

MAKING THE EYE OF SCIENCE.
BY C. H. CLAWDY.

Ask a man in the street what a lens is, he will probably answer: "A piece of glass." A lens is, indeed, usually a piece of glass, unless it is made of several pieces. So is a house several pieces of wood, a locomotive many pieces of steel, and a watch a collection of wheels and springs. But the house, the locomotive, or even the watch does not require more exquisite care than the making of a lens. The mechanical error in architectural work may be measured in fractions of a foot, in locomotives in fractions of an inch, in watches in fractions of a millimeter. In lenses it is measurable in microns, and a micron is the thousandth part of the thousandth part of a meter.

The lens for microscopes, the lens for telescopes, the lens for cameras, for spectroscopes, for 'scopes with all sorts of prefixes, each carries its own special standard, highest of all in microscopes, in cameras, and in telescopes. Telescopic lenses, with their large size and huge cost, are more or less familiar to the reading public, but comparatively little is known of the making of the eye of the magic tube which shows what the human eye cannot see, and the eye to that other equally magic tool of science, as well as plaything of us all, which limns, in a fraction of a second, a picture more perfect than the most expert artist could draw in a lifetime.

The first step in making any kind of lens is the procuring of the glass. Optical glasses of the newer kinds cannot be made anywhere and everywhere. Practically all of it is made in Jena, Germany. To the crown and flint glass of the earlier opticians, science has added a large number of new and different kinds which have in themselves, with-

out curvature, many different properties, different refractive indices, and, extremely important, different dispersive abilities. A lens not only refracts or bends light rays in a certain degree, depending on both curvature of surface and composition of material, but

it disperses color, separates the spectrum, or refracts different colors of light differently, in a manner dependent largely on its chemical constitution.

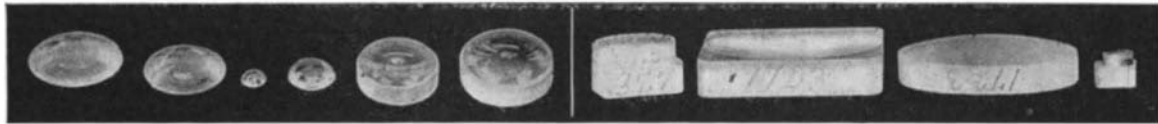
In making a microscope objective, or a telescopic lens, or the lenses for cameras, it is the great aim of

understood that neither the fine photographic lens, usually termed an "anastigmat," because free (over a certain area of image) from the aberration of astigmatism and its kindred ills, or the wonderfully tiny microscopic objectives, are made of one piece of glass.

The mathematician who calculates the lens puts curve against curve, glass against glass, refraction against refraction, dispersion against dispersion, until one corrected element balances the under-corrections of another. It would be simple enough if the making of a lens were merely the simple grinding of one piece of glass on both sides. It is the grinding of many glasses to form one lens, and making them fit both conditions and each other, that taxes both the man and his methods. All lenses, both photographic and microscopic, are ground by hand. The glass is cemented to a tool called a "block," and pressed with an abrasive and water into a revolving metal shell of proper curvature. The shell revolves, and the block revolves, the grinder constantly changing the angle of the block, so that all parts of the glass are ground evenly. Necessarily, all such lenses are ground on the section of a sphere. They are ground three times — "rough," "second," and "fine" grindings they are called—before being polished with rouge and time and care until the last faint abrasive mark is taken out, and nothing but the high "black" polish of the perfect lens remains.

