Mendeleeff, when he saw the law of the periodic arrangement of the elements, *knew* that elements exist which would fill the gaps; but it took many years of work by many men to find a part of them; and during the past few years a half dozen or more of the vacant places have been occupied. Each geologist, each scientist, now as in the past, is just as right as he should be. The scientific seers will ever go far in advance and guide others, even as did the spiritual seers of old.

The scope of these observations doubtless extends beyond geology. Much of what has been said is true of knowledge as a whole, not restricted to one subject. But I shall have accomplished my purpose if what I have said be true of geology; for if my conclusions be well founded, they furnish the basis upon which courses leading to degrees in professional geology should be laid out, and to methods of good geological work in the field and in the office.

C. R. VAN HISE.
UNIVERSITY OF WISCONSIN.

SECTION D, MECHANICAL SCIENCE AND ENGINEERING.

PAPERS were presented as follows:

The Trend of Progress of the Prime Movers: PROFESSOR R. H. THURSTON, Cornell University.

1. The great prime movers have been known in type and in some cases, in specific forms, still familiar, since the days of Hero of Alexandria and probably may have been in some forms known to prehistoric Greeks and Asiatics. The sources of power—heat, falling waters, the winds—all were well known when the earliest scientific writings were produced, and the famous Alexandrian 'Museum' contained illustrations and examples of even some of our simpler familiar types of steam-engine and steam-boiler.

2. The prime movers made little progress toward their present perfection until the commencement of the eighteenth century, when the steam-engine of Savery and Worcester, the old steam fountain of Hero the Younger, was displaced by the modern steam-engine, a real train of mechanism, devised by Newcomer, the inventor of the modern type of machine, about 1707. Meantime, water-wheels and windmills were taking form and the prime movers thus were preparing to do their part in the world. Improved by Watt, the steam-engine assumed the largest part of the load, but the water-wheels and windmills have always done a large amount of work in the aggregate. The industrial world came after a time to be moved as a whole by the prime mover of Watt, and steam power has of late performed vastly more work than could the whole population of the world, unaided.

3. The gas-engine has a history of about the same length as the steam-engine in its form of a prime mover for mills. It was introduced about a century ago and has progressed meantime less rapidly than its rival, but since the middle of the nineteenth century its advance has been steady, both in construction and in employment. To-day this motor has assumed a perfection of design and construction and has attained an excellence of economical performance which is rapidly bringing it into use in a great variety of fields and is, in fact, making it a promising competitor with the older motor.

4. The other motors have been meantime greatly improved. The modern hydraulic turbine has attained an efficiency of eighty per cent. and upward and the contemporary windmill is a scientifically designed, skillfully made apparatus of but little if any less perfection, for its purpose, or efficiency in utilizing its form of energy. All the common forms of prime movers have now, thanks to advances in sciences related to

engineering and to the progress of invention, become highly perfected and the next question of the engineer and of the employer of power has come to be: 'What new motor can be devised to more perfectly utilize the available energies of nature?'

5. The serious wastes of the best heat-motors are doubly serious and important in view of the fact that our coal deposits are of limited extent and that however great they may appear, that limit will be attained in one fifth of the time, even with the best practice of to-day, that would be secured could the wastes, now apparently inevitable, be extinguished. Our best steam and gas-engines waste four times as much of the thermal energies supplied them as they utilize. A substitute for these engines must be sought if they cannot be made thus practically perfect; but no way is known to which the purely thermodynamic wastes which constitute the greatest obstacle can be prevented.

6. Our existing stores of available energy may possibly be reinforced by more complete employment of the water-powers, the wind currents and the internal heat of the earth. Our present wastes of thermal energy might be reduced to comparative insignificance could a way be found of imitating nature in the complete utilization of the supply through other processes than thermodynamic. Nature actually does produce light without heat and apparently, at least, power without thermodynamic wastes; it would seem that man should be able to imitate her methods. If this could be done, our electric lighting could be provided or a substitute of similar value obtained that should reduce the wastes, as in the fire-fly and the glow-worm, with one four hundredth as much expenditure of energy as now is exacted in the production of light by our usual forms of illuminant. It would be possible to increase the amount of power derived from a stated quantity of potential energy four or five times. Heat drawn from the interior of the earth would provide us with what may be needed by man as long as man can live upon a cooling globe.

