

with water enough in it to protect any considerable part of it and yet let the flues become hot, must be subjected to a strain sufficient to open any weak places in it without the aid of internal pressure.

I am now running a boiler, similar to the one above referred to. The feed water enters through an ordinary stand pipe, near the back end. The engineer let the water get low and then crowded on the pump. The result was that one of the flues cracked for about 4 inches across its bottom just where the feed water strikes it. A boiler maker repaired it by putting on a soft patch, that is, a plate screwed on with red lead under it and it does very well. But on one occasion since, the water was low again, and it leaked as at first, but the pump was kept going, and when the flues were covered it stopped. These cases, and others of the same nature which I have known to occur, lead me to believe that a large per cent of explosions are due to expansion.

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P. BERGER.

Discriminating Flax and Cotton Fibers.

To the Editor of the Scientific American:

On page 194 of your current volume, Mr. C. R. Stodder says: "No chemical tests are known to distinguish flax from cotton fiber." Allow me to refer Mr. Stodder to the SCIENTIFIC AMERICAN, Vol. XIII, No. 3. "These two fibers are distinguished by rosanilin, or fuchsin. Loosen one end of a piece of linen so as to separate the wool and warp, and dip it into an alcoholic solution of fuchsin; wash in water as long as it colors the water, and then put it in weak ammonia. The ammonia will discharge the fuchsin from the cotton fiber but not from the flax, so that the cotton thread will become nearly white, while the flax retains its red color." This is Böttger's test.

H. M. WILDER.

AMERICAN LOCOMOTIVES.—THE BALDWIN WORKS.

Let a man stand beside a railway when an express train thunders past at forty miles an hour, with its ten or twelve heavy coaches and sleeping cars; and, if he does not feel mingled sentiments of awe and admiration, he must be very unimpressible. Grade or level, straight line or curve, all are alike; it whirls over one and round the other, never ceasing in its energy for a moment.

The modern locomotive is truly the most wonderful of all man's inventions; and though many may gainsay this, and point to another triumph of ingenuity as its peer, we think, when all its complex parts and the functions they are called on to discharge under trying circumstances are considered, the locomotive engine will stand out as one of the greatest of man's works. It is not alone required that it shall be powerful and capable of drawing great loads, but it must be enduring; it must adapt itself to the work required of it; it must be rigid and yet capable of a certain flexibility in its parts. It must ride on its springs and yet hold firmly on the track; its driving machinery must be permanently attached to its boiler and yet in a certain sense entirely independent of it; and the whole of the vast machine, although exercising the most varied and opposite powers, must be so designed as to work harmoniously together. One end of it—the furnace—generates the most intense heat while the other end is comparatively cool. One half, so to speak, the boiler, is undergoing tremendous internal and external pressure from the force of expansion and the steam within it, while the other portions have no strain whatever, except when in actual operation. When it is in operation, suddenly the driving machinery is called upon to not only carry and withstand the burthen of the boiler and its duties, but to transmit force in an entirely different direction; to do it economically and constantly, in all temperatures and all atmospheric changes; through dust and drought, and at a velocity of twenty or forty miles an hour as the case may be. It has not only to withstand its own internal forces, which tend to derange it, but also encounter others which it would seem impossible to provide against. Think of a mass of intricate machinery, thirty tons in weight, in motion all over, hurled at the rate of forty miles an hour over the face of the country, and then consider whether our claim is extravagant.

If such a specification as the foregoing were handed to an inventor at the present day, and he were requested to provide a machine to comply with the conditions, he might be pardoned for some incredulity as to the sanity of the man who drew it. It is a thing of slow growth, the modern locomotive.

From the rude germ of the first high pressure boiler and engine mounted on wheels has sprung, piece by piece and detail by detail, the present magnificent and wonderful machine, a piece of mechanism, capable of drawing—in the case of the heaviest machines fifty ton engines—forty times its own weight. Without apostrophizing the locomotive further, let us look into a modern locomotive shop—the largest of its kind in the country—and see what is being done there, and follow hastily the details necessary to produce such machines.

