PHOTOELECTRIC SENSITIVITY OF BISMUTHINITE AND VARIOUS OTHER SUBSTANCES

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The present paper summarizes the results of an examination[1] of various substances, to determine their electrical sensitivity to light, and describes the results of a more detailed examination of the photoelectric sensitivity of bismuthinite Bi_2S_3 and molybdenite, MoS_2.

All of the herein-described substances were examined for change in electrical conductivity caused by the action of light upon them, and two of them were examined for photoelectrical activity when they were charged to a negative potential in an evacuated bulb, and exposed to light.

When the substances were examined for an increase in electrical conductivity, a potential of 2 to 6 volts was connected, through a resistance of zero to 100 000 ohms, into a circuit containing a d'Arsonval galvanometer and the substance under investigation as illustrated in Fig. 1. In most cases the substances were slightly conducting when not exposed to light, so that the "dark current" caused an appreciable galvanometer deflection, which had to be annulled by passing an electric current in the opposite direction through the galvanometer. This counter current was obtained by shunting across a resistance of 100 ohms, which was

[1] Some of these substances were examined with the assistance of W. B. Emerson and the results published under joint authorship in the Jour. Wash. Acad. Sci., 7, p. 525; 1917.

in series with a cell of 2 volts and a variable resistance of zero to 70 000 ohms.

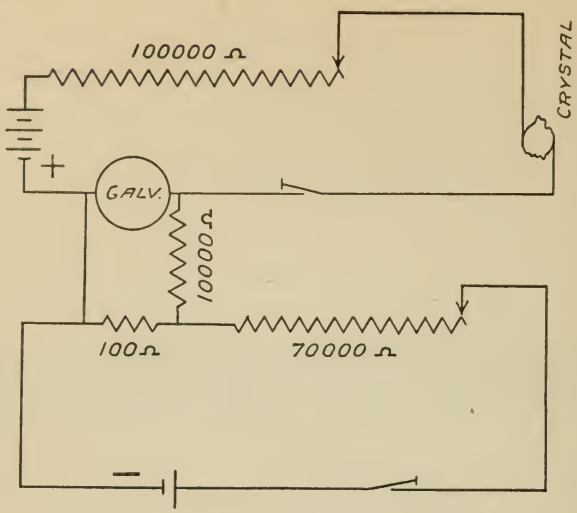

FIG. 1.—*Arrangement of electrical connections*

The source of light, when not otherwise specified, was a 16 cp carbon incandescent lamp, placed at a distance of 10 cm from the substance under investigation. One disappointing feature of this investigation is that no substance was found which is comparable with the potassium photoelectric cell and the selenium cell in sensitivity.

Part I.—PHOTOELECTRIC SENSITIVITY TESTS OF VARIOUS SUBSTANCES

Gallium.—The material examined was the highly purified metal prepared and supplied by Dr. H. S. Uhler. This metal was solid, thus differing from the impure material, which is a liquid. It was melted and solidified over a platinum wire sealed into a glass bulb, thus forming the negative electrode of a photoelectric cell from which the air was exhausted. The anode was a loop of platinum wire, situated at a distance of about 12 mm above the gallium electrode.

A potential of 340 volts was applied to the cell which was connected to a sensitive ($i = 5 \times 10^{-10}$ amp) ironclad Thomson galvanometer.

The results obtained proved quite disappointing, this metal being quite insensitive to light. When the cell was exposed to daylight the photoelectric current produced a galvanometer de-

flection of only 4 to 5 mm, whereas, similarly exposing a potassium photoelectric cell, the photoelectric current was sufficient to give a deflection beyond the range of the scale.

Silver Sulphide.—The sample examined was a thin flexible strip, 6 by 10 mm in area, prepared by G. W. Vinal.[2] In one test the silver sulphide formed the negative electrode of a photoelectric cell (evacuated glass bulb about 5 cm. diameter; with a ring of platinum wire for the anode) similar to the gallium cell just described. It was connected through an ironclad Thomson galvanometer to a battery of 340 volts. When exposed to daylight a deflection of perhaps 1 to 2 mm was observed, but no deflection resulted from exposure to the standard carbon lamp.

