of the American Mathematical Society will be held on Tuesday morning, December 27, jointly with Section A (Mathematics), Section K (Economics, sociology and statistics) and the Econometric Society, the topic being "Statistics." Wednesday afternoon will be devoted to a joint meeting of the society, Section A and the Mathematical Association of America. At this session Dean L. P. Eisenhart, of Princeton University, retiring president of the society, will deliver an address on "Some Recent Developments in Differential Geometry." Following this address, Professor E. R. Hedrick, of the University of California at Los Angeles, will speak on "Tendencies in the Logic of Mathematics." On Thursday afternoon there will be a business meeting and a general session of the society. Later in the afternoon, at 4:30 P. M., the tenth Josiah Willard Gibbs Lecture, entitled "Thermodynamics and Relativity," will be delivered by Professor R. C. Tolman, of the California Institute of Technology. Sectional sessions of the society will be held on Tuesday evening and on Wednesday and Thursday mornings.

The seventeenth annual meeting of the Mathematical Association of America will be held on Tuesday afternoon, December 27, 1932, and all day Wednesday, December 28. The program will consist of invitation addresses.

The mathematicians have arranged a trip to Princeton for Friday, the train leaving the Pennsylvania station in Atlantic City at 8:45 A. M. At 11:30 A. M., soon after the arrival in Princeton, there will be an opportunity to inspect the new mathematical building, Henry Burchard Fine Memorial Hall. In the afternoon at 2:00 P. M. in Fine Memorial Hall there will be a symposium on "Application of the Operational Calculus to Mechanics," at which Professor I. von Neumann, of Princeton University, and Professor G. D. Birkhoff, of Harvard University, will speak.

Section B (Physics) will hold joint meetings with the American Physical Society, the American Meteorological Society, the American Association of Physics Teachers and the Society of Rheology. The retiring vice-president of Section B, Dr. Bergen Davis, of Columbia University, will give an address on "Conquests of the Physical World." Other addresses of broad interest will be given at general sessions of the association by Dr. Dayton C. Miller and Dr. O. H. Caldwell (see SCIENCE, for November 18).

The American Physical Society plans meetings from Wednesday, December 28, to Friday, December 30. Plans are practically complete for a symposium on "Cosmic Rays," in which Dr. Robert A. Millikan, Dr. A. H. Compton and others will take part (see SCIENCE, for November 11). The meetings of the American Association of Physics Teachers on Friday, December 30, and Saturday, December 21, will be made up of invited and contributed papers. The Society of Rheology will meet on Tuesday, December 27, and Wednesday, December 28.

A new general lecture of the American Association for the Advancement of Science, known as the Hector Maiben Lecture, will be given by Dr. Henry Norris Russell, of Princeton University, on Friday evening, December 30, at 8:30 P. M. in the Municipal Auditorium (see SCIENCE, for November 18). In speaking on "The Constitution of the Stars," Dr. Russell will review the works of Eddington, Jeans, Vogt, Milne and others and point out the present status of the problem. Professor Harlow Shapley, of Harvard University, will deliver the annual Sigma Xi Lecture on December 28, on "Fact and Fancy in Cosmogony."

Section D (Astronomy) will hold joint meetings with the American Astronomical Society. Sessions for papers are planned for the afternoon of December 27, morning and afternoon of the 28th, and morning of the 29th. Dr. J. H. Moore, who was in charge of the Lick Observatory eclipse expedition to Fryeburg, Maine, has chosen "Solar Eclipse Problems" as the subject of his address as retiring chairman of Section D. This address will be given at one of the regular sessions.

