Abstracts of Bell System Technical Papers Not Appearing in this Journal

Voice-Frequency Carrier Telegraph System for Cables.[1] B. P. HAMILTON, H. NYQUIST, M. B. LONG and W. P. PHELPS. Carrier telegraph systems using frequencies above the voice range have been in use for a number of years on open-wire lines. These systems, however, are not suitable for long toll cable operation because cable circuits greatly attenuate currents of high frequencies. The system described in this paper uses frequencies in the voice range and is specially adapted for operation on long four-wire cable circuits, ten or more telegraph circuits being obtainable from one four-wire circuit. The same carrier frequencies are used in both directions and are spaced 170 cycles apart. The carrier currents are supplied at each terminal station by means of a single multi-frequency generator.

Metallic Polar-Duplex Telegraph System for Long Small-Gage Cables.[2] JOHN H. BELL, R. B. SHANCK, and D. E. BRANSON. In connection with carrying out the toll-cable program of the Bell System, a metallic-circuit polar-duplex telegraph system was developed. The metallic-return type of circuit lends itself readily to the cable conditions, its freedom from interference allowing the use of low potentials and currents so that the telegraph may be superposed on telephone circuits. The new system represents an unusual refinement in direct current telegraph circuits, the operating current being of the same order of magnitude as that of the telephone circuits on which the telegraph is superposed.

The following are some of the outstanding features of the present system. Sensitive relays with closely balanced windings are employed in the metallic circuit, and "vibrating circuits" are provided for minimizing distortion of signals. Repeaters are usually spaced about 100 miles apart. Thirty-four-volt line batteries are used and the line current is four or five milli-amperes on representative circuits. Superposition is accomplished by the compositing method which depends upon frequency discrimination, the telegraph occupying the frequency range below that of the telephone. New local-circuit arrangements have been designed, employing polar relays for repetition of the signals; these arrangements are suitable for use in making up circuits in combination with carrier-current and ground-return polar-duplex telegraph sections. New forms of mounting are em-

[1] Journal A. I. E. E., Vol. 44, p. 213, 1925.

[2] Presented at the mid-winter convention of the A. I. E. E., Feb., 1925.

ployed in which a repeater is either built as a compact unit or is made up of several units which are mounted on I-beams, and subsequently interconnected. In the latter case the usual arrangements for sending and receiving from the repeater are omitted, and a separate "monitoring" unit provided for connection to any one of a group of repeaters.

The metallic system is suitable for providing circuits up to 1,000 miles or more in length, the grade of service being better than that usually obtained from ground-return circuits on open-wire lines for such distances. About 55,000 miles of this type of telegraph circuit are in service at present.

Polarized Telegraph Relays.[3] J. R. FRY and L. A. GARDINER. This paper discusses two forms of polarized telegraph relay which have been developed by the Bell System for metallic telegraph circuits and for carrier current telegraph circuits. Both relays are of the same general construction except that one is more sensitive and carries an auxiliary accelerating winding. The more sensitive relay is required to operate on reversals of line current of one milliampere, and at the same time retain its adjustment over long periods and faithfully and accurately repeat signals. It is interesting to note that under average conditions the ratio of power controlled by the contact circuit to that required by the line windings is about 5,000 to one. The parts entering into the magnetic circuit of this relay except for a permanent magnet, are made of the new magnetic alloy (permalloy) recently developed in the Bell Telephone Laboratories. Permalloy lends itself to use in this relay because of its high permeability and very small residual effects. The design of the relay armature and the support for the moving contacts is such that contact chatter is practically eliminated. Photo-micrograms showing practically no destructive action are given of the contacts of a relay which was in continuous service for 8½ months, during which time each contact made and broke its circuit approximately 45,000,000 times.

Supervisory Systems for Remote Control.[4] J. C. FIELD. With the great growth in power distributor systems and especially with the advent of the automatic substations with no attendant there has arisen need for a supervisory system to indicate to the central load dispatcher the position or operating condition of each important power unit in the outlying stations and also to give him means to operate promptly these power units when desired.

[3] Journal A. I. E. E., Vol. 43, p. 223, 1925.

[4] Electrical Communications, Vol. 3, pp.127–133, 1924.

By the turning of a key the dispatcher can open or close any switch or circuit breaker, start or stop any of the machines and receive back almost instantly a visual and continuous signal of a red or green lamp. The present systems provide in effect a key and two lamps, one red, one green, for each unit supervised mounted in easy access of the dispatcher.

Two main systems known as the distributor supervisory and the selector supervisory have been developed to meet the varying conditions of service.

The distributor system is recommended when there is a large number of units to be supervised in a given station. It consists essentially of two motor-driven distributors, one in each station, running in synchronism. Brushes on each distributor pass over corresponding segments of two sets of 50 segments at the same instant. Thus by means of only four connecting wires between the stations the control and continuous indication of 50 power units is possible.

The selector system is recommended when there is only a few switches to be supervised in a single station or in several stations located some distance apart. It consists essentially of hand operated keys to send predetermined codes of impulses to operate selectively step by step selectors at the distant stations. After the selector has operated the power unit, an auxiliary contact on this unit operates a motor-driven key to send coded impulses to operate a selector at the dispatcher's station to indicate the condition of the unit by lighting a red or green lamp. Several stations can be supervised over the same three-line wires.

