usual in my experience in that the very small and short volume of vapors in the fireworks could do what it did. The fireworks in question were of the large spinning-wheel type, and also of the fountain and rosette types, where the flames were massed in a space of some foot or more in diameter.

The writer would call the attention of those interested to this unusual occurrence and would invite correspondence thereon.

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SPECIAL CORRESPONDENCE

GEOLOGIC RESEARCH WORK NEAR RED LODGE, MONTANA

THE program of cooperative research work in geology, described by the writers in the issues of SCIENCE for August 1 and December 21, 1930, has already led to highly interesting scientific results and promises disclosures of an even more fundamental character. Indeed, so much is this the case that a brief note as to the status of the project and a historical sketch of its development are believed to be warranted at the present time.

In the field of paleontology, one of the most important discoveries which has been made is that of the Lower Devonian ostracoderm and arthrodiran fauna which was discovered at Beartooth Butte, Wyoming, in 1931 by a party consisting of Professors R. T. Chamberlin, W. H. Bucher, Erling Dorf and E. L. Perry, and Richard F. Miller—the first of the fossils being found by Dr. Perry. The collections obtained in 1931 were described in a paper by William L. Bryant, director of the Park Museum, Providence, published in the proceedings of the American Philosophical Society. Additional collections obtained in 1932 by a Princeton Scott Fund Expedition, led by Professor Dorf, are also being studied by Director Bryant and were described in part in a paper read before the last annual meeting of the American Philosophical Society. This fish fauna is remarkable both for the number, variety and perfection of the primitive fish remains comprising it, and because it contains forms closely comparable to many of those which have been obtained from the famous localities of northwest Europe and Spitzbergen. A highly unusual feature of the Beartooth Butte locality is the occurrence of beautifully preserved Lower Devonian fossil land plants in direct association with the fossil fishes—these plants having been studied and described by Professor Dorf in a paper presented before the Paleontological Society in December, 1932. Further collecting at this locality during the coming summer and in 1934 is contemplated by Professor Dorf. Other important paleontological results include the demonstration, according to Dr. C. E. Resser, of the fact that the Cambrian fossil collections from the Red Lodge area prove an interdigitation of northern and southern Rocky Mountain Cambrian faunas, which should aid materially in correctly determining the correlation of the Cambrian formations of the West. The presence of upper Ozarkian and lower Canadian formations in the area is also suggested by tentative fossil determinations made by Dr. E. O. Ulrich, of the National Museum, and Dr. Rudolf Ruedemann, of the New York State Museum. Collections of foraminiferal fossils obtained from the Jurassic Sundance formation of the Big Horn Basin have been studied and described by Professor J. R. Sandidge in a recent issue of the *American Naturalist* and it has been suggested by workers on the Pacific Coast that this work may aid in demonstrating the Jurassic age of Pacific Coast formations hitherto regarded as of Lower Cretaceous age. A study of the fossiliferous Miocene deposits south of Livingston will be made by Professor Sinclair and Dr. Jepsen this summer, with the assistance of V. C. Miller and Dr. E. C. Marshall, of Livingston.

Studies in petrology and economic geology have been carried on under the direction of Professors Edward Sampson and A. F. Buddington. An outstanding development of the three years' work has been the accumulation of evidence that the Stillwater igneous complex in the northwestern part of the Beartooth uplift is a strongly differentiated noritic sheet of Precambrian age with a stratiform arrangement of facies extraordinarily similar to those in the Bushveld complex of Africa, a fact first recognized by Professor Sampson. The differentiation of the sheet as a whole has been studied by J. W. Peoples, the chromite-bearing horizons by Professor Sampson and copper-nickel sulfide mineralization and the contact metamorphism at the base of the sheet by Arthur L. Howland. One or more bands with a little disseminated sulfide carrying slight amounts of platinum have been defined within the complex. A strongly metamorphosed zone of banded iron formation has been found in the country rock at the base of the complex and also about thirty-five miles to the southeast on Rock Creek, where it, together with masses of ultrabasic rocks and associated chromite deposits, are being studied by Kenneth P. Wilson. The composition and mechanics of intrusion of the Tertiary

porphyries have been studied at three different localities by John T. Rouse, Kenneth P. Wilson and John S. Vhay, respectively.