In the second test, copper wires were melted to the ends of a strip (3 by 5 by 0.3 mm) of silver sulphide which was connected in series with a high resistance, a storage cell of 2 volts, and a d'Arsonval galvanometer. When exposed to the standard lamp, the galvanometer deflection was 10 mm. In another sample about 2 cm long, the ends joining the copper wires were covered to prevent thermoelectric currents. The exposed area was 14 by 4 mm. The radiation from the standard lamp produced a deflection of 13 to 17 mm. Both samples were quick acting, and after exposure to light there was no lag such as obtains in selenium in recovering its dark resistance.

Selenium.—A crystal of selenium, prepared by Dr. F. C. Brown,[3] having a receiving surface of less than 1 mm^2 area, when exposed to the standard lamp, gave a deflection of more than 50 cm, which shows its great sensitivity as compared with other substances.

The mounting of the selenium crystal consisted of metal electrodes between which the crystal was held by compression. When operated as a photophone, by connecting the selenium crystal with an audion amplifier, as described subsequently, a loud musical note was obtained.

Pyrites.—FeS_2. The sample examined was a fragment of a crystal, 1.2 by 1.5 by 4 mm, soldered to copper wires.

This substance gave no photoelectric response when exposed to the standard lamp; neither did it produce an audible sound when operated as a photophone in connection with an audion amplifier.

Tellurium.—This metal is said to change in resistance when exposed to light. The present tests were made upon a mirror of tellurium deposited upon a glass plate by cathode disintegration.

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[2] Vinal, this Bulletin, **14**, p. 331; 1917.

[3] Brown, Phys. Rev. (2), **4**, p. 85; 1914.

Suitable terminals were attached to a sample about 4 by 50 mm. No change in electrical conductivity was observed when exposed to light.

Silicon.—From the Carborundum Co., Niagara Falls, N. Y. The crystal, 1 by 1.5 by 3 mm, was attached to copper wires by means of solder.

No photoelectric effect was observed when exposed to the standard lamp; and no audible sound was produced when operated as a photophone. Thermoelectric effects were obtained by heating the connections with the copper-lead wires.

Boleite.—The sample of boleite ($3PbCl(OH)CuCl(OH) + AgCl$; from Boleo, Mexico) examined was a single rectangular crystal, 3 by 3 by 1.5 mm, held by compression between copper electrodes. No change in conductivity was observed when the crystal was exposed to daylight or to the standard incandescent lamp.

Cylindrite.—This is a lead-antimony-tin sulphide, which occurs in cylindrical form, mixed with inhomogeneous material.

The sample examined was about 1.5 mm in diameter and 6 mm long.

The standard lamp produced a deflection of 10 to 11 cm. A similar decrease in resistance was produced by the heat radiated from the hand, and by warming the substance by touching it with a hot wire.

Stibnite.—Samples of this same specimen of stibnite, Sb_2S_3, were supplied to Elliot [4] for investigation. The purpose of the present investigation was to obtain a comparison of its sensitivity with other substances containing stibnite.

The size of one sample examined was 4 by 7 by 0.5 mm. Terminals were attached to it by heating a copper wire to incandescence in a gas flame and bringing it in contact with the plate of stibnite.

The standard carbon lamp caused a deflection of 5 cm. A deflection equally as large as this was obtained by exposing the crystal to the heat radiated by the hand. Stibnite may be considered as sensitive as boulangerite, but the deflection drifted, due to a decrease in resistance with time (heating), as noticed by other observers.

Boulangerite.—The specimen of boulangerite ($3PbS,Sb_2S_3$, Irkutsk, Siberia) investigated was obtained from the Smithsonian Collection, No. 78395. Several samples were examined. In one

[4] Elliot, Phys. Rev. (2), 5, p. 53; 1915.

sample, 4 by 7 by 0.8 mm, the electrodes consisted of copper wires melted into the material, as just described. The radiation from the standard lamp gave a deflection of 10 to 20 cm.

