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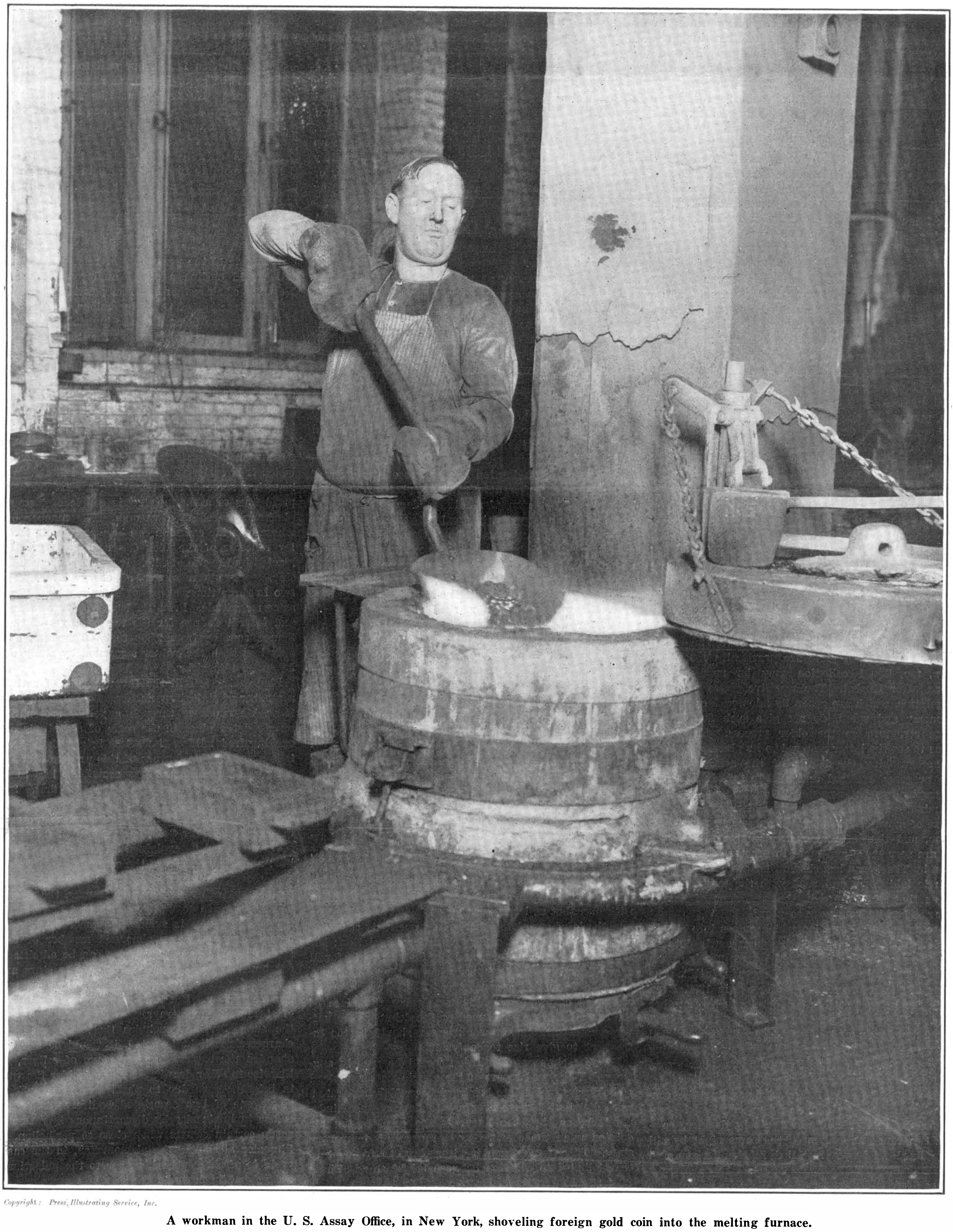


A workman in the U. S. Assay Office, in New York, shoveling foreign gold coin into the melting furnace.

MELTING DOWN FOREIGN GOLD.—[See page 248.]

Astronomy For 1915*

A Review of the More Notable Events, and Work Accomplished

By P. Puiseux, of the Paris Observatory

I. INSTRUMENTS AND METHODS.

THE faint stars which constitute a vast majority of the heavenly bodies visible to us were, for excellent reasons, neglected by early observers. Even yet we know but little of their physical states. Nevertheless, these stars are of ever increasing importance in science, since it has been recognized that they determine fixed directions in space. Their study is essential to verification with any degree of vigor of the principles of dynamics and the laws governing the propagation of waves, as regards both improvements in statement and investigation of consequences. The further we wish to extend these brilliant conquests, the more we are brought to feel the necessity of relying upon the large number of stars which we know certainly to be without proper motion. The catalogues compiled during the past century at the cost of such severe labor must be considered insufficient. Neither the meridian circle, an instrument extensively applied, but of small returns, nor the international photographic map, an enterprise on a grand scale but whose completion is still remote, begins to satisfy the impatience of astronomers. The search goes on for more expeditious tools, for reflectors permitting the comparison in a single field of widely separated stars, for lenses capable of photographing at a single exposure and without deformation a considerable part of the sky. The reflector systems proposed at various times seem to have remained in the domain of theory; but the photographic couple of two groups of lenses studied by Schlesinger has had an important application, pursued by the combined resources of the Lick and the Alleghany Observatories. In a field of four degrees radius, within which are always found a sufficient number of well defined stars, the clearness of the image is such as to assure a precision equal to that of the best meridian observatories; and the work can be conducted with considerable speed.[1]

Is is possible to increase this clearness still further, with perhaps some small sacrifice in the number of stars registered in a given time? This result is attained by Kapteyn, who places the plate to be measured beneath a developed plate of the same region of the sky, exposed with the same adjustment of the telescope, but with a different focus. Each star is then shown upon the screen by a tiny circle whose blackness is proportional to the intensity of the source, and whose sizes upon the second plate are practically equal.

Then, too, liquid collodion may be used to advantage, after Knobel. The sensitive plates prepared with gelatine, which are generally adopted for the sake of economy and speed, do not give such fine, homogeneous structure as the older process. Knobel is anxious to see the latter restored to its place, especially for photographing the details of the solar corona.[2]

The progress, realized and anticipated, in celestial photography has not arrested in any way the efforts to eliminate small errors in meridian observations. The use of movable threads with automatic register of position, and that of screens to obscure the brighter stars, are seen more and more in practice. But a discussion by Thackeray has shown that even for a meridian circle laid down and used with the most extreme care, as that of Greenwich, the coefficient of flexion can vary notably from year to year.[3]

The constant of aberration which enters into all observations of stellar positions, has been newly determined by Jones,[4] making use of a telescope floating upon mercury. The value found, 20.467 seconds, justifies the decision of the International Conference in 1896. Even though the solar parallax is obtained by another method with greater relative precision, the method followed by Jones, and of which application is still under way, retains a degree of interest as furnishing a value for the velocity of light in interstellar space, and information regarding latitude variation.

It is proposed by de Sitter to determine the constant of aberration by choosing four equational stars separated by intervals of about ninety degrees, comparing two consecutive arcs on the same night by aid of two fixed telescopes installed in the horizon and facing a fixed mirror, and combining four measurements of this sort effected at intervals of three months. The hope was held that elimination of the inevitable causes of error—refraction, annual parallaxes, proper motions, instability of apparatus—would be better effected by this method than with the system of multiple mirrors, already proposed or employed for the same purpose.[5]

In various connections the desirability has appeared of identifying the gravitational attraction with some other physical force, and of assigning to it a mode and a velocity of propagation. Experiments directed toward this goal have not given the hoped-for results. But, according to Eddington, it would be wrong to give up altogether effort in this direction. to recognize definitely the relation involved by this force as intangible, or its transmission as instantaneous. So there is nothing to prevent the supposition that in an intense gravitational field the progress of light waves is impeded. A favorable occasion for the verification of this hypothesis would be presented by an occultutation occuring during a total eclipse.[6]

II. STUDY OF STARS AND NEBULAE.

Is it possible to assign a center and bounds to the universe of stars, as we are accustomed to do without scruple in the case of the solar system? This great problem has been much debated. W. Struve and J. Herschel held opposite positions with regard to it. More than ever we may say that discussion of the question is in order, and that the affirmative reply of Herschel is visibly gaining ground. To the existence long ago observed, of a rough plane of symmetry marked off by the Milky Way, may now be joined other indications: the sharp limitations upon the membership of certain spectrum classes, such as the helium stars, the rapid diminution in numbers of the stars of ultimate magnitudes accessible by photography, the existence of a region of maximum density in leaving which we find the mean interval between the stars increasing, the direct correlation between the total velocity and the richness of the spectrum in lines of absorption, the inverse relations between the radial velocity and the galactic latitude, between total velocity and mass, between velocity and absolute brightness, the preference less marked of the stars for a particular direction as we advance in the spectrum series.

Such an accumulation of probabilities falls little short of the value of a demonstration. The relation between the velocity and the absolute brightness, less easily exhibited than the others, is now placed upon a firmer basis of fact by the recent labors of Adams.[7] These justify the attempts of Turner and Eddington to relate the general movements of the stars to Newton's Law. There are so few stars, relatively, whose mass is known that we can say nothing of the field of force determined by them. However, the present state of knowledge of velocities, if we speak only of those stars whose proper motions have been determined, is not too tenuous for us to verify that Kepler's Law holds. Eddington, enlarging the concept of Laplace, has undertaken with a degree of success to define the simple distributions of matter from which would necessarily be derived a universe, perhaps not identical with ours, but at least analogous to what we see. The hypothesis of complete spherical symmetry is the most convenient as a point of departure for calculation; but it is far from obligatory, and, in fact, there is found a certain advantage in introducing at the beginning a flattened form and a general rotation. In any event, a species of organization in time takes the place of the amorphous state assumed at the debut of the universe, and collisions, it would seem, should be too infrequent to give rise to confusion.

But the chances of collision would be greatly augmented if the major part of the cosmic matter, instead of being assembled into bright globes widely separated, were distributed more evenly in a dark state. Lindeman[8] claims that the latter is the case, basing his opinion upon the obscure appearances of temporary stars. This phenomenon is altogether too frequent to be attributed to collision between bright stars. These views, if accepted, would place, on an average, in a given space, four thousand times as many dark stars as visible ones; and according to Lindeman such a hypothesis clears up more difficulties than it introduces. King[9] is led to a conclusion even more surprising in inquiring what quantity of fine particles would have to be diffused uniformly through space to produce the illumination obscured in the nocturnal sky—an illumination feeble, but still too great to be explained on the ground of direct radiation from the invisible stars. He finds that this attenuated matter would have an aggregate mass one hundred thousand times as great as that of all the known stars combined. But this figure may be regarded with suspicion since it is entirely possible that the reflective particles are notably more numerous in the neighborhood of our globe than in interstellar space. Finally Turner, analyzing the zones already published in the astrographic catalogue, remarks in certain regions of the sky a pronounced deficit of feeble stars, and draws the conclusion that there exist local dark veils, particularly unfavorable to the perception of remote stars. Such a veil would outline a spiral analogous to the Milky Way, but of altogether different position.[10]

The attraction of these incursions, necessarily hazardous into the domain of the invisible, should not be allowed to induce neglect of the information to be derived from a study of the bright stars. One here feels himself upon more solid ground; but to effect any progress in a field already so well explored, it is necessary to call upon the resources of the most delicate physical experimentation. The annual parallaxes determined photographically by Davidson and Slocum with the great refractors of the Yerkes and Greenwich observatories are in this connection models which it is easier to admire than to imitate. W. Coblentz has succeeded in imparting a sensitiveness truly prodigious to a thermo-electric couple of bismuth and platinum placed in a vacuum. The number of stars whose calorific emission can be measured in the Crossley reflector of the Lick Observatory is greatly augmented by the use of this. It is established that a red star represents a source of energy averaging from two to three times as powerful as a white star of the same magnitude. From Coblentz's observatories, Burns and Merrill deduce for the temperatures of the stars figures running from 2,500 to 8,000 degrees, and notably less than the values suggested by study of their luminous intensities.

Photometry is still the favorite field of activity for a number of skilled specialists. Seares, by a long photographic exposure through a yellow screen, has determined the place in the scale of magnitude of stars one hundred million times less bright than Arcturus; it is a remarkable feature of this process that the last minutes of exposure always contribute less to the intensity of the final image than do the first. Stebbins has continued his use of the curious properties of selenium to betray minute variations in brightness. In the case of the star Orion, a part only of the temporary obscuration can be explained by the passage of a satellite; and the duration of the eclipse affords, as already was shown, an upper limit for the density. In this as in many other analogous instances, the density obtained is low in comparison with that of the sun; and this circumstance is sufficiently general to lead us to regard the sun as an abnormal member of the star aggregate. These low densities can be admitted without much difficulty so far as the white stars are concerned, for these may be considered as still undergoing contraction. But it is more surprising in the case of stars whose spectra are entirely similar to that of the sun. Perrine concludes that, if a maximum of characteristic light is noted, it would be advisable to abandon the explanation by means of eclipse, subject likewise to other drawbacks, and consider the variation in brightness as due to physical changes affecting a single one of two associated bodies. This would increase in luminosity by discontinuous increments, just as do certain comets when close to perihelion. H. C. Plummer attributes the phenomenon, in the case of a variable of short period, rather to the pulsations of a light-absorbing layer in the star.[11]

*Revue Générale des Sciences.

[1] The Observatory, XXXVIII, 129.

[2] The Observatory, XXXVIII, 209.

[3] Monthly Notices, LXXV, 548.

[4] Monthly Notices, LXXV, 542.

[5] Monthly Notices, LXXV, 458.

[6] The Observatory, XXXVIII, 93.

[7] Astrophysical Journal, XLII, 72.

[8] Monthly Notices, LXXV, 178.

[9] Nature, August 26th, 1915.

[10] Meeting of the Royal Astronomical Society, November 12th, 1915.

[11] Monthly Notices, LXXV, 566.

The powerful spectroscopes installed at the Lick Observatory have notably increased the list of nebulae to which we can assign a radical velocity. It appears pretty well established that small or regular nebulae are in general of more rapid motions than the extended nebulae, more mobile even than a majority of the stars. For the spiral nebulae, which are regarded as foreign to the Milky Way, the velocities found are explained in good part as apparent, due to a general translation of the galactic system.

III. STUDY OF THE STARS.

In view of the imposing array of established statistics which have been collected over such a long space of time, and upon a uniform plan, the observations of solar activity gathered in a single year have but little weight. They suffice, nevertheless, to show that the solar meteorology is as little amenable to mathematical formulae as is that of the Earth. In spite of an enormous expenditure of money and of labor, the success attained by Schwabe more than half a century ago remains an isolated one.

In the Spring of 1915 there was a recurrence of the great depressions and protuberances which came pretty close to the generally expected maximum. The relative calm which reigned during the last months of the year was quite unlooked for. The passage of the numerical preponderance to the southern hemisphere tends to create the belief, in accordance with past experience, that the maximum is already attained, often an increasing phase of notable brevity. But on the other hand the latitude distribution of the protuberances was, toward the end of 1915, almost the same as in 1903, two years before the maximum of the last eleven year cycle. Butter has had the good fortune to catch photographically an arch that was dissipated in less than a half hour, after having attained an altitude equivalent to a quarter of the sun's diameter. The phenomenon seems to have had some connection with a cloud of flocculi, but not with the visible depressions.

The diagrams and numerical tables established by the work of several successive years eliminate temporary irregularities and permit the drawing of more general conclusions. These discussions have usually been conducted in such a way as to throw light upon the correspondence between the solar activity and the terrestrial magnetism, the latter itself recapitulated in a form to eliminate the pertubative influence of the season. According to Maunder, the list of magnetic pertubations observed at Greenwich from 1904 to 1913 indicates, for that period as clearly as for preceding ones, a tendency of the perturbations to repeat themselves after an interval equal to a synodic resolution of the sun. The studies of P. Cortie, embracing the twenty-five years from 1889-1913, show that the equatorial sun spots disturb the magnetic needle more than do those of high latitude. The strongest perturbation of the present cycle, occurring on June 17, 1915, accompanied the conjunction with the Earth of an equatorial spot, which itself was of exceptional character. Of the three strongest magnetic perturbations of the year 1914, two accompanied the passage across the solar disc of the same spot, the largest that had been seen since 1910, while the third was contemporaneous with the passage of another spotted region, diametrically opposite the first.[12]

The study of the sun's rotation, by means of a comparison of the spectra of various points of its edge, calls for delicate observation and minute calculation above all, when no hypothesis is held in advance as to the distribution of velocities. It need occasion no astonishment that these investigations in general extend only over short intervals and see the light of day only after the expiration of a good long time. From the plates of June, 1911, Hubrecht has found[13] that the two hemispheres, north and south, do not turn together, and that the angular velocity, instead of decreasing uniformly from equator to pole, presents a minimum at a high latitude. These conclusions, as Fowler has remarked, agree poorly with those derived at other observatories, notably at the Lick by Adams and at Ottawa by Plaskett. To be sure, the intervals of time considered were not the same; but it can with difficulty be admitted that even the superficial rotation has changed its place in so short a time.

The Tower Telescope at Mt. Wilson, under the hands of Adams and Saint John, has brought about the realization of an advance in the spectral study of the extreme edge of the sun. These observers have succeeded in bringing out, under ordinary conditions, more of the bright lines than it has heretofore been possible to distinguish in the spectrum of a total eclipse. Compared with the corresponding Fraunhofer lines, these present a very slight divergence, easily explained by the varying elevations of the layers of vapor above the photosphere. Julius prefers to call upon the anomalous dispersion noticeable when two radiations of different chemical origin are registered in close proximity in the spectrum. But it is doubtful whether in doing this we can free the measurements from every systematic cause of error. Albrecht has called attention[14] to certain facts favorable to this explanation, and estimates at half an atmosphere the pressure in the reversed layer.

The efforts of Hale and Babcock to verify the Stark effect upon the lines of the solar spectrum have given little satisfaction. It appears that the intensity of the electric field must be very feeble on the level of the spots. Zeeman's phenomenon of the shape of the spots is comparatively easy to verify. It has been noted often enough that these are associated in couples parallel to the equator and of opposite magnetic polarity If this coupling be interpreted as indicating a local vortex of electrified matter, it is significant that the sense of the rotation, opposite on opposite sides of the equator, is a second time reversed at high latitudes.

Various detailed examinations of the photographs of the total eclipse occurring on August 21, 1914, have but recently seen the light. The more obvious features of the corona are readily recognized, after P. Cortie, as a somewhat divergent cluster of jets, each in the form of a conic section, and all issuing from the same disturbed area. The new line noted in the red portion of the spectrum of the corona exhibits a displacement which, according to Bosler, may be taken as indicating an equatorial velocity in the lower layers of four kilometers per second. It remains to be determined whether this velocity is that of a rotation *en masse*, or merely that of ionized particles possessing a special luminosity and an independent motion.

Abbott and Fowle have been able to send recording pyrheliometers up in balloons to a height of 24 kilometers. Even under these conditions the heat received did not exceed two calories per minute per square centimeter. The opinion of Langley, who believed that a considerable reduction of the solar energy was brought about by the upper layers of the atmosphere, becomes more and more untenable, save, perhaps, with reference to the violet end of the spectrum.

IV. STUDY OF THE PLANTS AND COMETS.

There were in 1915 no unexpected comets. As much cannot be said of the failure of the second periodic comet of Swift (1889 VI.) to make its anticipated return. The brightest comet of the year (1915a Mellish) presented from June to October a spectacle of a head divided into several fragments, difficult to characterize and to follow. Such an accident befell the great comet of 1882, and, much earlier, that if Biela. It was recognized, not long ago, that the orbit of this lost comet coincided quite well in two points with that of the comet 1896 VII, but it has not been explained how the launching of Biela's comet upon this new patch could have been effected.

Of seventy-four asteroids chronicled during the course of the year, a certain number have been identified after closer examination, with ones already known but temporarily lost to sight. Among these may be mentioned the planetoid Dike, looked for in vain since its first discovery in 1868, at the price of considerable labor. For this once chance has been more fruitful than calculated. But more value is rightly to be attached to a discovery resulting from methodic preparation, and credit should be given rather to the patient workers who break the way for careful measurements of the variations in brightness and the changes in the position of the planets. Thus, Hall reports[15] that from February to May the planet Neptune, as compared with two neighboring stars, underwent variations almost an entire magnitude in range, and of a period of 7 hours, 50 minutes and 6 seconds. The conclusion is drawn that the planet possesses two hemispheres of unequal brightness, and that the period given represents its time of axial rotation.