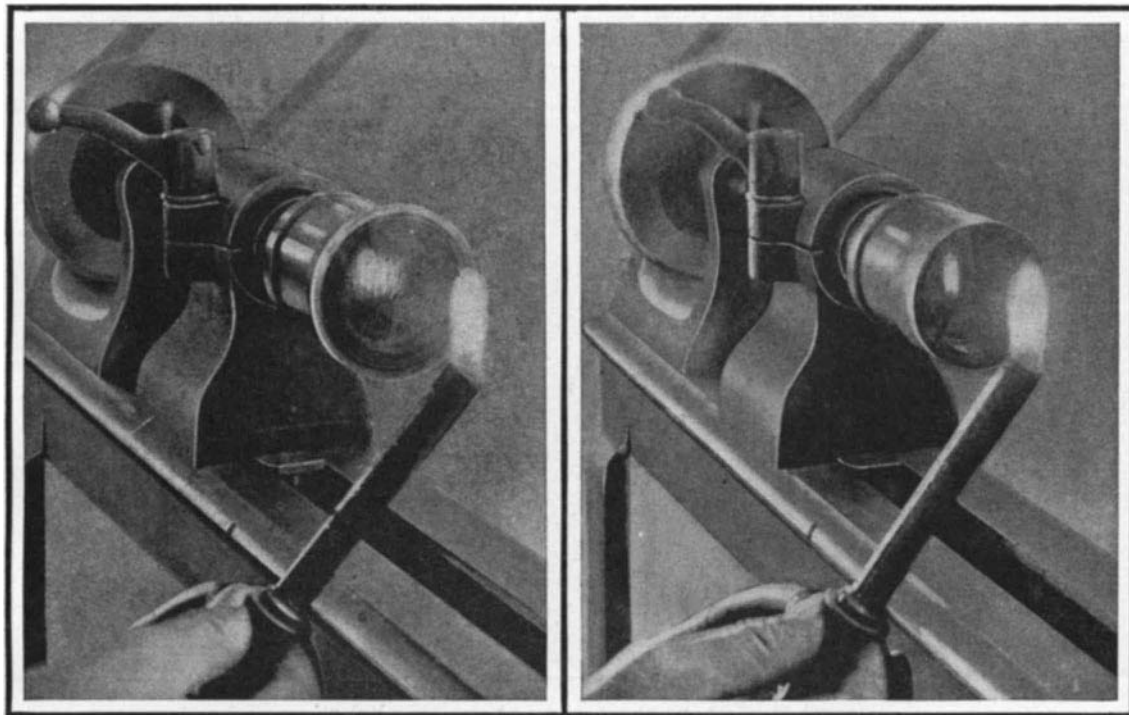
If the glass is to be a component of a fine photographic lens, it has now to undergo an ordeal. Two blocks of perfectly homogeneous optical glass have been formed to the shape of the lens element and curve to be tested. Every possible care has been taken in the making of these test glasses, and optical, refractive tests, far more delicate than any measuring engine test

could possibly be, have shown them to be as absolutely perfect examples of the desired curvatures as science and art can make. So that if the element tested exactly and perfectly fits this test glass, it is, obviously, (Continued on page 431.)



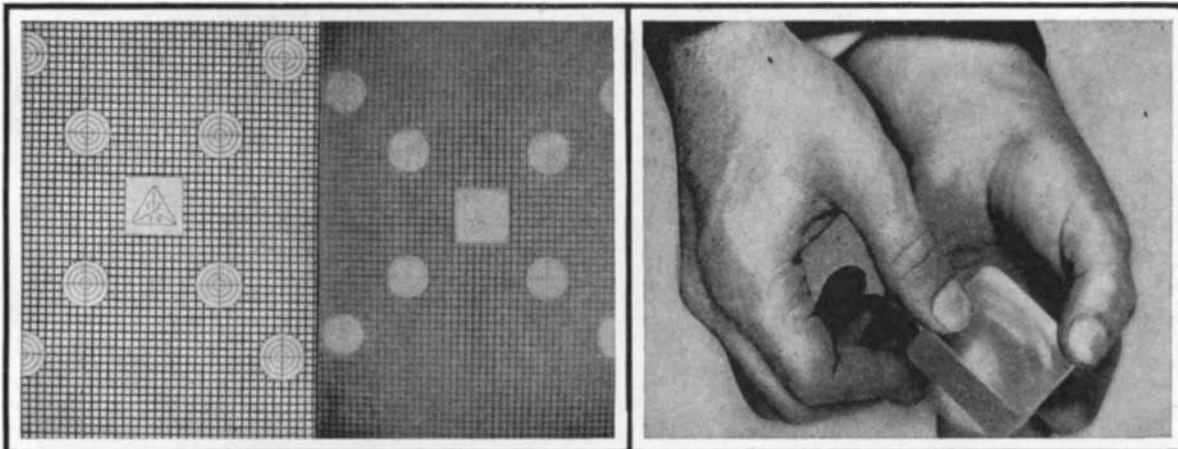
Elements of a one-twelfth inch microscopic objective (enlarged).

