duction of any superfluous keys or adjusting pieces which may either work loose or put it in the engineer's power to spoil his engine. These points and others which will appear as we proceed, have been kept carefully in mind in the design of this engine. First, in reference to the valve gear. It is well known by all familiar with the subject, that the use of a single slide valve to accomplish the admission, suppression and release of the steam to and from the cylinder is only possible when we are willing to sacrifice something of the peculiar characteristics which we should wish each of these elements of the distribution to have. In all engines therefore in which a correct distribution is sought the attempt to make a single valve accomplish so many different functions is abandoned, and in most cases, as in the Corliss, Sickles and other arrangements, four separate valves are set to admit and release the steam. This is the plan also which is adopted in the Allen engine, although as both exhaust valves are worked by a single stem, we might perhaps regard them as but a single valve in effect. A single eccentric moves all the valves, but the motion imparted to them is modified by interposing between each steam valve, eccentric rod and its valve stem, a bell crank rock shaft. The cut-off is varied by the govern or raising or lowering the ends of the rods which we have called the eccentric rods, in a curved slot or link formed in the eccentric strap itself, and in order that each steam valve may have exactly the motion required for its own functions, these rods, though starting from the same block, are made separate and of different lengths. This enables the following condition, which is the gist of the whole, to be obtained. Each bell-crank rock shaft is so placed that when the eccentric is at its full throw in the direction of opening its valve, the arm towards the eccentric is nearly on its center, or in line with the eccentric rod, while the arm connected to the valve stem is nearly vertical, or at right angles to the rod. By this means, it will be seen, a very slight motion of the eccentric produces a very rapid motion of the valve, while, when the eccentric is at the other extremity of its throw, the relative position of the arms of the bell crank being reversed, a very considerable movement of the eccentric produces but little motion in the valve. In other words it remains nearly at rest when closed until the time comes for it to admit the steam, when it rapidly opens a wide port and as rapidly closes it again. The exhaust valve receives a constant motion from the end of the link. The steam valves are placed in a separate chamber from the exhaust, the latter being situated beneath the former. There is a rather large amount of port space involved in this arrangement, but every care is taken to reduce it to a minimum. Equilibrium valves are used for the admission, constructed on a very simple and beautiful principle. The valve is a rectangular frame, like the four sides of a box without top or bottom. Over the back of this is a fixed plate which receives the pressure of the steam and under which the valve just freely slides. This plate is recessed on its under side, and its edges and those of the valve and seat are so situated that when the valve begins to uncover the port it also opens an equal space at each of its sides, top and bottom, thus giving in effect a port four times the length of the valve. The exhaust valve is also constructed so as to open twice its own length of port. The engine at work in the Exposition is running at 200 revolutions per minute, and the diagrams taken from it show a quick and free admission of the steam, giving an initial pressure but little below that in the steam chest (to which an indicator is also applied); a sharp cut-off, an early release, and complete escape of the steam before the returning piston, leaving but half a pound difference of pressure between the cylinder and condenser as measured by the same indicator, and lastly a small amount of compression just sufficient to ease the motion of the reciprocating parts.

The condenser is a part of the engine on which considerable thought has been bestowed. The condensing chamber and hot well, which are side by side, form the upper part of a square casting of which the lower portion is a water chamber forming the air pump. Into this works horizontally a pointed plunger keyed to a prolongation of the piston rod, which by its displacement draws in and forces out a certain quantity of water at each alternate stroke of the piston. The movement of the water produced by this means is as gentle as could be wished at this speed, since it only rises one inch at each stroke and escapes freely at the delivery valves in the bottom of the hot well. The foot valves of the condenser are on the same level as the delivery valves, and open downwards, so that the air entering the air-pump chamber from the condenser remains on the surface of the water and is the first to pass out at the delivery valves, the top of the chamber being slightly inclined to facilitate its escape. This is a very important point, and the proof of it is to be found in the fact that the vacuum obtained remains constantly at 27¼ inches to 27½ inches. To particularize all the points in which the mechanical construction of the engine has been adapted to high speed, would occupy too much of your space. But so carefully has this been done that many who at the first glance exclaimed that such a speed was necessarily too much for any engine, have after a more careful examination of it, confessed that the conclusion was irresistible that an engine could be designed as suitable for that as for a lower speed. In every part the designer has studied to have as few loose pieces as possible. Thus his piston is shrunk on to the rod and held firmly by that means alone. In the smaller sizes the packing consists merely of small grooves turned in the face of the piston, the action of which in preventing the flow of gases is well understood. In the larger engines Ramsbottom's rings are employed, which render all springs or other means of adjustment unnecessary. The crank-pin brass in the connecting rod is held in the solid end of the latter, in which is a wedge of a large bevel, and held by a single good bolt at the top of the rod, and another at the bottom, by means of which it can be set and firmly held at any position, the two bolts locking each other through the intervention of the wedge acting as a deep nut. Great care has also been used in the design of the crosshead to secure lightness, strength, and ample and hard surfaces. The pin is surrounded by a bush of hardened steel, with a square formed on its ends by means of which it is let into the body of the crosshead and prevented from turning. The thorough lubrication of all the parts is another vital point, and has been amply provided for, constant lubrication being in all cases adopted; in the cylinder and valve chest by Ramsbottom's "displacement lubricator" and in other parts by suitable oil cups and wicks. The economy of oil by such means in proportion to the useful effect produced, is sufficiently evident to secure more general attention to its use. I have given this full description of this engine because it unites in itself more features of correct engineering than any other in the Exposition, and moreover being entirely American in design, though English in construction, it is something in which we may take some pride, the more so as the contents of the space allotted to us are not quite such as we should like to have had here to represent the skill of our inventors and machinists. SLADE.