The empirical formula introduced by Newton to put the theory of the moon's movements in accord with observations no longer fulfils its purpose. Ross demonstrates this in discussing the occultations of stars noted during the year at Greenwich and at Washington. But it may be that the acceleration of our satellite is only apparent, and connected with an actual elongation of the sidereal day, conventional unit of measure for time. If this is the case, variations, less pronounced but still perceptible, should appear in the movements of the sun, of Mercury, and of Venus. The studies of Glanert, covering the period from 1870 to 1910, indicate that this is probably what has taken place; he puts the elongation of the sidereal day at .03 seconds.[16]

Insignificant as this figure appears, it corresponds to a considerable loss of kinetic energy, whose fate we are anxious to discover. The displacement of the tidal crest, which always lays at the meridian passage of the moon, might by its friction counteract the superficial cooling, and at the same time effect a certain transfer of energy from the rotatory motion of our globe to the movement of the Earth and the moon in their orbits. Other sources of loss would be found in the maintenance of the terrestrial magnetism, or in a progressive alteration in the disposition of material within the globe. Which of these items is most likely to be betrayed by discovery of its period, to be subjected to numerical evaluation? Apparently it is the disymmetric attraction of the moon upon the aqueous mass that causes the tides. The calculation has been attempted on numerous occasions, most recently by Sir Joseph Landor.[17] There is nothing to confound the hope of thus putting the ancient eclipses into accord with the modern theories of lunar movement. But it appears that in all these attempts the investigator has been content to represent the deformation of the terrestrial oceans by means of a formula altogether too summary and simplified. A better grasp upon the realities of the problem should result from the utilization of the important body of tidal observations made in recent years, either by the many polar expeditions, or in the permanent stations established in Australia.

Some years ago Kimura showed that terrestrial latitudes, at least along the parallel upon which are located the stations of the International Service, display an annual oscillation of .06 seconds, which cannot be accounted for by gravitational theory. It has been generally supposed that this variation was merely apparent, and caused by atmospheric refraction. The instrument and its case are cooled by nocturnal radiation, the surrounding air becomes deformed, and the observed height of the stars changes as the change of season accentuates or diminishes this action: so ran the argument. But this convenient explanation has fallen into discredit through the calculations of Sir Joseph Larmor.[18] To consider the annual variation in latitude as an atmospheric effect, it would be necessary to attribute to the process of nocturnal cooling an amplitude which is denied it by meteorological observations.

It was believed, not so long ago, that the old controversy regarding the oblateness of the terrestrial globe was settled. This is not strictly the case. To be sure, it is no longer a question, as in the time of Maupertuis and Mairan, of deciding whether the Earth is oblate or prolate, but rather one of fixing upon some figure between 290 and 300 as the reciprocal of its ellipticity. Geodesic measurements and lunar observations seem to demand a value less than 295. But gravitational observations and the theory of precession demand just as strongly a value greater than 297. With the system of compensation introduced by American scientists, the geodesic data have at length been made to accommodate themselves to the figure 297. But according to the investigation of de Sitter,[19] 295 is an absolute upper limit imposed by the theory of the movements of our satellite and by measurements of the lunar parallax. The only expedient which he is able to suggest to reconcile the conflicting evidence consists in regarding the moon as denser near the surface than at great depths; and he frankly points out that this is little short of an absurdity.

Jeffreys[20] has called attention to another divergence of opinion, with regard to the coefficients of compressibility of the Earth. The values assigned to these coefficients are very different, according to whether the variation of latitudes, the amplitude of the oceanic tides, the moon's deviation from the vertical, or the time of propagation of seismic shocks, is taken as a guide. The oscillation of geographic latitudes indicates a slow deformation, the participation of the terrestrial shell in the diurnal tides points to a rapid one. It seems, therefore, that the physical constants defined in accordance with laboratory experiment lose their significance when we come to consider the colossal pressures—quite inconceivable to our minds—which rule inside the Earth. Analogous remarks apply to the sun, and acquire here a real value in connection with the radical views of Innes, who considers such bodies as reservoirs of latent energy, capable of passing by explosion into the state of white stars or nebulae.

[12] *Monthly Notices*, LXXV, 496.
[13] *Monthly Notices*, LXXV, 611.
[14] *Astrophysical Journal*, vol. XLI.
[15] *Monthly Notices*, LXXV, 626.
[16] *Monthly Notices*, LXXV, 489 and 685.
[17] *Monthly Notices*, LXXV, 211.
[18] *Monthly Notices*, LXXV, 205.
[19] *The Observatory*, XXXVIII, 315.
[20] *The Observatory*, XXXVIII, 347.

The Making of a Photographic Objective*

Description of a Course in Applied Optics at the Emerson McMillan Observatory, Ohio State University

By Prof. H. C. Lord

PHOTOGRAPHY, in its more serious phase, has taken an important place in almost every field of human activity. As a condition for the best work, a high-grade lens is a necessity, and especially so for those extremely short exposures required in the photography of rapidly moving objects. It often happens that some of the most perfect and at the same time most difficult specimens of optical design are found on cameras so small that they can be easily carried in one's coat pocket. These so-called anastigmats furnish to the optician a difficult and yet at the same time most fascinating problem for mathematical investigation. Thousands of photographic objectives are placed on the market every year, yet though almost every branch of engineering is covered by our technical schools, I know of no place outside of Germany where a student can be instructed in the design and construction of a simple photographic objective. Professor Silvanus P. Thompson in his inaugural address as President of the British Optical Convention, held in London in 1912, states: "In the universities and colleges the only people who are learning Optics are merely taking it as a part of Physics for the sake of passing an examination for a degree, and care nothing for the application of Optics in the industries. They are being taught Optics by men who are not opticians, who never ground a lens or calculated even an achromatic doublet, who never worked an opthaloscope or measured a cylindrical lens." Farther on he speaks as follows: "What is wanted is an establishment where the whole atmosphere is one of optical interest; where theory and practice go hand in hand; where the mathematician will himself grind lenses and measure their performance on the test bench; where braincraft will be married to handcraft; where precision, whether in computation or workmanship, will be the dominating ambition."

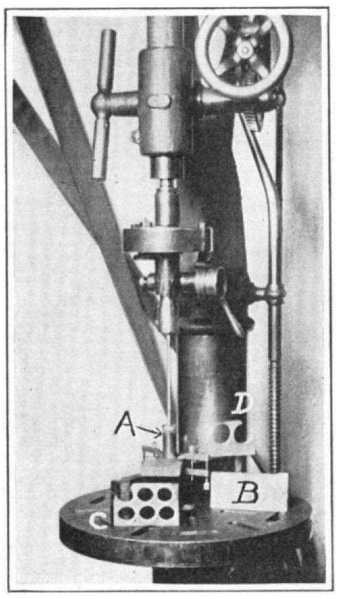


Fig. 1.—Cutting disks from a slab of glass.

Some four years before the above quotations were written, the author started to work up a course in Optics which should aim, not only to give to the student a knowledge of the fundamental theory of lenses, but should also apply those principles to the methods of optical design and thus enable him to compute the curves of the component lenses of a photographic objective. This has now been fairly well worked out and is given in the Arts college. The basis of this course is "A System of Applied Optics," by H. Dennis Taylor, the inventor of the Cooke lens. This splendid volume develops, from the standpoint of geometric optics, a complete discussion of the formation of an image by a combination of any number of lenses, but does not apply the methods and formulae there developed to the actual design of a photographic objective. The writer of this paper was, therefore, compelled to work out this part of the theory for himself and, as he had always felt that all mathematics should ultimately end in arithmetic, and that all arithmetic should ultimately end in doing something, he resolved at the outset that the course should end in laboratory work in the actual computation, grinding and polishing of lenses. As to how well this has succeeded, I will let the illustrations which accompany this article speak for themselves. Suffice it to say that the half-tone cuts were made from five by seven enlargements from negatives one and three quarters by two and one eighth inches, taken with a lens *designed* and *built* at this observatory and working at an aperture of *F* six. A peculiar feature of this lens is that it is composed of four lenses all cut from the same piece of crown glass. This lens beautifully illustrates the importance of adding to the theoretical side of the course the practical work in the laboratory in construction and testing, as this lens, though in the main satisfactory, has one serious defect and a defect which is very instructive in that it shows that at a certain point in the design the theory was weak and needed to be extended and enlarged. It should be stated that this theoretical investigation is now completed and ready to be put to the test of practice.

This observatory possesses a well-equipped instrument shop, which was used for the practical side of this work, and it has seemed to me that a description of how we used the ordinary tools of a machine shop, of what special appliances we were compelled to make, and how we finally ground and polished our lenses would be of general interest. These methods do not pretend to be the best, nor those actually employed by the manufacturer, but they do illustrate how a lens can be made and how a little ingenuity will enable one if he has the standard tools of a machine shop to carry out almost any kind of experimental work.

As a preliminary to this, a brief outline of the problem before the lens designer may be of interest. A simple lens consists of a piece of glass bounded by either plane or spherical surfaces, as these, except in large reflecting surfaces, are the only kind that can be made with sufficient accuracy. Such a lens would have a great many defects or errors and would be unable to give a sharp image on the photographic plate unless stopped down to a very small aperture. By changing the radii of the surfaces, and the thickness of the lens, the designer can vary these errors, but after all is said and done he can do but little to improve the single lens. He then combines lenses of different forms and of different kinds of glass into a single objective, in this way making the positive errors of some of the lenses balance the negative errors of the others, until he arrives at a combination which is more or less perfect according to his skill as a designer. How this is accomplished is far beyond the limits of this paper, so I will now proceed to the mechanical side of the problem.

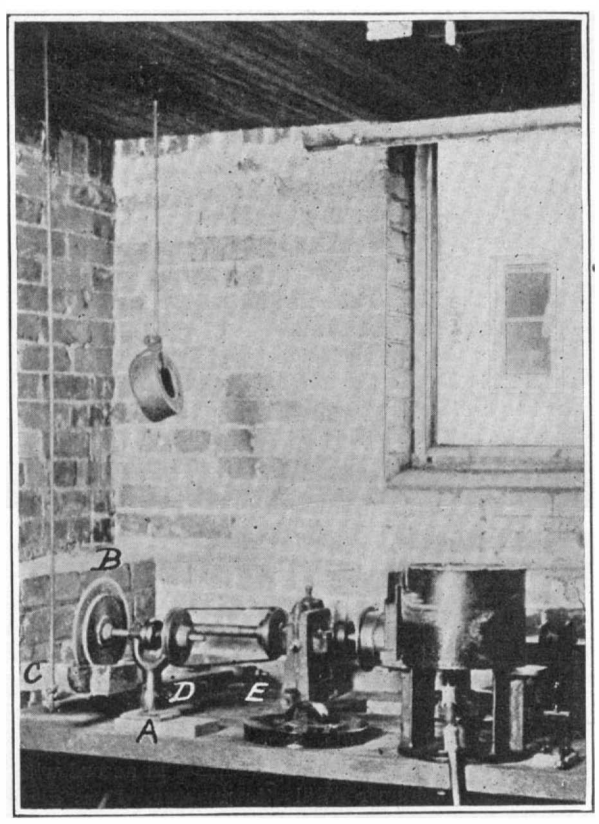


Fig. 3.—Sawing and shaping lens disks.

The first consideration is the glass; of course it must be what is known as optical glass, and its selection is really part of the work of the designer. Optical glass is nothing more than a very perfect kind of glass which has been exquisitely annealed. You are all familiar with the intense green of window glass when seen edgewise; a piece of white paper will hardly be changed in color when seen through 12 inches of a good optical crown. The best optical glass is not made in this country, but must be purchased from either Schott & Gen. of Jena or Mantois of France. The Jena glass has become very celebrated, and most of the lens makers state that their lenses are made out of it, and as a consequence most people think that Jena glass means a certain kind, while, as a matter of fact, their catalogue for 1909 shows about seventy different varieties. These differ in optical qualities and chemical composition, and cost from about a dollar to five dollars a pound, with a few special varieties costing as much as fifteen dollars. This glass comes in slabs, but will be cut by the makers with either a diamond saw or a sand saw, the purchaser paying for the "saw dust."

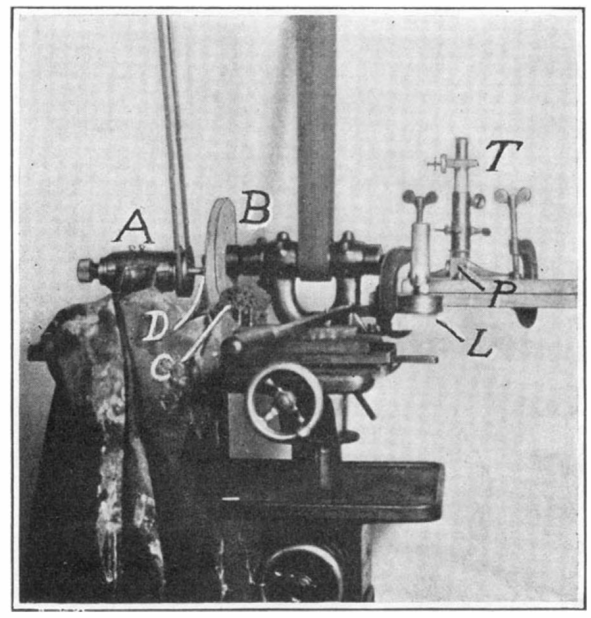


Fig. 2.—Grinding and shaping the edges of the disks.

The slabs that were used here were 2″ x 6″ x ½″, and the first operation was to cut from these round disks a little larger than the finished lens. This was accomplished in the following manner and is illustrated in Fig. 1. In the chuck of a drill speeder on a Barnes drill press was placed a ¼″ steel rod which carried at its lower end a copper tube, *A*, which was steadied at the bottom by a steel washer, bored to a loose fit to the tube, and clamped to the glass as shown. Number 40 carborundum was used and lubricated with *plenty of water*. The tube must be lifted frequently to allow the abrasive to flow to the cutting edge. This is done so often that it seems almost a continuous motion of lifting and pressing down again, the tool resting on the glass hardly more than two or three seconds at a time. The cutting may be done at such a speed as to allow of a slight heating. As soon as the tube has cut itself about a sixteenth of an inch into the glass, the guiding washer may be removed and the glass will then act as its own guide. A disk about one inch in diameter and a half of an inch thick could be cut out in a little over a half of an hour. At *B*, Fig. 1, is shown one of the uncut slabs, and at *C* and *D* two that are about used up. Though working rather slowly, this proved quite satisfactory, though wasteful of glass, as it cut a rather wide scarf; copper must be used; brass was tried, but the wear was so great as to render it almost useless while the copper shows almost none.

As these disks are cut out they are not only cone-shaped, but the edges are very rough, so that the next operation was to grind these to smooth and true circular disks. This was done on a Wells tool grinder shown in Fig. 2, which was slowed way down by placing a large pulley on the counter shaft. The glass to be ground was held by cementing it with pitch onto a piece of brass rod which in turn was held in the drawing collet of the head *A*. A special wheel *B*, made by the Norton people for grinding the rims of spectacle lenses, was used and the machine slowed until the wheel would keep wet when running against a sponge, *C*, resting in water. The glass disk was in this way kept dripping

* From the *Iowa Journal of Science*.

and heating entirely prevented. The grinding was then carried out just as with any other material and the edge was made beautifully smooth and true in a few minutes. The beauty of pitch as a cement for holding the glass is that a slight heating will soften it so that the disk can be shifted to any position, and then a dash of cold water clamps it in place, and at the same time the pitch will slowly yield to the slightest pressure, so that in a few minutes the glass is entirely free from strain. In manufacturing this sort of work is done with a diamond and is, of course, done much more quickly.

The disks were thick enough to make two lenses each, so we sawed them into two, as illustrated in Fig. 3. *A* is an old polishing head upon which was mounted a pulley at one end and a copper disk, *B*, at the other, the disk being held between large washers. *C* is a cast iron box fastened to an arm, *D*, hinged at *E* and kept pressed against the copper disk by a cord passing over two pulleys on the ceiling. This made a most excellent automatic feed. The glass to be split was fastened to a block of pine with pitch and the wood held in the iron box, *C*, with wedges. Number 40 carborundum was used with plenty of water and the glass was cut through faster than a power hack saw would cut through steel. The glass should be cut half way through and then reversed so that the final break will come in the middle and thus prevent the edges from spawling off. The chief defect of this machine was the way it scattered emery.

The disks are now ready for the grinding which is done on the machine on the right of Fig. 3, which consists simply of a vertical spindle run by a quarter twist belt from the counter shaft against the wall. The end of this spindle is tapered at the upper end to receive the grinding tool or laps, shown on the table in Fig. 5, which also shows the spindle raised so that the grinding lap is seen above the tin box, *C*, which surrounds the spindle to catch the abrasive that is thrown off in grinding. The glass is first smoothed down on a flat lap until it is of equal thickness at all points as measured by a micrometer, when it is ready to be ground to the proper curves. For this purpose the spherical laps, shown in Fig. 5, are turned in the special machine illustrated in Fig. 4. The compound rest of an old Sellers lathe was removed and in its place, on the cross slide of the carriage, was mounted the sphere turning rest. This consists of a base, *A*, in which the slide, *B*, is so mounted that it can be rotated about the center, *C*, by turning the milled head, *D*, which carries a worm at the opposite end. *E* is the tool post with the cutting tool *T* and *L*, the lap to be turned. A hole was drilled at *C* into which was fitted a round piece of steel, the upper end being pointed and then half cut away like a center reamer. This was used in finding the zero; the rod, pointed end up, was placed in the hole at *C* and the cutting tool adjusted against the flattened side. The zero position is then determined by measuring, with an inside micrometer, the distance from the tool post to a stop placed at the end of the slide, *B*. By adding to or subtracting from the zero reading of the micrometer the length of the radius of the grinding lap, the tool post may be set to the proper position for either a convex or a concave surface. This, however, is only approximate, for these laps must be made with the highest possible accuracy. After sufficient cuts have been taken to give a spherical surface, the radius is carefully measured with a special spherometer and the error in the radius corrected by changing the position of the cutting tool by an amount calculated from the readings of the spherometer. This spherometer we were compelled to build as we could find none of sufficient accuracy on the market, and it is described in a note at the end of this article.

In Fig. 4, *R* is simply a steady rest made with the large overhang to allow the slide, *B*, to swing under it in turning a convex surface. Two master laps, male and female, must be made and carefully ground together. Every effort should be taken to make these as accurate as possible, since upon these depends the goodness of our lens. This special tool is easy to make and leaves nothing to be desired in its operation. Detail drawings and directions for making it are given in a note at the end.

We now come to the grinding or lapping of the lenses themselves. This is done in a lap turned as above and carefully fitted to the master laps and which must be trued from time to time as the work progresses. This lapping of glass is entirely different from the lapping of metals in that, while in metals the lap is to be kept almost free from the abrasive, in glass the lap must be freely supplied with emery and water or deep scratches will result. The best way to apply the emery, is with a paint brush; the brush, saturated with emery, being held in front of the lens as it is ground. The lens may be held in the hand or cemented to a disk of brass having a center hole drilled in the back in which is placed a pointed piece of steel held in the hand, the lens being free to rotate about the pointed steel holder. Of course, where the lens has to be ground to a definite thickness, it must be held by hand. Flour of emery was used to rough grind, though coarser grades would have worked faster. The final smooth grinding was done with a special fine emery made for this purpose by Bausch and Lomb. Great care must be taken in the grinding to keep the lens as nearly centered as possible. A lens is said to be centered when the line which joins the centers of curvature of the surfaces passes through the center of figure. Obviously, if a double convex lens could be ground to a knife edge it would be centered, but if this were done, the edge would be almost certain to crumble in the final polishing and deep scratches result. The centering of a convex lens can be watched by keeping the edge as nearly uniform of thickness as possible; with a concave lens, if the original blank is made larger

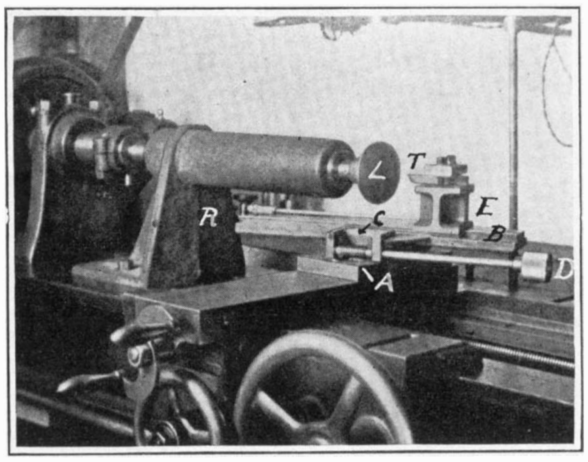


Fig. 4.—Making laps for grinding lenses.

than necessary and care is taken to make the sides parallel, the centering can be watched by keeping a flat edge of *equal width* around the concave portion, the lens being placed back on the flat tool, from time to time, as the work progresses. If care is used the lens need be but little larger than the finished size to allow for the final accurate centering to be described later.

