calculating tables of logarithms. Doubtless his theory was correct, but he lacked the mechanical ability or assistance to devise mechanism which would properly actuate the numeral wheels. The *Temple Bar Magazine*, of London, is authority for the statement that on one occasion Count Strezlecki remarked to Mr. Babbage that in China, where he had lately been traveling, they took a great interest in his calculating machine, and particularly wanted to know if it could be put in the pocket. "Tell them," replied Mr. Babbage, "that it is in every sense an out of pocket machine." This remark will doubtless apply to nearly every calculating machine ever worried over by a fond and hopeful inventor, because of the great mechanical difficulties met with in inventions of this kind which do not appear on the surface.

One great failing of inventors of such machines is, they seem to think if they only get something to do the work mechanically, it does not matter about the speed, rest to the mind being all that is necessary; but one who tries to sell a calculating machine which is not more rapid than the mind soon finds that the living world regards time of first importance, and is willing to sacrifice its brains and put up with mistakes rather than lose present time, regardless of the fact that it may be losing time by shortening its lives on account of overtaxing brains and turning men into veritable machines, until, as Wendell Holmes put it, "you would almost hear the clicking of machinery inside their heads." I have often wondered if he was thinking of calculating machinery or only recognized the mechanical future of arithmetical operations even when performed mentally. Another machine for calculating tables by means of common differences or ratios was exhibited to the Prince of Wales in June, 1855, and attracted considerable attention at the time. It was the invention of Edward Schentz, of Stockholm, and not only calculated the tables, but automatically cast stereotypes as fast as computed, from which the tables were printed, so that there could be no mistake in setting type. I believe that a modified form of this machine was eventually used to a great advantage in computing a book of logarithms, though, as yet, I am unable to find any authentic information on that point.

In a class by themselves may be placed the several crank-operated machines for multiplying and dividing which have been invented and sold with more or less success, according to the commercial ability and enterprise of their manufacturers. These machines are alike in mode of operating, differing only in their mechanisms. They all have several series of number indexes, running from one to nine, each standing for an order of numbers, and pointers for each index, which, in use, are set on the indexes, each to correspond to a figure of one of the factors of a problem to be computed, and a crank, which is turned a number of times to correspond with each respective figure of another factor of the problem to obtain the required answer. These are very good in certain classes of large examples, being very much better than the head.

Among the more prominent of this class of machines are those produced by Thomas, of France, and improved and manufactured by Tate, in England; that of Odhner, of Poland, a small and light machine which has not been much pushed in this country; that of Baldwin, of St. Louis, Mo., and Grant, of Cambridge, Mass.

In this country more attention has been paid to adding machines, of which the writer has knowledge of over fifty, not counting something like 150 cash and fare registers and numerous counting machines which have been patented, only a few of which have ever come into practical use. Most of these adding machines would not work accurately in practice. A few simple contrivances which could be made cheaply have been put on the market and have found quite a sale, because they were cheap, and many, dreading the mental strain of figures, would risk a small amount of money with the hope of escaping it.

In the accompanying cut will be found a computing machine of my own invention, known as the comptometer, which is operated by keys like the better class of typewriters. A large number of them are now in use, not only in this country, but in Europe, India, South America and Mexico. This machine is peculiar to itself and is wholly unlike any other calculating machine in the world, both in mechanism and manner of operation.

In using it the operation is wholly mechanical, one only having to touch keys corresponding to the numbers of the example and the machine does the rest, the carrying being done automatically by the machine and requiring no attention from the operator.

In addition the operator only has to strike one key for each figure, the same as an operator on a typewriter, and sixty words is not an extra speed for typewriter operators, which, figuring five letters to the word, is 300 keys. I have seen that speed reached on the comptometer; hence it is fair to say that a properly designed adding machine is more than twice as rapid as mental adding. No mental adder can begin to keep up with it when skillfully operated for ten minutes, or even for one minute, while for a stretch of several hours there is no comparison between a mental adder and it.

All the columns are added at once. The figures of each respective column on the paper are struck in the corresponding column of the machine.

