NOTES FROM THE RESEARCH LABORATORY, GENERAL ELECTRIC COMPANY.*

X-RAY CHEMICAL ANALYSIS.

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THE method of X-ray crystal analysis developed in the Research Laboratory of the General Electric Company just before the war is being further developed, as a method of chemical analysis, which promises to have a very wide and new field of application in that it gives evidence which other methods do not supply, namely, the form of chemical combination of each of the elements present.

The method consists in reducing the substance to be examined to powder form, placing it in a small glass tube, sending a beam of monochromatic X-rays through it, and photographing the diffraction pattern produced. The only apparatus required is a source of voltage, an X-ray tube, and a photographic plate or film. The amount of material necessary for a determination is one cubic millimeter. The method is applicable to all chemical elements and compounds in so far as they are crystalline in form.

The rays from the X-ray tube pass first through a filter, which absorbs all but a single wave length, then through two slits, which confine them to a narrow beam (about 1 mm. wide); then through the powdered material, which scatters or "reflects" a very small fraction of them; and thence to the centre of the photographic film. An exposure of from one to twenty hours is required, according to the amount of information desired.

When the film is developed it shows, in addition to the over-exposed line in the centre, where the direct beam strikes, a series of other lines on each side of the centre. These lines are caused by the "reflections" of the X-rays from the tiny crystals in the powder. Their distance from the centre of the film depends on the distance between the planes of atoms in the crystal, and there is one line for every important set of planes in the crystal. It is evident, therefore, that substances with different crystalline structures will give entirely different patterns of lines. Substances

* Communicated by the Director.

of similar chemical nature and therefore similar crystal structure give similar patterns, but the magnification or spread of the pattern is different for each one, being inversely proportional to the cube root of the molecular volume. Since no two similar sub-

FIG. 1.

stances have *exactly* the same molecular volume it is easy to distinguish them, as the difference is cumulative for lines far from the centre. A further distinguishing mark is the relative intensity of the different lines which differs greatly even in the most closely

FIG. 2.

related compounds, depending on the relative shapes and sizes of the atoms in the compound.

A knowledge of the theory of the production of these lines, and their relation to the crystalline structure of the substance, is not essential to their use for chemical analysis. All that one needs to use in a chemical analysis is the fact that every crystalline substance gives a pattern; that the same substance always gives the

same pattern; that no two different substances give the same pattern; and that in a mixture of substances each produces its pattern independently of the others, so that the photograph obtained with a mixture is the super-imposed sum of the photographs that would be obtained by exposing each of the components separately for the same length of time. This law applies quantitatively to the intensities of the lines, as well as to their positions, so that the method is capable of development as a quantitative analysis.

As illustrations of the general type of photographs obtained with simple compounds and elements, Fig. 1 shows a series of isomorphous alkali halogens, illustrating their similarity of pattern and their differences in spacing and intensity; and Fig. 2 gives a series of dissimilar substances, illustrating their different types of pattern.

Several actual analyses have already been made which will be described in detail elsewhere.¹ It has been found very easy to recognize at a glance each component in a three component mixture and in the case of the simpler salts many more than this could certainly be identified. Accurate quantitative tests have not yet been made, but it is anticipated that an accuracy of one per cent. will be easily obtainable, for components present to the extent of one per cent. or more of the whole sample.

Waste of Chemicals in Pulping Unbarked Wood by the Sulphate Process. ANON. (*Forest Products Laboratory, Madison, Wisconsin, Technical Notes No. C-5.*)—In the manufacture of sulphate and mechanical pulp, all bark must be removed from the wood before chipping or grinding, since any fragment of bark finding its way into the pulp makes its appearance as minute black specks in the finished sheet. For soda or sulphate pulp, the cleaning is often not so thorough, since the alkaline digestion tends to destroy the bark. Some mills bark the wood partly or not at all in the manufacture of sulphate pulp.

To determine the amount of chemical required to pulp unbarked wood, shipments of unbarked shortleaf yellow pine chips and of clear bark were tested by the Forest Products Laboratory of the U. S. Forest Service, at Madison, Wisconsin.

A determination upon a 10-pound sample showed that the unbarked chips contained approximately 96 per cent. wood and 4 per cent. bark, on a bone dry basis. Sulphate pulping trials on clear bark showed that 28.6 pounds of caustic soda and 10.6 pounds of

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