7. When the inventors and discoverers have thus performed their task, 'we shall be assured of a vastly longer persistence of civilization upon the globe, shall be able to employ mechanical power at a fraction of its present cost, shall secure light without heat and of a hundred times greater quantity at the same expenditure, shall distribute the electric current for whatever purposes at minimum expense, and shall make every civilized nation on the earth many times wealthier and shall extinguish poverty and, largely, crime.'

On Changes in Form as an Essential Consideration in the Theory of Elasticity: FRANK H. CILLEY, Engineer's Office, New East River Bridge, New York City.

While we perceive the necessity of recognizing and allowing for large distortions of elastic bodies under load, we are apt to think that, if the distortion be sufficiently small, it is negligible. We are apt to proceed on the supposition that changes in stress and deflection due to an added load are unaffected by the existence of other stresses at the time the load was applied. This is incorrect. Distortions, however small, may seriously modify the change in stress and deflection due to a given load. And the existence of other stresses at the time of the application of the load may be a most important consideration.

The consequences of small distortions may be fully taken into account by direct but highly mathematical analysis. But methods of approximation will usually answer the same end and be much simpler in single numerical cases. We have only to determine the distortion from the stresses as ordinarily found, and then recalculate the stresses for the changed form.

The cases in which this more exact procedure is most necessary are to be found chiefly among problems in thin plates, rods, trusses with very light webbing, arches and suspension bridges.

A simple case is the post under combined axial and transverse load. Standard posts may have bending moments and deflections a third to a half greater than they would were they simple beams. And this is equally true whether the end pressure be due to loads or to a stressed tie (primary stress).

The posts under combined axial and transverse loads are comparable to the parabolic arch ring under uniform load and bent by a concentrated load.

They are sufficiently slender to have materially increased stresses and deflections in consequence of their distortion.

Frameworks with sufficiently light webbing may have very different stresses and deflections from those determined by the usual methods. This is particularly the case with heavy bowstring trusses.

But the greatest divergencies in practice resulting from the application of the more exact analysis which takes account of small changes in form, are found in connection with suspension bridges. There the fundamental proposition of the usual analysis, that single loads on the stiffening truss cause a uniform increase in the suspender stresses, is sensibly in error and leads to many most incorrect conclusions.

To sum up, even small changes in the form of some structure have most appreciable consequences, and stresses existing at the time of the application of a load may most seriously modify its effects. These truths require more general consideration.

The Ratio of Direct to Transverse Change of Dimension under Longitudinal Stress (Poisson's Ratio): PROFESSOR THOMAS GRAY.

This paper consisted mainly of a description of the apparatus and methods of measurement employed in the determination of Poisson's ratio for metal bars.

The specimens used were round bars varying in thickness between one and a quarter and two inches. The stress, either tension or compression, was applied and measured by means of a Rhiele testing machine capable of applying a total load of 100,000 pounds. The lengths under test were usually either ten inches or sixteen inches, and the elongation or compression was measured by means of the author's autographic attachment to the machine (*T. A. S. M. E.*, Vol. XIII., 1892). The autographic record was omitted, the change of length as indicated by the magnifying levers being read, for particular loads, from a scale. The transverse change of dimension, which is much the more difficult to measure with accuracy, was obtained by means of a special calipering device contrived by the author of the paper and constructed in the Rose Polytechnic shops. This apparatus was carried by the specimen at the middle of the test length, in such a way that the points of contact of the caliper levers were at opposite extremities of a diameter and remained constant. The magnifying power was adjustable and could be made such that a change of diameter of less than one millionth of an inch gave a positive indication. The total change of dimensions which can be obtained, within elastic limits, is very small even for steel, being only about one three thousandth of an inch on a diameter of one inch.