CHARLES F. ROOS,
Permanent Secretary

THE NATIONAL ACADEMY OF SCIENCES

PAPERS PRESENTED AT THE ANN ARBOR MEETING

AT the autumn meeting of the National Academy of Sciences, held in Ann Arbor, Michigan, on November 14, 15 and 16, the following papers were presented:

Interpretation of phenomena due to accommodation coefficient of ions at cathode surfaces: KARL T. COMPTON. About three years ago the writer, in collaboration with Dr. C. C. Van Voorhis, discovered an apparent inequality between the rates of generation and dissipation of heat at the negative electrode in a tube through which an electric current was transmitted through gas at low pressure. The hypothesis suggested to explain this was that the positively charged gas ions which bombard the electrode under the influence of the applied voltage, and become electrically neutralized by capturing electrons when they strike the electrode, do not lose all their kinetic energy of motion (as has hitherto been supposed)

but rebound as neutral molecules with a considerable fraction of their impacting energy. From the thermal measurements, this fraction was estimated in the case of several gases. If this hypothesis is correct, the rebounding ions should exert pressure against the electrode, and recent tests made in collaboration with Mr. E. S. Lamar have confirmed this conclusion. The electrode was a small metal plate suspended like a pendulum bob in the center of an intensely ionized gas, and so delicately balanced as to be measurably deflected from its position of equilibrium by impact of the gas ions carrying only a few microamperes of current. These "momentum" tests have entirely confirmed the conclusions drawn from the earlier "energy" tests. The mechanism of this "rebound" of ions is pictured, to a first approximation, as simply the collision of the gas ion with an atom of the metal surface—like the elastic collision of a projectile ball with a target ball. Hence we should expect the rebound to be greatest if the projectile ball (the ion) is much lighter than the target ball (metal atom), and we should expect no rebound if the ion is heavier than the metal atom. The experiments verify all these conclusions; the rebound is greatest for helium (which is very light) and successively less for neon and argon ions striking a molybdenum electrode, and there is no rebound at all when mercury ions (which are very heavy) strike molybdenum. A point of theoretical interest in this work is that it apparently completes the available methods of investigating ionized gases by means of electrodes. There are three "conservation principles" which may be applied: conservation of electric charge, conservation of energy and conservation of momentum. The old methods of using exploring electrodes depend on the first of these principles. The work here reported utilizes the other two. The many complicated occurrences at electrodes must, in the last analysis, be inferred from a study of these three observable quantities, electric charge (current), energy (heat) and momentum (pressure).

Development and program of the differential analyzer: VANNEVAR BUSH (introduced by K. T. Compton). The differential analyzer, a machine for solving ordinary differential equations, announced a year ago, has now been in use on important problems at the Massachusetts Institute of Technology. Experience has shown that a precision of somewhat better than one part in one thousand can be attained consistently from individual units under average conditions of operation, the overall precision depending upon the specific nature of the problem. Errors due to manual following of curves average out to such an extent that their effect can be made less than that of machine errors. About thirty problems have been treated, involving about one thousand solutions of equations. Studies of transients in synchronous machines have especially illustrated the type of problem in which large numbers of specific solutions are necessary. The Thomas-Fermie equation, and the same equation after introducing the relativity correction, illustrate the solution of non-linear equations, the introduction of difficult boundary conditions and the

attainment of precision by solving for departures. The Schrödinger wave equation has been written with a self-consistent potential field, and by means of the machine has recently been successfully treated for several nuclear numbers in the case of the helium-like atoms. This involved solving a fourth order, non-linear equation with boundary conditions at zero and infinity, together with a normalization condition. A technique was developed which made it possible to obtain the solution for each atomic number in two days with a single operator at the machine. Several constructional additions have been made to improve precision and convenience. Recording has been made precise by an automatic printer capable of giving five figures on six variables. Experience has developed new short cuts in placing problems on the machine and ways of reducing the number of operators. Variable coefficients are now introduced automatically, wherever possible, by generating them simultaneously by a part of the machine allocated to the purpose. A program for the construction of more powerful machines of this sort may now be stated with some assurance.

