WESTERN UNION Technical Review

Building America by Telegraph

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Transmission of Intelligence

•

Dispatcher Switching System

•

Facsimile Transmitter

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Mobile Emergency Power

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Material Inspection

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To the Personnel and the Many Friends of Western Union

IN JULY 1952 the Western Union TECHNICAL REVIEW was five years old. The first issue, in its Foreword, expressed the wish that the project would help our technically-minded emloyees to become better informed on the technological progress of their Company. The high plane upon which the articles in the REVIEW have been cast has amply justified that hope.

In addition to its Western Union distribution, the REVIEW is circulated to some of our friends in the communications and scientific laboratory fields. They have added their praise to that of our own people, for the fine job done by our Technical Publication Committee, headed by Mr. F. B. Bramhall. Mr. Paul J. Howe (now retired), the former Chairman of the Committee, set the tone of the publication. The able manner in which Miss Nell Organ, its Editorial Secretary, handles the work of assembling and editing the REVIEW is a real contribution to its success.

In my travels over the years I have always found a keen interest on the part of our field people in what's new in the laboratory, or "what have you fellows got up your sleeve?"

It is my earnest hope that the REVIEW has served to answer some of these questions and to help the members of the Western Union family appreciate some of our technical problems and how we go about solving them. Western Union must always strive to keep its place in the forefront of the communications field.

H. P. Corwith.

VICE PRESIDENT—DEVELOPMENT AND RESEARCH

January 1, 1953.

Building America By Telegraph

H. P. CORWITH

WHEN ANNIE ELLSWORTH, daughter of the U. S. Commissioner of Patents, selected the words for the first telegram on May 24, 1844, she probably had no idea of the far-reaching effect of the phenomena she was about to witness; yet the phrase "What Hath God Wrought!" was quite appropriate. *For this was the initial demonstration of the usefulness of electric energy.* The telegraph, crude as it was at that beginning, had brought electricity out of the laboratory for its first practical application, turning the toy of the physicists into a working medium for the benefit of the public and commerce.

The organizers of the American Institute of Electrical Engineers themselves were largely telegraph men. At the organizational meeting in 1884, of the 25 founders 21 were associated with the telegraph industry. Norvin Green, the first president of the Institute, was president of Western Union at the time; Franklin Pope, the second president of the Institute, was also a telegraph man. Thus during the early period, while other electrical industries were in the process of development, telegraph engineers exerted important influence.

It was more than 20 years after the inception of the telegraph before the electric illumination field was opened by Brush and Thompson and fulfilled by Edison, or the electric power industry came to flower with the development of Gramme motor generators. Within these years the telegraph had spanned the continent, stitching together the growing Eastern seaboard cities and the fabulous Western frontier with a thin strand of communication; a strand beset by hostile Indians, toppled by buffalo, sometimes even sabotaged by evildoers for their own ends, but always back in service again keying and sounding out the commerce of the nation.

CYRUS FIELD, who first conceived and zealously promoted the idea of a transatlantic cable, became Vice-President of the Atlantic Telegraph Company which was reorganized as the Anglo-American Telegraph Company and finally laid the successful cable of 1866.

And the benefit of the telegraph was not only national, but international. Early in 1854, Cyrus Field, another telegraph pioneer, dared to think of a submarine telegraph cable spanning the Atlantic from Newfoundland to England. Refusing to accept defeat after repeated failures, in 1866 he finally succeeded in laying a practical cable, bringing instant communication with Europe that has since been continuous. His perseverance in the face of adversity and ridicule at last won him the right to be listed with those other immortal pioneers whose faith was boundless.

The inception of the telegraph hastened the application of electricity pointing the way to other work-a-day purposes. The operation of the telegraph required long lengths of wire. Ezra Cornell, one-time plow salesman, evolved the open-wire circuit with glass "door knob" insulators out of pure necessity when the underground pipe circuit devised by Morse developed faulty insulation while being installed. Edison, whose genius was to

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Abstracted from an address by Mr. Corwith, Vice President Development and Research, at the Centennial of Engineering in Chicago, Ill., September 1952.

touch so much of our home life as well as the needs of the electrical industry, did his early inventing on telegraph instrumentation and was eventually able to set up laboratories, culminating in his Menlo Park "Magic Shop", with $40,000 paid by Western Union for his Universal Ticker. A plaque marks the location of his first power house in New York, on 5th Avenue at 14th Street.

Edison obtained his early telegraph experience with Western Union lines along railroads. Without the railroads, the development of our inland country would have been a tortuously slow process. Without the telegraph the "Iron Horse" would have faced tremendous obstacles. As early as 1851, pioneered by the Erie Railroad, the dispatching of trains by telegraph was undertaken, opening up the single-track lines of that day to much more traffic than could have been handled otherwise. Since the railroads, with their long track-ways, were so in need of rapid communication, and the telegraph was so in need of rights-of-way to set poles, the two joined forces and grew up together all over the country. Both utilities were needed at the same places, the centers of commerce, and so one supplemented the other.

In villages and towns, the sounders clicking in the railway station and the operator in a green eyeshade handling a Morse key were for decades symbolic of Western Union. What a revolutionary change has taken place in telegraphy since the days of its inventor!

The essential purpose of the telegraph from the very beginning was to provide quick communication for business, the dissemination of news, and the functioning of government. During the early period of our history, communication traveled at a snail's pace. Couriers could depend only upon the speed of horse-relays and their own endurance to reach far distant points, and even in the East the long hauls by train and boat were not fast enough for the increasing needs of commerce and industry. The first short-line individual telegraph companies did little to alleviate this condition. Hiram Sibley, founder and first president of Western Union, foresaw that only chaos could be the result of ruinous competition between short lines. He therefore merged many small companies into what was called Western Union, an integrated telegraph company that filled the need for long-distance quick transfer of intelligence at uniform and low rates. Thus orders for goods, news of free-land operations, prices of commodities up or down, as well as reports of salesmen's dealings and whereabouts could for the first time be quickly passed from point to point at uniform rates.

HIRAM SIBLEY, first president of The Western Union Telegraph Company. He organized construction of the transcontinental telegraph line along the pony express route and backed a proposed overland pole line between New York and Paris by way of Alaska and Russia.

Over the years, transmission methods and service improved as mechanization of operations progressed. By the early 1920's telegraph operation by the original single wire, ground-return method had reached its peak, the multiplex and simplex printers fulfilling Morse's original dream of printed telegraphy. Increased demand for international communications following World War I had prompted further improvement in ocean cable facilities across the Atlantic. A continuously loaded submarine cable was designed and laid, operating at 400 words a minute, faster "than two women gabbing over the back fence." Vacuum tubes and signal-shaping amplifiers, developed for the new cable, provided increased speed.

We had a good system, both landline and cable, and we were making progress. But no business can afford to be static, as the harness-maker and the carriage-builder found out. The products of invention keep up a continuous change so that the situation is like that of Alice in the White Queen's land, where only by running very fast can you even stay in the same place. Western Union today is running faster than ever before, thanks largely to its engineers and technicians.

Today 15 modern high-speed message centers at strategic locations around the United States receive originating telegrams from their respective areas and, by automatic switching, transmit them on to the area center of destination practically instantaneously.[1] At the receiving end, manual operation of a push-button switchboard with over 200 destinations narrows down the receiving office to the nearest branch, the addressee's direct-wire connection, or other delivery media.

NORVIN GREEN, while president of Western Union, became the first president of the American Institute of Electrical Engineers. He was associated with the New Orleans and Ohio Telegraph Company Lessees, later the Southwestern Telegraph Company, still later part of Western Union.

While this system was being installed, transmission methods between offices were also being improved and now most telegraph signals are transmitted electronically over a frequency-modulated carrier — 20 channels are fitted into the spectrum required for a telephone or voice conversation, and each separate channel delivers its own message to its own destination. With our automatic telegraph reperforation equipment we furnish a leased service,[2] similar to a small telegraph company within itself, to a number of customers, the largest of which include the U. S. Air Force, U. S. Steel, General Electric, United Air Lines, the Kaiser Industries, Sears Roebuck and a number of large banks. In addition to the large leased reperforator systems, there are numerous smaller ones and a host of leased wires used by customers to direct stock-brokerage businesses, trucking lines, and miscellaneous warehouse systems.

Today submerged electronic repeaters,[3] placed in series with ocean cables on the ocean bottom about 150 miles out to sea and powered from the shore end, intercept the received signals in the quiet deep water and boost them to a clear, strong signal which enables us to triple the speed or word-volume capacity of the cable. This innovation enables the older cables to approach the speed of the most modern ones.

Truly phenomenal progress is being made in "Telefax," the facsimile method of transmission which can handle records of any kind, anywhere, without reducing them to arbitrary telegraph codes which will print only in the English alphabet and require letter by letter hand typing. Fac-

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Howard P. Corwith, a graduate of Cornell University, became an Engineering Assistant in the Traffic Department of Western Union in 1916. He gained wide experience in telegraph operations as operator, T. & R. attendant and multiplex supervisor in the New York office, and was head of the New York school for training multiplex operators. In 1925 he established the Water Mill Laboratory for radio experiments and observations, and in 1934 became head of the Electronics Division, Engineering Department, at Water Mill. Under his direction, cable plowing and depthometer equipment and [illegible] leader gear were developed, as well as new artificial cable lines and cathode ray [illegible] methods of cable balancing. The zirconium point source of light was also disc[illegible] and developed under his direction. Mr. Corwith became Assistant Chief Engine[illegible] Director of Research in 1946 and Vice President in charge of Development and [illegible] 1949. He is a Fellow of the AIEE, a Fellow of the IRE, and a Past President of the [illegible]rk Electrical Society.

simile will produce anything in black and white, manuscript or line drawings, using our proprietary dry recording paper "Teledeltos".[4] Today Desk-Fax transceivers[5] no larger than a portable typewriter, are in thousands of business offices to provide what might be termed picture reproduction of telegrams from the customer to Western Union and vice versa.

In Baltimore, an experiment in telegraph delivery is being carried on which is expected to result in better telegraph service to the residential users. The scheme is an extension of the Telefax facsimile system to mobile branch offices in automobiles called Telecars.[6] Equipped with two-way radios and facsimile apparatus, Telecars cruise the suburban streets automatically receiving telegrams even while they are in motion toward a delivery point. Answers to the telegrams can be flashed back to the main office by radio. Already in traffic service experimentally, High-Speed Fax Equipment[7] can reproduce an entire letter-size page of writing or diagrams in half a minute, at a speed faster than speech itself. Two transmitters are used alternately, because the transmission is so fast, to permit one to be loaded while the other is transmitting. The automatic recorder cuts off and ejects the received copy without assistance.

EZRA CORNELL, founder of Cornell University, aided in the construction and financing of the Baltimore-Washington-New York telegraph line. He controlled two telegraph companies which merged with Western Union, of which he was a large stockholder, and which he named.

Latest of the facsimile developments is Intrafax apparatus, an adaptation of the Desk-Fax message distributing system. Utilizing facsimile equipment which has already been received with enthusiasm by business men, this apparatus can be assembled in sections to take care of large or small installations, to interconnect many offices or a few. Operated with extreme simplicity, this equipment has already found large use by banks to verify signatures, by stores to transmit facsimiles of original sales tickets to warehouses, by air lines to handle records between offices and air-field centers, and for other purposes where quick and accurate written or diagrammatic information is essential.

We have thus literally "grown up" with the country as the requirements of commerce have expanded from border to border and from sea to sea. Our operations have increased in complexity and scope in step with the tempo of technology which has caused us to successively overcome competition from the stage coach, then from the "Super Chief", and now from "Flight 99". We expect to meet with atomic-powered devices any day and will be ready, as always, to keep up our end of the bargain.

References

1. Automatic Trunk Selection in Reperforator Switching, W. B. BLANTON, *Western Union Technical Review*, Vol. 6, No. 1, January 1952.
2. A Modern Reperforator Switching System for Patron Telegraph Service, R. F. DIRKES, *Western Union Technical Review*, Vol. 2, No. 4, October 1948.
3. Submerged Repeaters for Long Submarine Cables, C. H. CRAMER, *Western Union Technical Review*, Vol. 5, No. 3, July 1951.
4. Electrosensitive Recording Paper for Facsimile Telegraph Apparatus and Graphic Chart Instruments, G. HOTCHKISS, *Western Union Technical Review*, Vol. 3, No. 1, January 1949.
5. An Improved Desk-fax Transceiver, G. H. RIDINGS and R. J. WISE, *Western Union Technical Review*, Vol. 6, No. 3, July 1952.
6. Progress in Radio-Facsimile for Telegram Delivery, C. JELINEK, JR. and K. R. JONES, *Western Union Technical Review*, Vol. 5, No. 2, April 1951.
7. 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 1951.

The Transmission of Intelligence in Typescript

I. S. COGGESHALL

THIS is not a paper on Modern Communication Theory, although some of the precepts of MCT will be referred to. Rather, the presentation is more in the nature of a survey of the practical aspects of encoding and transmitting intelligence in the form of typescript, which, by and large, is the problem and the business of the telegraph companies, wire and radio, domestic and international. In a sense, then, this paper may be considered prologue to MCT—locating, in a manner of speaking, the points of departure from which the new mathematical theories may lead the communication arts to new attainments and usefulness.

PART I—THE EVOLUTION OF TRANSMISSION

The basic statements of the philosophy of transmitting information in the presence of noise interference have been mathematically demonstrated by Shannon, who showed[1] that the upper limit of the amount of information, measured in binary units per second (C) which ideally can be transmitted in one direction over a transmission system, in relation to the bandwidth (W) expressed in cycles per second occupied by the system, in the presence of Gaussian white noise of average power N, is related to the average received power (P) in the signal, in the relationship:

$$C/W = \log_2\left(\frac{P+N}{N}\right) \text{ or } C = W \log_2\left(1+\frac{P}{N}\right)$$

Hartley[2] had addressed himself to the total amount (S) of all the information transmitted over frequency range W in time T, which he found to be constant in the relationship $S = k\, W\, T$. Since $S/T = C$ in the new terminology, $C/W = k$. By relationship of bits to cycles per second, $k = 2$. In the new formula, $C/W = 2$ when $P/N = 3$, from which it appears that the old idea meets the new one as a special case.

The derivation of the new formulas of MCT, (and there are many of them in addition to the one cited), was forced upon communication specialists by the inadequacy of former theories to explain P/N relationships in the bursts of power characteristic of radar and other pulsing techniques, and to account for the ability of forms of wide-band transmissions, like FM, to override noise. The development of the new mathematical theories has involved the abstractions of multidimensional space[3] in fitting the informational content of messages and pictures to the informational capacity of systems to transmit them; and has given communication engineers new design ideals even before the full implications of the formulas and their correlatives are thoroughly appreciated. For example, the equation cited contains a signal/noise ratio, the stepping-up of which, either by expedients of increasing received signal power or of mitigating interference, the engineer knows a great deal about already and is now impelled to learn more; because, if a high ratio of P/N can be doubled in db, W can be halved without degrading the circuit, or if W is held constant, the informational carrying capacity of a circuit can be doubled.

A figure of 30 db separation between average received power and average noise is not unrepresentative of modern commercial communication circuits.[4,5] It may be worth while going through an example, step by step, to see what doubling P/N means. In the MCT formula, P/N is in power units, but the theorem is that bandwidth can be halved if P/N is doubled in decibels. Now, 30 db means $P/N = 1000$ in power units; doubling it to 60 db means increasing power units to $P/N = 1{,}000{,}000$. (For odd values, see handbooks[6]). If N is held constant while P is doubled in db, the received

A paper presented before the IRE Technical Conference on Communications, Cedar Rapids, Iowa, September 1952.

signal will have increased in the ratio 1000000/1000, or one-thousand times. In the formula, $\log_2 x$ may be replaced by its equivalent, $3.3 \log_{10} x$. In doubling P/N, the value of the log term has thus gone up from $3.3 \log_{10} 1001$ to $3.3 \log_{10} 1000001$, or from 9.9 to 19.8. With W held constant, a thousandfold increase in power thus might result in the approaching of a doubling of traffic capacity in the case of an ideal circuit; or, without increasing traffic capacity, the transmission band might be compressed to half width.

The respect given the possibilities expressed by this equation has already spurred a frontal attack on the narrowing of the prodigious bandwidths required by television and color TV, and is reflected in the work being done along other lines, including detecting the existence of radar signals through random noise[7].

There is aesthetic charm in a discovery like this, which, while profound, nevertheless can be couched in terms of a simple equation, demonstrating anew the mathematical formulation of Nature around what Copernicus termed "an orderly arrangement . . . a wonderful symmetry."[8] In another profound and extremely simple expression, $c^2 = e/m$, Einstein keyed the transformation of matter into energy[9], that led modern physics by logical steps to the atomic bomb. But it is worth observing that the indebtedness of nuclear science to Einstein is entirely different, as to mass-energy transformations, from that of the steam engineer, to whom Boyle's Law still represents Truth, within the ranges of refinement of his observations, measurements, and day-to-day requirements. In like manner it may prove that Modern Communication Theory, already finding its greatest potential applications in the vast bandwidths of television, will confer only minor gains on practical typescript communication. Nevertheless this must not be assumed: no engineer with discernment is assuming it.

The transmission parameters governing important segments of the world's work in telegraphy may be variously classified. As to the medium of transmission, we have wire, radio, and (as an incidental component) wave-guides. The media, largely, determine the d-c or carrier frequencies employed, starting with non-repeatered submarine cables on the low end and proceeding up through loaded and coaxial submarine cable, underground cable, open-wire lines, MF and HF radio, and coaxial cable, to SHF radio beams. As to the type of modulation, AM leads, FM is important, as is FSK[10], and there have been some probings with PAM[11] and PPM[12]. The number of quantized power levels is largely limited to two, although three are used on submarine cables, and historically quadruplex d-c telegraphy might be considered a form of transmission at four power levels.

To consider all the combinations of the parameters listed would be the function of a book rather than a technical paper, so only a few can be chosen. Those, in turn, can be considered in relation to only a restricted number of the subjects included within the scope of MCT. The best place to begin would seem to be in the great gulf fixed between radio and wire transmission.

Power and Noise

When a square-topped wave front of voltage is impressed on a wire, cable, or loop by closing the circuit or reversing the potential at the transmitter, the instantaneous change produces a transient surge of power which can be represented as a continuous spectrum of Fourier harmonics[13], the amplitudes of which will be attenuated, and their speed of propagation along the line will be retarded, both directly but non-linearly according to frequency, by the resistance, capacitance, inductance, and leakance of the line and the characteristics of the terminal equipment. (See Figure 1, top.) Attenuation, delay, lack of refinement in receivers, noise, and especially loading combine to establish a virtual cut-off frequency, f_c, that to all intents and purposes establishes an upper limit to the pass-band—all frequencies below it, down to zero, being to some extent present in the slope of the no-longer-vertical amplitude/time wave front as it arrives at the far end of the circuit. The higher the cut-off frequency of the system, the richer the high-frequency content of the arrival curve[14], the steeper its slope; and the steeper its slope the shorter the time-base, $t=1/2f_c$, which spans its rise from zero to maximum. This slope cannot be made steeper by a linear amplifier, for that would merely change the value of the maximum without changing its timing, or the duration of t. The slope can be changed by use of networks which will attenuate the low and emphasize the high-frequency components of the signal; and which will slow down early-arriving low-frequency components until the higher frequencies arrive to be effectively in-phased with them[15, 16].

