

## The colours of tempered steel

The well-known and characteristic tints that appear on the surface of a tarnishable metal when it is heated in contact with air have been usually regarded as interference colours due to the formation of a thin film of oxide on the surface of the metal. The correctness of this explanation has, however, recently been questioned (A Mallock, *Proc. R. Soc. London*, 1918), and rightly so, as a continuous film on a strongly reflected surface cannot on optical principles be expected to exhibit such vivid colours as those observed.

I have recently made some observations which shed a new light on this subject. It is found that the *missing colours* complementary to the tints seen by reflected light appear as light *scattered* or *diffracted* from the surface of the metal. In other words, if a plate of blue-tempered steel be held in a beam of light and viewed in such a direction that the regularly reflected light does not reach the eye, the metal shows a straw-yellow colour, and not the usual blue. It will be understood that the scattered light, being distributed over a large solid angle, appears much feebler than the regularly reflected colour, and in order to observe the effect satisfactorily the metal should have a smoothly polished surface before being heated up. Scratches and other irregularities show the ordinary colour of the film, and not the complementary tint. The most attractive effects are those exhibited by a heated copper plate, both on account of the vividness of the colours and on account of the ease with which the surface can be given a satisfactory polish.

It is clear from the observations mentioned above that the colours under discussion are in the nature of *diffraction effects* arising from a film which is not continuous, but has a close-grained structure. Interesting effects are observed when the surface of the illuminated plate is viewed through a nicol, the colour and intensity of the scattered, as well as of the regularly reflected, beams varying as the nicol is rotated about its axis. The most striking effect is obtained when the direction of observation is nearly parallel to the surface of the plate. The scattered light in this case is nearly completely polarised, and the colour of the regularly reflected light changes nearly to its complementary when the nicol is turned through  $90^\circ$ . The phenomena strongly recall to mind the observations of R W Wood on the colours of a frilled collodion film on a silvered surface, which have been discussed by the late Lord Rayleigh (*Philos. Mag.*, November, 1917), and it seems probable that the explanation of the phenomena will ultimately be found to be somewhat similar in the two cases.

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