WESTERN UNION Technical Review

Make-Break and Polar Operation

•

Ship Reporting by Radio-Telefax

•

A Microwave System

•

New Facsimile Transceiver

•

Design of a Facsimile System

VOL. 8 NO. 3
JULY 1954

WESTERN UNION

Technical Review

VOLUME 8
NUMBER 3

Presenting Developments in Record Communications and Published Primarily for Western Union's Supervisory, Maintenance and Engineering Personnel.

JULY
1954

CONTENTS

Published Quarterly by

THE WESTERN UNION TELEGRAPH COMPANY

COMMITTEE ON TECHNICAL PUBLICATION

Address all communications to THE WESTERN UNION TELEGRAPH CO., COMMITTEE ON TECHNICAL PUBLICATION, 60 HUDSON ST., NEW YORK 13, N. Y.

Subscriptions $1.50 per year — Printed in U.S.A.

A Comparison of Make-Break and Polar Operation

D. P. SHAFER

CONSIDERABLE interest has developed in polar operation, as applied in the field trial of centralized and simplified circuit handling using polar leg operation. Much of this interest was created by the paper on that subject in the January 1954 issue of TECHNICAL REVIEW. It is the purpose of this article to present the fundamental transmission characteristics of polar operation, upon which the system described is based, as compared to those in make-break operation.

Signal Distortion

The operation of a properly adjusted relay, teleprinter selecting magnet or other receiving device controlled by start-stop signals is governed by the effective duration or "length" of marking and spacing pulses. Optimum circuit margin is obtained when they are equal in length. When their average length is unequal, bias distortion results. Bias distortion (commonly referred to as bias) is frequently expressed in milliseconds (ms). It is also given in percent. For example, a perfectly timed 22-ms teleprinter marking signal distorted to an effective length of 20 ms will have a spacing bias of $\frac{22\text{-}20}{22}$ or 9 percent. In this article, originating signals, whether make-break or polar, are assumed to be unbiased; that is, each transition is assumed to be properly timed at the source of transmission.

There is an interval of time from the occurrence of a space-to-mark signal transition to the instant at which the relay tongue or teleprinter selecting magnet armature is operated. This interval of time is called the space-to-mark transition delay and is abbreviated SMTD. The instantaneous current at the moment of operation is called the "operate" value. The interval of time from the occurrence of a mark-to-space signal transition to the instant at which the relay tongue or teleprinter selecting magnet armature is released is called the mark-to-space transition delay and is abbreviated MSTD. The instantaneous current at the moment of release is called the "release" value.

The magnitudes of these delays are determined by the amount and distribution of the impedance components in a circuit at the instants of signal transition and by the design and adjustment of the receiving device. Characteristic and fortuitous distortion also affect the transition delays.

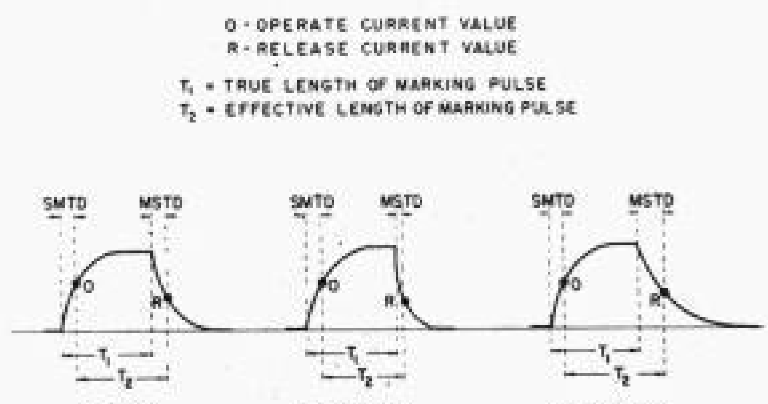
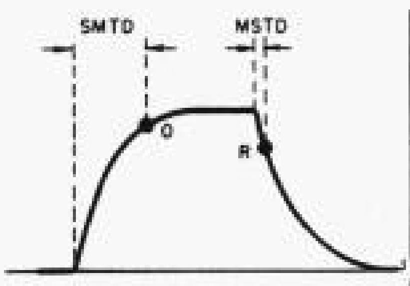


Figure 1

All SM and MS transition delays in a circuit will be constant provided conditions do not change. They may or may not be equal. When the transition delays are equal the signal is unbiased. When the SMTD is greater than the MSTD the effective length of the signal is shortened and a spacing bias is created. Conversely, when the SMTD is less than the MSTD the effective length of the signal is increased and a marking bias results. Figure 1 represents signals with no bias, spacing and marking biases, respectively.

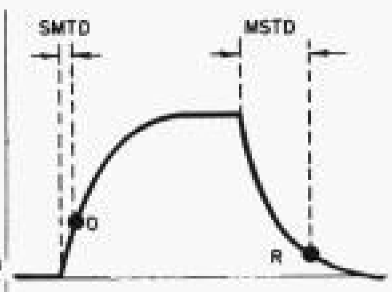
O and R represent the operate and release current values. T_1 and T_2 indicate true and effective signal timing, respectively.

The effect of bias distortion depends on the device to be operated. When the operate and release values are both high on the current wave, more time is necessary for the current to rise from zero to the operate point than to decrease from the steady state to the release point. This is usually true even when signal tailing is excessive because the early portion of each transition is steeper than the portion near its completion. The SMTD therefore exceeds the MSTD and a spacing bias normally would result under this condition, as shown in Figure 2. Marking bias is unlikely.



O AND R HIGH ON CURRENT WAVE - SPACING BIAS

Figure 2



O AND R LOW ON CURRENT WAVE - MARKING BIAS.

Figure 3

When the operate and release values are low on the current wave the bias will be spacing, zero or marking depending on the relationship of the MSTD to the SMTD. The nature and amount of bias under this condition therefore depends to a large extent on the amount of signal tailing. A marking bias normally results, as shown in Figure 3, especially when excessive signal tailing is present.

"Operate" and "Release" Values

For most efficient operation make-break relays are designed, insofar as possible, to operate and release at a value close to half the steady state current. The present standard of steady state current in make-break circuits is 70 ma, so theoretically the operate and release values should be 35 ma. Although some types of relays have operate and release points of approximately 37 and 33 ma, respectively, many others are found with considerable difference between the operate and release currents. Values approximating 42 and 30 ma will apply to most relays, 45 and 25 ma not being unusual. Actual values, in any case, depend on the type of relay and its adjustments.

Teleprinter selecting magnets, required to perform a mechanical function, show a much greater spread in the operate and release points. Pulling type magnets with properly adjusted spring tensions and air gaps should operate at a current not exceeding 42 ma and release at from 19 to 22 ma. Actual values depend on adjustments and differ considerably.

Single current or make-break receiving devices inherently have a higher operate and lower release value than the mid-current point because, in an unoperated condition, the air gap between the armature and pole piece is wide in comparison to that in the operated condition. The magnetic flux naturally has a different effect on the armature in the two positions. The wave form is altered somewhat by the change in inductance caused by variation in the air gap but the effect is slight.

The operate and release points on a teleprinter selector magnet or make-break relay depend on several factors, some of which are mentioned above. These factors are more or less fixed for a particular type of teleprinter or relay provided its adjustments are not changed. As would be expected, changing the spring tension on a teleprinter selecting magnet or relay using a retractile spring, or the bias current in a polar relay employed for make-break operation, has a considerable effect on the operate and release values.

This and other phenomena are common to teleprinter and relay operation. Although either type of receiving device may be used for illustration, an electrically biased polar relay will be used in the examples below in order to clarify the effect of armature travel time

Assuming for the moment that a make-break circuit containing a relay is purely resistive (a condition which can never be realized due to the inductance of the relay), the operating current will rise and fall instantaneously as the circuit is closed and opened. There will be no SMTD or MSTD. Under this theoretical condition there will be no signal bias distortion. Operation of the relay will be independent of the operating current value provided it exceeds the bias current plus a small amount necessary to overcome the banking force. Conversely, variation of the bias current within wide limits will not affect operation of the relay. However, if the bias current is extremely high the relay will fail to respond to marking signals, and if sufficiently low the relay will no longer respond to spacing signals.

Relay Tongue Travel Time

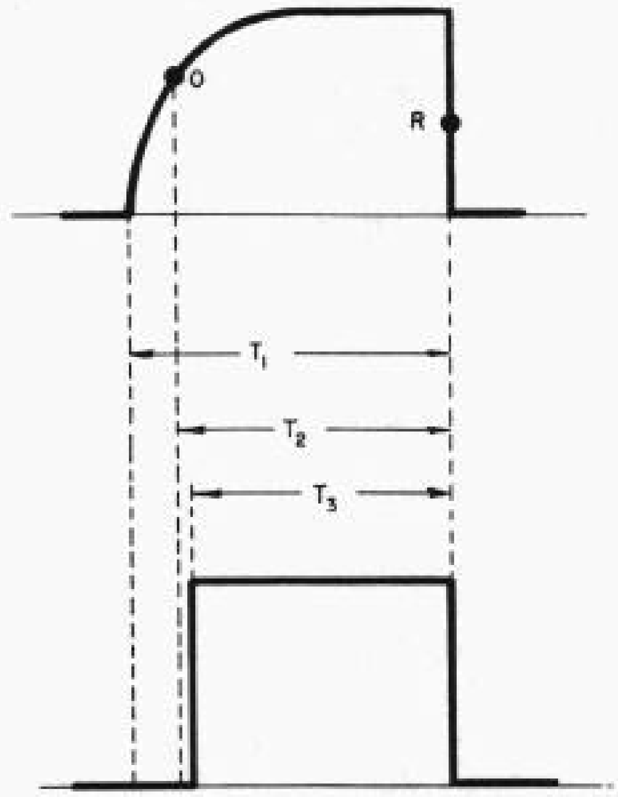
When the input or "driving" circuit contains inductance (but only a negligible amount of capacitance) there is an appreciable SMTD when the circuit is closed. The time interval depends on the amounts of resistance and inductance. The higher the ratio of inductance to resistance, the longer will be the SMTD. The relay tongue begins to move from its spacing contact somewhat later than the initiation of the space-to-mark transition. This, of course, shortens the signal delivered by the relay. Make-break operation of the relay "output" circuit is assumed and for the sake of clarity is considered to be purely resistive.

The output circuit is not closed, however, until the relay completes its travel from the spacing contact to the marking contact. This delay, added to that caused by inductive lag in the driving circuit, shortens the delivered signal still more.

When the input circuit is opened the operating current decays very rapidly, thus causing the relay tongue to leave the marking contact abruptly because of the short MSTD. The output circuit is opened at the instant the tongue leaves the marking contact, therefore the mark-space travel time has no effect on the timing of the delivered signal.

Relay tongue travel time (commonly called relay travel time) varies with the type of relay, its adjustments and, to some extent, the operating frequency. For example, it averages approximately 1.4 ms or 8 percent at 75 wpm in a properly adjusted relay.

Figure 4 illustrates the cumulative effect of inductance and tongue travel time in causing spacing bias in signals delivered by a make-break relay. T_3 represents the length of the delivered signal.



T_3 = EFFECTIVE LENGTH OF DELIVERED SIGNAL

$T_2 - T_3$ = RELAY TONGUE TRAVEL TIME

EFFECT OF INDUCTANCE AND RELAY TRAVEL TIME

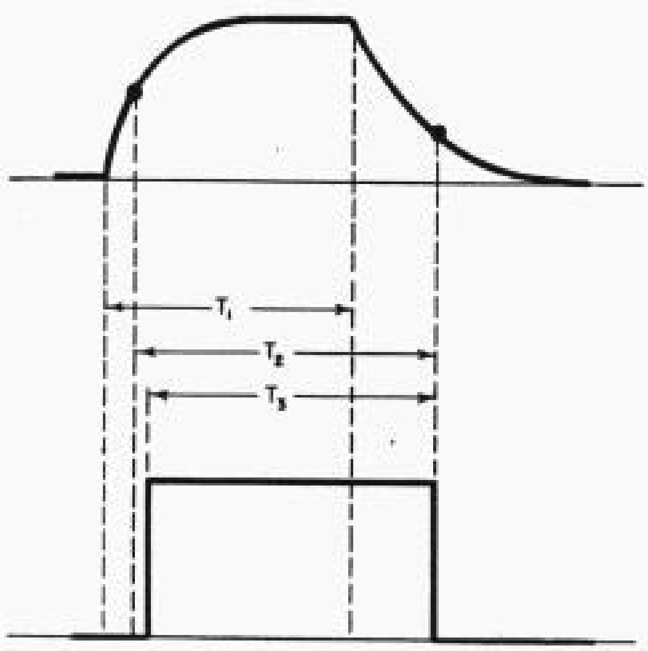
Figure 4

An examination of Figure 4 will show that if the bias current is increased the operate point will be higher (later) on the current wave and additional spacing bias will result. Conversely, if the bias current is lowered the operate point will be lower (earlier) on the current wave and the spacing bias will be reduced. It should be obvious, however, that although the bias current might be reduced to a very low value a spacing bias will always remain. An attempt to eliminate spacing bias in this manner will probably cause erratic action or complete "freezing" of the relay to marking because of insufficient local bias current.

Current Attenuation

If the circuit contains capacitance both SM and MS transition delays will be affected. The effect will depend on the amount and distribution of resistance, inductance and capacitance. Cable capacitance forms a shunt path for transient currents during the transmission of spacing as well as marking pulses. Signal tailing is caused whenever the charge or discharge current through the capacitance also passes through the point in the circuit at which the observation is made.

Under certain conditions signal tailing may occur at one terminal but not another, as for example when sending from a terminal at which there is no capacitance between the source of transmission and its terminating resistance, but where the circuit passes through a cable between the terminals. In this case no MSTD will occur at the sending terminal while, at the same time, signal tailing will be produced at the receiving terminal by the discharge transient current flowing through the intermediate cable capacitance and the receiving device.



MARKING BIAS IN DELIVERED SIGNAL CAUSED BY EXCESSIVE TAILING

Figure 5

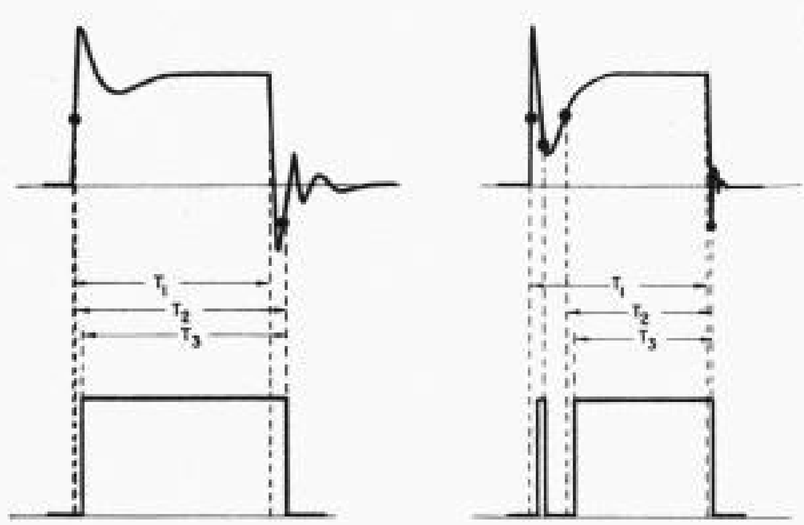
Signal tailing may occur at more than one location but is almost never uniform at both circuit terminals. Again, the effect depends on the distribution of resistance, inductance and capacitance and the source of transmission. In some cases signal tailing is intentionally produced by loading or "wave shaping" a leg circuit to offset the SMTD caused by inductance; in others, inductance is added to compensate for signal tailing caused by cable capacitance. In any case, the method, location and amount of wave shaping necessary to equalize the SMTD and MSTD for transmission from both terminals is rather involved. Further complications are added whenever changes are made in the size of cable conductors, when intermediate or additional equipment is placed, and so forth.

A single method of wave shaping can hardly be standardized to comprehend the many different conditions encountered. Although several methods are available, each one offers only partial correction and involves application on a specialized or "hand tailored" basis.

Excessive signal tailing causes severe marking bias, especially where the relay or teleprinter selecting magnet has a low release point. This is shown in Figure 5, again using an electrically biased polar relay for illustration.

Oscillatory Circuits

Certain combinations of inductance and capacitance in a make-break circuit often cause oscillatory components in the signal wave shape. High-peak oscillations occurring during the space-to-mark transition steepen the initial current rise and may offset the effect of inductive lag. On the other hand, they may cause the relay (or teleprinter selecting magnet armature) to have a tendency to chatter if the current



MARKING BIAS CAUSED BY OSCILLATIONS

RELAY CHATTER CAUSED BY OSCILLATIONS

Figure 6

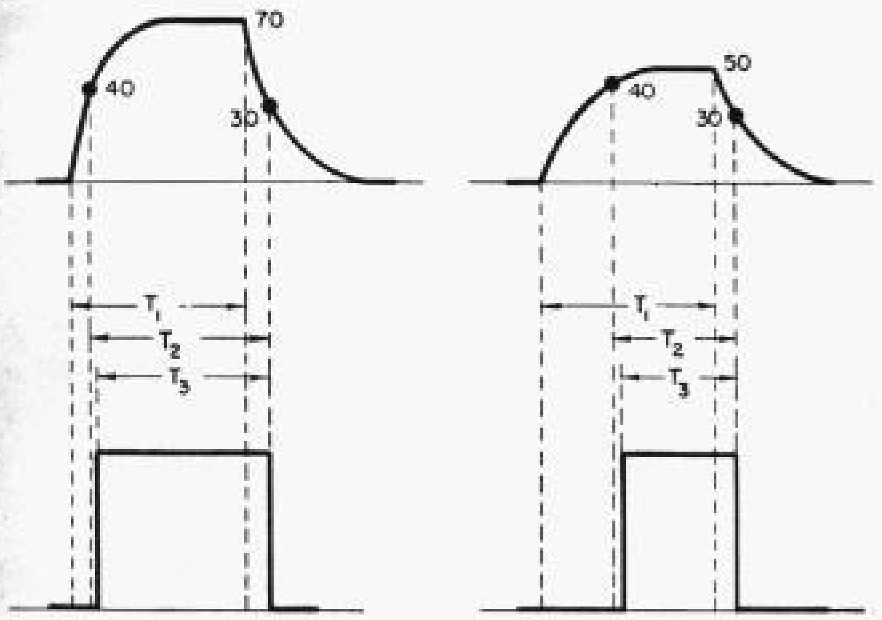
is not sustained above the operate value during its rise to the steady state. Oscillations on the mark-to-space transition may be of sufficient magnitude to hold a spring controlled single current relay (or teleprinter selecting magnet armature) in the operated position for an appreciable time after the transition has taken place. This, of course, causes a marking bias. The amount of bias will depend on the frequency and number of oscillatory peaks having an amplitude exceeding the release current value.

Figure 6 illustrates two typical wave forms in which low frequency oscillations cause serious distortion. In the first case the oscillatory peak is higher than the release value of a spring controlled single current relay or teleprinter selecting magnet armature and, although the current passes through zero, the "overthrow" occurs so quickly that (due to armature inertia) a release does not occur at the proper instant. Relay chatter is indicated in the second case. The oscillatory frequency is different for operate and release because the circuit is closed for the operate condition and at least partially open for the release condition.

A change in the steady state operating current, with the bias current unchanged, is another cause of bias. Line leakage or insertion of resistance will reduce the operating current and cause a spacing bias. If the line current is increased by removal of resistance or by an increase in applied voltage, a marking bias will result. The above applies to other than purely resistive circuits.

Figure 7 shows two wave forms, one of which has a steady state operating current of 70 ma and the other 50 ma. It is evident that the operate point (40 ma) is reached later on the 50-ma wave than on the 70-ma wave, thus creating a spacing bias in the delivered signal. The release point (30 ma) is reached earlier on the 50-ma wave, adding to the spacing bias.

