Letters to the Editor.

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The Constitution of Nickel.

My latest experiments have enabled me to obtain the mass spectrum of the element nickel by using the vapour of nickel carbonyl mixed with carbon dioxide. The ordinary discharge tube was employed to produce the positive rays, and difficulties of maintaining a steady discharge were overcome to some degree by the use of comparatively high pressure and a heavy current. The rays were analysed in the usual way by means of the mass spectrograph.

The spectrum consists of two lines, the stronger at 58 and the weaker at 60. They are most conveniently placed between the mercury groups of the third and fourth order, with which they can be compared with an accuracy of 1/10th per cent. The results were also checked by comparison with the CO_2 line 44, and appear to be integral within the above error. Nickel therefore consists of at least two isotopes. The intensities of the lines are about in the ratio 2 : 1, and this agrees with the accepted atomic weight 58·68.

F. W. ASTON.

Cavendish Laboratory, Cambridge, June 10.

A Novel Magneto-Optical Effect.

EARLY in April last, while my son, Malcolm Thomson, was operating, in a building of the River Works plant of the General Electric Co., a resistance welder for closing the seams of steel Langmuir mercury vacuum pumps, in which work the current is applied and cut off at about one-half second intervals, there was noticed by one of the working force, Mr. Davis, who happened to be favourably located, a peculiar intermittent illumination of the space near the welder as the current went on and off. My son at once placed himself in a similar position and saw the novel effect, and noted a number of conditions accompanying it, perhaps the most important being that a single-turn loop from the welding transformer to the work and back was carrying about 7000 amperes, and that the luminous effect was spread in the space in which would be located the magnetic field from this loop; that the sunlight was entering the building through high windows and shining across the space in which the field was produced at intervals; that the effect was most conspicuous when one looked towards the shadows and across the sunbeams, and also across the magnetic field.

This would be expressed by saying that the best effect was observed when the line of vision was downward at an angle intersecting the entering sunbeams, and into the shadows under the beam furnished fortunately by a partition a few feet high, over which the sunlight came. The magnetic field, neglecting the curvature of the lines, was, generally speaking, at right angles to the line of sight and to the direction of the sunlight. My son also noticed that the effect of increased luminosity was coincident with the putting on of the current, and disappeared at once on cutting off the field. It was thus clear that it depended on the establishment of the magnetic field. He reported these facts to me, and they were confirmed by me. Other observers were soon enlisted, and on several favourable sunny days all the above observations were confirmed by them. Further, my son had not been able to see any effect when looking across the sunbeam from the opposite side. This means that, with the sunbeams streaming in from the south, the effect was observed looking southward and downward, the windows admitting the light being to the south. Looking from the south across the beam gave no result, though it was not possible to look directly across the beam on a slant upward into any dark shadows and at the same time have the line of vision cross the magnetic field.

It is interesting to note at this point that the luminosity filled the whole space, and extended as far away as four feet or more from the magnetic loop, and that it was not especially noted as more intense near the loop than at a distance therefrom of, say, two feet or more.

Mr. Malcolm Thomson had further observed that by cutting out the loop from the secondary terminals (clamps) of the welding transformer, and simply joining those terminals by an iron bar, as is done in resistance welding, the luminous effect in the neighbourhood of the transformer was still visible, but was much more feeble than when the heavy loop was used. It occurred to me to examine the light by a large Nicol's prism. It was found that there was a distinct polarisation of the light from the space. This means that when the magnetic field was on the sunlight was scattered in the direction of the observer from the space occupied by the sunlight beam and the magnetic field, and that such scattered or deflected light was polarised.

It occurred to me, as a possible factor in the case, that as the building was used in part to carry on arc welding by iron arcs there might be suspended in the air of the building iron particles or finely divided oxides or compounds of iron which in some way were oriented by the magnetic field, resulting in the scattered light noted. This was confirmed in part by making the test observations when the large doors of the building had been open for some hours. The effect was present, though difficult to detect. This led to the suggestion to bring an iron arc into operation near the space in which the luminous effect had been seen. This was done, and with an enhancement of the effect.