The standard size has a capacity of eight columns (99,000,000), though larger sizes are made. As shown in the cut, there is a series of keys for each column of numbers, and the first on the right stands for units, the next for tens, the next for hundreds, etc., just the same as they are ordinarily written on paper. The register or place where the answer appears is just below and in front of the keys. In speaking of the keys, those running in a line up and down are called a column and those running in a line from left to right are called a row. Thus all the keys having a large 4 on top stand in a row and are called the row of 4's.

To perform multiplication on the comptometer, the operator begins at the right or the row of keys indicated by the first figure of the multiplier, and strikes each successive key in the same row toward the left as many times as indicated by the corresponding figure in the multiplicand, and then proceeds with each of the other figures of the multiplier as with the first, beginning always in the column of keys in which the figure of the multiplier stands.

Since the operator does not have to jump around from one part of the keyboard to another, always working in straight row, only jumping from one key to its next neighbor, the process is very simple, and requires little practice to acquire a high degree of speed.

Operations are performed on the comptometer so rapidly that any method is rapid enough. For instance, the example 718 × 423 can be performed by an ordinary operator on the comptometer in 4 seconds, and an expert operator can perform it or any similar one in 2½ seconds. Theoretically, this does not seem possible, but it is a fact nevertheless.

It is doubtful if one having a book of tables of multiplication before him, even if already opened at the right page, can, on an average, locate the answer in 4 seconds, or twice that time.

In dividing on the comptometer the number to be divided is first struck on the keys precisely as in addition and then the divisor is struck with respect to the smaller figures on the keys, which are red, the operator striking the proper keys continually (never more than nine times) until the figures in the complementary place agree with the number of strokes on the keys, and the thing is done.

It is a significant fact that the Cornell University, a school specially famous for its mathematics, is using four comptometers.

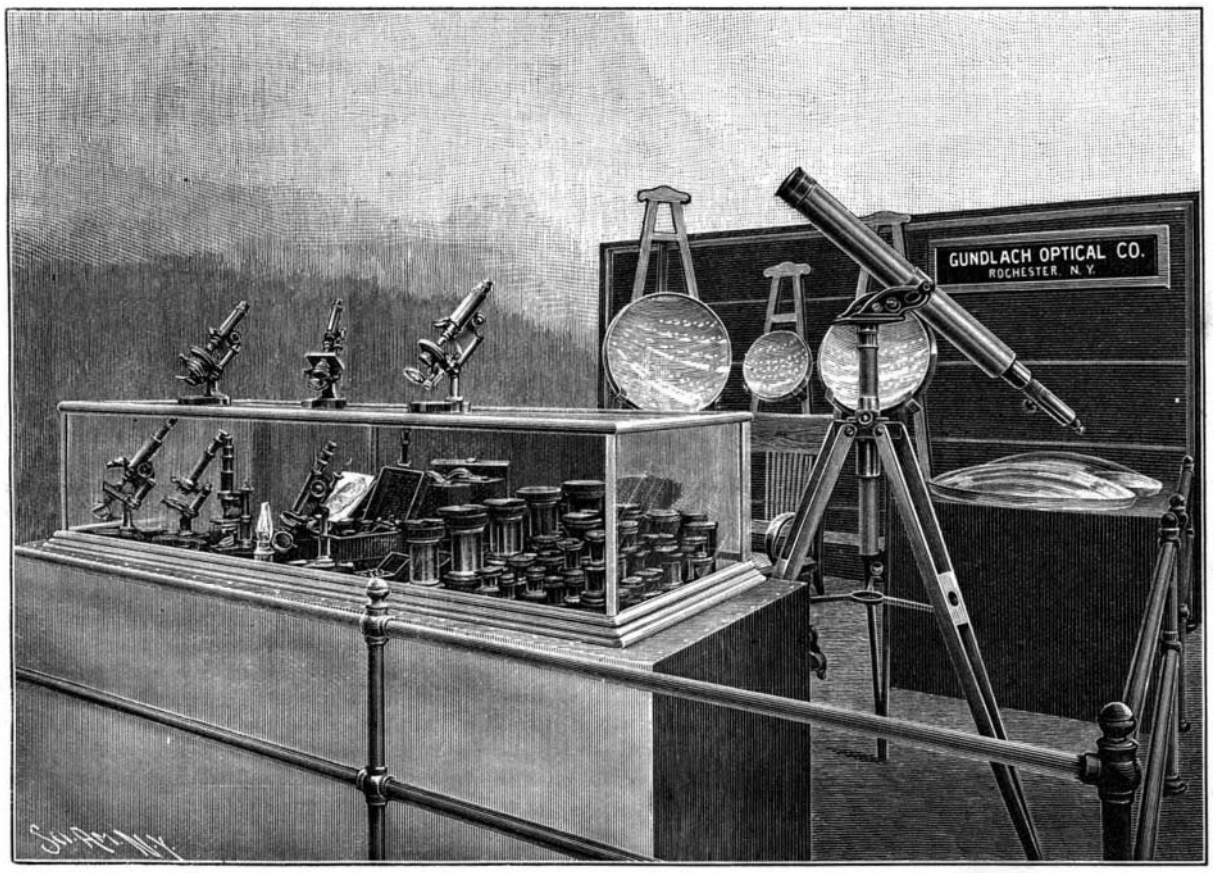
Its keyboard stands a simple and complete diagram of the very system of notation itself. Every key standing to represent a corresponding rung of the ladder of numbers and each key when touched affecting the register for results according to the numeral value for which it stands.