## Correspondence.

*The Editors are not responsible for the opinions expressed by their correspondents.*

### Velocity of Steam.

MESSRS EDITORS—In the SCIENTIFIC AMERICAN of June 8, 1867, on page 359 is the following paragraph:—"Velocity of Steam and other Gases.—Mr. R. D. Napier has demonstrated to his own satisfaction and that of others, first theoretically and afterwards by experiment, that the velocity at which steam will flow from a boiler through an orifice into a vacuum is rather less than half of that given in all published tables, and that it is no greater into a perfect or partial vacuum (at a pressure of two or more atmospheres) than into the air.—the general law is established, that a gas of any given pressure will rush into a gas of not more than half that at the same rate as into a vacuum."

There is an error in this paragraph, either on the part of Mr. Napier or his reporter. It is true that steam flows into a vacuum at only half "the rate" (or half the quantity in a given time) that is given in the published tables; not however because its velocity is less than the old theory assigns to it but because its density is reduced one half in passing the orifice. With this modification the views of Mr Napier as given in the paragraph are correct.

It would be a mistake however, to suppose that Mr. Napier was the first to advance these views. The same views were fully set forth and demonstrated theoretically in an article published in 1848 in the *American Journal of Science and Arts*, second series, Vol. 5, page 78; and the general law of the flow of elastic fluids which is there established theoretically, was afterwards shown to be in almost exact accordance with the results of experiment in another article published in the same work in 1851, Vol. 12, page 186. W.

### FACTS ABOUT EXPLOSIONS OF STEAM BOILERS.

If the causes of boiler explosions are ever ascertained so that they may be prevented or at least their destructive effects reduced, the facts and circumstances attending their occurrences must be recorded. For this reason we make room for two communications, the facts contained in which are somewhat commented upon.

MESSRS. EDITORS:—I have perused with much interest your articles on steam boilers, and their explosions, to see if I would find a case of explosion similar to one I once witnessed. The boiler explosion I refer to was in a saw mill belonging to my father in the interior of this state and occurred several years since—in 1857 I believe. There were two 30 in. cylinder boilers, 30 ft. long, enclosed in the usual manner by brick walls. The mill had been running until about 11 o'clock when the engine had been stopped for about ten minutes to sharpen the saw. Steam was blowing off at 60 lbs., making considerable noise, as the safety valve was not inclosed by an escape pipe, when the person in charge of the mill ordered the fireman to hang an old stirup lying by on the beam. It had not been there more than three minutes when the explosion took place. Both boilers exploded simultaneously, with a report like artillery; it was but a single instantaneous report. One boiler parted about 8 ft. from the front end in the middle of a sound sheet, or an apparently sound one, both ends flying apart, that is neither end flying sideways. The other boiler was torn like wet paper, completely to pieces, or at least in 19 separate pieces, some of them torn across the joint or lap of the sheets, some flattened out nearly straight, others doubled up, but neither head of either boiler, which were of cast iron, was broken or separated from the sheet to which it was fastened. The large or longest end of the first boiler described was blown through the brick chimney, 7 ft. square at the base, from thence taking out all the side posts on one side of a blacksmith shop about 20 yards off, then striking ground a little more elevated ploughing a furrow, its depth of diameter, about 130 yards and there stopping.

I cannot understand how steam, if steam it was, can tear a boiler almost to atoms. I have seen several explosions but none in which such fearful power was shown. The boilers contained sufficient water which was rather strongly impregnated with lime. The boilers were placed at right angles with the mill and about at the centre of the building, outside in a separate boiler house; so placed to guard against danger and destruction in case of explosion, it being supposed that the boilers would almost certainly fly sideways out of their bed. Is that supposition right, generally?

