DISCUSSION

COSMIC AND GOVERNMENTAL PHENOMENA

ON the basis of radio communication reports submitted to the Bureau of Standards, Dr. J. H. Dellinger[1] has recently announced a "cosmic phenomenon" which caused brief interruptions of long-distance, short-wave communications on four occasions in 1935. Such interruptions were effective over the entire illuminated half of the globe and were spaced approximately 54 days apart (twice the period of rotation of the central portion of the sun).

In 1933 we were fortunate enough to secure complete records of radio echoes reflected from the ionosphere during extremely turbulent periods associated with three successive minor magnetic storms, and it appears quite certain that the observed turbulence is sufficient to produce effects similar to those described by Dr. Dellinger. Magnetic storms have been known to recur, after approximate 27-day intervals, on as many as eight successive occasions.[2] A diagram published in one of our previous reports[3] gives an indication of the sudden and violent changes in radio echo patterns which commonly occur at such times.

On checking over the original photographic records, it is apparent that they agree very well indeed with the recent reports of communication interruption. The most violent echo disturbances last only a few minutes. They are preceded and followed by subsidiary changes which prolong the individual abnormal periods to about 15 minutes. At the peak of the disturbance transmission conditions are changing so rapidly that it is difficult to imagine that any long-distance short-wave communication *could* be successful, though the service interruptions might be so brief that they would escape casual observation. The abnormalities were noted while the observing station was on the illuminated side of the earth.

During the 1933 sequence the main disturbances occurred as follows:

Feb. 19, 9:10–9:15 A.M., E.S.T. (with a minor turbulence at 10:35 A.M.).
Mar. 19, 3:45–3:50 P.M., E.S.T. (with a minor turbulence at 11:35 A.M.).
Apr. 15, 1:32–1:40 P.M., E.S.T. (with a minor turbulence at 12:10 P.M.).

Like other solar phenomena, the sequence is approximately periodic, but successive intervals may differ in length by about one day. Minor disturbances often appear on days preceding and following the main event, but the period of greatest agitation is well marked. On the third occasion we awaited the event with considerable confidence and were able to obtain the "fine structure" of the echo pattern by means of an auxiliary high-speed photographic recorder which was prepared in advance and set in operation before the commencement of the violent phase.

Until the apparent double period of 54 days, indicated by Dr. Dellinger's 1935 communication records, is further substantiated, we prefer to consider that it is somewhat fortuitous and that brief intervening disturbances at the 27-day points may have escaped observation. It would seem that this might easily occur if the most active or most susceptible radio channels happened to lie on the dark side of the earth at the crucial moment, or if the event happened at an hour when communication traffic was relatively slack. In any case, it is probable that the 1935 "storm" has lasted about as long as it is likely to endure, and that further extensions of the existing sequence of dates need not be expected.

Unfortunately no continuous automatic records could be obtained during the 1935 period covered by Dr. Dellinger's report. During the past 16 months the Federal Communications Commission has repeatedly postponed the rephrasing of certain obsolete regulations, limiting the use of automatic apparatus, which effectively block the continuation of fundamental research. The commission freely admits that the ancient clause in the regulations has no engineering justification whatever when extended to our new experiments and has therefore repeatedly promised remedial action. Already an important part of the sunspot cycle has been completely lost, by governmental decree.

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[1] J. H. Dellinger, SCIENCE, October 11, 1935.
[2] G. Angenheister and J. Bartels, Handbuch der Experimental Physik (Wien-Harms), Vol. 25, part 1, p. 674, 1928.
[3] H. R. Mimno and P. H. Wang, *Phys. Rev.*, 43: 769, 1933.

THE EPICENTER OF THE HELENA, MONTANA, EARTHQUAKE

EARTHQUAKE shocks of a destructive nature, the epicenters of which are about two miles north of Helena, Montana, occurred on October 12, 18 and 31. Geological field investigations initiated by the Montana Bureau of Mines and Geology immediately following each of the shocks established the epicenter on the southern side of Helena Valley (Prickly Pear Valley on some maps). This determination has been verified by excellent seismograph records obtained by Franklin P. Ulrich and Dr. D. S. Carder, of the Coast and Geodetic Survey, from the strong shock on October 31 and numerous minor shocks since October 19.