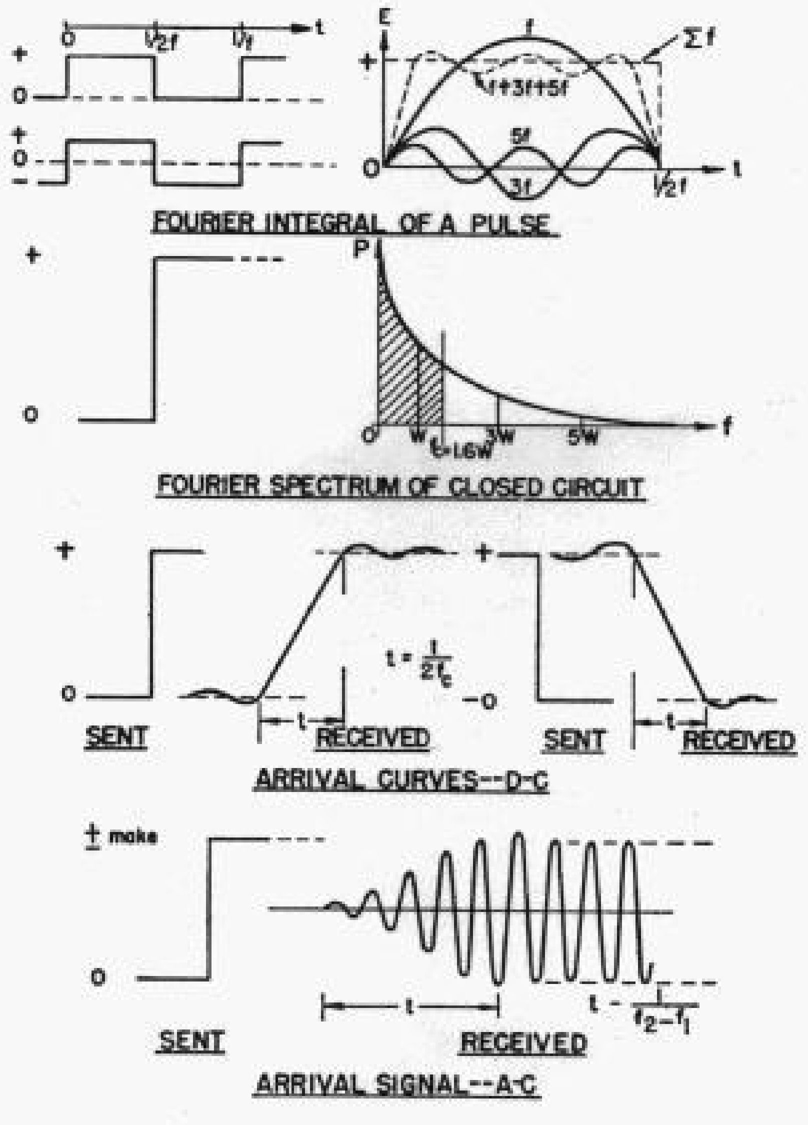


Figure 1

This art is called "shaping" the arrival curve by selective amplifications and phasing, and is important to cable operating speed. For it is evident that within the transmission limitations of the cable set by its construction—the amount of money which was put into the copper conductor; the dielectric constant and thickness of the insulation chosen from among the exceedingly few practicable materials available; the characteristics of the inductive loading, if any; and the nature of the earth-return—all of which collectively determine f_c—only by reducing t can W and C be increased, P/N being held constant.

As a matter of fact a submarine cable which will shape signals satisfactorily so that transmission can be maintained at 20 cps must deal with all frequencies from zero up to 32 cps; that is, $f_c = 1.6\ W$. It is customary to quote landline and cable speeds in terms of W rather than f_c, but the modest margin for harmonics must be guarded.

Turning attention now to radio, the medium presents to the establishment and maintenance of a continuous sinusoidal wave no such impediments as wire lines offer. Even after several revolutions around the earth the high-frequency carrier is protected from amplitude and velocity distortion. In that respect radio transmission conditions may be looked upon as uncircumscribed.

The sudden interruption of an a-c carrier, or its reestablishment, cannot, however, be accomplished without transient build-up and decay of amplitude and variations of phase due to the terminal equipment necessary to operation. (See Figure 1, bottom.) It can be shown[17] that for the comparatively narrow bands used in telegraphy the time of this transient $t = 1/(f_2 - f_1)$, the upper and lower limits of the pass-band. This time is twice as long as the time-base of a d-c arrival curve, $t = 1/2f_c$, indicating that for equal intelligence bandwidths, d-c telegraphy will convey more C in the same W than will carrier modulation, under the same conditions of P/N. However, this is of no moment in the frequency ranges where MCT operates, and it is entirely negligible in the realm of radio-frequency carriers.

The number of cycles of carrier embraced within the envelope of a single informational pulse may be of importance in the case of a short submarine cable, but negligible in transoceanic radiotelegraphy. A short submarine cable section between Nova Scotia and Newfoundland[18] is capable of transmitting a carrier of 80 cycles in one direction and 50 cps in the other, both being modulated at three quantized amplitude levels at 7.5 cycles per second.

$50/7.5 = 6.6$. The pulse envelope contains 3.3 cycles. By contrast, a transoceanic HF radio circuit on 18 mc is operated by Continental Morse at 150 words/minute, or 60 cps. $18{,}000{,}000/60 = 300{,}000$. The pulse envelope embraces 150,000 cycles of carrier.

Because of the differences between their transmission media, radio and wire[19] requirements for power are rich in contrasts. The dbm level of reference to power of 1 milliwatt indicates the order of magnitudes employed in landline telephone practice. Transpositions of pairs and shielding of circuits in underground cables has minimized noise to the extent that little if anything would be gained by raising power levels. Power falls off at the rate of approximately 0.05 db per pair mile at 1000 cps, which would total 10^{45} in power ratio loss (450 db) between points 900 miles apart, like New York and Chicago. As Osborne[20] has said, with the usual telephone input of about one milliwatt, were there no intermediate amplification in the circuit, "it would deliver only one electron in each two months, and even if all the power available in New York City or Chicago could be used at the input without burning up the circuit, the received current would be utterly inappreciable."

On the transatlantic section of a London—New York cable[21] formerly operated at 6.25 cps (Figure 2) with a transmitting voltage of 90, delivering to the cable an input power of 35 dbm, or 3 watts, the attenuation over its 2148 nautical miles of length was 0.034 db per mile, or 72 db over all, delivering signals at a power level of minus 37 dbm at the Newfoundland station repeater input, (curve A). This was ample to override by 21 db the noise present in the input at the station. Sufficient gain (72 db) was supplied by the station amplifier to raise the received signals to the 3 watts (35 dbm) required to operate the sending-on relays. It having been calculated that 99.9% of the noise (in terms of voltage) present in the signal at the station was the result of exposure over the last 150 miles of shallower water, it was decided to lay a repeater in deep water beyond that point, to lift the gain and override the interference which would be picked up on the shoreward end. The lower curve (B) shows the results of the final design. Transmitting voltage was lowered to 60, the input being 33 dbm or 2 watts. The speed of transmission was increased 233 percent from 50 words per minute to 167 wpm (20.83 cps). Attenuation went up accordingly, to 0.055 db per mile. If the signals were carried on to the terminal at that speed they would have been masked by the noise by 27 db. As they now reach the submerged repeater input, their level is minus 73 db. The repeater gain is 52 db. The signal then suffers attenuation and reaches Newfoundland at minus 30 dbm, or with an improvement of 7 db at the better than tripled speed.

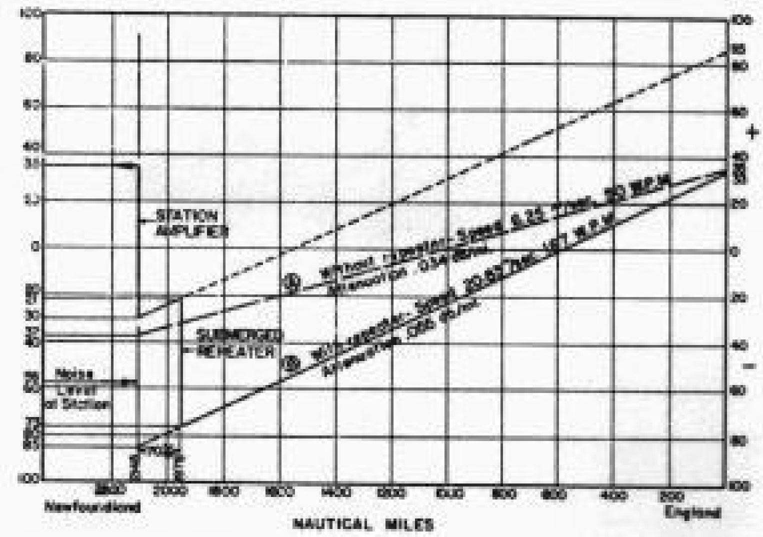


Figure 2

To have arrived there by increasing power at the transmitting point is depicted by the dotted upper curve of Figure 2. The sending level would have to be 85 dbm, or 316 kw, an obvious absurdity for cables ordinarily worked at 3 watts. Although cable insulation will withstand 40,000 volts on test before being laid, the hydrostatic pressure to which cables are subjected introduces mechanical hazards which are translated into possible lowered insulation. On account of high investment and repair costs, practice is very conservative as to voltages applied, and they rarely exceed 110 volts. The fastest cable across the Atlantic is permalloy loaded; its permeability characteristics limit the initial current permissible, so that less than 50 volts are applied to the cable[22].

Reference to power levels in kilowatts brings to mind the case of radio, where the chief deterents to raising power as high as possible in conventional AM and FSK transmitters are those of economics of design, construction cost, power consumption, and interference with other services. Cross-modulation products in the amplifiers produce sidebands of widths[23] greatly in excess of those associated with the relatively narrow informational bandwidths carried, including their requisite harmonic content. In the crowded portions of the commercial radiotelegraph spectrum, spectacular increases of power to gain bandwidth in accordance with modern communication theory will be approached cautiously, and if adopted will probably involve radical changes in design along the lines of pulse modulation. It is a great pity that in this one branch of telegraphy which might profit most by increases in P/N, power is expensive and its use beset with difficulties not present in wire transmission or when radio is confined to a line-of-sight beam.

Radiotelegraphy, like wire and cable telegraphy, ends transmission with the necessity of moving a relay to key its tone circuits at a level of, say, 35 dbm, (3 watts). In the absence of repeaters enroute, the required lift is concentrated in the final receiver amplifier. The P/N ratio is a function of the initial antenna power and the combined efficiency of the sending and receiving antenna arrays and reflectors. Only in the SHF quasi-optical bands is man-made and natural noise low, and transmission weakened only occasionally by local meteorology. In the rest, that is the most, of the record radio communication spectrum, carrier frequencies are critical with respect to diffraction through and reflection from the Heaviside layers, causing certain of them, depending upon the height, ionization, turbulence, and other characteristics of the layers, either to dissipate their power enroute or to establish multiple transmission paths of different lengths which set up wave-front interference patterns. These phenomena, if the intelligence band be wide, apply unequally to the intelligence frequency components at its extremes, giving rise to selective transmission discrimination[24, 25] among the modulated channels on the carrier.

Apart from these fluctuations, which are real and annoying to the operating people, radio's high-frequency carriers form the ideal vehicle for modulation with utmost freedom. It is true that, since wire transmission got away from variable leakage by getting off open wire lines into aerial and underground cable, it has been left with few natural amplitude variations that proved devices like temperature-operated automatic gain controls[26] won't cure. But in speeding up their lines for the establishment of a-c carriers dictated by the necessity of flexibility in handling telegraphy and telephony on the same plant, engineers have been hard put to secure the advantages which radio inherently enjoys. By the insertion of repeaters as closely spaced as may be required—250 miles, 50 miles, 8 miles, 4 miles—the ever higher cut-off frequencies of shorter and shorter sections have been made the determinants of the main line itself, power has been kept low, and P/N ratios acceptable. Lines have had to be equalized and standardized, frequency components phased and shaped, sending-end and receiving-end cross-fire eliminated, the advantages of inductive loading brought into proper relationship with its effect in retarding propagation, echoes suppressed and singing eliminated, power-line inductive disturbances rendered impotent, the circuits shielded from lightning and the plant from electrolysis, abrasion, and termites. It is a tribute to communication engineering that wire and radio media can be so closely comparable in effectiveness as they are in today's coaxial cables and SHF radio beams.

Sequential Codification

Modern communication theory concerns itself not only with manipulation of P/N and W; but, as to C—the number of informational pulses to be transmitted per second—it turns a searchlight on the historicity of the pulse sequences transmitted, to ascertain whether they contain statistical properties of movement that can be built into transmitters and receivers, alike, so that only the residue beyond the momentum of each sequence occupies bandwidth in transmission. Let us make our terminal apparatus more complex if necessary, says MCT, in order to minimize the number of pulses transmitted.

In a television picture, for example, the sequence of amplitudes representing the tones of gray, from black to white, on one horizontal line of scanning are pretty much what they were on the preceding line. Let the transmitter and receiver, then, contain identical memory devices, so that only the plus and minus increments in shade from line to line need be transmitted over the air[27]. At the transmitter, encode these increments in a quantized code which is nonuniform in time-length, sending the smallest increments (which predominate) in the shortest time intervals, and reserving maximal-timed code groups for abrupt transitions between white and black. This will result in a telescoping of the information before it is transmitted over the communication channel. At the receiver, with the same previously-scanned line available in its memory device as a moving point of reference, let the received information, quantized as to increments, be decoded, expanded into uniform time elements, projected on the screen, and stored in the memory for use on the following line.

Calling that process vertical prediction, a similar observation can be made of, and treatment given to, horizontal prediction; for here again, for the most part, the amplitude representing the gray level of one picture element is pretty much an extension, in slope, of the two elements which preceded it on the same line of scan. Only the incremental slope need be signaled, and that can be done in a short nonuniform code, as before. Finally, the horizontal and vertical predictions can be given an integrated treatment, called planar, and the code for signaling the increments be further compressed.

What is being taken advantage of, here, is the statistical quality of gray-level history and movement in a TV picture. In the same way, says MCT, we ought to be able, in the transmission of intelligence in typescript, to take advantage of what a transmitter and printer can be made to learn and remember about the sequence of letters in the English language[28]. From the viewpoint of MCT a uniform 5-unit, mark-space code like printer Baudot is an anachronism, not only because the letters E and Z each contain five pulses regardless of the fact that E is frequently and Z seldom transmitted, but because, having transmitted in succession a word-space and the letter Q, it assigns five units, instead of one unit or no unit, to the letter U, which is almost certain to follow. In other words, MCT frowns upon a code so long that, after each letter is printed, it insists on reserving needlessly a full measure of spectrum for all eventualities, most of which seldom occur. Deal not in single letters but in digraph and trigraph sequences, says MCT, and reserve your longest code groups for the greatest departures from normality; telescope your information at the transmitter; don't signal the letters, signal the departures; and at the receiver, expand while you decode, thus saving bandwidth on the line.

The forfeiture of terminal apparatus simplicity for reduction of bandwidth on the main line is not a prospect which practical telegraph men will embrace without a long second look. Over the years, a great many attempts have been made to strike a balance between shortening codes and designing trouble-free terminal equipment.

Part II — Telegraphic Codification, the final installment of this article, will trace these historical steps and discuss the lessons derived from the experience.

Bibliography

1. A Mathematical Theory of Communication, C. E. SHANNON, *Bell System Tech. Jour.*, Vol. 27, 1948, pp. 379-423.
2. Transmission of Information, R. V. L. HARTLEY, *Bell System Tech. Jour.*, Vol. 7, 1928, pp. 535-563.
3. Bandwidth vs. Noise in Communication Systems, D. G. FINK, *Electronics*, Vol. 21, January, 1948, pp. 72-75.
4. An FM Telegraph Terminal Without Relays, F. H. CUSACK and A. E. MICHON, *Western Union Tech. Rev.*, Vol. 1, No. 2, October, 1947, pp. 33-42.
5. A Microwave Propagation Test, J. Z. MILLAR and L. A. BYAM, JR., *Western Union Tech. Rev.*, Vol. 4, No. 2, April 1950, pp. 49-60.
6. Reference Data for Radio Engineers, (book), Federal Telephone and Radio Corporation, New York, 3rd ed., 1949.

(Continued)

7. INFORMATION THEORY AND THE DESIGN OF RADAR RECEIVERS, P. M. WOODWARD, *Proc. I.R.E.*, Vol. 39, 1951, pp. 1521-1524; also ON DETERMINING THE PRESENCE OF SIGNALS IN NOISE, I. L. DAVIES, *Proc. I.E.E.* (London), Vol. 99, Part III, No. 58, March 1952, pp. 45-51.

8. THE LIMITATIONS OF SCIENCE, (book), J. W. N. SULLIVAN, New Amn. Library, New York, Mentor ed., 1952, pp. 16, 140.

9. THE RELATION BETWEEN ENERGY AND MASS, F. SEITZ, JR., *Elec. Eng.*, Vol. 67, 1948, pp. 1-5.

10. CARRIER-FREQUENCY-SHIFT TELEGRAPHY, R. RUDDLESDEN, E. FORSTER, Z. JELONEK, *Proc. I.E.E.* (London), Vol. 94, Part III-A. 1947, p. 379.

11. PULSE MODULATION SYSTEMS FOR TELEGRAPHY, J. R. HYNEMAN, *Western Union Tech. Rev.*, Vol. 3, April 1949, pp. 69-76; also A SHORT-HAUL RADIO COMMUNICATION LINK CHANNELIZED BY TIME DIVISION, E. M. MORTENSON and C. B. YOUNG, *Western Union Tech. Rev.*, Vol. 6, January 1952, pp. 2-11.

12. PULSE-TIME MODULATION, E. M. DELORAINE and E. LABIN, *Electronics*, Vol. 18, January 1945, pp. 100-104.

13. MODERN COMMUNICATION SYSTEMS, F. LUSCHEN, *Proc. I.E.E.* (London), Vol. 71, 1932, pp. 776-798.

14. SUBMARINE CABLE TELEGRAPHY, J. W. MILNOR, *AIEE Jour.*, Vol. 41, 1922, pp. 118-136. *AIEE Trans.*, Vol. 41, 1922, pp. 20-38.

15. SIGNAL SHAPING FOR SUBMARINE CABLES, A. M. CURTIS, *Bell Lab. Rec.*, Vol. 6, 1928, pp. 237-241.

16. SOME MODERN TECHNIQUES IN OCEAN CABLE TELEGRAPHY, C. H. CRAMER, *Western Union Tech. Rev.*, Vol. 2, January 1948, pp. 17-27.

17. MODERN COMMUNICATION SYSTEMS, F. LUSCHEN, *Proc. I.E.E.* (London), Vol. 71, 1932, pp. 776-798.

18. SUBMARINE TELEGRAPHY IN THE POST-WAR DECADE, I. S. COGGESHALL, *AIEE Trans.*, Vol. 49, 1930, pp. 476-485.

19. THE INSIDIOUS DECIBEL, A. BOGGS, *Western Union Tech. Rev.*, Vol. 4, 1950, pp. 158-159.

20. THE PRINCIPLES OF ELECTRIC CIRCUITS APPLIED TO COMMUNICATION, H. S. OSBORNE, *Bell System Tech. Jour.*, Vol. 8, 1929, pp. 3-20.

21. SUBMERGED REPEATERS FOR LONG SUBMARINE TELEGRAPH CABLES, C. H. CRAMER, *Western Union Tech Rev.*, Vol. 5, July 1951, pp. 81-91.

22. HIGH-SPEED OCEAN CABLE TELEGRAPHY. O. E. BUCKLEY, *Bell System Tech. Jour.*, Vol. 7, 1928, pp. 225-267.

23. DESIGN OF MODULATION EQUIPMENT FOR MODERN SINGLE-SIDEBAND TRANSMITTERS, A. E. KERWIEN, *Proc. I.R.E.*, Vol. 40, 1952, pp. 797-803.

24. COMMERCIAL SINGLE-SIDEBAND RADIOTELEPHONE SYSTEMS, F. A. POLKINGHORN, *Communications*, November 1948, p. 24.

25. MULTI-CHANNEL TWO-TONE RADIO TELEGRAPHY, L. C. ROBERTS, *Bell Lab. Rec.*, Vol. 24, 1946, pp. 461-465.

26. THE PRINCIPLES OF ELECTRIC CIRCUITS APPLIED TO COMMUNICATION, H. S. OSBORNE, *Bell System Tech. Jour.*, Vol. 8, 1929, pp. 3-20.

27. EXPERIMENTS WITH LINEAR PREDICTION IN TELEVISION, C. W. HARRISON, *Bell System Tech. Jour.*, Vol. 31, 1952, pp. 764-783; also STATISTICS OF TELEVISION SIGNALS, E. R. KRETZMER, *Bell System Tech. Jour.*, Vol. 31, July 1952, pp. 751-763.

28. EFFICIENT CODING, B. M. OLIVER, *Bell System Tech. Jour.*, Vol. 31, 1952, pp. 724-750; also PREDICTION AND ENTROPY OF PRINTED ENGLISH, C. E. SHANNON, *Bell System Tech. Jour.*, Vol. 30, 1951, pp. 50-64.

Biography and picture of **Mr. Coggeshall,** who is now Director of Planning, International Communications Department, appeared in TECHNICAL REVIEW for January 1951.