Glasses which are used for testing an anastigmat lens.



In the picture on the left the flamedances as the lens is revolved and is stationary in the picture to the right. Observe the untrimmed edges in one and the trimmed edges in the other picture.

How the elements of an anastigmat are centered.



Photographs of a test chart made by a good and a poor photographic lens.

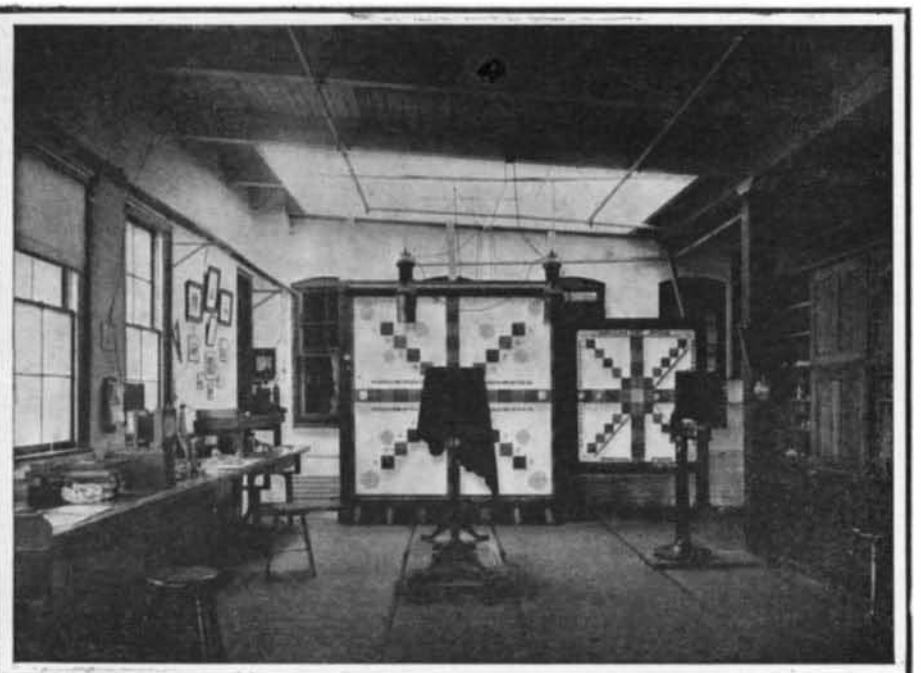
Using the test glass on an element of an anastigmat lens.

the optician to eliminate color fringes about the images formed, because they interfere seriously with the accuracy of observations or the perfection of pictures.

The proper glass obtained and the curvatures determined, the next step is grinding. But it should be



Grinding photographic lenses by hand.



Room for testing photographic objectives.

different parts of a coil, since such formulas have proved a very poor reliance when applied to an actual case. Slight differences in quality of material and sizes, or in thickness of insulation may lead one astray in the rigid application of a formula. Mr. Collins has taken up each part of an induction coil by itself and has discussed its size, construction, and adaptation to the other parts in a most complete and satisfactory manner. The best proportions are given for a series of coils giving a spark of twelve inches and under. Higher than this it is not necessary to go, since one requiring more energy than can be converted by a coil giving a spark twelve inches long will use a transformer and not an induction coil. The different uses of a coil are also considered and such variations as are necessary to adapt a coil to Roentgen-ray or wireless telegraph work are given. Of course these differences are principally in the secondary winding, where will be found in separate columns the data for these two services. This is a very important advantage of this book over other books recently published upon this subject. One cannot but notice the care with which small details are worked out. The numerous cuts show every separate piece in fullness and completeness. The volume contains 160 illustrations, while a single illustration may contain as many as 21 cuts as does the one on page 101, illustrating the construction of an interrupter. The data furnished in the form of tables are quite as full. Of tables there are 122, containing the sizes and dimensions of every detail of every part of an induction coil, and also the prices of every kind of material to enter into it. It is difficult to see how any one with the slightest skill in the use of tools can fail to build a good coil under the guidance this book affords. We believe it will displace all other books upon this subject.

