scales. I hope that the error of observation may not exceed four seconds of time, corresponding to about 0″·13 of arc. I shall be very glad to see, in a detailed form, a plan for making the proper measures by heliometric or photographic apparatus; and should take great interest in combining these with the eye-observations, if my selected stations can be made available. But my present impression is one of doubt on the certainty of equality of parts in the scale employed. An error depending on this cause could not be diminished by any repetition of observations. As, in the event of any national enterprise being promoted in the direction of photographic record, it is probable that the Astronomer Royal may ministerially take an important part, I venture to submit to the Board of Visitors that suggestions on the value and plan of such observations fall entirely within their competence."

All the American observers of the Solar Eclipse, as well as M. Janssen, have visited the Observatory during the past year.

The current reductions of observations, it is remarked, are in a healthy state. Regular reductions give, "in general, great facility for the most advanced inferences; the star-catalogues, and solar, lunar, and planetary errors, lend themselves immediately to investigations of a physical character; the magnetic reductions distinctly, though tacitly, exhibit some of those results (for instance, annual inequalities) which in various observatories have been the subject of special memoirs.

"But from time to time it becomes desirable to unite some of those annual or nearly annual results in groups, so as to exhibit the results justly derivable from masses of observations extending over long periods of years. These operations require new organisations; and, what is worse, they require additional grants of money. I have usually refrained from asking for these, without the distinct approval of the Visitors. I would now submit for their judgment the following subjects:—

"The vigorous prosecution of the Meteorological Reductions (exhibiting the results deducible from the photographic registers) already begun.

"The combination of the results of Magnetic Observations on disturbed days, from the year 1864.

"The discussion of Magnetic Storms, from the year 1858.

"Perhaps, also, the discussion of observations in groups depending on Lunar Declination, or other phases."

The report concludes as follows:—"There is another consideration which very often presents itself to my mind: the waste of labour in the repetition of observations at different observatories. The actual Greenwich system was established when there was little to compete with. Other observatories have since arisen, equipped with and principally using the same classes of instruments, and devoting themselves in great measure to the same subjects of observation (except the unrelenting pursuit of the moon, and perhaps the fundamental elements of the ecliptic). Ought this Observatory to retire from the competition? I think not; believing that there is greater security here than anywhere else for the unbroken continuity of system which gives the principal value to series of observations. Still, I remark that much labour is wasted, and that, on one side or another, that consideration ought not to be put out of sight in planning the courses of different observatories."

This is a very broad hint for some English as well as Foreign Observatories, and it will be well for the cause of Science if the directors of those observatories will take it.

THE SCIENTIFIC VALUE OF CHEESE-FACTORIES

THE American system of cheese-factories was established nearly twenty years ago, and in its present condition of maturity it retains all the essential features which were characteristic of its infancy.* The test of twenty years' experience in a country where apparent improvements are eagerly submitted to a fair trial is amply sufficient to prove the success of the system. Recently the question of its adaptability to English dairy districts has acquired considerable prominence in agricultural circles, and is now passing from the stage of discussion to that of experiment. The two great merits which are claimed for it are, economy in the labour of production, and superiority of quality in the produce. It is evident that if a dozen farmers convey their milk to one building (a factory) to be made into cheese or butter, fewer hands are required to perform the work than if the process were carried on at a dozen different places by as many sets of people. The factory can be furnished with better labour-saving machinery than the farm-dairy, and the former establishment requires no more supervision than the latter. The process of cheese-making, also, occupies practically the same length of time, whether the quantity of milk under treatment be large or small, so that two or three persons whose energies are concentrated at one place will produce as great an economic result as a dozen or more who are necessarily employed at as many different points, each one going through the same routine independently of the other.

The superiority in the quality of the manufactured article may be more difficult of explanation, for the best farm-dairies produce as good cheese as any factory. The reason why the establishment of factories has improved the *average* make of cheese is because fewer first-rate cheese-makers are required under the factory system. But when Mr. Jesse Williams established the first factory twenty years ago, the great bulk of American cheese was extremely poor, and for many years after it was almost unsaleable in the English market. At the present day, on the contrary, it can compete on even terms with all but the very choicest English makes, notwithstanding that it has to undergo the ordeal of a long sea-voyage. The factory-system, therefore, has not only improved the *average* quality of American cheese, but it has very considerably raised the standard of the choicest brands.