A Switching System for Dispatcher Test Wires

P. R. EASTERLIN

WITH the rapid growth in the last ten years of direct reperforator circuits between all areas, and the tremendous expansion in nationwide patron switching lease networks, the need for more flexible use of dispatcher test wire circuits has become increasingly apparent. These circuits, the majority of which are Morse, are used for urgent direct communication between divisional dispatchers, wire chiefs and repeater attendants in directing and coordinating the vast arteries of Western Union's land-line facilities. For example, the occasional land-line or carrier equipment failure on transcontinental circuits sometimes requires the prompt designation by the dispatcher of alternate facilities for each telegraph circuit, or perhaps the interruption of a nationwide patron circuit may require the immediate attention of wire and repeater attendants in several widely separated offices throughout the country at the same time.

Heretofore, the majority of the dispatcher circuits have been permanently terminated on a sectional basis using various types of available repeater sets which lack the flexibility of easy interconnection or rapid cut-through to other test wires. In certain instances this necessitates the relaying of emergency instructions through one or more centrally located dispatchers. However, the growth of overland reperforator and lease circuits has resulted in a frequent need for testing and regulating communication between attendants in distantly located offices to be performed on a nationwide basis for prompt maintenance and restoration of these telegraph channels.

To meet this need and also provide for the future requirements of an integrated and versatile dispatcher test wire system, a simple switching arrangement has been developed which permits offices on one test wire to select remotely and to interconnect to a maximum of 22 different test circuits terminated at a central switching office. This is accomplished by these offices transmitting prescribed selection signals either from a Morse telegraph key or by using character combinations on a standard teleprinter keyboard. This flexibility, coupled with an easy method of manually interconnecting these test circuits at all offices, is expected to result in an over-all decrease in the amount of telegraph facilities required for dispatching purposes. This article describes this new equipment, designated as Network Switching System, Plan 101-A, which is now being assembled for installation in offices throughout the system.

THEORY OF EXISTING NETWORK REPEATERS

Before describing the operation of this system, it will be helpful to review briefly the theory of a repeater circuit presently in use for combining three or more telegraph branches into one circuit at a central or hub office. Figure 1 shows the standard grouping arrangement widely used by Network Repeater 4617, and in modified form by older repeaters, whereby a number of line circuits are terminated and combined into one half-duplex circuit, providing singular transmission and re-

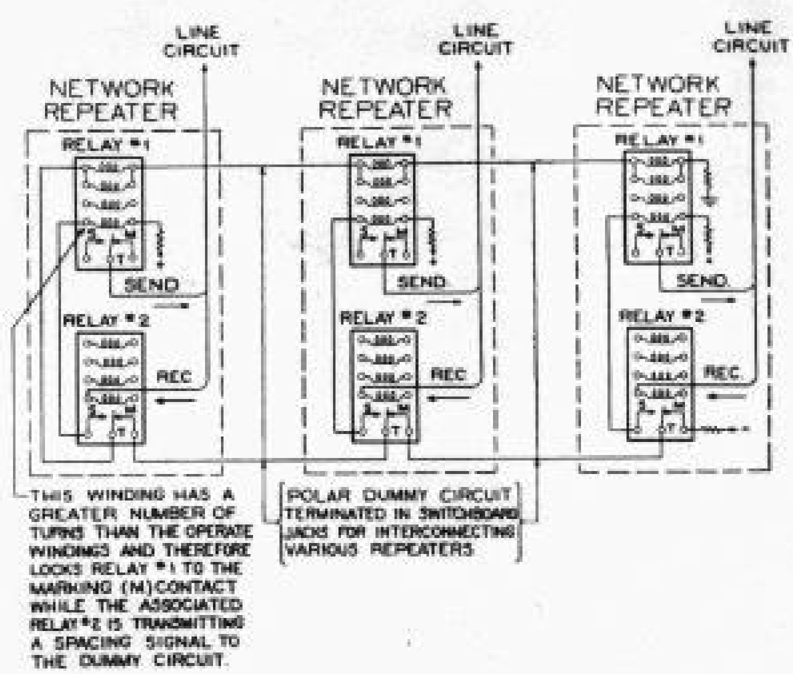


Figure 1. Theory of dummy circuit used on existing repeaters to interconnect a number of line circuits into one half-duplex network

ception between all offices. Each telegraph branch is represented by an individual repeater comprising two polar relays arranged so that the contacts of relay No. 1 and the windings of relay No. 2 transmit and receive signals, respectively, from each line circuit, employing conventional methods of line operation such as duplex over one-conductor or a two-wire arrangement over carrier or physical facilities.

The opposite components of each relay —the windings of relay No. 1 and the contacts of relay No. 2—are used for a polar dummy circuit which can be interconnected between each repeater at a switchboard to combine two or more repeaters and their line circuits into one network. Incoming line signals operate relay No. 2 of the respective terminating repeater and the spacing (S) and marking (M) contacts of this relay transmit polar signals to the dummy circuit, operating relay No. 1 in all other repeaters which in turn transmit directly to the individual line circuits. While a particular relay No. 2 is transmitting a spacing signal to the dummy circuit, its associated relay No. 1 is held locked to the marking contact by a holding winding in series with the spacing battery tap, preventing a bust-back to the incoming line signals.

Noteworthy at this point, for later comparison with a different method of interconnecting such repeaters, is the sequence in which the polar dummy circuit is connected to each repeater. For example, the transmitting contacts of relay No. 2 in all repeaters must be connected in a series manner ahead of all receiving windings on relay No. 1 so that signals from any line will be retransmitted to all other repeater sets in the hook-up.

THEORY OF NEW REPEATER

Functioning in the same general manner described above for terminating each line circuit and forming a component part of the Network Switching System is a newly designed repeater which employs a simpler principle of interconnection and, therefore, lends itself much better to selective control purposes. This rack mounted repeater, designated as Network Repeater 6611-A, is shown in Figure 2 along with an associated Network Sub-Set 6612-A, one or more of which can be used to extend the talk and selection facilities of the repeater to several convenient locations throughout an office.

Figure 2. Network Repeater 6611-A and Network Sub-Set 6612-A

Two or more of the new repeaters can be interconnected by simply joining or strapping together a single wire extending from each repeater, designated as the multiple connection. This common junction point of each repeater provides a means of adding or removing repeaters in a working network, without interruption of transmission or consideration for sequence as in the polar dummy circuit used in existing repeaters. In the Network Switching System to be described later, this connection between several repeaters for manually grouping two or more dispatcher circuits at intermediate or terminal offices can be easily made with conveniently located switchboard cords and jacks. Equally as important, however, is the ability of these offices remotely to select and interconnect two such repeaters at a central switching office by bridging this connection with the wiper and one point of a rotary switch.

Figure 3 shows the theory of the multiple connection between two or more of these repeaters located at an intermediate or terminal office and also the connections to the associated network sub-sets, one or more of which can be used with each repeater. The repeater consists of four polar relays comprising a Transmitting relay which receives from the multiple circuit and transmits to an individual line; a Main Line relay to receive from the line and transmit to the multiple circuit; a Sending relay which receives from the local sending leg and transmits to the multiple circuit; and a Receiving relay which receives from the multiple circuit and transmits signals to the local receiving leg. The latter two relays are required when an associated sub-set is used with the repeater, and in certain applications at intermediate offices these relays are omitted.

The multiple circuit differs from the conventional make-break neutral circuit where a closed circuit and attendant current flow represents a marking signal, while an open circuit and no current flow is interpreted as a spacing signal. Instead, the relays which receive signals from this circuit are arranged to interpret the no-current interval as a marking signal and conversely as a spacing signal when current flows.

Under the normal marking condition, the potential along this multiple circuit is 120 volts negative, emanating from two sources in each repeater. The relays which transmit signals to the multiple circuit are arranged to apply a ground for a spacing signal and this produces a current flow through the windings of all Transmitting and Receiving relays. This current, flowing through the D-U and (D)-(U) windings of each relay—while less than the steady bias current flowing through the 0-0′ winding acting to hold these relays to the marking contact—utilizes four times the number of winding turns and therefore exerts a force twice as great which accordingly operates these relays to the spacing contact. This arrangement keeps the combined current flow in the multiple circuit, which is keyed by the contacts of either one Main Line or one Sending relay, to a minimum value so that this current will not be excessive when a number of repeaters are connected together.

To avoid breaking back on signals received over its respective line circuit, the

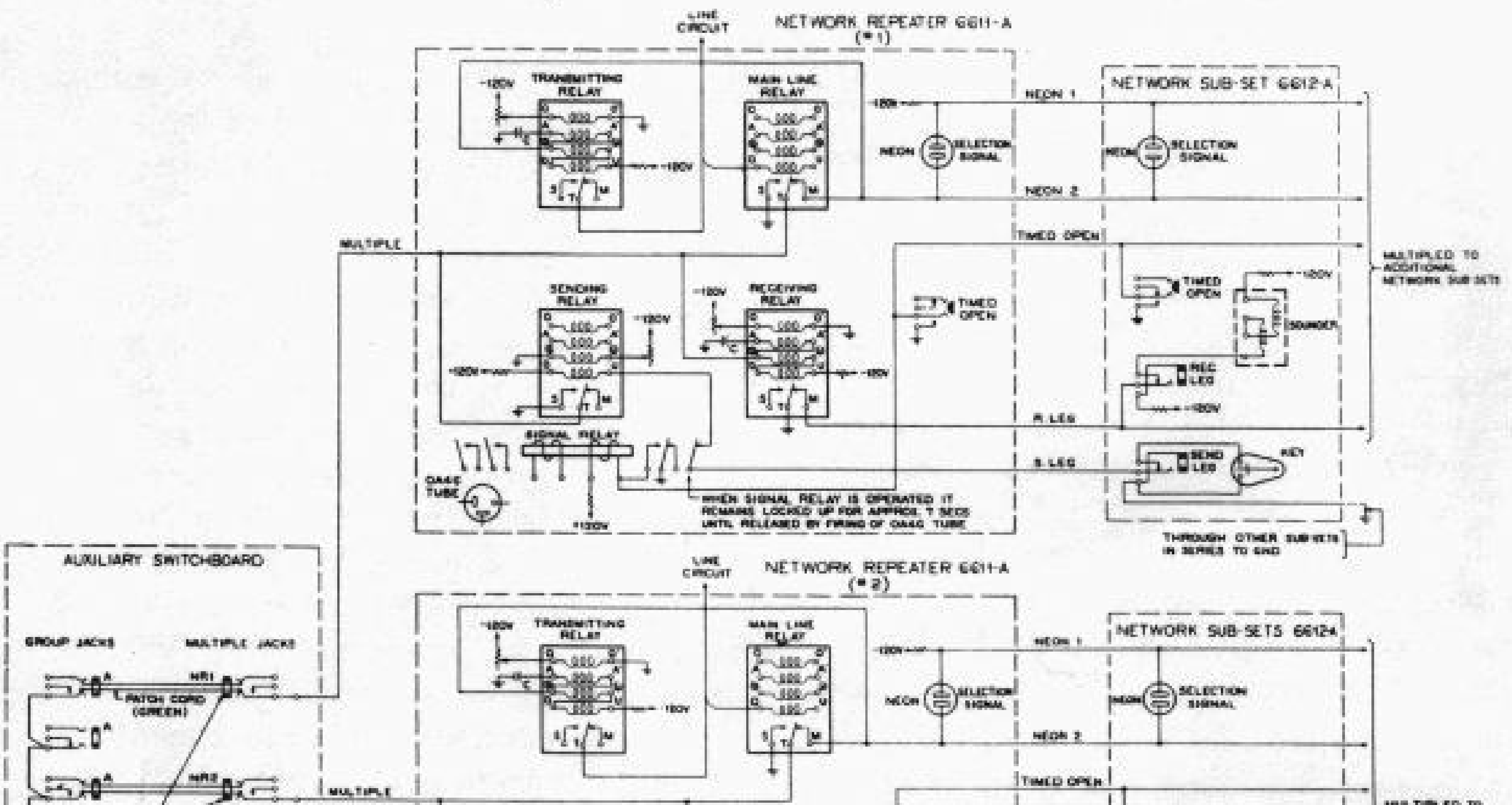


Figure 3. Theory of multiple circuit on Network Repeater 6611-A

windings of the Transmitting relay are connected to the multiple circuit through the marking contact and tongue of its associated Main Line relay. Therefore, the multiple circuit connection for the Transmitting relay is opened and it cannot follow the signals which are sent to the multiple circuit by its associated Main Line relay.

If not corrected, an inverse neutral multiple circuit of this kind would introduce signal bias due to the travel time of the Main Line or Sending relays adding to the marking signal. Also, the magnitude of the inductive current load which must be keyed by the contacts of the Main Line or Sending relays, as the case may be, will vary with the number of repeaters connected at one time by means of this circuit. Therefore, spark protection proportionate to this variable current load must be provided for the contacts of the Main Line and Sending relays and it should be applied in a manner which will not affect the character of the signals as received from the multiple circuit.

The means of overcoming travel time bias and providing proportionate spark protection for these senders is accomplished by using a condenser in series with the A-A′ windings of the Transmitting and Receiving relays. When the tongue of any Main Line or Sending relay removes ground from the multiple circuit by leaving the spacing contact, the condenser proceeds to charge through the D-U, (D)-(U) and A-A′ windings in series aiding, the effect of which is to tail out all spacing signals from the multiple circuit to a degree that causes all relays which receive from this circuit to repeat equally timed (unbiased) marking and spacing signals. In addition to the wave-shaping effect, the condenser in charging acts as a spark killer by absorbing the inductive energy stored in the D-U and (D)-(U) windings when the tongue of any Main Line or Sending relay removes ground from the multiple circuit. By means of a strap between terminals (D) and A′ on the subbase of these relays, this spark protection is individually associated with the inductive load of each receiver and therefore is disconnected from the multiple circuit when the relay is removed from the subbase. This arrangement avoids a change in spark killer constants when a receiving relay is removed and causes no transmission change on the multiple circuit when repeaters are added or removed from a working network.

THEORY OF NETWORK SWITCHING SYSTEM

The simplicity of interconnecting this new repeater manually at intermediate and terminal offices, as well as the ability of these offices remotely to select and interconnect two repeaters of this type at a centrally located switching office, explains the important function of this unit in the Network Switching System.

Shown in block form in Figure 4 is a typical application of this system, showing six out of a maximum of 23 circuits which can be terminated and selectively interconnected by timed open signals and spacing pulses transmitted from the network sub-sets associated with the repeater at any intermediate or terminal outoffice. Each network sub-set is equipped with a push button and selection signal lamp which are used for sending and receiving the timed open signals exchanged in the selection sequence between the selecting and switching offices.

Each circuit at all offices terminates in Network Repeater 6611-A and associated with each of these repeaters at the switching office is one Relay and Rotary Switch Bank 6616-A, Figure 5, 12 of which can be mounted on each side of Network Switching Rack 6614-A shown in Figure 6. This switch bank contains one 3-level, 25-point rotary switch, six switching relays and an OA4G tube which are used for the switching control functions. The multiple connection of each repeater is connected to the "B" level wiper of the associated rotary switch as well as to one point of the stator corresponding to the assigned selection code, and the respective points on the stator of all rotary switches are multipled together.

It will be seen from Figure 4 that if the wiper of rotary switch No. 1 is stepped to point 3, repeaters No. 1 and No. 2 will be interconnected by means of the multiple circuit, or a similar connection can be made by stepping rotary switch No. 2 to point 2. In this manner, each repeater can interconnect its multiple with that of any other repeater in this group when its associated rotary switch is stepped to the proper point.

Selection Sequence

The operational functions of the network switching system will now be explained by describing a typical selection and interconnection of two test wire circuits at the switching office. While the selection sequence is the same for all offices, the procedure and selection code used below is based on Outoffice A selecting and interconnecting to Outoffice F. Normally all rotary switches are on point 25 when not interconnected to other circuits.

To Select

1. The Timed Open push button on the network sub-set at Outoffice A is depressed and released. The associated

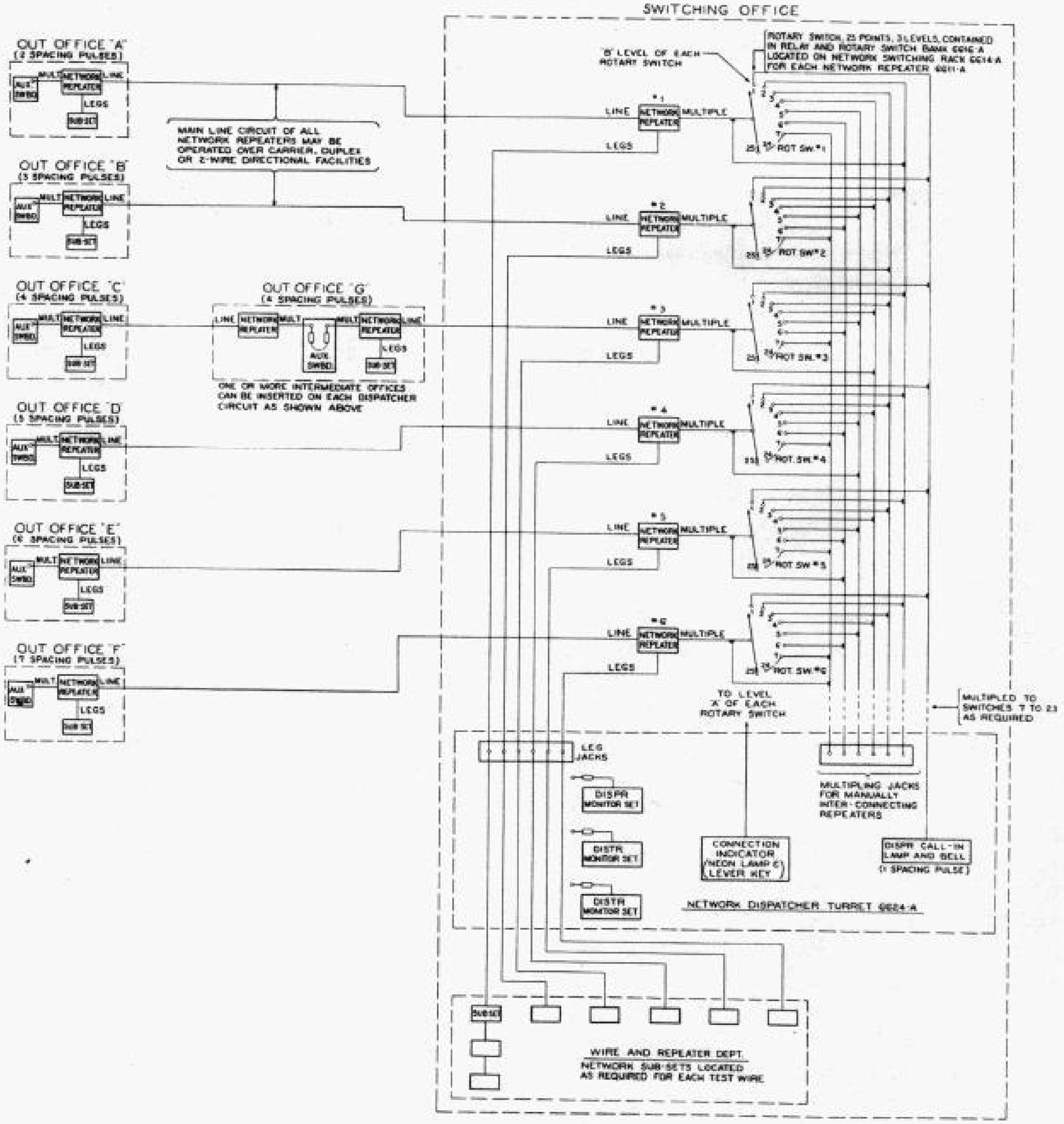


Figure 4. Theory of Network Switching System, Plan 101-A

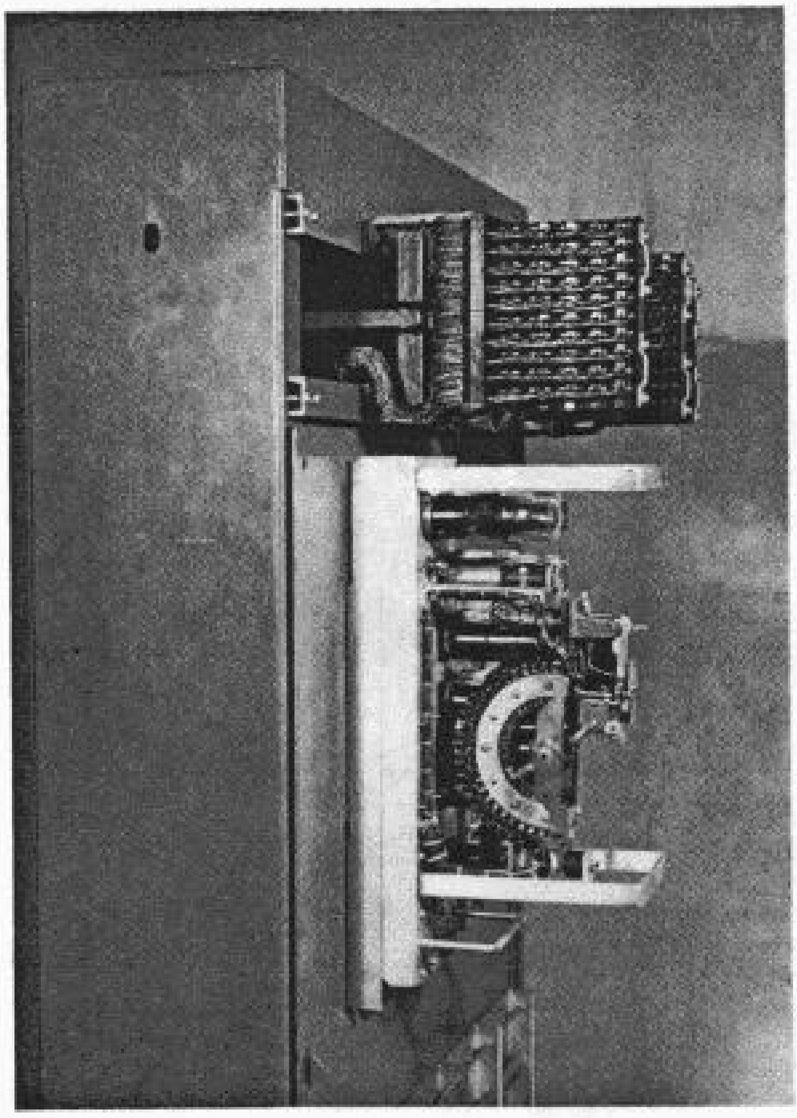


Figure 5. Relay and Rotary Switch Bank 6616-A

network repeater at Outoffice A, by means of a signal relay and tube, will transmit a 7-second timed open "initiate" signal over the line to network repeater No. 1 located at the switching office. While this signal is being transmitted, the Selection lamp on the network sub-set will burn steadily. Within five seconds, the equipment associated with repeater No. 1 at the switching office will respond to this "initiate" signal and will transmit back to Outoffice A the "go ahead selection" signal, consisting of a timed open signal which extinguishes the selection lamp.