In physiography, the work has been concentrated on the determination of the number and interrelationship of such peneplain and pediment surfaces as may be present. A simultaneous study is also being made of the time relationship of these erosion surfaces to the sedimentary deposits occurring within the Big Horn Basin, the Yellowstone Park and the valley of the Yellowstone River north of Gardiner. Attack upon the physiographic-stratigraphic problems thus involved is being led by Professors N. M. Fenneman, R. M. Field and D. W. Johnson. When work along these lines progresses to a point where precise dating of the stratigraphic, physiographic and diastrophic features of the region is to be attempted, further work will have to be done on the several remarkable vertebrate faunas which have already been found in the Paleocene, Eocene and Oligocene sediments of the Big Horn and Wind River regions by Princeton Scott Fund Expeditions under Professor Sinclair and Dr. Jepsen, or by their predecessors from other institutions.

Geological and geophysical study of the features of the Red Lodge region, which has been directed and led by Professors R. T. Chamberlin, W. H. Bucher and W. T. Thom, Jr., has demonstrated that the region is characterized by certain types of deformational features, systematically arranged—the morphology of the features and the manner of their arrangement affording highly significant information as to the origin and general structural characteristics of the various Cordilleran mountain uplifts—thus yielding important clues as to the nature of the mountain-building process. In July, 1932, Professors Chamberlin, Bucher and Thom selected a series of points between Boxelder, South Dakota, and Cody, Wyoming, at which a field party of the U. S. Coast and Geodetic Survey subsequently made pendulum observations, thus affording a combined geologic and gravity profile across the Black Hills, the Powder River Basin, Bighorn Mountains and Big Horn Basin. Formation samples, for specific gravity determinations, were obtained by this geological party at the time the station selections were made, and porosity and specific gravity determinations for these samples have since been made by Mr. Claude Langton, of the University of Chicago Department of Geology, under Professor Chamberlin's supervision. Through the cooperation of the U. S. Coast and Geodetic Survey, Professor Chamberlin is now preparing a reanalysis of the gravitational data obtained last summer, a study which promises to have a direct and very important bearing upon the whole problem of isostatic compensation, adjustment and uplift, and which in turn will prospectively profoundly affect scientific opinion as to the nature and manner of operation of the orogenic process. Further structural and geophysical work in the Red Lodge region is planned by Professors Chamberlin, Bucher and Thom for the coming summer, and a grant of funds to support this structural and geophysical work has recently been voted by the Geological Society of America. Particular emphasis will be placed this year both upon the continuation of the physiographic-stratigraphic-structural (and geophysical) attack upon the problems of mountain origin and evolution, and upon field conferences between participants in the Red Lodge project and the foreign and American members of the International Geological Congress party which will visit the Red Lodge area in August.

In conclusion, a few words as to the history of the Red Lodge project is believed to be in order, because of its past results and because of its prospective future accomplishments. The idea of carrying out such a cooperative undertaking in the cause of geologic science originated with the senior writer in 1927, and was cordially and most helpfully concurred in, not only by the members of the Princeton Department of Geology and University Administration, but by many who were members of other universities or research institutions, as was indicated in the article published in SCIENCE, August 1, 1930. The enterprise has been conceived and carried forward as a voluntary association of individuals and institutions sharing a common interest in the effective advancement of geologic science and education. The initiation of the project was made financially possible in the first place by a cooperative arrangement between Princeton University and the Northern Pacific Railway negotiated through the Council of the International Summer School of Geology and Natural Resources, of Princeton University. Funds allocated by Princeton University and by the Princeton Department of Geology have been and continue to be the primary basis for the financing of the geologic research work in the Red Lodge region,—except that the structural and geophysical studies which will be conducted during the coming year will be financed as a project of the Geological Society of America on funds recently voted by that society. Due to the interest of participating students and to the enthusiasm and cordial interest of the collaborating members of other institutions, many of whom have personally contributed their own research expenses, the combined total of funds, thus afforded, has again been doubled through cooperative arrangements made by the writers with various government agencies—especially by arrangements made with and through the Montana Bureau of Mines and Geology.