THE MANUAL OF STATISTICS. Stock Exchange Handbook. New York: The Manual of Statistics Company, 1909. 12mo.; 1194 pp. Price, \$5.

The thirty-first annual issue deals with railroad securities, industrial securities, government securities, stock exchange quotations, mining, grain, provisions, cotton, money, bank and trust companies. It is admirably printed and the maps are clear and numerous. The information conveyed is of exactly the nature which is of almost daily request in offices where financial matters are of any moment. It should be on the desk of every railway and bank official.

THE BANKING AND CURRENCY PROBLEM IN THE UNITED STATES. By Victor Morawetz. New York: North American Review Publishing Company. 12mo.

The author of this book, Mr. Victor Morawetz, is an authority on corporations and finance. His book is chiefly concerned with solving the problem of currency shortage, which seems to confront this country at recurring periods. He advances a plan for co-operation between the banks and the Treasury, which includes a note redemption fund to be elastic, regulating the uncovered volume of notes outstanding, and thus giving stability to financial institutions generally.

THE NEW BUILDING ESTIMATOR. A Practical Guide to Estimating the Cost of Labor and Material in Building Construction, from Excavation to Finish, with Various Practical Examples of Work presented in Detail, and with Labor Figured Chiefly in Hours and Quantities. A Handbook for Architects, Builders, Contractors, Appraisers, Engineers, Superintendents, and Draftsmen. By William Arthur, Box 482, Omaha, Neb. New York: Published by David Williams Company.

Probably no task requires nicer judgment on the part of the engineer or architect than the estimation of building costs. For this reason any book which will materially help him in solving the peculiar problems which are presented to him must be welcomed. Mr. Arthur in his previous edition has demonstrated the fact that he is certainly competent to guide the estimating engineer and architect. The new edition of his book brings the prices up to date and incorporates much new tabulated matter.

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Legal Notices

PATENTS

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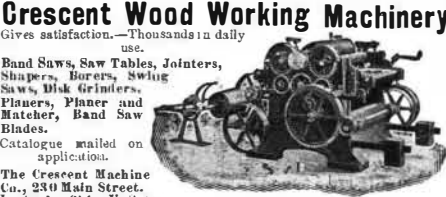
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SOME NEW AMERICAN AEROPLANES.
(Concluded from page 421.)
plane he has made use of eight of these propellers, and has arranged them in a line between the two planes, the idea being to give a propulsive effort throughout the entire width of the machine. It has also been proven that a number of small propellers will give a greater thrust per horse-power than one or two large ones. Mr. Kimball makes use of the same motor and wire-rope drive that he employed in his helicopter; but he has improved upon this drive by installing a friction clutch between the driving drum of the motor and the driven drum carrying the wire ropes. The clutch consists of a cast-iron floating ring, and also of a leather lining in these two drums. It allows a certain amount of slipping to occur at the start, so that the propellers are not strained and broken as before. It is also set so that it will slip with a 25 per cent overload. This improvement, according to the inventor, has made a rope drive for aeroplanes entirely practicable. The wire rope used is only 1/4 of an inch in diameter, and consists of six strands, each of which contains 19 wires. The rope has a tensile strength of 2,000 pounds, while the pull to which it is actually submitted is only 80 to 90 pounds. There are two endless cables, one for each set of four propellers. They are held under proper tension by a single idler for each one. The motor makes 1,900 revolutions per minute to 1,600 of the propeller, and the cable travels at the rate of 7,500 feet per minute, or about 86 miles an hour. The propellers have four blades each. They are 3 feet 10 inches in diameter, and have a pitch of 4 feet. The thrust obtained is about 175 pounds. The motor is a four-cylinder, two-cycle engine of an improved type, the cylinders being 4 x 4. It develops 50 horse-power at 2,000 R.P.M.