Another sample, 1 by 1.2 by 2 mm, held by compression between two heavy electrodes of copper, when exposed to the standard incandescent lamp, produced a deflection of 2 to 3 cm, which is comparable with the preceding when one considers the size of the exposed surfaces.

Although this substance seems fairly sensitive, it did not appear to be sufficiently so to investigate its spectral sensitivity, with a view of using this mineral as a selective radiometer.

Jamesonite.—$2PbS,Sb_2S_3$; Smithsonian Collection, No. 12 500; from Cornwall, England. The sample examined (size 2 by 7 by 1 mm) had the copper wire terminals attached by fusing the incandescent wire into the material. The standard lamp gave a deflection of only 1 to 2 cm, which seems to indicate that this material is not so light sensitive as is boulangerite.

Mixtures of galena, PbS, and Sb_2S_3 of various proportions were melted in a crucible and poured upon a plate of metal. Several samples, 5 by 10 by 0.5, were examined but none of them gave any indication of light sensitiveness (resistance change) when exposed to daylight or to the standard incandescent lamp.

Bismuthinite.—Bi_2S_3 was obtained from the Smithsonian Collection, No. 85 071, from Jefferson County, Mont. This is the most interesting substance examined, in view of the diverse results obtained and the explanation offered therefor.

The sample of bismuthinite examined consisted of a nonhomogeneous mass of acicular crystals, which was easily crushed into numerous fine needlelike crystals. The first sample examined was a small mass of crystals (size 1 by 1 by 0.7 mm) held by compression between two heavy electrodes of copper. When the crystal was exposed to the standard carbon lamp no change in conductivity could be detected with certainty.

A second sample, 3 by 6 by 1 mm, had the copper wire terminals attached by fusion, as already described. The emf's applied were the same as for the preceding sample. When exposed to the standard lamp no change in conductivity was observed. These results being contradictory to those published by Case[5] who used a three-stage audion amplifier to detect the change in conductivity of the crystals, the foregoing experiments were

[5] Case, Phys. Rev., 9, p. 305: 1917.

repeated in the manner described by him. For this purpose the light from an acetylene flame, shining through a slit 2 by 10 mm, was focused upon the crystal by means of a triple achromatic lens, 6 cm in diameter and 18 cm focal length. The light was interrupted by means of a sectored disk having 15 openings, operated by means of an electric motor, the speed of which could be varied. The usual speed used gave 240 interruptions per second. The crystal was connected to a three-stage audion amplifier and telephone receiver. A crystal of selenium or a selenium cell produced a loud note; but the samples of boulangerite and jamesonite, which by previous tests were light sensitive, did not give a musical sound in the telephone.

The sample of bismuthinite, with electrodes sealed on, produced no audible note when exposed to light.

At least a dozen samples of bismuthinite, held by compression between heavy copper electrodes, were examined in connection with the amplifier. Of this number only two samples appeared to be light sensitive. One sample produced only a faint sound in the telephone receiver. The second sample produced a loud note in the telephone. The sound was the loudest when the crystal was exposed along the line of contact with the copper electrode. Covering the crystal with red glass did not reduce the loudness of the note very much, indicating that the effect is due to heating of the material. Unfortunately, this crystal was crushed while under investigation. Prolonged tests on other samples gave negative results as regards the production of sound. (See further tests, described in Part II of this paper; using samples of smaller heat capacity and electrodes which prevented loss of heat by conduction, etc.)

In connection with these tests on bismuthinite, the following experiments on thin strips of metals are of interest.

Platinum and Gold.—It is of interest to record the results obtained when using thin, blackened strips of platinum and of gold leaf as radiophones, by connecting them through a battery to an amplifier.

These blackened strips were warmed intermittently by exposing them, through a rotating sectored disk, to the acetylene flame, as already described.