The earthquakes were caused by a northwest trending fault, but because of the deep cover of gravel and sand in the Helena Valley it is impossible to see the

fault plane. The fault zone extends for a distance of approximately 14 miles, from a point a mile or more to the northwest of Helena to an indefinite point between East Helena and Clasoil. The fault is probably of the normal type, and is part of the late Tertiary diastrophism. The zone of slipping is near the northern border of the Boulder Batholith.

According to the Rossi-Forel scale the intensity of the three more important shocks was determined as 8, 9 and 9 minus, respectively. The greatest damage occurred on October 18 at 9:47 P. M. This shock was felt over an area of about 200,000 square miles. At that time two lives were lost and property damage was estimated at about $3,000,000 in Helena and East Helena. Few buildings were completely destroyed, but many partially ruined. Many structures were so severely weakened by the shocks on October 12 and 18 that the shock on the 31st caused numerous buildings to collapse.

The after-shocks are still in progress and some are of great enough intensity to be felt 75 miles distant. The stronger after-shocks are severe enough to cause loose plaster and bricks to fall. To date more than 900 minor shocks have been recorded by W. E. Maughan, Federal Metrologist, at the Helena Weather Bureau.

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ON THE HISTORY OF NEGATIVE NUMBERS

THE history of the negative numbers has recently been extended backwards more than a thousand years by the discovery of the fact that the ancient Babylonians used such numbers occasionally in their statements relating to algebraic equations. It has commonly been assumed that the ancient Hindus were the first to employ actually negative numbers but that the ancient Greeks operated somewhat earlier with binomials of the form $a-b$, where a and b are positive numbers and $a > b$. In this connection Diophantus, in the second half of the third century A.D., stated that a subtracted number multiplied by a subtracted number gives an added number and that a subtracted number multiplied by an added number gives a subtracted number. These "rules" were later observed to apply to actually negative numbers as well as to subtracted numbers when the minuend is larger than the subtrahend, as was always assumed by Diophantus and by the other Greek writers.

Recently O. Neugebaur, who was formerly at Göttingen, Germany, but is now at Copenhagen, Denmark, published a volume in two parts under the title "Mathematische Keilschrift-Texte," which appeared as volume 3, Abteilung A, of the well-known periodical entitled *Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik,* which was started in 1930 and appears irregularly. On page 387 of the first part of this volume he calls attention to the fact that the second member of the ancient Babylonian equations was sometimes a negative number while at other times it was either positive or zero. On page 463 he gives an example of an equation of the former type and emphasizes the fact that it follows from the language that the writer was fully aware that he was dealing with a negative number as a second member of this equation.

The use of a negative number alone as a member of an equation is a noteworthy fact in the history of negative numbers but it should be emphasized that it does not imply that the ancient Babylonians understood negative numbers in the modern sense of this term. Such an insight does not seem to have been attained before about the beginning of the nineteenth century. In very ancient times the Babylonians had a special symbol, called lal, which corresponds to our minus sign, so that a lal b corresponds to our $a-b$, where a and b are positive and a exceeds b, but there is a considerable step from this use to the use of a negative number standing alone as a member of an equation. It is this step which is emphasized here, but beyond this there is a much longer step leading to the establishment of the legitimate use of negative numbers in the various elementary operations. The latter step presented the greatest difficulties and does not seem to have been undertaken by either the ancient or the medieval mathematicians.

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SYNCHRONOUS FLASHING OF FIREFLIES

IN a recent discussion of the synchronous flashing of fireflies, John Bonner Buck,[1] of the Zoological Laboratory of the Johns Hopkins University, contributes experimental evidence directly bearing on certain phases of this behavior as observed for some American fireflies.

In addition to the references mentioned by Buck, I have come across additional ones. Konrad Guenther[2] in 1931 says:

> In Petropolis, on New Year's Eve, as I walked through the gardens in a fragrant summer night, the lawns were as though illuminated, and with astonishment I noted how hundreds of green lights blazed out simultaneously and were simultaneously extinguished, with so regular a rhythm that it seemed as though the sparks were blown rapidly by a huge mechanical bellows that gave a puff every second. Of this extraordinary phenomenon I could give no explanation.

[1] SCIENCE, 81: 339–340, April 5, 1935.
[2] "A Naturalist in Brazil." (Translated from German by Bernard Miall), pp. 227–228. Houghton Mifflin Company, 1931.