foundation the difference in cost is even greater. There have been more failures of concrete and masonry piers than there have been of tubular piers. In most cases this is due to the poor construction of the masonry. The contractor, in his efforts to be low bidder, bids lower than good masonry can be built for. He is not required to work to any specifications and builds the class of masonry it is usual to build in the locality. Therefore there are many masonry piers built of the same class of stuff and in the same manner the mason employs when building a cellar wall in his locality.

It is selom best to award the contract to the lowest bidder for masonry work. Choose some man whom you know does good work; adopt a bridge masonry specification and see that it is followed. Some cases of concrete failures are known where the strictest precautions during construction had been taken, and where plain concrete was paid for at the cost of $13.50 per cubic yard, but these were caused by bad judgment, placing piers in the middle of streams when the bridges should have been one span structures instead of two spans.

The pressure against a tubular pier at time of high water is not great owing to its cylindrical form; it is also not apt to hold drift for this reason. It is bad practice to set a tubular pier on a rock foundation in a stream where it has only a foot or two of gravel or clay to penetrate. In this case it is best policy to build a concrete or masonry pier even though the first cost be twice that of a tubular pier.

It is generally supposed that steel rusts rapidly under ground, the reason for this supposition being that ground holds water longer than does the atmosphere. Water alone will not cause iron to rust as it may be submerged any length of time in pure limewater or a solution of soda, and will not lose its brightness. It is the joint influence of water, oxygen and carbonic anhydride which causes steel to rust. By means of these three agents ferrous carbinate is first produced on the surface of the steel, but this by absorbing a further proportion of water and oxygen becomes changed to a hydrated ferric oxide with the liberation of carbonic anhydride, which latter then reacts upon a fresh portion of the steel in the presence of water and oxygen and a further quantity of ferrous carbonate is produced and so the cycle continues to be repeated. The presence of carbonic anhydride appears essential to the oxidation of steel by moisture. We know that oxygen and carbonic anhydride are always present in the atmosphere and moisture is usually present, but it is not common that water holds carbonic anhydride in solution. There is a bridge in Perry County, built in 1876, resting on piers made of two Phoenix columns about 10 inches diameter. After digging a foot or so under the ground surface we found that the paint was still on the columns, though they had rusted somewhat above the ground.

ADVANTAGES OF HORIZONTAL RETURN FIRE TUBE BOILERS

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I have always been an advocate of fire tube boilers, generally of the horizontal return tubular form, but sometimes of the vertical, or even of the Scotch marine form. The horizontal return tubular boiler has the best record for safety of all types when built with butt joints, for there is no record of an explosion of such a boiler, as far as I can ascertain. This is unique in boiler history. The horizontal return tubular boiler can be built of any size up to, say, 500 horse power, and I know of several units of 400 rated horse power. They can be built for any pressure, for there is no reason for objecting to thick plates exposed to fire.

Horizontal tubular boilers will stand any amount of forcing. The 90-in. boilers referred to were rated at 400 horse power each on a basis of 10 sq. ft. of fire heating surface and are constantly worked to over 700 h.p. each, or 75 per cent. above their rating. In the same place some 500 h.p. vertical fire tube boilers, on the same basis of rating, are worked 24 hours per day at over 1,000 h.p. each, or more than 100 per cent. above their rating.

It requires less draft to operate horizontal tubular boilers than water tube boilers because the latter have many clean-out and other doors causing great air leakage, and more brick wall area which also causes air leakage, and the draft has to carry away the surplus air. The effect of these leakages is also to cool the gases so that they do not heat the boilers as much, and to render economizers less efficient because the gases coming in contact with them are cooler than in horizontal tubular boilers. When horizontal tubular and water tube boilers are in the same plant gas analyses will always show much more free air in the gases from the water tube boilers than from the others. Vertical fire tube boilers require even less draft than horizontal tubular boilers because there is no chance for air to leak in, unless they are built with loose smoke boxes and covers, as many of them are. These leakages have caused explosions in smoke flues and economizers, wrecking them completely.

All heating surfaces of horizontal tubular boilers are effective because there are no dead spaces and corners for the gases to short circuit, which is far from being the case with water tube boilers. The length and resistance of the path of gases from a transverse line in the furnace of the tubular boilers to a similar line in the uptake is the same through the various tubes and therefore there is no reason for any tube shirking duty. I do not think this is true of any other boiler.

The horizontal tubular boiler can be kept cleaner than a water tube boiler. The insides of the tubes of the former can be blown with the certainty that the jet of steam will strike every part, and they can be scraped in addition, while a jet of steam among water tubes strikes one side of some tubes, and others not at all. In some designs of water tube boilers the condition in this respect is better than in others, for example, those in which the jet is introduced in such a way that it travels lengthwise of the tubes. In these, however, the steam can dissipate vertically and horizontally and loses its cleaning power before it reaches the ends of the tubes.

The heating surface of water tube boilers is almost valueless because the tubes nearest the fire become incrusted in clinker, and, in some of them, tiles rest upon the other sides of the tubes, so that these tubes are all but useless as heating surface. To a slight extent this happens to the bottom of the shell of a tubular boiler.

It is often claimed for water tube boilers that they respond to demands for steam more readily than fire tube boilers. This is probably based upon the idea that the former contain less water in proportion to their heating surface than the latter. The horizontal tubular boiler contains less water in proportion to its heating surface than any water tube boiler that I am familiar with, although the vertical and marine types usually contain more. It makes no difference, however, which contains most water, as far as responsiveness is concerned, for after steam is once up, any additional heat can only make steam, as the water at a given pressure can contain no more heat. The steam made will depend upon the amount of heat liberated from the fuel, and the area of the heating surface