The dispatcher, by looking at the lamps on his control board, can thus tell at all times the electrical and mechanical conditions at all points in the system and has means to change the operating conditions at any substation according to the demand for power.

Note on Dr. Louis Cohen's Paper on Alternating Current Cable Telegraphy.[5] L. A. MacColl. This is a criticism of two papers which were published in the Journal of the Franklin Institute by Dr. Louis Cohen. It is shown that Cohen's development of the theory of cable telegraphy contains many defects and errors, and in particular that his criticisms of H. W. Malcolm's book, "The Theory of the Submarine Telegraph and Telephone Cable," are without foundation.

Telephone Circuit Unbalances, Determination of Magnitude and Location.[6] L. P. Ferris and R. G. McCurdy. This paper dis-

[5] Journal of the Franklin Institute, Vol. 199, p. 99, 1925.
[6] Journal A. I. E. E., Vol. 43, p. 1133, 1924.

cusses the effects of unbalances of telephone circuits on noise and crosstalk, and describes methods for detecting the presence of these unbalances and locating them when detected. The maintenance of telephone circuits in a high state of efficiency with respect to balance is important since unbalances contribute to crosstalk between telephone circuits and to noise when such circuits are involved in inductive exposures. Different types of unbalances are included and their effects under different conditions of energization of the unbalanced circuit and neighboring conductors are discussed. Methods are described for determining:

(1) The general condition of circuits with respect to balance by crosstalk measurements from their terminals.

(2) The approximate location of unbalances along a line by measurements over a range of frequencies with a bridge at one end of the line.

(3) The final location of unbalances by field measurements with an unbalance detector which may be operated by a lineman and which usually does not require interruption of telephone service, except momentarily.

Toll circuit office unbalances are briefly discussed and a special bridge for detecting and measuring the unbalances of composite sets is described. A mathematical treatment of the bridge method for locating unbalances and a discussion of the necessity of terminating the circuits involved in the tests in their characteristic line impedances are given in an appendix. The methods and apparatus described are widely used in the Bell System and afford operating telephone companies means for maintaining their circuits in the condition of minimum practicable unbalance.

The Theory of Probability and Some Applications to Engineering Problems.[7] E. C. MOLINA. The purpose of this paper is to suggest a wider recognition by engineers of a body of principles which, in its mathematical form, is a powerful instrument for the solution of practical problems. Certain fundamental principles of the theory of probabilities are stated and applied to three problems from the field of telephone engineering.

Note on the Least Mechanical Equivalent of Light.[8] HERBERT E. IVES. In this paper the value for the brightness of the black body at the melting point of platinum recently obtained by the writer is

[7] Journal A. I. E. E., Vol. 44, p. 122, 1925.

[8] Journal of the Optical Society of American and Rev. of Scientific Instruments, Vol. 10, No. 3, March, 1925, p. 289.

used to find a value for the least mechanical equivalent of light using the latest values for the black body constants and the melting point of platinum. The spectral luminous efficiency curve obtained by Tyndall and Gibson is employed. It is found that over the entire range of probable values of the black body constants, the values for the least mechanical equivalent of light may be plotted as a straight line in terms of $\frac{C_2}{T}$ so that the present computations may be expressed in a simple equation in which any desired values of the black body constants may be inserted. Using the latest values the least mechanical equivalent of light is found to be .00161 watts per lumen. This is practically identical with the value obtained by using the author's earlier experimental determination using the monochromatic green mercury light, when combined with the Gibson and Tyndall luminous efficiency curve.

Photoelectric Properties of Thin Films of Alkali Metals.[9] HERBERT E. IVES. The thin films of alkali metals which deposit spontaneously on clean metal surfaces in highly exhausted inclosures are studied. The alkali metals, sodium, potassium, rubidium, and caesium, in the thin film form all exhibit, to a striking degree, the selective photoelectric effect first discovered in sodium-potassium alloy. Experiments on varying the thickness of the deposited film show that the selective effect only occurs at a certain stage of the film's development; for very thin films the selective effect is absent, and it disappears again for thick layers of the pure alkali metal. The wave-length maxima of emission previously ascribed to the selective effect in the pure alkali metals on the basis of observations with rough or colloidal surfaces are absent in these thin films.

The Normal and Selective Photoelectric Effects in the Alkali Metals and Their Alloys.[10] HERBERT E. IVES and A. L. JOHNSRUD. The photoelectric currents from specular surfaces of molten sodium, potassium, rubidium, and caesium, and their alloys are studied at various angles of incidence for the two principal planes of polarization. The selective photoelectric effect is clearly exhibited only in the case of the liquid alloy of sodium and potassium. Wave-length distribution curves show maxima of emission, which are usually, but not always, most pronounced for light polarized with the electric vector parallel to the plane of incidence. The wave-length maxima previously assigned to the several elements are not confirmed; the

[9] Astrophysical Journal, Vol. LX, No. 4, November, 1924.
[10] Astrophysical Journal, Vol. LX, No. 4, November, 1924.

maxima vary in position for the same element with the condition and mode of preparation of the surface.