2. Outoffice A shall now transmit the proper selection code, consisting of 7 spacing pulses for connection to Outoffice F. For each spacing signal—not to exceed 5 seconds in length— rotary switch No. 1 at the switching office will be stepped electrically one point, stopping on point 7. Within reasonable limits, the length or irregularity of these selection pulses is unimportant and they may be transmitted by opening and closing a Morse key seven times—emulating the Gill selection technique — or by operating the "letters" or "blanks" key on a teleprinter keyboard seven times. Also, teleprinter keyboard character combinations having the correct number of spacing to marking signal transitions for a particular selection code may be used, such as "CBR" for point 7 as illustrated in Figure 7.

3. After having transmitted the selection code, the Timed Open push button at Outoffice A is depressed and released again, causing the network repeater to transmit the "selection completed" signal to the switching office. This signal, also a 7-second timed open, again operates the selection lamp at Outoffice A. The switching equipment responds to this signal and connects the multiple of network repeater No. 1 through rotary switch No. 1 to the multiple of network repeater No. 6. When this connection is made, the switching equipment transmits a single timed open signal of approximately 0.1 second to Outoffice A which blinks the selection lamp and indicates that the connection has been made. Outoffice A is now connected through to Outoffice F.

To Disconnect

Depressing the Timed Open push button at Outoffice A transmits a third 7-second timed open signal to the switching office which causes the equipment there to disconnect the multiples of repeaters No. 1 and No. 6 and to return rotary switch No. 1 to its home position on point 25. When the disconnect is made, the switching equipment does not send an acknowledgement or indicating signal to the outoffice originating the disconnect sequence. Also, the switching equipment responds only to a disconnect signal transmitted from the line circuit of the office which originates the cut-through and not by the selected office.

Connection to a Busy Circuit

If a connection is made to a test wire already involved in a cut-through with another circuit, no interference or break-up in transmission will result provided the selecting office, after connecting, does not proceed to transmit. When such a selection is made, the three dispatcher circuits are simply connected into one half-duplex network, and the busy condition can be recognized by the reception of signals being exchanged between the two circuits. The selecting office may either wait until the circuit is idle or a disconnect can be made. However, the 7-second "disconnect" timed open transmitted by the selecting office to the switching equipment will interrupt transmission on the busy circuit for approximately 5 seconds.

Failure to Disconnect

If for some reason an office forgets to disconnect upon completion of a cut-

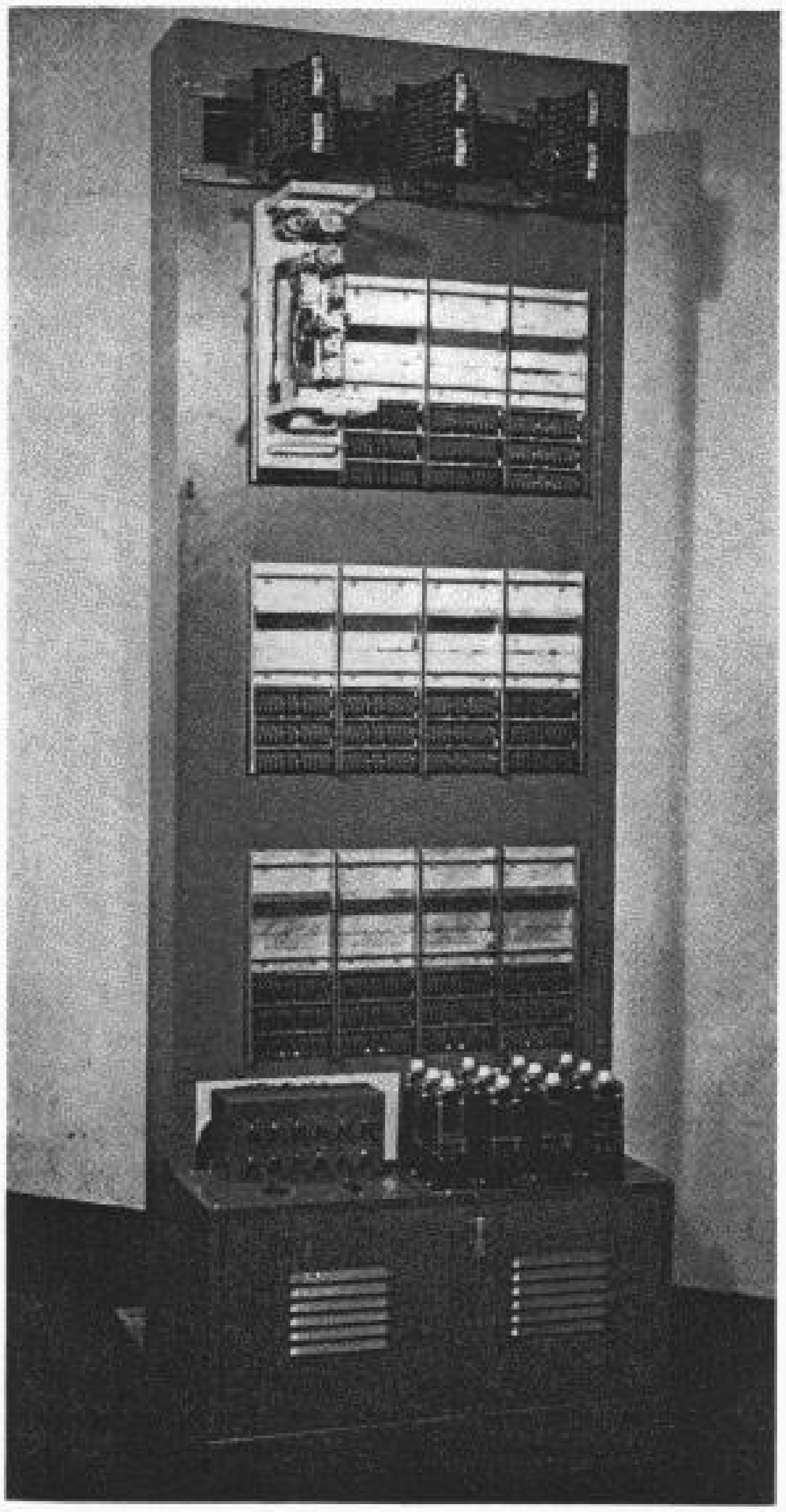


Figure 6. Network Switching Rack 6614-A

through to another circuit and later a new selection is attempted from the same office or perhaps an intermediate office on the same line, the control signals transmitted from the switching office will make this evident. For example, if a disconnect has not been made, transmission of the 7-sec-

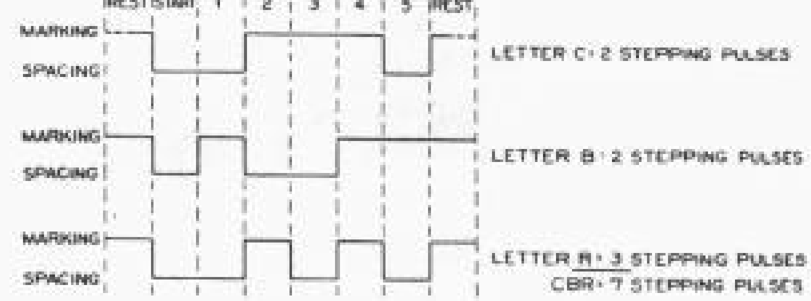


Figure 7. Method of transmitting selection code by using teleprinter keyboard character combinations

ond "initiate" timed open to the switching office will perform the disconnect but no "go ahead selection" signal will be received at the selecting office which normally extinguishes the selection lamp in approximately 5 seconds. When this signal is not received, it is understood that a previous disconnect has been omitted and the selection sequence is started again by operating the Timed Open push button. It is important, therefore, that disconnects be made immediately upon completion of each communication in order to avoid the transmission of unnecessary signals.

Line Interruptions

Interruptions on the line or carrier facilities for periods over 5 seconds can be interpreted as timed open signals by the switching office. However, the switching equipment is arranged to ignore successive false signals of this type provided no spacing pulses—open signals of less than 5 seconds—are intermingled between these long opens. The reaction of the switching equipment to each successive false open will be the same as when the "initiate" timed open is received. Also, one long open of this type, followed by 25 or more spacing pulses, will operate the rotary switch at the switching office one step for each pulse until the home position is reached, recycling the equipment without interference with other circuits. However, a false connection can be caused by these line failures when two such long opens are separated by one and not more than 24 spacing pulses.

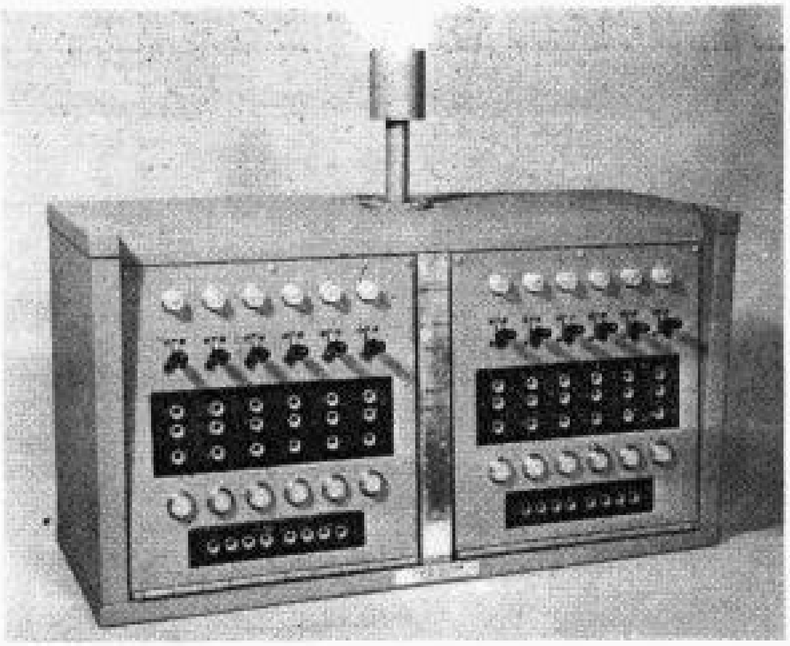


Figure 8. Network Dispatcher Turret 6624-A

Dispatcher Control

Facilities for monitoring and manual control of the complete system are provided by Network Dispatcher Turret 6624-A, shown in Figure 8, one of which is associated with each group of 12 repeaters at the switching office. This turret is equipped with group jacks which enable the dispatcher to manually connect any combination of repeaters into one or more separate networks. A connection indicator and disconnect circuit, consisting of a lever key and neon lamp for each repeater wired through the A level of the associated rotary switch, enables the dispatcher to determine which repeaters are selectively interconnected and also provides the means of manually disconnecting each repeater.

Any office wishing to contact the dispatcher can actuate an audible alarm and call lamp on the dispatcher turret by using the selection sequence routine, along with a selection code of one spacing pulse. An additional flexibility inherent in this system but normally performed manually by the dispatcher when necessary, is the ability of a group of offices to interconnect their circuits together selectively. Inasmuch as offices on each test wire can selectively interconnect to one additional circuit, a group of offices can, therefore, progressively select any part of the total circuits into one large network.

While this system has been specifically designed for application on Western Union's dispatcher circuits, the simplicity of the selecting principle has already been recognized for possible use on future patron switching installations where it can be adapted to group two or more circuits with one selection code. A patent application covering the various features of this switching system has already been filed.

Philip R. Easterlin began with Postal Telegraph in 1920 as a messenger in Atlanta, Ga. In subsequent years he worked successively as Morse and multiplex operator, testing and regulating attendant, wire chief, and manager of various New York newspaper press offices, before entering the Engineering Department in 1940. He participated in the design of the Postal Semi-Automatic Reperforator System, later supervising its testing in Postal offices, and during the war continued this work in Army Signal Centers throughout the country. At the time of merger, Mr. Easterlin was assigned to the Ocean Cable Engineer for one year before joining the Applied Engineering section where he was involved in the design of modern rack-mounted repeaters and Plan 21-A Reperforator Switching equipment. During the recent reperforator improvement program, Mr. Easterlin conducted several training schools for technicians and was in charge of the testing engineers at the Minneapolis and Detroit installations. He is now on the staff of the Electronics Applications Engineer concerned with the design of repeaters and automatic switching apparatus, one of his latest projects being the development of the switching system described in this article.

Page-Size Facsimile Transmitter

A MODEL page-size facsimile transmitter has been developed to fulfill the requirements of patrons who wish to use this modern method of record communications for the rapid transmission of correspondence, drawings, charts, business forms and layouts, typed or handwritten manuscripts and even pictorial material. Although this machine was especially designed for patrons' leased services, it possesses all of the fundamental advantages of Western Union's proven Telefax systems and may be used in public message service where the standard size is not adequate.

To accommodate all of the various sizes and shapes of subject copy likely to be encountered in widely varying applications, it was necessary to incorporate into this experimental machine a method of mounting the subject copy which is quite different from that employed in most Western Union Telefax equipment. The drum of this transmitter is provided with a transparent wrapper so that any size or shape of subject copy may be easily mounted for transmission. The maximum size that will be handled is 8½ by 14 inches, with a maximum scanned area of 8 by 13 inches.

A latch in the hand wheel on the right end of the drum is operated to release the wrapper. The wrapper may then be pulled forward to insert the subject copy. The copy is placed face downward on the wrapper, the hand wheel rotated forward and the latch depressed. A row of small wheels located directly beneath the drum operates to force the wrapper over a row of spring-mounted hooks so that the copy is held tightly against the drum. Since the wrapper is held under tension by means of the spring-mounted hooks at all times, fairly stiff cards may be mounted as readily as thin sheets and wrinkles in the subject copy are effectively ironed out.

Controls are provided on the transmitter to facilitate the handling of business forms, positive or negative subject copy, and for half-tone or black and white. The electronics of the unit provide for the transmission of subject copy with various colors of background without corresponding variations in the density of the recorded background.

In order to meet widely varying patrons' requirements and to permit operation over different kinds of circuits, the transmitter may be arranged to operate at any one of three different speeds. These range from twice to one-half normal Telefax scanning speed.

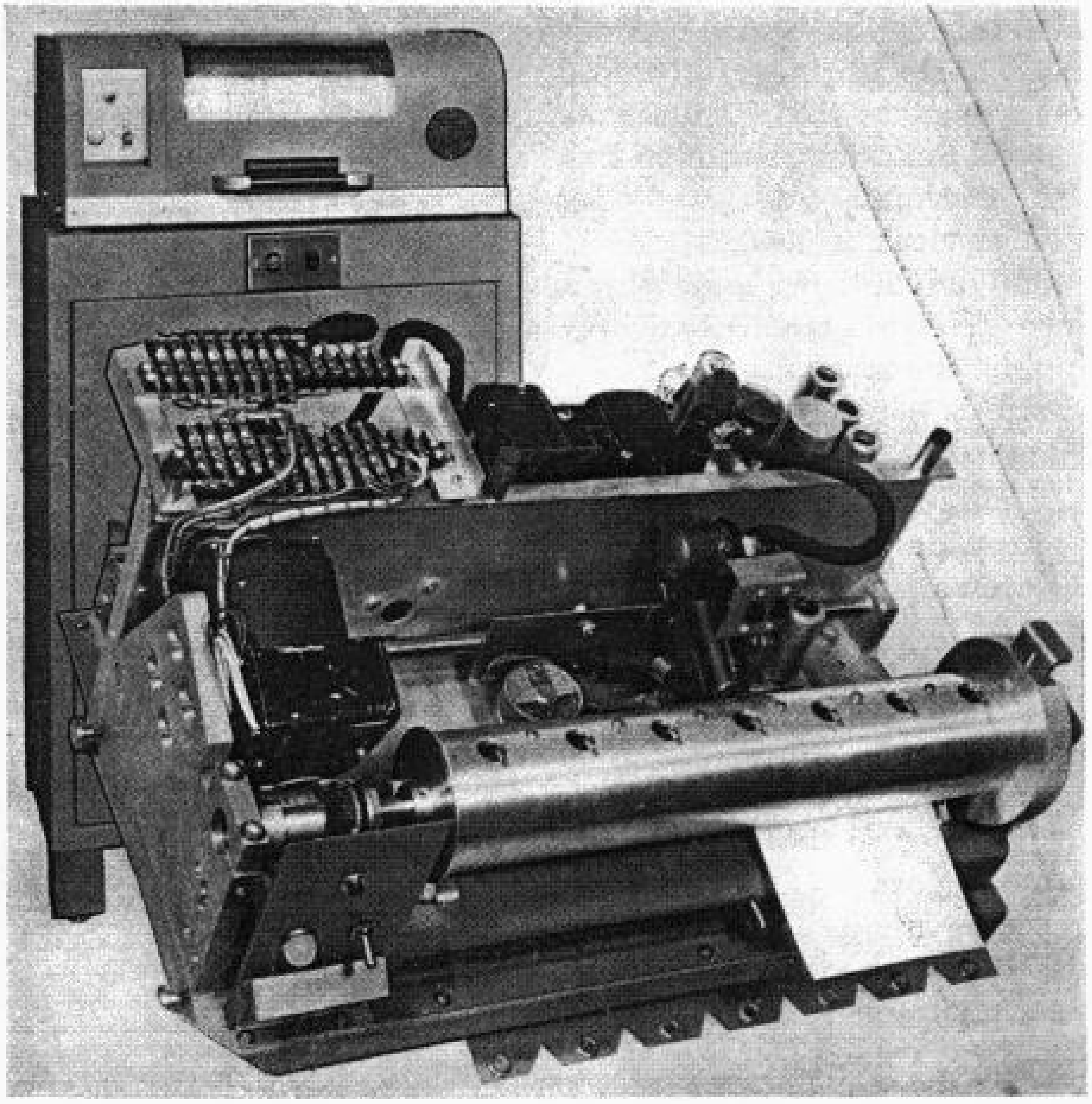
Letter to be scanned is placed between cylinder and transparent plastic wrapper of new model Telefax transmitter. Recorder is at left

The unit consists of a mechanism, preamplifier, modulator, and control panel assembled into a single unit and complete in itself, requiring only a source of 115-volt 60-cycle a-c power, the line pair and a ground. The transmitter unit is 21 inches across the front, 15 inches deep and 8½ inches high; it weighs about 66 pounds. It requires about 135 watts of power during operation. The controls are on a ground return simplex basis similar to the Desk-

Fax arrangement with control battery provided at the receiving end of the circuit.