The planning of the comprehensive program of physiographic-stratigraphic-structural researches now being carried forward in the Red Lodge region is being led by a volunteer committee consisting of Professors W. H. Bucher, R. T. Chamberlin, N. M. Fenneman, D. W. Johnson and the writers, W. T. Thom also serving as executive secretary responsible for the administration of the project.

W. T. THOM, JR.
R. M. FIELD

PRINCETON UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

VOICE TRANSMISSION ON A BEAM OF LIGHT

DURING the past months there have appeared several popular articles on the transmission of speech and music over a beam of light. These papers did not give the details. It is presumed that neon tubes and photoelectric cells were used.

Recently the author has set up a demonstration experiment using an ordinary direct current arc lamp and a photronic cell, or a photoelectric cell. This experiment worked so well it is thought that a somewhat detailed description might be of general interest.

This experiment was one of Indiana University's demonstrations at the State Fair. The operators say the experiment was the one demonstration which did not fail them during the week.

The set-up of the apparatus is shown in the diagram, Fig. 1. In this diagram the microphone, M, is

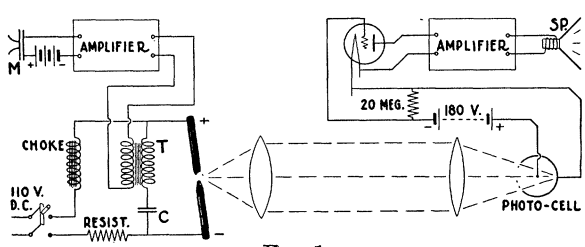

FIG. 1

connected to a two-stage microphone amplifier. The amplifier is connected to the transformer, T, which is an ordinary low impedance output transformer such as is used in connecting a tube to a dynamic speaker. The transformer, T, is connected across the terminals of the arc lamp through a four microfarad condenser, C. A large choke coil is placed in the D. C. supply line. This choke coil prevents the voice frequency being absorbed by the power line.

The diagram shows the receiving photoelectric cell connected to a resistance coupled amplifier. There should be two stages of resistance amplification and then two or three stages of transformer coupled amplification. The amplifier is then connected to a loud speaker.

It will be apparent that the exact connections will depend upon the amplifiers and speaker available.

The arc used was an old-fashioned arc projection lantern. This was focused so as to give a parallel beam of light. The parallel beam of light was focused on the light cell by means of a large reading glass.

Instead of the photoelectric cell a Weston photronic cell can be used. The photronic cell gives practically the same results with a stage or two less amplification in the amplifier. In the figure the photronic cell should be connected directly to the amplifier.

In the place of the microphone and the microphone battery a pick-up unit can be substituted and music from an ordinary record can be transmitted.

The connections of the arc lamp are the connections for a speaking arc. If the arc is working well one should hear the arc "talk" in a quiet room.

It is found that hard carbons give better results than the usual soft-cored carbons.

This set-up makes a striking experiment in a large darkened room where the length of the parallel beam is long, especially if there is enough dust in the air to make the path of the beam visible. Any object interposed in the beam causes the music to cease.

The early experiments involved in the above demonstration are:

Alexander Graham Bell[1] transmitted sound over a light beam from a mirror fastened to a membrane which was stretched over the end of a tube. By speaking into the tube the membrane was caused to vibrate. Then the light was reflected to a selenium cell. The variation of the light caused a variation of the resistance of the cell and this caused a reproduction of the sound in a receiving telephone.

Some thirty years ago it was found that an ordinary arc light could be made to talk if a microphone was connected properly across the arc. It seems that Bell and Hays in America and Simon in Germany discovered the speaking arc independently in 1897.

G. G. Blake[2] used an arc lamp and head phone.

R. R. RAMSEY

INDIANA UNIVERSITY

A UNIVERSAL STAGE FOR OPAQUE OBJECTS

THE difficulties involved in manipulating small opaque objects under the microscope have led to the

[1] *Am. Jour. Sci.*, p. 305, Series 3, Vol. 20, 1880.
[2] Exp. Wireless, p. 561, 2, 1925.