WESTERN UNION
Technical Review

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Facsimile and Its Place in Telegraphy

P. J. HOWE

Recent developments by various laboratories of facilities for transmitting facsimile reproductions of printed and written copy, drawings, maps, etc., have given rise to much speculation as to the applications which such developments will have in industry and particularly in the record communication business.

In Western Union's reperforator switching program which is now approaching completion, 15 area centers, all interconnected by fast automatically operated circuits, will directly serve nearly every sizeable community in the United States. There will be but two, and in many cases only one interchange of messages between the terminal cities, and these will be handled in the switching centers by either push-button or automatic switching. The most recently installed offices incorporate automatic switching to trunks from branch and tributary offices, and push-button switching in the reverse direction. As each new office is placed in service, another increment is added to the overall transmission speed of telegrams. Completion of the program is confidently expected to give all that can be desired with respect to intercity transmission.

Terminal Handlings

With this modern system of switching centers and interconnecting network of automatically operated trunk circuits, the transmission time for a message to flash between the most widely separated "area centers" in the country is only a matter of seconds. Obviously the next consideration involves getting the patron's messages into this telegraph system quickly at points of origin, and then getting them out again at points of destination to the parties for whom they are intended. This is now the link in the chain of telegraph operations on which research is being concentrated. It is the remaining operation which presently is most dependent on human effort, and represents a large share of the Company's operating expense.

In order to provide direct service to the greatest number of people, an electrically operated device for installation on patrons' premises must be made available, which will be very simple and low in cost, yet capable of producing good, readable, permanent copy. Teleprinters have been extensively employed in business offices for this purpose. They have the distinct advantage of being operable directly from the perforated tape on which incoming messages are recorded in a reperforator office. However, teleprinters are complex and costly, and for that reason they do not lend themselves readily to a program of expansion to low volume users.

Facsimile

Facsimile operation offers the greatest promise as a means for serving the general public on a broad scale. Transmission and recording by facsimile are simpler, fundamentally, than by teleprinters and facsimile machines are much easier for the average person to use. The telefax developments described in this and other issues of the TECHNICAL REVIEW represents, therefore, only the beginning of what portends a new day in telegraphy.

In discussing the future of facsimile operation at terminals, it is necessary to consider carefully the relationship of facsimile to the existing trunk network of printer-operated circuits which interconnects the terminating offices. Switching centers throughout the country, and the printer circuits which connect them with each other and with terminating and tributary offices, are operated by a code transmission. Every message must first be converted into this code, manually, on a keyboard similar to that of a typewriter.

Facsimile transmission and reception, on the other hand, are automatic, right from the start, and are accomplished through a process in which the written message is "read" by the transmitter and transmitted by means of a band of frequencies which are varied according to the variations in light and dark areas on the copy.

Simultaneous utilization of these two fundamentally different forms of transmission gives rise to message handling problems at the terminal offices, where messages must be interchanged between patrons' facsimile circuits and code-operated trunk circuits. Message transfer from trunk circuits to facsimile is simple, because the received printer copy of a message can be scanned and converted into facsimile signals automatically by facsimile transmitters. In the reverse direction, however, the message which has been received by facsimile must be converted into printer code by a keyboard process before retransmission. To what extent this "originating" operation may be modified or eliminated by future engineering developments remains to be seen.

Two of the developments now in process of commercial application are the Deskfax patrons' transceiver described in this issue of the REVIEW, and the associated central office equipment which will be discussed in a subsequent issue. The latter consists of continuous type recorders, automatic transmitters, and concentrators by which the patrons' service can be most efficiently operated. In the new central office recorders, Teledeltos recording paper is fed continuously from a roll, as the recording proceeds, and the messages are removed separately as rapidly as completed. The transmitter is a vertical drum type which accepts copy of telegram size, and transmits automatically. The copy will ordinarily be the original copy as received by teleprinter—either page or gummed-down tape—but also may be typewriting or handwriting. Concentrators for telefax service may be operated either manually or automatically but undoubtedly, as the service grows, central office recorders, ready to operate, will be connected automatically to patron lines whenever the patrons signal that they have messages to transmit.

The same types of transmitter and continuous recorder will also be used for operation outside the central office, whenever the volume of traffic is greater than can be handled expeditiously by the Deskfax transceiver. A combined installation of slot type automatic transmitter and continuous recorder is presently in operation in one of the large hotels in Washington, D.C. Similar equipment may be expected to become standard for broad scale use in hotels, agencies, office buildings, branches and numerous other points where telegrams may be sent and received, and thus will form the means by which better telegraph service will become more conveniently available to more and more people throughout the country.

The delivery of telegrams to people who do not have service media in the form of telefax, teleprinter, public telephone or other direct connecting devices will continue in the foreseeable future to require the services of a messenger. In order to reduce messenger travel to a minimum, it seems probable that unattended continuous type facsimile recorders can be advantageously employed in delivery areas not served by regular offices. Messengers working from stations within such areas should provide quicker delivery than possible when working from a more distant branch or central office. Similar equipment will also be used to serve apartment houses and one such house in New York is soon to be served by a continuous telefax recorder which incorporates an automatic message sealing device. The latter cuts the messages off the roll, as received, and folds and seals them automatically, without envelope, with only the address showing, ready for delivery.

Another approach to the solution of the delivery problem is by means of Telecar—a roving automobile equipped with an automatic, continuous-type telefax recorder, operated by radio from the telegraph central office. A car of this type was in trial service in Baltimore, Md., for upwards of two years, and now, anticipating the required licenses from the

Federal Communications Commission, a fleet of Telecars is being equipped to provide complete coverage in the suburban areas of Baltimore. In this installation, there will be four radio transmitters, located in different parts of the city, all controlled from the central office and each transmitting on its own wave length to the several cars in its respective area, each car being selectively called. Messages will be directed to the individual cars nearest the delivery points, permitting delivery to be made with the greatest promptitude. Depending on the economic results achieved in Baltimore, it seems probable that telecar delivery will take an important place in the future development of telegraph service, particularly in residential areas.

While the foregoing treats largely of telefax machines as already developed, it may truly be said that the field of facsimile has hardly been scratched and that various new types of mechanisms for facsimile transmitting and recording are already in advanced stages of laboratory development. Because of its simplicity of operation and lower cost, as compared with other forms of record communication, telefax will come into extensive use for interdepartmental communication in industry, at the same time affording each department ready access to Western Union for message service to distant points. As usage of facsimile expands and further experience is gained, technological advances in the art will open up new fields for its application, broader by far than any yet explored.

Facsimile Trunk Operation

"Through" operation from patron to patron by facsimile would offer certain service and operating advantages and open new fields of use now closed to any keyboard or oral public message transmission system. Transmission and recording at terminal and relay points could be automatic, once the technical and physical requirements had been met. Limited only by loss of definition where facsimile copy is scanned and retransmitted, there would be no chance of error at any point. Even the possible losses in definition that might occur due to repeated recording and re-scanning can be minimized through the use of magnetic recording for storing and retransmitting the facsimile signals themselves. The development of techniques for facsimile relaying has progressed far in the laboratory, and there is no doubt that the future will find extensive application of such developments.

There have been several obstacles to exploitation of country-wide use of facsimile for general telegraph communication. First, it is only in recent years that the facsimile art has reached a stage of development where it can be considered a practical public message service facility. Secondly, transmission by facsimile requires an increased number of circuit channels or channels having a much wider frequency band width than required for printer operation. Finally, the existing trunk circuit network and switching offices provide such fast automatic transmission between terminating offices that the installation of new circuit facilities for facsimile operation must necessarily be geared to the demand for any such super-service, the additional volume it may be expected to attract, and the all-important consideration of economics. With reference to the second item, the cost of intercity circuit facilities represents only a part of the cost of doing business and hence it is not unlikely that future developments in facsimile will result in a simplification of equipment and operations that will more than offset the cost of increased channel facilities. There is also the possibility that technical developments may improve the relationship between band widths and quantity of intelligence transmitted by facsimile.

A voice frequency circuit with a band width of 3000 cycles will yield one facsimile circuit, capable of transmitting copy at the rate of 14.4 sq. in. per minute. On the basis of normal sized handwriting or typing on the usual sized blanks, this is equivalent roughly to one message per minute. On the other hand, the same 3000-cycle circuit can be split into 20 teleprinter circuits, each capable of handling nearly two messages per minute with automatic transmission. If two-channel multiplex were employed, the capacity would be doubled.

The relationship between the message capacity of facsimile and code-operated circuits holds more or less constant, regardless of the frequency band width used. Western Union's 150,000-cycle carrier system, operated on its 4000-megacycle radio beam, is designed to accommodate 576 teleprinter channels, good for over 1000 messages per minute in each direction, whereas, if employed for facsimile it would yield only 32 3000-cycle facsimile circuits, equivalent to about 32 messages per minute. However, it should be pointed out that even in the brief period of time which has elapsed since this radio beam was engineered, there have been new developments in radio tubes and repeaters and radio terminal systems which make possible, today, a radio beam system with several hundred voice-frequency facsimile circuits. The principles of such a system have already had laboratory trials and system development work is now actively in progress.

