degrees in the rear. In this position, live steam is admitted from the main steam-pipe a (Fig. 3), thence through ports b', pipe a', and port g'', to cylinder H''; and at the same instant steam which has

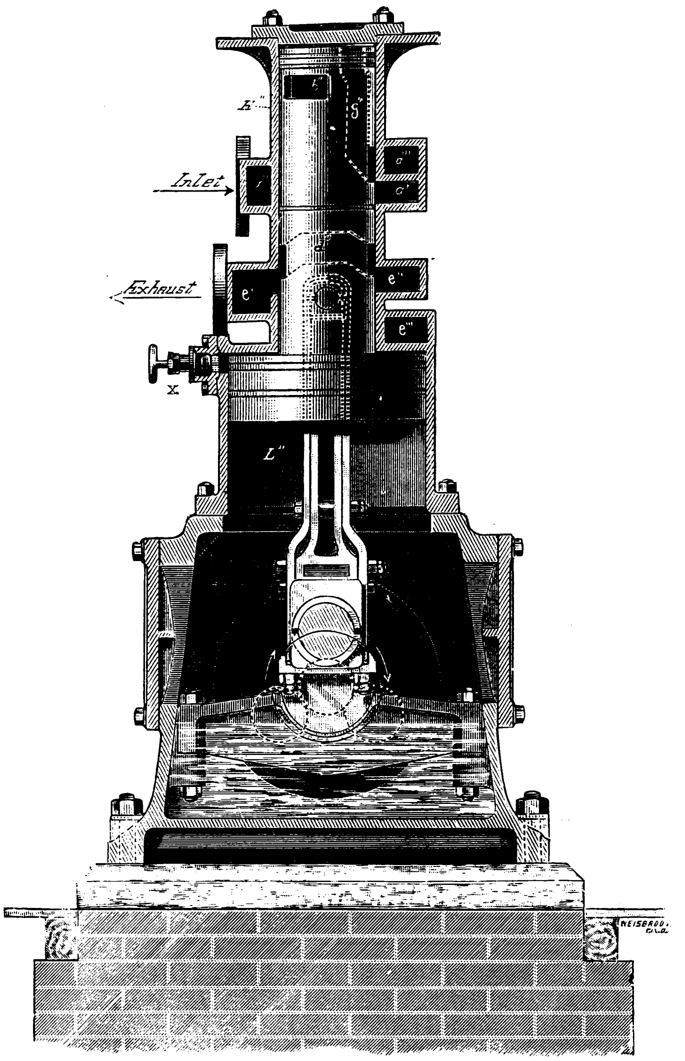

FIG. 2.

been partly expanded in cylinder H' passes down through port g' (Figs. 1 and 3) and pipe e', to cylinder L'', thus admitting live and low-pressure steam on one set of pistons at the same moment. Under the action of the steam, pistons H'' and L'' move downward, live steam being admitted until the upper edge of port g'' (Fig. 1) passes the lower edge of pipe a', at which point it is cut off, and expands in this cylinder until the lower edge of port g'' passes the upper edge of pipe e'', at which point it passes to cylinder L'''. At the same moment live steam passes from a through port b' (Fig. 3), pipe a'', and port g''' (Figs. 1 and 3), to cylinder H'''. At this point also, piston H', moving upward, closes the connection between cylinders H' and L'', and the steam expands in L'' for the remainder of the stroke. As piston L'' reaches the lower centre, port d' (Fig. 1) comes opposite pipe e', and the exhaust steam passes through this connection into pipe e (Fig. 4), which communicates with the atmosphere or condenser. When piston H' reaches the upper centre, live steam passes from a (Fig. 3) through port b''', pipe a''', and port g', to cylinder H', and the partly expanded steam passes from cylinder H''' down through port g''' (Fig. 1) and pipe e''' to cylinder L'. Cylinder L''' exhausts through pipe e'' and port d'' into e, and cylinder L' through pipe e''' and port d''' into e.