It has been customary to infer the value of this ratio for separate determination of the Young's and the rigidity modulus of elasticity on the assumption that the material is nearly enough isotropic. One of the objects of this direct measurement was to test the reliability of this method of inference. If E be Young's modulus in the rigidity modulus, and σ Poisson's ratio, the theory of elasticity gives, for an isotropic solid,

$$\sigma = \frac{E - 2n}{2n}.$$

Now for most metals E is about two and one half times n. Hence it is evident that a small error in the determination of E or n may be quite a large error in the inferred value of σ.

The results of the experiments in general were that for steel either hardrolled or annealed the results given by the above formulæ and those got by direct measurement are almost identical. In the cases of cast iron and alloys of the metals, however, the results obtained from the formulæ are not reliable. The following short table illustrates the results obtained by direct measurement:

Description of Specimens.	Diameter.	Range of Lod in Pounds.	Young's Modulus.	Poisson's Ratio.
Hammered tool steel 1.5 per cent. carbon, hard...	1.4985	50000	29.5×10^6	0.291
Hammered tool steel 1.5 per cent. carbon, annealed	1.4930	20000	29.5×10^6	0.291
Hammered tool steel 1.2 per cent. carbon, hard...	1.4988	50000	29.7×10^6	0.293
Hammered tool steel 1.2 per cent. carbon, annealed	1.5130	30000	30.0×10^6	0.294
Hammered tool steel 0.9 per cent. carbon, hard...	1.5513	50000	29.4×10^6	0.288
Hammered tool steel 0.9 per cent. carbon, annealed	1.4830	30000	30.0×10^6	0.295
Cast bronze 90 per cent. copper (compression)...	1.496	16000	10.8×10^6	0.297
Cast bronze 90 per cent. copper (tension)........	1.496	12000	10.9×10^6	0.303
Aluminum zinc alloy density 3.4...............	1.4970	7000	5.27×10^6	0.208
Aluminum zinc alloy density 3.5...............	1.2445	14000	7.79×10^6	0.290
Cast iron..............................	1.7485	5000	13.27×10^6	0.258
Cast iron..............................	1.7485	16000	11.81×10^6	0.245

Effect of Hardening on the Rigidity of Steel: PROFESSOR THOMAS GRAY.

Attention was called to this subject some months ago in a paper read before the American Society of Mechanical Engineers by Professor C. H. Benjamin. The principal subject in that paper was the resistance to compression of helical springs. Incidentally it was stated that the modulus of rigidity derived by calculation from these experiments was much higher than that usually given in the published data for steel. This seemed contrary to my experience, but on looking for direct evidence on the subject no record could be found. In consequence a few specimens of steel, containing different amounts of carbon, were prepared and tested directly for rigidity in their original state, and also after hardening by heating to redness and quenching in water. The results are given in the tabular form below. The percentages of carbon in these specimens were not determined as the exact amount did not seem of any importance. Specimen No. 3 had just carbon enough to admit of hardening.

The results show the effect of hardening

Kinds of Steel.	Diameter in Inches.	Length Under Test in Inches.	Modulus of Rigidity.
High carbon tool (soft)........................	1.430	12.24	11.61×10^6
High carbon tool (hardened)....................	1.430	12.25	11.46×10^6
Medium carbon tool (soft)......................	1.444	12.27	11.67×10^6
Medium carbon tool (hardened)..................	1.415	12.30	11.56×10^6
Low carbon tool (soft).........................	1.4895	12.06	12.32×10^6
Low carbon tool (hardened).....................	1.4895	11.44	12.23×10^6
Low carbon tool (blue tempered)................	1.4895	11.90	12.27×10^5
Special tool 1.5 per cent. carbon (soft)..........	1.4930	16.63	11.58×10^6
Special tool 1.5 per cent. (hardened)............	1.4900	16.27	11.51×10^6

on the rigidity to be small but instead of a large increase it is a diminution.

