center of the bridge above the water will be 130 feet, and the roadway 80 feet wide. The view from the latter will be one of the finest in the world, both in beauty and extent.

It is believed that this thoroughfare will, when completed, command an independent travel equally great with the existing ferries, which will retain their own business; and that even these two immense means of communication will ere long be insufficient to accommodate the rapidly increasing demands of the multitudes yet to line the shores, so that the building of submarine tunnels will eventually become a necessity.

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Contents:

(Illustrated articles are marked with an asterisk.)

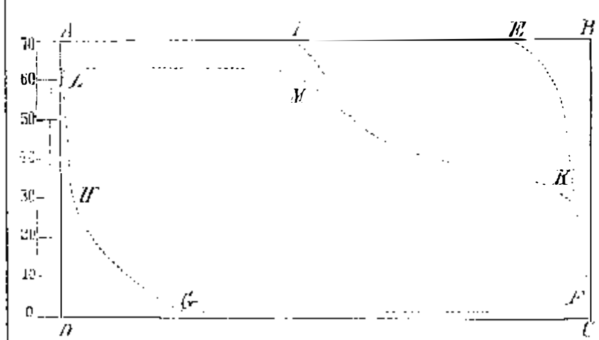
INDICATING STEAM ENGINES.

Questions from our correspondents, in relation to the power of steam engines, recur so often that we think it may be timely to devote some space to their general consideration. We are frequently asked what is the power of an engine of a given size, making a certain number of revolutions per minute, with a specified steam pressure. Most of our readers know that the horse power of an engine is equal to the mean effective pressure on the piston, in pounds, multiplied by the piston speed in feet per minute, and divided by 33,000. Hence those who send us queries of the nature mentioned above doubtless think that it will be an easy matter for us to determine the horse power. As a matter of fact, we suppose that very few of the answers we have rendered to these questions have been anything but rough approximation to the true solutions. We have been careful to hint as much, in working out each example; but perhaps it may be well to give a more definite explanation.

Referring to the rule for finding the horse power of an engine, it will be seen that the mean effective pressure on the piston is required. This, we believe, has never been sent to us. True, our correspondents give the pressure in boiler per steam gage, and sometimes mention the point at which the steam is cut off in the cylinder. They have never sent, however, to the best of our recollection, the amount of back pressure resisting the movement of the piston, the initial pressure of steam in the cylinder, the amount of steam and exhaust lead, and the point at which the exhaust cushion commences. We will endeavor to show how all these things affect the solution of the problem.

The following, taken from a back number of our paper, is a fair specimen of questions of this character: "What horse power has an engine of the following dimensions: Cylinder 9x16 inches, working at 63 revolutions per minute, with a pressure of 70 pounds to the square inch?"

Accepting our correspondent's statement as the correct one, we can readily represent the action of steam in the cylinder during the stroke by a rectangle, A B C D. Thus, while the piston is being acted upon by the steam, A B, 70 pounds above D C, on any convenient scale, will represent the steam or pressure line, the point, A, corresponding, to the commencement of the piston's stroke, and the point, B, to the end. When the piston has reached the end of the stroke, the exhaust valve opens, and the line, B C, represents the fall of the pressure from 70 pounds, per gage, to nothing. The piston then returns, and C D represents the pressure during exhaust. When the piston has returned to the starting point, the steam valve is opened, and the line, D A, shows that the pressure rises to 70 pounds again, for the next stroke. This, we say, is the graphical representation of the action of the steam, according to the data given by our correspondent. Our readers do not need to be told, however, that it is not usual to work engines in this manner, as it produces violent strains, and is far from being economical. The piston moves to and fro, and requires, of course, to be brought to rest before the direction can be changed. If it worked as represented in our diagram, the shocks that would occur each time the motion was reversed would be very severe. It is probable, then, that the exhaust valve commences to open, as at E, before the end of the stroke is reached. There will probably be some back pressure also, so that the exhaust line will be represented by F G, instead of C D. It is quite likely that the exhaust valve closes before the end of the return stroke, so that a cushion line, G H, is produced, and that the steam valve is set with lead, so



that it opens at H. It would appear, then, that perhaps a figure, A E F G H, may represent the action of the steam, instead of A B C D, and it will be seen that, if such is the case, the mean effective pressure per square inch will be considerably less than 70 pounds.