Where it is desired to operate the equipment over a carrier channel, an auxiliary carrier control unit is provided which when needed, are housed in the console supplied with the transmitter.

The transmitter can be arranged to operate with a continuous page-type of recorder as shown in the illustration, or it



Mechanism of experimental letter-size facsimile transmitter with transparent wrapper and hooks. Covered transmitter is shown on console in background

operates from the simplex controls of the transmitter. Where the transmitter and recorder with which it is to operate are not supplied by the same or interconnected power systems, an auxiliary synchronizing unit is provided. These auxiliary units, can be connected to operate into a concentrator for pick-up and distribution services in a manner similar to the Desk-Fax. A field trial of the former arrangement is now being conducted in Washington, D. C.—J. H. Hackenberg.

Mobile Emergency Power

I. T. BARTLETT, JR. and H. M. WARD

A RECENT news release stated that electric power usage in the United States has doubled since the end of World War II. The tremendous increase in productive capacity in this country has in no small degree been accomplished through increased use of electrical energy in all varieties of industrial and technical activities, including communications.

The power companies have energetically improved the reliability of their service through interconnection between systems, expansion of underground networks in large cities, duplication and isolation of primary feeders, automatic switching and a multitude of other safeguards. Nevertheless, the expansion of usage during and after the war has been so phenomenal that difficulty in procuring the necessary additional generating and distribution equipment has prevented full attainment of their goals. Power interruptions still occur, and the necessity for emergency power plants has increased in the telegraph office as well as in a myriad of other industries where power interruptions would result in loss of production, damage to plant equipment and products, or introduce hazards. For example, consider the confusion and danger that would result at any modern airport upon failure of the regular supply if emergency power were not immediately available for runway lighting, radio communications to and from planes, and directional beam equipment.

The extensive changes and improvements in telegraph equipment and operating methods which have taken place during these same years have had more than incidental effect on the requirements for emergency power plants. This subject is too broad to be covered here except in general terms, therefore detailed emphasis will be placed on the portable trailer-mounted emergency plants, shown in Figure 1, which have recently been provided as one phase of the program to meet these changing requirements. A brief review of major changes in Western Union power demands and operations which have affected the requirements for, and the design of emergency plants during the past 25 or 30 years is pertinent, however, in explanation of the need for and development of the trailer units.

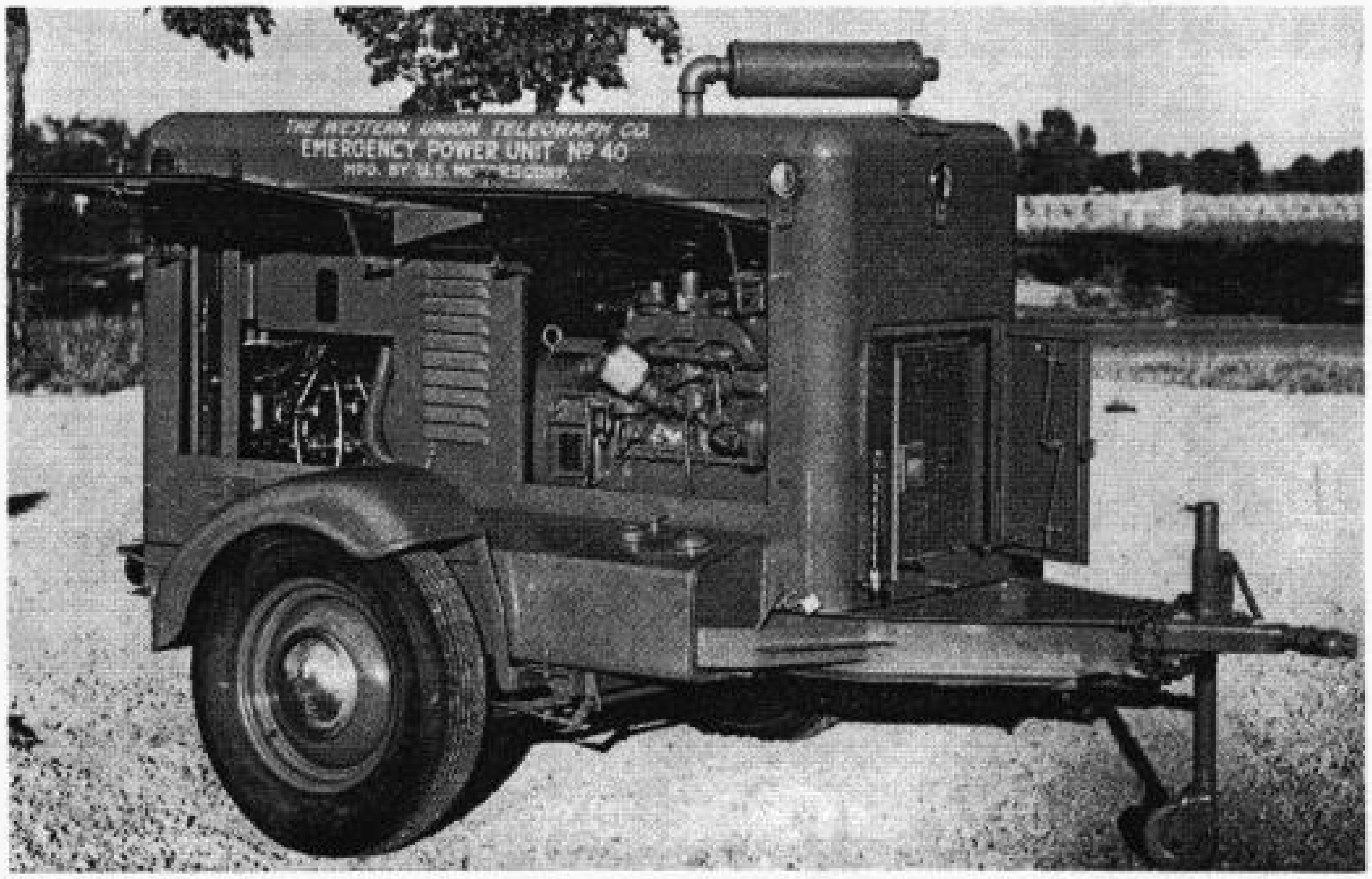


Figure 1. Modern trailer-mounted portable power unit

Increase in Power Demands

The recent concentration of operations in the various reperforator offices resulted in increases of from 300 to 400 percent in the a-c and d-c power loads at most of these centers. Operation of these offices during power failures is obviously of paramount importance. Permanent emergency plants, adequate to carry the full telegraph power load and approximately one-third of the normal operating area lighting, plus essential building loads, and with reasonable margin for growth, have been installed at each such office. Generally these new plants are Diesel engine driven, because of the decreased hazard in the storage and use of fuel oil as compared to gasoline. Availability of suitable Diesel engines, reasonably comparable in price to gasoline engines of equal power, is due largely to the development and quantity production, during the past 10 or 12 years, of high-speed Diesel engines for heavy trucking, industrial power, earth moving and tractor drives. Use of these engines during the war for landing craft propulsion and for generating plants further accelerated their development and reliability.

An indication of the increased power demands for telegraph operation is the fact that a total of 250 kilowatts of emergency power capacity was provided in most of the reperferator centers, consisting of one 100-kw d-c and two 75-kw a-c units. Capacity for growth was provided in the a-c portion of these modern plants to a larger extent than in the d-c, because of the pronounced trend towards more and more direct use of alternating current for operation of telegraph equipment, particularly for a-c synchronous motor drives. Except for offices such as New York, Chicago, Boston and Philadelphia, an emergency plant of larger than 50-kw capacity was rare indeed, before the reperforator switching era. In 1930, when the new Western Union building in New York City was completed, there was no alternating current whatsoever used for telegraph power there, although an a-c service connection was available in the building and was used for pneumatic tube blower and compressor operation, as well as for some building power loads. The primary purpose of the a-c service connection at that time was to drive a 300-kw motor generator set to provide an emergency d-c supply. Now plans are being formulated to install a 300-kw Diesel-driven a-c emergency plant there, indicating not only the extent to which the use of alternating current has increased, but also the increased demand for power of both types. The original 300-kw motor generator and 250-kw d-c steam turbine driven emergency plant will still be required and may even have to be replaced with a larger capacity Diesel-driven d-c plant in the not distant future, in order adequately to protect the office.

Emergency power facilities were formerly provided in central offices in practically all major cities, on the basis of the relative importance of the local traffic handled through those offices and the rela-

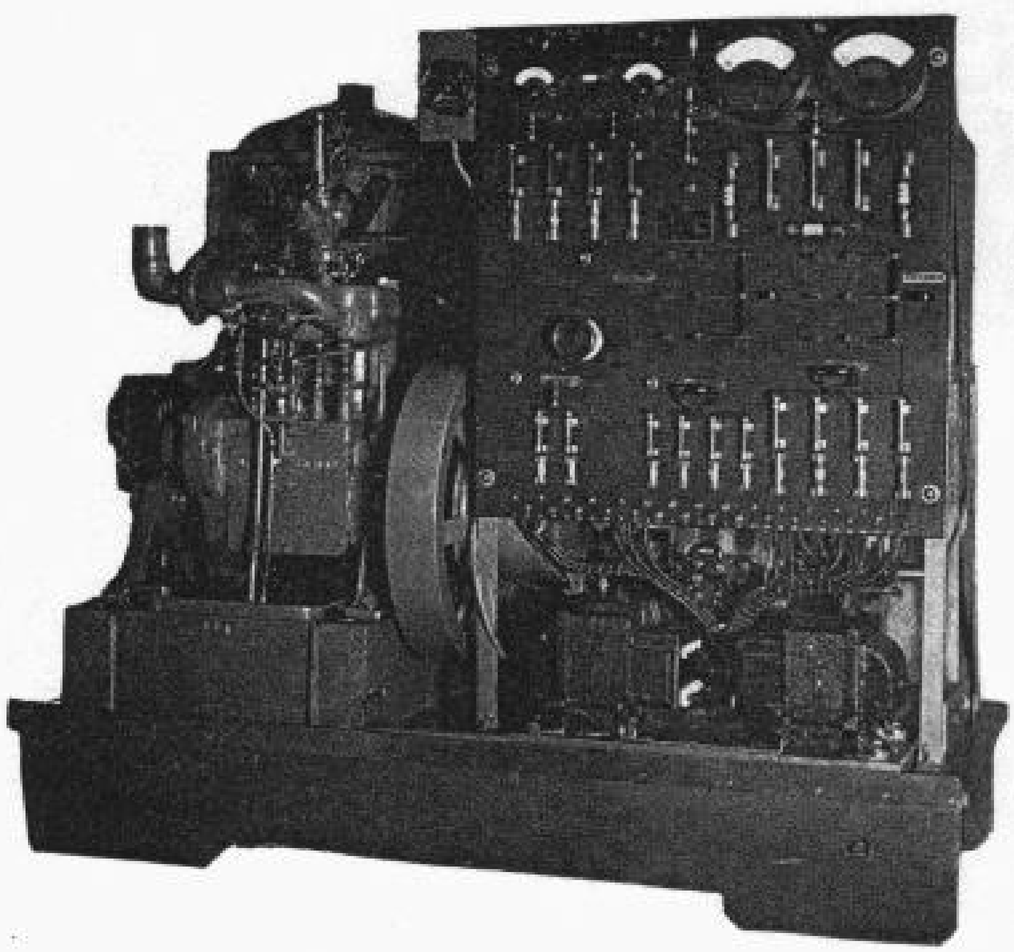


Figure 2. 5-kw ac-dc "portable" unit, 1920—Control panel side

tive reliability of the regular supply of power. Such offices were invariably major repeater points and these plants also afforded protection to through circuits. Practically all other earlier emergency installations were in offices whose major function was as a repeater point and where a capacity of 5 to 10 kilowatts was generally adequate.

Early Development and Use of Portable Emergency Units

Subsequent to the first World War "portable" emergency plants, shown in Figures 2 and 3, were constructed, primarily for use where fire, flood or other disaster had destroyed the regular motor-generator equipment. These consisted of a 5-kw double-wound generator, capable of delivering both a-c and d-c power, chain-driven from a 2-cylinder, 10-horsepower gasoline engine. Transformers to obtain various voltage and phase combinations and a control panel with necessary switches and meters were included. This equipment was mounted on a low wooden platform or "palette," which could be handled by hand-lift trucks for shipment in express or baggage cars. The capacity of these units was so small that their usefulness was limited. Later a larger unit utilizing a Ford V-8 engine driving a 25-kw d-c generator was purchased as the first step in developing a more generally useful portable plant for protection of moderate-sized offices not equipped with permanent engine units. This was mounted on steel skids, so that it could be loaded onto a truck or railway car for transportation, and after arrival could either be unloaded and moved into a suitable location or left on the truck for connection to and operation of the office load.

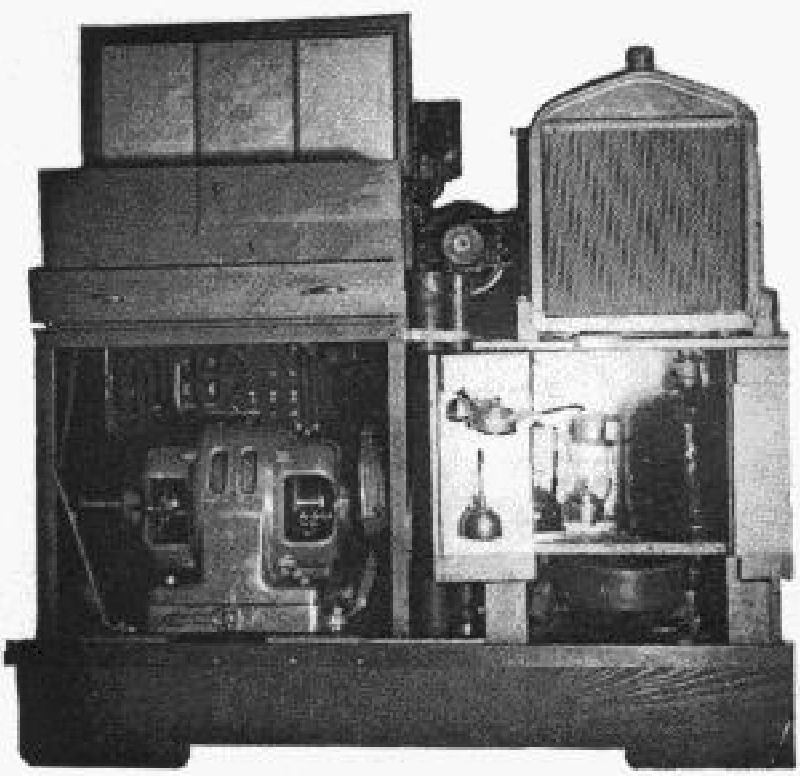


Figure 3. 1920 "portable" unit—Generator side

This original Ford d-c unit was put into service soon after delivery, during the disastrous flood of 1936. A similar a-c unit was purchased when the potential seriousness of this flood first became apparent, and was delivered by Western Union truck from Detroit to Pittsburgh within less than 24 hours of purchase, just barely before access to Pittsburgh from that direction became impossible. Although a permanent emergency plant consisting of two 40-kw gasoline engine units had been provided in Pittsburgh, these were completely flooded. Emergency engine installations on upper floors had previously been made in several cities, such as New Orleans and San Antonio, where flood danger was recognized, but previous high-water records at Pittsburgh did not serve as adequate warning of the record-breaking levels reached during that 1936 flood. It required four days to dry out the regular emergency equipment and restore it to service. During this four-day period the portable units provided the power for operation of the Pittsburgh office. The a-c portable unit was sent to Louisville, Ky., during the 1937 flood and provided all of the power for operation of that office for 26 days.

Based on experience with these two

Figure 4. 25-kw ac-dc portable unit—1938

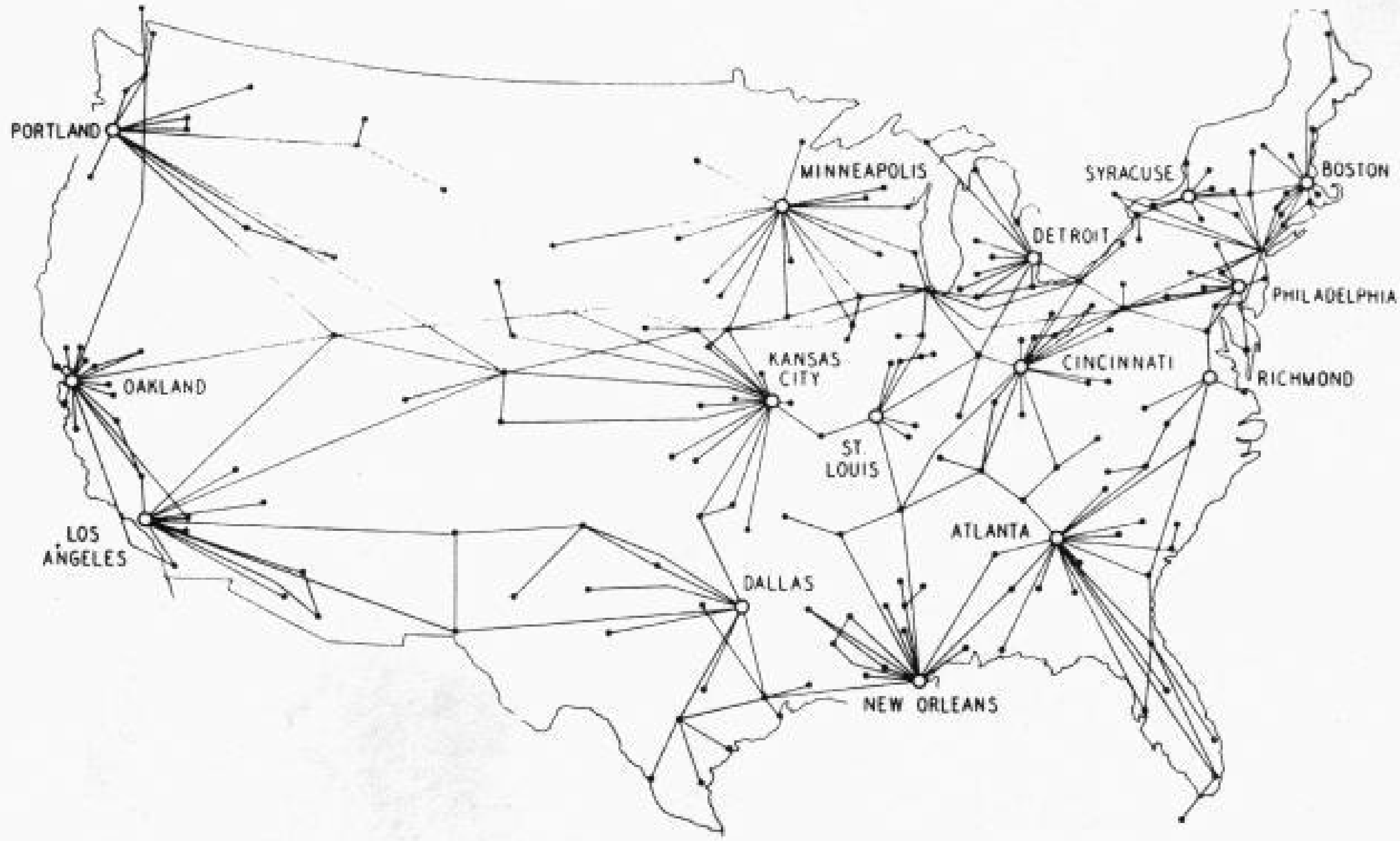


Figure 5. Tributary FM carrier circuits

Ford units, five additional portable plants, shown in Figure 4, similar except as to generator characteristics, were purchased and distributed to strategic locations throughout the country. Although direct use of alternating current for telegraph equipment was limited at that time primarily to printer motors, it was required for operation of motor generators, rectifiers and other essential equipment, wherever the regular supply was alternating current. Similarly, direct current was required not only for actual telegraph circuit operation in offices where the regular motor generators might have been put out of commission, but also for driving motor generators and other equipment wherever the regular supply was direct current. This meant that when a major disaster threatened or occurred, care had to be exercised to make sure that the unit shipped matched the regular power supply, and also to determine whether both units might be required at the same point.

Therefore special generators were developed, capable of generating 3-phase alternating current and 120-240 volt 3-wire direct current at the same time and in any desired ratio of the total 25-kw capacity, for use on these five Ford engine portable units. These generators were highly successful and constituted the almost perfect answer to the varied requirements of Western Union service. Manufacturing problems involved in production of generators of such special design have, however, prevented subsequent purchase of similar equipment at reasonable cost, particularly during and after World War II, when all manufacturing facilities have been at a premium, even for standard designs.