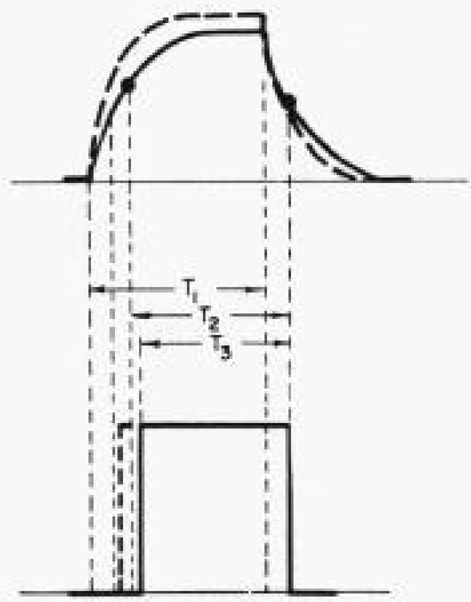
The insertion of inductive apparatus in a working circuit (unless compensated for) not only reduces the steady state current but increases the SMTD more than the MSTD—both effects contributing to spacing bias. The combined effect is illustrated in Figure 8. The wave form, before insertion of the inductive apparatus, is indicated by a dotted line.



OPERATING CURRENT 70 MA
NO BIAS

OPERATING CURRENT 50 MA
SPACING BIAS

Figure 7



SPACING BIAS CAUSED BY
INSERTION OF INDUCTIVE APPARATUS

Figure 8

Other Distortion Effects

In addition to bias, there are two other types of signal distortion; namely, characteristic distortion and fortuitous distortion.

Characteristic distortion is an effect, caused by current transitions occurring before the steady state is reached, whereby signals at the receiving terminal are lengthened or shortened, usually shortened. It is related to the amount and distribution of resistance, inductance and capacitance in a circuit and depends on the length of the transmitted signals; that is, on the operating speed. It is most evident on single pulses because of the greater proportional change in signal length at the receiving terminal. Characteristic distortion is not usually troublesome except where leg circuits contain much unloaded cable and/or are operated at high speed. Where characteristic distortion is present, it has the effect of what appears to be a constantly shifting bias, adding to distortion from one or more of the several causes already discussed.

Figure 9 illustrates a case of characteristic distortion and its effect on the signal delivered from a relay. It may be seen that the delivered signal shows the cumulative effect of impedance lag, relay travel time and characteristic distortion.

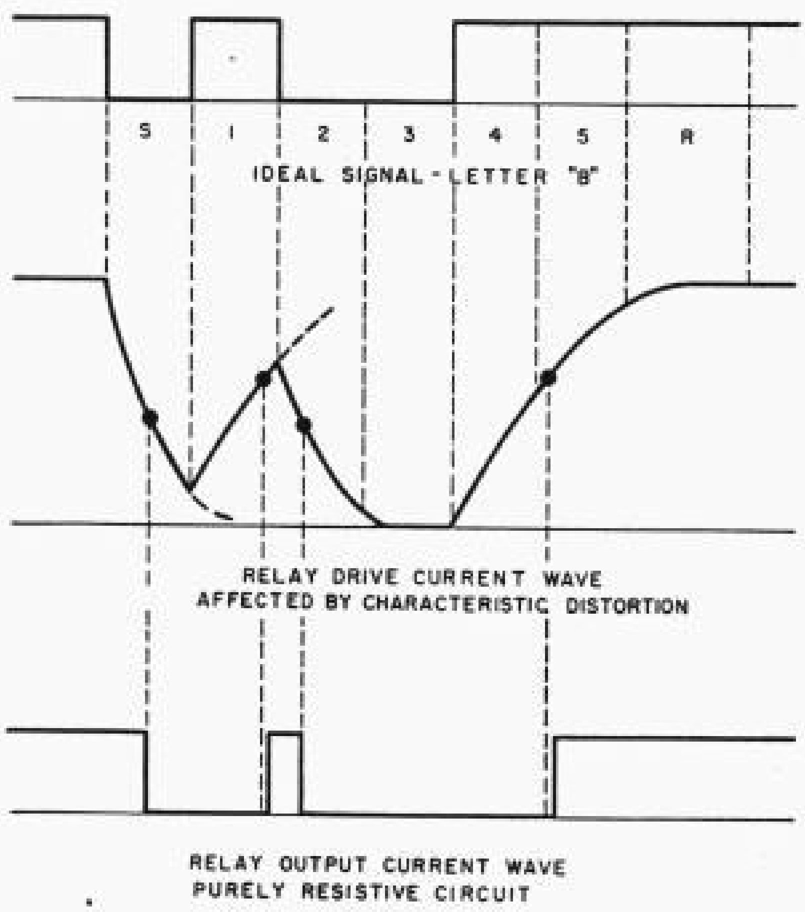
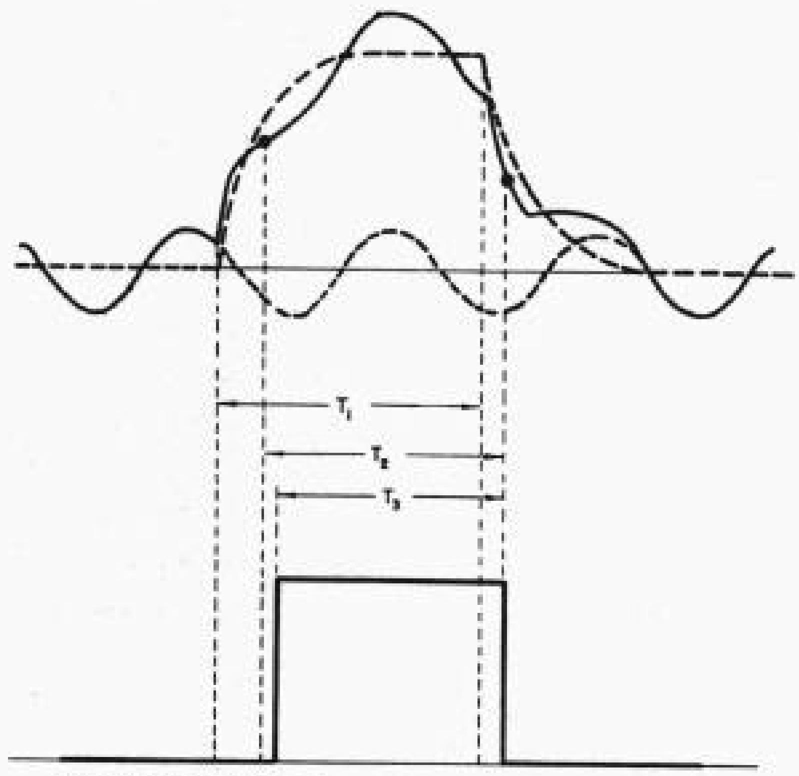


Figure 9

Fortuitous distortion is caused by momentary fluctuations in the applied voltage, power induction, cross fire from other circuits, "hits" to ground or foreign battery, and so forth. This results in intermittent false, advanced, or delayed MS or SM transitions of current at the receiving end of a circuit. When severe it may cause erratic action of the receiving device or possibly a complete circuit failure. Earth currents are, on occasion, a cause of fortuitous distortion.

Figure 10 illustrates a case of fortuitous distortion, wherein heavy a-c induction distorts the normal wave form (dotted) so much that both the operate and release points are displaced.

As would be expected, total signal distortion is the cumulative effect of many causes. Bias may be caused by inductance and capacitance, separately or in combination, changes in operating and local bias currents, or relay travel time. Characteristic and fortuitous distortion may also be present. Several of these factors are usually effective simultaneously.



FORTUITOUS DISTORTION CAUSED BY POWER INDUCTION

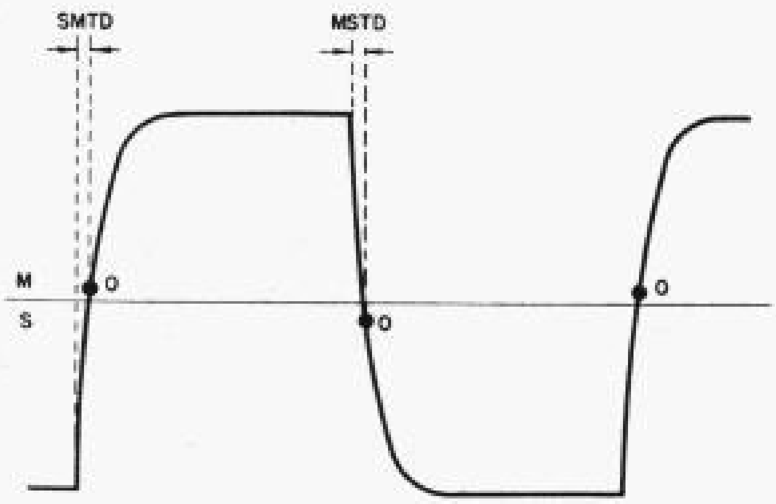
Figure 10

In make-break operation, leg currents must be adjusted (or compensation provided to do so) whenever monitorial or test equipment is inserted or removed from a circuit, for voltage changes and leakage, or when a circuit is rerouted temporarily. The operating current on many circuits is 70 ma; on others 120 ma. Compensation through wave shaping, as described above, or through regulation must also be made for the unlimited number of combinations of resistance, inductance and capacitance in leg circuits and terminating apparatus. Teleprinter overlap ranges at outstations operated on single conductors are often less than desired because wave forms of transmitted and received signals are unlike. There is a wide variation in the operate and release point of relays, teleprinters and carrier channels. Bias due to relay travel time is cumulative whenever signals are repeated through successive make-break circuit sections and often causes serious deterioration of signal quality. It becomes difficult, therefore, to control bias when there is so much variance in response to make-break signals.

Polar Operation

In polar operation, no bias circuit (or spring) is necessary for the receiving device to respond to a spacing signal. This permits simplification of design. Adjustments are much simpler on polar relays — so are testing procedures. A single standard of "centering" polar relays for zero bias entails no complications under any circuit condition.

Unbiased polar transmission depends on three basic conditions— (1) that equal but opposite potentials are applied at the sending end, (2) that the impedance of the circuit remains constant for both marking and spacing pulses, and (3) that the armature of the polar relay or other receiving device be centered under zero current conditions.

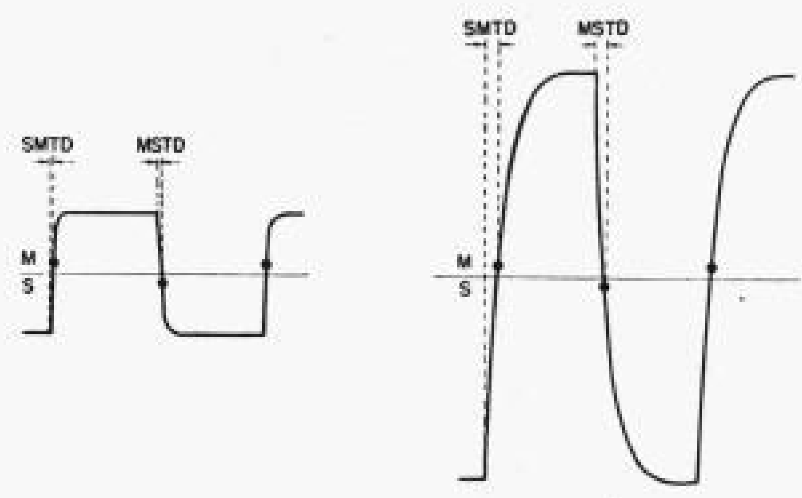


POLAR CURRENT WAVE
MARKING AND SPACING PULSES
O=OPERATE POINT

Figure 11

Under these conditions, easily met in practice, equally timed marking and spacing pulses will produce identical but opposite wave forms, as shown in Figure 11. The steady state current values will be equal and opposite. Marking signals appear above the zero axis and are produced when negative battery is applied at the source of transmission. Spacing signals appear below the zero axis when positive battery is applied. The SM and MS transition delays will be equal; in fact they will remain so although the steady state current may be altered by a change in the applied voltage or by leakage. Similarly they will be equal when inductance or capacitance is added, since the effect is identical on both marking and spacing signals. The dots represent the instantaneous current values at which the relay responds to the SM and MS transitions, respectively. These two "operate" points may be compared with the operate and release points in make-break operation. Both of them lie very close to and are equidistant from the zero axis, however, because in polar operation there is no local bias current or spring tension to overcome and a current of only a few milliamperes will cause the relay tongue to move from its spacing or marking contact to the other.

In polar operation the current value is not critical. This is exemplified in Figure 12. Here, there are two values of steady



30 AND 100 MA POLAR CURRENT WAVES
IN EACH WAVE SMTD AND MSTD EQUAL
(NO BIAS)

Figure 12

state current; 30 ma and 100 ma, respectively. The operate points are displaced somewhat due to the difference in steepness of the two waves but since this displacement is identical for both SM and MS transitions no change in signal timing occurs. No bias is produced, regardless of the steady state value, within the operating limits of the relay.

The fact that zero bias is obtained, despite changes in current, is a very important advantage of polar operation. It is readily apparent that polar operated circuits may be set up and reassigned as necessary without having to adjust for bias or leg currents.

Polar Versus Make-Break Operation

In polar operation, the over-all current change is usually more than double that in make-break operation. This means, of course, that polar operated circuits contain a higher ratio of resistance to inductance and capacitance, so it follows that SMTD's and MSTD's are shorter (in ms) and more nearly ideal. The effect of steeper wave fronts in polar operation is to determine more accurately the instants at which the current passes through the SM and MS operate points. Since the current passes through these values more rapidly, the wave is less susceptible to the effects of oscillations, characteristic distortion and fortuitous distortion. Relay action is snappier and the tongue less likely to bounce. These factors result in stability of delivered signal timing.

Figure 13 shows superimposed make-break and polar current wave forms to clarify the above. Sufficient signal tailing of the make-break signal to produce zero bias is indicated so as to illustrate the fact that, although no bias is present in either wave, the slope of the polar signal is steeper than that of the make-break wave. This is true of both SM and MS transitions.

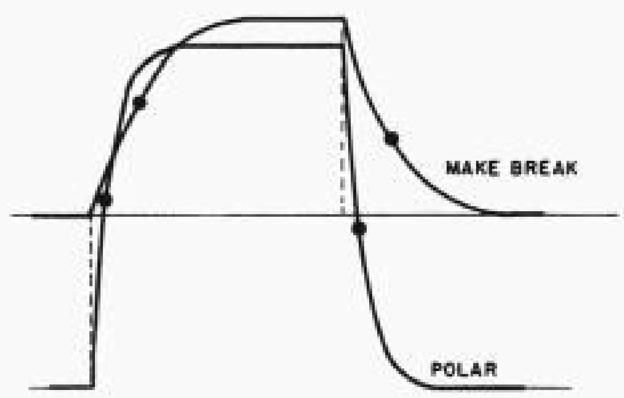


Figure 13

Relay travel time introduces no bias where the output circuit is polar. Since the SM and MS wave fronts in the driving circuit are identical but opposite, the interval of time during which the relay tongue travels from the spacing contact to the marking contact is identical to that during which it moves from the marking to the spacing contact, in responding to marking and spacing signals, respectively. Marking and spacing pulses delivered to the output circuit are therefore shortened by an equal amount. The effects cancel so there is no bias. This is illustrated in Figure 14 for the purely resistive polar output circuit and also for the practical condition where an antinoise set is connected in series with the relay tongue. As shown, the antinoise set produces smooth and somewhat sloped transitions in the output current wave, yet signal timing is perfect.

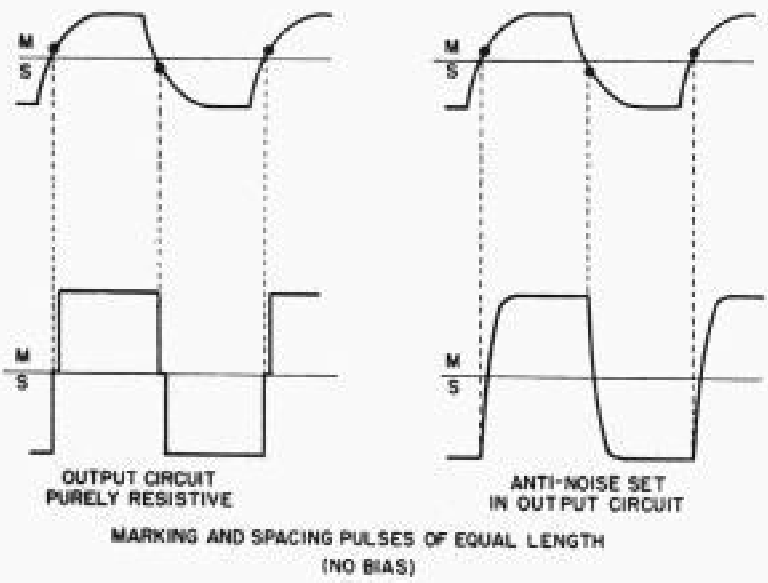
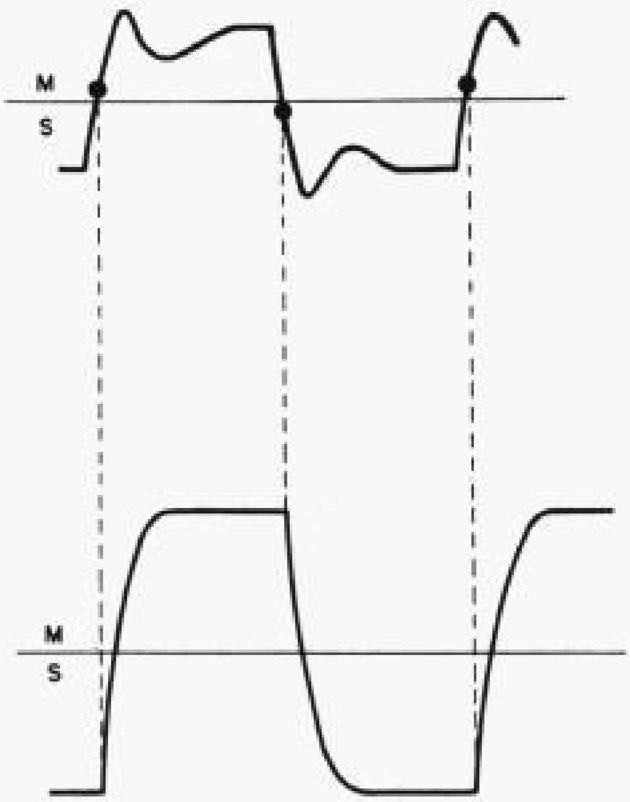


Figure 14

Where polar operation between the main office and an outer drop is employed, no bias is introduced by the interconnecting legs. Regardless of their make-up—whether they be short or long conductors, in open wire or cable (loaded or unloaded), with or without monitorial equipment or other apparatus—bias to and from the drop is nonexistent when the three basic conditions, already stated, are met. Figure 15 makes this clear. As before, both marking and spacing wave forms are identical but opposite. The relay will mark when the SM operate point is reached and will remain on marking, regardless of wave distortion within wide limits, until the current reaches the MS operate value. Then the relay will space and remain spaced until the SM operate value is reached. If equally timed signals are applied the delivered signals, if polar, will also be unbiased.

It should be evident from the foregoing that, because of the independence of current value and absence of bias, optimum operating margin is an inherent characteristic of polar operation. This feature gives excellent flexibility under normal and emergency conditions in that individual circuit components (facility and/or apparatus) may be readily isolated in event of trouble or readily interconnected without the necessity for regulation or adjustment.



