RECENT WORK WITH RÖNTGEN RAYS.

IN our last week's number, Prof. J. J. Thomson brought together and discussed observations of prime importance selected from the mass of material recently published on Röntgen rays. As a supplement to this, and in continuation of the general summaries which have already appeared in NATURE, we present the following notes on papers and communications received during the past few days.

Prof. Oliver Lodge has sent us the following announcement, dated April 20.

"It has been asserted that the action of X-rays on a film is a photographic one, depending on the fluorescence of the glass backing. The truth is that a film on a ferrotype plate is just about as rapid as a similar film on glass. Thick films are much better than thin. It may be further interesting to state that if the platinum disk on which the kathode rays inside the bulb are converged is connected to the kathode, it fails to act as a source; if it be insulated, it acts fairly; while if it is connected to the anode, it constitutes a vigorous source."

It will be remembered that Prof. Röntgen found that "films can receive the impression as well as ordinary dry plates" (NATURE, January 23, p. 274), but he was doubtful whether the photographic effect was secondary or not.

From a number of papers dealing with various properties of Röntgen's rays, we learn that Herren V. Novák and O. Sulc (Prague) have observed the relative opacity for X-rays of different substances, both simple and compound (*Zeitschrift für Physikalische Chemie*, xix. 3). They conclude that the absorbing powers of the chemical element depend on their atomic weight alone, and that the absorbing power of a compound depends only on the atomic weights of the elements of which it consists, and not on the complexity of its molecules. It seems probable that the *average* atomic weight of a compound affords an index of its absorbing power. In the *Jenaische Zeitschrift für Naturwissenschaft*, Dr. A. Winkelmann and Dr. R. Straubel (Jena) have investigated the refraction of Röntgen rays, and by using prisms of various metals, obtain in each case a value of about 1 : 0·0038 referred to air. They also have measured the reflection produced by a sheet of tinfoil, and the relative transparency of different kinds of glass to Röntgen radiations. All glasses made with lead are found to be comparatively opaque. The same writers have experimented on the action of fluor-spar in intensifying the actinic effects of X-rays, and have found that the best results are obtainable with a coarse powder of the fluor-spar; finer powders producing a less marked effect. This effect is due to fluorescence, the spar emitting radiations whose index of refraction is about 1·48; indicating a wave-length of 219×10^{-6}. The March number of the *Atti della Reale Accademia dei Lincei* contains two papers, one by Signor Augusto Righi, and the other a joint paper by Drs. A. Fontana and A. Umani (Rome), both of which deal with the effect of Röntgen rays in stopping the action of Crookes' radiometer. The effect is found to be purely electrostatical, and to be due to the electrification of the glass bulb containing the radiometer; when the bulb is wetted, or electrification prevented by the interposition of a conducting screen, the radiation from a Crookes' tube does not affect the radiometer in any way whatever.

Mr. A. W. Isenthal has sent us the following letter, *à propos* of Winkelmann and Straubel's paper. He says:—"It may be of interest to your readers to learn that, within the last few weeks, Prof. Dr. Winkelmann and Dr. Straubel, of Jena University, have been successful in reducing the exposure required for the production of radiograms to a few seconds only. Acting on the few directions given, I have made a few preliminary trials, the result of which is very promising. By simply backing the sensitive plate with a most inexpensive material, I have obtained fair negatives of the finger-bones in about ten seconds, using only a 3-inch spark. As the rays in this method have first to pass through the glass of the sensitive plate, there is a probability of still further reducing the necessary exposure by substituting sensitive films (on celluloid) for the ordinary photographic plate."