The Advantages of Siamesed Hose Lines for Fire Steamers: MANSFIELD MERRIMAN. Lehigh University, South Bethlehem, Pa.

The method of using several parallel lines of hose from a fire steamer to a siamese joint is explained, and formulæ for the discharge and effective velocity head of the stream from the nozzle are established. The effects upon the discharge and velocity-head of two, four and six lines of hose are illustrated by practical examples and exhibited graphically. The great increase caused by two or three lines is noted, as also the much smaller increase caused by additional lines. It is shown that more than six lines are rarely advantageous and that four lines probably give the best practical results. In conclusion the author briefly notes and compares the analogy between the formulæ for the common and viscous flow of water in pipes laid in parallel with that for the flow of electricity in metallic conductors.

The Nomenclature of Mechanics: R. S. WOODWARD, Columbia University, New York.

The object of this paper is to advocate the desirability of adopting definite and unique meanings for the principal technical terms of mechanics, of discarding all secondary meanings of such terms, and of inventing new terms when essential to distinguish mechanical principles and properties differing from one another.

On a Type of Planetary Orrery Utilizing the Mechanical Principle of the Conical Pendulum: DAVID P. TODD, Director of the Observatory of Amherst College.

This machine is intended to employ the principle of the conical pendulum. Pendulums of different length, suitable to the revolution periods of the planets, are attached at the upper end to concentric arbors, properly geared; the spheres representing the planets are attached to the lower and outer ends of these pendulum rods. In this way the relative periods of revolution of the planets and their sizes can be conveniently illustrated mechanically on as large a scale as may be desired.

The Viscous Dynamometer: J. BURKITT WEBB.

Some years since the author designed an absorption dynamometer depending on the viscosity of water for use in testing the Whitehead torpedo and the results were published in the *Stevens Indicator*. In the use of it a very convenient property which it possessed was discovered, namely, that a sufficiently exact relation existed between the moment tending to rotate it and the number of revolutions, to make it possible to get the horse-power from an observation of the moment only. This was especially valuable in Whitehead torpedo work on account of the engine running but a short time.

The dynamometer was redesigned three or four years ago for testing turbines for electric light work and is now used largely for that purpose. The one first built consists of two steel disks (circular saw blanks) mounted on a horizontal revolving shaft on which is journaled a cast-iron case enclosing the disks and supporting a stationary disk between them. The sides of the case are also turned true so that each revolving disk has a fixed surface about one eighth of an inch distant from it. The case is supplied with water which is allowed to run slowly through it to prevent a rise of temperature, and means are provided to regulate the amount of water in the case, which is kept by centrifugal force in annular layers or disks at the other part of the case cavity. The shaft being now connected with a source of power of sufficient speed, the viscosity of the layers of water tends to carry the case and fixed discs around with it, which being prevented by a spring balance attached to a radical projection from the case, the moment is readily obtained.

Various interesting facts developed themselves in the use of this instrument and experiments in progress by a large electric company confirm the theoretical formulas for the moment by which the dynamometer can be correctly designed.

The horse-power absorbed is adjustable by varying the amount of water retained in the case, which is easily done.

A specially interesting thing was the effect of handling the water entering the dynamometer; let the hands be wiped (not washed) ever so carefully, after handling the ordinary slightly greasy tools and parts of machinery, and held under the stream of entering water, there would be an immediate reduction of the moment by about ten per cent.

As an illustration of the effectiveness of this dynamometer it is sufficient to say that the two revolving disks two feet in diameter absorbed the whole one hundred and ninety horse-power of a turbine of twice their diameter.

