"dark" battery current through the crystal. In the present instance the photoelectric current is amplified or weakened, according as the external battery current flows with or against the thermoelectric current. As a result of this selective action, instead of obtaining the same photoelectrical reaction (the same galvanometer deflection, after correcting for any difference that may exist in the "dark" conductivity) on reversal of the battery current, there is an outstanding difference (1.5 to 2.5 times) between the maximum and the minimum photoelectrical effect. This is true of both positive and negative maxima of thermal e.m.f.'s.

47. **Photoelectric effect of cæsium vapor and a new determination of Planck's universal constant h.** JAKOB KUNZ and E. H. WILLIAMS, University of Illinois.—The ionization potential V_I is related to the convergence frequency ν_I of the principal series in the spectrum of the vapor by the expression $V_I e = h\nu_I$ where h is Planck's universal constant and e the charge of the electron. In view of the results in the x-ray region, we may expect an interchangeability in the effect of electron collision and radiation, *i.e.*, we may expect a gas to be ionized whether it is struck by an electron moving with the critical velocity corresponding to V_I or illuminated by radiation of the corresponding wave-length. To test this cæsium vapor was illuminated by ultra-violet light. The result was that for light below a certain wave-length, about 318 m μ, ionization was produced, whereas above this value no effect could be detected. Substituting in the above equation the frequency corresponding to this wave-length and the known values of V_I and e, we obtain for h the value $6.58 \cdot 10^{-27}$, while the accepted value is $6.554 \cdot 10$ erg sec.

48. **The transfer of radiation momentum in quanta.** WILLIAM DUANE, Harvard University.—According to the idea that radiation carries with it momentum as well as energy, whenever a ray changes its direction it changes its momentum also. If the law of the conservation of momentum applies to such changes, the transfer of momentum must take place between the radiation and matter. The fundamental assumption is now made that a transfer of momentum of this kind takes place in quanta, each of which is proportional to the action constant h. Dimensional reasoning suggests that a quantum equals a whole number multiplied by h and divided by a distance. The theory explains the normal reflection of x-rays by a crystal, including the reflection of rays characteristic of the chemical elements in the crystal (discovered by Dr. Clark and the author) according to the usual law. The paper includes applications of the theory to ordinary light in which equations are deduced for a number of problems of interference and diffraction. The distance to be used is the length characteristic of the apparatus in the direction considered. In general an equation derived from the principle of interference may be transformed into one representing the difference between two radiation momenta as equal to nh divided by a distance.

49. **Wave-length measurements of scattered x-rays.** ARTHUR H. COMPTON, Washington University.—X-rays from a tube with water-cooled, molybdenum target are scattered by graphite at different angles, and the spectrum of the scattered x-rays has been investigated. It is found that a single line in the primary beam is broken up into two or more lines in the scattered beam. If λ_0 is the wave-length of the primary beam, the shortest line in the scattered beam is λ_0, and the longest is $\lambda_0 + \delta\lambda$, where $\delta\lambda = (1 - \cos\theta)h/mc$, h, m and c having their usual significance. Thus $\delta\lambda = .0242(1 - \cos\theta)$ in Ångströms. When the x-rays are scattered by the graphite at 135°, there may be a third line between these two extremes.

The quantum theory, proposed by the writer to account for the change in wave-length of x-rays due to scattering, suggests that the longest line is scattered by very loosely bound electrons which are free to recoil from the momentum of the scattered x-ray quantum, while the line of unchanged wave-length is scattered by electrons held too firmly to recoil in this manner. Any intermediate lines on this view are due to electrons which recoil only after losing an appreciable amount of energy. It may thus be possible to distinguish the scattering by the different groups of electrons within the atom.