After being smooth ground the lens is beautifully smooth and velvety to the touch, but is just as much ground glass as ever, that is, it is absolutely opaque. We now come to the polishing. This is done with specially prepared rouge and only an excessively small amount of glass is taken off. Lord Rayleigh in a paper on "Polishing of Glass Surfaces," read before the British Optical Convention, held in 1905, states: "I started with a finely ground surface, rather more finely ground I think than is used in practice, and I found that in order to obtain a pretty good polish it was necessary to remove a weight of glass corresponding to a depth of

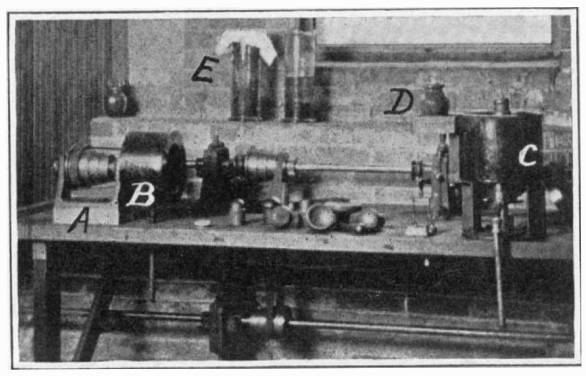


Fig. 5.—Machine with two polishing heads, one horizontal and the other vertical.

about six wave lengths. I do not pretend that such a polish would satisfy the requirements of commerce; probably the six would have to be raised to ten or twelve in order to get to the bottom of the deepest pits." When it is remembered that a wave length is about the fifty thousandth part of an inch we realize how very delicate such lapping must be. For this work the lap is covered with pitch which has been brought to the proper degree of hardness either by boiling to harden it or by adding asphalt varnish to soften it. The proper degree of hardness is very important and must be adjusted to the temperature of the room. Obviously if the pitch is too soft it will not hold its shape, and it will be impossible to hold the polishing tool to the proper radius. I have put three different curves on a lens about an inch in diameter in a few minutes, and it had to go back on the grinding machine before it could be finished.

The polishing tool is prepared as follows: A disk of pitch, about one and a quarter inches thick, is cast by pouring it in a mold made by a strip of brass bent to a circle, the ends clamped with a toolmaker's clamp, and rested on a piece of cold cast iron which has been planed smooth. This should be of such size that when bent to the proper shape it can be molded over a tool similar to the grinding tool but with a radius changed by about the thickness of the pitch. This tool is then heated and painted with a stick of pitch, the disk warmed, and the two pressed together; when cooled the pitch will stick tight to the iron but will be far from a smooth surface. This and the master tool of the opposite curvature are placed in warm water and pressed together, and at the same time slowly rotated, one about the other. When a good fit is secured they are cooled and a number of small holes, about one-eight inch in diameter, are drilled all over the pitch to distribute the abrasive, which of course spoils the surface and the tool must be again pressed. This pressing to shape must be done repeatedly and requires great care and some practice in order to have the pitch come to the exact opposite of the pressing tool. The most important thing is to do the pressing slowly and in fact in the whole process of this work one must never get in a hurry. Ritchey, in his memoir on the construction of the great sixty-inch at Mount Wilson, recommends covering the pitch with beeswax, and for quicker and poorer work a cloth polisher may be used, the cloth being a special felt and cemented to the cast iron tool with a thin layer of pitch.

The abrasive is rouge or red oxide of iron and its preparation is fully described in the above mentioned work by Ritchey. We purchased the anhydrous red oxide of iron from Merck & Co. This was mixed with plenty of water in the jars shown at *E*, Fig. 5. The rouge will rapidly precipitate, the coarse particles falling to the bottom, and leaving clear water above the precipitated rouge. The upper two thirds of the rouge will be almost perfect and will give a beautiful polish when carefully siphoned off. This should be kept in tightly corked bottles, one of the best things is a horse-radish jar, as this has a place for the handle of the brush in the glass stopper, and all dust and grit can be easily washed off before the jar is opened. For polishing, the lens is cemented to a handle at whose end is a piece of brass turned to fit the lens in the sphere turning machine already described. Even in a small lens the polishing tool must be run slowly; the speeds of our machines run from 170 to 300 revolutions per minute, and the fastest can seldom be used. The reason of this is that the lens fits the polisher so perfectly that almost a perfect vacuum is formed, and the lens hugs the polisher so closely that it is impossible to hold it in small sizes by hand alone, and in the case of a convex surface, if the cavity is carried clear out to the edge of the glass disk, this may be broken simply by the friction due to this grip of the glass and pitch. Fig. 5 shows a horizontal polishing head at *B* and a vertical one at *C*. There is little choice except that for convex surfaces *B* seems the best, as it can be run faster, while for concave *C* seems better.

The lenses are now ready to be centered, that is, the circumference so turned that the line which joins the centers of curvature of the two spherical surfaces shall pass through the center of figure. In order to accomplish this, the lens is first cleaned from the pitch used to cement it to the handle used in holding the lens for polishing. For a long time I could find no way of doing this satisfactorily when pitch was the cement; finally, I laid my troubles before Dr. A. M. Bleile, head of the department of physiology, and he suggested to first soak the lens in lard and then wash it in benzol (C_6H_6). This worked like magic, though the first time I tried it I used some lard that had been heated with some pitch in it, which made the lard very soft, in fact, almost as soft as it could be and yet not be an oil, and this same lard was used over and over again. The action is rather peculiar; the lard does not apparently affect the pitch at all, but, after a few minutes in the benzene it all flakes off and leaves the lens perfectly clean. The actual centering is then carried out on the grinding machine shown in Fig. 2; *A*, holder; *D*, whose front face has been turned in the spherical turning machine to fit one of the surfaces of the lens, is held in the head, *A*. If the lens be cemented to this with a thin coat of pitch, it is obvious that the surface of the lens next to the holder will have its center of curvature coincide with the axis of rotation of the spindle of the head, *A*, but the center of curvature of the other lens surface will probably fall outside of this axis. A lamp, *L*, has a tin chimney with a pin hole in it turned toward the lens, this pin hole forming a brilliant point of light, an image of which is formed by each surface and reflected by the total reflecting prism, *P*, into the telescope, *T*, where it is seen through the eyepiece. If the centers of curvature of both surfaces do not ac-

curately coincide with the axis of rotation of the head, *A*, the images of the pin hole will describe circles as this axis is rotated. The back surface will, of course, be centered if the layer of the pitch used as cement is of uniform thickness, which will generally be the case if the work has been carefully done; but in any case the image formed by it should be examined. If the front surface is out of center, as it generally will be, the holder should be warmed and the lens shifted, care being used to keep it tight against the surface of the holder as it is being shifted. As soon as both images remain stationary as the head, *A*, is rotated, the lens is fed against the wheel, *B*, and ground true and to size. This worked beautifully and the tests were wonderfully sensitive. As soon as the component lenses of the objective have all been thus centered, they are ready to be assembled in the cell or shutter in which they are to be used; but as this is simply a matter of careful machine work, I need not describe it further.

I know of no literature on the grinding of small lenses though the following memoirs on the making of large reflecting telescopes should be in the hands of any one interested in this work:

On the Construction of a Five-foot Equatorial Reflecting Telescope.—By A. A. Common, LL.D., F.R.S. Memoirs of the Royal Astronomical Society, Vol. L., 1890-91.

On the Construction of a Silvered Glass Telescope, Fifteen and a Half Inches in Aperture, and Its Use in Celestial Photography.—By Henry Draper, M.D., Smithsonian Contributions to *Knowledge*, Vol. 34.

On the Modern Reflecting Telescope and the Making and Testing of Optical Mirrors.—By George W. Ritchey. Smithsonian, Contributions to *Knowledge*, Vol. 34.

Ancient Volcanoes in South Africa

It has long been known that there are in Cape Colony and the adjacent territories many interesting relics of volcanoes of ancient date. Some of these are so old that they have been reduced to the general level of the surrounding country, and may even form depressed areas; while in others the original form of the mountain is to a certain extent still preserved. In the former category come the well-known pipes of Kimberley and the Premier mine, which are filled with a peculiar rock known as "Blue Ground." In this are found diamonds. The special feature of this sort of breccia is that it is not composed of volcanic rocks in the ordinary sense of the word, but consists chiefly of fragments of the sediments through which the pipe has been drilled, with an admixture of blocks of igneous rock that appear to have been brought up from great depths by the explosion. Other necks, again, contain a plug of the rather rare rock type, melilite-basalt. It has been suggested that the blue-ground plugs are the result of a very watery kind of eruption, taking place at a comparatively low temperature, and perhaps partaking rather of the nature of a mud-volcano. Dr. A. W. Rogers has recently described, in *The Transactions* of the Royal Society of South Africa, another interesting volcanic mountain presenting some novel features. This mountain, called "Geitsi Gubib," is situated in what was formerly German Southwest Africa, near the Keetmanshoop Railway, rising to a height of about five thousand feet above the sea and one thousand eight hundred feet above the high plateau on which it stands. It is ring-shaped, and shows a very well-marked central depression, which, however, does not seem to be in reality the original crater, but merely a hollow produced by the more rapid weathering of the softer rock of the plug. The original outlines of the volcano were probably destroyed long ago by denudation. The central plug is very large, about two miles in diameter, and is filled by a peculiar breccia, consisting for the most part of sedimentary material, some of which may have come from the Karroo series. There are likewise abundant fragments of quartz-gabbro, and of felspar and augite, derived from the gabbro; but there are no specimens of those peculiar igneous rocks, such as ecolite, which are so characteristic of the Kimberley breccias. Around the neck the strata of the Fish River series show a very well-marked dip toward the center, such as is seen in many other volcanoes, and they are likewise penetrated by two or three dykes filled with tuff. The breccias and tuffs resemble those filling pipes and fissures at other localities in South Africa, such as Saltpeter Kop, Kobe River, and Grenaat Kop, and also appear to have close affinities to some of the tuff-filled Carboniferous necks of Scotland. The most noticeable feature is undoubtedly the complete absence of fragments of lava of the ordinary types.

The origin of tuff-filled necks of this kind presents a difficult problem, and several different explanations have been suggested. Some writers have even supposed that they may be due to the impact of gigantic meteorites, which burrowed down far within the crust of the earth, churning up the rocks and causing them to rise as a kind of pasty mass within the hollow thus produced. This explanation was suggested and discarded by G. K. Gilbert in the case of the Coon Butte crater in Arizona, since the difficulties involved were very great. It cannot, however, be rejected as wholly impossible in all instances. Nevertheless, it seems more probable that these breccia-pipes originated from a single great volcanic explosion at a considerable depth, which blew out the overlying rocks mingled with steam and gases, ceasing before lava had time to rise to any considerable height in the vent. At any rate, it is clear that the last word has not been written on this subject, and further investigation of the remains of old volcanoes in South Africa may be expected to yield results of great interest and importance.—*Knowledge.*

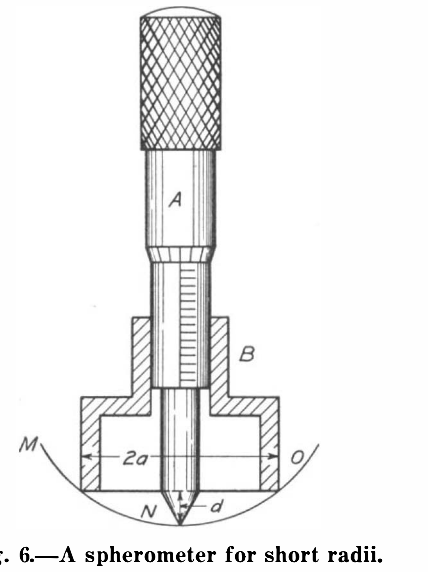


Fig. 6.—A spherometer for short radii.

In Fig. 6, *A* is a regular Brown & Sharpe micrometer head with the measuring point ground to an angle of 60 degrees and slightly rounded; *B* is a round steel base all machined at one setting in which the micrometer head is clamped by a set screw not shown.

Let r be the radius of the spherical surface, *MNO*, and we will have at once $r=(a^2+d^2)\ /\ 2d$. The advantage of this form of spherometer is that it is very easy to make the point of the micrometer exactly central with the base and the value of $2a$ can be accurately determined by means of an ordinary micrometer caliper. For a convex surface, $2a$ should obviously be the inside diameter of the base, *B*.

In using the instrument, two tables, one for concave and one for convex surfaces, should be prepared; these tables to give the power in dioptres for each one thousandth of an inch in the value of d. Using the American Optical Company's Standard Index, namely, μ equal to 1.5000 and one dioptre as being the power of a lens of 40 inches focus, we have, for a plano lens, $p=40/f=40d/(a^2+d^2)$ since $f=r/\ (\mu-1)$.

The advantage of forming the table in dioptres in place of radii directly is that the tabular differences are small at all parts of the table so that interpolation can be readily done and this is not the case in tables which give the radii directly.

If upon measuring the radius of the tool or lap being turned in the sphere turning machine, Fig. 4, with this spherometer, the tool is found to be in error by an amount $\triangle p$ this may be corrected by changing the position of the cutting tool by an amount $20\triangle p/p^2$.

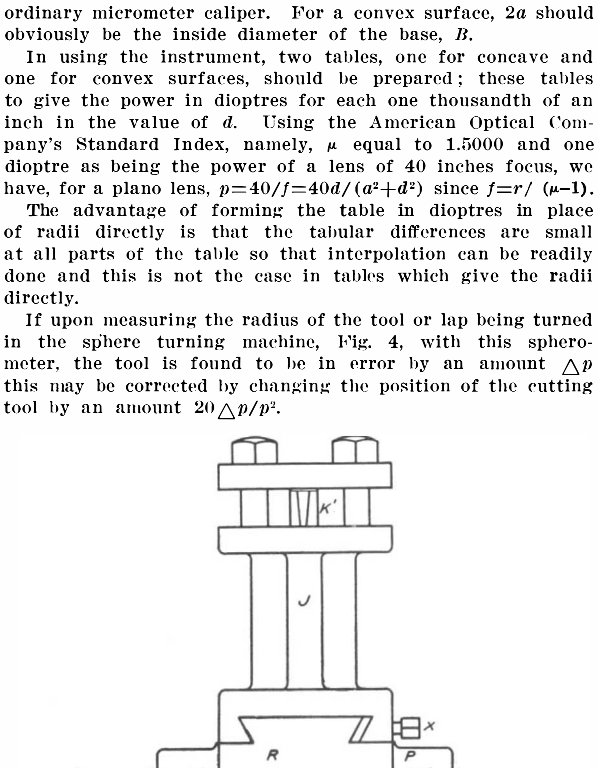


Fig. 7.—Cross-section of sphere turning rest.

In Fig. 7 is shown a cross section of the sphere turning rest further illustrated in Fig. 4. In machining this the following suggestions should be followed. The piece *M* should be cast with a lug projecting from the face *PQ* to chuck it by and all the turning done at one chucking. It should be made a close fit to *R* and bolted tight against *DG* and *ED'* with the bolts S_3 and S_4, clearance being given along the line *HF*. To compensate for wear the face *DG* and *ED'* can be releaved from time to time with a file. The base *N* should be planed along *AB*, where it fastens to the cross slide of the carriage, then bolted to a face plate of the lathe and finished, care being used to leave the setting of the compound rest unchanged between machining the faces *CD* and *C'D'* of the pieces *M* and *N*. The dove tail on *R* should be first planed and then this bolted to a face plate and the boss *GHFE* and the faces *KG* and *EL* turned at one setting. If these directions are followed almost no hand work will be needed. *W* is a brass worm wheel held by screws not shown, and *J* is the sliding tool post clamped at *X* with the tool at *K'*.

Swimming-Pool Sanitation

In large cities the question of supplying adequate swimming-pool facilities, and their sanitation, is a very pertinent one. Because of the mode of living, especially in the congested districts, this offers really the only means of sufficiently cleansing during weather when this seems most necessary, besides offering the readiest, though temporary, relief from the depressing heat of the Summer months. It is for them a stimulant of first value in overcoming the relaxation and the exhaustion accompanying such weather. At least for bathing and cleansing purposes, the pool—or its prototype in miniature, the bathtub—method is entirely unsatisfactory because it entails rewashing in the water contaminated by the very materials one desires to get rid of by the bath. At best, this method is unsanitary, and the sooner all pools and tubs are replaced everywhere by the shower bath the better. If this is properly and not extravagantly used, the consumption of water may be very small.

In cities like New York, situated on tidal water, the use of stream pools for bathing purposes in the Summer is a universal practice. The question of the safety of these stream pools is most important, especially when the waters are depositories for sewage. Even the tidal waters surrounding such a city as New York are not sufficient to remove the enormous amount of sewage deposited. While ordinarily the typhoid-colon element in water is not a large one, because usually so soon and so much diluted, where there is bathing at the very points of discharge of the sewage, the danger to health is great, especially in respect to the spread of typhoid where there is a large carrier population. Moreover, the whole gamut of pathogenic bacterial infection can be spread by pool water. Epidemics of vulvovaginitis, venereal disease, aural and ocular conditions have been reported as having been spread by swimming pools.

As a later development in swimming pools, the indoor pools offer a great many advantages, and obviate the prolific source of infection carried by live sewage. The usual drinking water being used, the opportunity for infection is only that of drinking water, and to a much lesser degree if the water is kept fresh and wholesome by one method or another. The element of colon contamination is supplied almost entirely by the bathers themselves, the dilution depending upon the amount of fresh water added, and the frequency of the addition. Investigations carried on by Manheimer (Public Health Report No. 229) showed that this element of pollution was quite appreciable. He made the amount of the bacterial content of the water and the presence of colon bacilli as his bacteriological index of the purity of the water, and the clearness and the ability to see the bottom of the pool as his practical index, being especially the index of the amount of solid matter suspended in the water. The larger the pool capacity in relation to the daily attendance, and the greater the frequency of the change of the water the safer is the pool. The least expensive and the best method of maintaining pool sanitation is by refiltration of the water used, combined with some chemical treatment, usually a coagulent like alum or calcium hyperchlorite. When the latter is used, a trace of chlorine must be present in the water to make it adequate.

The installation of indoor swimming pools, as recommended by the New York Department of Health, will soon take the place of the highly unsanitary stream swimming pools. But the installation must be along proper lines as to capacity, attendance, refiltration, and chemical treatment, else all the good that might accrue from the indoor pool will be lost.—*Medical Record.*

Treatment For Burns

In the treatment of sepsis we use chiefly hypertonic saline solution for burns of the extremities, if possible as a bath, as this serves the double purpose of keeping away air and cleansing the wound. To the face, if it is impossible to apply a continuous saline douche so as to cover completely the whole surface, we apply an oil consisting of menthol, 2 grains; eucalyptus oil, 3 min.; carron oil to the ounce. We on no account apply a dressing; the oil is applied from a bowl kept at the bedside, from which it is carried to the face on cotton-wool. This is applied at frequent intervals, the eyes at the same time being irrigated with boric lotion. At least three or four times a day the face is slightly sponged with saline so as to remove any pus which may be present and the greater part of the oil. This ensures that the oil is kept fresh and that no pus is allowed to be imprisoned under scabs, which quickly form if this precaution is not taken. If this is done frequently it is the simplest matter, and even the slightest hæmorrhage is avoided, and above all any little islands of epithelium from which the new skin will be produced are preserved.—*Lancet.*

Notes on Carburetion*

Principles of Operation and Functions of Vaporizing Devices

By Edward E. Dean

CARBURETION in this paper will be confined to the induction principle—that is, one in which the flow of air and fuel is induced and maintained by air displacement. It will therefore be apparent that the flow must vary from zero when the piston is at rest to maximum velocity when the piston has attained its maximum velocity. As soon as the piston begins to move on its induction stroke, air displacement occurs and the pressure in the passages between the carburetor and piston head become negative, decreasing gradually until maximum velocity is reached.

The simple carburetor consists of a tube of constant diameter, having a fuel jet in communication with the air flow. As the quantity of both air and fuel vary as the square of the tube diameter, it would seem necessary only to so proportion the tube and fuel duct to attain a proporional mixture for all air velocities.

If one were dealing with a perfect gas or were able to so deliver the fuel to the air stream thoroughly atomized, homeogeneously mixing it with the air without any expenditure of energy of the air stream, a proportional mixture of the air and fuel for all speeds might be expected. This, however, is not possible as friction head, viscosity and other retarding influences that vary with the velocity must be contended against.