The Dynamophone, a new Dynamometer: J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

The dynamophone is a new form of transmission dynamometer. In a large number of cases when power is to be measured mechanically it is done by observing the extent to which some elastic substance yields and deducing therefrom the stress caused in it by the transmission of the power to be measured. Power is transmitted mechanically mainly by rotating mechanism, and such transmission is invariably accompanied by a *change of phase,* that is, the driven part lags behind the part that drives. The simplest and most common example of this is an ordinary line of shafting in which we have only to determine the torque and number of revolutions to find by their product the energy transmitted. About 1880 I was working under the direction of Professor Helmholtz upon the change of phase in an alternating current in a circuit containing an electrolytic cell as well as resistance, capacity and inductance, and invented an apparatus (of which the dynamophone is a modification) for making and measuring a difference of phase. After my return to the United States this remained packed away, until recently the problem of measuring the power transmitted to a marine propeller presented itself. The motor being an improved form of turbine, the ordinary steam-engine indicator could not be used, and so a portion of the shaft was prepared for the purpose and exactly calibrated by ascertaining the torque required to twist it from one degree up to ten degrees. To measure the twist of the shaft when revolving from 400 to 700 times a minute and transmitting from 100 to 2,300 horse power the dynamophone was successfully employed and in the following manner:

Upon each end of the calibrated length of shaft a wheel twelve inches in diameter was mounted, having 36 teeth. In front of each wheel a telephone magnet and coil was supported, the axes of the magnets at right angles to the shaft. The ordinary vibrating disks of the telephones were thus replaced by the toothed wheels, which thus induced in the telephone circuits a musical tone the strength and quality of which could be adjusted by screws which varied the distance of the magnets from the wheels. These telephones were further mounted so that they could be revolved about the center of the shaft with a scale and microscope to measure their angular position, and such a revolution must of course change the phase of the tone vibrations. To compare the phases of the two telephones, their circuits were connected in series with one (or more) receiving telephones, so that one (or more) observers could hear the combination or algebraic sum of the tones. Now the tones being adjusted to equal strength by the adjusting screws and to the opposite phases by revolving one of the mounted magnets, the receiving telephone gave no sound, and this condition of things was evidence that the teeth at both ends passed before their magnets at the same time. Now the zero having been determined with the propeller disconnected, it remained only to observe the angle through which the observing magnet had to be moved when the shaft was running under torsion, to have a measure of the twist of the shaft.

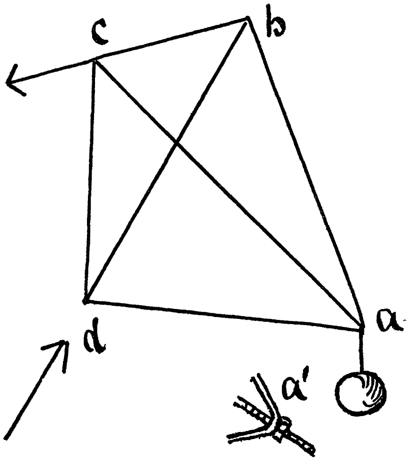
The apparatus gave perfectly accurate results with a precision of from one quarter to one per cent. The zero was readily and certainly obtained by a particular method of observation and in spite of the noises of the running machinery, and the results required only a single multiplication to give the horse-power corresponding to any particular observation. A model of the dynamophone was exhibited to the Section, with photographs connected with a recent test of the new turbine yacht *Revolution*.

The Deflection of a Complete Quadrilateral: J. Burkitt Webb.

The object of this paper is to outline a method which I have used for some years at Stevens Institute for investigating the stresses in framed structures with superfluous members. Suppose we consider *ac* as superfluous and imagine the joint *a* to be constructed as indicated in the figure.

Now remove the weight and screw up the nut until the perfectly definite stresses thus produced in the members amounts to some convenient amount, say a tension of minus 40 in *cb*. An ordinary force polygon is then drawn, giving the corresponding stresses in the members, and, the material and dimensions being known, the strains due to these stresses are tabulated for all the members.

This primary part of the process is completed by finding the displacements of all the joints and the lower end of *a* by means



of a displacement polygon (treated of in a paper before Section A), which gives the *distance* which the nut must be screwed up to produce the assumed stresses.

Secondly, the nut is run down entirely out of the way and the weight put on to produce a stress of plus 40 in *bc* and another force polygon is constructed with its corresponding deflection polygon.