Thermal agitation of electrons in a metallic conductor: N. H. WILLIAMS and D. A. WILBUR (introduced by M. Gomberg). The development of the screen grid radio tube made possible very large amplification of high frequency electrical impulses, and opened the way for new methods of measurement of such quantities as the electron charge and the charges of positive ions in vacuum tubes. The fact that electricity is made up of discrete charges of finite magnitude gives rise to an effect analogous to the Brownian movement in liquids. In an ordinary radio tube operating with temperature limitation of the current, the electrons arrive at the plate with a perfectly random distribution in time and cause minute fluctuations of the potential of the plate. From measurements of these fluctuations, it is possible to compute the charge of the electron. This has been done with considerable precision. Determinations of the charges carried by positive metallic ions in evacuated space have also been made with accuracy. In accordance with the accepted ideas of the constitution of matter, we should expect the electrons in a metallic conductor to share the thermal agitation of the atoms of the substance, and accordingly there should be minute fluctuations of the potential difference between the ends of the conducting wire. Johnson, of the Bell Laboratories, discovered the existence of the phenomenon, and Nyquist, of the same laboratory, deduced an expression for its magnitude. The theory shows that the mean square of the fluctuating potential difference should be proportional to the resistance of the conductor and proportional to its absolute temperature. The experiments reported here accurately verify these proportionalities between the temperature of liquid air and that of boiling water. The most striking thing about this phenomenon is that it furnishes a new and independent means of determining Boltzmann's constant. The purpose of this work was the precision measurement of this important constant. The average result obtained from 85 indepen-

dent determinations is within a tenth of one per cent. of the value obtained from measurements of the gas constants, while the average deviation from the mean is seven tenths of one per cent.

Topological definitions of simple figures: WILLIAM L. AYRES (introduced by H. D. Curtis). The paper discussed the simple figures of topology such as the simple continuous arc, the simple closed curve, the simple closed surface, the number plane, etc. An exposition of the various definitions for these figures given by topologists from Schoenflies to the present time is given.

Report on metagalactic studies: HARLOW SHAPLEY.

Absorption and space reddening in the galaxy, as shown by the colors of globular clusters: JOEL STEBBINS. Most heavenly bodies are so remote that only for the nearer ones is it possible to measure the distances by triangulation. When the angles involved become too small, recourse is had to what may be called the photometric method. When the intrinsic luminosities of nearby bright stars are known, the distances of fainter stars of the same characteristics can be estimated from measures of their relative light. However, this method must be modified in cases where the intervening space is not perfectly transparent. With a photoelectric cell attached to the 100-inch reflector at Mount Wilson, the brightness and colors of various faint objects have been determined and the results show that there must be an absorbing region in space. Just as the setting sun appears red because of the greater amount of air we look through near the horizon than when the sun is overhead, so do the stars and clusters near the central line of the Milky Way appear reddened. The so-called space reddening is due presumably to an extended cloud of small particles, gas or dust, which obstructs and scatters the light from stars in and beyond this region but does not blot them out completely. Because of this absorption, the evidence is that some objects, like the globular clusters, have hitherto been estimated to be as much as four times as far away as they really are. At right angles to the Milky Way, that is, where there are fewer stars and where we can see better out in the open, the observations indicate relatively little absorption, and previously estimated distances need to be revised by not more than 10 per cent. The presence of the thin absorbing layer in the central plane of the galactic system is additional evidence that the group of a billion or more stars, to which the sun belongs, is similar to other systems which we call the spiral nebulae. The present paper supports the view that our own galaxy has no privileged position or special importance in the universe.

A suggested mechanism of class Be stars: DEAN B. McLAUGHLIN (introduced by H. D. Curtis). Many class Be stars show double emission lines of hydrogen, the duplicity being due to an absorption line which divides the emission centrally. These two emission components change in relative intensity, and at times one may be two or three times as strong as the other. Shifts of these lines are associated with the intensity changes. The displacements are towards the shorter wave-lengths when the component of greater wave-length is stronger, and vice-versa. The irregularities of the periods of these variations are such as to rule out conclusively any explanation in terms of orbital motion in a binary system. It is suggested that the atmosphere of a Be star is of great extent, much like a small planetary nebula. The emission lines are believed to originate mainly in the inner part of the atmosphere through photoelectric ionization of the hydrogen atoms and subsequent recombination. The outer atmosphere would be shielded from the ionizing radiation by absorption which occurs in the inner layers of atmosphere. Hence the outer layers produce the absorption lines upon the emission. The variations are explained purely in terms of the Doppler effect. The rotation of the stellar atmosphere produces the widened emission lines. Upon the broadening due to rotation is superimposed an asymmetry due to outward or inward streaming of the atoms. In a stage of atmospheric expansion the receding gases on the far side of the star give the strong emission component of greater wave-length which is not subject to absorption by the approaching gases on the near side of the star because of the Doppler shift, due to their relative velocities. The component of shorter wave-length, however, is subject to absorption by the approaching gases and is therefore weakened. At this phase the absorbing gases are approaching rapidly, giving the shift towards the shorter wave-lengths. Opposite effects occur when the expanded atmosphere collapses. A change of temperature of the star with consequent change of selective radiation pressure is postulated as the cause of the variations. The phenomena of Be stars are therefore regarded as a special case of stellar variation of the pulsation type.