Why does a simple carburetor seemingly deliver an increasingly richer mixture as the air velocities increase? This in the opinion of the writer is due to inefficient atomization when air velocities are low and lack of thorough saturation of the air stream with the fuel molecules. To offset this condition fuel must be admitted under less retardation, or in other words, the fuel orifice must be increased. As the air velocities increase, so also does the efficiency of atomization. The increase in the fuel orifice, which was necessary for low air velocities now becomes excessive, consequently the quantity of fuel molecules becomes greater as the air velocities increase, resulting in an over-rich mixture. The simple carburetor must of necessity be limited in its range of capacity and is at best wasteful of fuel.

A combination of the mixing valve and the simple tube carburetor becomes the foundation of our present instrument. The range of the mixing valve is far more limited than the simple tube, the tendency being toward rapid impoverishment as the air velocities decrease with air-valve opening. It will be noted that its action is the reverse of the simple tube carburetor. The mixing valve delivers an increasingly weaker mixture as the air quantities increase, while the tube delivers a richer mixture under the same conditions.

Attempts to correct the tendency to over-richness exhibited by the simple carburetor led to the early adoption of the auxiliary air valve. The popular conception of its function seems to be that of correction by diluting with air the over-rich mixture delivered by the simple tube portion of the carburetor. This is true, but its dual function is to not only add an extra amount of fresh air, but more particularly effect a modification of the air velocities at the fuel jet; that is, it increases the air supply, which decreases the tension on the air flow at the jet and consequently effects a reduction of inspiration, resulting in a weakened mixture.

As will be apparent from the foregoing, the auxiliary portion, be it spring or weight, can serve but one purpose—that is, to correct an over-rich mixture and at one point at a time.

It therefore follows that no adjustment of spring tension can do more than slightly modify this tendency toward impoverishment of the mixture, while the addition of various forms of subsidiary springs becoming operative only at some point of valve opening can do no more than correct the air at one given point and then start, as it were, merely a new scale of errors. This is not only true when springs are used, but is an unavoidable fact when correction is attempted in this manner by any means.

The multiple-jet type may be compared to the auxiliary-air type, being an attempt at correction by the addition of jets as needed, and is subject to the same criticism as pointed out in the auxiliary air-valve construction. Results approaching perfection may be attained by this method, but of necessity they must be sensible in construction. The jets in the smaller sizes must be minutely small if any number are to be employed, with consequent troubles from water and foreign matter in the fuel.

The variable-fuel orifice type, in which a tapered valve is withdrawn from the fuel orifice in relation to the quantity of air passing through the carburetor, in principle approaches the ideal. However, when one considers that the fuel and air ratio by volume is about one to eight thousand, and as this method is a direct graduation of the one part, its sensitiveness will be apparent.

The successful carburetor must accomplish as fully as possible atomization of the fuel at all working air velocities and a thorough saturation of the air stream with fuel molecules, consistent with volumetric efficiency of the motor, and must so deliver the mixture to the manifold. It must be simple, with no more moving parts than absolutely necessary, and its principle must consist in controlling the air pressures which directly effect inspiration.

To successfully utilize kerosene or other fuel oils in an internal-combustion motor of the carburetor type, it becomes necessary to deliver the fuel charge to the combustion space thoroughly saturated with the fuel molecules in a correct proportion for all air velocities. The accomplishment of this depends upon several factors.

The correct design of carburetor would be one in which the air velocities must be maintained sufficiently high at all speeds to effect a thorough atomization of the fuel stream from the jet and at the same time not so high as to cause wire drawing, resulting in a partial charge and loss of power.

The writer would divide the process of carburetion of air and fuel into three stages, the carburetor being responsible for the first stage, the manifold and inlet passages the second stage, and the period of compression the third and final stage.

Assume that the mixture has been delivered to the manifold in a thorough state of saturation, which is the completion of the first stage. Throughout the second stage this thorough admixture of air and fuel not only must be maintained, but must be assisted by partial vaporization and delivered to the third stage. In the third stage occurs gasification due to compression, which accomplishes a closer commingling of the fuel molecules with the air, resulting in rapid flame propagation. This is assisted materially by the rise in temperature due to compression and heat from the cylinder walls. Summarized, we find: First stage, atomization; second stage, vaporization; third stage, gasification. Where these three stages are accomplished successfully, the use of fuel oils is possible.

The temperature of the incoming air is subject to considerable change in passing through a carburetor dropping practically 50 per cent under normal conditions. This is due to expansion after leaving the tube restriction and loss from evaporation of the fuel.

As kerosene begins to give off a vapor at about 80 deg. Fahr., it follows that the temperature must not fall below this figure at any time and should be somewhat higher consistent with volumetric efficiency. To offset this temperature drop, we may increase the temperature of the incoming air. However, this is not enough. If we could maintain a suspension of fuel molecules in the air stream without any deposition, this would be sufficient. Unfortunately we must have bends and turns in fuel passages, and as the fuel molecules have a greater specific gravity than the air, they will be impinged or thrown against the sides and remain in a liquid state. This means an impoverished mixture. This must be avoided and can be by applying heat to the sides or walls of the manifold, which will materially assist in revaporizing these molecules and sending them back into the air stream.

Modern practice seems to point out the advisability of applying heat to assist carburetion. There are at least three practical methods being used successfully: Raising the temperature of the intake air, heat jacketing the manifold, and applying heat directly to the fuel supply. The successful burning of the lower-grade distillates depends upon at least the two former means. The third may be employed with good results.

In the application of heat we are attempting to maintain a temperature within the carburetor and passages sufficiently high to assist and maintain vaporization. This is best accomplished through the medium of raising the temperature of the intake air. Preheating the fuel will assist in atomization, but owing to the extremely small amount entering the air stream, can have but slight effect in maintaining the necessary temperature for vaporization. Applying heat to the fuel passages is very necessary, especially where the charge has some distance to travel. Deposition of fuel must inevitably take place, and unless this can be got back into the incoming charge, it must arrive at the combustion space in an impoverished condition. It is therefore very essential that heat be applied to the manifold and brought as near to the carburetor as possible.

As the specific gravity of the fuel increases, so should the temperature of heat application increase. With present-day gasoline much benefit could be derived by jacketing the manifold with hot water throughout its entire length; but with kerosene, hot water is not sufficient—exhaust gas must be used. Here arises a situation which does not lend itself to direct application when best results are sought.

At low motor speeds, when air velocities through the carburetor are low and atomization is incomplete, we should have the highest temperatures, especially around the manifold jacket. The temperature and quantity of exhaust gas is limited at this time. Therefore the supply of exhaust gas is inversely proportional to the needs. To offset this condition a governing means might be employed so as to utilize all the exhaust at low speeds, controlling it as much as may be found necessary for the increase in speed.

The manifold should be as short as possible consistent with good diffusion and proper distribution. It should have few bends and large radii, avoiding pockets and change of cross-section to such an extent as shall affect the velocity of the incoming charge.

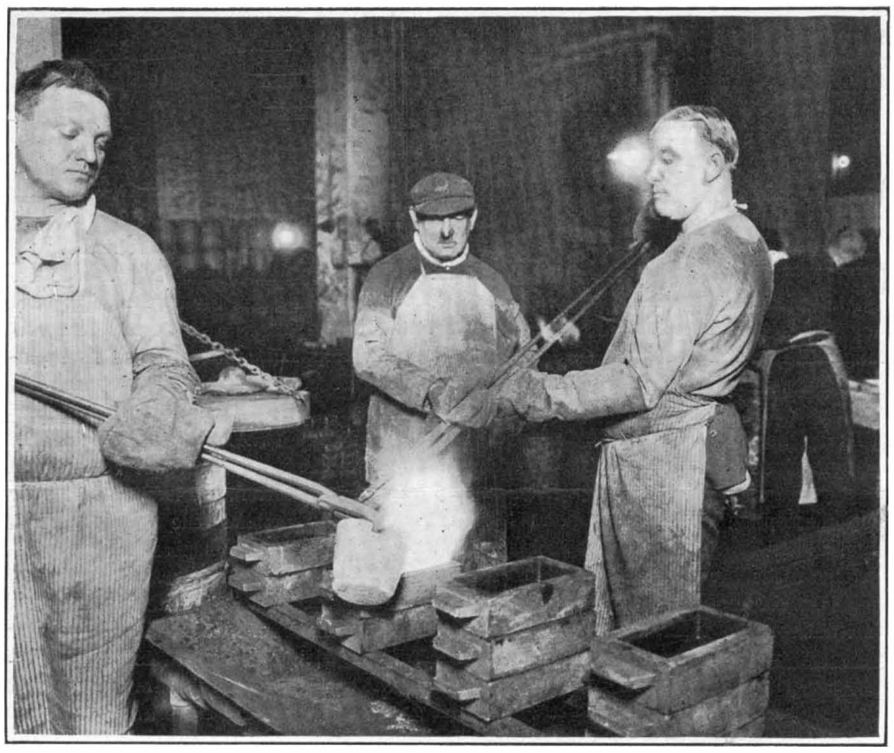
*From paper read before the National Gas Engine Association convention at Chicago, June 27-29, 1916.

Can Cannon Fire Cause Rain?

THE cause of the prolonged rainy period that prevails in France is traced by some persons to the cannon firing, and there is a difference of opinion in this regard among the public. In order to learn what competent authorities thought about the matter, the *Journal* consulted Prof. A. Angot, director of the Central Meteorological Bureau at Paris. He considers that there is no relation whatever between the rain and the cannonading that is now going on, and remarks that the years 1910 and 1912 were notable for heavy rains, and in the former year there occurred the inundations of the Seine. On the contrary the year 1911 was unusually dry. Experiments have been made in this and other countries to bring about rain by firing numerous and very heavy charges of explosives, but without producing the desired effect. It should be noted that the production of rain is always connected with the general movements of the atmosphere. To cause rain the moist air must be drawn up by an ascending air current, which is sufficiently rapid and prolonged, and it rains at a certain place because the winds, often coming from a long distance, being moist air to this point and are at the same time strongly ascendant. It is worthy of remark that these ascensional movements are made by enormous masses of air compared with which the air displacements caused by the explosion of shells or firing of cannon are quite negligible. Such effects are so minute in comparison with the complex phenomena of the atmosphere that man's action would be quite chimerical should he attempt to control such phenomena, at least in the present state of our knowledge.

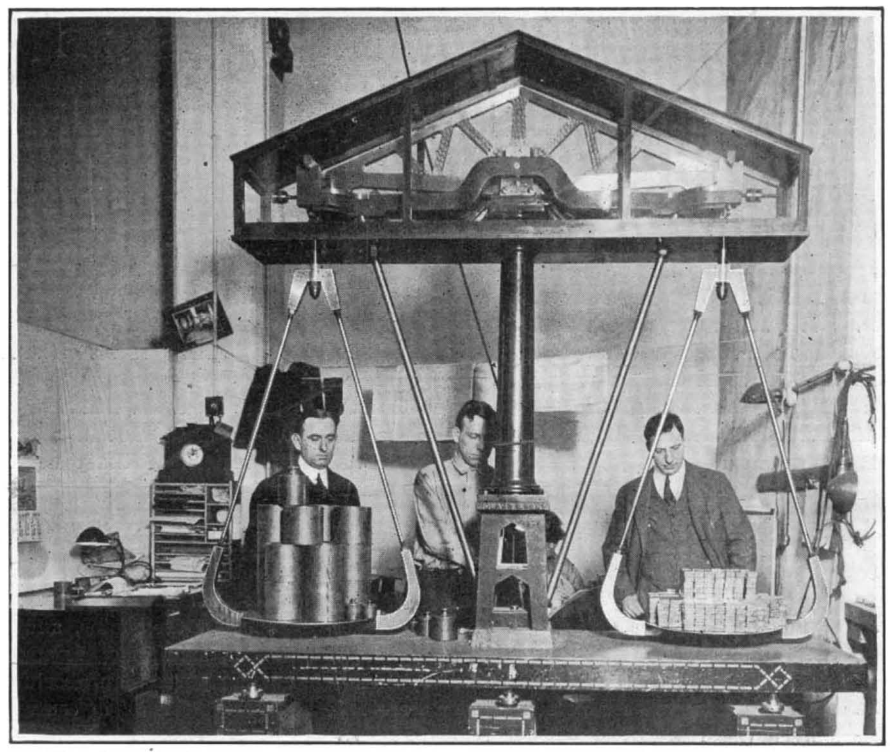
Army Service Museum

A MUSEUM which presents a special interest at this time was recently inaugurated at the Val-de-Grace Hospital of Paris, which takes a prominent part as regards the scientific treatment of the wounded. The museum, which is in charge of Prof. Jacob, has two large rooms devoted to surgical subjects, among which are remarked the numerous models relating to reconstitutions of parts of the human body. Other rooms contain a large collection of modern scientific means of destruction used in the war and also a series of protecting masks for asphyxiating gases. We also remark the well-fitted laboratory, which is devoted to anti-typhic vaccination, and in another place there is installed a miniature representation of the working of the health service in the army.



Press Illustrating Service, Inc.

Casting molten gold into ingots in iron molds.



Press Illustrating Service, Inc.

Weighing ingots of gold at the U. S. Assay Office.

Melting Down Foreign Gold

What Becomes of the River of Coin Flowing From Europe

When the great war began the allied countries found themselves not only inadequately provided with the materials which had heretofore been considered necessary for the conduct of a military campaign, but they were also practically destitute of the hundreds of things that the new methods of warfare since developed have made indispensable. They were short of arms of every description, from the pistol and bayonet to the great siege guns that were so sensationally disclosed by the Central Powers, together with ammuition for the same. They needed clothing and food in immense quantities, motor vehicles of every description for the transportation of men and materials, locomotives, aeroplanes, motors, balloon material, barbed wire and thousands of other articles, and these so quickly that their own resources were able to meet but a fraction of the demand; and naturally they turned to the vast resources of America for assistance.

It is not alone for materials for the armies that the resources of America have been requisitioned, but supplies of every description have been needed for home consumption, as the diversion of every available manufacturing establishment to the making of munitions, and the lack of men to cultivate the fields has resulted in a shortage of almost everything in all the countries engaged in the strife, so that a double demand has been thrown upon the United States that is steadily draining it of material that is actually needed at home.

In payment for this vast mass of material gold, largely in the form of the coin of the various purchasing nations, has been flowing into this country in vast amounts for more than a year, and the tide is still on the flood. Not only have these payments come from Europe, but gold has poured across the border from Canada so fast in recent weeks that a recent shipment of $20,000,000 had to be divided between the New York Assay office and the Philadelphia Mint in order to give employes of the former institution a chance to get caught up with their work.

While records are not complete to the final dollar's worth of gold imported so far this year, in round numbers the total has been around $500,000,000, and of this amount $294,000,000 has been entered since May 10 either at the New York Assay office or at the Philadelphia Mint for the account of various banking houses.

So far it has not been found necessary or expedient to make shipments to the Denver Mint, as was suggested when the unusual quantity of gold began to arrive. The Assay office in New York was prepared from the middle of July on to receive approximately $3,000,000 a day on the average of the bars and coin exported by Canada and England, though the shipments were not expected to be regular. There have been many scattered receipts of amounts ranging from $10,000,000 to $25,000,000, but the bulk of the importation has been divided into shipments of $2,500,000 up to $5,000,000.

No less important from the banker's point of view than the extraordinary total imported is the prospect that the inflow will continue for an indefinite period. The influence of this gold on the credit facilities in this country cannot be estimated.

Comparisons with the amounts received in previous years is most interesting. The gain in gold reserve since the beginning of 1914 has been nearly two-thirds as large as the entire per capita resources in 1896.

So great has the amount of foreign coin been that it has been impossible to utilize all of it in its original form, and consequently a very large proportion of this coin has been sent to the mints of the United States to be melted down into bars and ingots, which later can be re-coined into United States money, or made use of in these forms for future transactions. Most of this work of melting down the foreign gold has been done at the U. S. Assay Office in New York, and the accompanying illustrations show some of the operations. In the cover illustration a workman is shown in the act of shoveling gold coin into a melting furnace, and it is startling to see such wealth being handled with an ordinary coal scoop. Another picture showing the weighing of gold bullion on a scale of great size, but necessarily of extreme accuracy, gives a striking impression of the difference in mass between the brass weights and the bars of fine metal.

Some Curious Electrical Experiments

X-ray Investigation.—Take an ordinary electric light bulb, coat it with aniline violet collodine. Take an ordinary piece of glass; coat same with a little sulphate of quinine dissolved in gum-water. Expose a plate for X-ray photograph in ordinary way to the light of violet lamp passing through the quinine sulphate screen. X-ray effect clearly observed.

Take same violet lamp, place in a small mount, and attach to the eyepiece of any telescope. Put the lamp in series with a dry cell (sufficient to send a current through lamp, but not to incandescence). Insert in the circuit a telephone receiver, in front of which is a microphone augmenter in circuit with a second telephone. By winding round the ebonite case of the first receiver telephone 50 to 100 turns of No. 30 wire in series with an independent battery and adjustable resistance, a stellar bolometer for measuring radiant heat is obtained far superior to the ordinary Lawley bolometer. The arrangement can also be used as a very delicate thermograph for measuring low temperature; even liquid air and hydrogen providing compensating resistance is sufficient.

Take the same lamp (violet), place in series with battery (to light), and an ordinary electric bell contact-breaker; place lamp by the side of any potted plant, so that light-wave can pass (actinic wave, that is), through flower-pot to roots of plant, stimulated growth is obtained.

Take same lamp in series with lighting battery and sound-augmenter microphone, which should be carried into a distant room where music is being played. Place the lamp in a dark room, and sit beside it while the music is being played, and note the effect of the violet-light vibration (from music) on the weary brain. Beats all spirit hanky-panky business—a genuine cerebral phenomenon that requires no half-guinea medium to produce.

Take same violet lamp and screen battery (sufficient for current only) in series with telephone receiver. Attach a microphone sound augmenter in series with second telephone and battery. Place the violet lamp and screen on any dead body—plenty of cats about—but do not use the landlady's pet Tommy, or look out for the S. P. C. A. A faint humming in the second 'phone will be produced as long as any organic life is present in the corpse. It does not cease until days after the normal physical life is dead—in fact, the aroma of the corpse will stop experiment long before the telephone thinks of going on strike.

Take the same lamp and screen (lamp current not sufficient to light); connect series to battery and telephone sound augmenter and second telephone. Place lamp where you please. If any person or object crosses the path of the lamp—providing any ray of light touches the moving body or person—the distant 'phone will "hum"—in fact, there are times when the "hum" will be produced from a dark room without a stray ray of light in same. Now we shall have the spirits moving to tell us the reason why. Well, never mind the spirits; but what price a good burglar-detector? Once Bill Sykes crosses the path of the lamp, and the faint light of his lantern or electric torch kindly rings the bell for P.C. A7 round the corner to make a friendly call. It ought to be superior to that door contact he has just put out of action!—*C. Mayfield, in English Mechanic.*

A Cheap Disinfecting Fluid

A most useful work that is being performed by municipal and government electric plants in various parts of the world is the preparation of a disinfecting fluid, quantities of which are required in every city and town. This fluid as usually produced is prepared by the electrolysis of a saturated solution of chloride of magnesium together with certain proportions of common salt and caustic soda. In some cases, at stations situated on the sea coast, sea water is converted directly without the addition of any other material, and the only expense is for the electric current. The disinfectant produced as above described costs but a trifle, so that any town possessing apparatus for the purpose can afford to use the liquid quite freely.

Peanuts stacked in the fields to cure before picking.

Picking peanuts by hand from the field stacks.

The Cultivation of Peanuts

A Valuable Crop That Grows in Many Climates

THE peanut is the fruit of a leguminous plant closely allied to the common garden bean or pea. It is known botanically as *arachis hypogea*. The generic name *arachis* is derived from the Greek word *arachos*, meaning weed, and the specific term *hypogea* comes from *hypo*, under, and *gea*, earth, an allusion to the fact that the fruit of this plant develops in the ground. The unripened pistils are thrust into the ground immediately after flowering, where they develop into pale, yellowish and slightly curved pods several inches in length holding from one to four seeds. The fruits are commonly, though incorrectly, known as nuts, when as a matter of fact they are peas and are sometimes called grouper peas or ground peas. In the trade they are referred to as groundnuts, earthnuts and monkeynuts. A true nut botanically bears no relation to the fruit of the so-called peanut.