The final operation is to screw up the nut any desired distance and then add the stresses thus produced to those already due to the weight. Evidently the final stresses consist of the weight stresses plus the primary stresses multiplied by a fraction, the denominator of which is the distance determined as corresponding to the minus 40 in *bc*, and the numerator of which is the distance the nut may be finally screwed up.

A New Photometer for the Measurement of the Candle-power of Incandescent Lamps: Professor C. P. Matthews, Purdue University.

Nearly every one in this age of electric lights knows that the familiar incandescent lamp is made in several sizes of different brightness or candle-power. The common size yields nominally a light in the direction chosen for rating equal to that emitted by sixteen standard British candles. The light emitted in other directions depends on the form in which the filament is coiled. Now, it is possible for each of two lamps to yield light in the measured direction of 16 c. p. intensity, and yet to produce quite different total amounts of light. This means that the lamps, although nominally of the same candle-power, are actually of quite different power as producers of general illumination.

Clearly the only true criterion of the worth of lamps as producers of light is the average light produced in all directions. This value is called the mean spherical candle-power.

A new form of photometer has been devised by Professor C. P. Matthews, of Purdue University, that gives this value with the ease and simplicity of the ordinary photometric measurement. A double ring of mirrors produces on one side of the photometer screen an illumination proportional to the mean spherical candle-power of the lamp to be tested. This illumination is balanced or equalized against that due to a light of known candle-power at a distance that can be read from a convenient scale. The instrument is adapted to all forms of photometric measurements or incandescent lamps, gas flames and sources of like intensity.

The Proposed Air-ship Contests at the St. Louis Fair: CALVIN WOODWARD, Washington University.

It is the expressed opinion of many, perhaps the conviction of most people, that nothing ever will be accomplished in the way of aerial navigation that is of permanent commercial or social value. It is admitted that balloons may furnish valuable positions for observations in war, but no air-ship will ever be able to make trips to and fro, carrying either freight or passengers. With all due respect to such people, the author is bound to differ. They beg the question. He freely admits that the problem has not been solved; that our appliances for the transformation and utilization of energy are at present inadequate; even the line along which progress is to be made has not been fully determined; but he has no doubt of the result. It may, and probably will, take many years, but there is plenty of time, and even the wisest of us 'do not know it all.'

History ought to teach us something of the proper attitude toward unsolved problems. It will be remembered that a commission consisting of the most eminent of the engineers of England headed by Rennie opposed the use of the locomotive on the first complete railroad, but Stephenson persuaded the owners of the Liverpool and Manchester road, who had expected to pull their trains by cables moved by stationary engines, to offer a prize of $2,500 for the best locomotive and to open the competition to the world. The result was the entry of five engines, among which was the victorous 'Rocket' which demonstrated the possibility of a successful railroad locomotive. The result proved the great value of an open competition.

Scientific men sometimes nod. Professor Lovering, afterwards President of the American Association for the Advancement of Science, when Cyrus W. Field was preparing to lay the first Atlantic cable, in a lecture to the author's class at Harvard, proved the utter impossibility of telegraphic communication under an ocean 3,000 miles wide.

The Executive Committee of the Louisiana Purchase Fair believe that progress in aerial navigation is possible and they have proposed to stimulate it. They have decided to offer liberal prizes and to enforce conditions which will call out the best efforts of the best investigators.

They specify no device or machine; they base everything on performance, on a return course requiring a high degree of control. They have fixed a minimum which greatly exceeds any recorded maximum.

Before reading their rules the author wishes to call attention to two considerations touching the possibility of progress and the probable line of approach.

Rapid progress is being made in the matter of reducing the weight of prime movers per horse-power. The diminution of the steam-boiler, as shown by the gas-engine and the Diesel motor, has made it quite possible to construct an engine as strong as a horse and as heavy as a goose. Human ingenuity will surely suffice sometime to enable such an engine to fly.