It must not be overlooked that the equipment for dividing voice bands into teleprinter and two-channel multiplex is not cheap and that hence, the relative costs of facsimile and printer circuits for handling a given amount of intelligence are not nearly as unfavorable to facsimile as above indicated. Facsimile would have to bring about only a small reduction in equipment and operating expenses, together with an improvement in service, to justify a considerable increase in the overall cost of the communication channels.

Ultrafax and Radio Beams

Recently, there have been demonstrations by the Radio Corporation of America of an ultrafax system which, through the employment of television techniques and a wide-band radio beam, can transmit copy at higher speed than possible by any previously known system. In its public demonstration, ultrafax transmitted over a short distance 445 book pages per minute, a capacity which approximates in round numbers the 1000 telegram per minute capacity of Western Union's teleprinter-operated radio beam. Even though the ultrafax probably used twice as much radio frequency spectrum as the Western Union radio beam, its performance furnishes evidence that the combination of microwave radio and television techniques offers very interesting possibilities. This development, together with the previously mentioned new techniques for providing several hundred facsimile circuits on a radio beam, indicates that the handicap for intercity communication which facsimile has suffered in the past will be largely overcome.

From an operating standpoint, the fundamental difference between the ultrafax and the Telegraph Company's system of code-operated teleprinter circuits is that with ultrafax, the messages transmit seriatim, with a vast amount of traffic concentrated in individual sending and receiving units at the terminals, whereas with teleprinter operation, many telegrams travel simultaneously, side by side, over individual channels which fan out in all directions to the terminating points. This latter system reduces to a minimum the task of collecting large volumes of traffic from various sources for transmission, and subsequently sorting, distributing, and retransmitting the telegrams to their multitudinous destinations, for delivery.

Ultrafax may become valuable for use where large volumes of written or printed copy must be transmitted in a great hurry between two terminal points. At the present time there is no normal demand in commercial telegraphy for any such volume transmission. Any attempt to channel into such a circuit enough commercial telegraph traffic to utilize even reasonably the circuit capacity would, at the present state of the art, immeasurably increase the complexity and cost of concentrating such loads from various origins onto a single circuit, and redistributing them to their various destinations at the receiving terminal.

The fact that Western Union is operating a radio beam system between New York, Philadelphia, Washington and Pittsburgh, and has already installed a television circuit on the beam between New York and Philadelphia, has a direct bearing on the future development of facsimile services. The present beam not only offers potentialities for wide-band circuits for facsimile, but it also, at least in the New York-Philadelphia television circuit, suggests the possibility of applying some of the principles of ultrafax to telegraph message service. Obviously the present beam possesses the properties necessary for ultrafax transmission, so that utilization of the method would depend principally on the development of ways and means for fitting it into an existing telegraph system. It may be that, ultimately, some form or modification of ultrafax will be found to offer over-all advantages in the public message business and hence these possibilities are not being overlooked in the Company's planning for the future.

Conclusions

The foregoing discussion offers an overall picture of the present status of facsimile development in the telegraph business and also some of the major considerations, with both pros and cons, that will govern its future progress. There are still many problems to be solved before the future of facsimile will be completely unfolded, but it seems evident that the technical advances of the past few years are but stepping stones to the day when private and business correspondence by facsimile will become commonplace.

THE AUTHOR: P. J. Howe, Director of Systems Development of the D. & R. Department, came to Western Union in 1910 as an Engineering Assistant, after spending several years in the Engineering Department of the A. T. & T. Co.; he had previously graduated from Stevens Institute of Technology. In 1913 he was appointed Construction Engineer, responsible for outside plant engineering and, later on, for material inspection. While in this position, he organized new engineering groups which subsequently became the Transmission Research, Physical and Chemical Research, and Engineering Personnel Divisions. Mr. Howe became Central Office Engineer in 1934. He had charge of the planning and engineering of the first major reperforator switching installation at Richmond, Va., and the larger switching centers which were installed later at Atlanta, St. Louis and Dallas. He was made Assistant Chief Engineer in 1943, and in 1946 was appointed to his present position. In connection with the Telegraph Centennial in 1944, he co-authored with Vice President d'Humy, the Engineering Society paper "American Telegraphy after 100 Years", and he subsequently compiled for the Company's records a "History of Technical Progress, 1935-45", covering the Western Union engineering developments that led up to the present mechanization program. Mr. Howe became Chairman of the Committee on Technical Publication in 1946 and was largely instrumental in the establishment of TECHNICAL REVIEW.

Electrosensitive Recording Paper for Facsimile Telegraph Apparatus and Graphic Chart Instruments

GROSVENOR HOTCHKISS

AWARD of a Medal for "development of a dry electrosensitive recording blank which can be stored and handled like ordinary paper with practically no deterioration or change and which can be permanently marked by simple means" has been made by The Franklin Institute of the State of Pennsylvania.* This is a brief review of the development so honored, with some comments about a few of the many industrial and scientific instruments in which this electrosensitive paper and modern electrical recording techniques have found application.

This non-electrolytic recording material, which is insensitive to light, not readily marked by heat, unaffected by cold, and impervious to destructive fungus growth and parasitic organisms which were such a serious problem for the armed forces, was developed initially for recording facsimile telegrams. While it is used now for recording over a million telegrams a year, it is employed extensively, also, in graphic chart recording instruments for which it is marketed as a by-product of research of The Western Union Telegraph Company's laboratories under the registered trade name "Teledeltos".

Instantaneous, Dry, Permanent

Basically, Teledeltos is an electrically conductive paper thinly coated with opaque material which provides a light gray surface that instantaneously becomes black at any point where an electric current passes through the composite sheet. Its marking characteristics are such that good half-tone reproduction as well as clear-cut line recording may be obtained. In general, it is suitable for electrical recording over a broad range of speeds and under a wide variety of conditions.

CROSS-SECTION OF TELEDELTOS GREATLY ENLARGED

A—Electrically sensitive coating. B—Paper. C—Aluminum back.

The ability of this recording paper to give optimum performance when dry is significant, not only because it makes possible direct electrical dry recording but also because, in doing so, it contributes greatly to simplification of design and ease of maintenance of recording instruments. Moreover, when Teledeltos is used for technical charts where exact dimensions may be vital, expansion and contraction caused by moisture are negligible.

Beginning in May, 1934, when Western Union research executives decided to develop intensively a facsimile system for the transmission of telegrams, recording processes were explored in detail. Although study was given to photographic methods, and as a result one such process was developed to a practical, commercial stage and used successfully for transatlantic cablephoto transmission,[1] efforts to adapt photographic methods to landline telegraph service soon were abandoned because available photographic processes were both slow and comparatively costly.

Other experiments were made with percussion recording on wax-coated paper.

*Announcement of award appeared in Western Union TECHNICAL REVIEW, Vol. 2, No. 4, October 1948, page 176.

with heat-sensitive chemicals, and with hot air jet recording methods. Further research centered on contact stylus recording schemes with chemically treated wet papers. In this there was some familiarity with the prior art because chemical tape recorders had been used in telegraphy

Cablephoto film recorder was designed for Western Union's transatlantic picture service

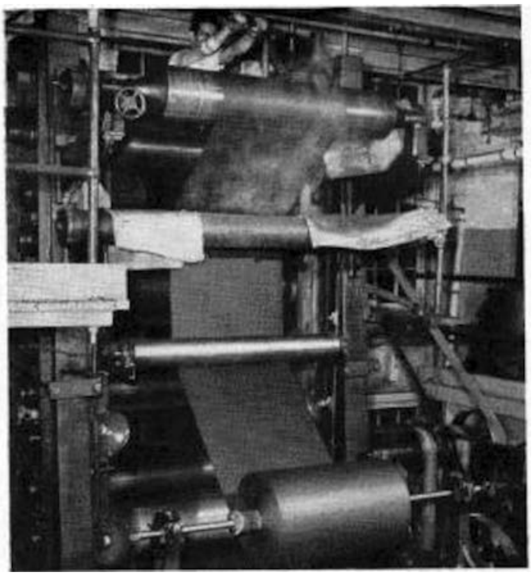
for many years and Western Union's transmission testing machine then employed a method of chemical recording.[2] Although results did not meet the requirements of commercial telegraphy, advances were made, nevertheless, and a number of patents involving electrolytic action have been issued to Western Union research investigators in this branch of the telegraph art.[3]

Realization of how valuable a dry electrosensitive recording paper would be in overcoming the difficulties associated with electrolytic and other materials and methods was one important outcome of all this experimentation. As a result it was decided to re-examine every possibility in the field of dry electrical recording.

In the course of the ensuing investigation, conductive paper was coated with innumerable compounds of great variety. Among the many coatings tested, one, in comparison with the rest, gave decidedly superior records. This was essentially vermilion printing ink which, on analysis, was shown to be pigmented with mercuric sulphide, an allotropic compound having, like carbon, the ability to exist in two different forms. In this case red mercuric sulphide was changed to black mercuric sulphide by the recording currents and excellent message reproduction was obtained at a stylus speed over the paper of about 24 inches per second, a rate sufficiently fast for telegraphy. With some other materials, however, it was found that recordings were produced primarily by blasting off the coating. Apparently, the passage of current produced forces which were electrostatic, electromagnetic, mechanistic and thermal, so that a chemical or allotropic color change was not always essential for marking. It has been shown, however, to be an important factor which assures superior definition of line.

