could be easily cleaned out. They were fired under the bottom and had a wheel draft all around the sides. They were not economical of fuel, as they did not evaporate more than 5 lbs. of water per lb. of good coal.

The other boiler in use was called the Lancashire, and was generally from 26 to 30 ft. long, with two internal furnaces of circular form. Modifications of these boilers are still in general use in the English manufacturing districts. It is claimed for them that their economy of fuel is equal to the multitubular boiler in common use now A number of these boilers imported from England within the last few years are in use in Canada. Frequent disastrous explosions of these boilers took place, and were looked upon as mysterious, until Mr. William Fairbairn demonstrated that their strength was inversely as the length and diameter of their furnaces. This brought about an improved form of furnace with strengthening rings. Since their introduction and the general adoption of steam boiler inspection, explosions have become very rare. In my younger days, Charles Wye Williams, a consulting engineer in the employ of the City of Dublin Steam Packet Company, was engaged in experimenting on steam boilers, with a view to their greater efficiency and the prevention of smoke. I had an opportunity of seeing one of his boilers tested in the yard of the City of Dublin Company, Liverpool, under M. Williams' superintendence. Although his furnace was shown to prevent smoke to a great extent, it did not come into general use, as it was not shown that it was more economical than those in use. I may however state, that Mr. Williams constructed a fire box boiler of the locomotive type, the tubes of which were 8 ft. long, divided into eight water-tight divisions, the first division being 6 inches from the fire-box tube plate. The result of this experiment showed that the firebox made more steam than the balance of the boiler, and the first 6 inches of the tube more than all the rest—the two last divisions making no steam, as the temperature of the water in them could not be raised to the boiling point.

About the same time the Stephenson long boiler locomotive engine was constructed, with very long tubes. It was not found to make steam any better than the short boilers, and its manufacture was soon abandoned.

In the colliery districts of Lancashire, the haystack and waggon boilers then in use did not run with more than 1½ to 2 lbs. of steam. The pumping engines had open topped cylinders, the steam being used to displace the air, and then condensed by a jet of water in the bottom of the cylinder, the pressure of the atmosphere on the piston doing the work of pumping. The boys used to amuse themselves by getting on the beam and piston when the engines were in motion, the strokes not being more than 3 or 4 per minute. I have been informed that some of these engines and boilers are still at work in the colliery districts.

When multitubular boilers first came into use for stationary purposes, the manufacturers placed too many tubes in them, and kept them too close to the shell bottom over the fire. As a consequence they gave a large amount of trouble, the shell plates giving way and getting hot through the want of proper circulation of the water. The writer was often asked at that time as to the cause of the trouble. I showed the impossibility of the water getting down on the furnace plates while the large body of steam was ascending through the tortuous passages around the tubes. I have seen a new boiler constructed this way, and made of the best lowmoor iron, give out entirely in two weeks, while those that were constructed with sufficient space for circulation, worked very economically and gave no trouble whatever.

The matter of circulation of the water and liberation of the steam was exhaustively experimented on by Mr. Robert Isherwood, Chief Engineer of the United States navy, on the steamer Michigan of this navy. This gentleman caused a reduction of the number of tubes in the boilers by about one-third, reducing the consumption of fuel, and increasing the steam available to propel the ship—clearly proving that increased circulation of water in a steam boiler largely increases the production of steam and adds to the life of the boiler.

A new steam boiler was built and placed in position in a foundry and machine shop in Toronto in 1867. The owner designed it himself and filled it close to shell and bottom with tubes. In one month it had to be replaced by a new one, as it bagged over the fire until the plate split. It made very little steam considering its heating surface. I saw this boiler before it was set in brickwork, and told them what might be expected. The same thing happened from the same cause to three boilers in Hamilton. Repeated failures of steam boilers from this cause has taught a lesson to the manufacturers that has passed through the trade, so that most of the boilers are now not deficient in this respect.

When I went to Liverpool to serve my time, there was no official inspector of boilers, engines or steamboats, nor any examination of or certificates given to steamboat engineers, the managers or the owners of the boats taking the best or cheapest men from the shops, or from those that had raised themselves from firemen in the boats. Neither were there any boiler inspectors on shore, or boiler insurance companies. As a consequence, explosions and loss of life were very frequent, very much more so than at the present time when there are boiler insurance and inspection companies always available.

I recollect going into a factory on Sparling Street, Liverpool, at the dinner hour; I saw a man sitting by a steam boiler with two heavy weights on the lever of the safety valve. I said to him, "what have you the two weights on for?" He said, "Mr. Twiss told me not to let the steam blow off, it rusts the machinery." I told him to lift it up gradually until it let all the steam out that would come out, leaving the old weight on, and made off down the street as quickly as possible.

I have met many men in this country in charge of boilers who had very little more knowledge of steam than this one. Any man in charge of steam boilers can now have no excuse for his want of knowledge in this respect, as he may join the Stationary Engineers' Society, and receive necessary instruction that would fit him to take charge of any land engine or boiler without fear of accident.