With reference to the use of fluorescent screens in reducing the time of exposure, we have received the following letter from Dr. H. Van Heurck, of the Botanical Gardens, Antwerp, through Dr. Wynne E. Baxter:—

"I notice in your issue of April 16, that Messrs. L. Bleekrode and J. William Gifford announce that they have been able to reduce the time of exposure in radiography by the use of a fluorescent screen. Mr. Basilewski communicated the same fact to the Paris Académie des Sciences on March 23 last. Allow me, however, to lay claim to priority in this application of fluorescent screens, as the same was announced by me in various Antwerp journals on March 8, and again on the 12th of that month, in the *Annales* (*Belges*) *de Pharmacie*, an extract from which, in pamphlet form, I send herewith. You will also find described therein a chemical substance, viz. a newly-discovered double fluoride of uranyl and ammonium, with which screens can be made, at a nominal cost, of a luminosity and of a clearness superior to that of any screen now known to exist."

The combination of a fluorescent screen with a photographic plate was one to which every worker with Röntgen rays would naturally be led. Prof. M. L. Pupin gave a description of the combination before the New York Academy of Sciences on March 2. At a meeting of the Academy on April 6, reported in *Science* of April 10, he described an arrangement of apparatus by means of which it was found possible to produce very strong photographic effects, "but not sufficiently strong for penetration through the thigh and the trunk of the human body at reasonably short exposures and at long enough distances from the tube to obtain the desirable clearness in the pictures of these massive parts. A completely successful application of Röntgen's beautiful discovery to surgery depends for the present on a successful solution of the problem just mentioned. I have obtained one satisfactory solution with the method which I first described before the Academy on March 2. It consists in placing in contact with the photographic plate a fluorescent screen, and thus transforming most of the Röntgen radiance into visible light before it reaches the sensitive film. Photographs of the hand were thus obtained at a distance of twenty-five feet from the tube with an exposure of half an hour. At the distance of four inches the hand can be photographed by an exposure of a few seconds. It was in this manner only that I succeeded in photographing on a single plate the whole chest, shoulders, and neck of my assistant, with an exposure of seventy minutes and at a distance of three feet between the plate and the tube. The collar-button and the buttons and clasps of the trousers and the vest show very strongly through the ribs and the spinal column. This result seems to prove beyond all reasonable doubt the applicability of radiography to a much larger field in surgery than was expected a few weeks ago."

A communication on the same branch of the subject has been received from Mr. A. A. C. Swinton, under date April 22. We print his letter in full.

"The chemical action of the Röntgen rays upon a photographic film may be either a direct action or may be a secondary effect, due to the fluorescence produced in the support, or in the gelatine and silver bromide of the film itself. Be this as it may, the fact that an ordinary photographic film supported on celluloid is almost completely transparent to the rays, as may easily be proved with a cryptoscope, and also the fact that it is possible to simultaneously impress many super-imposed films, show that only a very small fraction of the energy in the rays is utilised under ordinary circumstances.

"As long ago as January 30, in some remarks that I made at the close of Mr. Porter's demonstration at University College, I suggested as a means of more completely utilising the energy in the rays, and thereby shortening the necessary exposure, the use of suitable fluorescent material applied either in the form of a screen behind the photographic film, or introduced into the substance of the film itself.

"Since I first made this suggestion, I have tried numerous experiments in the direction indicated. These were at first unsuccessful owing to the screens used not having been properly prepared. Some weeks ago, however, on renewing the experiments with a screen thickly coated with potassium platinocyanide and gum, placed behind a celluloid photographic film, I obtained conclusive evidence that by this means the necessary exposure could be greatly shortened, and that in a less degree the same result could be accomplished by the employment of a screen thickly covered with powdered fluor-spar.

"The chief objection to this method lies in the fact that it is very difficult to avoid granular results. Unless the fluorescent material be in a very fairly divided condition, its grain shows distinctly and mars the detail of the finished picture. The platino-cyanide does not work so efficiently when finely powdered as when in moderately coarse crystals, but good results can be obtained by thickly coating a thin celluloid film with an emulsion of this salt ground to fine powder in collodion, and using the screen so prepared with its celluloid surface in contact with the sensitive surface of the photographic film. I have obtained considerably better results with a finely ground sample of tungstate of calcium, prepared for me by Messrs. Hopkin and Williams. This may be used either in loose powder or made up with gum into a paste and dried.