At this stage the further observations were carried on in the Thomson Laboratory at Lynn, Mass., with the aid of the laboratory staff (A. L. Ellis, H. L. Watson, Dr. Hollnagel, and others).

Two sets of test apparatus were prepared at my suggestion. One large welding transformer was mounted in a special room, into which the sunbeams could be received in the afternoon as the windows faced south by west. The secondary terminals were joined by a large loop of heavy copper cable (about 12 sq. cm. section) of a loop diameter of 0·6 m. The loop consisted of two turns. The plane of the loop was vertical and was nearly north and south; or in a plane parallel to the direction of the entering sunbeams, so that the magnetic field would be in the main horizontal and transverse to the light of the sun entering downward as before. An iron arc was arranged to be operated so that the smoke from it would rise from below and enter the field of the loop, and by changing the relative position of the arc the smoke column, widening as it rose, could be made to bathe the turns of the coil, cross its axis, or, at a distance away, merely enter the field. As the experiments thus far had always involved connection to the shop plant, with 60-cycle alternating current, a check apparatus was set up, consisting of a storage battery (of a type such as is used in automobile

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starting) arranged on a stand. In circuit with it, and under control of a switch, was a coil of about 0·2 m. diameter, and giving a field due to about 2500 ampere turns when the switch was closed. This second apparatus could be moved about, and was entirely independent of supply circuits or static disturbances which might be present in them.

The first tests were made with the transformer loop (representing a field of 20,000 ampere turns), and were very striking. The rising smoke from the small iron arc, only moderately visible in the sunbeam, became decidedly luminous when the field was put on. Each closure of the current switch to the primary of the transformer was instantly followed by the brilliant smoke effect, and the effect instantly disappeared on the opening. A black background had been provided in front of which the smoke rose. After the arc had been running a few minutes only it was seen that the air of the room was carrying sufficient of the smoke particles to give the effect anywhere in the space covered by the magnetic field and the sunbeams, even a number of feet away from the coil. In this case the appearance was as if in the air there were diffused some substance or material which became visible only in the combined sunlight and magnetic field. That in this case the luminous effect is not greater near the coil loop than some feet away indicates that orientation, or whatever causes the effect, is complete even in a rather weak field. Thorough ventilation of the room by opening windows caused the effect to fade out gradually by removal of the active particles.

The experiments with direct-current coil and battery conclusively showed that the effect was present with it as with alternating current, and incidentally established the fact that the effect on the particles is independent of the direction of magnetisation. It is doubtful if high-frequency tests would allow us to discover whether the establishment of the effect requires time. Probably not. Observations made through the axis of the loop of two turns show a minimum of effect, from which it may be inferred that it is not present if the viewing is exactly along the field-line direction.

Polarisation.—Having obtained, as described in the foregoing, a controllable and relatively brilliant source of the luminosity, tests with the Nicol's prism were resumed. It was soon noted that the polarisation was decided as controlled by the magnetic field. Moreover, the very curious fact was discovered by me, that the fumes from the iron arc were composite so far as analysis by the polarising prism was concerned. The bluish-coloured smoke arising gave but little effect, but there was with it a yellowish-grey fume, which was highly luminous in one position of viewing by the prism, and invisible when the prism was at right angles to that position. This indicates complete polarisation when the field is on for the light diffused from the particles in the yellowish-grey fumes. This is an extraordinary effect for which no explanation suggests itself, for the field lines are not straight, but wrap themselves around the coil or loop in curved directions, and the effect is apparently complete even with the fumes rising in the space where the lines are strongly curved.

It remains to use a vertical beam of light and make tests from opposite directions across the field, also to use artificial light instead of sunlight. It would seem possible to design a small demonstration apparatus consisting of a coil to be put on a battery or lighting circuit, A.C. or D.C., a small iron arc between two wires, a box with darkened interior to be filled with fumes, having two sides of glass, one for the admission of the light beam and the other a window at right angles for observation. Two coils placed outside the box space and opposite each other, or capable of application in different relations, would have advantages. Eye shields to cut out extraneous light and a tortuous chimney conveying the smoke, but cutting off the light from the iron arc, are desirable additions to the equipment, as also an analyser as part of the apparatus for the polarisation effect.