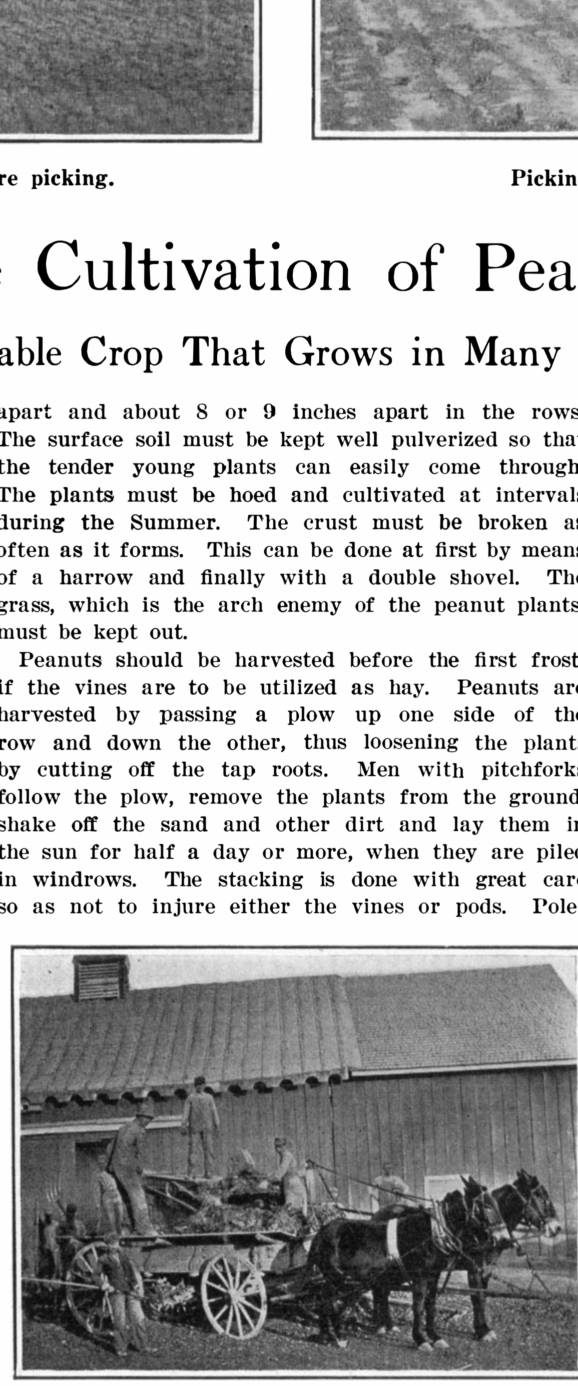
The peanut is an important agricultural crop and is now almost universally cultivated, finding a congenial soil in nearly all parts of the world. It is one of those plants that cannot, strictly speaking, be classed either with the products of the temperate climates, or with those of the tropics. It holds a certain intermediate place, and gives best results in a region that had originally a dense growth of hardwood forests. It will not stand frost, however, and can be cultivated successfully only where the growing season is long enough for the plant to attain maturity. Yet as it is but a short time in the ground, it can be grown in any place where the grapevine will thrive successfully.

The peanut is said to be a native of Brazil, and it seems peculiar that it grows at all in temperate regions. For the best results with peanuts, a growing period with no extremes of temperature is essential. While it does not do well in extreme heat, it is cultivated in nearly all tropical countries. In the United States it is confined chiefly to the Southern States, though it is cultivated also in the Middle States. It has been introduced into the states of the Middle West, Southwest and into California. The peanut industry has been greatly developed in the South since the Civil War, where it is gradually becoming more promising and forms one of the paying crops.

Although peanuts will grow in fairly well-drained, rich, loamy soil, it will yield best results in deep, rich, warm and loose soil that contains sand and gravel. Some experienced growers describe the best soil for peanuts as a light, gravelly clay. Peanuts will grow well in sandy soils but only on condition that the plants are well supplied with suitable plant food, otherwise their growth, though encouraging at the first, will be disappointing in the end. On stiff clay the plants are unable to push the young pistils into the ground and they will soon wither and fail to attain perfection. On humus soils where vegetable matter abounds, the plants grow with great vigor and luxuriance. But peanuts will grow reasonably well on any soil that is moist, friable, and plentifully supplied with plant food in available form.

The methods of cultivation are fairly uniform throughout. After the land is plowed early in the Spring, it must be thoroughly pulverized immediately before planting. The seeds are carefully hulled out by hand so as not to break the inner thin husk, and planted about 2 inches deep in rows about 30 inches apart and about 8 or 9 inches apart in the rows. The surface soil must be kept well pulverized so that the tender young plants can easily come through. The plants must be hoed and cultivated at intervals during the Summer. The crust must be broken as often as it forms. This can be done at first by means of a harrow and finally with a double shovel. The grass, which is the arch enemy of the peanut plants, must be kept out.

Peanuts should be harvested before the first frost, if the vines are to be utilized as hay. Peanuts are harvested by passing a plow up one side of the row and down the other, thus loosening the plants by cutting off the tap roots. Men with pitchforks follow the plow, remove the plants from the ground, shake off the sand and other dirt and lay them in the sun for half a day or more, when they are piled in windrows. The stacking is done with great care so as not to injure either the vines or pods. Poles about 7 feet high are driven into the ground with several sticks on the ground so as to keep the vines from getting in contact with the soil, thus insuring a freer circulation of air and preventing heating. The piles are sometimes covered with straw or corn fodder to keep off rain and to insure quicker drying. They are then passed through a peanut thresher, which separates the pods from the vines. This operation was formerly performed by men, women and children, but the new method of removing the pods by machinery is not only less tedious but also much quicker and less expensive. These threshers have been pretty generally introduced, though there are still some growers who have the pods picked by hand, usually paying from 8 to 12 cents a bushel.



Delivering the vines at the thresher house.

When properly cultivated peanuts will yield from 50 to 70 bushels of pods per acre and from 1 to 2 tons of good hay. The vines produce excellent fodder for cattle, especially when well cured. If they are injured by frost prior to harvesting they are unfit for cattle, but should be fed to hogs or placed back on the field as manure. The vines, like the plants of clover and cow peas, are excellent for green manuring. The roots develop an abundance of tubercles which contain bacteria-like bodies which elaborate nitrogen for the use of the plant.

The importance of the peanut industry in the United States is generally recognized. The splendid results that have been obtained in the Southern States for many years have focused attention upon the peanut possibilities of the Middle West and the Southwest. California is also an important peanut-producing region, but with all this enormous production of peanuts this country does not produce all the peanuts required for home use. The average annual imports from Africa, China and India amount to more than 20,000,000 pounds, valued at about $1,000,000.

Simple Astronomical Instruments for the Teacher

So far as my knowledge goes, not even a name exists for what I am about to refer to; hence I will coin the term "Equatorial Pointer." What I have in mind is really a working model of an equatorial telescope; sufficiently accurate when placed level in the meridian to point—when set by its circles—to constellations, clusters, and with some approach to accuracy to stars.

I have no lathe, and no opportunity for working in metal, but a few years ago I constructed a wooden instrument of the sort suggested. The "telescope" or finder was simply the empty tube of a worn-out garden syringe with the piston removed, the eye being placed at the small end. The Declination Circle was a brass protractor such as schoolboys use, and cost threepence. The hour circle was a tin can lid, painted black and then divided into hours and quarter-hours. The clamp on the Declination Axis was a common window sash fastener. Two spirit levels costing sixpence each were fixed on the base, also a compass. I only intended it to be sufficiently accurate to enable a pupil of mine to understand the principle of the thing; to distinguish Castor from Pollux, to locate the Pleiades, to find Coma Berenices and Præsepe, and to distinguish Saturn from Aldebaran. But it did much more than this. In the twilight, when one had no other guide to position, it located Mercury by presenting one small circle of the heavens only. If the planet was not exactly at the center of the field, in every case it was within the circle presented for examination. In the same way, Venus was found by daylight. The instrument was useful for indicating to others the exact spot where the sun or moon would rise or set on any given day of the year, and to indicate the direction at any moment of the object, whether above or below the horizon. Likewise the diurnal arc of the sun in December or in June could be shown. There were, of course, no lenses—simply a tube, a pointer. To students and to teachers alike, a neatly made model of this nature would be of immense value.

Real working models of steam engines and scores of other things can be had for a few shillings, why not such an educational contrivance as an equatorial pointer? The Hour Circle in five-minute divisions, and the Declination Circle in half-degrees would be amply accurate enough. The diameter of the field of view might be large enough to cover the Pleiades. Finally, the cost must be low.

A cheap transit instrument (for teaching purposes) is also needed—one to give the time from rapidly moving Equatorial stars with about the same accuracy as a sundial, say within a couple of minutes.

I also made an instrument of this sort, again using a brass garden syringe tube without lenses.—*Frederick G. Taylor, in the English Mechanic.*

The Naval Reserve Force

A Portion of a Bill Approved by Congress August 29, 1916

THERE is hereby established, under the Department of the Navy, a Naval Reserve Force, to consist of six classes, designated as follows and as hereinafter described:

First. The Fleet Naval Reserve.
Second. The Naval Reserve.
Third. The Naval Auxiliary Reserve.
Fourth. The Naval Coast Defense Reserve.
Fifth. The Volunteer Naval Reserve.
Sixth. Naval Reserve Flying Corps.

The Naval Reserve Force shall be composed of citizens of the United States who, by enrolling under regulations prescribed by the Secretary of the Navy or by transfer thereto as in this Act provided, obligate themselves to serve in the Navy in time of war or during the existence of a national emergency, declared by the President: *Provided*, That citizens of the insular possessions of the United States may enroll in the Naval Auxiliary Reserve.

The Secretary of the Navy shall make all necessary and proper regulations not inconsistent with law for the administration of the provisions of this Act which relate to the Naval Reserve Force.

Members of the Naval Reserve Force may be ordered into active service in the Navy by the President in time of war or when, in his opinion, a national emergency exists.

There shall be allowed in the Naval Reserve Force the various ratings, grades, and ranks, not above the rank of lieutenant commander, corresponding to those in the Navy. Officers of the line may be appointed for deck or engineering duties, as they may elect.

Members of the Naval Reserve Force appointed to commissioned grades shall be commissioned by the President alone, and members of such force appointed to warrant grades shall be warranted by the Secretary of the Navy: *Provided*, That officers so warranted or commissioned shall not be deprived of the retainer pay, allowances, or gratuities to which they would otherwise be entitled. Officers of the Naval Reserve Force shall rank with but after officers of corresponding rank in the Navy.

Enrollment and reenrollment shall be for terms of four years, but members shall in time of peace, when no national emergency exists, be discharged upon their own request upon reimbursing the Government for any clothing gratuity that may have been furnished them during their current enrollment.

Persons enrolling shall be required to take the oath of allegiance to the United States.

When first enrolled, members of the Naval Reserve Force, except those in the Fleet Naval Reserve, shall be given a provisional grade, rank or rating in accordance with their qualifications determined by examination. They may thereafter, upon application, be assigned to active service in the Navy for such periods of instruction and training as may enable them to qualify for and be confirmed in such grade, rank or rating.

No member shall be confirmed in his provisional grade, rank or rating until he shall have performed the minimum amount of active service required for the class in which he is enrolled, nor until he has duly qualified by examination for such rank or rating under regulations prescribed by the Secretary of the Navy.

No person shall be appointed or commissioned as an officer in any rank in any class of the Naval Reserve Force, or promoted to a higher rank therein, unless he shall have been examined and recommended for such appointment, commission, or promotion by a board of three naval officers not below the rank of lieutenant commander, nor until he shall have been found physically qualified by a board of medical officers to perform the duties required in time of war, except that former officers and midshipmen of the Navy, who shall have left the service under honorable conditions and who shall have enrolled in the Naval Reserve Force, may be appointed in the grade and rank last held by them without examination other than the physical examination above prescribed.

The retainer pay of all members of the Naval Reserve Force, except the Volunteer Naval Reserve, while enrolled in a provisional rank or rating, and until such time as they shall have been confirmed in such rank or rating, shall be $12 per annum. Thereafter, the retainer pay shall be that prescribed for members in the various classes.

Retainer pay shall be in addition to any to which a member may be entitled by reason of active service.

Retainer pay shall only be paid to members of the Naval Reserve Force upon their making such reports concerning their movements and occupations as may be required by the Secretary of the Navy.

Members of the Naval Reserve Force who reenroll for a term of four years within four months from the date of the termination of their last term of enrollment, and who shall have performed the minimum amount of active service required during the preceding term of enrollment, shall, for each such reenrollment, receive an increase of twenty-five per centum of their base retainer pay: *Provided*, That enrolled members who shall have completed twenty years of service in the Naval Reserve Force, and who shall have performed the minimum amount of active service required in their class for maintaining efficiency during each term of enrollment, shall, upon their own application, be retired with the rank or rating held by them at the time, and shall receive in lieu of any pay, a cash gratuity equal to the total amount of their retainer pay during the last term of their enrollment.

Retainer pay shall be paid annually or at shorter intervals, as the Secretary of the Navy, in his discretion, may direct.

No existing law shall be construed to prevent any member of the Naval Reserve Force from accepting employment in any branch of the public service, except as an officer or enlisted man in any branch of the military service of the United States or any State thereof, nor from reeciving the pay and allowances incident to such employment in addition to his retainer pay.

Enrolled members of the Naval Reserve Force shall be subject to the laws, regulations, and orders for the government of the Regular Navy only during such time as they may by law be required to serve in the Navy, in accordance with their obligations, and when on active service at their own request as herein provided, and when employed in authorized travel to and from such active service in the Navy. Members of the Naval Reserve Force shall be issued a distinctive badge or button which may be worn with civilian dress, and whoever, not being a member of the Naval Reserve Force of the United States and not entitled under the law to wear the same, willfully wears or uses the badge or button or who uses or wears the same to obtain aid or assistance thereby, shall be punished by a fine of not more than $20 or by imprisonment for not more than thirty days or by both such fine and imprisonment.

All members of the Naval Reserve Force shall, when actively employed as set forth in this Act, be entitled to the same pay, allowances, gratuities, and other emoluments as officers and enlisted men of the naval service on active duty of corresponding rank or rating and of the same length of service. When not actively employed in the Navy, members of the Naval Reserve Force shall not be entitled to any pay, bounty, gratuity, or pension except as expressly provided for members of the Naval Reserve Force by the provisions of this Act.

Enrolled members of the Naval Reserve Force may, in time of war or national emergency, be required to perform active service in the Navy throughout the war or until the national emergency ceases to exist.

Members of the Naval Reserve Force shall, upon first reporting for active service for training during each period of enrollment, be credited with a uniform gratuity of $50 for officers and of $30 for men.

Upon reporting for active service in time of war or national emergency the uniform gratuity shall be $150 for officers and $60 for men, or the difference between these amounts and any amounts that may have been credited as a uniform gratuity during the current enrollment: *Provided*, That should any member of the Naval Reserve Force sever his connection with the service without compulsion on part of the Government before the expiration of his term of enrollment, the amount so credited shall be deducted from any money that may be or may become due him.

Hereafter, in shipping officers and men for service on board United States auxiliary vessels, preference shall be given to members of the Naval Reserve Force, and, after two years from the date of approval of this Act, no person shall be shipped for such service who is not a member of the Naval Reserve Force herein provided.

Members of the Naval Reserve Force may, upon application, be transferred from one class to another class for which qualified under the provisions of this Act; and may in time of war volunteer for and be assigned to duties prescribed for any class which they may be deemed competent to perform.

The Secretary of the Navy shall prescribe a suitable flag, or pennant, that may be flown as an insignia on private vessels or vessels of the merchant service commanded by officers of the Naval Reserve Force: *Provided*, That it shall not be flown in lieu of the National ensign.

The Secretary of the Navy is hereby authorized to establish schools or camps of instruction at such times and in such localities as he may deem advisable for the purpose of instructing members and applicants for membership in the Naval Reserve Force. No applicant shall be accepted for instruction unless he agrees to abide by the regulations of the school and pursue the course prescribed by the Secretary of the Navy. Persons who satisfactorily complete the course will be given certificates of qualification for the rank or rating for which duly qualified, and may be permitted to enroll in the proper class of the reserve in such rank or rating. For the purpose of carrying into effect this paragraph of the Act there is hereby appropriated, out of any money in the Treasury not otherwise appropriated, $30,000, which is hereby made available to be expended as the Secretary of the Navy may direct in the necessary equipment and maintenance of such schools and camps.

FLEET NAVAL RESERVE.

All former officers of the United States naval service, including midshipmen, who have left that service under honorable conditions, and those citizens of the United States who have been, or may be entitled to be, honorably discharged from the naval service after not less than one four-year term of enlistment or after a term of enlistment during minority, and who shall have enrolled in the Naval Reserve Force shall be eligible for membership in the Fleet Naval Reserve.

In addition to the enrollments in the Fleet Naval Reserve above provided, the Secretary of the Navy is authorized to transfer to the Fleet Naval Reserve at any time within his discretion any enlisted man of the naval service with twenty or more years' naval service, and any enlisted man, at the expiration of a term of enlistment who may be then entitled to an honorable discharge, after sixteen years' naval service: *Provided*, That such transfers shall only be made upon voluntary application and in the rating in which then serving, and the men so transferred shall be continued in the Fleet Naval Reserve until discharged by competent authority.

The Secretary of the Navy is authorized to assign any member of the Fleet Naval Reserve to active duty for training on board ship, upon the application of such member, but any member who has failed to perform three months' active service with the Navy in any term of enrollment shall, on the next reenrollment, receive retainer pay at the rate of $12 per annum, until such time as he shall have completed three months' active service. The three months' active service with the Navy may be taken in one or more periods, at the election of the member: *Provided*, That no member shall be entitled to travel allowance unless the period of such active service is for not less than one month, or unless specifically provided for by such regulations as may be prescribed by the Secretary of the Navy.

Men enrolled in the Fleet Naval Reserve with less than eight years' naval service shall be paid at the rate of $50 per annum; those with eight or more years and less than twelve years' naval service shall be paid at the rate of $72 per annum; and those with twelve or more years' naval service shall be paid at the rate of $100 per annum, such pay to be considered as retainer pay for the obligation on the part of such members to serve in the Navy in time of war or national emergency: *Provided*, That for all purposes of this Act a complete enlistment during minority and any enlistment terminated within three months prior to the expiration of the term of enlistment by special order of the Secretary of the Navy, shall be considered as four years' service. The annual retainer pay of officers of the Fleet Naval Reserve shall be two months' base pay of the corresponding rank in the Navy.

Reenrollments in the Fleet Naval Reserve shall be for four years. Officers and men enrolling in the Fleet Naval Reserve within four months of the date of the termination of their last naval service or reenrolling within four months of the date of the termination of

their last term of enrollment shall receive an increase of twenty-five per centum of their retainer pay for each such enrollment: *Provided*, That men who have enrolled in the Fleet Naval Reserve within four months of the date of their discharge from the regular naval service shall, upon reenlistment in the regular naval service within four months of the date of discharge from the Fleet Naval Reserve, be entitled to the same gratuity and additional pay as if they had reenlisted in the regular naval service within four months of discharge therefrom.

Members of the Fleet Naval Reserve who have, when transferred to the Fleet Naval Reserve, completed naval service of sixteen or twenty or more years shall be paid a retainer at the rate of one-third and one-half, respectively, of the base pay they were receiving at the close of their last naval service plus all permanent additions thereto: *Provided*, That the pay authorized in this paragraph as a retainer shall be increased ten per centum for all men who may be credited with extraordinary heroism in the line of duty or whose average marks in conduct for twenty years or more shall not be less than ninety-five per centum of the maximum.

Any pay which may be due any member of the Fleet Naval Reserve shall be forfeited when so ordered by the Secretary of the Navy upon the failure, under such conditions as may be prescribed by the Secretary of the Navy, of such man to report for inspection.

Members of the Fleet Naval Reserve who have established their qualifications by examination to the satisfaction of the Secretary of the Navy may be given warrants or commissions in the Fleet Naval Reserve in the grades of boatswain, gunner, carpenter, machinist, pharmacist, pay clerk, ensign for deck or engineering duties, or in the lowest grades of the staff corps: *Provided further*, That those so warranted or commissioned shall not be deprived of the retainer pay, allowances, or gratuities to which they would be otherwise entitled.

Men transferred to the Fleet Naval Reserve shall be governed by the laws and regulations for the government of the Navy and shall not be discharged from the Naval Reserve Force without their consent, except by sentence of a court-martial. They may, upon their own request, upon completing thirty years' service, including naval and fleet naval reserve service, be placed on the retired list of the Navy with the pay they were then receiving plus the allowances to which enlisted men of the same rating are entitled on retirement after thirty years' naval service. They shall be required to keep on hand such part of the uniform-clothing outfit as may be prescribed by the Secretary of the Navy.