"With this substance it is easy to obtain sharp and fully-exposed negatives of the hand in from five to ten seconds with a moderately excited tube, with which, with ordinary arrangements, one to two minutes' exposure would be necessary.

"I have also tried some special plates prepared for me by Messrs. Marion, into the sensitive emulsion of which fluorescent substances such as powdered fluor-spar and calcium tungstate were introduced before application to the glass. Though the results so far obtained by this method are not very satisfactory owing to granularity, the presence of the fluorescent substance in the photographic film appears undoubtedly to increase its sensitiveness to the rays.

"There is a wide field for further research on the lines above indicated, both with regard to suitable fluorescent substances and the best method for their application."

A paper by Dr. Ferdinando Giazzi, of the Regio Istituto Tecnico, Perugia, is of importance in this connection, and the following translation of it, by Mr. G. H. Baillie, will be useful to chemists who are preparing fluorescent salts for use with Röntgen rays:

"Some days ago Prof. Ruata called my attention to the telegram sent by Edison to Lord Kelvin, and published in NATURE, according to which calcium tungstate, when suitably crystallised, showed fluorescent phenomena under the action of X-rays in a far more marked degree than barium platino-cyanide.

"I immediately consulted Prof. Bellucci, who informed me that calcium tungstate could be easily obtained from either sodium tungstate or tungstic acid, two commercial products selling at a low price. Having obtained these from the firm of Bonavia of Bologna, I set to work and produced some calcium tungstate, but in an amorphous form, which was, as far as I could test with the coil at my disposal, insensible to X-rays. I shall not describe all the attempts I made by wet and dry processes to obtain the salt in the desired form. I merely say that I never have dealt with a body so intractable. The following is the process I finally adopted in preparing it for surgical purposes. I treated a dilute aqueous solution of sodium tungstate with a solution of calcium chloride, given to me by my colleague Prof. Corneliani; I thoroughly washed the resulting pure white precipitate, and dried it at a gentle heat in a porcelain capsule. Next I made a small hole in a piece of fresh retort-carbon, and filled it with the precipitate, which I fused and boiled by means of a small flame from an oxyhydrogen blowpipe. After boiling for some seconds (at a bright white heat), I gradually removed the substance from the hottest parts of the flame, so that solidification took place only after a few minutes. In this way I obtained five globules of calcium tungstate of the required structure. I powdered them in an iron mortar and sifted the powder on to a gummed card, which I exposed in the camera to Röntgen rays. The result was most striking; I saw at once the shadow of the skeleton of my hand more clearly than I ever have with other preparations. A surgeon with this product, good Crookes' tubes. a large coil, and an apparatus such as I have arranged, could certainly dispense with the tedious process of photography.

"I publish this note for the assistance of those who perchance have not yet succeeded in preparing the invaluable tungstate in the desired form."

So far as the utility of the method of reducing exposure by means of fluorescent screens is concerned, the advantage gained must be understood only in a comparative sense. Some investigators obtain excellent results without the use of the screen in less time than others with a screen. Dr. John Macintyre, who has sent us several communications previously upon his work with Röntgen rays, has something to say about the reduction of exposure by screens, in a letter just received. He remarks:

"The object of this note is not to minimise the importance of any aid which the physicist may place in the hand of the surgeon. I have been aware of this new method, but my experience in practice has not encouraged me meantime to pursue it largely, because of want of time in developing what I consider of greater importance, viz. a better Crookes' tube. In surgery what we require may be divided into two parts: (1) rapid views of objects, and (2) permanent records. In practice we must have for the former not photographs but direct vision, and for the second, of course, rapid exposures. Now it may occasionally happen that a permanent record is desirable o. what must be done almost instantaneously. That point I think ought to be reached ere long.

