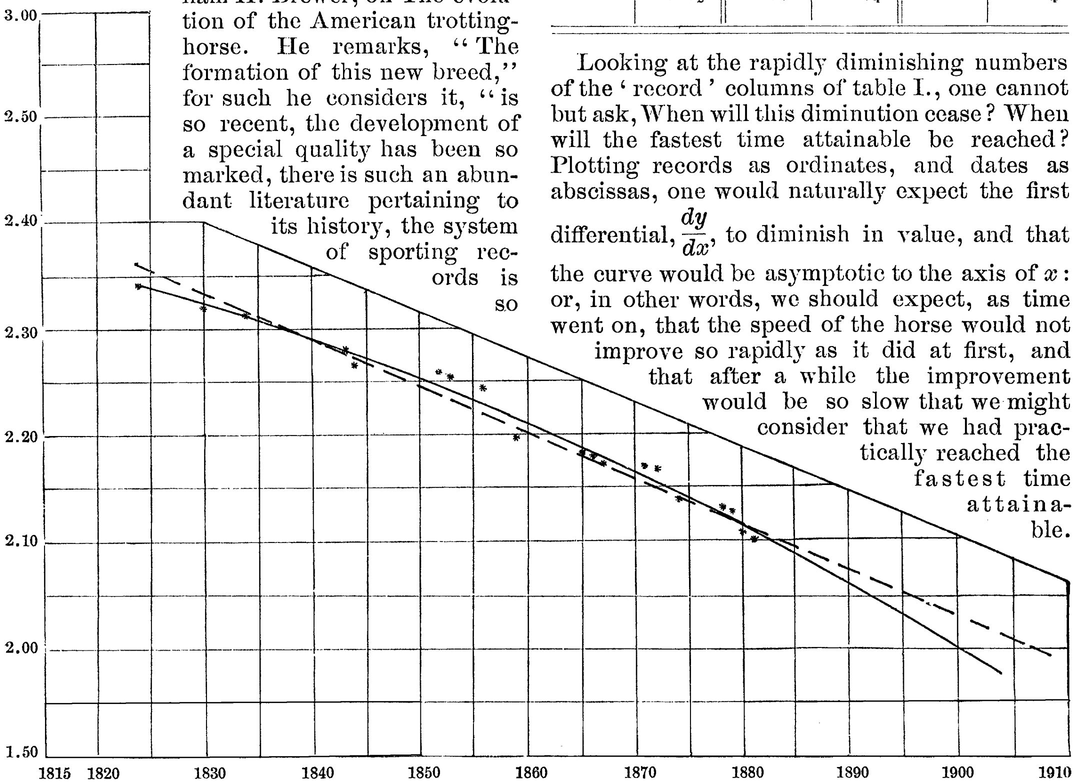
the workshop at the Yale museum. The pillars between which it hangs are fourteen feet high. On the floor, in the back part of the room, is the mould of the body, and bases of the arms. At the left, against the table, is the mould for the under sides of the bases of the arms, and at the right, on the floor, one of the arm-moulds, with the two parts fitted together.

J. H. EMERTON.

HORSE-TROTTING FROM A MATHEMATICAL STAND-POINT.

IN the April number of the *American journal of science* is a very interesting article by William H. Brewer, on The evolution of the American trotting-horse. He remarks, "The formation of this new breed," for such he considers it, "is so recent, the development of a special quality has been so marked, there is such an abundant literature pertaining to its history, the system of sporting records is so carefully planned and comprehensively conducted, and withal has become so extensive, that we have the data for a reasonably accurate determination of the influences at work which led to this new breed being made, the materials of which it is made, and the rate of progress of the special evolution." Towards the end of the paper are given some tables, which are copied in part beyond. The writer concludes by hoping that some one will plot the curves which naturally suggest themselves, and determine "how fast horses will ultimately trot, and when this maximum will be reached."



ABSCISSAS REPRESENT DATES; ORDINATES, THE BEST RECORD OF MILE HEATS.

I.—Best record of mile heats up to the present time.

Date.	Record.	Date.	Record.	Date.	Record.
1818	3.00	1852	2.26	1871	2.17
1824	2.40	1853	2.25½	1872	2.16¾
"	2.34	1856	2.24½	1874	2.14
1830	2.32	1859	2.19¾	1878	2.13¼
1834	2.31½	1865	2.18¼	1879	2.12¾
1843	2.28	1866	2.18	1880	2.10¾
1844	2.26½	1867	2.17¼	1881	2.10¼

Looking at the rapidly diminishing numbers of the 'record' columns of table I., one cannot but ask, When will this diminution cease? When will the fastest time attainable be reached? Plotting records as ordinates, and dates as abscissas, one would naturally expect the first differential, $\frac{dy}{dx}$, to diminish in value, and that the curve would be asymptotic to the axis of x: or, in other words, we should expect, as time went on, that the speed of the horse would not improve so rapidly as it did at first, and that after a while the improvement would be so slow that we might consider that we had practically reached the fastest time attainable.

