produced. Light scattered by the first screen suffers distortion by the system to form the error wave-front; but the second or reference wave-front is substantially free from error since its parent beam has traversed that system in concentrated fashion. The fringe pattern therefore represents the wave-front error with which the entrance pupil is being imaged on to the exit pupil, a bright achromatic fringe covering those portions of the field for which the transit time is the same as for the directly illuminated patch.

The practical possibilities of these fringes of equal thickness do not seem to have been explored. For optical testing they have one advantage in that they do not lose contrast in the presence of considerable tilt or asphericity. Of particular interest is their application to imaging systems of unit magnification such that one screen is (1) imaged by a through type or autostigmatic system on to an identical replica; (2) imaged back on to itself enantio-stigmatically; or (3) repeatedly imaged on to itself in a multiple-beam arrangement.

Preliminary experiments on the first two types suggest that the fringes may be useful for testing large mirrors, camera lenses and microscope objectives, and possibly for interference microscopy. The fact that the fringes are self-compensating for path-length and, in the second case, for odd azimuthal errors suggests various engineering applications. Further investigation is taking place.

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Kramer and Russell Effects with Single Crystals of Zinc

A SHORT while ago, Kramer¹ directed attention to the fact that abraded or worked metal surfaces emit negatively charged particles which can activate an open-ended Geiger-Müller counter operated in air. Kramer assumed the particles to be electrons, emitted owing to phase changes occurring on the freshly disturbed metal surface. Haxel, Houtermans and Seeger² confirmed these observations, but offered an explanation based on adsorption phenomena. Gobrecht and Barsch³ brought forward evidence that changes of phase are not directly responsible for the phenomenon. Work at the Mechanical Engineering Research Laboratory confirmed the previous observations, but also established by measurements of ionic mobility that the particles triggering the counter are oxygen-molecule ions. It was further found that the 'active' areas behave essentially as having a lower work function than is usually ascribed to the particular metal. Abraded specimens or evaporated films gave thermionic counts at lower temperatures and photoelectric counts at longer wave-lengths than aged or unabraded surfaces of the same metal.

Experiments carried out with single crystals will illustrate this. Single crystals of zinc (kindly given to us by Dr. A. J. W. Moore) were cleaved in the (0001) plane. One of the cleaved surfaces was abraded, whereas the other was left undisturbed. Both surfaces were investigated by means of an open-ended Geiger-Müller counter operating at a pressure of 10 cm. of mercury (9 cm. mercury of air + 1 cm. mercury of ethyl alcohol). The response of the two surfaces to daylight through glass (with most

of the ultra-violet wave-lengths cut off) was determined. Great care was taken to make the geometrical and illumination conditions identical in both experiments, and alternate counts were taken from the two surfaces in order to take account of the decay of the response. To eliminate stray fields from the counter, a zinc grid was interposed between counter and specimen and operated at a positive potential so that the field between the specimen and grid was 20 V./cm. Under these conditions, the cleaved surface gave 40 counts/min., whereas the cleaved and abraded surface gave 275 counts/min.

The cut-off wave-length for the photoelectric response of zinc lies normally well in the ultra-violet at about 3000 Å. The fact that the cut-off wave-length had been shifted into the visible spectrum to about 5000 Å. indicates that the abrasion process produces, on the surface, areas of low work function, possibly by the intermingling of oxide and metal phases.

The behaviour of the surfaces was further checked by means of the Russell effect, which, as has previously been suggested⁴, is usually associated with surfaces giving Kramer counts. Another single crystal of zinc was treated as in the previous experiment. Both the cleaved and the cleaved and abraded surfaces were exposed to an Ilford Q plate for 20 hr. After development the image shown in the accompanying photograph was obtained. The cleaved and abraded surface gave a very dark image, whereas the cleaved surface gave scarcely any image.

(a) Cleaved (b) Cleaved and abraded

These and other experiments of similar nature lead us to believe that the abrasion of metals causes the formation of sites of low work function, and that these sites are responsible for the so-called Kramer effect.

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⁴ Grunberg, L., and Wright, K. H. R., *Nature*, **170**, 456 (1952).

The New Classical Electrodynamics

EXCEPT for a gauge-fixing condition, Dirac's recent theory¹⁻³ corresponds to the natural form of Maxwell-Lorentz electrodynamics for very fine-grained streams of charged corpuscles all with the same constant mass μ and charge e ; the velocity field in the stream is supposed to be continuous and differentiable. The ratio μ'/e is written k ; here μ' is the measure of μ in energy units: $\mu' \equiv \mu c^2$. (We call this first special form of the theory the *superconductive theory*, since