"Some weeks ago I recorded a photo of the elbow-joint in $1\frac{3}{4}$ minutes, and that at a time when we did not understand the tubes as well as now. Since then I have obtained records of metallic objects in half a second, and the bones of the hand in six seconds, without the aid of fluorescent screens. What we desire most, however, in practice is a better Crookes' tube for fluorescent screens in direct vision. At present I go while the tube is being exhausted, and test the result before it is taken off the pump. When I am examining an object with the screen, or about to photograph, I heat the tube and keep the current passing through until the maximum effect is obtained. I have now seen by this means the different bones of the extremities and joints; moreover, I have no difficulty in seeing through the body itself. The spine ribs, sternum, clavicle and scapula can be seen; and I have shown to several medical men the shadow of a coin in the gullet (impacted for six months), opposite the fourth dorsal vertebra. Foreign bodies in the extremities are, as a rule, easily seen.

"For the examination of the cavities inside the head, *e.g.* the antrum, or mouth, or pharynx, also the teeth, I now place fluorescent screens in the mouth, and the Crookes' tube outside, either above or below the level of the buccal cavity as required, and sharp images are thus obtained on the screen of not only foreign bodies, but also of the bones of the face, and roots of the teeth as well.

"Other tissues than the bones are now yielding. I have photographed the side of the neck, and shown the tongue, hyoid bone, the pharygeal cavity, cartilages of larynx and trachea of the living adult subject.

"At present we cannot afford to ignore any aid, and hence we are glad to have such hints as the fluorescent screens in photography; but it is not unlikely that all such will be more or less dispensed with as a better source of the X-rays is obtained, viz. a still better Crookes' tube."

Since the above was written, and in consideration of the question at issue, Dr. Macintyre informs us that he has made a further series of experiments on the question of rapid exposures. The tube used was one of the now well-known ordinary focus tubes, made in Glasgow. He has obtained a well-defined image of metallic objects, and distinct, though faint, image of the bones of the fingers with one flash of the Crookes' tube, produced by a single vibration of the mercury interrupter, a large coil giving an eleven-inch spark, and, of course, without using any fluorescent screen. What the extent of the time of exposure was cannot be said, but he describes it as an unknown, unmeasured, small fraction of a second. In another experiment he was able to obtain a distinct image of the bones of the forearm with sixty similar flashes of the tube.

Prof. O. N. Rood found indications of reflection of Röntgen rays from a platinum surface on March 9, and on March 13, after an exposure of ten hours, he obtained a good negative, capable of furnishing prints, of a piece of iron wire netting reflected from a sheet of ordinary platinum foil and through a plate of aluminum (*Science*, March 27). The conclusion he arrived at from inspection of the image was that "in the act of reflection from a metallic surface the Röntgen rays behave like ordinary light." Experiments made to ascertain the percentage of the rays reflected, indicated that platinum foil reflected the 1/260th part of the X-rays incident on it at an angle of 45°.

Upon the question of reflection and refraction of Röntgen radiance, Prof. Pupin pointed out in his paper read before the New York Academy of Science, on April 6, that it was discussed by Prof. Röntgen in Sections 7 and 8 of his origina essay. Neither by photography nor by the fluorescent screen could Prof. Röntgen detect an appreciable refraction with certainty. A reflection from metallic surfaces in the immediate vicinity of a photographic film was detected, "but," translating Röntgen's own words, "if we connect these facts with the observation that powders are quite as transparent as solid bodies, and that, moreover, bodies with rough surfaces are, in regard to the transmission of X-rays, as well as in the experiment just described, the same as polished bodies, one comes to the conclusion that regular reflection, as already stated, does not exist, but that the bodies behave to the X-rays as muddy media do to light." "In face of these observations," continues Prof. Pupin, "Prof. Rood's and Mr. Tesla's experiments must be interpreted as a confirmation of Prof. Röntgen's results, and not as a demonstration of the existence of a regular reflection. Mr. Tesla infers regular reflection from his theory of bombardment. His experimental method is the same as that of Prof. Rood; that is, he places a reflecting plate at an angle of forty-five degrees to the direct ray, and then places the photographic plate at right angles to the direction in which the reflected ray should pass if regular reflection existed. On account of the greater power of his apparatus, his time of exposure was one hour, whereas that of Prof. Rood was ten hours. It is evident, however, that an effect upon the photographic plate does not prove the existence of regular reflection."