In the majority of engines, the steam valve has some lap, so that it is closed before the end of the stroke, and the steam is allowed to expand, producing an expansion curve, I K, on our graphical representation, in which case, A I K F G H, giving a still smaller mean effective pressure, will represent the action of the steam.

In general, the initial pressure of steam in the cylinder is less than the boiler pressure, from which it would appear that L M K F G H more probably represents the state of affairs, in our correspondent's engine, than A B C D.

Those who have followed us thus far will doubtless accept our original statement, that the best answers we can give to questions like the one under consideration will only be rough approximations. But it is possible to arrive at the truth, in cases of this kind. If a gage were attached to the cylinder, it would mark the varying pressure at different points of the stroke. The steam engine indicator performs this office admirably, recording the pressure at each successive point, thus forming essentially such a diagram as we have already represented. This is the only accurate method by which the mean effective pressure of the steam can be ascertained. The indicator shows, in addition, many things of interest and importance which our space will not permit us to consider at present. The importance of knowing the true power developed by an engine must be apparent to all our readers, and we need not enlarge upon it. The test of an engine with the indicator frequently discloses derangements and imperfections that could not be otherwise discovered. The indicator, however, is an exceedingly delicate instrument, and must be carefully manipulated to secure accurate results; hence tests of this character should be made by those who are truly experts.

We can readily perceive, from the numerous inquiries on the subject, that many of our readers realize the importance of knowing the power developed by their engines, and perhaps our remarks will be useful in showing them the means by which they can have their questions correctly answered.

DR. HENRY DRAPER'S RECENT DISCOVERIES IN SPECTROSCOPIC ANALYSIS.

In a recent number of the *American Journal of Science and Art*, there is an important paper on "Diffraction Spectrum-Photography," by Dr. Henry Draper, which is being reprinted in England, France, Germany, and Italy. Until quite recently, spectroscopic investigation has been conducted almost entirely by the aid of prisms; but the prismatic spectrum is far less suitable for exact inquiry than the diffraction spectrum produced by a grating of fine lines ruled on glass; because in the former case, the red end of the spectrum is contracted and the violet dilated, while in the latter the rays are presented in the true order of their wave lengths. Moreover, no two prisms give spectra that are exactly alike in the amount of this contraction and dilatation; and hence various observer have great difficulty in comparing their results together.

As all diffraction spectra are exactly alike, and, to use a technical term, they have no "irrationality of dispersion," it seems singular that prismatic observation has not long since been abandoned. But gratings have hitherto been very difficult to obtain; and, besides the spectrum produced by a grating is much fainter than that by a prism. Our distinguished townsman Mr. Rutherford has, however, constructed a machine which makes better rulings on glass than any heretofore produced, and it is with one of these that Dr. Draper has worked.

The main object of the present research has been to furnish a photographic map of the violet and ultra violet rays of the spectrum, to serve as a permanent reference map and to complete the great work of Angström, whose "*Spectre Normal du Soleil*" is unquestionably the most laborious and exact contribution to spectrum analysis made in recent times. Angström has, up to the present, failed in his attempts to do the very thing that Dr. Draper has succeeded in accomplishing so thoroughly. In many respects, indeed, Dr. Draper's work at the violet end of the spectrum exceeds in exactness that of Angström int he visible regions, as is well seen in the part between the fixed lines G and H, where the map of one observer overlaps that of the other. Many line that Angström has omitted or misplaced are corrected by Draper; and in one place alone, 17 new lines are added.

By an ingenious device, the wave lengths of rays entirely invisible have been measured with an exactness exceeding that of those that are visible; and errors have actually been detected in some of the fundamental wave lengths of the standard test books.

The photograph which accompanies the paper is of beautiful definition and large size. If the whole solar spectrum were presented on the same scale, it would be about 10 feet long.

GAIL BORDEN.