Development of a new coating which has replaced the original vermilion, resulted in simplification of processing and permitted speedy, large-scale production. The improved paper has a light gray surface. To provide flexibility for its use with many different electrical recording circuits, Teledeltos now is made in two types designated "H" for high electrical resistance and "L" for low electrical resistance. Refinements of formulation, of materials, and of processing techniques have been continuous, with further improvements in prospect.

Manipulation of beater rolls governs fiber length and dispersion of conductive material



Supercalendar steams and presses black paper for correct resistance and smooth surface

Electrical Characteristics

Electrical characteristics of the finished product depend in large measure upon the use of high quality fibers or pulp, the proper degree of "beating", and the retention and uniform dispersion in the paper stock of a correct amount of conducting material for the type of Teledeltos being manufactured.

Marking current may be alternating or direct, of either positive or negative polarity, and may be applied to the electrosensitive coating by means of a metal stylus such as a steel wire 5 to 15 mils in diameter in a circuit completed through a metal platen or cylinder underneath the Teledeltos. When direct current is used, best results usually are obtained with a positive stylus. The potential required is a function of the speed at which the stylus moves over the Teledeltos. At comparatively low speeds, one inch per second for example, distinct marking is obtained on type L paper with either alternating or direct current at 110 volts applied through a current limiting resistance of 6,000 to 10,000 ohms to give some 10 to 20 milliamperes. On the other hand, with relative motion between stylus and recording paper 24 inches per second and above, the open circuit potential should be at least 200 volts and the current through the Teledeltos should be from 15 to 30 milliamperes to produce marks of maximum contrast. With single-phase 50- or 60-cycle alternating current, a uniformly broken line is recorded since the potential passes through a zero value during each cycle. At higher frequencies or low recording speed the line appears unbroken. Good test records have been made at 350 inches per second. With proper circuit characteristics and with stylus or paper travel suitably adjusted, marks representing one ten-thousandth of a second can be recorded readily.

The degree to which voltage and current requirements for satisfactory marking depend upon the relative motion between the stylus and the Teledeltos is indicated in the accompanying Table, prepared by C. E. Mobius and W. N. Engler, for speeds from 0.1 to 2800 inches per minute. Voltage drop shown there is that from the stylus to the metal platen, and current is that required to produce a continuous mark or line of good intensity. The data for this Table were obtained with a stylus 10 mils in diameter, a stylus pressure of 15 grams and alternating current at 2,500 cycles. To control the mark-

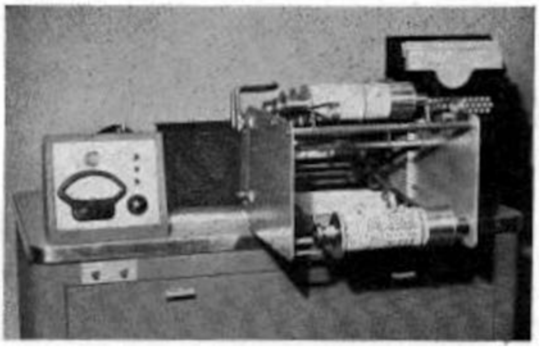
Electrical tests are made during production. Note unfinished stock rolls in background

Voltage and Current Requirements for Various Stylus Speeds

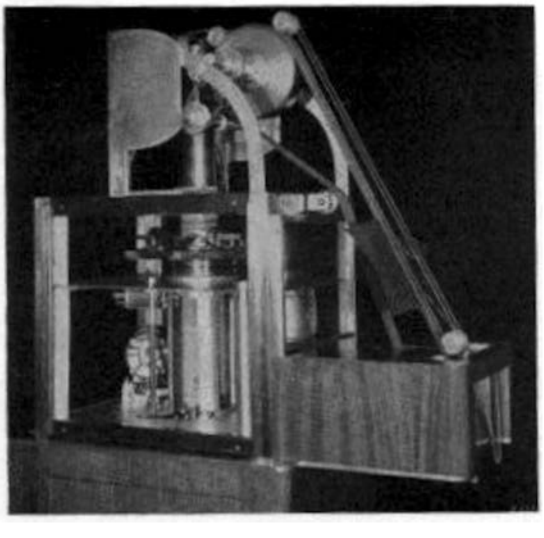
Recording Speed Inches per Minute	Low Resistance Teledeltos Type L (39) Milli-amperes	Voltage Drop	Open Circuit Voltage	High Resistance Teledeltos Type H (39) Milli-amperes	Voltage Drop	Open Circuit Voltage
0.1	10	20	45		(Not suitable)	
1.4	10-15	25	50	5	80	145
140	10-25	30-50	55	5-10	100-130	175
700	15-30	70-100	110	10-15	175-205	275
1400	15-30	80-115	200	10-20	230-325	350
1750	15-30	100-130	215	10-20	275-370	420
2800	15-30	100-140	220	10-20	275-380	440

ing current, it is recommended that the supply voltage be in excess of the open circuit voltages indicated and that suitable resistances be used in the stylus circuit to limit the current to the minimum required for satisfactory marking as, otherwise, excessive burning and an accumulation of carbon at the stylus may occur.

High-frequency signals may be applied directly to the stylus and platen. If an amplifier is used, best results are obtained when the output transformer provides an approximate impedance match to the recording paper. Such an amplifier should be capable of delivering power adequate to meet requirements given in the Table.



Drum-type facsimile telegram recorder

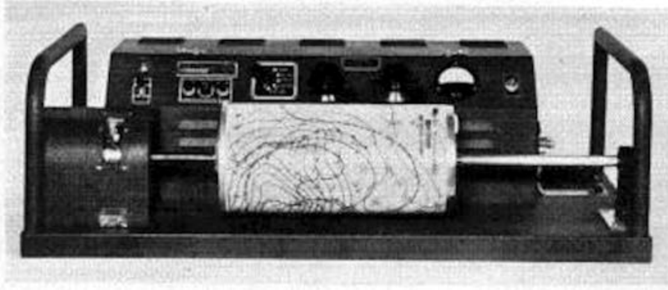


Telegram recorder with stationary drum, revolving stylus and continuous paper feed

Recording Apparatus

Because Teledeltos was perfected originally for use with facsimile telegraph recorders where instantaneous, permanent message recordings requiring no drying or other processing are a fundamental requirement, it is natural that many such recorders have been designed to use this paper.

At least six distinctly different facsimile recorders have been used in Western Union Telegraph Company services and two new models now are in production.[4, 5, 6, 7] The most common facsimile carrier frequency employed is 2500 cycles with a maximum modulating frequency of 1200 cycles per second. The stylus travel with respect to the paper, as a rule,



Signal Corps type facsimile transceiver TT-1B TXC-1 with weather chart recording

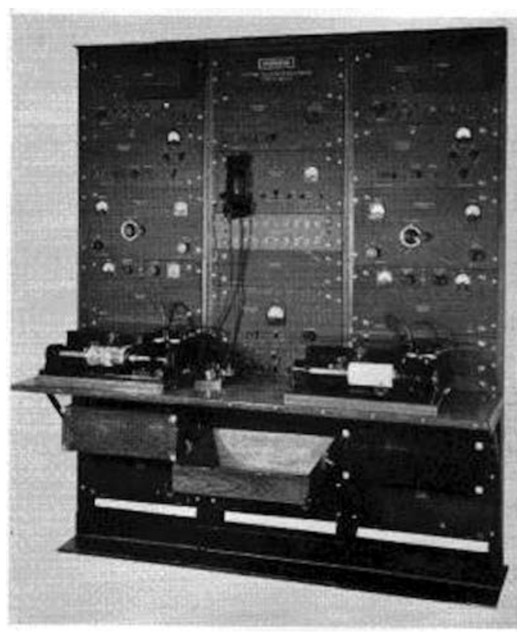
is about 24 inches per second, and excellent recording is obtained with type H Teledeltos using 350 volts, open circuit, and some 15 milliamperes of modulated 2500-cycle alternating current at the stylus. For stylus material, steel piano wire of 10 mils diameter usually mounted on a piece of flat spring has been satisfactory but for continuous service, re-

Message-a-minute facsimile telegram recorder used in mobile Telecar motor delivery service

placements with longer-wearing hard-drawn tungsten wire are being made.

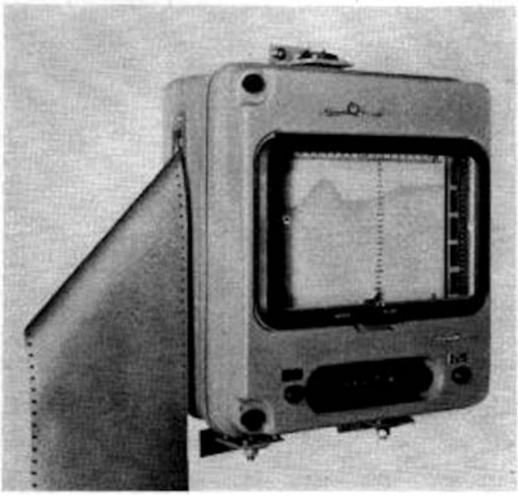
An outstanding facsimile transceiver especially well suited to reproduce 12- by 18-inch weather maps on type H Teledeltos is widely used by the Army and the Navy. This machine, made by Times Facsimile Corp., has a 6-inch diameter drum operated at 60 rpm; thus the stylus travels over the paper at 18.8 inches per second. A tungsten wire stylus is used.