In his own experiments on reflection, Prof. Pupin aimed at getting rid of the photographic plate and substituting the fluorescent screen in its place.

He concludes as follows:—"These experiments prove beyond all reasonable doubt that the Röntgen radiance is diffusely scattered through bodies, gases not excepted. We may call it diffuse reflection, if we choose, provided that we do not imply, thereby, that we must necessarily assume an internal inter-molecular regular reflection, in order to explain the phenomenon. For if a puff of smoke be forced through a pile of wood, some of it will come out pretty well scattered, although we cannot speak here of a reflection in the ordinary sense, but rather of deflection, reserving the term 'reflection' for those particular cases in which the angle of incidence is equal to the angle of deflection. It might turn out, for instance, that the X-rays are due to a circulating motion of ether, and that the stream lines are deflected and diffusely scattered within the molecular interstices of ponderable substances. Appearances seem to speak more in favour of this view than in favour of a wave motion of ether. The diffuse scattering of the Röntgen radiance by bodies placed in its path may be also described by saying that *every substance when subjected to the action of the X-rays becomes a radiator of these rays*. . . . The fact that opaque bodies, like metals, are less effective in producing this secondary radiation, leads to the conclusion that there is in these bodies an internal dissipation of the Röntgen radiance much greater than in the case of transparent dielectric substances. A properly constructed bolometer should give us much information on this point, and it is my intention to take up this subject as soon as time and facilities will permit. These diffusion effects, which are present even in air, bring the Röntgen radiance into still closer resemblance to the principal features of the kathode rays which were studied by Prof. Lenard. The difference in their behaviour towards magnetic force is still to be explained. Is it not possible that this magnetic effect in air is masked by the diffuse scattering of the X-rays?"

Our American correspondent says:—"Tesla has found that the X-rays are reflected from certain metals tested in the same order as in Volta's electric contact series in air. Zinc reflects 3 per cent. at an angle of 45°. Below it stand lead and tin, but his observations do not yet show which reflects more highly. Below these in order come copper and iron about the same, then silver. His first observations led him to infer that magnesium would reflect still more than zinc, and sodium most of all. Subsequent experiment has verified the conjecture as to magnesium; but sodium has not yet been tested. By availing himself of the reflection from a zinc cone, he has taken a picture of the ribs of an assistant at a distance of four feet from the vacuum tube, and with an exposure of forty minutes. His apparatus is so constructed that the bulb or bulbs are at the large end of the cone, and the subject at the small end, where the rays are concentrated. The cone or funnel is constructed at an angle less than 30°, so that the incident rays are reflected more than 3 per cent; and especially more the small end of the funnel the rays approach within a very few degrees of parallelism with the reflecting zinc. Prof. Tesla thinks the theory that the X-rays consist of streams of radiant matter, is confirmed by these results. He has not yet been able to detect any refraction of the X-rays."

In the summary of work done in connection with Röntgen rays (page 522), we give an account of experiments made by Prof. Joly, which demonstrate the existence of reflection.

"In confirmation of these experiments," writes Mr. Alfred W. Porter, "may I point out that a similar phenomenon to that described by Prof. Joly has been present on all my skeletal radiographs. Immediately surrounding the sharp geometric shadow of the flesh of the fingers a black line exists on the *negative*. This is especially noticeable where two fingers overlap one another; the partial shadow cast by one finger preventing the deposit on the plate from becoming so dense as to obscure th presence of the black line. I enclose a *positive* which shows th presence of the corresponding white line very clearly. M attention was first called to the presence of this line on my pictures on January 28, by Mr. John T. Morris, of this College. I believe that the prominence of the finger-nails is due to the same cause. I have also taken graphs of over-lapping wood, metal, and ivory objects which exhibit the same phenomena."