The valve X (Fig. 2) is merely a live-steam connection with the low-pressure cylinders for heating up and starting. Thus, with the exception of the cut-off, each set of pistons controls the steam in the cylinder next preceding, in the order of rotation, and, when acting as a valve, is at or near its maximum speed; while the pistons in the preceding cylinders are at or near their slowest speed. This simple expedient controls the steam in this engine in a manner unexcelled by any valve device.

All lubrication is automatic, consisting of a sight-feed lubricator on the steam-pipe, a drop-sight-feed cup on each end-bearing of the shaft, and a mixture of oil and water in the crank-case, perfectly lubricating all parts within. The cylinders are cast in one piece, and bored at the same time on a tool especially designed for the purpose, by which means they are made absolutely parallel, and the danger of leaky joints is avoided. The bearings for the shaft are bored out after being bolted in place, insuring perfect alignment; and all wearing surfaces are exceptionally large, so that internal friction is reduced to a minimum. The only adjustments consist of two keys in the connecting-rods, which take up all the wear in both boxes. The pressure being always downwards, these adjustments are seldom necessary; and the engine, it is claimed, will run indefinitely without stoppage, and with but little attendance.

THE TENSILE STRENGTH OF SHEET ZINC.

So little has been published about the strength of zinc, that any contribution to this question must be welcome. The most careful tests which Professor Martens made on some zinc sheets supplied by the Schlesische Actien-Gesellschaft für Bergbau und Zinkhüttenbetrieb at Lipine, in Silesia, on behalf of these works, hence, deserve all the more attention. These tests, according to *Engineering* of Jan. 31, were carried out at the Royal Technical Testing Station at Berlin, of the mechanical department of which Professor Martens is chief, and are described in the official reports of that institution, 1889, IV.

The reputation of zinc as a structural material is not particularly good, and these tests do not tend to show that the metal deserves a better name for constancy and reliability of its mechanical properties. A great many tests had to be made to arrive at fair averages. The test samples were five sheets, supplied by the Silesia mills of the above works, two specimens from foreign works; and finally eleven sheets rolled before Professor Martens

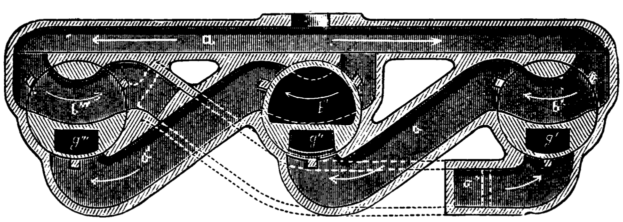

FIG. 3.

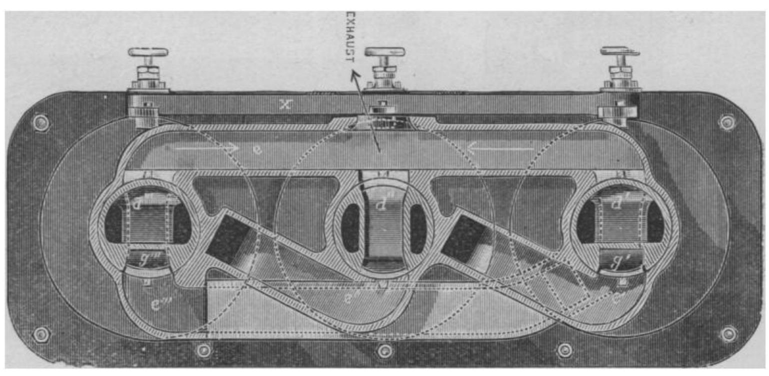

FIG. 4.

out of bar plates of 1 foot width. Three of these latter were rolled out to two, three, and four times their length, to thicknesses of 6.1, 5.4, and 3.1 millimetres: the other eight were rolled in bundles, first in one direction, then at right angles to this direction, test-pieces being cut out each time when the length had increased by 500 millimetres. The final plate varied in length from 1,210 to 4,710 millimetres, and in thickness from 1.1 millimetres to .6 of a millimetre. The chemical analyses of the various plates agreed very closely: they all contained about 1 per cent of lead and .02 of one per cent of iron; the two foreign plates showed traces of antimony; no other metals were observed.