Effect of Carrier Program on Emergency Power Needs

The nationwide conversion to FM carrier circuit operation,[1] in lieu of open-wire pole lines along railroad routes, is perhaps the major factor which has stimulated development of the portable trailer-mounted emergency units. This phase of the "Improvement Program" has in large measure eliminated the old style repeater offices and along with them the need for many small permanent emergency plants. The leased carrier bands are protected from terminal to terminal by extensive emergency facilities. Where wire lines or radio relay systems are used for major carrier circuits, repeater and relay points are protected against even momentary failure by floating storage batteries and automatic transfer switching facilities. At the terminals, whether these be in reperforator offices or other major traffic centers, the carrier equipment receives protection from our own central office emergency plant. Two thirds of the total number of carrier channels originating in the reperforator and other major offices are, however, terminated at small "tributary" offices, from where they are further fanned out to provide circuit facilities to other cities and towns in that immediate area, for leases and so forth, by means of sub-band patches or individual channel extensions. Figure 5 is reproduced from the detailed description[1] of the FM Carrier Network to illustrate this.

Under the former scheme of operation, only a small percentage of the present tributary offices required emergency power, primarily for protection of the local traffic to that office. With all of the traffic to and from other nearby cities and towns now being served through the tributary offices, a power interruption at any of them is more serious than heretofore. However, of approximately 150 power failures during recent years, 65 percent were of less than 1-hour duration.

The Portable Trailer-Mounted Emergency Unit was designed to provide a more economical source of emergency protection during occasional prolonged failures. Many factors were considered and incorporated into basic specifications in order that the trailer units might be adapted as universally as possible to the wide range of Western Union requirements. Certain flexibility in detail design was allowed under the specifications so as to permit various manufacturers to follow their own standard practices in the interest of economy, wherever those would meet the basic essential requirements. Western Union has purchased a number of these units. The portable units purchased in 1920, shown in Figures 2 and 3, had less than half the capacity, cost one third more, and had far less mobility than the modern trailer plants.

Modern Mobile Units

The diversity of problems involved is best illustrated by the following detailed description of these new mobile units. Each unit consists of a 10-kw, 12.5-kva, 3-phase, 60-cycle alternator, direct-connected to a 26-horsepower, 1800-rpm, 4-cylinder, L-Head, radiator-cooled Hercules gasoline engine, mounted on a 2-wheel trailer with weatherproof housing, as shown in Figure 1. It may be attached to any medium-sized passenger car or light truck and hauled at high speed over our modern highway system to any office where emergency power may be needed.

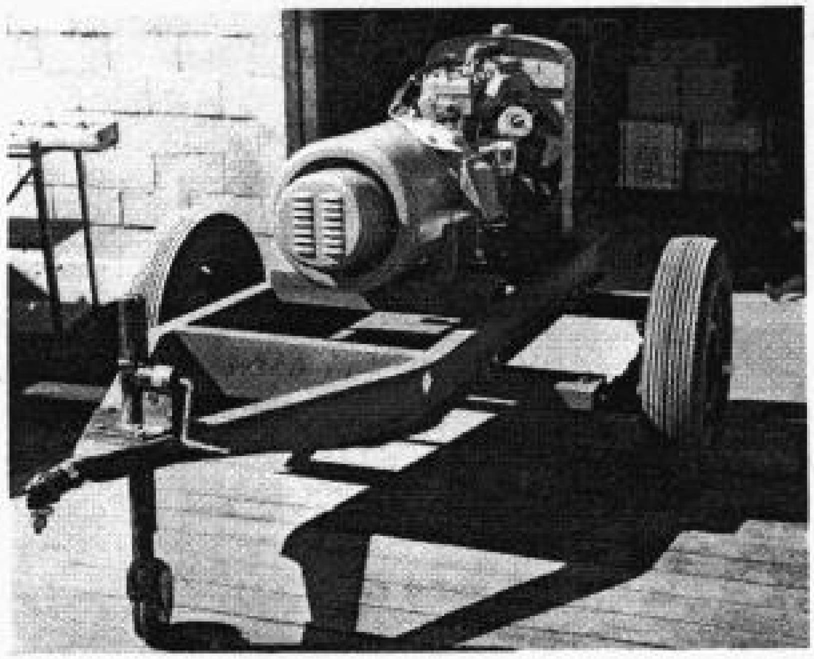


Figure 6. Trailer framework

Upon arrival, it may be parked in a convenient location adjacent to the office by utilizing the front "dolly" wheel, connected by portable cable to the office load and operated to restore communication facilities. The alternator, manufactured by Electric Machinery Manufacturing Co., is equipped with a separate direct-connected exciter and "Regulectric" voltage regulator, which maintains the output voltage constant within less than 3 percent of rated value. The engine speed is controlled by a positively-driven centrifugal governor which holds the speed and alternator frequency constant within 1 percent of rating at any constant load and within less than 3 percent through any load variation between no load and full load. The alternator windings are arranged so that they may be readily reconnected, as explained in later paragraphs, to match as to type or

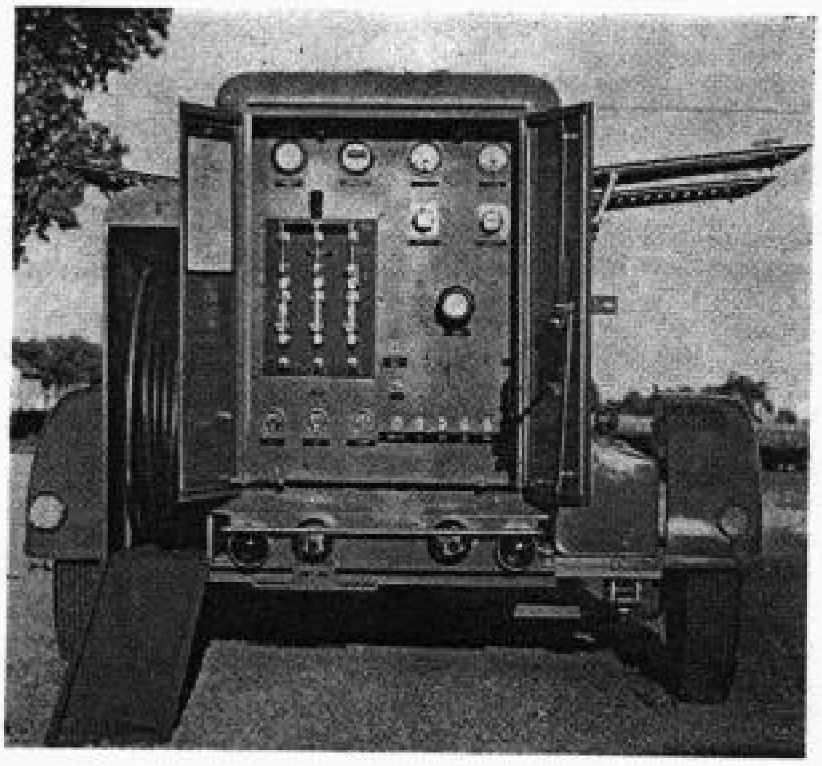


Figure 7. Control panel and cable reels

voltage any single or 3-phase 60-cycle regular power and light service used in our offices.

The engine alternator unit and radiator are mounted on a structural steel framework, shown in Figure 6, which also serves as a frame for the wheels, hitch, control panel and weatherproof housing. The housing has doors on both sides, front and rear, which give access to the power unit, but which may be locked to prevent unauthorized entry. The top of the housing can be completely removed if it becomes necessary to remove the engine for a complete overhaul. The entire bottom of the frame is covered with a steel splash pan to prevent any road dirt from entering the engine-alternator compartment. The trailer is equipped with 6.00 by 16 tires and a third wheel on a parking jack, to facilitate moving the trailer when detached from the towing vehicle. The axle has longitudinal springs to eliminate any swaying when the trailer is being towed.

On the right-hand side of the housing, shown in Figure 1, is mounted a 20-gallon capacity fuel tank with gauge, which provides sufficient fuel to operate the engine unit at full load for approximately 15 hours. On the other side of the housing a large tool box, which also holds the battery, is mounted forward of the wheels and a cable reel box, which opens at the rear, is mounted behind the tool box. One hundred feet of Number 6 gauge extra flexible, 4-conductor neoprene jacketed cable, one end of which is equipped with a 4-conductor plug, is rolled up on the cable reel as shown in Figure 7. This cable may be quickly removed from the reel and plugged into the weatherproof receptacle mounted at the rear of the unit as shown in Figure 8. The other end of the cable is provided with lugs which may be connected at some convenient suitable location in the office from where the power may be distributed through existing regular wiring.

At the rear of the unit, Figure 7, is a control panel on which are mounted engine instruments, elapsed time meter, generator rheostat, ammeter, voltmeter, frequency meter, meter switches, starting controls, trailer light switches and main generator switch. The generator switch is equipped with lugs where output leads may also be connected if desired. The control panel is mounted on vibration mountings so that road vibration will not be transmitted to and damage the meters. A switch is provided on the panel to give manual voltage control of the generator with the field rheostat if the automatic voltage regulator should fail. Lights operated from the trailer battery are mounted over the control panel and in the engine compartment, and a socket is provided on the control panel for a portable 6-volt trouble light. A set of tail and stop lights operated from the towing vehicle and a separate tail light system powered by the engine unit starting battery are provided.

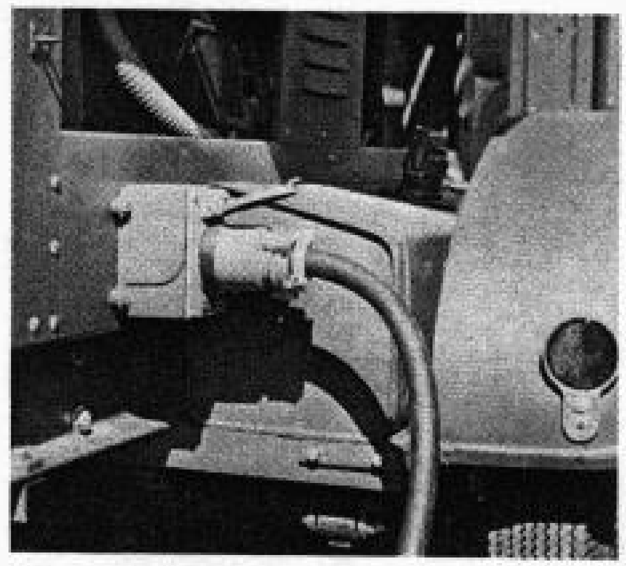


Figure 8. Output connector and receptacle

Before preparation of specifications for the trailer unit, a survey was made of motor vehicle laws in all states where the units were to be registered. Reflectors, tail lights, stop lights, trailer hitch, safety chains and brakes are such that they comply with all applicable vehicle laws. All trailers are equipped with a hand-operated parking brake in order to prevent any movement while the unit is in service or parked and not attached to the towing vehicle. Those trailers assigned to the few states where driver-operated brakes are required by local motor vehicle laws were also equipped with electric brakes. These brakes require a control unit which is normally mounted on the steering column of the towing vehicle.

The engine used for the power unit is similar to that used for the 10-kw auto-

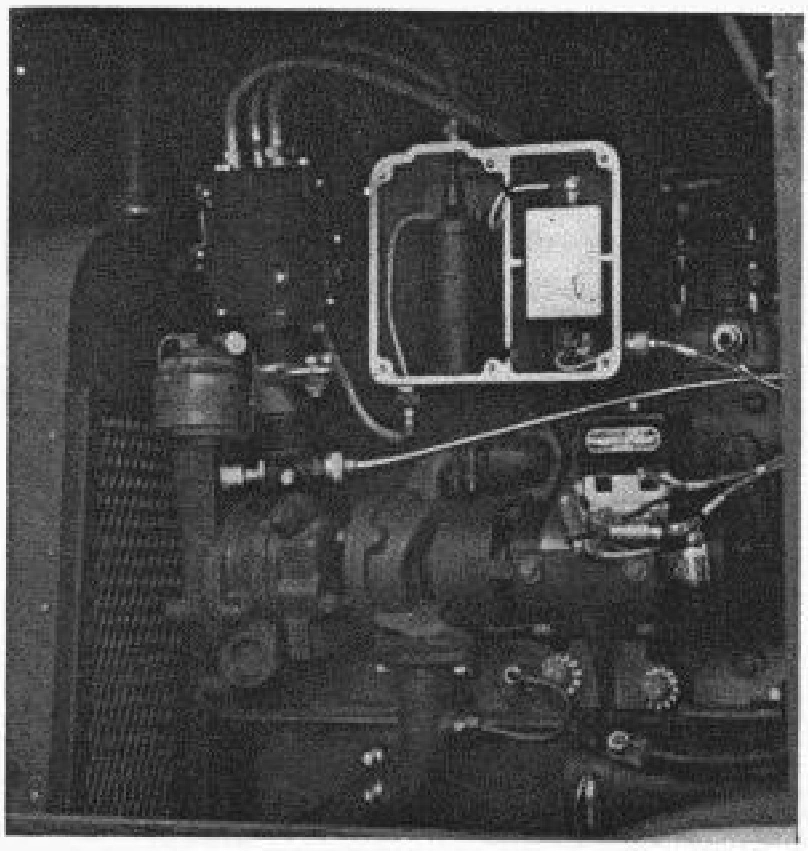


Figure 9. Engine, left side—Coil and filter box cover removed

matic emergency power units installed at radio relay towers[2] except that the magneto ignition is replaced with battery type ignition. The ignition system on the engine is completely radio shielded in conformity with Army Specifications 71-3004. Some features of the radio interference suppression system, shown in Figure 9, are: complete enclosure of the distributor, high-tension leads, coil and filter; aircraft type spark plugs, and bonding of all component parts to each other and to the frame with internal-external toothed lockwashers. All interference-radiating elements of the generator and engine electrical system are by-passed to ground with special Signal Corps type low series resistance—low series inductance capacitors. The alternator voltage regulator has no moving contacts, thus eliminating one major cause of radio interference.

The engine is protected against high cooling water temperature, low oil pressure and overspeed with an ignition grounding circuit which automatically shuts the engine down should any of these conditions develop.

The cooling water for the engine is easily drained from one point at the front of the housing and the crankcase oil drain is extended to the underside of the splash pan of the trailer to facilitate oil changes. Other special features on the engine include: manually-operable diaphragm type fuel pump, efficient air cleaner, filtered crankcase breather, automatic choke, carburetor throat drain, battery-charging generator with two-rate regulator and residential type exhaust muffler, as shown in Figures 9 and 10.

The power unit housing was designed to permit convenient access for all repairs except major engine overhauls. The generator brush and regulator covers as well as the engine oil pan and cylinder head may be removed without disassembling any part of the enclosure. The rear of the main instrument and control panel is

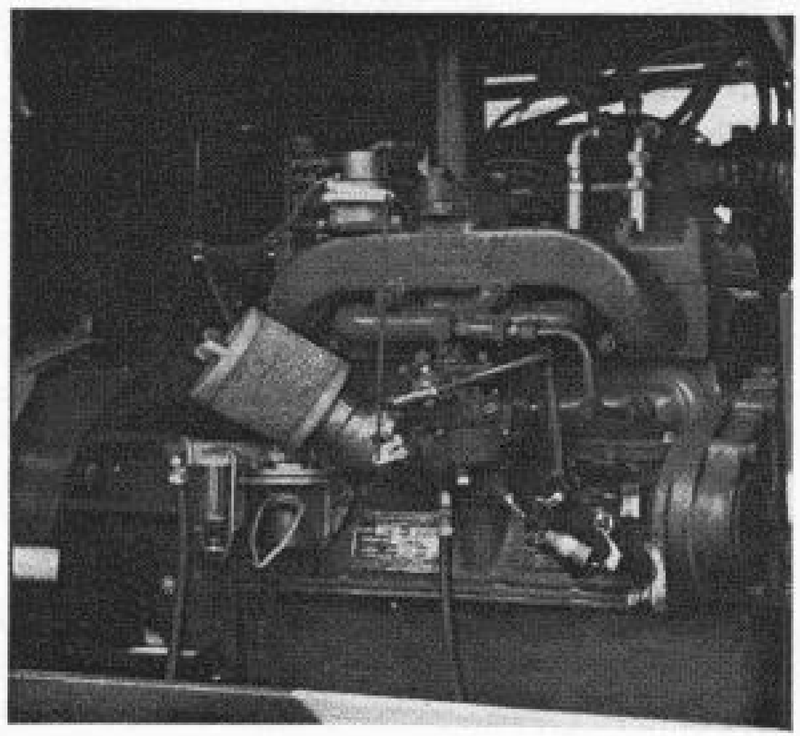


Figure 10. Engine—Carburetor side

easily accessible through one of the doors at the side of the housing.

The alternator is a 3-phase, 6-coil, 12-wire type with both ends of each stator coil terminated on a compact panel at one side of the unit. Thus, the alternator windings may be readily reconnected by use of the copper straps provided for either 120-volt, 3-phase delta; 240-volt, 3-phase delta; 120/208-volt, 3-phase, 4-wire wye; or 120/240-volt, single-phase, 3-wire output. With the coil connection diagram, Figure 11, mounted on the cover of the panel enclosure, an inexperienced operator can reconnect the alternator output in a matter of a few minutes to match properly the type of regular service at any particular telegraph office.

Operating Characteristics

The completed units were thoroughly tested at the manufacturer's plant to determine how they would operate under various conditions. The tests clearly indicated that the engine had more than ample power for operation at full rated load. Although the specifications require that the unit deliver full output up to an altitude of 3500 feet, the engine has sufficient spare horsepower to deliver full output at 6000 feet, and with a decrease of only about 2 percent at 7500 feet. The change in engine speed from no load to full load resulted in a drop in frequency of less than two cycles. The alternator voltage regulation was also considerably better than required by the specifications, which permitted a maximum change of 3 percent from no load to full load. The application of full load of 12.5 kva at 0.8 power factor resulted in a drop of only 4 volts from no load voltage of 212 volts, and a drop of approximately 5 volts with a unity power factor load. The voltage regulation even proved to be within the 3 percent variation allowed with loads of 125 percent of the unit rating. These excellent speed and voltage regulation characteristics observed during the factory tests will permit operation of the units for extended lengths of time without attendance, which otherwise would be required to adjust speed or voltage manually to compensate for load changes. Although the alternator is rated by the manufacturer at 40 degrees C. temperature rise, it was found during the tests that its design was so liberal as to permit operation at 125 percent of rated load for extended lengths of time with a temperature rise of slightly over half that figure. This feature will permit overloads on the alternator for reasonable periods of time without any detrimental effects on the insulation or windings.