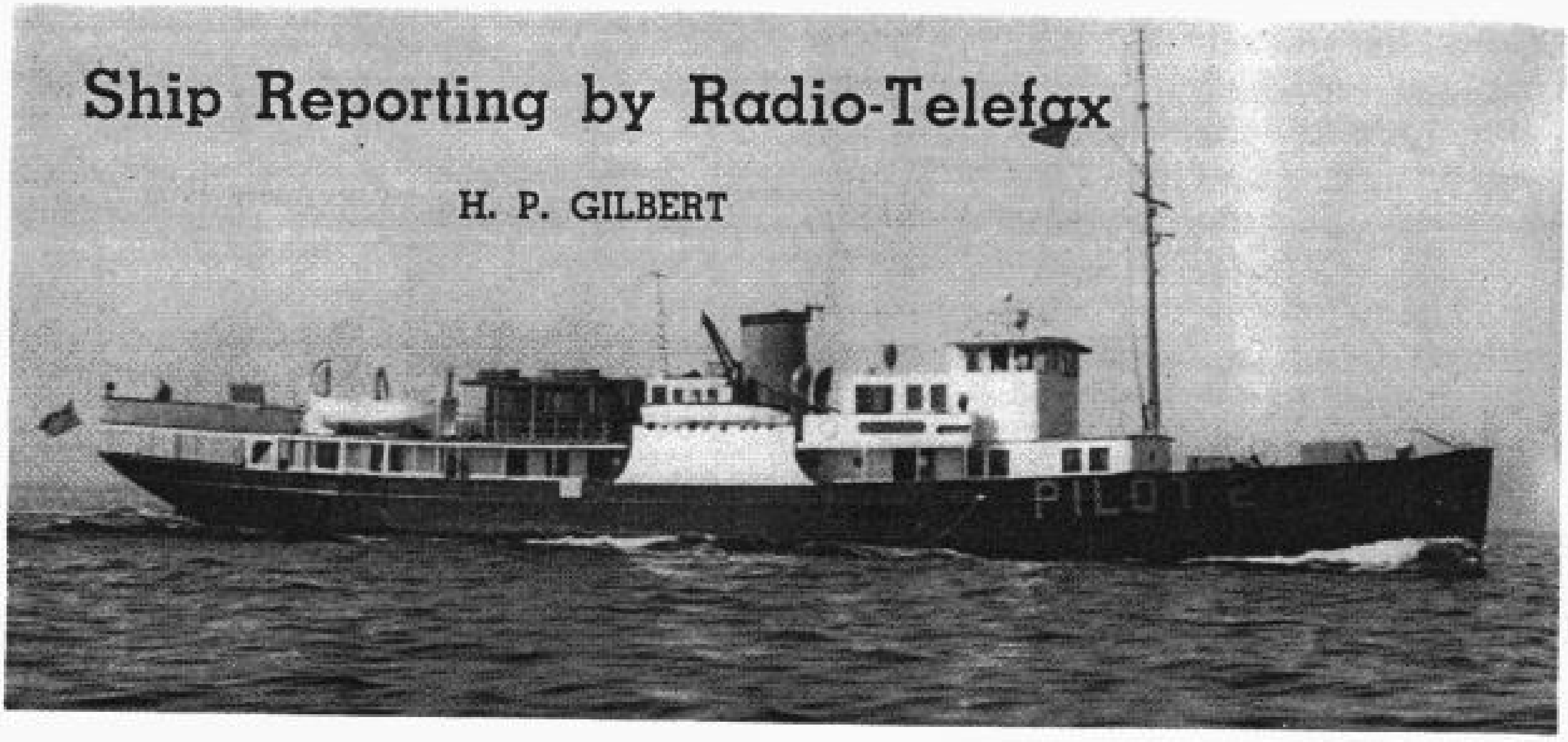
INPUT CURRENT WAVE DISTORTED
DELIVERED SIGNALS PROPERLY TIMED
(NO BIAS)

Figure 15

D. P. Shafer's interest in communications started with amateur and seagoing radio experience before attending Johns Hopkins University. Upon graduation with the degree of Bachelor of Engineering (Electrical) in 1926 he began his career with Western Union as an engineering apprentice at Richmond, Va. His subsequent experience included assignments as Chief Operator, Night Traffic Manager, Wire Chief, Division Traffic Inspector (T&R) and General Operations Supervisor. His supervisory experience embraces the mechanization and carrier conversion programs, major emergencies, special events, office moves, cutovers, dispatching and personnel development. He has conducted several T&R training courses and was responsible for the layout of the Operations School at Chattanooga. He has written a considerable amount of educational material, including a major portion of the Operations (T&R) Manual. Mr. Shafer holds commercial radiotelephone and radiotelegraph licenses and is a member of Tau Beta Pi. Appointed as General Supervisor of Operations in 1952, he acts as assistant to the Director of Operations.

Ship Reporting by Radio-Telefax

H. P. GILBERT



MAN HAS ALWAYS demonstrated considerable curiosity as to when, if ever, his ship is coming in. At New York City, the chief Atlantic port, as elsewhere, there has been over the years great interest in the arrival of vessels in the harbor. Various means of satisfying this interest have appeared, as the art of communication developed. Many years ago a system of arm semaphore signalling with stations located within telescopic visual range of each other was established from vantage points on Long Island, Staten Island and New Jersey, over which information of sighting of ships was rather laboriously transmitted to New York City. Following development of the electric telegraph, ship reports were transmitted by this newer means from towers at Sandy Hook, N. J., to a central point in New York for distribution to those interested.

In recent years a system of radio-facsimile transmission has been inaugurated which it is the purpose of this article to describe. This is believed to be the first instance of commercial "sea-going" facsimile operation, and is an outgrowth of Western Union's intensive development of this form of telegraph transmission.

Today, reports of incoming vessels originate with the harbor pilots, whose function it is to bring into the harbor and docks (and to take out of the harbor) most of the large vessels entering the port. In the Port of New York, this activity is conducted by two organizations whose operations are combined under the designation United New Jersey and New York Sandy Hook Pilots Association. This group has a well-integrated service operating two regular harbor vessels, the *New York* and the *New Jersey;* a third boat, the *Sandy Hook,* newly built, which takes over harbor station duties on occasion; and five smaller power boats, one or two of which are kept on duty on station for the purpose of transferring pilots from the station ves-

sel to incoming ships, or taking pilots from outgoing ships to the station pilot boat. The working station or anchorage is off Sandy Hook, N. J., some 15 to 20 miles from downtown New York City. The *New York* and *New Jersey* are sizeable craft, about 200 feet in length, while the *Sandy Hook* is about 90 feet long. These are comfortable vessels, with sleeping quarters for crew and pilots, and can remain on station for two weeks or more.

Through arrangement between the Pilots Association and Western Union, the latter has equipped the three larger boats with radio-Telefax and two-way voice-operated radio equipment operating on 156.9 megacycles. A fixed station is maintained in the Western Union building at 60 Hudson Street, New York City, where a remote control connection is also provided to the headquarters of the Pilots Association for their administrative work. Under the operating arrangement, the captain of the pilot boat reports to Western Union the arrival and departure of ships from the pilot boat station. Western Union maintains this Telefax and radio equipment in operating condition.

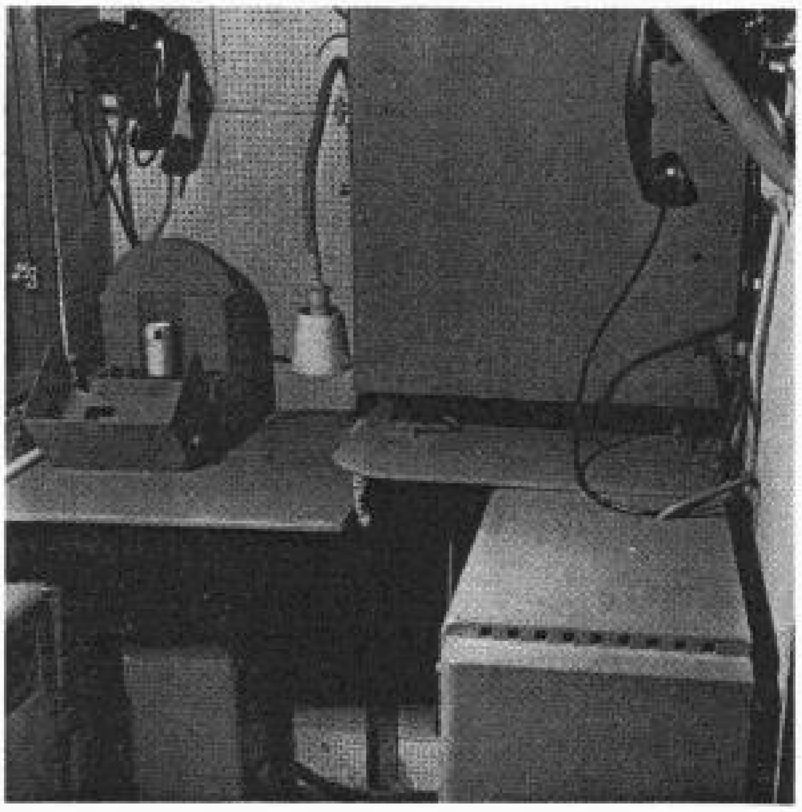
The pilot boats are equipped, in addition to the radio apparatus, with facsimile transmitting equipment which operates very much like the well-known Desk-Fax now in general use, although somewhat different in appearance. The signals which are sent from this facsimile equipment would be entirely unintelligible to any one who set up a radio receiver on this frequency and listened in. The copy received at 60 Hudson Street is written information and, in addition to being meaningless to the casual listener, provides the same freedom from misunderstanding of the spoken word that the Desk-Fax provides in ordinary business use.

The facsimile system used in this service differs in two important particulars from that of Western Union's other mobile radio-facsimile venture—the Telecar. On the pilot boats the facsimile *transmission* takes place from the mobile unit, whereas the mobile unit does the *recording* in the Telecar system. Also, the pilot boats have a source of 110-volt electric power available for operating the Western Union equipment, while the Telecar is dependent on a 6-volt storage battery.

Facsimile equipment on the pilot boats consists of a Telefax Transmitter 715-B, driven by a Synchronous Amplifier 141-B which is controlled by a 60-cycle frequency standard. This transmitter is the

Former marine observatories operated by Western Union to report ships entering and leaving New York Harbor. Left—Fire Island, N. Y.; center—Highlands, N. J.; right—Fort Hancock, Sandy Hook, N. J. Narrow horizontal covered openings at various levels of towers permitted ship observations by telescope.

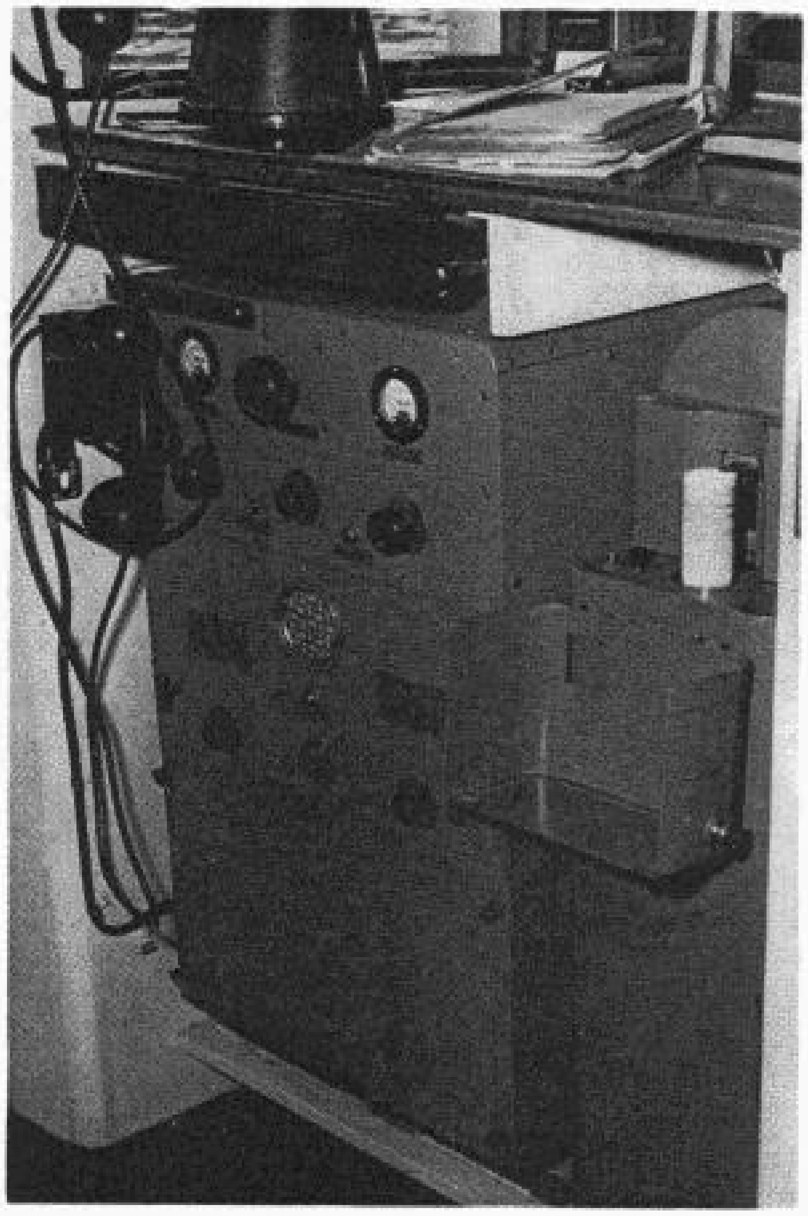
so-called "bottle" type, in which the message, on a 3⅜ by 5½-inch sheet, is inserted into a transparent cylinder, against the inside of which it is held by centrifugal force as the cylinder is rotated for scanning. Scanning is at 100 lines per inch with a cylinder speed of 180 rpm. A light chopper giving a carrier frequency of 2500 cycles is used in the usual optical scanning arrangement.



Radio-facsimile installation on the *New Jersey*. Radio transmitter-receiver at lower right. Facsimile transmitter at left

As is usually the case, space is at a premium on shipboard as may be guessed from the photographs of the installations on the *New Jersey* and *Sandy Hook*. On the *New Jersey* all Western Union equipment is located in a radio room just aft of the wheelhouse. On the *Sandy Hook*, —, the latest installation, — the radio equipment, frequency standard and synchronous amplifier are installed in a compartment especially built for them in the forecastle (the crew's quarters below the main deck) while the facsimile transmitter is in the wheelhouse. This latter arrangement is very convenient from an operating standpoint.

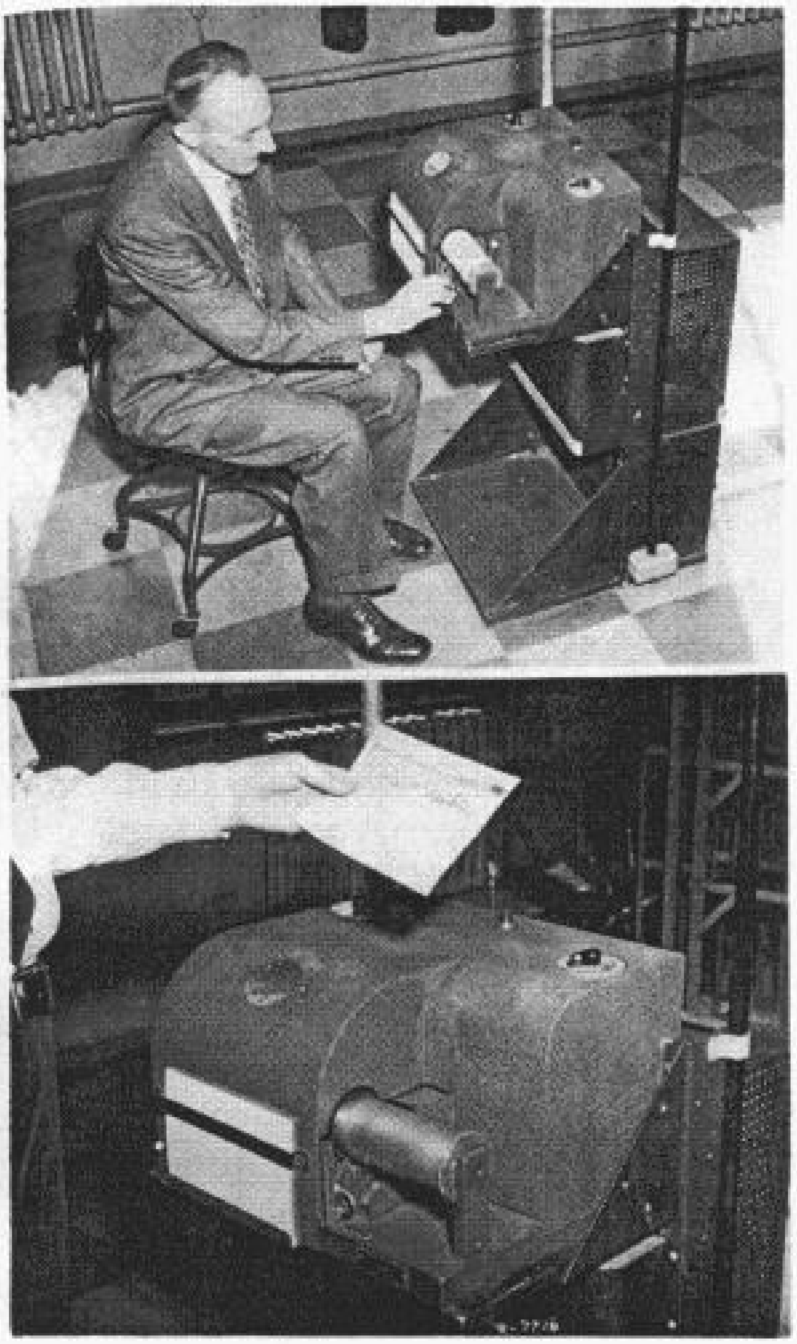
The facsimile signals are transmitted over the radio circuit without inversion, to eliminate some circuit complexity at the mobile station. The carrier frequency, therefore, is present on the radio signal during the scanning of the background or "white" portion of the message, and is suppressed during the scanning of the written or "black" portion. There has been some discussion as to whether or not this method of operation tends to reduce the visible effects of noise in the facsimile copy. However, the fact that this system operates with very little trouble from noise cannot be taken as proof of this



Facsimile transmitter in wheel house of *Sandy Hook*. Transmitter pedestal at right

theory, since signal levels over the path covered are good and provide good noise suppression. While the boats cannot be seen from the Western Union building in New York, the height of this building brings the 20-mile path well within the theoretical line-of-sight range. The boats are all equipped with vertical coaxial dipole antennas, at a height of about 30 feet above the waterline.

Radio equipment used on the boats and at the Western Union terminal has a power output of about 60 watts at the radio fre-



Facsimile recorder, frequency standard and synchronous power amplifier at Western Union building

quency used. It is "frequency modulated" with the usual deviation of 15 kilocycles and has an audio bandwidth of about 3 kilocycles for voice and facsimile signals. Power for the radio and facsimile apparatus on the *New York* and *New Jersey* is obtained from rotary converters producing 110 volts alternating current from the boats' direct-current supply. The *Sandy Hook* is equipped with 110-volt a-c generators which makes the use of converters unnecessary.

The modulation of the radio transmitters, while loosely called frequency modulation, is in reality phase modulation, since the transmitters are crystal-controlled for frequency stability. This form of modulation results in a transmitter frequency deviation which is proportional to the frequency of the modulating signal as well as to the audio level of the modulation. There is, therefore, an automatic high-frequency pre-emphasis in transmission, and this is compensated for by a de-emphasis network in the receiver to restore the balance of audio frequencies. This pre-emphasis amounts to approximately 6 db per octave.