I am using now in a horizontal tubular boiler, water very strongly impregnated with sulphur; will that sulphur injure the iron or how will it affect it? My boiler primes badly; will carrying my steam pipe from the dome on the side from the engine, down the side of the boiler, and under the grate bars, thence upward as high as the dome and to the engine, infringe on anyone's patent for superheating steam, and will it not accomplish the object? W. B. VAN VALKENBURG.

St. Mary's, Ga.

This is undoubtedly a case of genuine explosion, some of the characteristics of which are an entire destruction of a boiler, the ruptures generally taking place in the strongest parts of the boiler, or, in other words, not in the parts where it was riveted, but through the solid sheets.

It is here proper to say that by actual experiment it is found that a single riveted joint loses 44 per cent. of the strength of a plate not riveted.

Now it seems one boiler was torn through a solid sheet and not in the line of rivets. If the rupture had been caused by a gradual accumulation of pressure it would undoubtedly have given way in the weakest part along the line of rivets, being there but about half the strength of the solid plate. The other boiler, its mate, it seems was thrown into a large number of pieces—rents at random—and all with the safety valve open!

The inevitable conclusion is that there must have been an instantaneous increase of pressure, so instantaneous as not to give the safety valve time to open more to relieve the boilers; in fact the entire destruction of one boiler was not sufficient relief to save the other!

The direction that the two pieces of the boiler took was that due to the force that propelled them. Under the circumstances the boilers could not have gone sideways. Had a rupture taken place on the side, the boilers would have been propelled in the opposite direction; if on the bottom the boiler would have gone up.

This is a very rare case. A prominent engineer with an experience of over 40 years with steam boilers has seen but three cases of the kind; the cause for these terrific explosions is not yet understood.

The sulphur in your water will, without doubt, cause your boiler to prime. You will be relieved of your priming by suspending a platform of wood or metal, at the water line directly under the point where your steam is taken off. Let it be of sufficient size (square) to fill the space at the water line. You will cool rather than superheat your steam by the method you propose of conducting your steam down the side of the boiler and under the grate bars.

MESSRS. EDITORS:—Your correspondent G. W. D., of Providence, R. I., was not correct in the statement of the cause of the boiler explosion that lately took place in Massachusetts, as given in your paper No. 23, Vol. XVI, page 358. The superintendent has never attributed the cause to an excess of water or yet to any known cause. The boilers were plain cylinder boilers, 36 ft. long 30 in. diameter, and carrying the usual amount of steam at the time of the explosion—"about 80 lbs." They were fed at the rear end, water being pumped through a tank into them, the pipes so arranged that the check valves could hardly be said to be nearer one boiler than another; the boilers were placed in two sections, four in each. The coal used was pea and dust mixed, consequently the fires had to be cleaned out at least once a day. At the time of the explosion the fires were about to be cleaned, having some six or eight inches of dead ashes on the grate bars, with two or three inches of fire on that, which was low in order to clean them out, usually done by pushing back the fire to the bridge wall, then drawing out the ashes, pulling the fire down on the grate bars, and adding fresh coal. Just before cleaning the boilers were always filled with water. The fireman had just stopped the pump as the agent of the mill came into the room, and trying the gages of each boiler himself and finding a full gage at the upper cock, he cautioned the firemen not to fill the boilers too full as he thought it not good economy in making steam. He went directly to the office and had hardly seated himself when the explosion took place. One of the center boilers was broken about six feet from the end, or the length of two sheets from the head of the rear end, parting in the rivet holes. The short end of the boiler lodged in the chimney, the other was thrown some 800 feet from its bed, almost in a direct line; the one next to it was lifted up and thrown over the other two outside of the building. All of them seem to have been lifted up as from a pressure below; the walls were leveled even with the ground, scarcely one brick left upon another, and even below the ground the flues leading to the chimney were more or less shattered. The explosion took place at once upon stopping the blower. There was heard a sound as of a heavy rush of air, as described by those working in a building near by. One hearing this sound jumped from his chair and reached the centre of the room before hearing the report of the explosion.

Now, Messrs. Editors, what was the cause of the explosion? Was the space under the boilers charged with gas, a space perhaps, 20 ft. long, 3 ft. deep, and of the width of each section? Some have thought so. The fireman has since said his furnace doors have sometimes sprung open and the smell of gas was quite strong, particularly when the blower was being used, or the fires buried at night, at which time the damper was nearly closed. I think no argument would convince the agent of the mills that the cause was absence of water, after trying them himself. Could a boiler foam out its water in ten minutes, or less than that time, with such low fires as were burning at the time of the explosion?

Hebron Mills, Mass. C. T. CARPENTER.

[The above was probably not technically an explosion, but the giving out of the part under a gradually accumulated