I do not understand how it is, looking to the many boiler explosions that take place in Canada, with the consequent loss of life and property, that the Ontario Government can not be prevailed upon to pass a law making examination of engineers compulsory, as also inspection and tests of steam boilers. Perhaps the lives saved by a law would not be a sufficient set-off to the political patronage but from those who selfishly oppose getting such a law.

This letter is, I am afraid too long; I am therefore constrained to stop here before being through with my subject. By your leave I will return to it in a future number, when I hope to relate some experiences with engines and boilers that your readers were not previously conversant with.

THE EASTON ARC DYNAMO AND LAMPS.*

By T. F. Pickett.

The invention of the Easton system of arc lamps is due almost solely to the efforts of Mr Jas. W. Easton, who designed and perfected the system. He was employed at first by the Ball Electric Light Co., of Canada, in London, Ontario, and afterwards by the Ball Electric Light Co., of New York. During this service he suggested many of the distinctive features which made the Ball dynamo a practical and commercial success. So far as was desirable these features were incorporated in his subsequent work, and for this reason the external appearance of the Ball and Easton dynamos is somewhat similar.

The fragility of parts inseparable from a profitable manufacture of a double armature machine gave endless troubles from break-downs, and Mr. Easton was certain that a better type could be designed. With that end in view he studied the defects of all the dynamos under his observation. The "burning out" of armature sections was the first defect he succeeded in overcoming, after he awoke to the fact that his previous work had been calmly appropriated by others. This defect was ordinarily due to a defect in the commutator, seldom occurring from an inherent armature trouble, and the device for overcoming it consisted in connecting the armature in a closed circuit, independent of any external connection to the *commutator*, and making the connection between the armature and commutator by fusible wires.

By the accompanying diagram it is seen that the current flowing through the armature wire does not flow out past A2, unless the brush is in contact with C2, and therefore F2 carries current only while the brushes make such contact, which is about 1-60 part of the time, and the fusible connections are adapted to carry about 1-60 of the normal current of the dynamo. If a short circuit is formed as between C1 and C2 the current generated in the wire between A1 and A2 flows in this short circuit through the fuses for the *whole* time, and therefore if the short circuit has sufficient resistance, so that only the normal current flows through it, the fuses will be subjected to about 60 times the normal heating effect and will blow out, but as the short circuit is usually of low resistance and the current abnormally large, the heating effect is increased in the fuses as well as in the armature coil and the fuse blows at once, so that the protection is the more rapid as the possibility of damage is increased. In actual tests, there is no appreciable lapse of time between energizing the magnets, and blowing of fuse, when the short circuit is practically of no resistance. The two short circuited plates in the commutator become practically one and two sections in the armature operate as one section of double length connected and protected by the fuses F and F2. The number of sections being large, the consequent increase of spark at this double section is not destructive; in fact machines have been knowingly operated for months with a number of fuses out, without any serious damage to the commutator, so that there is no necessity to shut down for a short circuit in the commutator of this machine. The next most noticeable improvement was the automatically tightening armature mounting device. The need for such an improvement was pressed upon the inventor's attention from the trouble experienced in mounting the smooth "Gramme ring" armature, which has been so satisfactory for high tension work. These armatures when mounted upon the ordinary spider, *would* get loose and cause wires to break, and the whole armature would sometimes move bodily "out of centre" and strike the polar faces of the magnets. As the causes of loosening were almost solely attributable to the shrinkage of the insulating material in the mounting, and compacting of the armature wire, the correction could be practically uniform all around in "taking up the slack." The device for overcoming this defect consists in making the shaft itself, a single screw bolt the strain of driving the armature being perpetually applied to force a conical nut or cone into a conical seat, and thus expand the insulating material, against the inner surface of the armature, and any looseness is at once taken up by a relative movement of the shaft and mounting. As the shaft is dead true, the running gear can turn upon it without altering the centre of motion, or the balance. Actual experience proves that the shaft, with a screw of two threads to the inch, gains about one turn in the first ten millions, and this tightens everything up solid, the relative motion of the two parts being very slow thereafter. The result of this device has been to effectually overcome the troubles which called it into existence.

Another radical departure from the known types of machines, was the one intended to secure the maximum action from the minimum of material in the armature core. This consists in placing the polar faces of the magnets so that the centre of the armature is subjected to the direct inductive action of both poles, while each end is subjected to the direct action of one only, and the indirect action of the other. The theory for this is found in the fact that the self repellant action of magnetic lines of force have similar direction of flow, causing the ends of a cylinder subjected to a uniform distribution of inductive action to become saturated first and requiring expenditure of energy to get the centre saturated under these conditions.

The same property of magnetic lines of force also causes the ends of a magnet polar face to be the strongest in effect, and the inductive action to

* Paper read before the Montreal Electric Club.