When a sensitive platinum bolometer receiver was used as a radiophone, the sound produced in the telephone was not very audible. This no doubt was owing to the great heat capacity of the material, which prevented the rapid alternations in resistance,

and hence in electric current, from being of sufficient magnitude to affect the telephone receiver.

Using a lightly smoked strip (6 by 2.5 mm) of gold leaf, the ends of which were clamped between thin (0.02 mm) strips of tin, the sound produced in the telephone receiver was as loud as was observed in the photophone made of selenium, just described.

This device was mounted in a glass bulb, which could be evacuated. As was to be expected, there was no marked difference in the intensity of the sound produced when operated in air and in a vacuum.

In the gold-leaf radiophone as used the limit of audibility was attained for a light (radiant power) intensity of 4.8×10^{-5} watts. Using a larger receiver and amplifier and a larger current (which was 0.2 amp in the present tests) through the receiver, the sensitivity could be greatly increased.

Part II.—ADDITIONAL PHOTOELECTRIC SENSITIVITY TESTS OF BISMUTHINITE AND MOLYBDENITE

In view of the fact that some of the results obtained with bismuthinite seemed somewhat contradictory, a more detailed examination of its photoelectric sensitivity was undertaken. The method of supporting the crystals by compression between copper electrodes was unsatisfactory, because of the fragility of the crystals, which were easily crushed. Moreover, the noise produced in the telephone (when using the amplifier) as the result of poor contact at the electrodes also militated against the use of such a holder. It was found that while ordinary solder usually does not adhere to bismuthinite, it can be melted in a large globule, around the end of a crystal and onto a copper wire. On solidifying, the solder holds the crystal very securely. In this manner it was possible to mount thin, fragile crystals (0.5 mm in diameter and 2 to 5 mm in length) which would have been crushed in the compression mounting just mentioned.

The thin lamina of molybdenite are easily mounted, because the molten solder readily adheres to the surface of this substance.

In the preceding tests the crystals (which have a massive, fibrous structure) were placed with the needle crystals parallel to the copper electrodes; and the question arose as to whether the photoelectric sensitivity depended upon the direction of the current through the crystal. In the present tests the electrodes being attached to the ends of the bundles of needle-like crystals,

the current passed along the needles instead of across them. However, as will be shown presently, it was then found that the high photoelectric sensitivity observed with an audion amplifier occurs in small spots in the crystal, usually at the boundary or intergrowth of two masses of acicular crystals.

It is important to distinguish between the purely thermal and the so-called photoelectric effect of radiation upon the electrical characteristics of selenium, and the various sulphides just described, which have a negative temperature coefficient of resistance.

A selenium cell having a resistance of 1 000 000 ohms at 20°C, has a resistance of about 3 000 000 ohms at 0°C. When such a cell is exposed to diffuse daylight, its resistance decreases one-tenth to one-fiftieth of its value when unexposed to light, in spite of the fact that its temperature has not changed by an appreciable amount. Furthermore, this photoelectric change (decrease) in resistance is greatest for radiations of wave lengths which are the least absorbed; and it is not produced by an appreciable amount for rays of wave lengths greater than 1μ. If appreciable radiation were absorbed, the temperature would rise and the resistance would decrease. It is therefore an easy matter to distinguish the purely thermal effect from that produced by exposure to radiant energy.

On the other hand, the herein-described tests show that the electrical resistance of bismuthinite and other sulphides mentioned decreases with rise in temperature. The effect of radiant energy is also a decrease in resistance, and in view of the fact that it is not very marked (as compared with selenium) it is a difficult task to distinguish between the photoelectric and the purely thermal change of resistance. This is especially true since the infra-red rays of wave length greater than 1μ have an appreciable effect (as shown by the insertion of absorption screens in the path of the rays), whereas selenium is not sensitive to infra-red rays beyond 1.5μ.

Herewith follows a description of the behavior of various crystals of bismuthinite and molybdenite, soldered to copper terminals and tested for photoelectrical activity (1) by continuous exposure to the radiations from the 16 cp standard lamp, and (2) by interrupted exposure to an acetylene flame, in connection with an audion amplifier, as previously described.