At 60 Hudson Street, a vertical coaxial dipole antenna with director and reflector elements to provide a directional characteristic is mounted on a mast on the roof and aimed at the boat station off Sandy Hook. The radio apparatus is installed in a room at the top of the 24-story building, and provided with an audio circuit to the

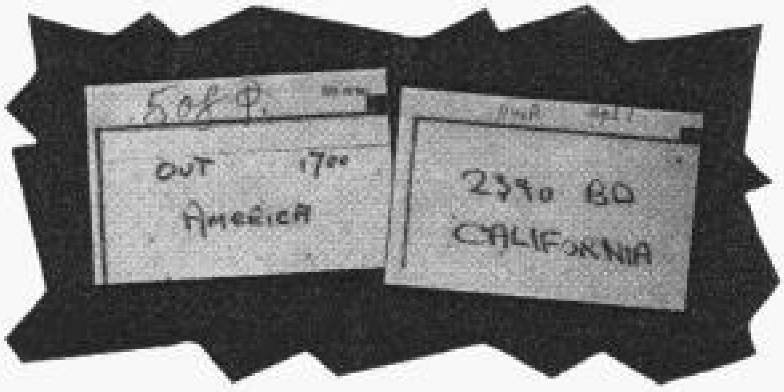
SHIP REPORTING SERVICE

LOG — DECEMBER 1953

DATE	SHIP ON STATION	NO. OF REPORTS*
1	*New York*	58
2	*New York and New Jersey*	48
3	*New York*	52
4	"	55
5	"	58
6	"	41
7	"	46
8	"	54
9	"	51
10	"	62
11	"	71
12	"	58
13	"	44
14	"	34
15	"	43
16	"	68
17	*New York and New Jersey*	55
18	" "	56
19	*New York*	61
20	"	52
21	"	51
22	"	53
23	"	57
24	"	70
25	"	27
26	"	30
27	"	38
28	"	39
29	"	51
30	"	46
31	"	58

*May cover two or more ships each

Commercial News Department on the 8th floor, where the facsimile recording equipment is located, and from which location the radio apparatus is remotely controlled. Facsimile Recorder 809-A, a rotary drum type, is driven by a Synchronous Amplifier 141-B and a 60-cycle standard fre-



Facsimile messages received at 60 Hudson Street

quency generator similar to the equipment on the boats. Phasing is accomplished by means of signals transmitted from a phasing block at the top of the sending blank. The recording blank is 8 by 5⅜ inches in size, so the received copy is larger than the original. The recorder drum operates at 180 rpm, but is larger in diameter than the transmitter cylinder, and the recorder scans at approximately 60 lines per inch.

A cavity resonator tuned to 156.9 megacycles is inserted in the antenna lead to the receiver at the Western Union building to remove intermodulation interference from other powerful transmitters operating in this band in lower New York City. The boat station is far enough out so that this trouble is not experienced at the mobile units.

This circuit is in operation 24 hours a day every day, and a surprising number of reports are handled during the night. A log of operation for the month of December 1953 gives an idea of the number of reports made. Other reports are received by land-line telegraph from Quarantine, and all reports are retransmitted over a self-winding ticker circuit to regular subscribers for the full ship reporting service. These subscribers are largely steamship companies, although companies engaged in other types of transportation are also included. Numerous other subscribers get special reports on certain vessels only.

Henry P. Gilbert began his communications career with an amateur "wireless" station while in high-school. Following graduation he went to sea as a wireless operator, entered the Navy at the start of World War I, and left the service after the war with a commission as Ensign for Engineering Duties. He entered the electrical engineering school at Virginia Polytechnic Institute, graduated in 1923, and came to the Engineering Department of Western Union that same year. Mr. Gilbert worked for a number of years on the design and development of telegraph terminal sets and repeaters and the components that make up these sets, and on telegraph transmission problems. In later years he has returned to his first love, now known as radio, and had a part in the development of Western Union's radio beam system and the training of operating personnel for it, and in mobile radio-facsimile applications, particularly the Telecar.

A Microwave System for Telegraph Service

J. J. LENEHAN

Introduction

THE SYSTEM described in this paper was designed to provide trunk facilities for telegraph purposes. The accumulated experience the telegraph company gained from its New York-Washington-Pittsburgh radio relay triangle was of value in the early stages of planning. This commercial service, which was installed in the latter part of 1946 and placed in operation early in 1948, highlighted many of the problems that are encountered with this transmission medium.

Simultaneously with the operation and monitoring of the triangle circuit, Western Union embarked on long-term propagation tests. The results of these tests, which have been described in technical papers,[1, 2] were conclusive enough to establish that the effective radiated power of the transmitters would have to be increased to meet the continuity of operation demanded by telegraph service. The additional margin of 20 db that was desired was achieved by placing a SAC-41 Klystron amplifier after the original 2K56 transmitter reflex tube. The SAC-41, which was developed by the Sperry Gyroscope Company under Western Union contract, covers the 3700-mc to 4200-mc common carrier band, and as an amplifier delivers about 10 watts. The reduction of fading outages[3] with this added power made this a reliable service.

In addition to engineering improved propagation reliability in the new system, the effects of "aging" between regular maintenance intervals were explored. This aging normally manifests itself in a marked reduction in signal-to-noise, and if serious enough actually reduces the load carrying capacity of the system. Aside from its obvious disadvantages to the Operating Department and those responsible for radio maintenance, this aging effect also entails a rather sizeable capital investment in test equipment. To reduce such effects, the new system employs subcarrier and heterodyne repeaters.

The heterodyne feature eliminates the distortion inherent in modulating and demodulating with the basic intelligence at each repeater, and the subcarrier features permit long-term variations in repeater amplitude and phase characteristics with minimum effect on the modulation.

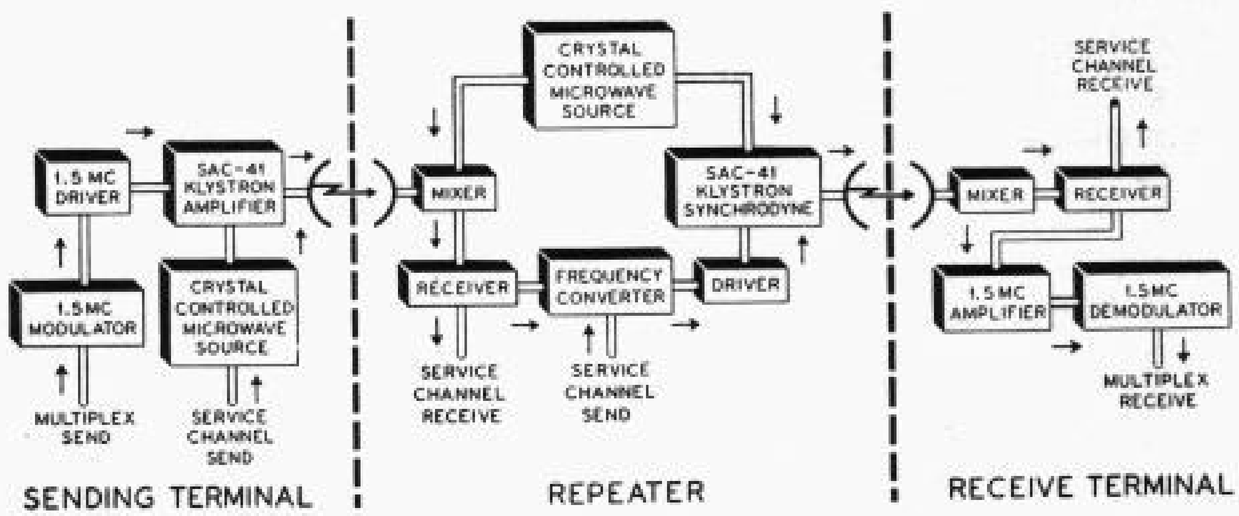


Figure 1. MLD-4A System—block diagram

Modification

A simplified block diagram of the MLD-4A microwave system appears in Figure 1. The 1.5-mc modulator was de-

A paper presented before the IRE Microwave Radio Relay Systems Symposium in New York, N. Y., November 1953.

signed to handle the bandwidth required for a 40-voice-band frequency division type of multiplex equipment. The composite output signal of the multiplex terminal frequency modulates the 1.5 mc produced in this unit and on peaks achieves a deviation of ±500 kc. With this deviation and suitable band-pass characteristics, the subcarrier is maintained within the octave of 1 mc to 2 mc and some improvement in cross-talk suppression is realized over the method which employs more than an octave.

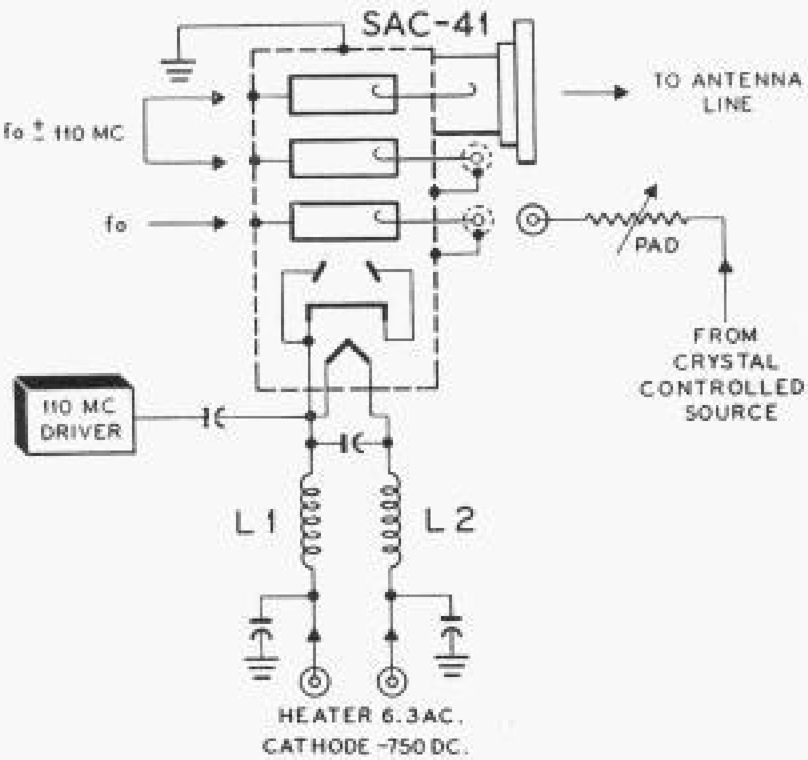


Figure 2. MLD-4A Repeater—SAC-41 transmitter circuit

The modulation of the SAC-41 by the 1.5-mc output of the modulator is somewhat different from the more conventional means employed with reflex tubes. In a klystron of this type the anode potential is varied at the modulating frequency rate, which produces phase modulation of the tube's electron stream. With a beam potential of 750 volts, the modulating potential is approximately 25 volts rms for the equivalent FM deviation of ±3.25 mc. To produce this voltage with the relatively heavy loading of the klystron electron stream, it was necessary to design a high-power 1.5-mc driver, which is illustrated schematically in Figure 2. The driver output is developed across chokes L_1 and L_2, and the modulating potential is in effect placed in series with the klystron's beam voltage. The RF source is coupled to the first of the three synchronously tuned cavities and because of variations in tubes, the microwave input must be adjusted for optimum drive. The phase modulation characteristic in the SAC-41 is changed to equivalent FM to achieve the optimum improvement factor by maintaining a 6-db slope over the modulating frequency range of 1 mc to 2 mc.

Crystal Control

The microwave frequency employed for the receiver local oscillator and transmitter source is developed in the crystal-controlled multiplier. The advantages of this method are high stability and minimum maintenance adjustment. The basic frequency in the multiplier range is produced by a temperature-controlled crystal with a stability of ±0.005 percent. Multiplication to the 200-mc range is accomplished by typical lump constant circuitry, and two cavity-tuned lighthouse stages are employed as doublers to reach 800 mc. The multiplication from 800 mc to 4000 mc is obtained by an SMC-11-H Klystron. This type contains within one envelope an input cavity tunable over the range of 740 mc to 840 mc, and an output cavity that will cover the 3700-mc to 4200-mc common carrier band.

The front view of the crystal multiplier showing the relative position of the stages is pictured in Figure 3.

At terminals, the service channel, which is independent of multiplex channels and

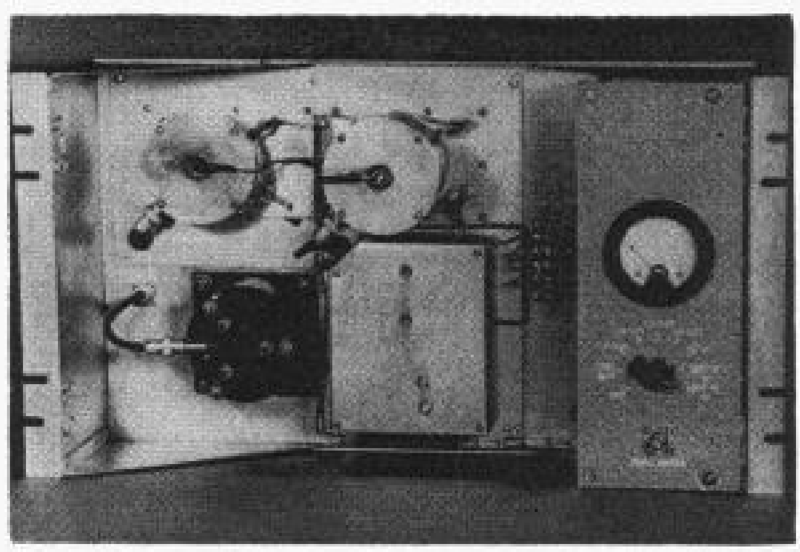


Figure 3. Front view—crystal-controlled microwave source

is employed for maintenance and the fault-locating functions to be described later, modulates the crystal multiplier. The normal service channel deviation is ±100 kc and is accomplished by phase modulation in the second stage of the multiplier chain.

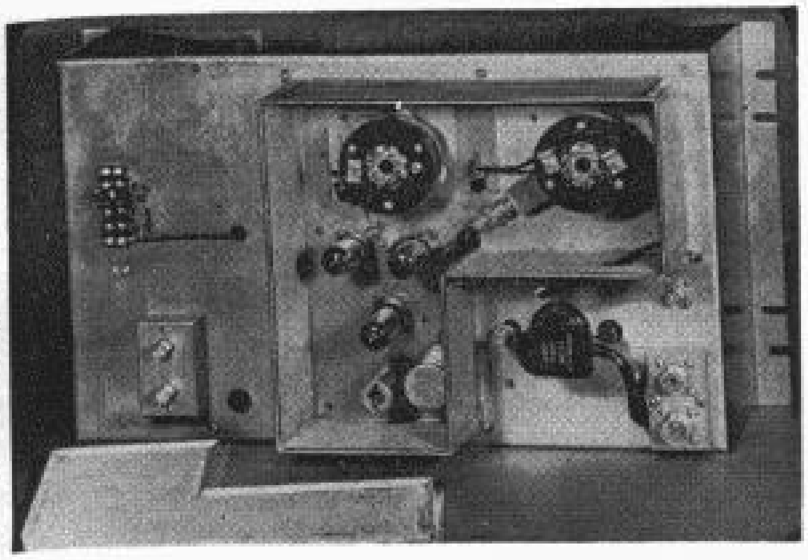


Figure 4. Rear view—crystal-controlled microwave source

In the design of the multiplier, it is necessary to be aware of the relatively strong fields at the frequencies of the multiplier chain that can appear as interfering signals in the RF and IF amplifier units of the system. The first obvious precaution is the choice of frequencies for the individual stages, which do not fall into the band pass of any of the units. Aside from these, however, are the other harmonics always present as well as sums and differences that can mix in the receiver crystal input and fall in the amplifier band pass. This effect becomes more prominent as the noise figure of receiver is improved. To minimize radiation effects, a shield is placed over the rear of the multiplier which is equipped with a press-fit cover that can be removed for maintenance. A rear view of this unit is shown in Figure 4 with the shielding cover removed.

Frequency Allocation

When designing a relay system employing heterodyne repeaters, one of the basic problems is the relationship of transmitter frequency to received frequency at each relay station. In the design it was realized that since Western Union is co-user with other common carriers of the 3700-4200-mc band, it would be best to maintain a circuit frequency allocation that was compatible with systems already in the field. The upper section of Figure 5 shows the channel assignment employed by the Telephone Company's TD-2 system, and it can be seen that 20-mc-wide channels are placed at 40-mc intervals. To reduce the mutual interfering effects on parallel and crossing paths, it was decided to interleave the MLD-4A channels so that they fall be-

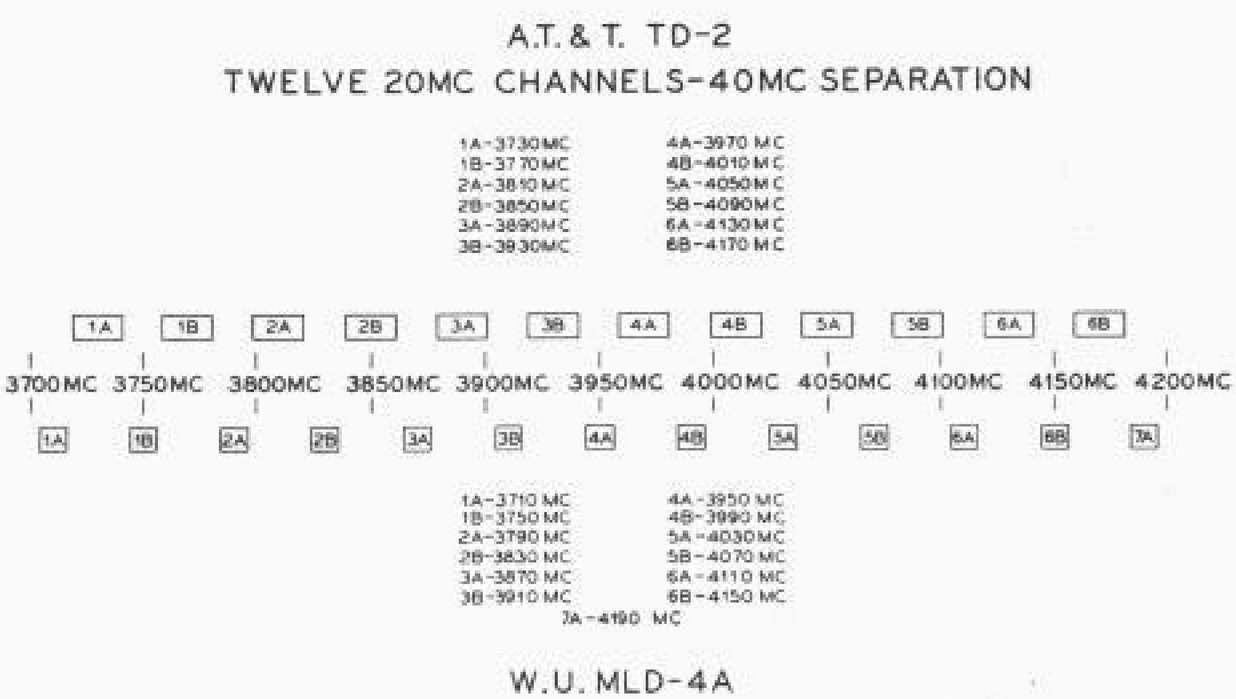


Figure 5. 3700-mc to 4200-mc frequency allocation

tween those occupied by the Bell System. The Western Union frequency allocation for the MLD-4A is shown in the lower section of Figure 5. With this method of channel interleaving, optimum utilization of the band is achieved by employing a ±40-mc relationship between the received and transmitted frequency at each repeater.

Repeater

The units that provide the necessary repeater gain and produce the desired relay frequency translation are depicted in the block diagram of Figure 6. At each

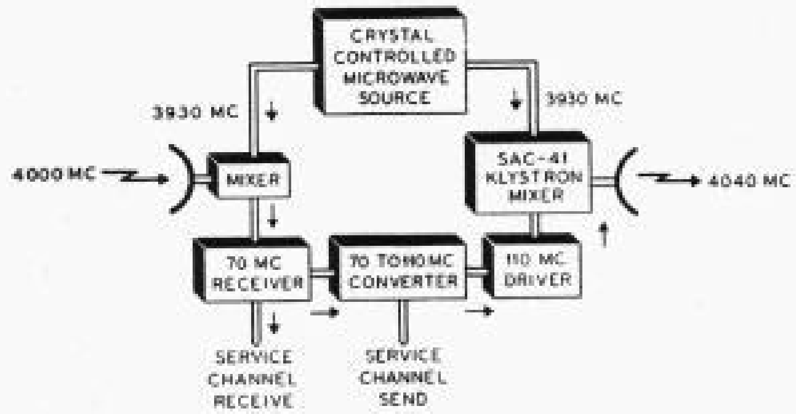


Figure 6. MLD-4A Repeater—block diagram

repeater the incoming signal is converted to the 70-mc intermediate frequency by mixing with the energy supplied by the crystal-controlled microwave source. The receiver amplifier is flat within less than 1 db over a 10-mc range and includes agc and limiting. The next step in the relay frequency translation is accomplished in the 70-mc to 110-mc converter. This unit produces the frequency shift by heterodyning the receiver amplifier output with a crystal-controlled 180-mc oscillator. There are additional stages to provide the necessary selectivity and band-pass characteristics for the 110-mc difference frequency.

