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THE LUIZ I. BRIDGE, OPORTO.

WE conclude in the present number our series of illustrations of this interesting structure. For the description of the engravings here given and for other illustrations, see our preceding SUPPLEMENT, No. 557, page 8888.

THE COLD ZONE IN WATER VESSELS.

By T. FLETCHER, F.C.S.

DURING my experiments on the state of things in that almost unknown space between a flame and a vessel containing water, some most extraordinary facts have come to light, which are not only of the greatest importance to steam users and boiler makers, but explain many curious points in connection with the heating of water.

It is well known that a flame does not come in contact with any ordinary vessel containing water, and that a paper label will remain on the bottom of a tin or copper kettle placed on a sharp fire, until by drying it gradually becomes loosened, and loses its contact with the metal, and so becomes burnt. I have myself seen labels on the bottoms of ordinary kettles and pans, the labels being quite perfect after some weeks' use over gas burners and fires. The work obtained from any source of heat by a limited surface is in direct proportion to the difference between the temperature of the vessel and that of the source of heat in absolute contact with it, and it therefore becomes a matter of serious importance to discover what the actual temperature of this cool and flameless zone is, and whether it can be removed. As is no doubt well known, my efforts to remove this, which is practically a wet blanket, from between the vessel and the fire have been partially successful by the use of projecting studs or webs of definite proportions, and the experiments already published prove that at the ends of copper rods four diameters long, flame contact exists, at all events sufficient to char paper, and to multiply the available duty, surface for surface, six times as compared with either water tubes or ordinary boiler plates, and that the evaporating power of any properly proportioned studded or ribbed plate has no limit except the practical one of removing the steam quick enough to prevent it lifting the water bodily out of the boiler.

After proving beyond doubt that under ordinary conditions flame does not come in contact with a vessel containing water, I endeavored to get this contact, and the corresponding increase in evaporating power, by directing flame against the water vessel with the assistance of a powerful blast, the result being, much to my surprise, that I found an impenetrable cold zone surrounding the vessel, absolutely impassable not only to a powerful blow-pipe flame, urged with an air blast of $1\frac{1}{4}$ lb. per square inch pressure (the heaviest blast a gas blow-pipe flame will stand under ordinary conditions), but that it was equally impassable by radiant heat from a sheet of white hot platinum, held as

FIG. 4.—MOUNTING OF THE ARCH.

FIG. 1.—LUIZ I. BRIDGE IN PROCESS OF CONSTRUCTION.

close as possible without absolute contact. In making these tests, the result was proved by the fact that sheets of paper pasted on the water vessels were exposed to both the direct impact of the blow-pipe flame and also to the radiant heat from the platinum, until the water in the vessel boiled, the paper being perfectly free from charring or discoloration at the end of the test.

Another important fact came out as the result of these experiments. Not only can the maximum temperature be determined by the presence or absence of charring of known organic substances, but also the thickness or depth of the cold zone can be measured by using paper of different thicknesses pasted to the surface of the vessel. When the paper used is thicker than the depth of the cold zone, the surface is charred or completely burnt to an invariable depth by each source of heat; but if this charred surface is cleared off with glass paper, the under part will be found perfectly white and clean, and on again directing the flame on this clean surface, it remains untouched.

Another curious and important fact is that this cold zone, although impassable by flame, hot air, or radiant heat, is powerless to resist the carrying of heat through it by solid bodies, and while the blow-pipe flame is being directed on the paper without the slightest effect, a wire passing through the flame and touching the paper will burn it instantly and completely, although the actual temperature of the wire must of necessity be far below that of the blow-pipe flame.

The extraordinary part of the whole series of experiments seems to be the existence of a zone of cold against all surfaces of metal having water behind them, this space being, to radiant heat and flame, almost as impenetrable as the metal itself is to the water. Some heat certainly does pass, or the water would never boil; but the quantity which does make its way through is very trifling as compared with what would pass, and, in fact, what does pass under such conditions as permit of direct flame contact with the metal.

The result of these experiments does not fit the ordinary accepted theories of radiation and absorption of heat. The fact is that the high temperature

stops suddenly at a very clearly defined distance, the division line being sharply drawn. It cannot be said that the heat is absorbed at a sufficient speed to produce this cold zone, because, as a matter of fact, the heat rebounds and is dissipated to a large extent sideways, and this rebound takes place at an invariable distance from the vessel, irrespective of the angle at which the flame is driven and depending only on the force of impact of the flame. If we could imagine the surface of the vessel covered with a layer of elastic material which is compressed by a torrent of small shot driven steadily against it, we get a mechanical representation of the actual state of things between a flame and a cold vessel, additional force of impact reducing the thickness of the elastic layer, but being powerless to annihilate it.—Industries.