For convenience in examination the samples were soldered, two at a time, to copper wires (No. 26), which were securely attached to light wooden mountings designated as *A*, *B*, etc., in presenting these data.

The image of the slit which was in front of the acetylene flame or of a Nernst glower was about 1.5 mm wide. This enabled the observer to project the light upon different parts of the various crystals (3 to 5 mm in length) and thus locate the most sensitive spots.

BISMUTHINITE (Bi_2S_3)

For convenience in discussion, the various samples of bismuthinite examined may be classified into four types—(1) straight rods of material of fibrous structure, or needles, 3 to 5 mm long and 0.3 to 1.5 mm in thickness; (2) spindle-shaped (sometimes flattened) masses of fibrous material consisting of two bundles of acicular crystals joined end to end, 2 to 5 mm long and 1 to 2 mm wide at the center; (3) flat bars consisting of two straight masses of acicular crystals joined together, end to end (usually at the center of the rod), at an angle of about 120°; and (4) straight rods (1 to 2 mm in thickness) of material, composed apparently of short crystals, which appeared fibrous in structure, but which were easily broken into lengths of 1 mm to 2 mm.

Samples A_1, A_2, and B_2, type 1, produced no sound when operated as a radiophone, in connection with the audion amplifier and telephone receiver.

Sample B_1, length 3.5 mm between the solder electrodes, type 4, produced a loud sound in the radiophone. On one side of the crystal the sound was loudest at the center of the cyrstal; on the opposite side, the sound was loudest near the end.

This crystal became detached and in resoldering it the distance between the electrodes was reduced 2.5 mm. A loud radiophonic sound was produced as before, especially in the center, at which point, later on, the crystal separated, leaving very ragged edges along the line of contact.

Samples C_1 and D_1, type 1, size 0.5 by 4 mm, gave no sound in the radiophone.

Sample C_2, type 3, size 1.5 by 4.5 mm, at first produced no sound. On cutting it thinner, a slight sound was produced when one side was exposed to radiation.

Sample C_3, size 1.5 by 5 mm, seemed to be a mixture of short crystals (type 4), which was light-sensitive in spots. No sound was produced when the light was projected on the ends of the crystal, showing that the phenomenon is not localized at the electrodes, as might be inferred from the earlier experiments with samples held by compression between copper electrodes.

This crystal had a small region on one side, near the center, which produced a fairly loud sound in the telephone receiver; and a faint sound was observed on the opposite side near the end. When this crystal was (accidentally) broken the fracture was along the line joining these two points. The fracture was very ragged and somewhat conical shaped.

Some interesting experiments were made on the light-sensitive spot in this crystal. Painting the ends of the crystal with lampblack did not affect the sound production; but on painting the sensitive spot no sound was produced. Removing the lampblack restored the sound, which became louder when the sensitive spot or the whole crystal and the electrodes were covered with alcohol. On immersing this sample in alcohol, the crystal separated into two parts (no force having been applied), and the question is whether, in this case, the sound was the result of a variation in resistance (at the surface of contact) with fluctuation in temperature.

Sample C_4, type 3, size 1.5 by 3 mm, gave a faint sound when one side was exposed to radiation, and a loud sound on the opposite side. The sensitive line between these two points marked the line of contact and partial intergrowth of two fibrous masses of crystals.

When exposed to the standard incandescent lamp, Fig. 1, a galvanometer deflection of 5 to 10 cm was produced, indicating a decrease in electrical resistance.

Sample C_5, type 2, flat rod, produced a faint sound when one side was exposed to radiation; but no audible sound was produced when the opposite side was similarly exposed.

Exposing either side to the standard lamp produced a deflection of about 3 cm. In comparison with C_4, the size of the deflection seemed to be in proportion to the sound produced in the radiophone, though tests on other crystals do not indicate any relation between radiophonic sensitivity and change in conductivity produced by exposure to the standard lamp.