The circuitry used for high level mixing of repeaters is similar to that employed at terminals for modulation. Figure 7 is a schematic illustration of this circuit. The 110-mc phase modulates the microwave input and as in any modulation system there is a signal distribution of first, second, etc., order of sidebands. The second and third cavities will not pass the entire modulated band, but are tuned to either the upper or lower first order sidebands. The level of 110-mc is set for maximum first order sideband while the microwave input is adjusted for optimum drive. With this method of synchrodyning, the transmitter power is of the order of 6 to 8 watts.

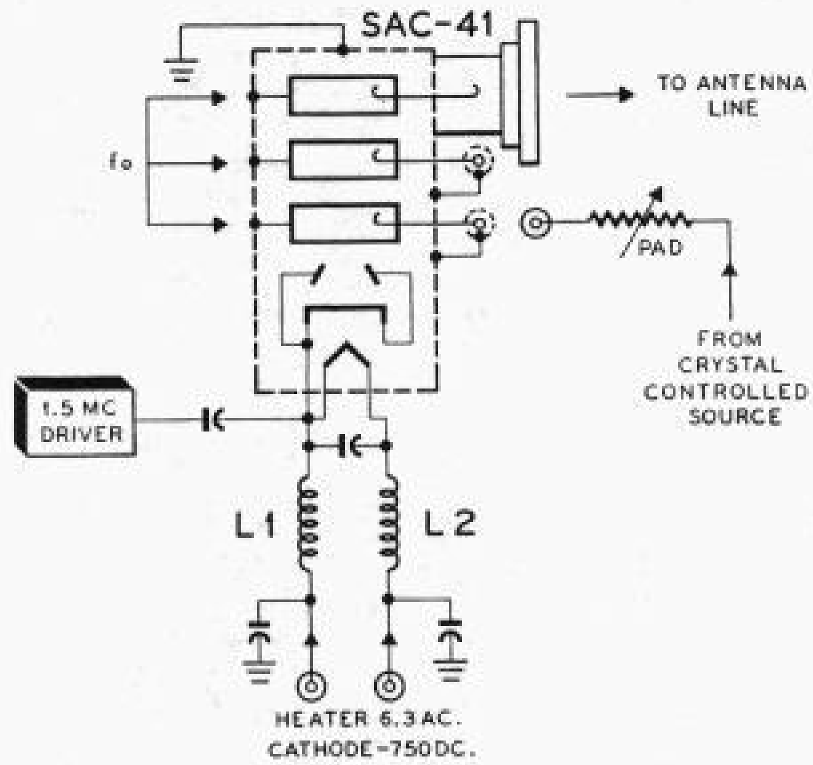


Figure 7. MLD-4A Terminal—SAC-41 transmitter circuit

The front and rear views, respectively, of a two-way MLD-4A repeater appear in Figures 8 and 9. In general, all metering and tuning can be done from the front, while tube replacement is accomplished from the rear.

Demodulation

The functions of the terminal can best be described by referring to Figure 1. As at a repeater, the incoming signal is converted to 70 mc, and within the same unit the signal is demodulated by a 70-mc discriminator. This discriminator is also available in the receiver panels at repeaters. At terminals, where both the 1.5-mc and service channels are desired, a filter provides the necessary selectivity. The 1.5 mc is amplified to the proper level for extended cable runs, before it is fed to the 1.5-mc demodulator which removes the composite multiplex intelligence for operation of the carrier terminal.

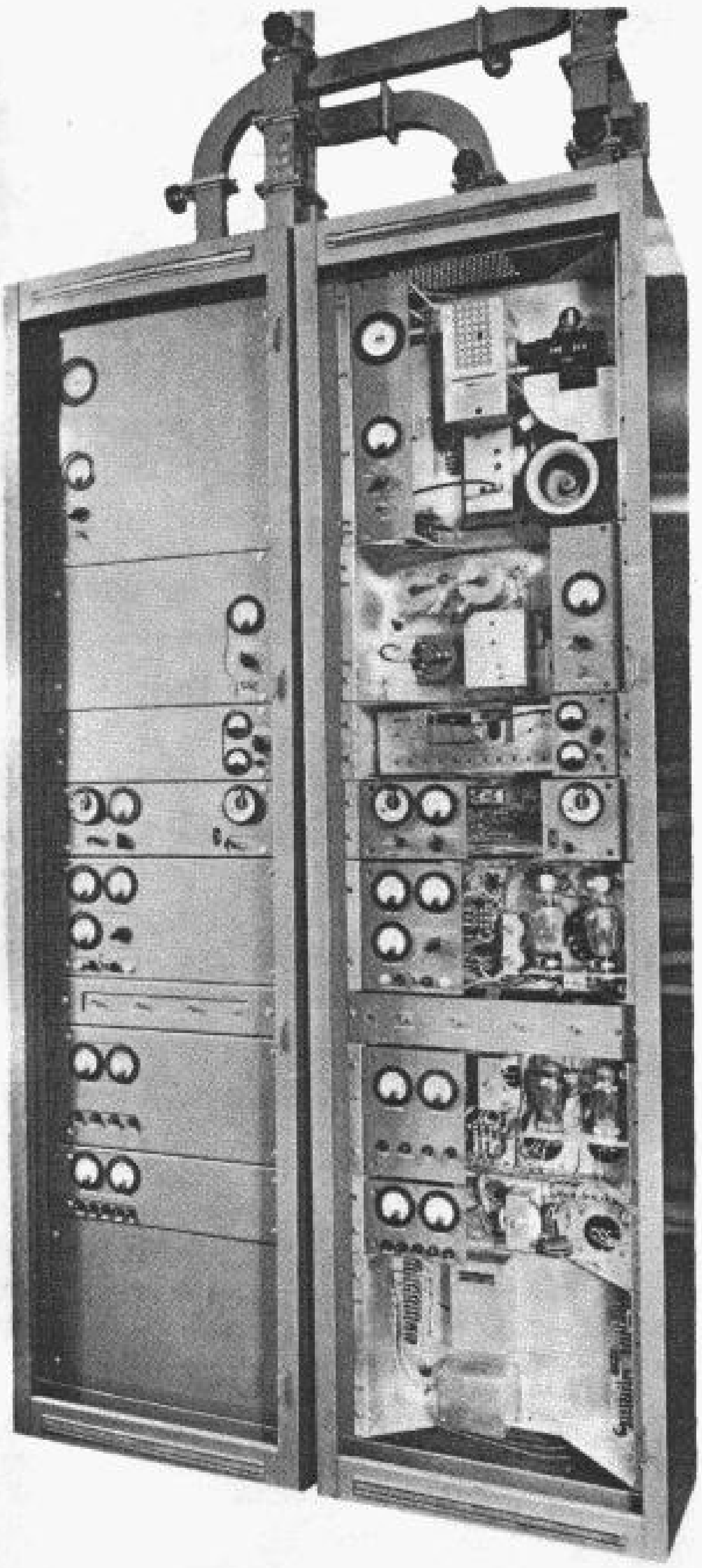


Figure 8. MLD-4A two-way repeater—front view

Fault Locating

In any system that employs unattended repeaters, the fault-locating system has, as a minimum requirement, the location of the tower at which a system failure occurs. Figure 10 is a block diagram representing a failure between towers A and B. This failure is of the simpler type since the circuit is assumed to be operating normally in one direction. The fault-locating equipment at each station monitors receiver agc current as well as relative transmitter power. When either of these falls below a predetermined level, that station sends back a tone whose frequency is peculiar to the repeater, and coding of the tone denotes whether it is low agc or low transmitter power. In the failure shown in Figure 10, the west terminal would receive a coded tone from B if the failure is in the receiver at Station B. If the failure is due to low transmitter at Station A, the west terminal will receive this information from repeater A as well as the information from tower B.

The more complex fault is one where the circuit fails in both directions. This type of failure is especially serious in

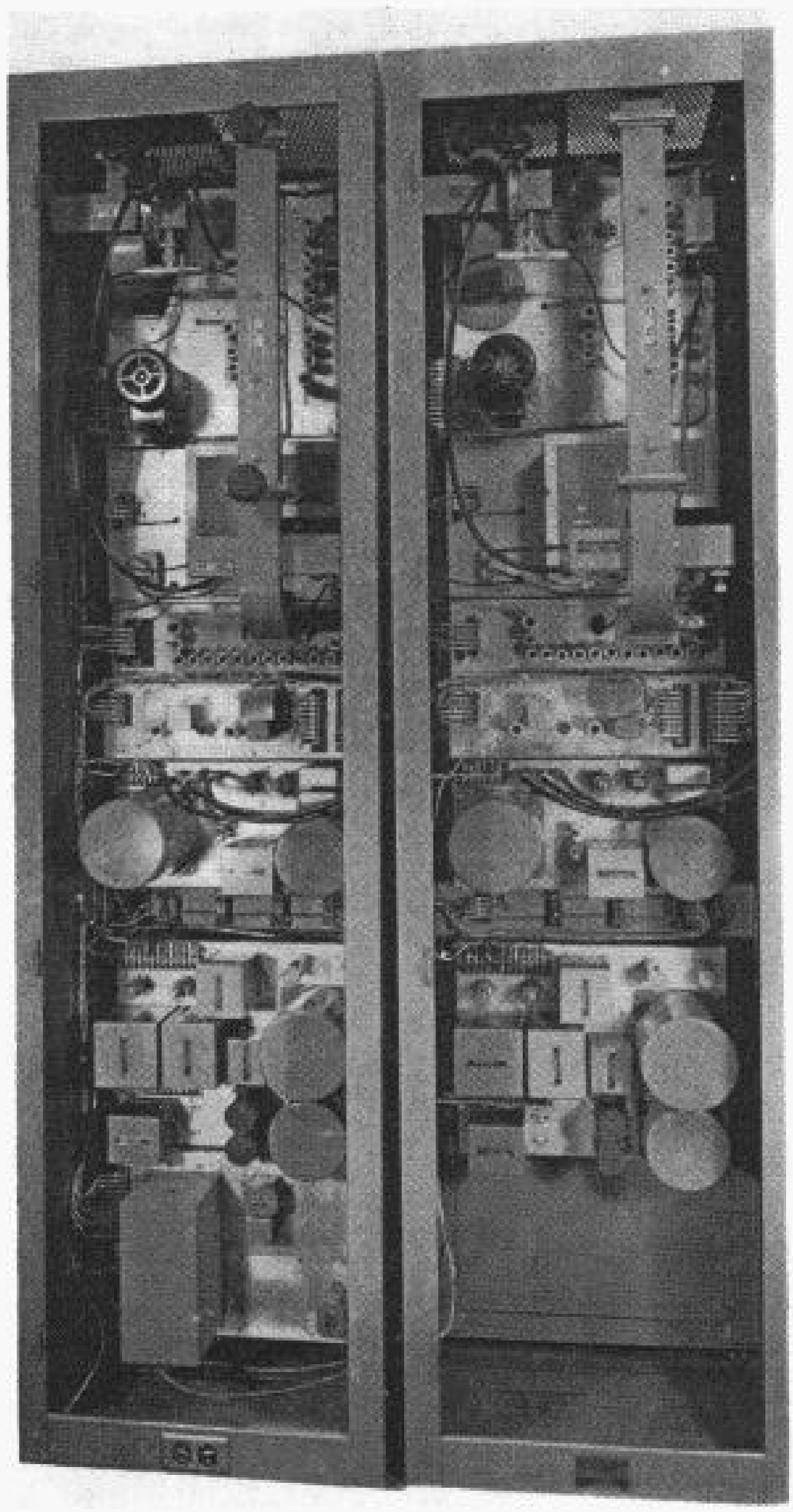


Figure 9. MLD-4A two-way repeater—rear view

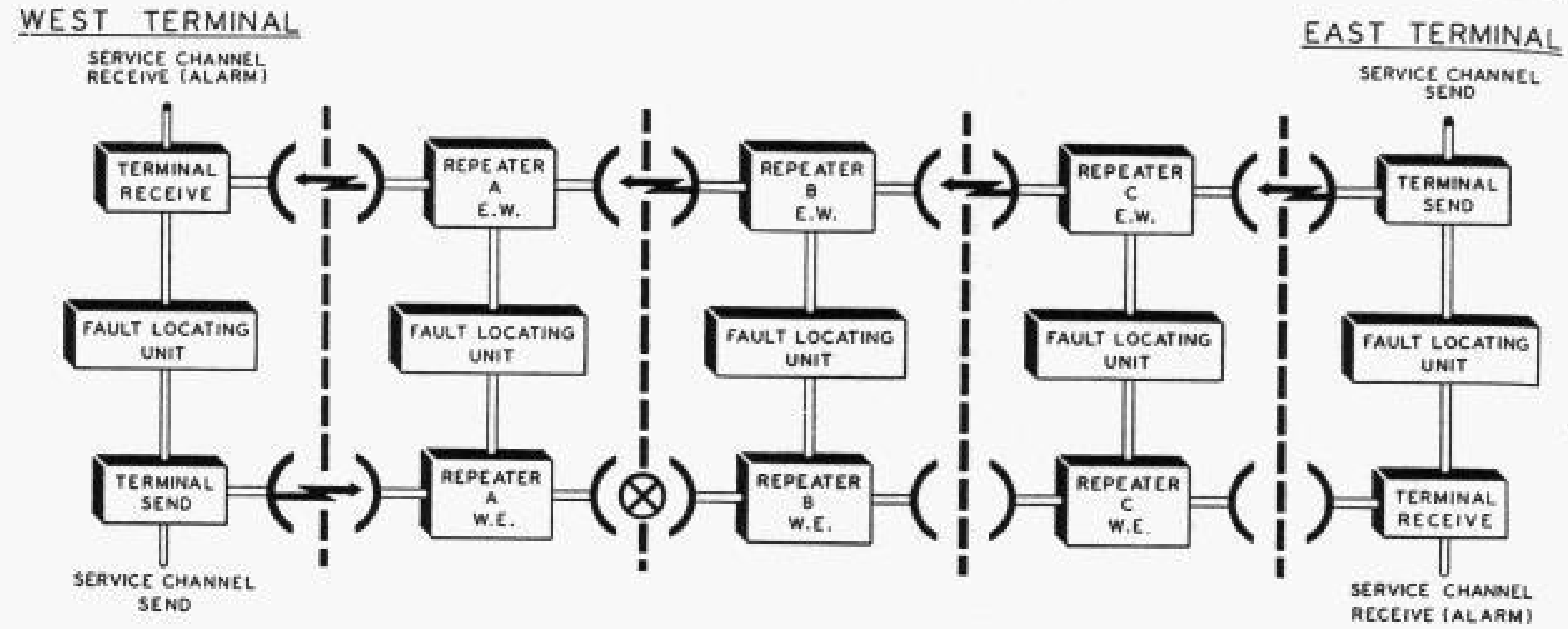


Figure 10. MLD-4A fault locating system—block diagram

heterodyne type repeaters where transmission at each station depends upon a received signal. With any break the RF path is lost beyond the break, and in order to restore the transmission path, a 70-mc reinstatement oscillator is activated and replaces the receiver output as drive to the 70-mc to 110-mc converter.

Figure 11 is a more detailed block diagram of the repeater fault-locating functions.

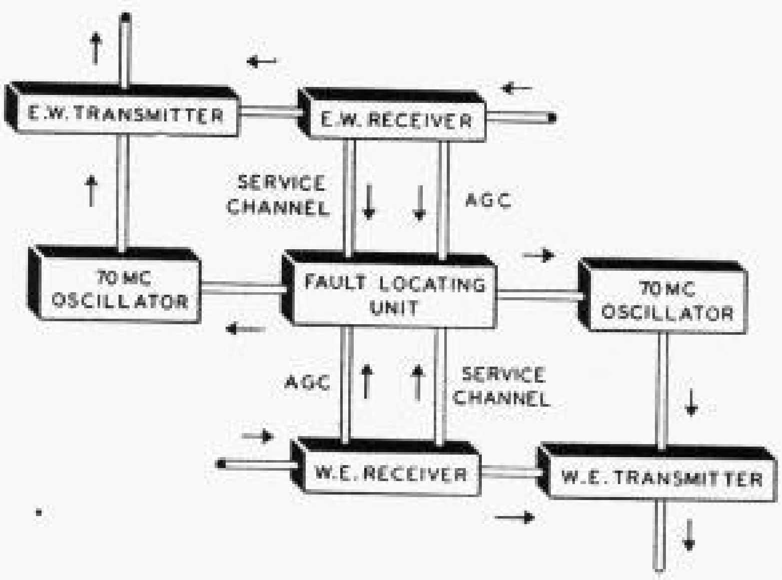


Figure 11. MLD-4A fault locating repeater—block diagram

The point at which the 70-mc reinstatement oscillator of each station comes on is a function of the agc potential, but this cannot be the only determining factor. The point where the received signal has dropped low enough to cause circuit interruption is not a fine line, as it is determined among other things by operating conditions on the other links of the system as well. To insure that the 70-mc oscillator does not come on while the circuit is still capable of carrying traffic, one additional requirement has been placed on the operation. When an actual break has occurred, the terminal sends out a 20-kc tone. The reception of the tone activates a relay and the combination of this tone and low agc places the reinstatement oscillator in operation.

Antenna System

It is not within the scope of this paper to detail the design efforts involved in the antenna equipment, but the pertinent points of interest from an over-all standpoint will be described briefly.

The economic advantages of the passive-reflector method made this type of radiating system attractive. In order to determine quantitatively the cross-coupling effects with such devices, Western Union made a test installation at Monsey, N. Y. An analysis of the results of these tests has been published,[4] but it might be briefly stated here that passive reflectors are desirable for routes which have a small number of RF channels and where it is possible to use a separate frequency for each transmitter and receiver at a given station. On heavily loaded routes where a large number of circuits are required, and the resulting necessity for frequency conservation reduces the two-way transmission to two frequencies, that is, to receive on one frequency from both directions, and to send on a second frequency in both directions, a more elaborate antenna system is required. A type that appears promising for this application is the "hog-horn" or horn reflector shown in a test setup in Figure 12.

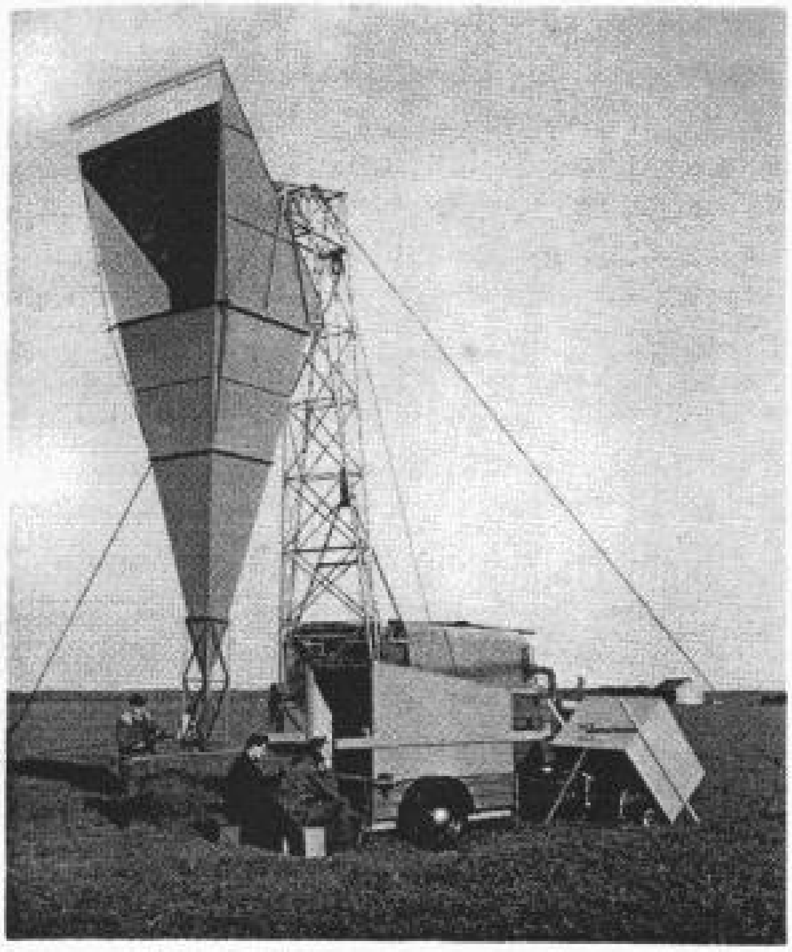


Figure 12. Horn-reflector antenna

In addition to the radiating elements, the antenna system of the MLD-4A consists of suitable wave-guide components for either duplex or multiplex operation. When duplexing, the received and transmitted RF signals to be separated in the filter system are spaced by 120 mcs, so that a single antenna may be used for both transmitting and receiving on one side of a repeater.