The main planes of the Kimball machine are 37 feet by 6 1/2 feet, and they are spaced 4 feet 2 inches apart. They have a very slight curve of about 1 in 26, and their angle of incidence is about 5 deg. The rear edges project out 18 inches beyond the main plane and are rather flexible. The machine is provided with movable wing tips, 4 by 4 feet in size, on the ends of both planes. There is a double-surface horizontal rudder in front, 12 by 2 1/2 feet in size, the planes of which are spaced 3 feet apart. This rudder is located 9 3/4 feet in front of the main planes. It is operated by a lever convenient to the right hand of the aviator, while another lever worked by the left hand operates the two sets of four vertical rudders each, placed on the rear of the movable wing tips. This lever also operates the front wheel, in order to steer when running on the ground.

The main features of the Kimball aeroplane are the use of multiple propellers and fitting of quadruple vertical rudders close to the main planes, near their extremities. If the inventor can run his propellers at a high enough speed to obtain from 300 to 400 pounds thrust, he will probably be able to get in the air; but at the present writing he has made only one attempt, which was unsuccessful in this respect.

MAKING THE EYE OF SCIENCE.
(Continued from page 425.)
of the proper shape and curvature. But, you will want to know, how does the workman know when the glass to be tested fits the test glass? It is in this "how" that the exquisite fineness of the test resides, for the beautiful phenomena of Newton's rings comes into play here. Any extremely thin and attenuated film will show diffraction colors—soap bubbles are common examples. Every child knows that the bigger the bubble, the more beautiful the colors, and the grown-up knows that the bigger the bubble, the thinner the film. When the glass to be tested is laid in the test-glass hollow, there is a thin film of air left between
(Continued on page 432.)

to the magnification of the object seen. It is essential, therefore, that the mounting be absolutely accurate, a condition satisfied by using the same lathe for both making the mount and trimming the lenses of the objective.

A photographic lens of high quality must pass tests of great difficulty and searching power. It is put in a camera and tried out on an accurate chart, and must "cover" a certain area of this chart at a certain distance, while rendering the image perfectly flat and without distortion. Uncorrected photographic lenses have a great many aberrations—curvature of the field, spherical aberration, coma, flare, astigmatism, curvilinear distortion, chromatic aberration; and a good photographic lens must be without these, or it fails to pass its tests. In the optical factory in which the illustrations for this article were made, every photographic lens is provided with a ticket, and on this chart the expert lens examiners put down a check mark against every fault or aberration of the lens under examination. A perfect lens, such as is marketed, shows on its chart nothing more damaging than the presence of a few minute air bubbles, impossible to avoid in the special optical glass which is used in the production of "anastigmats." These air bubbles, often giving great concern to purchasers who do not understand their harmlessness, do nothing more damaging than to decrease the light-passing capacity of the lens by a percentage equal to the percentage their area is to the area of the lens—a small fraction of one per cent.

In addition to testing out for optical aberrations, the tester hunts for striæ, streaks in the glass, for strains, for improper centering, for imperfections of cementing, for poor mounting, for defects in the glass not classified, as scratches and marred places, so that, when a lens has finally passed the inspector, it is a perfect specimen so far as human ingenuity can make it.

Microscopic objectives, on the work of any one of which may depend not only the success of scientific experiments and the obtaining of new knowledge in a hundred branches, but even human lives, are the subject of the most minute care in testing. An unskilled observer may find it difficult to distinguish between the image made by a poor and a good one-twelfth, but the scientist who uses it, and equally with him the trained man who examines it before its being put in stock, has no difficulty in finding out from the severe test objects whether it will properly "resolve" the fine markings on a diatom, whether it has "color fringes" or not, whether its field is flat or not.