The Baldwin Locomotive Works of Philadelphia has a world-wide reputation for its engines; and, being recently in that city, we were accorded permission to visit them. The concern has been in existence nearly forty years, and in that time has built engines for nearly all quarters of the civilized globe. At the present time the average rate of production is nine complete engines per week. Of these, some are for home use and some for foreign countries, but the essential character of them remains the same. All are built according to well known plans and specifications, such as have been proven and found reliable. Respecting those for foreign countries, the works are now just finishing a number for Rus-

sia, which are of the usual American type of wood burning engines. Some months ago the company sent a number of engines to Russia to show engineers in that country how to use their anthracite coal, of which large veins exist in the southern part. Until the advent of these machines, the Russian capitalists had become quite skeptical as to the possibility of utilizing the coal, for their own mechanics had essayed the solution of the problem in every conceivable type of boiler and grate, only to abandon them all. The intense heat generated burned out all their appliances, and it remained for American engineers to put the American locomotive in successful operation. The result is that large orders may be in time expected from the country, and it is to be hoped that the Baldwin Works, who, if we are not in error, were the pioneers in this enterprise, will reap some profit, the first venture being quite unprofitable. The Russian mechanics were so dilatory and slow to comprehend that a force had to be sent out from the Baldwin Works to erect the machines and put them in operation.

Of course, in making such a number of engines as these works turn out—over 450 annually—the greatest exactness and rigid attention to system must be observed, else all would be confusion. Therefore, as the first step toward getting machines under way, systems of "cards" or specifications are provided for the guidance of the foremen in charge of the several departments. For example, the superintendents, or parties immediately in charge, decide that engines of such a type must be ready on the 20th day of May. Immediately upon this decision, the schedule for so many crossheads, so many feed pumps, so many guide bars, rocker arms, links and reverse levers is made out and handed to the foremen in charge of the shops where these parts are made, and the date is mentioned when they are to be delivered to the company—say for April 5th. The same plan is observed with all the other details, parts, and appurtenances; and it is found to work harmoniously and satisfactory. It has the great merit of reducing every foreman to his own place, or, more properly, of confining his attention to his own affairs. It will readily be seen that the foreman knows nothing as to whether the parts he makes are needed now or next year, but that all he has to do is to make them out of the material furnished. He cannot say, as some might: "Why, they don't want these now; the boiler ain't made yet," and then give his attention to what he thought most satisfactory; but he does the work he came to do, and leaves the direction of it to the persons who undertook that department. This is really the secret, if it is a secret, of the possibility of making nine or more engines per week. Without it the other vast capabilities of the works would go for nothing.

The usual routine of machine work is so well known and familiar that we shall not attempt to describe any "ponderous shears that bite cold iron as a cat does cheese." These and kindred machines have no especial novelty in them, but there are some points about the system employed in duplicating work which are worthy of attention. A routine similar to that observed in the manufacture of sewing machines and pistols is practiced wherever possible. For example: All engines of a certain type have their details exactly alike. For such machines a system of "jigs," or cast iron frames, are provided, which have holes in them wherever the part under execution at the time should have them. These jigs are, therefore, merely bolted on to the rough casting—the crosshead for example—and the drill operated through the hole in the jig. There is no marking off or "laying out," and no possibility of making any mistakes. Similarly in regard to the jaws of the crosshead. A gage or template is put over the end, clamped in its place, the whole put into the planer together, and the surfaces reduced until the tool comes down to the gage. In this way, or by this plan, the matter of executing each piece exactly alike is reduced to a certainty. Every bolt, taper or straight, has its gage, merely a hole drilled in a block of cast iron, the exact length of the part the bolt goes into. Men don't run up and down stairs in the Baldwin Locomotive Works, trying bolts in holes in the frames, so anxious to make a good fit of them that they fail after all; but they save their own shoe leather and the company's time, and fit the bolts to the gages on their lathes; if they are right by them, they fit the holes the rimmers make.

"So all things work together for good." All things that possibly can be, are tested before they leave the works. The pumps, on which so much depends and which have so much to perform, are all tried before they are attached to see if their joints are perfect. Nothing is left to chance. Everything is looked after and seen to, and nothing is left to supposition. As our informant, Dr. Williams, remarked: "We can't run on reputation one day; we try every day to do better work than the day before." And he is right. A locomotive is a machine which will not build itself or run itself, but if not carefully made will soon show it in all its parts.

We specially noticed the boilers in these works, and can testify to their excellent and thorough construction. Every one is caulked inside as well as out, and we noticed, as we passed through the works, one man caulking the rivet heads in the bottom of the firebox frame. The engines made by this company are all "outside connected," that is to say, the cylinders are outside of the frames. This practice is exclusively American in its universal application for all kinds of traffic, and seems well adapted to our wants. It is safe to say there are no inside connected engines built in the country today.

