 period—an amount more than twice the company's net plant investment at the beginning of the period.

This program has changed the company from a narrow band telegraph company, handling only telegrams, to a telecommunications company with greatly enlarged service capabilities for handling facsimile, voice, data, and messages—both separately and in combination. And we are providing industry and government with real-time computer equipped private wire systems capable of handling vast amounts of data at high speeds and low cost.

In appraising the future growth of telecommunications one thing should be emphasized. We are now using new terms and new meanings.

Communication, as we know it today, includes both language and non-language. I refer, of course, to data communication which is simply the transmission of coded impulses between machines. It is expected that in the next 10 years at least half of all communication will be of a non-language variety. And it has been freely predicted that, as time goes on, the amount of communication between machines may exceed the amount of communication between people.

Recognizing these future trends, Western Union, in its new role as a telecommunications company, has set for itself three major objectives:

1. To maintain and expand its public services.
2. To continue to design, install, and maintain communication, data and management information systems to meet customer needs.
3. To establish a national information utility that will make it possible for large and small users of every kind, everywhere, to fill their total needs for information systems and services on the most efficient, economical basis.

This concept of Western Union's role as the nation's information utility is one of the boldest, far-reaching ideas of public service in the company's long history. . . . .

. . . . . . There is little question that the need for a new, national information utility is now rapidly developing. Just a few years ago such an idea would have been not only unrealistic but impossible. However, with the development of real-time, communications-oriented computers and associated equipment now available, with more advanced models on the way, there is no substantial technical bar, even now, to the establishment of a nationwide information utility.

Just as an electrical energy system distributes power, this new information utility will enable subscribers to obtain immediately, economically, and efficiently, the required information flow to facilitate the conduct of business, personal and other affairs.

As we envisage it, such a utility would make available, through a national, regional and local network of computers, a gigantic real-time communication service.

The utility would gather, store, process, program, retrieve, and distribute such information on the broadest possible scale. It would be designed to serve, economically and efficiently, all kinds of business and industry, civilian and military government, the professions, and countless other organizations and individuals. . . . . . .

. . . . . . Computers and associated equipment, the methodology, and techniques are already available. Their harnessing into a national information system presents no problems, essentially more difficult, than the placement, a half-century ago, of steam turbines and the building of the necessary distribution facilities.

Such a utility would require fundamentally different and more advanced transmission facilities, bandwidths far broader than those now adequate for telephone service.

. . . . . . Western Union is uniquely qualified to provide a national information service in the years ahead—and we intend to do so.

P. J. Birkmeyer, Senior Engineer—Information System and Services Dept.

Economical Packaging

The expensive procedure of designing a cabinet for every packaging requirement led Western Union to design a general purpose cabinet which may be adapted to many types of electronic units used in our Information Systems and Services. Need for rack mounting enclosures, including cabinet racks and bays, necessitated a design study of a single enclosure which would fulfill the varied packaging requirements of the company. Encouraged by the success in fulfilling such needs for the AUTODIN network study—which included carrier and modem cabinets, racks and bays, it became apparent that the general purpose cabinet used for this system could be adapted to many other systems.

General Purpose Cabinet

The General Purpose Cabinet 12001, designed for AUTODIN, is available with or without doors on the front surface as shown in Figure 1. It may have doors or "lift off" panels on the rear surface, as shown in Figure 2.

Side panels, are a primary requisite for a general purpose cabinet. This cabinet design had to be inclusive of these and suitable also for the packaging needs of multiple unit installations, where such side panels could be removed.

Rack mounting angles for general use and rack mounting channels for special modem needs were designed 77 inches long, providing a maximum of 44 standard rack mounting spaces, each 1¾ inches high. The need for 44 spaces suggested an overall cabinet height of 7 feet. Because rack mounted chassis, panels, etc. vary in depth according to the various kinds of equipment involved, a total of 21 possible mounting holes for the rack mounting angles were designed into this unit. These holes are used for mounting vertically disposed items, such as: power troughs with outlets, signal wire troughs with cable holes, grounding bars, tie bars and terminal blocks.