Students of nature are perfectly well aware that the most sure and rapid progress is made by means of association and co-operation. The same phenomena are observed from different points of view by workers in the same field; a comparison of their notes leads to the grouping of kindred facts; the apparent exceptions are seen to be the product of attendant variations in the methods or circumstances of observation; and by a process of induction an explanatory theory is arrived at, to be confirmed or rejected by future investigations. In this manner the cheese-factory system has gone far towards the establishment in America of a science of cheese-making. Each factory has been the theatre of exact observations, which have been duly recorded. The results of comparisons of these records have been embodied in papers read before the American Dairymen's Association; and the conclusions of the authors have been frequently put to the crucial test of experiment.

The American Dairymen's Association is only a child of the Factory-system. It is organised on a plan similar to that of the British Association for the Advancement of Science, and like that institution, holds an Annual "Convention," at which papers are read and lectures are delivered. These contributions to the literature of dairying, and the discussions thereon, are published in an annual "Report," which also contains detailed reports from numerous cheese and butter factories, giving the dates of commencing and finishing work, the number of cows supplying the factory, the quantity of milk received, the quantity of cheese made, the percentage of cheese to milk at different periods of the year, and as compared with

* For detailed descriptions of this system, *vide* Journal Royal Agricultural Society, 2nd Series, vol. vi. p. 173, and vol. vii. p. 1.

previous years, as well as other data, including peculiarities in modes of manufacture, which may be useful for comparison with the methods pursued and the results obtained at other factories. There can be no doubt that these efforts must sooner or later result in the formation of a dairy science, and in the establishment of sound theories of dairy management.

But the functions of the American Dairymen's Association are not confined to observation and experiment at home. Already the inquiries of its officers have enabled its members to improve their cheese-making practice by adopting some features of our Cheddar system; and in the last volume of the Report of the Association is an able paper by Prof. Caldwell,* showing some features common to the numerous cheese-making processes followed in Holland, Switzerland, France, and Italy. One of the most interesting points brought out is the intimate connection that exists between the ripening of cheese and the development and growth of *Micrococcus* and other forms of mould. As a matter of commerce it is important to the farmer to ripen his cheese as soon as possible. This is done in various ways, all having for their object the introduction of large numbers of germs of the appropriate fungus. The ripening of Stracchino cheese is thus induced by the introduction of layers of old curd; that of Roquefort by an admixture of mouldy bread, containing germs of *Penicillium*, and that of Brie by packing the thin cheeses between layers of musty hay. Another observation of interest is, that the presence of free ammonia in the curing-room hastens the ripening of the cheese, a fact which may have some bearing on the well-known property of American cheese (which is always packed in boxes) to ripen more rapidly than English makes.

These evidences of a process of scientific investigation induce us, therefore, to regard the factories, or associated dairies, as they are termed, as possessing a scientific value, both as educational establishments and as laboratories. But, it may be asked, why is this not true also of the farm-dairy? Our answer is, that while the manager of a factory makes cheese-making his sole business, his success in which depends entirely on his skill and knowledge, the English dairy-farmer has little or nothing to do with cheese-making, but occupies himself with the management of his farm. With the production of the milk his supervision ceases, and the manufacturing process is either carried on by his wife, who has household cares to occupy her time and thoughts, or by a dairymaid, who has no interest in the matter, and who knows that her services are at a premium.

Thus, with the exception of the additions to our knowledge of the *rationale* of cheese-making, for which we are chiefly indebted to Dr. Voelcker's chemical researches,† the manufacture of dairy products in England can hardly be said to have advanced during the last half century, while it has made enormous strides in America during the last ten years. Let us hope that the establishment of cheese-factories in England, commenced last year at the risk of some liberal-minded Derbyshire landlords,‡ may also be the dawn of an English era of progress in this most important agricultural industry.