Teledeltos recorders have been used to monitor both the transmission and reception of pictures over cable, radio and land-line photo-process systems wherein, otherwise, the results are not known until film negatives have been developed. Messrs. Muirhead & Co., Ltd., of Elmers End, Kent, in England, furnished the recorder used for this purpose on HMS *Vanguard* during travels of royalty.[5] This equipment, having a 66-mm (2.6 inch)-diameter drum normally operated at



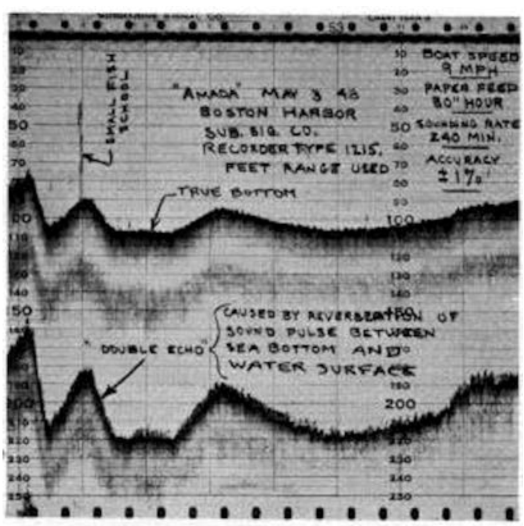
Muirhead picture telegraph equipment with Teledeltos monitor recorder at right

60 rpm has a stylus-to-paper speed of 8.2 inches per second. The stylus is platinum-iridium wire attached to a short spring arm adjusted for 15 grams pressure. Open circuit potential at the stylus is 300 volts direct current. A 10,000-ohm resistor is connected in parallel, stylus to ground. Current is 10 to 50 milliamperes.



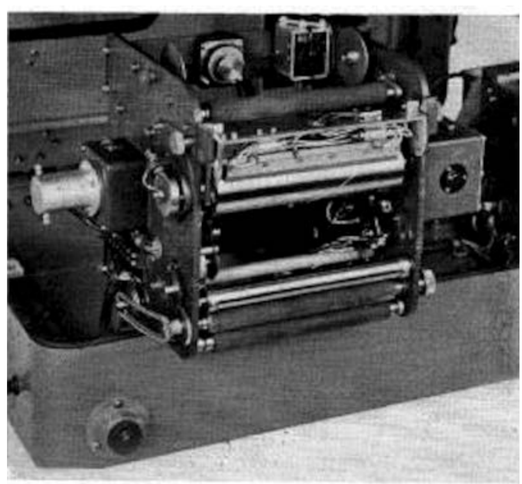
One type of Recording Fathometer or depth recorder made by Submarine Signal Company

Among important industrial instruments using Teledeltos are marine Depth Recorders or Fathometers which, by means of echo sounding, show the distance below surface level of anything having density different than that of the water, for example, sea bottom, submerged objects, and schools of fish. With continuous operation, the contour of the bottom over which a vessel moves is permanently recorded and its nature often may be distinguished. In addition to being a valuable aid to navigation this type of instrument now is used extensively by commercial fisheries all over the world.



Echo sounding chart depicts harbor bottom

Fathometers produced by Submarine Signal Company, Boston, Mass., employ both type H and type L Teledeltos with a conventional wire stylus of chrome-plated steel, usually 10 mils in diameter, mounted either at the end of rotating radial arms or on a belt which moves across the chart. Stylus pressure is adjustable between 2 and 10 grams and not critical within these limits. In different models, stylus scanning velocity is from 1.4 inches per second to 84 inches per second. Chart movement is from 1.5 inches per hour for deep sea navigation to 24 feet per hour for precision surveying in coastal waters.[9]

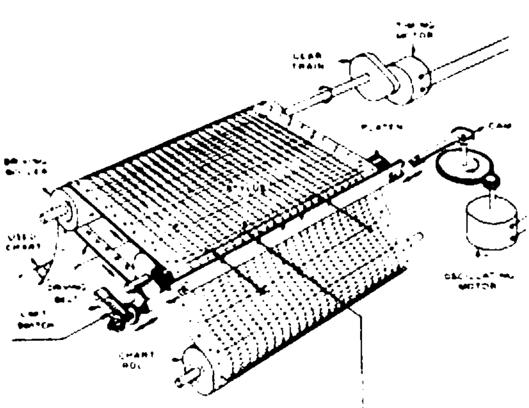


Spiral wire-and-blade recorder assembly of Bludworth Marine echo sounding equipment

In the Bendix-Marine instrument made at North Hollywood, Calif., wire styli are mounted on a revolving ring gear driven by a rubber pinion and guided by rubber rollers. For recording depth in feet, the type L chart paper moves 1 inch per minute; for depth in fathoms, 1 inch in 6 minutes.

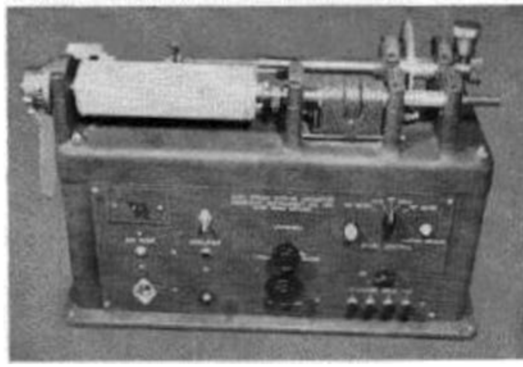
One depth recorder made by Bludworth Marine draws Teledeltos chart paper between a contact blade and a roller which carries a spiral wire conductor. The axial position of this spiral conductor at any moment fixes the point with respect to the base line at which a received impulse marks the chart. This is similar to an arrangement used in some facsimile telegraph recorders.

Automatic Train Recorders made by General Railway Signal Company, Rochester, N. Y., also employ Teledeltos, type L. These multi-stylus chronographs, associated with Centralized Traffic Control Machines, record the movement of trains on graphic charts varying in width from $9\frac{5}{8}$ inches to $29\frac{5}{8}$ inches and printed with time of day graduations scaled at 2 inches an hour. A distinctive feature of this slow-speed recorder is continuous transverse vibration of all styli by a motor, cam and guide bar to produce a mark that is 1/16-inch wide each time a stylus is energized momentarily.



Oscillating stylus mechanism featured in G-R-S automatic train recorder

An apparatus made by American Instrument Company, Inc., Silver Spring, Md., from designs by Professors Taylor and Draper of Massachusetts Institute of Technology aeronautical engineering staffs[10] is distinguished from most other Teledeltos recorders by the fact that it successfully employs spark recording with an air gap one-eighth inch or less between stylus and electrosensitive paper. This is a recording high-speed engine indicator

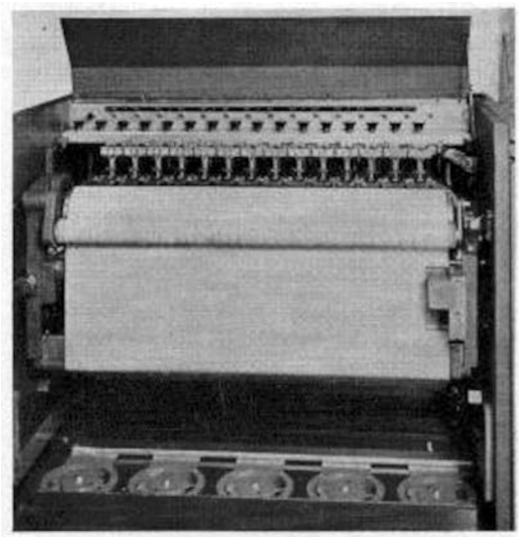


Spark recording high-speed engine indicator

which gives accurate pressure-time diagrams in testing internal combustion engines and fuels. The recorder drum about which the chart paper is clamped has a circumference of 9 inches and revolves normally at 700 to 2,400 rpm but may go as high as 5,000 rpm. The stylus arm carries a hard steel phonograph needle as the sparking stylus.

A noteworthy precision instrument is a multi-channel high-speed recorder specially designed and built for Wright Aeronautical Corp. by Graydon Smith & Company of Boston. This instrument, which is employed in gas turbine and other aircraft engine testing, is representative of many unique recording devices designed and built to meet the requirements of a specific research program. Graphs of 14 variables such as stress, strain, pressure, torque, speed and temperature may be made simultaneously together with 15 time-base reference lines.