Also it is interesting to note how opinions vary with experience gained. In 1838 a locomotive with cylinders 12½ × 16, weighing, loaded, 26,000 lbs., was believed to be as heavy as would be needed! It causes a tendency to smile now, in the mind of a railway man, to note this and the weights of

even switching engines. The heaviest engines the Baldwin Locomotive Works build are sent to South America, or, rather, the railways of that country demand the heaviest, which have cylinders 20 inches diameter and 24 inches stroke. They have four pairs of drivers of 48 inches diameter, and a total wheel base of 21 feet 10 inches. The weight on drivers is 87,000 lbs. and about 9,000 lbs. on the pony truck, the total weight being 96,000 lbs. An engine of this class will draw 2,000 tons, gross, on a level, beside itself and tender, and they have in actual use taken 150 gross tons of cars and load up a grade of 145 feet to the mile, with sharp curves, at a speed of ten miles an hour and with a steam pressure of 110 lbs.; also 268 gross tons and load up a grade of 116 feet to the mile with 120 lbs. steam and at a speed of one mile in 7½ minutes. Engines of this class can run around curves of 400 feet radius, and even less.

The force employed in these works now amounts to 2,800 men of all trades. The pay roll will average \$14 per head.

It is also interesting to note that, where American engines are brought in competition with foreign ones, they are at once able to prove their superiority, not only in point of workmanship, but in design and practical working. Many instances might be cited of the truth of this assertion, but we content ourselves with only one, the Dom Pedro Railway of South America, where both English and American machines were employed, but the latter proved so superior that none others have been bought since 1863.

The thinker may well ask: "What becomes of all the locomotives?" There is one factory in Philadelphia which makes 450 annually. There are three more factories in Paterson, N. J., which do not turn out less than 500 more. At Taunton, Mass., there are two which may make 200 more. One in Boston produces, or could produce, 200 more, and one in Manchester, N. H., 200 more; in Providence, R. I., 200 more; in Schenectady, N. Y., 200 more: to say nothing of smaller concerns scattered all over the country, and the repairshops of the railways, which also make no small proportion of their own work—an average of at least 1,500 locomotives turned out yearly from the shops alone.

Preparation of Sewage and Stable Refuse.

Millions of dollars worth of valuable material yearly finds its way, from the sewers of our great cities, into the sea, serving no purpose except to contaminate adjacent waters, while sums, equally large, are expended by agriculturists for the regeneration of worn out soil by artificial fertilization. The collection of sewage presents no special points of difficulty, but its transportation to desired points is by no means readily accomplished. For this purpose an effective plan is greatly needed. One system, which we believe has recently been made the subject of a patent, consists in compressing the manure into cakes with dry peat, and covering the mass with soft clay or equivalent substance to prevent fermentation and evaporation. The idea seems to be a feasible one, though we have no record of its being successfully put in practice.

Other patents have been granted for the preparing and baling of stable manure. This substance, in order to prevent its otherwise too large accumulation, it is necessary to remove from city stables before the straw contained in it is in a sufficiently decayed state for fertilizing purposes. Consequently, the straw must be got rid of, and as it can be utilized for bedding for horses, or for the manufacture of coarse varieties of paper, it is suggested to winnow it out of the mass by means of a suitable machine. Then the residuum is compressed so as to exclude the air, to which the heat and steam of manure is due; and finally the whole is covered with a coating of clay, plaster, or cement. Handles of wisps of straw for convenience in carrying and packing may be compressed with and so attached to the bale. The cakes can thus be readily stored in vessels with sufficient air space between them to obviate all danger of heating, while the use of forks and shovels is necessarily avoided.

Edible Earths.

Dr. C. Schmidt has made analyses of the comestible earths of Lapland and Persia. One hundred parts of the substance obtained on the coasts of the White Sea have been found to contain

Water, left at 100°	0.269
Water, left at red heat	0.835
Aluminum	40.797
Oxide of iron	0.310
Magnesium	0.618
Lime	traces.
Soda	1.829
Potassium	9.845
Silicic acid, traces of fluorine, loss, etc.	45.506

The inhabitants of the country mix this earth with the flour from which they make their bread.

The edible earth found in Persia, and termed Gheli-Giveh, contains

Carbonate of magnesium	66.963
Carbonate of lime	23.634
Chloride of sodium	3.542
Sulphate of soda	0.298
Carbonate of soda	0.598
Hydrated magnesia	1.311
Oxide of iron	0.092
Aluminum	0.227
Silicic acid	0.765
Water combined at 120°	1.153
Water	1.422

ANTHRACEMINE.—This new base is one of the products of the action of nitric acid on anthracene. It appears as a very pale yellow pulverulent body, forming soluble and crystallizable salts with hydrochloric and sulphuric acids. Its composition is C₂₈H₁₁N.