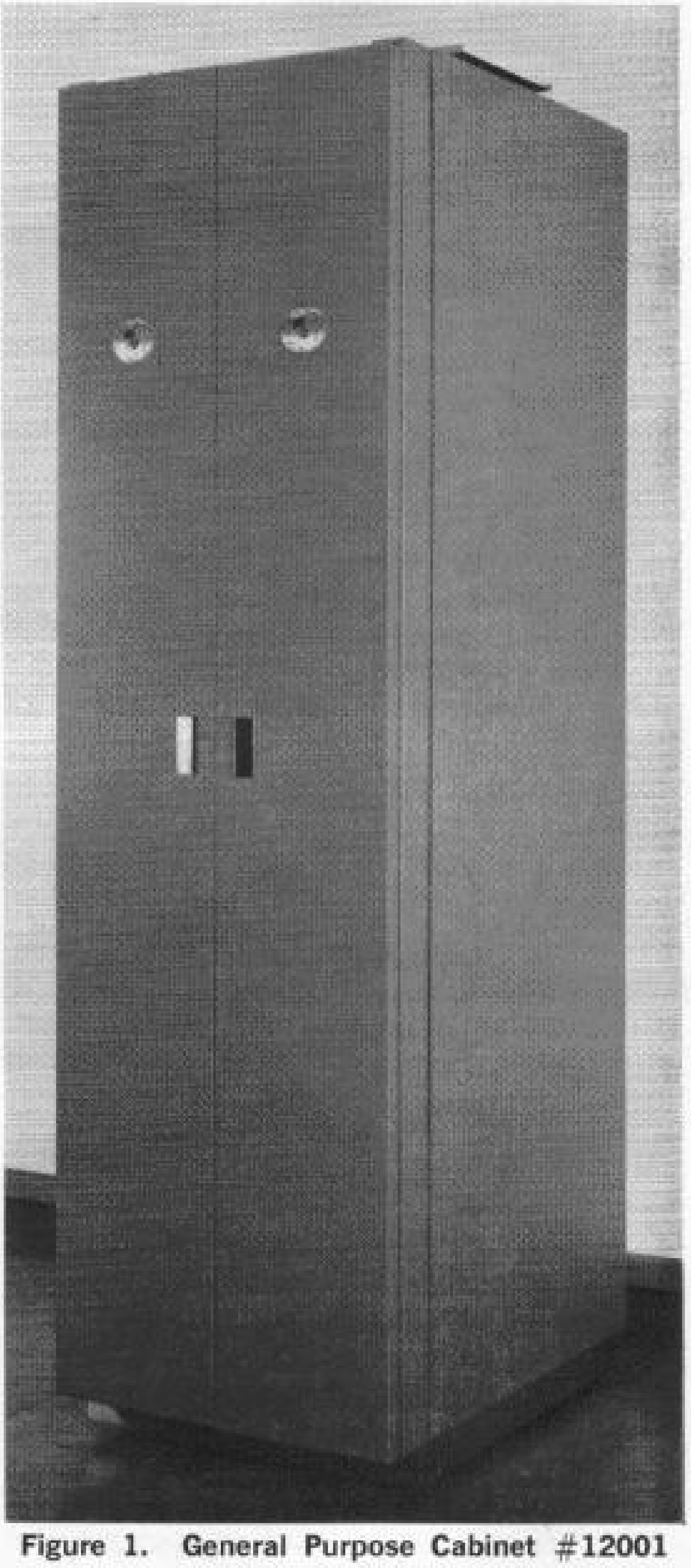


Figure 1. General Purpose Cabinet #12001

Economy in Construction

Economy in construction of the main frame and the design of the applied items of the cabinet were achieved as follows:

a. Main Frame

An all-welded, easily constructed main frame is the basic unit around which the General Purpose Cabinet 12001 is built. It consists of a rectangular shaped frame, held in place by four channel corner-posts, as shown in Figure 3. All parts of the main frame are firmly joined, square and level. Any sheet metal shop could manufacture the frame from this design, at a very nominal tooling cost.

b. Doors

In some cases, such as multiple unit installations, it may be advisable to install these cabinets without front doors. Doors may readily be added, when desired, because the doors are hinged on removable brackets, mounted to the inside of the corner posts. The doors are firmly held in place by magnetic latches, fastened to the top and bottom frame.

c. Lift Off Panels

Two types of "lift off" panels for the rear of the cabinet may be used. One type is flush with the frame, while the other extends rearward to provide additional space for terminal blocks.

d. Side Panels

Side Panels are constructed for left-hand or right-hand mounting, to make for greater economy in construction, handling and storage.

e. Rack Mounting Angles

The material for these angles is furnished as flat plates, cut to the exact size required. The 77 holes may be punched in only three operations by gang punches. Only a few seconds are required for tapping out each of the mounting holes. The steel flats are formed into angles in a power brake after punching and tapping out the holes.

f. Power Wire Troughs

Power wires in armored cable are brought into a top plate and to the base of the cabinet via the channels. The power troughs, including mounting holes for receptacles, are uniform in design. This makes for maximum economy in construction.

g. Signal Wire Troughs

These troughs have protective eyelet holes which permit wires to terminate in connectors and engage plugs in the chassis, panels or shelves. Left and right-hand wire troughs with covers are interchangeable.

h. Terminal Blocks and Wire Tie Bars

Various arrangements of terminal blocks and tie bars have been designed as frame assemblies and fastened in place in the hat-shaped horizontal braces.

i. Top and Bottom Panels

Provisions for mounting all items listed above were made in the top and base frames, in mounting angles and in hat-shape braces. This eliminates the necessity for making special drillings.

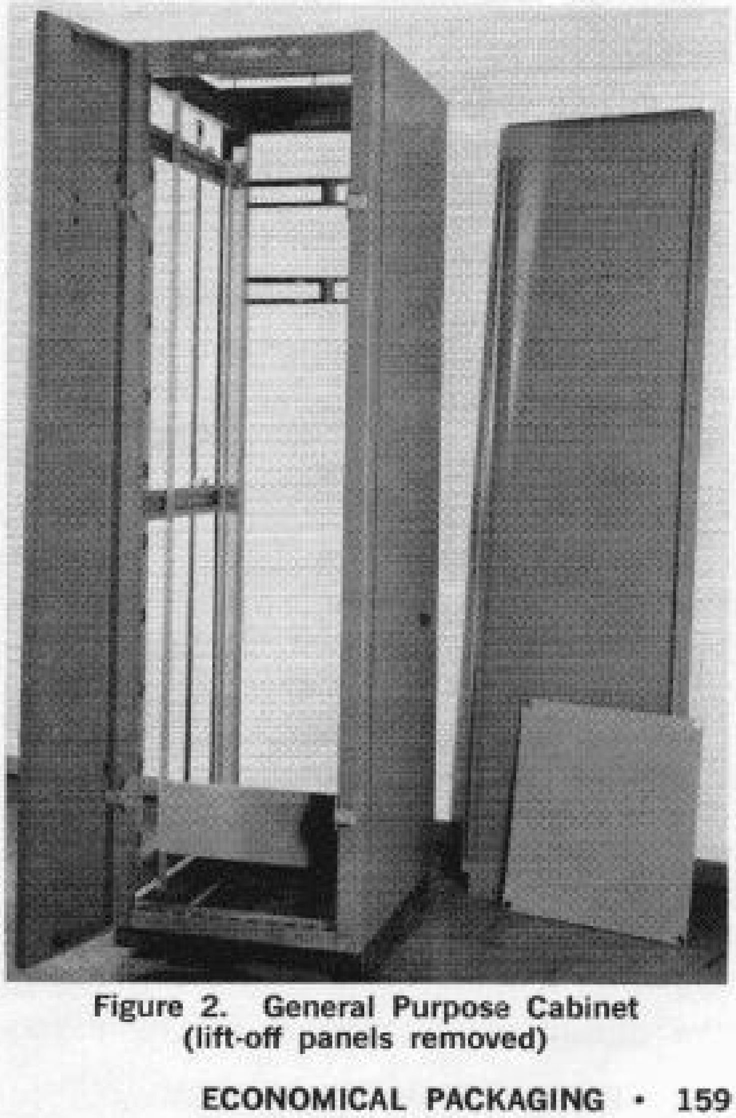


Figure 2. General Purpose Cabinet (lift-off panels removed)