The trailer was also tested for general roadability, these tests indicating that the unit would hold the road without any

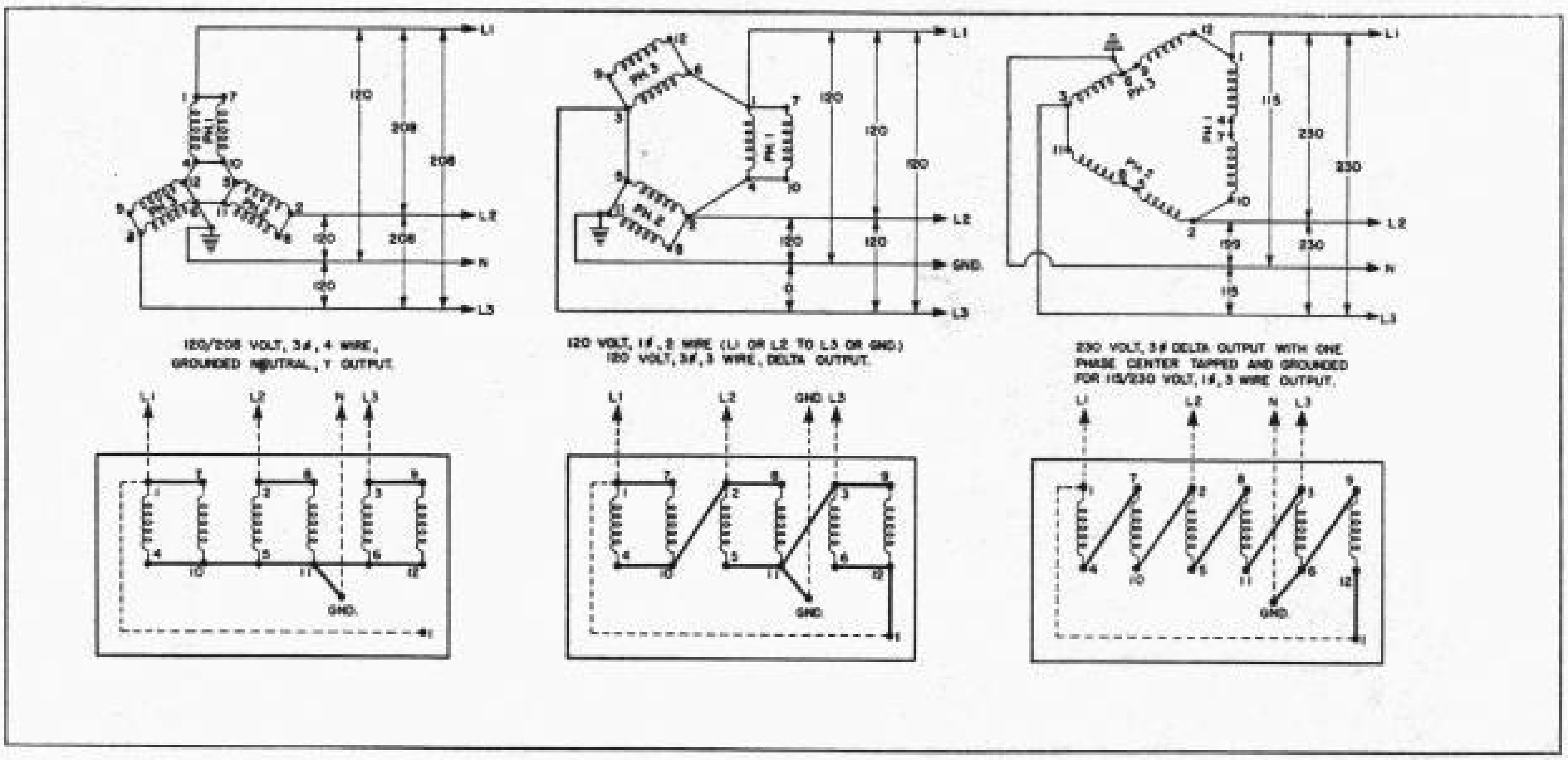


Figure 11. Theoretical alternator coil connections and arrangement of straps on terminal panel

noticeable bouncing which could be expected due to the absence of shock absorbers. Although the total weight was 2250 pounds, the unit could be pushed around on level hard surface roads by one man with comparative ease.

The weight of the trailer units requires, for the sake of safety, that a permanent trailer hitch be bolted to the frame of the towing vehicle. It is proposed to select a limited number of cars or light trucks in each area and equip them with a suitable hitch and necessary wiring connections, to insure that at least one will be promptly available for towing purposes in an emergency. Since the life of the trailer will far exceed that of the towing vehicles, a study is being made by the Maintenance Section to determine how many and which particular vehicles should be so equipped, in order to avoid unnecessary recurring expense.

Surveys are also being made in the areas to determine how best to equip the various tributary offices to facilitate prompt connection of the portable output cable from the power unit. This includes the necessity of definitely determining the particular type of regular service so that the alternator may be properly connected to match. The proper phase rotation at each office must likewise be determined, so that polyphase motors will run in the proper direction when supplied from the emergency unit. A multiplicity of other similar problems will be discovered when the mobile units are exposed to the acid test of actual service, but it is expected that they will meet this test adequately, and further improve the reliability of Western Union service.

References

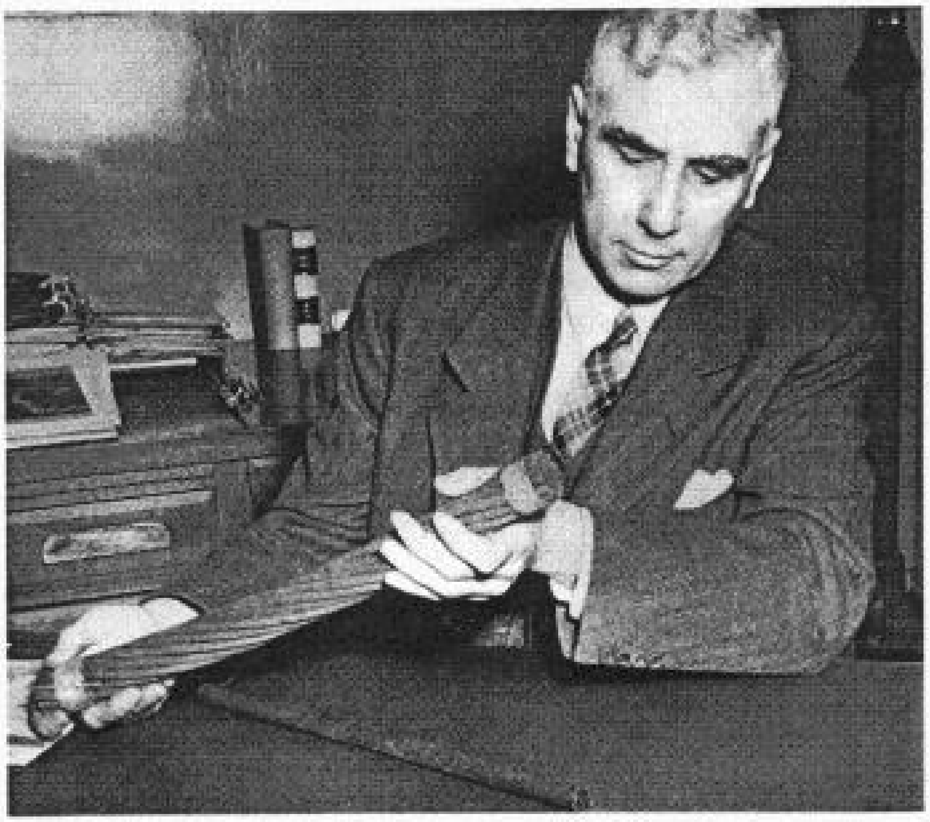
1. A Nation-Wide FM Telegraph Network, F. B. BRAMHALL and L. A. SMITH, *Western Union Technical Review*, Vol. 5, No. 2, April 1951.
2. Power Supplies for Microwave Relay Systems, H. M. WARD, *Western Union Technical Review*, Vol. 3, No. 4, October 1949.

I. T. Bartlett, Jr., was graduated from the University of Rochester in 1945 with a B.S. in Mechanical Engineering. After serving in the U. S. Navy, he joined the Central Office Engineer's division of Western Union in 1946. He has engaged in the design of power and emergency engine plant installations for several of the new reperforator offices, and was responsible for a major portion of the Minneapolis power and the Chicago emergency Diesel power installations. He is now engaged in power engineering on the staff of the Director of Installation.

H. M. Ward joined the staff of the Central Office Engineer after graduating from Ohio State University in July 1921. He engaged in power engineering and the development of special power equipment for central offices, and designed most of the telegraph power plant at 60 Hudson Street. He was associated with the development of rectifiers for telegraph power supply, and was responsible for the design of rectifier installations at the Hammel and North Sydney cable stations. More recently, in addition to designing radio beam power plants, Mr. Ward has directed the development of power installations for reperforator switching centers. He is a licensed professional engineer, a member of Eta Kappa Nu, honorary electrical engineering fraternity, and Sigma Xi. He is now Assistant Building Installation Engineer, on the staff of the Director of Installation, in charge of the engineering and installation of power equipment.

Telegraph History

IN THE course of work on renewal of shore sections of Western Union's cables which land at Valentia, Eire, during June, 1952, the cable ship *Edouard Suenson* while grappling in a depth of 26 fathoms recovered a short length of well-preserved old cable. With the aid of Submarine Cables, Ltd., this cable was identified by Western Union's London Office as a shore end of the ill-fated first Atlantic cable laid in 1857.



Shore end and core of 1857 Atlantic cable recovered off Valentia, Eire, are examined by General Plant Engineer C. S. Lawton of Western Union International Communications Department

As in the deep-sea section, the center of the core consists of a strand of seven No. 22 copper wires, the equivalent of No. 14 gage, insulated with gutta-percha to a diameter of ⅜ inch. Additional gutta-percha mixed with wood dust was added, however, to provide a ¾-inch diameter core for the shore-end cable. The sheathing armor consists of 12 No. 0 gage iron wires or, possibly, rolled iron rods. The interesting fact that these sheathing wires have a right-hand lay is good evidence that this cable was made by Messrs. R. S. Newall & Co., at Birkenhead near Liverpool, one of the two firms which manufactured the 1857 cable. It seems that Messrs. Newall, in using a right-hand lay, followed existing practice for rope and telegraph cable but Messrs. Glass and Elliot, the other cable contractors, laid up the sheathing the opposite way to avoid stresses which might be met in coiling finished cable into the tanks of the ships. This difference was not discovered for some time.

Between core and sheathing were layers of hemp saturated with a mixture of tar (from Norway), pitch, linseed oil and wax. The cable core, a piece of which is on the table in the picture above, was made by the Gutta-percha Company of London, a firm which joined with Glass, Elliot and Company in 1864 to form Telegraph Construction and Maintenance Company.

Although the U. S. steam frigate *Niagara*, pride of the U. S. Navy and largest steam frigate in the world, and H. M. battleship *Agamemnon*, famous as Britain's flagship at the bombardment of Sebastopol, were the ocean-going cable carriers for the 1857 expedition, two smaller vessels were used to lay the shore end in Valentia Harbor. A small steamer, the *Willing Mind*, aided by H. M. tender *Advice* and several launches placed the shore section between Ballycarberry, a little cove near the town of Cahersiveen about 1½ miles east of Knightstown, Valentia Island, and a buoy near the harbor mouth on August 5, 1857. The next morning the *Niagara* spliced on at the buoy and steamed westward toward America.

On August 11, the ocean cable broke under strain in rough seas and sank in 2050 fathoms, 274 nautical miles from shore. Because so much cable had been lost the project was then abandoned. Further lengths of deep-sea cable were manufactured, however, and a new, and this time successful, expedition completed the first Atlantic cable in 1858. This time two laying vessels commenced in mid-ocean, H. M. S. *Agamemnon* laying the eastward portion and again splicing on to the Ballycarberry shore end laid in 1857 — and recovered in part by C. S. *Edouard Suenson* in 1952.

The 1858 cable, completed on August 5 of that year, carried messages intermittently in a period of great celebration from August 10 until October 20 when permanent failure occurred. The reason never was precisely ascertained. It had been demonstrated, however, that it was possible to lay a cable across the Atlantic and to send and receive telegraph signals through its span of over 2000 miles.

Inspection of Telegraph Material

B. POMERANTZ

AN EFFICIENT organization capable of inspecting a great variety of products is an essential part of any large industrial establishment. The importance of material inspection in the Western Union system can be appreciated when it is realized that the Company's expenditures for new apparatus since World War II have exceeded $100,000,000 in value.

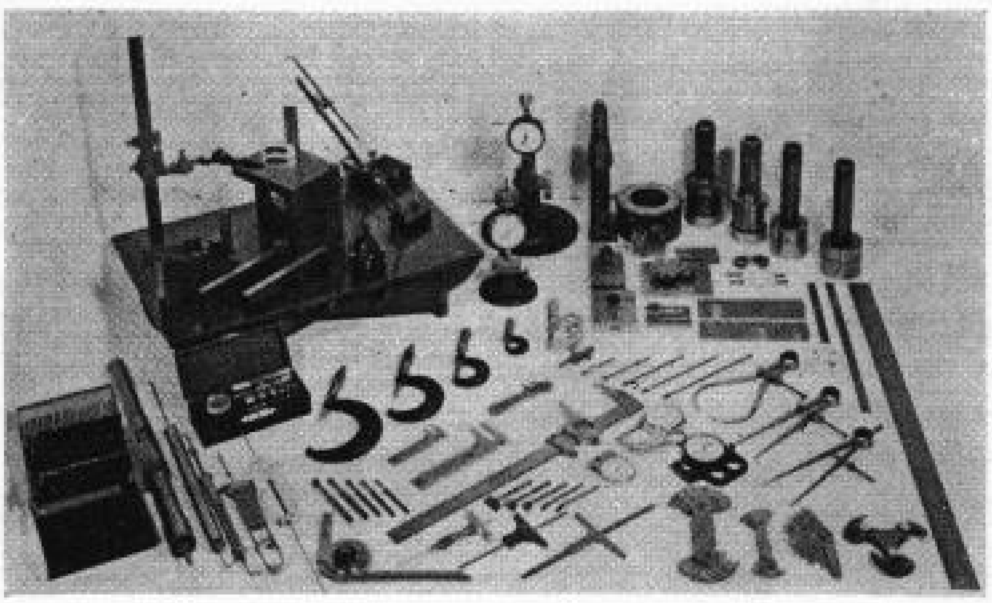
Primarily, the purpose of inspection is to insure that all material furnished to the Company under contract or purchase order terms complies with the requirements of specifications, and arrives at its destination in the same physical state as when accepted. In a nonmanufacturing corporation such as Western Union, the main concern is "procurement" or "vendor inspection". The Material Inspections Division has been developed to provide an efficient organization capable of inspecting an extreme variety of products ranging from heavily armored ocean cables to magnet wire, from insulator pins to radio beam towers, and including carrier bays, teleprinters, facsimile machines, solder and soap. These items which are purchased from about 200 vendors, must all satisfy rigid requirements of the telegraph system.

Because of the geographic dispersion of Western Union suppliers, it has been expedient to establish two main inspection areas, at New York City and Chicago, to simplify the inspection task. A third inspection area, limited chiefly to timber products, is centered about Shreveport, Louisiana, which area is the principal source of line poles and crossarms for the Company. These three areas are all under the supervision of the Material Inspections Engineer whose headquarters is in the main office of the Company in New York City.

The inspection function begins with receipt of a copy of an order or contract from the Purchasing and Stores Department. Depending upon the conditions of the order and the classification of equipment, a decision is made as to whether inspection may be waived, or is required either at destination or at the source of manufacture.

If inspection is to be waived, the supplier will be instructed to ship the subject material without inspection. Such action is generally taken on small items such as name plates, screws, nuts, and so forth, on commercial items and inexpensive parts of simple design intended for noncritical usage, which are supplied at locations that are not readily accessible. Inspection may sometimes be waived on wire orders, in which cases the reliability of the supplier must be well established and he must accept liability for the quality of the material delivered.

If inspection is to be performed at destination, the supplier is so advised. Such inspection will usually be performed at convenient destination points, generally the Jersey City and Chicago Warehouses as they are easily accessible to our inspectors.



Measuring tools of inspection

Orders for material that is to be source inspected are distributed between the New York City and Chicago offices

Checking a geneva wheel with a toolmaker's microscope

depending upon the location of the supplier. Such material can be divided into three classifications, as follows, depending upon the complexity of the purchased item, the quantity of material involved, and the total value of the equipment.

1. Spare parts and nonfunctioning equipment which are inspected for applicable features such as dimensions, mechanical, chemical and electrical requirements, assembly, workmanship, marking, quantity, and packing.
2. Complex assemblies and simple functioning equipment such as rectifiers, relays, motors, and electronic timers, which are subjected to inspection for applicable features of the foregoing list, and which in addition may be required to pass a performance or operating test.
3. Complex functioning equipment of Western Union design, such as numbering machines, printers, reperforators, carrier and telefax equipment, which are subjected to the same inspection as the previous items, and in addition must pass a performance or operating test. Normally, items in this category require the services of a resident inspector at the supplier's plant to inspect piece parts and subassemblies during the manufacturing period.

Specification requirements demand that equipment be inspected thoroughly prior to acceptance. This involves one or more of the following categories of inspection:

(a) Visual inspection for finish and workmanship.

(b) Dimensional inspection.

(c) Electrical tests for resistance, inductance, capacitance, insulation resistance, and continuity.

(d) Chemical tests

(e) Physical tests

(f) Operating and performance tests

(a) Visual inspection is perhaps the most difficult to carry out with uniformity as it necessarily is dependent upon the personal judgment of the inspector. Opinions of different inspectors, as well as those of the vendors, may vary considerably because of varying experiences. Interpretations of surface roughness requirements, in particular, are very difficult unless some comparison standard is used to permit classification of the varying degrees of roughness normally encountered in machine work. Such a

Rockwell hardness testers

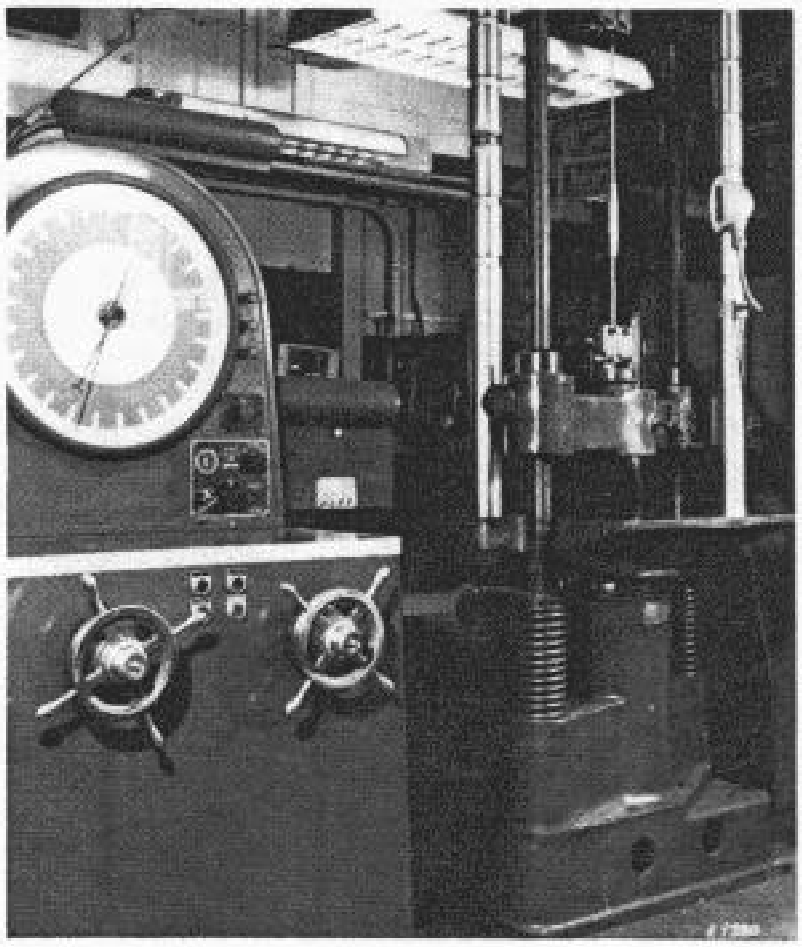
standard is the General Electric Standard Roughness Scale which provides actual samples of ten degrees of surface roughness varying from 4 to 2000 microinches average. These values of roughness represent the average deviation from a center line on a profile contour of the surface. Comparison of a finished surface with the samples will allow an inspector to judge properly the roughness classification of the unknown surface, thus permitting positive acceptance or rejection. In a very similar fashion, sample chips taken from the Federal Color Specifications are now used to standardize Western Union sign colors.

(b) Measurements of dimensions can be made as accurately as desired if proper tools and instruments are provided, and the time for performing the task is available; however, inspection measurements are normally desired quickly and to a limited degree of accuracy. The basic measuring tools for such work include the steel scale, the micrometer, the vernier caliper, the thickness gage, the vernier height gage, the dial indicator and the surface plate. All of these instruments are measurers of variables which inform the operator of the exact measured dimension.

There is another classification of inspection measurement wherein fixed limit gages are employed. One class of fixed limit gages is the familiar "Go-Not Go" type which indicates whether the part being measured is acceptable, or undersize, or oversize. Such gages measure attributes and are normally single purpose tools commonly used on large production runs for checking one dimension only. The fixture gage is another of this type and is designed to check a number of critical dimensions simultaneously while the part is within the nest provided for it. If any dimension is out of limits, the part will not fit and will be rejected.

To measure small parts of any shape, a toolmaker's microscope may be used. This instrument is essentially a microscope with a special measuring stage for reading coordinate dimensions directly with the aid of micrometer screws calibrated to read in ten-thousandths of an inch, and angular dimensions directly through use of a 360-degree rotary stage calibrated to read in minutes of arc. It is an exceptionally versatile tool and enables measurements to be made within a fraction of the time required with surface plate inspection methods.

It is extremely important in any inspection work that standards of measurement be available to check the tools of inspection, since no instrument will remain accurate with routine use. Normal wear, without any abuse at all, will necessitate that corrections be made to micrometers and vernier calipers. The basic linear standards in inspection work are gage blocks which are accurately finished blocks of hardened steel having absolutely flat and parallel gaging surfaces within an accuracy to 0.000004 inch per inch of length. The correct use of such blocks obviates the possibility of any disagreement ever occurring with regard to ordinary linear measurements. They are the basis of our mass production system requiring interchangeability of parts, as they are a never-varying standard available to every manufacturer.