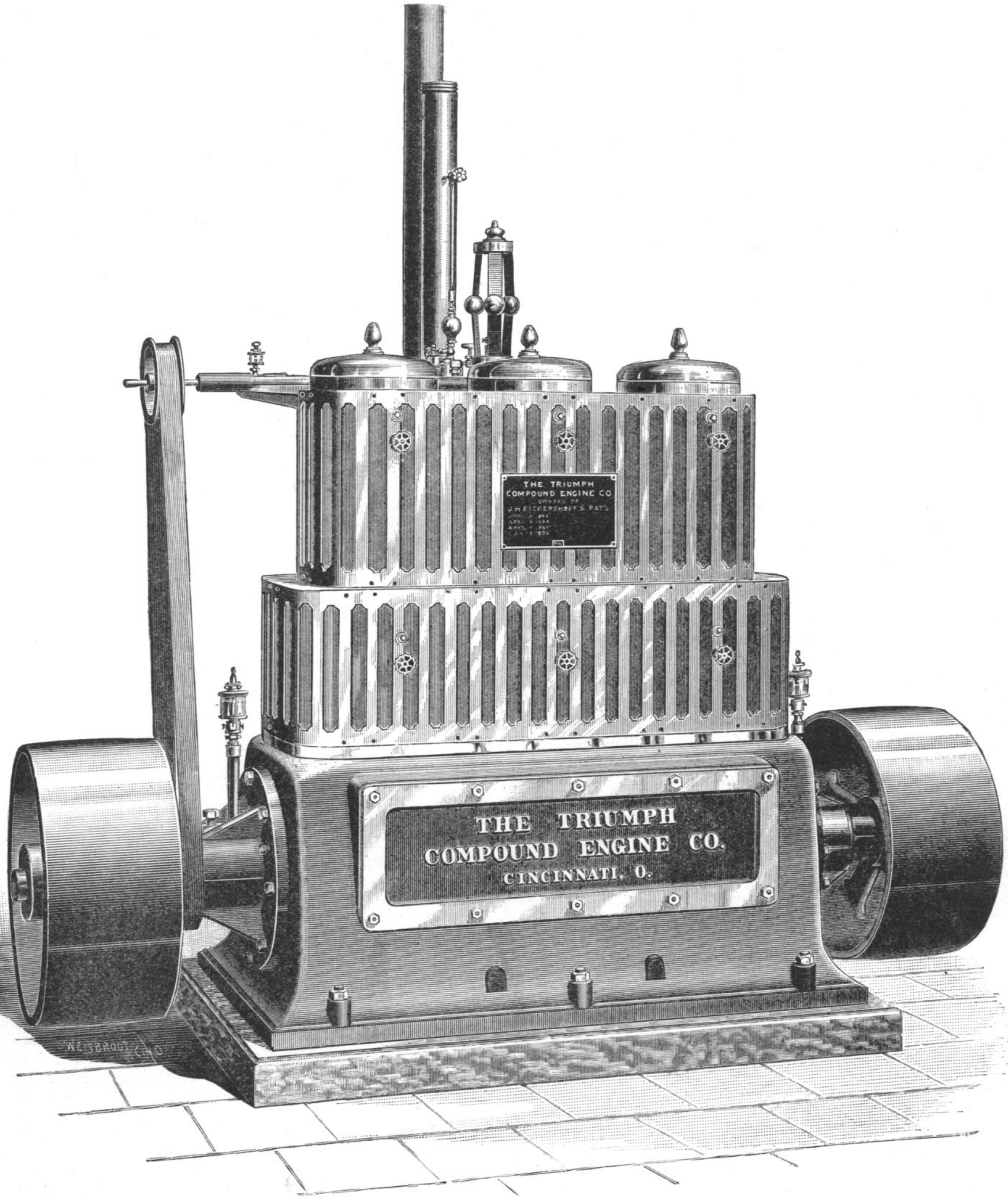

FIG. 5.—TRIUMPH COMPOUND VALVELESS STEAM-ENGINE.