The skillful teacher at the swimming school gently buoys up the novice while he learns how to move his arms and legs. As his pupil masters the movements and coordinates the strokes he needs less and less of help from the fish-pole and line of the instructor, and soon he swims without assistance and to his great surprise.

Will it not be so with the navigator of the air? At first he needs the buoyancy of a balloon attachment while he elaborates his propellers, planes and guides. As these increase in efficiency the balloon attachment diminishes, until finally it may disappear altogether. Who can say it will not? The writer has no hope from the balloon pure and simple. He has at present small hope of a pure flying machine; but he has great hope of a device which, while flying, accepts more or less aid from a buoyant gas.

New Methods of Experimentation in Aerodynamics: A. F. ZAHN.

In this paper Zahn outlines some researches in aerodynamics by Mr. Mattullath and himself at the Catholic University of America. Their investigations cover a variety of subjects important to the science of practical dynamic flight, but the paper is confined mainly to the description of a new laboratory and equipment for generating a uniform rectilinear flow of air and measuring its effects upon various models and shapes of scientific and practical interest—in other words, the description of an aerial 'model basin.'

In a special building erected on the campus by Mr. Mattullath is a wooden air tunnel fifty feet long by six feet square in cross sections, having a five-foot suction fan at one end and a netting or two of close mesh at the other. A wind is thereby generated of practically uniform velocity and direction, the speed varying less than one per cent., the direction but a small fraction of a degree. In this current are held objects whose lift, drift, skin-friction, etc., are to be measured.

A general description is given of the apparatus for generating and controlling the wind, the devices for proving its uniformity of velocity and direction, the instruments for measuring its effects on immersed bodies. Among the various anemometers and wind balances designed is a pressure gauge graduated to millionths of an atmosphere, and which may be adjusted to read to less than one ten-millionth. It is connected by hose to one or more Pitot nozzles, and is used to measure the air velocity and pressure at all points of the stream, particularly in the neighborhood of the exposed body.

The results of each investigation will be given in technical detail in a series of papers, excepting those that are withheld for business reasons. The prime motive of these researches is to furnish a basis for calculations in aeronautics, particularly in the theory of mechanical flight.

Long Distance Electric Transmission Regarded as a Hydrodynamic Phenomenon: HENRY T. EDDY, University of Minnesota. (A full abstract will be published later.)

The Effect of Weeds and Moss upon the Coefficients of Discharge in Small Irrigating Canals: J. C. NAGLE, College Station, Texas.

This paper gave the results of a half dozen measurements made during the summer of 1901 upon small irrigation canals discharging from about three and one half to twelve cubic feet of water per second, and will show the retarding effect of moss and weeds in some of the canals.

The Compound Pendulum: ALBERT KINGSBURY, W. P. I., Worcester, Mass.

The paper referred especially to a diagram by means of which the relations between the centers of suspension, of gyration and of oscillation are graphically determined; the identity of centers of percussion and of oscillation; the interchangeability of centers of oscillation and of suspension; the position of the axis of suspension for minimum time of small oscillations; and the two cylinders of positions of the axis of suspension for any given time of oscillation.

Crushed Steel and Steel Emery; an Artificial Abrasive produced from Steel: M. M. KANN.

The Mechanics of Reinforced Concrete Beams: W. KENDRICK HATT.

A Test of a Ball Thrust Bearing: THOMAS GRAY.

Determination of the Exponent in the Equation pv^n of Heat Engine Indicator Diagrams: W. T. MAGRUDER, Ohio State University.

Some Experiences with a Simple Babbett Testing Machine: E. S. FARWELL, New York.

