invented a machine for performing the operations of addition and subtraction, following this in 1663 by another for working out questions in plane trigonometry, and yet another three years later adapted for the addition of money.

In 1671 Leibnitz constructed a calculating machine, which was very complicated and never came into general use. About the same time Polenius, an Italian, invented a multiplying machine. In 1700 Deleprene and Boitissendeau brought out a machine for performing the four arithmetical rules. Viscount Mahon made a small machine in 1750, and in 1775 a larger one, and again in 1777 still another, all of which would perform the four arithmetical operations. In 1815 Dr. Roget brought out the double logarithmic scale or sliding rule, thus improving Gunter's invention of nearly a century before. From 1815 to 1871 Professor Babbage devoted his energies to the construction of his great difference and analytical engines. He completed his first difference engine about 1820, and although he laboured at the second and improved one for some fifteen years, and received various sums from the British Government amounting in all to £17,000, the engine was never completed. His great effort was the construction of the analytical engine, which, though certain parts were put into working order, was never completed, and remains to this day a philosopher's dream. He died in 1871, and left no working plans that would assist a successor in carrying on the work, although his writings and descriptions of the engine no doubt opened up the way for the machines that followed. From 1837 to 1842 Sheutz and his son designed and constructed their first experimental machine, but it was 1853 before the complete working machine was finished. This machine is about the size of a small piano, and its construction was doubtless suggested by Babbage's reports. It is in essence a difference engine, and by a simple adjustment would give results in the mixed senary system of notation, as in degrees, minutes, and seconds. It would not only calculate tables but would stereo the results in lead sheets for any number of reproductions. Another important feature of its work was the automatic correction of the last retailed figure of the results which increased by one if the first discarded decimal was 5 or over. This machine was bought from the inventors by an American gentleman, and is now to be seen in the Dudley Observatory at Albany, New York.

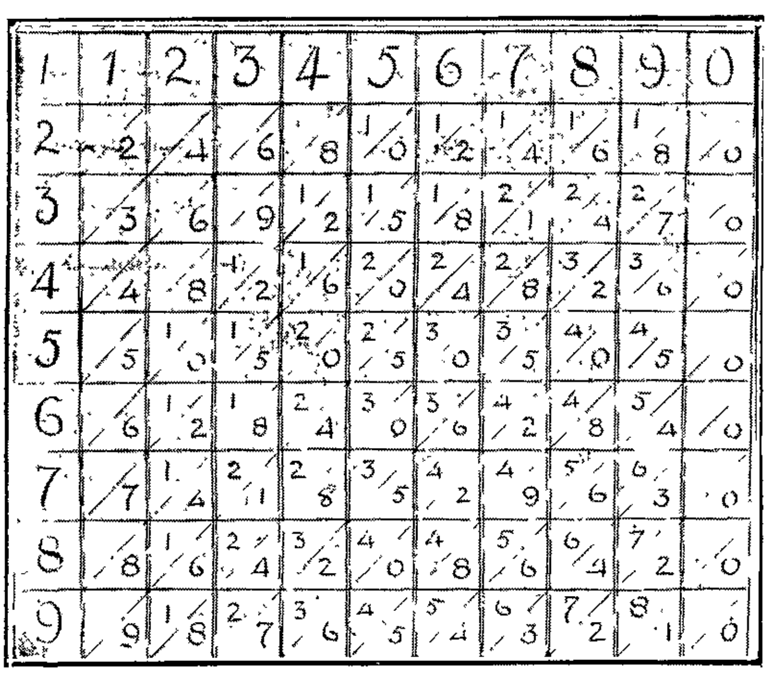
On the strong representations of Dr. Farr, the British Government arranged with Messrs. Scheutz and Mr. Donkin, an English engineer, to construct an improved machine at a cost of £1200. This machine was a beautiful piece of work, and may still be seen in Somerset House by authorised persons. It was used in calculating and stereotyping, at one operation, a large portion of the English Life Table No. 3. The great drawback was its extreme delicacy, and that, combined with its high cost, prevented its adoption for general purposes. About 1840 Staffel, a Russian inventor, brought out a machine of different construction from all its predecessors, but it does not appear to have been successful.

In 1850, Thomas (de Colmar) invented a small machine to perform arithmetical operations. It was improved by him and others, and came into general use as the Arithmometer. About seventeen years ago this machine was further largely improved by an English mechanic named Tate.* It has since been regarded as the standard calculating machine. Hundreds are in daily use in all parts of the world. I have used one of these machines for sixteen years, and it is still in splendid working order. Its mechanism is beautifully constructed, and its workmanship is thoroughly British; not made to wear out in a year or two, but to last a lifetime if it is properly treated. In operating this machine for multiplication, the multiplicand is set on to the bottom plate by hand; the units figure of the multiplier is then expressed by turning the motor handle as many times as that figure represents. The result is shown on the top movable slide, which is then pushed out to the right one division. The handle is then turned as many times as will express the tens figure of the multiplier, the product of which is simultaneously added on to the previous result, and so on. The extent of the numbers to be multiplied together is not limited by the size of the machine, as partial results can be worked and combined.