The first series of tests was made with a horizontal Rudeloff testing-machine with scale-pan, screw, and nut-feed; the prismatic test-pieces, 20 millimetres (.8 of an inch) in width, being fixed in caps, and tightened there by means of wedges. The pieces frequently broke close to this clamp; and it was found that the length of the wedge, and the distribution of the pressure, were of considerable importance. The wedges should press out the mouth of the clamp slightly, but more and more towards the back. Direct application of the loads proved quite unsuited, as zinc is highly influenced by the rapidity of the changes. Professor Martens, therefore, resorted to a testing-machine of his own design, three different modifications of which were employed. As indicators for these apparatus, a circular vessel filled with mercury was employed, from the side of which a vertical tube branched off. The cover of this vessel was formed by a strong central plate supporting a weight surrounded by a ring of german-silver. The strain imparted to the test-piece was partly taken up by the weight, the mercury column effecting the balance. This arrangement, which resembles others employed for similar purposes, did not answer; it was, moreover, not self-recording. The mercury-tube was therefore replaced by a horizontal cylinder with a piston-rod ended in another piston moving in a second cylinder with a slide-valve, which was actuated by an electric device comprising electro-magnets and relays. The common piston-rod carried a pointer recording on a paper drum. A third device, also electrical, but worked by gravity instead of water-pressure, was employed for the highest loads up to 50,000 kilograms. These three arrangements labored under the disadvantage that the cover of the mercury vessel retained an amount of mobility sufficient to affect the accuracy of exact measurements. Professor Martens hence returned to an often-employed arrangement, utilizing the elasticity of a spring of an elastic steel rod. The idea is, that the variations of the rod are marked directly (and without being magnified by multiplying levers or other devices whose accuracy Mr. Martens altogether questions) by means of a little conical diamond point on glass plates of the size for microscopic slides, fixed on a platform moved by means of a micrometer-screw and adjusting-spring, in a direction at right angles to that of the axis of the rod. Two of the resulting curves would occupy a space of not more than a square millimetre. The plates were examined and measured in a large Zeiss microscope provided with micrometers for both object and ocular glasses In this form, the recording device has been constructed by Mr. Boehme. It is, however, intended to leave the platform at rest, and to register the movements in the direction of both the abscissæ and the ordinate.

The chief objects of the tests were to ascertain the elasticities at ordinary temperatures and at 80°, 120°, 150°, 170°, and 200° C. (between 176° and 392° F.), and to ascertain the influences of different modes of rolling and of time-effects The latter are striking. One can hardly speak of the elasticity of rolled zinc, as even under very small strains the permanent expansion varies with each change of load. There was always a noticeable after-stretching. When cold, the breaking strength was 23 per cent larger, the breaking extension 22 per cent smaller, and the "fulness degree" (i.e., the ratio of the area comprised by the curve to the rectangle formed by the greatest extension multiplied by the greatest force) neither larger nor smaller, in a direction at right angles to the rolling, than in that of the rolling. The two samples supplied by other works showed, however, opposite characteristics, and one test-piece particularly deviated in a manner probably to be accounted for by some peculiar treatment during manufacture, the chemical composition seeming to afford no explanation. Rising temperatures modified the results. The breaking strength increased considerably in thinner sheets; that is, in such as have undergone greater and more continued pressure in the rolls. It rose from 11 kilograms per square millimetre for 6-millimetre plates, to 19 kilograms for plates .48 of a millimetre thick. The English equivalents of these values are 17.5 and 30 tons per square inch respectively for plates of .24 and .019 of an inch in thickness. The breaking extension decreases first, and increases rapidly afterwards. For the temperature tests, the pieces were heated in a linseed-oil bath. The results confirm the well-known and important fact, first established by Silvester and Hobson of Sheffield, that zinc should be worked, rolled, stamped, turned, etc., at 300° F., and that any higher temperature should carefully be avoided. On the whole, the tests demonstrate clearly that ordinarily tensile strength tests are not alone sufficient, and should be combined with folding and bending tests.