Sample D_2, club-shaped, size 1 by 1.5 by 2.5 mm, produced a faint sound when the thick end was exposed to radiation; loudest on one side containing a projecting fragment of crystal.

The standard incandescemt lamp produced a deflection of 10 cm.

Samples E_1, E_2, E_3, E_4, and E_5 produced no audible sound. E_4 was a very fine crystal, 0.2 mm by 4 mm, of type 1. E_6 gave a faint sound at one end. It was of the same type as D_2, and after

removing a protruding edge no sound was audible. E_7, size 1.5 by 2.5 mm, produced a faint sound; and when broken the fracture occurred along the sensitive spot. E_8 produced no audible sound. E_9 produced a faint sound. This crystal broke very easily; type 4. E_{10} consisted of one end (length 2 mm) of E_9 remounted. It seemed more structureless than the average sample, having very short crystals. It produced a faint audible sound on all sides exposed; but one side, which appeared rough and structureless, produced a quite audible sound. The standard lamp gave a deflection of 6 to 8 cm whichever side was exposed.

Sample F_1, type 4, 1 by 1.2 by 2 mm, gave a loud sound when one side was exposed to radiation, but no sound was audible when the opposite side was exposed. The cleavage seemed rather structureless. The standard lamp produced the same galvanometer deflection, 2.5 cm, whichever side was exposed. The heat radiated by the hand held near the crystal produced a similar deflection, indicating a decrease in resistance as a result of warming of the crystal. This change in resistance was slow (exposure to light 15 to 30 sec.) and appeared to be the result of warming of the crystal.

F_2 produced no audible sound when exposed to the interrupted light.

Sample G_1, 1.5 x 3 mm, produced a fairly audible sound. The standard lamp produced a deflection of about 1 cm. In G_2, size 0.6 by 2.5 mm, no audible sound was produced. The standard lamp gave a deflection of about 3 cm. G_3, size 1.5 by 2 mm, produced a fairly audible sound when one side was exposed to radiation. The standard lamp caused a deflection of 2.5 cm. Radiation from the hand, or from a warm soldering copper, held near the crystal produced a similar deflection. This is not a thermoelectric effect, as was shown by heating alternately the junctures where the crystal touched the copper wires.

The results of this examination show that of the 26 samples of bismuthinite examined by the radiophonic method, 12 samples produced an audible sound. All of the 8 samples showed a decrease in resistance when exposed to the standard lamp or when warmed by radiations (from the hand) of wave lengths dominating at 8μ. Samples which responded to radiation stimuli from the standard incandescent lamp did not produce an audible sound when operated as radiophones; but this might have been owing to lack of intensity of the light stimulus.

Experiments must be made, using stimuli of equal energy of different wave lengths, and noting the heating produced, etc., in order to determine how much of this decrease in resistance is caused by rise in temperature and how much of—and for what wave lengths—this decrease in resistance is caused by a true photoelectric (radioelectric) change in this substance. Bismuthinite is sometimes seleniferous, and it will be of interest to determine whether the presence of selenium has any effect upon its photoelectrical sensitivity.

MOLYBDENITE (MoS_2)

The samples of molybdenite examined were soldered to copper terminals. A number of samples, which were 0.03 to 0.07 mm in thickness, 2 to 3 mm in width, and 5 to 20 mm in length, were tested. When exposed to the standard lamp a deflection of 2 to 3 cm was noted. The radiations from this same source, which remained after passing through red glass produced half this deflection; and large deflections were obtained for radiations from the hand and from a hot soldering copper.

These same samples, also others held by compression between copper electrodes, produced an audible vibration when operated as radiophones in connection with the audion amplifier. The sound produced was to some extent a function of the thickness of the lamina exposed to radiation. Some samples were sensitive in spots, as observed in bismuthinite. Audible vibrations were produced in spots on (1 mm) thick samples which were exposed to radiation.