Motion pictures of celestial phenomena taken at the McMath-Hulbert Observatory of the University of Michigan: ROBERT R. McMATH, F. C. McMATH and H. S. HULBERT (introduced by H. D. Curtis). The McMath-Hulbert Observatory, a branch of the Observatory of the University of Michigan, was founded for the purpose of recording changes or movement in the celestial objects by the motion picture method. One of its aims is to provide educational films which should be a valuable adjunct to instruction in astronomy. The film which accompanies the paper shows some of the preliminary results which have been secured during the past three years, as well as improvements to the telescope and mechanical aids which experience has proven necessary for success in this rather difficult field. This film shows, among other subjects, the phenomena of sunrise and sunset on lunar craters and the motion of Jupiter's satellites. An occultation of Delta Capricorni is also shown, in which the moon moves across the field of the telescope, showing both immersion and emersion. The method is now being extended to other subjects, such as the recording of the changes of variable stars, the rotation of Jupiter, etc. A spectroheliokinematograph has been designed and constructed

and is now being used to record the changes in the surface features of the sun, the motions within solar prominences and their growth and decay.

Biographical memoir of Jesse Walter Fewkes: WALTER HOUGH (read by title).

Biographical memoir of Thomas Alva Edison: ARTHUR E. KENNELLY (read by title).

To what extent are the so-called ketyls free radicals? WERNER E. BACHMANN (introduced by M. Gomberg). In 1891 Beckmann and Paul discovered that aromatic ketones react with metallic sodium. In 1911 Schlenk interpreted the structures of the sodium derivatives on the basis of free radicals. These ketyls are formed as follows:

$$(C_6H_5)_2C = O + Na = (C_6H_5)_2C - ONa$$
$$I$$

$$(C_6H_5)_2C(ONa)(NaO)C(C_6H_5)_2$$
$$II$$
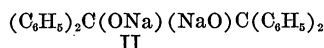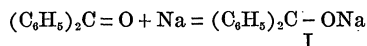
According to Schlenk, none of the expected dimolecular compound, sodium pinacolate (II), is formed. The chief support for the structure (I) is the fact that Schlenk obtained only the "single" molecules, $(C_6H_5)_2CO +$ $(C_6H_5)_2CHOH$, on hydrolysis of the sodium compounds and none of the "double" molecule, pinacol, $(C_6H_5)_2$ $C(OH)(HO)C(C_6H_5)_2$. We have reinvestigated this hydrolysis reaction and have found that by careful hydrolysis and manipulation, nearly quantitative yields of the "double" molecule, pinacol, can be obtained. The pinacol is always the initial product of hydrolysis, but under the conditions of hydrolysis is rapidly decomposed into the "single" molecules, ketone and hydrol. Schlenk's conclusion regarding the structure is based on erroneous experimental results; instead of being monomolecular, the compounds are nearly entirely dimolecular. It is considered that there may be a small amount of the sodium ketyl in equilibrium with the sodium pinacolate.

$$(C_6H_5)_2C(ONa)(NaO)C(C_6H_5)_2 \rightleftarrows 2(C_6H_5)_2C - ONa$$
$$< 100 \text{ per cent.} \qquad \text{small amount}$$
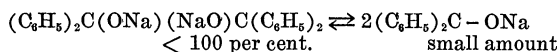
The Li, K, Cs, Rb, Be, Mg and Ca derivatives of ketones have structures similar to the sodium compounds.