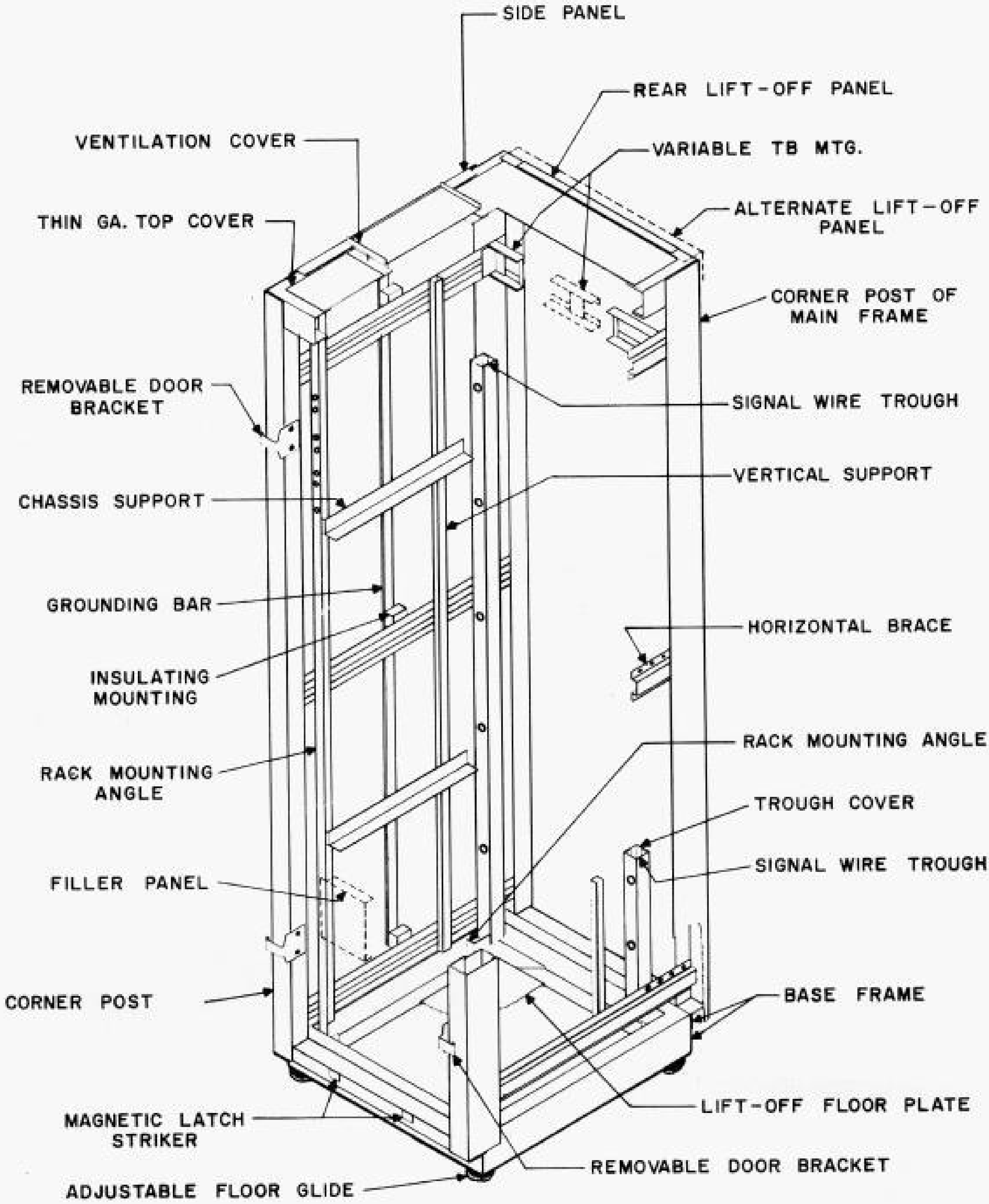


Figure 3. Cutaway View of General Purpose Cabinet

Figure 3 is a cutaway view of the cabinet. It illustrates some of the features of the design which provide the necessary flexibility for efficient operation.

This illustration designates the component parts of the cabinet after assembly.

Assembly of Units in Cabinet

The 44 rack-mounting spaces are stencilled on the rack mounting angles or channels at spaced intervals. This will allow a chassis or panel to be shown in a block diagram without dimensions or scale drawing. Chassis "X," for example, may be identified by its item number followed, by its space numbers in parenthesis. Chassis "X" may be called item 123 (14-17) where 123 is the item number and (14-17) indicates that it is mounted in spaces No. 14 to 17. Blank panels are available to fill any or all unused spaces.

The 21 mounting holes in the horizontal hat-shaped braces are stencilled at spaced intervals. This allows the location of vertically mounted items to be listed with the number of the mounting holes in parenthesis on a block diagram without dimensions or scale drawings. Items such as power channels, rear chassis supports, ground bars, signal wire troughs and terminal block mountings are shown in Figure 3.

Installation

An individual unit, General Purpose Cabinet may be fastened to the floor, when necessary, by means of floor glides used in conjunction with the fastenings. These floor glides hold the unit level and firm. They also provide added ventilation.

As mentioned previously, the cabinets may be installed in rows. In some cases side panels may be desirable to shield one set of chassis from the adjacent set. However, they may be omitted between adjacent units and installed only at each end of the row. In the latter case, the cabinets are bolted together at the top frame and base frame to maintain alignment. Floor fastenings should be made under every 2nd or 3rd cabinet, to prevent the cabinets from being shifted out of alignment when equipment is being maintained. In those types of installation, where visual checks or adjustments of the equipments are periodically necessary, the cabinets may serve as racks, without front doors. Doors, however, are desirable on the rear, when access space permits. Otherwise lift-off panels will generally be advisable.

Advantages of Design

This cabinet was designed seven feet high to provide for maximum rack mounting needs in AUTODIN and modern installations. The basic design may be used for smaller general purpose cabinets. The existing general purpose cabinet has the advantages of lower first cost, availability on short notice, ease of assembly, wiring and installation as well as flexibility in application.

* * * *

Acknowledgement

The author is indebted to members of the production, engineering and shop forces of the Chattanooga Works for valuable assistance in the development of a cabinet framework design in accordance with practical manufacturing procedures.

Mr. Paul J. Birkmeyer, Senior Engineer in the Information Systems and Services Department, is responsible for the design of consoles, cabinets, racks and other enclosures, for packaging electronic equipment in the Technical Control area of AUTODIN centers and outstations. This assignment followed similar experiences in the offices of the Central Office, Apparatus, Planning, Facsimile Applications, Electronic Applications and Patron Systems Engineers.