Lens calculated, glass selected, shells and blocks carefully machined, glass ground once, twice, and again, lens elements tested, repolished or ground if necessary, centered, mounted, again tested, charted, and reinspected, the glass eyes of the microscope and the camera, twin eyes of science and the two most important tools in the laboratory, go from the factory all over the world to the laboratories where are made a large per cent of all the discoveries in science of all kinds, but particularly in the natural sciences and in all those departments of human knowledge which have to do with the body and with health and the cure of disease. And all the work done in these laboratories depends in the first instance on a little bit of glass, a mathematical formula, and the precision with which the glass can be made to fit the x^2n^2 of the master optician.

Testing Ancient Bronzes.

Old objects of bronze and copper are usually covered with thick layers of oxide which make it impossible to recognize the true character of the metal or alloy. The removal of this highly valued patina is not generally allowable, and the metallic surface that may be exposed at sharp

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points and edges is too small to afford the desired indications. Two German investigators, having found that pure copper and bronzes containing various proportions of tin give characteristic streaks when rubbed on a touchstone, have devised a method of determining approximately the composition of any bronze object by comparing its streak with those made by a series of bronze bars of known composition. In practice, four such bars are found sufficient. The four bars are rubbed on the touchstone (Lydian slate or polished biscuit ware) and by the side of the four marks a fifth is made with a point or edge of the object under investigation. Pure copper gives a pure red streak, but a tinge of yellow is added by as little as 1 per cent of tin.

Chemical analyses of prehistoric bronze show percentages of tin ranging from 1.5 to 30, but very few specimens contain less than 6 or more than 12 per cent of tin. Silver, lead, antimony, arsenic, bismuth, nickel, and cobalt occur only in traces, and the proportion of iron is also very small in most cases. It is a remarkable fact that nearly all prehistoric bronzes are very nearly or quite free from zinc, of which many modern bronzes contain as much as 10 per cent.—Umschau.

America's Heavy Fire Loss.

At the forty-third annual meeting of the National Board of Fire Underwriters, held in New York city May 13th, President J. Montgomery Hare made an address, in which he stated that a comparison with statistics of losses in foreign countries shows that the loss per capita in the United States is from 10 to 30 times greater than in the principal European cities. For the last five years, he said, the annual fire loss in this country has averaged \$269,200,412, the total for the period being \$1,346,022,059, or about three-quarters of a million for each day of the five years. In this period the figures were largely increased by the San Francisco conflagration, but even taking the two years since then the losses have kept well above the \$200,000,000 mark.

Without counting losses from forest fires, the destruction of property in 1907 by fire totaled \$250,084,709, and in 1908, \$217,885,850. The figures for this year give no promise of improvement, President Hare said, having reached a total of nearly \$53,000,000 for the first three months.

According to dispatches from Atlanta, nothing which has been suggested for the benefit of the South since the war has aroused such unanimous enthusiasm as the proposed highway from New York to Atlanta. Whereas the suggestion originated with automobile users, it is obvious that any scheme for the promotion of good roads through country districts remote from railroads must directly benefit agricultural and other large communities largely dependent upon highways for transportation. Three alternative routes have been suggested, all of which follow the same course from New York to Philadelphia. Two routes thence to Washington are identical, whence one lies through Rapidan, Charlottesville, Lynchburg, Danville, Greensboro, and Salisbury, where it joins the third route and reaches Atlanta via Charlotte, Blackburg, Spartansburg, Hartwell, and Winder; while the other goes through Richmond, Petersburg, Raleigh, Columbia, S. C., and Royton to Winder. The third route leaves Philadelphia westward to Harrisburg, thence down the Cumberland and Shenandoah valleys to Harper's Ferry and Lexington, crossing the mountains to Martinsburg and Salisbury and continuing as above. The New York Herald and Atlanta Journal have offered prizes for the best sections of road in the various districts, and an endurance test for automobiles is projected, with the object of comparing the results on different routes, the ultimate decision as to the highway route being dependent upon the local road conditions achieved by local authorities.