We have received the prints referred to by Mr. Porter, and they entirely bear out his description of the appearance presented.

For some time past Prof. FitzGerald and Mr. Fred. T. Trouton, at Trinity College, Dublin, have sought evidence of crystalline action, both on transmission and reflection at grazing incidence of Röntgen rays. Though so far this has been without success, we learn that they have noticed a marked scattering of the rays in transmission through some substances. The following arrangement is convenient for showing this. "On a plate of lead, which has a slit cut in it, is placed a sheet of, say, solid paraffin 2 or 3 m.m. thick, so as to cover one end of the slit; over this is laid a strip of lead—but slightly wider than the slit—so as to just entirely cover the slit. No direct radiation then can pass from a Crookes' tube, placed vertically over the slit, to a sensitive plate placed behind the lead; but with a lengthened exposure (20 to 30 minutes) with a focus tube, a darkening is found on developing at the end where the paraffin is placed. If the paraffin be then moved to the centre or other end, so as to eliminate accidental effects, on again exposing the darkening action is found to follow the paraffin. Some darkening always occurs even where there is no solid body. How much of this is due to successive reflections from the lead sheet and strip, or how much is due to scattering of the rays by air, is not easy to say."

Mr. Dayton C. Miller has obtained some good results at Case School of Applied Science in Cleveland, Ohio, U.S.A., but the exposures he finds necessary are longer than those given by the foremost workers in Great Britain. The tube used by him is spherical in shape, and about five inches in diameter. The coil gives a six-inch spark in air, and is excited by a current of about sixty watts, obtained from fifteen cells of storage battery. The voltage used varies from twelve to twenty. With this apparatus and power, Mr. Miller says:—

"The bones of the fingers are distinctly shown with exposures of ten seconds, while exposures varying from two to ten minutes are regularly used in locating bullets and shot in the hand, and in examining injured or deformed hands. An excellent picture of a hand and fore-arm, placed diagonally across an 11 × 14 plate, has been made with twenty minutes' exposure. The entire detail of the lettering and design of an aluminium medal has been taken in five minutes. Numerous interesting surgical cases of fractured and diseased arm-bones have been examined with satisfactory results. Photographs of the chest and head have been made with exposures of one hour in each case. A surprising amount of detail is visible. The chest picture shows the shoulder-joint, the collar-bone, the spinal column with its articulations, and a dark streak along its length corresponding to the spinal cord, and eight ribs on each side of the spine. In the region of the heart the detail is less conspicuous, indicating that the heart is more opaque than the lung tissue."

Mr. W. L. Goodwin, of the School of Mining, Kingston, Canada, has sent us the results of experiments made to determine the relative opacities of various substances to Röntgen rays. The only details as to the method employed is that the results were obtained "by photography with a small Crookes' tube similar in shape to a radiometer, but constructed to show the revolution of a platinum vane covered on one side with mica." The relative opacities thus determined are as follows:—

I. SOLIDS:—

Transparent: Paraffin wax, wood charcoal, coke (in part), asphalte, albertite, starch, diamonds.

Fairly transparent: Citric acid, jet, anthracite, amber, natrolite, caustic potash, caustic soda, borax, soda crystals.

Somewhat transparent: Silicified wood, Epsom salts, serpentine, staurolite, stilbite, lazulite, $H_2(NH_4)PO_4$, cryolite, Mohr's salt, analcite, Na_2CO_3, borax glass, nitre, Rochelle salt.