Upon a shady knoll in the beautiful cemetery of Woodlawn near this city, in full view from the windows of the New Haven railway cars, stands a substantial family monument in granite, which at one time attracted the attention of the passing traveller by the peculiarity of the emblem by which it was surmounted. That emblem consisted of a milk can, cut of solid stone, representing in form and size the familiar utensil so commonly used here in our streets, for the transport and sale of milk. This was the chosen monument by which our friend Gail Borden, inventor and originator of the great industrial product now known as Condensed Milk, had desired to mark his last earthly resting place, when he should have been gathered to his fathers. The desire thus expressed was honorably characteristic of the individual. He was emphatically a man of the people; and although in process of time, by the success of his most excellent and useful inventions, he acquired great wealth, he ever regarded himself as one of the humblest of workers in the family of man; and the possession of riches never led him to put on aristocratic airs. He despised that sort of pride which makes some people ashamed of the humble origin of their progenitors, and wished that, in this respect, the very stones above his grave should teach a useful lesson. Surely they commemorate the truth that honest industry is better than titled birth.

Gail Borden was born in Norwich, N. Y., in 1801, his parents being New England people. In 1829 he removed to Texas, where he was always esteemed for his probity of character and earnest efforts for the public good. He was at one time a United States Surveyor, afterwards a newspaper conductor, then the Collector of the port of Galveston, when Texas was known as the Lone Star Republic. In 1853 he succeeded in producing Condensed Milk, as a permanent article of manufacture, which he accomplished by concentrating in vacuo. We well remember his early efforts in this direction, which were most persevering and arduous. The Patent Office for a long time refused to issue his patents, but finally yielded, and the new manufacture then received its first impulse. Mr. Borden's patents were obtained through this office. For over twenty years we enjoyed the uninterrupted friendship of this truly excellent man. Genial, kind-hearted, benevolent, his life was a most useful one and his memory blessed. He died on the 11th of January, 1874, aged 73 years, at Bordenville, Texas, where he had established a large factory for the production of concentrated foods, chiefly meats. He leaves a large and interesting family. His remains are to be brought to Woodlawn. The trustees of the cemetery have removed the granite milk can from his monument, as an infringement upon the rules of fastidious taste. But no one can blot out the record of his noble life, nor the splendid results of his long and useful labors.

Gail Borden was the inventor and first introducer, in merchantable form, of Condensed Milk. He may be said to have supplied the world with a new article of food. Medical authorities give it the highest place in the nourishment of the sick and the young. He lived to see the use of this most valuable product extended over the globe. Nearly all civilized nations, following his patterns and instructions, now have their factories for the supply of the article, which, as the years roll on, will be still more highly valued, while the work of its production will employ the industry of thousands of people. Gail Borden may be truly styled a benefactor of his race.

STEAM ON CANALS.

We have before us a report of the trial trips of the steam canal boat, William Newman, through the Erie canal, in the seasons of 1872 and 1873. We have also the report of Engineer Greene on the trials of 1872. His report on the trials of last season has not yet been received. The figures in these reports only confirm what has frequently before been shown by experiment: that it is not sufficient to put a good engine into a boat to ensure success; the boat must also be modeled to suit the engine. The ordinary canal boat, built in the form of a box in order to obtain great carrying capacity, cannot be propelled directly by steam power as cheaply as it can be towed. Thus it appears, from Mr. Greene's report that the engine of the William Newman, in the trip made in 1872, developed an average indicated horse power varying between 30 and 35, to produce an average speed of 2·727 miles per hour. This same speed could probably have been effected by towing with from 3 to 4 horses, and it is easy to see that the steam power is much the most expensive. The power developed in the trial trip in 1873 is not stated; but from the data given, it probably exceeded 50 horse power, to produce a speed of 3·691 miles per hour. It is because such slow speeds are required on the canals that the inefficiency of this mode of propulsion is not at once apparent. If an ocean steamer only utilized about 12 per cent of the power developed by the engines, probably the vessel would not be large enough to contain the machinery that would be required to produce a speed of 14 knots an hour. It appears to