When two or more channels are required on one route, a system of multiplexing is employed so that all the transmitters for one direction are on a common antenna and all receivers are on a second antenna. With this method the receiver and transmitter frequencies alternate their positions in the band at each station.

Emergency Power

Figure 13 is a view of the emergency power equipment to be used with the MLD-4A installations. It consists of a common shaft coupled a-c motor, a-c generator, and d-c motor-generator. Under normal conditions the a-c motor is operated on the commercial power and the a-c generator provides the primary source for operating the radio equipment. At this time the d-c machine is functioning as a generator and is providing trickle charge for a bank of batteries. If the commercial power fails, the d-c machine instantly becomes a motor driven by the batteries, and the a-c generator continues to supply power for the MLD-4A equipment.

The battery life cycle here would be about three hours which is hardly sufficient to cover some serious power failures. These are covered by a gasoline-driven alternator that comes on when the commercial power fails. It does not, however, take over the load until it has reached proper voltage and frequency. The entire system is an improvement on the one employed on the New York-Washington-Pittsburgh triangle, in that it eliminates vibrators but maintains its predecessor's ability to switch without losing even one telegraph signal pulse.

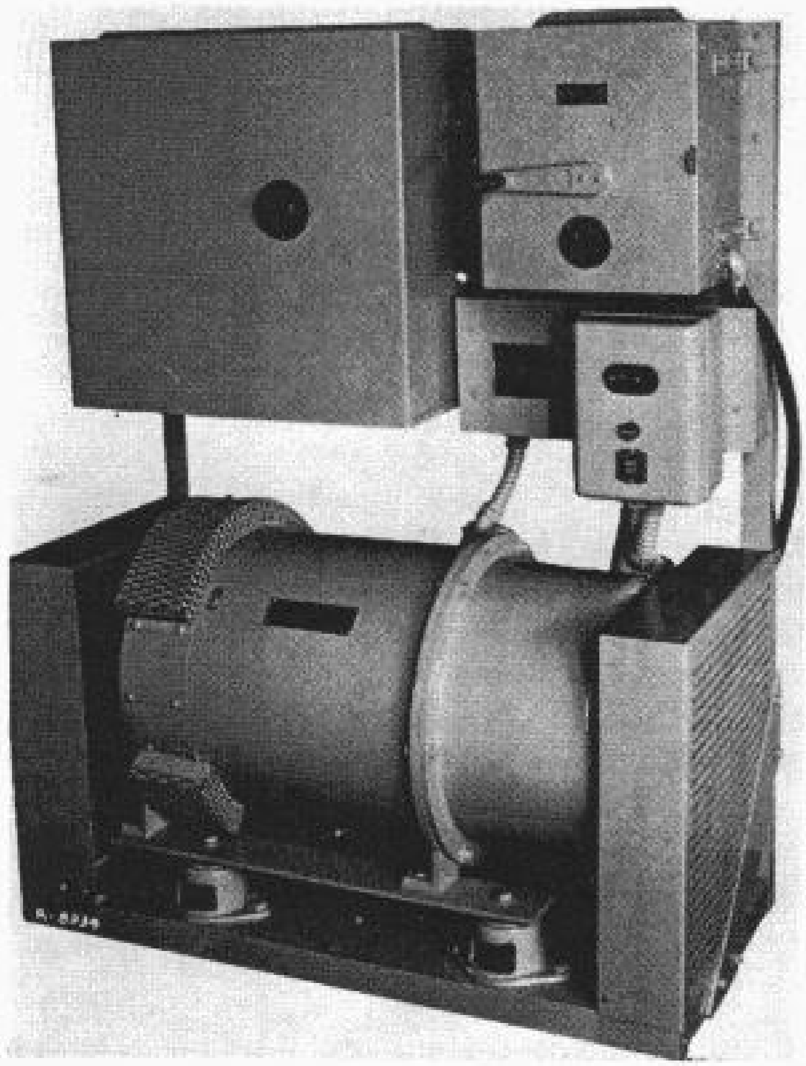


Figure 13. Emergency power—3-unit machine

Figure 14. Passive-reflector tower at Woodbridge, N. J.

Conclusion

The MLD-4A microwave system described above has as its major objectives increased load carrying capacity, improved signal-to-noise performance, and a high degree of reliability. To assess the ability of the equipment to meet these demands, laboratory and field tests have been made and continue. The field trial consists of the installation of a repeater of this type (Figure 14) at the Woodbridge, N. J., station of the New York-Philadelphia radio circuit. This test, which began in November 1953 and is still in progress, indicates a minimum of maintenance is required.

References

1. A Microwave Propagation Test, J. Z. MILLAR and L. A. BYAM, Jr., *Western Union Technical Review,* Vol. 4, No. 2, April 1950; *Proceedings of the I.R.E.,* Vol. 38, No. 6, June 1950.
2. Notes on Microwave Propagation, J. Z. MILLAR and L. A. BYAM, Jr., *Western Union Technical Review,* Vol. 7, No. 3, July 1953. *Convention Record of the I.R.E., Part 2—Antennas and Communications,* 1953.
3. A Radio Relay System Employing a 4000-mc 3-Cavity Klystron, J. J. LENEHAN, *Western Union Technical Review,* Vol. 6, No. 3, July 1952.
4. Passive Reflector-Antenna Systems, R. E. GREENQUIST and A. J. ORLANDO, *Western Union Technical Review,* Vol. 8, No. 2, April 1954.

J. J. Lenehan received his Bachelor's Degree in Electrical Engineering from New York University in 1947. He has been a member of the Radio Research Division since his separation from the Navy in December of 1945. His duties have included preparation of a training program for the engineers and maintenance personnel of the radio relay system, the early propagation studies, and the installation and testing of the New York-Washington-Pittsburgh triangle. He is Assistant to the Radio Research Engineer and is presently involved in the development of equipment for microwave systems. Mr. Lenehan is a member of the RETMA Committee "Microwave Relay Systems for Communication," and chairman of the subcommittee on "Multiplexing and Terminating Equipment."

A Letter-Size Facsimile Transceiver

WITH the development of the Desk-Fax transceiver[1,2] and its successful adaptation to the terminal handling of telegrams in Western Union services, it was natural that efforts would be made to enlarge its field by developing apparatus that could be leased to customers having similar local communication problems. Accordingly Intrafax concentrators[3,4] were designed and are meeting this need. Further expansion of the use of Desk-Fax in the leased service field is limited, however, because of the relatively small size blank (4½ by 6½ inches) for which it was designed and which is adequate for the exchange of telegrams. It was decided, therefore, that a transceiver capable of handling letter-size copy (8½ by 11 inches) should be provided.

It might seem that this could be accomplished merely by using a larger and longer drum on the present Desk-Fax electronic chassis, and by turning the drum faster to keep transmission time brief. Examination of the problem revealed, however, that a number of new factors are involved when the size of the copy is increased and the transmission rate is doubled. A few of these are:

1. Assuming the transceiver should be capable of operating at either 180 or 360 rpm, because of the inherent increase in weight of the drum due to its larger size a much larger and more powerful motor is required to revolve it at the double speed.
2. In order to record satisfactorily at 360 rpm the single ended (6V6) recording amplifier of the Desk-Fax was not adequate. A push-pull amplifier (2—6V6) was required, together with a proportionally larger power supply.
3. For operation together (one-to-one), it was felt that instead of using the optical type inverter a modulator should be provided which would automatically set up on the background of the subject copy, thus permitting employment of originals having a wide range of background color.
4. In the Desk-Fax, the copy sheet is held on the drum by a single spring garter and a flange at the left end of the drum which was not considered adequate for the 8½- by 11-inch sheet. Four garters are used to hold the larger blank, two at the top which are not handled by the operator but are under control of the carriage. The operator places the sheet on the drum and rolls on the two garters at the bottom of the sheet. During transmission, the garters at the top are rolled onto the sheet automatically by the carriage, and at the same time those placed on the copy by the operator are rolled off by the carriage.
5. An end-of-message switch adjustable by the sending operator is provided to save transmission time. At the receiver, a signal is provided to indicate whether the incoming message is long or short, thus enabling the operator there to place the appropriate length Western Union *"Teledeltos" recording sheet on the drum.

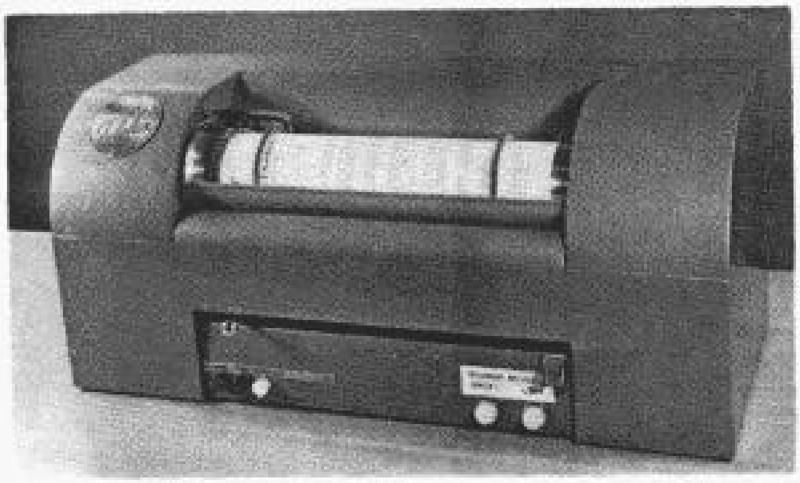


Figure 1. Model Transceiver EM2127—mechanical unit

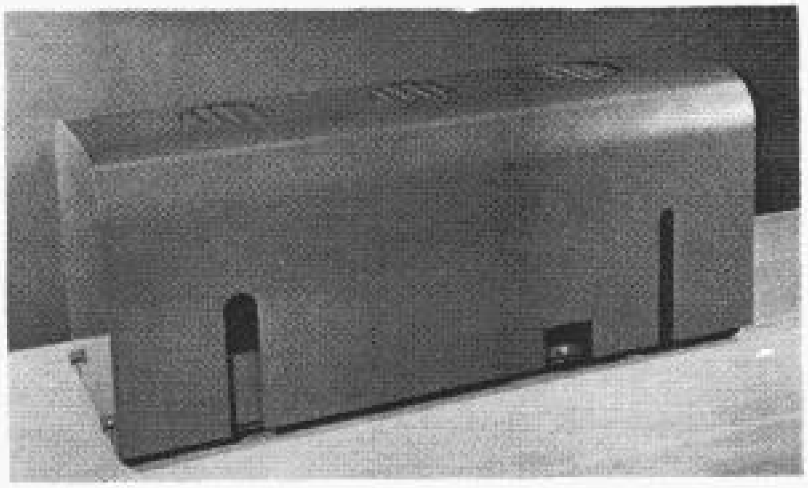


Figure 2. Model Transceiver EM2127—electronic unit

When these factors were taken into consideration and the design made to include the new requirements with the larger components, it became evident that the transceiver was going to be too large and heavy to be handled easily by one man. Therefore, to facilitate installation and maintenance, the

* Registered Trademark W. U. TEL. CO.

model transceiver was designed in two units: a mechanical unit, Figure 1, and an electronic unit, Figure 2, interconnected by a detachable cable.

Operation of the new transceiver is very simple. The machine is provided with "Incoming" and "Outgoing" buttons which automatically set up the transceiver as a transmitter or receiver, depending upon which button is pressed. Of course means are provided to prevent the transceiver from being incorrectly set up if the wrong button is pressed for the desired use. An adjustable arm directly below the drum is used to set the end-of-message switch, and the position of this arm determines automatically if a "long" or "short" message light will appear at the distant recorder. There, an incoming call is indicated by a buzzer sounding, and the lighting of the appropriate "long" or "short" message light.

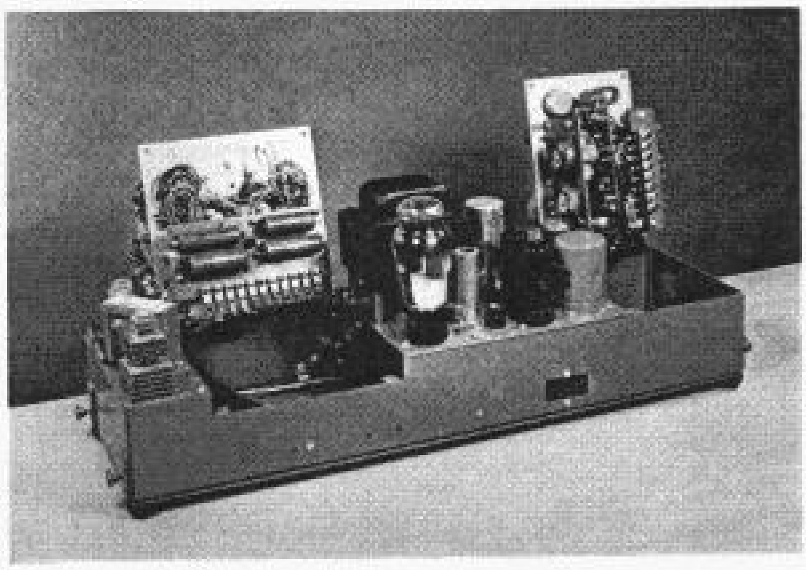


Figure 3. Components of electronic unit

To further aid in and reduce the cost of maintenance the electronic section of the transceiver is composed of four units: the transmitting modulator, the recording amplifier, the control unit, and the d-c rectifier unit. The components of these units are assembled and wired together on flat "chassis" and hinged to the main electronic frame (Figure 3) for easy access and replacement. The various level controls are accessible through holes in the main cover.

Although this transceiver is designed primarily to handle copy 8½ inches wide, smaller sheets can be employed by using a holder consisting of a transparent plastic sheet "hinged" to a sheet of regular paper; the copy to be transmitted is put between the sheets and the assemblage then placed on the drum.

The control circuits between transceivers are d-c ground-return circuits composited to the pair carrying the facsimile signals. Development of an attachment to the transceiver which will convert the d-c control signals to carrier is well under way and when completed will permit the operation of the transceiver over regular 2-way voice bands.

The essential characteristics of Letter-Size Transceiver EM2127 are:

Carrier frequency: at 180 rpm, 2000 cps
at 360 rpm, 4000 cps

Lines per inch: 100

Index of cooperation: 825

Length of circuit: 25 db

Controls: Composite, d-c ground-return

Power: 225 watts, 115 volts ± 10 percent, 60 cycles

Size: Mechanical unit 22 by 9½ by 9¾ inches; 37 pounds
Electronic unit 22 by 7¼ by 8¾ inches; 36 pounds

Of the engineers who have assisted in the development special mention should be made of Mr. R. D. Parrott who was responsible for the major mechanical design, and Mr. G. B. Worthen who handled the design of the modulator and recording amplifier.—G. H. RIDINGS, Ass't Telefax Research Engineer.

References

1. A FACSIMILE TRANSCEIVER FOR PICKUP AND DELIVERY OF TELEGRAMS, G. H. RIDINGS, *Western Union Technical Review*, Vol. 3, No. 1, January 1949.
2. AN IMPROVED DESK-FAX TRANSCEIVER, G. H. RIDINGS and R. J. WISE, *Western Union Technical Review*, Vol. 6, No. 3, July 1952.
3. A NEW FACSIMILE PICKUP AND DELIVERY CONCENTRATOR, G. H. RIDINGS, *Western Union Technical Review*, Vol. 6, No. 1, January 1952.
4. THIRTY-LINE CONCENTRATOR FOR PRIVATE FACSIMILE SYSTEMS, H. H. HAGLUND, *Western Union Technical Review*, Vol. 6, No. 4, October 1952.

Design of a Commercial Facsimile System

T. F. COFER

As DESCRIBED in the previous issue, message element transmission for a commercial facsimile system is practicable over a metallic or 2-wire circuit designed to carry conversational audio frequencies.

Operational Control

Where the primary power is derived from the same a-c network at both ends of the circuit, synchronism between driving motors may be obtained very simply. Auxiliary circuits are necessary, however, in both directions between sending and receiving units to schedule the handling of messages. These control circuits ordinarily are required to pass operational information alternately between the sender and receiver before and after the transmission of the facsimile message. The operations are usually as follows:

1. Sender signals receiver that a message is waiting.
2. Receiver answers, showing equipment is in receiving condition.
3. Phasing signals are sent.
4. Confirmation of phasing starts message element signals.
5. Sender indicates end of transmission.
6. Receiver acknowledges receipt of message in good order.

In addition to the above, the control circuits must be designed to test the line for continuity, to determine positively that two transmissions in opposite directions will not take place, and must "fail safe" so that messages cannot be sent "to the wind" even by oversight of the operators.

Owing to their sequential nature, most of these control functions can be accomplished by relatively simple arrangements. Where a metallic conductive line is available between locations, as in the majority of cases involving commercial facsimile systems for telegram delivery purposes, the d-c path between line conductors and ground offers a convenient auxiliary circuit. Either a two-path one-polarity arrangement or a single-path two-polarity system, both using make-and-break signalling, can be utilized to provide both the required safety features and the control functions listed above.

Concentrator Control Circuits

Where a large number of stations work into a communications center it is advantageous to furnish the line "concentrator" with two-polarity control circuits operating over center-tapped connections to each line, providing "simplexed" circuits to ground. The tributary station connections include both positively and negatively poled rectifiers forming two branches of the simplex circuit. Under stand-by conditions the concentrator applies one potential to the line so that signalling can take place from the distant station without need for a control circuit power supply at that point. An additional advantage accrues from the fact that the use of the two line wires in parallel to ground does not interfere with the insertion of standard "H" attenuation pads in the lines for building-out purposes, as will be explained later.

Because the grounded simplex circuits are supplied with power from only one end, however, lines with high or variable leakage to ground would not be practicable for connections to stations, but since these lines are usually in metallic-sheath cable ordinarily no difficulty arises from this factor. With the control circuits arranged as described, it may also be noted that the tributary stations cannot communicate with each other directly. Similarly, intercommunication between concentrators cannot take place without the addition of special equipment.

