plates are in perfect metallic contact with the metal of the boiler, how long is it likely that the surfaces will remain perfectly bright?—possibly half an hour—when a thin skin forms, and taking into consideration the weakness of the electrolyte (boiler water is never a strong electrolyte in practice), all current stops; though I am afraid that after the years it has been accepted, all discussion on this point will not stop here. Another reason that causes me to think that zinc plates do not continue to act as the positive element in a boiler, is that you never find zinc deposits on the steel of the boiler, which should happen if zinc was the anode and steel the cathode. I expect some of the members are wondering how I account for the wasting away of the zinc; well I think this can be explained as follows: Hot water acts as a solvent on zinc and the oxygen in the water chemically combines with the zinc forming zinc-oxide.

Zinc		Oxygen		Zinc-oxide
Zn	+	O	=	ZnO.

It is worth noticing that, when two dissimilar metals are immersed in a liquid capable of chemically acting on them both, but not connected, they both corrode; connect them as shown in diagram, and as soon as current flows, one is eaten away while the other is preserved. I have an idea that galvanic action might be made to preserve the boilers, for we know that if two plates of similar nature be immersed in two separate vessels, and a current made to pass from one plate to the other through the liquid, then the one the current leaves becomes corroded, while the other is preserved.

Let A and B be two vessels each containing the same kind of electrolyte, and let C and D be two plates of steel and E and F two plates of carbon, which is non-corrodible, then the current leaving the battery passes through C into and through the leectrolyte into E, then into F, through the electrolyte in B and into D, thence back to the terminal of battery; here the plate C will become corroded. Surely this is a field which would amply repay investigation by those interested in galvanic action in boilers.

There is another action set up in boilers called thermo-galvanic action; this is caused by unequal heat in the plates, even though it is the same plate, and of the same material; one of the principal places where this takes place is on the sides of the furnace tubes about the line of fire bars; but I do not think this action exerts much influence in the corrosion of boilers. The action of stray electric currents is blamed for a great deal more than it deserves, and personally, the only defect I can see this will cause, is the eroding of copper feed pipes.

Another and important factor in deterioration of boilers is faulty construction, and bad workmanship in working plates, etc. When a boiler structure is so combined that certain parts are kept in a state of restlessness, either difference of expansion and contraction, or any movement causing alternate strains, then, all such restlessness tends to wear out the parts thus exposed, not so much by the mere friction as by the process of disintegration, whereby the incipient oxide is prematurely scaled from the surface of the plates, and causes what is known as grooving. This restlessness also causes fatigue and shows as brittleness in the plate. If a boiler is so constructed as to have a tendency to restrict circulation, it may give trouble. This has been known in a boiler that had too little space over the furnaces, to so overheat the crowns as to cause them to collapse; such was the case in an Atlantic steamer, where the crowns came down nearly every trip. At first the owners tried to remedy this by discharging the engineers, but finally remedied it by drawing the row of tubes above the furnace. Restricted circulation causes the heating surfaces to become hotter than they otherwise would, and it is a recognized fact that acids will attack the hottest part of the plates. Methods of working the plates such as local heating, flanging and working at a blue heat, often cause cracks, etc. It has been found by experience that between 450° and 550° F. (known as blue heat) steel appears to become rotten, though above or below this temperature it may stand bending or other tests. I think the usual methods of annealing plates leave much to be desired.

Scale.—Always keep scale from accumulating on tubes, especially round the necks, as apart from the loss of economy, it causes leaky tubes, and I suppose nearly all members here remember the pleasant task that at some time or other has been theirs in the back ends. But it is seldom explained why thick scale round the necks of the tubes causes the tube ends to leak; it has been told me that they overheat, and the expansion and contraction causes it, but it always seemed to me that it was rather vague, till on further considering it I have come to the following conclusion: before tubes are put into a boiler they are annealed, then on expanding a certain action takes place in the metal, resembling, if not, tempering it, which gives it elasticity. Supposing the tube ends are overheated through the heat not passing away to the water rapidly enough, caused by thick scale, then the ends become annealed again, and it may be noted that often the tubes do not leak till a change of temperature takes place, as from a lower to a higher, such as lighting up fires again; this leaking is caused by the tube ends not now possessing that requisite elasticity to follow up the longitudinal and compressive strains in the tube and the strains in the tube holes. This is remedied by re-expanding, and thus giving the metal elasticity again.

I would like to mention before I finish this paper, a case in which corrosion resisted the efforts of the engineers, until they boiled the boiler out for twenty-four hours with caustic soda. This would generally be thought to be a rather drastic treatment, but it was so effective that they were not troubled with corrosion again, though even after several "washings out" with fresh water before closing up, the boilers were inclined to prime when they first "got away." Another case that happened was this: the boilers when opened were found in excellent condition, they were brushed down and then washed out with sea water. A delay occurred so that the fresh water was not put in until two days later; then, when the engineer went to have a final look round, he found that the backs of the combustion chambers were bleeding: this was remedied by painting with white zinc and kerosene.

If you are in charge of boilers in good condition, I would recommend the following:—See that steam is raised slowly, and that the water is kept circulating when raising steam, keep boiler water slightly alkaline, scum and blow frequently—by scumming you get rid of grease, etc., and acid, though at the expense of the freshest water in the boiler; by blowing you get rid of sediment and denser water. When blowing do not let vibration take place any more than is possible, and do not blow at less than 53 lb. gauge pressure or 300° F., since water as it cools will resume the sediment to its full carrying capacity. And always avoid shock action in a boiler.

After trespassing so long on you patience, I will not further enumerate the many other things relative to boilers. I am leaving them for the other members to bring forward at the discussion to follow, which is the reason of my attempting this paper, as I think this an excellent opportunity to get the opinions of experienced engineers.