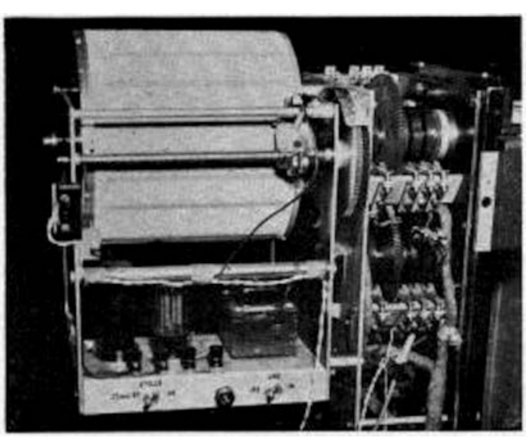
Each galvanometer stylus is 7-mil-diameter tungsten wire 3/16-inch long mounted at the tip of an arm made of phosphor bronze tubing 40 mils in diameter and having a 1-mil wall, formed into a narrow triangle 5 inches long. Stylus pressure is about 2.5 grams. Type H Teledeltos is used. Maximum stylus motion occurs in recording a 35-cycle-per-second sine wave of 1.5-inch amplitude at a chart



Instrument for engine research plots 14 variables and 15 time lines simultaneously

speed of 2 inches per second. Chart speeds of 2.0, 1.0, 0.5, 0.2, 0.1 and 0.05 inches per second are available.

At the Engineering Laboratories of International Business Machines Corp. a specially designed recording timer has been constructed for use as a test instrument to record mechanical movements and electrical impulses at a recurring rate of 200 per minute. A recording drum 8 inches in diameter is coupled or geared to the machine being studied. The stylus, which is 10-mil-diameter steel wire adjusted to 12 grams pressure, is moved parallel to the axis of the drum about 0.035 inch per drum revolution and, in operation, type L Teledeltos passes under the recording stylus at nearly 7 feet per second.

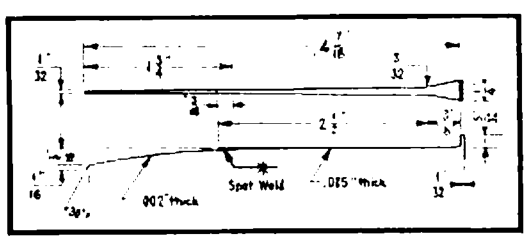


Laboratory chronograph made by International Business Machines Corp.

Modified Ink Recorders

While many industrial recorders have been made for Teledeltos, in some instances conventional ink recorders have been modified to use electrosensitive chart paper. For example, a modified Leeds and Northrup Micromax recorder, model S-40,000 series, in which the single pen was replaced by 20 styli and the paper drive speed increased to 2.5 inches per minute, has been used by Western Electric Company to chart the operation of oven thermostats for processing crystals. A timer interrupts the stylus current 1 second every 5 seconds to provide a measure of on-and-off intervals. The styli are 10-mil-diameter piano wire mounted on 5-mil-thick beryllium copper flat springs set at 5 to 10 grams pressure. With type H Teledeltos, 200 volts direct current applied through a current limiting resistance of 25,000 ohms for each stylus gives optimum results.

In a modified Esterline-Angus graphic ammeter, model AW, rated at 5 milliamperes, the pen was replaced by a stylus



Stylus for modified graphic ammeter

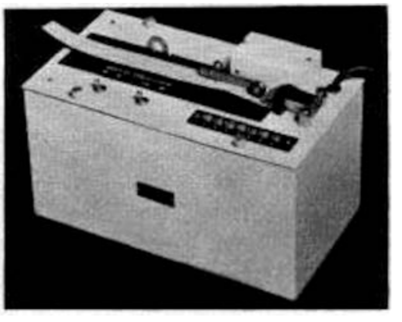
to obtain desired high definition in recording radio signals. In this adaptation, a stylus made from 2-mil stainless steel sheet tapered to a point and bent at the tip for writing contact was found to be simple and serviceable. For extremely light pressure, a tapered endpiece was made about 2 inches long and narrowed from 1/16 inch down to 1/32 inch near the tip, then this 2-inch section was welded to a more rigid member to form the whole writing element. With the point adjusted to barely touch the chart paper there is sufficient flexibility and no appreciable drag. The Teledeltos is held firmly and makes good contact against a metal backplate. Using type L Teledeltos, the current is limited to 2 milliamperes by resistance in series with the power source, preferably positive and not less than 300 volts.

A sound spectrograph developed at Bell Telephone Laboratories, now located at Murray Hill, N. J., employs Teledeltos for spectrogram pattern recording.[11] This instrument is a wave analyzer which produces a permanent visual record showing the distribution of energy in both frequency and time. With it there can be made visible patterns of speech and of other sounds, a development of significance in the field of speech training and education for the deaf. This application takes advantage of the fact that Teledeltos gives variable density or blackness of record with variable current so that energy intensity may be recorded.

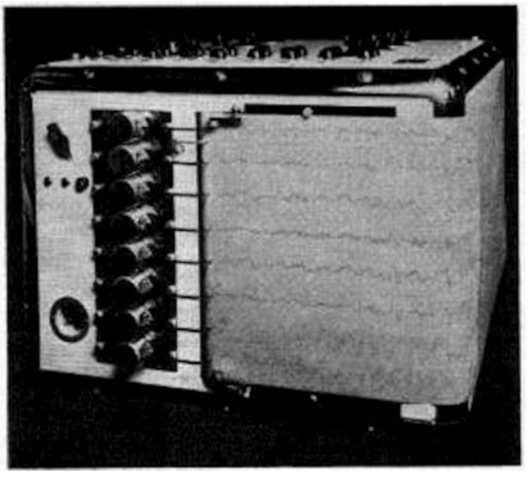
Among "pattern" recorders using Teledeltos there is the phase-front plotter for centimeter waves made at RCA Laboratories, Princeton, N. J.[12] This plotter can be used to test centimeter-wave antennas, to demonstrate principles of physical optics, or to measure the refractive index of dielectrics at radio frequencies. The recordings are equivalent to pictures of radio waves.

Since Teledeltos first became available it has been employed in various instruments made by Electro-Medical Laboratory, Inc., at Holliston, Mass. These range from simple chronographs for recording with straight lines the time relation of events, to multiple-channel direct-writing oscillographs for wave form charting and analysis.[13]

In the Garceau oscillograph, made by Electro-Medical, stylus design is of special interest. The stylus arms are ⅛-inch solid aluminum rods having replaceable tips. Each stylus tip is a small conical



A Garceau recording timer or chronograph



Top view of Garceau electroencephalograph, an 8-channel oscillograph brain wave recorder

point of refractory ruthenium alloy accurately ground and welded to a copper shank which is inserted into a hole bored in the end of a stylus arm. When the tip wears, after making some thousands of feet of record, it is removed like a phonograph needle and replaced.

One oscillographic direct-writing Teledeltos recorder for the medical profession actually is based on Western Union research in recording the minute signal impulses of submarine cable telegraphy. This is the Cardiofax, a new portable electrocardiograph to register electrical impulses of the heart, made by Electrofax, New Canaan, Conn. Licensed under Western Union patents, the amplifier and recorder combined are linear over a range of approximately 0.2 to 50 cycles per second. The stylus movement is 20 mm each side of the center, a total of 40 mm. In this instrument, the stylus arm is unusually long and carries a long flexible stylus of 5-mil stainless steel sheet material which is not easily damaged.

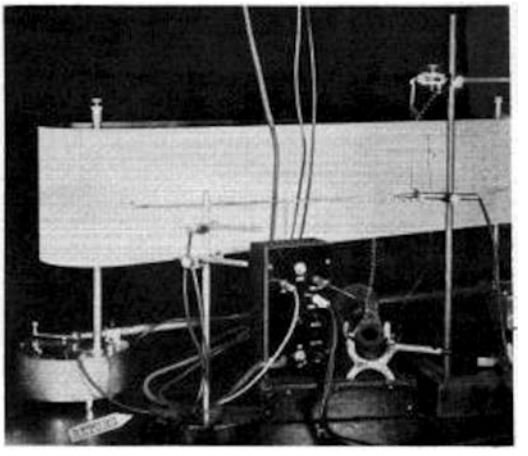
The stylus pressure is not critical, the usual adjustment being of the order of 1 gram. The stylus current of approximately 3 milliamperes is applied in series with a 100,000-ohm resistor from the amplifier B supply. The stylus arm is driven by an especially designed dynamic type of oscillograph mechanism which produces an unusually large torque with the result that the drag of the stylus on the type L Teledeltos recording paper is entirely negligible.

Closely associated with medical instrument application is the use of Teledeltos in study and research laboratories at Boston University, Boston, Mass.,[14] and other institutions where electrical recording devices have superseded the traditional smoked paper kymograph. At Boston University School of Medicine, recording is effected with 110-120 volt, 60-cycle,

Cardiograph developed in Western Union's research laboratories charts heart impulses

alternating current through 10,000-ohm resistors and most styli arms are of music wire, fairly long, and tipped with writing points made from blunt ends of steel phonograph needles. In student laboratories, elimination of complicated apparatus and procedure helps focus attention on results rather than equipment.

There are, of course, many other situations in which Western Union Teledeltos is employed advantageously, but the few described were selected as typical and indicative of the broad field in which recording apparatus and techniques have been modernized by use of this unique by-product of telegraph research.