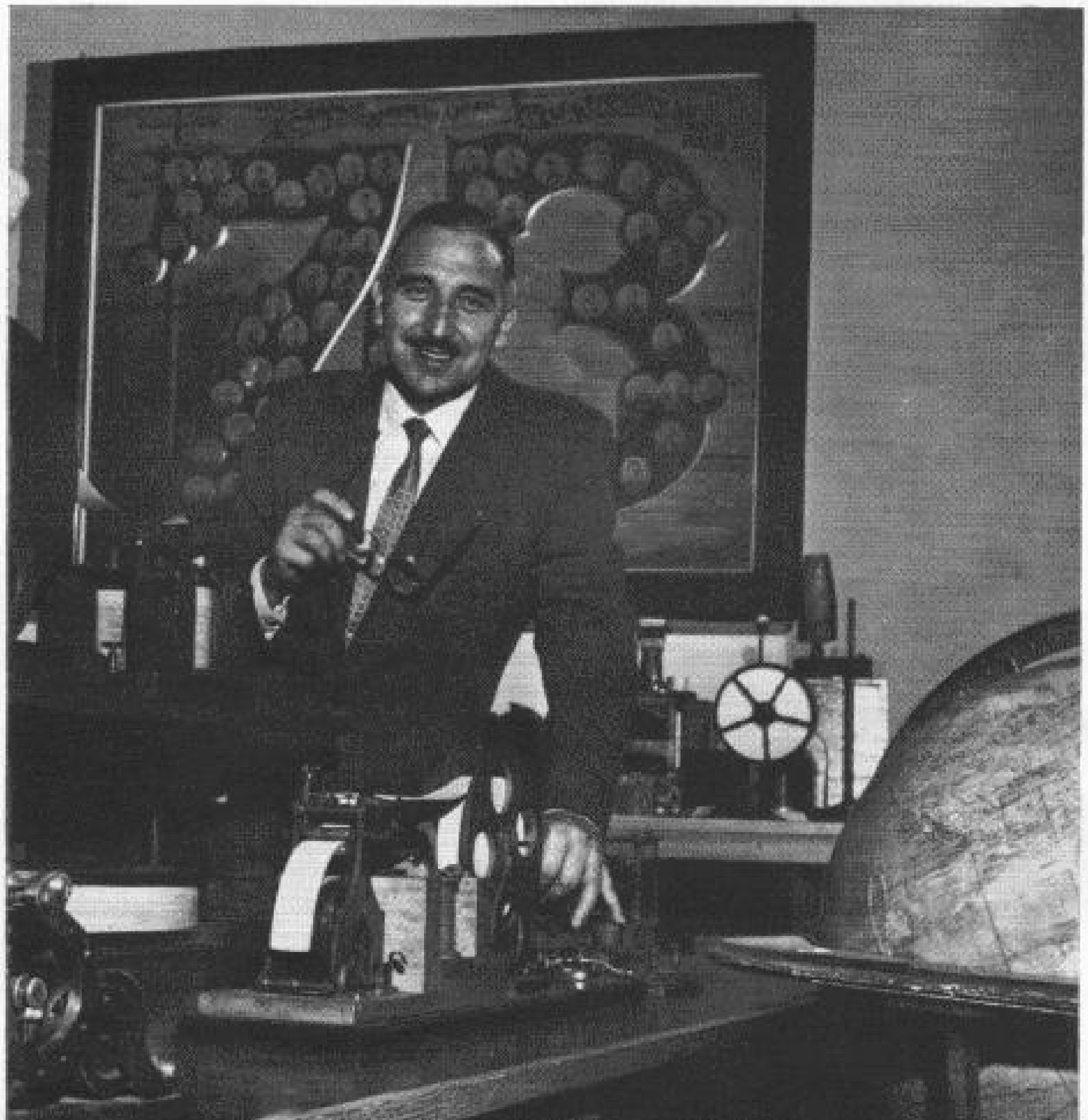
He received his Bachelor of Electrical Engineering degree from Ohio State University in 1923. He holds a registered Professional Engineer's license in the state of New York.

Mr. Birkmeyer has received a number of awards for packaging in several national design contests.

J. E. Stebner, Curator of Museum—Information Systems and Services Dept.

Western Union Museum

The Western Union Museum had its beginning at 195 Broadway in 1912 and is now located on the mezzanine at Western Union headquarters. Mr. H. W. Drake, Equipment Engineer, at the time, had planned to set aside old telegraph equipment for reference purposes. Having acquired a small collection of such antiquated equipment, he exhibited his first modest collection in December 1915, in a cabinet that had previously housed exhibits at the Columbian Exposition in 1892. Today, the Western Union Museum covers approximately 7000 square feet of space and is considered one of the most complete collections of telegraphic history in the U.S. There are over two thousand items in the collection.



"73" in the above picture hanging on the wall of the Museum, symbolizes "Best Regards" of a group of telegraphers in the Cleveland, Ohio Office of Western Union in 1889. It is the telegraphers and the engineers who have donated much of the equipment now on exhibit in the Museum at Western Union Headquarters.

Morse "Picture Frame" Instrument

While returning from Europe aboard the packet ship "Sully," late in 1832, Samuel F. B. Morse, a noted painter joined in some lively discussions about electricity and magnetism with fellow passengers. Morse had been interested in this subject and had attended lectures at Columbia College. As a result of these discussions Morse conceived the idea of an electric telegraph. He made sketches of his first instrument and devised a code of dots and dashes for transmitting intelligence before the ship reached New York.

A replica of this device, shown in Figure 1, is in our Museum, the original was donated to the Smithsonian Institution in Washington, D.C., in 1900.

This device is called the Morse "picture frame" instrument. A frame from one of his canvasses was erected on the edge of a table. An electromagnet was attached at the bottom of the frame; suspended from the upper part of the frame was a triangular device for holding a pencil and an armature. A paper strip was arranged to move over a roller and under the pencil at a uniform rate by a clock mechanism. A small weight attached to the pencil holder enabled the armature to move away from the magnet when the electrical circuit was opened and to move back to the magnet when the circuit was closed. Short or long marks were recorded on the paper tape in response to the remote signalling. Transmission was accomplished semi-automatically by use of the device shown in Figure 1. Letters of the Morse code were cut out and set in the form of type in a holding device. This set type was driven by a hand cranked belt, under a lever which responded to the coded letters. At the other end of the lever contacts opened and closed in response to its movement. This device was not demonstrated publicly until 1837. Although it received the endorsement of the Franklin Institute in Philadelphia, adverse newspaper publicity had caused public rejection.