Somewhat opaque: Mica, tourmaline, wulfenite, axinite, spinel, calcite, aragonite, kaolin, $NiSO_4(NH_4)_2SO_4.6H_2O$, $NiSO_4.K_2SO_4.6H_2O$, &c.

Opaque: Roll sulphur, crystal of rhombic sulphur, fluorspar, topaz, beryl, ruby, quartz, NaCl, chalco-pyrite, $H_2(NH_4)AsO_4$, H_2KAsO_4, K_3FeCy_6, $K_2Cr_2O_7$, orpiment, anhydrite, celestine, barite.

Sulphuric acid is as opaque as the same thickness of sulphur. Water is more opaque than paraffin wax.

A number of crystals of about the same thickness were photographed on the same plate, and an attempt made to judge of their relative transparency with a scale from 1 to 10, with the following results:—

H_2KAsO_4	1
$H_2(NH_4)AsO_4$...	2
$NiSO_4.(NH_4)_2SO_4.6H_2O$	3
$MgSO_4.K_2SO_4.6H_2O$...	3
$NiSO_4.K_2SO_4.6H_2O$	3·5
$MgSO_4.(NH_4)_2SO_4.6H_2O$	4
$ZnSO_4.(NH_4)_2SO_4.6H_2O$	4
$CoSO_4.K_2SO_4.6H_2O$	4
$CoSO_4.(NH_4)_2SO_4 6H_2O$	4
$H_2(NH_4)PO_4$	5
Paraffin wax	10

The different values of arsenic and phosphorus in the isomorphous acid arseniates and phosphates are to be remarked.

Thin sections of a granite composed principally of quartz and feldspar and of a hornblende-gabbro were photographed. In both cases the feldspar was found to be distinctly more transparent than the other constituents.

Prof. E. Doelter, of Graz, has communicated to the *Naturwissenschaftliche Verein für Steiermark* some observations relating to the opacity of different rocks and minerals for the Röntgen rays, and their use as providing a test of the genuineness of precious stones. Dr. Doelter finds that (1) the opacity does not always increase with the density, although minerals having a specific gravity greater than 5 are relatively opaque; (2) the complexity of the chemical constitution of a mineral affects its opacity, but no general law of relationship can be enunciated; (3) dimorphous minerals exhibit but slight differences in their behaviour with regard to the rays in their different forms; (4) in most crystals, the amount of absorption does not depend sensibly on the direction of the incident rays; (5) all minerals naturally fall into about eight well-defined groups, according to their opacity, the order being as follows: diamond, corundum, talc, quartz, rock-salt, Iceland spar, &c. The diamond is ten times as transparent as corundum, and 200 times as transparent as tinfoil.

Mr. W. Ackroyd and Mr. H. B. Knowles have systematically examined the opacity of a number of substances for Röntgen rays, with a view to determining whether it bears any relation to molecular weight (*Journal* of the Society of Dyers and Cleaners, April).

With this view they have compared the isomorphous sulphates, $RSO_4, 7H_2O$ of the eighth group of metals, iron, nickel, and cobalt; the oxides, RO, of some members of the second natural group, viz. magnesium, zinc, and mercury; the isomorphous oxides, R_2O_3, of the metals aluminium, chromium, and iron. In each of these series there are presumably similarly shaped molecules for comparison, and the disturbing factor is the difference of molecular weight. The result of an hour and a half's exposure showed that the alumina was practically transparent, the chromium sesquioxide semi-transparent, while the ferric oxide was opaque. In other words, the opacity of the substance was in some direct relation to the molecular weight. There are here marked differences with big jumps in molecular weights. The same observation applies to the oxides of magnesium, zinc, and mercury. The isomorphous sulphates of iron, nickel, and cobalt are extremely interesting, because of the nearness of the specific gravity numbers, and also of the molecular weights. The iron compound, with lower specific gravity and molecular weight, appears to be the least opaque of the three, while the nickel and cobalt compounds of nearly the same specific gravity and molecular weight have approximately the same degree of opacity. The following table correlates these facts with other properties:—