No marked increase in loudness of the sound was observed after covering a sample of molybdenite with a thin layer of (soot) lampblack. This is probably to be expected in view of the fact that the reflecting power [6] of molybdenite is only about 30 per cent, so that the effect of the increased absorption caused by the lampblack might be outweighed by the increased heat capacity, etc.

The behavior of molybdenite when operated as a radiophone is similar to that of platinum and gold leaf, already described; with this difference, that in the former the resistance decreases with rise in temperature. From tests made in this laboratory and from the measurements made by Reichenheim,[7] the temperature coefficient of resistance of molybdenite is about $a = 0.0026$ to 0.003.

[6] Coblentz, Publication No. 97, p. 14, Carnegie Institution of Washington, 1908.
[7] Reichenheim, Inaug. Diss. Freiburg, p. 26; 1906.

In the case of cylindrite, molybdenite, etc., the alleged photoelectric effect and the rise in temperature, which results from the absorption of radiant energy, both tend to decrease the electrical resistance of the substance. From rough tests, made with radiations dominating in intensity at wave lengths 0.5μ, 0.75μ, 1.2μ, 2.5μ, and 4.4μ, respectively, the results show that molybdenite is sensitive to all of these radiations, and has a maximum sensitivity at about 1μ. For radiations dominating in intensity at 8μ to 9μ the tests are inconclusive to establish a resistance change which is greater than would result from absorption of radiant energy and the consequent rise in temperature, which, in comparison with selenium, is a criterion for distinguishing these two phenomena.

Further investigations are therefore in progress to determine (1) to what extent this decrease in electrical resistance is caused by rise in temperature when this substance is exposed to radiation, and (2) to what extent it is caused by radioelectric activity when stimulated by radiation of equal energy value but of different wave lengths.[8]

Molybdenite has a high specific resistance, but from consideration of some of its physical properties it seems to be promising material for a bolometer, in stellar radiometry where a short receiver of high resistance will be useful in connection with a string galavanometer or with an audion amplifier. It is quite sensitive to fluctuations in light intensity, so that, like selenium, it produces an audible vibration in a telephone receiver without the use of an amplifier.

SUMMARY

This paper summarizes the results of an investigation of various substances (1) for an increase in electrical conductivity caused by the action of light upon them, and (2) for photoelectrical activity when they were charged to a negative potential in an evacuated chamber and exposed to light.

Pure gallium and silver sulphide were found to have but small photoelectric discharging action when charged to a negative potential and exposed to light.

No change was observed in the electrical conductivity of tellurium, boleite, pyrites, silicon, and mixtures of the sulphides of lead and antimony when exposed to light.

[8] As this paper goes to press further data are being published; Amer. Phys. Soc., Apr. 27, 1918.

An increase in electrical conductivity was observed in crystals of selenium, stibnite, boulangerite, jamesonite, bismuthinite, cylindrite, molybdenite, and silver sulphide when exposed to light.

Radiophonic experiments are described in which some of these substances were joined through a battery to the grid circuit of an audion amplifier and a telephone. A change in current in this circuit affected the telephone. The light stimulus was interrupted by means of a rotating sectored disk, as used in Bell's selenium photophone. When using a cell or crystal of selenium the fluctuations in light intensity produced a sufficient change in conductivity to cause a musical note in the telephone. Similarly, in several samples of a crystal of bismuthinite a change in conductivity was produced, which caused an audible vibration in the telephone. In the case of bismuthinite this change in conductivity (production of an audible vibration) is confined to quite narrow regions along the length of the crystal; occurring usually at the intergrowth or line of contact of two bundles of acicular crystals. In the case of molybdenite the change in conductiviy is to some extent a function of the thickness (heat capacity) of the lamina. Further experiments are in progress to determine to what extent and for what wave lengths this resistance change is a true photoelectric phenomenon.

Experiments are described in which a thin, blackened strip of platinum or gold leaf is joined through a battery to an audion amplifier. The variation in temperature and hence resistance of, and current through the strip, caused by the fluctuation in intensity of the intermittent light, was sufficient in magnitude to produce an audible sound in the telephone receiver.

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