It was at this time that Alfred Vail made a chance visit to Professor Morse and succeeded in securing some financial aid for their further development.

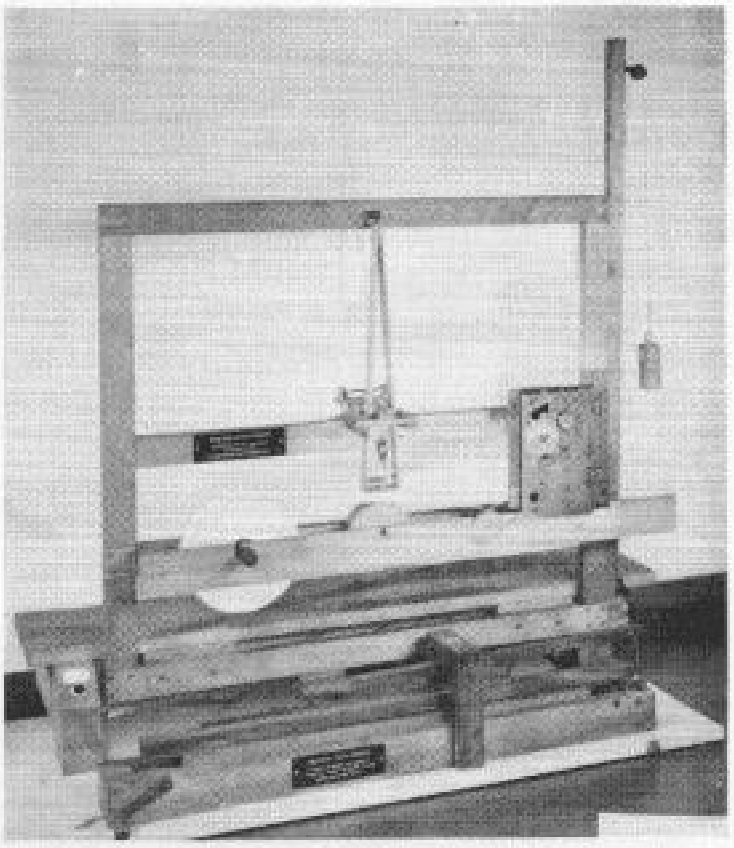


Figure 1. Morse Picture Frame Instrument

Register

With this financial aid and the mechanical skills of Mr. Vail, another device called the Register was constructed and tested. The "Register" was used successfully on May 24, 1844 to send the famous "What hath God wrought" message from the Supreme Court chambers, then in the Capital Building at Washington, D.C., to the Baltimore & Ohio railroad station in Baltimore.

The Western Union Museum has built two replicas of the "Register," one of which is on display in our Museum and shown in Figure 2. The other has been loaned to

Figure 2. Register

various organizations for displays and exhibits all over the world. Prior to the construction of these two replicas, J. Schmid, the former curator, created a model of the original register from the patent drawings of Mr. Morse. This very interesting model has a place of honor in the Museum.

These early devices recorded on paper tape, marks which corresponded to the dots and dashes of the Morse code. These marks were transcribed into the telegraph message from the paper tape. It was not until 1856 that the telegraph operators were discovered transcribing the messages from the sound of the armature of the register striking its stops. Thus the sounder was born.

A few of these early sounders are now exhibited in our collection. Remarkably little change has taken place in this device from those early days to the present time.

Telegraph Keys

Morse gave up the idea of "automatic transmission" of messages when he designed the Register. A telegraph key was substituted. A large collection of over 100 keys, covering the period from the early days of telegraphy to the present time, are now on display. Among these are a silver key used by President Grant and a Japanese key from the Nagasaki R.R. station recovered after the Atomic explosion in 1945 and many more.

Cables

A large display of underseas cable equipment is shown in a special section of the Museum, devoted to this phase of telegraphy.

Dining Room furniture of Cyrus Field, a donation of William Judson, grandson of Cyrus Field, is exhibited in this section. The discussions and plans of the Atlantic cable were made around this table and the contract for laying the cable was signed thereon.

After the first Atlantic cable was laid, the surplus was bought by Tiffany and Company of New York. This was cut into four inch pieces which were bound at each end, and sold to dealers and interested parties for $25 per 100 pieces. They were retailed for fifty cents each, "so that everyone could participate in this great venture." Twenty miles of this surplus cable was submerged to the bottom of the Atlantic Ocean to make it authentic for souvenir sales. A facsimile of a statement by Cyrus Field, stating that the cable was authentic was furnished with each piece. A number of these pieces are on display.

Equipment used in the operation of the early cable such as mirror galvanometers, the oil lamps and scales used in conjunction with them and other associated devices are also displayed here.

Many other pieces of cable history from the first cable to the first underseas cable repeater which span the years of total cable operation, are exhibited in the Museum.

Thompson Siphon Recorder

A Thompson Siphon Recorder has been refurbished and put in working condition for the Museum. It is currently on loan to the Ford Motor Company. We believe this to be the only one of its kind still in existence in the world. This device, shown in Figure 3, was used to record the transatlantic cable messages in dot-and-dash form, on a paper tape.