General Control Circuits

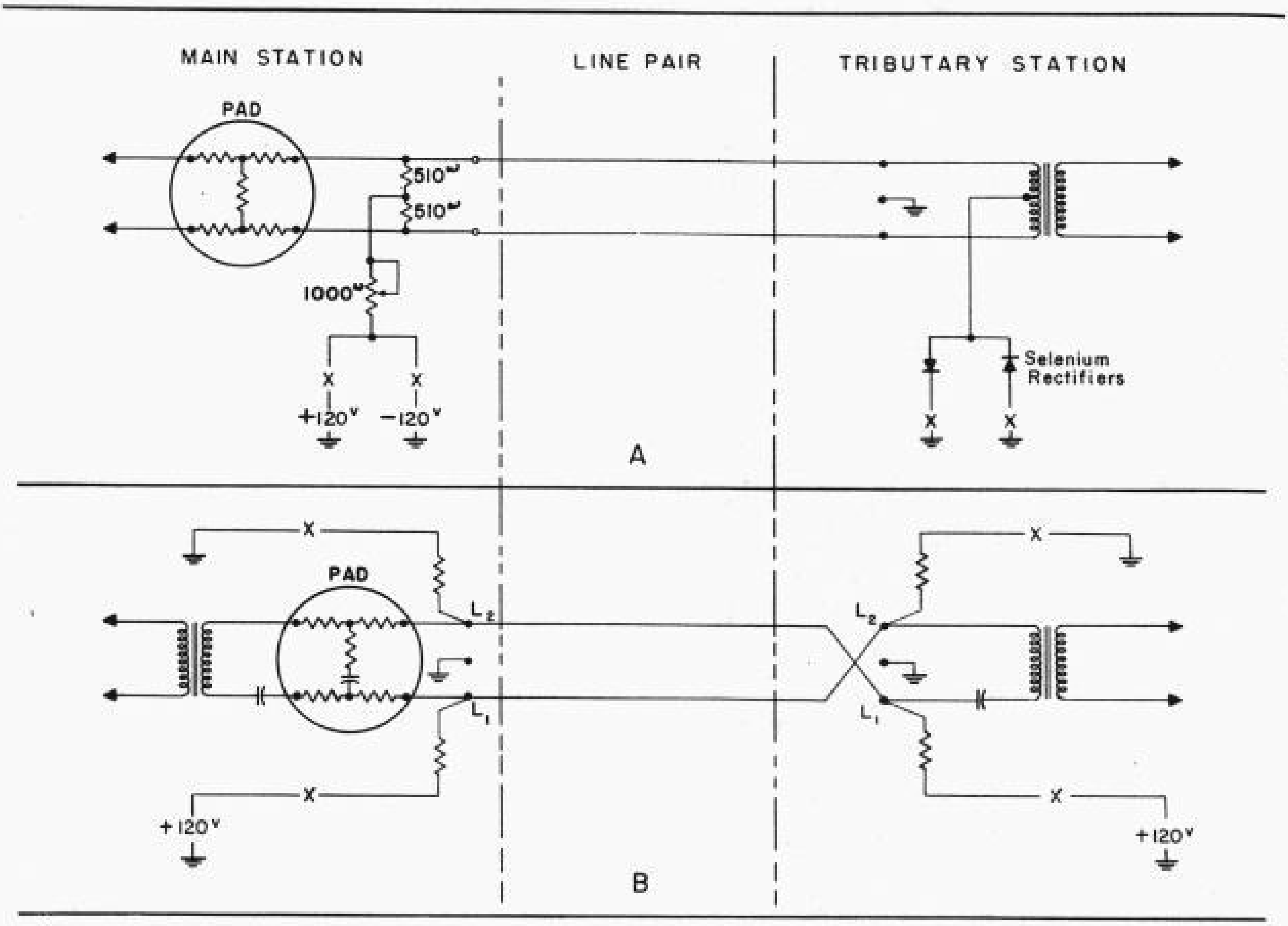
Where general intercommunication between facsimile apparatus is desirable a different arrangement of control circuits is necessary. In the simplest form, for use over metallic conductive lines, a "composite" arrangement is used which provides one make-and-break d-c circuit to ground over each of the two metallic wires. Each facsimile set can then be provided with control-circuit power supply and one circuit can be set up for control purposes in each direction. To permit such arrangement, the two line terminals must be marked to distinguish the send and receive control circuits and their proper poling to each other ensured in connecting or switching the facsimile circuits.

As explained previously, before a facsimile message can be transmitted, the sending and receiving copies must be framed and phased to each other even though synchronism of scanning is already ensured. It is often desirable also to limit transmission to a part of each scanning line, introducing the idea of "blanking." The method of controlling these functions is important enough to warrant description in some detail.

Framing

Determining a satisfactory position for the copy between the top and bottom edges of the recording sheet is usually not difficult. There is ordinarily ample margin on the subject copy at these points. In any case the progression of scanning "down the page" is relatively slow. Thus for 100 lines per inch resolution at 3 scans per second, the progression is only 0.03 inch per second. A difference of a second or two between framing at the sending and receiving ends will be of small consequence unless the copy is unduly crowding the message blank.

For commercial purposes, framing the messages is most easily accomplished by furnishing standard size blanks, with the area where message information may be added outlined; taking precautions to have the blanks correctly positioned in the equipment; and causing the scanning mechanism to return automatically to a



Control circuits may use two polarities and a single path (A) or one polarity and two paths (B) predetermined point at the beginning of each transmission. The ending of each transmission can then be determined by a limit switch operated by the scanning mechanism at its maximum excursion. The Western Union Desk-Fax uses such an arrangement.

Phasing

Determining the left and right limits of the copy is much more difficult than framing. Where the copy is wrapped around a drum, the lateral limits may become coincidental and the locating process becomes one of "phasing" the rotation of the sending drum to the receiving equipment. At the normal rate of three scans per second the operation involves starting a process which may cover almost eight inches in one-third second, within a range of plus or minus one-quarter inch or less. The accuracy of timing is therefore about plus or minus 0.01 second or telegraphically speaking 10 milliseconds. Relay circuits have little difficulty operating within such speeds, but at higher scanning rates, especially those in the order of ten times normal, special electronic phasing circuits are required, as described later.

The mechanics of phasing can be considered conveniently in two classes, one where the two motors driving the sending and receiving scanning mechanisms run at synchronous speed only, and the other where one motor speed is variable. The first arrangement provides the most simple approach to the phasing process while the second involves somewhat less elaborate equipment. The Desk-Fax concentrators with their tributaries are a good example of the first class; systems using the general two-way control-circuit scheme ordinarily use phasing of the second class.

(In phasing of the first class, the main driving motors at the distant stations run at synchronous speed when energized, sending "phasing pulses" consisting of momentary "opens" over the control circuit during rotation. Each of these pulses indicate the time of passage of the coincident left and right margins of the message blank wrapped on the drum. At the concentrator the main motor of either transmitter or recorder runs up to synchronous speed quickly while mechanically disconnected from the equipment by a friction clutch with a latch detent. Sequential relay operations in the calling or answering routine cause the phasing pulse to release the latch upon its next occurrence following the starting of the motors, thus engaging the clutch at the correct moment to achieve the desired in-phase position. Because the phasing operation is always initiated at the tributary station, it is practicable to obtain adjustments of pulse cam and clutch latch that will compensate for time loss in the relay circuit. For accurate phasing, however, it is necessary that the signalling pulse be sharply defined. The length of the lines to the distant stations therefore may be limited more by the distortion of the phasing pulse transmitted over the high-capacitance simplexed circuit than by the attenuation of the average element signals over the metallic circuit.

In phasing of the second class, the terminal initiating the call starts its drive motor at synchronous speed and sends phasing pulses, on its transmitting side of the control composite, to a relay in the receiving terminal. The drive motor at that end is started at a somewhat slower speed by initially dropping part of its starting capacitor. Phasing pulses from the receiving drum are sent locally into another relay, associated with the first mentioned in what is called by switching engineers an "and" type of circuit. [For instance, each of these pulsing relays may remove one of two short circuits around a third relay.] Due to the difference in rotating speeds, the time sequence of the two pulses will converge so that after a reasonable interval they must occur together, satisfying the "and" condition. Subsequent reactions will then cause the receiving motor to run at synchronous speed, will send a "readiness to receive" signal back to the transmitting end, shut off the pulsing signals, and start the scanning process at both terminals. All of this seemingly complicated procedure is accomplished with comparatively simple mechanisms.

By equipping the drum shafts with separate movable cams for the local and the transmitted signals, timing of the phasing pulses may be adjusted to take care of delays of individual machines and of lines in association to almost any degree of accuracy. It is unwise, however, to make adjustments so critical as to require extremely long periods of pulsing before synchronism is effected.)

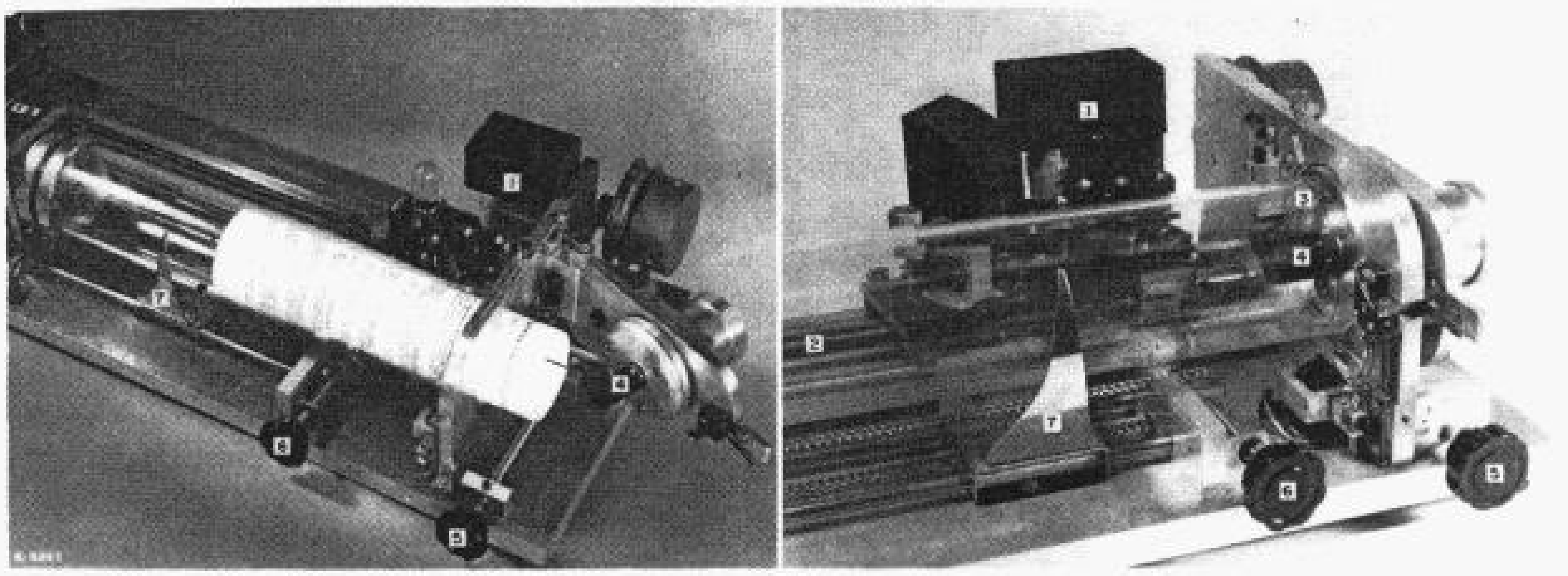
Phasing High-Speed Circuits

The previous discussions apply primarily to phasing facsimile circuits at moderate rates of scanning, say up to 50 inches per second (360 rpm). For truly high-speed scanning, around 250 inches per second, phasing becomes still more difficult because it needs to be more precise. Cam and follower pulsing becomes too clumsy and may be replaced by a system comprising a permanently magnetic slug, inserted in the drum and associated with a stationary pickup coil.[1] When the magnet passes by at high speed, the coil circuit emits a single sharp pulse which can be used both for initial phasing and for a continuous check of the phasing during transmission of long messages.

Blanking

Somewhat analagous to phasing is the mechanism required to transmit copy too narrow to cover the entire working surface of the scanning drum. Although phasing is intended to determine the lateral limits of the copy, the mechanisms mostly used for the purpose can determine only that the sending and receiving scans are in unison referred to certain reference marks on the machines themselves. If the sending copy is not continuous around the drum, some of the recording will be affected by conditions on the drum surface itself unless means of suspending transmission through this portion of the scan is included.

In its simplest form, a blanking mechanism may consist of an adjustable-lobe cam, rotating with the drum, affecting two electrical contacts on the machine frame. These contacts may be connected so that no element signals can be transmitted to the line during the portion of a revolution where the cam is adjusted for blanking. The cam may be designed always to blank the location of the paper lap and to be expanded when necessary to cover one-third to one-half the length of the scanning line, in one direction from the phasing reference position.



Phasing and blanking may be combined in the transparent drum transmitter

1. Scanning carriage
2. Carriage lead screw
3. Copy guide line
4. Phasing-blanking light source
5.-6. Upper and lower frame adjustments
7. Lower frame marker

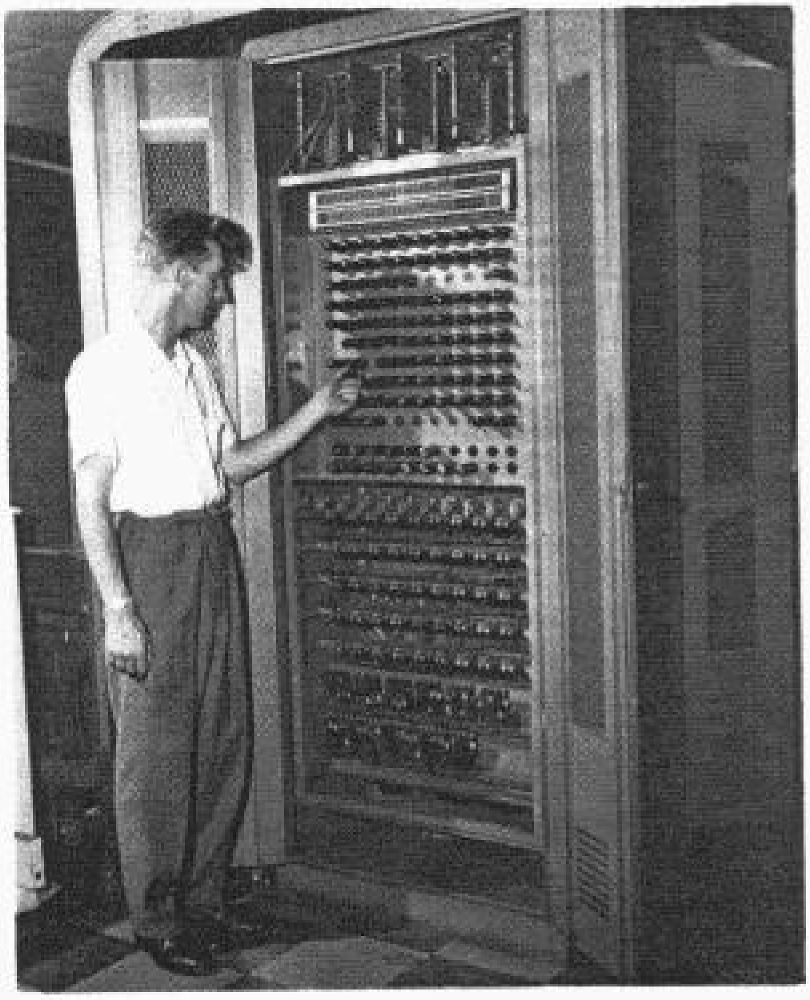
A more general arrangement can be applied to the plastic cylinder drums used for high-speed operation. Here phasing and blanking can be combined. Taking advantage of the transparent cylinder wall, a photocell can be mounted outside the cylinder and a small light source arranged to project inside the cylinder opposite the photocell, both near the end kept open for loading.[2] Copy placed inside the cylinder will obstruct the light from the auxiliary photocell except in the space between edges. The transmitter can therefore phase on one edge of this space and also blank the entire space. With such an arrangement it is obviously necessary for the copy to be narrower than the inside periphery of the cylinder. The copy must also be inserted squarely into the cylinder and not beyond the limits of the phasing photocell.

Transmission Levels

In the previous discussion no mention was made of the actual energy levels of the message-element signals or the control-circuit currents. These factors can vary widely according to the circuit conditions to be met. In practice, however, such levels are limited by the transmission medium. Thus on a voice-frequency channel derived from a radio or a landline carrier circuit, the facsimile levels must be adjusted to fall within the overload values of the circuit. This fact may offer some difficulty where control-circuit channels must be included along with the message-element signals.

The large number of facsimile circuits in a telegram distribution system, however, involve Desk-Fax tributary stations connected to concentrators by metallic cable conductors. While such passive circuits have no saturation or overload characteristics, the proximity of numerous other services using the same frequency spectrum brings about a limitation of individual circuit levels to minimize mutual disturbance. Although these level limitations apply to control-circuit currents as well as to message-element signals, the permissible ground-return currents are sufficiently large to obtain reliable control-circuit operation without requiring the best quality relays.

In the case of the message-element signals, the level limitation on transmission, usually to plus 5 dbm, reacts to necessitate low noise levels on the metallic circuit, which in turn requires good balance. Thus where the black-to-white level difference may be as great as 27 decibels, restriction of the maximum transmission level to plus 5 dbm infers that signal energies down to minus 22 dbm should be transmitted. Since it is desirable to operate over lines of as much as 25-decibel loss at the carrier frequency in order to reach the required distances over small gauge cables, the minimum received levels will be quite low. To obtain a desirable signal-to-noise ratio of about 20 decibels, the lines should exhibit no more than 60 to 70 dbm of noise within the message-element transmission band. Since the facsimile lower sideband does not extend into the low frequencies where the effects of power-frequency currents and their main harmonics are present, most cable pairs



Desk-Fax circuits are built out to a standard 25-db loss with resistance pads

will give satisfactory noise levels. As will be shown later, the recording amplifier pass-band must be coordinated with the message-element signal band to realize this advantage.

Where several transmitters and recorders are shared by a number of lines, the transmission levels at the switchboard must be standardized for both sending and receiving. To accommodate lines of various lengths and gauges it is convenient to "build-out" all lines to a common transmission loss with attenuation pads, located in the concentrator apparatus cabinet. In the Western Union Desk-Fax system a loss of 25 decibels is the standard, the adjustments being made at the time the circuit is installed.

Recording Amplifiers

The design of recording amplifiers for facsimile receivers is influenced both by the transmission requirements and by the medium used in producing the records. Western Union facsimile equipment is designed around the characteristics of "Teledeltos" recording paper.[3] "Teledeltos" is a "power" paper requiring, in round numbers, about one millijoule of energy at an impedance of several thousand ohms to make one full black dot 0.01 inch square. At the normal resolution of 100 lines per inch the minimum power to be furnished the stylus to make a good solid black line is about 2.4 watts for three 8-inch scans per second, proportionally more for higher scanning rates. To obviate distortion of signals, the amplifier should be capable of delivering at least twice the energy required by the stylus. This works out to a power gain, based on the received levels at the line, of around 56 decibels with a somewhat higher voltage gain because the paper impedance is considerably higher than that of the cable pair line.

Since the transmission band needed for general telegram distribution equipment lies in the upper voice frequencies, it is not difficult to provide the necessary power and voltage gains by the use of pentode or beam power tubes together with inexpensive input and output transformers where necessary. The pass-band of the amplifiers should show greatly reduced gain at the lower voice frequencies where low-frequency noise is prevalent, but the transition should take place neither suddenly nor too near the frequencies of the lower sideband of modulation. Because of the type of signal to be reproduced by these amplifiers, the dynamic response is as important as the sine-wave reproduction.

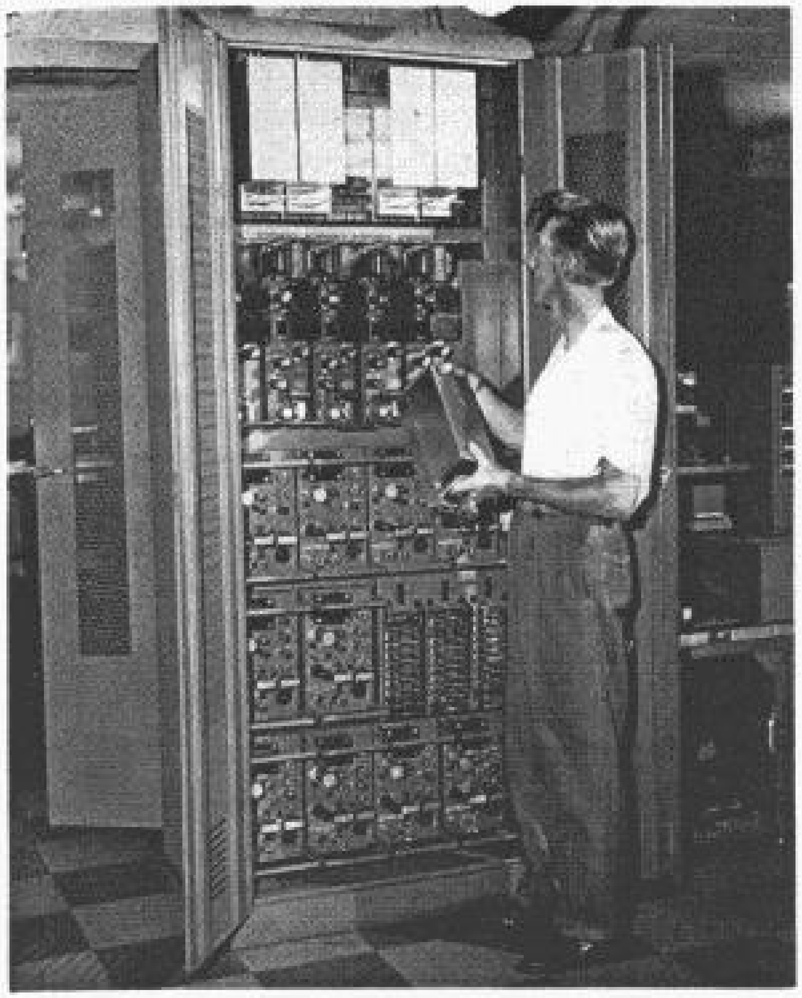
In the compact tributary station equipment the recording amplifier can be arranged to be directly coupled to its output system at all times when energized. Amplifier equipment at concentrators, however, is usually designed to be housed in a cabinet which may be located at some distance from the actual recording stylus, requiring a connecting transmission line. Since this line is usually electrically short at the frequencies used, it can be operated conveniently at 500 to 600 ohms impedance in cabled conductors. Because of the very high levels to be transmitted, however, the conductors should be shielded and well segregated from low-level audio-frequency circuits. With pentode output tubes in the amplifiers, lightning arrestors should be installed across the output transformer terminals to dissipate the high voltages developed in case an open line circuit occurs when high signal levels are present.