Teledeltos is superior for kymograph records

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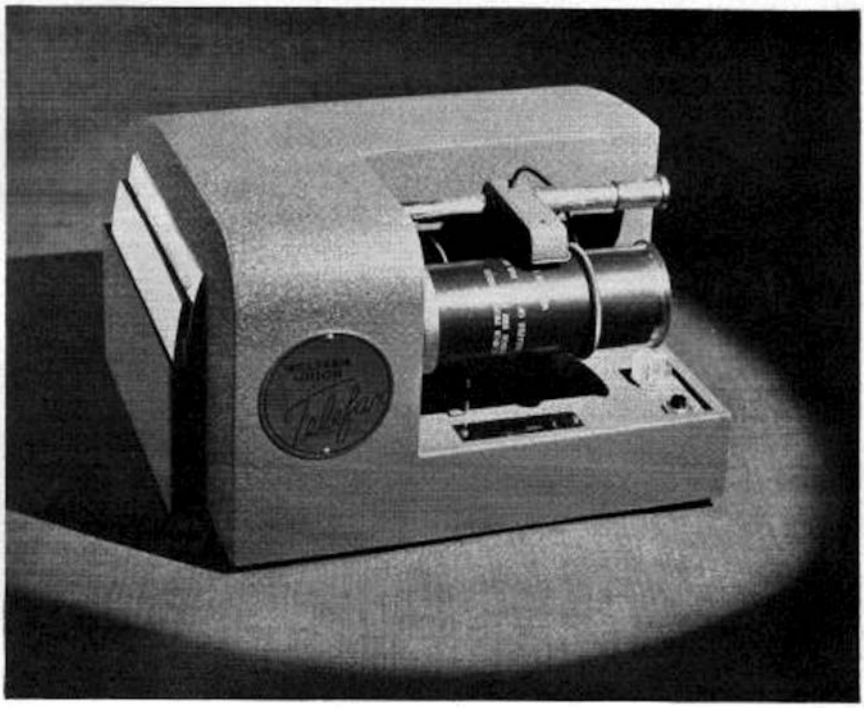

WESTERN UNION'S NEW DESKFAX

A Facsimile Transceiver for Pickup and Delivery of Telegrams

G. H. RIDINGS

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in Pittsburgh, Pa., January 1948.
(Revised)

The mechanization program of Western Union, regarding which much has been said and written, has placed great emphasis on getting telegraph communications from one city to another in the quickest time practicable, at the least cost and with a minimum of human intervention. Direct circuits between the various cities have been increased in number many fold, and manual handling of messages has been replaced largely by mechanical switching methods at all but the terminating pickup and delivery points. All of these improvements have a great impact on the overall speed and dependability of telegraph service. However, there is a vast majority of the American public whose use of the telegraph is only occasional, and who have no way of getting their telegrams to and from the telegraph office except by messengers or by telephone.

The most promising approach to the problem of providing faster terminal handling to these smaller patrons is the development and application of mechanical recording and transmitting devices which will be low enough in first cost and in operating and maintenance charges to permit their employment on a broad scale for use in pickup and delivery service. The patrons to be served may be roughly grouped as:

1. Individual business houses.
2. Large office buildings, apartment houses and hotels, giving the occupants the benefit of direct connection to the central office, even though their individual use of the telegraph may be infrequent.
3. Residential areas, to be provided with automatic, conveniently located devices for pickup and Telecars for delivery. Telecars are automobiles equipped with message recorders having direct radio connection to the nearest central office.

It should be noted that all three objectives require direct wire communication with the central office by means of automatic or semi-automatic machines that will be simpler, less expensive, and easier to operate than telegraph printers, and better suited to written message service requirements than telephone recording. These requirements can be met only by employing some form of facsimile process.

What Has Already Been Accomplished

The basic ground work for a "Telefax"* service for pickup and delivery of telegrams by facsimile methods has been well laid and further progress should be at a rapid rate. The key of this development is a recording paper called "Teledeltos",* developed by Western Union and described in a separate article in this issue of TECHNICAL REVIEW.

Teledeltos is a dry recording paper which, unlike most recording media, requires no processing of any kind before or after recording. The coating of this conducting paper is light in color and turns black when an electrical current of about 20 milliamperes passes through it. Either alternating or direct current may be employed in recording. The paper is sensitive only to electrical impulses and is affected by light or moisture much less than is ordinary writing paper. It produces a clear-cut and permanent record, with no "fixing" of any kind required. There is no apparent ageing of records many years old. Teledeltos is extremely fast, pulses of 0.0001-second duration being easily recorded. It is capable of reproduction speeds many times the highest yet employed in commercial facsimile equipment. Its current density characteristic is such that fairly good half-tone reproduction may be obtained if desired, without special circuit arrangements. Its

Figure 1. Telefax transmitter-recorder with optical scanning

cost is a small fraction of the cost of photographic paper. Only the simplest of recording equipment is needed. Amplified tone signals, without rectification, may be applied directly to the paper by means of a stylus riding continuously on its surface.

A number of different types of automatic and semi-automatic transmitters, transmitter-recorders and recorders have been developed and employed commercially on a limited scale for the pickup and delivery of telegrams. Among these is the

*Registered Trademark of the Western Union Telegraph Company.

transmitter-recorder shown in Figure 1, designed for use in a patron's office. It is about the size and shape of a teleprinter or typewriter. This machine may be placed on a table or desk or may be furnished complete with a pedestal. The machine is 11 inches high, 16½ inches wide and 15½ inches deep. It is self-contained, requiring only a pair of line wires, a ground, and a source of 110-volt, 50-60-cycle alternating current for its operation. This machine has three controls: a send-receive switch, a vernier control for adjusting the density of the recorded copy, and a starting switch. To transmit a telegram, the copy, either typed or handwritten on a blank of proper size, is wrapped by hand around the drum which protrudes from one side of the cover. The send-receive switch is set to "send" and the starting switch operated. Thereafter operation is entirely automatic. A call is set up in a concentrator at the central office. There, a switching unit in which the patron's lines terminate automatically connects an idle recorder to the circuit and the message is recorded. The scanning of the message for transmission is by a light beam and photoelectric cell, associated with a suitable system of lenses. After the message has been completely scanned, the patron's machine shuts down automatically.

To transmit a telegram from the central office to a patron, the attendant wraps the message about a drum and inserts it into one of several transmitters which are a part of the concentrator. She then connects the transmitter to the patron's line causing a buzzer to sound summoning him to his machine. The patron places a sheet of Teledeltos on the drum, sets the send-receive switch to "receive" and operates the start switch. Transmission starts immediately and automatically. When the message has been recorded and the transmitter stopped, a red signal lamp on the top of the patron's machine will light and the patron may stop the machine and remove the telegram. If the patron does not stop the machine it will continue to scan until the entire blank has been scanned, at which time it will shut itself off automatically. If, in sending or receiving a message, the send-receive switch is inadvertently placed or left in the wrong position, the red signal lamp will light and transmission will not start until the switch is operated correctly.

Figure 2. Automatic Telefax transmitter

Another Telefax development is the transmitter shown in Figure 2, designed to facilitate the pickup of telegrams in office buildings, apartment houses, hotels, and similar locations. In this equipment another step has been taken towards the goal of a completely automatic telegraph system. With these machines, it is easy to file a telegram. The sender or agent simply presses a button and drops the telegram into the slot in the front of the machine. This is all that is required of him. The telegram automatically wraps itself about the drum of the transmitter and the entrance to the slot closes, preventing the insertion of another telegram until the first one has been transmitted. Several of these machines may be operated over one line pair where the volume of business is light. Circuits from these transmitters terminate, in a central office, in a facsimile receiving concentrator from which all of the functions of the transmitter are controlled. After the message has been recorded at the central office, the telegram is stripped from the drum of the transmitter and deposited into a receptacle beneath the drum, and the transmitter released.

Two types of transmitters are employed in this service. One is a wall model about 30 inches high, 15 inches wide and 8 inches deep. The other, illustrated in Figure 2, is a table model, 24 inches high, 16 inches wide and 12 inches deep. This model may be equipped with a pedestal, if desired, so that it will rest directly on the floor. Both machines are completely self-contained, requiring only a pair of line wires, a ground, and a source of 110-volt, 50-60-cycle alternating current for their operation. Where an agent is employed to operate it, the machine is equipped with a push-button for starting. Where it is to be installed for unattended service, in an office building lobby for example, it may be equipped with a lock switch, for which charge account patrons in the building will be supplied with keys. In the case of the unattended installation in a public place, a coin slot mechanism may be employed.

Figure 3 illustrates an automatic Telefax recorder employed in the Telecar delivery service previously referred to. This recorder, which is controlled by radio from the central office, employs a roll of Teledeltos from which a length sufficient for one message is automatically formed into a cylinder and scanned internally, then cut from the roll and ejected from the front of the recorder. The process is automatic and while the operator of the car is delivering one telegram, another is being recorded and deposited into the convenient receptacle just under the dash of the car. Radio and control equipment is located in the trunk of the car.