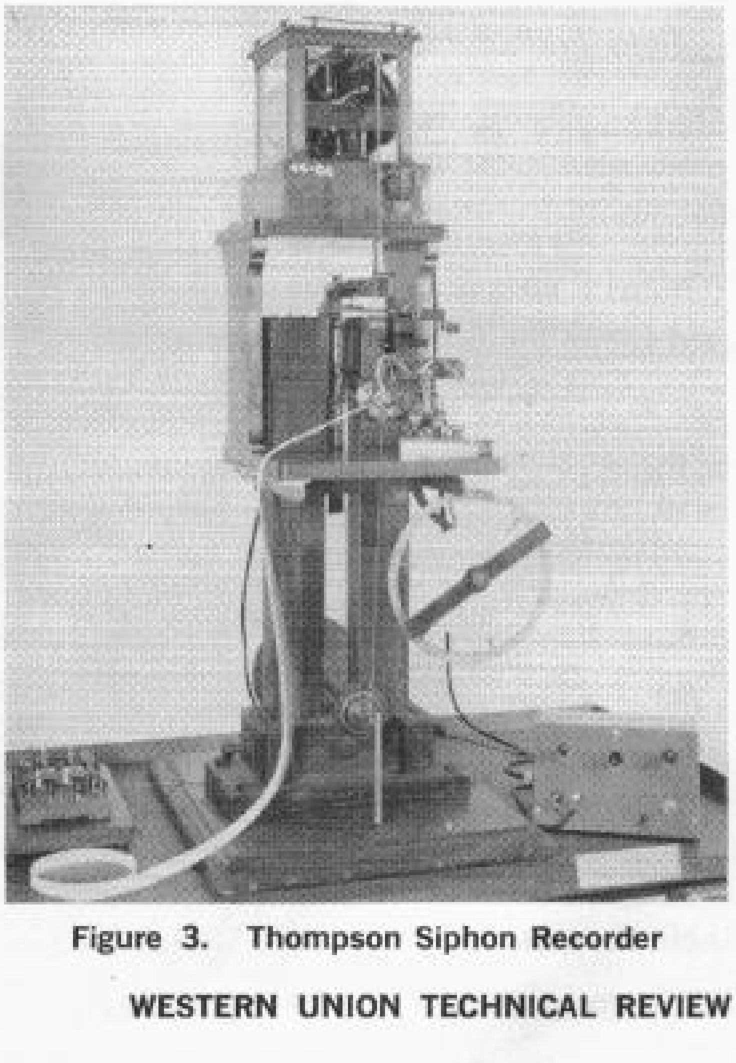


Figure 3. Thompson Siphon Recorder

Russian-American Telegraph

The failure of the first Atlantic cable caused doubts as to whether a cable spanning the ocean was practical. With the successful completion of the transcontinental line the concept of communication with Europe via Alaska and Siberia using a short cable across the Bering Sea was considered. Agreements with the Russian Government to construct part of the Siberian section and with the American company to construct the North American and some of the Asian portions of the line were made. Work was well under way, when in 1866 Cyrus Field laid his third and successful cable. Although this Russian-American telegraph line was partially completed it was abandoned as an intercontinental system.

A piece of the line from this historic venture that was enveloped by the growth of a sapling into a tree is on exhibit. It was recovered in British Columbia. In retrospect this historic venture could not be called a failure. It was through the conferences, in connection with building the line, and the information gained about Alaska during its construction, that Hiram Sibley, President of Western Union, recommended that the territory be purchased by the United States.

In reference to the transcontinental line mentioned above, a few insulators recovered from it are also displayed. Numerous items of this early period of the development of the telegraph are on exhibit.

Printing Telegraph

Morse's first and second telegraph devices were of the recording type, recording dots-and-dashes on paper type. In the year 1846, two years after Morse's successful demonstration and the year in which the telegraph was extended as far as New York, Royal E. House patented a printing telegraph system which could send and receive fifty words a minute in Roman letters instead of dots-and-dashes. A model of House's invention is the earliest of our exhibits of printing telegraph equipment. In the 1930's Western Union developed its own line of printers and printer-perforators.