Compound.	Sp. gr.	Molecular weight.	Colour.	Behaviour to Röntgen rays.
$FeSO_4, 7H_2O$	1·85	278	Light green	Slightly less opaque than others in this group.
$NiSO_4, 7H_2O$	1·95	280	Deep green	About the same relative opacity.
$CoSO_4, 7H_2O$	1·92	281	Pink	
Al_2O_3	4·00	103	White ...	Transparent.
Cr_2O_3	4·99	153	Green ...	Semi-opaque.
Fe_2O_3	5·13	160	Brown ...	Opaque.
MgO	3·42	40	White ...	Transparent.
ZnO	5·47	81	White ...	Semi-opaque.
HgO	11·13	216	Red	Opaque.

The foregoing figures, conclude the authors, demonstrate the weakness of an unqualified law of density, as the denser oxide of zinc is more transparent than the less dense ferric oxide. But they point out that, adopting the legitimate method, which they have initiated, of comparing only compounds with kinship, each of the above bodies conforms to the law of density as well as of molecular weight in relation to opacity.

Dr. A. Sella and Dr. Q. Majorana (*Rend. R. Accad. dei Lincei*) describe certain experiments on the influence of Röntgen rays on the sparks produced by the discharge of an induction coil in air. The sparking distance is found to be shortened by the Röntgen rays, this effect taking place whenever these rays fall on the positive pole. In this respect the phenomenon is the reverse of that obtained by Hertz with ultra-violet light, the effect of which is to lengthen the sparking distance whenever it falls on the negative pole. The authors found that the simultaneous actions of Röntgen rays and of ultra-violet light could be made to neutralise each other by arranging the coil to give a spark of suitable length (in their experiments about 30 mm.). When the sparking distance was less, the Hertz effect predominated; when the sparking distance exceeded 30 mm., the Röntgen rays had the greater influence.

Dr. Filippo Campanile and Dr. Emilio Stromei communicate to the *Rendiconto dell' Accademia delle Scienze fisiche e matematiche* (Naples) a note on the phosphorescence and the Röntgen rays in Crookes' and Geissler's tubes. The conclusions arrived at are as follows: (1) When in the circuit of an induction coil, containing a Crookes' tube, a spark is thrown off from the positive pole, the phosphorescence of the tube and the efficacy of the Röntgen radiations are augmented. (2) As the length of the spark increases the phosphorescence at first increases to a maximum, and then decreases. (3) If, on the other hand, the spark is thrown off from the negative pole, the phosphorescence and the Röntgen rays are thereby diminished. The same experimenters have also succeeded in obtaining Röntgen rays with an ordinary Geissler's tube. These radiations possessed all the characteristics of those which emanate from a Crookes' tube.

Signor E. Villari, writing in the same journal, considers that the phenomena of discharges in tubes seem to indicate the existence not only of kathodic but also of anodic rays. While the kathodic rays travel in straight lines and produce a negative charge wherever they strike the tube, the suggested anodic rays diffuse themselves all round the anode, and communicate a positive charge to the whole surface of the tube over which they are diffused.

The fundamental character of the new rays has led speculators to make various surmises as to a possible connection between these radiations and the phenomenon of gravitation, and two lengthy memoirs have been written on the subject by Rudolf Mewes.[1] In the second of these the author claims to have proved experimentally that gravitation is propagated through the ether with the velocity of light.

Finally, attention may profitably be called in this summary to the April number of the *Proceedings* of the Physical Society. In the admirable collection of abstracts of physical papers there published, will be found concise descriptions of the scope and results of no less than forty papers concerned with Röntgen rays.

1 "Licht Electricitäts und X-Strahlen" (pp. 54); "Die Fortpflanzungs-Geschwindigkeit der Schwerkraftstrahlen" (pp. 93). (Berlin: M. Krayn, 1896.)