The Secretary of the Navy is authorized in time of war or when a national emergency exists to call any enlisted man on the retired list into active service for such duty as he may be able to perform. While so employed such enlisted men shall receive the same pay and allowances they were receiving when retired.

NAVAL RESERVE.

Members of the Naval Reserve Force who have been or may be engaged in the seagoing profession, and who have enrolled for general service, shall be eligible for membership in the Naval Reserve. No person shall be first enrolled in this class who is less than eighteen or more than thirty-five years of age, nor unless he furnishes satisfactory evidence as to his ability and character; nor shall any person be appointed an officer in this class unless he shall have had not less than two years' experience as an officer on board of lake or ocean going vessels.

The minimum active service required of members to qualify for confirmation in their rank or rating in this class shall be three months.

The minimum active service required for maintaining the efficiency of a member of this class is three months during each term of enrollment. This active service may be in one period or in periods of not less than three weeks each year.

The annual retainer pay of members in this class after confirmation in rating shall be two months' base pay of the corresponding rank or rating in the Navy.

NAVAL AUXILIARY RESERVE.

Members of the Naval Reserve Force of the seagoing profession who shall have been or may be employed on American vessels of the merchant marine of suitable type for use as naval auxiliaries and which shall have been listed as such by the Navy Department for use in war, shall be eligible for membership in the Naval Auxiliary Reserve.

In time of war or during the existence of a national emergency, persons in this class shall be required to serve only in vessels of the merchant ship type, except in cases of emergency, to be determined by the senior officer present, when said officer may, in his discretion, detail them for temporary duty elsewhere as the exigencies of the service may require.

The requirement as to qualifications of officers and men for confirmation in rank or rating, and as to the maintenance of efficiency in rank or rating, shall be prescribed by the Secretary of the Navy and shall be limited to the requirements for the proper organization, discipline, maneuvering, navigation, and operation of vessels of the merchant ship type while performing auxiliary service to the fleet in time of war, and length of time of employment on board such vessels in the merchant service.

Officers in the Naval Auxiliary Reserve shall exercise military command only on board the ships to which they are attached and in the naval auxiliary service.

The annual retainer pay of members in this class after confirmation in rank or rating shall be for officers, one month's base pay of the corresponding rank in the Navy, and for men, two months' base pay of the corresponding rating in the Navy.

NAVAL COAST DEFENSE RESERVE.

Members of the Naval Reserve Force who may be capable of performing special useful service in the Navy or in connection with the Navy in defense of the coast, shall be eligible for membership in the Naval Coast Defense Reserve.

Persons may enroll in this class for service in connection with the naval defense of the coast, such as service with coast-defense vessels, torpedo craft, mining vessels, patrol vessels or as radio operators, in various ranks or ratings corresponding to those of the Navy for which they shall have qualified under regulations prescribed by the Secretary of the Navy: *Provided*, That the Secretary of the Navy may permit the enrollment in this class of owners and operators of yachts and motor power boats suitable for naval purposes in the naval defense of the coast; and is hereby authorized to enter into contract with the owners of such power boats and other craft suitable for war purposes to take over the same in time of war or national emergency upon payment of a reasonable indemnity.

The amount of active service required for confirmation in rank and rating and for maintaining efficiency in rank and rating shall be the same as that required for members of the Naval Reserve.

The annual retainer pay of members of this class shall be the same as that of members of the Naval Reserve.

VOLUNTEER NAVAL RESERVE.

The Volunteer Naval Reserve shall be composed of those members of the Naval Reserve Force who are eligible for membership in any one of the other classes of the Naval Reserve Force, and who obligate themselves to serve in the Navy in any one of said classes without retainer pay and uniform gratuity in time of peace.

NAVAL RESERVE FLYING CORPS.

The Naval Reserve Flying Corps shall be composed of officers and student flyers who have been transferred from the Naval Flying Corps to the Naval Reserve Flying Corps and of enlisted men who shall have been so transferred under the same conditions as those provided by law for enlisted men of the Navy transferred to the Fleet Naval Reserve: *Provided*, That surplus graduates of the aeronautic school may be commissioned as ensigns in the Naval Reserve Flying Corps and promoted therein under such regulations as may be prescribed by the President. Members of the Naval Reserve Force skilled in the flying of aircraft or in their design, building, or operation, shall be eligible for membership in the Naval Reserve Flying Corps. The amount of active service required for confirmation in grade, rank, or rating, and for maintaining efficiency therein, shall be the same as that required for members of the Naval Reserve. The retainer pay of members of the Naval Reserve Flying Corps shall be the same as that of members of the Naval Reserve.

The Food Consumption of Adolescent Boys

STATISTICS of the food consumption of normal adults are available in large numbers, particularly since the modern era, in which a profound interest in the problems of human nutrition has begun to engross the attention of physiologists. The recent trend of interest in the subject of infant feeding has also brought with it illuminating data regarding the needs of the human individual in the early periods of life. Pediatric literature is not devoid of well established facts respecting the caloric requirement of the infant; but there is a singular dearth of statistics pertaining to the actual food intake and consequent dietary habits of young boys and girls. Indeed, both the physiology and pathology of the adolescent period offer abundant opportunity for the extension of knowledge.

Somehow it is difficult and unusual to collect the basic facts regarding the functional needs and performances in this period of youth. Du Bois has shown, by accurate measurements in the respiration calorimeter at the Russell Sage Institute of Pathology, that the basal requirement of boys in metabolism is 25 per cent above that of the adult. A recent investigation by Gephart of the same laboratory[1] affords an insight into the actual amounts of nourishment taken by more than 300 boys in one of the largest private boarding schools in the United States. The total animal supply for such an institution containing 355 boys was computed as follows, in metric tons:[2]

	Protein	Fat	Carbohydrate
Food supply	20.5	25.6	60.5
Waste	3.8	5.4	4.2
Food fuel	16.7	20.2	56.3

The quantity of food, computed on the basis of the individual meal served, appears as follows:

	Pounds	Grammes	Calories	Calories Per cent.
Protein	0.1107	50.2	206	14*
Fat	0.1332	60.4	562	39
Carbohydrates ..	0.3717	168.8	692	47
			1,460	100

The food was of the best quality, and included 193 separate varieties. The cost per meal was 20 cents, or 13.8 cents per thousand calories. This is twice what the poor man in New York City pays for his food. But these growing athletic boys were not satisfied with the conventional 3,000 calories per day. The investigator of their dietary ascertained that besides the 4,350 calories which they consumed daily at the table, they bought 650 additional calories in food at a neighboring store, the principal item being chocolate.

Lusk[1] has called attention to the fact that the 5,000 calories thus contained in the daily diet of active American boys of school age are half again as much as a farmer at work is believed to require. This salient statistical discovery, based on a liberal series of observations rather than on a few scattered data, deserves emphasis to medical men, who are often called on to advise in matters of diet during childhood and adolescence. The total fuel intake of the boarding school boys was three times that of the basal level of from 1,700 to 1,800 calories, which is the heat production of boys from 13 to 16 years of age when resting or asleep. Such findings explain the ravenous appetite of boys. Lack of appreciation of this, says Lusk, and lack of provision for it, are the probable causes of much of the undernutrition seen in children of school age.

A liberal and adequate dietary does not necessarily draw heavily on many sources of food. In the selections for the school referred to, twelve dietary items yielded 75 per cent of the requisite fuel value, the remaining 25 per cent being distributed among the 181 other varieties of food. It is surely not without significance that bread, butter, milk and sugar together furnished half of the food fuel. They form an exceptionally wholesome combination.—*Journal of the Am. Medical Association.*

Permanence of Writing-Ink

ATTENTION was first called to the bleaching effect of air and light on writing-ink, as used in modern times, by the fact that signatures on certain certificates had become illegible through the fading of the ink. As it was impracticable to test a sample of ink by exposure of writing for a period of years, it was considered that a limited application of hydrogen peroxide would be the nearest chemical equivalent to the bleaching effect of the atmosphre. Writing done by different inks was exposed to light, the paper being occasionally moistened with a 3 per cent solution of hydrogen peroxide, the result being that the handwriting gradually became invisible, in some cases more quickly than in others. Taking ferric tannate, indigo, and aniline-blue as the principal substances used in making writing-ink, it was found that all of them are rapidly decolorized by warming with hydrogen peroxide solution. With solutions of these substances in test-tubes at the ordinary temperature the same change was slowly produced. The violet ink used for typewriters was less readily acted on, but was quickly bleached by sulphurous acid. If an ink could be produced possessing the desirable properties of perfect fluidity and being non-depositing, and at the same time incapable of being decolorized by oxidizing or reducing agents, there would be good reason to believe that the writing done by such an ink would be practically permanent. In the meantime, when writing is of an important nature and is desired to endure, some form of carbon ink appears to be the only trustworthy preparation.—*D. B. Dott in the Journal of the Society of Chemical Industry.*

[1]Lusk, Graham: Food Economics, *Jour. Washington Acad. Sc.*, 1916, vi, 390.

[2]One metric ton equals 2,200 pounds.

*Seventy per cent of this was in animal protein.

The Evolution of Big Guns*

From the Cast Iron Smooth Bore to the Modern Breech-Loader

Our modern guns date from the period of the Crimean war (1855) when cast-iron smooth bore muzzle-loaders were used. But though when the 64-pounders failed to reduce the Baltic forts the authorities realized that the guns of Trafalgar and Waterloo had become obsolete, a long time elapsed before cast-iron was abandoned, and in the United States it was retained in fort service until the late years of the nineteenth century. The success of the American guns was due to the system of casting and cooling developed by Lieutenant Rodman, after whom they were named, and also to the superiority of the American iron, which had a tensile strength of over 40,000 pounds per square inch, against an average of 20,000 pounds of the English product at that period.

The casting of iron guns was always an operation calling for the highest skill of the founder. Generally they were poured vertically, with the breech end upwards, and with a very deep head of metal to consolidate and feed the metal in the actual gun, and to receive any sullage and air bubbles that might rise. Many were cast solidly, leaving the entire bore to be removed by cutting, but many others were cored. In either method the ordinary practice was to leave the guns to cool down normally. What happened then was that the heat radiated first from the exterior, which becoming set firmly was no longer free to shrink, while the inner portions remained in a semi-molten condition in which correspondingly large shrinkages had yet to take place. When these occurred the inner zones were drawn away from the outer rigid portions, leaving open metal, the sponginess of which was a source of weakness. Lieutenant Rodman therefore cooled the interior first, by circulating a stream of water through the core, and building fires outside to retard the cooling there. This was in some sense an anticipation of the present method of shrinking steel jackets and rings around an inner tube, because the result in both cases is to compress the inner layers, and thus reinforce them to resist the pressures of the explosion. True, the effect in cooling was far from being uniform, but it nevertheless went a long way in the desired direction, and insured a long lease of life to cast irons, until steel had established itself as a more reliable material.

The mere endurance of the old cast-iron guns is something to envy now when the big guns of alloy steel become eroded rapidly, and there are records of their remaining serviceable after firing from 3,000 to 6,000 rounds. Many were of large caliber. American Rodmans were made of 8-inch, 10-inch, 15-inch, and even 20 inches in bore. In the last (Fig. 1) the shot weighed 1,000 pounds, the length of bore was 210 inches, the maximum diameter over the chamber 64 inches, and the weight 115,200 pounds. It is believed that the last naval engagement in which cast-iron ordnance was used was that fought in the English Channel in 1864 between the "Kearsarge" and the "Alabama."

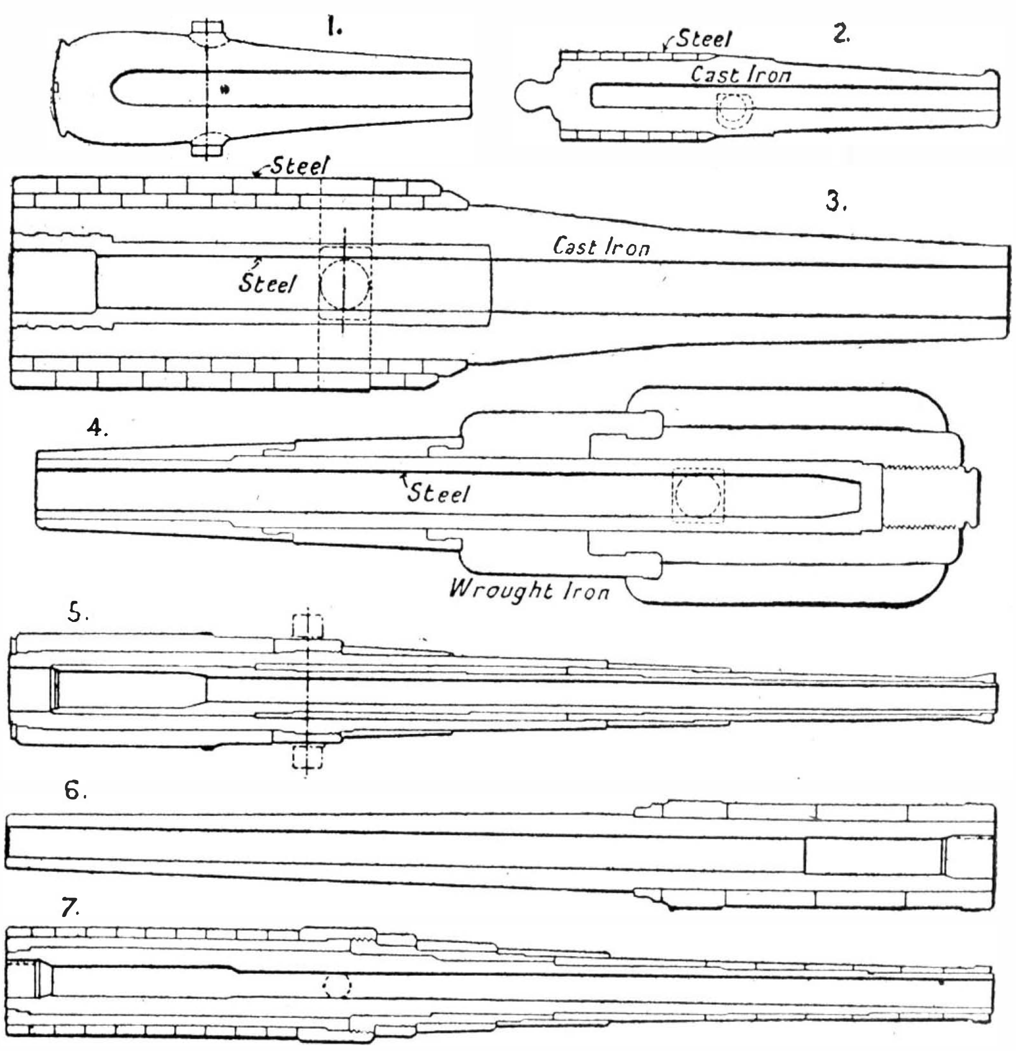
WROUGHT-IRON GUNS.

In England the Armstrong guns began to displace those of cast iron immediately after the Crimean war, 3,000 having been supplied between 1855 and 1863. These were built of concentric tubes formed by welding together lengths of rectangular wrought-iron bars. The iron used was a mixture of 85 per cent of Yorkshire brands and 15 per cent of Swedish charcoal iron, with a tensile strength ranging between 25 and 27 tons per square inch.

Later, along with the heavy American cast-iron guns just described, a much lighter class was being constructed in wrought iron for field service in the United States. They were built up on a system which was in substance that of piling. A number of rolled bars or staves were laid round an arbor, and placed in a lathe, on which a long bar was wound spirally. Over this another bar was wound with the spirals running in the opposite direction to the first, until in the 3-inch gun five layers were wound. Then another bundle of staves was bound on the outside, and a plug was driven in the breech. The whole mass was raised to a welding heat, upset by about 2 inches, and rolled out from a length of 4 feet 6 inches to 7 feet. The trunnions were welded on subsequently, after which boring, rifling, etc., followed.

COMPOSITE GUNS.

A period of transition came in all countries about 1872, when combination designs formed connecting links between cast-iron, wrought iron and steel, including many converted guns. At the same time muzzle-loading was being abandoned for breech-loading. In America many cast-iron guns of the period of the Civil war had been reinforced with a hoop of wrought iron shrunk round the breech. These were the Parrot guns, of which 2,000 were cast between 1861 and 1864. About 1872 many cast-iron smooth bores were converted into rifled guns by inserting in some cases wrought iron rifled tubes, in others steel rifled tubes, the insertion being sometimes by the muzzle, sometimes by the breech. Generally they were not very successful, though a good number were retained for fort service.



Sections of typical guns.

1. American Rodman gun, 20-inch bore, weight 51 tons. 2. French gun, 6.489-inch bore, weight 8.239 pounds. 3. French 32-centimeter (12½-inch) gun (1870-1890). 4. The "Woolwich Infant," 81 tons. 5. 9-inch Armstrong breech-loading gun (1888). 6. All-steel French gun (1881). 7. French Canet gun (1890).

A French rifled gun of 6.489-inch bore (Fig. 2), used in the Cochin-China campaign, was of cast-iron, reinforced by seven steel rings extending from the breech nearly to the trunnions. It was rifled with three grooves of increasing pitch. The types of heavy French guns existing or built in 1870 were still of cast-iron, but had a lining tube of steel forced in, with outer steel rings shrunk on. They were breech-loaders. Bronze guns were also largely used in the Franco-German war.

The adoption of a steel lining tube was the direct result of the introduction of rifling. Attempts were made to convert smooth bore cast-iron guns by rifling them, but invariably failed, though as smooth bores the guns had possessed great endurance under continuous firing. When cast-iron guns exploded they failed at the rear of the trunnions, and therefore the practice of reinforcing that part of the gun with steel rings was adopted, and also of inserting a steel tube at the hinder part of the gun. A gun thus reinforced is shown in Fig. 3, being a type that was in use for many years (1870-1890). The safe working pressure for these guns was about 15 tons per square inch, which is not much below that allowed for the best steel guns now made. But the margin of safety was much less in them than it is in those of steel, and they were apt to burst under any serious accidental increase of pressure. Experiments proved that the reinforcing of the cast-iron body with a steel tube and two rows of jackets increased the strength of the gun fourfold.

The introduction of steel lining tubes caused much trouble, because at first the attempt was made to force them in. The difficulty was afterward surmounted by shrinking the gun round its tube. The turned and bored gun was placed with its breech upward in an annular coke-heated furnace, which was separated by an inner lining tube from contact with the gun. When the gun had expanded sufficiently the furnace was removed, the lining tube inserted, and retained permanently by the shrinking of the body upon it.

THE "WOOLWICH INFANT."

In 1874-75 the biggest thing in British ordnance was the famous 81-ton gun—the "Woolwich Infant" (Fig. 4). The inner tube was of Firth's steel, encased with five coils of wrought iron, and having a cascabel or plug screwed into the inner coil close to the steel tube. Like all our guns of that time it was loaded at the muzzle. It was rifled with eleven grooves having an increasing twist. At the trunnion coil it was 6 feet in diameter. Its length was 28 feet 9 inches, and its bore was 24 feet long and 14½ inches in diameter, afterward increased to 16 inches. The weight of the 14½-inch projectile was 1,258 pounds, and the powder charges varied from 170 pounds to 240 pounds, with initial velocities from 1,393 feet to 1,550 feet per second. The pressure in the powder chamber varied from 24 tons to 27 tons per square inch, considerably in excess of that at the present time.

The construction of this gun taxed the resources of Woolwich heavily, and special machines and plant had to be installed for dealing with it. The principle adopted, that of shrinking thick massive tubes upon the interior tube, was in opposition to that embodied in the Armstrong guns of the time, in which a larger number of thin tubes were employed. These jacket tubes were coils of wrought-iron bar welded together. The bar of which the trunnion coil was composed was 200 feet in length.

The 81-ton gun was eclipsed in 1876 by the 100-ton gun built at the Elswick Works for the Italian government. With a bore of 17 inches and a length of 32 feet 10½ inches, the latter was built up with a steel tube in two lengths surrounded with coil jackets, and was rifled with twenty-seven spiral grooves. The period of the eighties was the age of the mammoth guns. The heaviest ordnance at that time in service was the 110-ton gun of 16.25-inch bore, carrying a projectile of 1,800 pounds. Six of these guns were built for the British navy by the Elswick firm, who also supplied thirty guns of 100 tons weight or more for the Italian navy. Eight of these great guns were muzzle-loaders. Their length was one of their most characteristic features.

*London Times Engineering Supplement.