Testing the holding strength of a 5/16-inch strand cable grip on a universal testing machine

(c) The basic measuring instruments used for electrical testing are voltmeters, ammeters, wattmeters, Wheatstone bridge, impedance bridges and decibel meters. These instruments measure circuit conditions and electrical values of components. To provide the necessary power for measuring purposes, standard power supplies such as rectifiers and oscillators must be available.

For elaborate and complicated operating tests, the cooperation of the Engineering Laboratories and personnel is often required. This is true, for instance, in connection with Klystron tubes for the radio beam system which can be tested, at the present time, only in the Radio Beam Laboratory. It applies also to high voltage electrical tests on equipment, such as lightning arresters, which are conducted in a special laboratory for high voltage studies. If required, these facilities are all available for inspection purposes.

(d) and (e) Inspection for chemical and physical properties is performed on representative samples of the materials, as it is generally not practical to test the entire lot. Such tests are intended to guard against process failures and are very satisfactory as such. Chemical analysis tests for items such as solder, soap, and creosote are performed in the Chemical Laboratory of the company. Physical tests for hardness or strength of materials are performed in the Metallurgical Laboratories where Rockwell hardness machines, a durometer instrument, a universal testing machine, and a fatigue strength testing machine are available. Microscopes are used to examine and, in conjunction with a camera, to photograph etched and polished specimens to observe the structure of materials, and in some instances the depth of case in special hardness treatments.

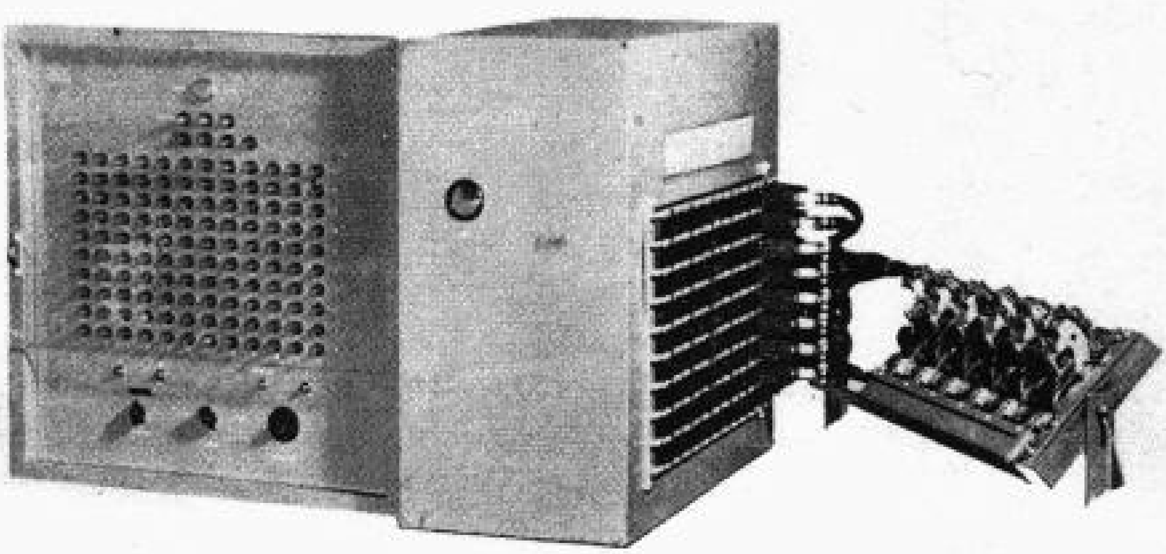
Rockwell hardness machines are used to test the hardness of metals and similarly hard materials. The hardness number of a specimen under test appears upon the scale of the instrument, and indicates the resistance of the material to penetration by a steel ball or diamond point of specific size and shape and under a calibrated load.

The durometer is another type of hardness testing machine used on relatively soft materials such as felts, rubbers and certain plastics. Its reading is also based on resistance to penetration properties of the material being tested.

The universal testing machine may be used to measure the tensile strength of wire, rod or cast metal specimens or the compressive strength of concrete blocks or columns. With this information and the physical dimensions of the samples known before and after the test, the elongation and Young's Modulus of Elasticity can be computed.

For testing paper[1], which is an item of prime importance to the operation of the telegraph system, a special humidity controlled room is available and is equipped with special instruments for measuring the tearing, bursting and stiffness characteristics of the material.

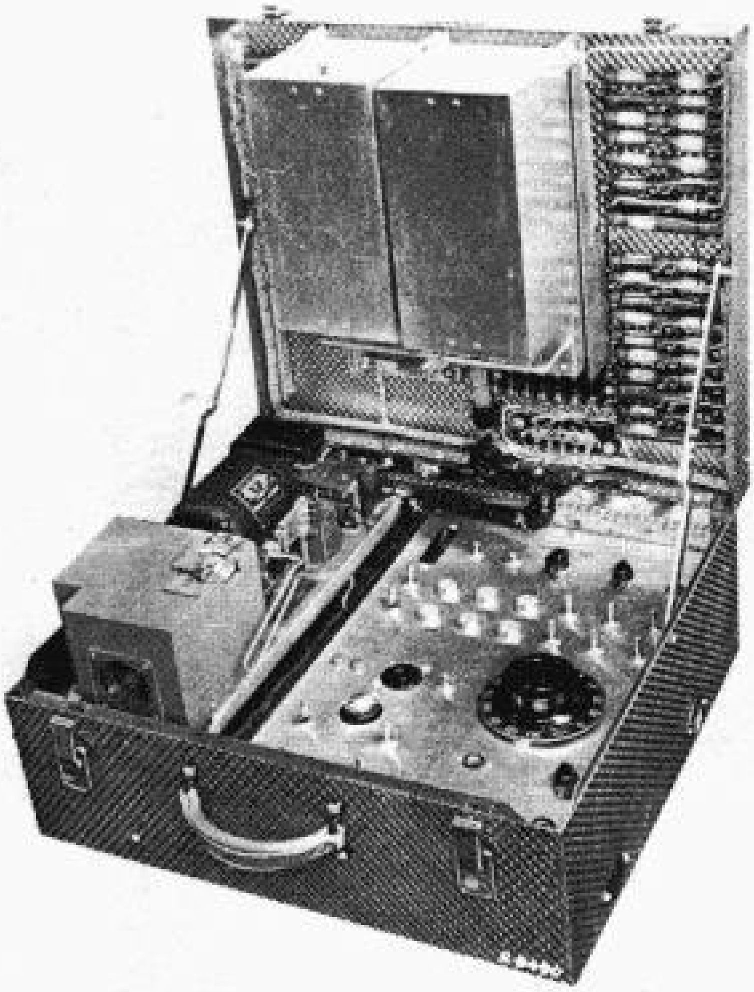
(f) No matter what inspection may be performed on operative equipment in its static state, an operating test is required before acceptance. Items such as tape transmitters, numbering machines, printers and Desk-Fax, require special telegraph circuits and equipment for their operation. It is therefore necessary



Test Set 5124-A and rotary switch shelf

B. Pomerantz attended Cooper Union School of Engineering and graduated from Cornell University in 1945 with a degree of B.S. in Mechanical Engineering. After service in the U. S. Navy, in 1946 he entered the Material Inspections Engineer's office, Plant and Engineering Department, where he has since been concerned with material inspection and associated engineering problems. M. Pomerantz is a member of the ASME and the American Society for Quality Control.

that convenient test circuits be designed as semi-portable test table units that will duplicate as closely as possible the actual service conditions the equipment is expected to meet. By operating the unit for a specified length of time, its acceptability can be determined. One such test set is the "Portable Test Set 6030-B"[2], which was designed to perform operating tests on Distributor-Transmitters Types 5031 and 5032 and associated equipment. Another test set, "Rotary Switch Shelf Test Set 5124-A"[3], was designed to trouble shoot and test automatically the operation



Portable Test Set 6030-B and Distributor-Transmitter 5032-A

and wiring of the many rotary switch shelves that are used in all of the reperforator switching centers. Items such as carrier equipment, motors and rectifiers, do not need to meet a time function requirement but must meet certain performance tests which can be determined with electrical measuring instruments and standard test procedures.

Theoretically, an inspector's function is simply to determine if a given product meets the requirements of our specifications. If it does, he applies his approval stamp and goes away. Unfortunately, few inspections of anything but very simple and standard products turn out to be so easy. As errors may be made by even the best workmen, and specifications may not be perfect, a difference in interpretation can result between the producer and the inspector. Conferences must then follow to determine whether the error has made the apparatus entirely unusable, whether it can be corrected, or whether some changes can be made in the specifications that will permit a suitable correction. Operating tests on new equipment may even uncover certain weaknesses in design that will involve changes in material or construction. The Material Inspections Engineer must take a prominent part in all such adjustments, for his paramount duty is to see that the quality of material purchased by Western Union shall be up to the standard required by its specifications.

This description of the operation of the Material Inspections Division refers only to its primary function, that of sorting material to separate good from bad. The

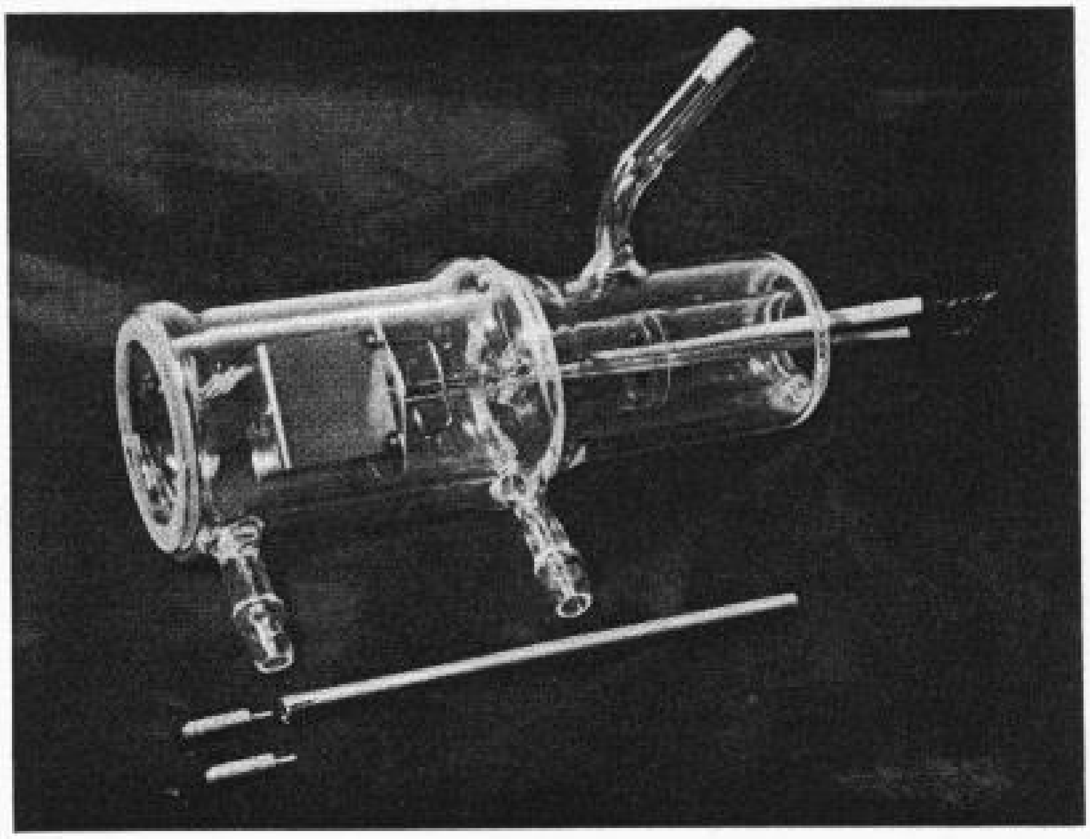
Division is in addition interested in preventing unsatisfactory material from being manufactured and it therefore steps out of the very narrow confines of an Inspection Group and attempts to assume the functions of a Quality Control Organization. This is a "cradle to the grave" concept for product manufacture, guarding the quality of the product from its initial conception, through its evolutionary period of manufacture, and to its final emergence as a finished product.

References

1. Paper Research Aids the Telegraph, W. N. ENGLER, *The Western Union Technical Review*, Vol. 4, No. 3, July 1950.
2. Apparatus for the Modern Reperforator Office, W. H. FISHER, *The Western Union Technical Review*, Vol. 3, No. 4, October 1949.
3. A Test Set for Rotary Switch Shelves, W. H. KLIPPEL, *The Western Union Technical Review*, Vol. 3, No. 3, July 1949.

CONCENTRATED-ARC LAMP FOR INFRARED SPECTROSCOPY

This rather complicated device is a special Western Union zirconium arc lamp recently constructed in the vacuum tube and glass working section of the Electronics Research Division's Water Mill laboratory, for the University of California, as an infrared source for infrared spectroscopy.



In this lamp the zirconium electrode is mounted within a water-cooled jacket which has a flat open end to which the user cements the particular infrared-transmitting window required for his work. Rock salt or thallium bromide-iodide windows are frequently employed. Before use, the lamp must be evacuated and then filled with argon.

Infrared spectroscopy is a recently-developed method for the qualitative and quantitative analysis of organic chemicals. Its underlying basis is the fact that practically all organic substances possess selective absorption at certain frequencies in the infrared portion of the electromagnetic spectrum. A plot of these absorption values versus frequency constitutes the infrared spectrum of the compound. This spectrum is a unique fingerprint which cannot be duplicated by any other compound. By this method analyses are easily made which would be impossible by any other technique. Research laboratories throughout the country are reporting thousands of hours of highly satisfactory service from Western Union zirconium lamps in infrared spectroscopy equipment. —W. D. Buckingham

Patents Recently Issued to Western Union

As a new feature of the REVIEW it is planned to publish brief abstracts of significant patents recently issued to Western Union. Readers should remember that since it is not usually feasible to file patent applications promptly following conception of the invention, and further a period of a few years usually elapses between the filing of an application and the issue of the patent, appearance of the patent may lag conception of the invention by a number of years. If desired, copies of patents may be obtained from the Commissioner of Patents, Washington, D. C., for 25 cents each.

Two-Way Facsimile Communication System
G. H. RIDINGS, F. G. HALLDEN, F. L. CURRIE
2,606,963—AUGUST 12, 1952

A facsimile patrons' concentrator which conditions the patrons' machine to operate automatically as a receiver when called by the central office, and as a transmitter when calling the central office. Various signal lights indicate at each point the operative condition of the distant station.

Stylus Assembly for Facsimile Recorders
G. H. RIDINGS, J. H. HACKENBERG
2,607,654—AUGUST 19, 1952

To avoid damage to the stylus as a result of rotation of the drum in the wrong direction, the stylus arm is pivotally suspended so as to swing backward into a safe position upon reversal of the drum direction. Other features relate to a protective casing for the stylus and means for ungrounding it when in the non-recording position.

Testing Arrangement for Automatic Telegraph Switching System
W. B. BLANTON, A. H. SCHEINMAN
2,611,026—SEPTEMBER 16, 1952

Automatic "Bust This" unit. A system for automatically checking the identifying characters of messages received at an automatic reperforator sending position after cross-office transmission. Upon failure of the message identifying characters in the tape to compare correctly with predetermined identifying signals, test signals are automatically transmitted to the sending position as a test of the cross-office circuit and equipment where they are stored in the sending tape, then transmitted to the distant office. Upon favorable checking of the test signals the sending position is released.

Magnetically Influenced Arc Device
W. D. BUCKINGHAM
2,608,675—AUGUST 26, 1952

To maintain a desirable shape and condition of the arc stream between two concentrated-arc electrodes mounted at an angle to each other, electromagnets are mounted alongside the arc and their windings are so connected to the arc circuit that the magnetic effects of the two windings are proportional respectively to the arc current and the arc voltage. A permanent magnet is also included to produce a field transverse to the direction of the arc stream.

Wheatstone Bridge Having Stylus Shunting One Arm
F. T. TURNER
2,607,844—AUGUST 19, 1952

The stylus circuit of a facsimile transmitter shunts one arm of a bridge network which acts as a keying circuit. As adjusted, the bridge is balanced whenever the stylus contacts an unmarked (non-conducting) area of the message sheet. When the stylus makes contact with a marked (conducting) area, the change in resistance unbalances the bridge to produce an output signal.

Submarine Cable Over-Current Protective Device
P. H. WELLS, C. H. CRAMER
2,611,032—SEPTEMBER 16, 1952

A submarine cable over-current protective system which, in response to an excessive current flow in the cable, cuts off power to the cable, introduces protective impedance elements in series with the cable and operates an alarm. Restoration is manual.

Two-Way Facsimile Communication System Between Two Facsimile Transceivers
G. H. RIDINGS
2,616,963—NOVEMBER 4, 1952

The starting switch of one transceiver of a two-way facsimile communication system automatically conditions the transceiver for transmitting, conditions the transceiver at the other station for recording, and signals the attendant at the latter station to wrap the drum and close the starting switch to permit initiation of transmission from the first station. The units operate automatically and shut down at the end of transmission.

Telecommunications Literature

STORAGE TUBES AND THEIR BASIC PRINCIPLES—M. KNOLL and B. KAGAN—John Wiley & Sons, Inc., N. Y., 1952. 143 pp., $3.00. Electronic storage for television, computers, and signal-converter applications depends upon establishing and removing electrical charges on an insulating surface. Discussion starts with the establishment of positive and negative equilibrium potentials, or charge pattern, on an electron-bombarded target by controlling secondary-emission and bombardment-conductivity currents. Definitions primarily applicable to charge-controlled storage tubes are followed by writing and reading methods, before taking up storage tubes under the following four classifications according to application: Signal-converter, Viewing, Computer, and Television-Camera. They are discussed under various types depending upon the method of modulation, or application of the input signal, including: primary-current-modulation, cathode-modulation, collector-modulation, backplate-modulation, and light-intensity-modulation types, which differentiates the tubes on the basis of their circuit operation. They are further classified according to basic writing and reading mechanisms which take place within the tubes. While a broad subject is given concise treatment, it is well organized and carefully written. Should the reader desire to delve further he is referred to a five-section bibliography listing a total of 90 references with brief synopses of many of them.—A. E. FROST, Ass't Equipment Research Engineer.

THE BUILDER: A BIOGRAPHY OF EZRA CORNELL—PHILIP DORF—The Macmillan Co., N. Y., 1952. 459 pp., $5.00. An inspiring story has been written about the life of the man who helped Morse build his first telegraph lines. It was Ezra Cornell's subsequent investment in the rapidly growing telegraph industry and his astute Yankee management of that investment that brought him a fortune adequate for his generous donation toward establishment of an agricultural college that became Cornell University. Cornell was an ingenious mechanic. At one time, says the author, he proposed to substitute a relay of his own design for one Professor Morse had made, much to the annoyance of Morse and his associate, Alfred Vail. Although Cornell's relay worked, Vail angrily opposed using it in the Philadelphia telegraph office.—GROSVENOR HOTCHKISS, Coordinating Engineer.

ESSENTIALS OF MICROWAVES—ROBERT B. MUCHMORE—John Wiley & Sons, Inc., N. Y., 1952. 236 pp., $4.50. This book presents the physical principles that underlie the operation of all microwave devices. It is written for those desiring a sound, workable explanation of microwave phenomena. The reader seeking a general review of microwaves regardless of his technical background will find this book useful. The author has spared the reader the necessity of reading pages of computations, formulas, and complicated theoretical considerations. Instead numerous photographs and diagrams are used to illustrate the book, which covers all phases of microwaves, the basic electromagnetic laws of Maxwell, the characteristics of waveguides, and a complete chapter on microwave measurements.—H. E. STINEHELFER, SR., Engineer, Radio Research Division.

ANTENNAS—THEORY AND PRACTICE—SERGEI A. SCHELKUNOFF and HAROLD T. FRIIS—John Wiley & Sons, Inc., N. Y., 1952. 639 pp., $10.00. The authors have prepared a fundamental text on antenna theory suitable for use at the graduate level of study. The book is complete in that all types of antennas, including horns and lenses, are covered. A serious attempt has been made to simplify antenna theory without sacrificing rigor. Though basically a text, the book is an excellent reference, particularly for fundamental concepts and approaches, for communications engineers concerned with antennas.—R. E. GREENQUIST, Engineer, Radio Research Division.