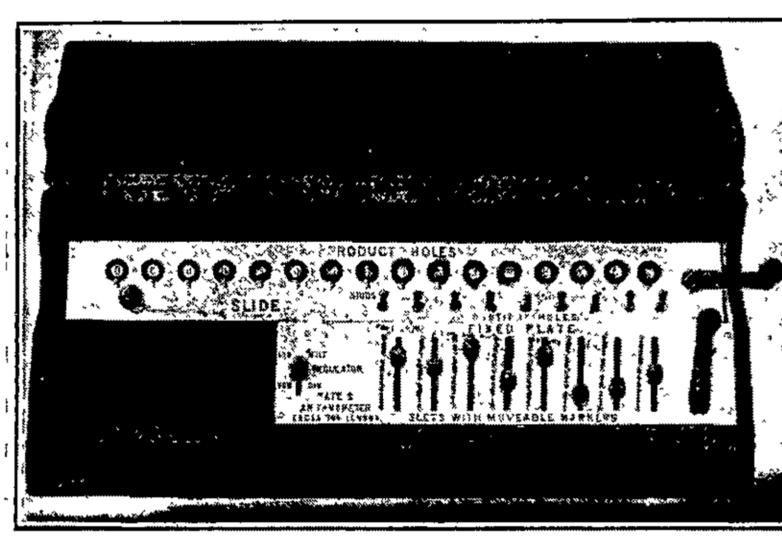
In division the regulator is pulled over to the division sign, and the divisor set on the left of the fixed plate, whilst the dividend is set on the movable plate as far to the left as possible. The handle is then turned until the amount showing on the movable plate becomes less than the divisor, when the movable plate is shifted to the right, thus bringing in a new figure as in ordinary division. The result, the sum of which equals the number of turns of the handle, gradually appears in the small holes called the quotient holes. This operation may also be extended indefinitely.

It is possible, by the use of two or more Arithmometers working in conjunction, to perform the work of a difference engine, but as this paper is not a scientific treatise, I merely state the fact without further comment.

(To be continued).



NEPER'S RODS.



IMPROVED ARITHMOMETER.

Distillation of Iron, Nickel, and Other Allied Metals.

In a recent number of the *Comptes rendus de l' Academie des Science*, Moissan describes further experiments on the distillation of metals in the electric furnace. This investigator, who has already succeeded in distilling copper, gold, and the metals of the platinum group, has now turned his attention to iron and its allies (vide *The Times Engineering Supplement*, February 7, 1906, page 47; and March 7, 1906, page 75). Manganese was found to be the most volatile metal of this series, a specimen containing 2 per cent. of carbon readily distilled when heated with a current of 500 amperes and an E.M.F. of 110 volts. The distilled metal was distinctly crystalline. Another sample of this element free from carbon but containing 4 per cent. of silicon was volatilised even more readily, but the ebullition was rendered irregular by the violent evolution of occluded gases. Nickel and chromium came next in order of volatility, about half a pound of the former distilled completely in nine minutes with 500 amperes and 110 volts. In the case of iron, an experimental difficulty arose owing to the molten iron carbide occluding gases and liberating these subsequently with considerable violence as the boiling point was reached, so that a large proportion of the metal was projected from the crucible. In this case the best result was obtained by heating the metal gradually with a current of 1,000 amperes and 110 volts, when 50 per cent. of a 2lb. specimen was volatilised in 20 minutes. The boiling point of uranium is somewhat higher than that of iron, a current of 900 amperes and 110 volts being required to volatilise this element. Molybdenum and tungsten were found to be the least volatile metals of the series and only boiled regularly after prolonged heating with the foregoing current. Like iron and manganese, molybdenum occludes gases when in the molten condition. Tungsten has the highest boiling point of any metal hitherto examined in the electric furnace.

German Locomotive Tests.

The entire space in the June issue of the *Verhandlungen des Vereins zur Beforderung des Gewerfleisses* is devoted to an account of the trials of three different types of locomotives at express speeds on the Hanover to Spandau Railway, over a length of 151.3 miles, more than two hours being necessary for the trip. It was felt that the former speed trials between Marienfelde and Zossen were over too short a length of line to secure accurate results in points of fuel consumption and steam-raising capacity. Even here, however, the fuel needed to get up steam was about 25 per cent. of the whole quantity used for the run. Some details in connection with the running of the Paris and Calais express trains are discussed, and formulæ are given based on these results, obtained by four coupled, four-cylinder locomotives of the Atlantic type. The three test engines are described in detail and fully illustrated. The Hanover coupled, four-cylinder, compound Egestorf engine, No. 608, delivered in November, 1903, was in the best running condition. The Cologne Grafenstaden, No. 58, coupled, four-cylinder compound engine, built in 1902, was not in equal condition; the tubes at the insertion into the firebox leaked badly, and certain of the axles ran hot, and other defects are enumerated. The Elberfeld coupled No. 6 engine, with steam superheat, built by Borsig in 1903, was likewise in faulty condition; the tubes were leaky and other defects were apparent. A detail section is given of the gradients, together with a plot of the curves on the whole length of line selected for these experiments, and full particulars are given of the rails and road formation. There were 20 runs in all, 17 with trains and three light. Very searching tests and measurements here described were taken at intervals of one minute throughout the run in all cases, and the results are plotted as graphic diagrams. External air temperature, wind force or pressure, and temperature of the feed water were likewise ascertained. The intention was to consider both the outward and homeward runs, but it was found that the period arranged for the stay at Spandau did not always suffice to execute the requisite repairs to the engines, so that only the figures on the outward trips were recorded. For various reasons only six of the runs were strictly comparable, and from these a series of tabular statements have been drawn up. The results are fully discussed from the points of view of fuel consumption, feed water supply, steam production, use of oil and grease, speed, tractile power, and vibration, and many other considerations incidentally arising are dealt with by Mr. Leitzmann in this exhaustive essay.

*Since the above was written Tate has put on the market an important machine with much simpler parts and at a greatly reduced price. I have been using one of these for some time and am thoroughly satisfied with it in every way.—J.W.K.