Having this, you have a machine which will rapidly compute addition, subtraction, multiplication, division, square and cube root, by the application of which everything in arithmetic is calculated.

Though it is less than four years since the Felt & Tarrant Manufacturing Co., 52, 54 and 56 Illinois Street, Chicago, started to manufacture the comptometer, its business has increased until its large factory fitted throughout with special machinery for manufacturing comptometers, is continually driven to its fullest capacity to fill orders.

OPTICAL GOODS AT THE EXPOSITION.

The accompanying illustration represents one of the most notable exhibits at the World's Fair, that of the Gundlach Optical Company, of Rochester, N. Y., a company which ranks among the leading manufacturers of optical instruments of the world. Three awards were made to this company for the excellence of their goods. The business had a very modest start about ten years ago, with the optical work of Mr. Ernst Gundlach as a basis. From Mr. Gundlach the firm took its name, and he is still connected with it as consulting optician, while the firm proper consists of Henry H. Turner, John Zellweger, and John C. Reich. Microscopic objectives were the first articles manufactured, but the firm was brought into especial prominence by the superb line of photographic lenses which they originated and placed on the market. These lenses are of peculiar construction, and are protected by letters patent. They are so constructed as to eliminate to a great degree the defects which are inherent in all photographic lenses. In addition to this, they are so constructed that either the front or back combination can be used as a separate objective, and a longer focus thus obtained than the combined objective gives. In this way lengths of focus can be secured varying as 2: 3, and 4. A year or two ago the firm added the manufacture of portable telescopes and microscope stands to their business, and at once took a prominent place in both these lines. In the microscope department they received two awards, being the only firm in this country to receive any awards in this line. The microscopes embrace a wide range of instruments, and are all made on the most approved models and with the greatest attention to detail and excellence of workmanship. The portable telescopes are also receiving deserved recognition, as they are of the highest optical excellence, and mechanically have many new features for portable instruments. They are made in size from 2½ inches aperture up. Many are in use in various parts of this country, while the company is preparing to fill a European order.



THE WORLD'S COLUMBIAN EXPOSITION—EXHIBIT OF THE GUNDLACH OPTICAL COMPANY.

One of the unique parts of the exhibit is the fine display of Mangin mirrors, such as are used in the great marine search light projectors. This firm is the only manufacturer of these mirrors in America. The mirrors vary in size from 30 to 75 centimeters, and one requires some knowledge of the *technique* of the glass business to fully appreciate the great difficulties encountered in their manufacture. The exhibit as a whole was a most complete and satisfactory one.

CITRIC ACID BY SYNTHESIS.—Charles Wehmer.—The author obtains citric acid by the fermentation of glucose set up by certain fungi, *Citromycetes pfefferianus* and *C. glaber*. Herr. Wehmer states the spores of these fungi are abundant in the air, and can be obtained pure by cultivation.