Because the concentrator recording amplifiers are usually preceded by an inverter, described previously, which raises the signal level appreciably, the voltage gain required is somewhat less than that of the station transceivers. Conversely, because there may be appreciable loss in the connecting cables and coupling transformers, the available output power should be more than twice that needed by the stylus. Thus for instance where a single 6V6 tube suffices in the transceiver output, two in push-pull are needed in the concentrator output stage.

Recording

Facsimile recording requires that a metal stylus, connected to the output of the recording amplifier, scan the receiving message blank with a motion matching that of the sending scanner in exact proportions but not necessarily in exact dimensions. (The condition may be compared to a pantograph tracer or even to a photographic projection printer where changes in size of the object are not accompanied by distortions in shape.) The "index of cooperation," relating the length of the scanning line to the progression at right angles between lines, determines whether a transmitter can operate with a particular receiver without copy distortion. This factor is variously stated as an index number.

The Desk-Fax telegram distribution



Concentrator electronic equipment, in a separate cabinet, may be located at a distance from the operating point

systems operate with a dimension ratio of 5 to 4 between the concentrator equipment and the station transceivers. Other equipment, including Desk-Fax transceivers working to one another, has a 1-to-1 ratio.

The most simple arrangement for recording facsimile messages is to utilize the rotating axial-progressing drum described previously as used in sending. Machines built to use the drum interchangeably for sending and receiving are called "transceivers" and are generally constructed like the Desk-Fax transceiver. In this device the receiving stylus is attached to a hinged mounting controlled by a small motor. When transmitting, the stylus is retracted from the drum, out of the way of the optical scanning system. When the transceiver is switched to the receiving condition and phased, the small motor drives the hinged mounting toward the drum until stalled by an adjustable stop. The stylus pressure is adjusted with reference to this position. The optical system does not touch the paper so its parts do not interfere with the stylus positioning.

For the lightly loaded tributary stations, space and cost factors dictate a compact transceiver and thus infer a drum-operated device. At the concentrators, however, with 5- or 10-to-1 ratio of equipment to lines and a minimum of operators desired, the economic factors favor a more efficient recorder.

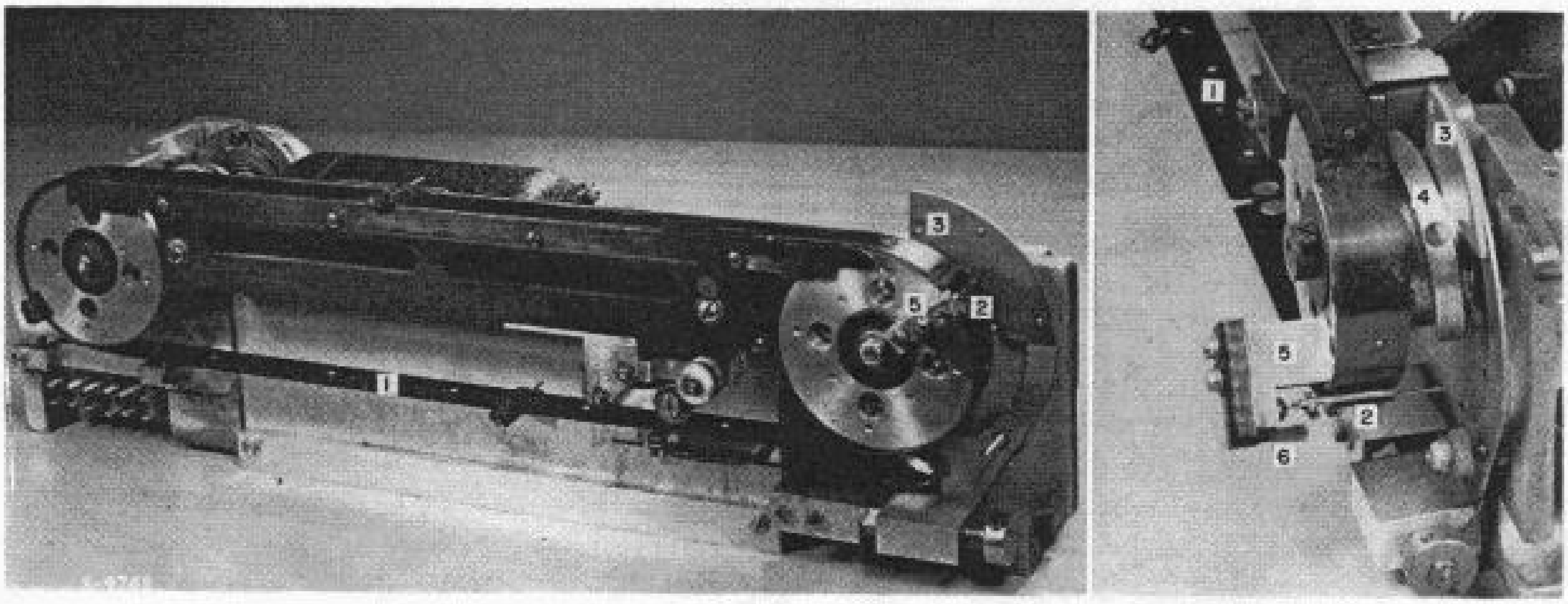
Continuous Recorders

Continuous facsimile recorders can be designed more readily than their counterpart sending flat-bed scanners. It is practicable to devise relatively light mountings supporting several styli for scanning purposes. The required sliding electrical connections, operated at fairly high voltages, offer little difficulty. In principle, then, a practicable continuous recorder consists of a strip of recording paper of suitable width, fed from a roll, driven over a platen at a rate to produce the desired number of lines per inch, scanned crosswise by styli mounted on a belt which moves at the desired number of scans per second. The design problem from this point on is almost entirely one of mechanical arrangement of parts to rather close tolerances. It is convenient to design the recorder in two detachable parts, a paper feed mechanism and a scanning head.

Because as one stylus leaves the scanning line another must be entering, the minimum number of styli is three. It will be found in practice that the use of three is quite restrictive as to placement of parts which at high scanning rates introduces difficulties due to centrifugal forces on the fast-moving belt. For these reasons a four-stylus system is more generally applicable. In Western Union telegram distribution systems, however, the three-stylus variety has given good service at three scans per second and is still the standard for low speeds. Both the three- and four-stylus recorders have been very well described in previous articles in Technical Review.[4, 5, 6]

Stylus Belts

The belts which carry the styli in the continuous recorder are the most difficult part of the equipment to design and to maintain. The belts must be flexible at right angles to their length but must not stretch lengthwise more than a very few thousandths of an inch. They slide at appreciable speeds along rigid guides but must not wear rapidly though they are only lightly lubricated since they operate close to the paper and must not splash lubricant on the copy. They must offer positive support for the stylus mountings, must have a positive drive, and must be strong enough to absorb the shock of sudden starts and stops. Yet the belts must be capable of piece-part production to fit any recorder of the design series.



Automatic stylus spacing device decreases maintenance on continuous recorders

1. Steel stylus belt
2. Straight-wire stylus mounting
3. Stylus spacing hammer
4. Hammer cam
5. Spacing anvil
6. Cleaning brush

The original spring-steel belts with riveted and soldered attachments and loop closure have given way to similar material put together by welding, the latter made possible by the use of high-current short-period welds. Full use is made of special jigs and accurate tools for producing the exacting dimensions required. Experiments have been going forward for some time looking toward a reinforced rubber or plastic belt which will depend on an accurate special mold case.

Stylus Mountings

It was originally believed that the styli on the recorder belts must be very stiff and rugged. A special stylus made like a long-playing phonograph needle was used, with a heavy shank held in the mounting with a set screw. As these styli wore down in normal use, they could be reset to the proper length by adjustment to a built-in anvil associated with the recording-head mechanism. Further thinking, after field experience, indicated that the stylus should be much weaker than the mounting, bringing about a change to straight-wire styli. The use of these altered the mounting to advantage since the mounting plate could be installed on the belt first and a slot for the wire milled afterwards to exact spacing. A screw and washer hold the wire in the shallow slot. Still further thought showed that the stylus could be crimped into a small copper tube, held medium tightly by the screw, and a light hammer could be arranged to tap each stylus against the spacing anvil on each revoultion of the belt. This latter feature, although not yet generally applied, can greatly extend the time between maintenance adjustments of the continuous recorder.

Stylus Material

As pointed out earlier, considerable energy is dissipated in recording on "Teledeltos", much of it at the point of contact of stylus and paper. The stylus should therefore be made of a strong stiff metal with a high melting point. Tungsten wire fulfills all the requirements for strength, stiffness, and availability. Such wire, used in either 0.008 or 0.010 inch diameter, gives better service than any other. Because tungsten wire is sintered it should not be pinched off but should be sheared, and recording is improved by smoothing the point with fine emery cloth. Since solder will not adhere to tungsten, the material must be clamped in place or plated with a solderable substance. For Western Union apparatus the tungsten wire is furnished either in precut straightened lengths for the continuous recorders, in rolls of wire for the telegram service Desk-Fax, or in a multiple-stylus wheel arrangement for the leased Intrafax service.

Desk-Fax installations are increasing at a substantial rate as the machine becomes available

Platen

Ordinarily facsimile practice utilizing wire styli infers a fixed platen behind the recording paper and some spring action on the stylus mounting to maintain proper pressure. In the continuous recorder the required exactness of positioning of the several co-operating styli makes impracticable any degree of freedom of the belt or stylus mounting at right angles to the paper. The platen must therefore furnish the pressure-controlling movement. While this requirement can be met with a light spring-loaded aluminum platen at stylus pressures of 15 grams or more, at lower pressures proper spring adjustments are very difficult to maintain over the length of the scanning line. A much simpler arrangement dispenses with the platen entirely, supports the paper positively above and below the scanning line, and depends upon the natural resilience of the paper itself to maintain stylus pressure. For pressures around 5 grams this expedient is highly successful. Its disadvantages are that scanning cannot begin close to the upper edge, thus somewhat wasting paper, and there is some change in the apparent paper impedance due to the stylus current traveling edgewise to the frame of the machine instead of straight through the paper from front to back.

Maintenance

Experience over a number of years has shown that maintenance for telegram distribution facsimile circuits is less expensive than for teleprinter tie lines, although the latter may still be preferable on heavily loaded circuits. Electronic troubles in the equipment have been quite low, showing that vacuum tubes operated at conservative ratings have longer useful life than might be expected. It is not necessary to utilize special high quality tubes. The exciter lamps in the optical scanning system also realize full life expectancy and more, due to moderate voltage applications. Mechanical parts of the machines have performed well.

As might be expected, the styli on the Desk-Fax tributary-station transceivers account for the majority of part replacements. While ordinary wear produces some of these cases, many are due to mishandling of the receiving blanks as is natural with manual loading by personnel of various degrees of aptitude and training.

Two test tables have been standardized for maintenance purposes. A large one can test both concentrator equipment and lines as well as transceivers and is normally located at the communications center. One or two line circuits from each concentrator switchboard may be run to this table for testing purposes. A small table, for testing transceivers, is usually installed where convenient for the tributary-station maintainers.

A stamped plate fastened to the top of each Desk-Fax transceiver used in a customer's office gives instructions both for operating the machine and for summoning a maintainer if required. In any case, routine trips to each tributary station are scheduled at intervals of one or two months depending upon the number of messages handled by the tie line. At these periodic visits preventive maintenance is performed which in many cases suffices to forestall trouble.

Future Plans

At present the facsimile installations of Western Union provide areas of excellent local service in the major cities. While expansion of these networks is proceeding at a substantial rate, plans are under way to interconnect the local systems so that interchange of facsimile messages will be practicable. A larger new automatic concentrator, in the development stage, includes facilities for recording such interchange messages on magnetic storage devices for retransmission without rescanning. The facsimile system of the future may therefore fulfill the purposes expressed in the first installment of this article,—to transmit anything that can be marked or engraved on the sending blank.

References

1. A High-Speed Direct-Scanning Facsimile System, C. R. DEIBERT, F. T. TURNER and R. H. SNIDER, *Western Union Technical Review*, Vol. 6, No. 2, April 1952.
2. A High-Speed Facsimile Transmitter, L. G. POLLARD, *Western Union Technical Review*, Vol. 6, No. 2, April 1952.
3. Electrosensitive Recording Paper for Facsimile Telegraph Apparatus and Graphic Chart Instruments, GROSVENOR HOTCHKISS, *Western Union Technical Review*, Vol. 3, No. 1, January 1949.
4. Three-Stylus Facsimile Recorder for Concentrator Service, F. G. HALLDEN, *Western Union Technical Review*, Vol. 4, No. 1, January 1950.
5. Three-Stylus Facsimile Recorders for Terminal Handling, L. G. POLLARD, *Western Union Technical Review*, Vol. 4, No. 3, July 1950.
6. A High-Speed Telefax Recorder, D. M. ZABRISKIE, *Western Union Technical Review*, Vol. 6, No. 2, April 1952.

Mr. Cofer's biography appeared in the April 1954 issue of Technical Review.

Patents Recently Issued to Western Union

Concentrated-Arc Lamp

W. D. Buckingham

2,662,196—December 8, 1953

An enclosed type of Concentrated-Arc Lamp intended for a-c operation embodying two identical electrodes spaced apart from each other in an atmosphere of inert gas. The electrodes serve alternately as the luminous light emitting cathode and may be disposed at an angle with respect to each other so that the luminous ends are not shadowed. Each electrode comprises a hollow tube packed with an oxide of zirconium or hafnium, which reduces at the electrode tip to a thin film of the metal to form the exposed luminous layer. To equalize the surface consumption of the electrodes a magnetic field may be provided which causes rotation of the arc over the faces of the two electrodes.

Regulated Power Supply

P. H. Wells, A. A. Steinmetz, W. D. Cannon

2,663,759—December 22, 1953

Voltage regulator and current stabilizer for a shore station supplying d-c power to a submerged repeater over the cable conductor. The regulator provides a substantially constant flow of current to the cable apex despite voltage variations in the commercial supply and variations in magnitude and polarity of earth potentials. The regulation is accomplished by a vacuum tube impedance in series with the grounded positive lead of the d-c source, this impedance being controlled jointly by the voltage with respect to ground of the negative bus and also by the current itself flowing into the cable.

System and Apparatus for Facsimile Telegraph Transmission and Recording

F. G. Hallden, G. H. Ridings, D. M. Zabriskie, R. D. Parrott

2,672,503—March 16, 1954

A system for radio-facsimile transmission of telegrams from a main office to one or more mobile units. Each car is provided with a radio transmitter and receiver, a facsimile recorder and radio telephone equipment. To transmit a telegram, the main office sends a tone signal to select the car and condition its recorder to receive the message. In the recorder, paper feeds from a roll into a cylindrical wrapping mechanism which positions the paper for inside stylus recording. When recording is concluded, the message is automatically sheared off and dropped into a receptacle and new paper is fed into the wrapper. The two-way telephone circuit is for handling service messages and transmitting telegrams to the main office.

Facsimile Receiver

E. S. Grimes

2,672,504—March 16, 1954

A facsimile receiving system especially adapted for the suppression of background, or spacing noise, prevalent on radio circuits. Advantage is taken of the fact that if the received signal band traverses a frequency doubler the noise potentials, lying predominantly at the bottom of the band, remain at a relatively low frequency after doubling, whereas the facsimile carrier is doubled to a relatively high frequency. Since the modulated side bands retain their original relationship with respect to the now doubled carrier, the separation between the essential signal and the noise frequency ranges is greatly increased. The noise band is then readily rejected by a filter. A second doubling and filtering stage is optional. In addition, by adding a bias to the doubler rectifiers all potentials below a selected threshold are suppressed. By incorporating a negative feedback circuit in the recording amplifier the threshold effect is further enhanced, and the narrowed input voltage range is expanded to best match the recording characteristics of the copy paper.

Pulse Modulation Phasing

J. E. Boughtwood

2,672,517—March 16, 1954

Method of phasing the receiving electronic distributor of a multichannel pulse modulation system by superimposing upon one of the several channels a phasing frequency which is selected at the receiver and applied to a stepping device. While the receiver is in phase the phasing frequency arrives in the allocated channel position and the stepping device is thereby disabled. If the distributor is out of phase, absence of the phasing signal will release the stepping device to rapidly advance the distributor until the phasing channel appears in its proper position and the stepping device is again disabled by the action of the phasing frequency. Synchronism is effected by the transmission of a continuous control frequency derived from the stabilized oscillator at the transmitter which also controls the transmitting distributor.

Telegraph Message Allotting System

G. G. Light, F. L. Currie

2,673,235—March 23, 1954

Arrangement for manually allotting messages according to a prescribed ratio between two or more circuits, e.g., between the two Canadian telegraph carriers at a gate-way city. Indicating lamps for each circuit controlled by a rotary switch type of counter in accordance with the quota ratio indicate to the attendant which circuit shall receive the next message. "Exclusive" messages, such as service messages, messages destined for locations exclusive with one carrier, and the like, are switched independently of the quota allotter.

Facsimile Signal Inverter

R. J. Wise, G. H. Ridings

2,675,489—April 13, 1954

An optical or mechanical type of signal inverter employing as essential elements a scanning beam, a balancing beam and an adjustable light attenuator therefor, a light chopper which interrupts both beams but in alternating phase, and a photocell common to both beams. When scanning white, interrupted light from both beams reaches the photocell in complemental pulsations to produce a constant illumination of the photocell and hence no a-c output is produced. When scanning black, no light from the scanning beam reaches the photocell and a steady alternating current is then transmitted in response to illumination from the balancing beam alone. This gives an inverted output signal. Polaroid elements are specified for the light attenuator.

Polar Relay

W. D. Cannon, T. Rystedt

2,677,028—April 27, 1954

A polar relay comprising a C-shaped laminated core with coils on each leg, a permanent magnet extending between the yoke of the core and a transverse pole piece which is spaced from the open ends of the core legs, or pole faces, and parallel to the armature. A bar armature, carrying contacts at the ends, subtends the pole faces, and is positioned for rocking motion between a pair of adjustable stationary contacts by virtue of either a flat spring or a post support at its center, whereby the armature effects a sliding action in respect to the adjustable contacts. Another feature is that the operating current flux by-passes the permanent magnet.

Automatic Message Sealing Machine

L. G. Pollard, G. H. Ridge, G. Johanson

2,678,589—May 18, 1954

An automatic message sealing machine intended especially for facsimile recorders which folds and seals a message blank while leaving only the address portion visible. The machine performs a timed sequence of automatic operations which fold the message blank into an open U shape with the address portion above the fold, compress the blank into a closed fold, pierce holes through the folded portion, the pierced paper forming an extruded rim around each hole. The extruded paper rim is then crimped against the blank to form integral rivets effectively sealing the folded message blank whereby the sealed blank can be opened only by tearing the rivets.