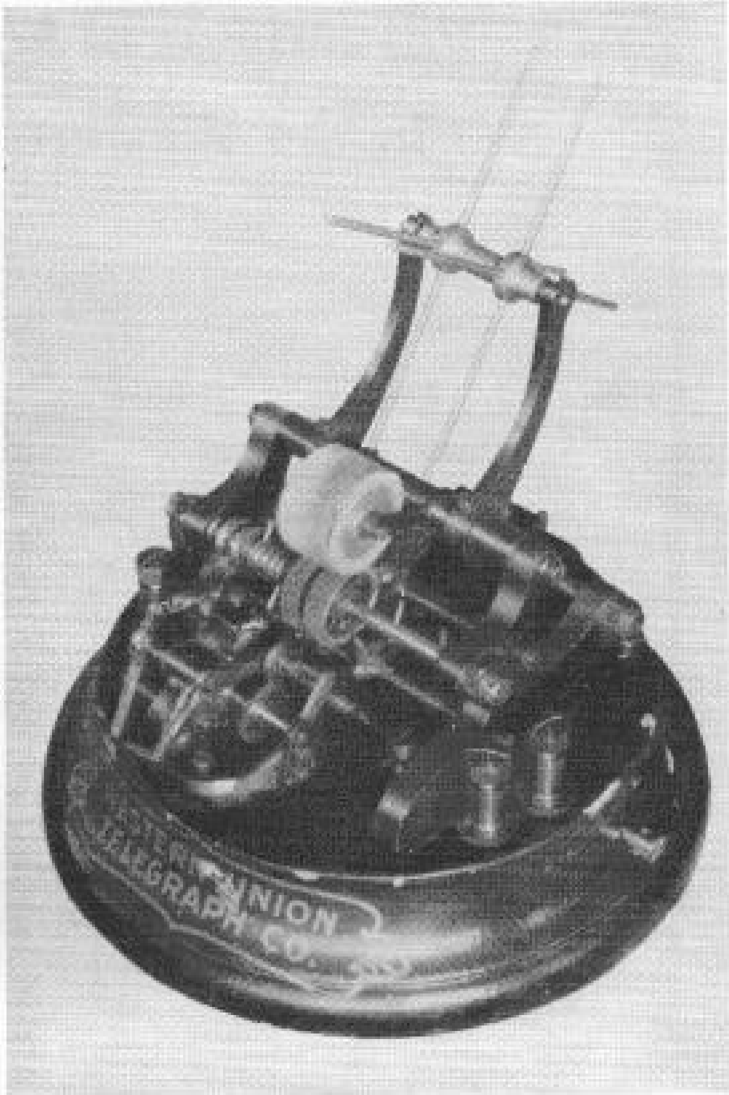


Figure 4. Stock Ticker

Stock Tickers

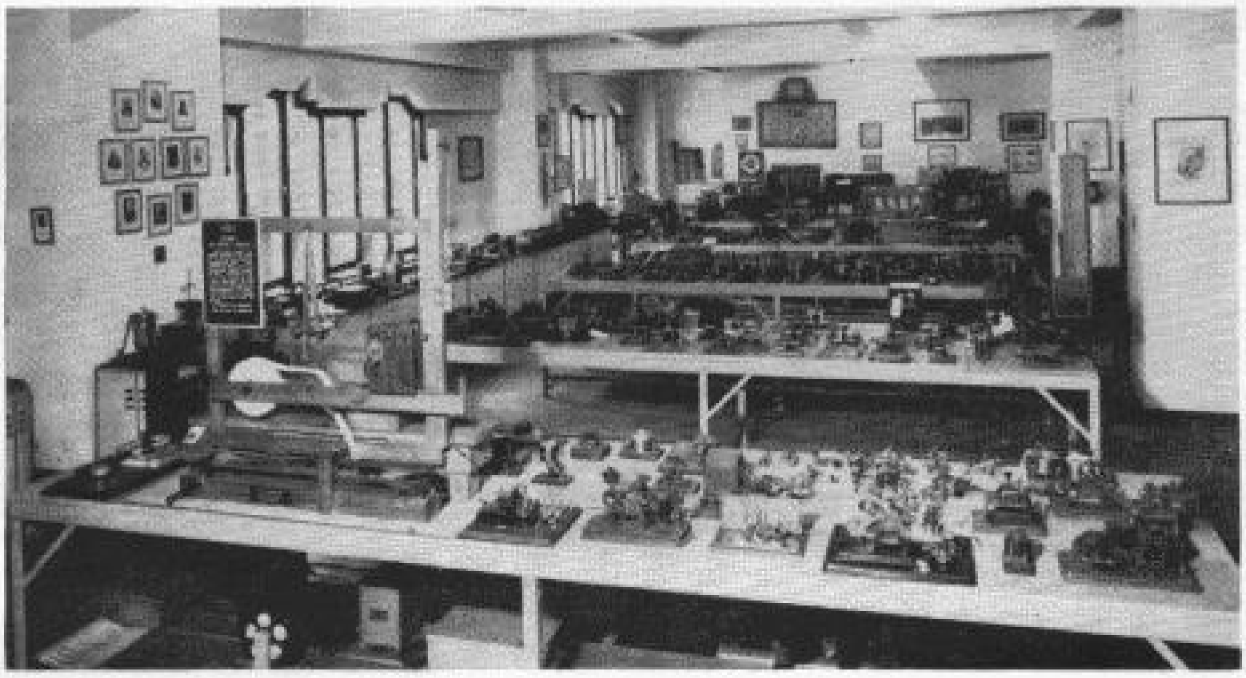
Stock market quotation telegraph equipment, some of which were developed by Thomas A. Edison, are displayed in a section of the Museum devoted to ticker development. A Universal Ticker is shown in Figure 4.

Vacuum Tubes

Early in the development of the vacuum tube, Western Union engineers visualized the possibilities of this electronic device. A number of DeForest tubes are among our valued treasures. Some of these are of the baseless type. The leads for their connections are extended directly through the glass envelope. Others of these tubes have screw type bases for the filiament connections and wire leads for grid and plate connections.

An interesting exhibit of the early days of tube development is the equipment used by Major Armstrong in his invention of the regenerative circuit in 1912. It was donated to our Museum by his estate.

Views of Some Displays In the Western Union Museum



Facsimile

In another section, our Facsimile telegraph history is recorded from the early lathe-bed machines to the present day "Telefax" models. In this exhibit, equipment which was used to transmit photographs from London to New York are shown. A brochure of photographs received on these machines make an interesting addition to the history of that era.

The model of the original "Desk Fax" using a fruit juice can is shown in Figure 5. It was assembled in the basement work shop of its inventor. The complete evolution of the development of the "Desk Fax" is exhibited.

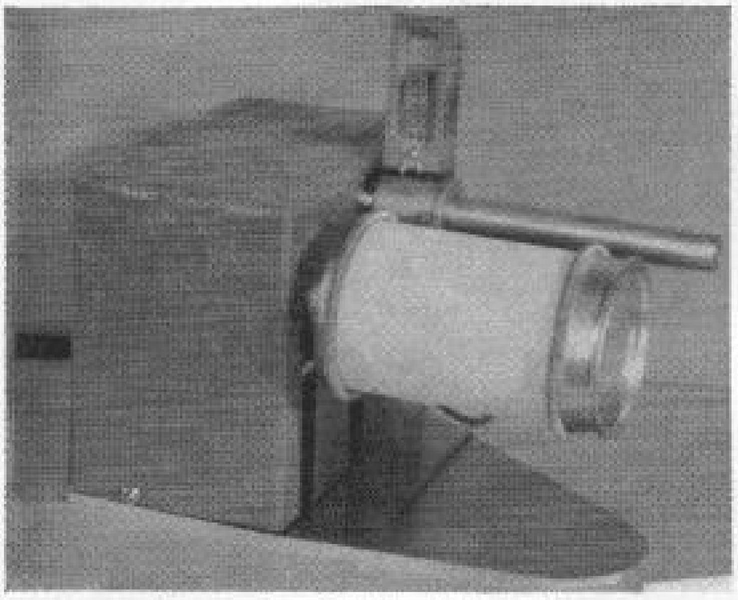


Figure 5. Original Desk Fax

Switchboard

One of the largest single pieces of equipment on exhibit is an 80-spring-jack peg-type switchboard from Pueblo, Colorado circa 1880. This switchboard made of oak, about 8 ft. high and 10 ft. long and about 4 ft. deep, was shipped to us intact. It had to be dismantled to transport it from our receiving platform to the Museum space and then reassembled for exhibit.

Smaller Exhibits

Two of the smallest items is a "subminiature diode" used in present day telegraph circuitry, and an old door knob. This is a very special door knob from a conference room in the Reynolds Arcade Building in Rochester, New York where the Western Union Telegraph Company was founded.

Photographs, documents, books, papers and many other items that make up our vast collection are cataloged. A card file, giving a short history and reference number for each piece, plus the name of the donor as well as other pertinent information is kept by the Curator.

Loans and Tours

While the era of Dot-Dash Telegraphy is now only history, it may be interesting to note that telegraphy opened the door to new paths in the young science of electricity and led to later developments in telephone, radio, television and the whole electronic era of today, including Satellite Communications.

Parts of the collection have been loaned to other museums for special occasions and exhibits. Some pieces have been used in movies and TV shows, as well as for our own reference.

The Curator is available to conduct a tour of interested employees or others through the Museum on appointment. The education of those unfamiliar with the heritage of Western Union and our early developments in the Telegraph art is a basic function of the Western Union Museum.