The 110-ton gun had a length of 42 calibers, a proportion which was common in all sizes of the Armstrong guns of that period. But a reaction set in in favor of smaller and lighter guns of 67 tons weight and 13.5-inch bore. The very brief life of the heavy guns was one cause of this reaction; another was that for the time being the guns had proved superior to the armor plate of wrought iron and steel; and finally the growth in favor of the secondary armament called for a pause. The quick-firing guns of small bore were now coming into service, and so from all these causes combined the very big guns disappeared for a season.

THE LATER ARMSTRONG GUNS.

In the eighties and nineties the later Armstrong guns led the way to present practice. The early Armstrong guns were made of wrought iron, because the steel of that time was too uncertain. But when the open-hearth product became reliable it took the place of wrought-iron for English and foreign ordnance. Then, as now, steel ingots were cast and forged, either solidly or as hollow cylinders, tested, bored, turned, tempered in oil and finish-bored, and turned, and the various elements shrunk on each other. The fluid compressed steel was a satisfactory solution of the metal problem, but before it could come into general use steel makers had been able to secure sound ingots.

Fig. 5 illustrates a naval breech-loading Armstrong gun of about 1888, and the resemblance to the guns of the present day are apparent in the increased length, the thin tubes, especially the very thin inner tube, which even if cracked would be supported by the encircling hoops, the greater strength afforded in the longitudinal direction by the tying together of the hoops from breech to muzzle, including the reinforcement of the trunnion hoop, the enlargement for the shell at the breech, and the screwed end for the breech block. One of the principal objects sought in the Armstrong guns was to afford support to the inner portion of the gun where the full stress of the explosion occurs. This cannot be properly fulfilled in cast iron, which is homogeneous throughout. If the inner portion of the bore is strained beyond the elastic limit the outer portions must give way in course of time. Any building-up system in some degree equalizes the strains. When wrought-iron coils were welded under the hammer the fiber was disposed in the best possible way to resist a bursting strain. The shrinking-on put the coils into permanent tension, and thus supported the internal parts against rupture.

BREECH-LOADING.

As late as 1863 a Select Committee on Ordnance in England had reported that "the preponderance of opinion seems to be against any breech-loading system for the larger guns, and that the guns of the future must be muzzle-loaders." So the clock was set back, and for fifteen years many millions were squandered on muzzle-loading guns when all our rivals were making breech-loaders. Moreover, muzzle-loading on the long guns used on board ship was impracticable without running the guns back, which entailed many inconveniences. Besides there was the possibility of double-loading—proved to be the cause of the bursting of a 38-ton gun on the Thunderer in 1879. Such an accident could not occur in a breech-loading gun. But not until 1882 was the muzzle-loader definitely abandoned in England and breech-loading, all-steel guns adopted.

ALL-STEEL GUNS.

In 1881 the French were building all-steel guns, all breech-loaders, of steel made at the Creusot works. Some of these (Fig. 6) were of immense size, being 16.54-inch, 14.57-inch and 13.39-inch in bore. The 14.57-inch (37 centimeter) gun weighed 72 tons and threw projectiles of 1,180 pounds. The 16.54-inch (42 centimeter) gun weighed 75 tons and threw projectiles of 1,430 pounds.

Then, as now, the steel was cast in ingot molds. The shape was that of a truncated cone, but solid instead of hollow, with supplementary metal to be cut off from top and bottom of the ingot. It was roughed out to shape under a steam-hammer between several reheatings, rough-turned, and then rough-bored from the solid by a trepanning process, an annular cutter removing a solid core. This was followed by tempering in an oil bath. The rings, being large, were rolled like railway tires, and turned, bored, tempered in oil, and shrunk on. Afterwards the rifling was done. The development of the built-up guns passed through several phases. With every increase in length designs were modified to afford the necessary longitudinal stiffness. A tendency to droop at the muzzle was counteracted by increasing the length of the hoops, and sometimes by registering them into each other.

By 1890 the French Canet guns had an established reputation, and were avowed rivals of the products of the Krupp firm, over which superior efficiency was claimed. The construction adopted was that of an inner tube of the entire length of the gun, reinforced with jackets shrunk on and connected with the trunnion rings. Over the jackets a number of steel rings were shrunk, their number and thickness varying with the caliber of the gun. Fig. 7 illustrates the Canet 13.39-inch (34 centimeter) gun. The object in extending the jacket the whole length of the tube was to reinforce the gun tube to enable it to offer longitudinal resistance to the smokeless powders which were then coming into use.

In 1884 the first all-steel gun was made in the United States. It comprised a steel tube surrounded with a jacket or trunnion hoop and a sleeve. It was successful, and steel ordnance was used henceforth for light artillery. One of these guns of 3.2-inch caliber comprises the steel rifled tube inserted in the jacket from the rear, and abutting with a shoulder in tube and jacket. The trunnion jacket fits over the inner tube, and is also shouldered over the end of the jacket adjacent. A sleeve in front of the trunnion jacket strengthens the gun there. It is prevented from movement by fitting over a locking ring, which in turn is covered with a key ring. A base ring is screwed into the rear of the jacket, and contains the interrupted screw to receive the breech-block.

THICK AND THIN RINGS.

The long retention of the Fraser, or Woolwich, system, instead of the Armstrong, was a retrogressive movement in England. It originated in the idea that it was simpler and cheaper to employ one or two thick rings instead of a large number of thin ones. Sir William Armstrong had applied four or five concentric rings to his heavier guns, anticipating the modern ordnance. At Woolwich one was employed, or two for guns of over 9-inch caliber. The cost and the difficulties of manufacture are much greater with the first method than with the second, and the Woolwich authorities were swayed by this consideration. But it was a mistake. It can be shown mathematically, and has been borne out by costly experience, that the more numerous the rings the stronger the gun. The error of using one coil or ring only is of the same kind as that which has wrecked so many solid cast guns. Mere thickness increased beyond moderate limits does not add to the strength, for the increase of which the stress must be taken by the outer rings or layers, which must be put on under varying tensions decreasing gradually from the inner to the outer rings.

WIRE-WINDING.

In the modern gun the tension on each coil is carefully calculated, and adhered to in the shrinking-on process. This is why wire-winding is adopted so extensively in the heaviest guns. It affords a more precise method of regulating the stress than does the shrinking on of hoops. The outer hoops which surround the wire have little to do, but they reinforce and confine the wire as this reinforces the inner tube. Mr. J. A. Longridge proposed wire-winding so long ago as 1855, but his idea was rejected by the then Secretary of State for War. Afterwards Captain Schultz took it up on behalf of the French government and constructed several guns, and later Sir William Armstrong adopted it. Not till 1881 was the system taken seriously by the Woolwich authorities. Those who like to trace great inventions back to their crude prototypes may be reminded that Gustavus Adolphus is supposed to have originated the idea of winding. At Woolwich and Paris there are examples of guns in which a thin barrel of copper is surrounded with hempen cord, and enveloped in leather. The length of these guns is 16 feet 5 inches, the caliber 2.17-inch, and the weight about 120 pounds.

LENGTH OF GUNS.

The firing power of a gun can be increased in two ways, either by lengthening the tube, or by increasing the pressure of the firing charge. An advantage which a long gun of large caliber possesses over one of a smaller bore is that the muzzle velocity can be reduced while the muzzle energy can be increased. The result is that the life of the gun is prolonged, while its destructive powers are increased. Opposed to this is the question of the weight and space which have to be provided for afloat. Sir Trevor Dawson has put the contrast between the 12-inch muzzle-loading guns of 1864 and the modern 12-inch breech-loaders tersely thus: The earlier gun has a length of 12 calibers, the later one of 50 calibers, an increase of 38 feet. The weight of the projectile in the first was 614 pounds, in the other 850 pounds. But the difference in muzzle energy is enormous, in consequence of the employment of nitro-explosive in place of black powder. In the first it was 7,195 foot tons, in the second it is 53,045 foot tons, nearly eight times more. Yet the weight of the gun has been only trebled.

The materials used in the later guns are much superior to those of the early ones. The wrought iron used had a tensile strength of about 23 tons per square inch, whereas the nickel-steel used now ranges from 45 to 55 tons. The elastic limit which measures the resistance to permanent deformation was 12 tons per square inch in the wrought iron, but is 21 tons in the steel. The great increase in the length of the guns is a consequence of the employment of the smokeless powders first used in France in 1885, and the introduction of cordite has profoundly influenced gun design. Much larger volumes of gas are generated than with black powder, but the generation is less violent and more gradual. The maximum pressure is not much increased, but the total propelling force is greater. This explains why in the old guns using black powder the breech was made very large to resist the intense local stresses set up by a violent explosion.

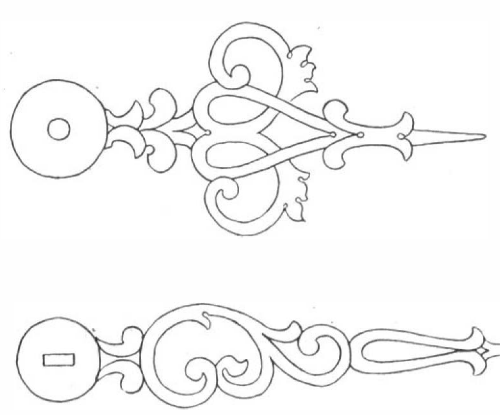
Clock Faces and Hands

Clock faces, in relation to the reading of time, have afforded an object of much careful study and some curious results have been obtained. The designer of the great clock in the Philadelphia, Pa., City Hall prepared an elaborate paper upon the subject. It was published in the *Journal of the Franklin Institute* not long after the clock was put into operation. After a most careful investigation of clock faces and figures had been made, the conclusion arrived at was that blocks in place of the usual figures would answer every purpose and that few persons would discover the difference. The hour marks on the great dial are marked by a character which appears like a thickened capital I. They are sufficiently distinct and no one appears to notice the departure from ordinary practice. Here the investigations stopped. The writer before mentioned assumed that people cared only for something by which they could locate the hour and did not pursue the subject further. The great thirty-foot clock face is proportioned like that of the smallest size of ladies' watches. The monster dial can be seen for miles. The location of the hours can be distinguished, but the reading of time, the fundamental purpose of a clock, is difficult, if not impossible, half a mile away.

The fault of the great clock and of most other large clock faces is a basic one. The face is not what enables us to read the time, but the hands. If the hands can be seen, the face is of comparatively little use except for minute sub-divisions of time. Since it is the hands alone by which we are able to read the time, and as the hands without figures (or even without a dial) will indicate a fair time reading, it should be those which should receive the greatest attention and they should be as plain as possible instead of being (as they usually are) an inconspicuous feature of the time piece.

The Swiss watch makers have given this subject some study and they frequently put on their watches hands of a sort to make the reading of time both certain and easy. As an experiment a clock with a ten-inch dial of a deep blue color was made.

Out of sheet aluminium a pair of hands were cut, after an enlarged pattern made from the hands on a Swiss watch. When these hands were in place one saw the time at a glance even in the half light of evening. Indeed, when the face becomes lost in the dusk the hour and minute could be observed by the position of the hands. The accompanying illustration shows the form of these. The hour hand is short and broad, so broad at the widest point as to make the distinction between the two exceedingly plain. The minute hand, tapering more gradually, is long, but has sufficient width to make it readily visible. With such hands, and a plain face showing only dots for the hours, it would be possible to read time, in most cases to the minute, without any difficulty.



An excellent design for clock hands, fashioned after those of a watch.

Good Lighting*

Some of the Fundamental Principles and Modern Practice

By P. G. Nutting

THERE are three chief classes of principles upon which the character of lighting depends: (1) those relating to the sources of the light, (2) those relating to reflecting and scattering properties of objects within the field of view receiving that light, and (3) the properties of the eye itself. What the eye sees depends as much upon the eye itself as upon what is to be seen. What is to be seen is largely within our control, but the seeing ability of our eyes is quite without our power to control. Hence it is that obtaining proper lighting is largely a question of photometric study, specification and design. The question of what *is* proper lighting, on the contrary, can only be answered by careful study of the properties of the eye itself. The scientific foundation of illuminating engineering consists therefore of two main branches: the photometry of sources of light and of diffusing media, and a formulation of the complex visual properties of the human eye.

Of the fundamental principles concerned in lighting, the question of cost of light may be passed since it is simply one of reduction; questions of the choice and placing of illuminants and of reflecting and diffusing media must be referred back to the properties of the eye to determine what is desirable. *The eye furnishes the sole means of judging whether lighting is good or bad* and only by a careful study of the properties of the eye shall we be able to say what lighting is best and what are safe limits of tolerance under any given fixed conditions.

The properties of the eye, upon which the principles of lighting depend, are the reactions of the retina to radiation of any given quality and quantity. Regarded as a physical instrument the eye is very similar to a photographic camera, consisting essentially of a lens and a sensitive surface. Curiously enough, the reaction of the retina and of the photographic plate to light were first carefully investigated at about the same time, twenty years ago, the latter by Hurter and Driffield in England and the retina by Arthur Konig and various collaborators.

The principles of good lighting involve directly but a few of the physical properties of the eye, namely, those related to visual efficiency and tolerance. Criteria of good lighting rest ultimately with the performance of the eye itself; that is, upon the ease, comfort and precision with which the eye functions. The eye accommodates itself to certain changes in lighting conditions with extreme facility, to others with great difficulty or not at all. The greatly increased use of artificial light, cinematography and other conditions have burdened the eye in many new ways, conditions for which it has never been prepared by evolution. The statement, however, may be ventured that when certain rules of lighting are obeyed the eye will be *less* subject to strain than ever before.

For hundreds of generations human eyes have been fitted to operate efficiently by natural light and we have every reason to believe that eyes were originally developed to work best under natural conditions of illumination. For three-fourths of his waking hours man was accustomed to a daylight characterized by a high level of brightness, moderate brightness contrasts and considerable color contrasts. The remaining quarter of his active existence was spent with a very much lower illumination, and at this level vision was sufficient merely for finding his way about. The eye has never developed more than the crudest discrimination for color or color differences nor for brightness contrasts at the lower level of natural illumination.

Since man has lived in caves, huts and houses, his eyes have been subjected not only to extremes in brightness, but to excessive contrasts as well. Light coming largely from a single direction throws dense shadows and these together with the source of light itself, cause contrasts far in excess of those ordinarily met with in the open. Whether or not the eye has changed to meet these increased requirements we have no means of knowing. Very likely it has, judging by its adaptability and its present state of adaptation for operating under extreme contrasts.

In recent times a large part of the civilized peoples spends a considerable proportion of its time within doors and nearly half of that with artificial illumination. Both daylight and artificial lighting conditions are largely in the hands of the architect and illuminating engineer and with abundant illumination available we may well inquire carefully into the lighting conditions leading to a maximum of eye comfort and efficiency.

BRIGHTNESS OF FIELD OF VIEW.

In respect to the absolute brightness of the field of view, the eye not only tolerates a very wide range indeed—a range of at least one hundred million to one but operates with precision over a range really enormous compared with that of any instrument constructed by man.

Provided the surroundings are of the same order of brightness, a newspaper may be read with fair comfort by the average person when it is illuminated by full sunlight. This is about the maximum brightness tolerable to an eye exposed continuously to it and with no very much darker areas within the field of view. For convenient reference, it may be stated that this brightness is about 10 lamberts, or roughly 20 candle power per square inch. The minimum of brightness required for comfortable reading, again assuming a normal eye and no excessive contrasts, is about 1/100,000 of this value, or numerically, 0.1 mililambert. One object may be distinguished from another when its brightness is but a ten-thousandth of the latter figure.

The eye operates over as wide a range as would a pair of scales which could weigh anything from a ton of hay to a marble with equally high precision and would swing perceptibly to the weight of a fly's leg. The eye accomplishes this wonderful feat by automatically varying its own sensibility to correspond with the brightness of the field viewed. Through the middle range of brightness, the sensibility decreases to about 1/20 its value for an increase of 100 times in brightness of field.

When the brightness is changed abruptly, as it is when an electric light is switched on or off, the sensibility does require time to adapt itself. Roughly the sensibility is doubled or halved in about one second, it varies by a factor of ten in about five seconds and a factor of one hundred in ten minutes.

These apparently trivial and well-known facts reach the very foundations of the principles of good lighting, and it will be necessary to give them more detailed attention. What immediately concerns the illuminating engineer and the producer of gas or electricity is how much illumination is best under the various working conditions, in houses and factories and on streets, where lighting units should be placed, and the distribution of light which is most favorable. The answers of all these and similar questions are contained in the properties of the eye, such as are outlined above and cannot be obtained elsewhere.

BRIGHTNESS LEVELS.

The relation of the properties of the eye to lighting problems is perhaps best set forth by considering but a few of the lighting levels of most importance rather than a whole series of levels. We have to deal largely with retinal sensibility because the brightness of objects seen varies with the sensibility, and lighting is rated in terms of apparent brightnesses. A headlight that is dazzling at night is barely noticeable at noonday; it is not the actual brightness of the headlight that is of consequence, but the brightness sensation produced by it.

The lighting conditions under which most of our time is spent fall chiefly into four distinct groups: (1) bright daylight in the open, (2) interiors in daylight,

	Level Brightness Mean	Sensibility Difference	Threshold	Relative Sensibility		
				Glare	Contrast	Threshold
	m. l.		m. l.			
1. Exterior Daylight....	1000	0.0175	0.35	1	1	1
2. Interiors in Daylight.	10	0.030	0.017	200	60	20
3. Interiors at Night...	0.1	0.123	0.0014	18000	1400	350
4. Exteriors at Night...	0.001	0.79	0.00011	160000	22000	3100

(3) interiors under artificial illumination, and (4) out of doors at night. A great many measurements have been made of the brightness of objects commonly within the field of view in each of these four cases. Rough averages give the corresponding brightness levels as listed in the table above.

A rough average of the brightness of objects out of doors in full sunlight is about 1 lambert or 1,000 millilamberts (m.l.), the brightness of the clear sky at midday being also roughly 1 lambert.[1] Similarly, a rough average of the brightness in an average interior with bright daylight outside is 10 millilamberts, one-hundredth as bright as objects out of doors. A comfortable brightness in interiors at night is 0.1 millilambert, and of objects out of doors at night 0.001 millilambert, each brightness level being 1 per cent of the next higher. In an avearge room, reading or writing on a very dull overcast day, we turn on the lights when the mean brightness of the field of view is about 1 millilambert.

In the second column are the just perceptible differences in brightness expressed as fractions of the whole. In the third column are the brightness just perceptible with the eye accommodated for some time to the brightness of the first column.

In the last three columns are data showing the relative sensibility of the retina at the four chief adaptation levels. Three kinds of sensibility are represented; sensibility to brightness glare, to contrast, and threshold sensibility. Relative sensibility to glare is roughly inversely proportional to the brightness of objects just painfully bright when the eye is adapted to the brightness level indicated in the first column.

Other things being equal, these data supply a fund of useful information to the illuminating engineer, relating to best lighting levels, glare and threshold limits, etc. But other things are not equal, contrasts vary enormously in offices, factories, public halls, and living rooms. Lighting costs must also be considered. Different kinds of work require varying degrees of attention. For such work as drafting, color matching and proof reading, require the closest observation, the nicest possible adjustment of illumination will be found to pay.

But for ordinary work, presenting but moderate contrasts and requiring but moderate visual attention, there is little to choose between a general brightness level of 100 millilamberts and one of 0.1 millilambert, a thousand times less. For work requiring close attention probably *the best mean brightness is about* 10 *millilamberts* if the whole field of view is of fairly uniform brightness, 100 millilambers, if bright highlights and deep shadows are visible.

RATE OF ADAPTATION.

The rate of retinal adaptation from one sensibility to another is an important factor in a few lighting problems. A flickering light is intensely disagreeble and is not tolerated in ordinary lighting. A periodic flicker of a frequency of over about 40 per second is not noticeable. In lighting by alternating current arcs or a Moore tube, the frequency of flicker is usually 60 cycles. It is not apparent to the eye, does not depress visual acuity nor does it produce eye fatigue. In motion picture projections the flicker with a good machine having a three-blade shutter is just beyond the perceptible limit. The discomfort observed in seats near the screen is probably entirely muscular, due to displacement, not intensity flicker.

Nor is a single quick flash very harmful to vision, provided its duration is extremely short. The total energy received at any one point of the retina is very small even in viewing a lightning flash, and it is energy rather than intensity that determines the impression in such a case. A longer flash, however, such as may be obtained from an electric switch or the flash of a headlight, is the most injurious of all, for the total amount of light emitted is considerable and the damage is done before the eye can adapt itself to the high intensity.

