

+  $\sigma$  derived from the copper, and so would reduce the zinc to its original potential. Under these circumstances statical equilibrium could, as it appears to me, never be attained. But if there exist repulsive forces between dissociated atoms of oxygen other than those due to their negative electrification, we may obtain our repulsive force  $-2\pi\sigma$  without introducing so many atoms as that their negative charges, referred to unit of surface of the zinc, shall be  $-\sigma$ . It may be  $-\sigma'$ , where  $\sigma'$  is less in absolute value than  $\sigma$ . And so we should, on making contact with copper, obtain a total charge on the zinc  $\sigma - \sigma'$  per unit of surface. This is positive. The zinc may then be raised to the same potential with the copper, and at the same time the attractive and repulsive forces on dissociated oxygen atoms near the zinc may be in equilibrium. So it seems to me that, assuming the electrification of oxygen and its attraction by the zinc to be as stated by Dr. Lodge, the theory consistently explains phenomena up to this point, and may explain also the variations due to moisture of the zinc or other conditions.

(4) As regards the "intrinsic step" of potential relied upon by Dr. Lodge to explain the aluminium needle experiment, I cannot so easily follow him. Consider the surface of the isolated zinc, and let  $c$  be a point just so distant from it that the potential at  $c$  is sensibly unaffected by the presence of the zinc with its negative charges, and those of its attendant oxygen atoms.  $c$  is then at zero potential, that of the zinc being  $-1.8$ . Intermediate points are at intermediate potentials. When, on making contact, you introduce the positive electricity from the copper, you raise the potential of the zinc by half a volt. But the potential at  $c$  is, *primâ facie* at all events, no more affected by the positive than it was by the original negative electrification of the zinc, and remains zero. You have diminished the "step" by half a volt. As before, intermediate points would have intermediate potentials. In fact, so far as the potential at  $c$  is concerned, may we not suppose the newly introduced positive electricity simply to neutralize an equal quantity of the negative electricity previously found on the zinc?

S. H. BURBURY.

On this head I would say that a point outside the surface-film, beyond the molecular range, is naturally unaffected by the chemical affinities of the surface; but it is by no means therefore uninfluenced by the ordinary dielectric strain of a static charge imparted to the zinc in any adventitious manner. Such a charge alters the potential of the whole neighbourhood, but does not alter the slope of potential existing in the surface-film. Nothing can alter that but a modification of the surface or of the adjacent medium.

Thus I state my position briefly in order that the sole remaining divergence of view between Mr. Burbury and myself may likewise disappear.

OLIVER J. LODGE.

PERHAPS the following slight elaboration of Dr. Lodge's views on the electrical condition of air films in contact with metals will commend itself to Mr. Burbury. It seems to me that by its means the difficulty of realizing the source of the negative charge on the oxygen atoms is to a certain extent got over without thereby forfeiting any of the essential features of the air film theory.

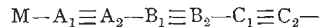
Assuming the truth of this theory, the fact to be explained is that when clean zinc is put into pure oxygen it becomes coated with a film of that substance which is at a higher potential than the zinc by 1.8 volt.

If the film be regarded as a conductor, this step of potential has to be brought about in the first instance by combination of a few zinc atoms with oxygen, so that the film becomes coated with + electricity on both its surfaces; the field set up by this and a corresponding - charge on the surface of the metal underneath representing the 1.8 volt step of potential between the two. It is at this point that the difficulty of the - charge on the oxygen atoms arises, as they have just been assumed to be +; and, also, this other smaller difficulty, that the + and - charges on the opposed film and metal surfaces, corresponding to 1.8 volt and at molecular distance apart, are such that every atom in each surface is charged with a quantity of electricity which is of the same order of magnitude as its electrolytic charge; a fact which necessitates the previous combination of every atom in the zinc surface with oxygen from the film if the ordinary laws of electrolysis are to be assumed; whereas according to

the film theory, wholesale oxidation of the metal surface destroys the Volta effect altogether.

If, however, the film be regarded as a non-conductor, both these difficulties vanish.

The molecules which form the film would be gaseous except for the presence of the metal. The latter holds them to itself, and may be looked upon as, in a sense, polarizing them into chains or rows normal to its own surface. Supposing such chains to consist each of what were originally three distinct diatomic gas molecules,  $A_1A_2$ ,  $B_1B_2$ ,  $C_1C_2$ , with a metal atom  $M$  next to  $A_1$ , there will be a tendency to combination between  $A_1$  and  $M$ , which will slacken the



bonds between  $A_1$  and  $A_2$ , leaving  $A_2$  partially free to hold on to  $B_1$ , which again will promote a holding on between  $B_2$  and  $C_1$ , so that  $C_2$  is partially uncombined. The bonds between  $A_2$  and  $B_1$ ,  $B_2$  and  $C_1$ , represent in fact the cohesion of the film (or part of it), and are the result simply of the tendency to combination between  $M$  and  $A_1$ . If this be very great, actual combination may occur, which will set free  $A_2B_1$  and  $B_2C_1$  as gas molecules, leaving  $C_2$  to find another partner. On the other hand, the tendency to combination between  $M$  and  $A_1$  may be too small to do more than polarize the molecules, and this is perhaps what occurs with zinc in dry oxygen.

If, now, the essence of combination between zinc and oxygen is that the zinc atom is + and the oxygen -, we may assume, without entering on ultimate problems, that the row of molecules is polarized *electrically* as well as mechanically.  $A_1B_1C_1$  all -; and  $MA_2B_2C_2$  +; so that the film may be looked on as a dielectric plate, with a coating of metal on one side only, and a + charge on the other. The slope of potential between film and metal (*i.e.* the Volta effect) occurs now, not between their surfaces of contact, but right through the film, the 1.8 volt existing between the *outside* surface of the latter and the metal. No actual chemical combination is necessary to bring it about; and, indeed, any combination at all is prevented by the internal affinities in the film itself just described.

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### Pectination.

REFERRING to Mr. E. B. Titchener's letters in NATURE (see December 4, p. 103, and January 15, p. 248), I am able to confirm the view that pectinated claws are used by the birds possessing them for the purpose of scratching themselves.

On December 9 last I shot a cormorant, and found the fissures between the teeth of one of its pectinated claws choked up with fragments of down. This down corresponds with the bird's own down, and there can be little doubt that it is the bird's own down, and that it became thus situated through the claw being used for the above-mentioned purpose. I may also mention that I have since found minute fragments of feather in the claw of a barn owl.

Many birds use the middle claw to scratch themselves with, as Mr. Titchener remarks; and this claw appears to be very generally modified for the purpose. The modification consists in this, that the inner edge of the claw is bent out, and developed into a curved blade running along the inner side of the claw. Such a blade is well developed in guillemots and razorbills. It may also be easily seen in wild duck, teal, gulls (some at any rate), oyster catchers, golden plover, starlings, fieldfares, redwings, larks, and many others. In some birds the modification is very slight, but in all I have been able to examine (not an extensive collection) it seems to exist in some degree. In the divers, the claws are so flattened that the inner edge naturally forms a scraper, and the same may be said of other birds, such as partridges and pheasants.

Pectination is only a further modification of this blade, or inner edge of the claw, in that it becomes divided up by notches or fissures, placed at more or less regular intervals, into a comb-like structure. As is known, the middle claw is not pectinated in young nightjars. I have now in my possession a young, though almost full-grown male of this bird, and it has the middle claw provided with a well-developed blade, but there is no trace of pectination. I may mention too, that I have found the edge of the blade in a guillemot, slightly indented here and there, thus offering an approach, though but a very distant one, towards pectination.

The pectinated claw, then, should not be regarded as a structure