The infra-red spectrum of H^2Cl: J. D. HARDY, E. F. BARKER and D. M. DENNISON (introduced by M. Gomberg). The fundamental bands at $3.46\,\mu$ due to absorption by the gases H^1Cl^{35} and H^1Cl^{37} are well known. Each consists of a series of sharp single lines, with one line at the center absent, and the two bands are almost exactly superposed. If an isotope of hydrogen exists with a mass of approximately 2, there should be a second pair of bands corresponding to the absorption by H^2Cl^{35} and H^2Cl^{37} molecules. The positions of the lines in these two bands would depend upon the relative masses of H^1 and H^2 and upon the molecular force fields, which are

presumably identical for H^1Cl and H^2Cl to a high degree of approximation. The bands should lie in the neighborhood of $4.8\,\mu$, a region very favorable for experimental investigation. Observations have been made with an infra-red spectrometer of high resolving power and an absorption cell seven meters long, having mica windows. Ordinary HCl was used, and also HCl generated from the water residue of electrolytic cells which should be somewhat enriched in the heavier hydrogen isotope. In both cases the absorption lines of H^2Cl were unmistakable. The positions of nineteen lines in the H^2Cl^{35} band and of seventeen lines in the H^2Cl^{37} band were determined with precision, and compared with those computed for an assumed ratio mass H^1: mass H^2. The slight differences provide an accurate correction for the mass ratio, for which the final value is 0.514430 ± 0.000004. The consistency of the results provides a convincing argument for the assumption of identical fields of force. The relative intensities of the bands due to H^2Cl^{35} and H^1Cl^{35} indicate an abundance ratio of about $1:35000$ for the two types of molecules in ordinary HCl. If 1.00778 be used as the mass of H^1, then the mass of H^2 is 2.01367 ± 0.00010, and the mass defect is 0.00189 ± 0.00010, measuring the energy of formation of the H^2 nucleus from elementary particles. The mass defect depends very little upon the accuracy of the mass assumed for H^1.

The neutron and atom building: WILLIAM D. HARKINS.

The determination of reaction probabilities of some elementary mechanisms: WORTH H. RODEBUSH (introduced by W. A. Noyes).

Types of chemical reactions: WILLIAM A. NOYES. Reactions are classified, in accordance with their electronic character, under five heads: (1) Formation of ions; A, with complete octets, B, from covalences, one with eight electrons, one with six. (2) Ionic reactions; A, ions with complete octets, B, ions formed from covalences. (3) Dissociation and reactions of electrically neutral atoms and molecules. (4) Formation of covalence groups with more pairs of electrons than the number of valence electrons in the central atom. Odd electrons may be transferred either to such covalence groups or to atoms forming ions exterior to the complex. (5) Sidgwick's terms, "donor" and "acceptor," are extended to include odd electrons, and the electronic theory is developed in such a manner as to include all classes of compounds.

The reaction of hydrogen atoms with oxygen: JOHN R. BATES (introduced by M. Gomberg). It has been shown that 90 per cent. hydrogen peroxide may be obtained in the reaction products of hydrogen atoms with oxygen. The atoms are produced by the action of excited mercury atoms. This result is in contradiction of a generally accepted mechanism proposed by Haber for this reaction. The influence of water vapor on the reaction is also shown to be in disagreement with a modified mechanism suggested by Frankenburg and Klinkhart. Furthermore, from a study of the photo-oxidation of

hydrogen iodide it appears that the life of the complex HO_2 involved in this reaction must be of the order of 10^{-9} seconds, a value much larger than that generally accepted for such quasi molecules.