Theory of the Schroteffekt.[11] T. C. FRY. The current from a vacuum tube is composed of discrete particles of electricity which emerge according to no regular law but in an accidental, statistical fashion. The current therefore fluctuates with time. If the fluctuations are amplified sufficiently they may be heard in a telephone receiver as "noise"—a type of noise which is due to the mechanism of electron emission itself and not to outside interference. This noise is called the "Schroteffekt."

The effect is of certain importance from the telephone standpoint, for it appears that signals, the intensity of which is lower than that of the accidental current fluctuations, can never be rendered intelligible by vacuum tube amplification since the noise due to the statistical fluctuations of space current would be amplified to the same extent and would mask the signals. Fortunately, however, the effect is much less pronounced under operating conditions than it is under the conditions which are most favorable for laboratory study. This is due to the fact that the presence of space charge under operating conditions smooths out the electron stream to a very material extent, and thus reduces the tube noise. The limitation imposed upon amplification is therefore not serious.

The present paper deals with what we have termed "laboratory conditions" as distinct from "operating conditions." Its principal result, arrived at by theoretical consideration, is: That if the electrons are emitted independently of one another the intensity of the noise in the measuring instrument is

$$S = \nu \overline{w}_1,$$

where ν is the number of electrons emitted per unit time and $\overline{w}_1$ is the average over all electrons of the energy that each would have caused to be dissipated in the measuring device if not other had ever been emitted.

When this formula is applied to the type of simply tuned circuit that was considered by earlier writers, it leads to substantially the the same results as they had obtained. It is more general than these earlier results, however, and rests on less questionable methods of derivation. It is, in fact, more general than the problem of the Schroteffekt itself and applies equally well to the absorption of energy from any type of accidental disturbance which satisfies the condition that the individual electromotive impulses occur inde-

[11] Journal of Franklin Institute, Vol. 199, p. 203, 1925.

pendently of one another. Static in radio telephony and certain types of crosstalk probably satisfy these conditions.

The Transmission Unit.[12] R. V. L. HARTLEY. The Bell System has recently adopted a new transmission unit, abbreviated *TU*, for expressing those quantities which heretofore have been expressed in miles of standard cable, or in Europe in terms of the βl unit. It is shown that units of this type measure the logarithm of a ratio, and that the present art requires that this ratio be that of two amounts of power. Any of the proposed units may be so defined. Their essential difference is in the ratio chosen to correspond to one unit. The ratio chosen for the *TU*, $10^{0.1}$, makes it nearly the same in size as the 800-cycle mile, which has advantages. It also facilitates the use of common logarithms in preference to natural logarithms for which the ratio e of the βl unit is adapted. A distortionless reference system calibrated in *TU* is discussed, and conversion tables for the various units are given.

The Thermionic Work Function of Oxide Coated Platinum.[13] C. DAVISSON and L. H. GERMER. Measurements of the thermionic work function of pure platinum coated with oxides of barium and strontium have been made simultaneously by two methods for the same segment of a uniformly heated filament. The theory of the measurements and the experimental arrangements are the same as used in an earlier experiment on the thermionic work function of pure tungsten.[14] Filament temperatures accurate to $\pm 5°$, were found from the resistance of the filament at 0° C. in conjunction with the temperature coefficients of resistance. (1) In the Calorimetric method the equivalent voltage of the work function was computed from the sudden voltage change resulting from switching off the space current, due to the cooling effect of the emission. The determination was much more difficult that in the case of the tungsten filament, and measurements were made at the signle temperature, 1064° K. At this temperature the work function ϕ was found to be equal to $1.79 \pm .03$ volts. (2) In the temperature variation method it was found that, after the temperature had been changed suddenly from one value to another, the emission changed approximately exponentially from an initial value to a final steady value. The half value period of this change varied from a few seconds at high temperature to over a quarter of an hour at low temperature. Interpreting this

[12] Electrical Communications, July, 1924. London Electrician, January 16 and 23, 1925.

[13] Physical Review, Vol. 24, p. 666, 1924.

[14] Davisson and Germer, Phys. Rev., 20, 300 (1922).

phenomenon as due to a progressive and reversible change of the character of the filament with temperature, the initial emissions after temperature changes from 1064° K, were used to determine the b constant of Richardson's equation corresponding to the equilibrium character of the filament at 1064° K, and similar measurements were made for the b constant corresponding to the character of the filament at 911° K. The two determinations lead, through the relationship $\phi = bk/e$, to 1.79 volts and 1.60 volts for the corresponding values of ϕ. For 1064° K, then, the two methods give values for ϕ in agreement. The measurements are, however, not sufficiently accurate to give any indication whether or not an electron within the metal possesses the thermal energy $3kT/2$. The various corrections made and possible errors are thoroughly discussed. It is pointed out that if the transition from the equilibrium state at one temperature to that at another had occurred so rapidly as to avoid observation, a disagreement of 25 per cent. between the values of ϕ given by the two methods would have been obtained which might have been misinterpreted.