But we find, with the exception of the first, that all the points lie very nearly on a curve which is convex upwards: in other words, that the rate of improvement of the record is increasing instead of diminishing, and that it will cross the two-minute line about the year 1901.

It is very evident that this state of things cannot go on indefinitely: otherwise we should in course of time have a horse trot a mile in no time at all. So that our curve must sooner or later become a straight line, and ultimately concave upwards. Drawing a straight line which shall agree as nearly as possible with our observations, we shall find from it, that the speed of the trotting-horse is increasing at a nearly uniform rate of $4\frac{1}{3}$ seconds in ten years; so that, on this supposition, it would cross the two-minute line in 1907, and the one-minute line in 2045. It is highly probable that the curve will have become concave before the latter period; but it does not seem too rash to predict that a horse will be born before 1907 that can trot a mile in two minutes.

II. — Total number of horses capable of trotting in 2.30 or better.

Date.	No.	Date.	No.	Date.	No.
1843	1	1859	32	1871	233
1844	2	1860	40	1872	323
–	–	1861	48	1873	376
1849	7	1862	54	1874	506
–	–	1863	59	1875	–
1852	10	1864	66	1876	794
1853	14	1865	84	1877	836
1854	16	1866	101	1878	1,025
1855	19	1867	124	1879	1,142
1856	24	1868	146	1880	1,210
1857	26	1869	171	1881	1,532
1858	30	1870	194	1882	1,684

Table II. shows the enormous rate of increase of this new breed of animals, amounting to about twenty per cent a year. Treating the observations by the logarithmic method, we find, that, since 1864, the increase may, with a reasonable degree of accuracy, be represented by the formula $y = .0016\,x^4$, where y represents the number of horses, and x the number of years since 1850. Thus, for 1882, we have $y = .0016 \times 32^4 = 1678$. Applying this formula, we find, that, if the present rate of breeding is continued, the trotting-horses of America in 1900, that can travel a mile in 2.30 or better, will number not far from 10,000.

Wm. H. Pickering.

THE ORIGIN OF CROSS-VALLEYS.[1]

II.

Returning now to Virginia and Pennsylvania, we have to consider not only why the rivers there cross the mountains, but also why they flow to the south-east instead of to the north-west. Taking the last question first, we are forced to suppose that the north-westerly slope, which must have existed at least up to the end of the carboniferous, was then or soon after reversed in the slow writhing of the surface. This is demanded by the lay of the land, and by the now small area of what must have been, in paleozoic time, a large crystalline land-mass. The slope being changed early in the growth of the folds, or before their beginning, the streams tried to make their way to the eastward; and the Hudson, Delaware, Susquehanna, Potomac, and James are the descendants of those that succeeded. Their rectangular courses, alternately longitudinal and transverse, bear witness to their defeats and victories. Lakes must have been numerous here once, though they are now all drained. It is known that rivers often chose cross-faults of small throw as points of attack in cutting their way through the growing ridges; and it is very probable that they made use of pre-existent valleys when they advanced over the old sinking land.

In considering the applicability of backward-cutting lateral streams to the production of our cross-valleys, we should test the past by the present, and examine such ridges as Kittatinny or Bald Eagle mountains in Pennsylvania, or Clinch mountain in Tennessee, rising between parallel longitudinal valleys, to see if they show embryonic cross-valleys in the more advanced stages of development. They do not. The continuity of their crest-line is most characteristic and remarkable: it very rarely departs from its line of almost uniform height. The exceptions are, first, the finished water-gaps, or transverse valleys, whose origin is in discussion; second, the occasional wind-gaps, or notches, which sometimes cut the ridge a third or half way to its base, and which are, we believe, always determined by small transverse faults; third, the less conspicuous serrations of small value. It is difficult to assign any reason why lateral streams should not now, as well as in former times, show us the later stages of breaking down the ridge on which they rise; and yet these almost-formed cross-valleys between adjoining longitudinal valleys are practically unknown in our Appalachian topography. The reason of their absence can hardly be, that there are now enough completed water-gaps for all practical purposes, and hence the lateral streams stop making any more; for this would imply a consciousness of the end that plays no part in geological operations, and we are therefore constrained to think that Löwl's explanation cannot apply to the Appalachians in any general way.

But it has a certain limited application in

[1] Concluded from No. 12.