Mr. J. E. Stebner, Project Engineer, Data Systems Division, Information Systems & Services Dept. was appointed Curator of the Western Union Museum in 1962. He has been responsible for securing additional exhibits, for loans of equipment to other museums and exhibitions, all necessary cataloging of the exhibits and for conducting tours of the Museum.

He joined Western Union Telegraph Company as an Equipmentman in 1929. Upon graduation from Pratt Institute in 1943 he was transferred to the Engineering Department and was assigned to the Switching Systems Division where he was associated with the development of switching systems for Plan 20 through Plan 301.

Data Cards
Printing Techniques
Data Processing
Quality Control

Fisher, W. H. and Calderone, F. J.: Conductive Printing of Mark-Sense Data Cards

Western Union TECHNICAL REVIEW, Vol. 19, No. 4 (October 1965)
pp. 130 to 141

Western Union's conductively-printed, Mark-Sense Data cards have been designed for a vast number of applications in the automation of information collection at the data source. The card is used in the Western Union Data Card Transmitter for transmission of information and data over a telegraph circuit.

This article describes the principles of this unique card design, the printing ink used, the art work, and plate making as well as the various printing techniques used. The Quality Control measures taken to insure reliability and accuracy of the cards are included.

Switching Systems
Broadband Switching
Traffic

Sinnave, J. A.:
Broadband Switching Centers for Broadband Exchange Service

Western Union TECHNICAL REVIEW, Vol. 19, No. 4 (October 1965)
pp. 142 to 147

The initial phase of the Broadband Exchange Service was made operational in 1964. The network interconnects any 200 more subscribers in 22 different cities across the United States.

This article describes "how a call is made," the specifications for planning the Switching Centers and performance or test results obtained before these centers were turned over to traffic.

Future expansion of the Broadband Exchange Service is outlined.

Optical Systems
Data Processing
Character Recognition

Deibert, C. R. and Turner, F. T.: Optical Character Reader

Western Union TECHNICAL REVIEW, Vol. 19, No. 4 (October 1965)
pp. 148 to 155

The Optical Character Reader was designed by Western Union as a low-cost, slow-speed reader which meets the requirements of the telegraph industry. It has many applications in the data processing field as well.

This article describes the principles of operation of the machine and the accuracy it has achieved. The new low-speed, low-cost machine will achieve accuracies quite comparable with those reported for the higher priced units.

Announcements
Information Processing

McFall, R. W.: Western Union in the Information Explosion

Western Union TECHNICAL REVIEW, Vol. No. 19, No. 4 (October 1965)
pp. 156 to 157

This is a reprint of an address to the Columbia Graduate School of Business at Columbia University describing the information revolution and its relationship to the telecommunication field.

Western Union is playing a key role in the information revolution to meet tomorrows communications needs.

Cabinets
Equipment

Birkmeyer, P. J.: Economical Packaging

Western Union TECHNICAL REVIEW, Vol. 19, No. 4 (October 1965)
pp. 158 to 161

A General Purpose Cabinet was designed by Western Union to standardize their many types of packaging requirements. The economy in constructing such a cabinet is pointed out in this article.

This 2-door unit is extremely flexible and can be adapted to single or multiple installations. It provides for maximum rack mounting needs.

Museum
Telegraph History
Facilities

Stebner, J. E.: Western Union Museum

Western Union TECHNICAL REVIEW, Vol. 19, No. 4 (October 1965)
pp. 162 to 167

The Western Union Museum had its beginning in 1912 and since then has acquired a vast collection of old equipment associated with the history of the telegraph art and Western Union. Over 2,000 units of such unique equipment are assembled in the Museum at Western Union Headquarters.

This article describes some of the novel displays and relates the circumstances surrounding their use and acquisition.

The Museum Curator conducts tours of the displays and arranges loans of some equipment for special events.

THESE ABSTRACT CARDS MAY BE CUT OUT AND PASTED ON LIBRARY CARDS FOR FILING.

TWO YEAR INDEX

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Switching Systems

Telegraph Equipment

Telex

Miscellaneous

AUTHOR INDEX

Patents Recently Allowed

Telegraph Signal Display Device
W. V. JOHNSON, A. V. SCIMECA
3,170,989—FEB. 23, 1965

A device for the inspection, adjustment and repair of automatic telegraph code transmitting and receiving equipment. It consists of a rotating indicator lamp assembly propelled by a constant speed motor coupled to a variable speed friction drive having infinitesimal adjustment capabilities within the desired speed range of interest. The variable speed is obtained by movement of the rotating shaft laterally across the face of a cone so as to rotate the cone at speeds proportional to the radius of its contact point to the center of the cone. This type of friction drive minimizes wear to provide longer maintenance-free operation of the device.

Tape Crimper
O. W. SWENSON
3,185,764—MAY 25, 1965

A device for overcoming tape snarls which occur when perforated tape is pushed into a storage container. The tape crimper imparts to the tape a longitudinal crimp which makes the tape rigid and thereby renders it less susceptible to snarls. It also avoids the loss of a broken tape end in the storage bin and is capable of supplying a tape tie up alarm signal adapted to simple detection equipment. Speeds of up to 200 words per minute are obtainable.

Network Repeater
H. C. LIKEL
3,185,766—MAY 25, 1965

A transistorized network repeater module which is small in size, light in weight, economical to build and affords a reliable and improved mode of operation. The repeater may be inserted or removed from a circuit containing other network repeaters without requiring circuit adjustments to maintain network stability. Also incorporated into this repeater network is a novel circuit which prevents revertive transmission. An overall configuration of a repeater system employing a number of these networks interconnected, would consist of a common hub or drive amplifier whose input is connected to a set of series connected transistors and whose output feeds a set of parallel connected output networks.

Telegraph Signal Bias and Distortion Meter
W. D. CANNON, D. J. BERTUCCIO
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An indicating device for measuring bias and distortion present in permutation code telegraph signals and distortion present in high speed marking and spacing data signals. This device can indicate simultaneously both bias distortion and distortion other than bias distortion for signals of all unit lengths. A frequency which provides sixty four cycles per bit length is generated to measure the desired pulse length of the signal. If there is spacing bias present the count transferred to the storage section will be sixty four plus an amount which represents the degree of spacing bias and if there is marking bias present the count transferred will be sixty four minus an amount which represents the degree of marking bias. When there is no bias the count transferred will be exactly sixty four. Measured distortion (other than bias) indicates the differential between the average pulse length and the shortest pulse length in a wavetrain.