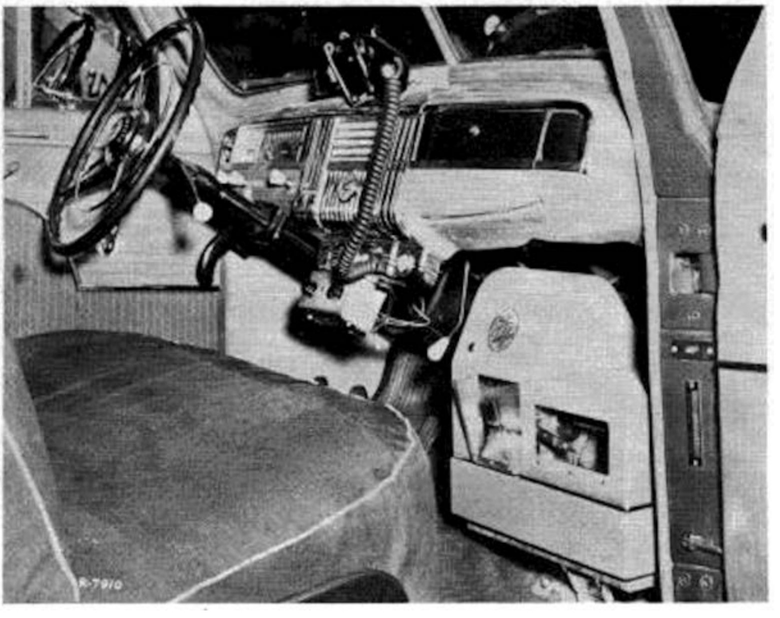

Figure 3. Telefax recorder for mobile delivery of telegrams

Radical Changes in Design Necessary to Lower Equipment Cost

When the patron's transmitter-recorder, shown in Figure 1, was developed, it was expected that it would answer the service requirements of a large majority of small businesses. The results of the limited installations which have been in service throughout the war years have been highly satisfactory. However, post-war economic conditions have made it necessary to develop a simpler and cheaper machine to serve a larger portion of the Telegraph Company's patrons, particularly those in the "small business" category, and thus make possible nationwide expansion of patron Telefax service.

To undertake such a development, it was necessary to think along radically different lines than heretofore. Conventional methods of scanning, line-feed, etc., had to be discarded. The simplest means of facsimile recording is that wherein the facsimile signals are applied directly to a stylus riding continuously on the surface of an electrosensitive record sheet. Since Teledeltos was already available for this purpose, this method of recording was retained for the new model transceiver. Now, it was reasoned, if some form of conductive pickup could be employed, this same stylus could be utilized to scan the sending copy and a really simple transceiver would result. Why not use conductive pickup? The principle is sound, as old as facsimile itself. True, it will not give good half-tone characteristics, but for message transmission this is not necessary.

What about the preparation of copy? The use of conductive pickup would simply mean furnishing patrons with a different kind of blank than would be provided for use with some other type of transmitter. The problem then resolved itself, for the most part, into the development of a simple, economical, easy-to-use sending blank upon which writing and typing would have a different conductivity than the blank itself. Two methods for the preparation of sending copy have been developed. One method employs a sheet of Teledeltos similar to that which is used for the receiving copy. Over this is placed a sheet of special carbon paper; writing or typing on the back of this carbon paper transfers the electrically conducting carbon onto the surface of the Teledeltos. The carbon penetrates the thin insulating coating of the Teledeltos, making contact with the conductive base of the paper. A stylus scanning such copy would traverse characters of low resistance, whereas the background of the paper would present an extremely high resistance—practically open circuit.

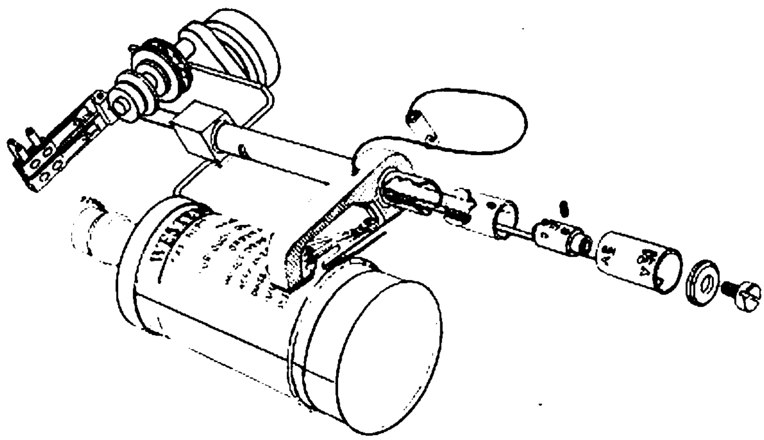

Figure 4. Schematic view of scanning mechanism of Deskfax transceiver

The second method employs a sheet of black conducting paper, which is the same as ordinarily coated to form Teledeltos. This method also involves the use of a special "carbon paper". In this case the so-called carbon paper is coated with a white insulating wax so that writing or typing on its reverse side transfers white insulating characters to the black conducting paper. A stylus traversing this subject copy would encounter characters of very high resistance—practically open circuit, whereas the background of the paper would present a fairly low resistance. Using such a sending blank, it is a simple matter to key or modulate the output of a vacuum tube oscillator. With the aid of a bridge arrangement, it is equally easy to provide for signal conversion so that, with a simple adjustment, a "positive" or a "negative" may be transmitted from either of the two types of subject copy.

Mechanism of the New Transceiver

The simplest scanning mechanism for a facsimile machine consists of a drum upon which the original copy or recording sheet is mounted, and which rotates at constant speed while the scanning point or stylus moves at a uniform rate along the length of the drum. Of course, the same relative motion could be secured by causing the drum to move along its axis as it rotates, with the scanning point remaining fixed in space, but the former method is usually employed. Conventionally this relative motion, or line feed, is secured by means of a feed-screw and half-nut, but in the new transceiver, shown schematically in Figure 4, it is accomplished by winding up a cord on a drum or reel powered by a small clock motor. The reel is frictionally coupled to the motor shaft so that the stylus housing may be manually returned to the start position after the completion of each transmission. A slotted tubular track is provided to support and guide the stylus housing, with the slot fashioned in such a manner as to cause the stylus housing to be raised from the drum in the start position, to facilitate loading. The cord which is attached to the stylus housing at the pin projecting through the slot in the tube, passes over the pulley at the right end of the tube then back again through the tube to the reel on the clock motor shaft at the left of the machine. The motor causes the stylus housing to feed to the right and it is returned manually by pushing it towards the left at the end of transmission. The pin riding up the incline in the tube slot at the extreme left lifts the stylus housing to a vertical position. The stylus holder is a replaceable unit to facilitate renewal, and the stylus itself is pivoted so that when the housing is in an upright position the stylus is completely withdrawn into it. Pivoting the stylus also prevents damage to this vital part of the mechanism, if the patron should improperly remove a blank from the drum without first returning the housing to the start (upright) position.

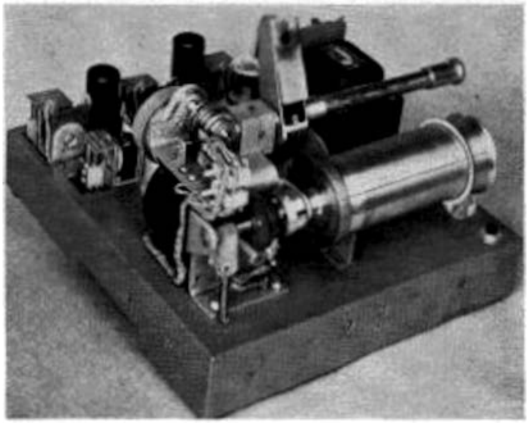

Figure 5. Deskfax transceiver - cover removed

"Deskfax"

Figure 5 is a close-up of the mechanism of the new transceiver. The subject copy or record sheet is held on the drum by the flange at its left end and by a toroidal spring which is rolled onto it from the right end. A small synchronous motor mounted on the rear of an L-shaped bracket drives the drum through a single set of gears, and a simple fabric brake on the drum shaft takes up any back-lash. On the drum shaft is a commutator which is used for phasing. Above the drum motor, on top of the bracket, is the small clock motor with frictionally coupled reel which causes the stylus housing to move out along the tube parallel to the drum. At the extreme right end of this tube is a sleeve which is connected by means of a rod extending through the tube back to a "start-stop" switch mounted on top of the bracket. This sleeve, which is operated manually to the left to start the transceiver, will be moved to the right or "off" position by the motion of the stylus housing as it completes the scanning of the message blank.

The controls of this transceiver are simpler than those of the larger machine of Figure 1. Both machines employ a start-stop switch which also serves as an end-of-message switch, but this newer transceiver does not have a send-receive switch nor a control to regulate the density of the recorded copy. In this transceiver, operation of the start switch automatically sets up the machine as a transmitter unless a call has been placed at the central office causing the buzzer to operate in the patron's machine. Under these conditions operation of the start switch automatically sets up the transceiver as a recorder.

Since the circuits from these transceivers may terminate in large concentrators at the central office, the use of number sheets there would be extremely cumbersome. Provision is therefore made for the patron to acknowledge individually the receipt of each telegram. This is accomplished by means of a push-button which he operates, after a small neon lamp and buzzer, on his machine, have indicated that the transmission to him is complete.

The mechanism is assembled from simple stamped and bent sheet metal parts and die castings wherever possible, with a minimum of machined parts, most of which are of the screw-machine variety. The drum and stylus-feed motors, gears, start-stop switch and stylus connector are inexpensive commercial items. There are no close tolerances and the stylus construction is such that considerable eccentricity of the drum may be tolerated. The entire mechanism mounts on the L-shaped bracket and may be assembled or disassembled in a very few minutes with no special tools. There are few adjustments, none critical.