METEOROLOGICAL OBSERVATIONS ON PIKE'S PEAK.

Since the Boyden fund of the Harvard College Observatory was established for the purpose of obtaining astronomical observations at some station of great elevation above the level of the sea, an inquiry into the meteorological character of such stations seemed desirable before undertaking the proposed work. It was known that a long series of meteorological observations at the highest station ever permanently occupied for such a purpose had been made by the United States Signal Service on the summit of Pike's Peak, in Colorado. It was accordingly proposed to the chief signal officer of the United States Army, Gen. A. W. Greely, that these observations should be printed at the expense of the Boyden fund, in the "Annals of Harvard College Observatory;" and his courteous co-operation has enabled this plan to be carried out, as shown in Vol. XXII. of the "Annals" of the observatory, just published.

The summit of Pike's Peak, Colorado, is situated in latitude 38° 50′ north, longitude 105° 2′ west, and has a height of 14,134 feet above sea-level, as determined by spirit-level from Colorado Springs. It is the highest meteorological station in the world; Leh, Ladakh, being 11,503 feet, and the Sonnblick, Austria, 10,154 feet. The station on the summit of Pike's Peak was established in October, 1873, and the first telegraphic report sent on Nov. 6 of that year. The telegraph line was frequently interrupted, and for long periods, until November, 1882, when it was virtually abandoned, owing to the great cost and the difficulty of its maintenance. Observations, however, were continued until September, 1888.

During the first few weeks the observations were more or less interrupted, and it has been deemed best to commence the publication from Jan. 1, 1874, at which date the station was in complete working order.

Pike's Peak rises very abruptly from the eastward, being about 8,000 feet above Colorado Springs, which is within ten miles or so from the summit. The open plain extending to the eastward affords unusual advantages for noting such cloud and storm phenomena as originate or move to the eastward of the mountain; and even the peaks to the westward are enough lower to permit observation of storm and cloud conditions below the level of the observer on Pike's Peak.

Perhaps the most notable fact resulting from a cursory examination of the meteorological elements is the remarkable resemblance between the recurring annual phases of atmospheric pressure and the temperature of the air. The curves of these elements not only are alike in having a single bend, but the maximum phase of both occurs in July, and the minimum in January. Not only are these elements coincident in their extreme phases, but the annual march is the same; so that the two curves are not only parallel, but almost coincident. When examined mathematically, it will be seen that not only are the plus and minus changes from month to month the same for both elements, but they bear a close, definite, and apparently dependent relation to each other, the mean monthly pressure rising or falling about .016 of an inch for each change of one degree Fahrenheit in the monthly mean temperature.

A similar relation between the mean monthly pressure and mean temperature obtains on the summit of Mount Washington, New Hampshire (elevation 6,279 feet above the level of the sea); but the barometer and temperature curves for the year at this last-named station are not as regular as on the summit of Pike's Peak. On Mount Washington, while the extremes of monthly mean temperature fall likewise in January and July, yet the maximum monthly pressure shows a tendency to prolong itself into August, and the minimum pressure to continue throughout January, February, and March. The relation on Mount Washington of monthly changes of pressure to like changes of mean temperature differs slightly from that of Pike's Peak, being about .012 of an inch rise or fall for each degree Fahrenheit.

The actual atmospheric pressure at Rocky Mountain stations above 4,000 feet elevation attains its minimum in January and its maximum in July or August; and the barometric phases