The Microscope.—Attempts have been made to catch the particles in the smoke from the arc upon a glass slide for microscopic examination as to their form under high powers. That they are exceedingly fine is evident from their remaining in suspension so long in the air and diffusing themselves rapidly through the air. That an exceedingly small amount of material suffices for making the whole air of a large room capable of showing the effect is evident also. The sunbeam may enter the room, and its course is not disclosed by them unless the magnetic field exists. It seems natural to suppose that the particles consist of some form of iron or iron oxide, but without proof this cannot be fully decided. Other particles might exist, giving such an effect, but it must be confessed this does not seem probable. Other fumes and smoke from arcs so far have given no results. The smoke from a nickel arc does not give the effect. Whether a cobalt arc will yield fumes behaving like iron smoke is not yet known.

The fumes and smoke of an iron arc were caught on a clean microscope slide until a patch of sediment of a slightly yellowish-brown tint, but very pale, was deposited. Under moderate powers very little of any definiteness is shown, but under the high power of an oil-immersion lens of about 1½ mm. focal length there is disclosed a curious structure of particles seemingly between 0·0002 and 0·0001 mm. diameter, which particles are frequently strung together, 4, 5, 6, or more, in a line, giving the effect of a short piece of chain made of small roundish particles, slightly spaced apart, or of a short section of a string of beads (round beads) not touching one another. Many of these structures appear to be straight, and some are curved. Evidently in a magnetic field these chains of particles, presumably of oxide of iron and magnetic, would line up and reflect or diffuse light of the sun striking them. If the direction of vision was such as to favour polarisation of the rays in a direction nearly at right angles to the incidence of the solar beam the polariscope effect would be accounted for measurably. Apart from polarisation, the lining up of the chains would also account for the extra *visibility* of the smoke under the conditions of the experiment.

It would seem from the foregoing that a considerable length of column of smoke from the iron arc, subjected transversely to a magnetic field, might be expected to act as a means of obtaining polarised light in the direction of the beam itself. This assumes that there will be a considerable scattering of light polarised as above described in a direction sidewise, leaving the light which passes through polarised in a plane at right angles. The apparatus might be compared in its action to a Nicol's prism, transmitting rays in one plane and throwing out laterally those in the other. This suggestion will be tested as soon as proper arrangements can be made.

The polarised light which is sent out from the smoke particles in a direction transverse to the sunlight beams, when the magnetic field is put on, is in the same plane as that reflected from a sheet of glass at the polarising angle receiving the same beam. This fact is in accordance with what might be ex-

pected if the short sections of chain or beaded particles were oriented or lined up by the magnetic field; the transverse waves of light vibrating in a plane intersecting the length of the chains would not be deflected on account of the extremely small diameter of the particles composing them, but waves vibrating in the plane of the length of the chains would be reflected to the side, and this would account for their plane of polarisation being what it is. Such waves would behave as if reflected from short rods in line with the plane of vibration, while the extremely small diameter of the rods would not sufficiently intercept the light vibrating in a plane transverse to their length.

The continuation of the investigation with artificial light and other varied conditions is anticipated.

ELIHU THOMSON.

Thomson Laboratory of General Electric Co., Lynn, Mass., May 23.

Geometrical Isomerism in Monomolecular Films.

IN the course of investigations on these films by a method differing only in details from that described by Langmuir (Journ. Amer. Chem. Soc., 1917, p. 1868) I have found striking differences between the properties of films formed from the "cis" and "trans" forms of some fatty acids containing an ethylenic linkage, which indicate that of the two pairs of acids, oleic and elaidic, erucic and brassidic, oleic and erucic are the "cis" forms and elaidic and brassidic the "trans." The results appear to be consistent with Langmuir's conception of the structure of the films, and this stereochemical configuration is that usually regarded as correct from chemical considerations.