Electronics and Control Circuits—Characteristics

The mechanism mounts across the front of a sheet-metal chassis which contains the electronics and control circuits. Wiring of the mechanism terminates on convenient terminal strips on the chassis to facilitate servicing or replacement. Figure 6 shows the complete unit with cover removed, and Figure 7 shows the underside of the chassis with bottom plate removed. Although the chassis measures only 10⅛ by 11⅛ inches, there is no crowding of parts;

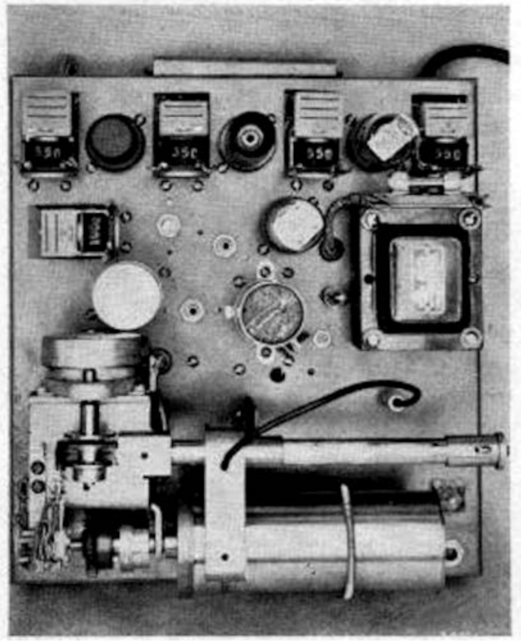

Figure 6. Top view of Deskfax transceiver showing layout of parts

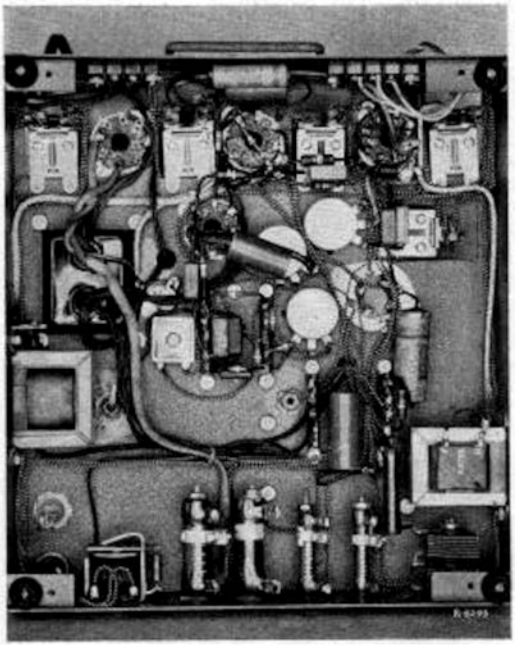

Figure 7. Bottom view of Deskfax transceiver showing accessibility of components

relays, vacuum tube sockets, terminal strips, and other vital components are readily accessible for test or maintenance purposes. The electronic circuits employ four tubes,—a rectifier for power supply, a dual triode which serves as oscillator and transmitting amplifier, and a high-*mu* pentode and a power output tube which serve as the recording amplifier. The use of separate tubes for transmitting and recording would appear an extravagance, but such is not the case. By switching tubes from one circuit to the other, one tube at most would be saved, the cost of which is more than outweighed by the simplification of switching and wiring which the use of separate tubes permits.

Controls are provided for transmitting and recording levels and for bridge balancing. These are set for each installation and remain unchanged unless servicing is required. A terminal strip is provided for attaching line wires and ground, another for attaching a rubber-covered power cord so that the desired length of cord for each installation may be provided. With the exception of the oscillator coil, all components of the electronic and control circuits are inexpensive commercial items. The power transformer is similar to that used in the smallest a-c table model radios. A transformer couples the amplifier to the line pair, serving as an output transformer when transmitting and as an input transformer when recording. Control relays are the inexpensive rugged type employed in juke boxes and pinball machines. No critical adjustments are required. The relays are mounted so that the contacts are accessible for cleaning. Wiring of the unit is comparable to that of a small table model radio and can be done in economical assembly-line fashion. The overall dimensions of the transceiver with cover and blank holder are 11⅛ by 11¼ by 7 inches high. It weighs about 19 pounds. Maximum power consumption is 100 watts, and no power is consumed when the machine is idle.

The oscillator frequency is about 1900 cycles and since a total band width of 1900 cycles is adequate, the transceiver will operate over an ordinary telephone pair. The two-inch drum rotates at 180 rpm and the line feed is 125 lines per inch, to match the index of cooperation of the central office equipment which employs a larger size blank. Blank size is 6½ by 4½ inches, with a useful message area of 5⅜ by 3 inches. This will accommodate about 150 typewritten words and is transmitted in two minutes. No special provisions for synchronization are made, the synchronous driving motor being operated from the same commercial 50- or 60-cycle a-c power source employed at the central office. Phasing, signaling and other necessary control functions operate on a d-c basis using the physical wires with ground return through a center-tapped primary of the line coupling transformer. Phasing clutches on the central office transmitters and recorders are controlled by the commutator of the patron's machine.

**Central Office Equipment—
Circuit Operation**

Circuits from patrons' transceivers terminate in Western Union central offices in concentrators made up in multiples of 50-patron units. Each 50-patron unit is provided with four conventional telegram-size optical transmitters and six conventional size page-type continuous recorders. The transmitters employ the so-called "color sensitive" photocell and improved electronics, so that messages received by tape printer, page printer and various other means may be retransmitted by Telefax with equal fidelity.

To send a message to a patron, the central office operator wraps the message about a drum, inserts the drum into a transmitter and plugs up to that patron's circuit. This removes positive standby potential and applies negative potential to the line over the simplex circuit which operates a relay in the patron's transceiver, causing the buzzer to sound. When the patron answers the call by loading his drum with a Teledeltos recording blank and operating the start switch, the buzzer stops and his transceiver is automatically set up as a recorder. As soon as the transceiver's tubes heat up, a relay operates to start the stylus-feed motor

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and to send out phasing pulses (interruption of the direct current over the simplex loop). The central office transmitter phases immediately and the transmission of the message proceeds. When the message has been transmitted, the transmitter stops and polarity of the battery on the line is reversed, causing the acknowledge lamp and buzzer to operate in the patron's transceiver. After the patron has examined the recorded message he operates the acknowledge push-button which extinguishes the light, stops the buzzer and opens the simplex loop, giving an acknowledgement indication to the central office operator. The operator then removes her transmitter from the line.

To send a message to the central office, the patron wraps the subject copy, prepared as described previously, about the drum and operates the start switch. This sets up the transceiver as a transmitter and operates a relay at the central office which gives appropriate indication to the operator that a call from that patron is waiting. She connects a recorder to the calling circuit and operates a start button. As soon as the heat relay of the transceiver has operated, the recorder phases from the first phasing pulse from the transceiver's commutator. Contacts on the phasing relay reverse the potential on the line which starts the stylus feed motor at the transceiver. Transmission continues until the transceiver shuts down automatically or until the patron manually operates the start-stop switch. The recorder also stops and a light indicates to the operator that the message is complete. She rotates a paper-feed-out knob on the recorder until the conventional telegram blank length of paper is fed out, at which time the light is extinguished. The message is then torn off and the recorder disconnected.

The first concentrators for this service will be of the plug-and-jack manual type, the switching turret resembling the familiar PBX switchboard. Circuits have been worked out for a more automatic concentrator, with automatic line finders on the receiving side and push-button switching on the sending side, should this method of operation be found desirable.

Patron-to-Patron Transceiver

A machine similar to the Deskfax described above has been developed for patron-to-patron use. That is, two machines work together, directly, without any central office concentrator equipment. The same mechanism is employed with some rearrangement of the control circuits and a simple phasing circuit whereby one motor drifts into step with the other. Phasing is accomplished without the use of conventional magnets or clutches, employing the commutator on each motor shaft and an added capacitor which is connected across the recorder driving motor, causing it to run slightly under synchronous speed until pulses from the two commutators are in step, at which time the capacitor is removed and both motors run synchronously. Such machines may be used to provide intercommunication for business organizations or for pickup and delivery of telegrams, where only a few patrons are involved and a concentrator is not justified.

Installations of this type have been in operation in one of the Eastern cities for the past several months, from which considerable information has been obtained that has been helpful in improving the design. A number of ways were found to simplify and improve the mechanism and reduce the manufacturing costs. The trial installations have so decisively demonstrated the effectiveness of Telefax as a means for pickup and delivery of telegrams that quantity production of transceivers, incorporating all of the improvements resulting from the trials, is now under way. The manufacturing cost of the new unit is expected to be about one-third that of the larger patron's machine shown in Figure 1. Central office concentrator equipment is being manufactured for installations in six major cities. Although over a million telegrams a year are currently handled by facsimile equipment, the new installations will increase the volume of telegraph traffic handled by facsimile methods many fold, and should pave the way for still larger installations in the future, particularly for small volume telegraph users.