with $\beta' = 180^{\circ} - \beta$. Symbol (*h0l*) transforms to (*h'0l*). From the equation of the trace of the (*h0l*) plane and the equation of 0a',

$$h(x/a) + l(z/c) = 1$$

and

$$z = x \cos \beta'$$
,

we find x_0 , the abscissa of the point of intersection Q of the two lines. We then obtain

$$h' = h + ql,$$

$$q = (a/c) \cos \beta'.$$

As an example let us take the calculation of a two-dimensional Fourier series in "ferri-annite," a one-layer monoclinic synthetic iron mica,

$$KFe_{3}^{2+}$$
 (Si₃Fe³⁺) O₁₀ (OH)₂,

which crystallizes in space group C2/m. With the axes zx' and the mesh ca', the electron-density projection onto (010) is given by (2):

$$\rho(x',z') = \frac{1}{A} \sum_{l'} \sum_{h'} F(h'0l') \times \cos 2\pi (h' \frac{x'}{a'} + l' \frac{z'}{c}),$$

(where $A = ca' = ca \sin \beta'$ is the mesh area) or, replacing h' by its value and noting that F(h'0l') = F(h0l), by

$$\rho(x',z') = \frac{1}{A} \sum_{l} \sum_{h} F(h0l) \times \cos 2\pi \left[(h+ql) \frac{x'}{a'} + l \frac{z'}{c} \right],$$

where (h0l) refers to the mesh *ca*. For the practical summation we write

$$\rho(\mathbf{x}',\mathbf{z}') = \frac{2}{A} \left(\sum_{l=0}^{L} C'_{l} \cos 2\pi l \frac{z'}{c} \right) - \frac{2}{A} \left(\sum_{l=1}^{L} S'_{l} \sin 2\pi l \frac{z'}{c} \right),$$

with

$$\mathbf{C'}_{i} = \mathbf{C}_{i} \cos 2\pi q l \frac{x'}{a'} - \mathbf{S}_{i} \sin 2\pi q l \frac{x'}{a'},$$
$$\mathbf{S'}_{i} = \mathbf{S}_{i} \cos 2\pi q l \frac{x'}{a'} + \mathbf{C}_{i} \sin 2\pi q l \frac{x'}{a'},$$

and

$$\mathbf{C}_{l} = F(00l) + \sum_{h=1}^{H} \left[F(h0l) + F(\overline{h}0l) \right] \times \cos 2\pi h \frac{x'}{a'},$$

for l > 0,

$$C_0 = \frac{1}{2} F(000) + \sum_{h=1}^{H} F(h00) \cos 2\pi h \frac{x'}{a'},$$
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Fig. 2. Electron-density projection of monoclinic mica "ferri-annite" onto ca' plane. The parallelogram (or asymmetric domain) is one-quarter of the mesh. Contours are drawn directly on the print-out. x' increases from left to right, z' from top to bottom (see numbers along left edge).

for
$$l = 0$$
,

$$S_{l} = \sum_{h=1}^{H} [F(h0l) - F(\overline{h}0l)] \sin 2\pi h \frac{x'}{a'}$$

The summations C_i and S_i are carried out over integral values of h; they are given the ordinary summation formulas for space group C2/m. The only change required by introduction of the nonintegral h' indices is that, in summations over l, the coefficients C'_i and S'_i must be used instead of C_i and S_i .

The value of q is constant for a given mesh ca, so that for fixed l and (x'/a')a'), the sine and cosine of $2\pi q l(x'/a')$ are also constant. In order to avoid having to compute these values for every l and (x'/a'), we use the formulas for the cosine and sine of the sum of two angles, in the following form:

$$\cos 2\pi \frac{p+1}{M} =$$

$$\cos 2\pi \frac{p}{M} \cos 2\pi \frac{1}{M} - \sin 2\pi \frac{p}{M} \sin 2\pi \frac{1}{M},$$

$$\sin 2\pi \frac{p+1}{M} =$$

$$\sin 2\pi \frac{p}{M} \cos 2\pi \frac{1}{M} + \cos 2\pi \frac{p}{M} \sin 2\pi \frac{1}{M},$$

where M is the number (not necessarily integral) of subdivisions in the period and p is an integer. These formulas have to be applied twice, as l and (x'/a') are made to increase. They are also used to compute $\cos 2\pi X$ and $\sin 2\pi X$, which are needed in Takahashi's formulas.