In order to select the most suitable babbett metal for use in paper mills a series of tests were undertaken with a machine consisting of a three and one fourth-inch mandril rotated at about 775 revolutions. The test block was held against the bottom of this mandril by a long bent lever to which weights were applied. The block and mandril were immersed in oil. After a number of failures which are described, and the discovery that the readings of the thermometer were vitiated by the heat from the main bearing the machine was remodeled. As remodeled it consisted of the same mandril and two test blocks held against opposite sides by a pair of levers acting like nut crackers. The weights were added to the outer end of the upper lever, while the outer end of the lower lever rested on a platform scales. The other end of the levers was counterbalanced so as always to produce an equal pressure on both blocks. As thus reconstructed the coefficient of friction may be determined as well as the breaking load. Observations on several methods of lubrication are given as well as other experiences with this simple but accurate testing machine.

Notes on the Electrical and Mechanical Equipment at the Charleston Exposition: J. H. GRANBEY, Elizabeth, N. J.

A short paper giving a résumé of the data regarding operation and equipment of the exposition at Charleston, S. C. Some details of interest in the installation of temporary underground lines are given, and attention is called to some departures from the accepted practice in engineering work, used for special features.

The following papers were presented by title:

U. S. Work in the Ohio, Allegheny and Monongahela Rivers near Pittsburgh: THOMAS P. ROBERTS.

C. A. WALDO,
Secretary.

SECTION F—ZOOLOGY.

AT the first morning session on Monday, June 30, 1902, in the absence of Vice-President Charles C. Nutting, of the State University of Iowa, the meeting was called to order by Professor Henry B. Ward, and Professor Carl H. Eigenmann was elected temporary chairman.

In the regular order of business, the following elections were made to the positions mentioned:

Member of the Council: Dr. W. J. Holland, Pittsburgh, Pa.

Members of the Sectional Committee: Professor Charles W. Hargitt, Syracuse University; Professor Henry F. Osborn, Columbia University; Professor F. M. Webster, Wooster, Ohio.

Member of the General Committee: Professor Herbert Osborn, Ohio State University.

Press Secretary: Dr. Ch. Wardell Stiles, U. S. Dept. of Agriculture.

At the afternoon session the meeting was called to order by the Secretary.

In the absence of President David Starr Jordan, his vice-presidential address was presented by Professor Carl H. Eigenmann. The secretary announced that the Sectional Committee had elected Professor E. L. Mark, Harvard University, to serve as vice-president during the Pittsburgh meeting.

At the morning session, on July 1, Professor E. L. Mark in the chair, the following papers were presented:

A New Microscopical Cabinet, Made of Metal: CHARLES SEDGWICK MINOT, Harvard Medical School.

A metal cabinet containing metal trays for microscopical specimens was exhibited. It has the advantage of being relatively safe from fire, and much more compact than wooden cabinets, and is therefore recommended especially for permanent and valuable microscopical collections. The case is made of tin japanned, and the trays also. Each tray is made with a double bottom to prevent warping and has space for twenty-four 3x1 slides. Each cabinet, having thirty trays, will take 720 slides. The cabinets cost $12.50 each and may be obtained from Peter Gray and Son, 11 Marshall Street, Boston. (Discussed by E. L. Mark.)

Insect Enemies: A Matter of Taste: FRANCIS M. WEBSTER, Wooster, Ohio. (Will appear in *Entomological News.*)

The speaker gave an account of experiments in feeding living insects to mice, and called attention to the fact that distasteful insects are not always rejected by all individuals of the same species of bird.

Remarks on the Finding of Bones of the Great Auk in Florida: OLIVER PERRY HAY, American Museum of Natural History. (Will appear in full in *The Auk.*)

The speaker stated that bones of the great auk were found in a shell-mound at Ormond, Fla. He described the situation and character of the mound and discussed the probability of the bird's having lived in that region. (Discussed by L. L. Dyche.)

Variation Among Hydromedusæ: CHARLES W. HARGITT, Syracuse University.

A continuation of earlier observations on this subject confirms the conclusions published elsewhere by Dr. Hargitt and extends them to other genera and species. An examination of several hundred specimens of *Coryne mirabilis* confirms the statements of Bateson relative to the remarkable constancy of this medusa, since not the slightest variation was noticed in any essential organ. The trachomedusa, *Trachynema digitale,* showed the comparatively low ratio of eight per cent. in total