When the eye is subject to a bright light for a short time as in passing an automobile headlight, for example, the sensibility falls very rapidly at first, then more slowly. If again exposed to darkness the sensibility recovers in a similar manner and at about half the rate. We have some data for a brightness of 25 millilamberts, a brightness quite blinding to an eye adapted to darkness, but yet only a thousandth as bright as the average auto headlight.

If suddenly exposed to such a light, the eye in five seconds drops to 1/16 its sensibility, and after ten sec-

*A paper read before the National Commercial Gas Association, and reported in *The Gas Industry*.

[1]The lambert is the unit of brightness recently adopted by the Illuminating Engineering Society. It is the brightness of a perfectly diffusing surface radiating or reflecting one lumen per square centimeter. Brightness expressed in candles per square inch may be reduced to lamberts by multiplying by 0.4868.

Brightness is preferably expressed by lamberts not only because of the brevity of the name, but because of the apparent ambiguity of other terms in many cases. It is difficult, for example, to think of the brightness of the sky in actual candles per square inch.

onds' subsequent exposure to darkness has by no means recovered its sensitive state.

We see largely by contrasts in brightness; we see best when contrasts are over 10:9 and less than 20:1.

Time	1 second,	sensibility	increase,	2.1	times,	decrease	1.6 times
"	2 seconds,	"	"	4.2	"	"	2.6 "
"	5 "	"	"	16.2	"	"	7.6 "
"	10 "	"	"	58	"	"	14.4 "
"	10 minutes,	"	"	120	"	"	20.9 "

When the eye is adapted to darkness, as it is out of doors at night, objects exhibiting but faint contrasts do not become visible as rapidly as those with greater contrasts.

In the following table are given the brightness of background against which a darker strip is just visible after 0, 5, 10 and 30 seconds:

Contrast	1:0	10:1	2:1	10:9
Instantaneous	.0010	.0013	.0044	.021
5 seconds	.00013	.00014	.00053	.0053
10 seconds	.000053	.00010	.00042	.0042
30 seconds	.0000021	.000028	.00018	.0030

These data show the rate at which contrasts shown at the top of each column become visible. With a contrast of but 100:97 (just perceptible) the sensibility did not increase at all after the first few seconds.

In passing rapidly along a street the eye is subjected to large fluctuations in brightness at quite regular intervals and this causes a very considerable depression in sensibility for the reason just stated. The sensibility adapts itself to the brighter places more rapidly than it recovers in the darker, the net result being that the retina is less sensitive than it would be if exposed to a steady average brightness. Street lighting is vastly more efficient when more evenly distributed. It would be much less efficient than it is were there not such a lag of sensibility behind the sensation.

Similarly, in viewing any contrasty field with the attention constantly wandering from light to dark and from dark to light objects, the rate of adaptation is involved. The general effect is to lower sensibility and the result is that much more illumination is required to attain visual comfort and acuity than in a field of but modern contrasts. The subject will be considered further in the discussion of excessive contrasts.

THE EFFECT OF CONTRAST.

The degree of contrast within the field of view has a very considerable influence upon the sensibility of the retina and, therefore, upon the level of illumination that is desirable in any given case. Under natural illumination in the open, contrasts exceeding 20:1 in ratio of brightness are rarely met with, while in interiors they are common. Excessive contrasts are annoying and very probably for the reason that the eye has not yet been developed to operate comfortably when excessive contrasts are present.

Now contrasts are due almost entirely to two causes: differences in reflecting power and depth of shadows. The reflecting powers of ink and paper are in about the ratio of 1:20. Out of doors, shadows are not as a rule very deep, because even on a clear day from 15 to 30 per cent as much light comes from the sky as from the sun and the shadows are illuminated by sky light. In interiors, when the light is not well diffused, very dense shadows are the rule because largely unlighted. Further, glossy furniture, paper and other objects reflect sources of light specularly, giving glare spots often many times as bright as their surroundings.

Some recent work on this subject, reported upon at the September I. E. S. Convention, indicates that both the shadows and the glare spots tend to depress retinal sensibility below that corresponding to the general level of brightness. A large white card in front of the observer contained a window of opal glass which could be illuminated from behind. After gazing steadily at the white card illuminated to a fixed known brightness for some time the light was switched off and a brightness of opal window found that was just visible. This instantaneous threshold was found to increase very considerably as the area of white card viewed was more and more constricted. When this was further constricted by viewing through a black lined tube with but a small hole at the distant end the opal window had to be made twenty to forty times as bright to be just visible as when the eye was accommodated to the whole field of view. That is to say, darkening all the field except that directly viewed not only did not increase the sensibility of the retina (apparent brightness of spot) as might have been expected, but actually *decrease* it by a large factor. And these results are obtained with but moderate working brightness, in fact the effect is less with excessively bright fields.

This depression of sensibility when the area viewed is considerably brighter than its surroundings is of extreme importance, because it is not only large, but occurs very commonly in practice. Whenever we view a printed page this condition obtains. The obvious remedy is a light distribution to give *lighter surrounding objects free from large and deep shadows.*

A bright glare spot within the field of view, but at one side of the object of our attention, is also of very common occurrence. Such a spot has two distinct effects on vision, discomfort and a depression of sensibility. The ocular discomfort caused by a lamp flame or filament within the field of view is so far as we know largely a matter of intrinsic brilliancy of source and is relieved by a diffusing shade.

The depression of sensibility, on the contrary, is not relieved by a diffusing shade. We have plenty of data to show that the depression of sensibility caused by a source of given candle power is *not* lessened by spreading the source and keeping the total candle power constant. If the brightness is kept constant and the area (i. e., total candle power) varied, then the depression varies as the square root of the candle power or area. If both area and candle power are kept constant, and the angle from the axis of vision varies, then the depression is about half as great at 25 degrees as at the axis, and is almost negligible at angles above 40 degrees from the axis.

PRACTICAL APPLICATIONS.

In practice, then, contrasty fields of view are to be avoided whenever it is possible. When they are unavoidable they should be illuminated to a much higher mean level of brightness than fields presenting but moderate contrasts. For example, in offices and in the living rooms of houses conditions may be so arranged that only contrasts of twenty to one or less are presented to the eye. This means only indirect or semi-indirect illumination, white ceilings, light colored walls, an absence of very dark furniture and no glossy surfaces anywhere. Under such conditions the eye operates with comfort and precision with an average brightness of objects as low as 0.1 millilambert and a brightness of paper or other object worked upon of but 1 millilambert.

On the other hand, consider the opposite extreme in which contrasts are excessive and cannot be greatly reduced. Such conditions obtain in machine shops, foundries and rolling mills. Bright metal parts abound, most surfaces have but a very low diffuse reflecting power. The work given closest attention is a mass of contrasty detail. Indirect illumination and white ceiling or walls are alike impracticable. Under such conditions the eye operates at low efficiency and the best that can be done is to provide abundant illumination. Fully ten times the mean brightness and 100 times as great illumination are required as in rooms containing but moderate contrasts. It goes without saying that excessive contrasts, particularly those due to glossy surfaces, are to be avoided whenever possible. Much less light is required and eye work is far less fatiguing.

The question of glossy surfaces on print paper and on furniture has been given considerable attention. Printers would prefer glossy paper and ink for the reproduction of pictures. Mat papers are available that will take half-tone printing, but they are expensive and tend to foul the plates. By one process good reproductions may be made even on newspaper stock, but the process is expensive. Why not, then, print on glossy paper and depend upon diffuse illumination to avoid spot glare? The reason is apparent to any one who will view a glossy print under the very diffuse light of the open sky. The diffuse skylight specularly reflected from the glossy surface, produces a gray veil over the whole picture, more or less concealing the details of the print itself. We prefer to view a glossy print under directed light, inclining it at such an agle that no glare spot is seen rather than have a gray veil over the whole which cannot be got rid of.

Much the same reasoning applies to glossy furniture. Mat furniture finishes are not common and are objected to on the ground that they are more difficult to clean and tend to conceal the fine detail of the wood grain. However, with glossy furniture, the veiling glare with indirect illumination is worse than the spot glare with direct illumination, so that the choice of finishes will be a matter of preference until satisfactory mat finishes are available. The chief advantage of indirect over direct illumination is not that it avoids spot glare, but that it eliminates the eye discomfort due to a bright source in the field of view. In other words, while direct illumination on glossy surfaces gives spot glare which is bad, indirect illumination gives veiling glare which is quite as distateful to most persons. Glare spots are to be eliminated by avoiding glossy surfaces rather than by diffusing the illumination.

In one typical case direct illumination is much preferred if not essential, and from it valuable general conclusions may be drawn. Needle work is much more difficult and trying to the eyes under very diffuse than under directed illumination. Needles and fibers are a mass of fine bright cylinders and depth discrimination is important. Under directed lighting, needles and fibers are imaged largely as fine bright lines with interspersed shadows as a background. Under highly diffused lighting, bright lines and shadows all tend to merge and seeing conditions are bad.

The degree of attention given the object viewed is an important factor in retinal adaptation and, therefore, one which must be reckoned with. On entering a dark room we "get our eyes" far more quickly when we try to distinguish objects or details than if we merely close the eyes. The difference is readily measurable. In our experiments on the rate of dark adaptation, the time is noted after which a test object with a given faint illumination first becomes visible. If a keen effort be made to see the test object it becomes visible considerably sooner than if we close the eyes and wait. A similar effect may be noted in adaptation from a lower to a higher brightness.

The inference relating to good lighting is obvious and has been long recognized. Where work requires close attention, such as proof reading, drafting and certain textile work, great consideration must be given to securing proper lighting to minimize the strain due to close attention. Where there is the least gloss, to avoid veiling glare the lighting should not be too diffuse and should be so directed that there is no spot glare into the eyes. Both extremes of diffusion are common in drafting rooms; the happy medium is rarely found.

LIGHTING PRACTICE.

In order to obtain a more concrete view of the lighting principles just discussed let us consider more particularly the problems of (1) interior daylight lighting, (2) interior lighting by artificial light, and (3) street lighting.

In any *interior lighting* the bulk of the light should come from above the eye level. The brightest objects within the field of view should not be over 100 times as bright as the darkest objects or shadows. Within 30 degrees of the eye level, the mean of brightness should not be above 100 millilamberts nor below 1 millilambert and no contrast should exceed 20.1 or 1.3 units in the subjective brightness scale.

Such ideal conditions are, of course, very rarely found indoors. During the daytime the bulk of the light enters through windows largely at eye level. If a window is within the field of view, we see perhaps a patch of sky a full lambert in brightness and adjacent to it a strip of casing or wall not lighted, frequently of low reflecting power and not over a millilambert in brightness. The bright light from the sky goes largely to the floor instead of the ceiling, a ceiling frequently finished in materials of low reflecting power and sometimes even in wood with a dark finish. Such dismal quarters are tolerated only because so common.

The best practice appears to be to have snow white ceilings, walls of a fairly light tint and floors or floor coverings not darker than new oak or pine. The window problem is a difficult one. Ribbed glass panes and white shades are worse than useless, for they become themselves powerful sources of light at eye level. All inclined opaque shade, extending into the room at the level of the middle of the window, mat white below and coated with metal paint above, keeps the directed skylight from the eyes and throws it on the ceiling where it is best to have it.

The artificial lighting of interiors is less difficult to put on a reasonably correct basis. A suitable shade may be used to reduce the brightness of any lighting unit to within the limit of comfort (about 250 millilambers) and throw the bulk of the light on a white ceiling. A suitable number of units properly placed will prevent dense shadows. The best tints for ceilings, walls and floors are such as are also suitable for daylight lighting. Glossy and dark colored furniture and fixtures are to be avoided, particularly near the center of a room.

Good *street lighting* presents many very serious difficulties. It is much more important to secure greater uniformity of lighting than to increase the total light. At the present time amply lighted streets are common, streets with properly distributed illumination very rare. Much light escapes in the upper hemisphere that might easily be thrown downward. Much light is thrown laterally toward residences where it is neither desired nor appreciated. A little judicious use of reflectors would throw this light to the street and sidewalk where it would be of most service. Fortunately, dazzling lights are becoming less common and increasing attention is being given the distribution of light.

All things considered, but little progress has been made in the application of the principles of correct lighting. This fact is surprising in view of the simplicity of those principles and the comparative ease with

which lighting may be modified. It is gratifying that there has been little if any opposition to such improvements on the ground of probable disturbance in the demand for gas and electric supply. Lack of progress is rather to be attributed to ignorance and indifference in the face of other more urgent problems involving far greater financial outlays.

How to Select Metals for Magnets

By Arthur E. Paige

It is the purpose of this article to indicate some conditions and elements which determine or affect the magnetic quality of commercial iron and steel alloys, and to facilitate the selection thereof by those without special knowledge of electrical science.

Magnetization of ferromagnetic metals affects many of its physical properties, for instance, its elasticity, its electric conductivity, its thermo-electric power, and its dimensions. Conversely, the magnetic properties of such metal are affected by changes in its physical properties, for instance, by mechanical stress and changes of temperature. For instance, the length of an iron or soft-steel bar is increased by magnetization, proportionally to the square of the intensity of magnetization up to the saturation point of the metal, but, if the magnetizing force is increased beyond that point the bar gradually shrinks, until it becomes shorter than when unmagnetized. Such elongation generally reaches the maximum under a magnetizing field of 50 to 120 C. G. S. units, vanishes under a field of 200 to 400 units, and retraction is effected under higher fields and apparently reaches its limit in fields where H equals 1,000 to 1,100 units. Other paramagnetic metals are variously contracted or expanded when subjected to magnetizing forces; the behavior of cobalt being opposite to the iron or soft steel above contemplated. Hardened steel changes in form in a manner similar to that of soft iron or steel above noted, except that it regains its original length when the magnetizing field reaches a *critical value* depending upon the hardness of the metal, which value *diminishes* as the hardness increases up to the point where the metal is colored yellow by its surface oxide. However, above that point the critical value *increases* until it reaches its maximum height with the hardest steel. Plain carbon steel which has been hardened by sudden cooling and then tempered yellow as above contemplated manifests a smaller critical value of the magnetizing field than steel which is either softer or harder, such value being in fact so small that such metal contracts, even under weak magnetizing fields, without undergoing any appreciable preliminary elongation.

All such changes require time and are accompanied by modifications in the form of energy—heat appears as magnetization vanishes, and *vice versa*. Therefore, there is apparent lag in magnetization and demagnetization in metal in sequence to changes in the inducing field and loss of energy; and both vary with the composition and state of the metal. Such lag is termed *hysteresis*, and such loss *hysteretic*, and both should be considered in selecting metals for magnets, particularly for temporary magnets subjected to rapid reversals or other variations in magnetic fields, as in electric generators and motors.

The apparent relations between the amount of energy dissipated in subjecting iron or steel to a magnetic cycle, i. e., a double reversal, and the maximum amount of induction manifested in the cycle, may be simply expressed as $W=\eta B^{1.6}$ where W=the work in ergs upon a cubic centimeter of the metal, B=the maximum induction, and η a hysteretic constant, varying, in soft iron and steel, from 0.001 to 0.004 and approximating 0.002. This formula is applicable to Swedish iron up to $B=$ 18,000 gausses; to tungsten-steel and cast cobalt up to $B=$ 8,000, and to nickel and annealed cobalt up to $B=$3,000. Constants applicable to various commercial metals are as follows:

Best annealed Swedish iron, thin sheets	0.001
Best annealed Swedish iron wire	0.002
Ordinary sheet iron	0.004
Best annealed cast steel	0.008
Best annealed machine steel	0.009
Ordinary cast steel	0.012
Ordinary cast iron	0.016
Ordinary hardened cast steel	0.025

The standard expression of *hysteretic loss* is in watts per pound of the metal, with induction 2,500, at a frequency of 100 double reversals of cycles per second, but some manufacturers express it in horse-powers per ton, of their metal, or in ergs per cubic centimeter per cycle; it is to be noted that as one horse-power=746 watts, and one ton=2,240 pounds, the factor for reducing horse-power per ton to watts per pound is simply ⅓. The loss for any induction B within the range of said formula, may be converted to the standard B=2,500, by dividing it by $B^{1.6}/2{,}500^{1.6}$

It is usual to select for electromagnets the best Swedish charcoal-iron, and such metal (of the best grade now obtainable in the market) averages 0.03 per cent of carbon and manifests B=16,800 for H=45, residual B=9,770, permeability μ=1,625 for H=8, and a coercive force of but (reverse) H=1.66 is required to eliminate said residual B. Such metal is subject to hysteretic loss amounting to 0.382 per pound for maximum $B=$ 9,000 at 100 cycles. Of course, for temporary magnets, such Swedish metal is far superior to the average cast iron of American manufacture, which averages $\mu=$ 62 for H=40. However, it is far inferior to silicon-iron containing Fe, 97.3; C, 0.2 and Si, 2.5, which, in fields up to H=10, not only manifests greater permeability than the best Swedish metal, but, for the same maximum B and frequency, suffers hysteretic loss of but 0.254 watt per pound.

Whether metal is being selected for temporary or permanent magnets, it should be as free from manganese as possible, for that element suppresses the magnetic quality of any ferro-magnetic in which it is included. For instance, the addition of 12.36 per cent of manganese to a high-grade iron of excellent magnetic quality was found to reduce its permeability to 1.27 for H=8.

Although it is usual to select, for permanent magnets, plain high-carbon steel, hardened and tempered as above described, ordinary commercial chrome-steel is better for that purpose, in that it manifests a coercive force of 9 when annealed and may manifest as much as 38 when oil hardened. However, such coercive force is far exceeded by other alloy-steels, of more costly composition, as indicated by the following table, in which several are arranged in the order of their coercive force:

Element	Per Cent	B for H=45	B Residual	μ for H=8	Coercive Force
1 Molybdenum	4.0	....	....	....	85
2 Molybdenum	3.5	....	....	....	80
3 Tungsten	2.35	....	....	....	70.7
4 Tungsten	3.44	....	....	....	64.5
5 Nickel	19.64	7770	4770	90	20.0
6 Tungsten	7.5	15230	13280	500	9.02
7 Nickel	3.82	16190	9320	1375	2.76
8 Carbon	0.03	16800	9770	1625	1.66
9 Nickel	31.04	4460	1720	357	0.5
10 Manganese	12.36	....	....	1.27	....

Specimens Nos. 8 and 10 are included in said table for comparison with the other alloys; No. 8 being a sample of Swedish charcoal-iron and No. 10 being the iron to which manganese was added as above described. It may be observed, with reference to said table, that the alloy containing but 2.35 per cent of tungsten has more than seven times the amount of coercive force of the alloy containing 7.5 of tungsten, and, consequently, is accordingly superior for permanent magnets. However, the best alloy for that use, so far discovered, contains four per cent of molybdenum. Of course, such alloys are costly, and, for many uses, permanent magnets of satisfactory coercive force may be formed of ordinary cast iron which has been chilled by the ordinary processes for surface hardening such metal. Such processes, when effective for that purpose, are found to have changed the cast iron so that there is more combined carbon (cementite, Fe_3C) at the surface than is present in the other portions of the metal. Such processes are most effective when the metal is quenched in an acid solution maintained below the freezing point of water. In this connection, it may be noted that an alloy containing 0.25 nickel and normally manifesting permeability 1.4 for any value of H; when cooled below the freezing point of water, becomes as magnetic as the average cast iron and thereafter retains its magnetic properties until heated to 580 degrees Centigrade, at which temperature it loses its susceptibility to magnetization, and therefore remains in that state, until it is again frozen. From this and similar phenomena, it may be reasonably presumed that all metals may reach the magnetizable state, at some temperature.—*Electrical Review and Western Electrician.*

Behavior of Metals Toward Acids

A mixture of hydrochloric acid (sp. gr. 1.125) and 30% hydrogen peroxide solution dissolves copper, bismuth, nickel, gold, platinum, and antimony, but not silver or mercury; lead is only slightly soluble in the mixture owing to the formation of insoluble lead chloride. Dilute sulphuric acid containing hydrogen peroixde dissolves copper, silver, nickel, and bismuth, but not tin, lead, gold, platinum, or antimony. Copper, silver, mercury, lead, and bismuth are soluble in acetic acid containing hydrogen peroxide; tin, nickel, gold, and platinum are insoluble. The solubility of aluminum in the three acids mentioned is not affected by the presence of hydrogen peroxide. Since the solvent action of a mixture of hydrochloric acid and hydrogen peroxide is the same as that of chlorine, the insolubility of mercury in the mixture is difficult to explain; it is not due to the catalytic action of the metal on the hydrogen peroxide, or gold and platinum would not be dissolved, nor to the reducing action of hydrogen peroxide on the mercury salt, for although hydrogen peroxide reduces mercuric acetate to mercurous acetate, it has no action on mercuric chloride.—*E. Salkowski, Chem.-Zeit.*

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Table of Contents