HYDRAULIC BUFFER FOR CHECKING THE RECOIL OF HEAVY GUNS

THE ingenious instrument, the name of which stands at the head of this paper, deserves some notice, not only on account of its utility for its purpose, but as an interesting method of meeting and overcoming those violent efforts of nature to which she is provoked by explosion. In the recoil of a heavy gun, we have an example of the greatest force which man attempts to control. The inventions of Captain Moncrieff, which no long ago formed the subject of an article, seek to utilise this force; other gun carriages lead it to expend itself as harmlessly as possible.

The Hydraulic Buffer accomplishes this latter object in a manner very ingenious, and affording some interesting illustrations of Nature's laws; it also possesses several advantages over other methods which have been and are still used. For it the public service is indebted to Colonel Clerk, R.A., F.R.S., Superintendent of the Royal Carriage Department in Woolwich Arsenal. Before the introduction of the Hydraulic Buffer into the English service, and in those cases where it is not yet applied, the method employed to overcome the recoil was the friction of iron plates. To the bottom of the gun-carriage several plates are fixed, which pass between long plates placed along the middle of the slide or platform on which the carriage runs; and the friction of their surfaces in contact overcomes the force of the recoil, and brings the gun and carriage to a standstill. The amount of the friction can be regulated by the compression given to these plates, and requires to be altered for the various charges used. The compression must be taken off to allow the gun to be run forward to the firing position, and must be again set up to meet the recoil.

The Hydraulic Buffer, on the other hand, is always ready for use, and never needs any adjustment. This is one of its advantages, and one which is of special importance in the heat and excitement of action. It consists of a cylinder (A B in figure) placed in the platform, and lying along its length. In the cylinder is a piston pierced with four holes, and the extremity of the piston-rod is attached to the carriage. When the gun and carriage are run out for firing, the piston is moved to the lower end of the cylinder (A), which is filled with water, except a small air-space exceeding slightly the cubic content of the piston-rod, so as to allow for the displacement of the water when the piston is driven to the other end of the cylinder. When the gun is fired, and with its carriage begins to recoil, the piston is driven back into the cylinder. The first effect of this is to compress the air in the cylinder very violently, then the water begins to run through the four holes in the piston, this motion soon attains a very great velocity, and in imparting this to the water, the force of the recoil is soon exhausted. It is spent in transferring the water with very great rapidity through these orifices from one side of the piston to the other.

This rapidity depends on the ratio of the area of the piston to the area of the four holes in it. A very small diminution in the area of these orifices would cause the recoil to be checked very much sooner; a correspondingly slight increase would allow the piston to strike with violence against the end of the cylinder. It was found in an experiment with a 20-pounder gun, that when the holes were 0·562 of an inch in diameter, the recoil extended the whole length of the cylinder, 2ft. 9in., and struck violently the end of it; when a piston was used with holes 0·437 in. in diameter, the recoil was only 1ft. 11in., and ended quietly, the same charge being used. In another experiment with a 12-pounder gun in a boat carriage the holes in the piston were five-eighths of an inch in diameter, the recoil was 2ft. 2in.; when the diameter of the holes was increased by one-sixteenth of an inch the recoil was 3ft. 2in.* The proper ratio of the area of the holes to the area of the piston is evidently that which will allow the recoil to expend its force in nearly, but not quite, the whole length of the cylinder. When once this ratio is fixed, it is very remarkable that the amount of the charge, or the slope at which the platform is placed, whether up or down or

* Sixth Annual Report, Syracuse, N.Y., 1871, p. 25.
† Vide Journ. Royal Agric. Soc., vol. xxii. p. 29, and vol. xxiii. p. 170.
‡ Ibid, 2nd series, vol. xii. p. 42.

* The reason of this is evident from a little consideration: first, every addition to the area of the holes diminishes the area of the piston, which acts on the water; secondly the difference of the work done by the recoil is proportional to the difference of the *squares of the velocities* given to the water in passing through the orifices in the two cases.