The solubility of rare earth salts in non-aqueous solvents: B. SMITH HOPKINS and L. L. QUILL (introduced by R. Adams). All the methods of separating the members of the rare earth group, almost without exception, have been applied to aqueous solutions. Separations by these methods are tedious and not effective. Some of the non-aqueous solvents are known to possess differential solvent action when applied to the anhydrous salts of this group. The salts studied have been the anhydrous chlorides and nitrates of lanthanum, cerium, praseodymium, neodymium, samarium and gadolinium. The solvents employed included various alcohols and ethers, ethylene glycol, glycerol, dioxan and ethyl and methyl cellosolve. It has been shown that under favorable circumstances ethyl ether may be used to effect a rapid separation of neodymium and praseodymium.

The value of free energy determinations of organic reactions: DONALD B. KEYES (introduced by W. A. Noyes). To be printed in SCIENCE.

Magnetic moments of atomic nuclei: SAMUEL A. GOUDSMIT (introduced by H. D. Curtis). (Read by title.)

Ceric sulfate, a new reagent in analytical chemistry: HOBART H. WILLARD (introduced by M. Gomberg). (Read by title.)

A geographic study of cosmic rays: ARTHUR HOLLEY COMPTON.

The agglomeration theory of sleep: WILDER D. BANCROFT. It is very generally admitted that the sleep due to chloroform, morphine or alcohol is the same in principle as ordinary sleep, though differing in details. Sleep is therefore due to a reversible agglomeration of some of the proteins of the centers of consciousness by a substance or group of substances which has not yet been identified completely and which we will call X for the present. The concentration of X increases when work is done. The agglomerating effect of X can be counteracted to some extent by the effect due to the irritability of the sensory nerves. It is the balancing

of these two effects which makes going to sleep a voluntary action to some extent. A peptizing agent, such as sodium rhodanate, will decrease this irritability and may thereby make sleep possible, though not causing it. We have counteracted the effect of coffee in this way. A larger dose of the peptizing agent may act also on the centers of consciousness and thereby prevent sleep. We make use of that when counteracting the effect of morphine. That one person wakes readily at one noise and another at another is due to conditioned reflexes, the stimulus to which one is conditioned acting like a loud-speaker. Since most of us wake before digestive disturbances become effective, we must postulate the excess production during sleep of a substance—possibly adrenalin—or group of substances which we will call Y. It irritates the sensory nerves and wakes the sleeper eventually, unless he is waked sooner by some other cause—hunger, thirst, need to relieve oneself, light on the face or an alarm clock, for instance.

The functions of the olfactory parts of the cerebral cortex: C. JUDSON HERRICK. In the human cerebral cortex the non-olfactory (neopallial) part is more massive and complicated than the olfactory parts. In the lowest mammals these relations are reversed. The differentiation of the olfactory cortex has culminated in the lowest extant mammals with little farther specialization in any higher forms, but the neopallium is progressively elaborated from meager beginnings in primitive mammals up to the human complexity. It is suggested that the olfactory cortex performs two dissimilar functions: (1) a specific participation in associational processes, similar to that of other sensory systems, save for lack of any participation in the localization of the source of the stimulus; (2) a non-specific activation or inhibition of cortical or subcortical activities whose pattern of performance is dependent upon the non-olfactory components of the total situation. Similar specific and non-specific functions are performed by all cortex. In neopallium specific and localized functions predominate, more so in higher mammals than lower. In the olfactory cortex of all mammals the non-specific type predominates. In lower forms, where neopallium is small and undifferentiated, cortical functions are more nearly equipotential than in higher forms where olfactory cortex is relatively small and neopallium is large and highly specialized.

(To be continued)

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AUTOMATIC WATER-LEVEL REGULATOR FOR AUTOCLAVES

MANY laboratories are equipped with the horizontal steam pressure autoclave, which is not supplied by a live steam main but depends on steam from water boiled in a generator directly beneath the sterilizing chamber and connected to it by a pipe. In the usual operation of the apparatus, the generator is filled two thirds full of water by a hand-operated valve on the

water system line, a gauge on the generator indicating the desired level. There is then sufficient water for sterilization at 15 pounds for a short period of time, but the operator must glance at the gauge occasionally to make sure that the water level has not dropped so low that the intense heat from the gas flame will burn out the generator. Should the water level drop, the operator can let more water into the generator and continue sterilization. This constant