According to the theory, the films are one molecule in thickness. With saturated acids, such as palmitic, the molecules are attracted to the water by the

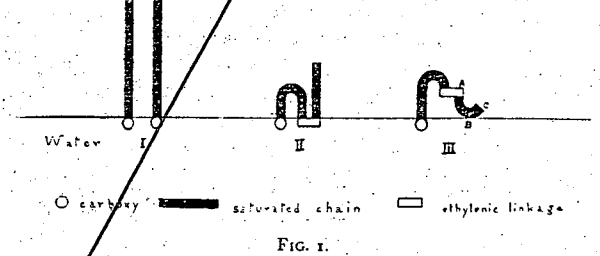

FIG. 1.

carboxyl groups, and are arranged as in Fig. 1, I. Unsaturated acids are also attracted by their ethylenic linkages, and when, as in the acids mentioned, these are approximately in the middle of the chains, the molecules in the film will take up the position in Fig. 1, II. or III. The attraction of the double bond for water is less powerful than that of the carboxyl, and when a lateral compression is applied to the film the area per molecule will diminish by some or all of the molecules straightening out to the position I.

Fig. 1 shows that a difference is to be expected between the "cis" and "trans" isomers. The double bond in the "cis" form can approach as closely as desired to the water, but in the "trans" form *the saturated portion of the chain ABC must be forced in among the water molecules*. Although it is known from stereochemical considerations that a hydrocarbon chain is flexible, yet its radius of curvature cannot be reduced below that of a ring of five carbon atoms without encountering resistance; there will, therefore, probably be a considerably greater resistance to the approach of the double bond to the water in the case of the "trans" form than in the case of the "cis."

The results obtained point clearly, I think, to a greater tendency to occupy the larger area with oleic than with elaidic acid, and a larger with erucic than with brassidic acid. Oleic acid, when first put on distilled water and a compression of about 1·4 dynes per cm. applied to the film, occupies about 40×10^{-16} sq. cm. per molecule; the area decreases steadily with time, however. Elaidic acid occupies about 30 units of area at the earliest moment when readings can be taken, and the area diminishes rapidly to about 22 units, when the film behaves like one of palmitic acid.

In the 22-carbon series there appears to be a smaller tendency than in the 18-carbon series for the double bond to approach the water. Erucic acid gives films rather similar to elaidic acid, but brassidic acid occupies the greater area for so short a time that the curves of compression of the films are not very different from those of a saturated acid such as palmitic.

It is hoped to amplify these experiments and publish full details later.

N. K. ADAM.

Trinity College, Cambridge, May 28.

Sources and Sinks.

LORD KELVIN in a paper "On the Forces Experienced by Solids Immersed in a Moving Liquid" (Proc. Roy. Soc. Edin., 1870) compared two tubes, with liquid flowing through each, with two hard steel magnets and stated that the forces are opposite in the two cases; unlike poles attracting and like poles repelling in the magnetic system, while in the hydrokinetic there is attraction between like ends and repulsion between unlike.

That two sources of like sign attract and two of unlike sign repel, as here stated, is generally accepted. An examination, however, of the case of a source and an equal sink appears to contradict this. When source and sink coincide the fluid medium is at rest, but when they are separated it is in motion and possesses kinetic energy. Work, therefore, must be done to effect the separation. This suggests that the force between source and sink is one of attraction. That this is actually the case is shown by the following experiment.

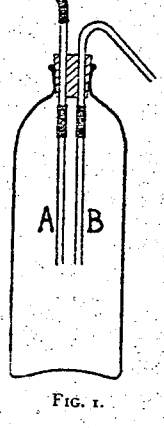

FIG. 1.

Two glass tubes A and B (Fig. 1) are connected by short lengths of rubber tubing to short tubes, which pass about 1 cm. apart through a cork in the neck of a Winchester bottle full of water. The tube A is connected to a water-supply and its open end constitutes an experimental source. The end of the tube B is an equal sink. The source and sink attract smartly and the ends of the tubes remain in contact so long as the water flows.

A. F. DUFTON.

The Royal School of Mines, South Kensington, May 25.

Polarisation Phenomena in an X-ray Bulb.

HITHERTO the potential difference required to produce a discharge through a well-exhausted vacuum tube has been considered to vary only with the pressure of the gas. In the course, however, of some experiments with an X-ray bulb (where the pressure