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.

He refers also to the rhythmic flashing of the Indian fireflies.

F. P. Connor[3] refers to the "rhythmic flash of swarms of fireflies on a dark night, so beautifully seen in the Terai districts of this region [India]."

On July 22, 1933, I made a trip to the top of Hawksbill Mountain in the Blue Ridge of Virginia, pitching a tent on the plateau or Summit Pene plain just below the knob. As darkness came on, I began scouting over the pastures with a powerful spotlight. At 8:10 the first fireflies were seen in flight, spotting the darkness with an occasional flash of brilliant light. The flashes were never rapidly delivered, a considerable interval of rest always following each flash so that it was difficult to follow the insect in the darkness by its light. Even the flash itself was a leisurely delivery of light. Probably not more than eight or ten of these flying males were seen.

Points of light also came and went in the low herbage around, and these were traced to wingless females. The flying males and the wingless females were identified by Mr. H. S. Barber, of the U. S. National Museum, as *Photinus scintillans* Say.

I soon found that the flash of my light stimulated the flash of these wingless females. Their flashing response came very soon after the beam of my light went forth. I became much interested in the responses of these quiescent females. It was a matter of a nice synchronism on the part of a number of females every time I flashed my light. It was rather impressive to throw the spotlight over the low shrubbery one to two hundred feet away and to behold the reaction of half a dozen or more females flashing an almost immediate response with their tiny lights. This play with these insects continued for some time. At 8:30 the males had ceased to fly, but the females continued to respond to my flashlight in the herbage until 9:00 P.M., when their responses ceased.

In this instance the quiescent, wingless females were synchronizing their flashes in response to my light, and presumably they would behave in the same way to the perceived flash of a flying, flashing male. My stronger beam of light, affecting a far greater area, stimulated many or all the females to flash their signal, resulting in a nice synchronism within a scattered population every time I flashed my light. In this instance synchronism was experimentally induced in a population of females, but with a population of males flying and flashing around indiscriminately, there could have been no synchronism induced. At no time did the few males observed tend to flash in unison, and none were observed to descend to the females.

[3] *Jour. of the Bombay Nat. Hist. Soc.*, 36: 4, 1018, 1933.

While the observations I have reported appear to be relating to the mating impulse, I feel convinced that the remarkable synchronous flashing of many tropical fireflies does not necessarily fall in this category. A recent contribution by Hugh M. Smith[4] on the synchronous flashing of certain fireflies in Siam makes this plain.

The spectacular rhythmic flashing of groups of males as observed by Smith parallels perfectly the behavior of certain crickets and katydids, the snowy tree crickets, outstanding among these, which chirp in unison, not as a mating adaptation, but purely from some organic law of rhythmic appreciation which governs their chirping.

My original note in SCIENCE[5] appears to have led to the erroneous conclusion that the synchronism which I observed proceeded in waves from one or more sources. I did not observe a moving of the impulse in waves. My wording may have been a little ambiguous on this point. My use of the word "wave" as I have expressed it, "of alternate waves of illumination and darkness in the distance," had reference to that content of the word "wave" as a period of marked activity, as a *wave* of enthusiasm, not as an impulse moving along.

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STUTTERING

IN a series of twenty-four cases of stuttering studied this summer in the laboratory of biolinguistics, at the University of Michigan, a marked improvement, even to a complete cessation of stuttering, was noted when the stutterer spoke while walking on all fours. When the stutterer assumed this position the arythmicity and lack of coordination decreased.

As yet, no explanation of this phenomenon has been discovered. It is conceivably due to the reinforcement of reflexes. More specifically, stuttering as a spastic phenomenon may be caused by a temporary stimulus applied to an upper motor neuron. This might be due to a temporary dilatation of the capillaries of the precentral cortex. By the assumption of the quadrupedal position an alteration of blood pressure possibly ensues, which releases the blood that dilates the capillaries. Hence, the spasticity ceases and the patient carries on a more nearly normal conversation.

If this view proves correct, then present theories and methods for correcting stuttering should be revised and greater effort should be made to place them upon a physiological basis.

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[4] SCIENCE, 82: 151–152, August 16, 1935.
[5] SCIENCE, 44: 710, November 17, 1916.