Skirt marker, Wells & Meek..... 922,740
Skirt marker, J. D'Elia..... 922,029
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Sleeve, splicing, H. Frankel..... 922,690
Slicing machine, bread, G. A. Kinder..... 923,125
Sliding gate, W. W. Vanden..... 922,548
Slip coupling, E. J. Gulick..... 923,043
Smoke consuming furnace, P. J. Flanagan..... 922,871
Snap hook, W. Gronke..... 922,473
Soap holder, liquid, E. L. W. Bugner..... 922,453
Socket fastener, E. L. Miller..... 922,936
Soy or sauce substitute, manufacturing, K. Okazaki..... 923,070
Speculum, C. H. Borden..... 922,845
Speed adjuster, L. R. Culver..... 922,674
Speed controller, W. J. Seitz..... 922,525
Spindle, J. N. Kelsea..... 922,912
Spoke, T. H. Walbridge..... 922,737
Spring wheel, E. B. Anderson..... 922,658
Spring winding tool, A. Worcester..... 922,656
Sprinkler system, automatic, J. P. Casey..... 922,456
Stadia reading apparatus, E. J. Young..... 922,833
Stalk cutter, raspberry and similar, M. B. Sherman..... 922,520
Station indicator, H. C. Wallace..... 922,984
Steam generator, H. Ritchie..... 922,817
Steam generator and heater, F. L. Dutcher..... 923,034
Steencil machine, G. Remsnider..... 922,815
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Strain resisting mechanism, G. H. Forsyth..... 923,040
Strainer for lubricating systems, C. H. Worsey..... 922,657
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Stream motor, P. J. Hanson..... 922,890
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Suit case attachment, T. Cosgrove..... 922,567
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Swing attachment, M. R. Grant..... 922,886
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Telescope, hinged double, E. Donitz..... 922,679
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Threshing machine feeder, J. H. Schleiter..... 922,520
Threshing machine separator, R. McLaughlin..... 922,615
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Tire protector, E. J. Weldner..... 922,739
Tire tool, J. A. Swinehart..... 922,541
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Tire, wheel, A. R. Bangs..... 923,104
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Toy vehicle, J. C. Kingsbury..... 922,815
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Truck, railway, A. M. Clark..... 922,750
Tube forming machine, L. C. Smith..... 922,536
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Turn table, H. M. Verplanck..... 922,643
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Type ribbon handling device, E. C. Magnus..... 922,927
Typewriting and calculating machine, combined, H. D. Bolton..... 922,559
Typewriting machine, G. C. Carhart..... 923,016
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Typewriting machine, E. E. Barnes..... 923,106
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Valve, W. C. Westaway..... 922,986
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Valve, gate, A. P. Smith..... 922,636
Valve lock, L. Toback..... 923,090
Vamp trimming machine, J. B. Hadaway..... 922,607
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Vehicle exhaust dissipating apparatus, motor, G. E. Whitney..... 922,741
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Wagon jack, G. W. Harris..... 922,474
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Washer or button feeding attachment for setting machines, E. B. Stimpson..... 922,640
Washing machine, A. Hofmann..... 922,900
Washing machine, G. R. Adams..... 923,101
Watch, A. P. Lister..... 922,819
Water closet, seat, W. S. Emery..... 923,039
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Watering device, stock, G. E. Odell..... 922,943
Watering tank, stock, A. N. Eaton..... 922,681
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Window fastening device, L. H. Vogel..... 922,644
Window lock, J. E. Hissong..... 922,599
Window pane fastener, J. B. La Venture..... 922,785
Wire bed bottom, woven, G. Boehm..... 923,006
Wire drawing, plate stand for, P. Vanderauwera..... 922,979
Wire gripper, J. H. Reece..... 922,814
Woven fabric, T. Taylor..... 922,641
Wrench, Bean & Baldwin..... 923,103

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