The next step is to produce an undeformed map. This is done as in the case of the orthogonal mesh (see above). The map obtained (Fig. 2) is on the scale of 1 angstrom to 2 inches on the print-out. The horizontal edge a' was divided into 53.475 parts; the vertical edge c, in 123.84 parts. With two digits the value of the function may increase from -9 to 109 (printed as 09).

For a three-dimensional triclinic synthesis, the method could be generalized, the triclinic cell being replaced by a rectangular parallelepiped, or else printed rectangular sections could be stacked with the appropriate offset for the inter-section spacing.

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 Although the z axis remains the same (c' = c),
- 2. Although the z axis remains the same (c' = c), the z coordinate changes and is therefore designated z'. Thus $z'/c \neq z/c$, but x'/a' = x/a.
- ignated z'. Thus $z'/c \neq z/c$, but x'/a' = x/a. 3. Paper presented at a symposium of the International Union of Crystallography, Rome, Italy, 17 Sept. 1963. Work supported by the National Science Foundation (GP 1565). Computations performed on I.B.M. 7094 at the Johns Hopkins computation center. Gabrielle Donnay and Charles W. Burnham kindly read the manuscript.

29 October 1963

Natural Carbon-14 Activity of Organic Substances in Streams

Abstract. Carbon-14 measurements made on organic contaminants extracted from streams show percentages of industrial waste and domestic sewage. The method, used previously for studies of the atmosphere, can be used in studies of pollution sources.

The two most important sources of organic chemical pollution of water are industrial wastes and domestic effluents (sewage). It is desirable to distinguish between these substances in streams in order to plan abatement measures, for they injure water quality in different ways. By recovering the organic substances from a polluted stream

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Table 1. Carbon-14 assays of organic extracts from streams.

Extract	Conc n. (parts in 10 ⁹)	Contem- porary carbon (%)	Sample No.*
Raw wat	ter with in Nitro, V	ndustrial poll V. Va.	ution,
Chloroform	1673	5 ± 2	W-1014
Ethanol	297	42 ± 2	W-1081
Tap water poli	with dom ution, Cin	estic and in cinnati, Ohio	dustrial
Chloroform	120	50 ± 2	W-1079
Ethanol	288	66 ± 2	W-1080
Raw wate petroleu	r with nat m pollutio	ural, domest n, Whiting,	ic, and Ind.
Chloroform	202	30 ± 2	W-1015
Ethanol	269	72 ± 2	W-1013

* U.S. Geological Survey radiocarbon laboratory.

and determining their carbon-14 activity, it is possible to estimate the relative contributions of both types of organic wastes. The method considers that domestic (or "municipal") wastes consist primarily of animal and vegetable matter in garbage and sewage. These are contemporary in their content of the radioactive isotope, carbon-14. Conversely, organic industrial wastes are discharged by industries that utilize nonradioactive fossil carbon materials-coal, petroleum, or natural gas. A similar determination has been made (1) of the sources of air pollution.

The sample of organic contaminants required for carbon-14 assay is recovered from the stream by use of an activated carbon filter sampling system (2). Adsorbed organics are recovered by successive extraction with chloroform and with 95-percent ethanol. Industrial wastes are usually concentrated in the chloroform extract, whereas the more polar compounds of domestic wastes are more abundant in the ethanol extract. The weight ratio of these two extracts is in itself an indication of the type of pollution source.

The described premise is, of course, a simplification. Domestic wastes may contain a portion of fossil compounds, such as detergents and antifreeze. Industries dealing with vegetable and animal matter, such as dairies and canneries, have been classified as "domestic" because of the nature of their wastes. Finally, to a limited and unknown degree, natural biological cycles of oxidation and photosynthesis may rearrange a portion of both the contemporary and fossil carbon (organic and inorganic) in the stream into new organic compounds resembling those of domestic waste. Nevertheless, experimental data appear to justify disregarding these factors in a first approximation, for the results of several isotope assays agreed with the actual pollution sources, where these were known.

Organic chemical contaminants were collected from surface waters representing three classes of pollutional situations. The contamination of the Kanawha River at Nitro, West Virginia, is almost entirely due to chemical industrial wastes. At Cincinnati, the Ohio River reaches a maximum loading of organic products of both industrial and domestic origin and the products have had opportunity for oxidative stabilization. Samples from Lake Michigan at Whiting, Indiana, represent water containing oxidized natural and sewage organics, together with the discharged wastes of many petroleum refineries.

For carbon-14 assay the tar-like samples were converted to acetylene for counting in the radiocarbon dating apparatus of the U.S. Geological Survey. Difficulty was encountered in burning the samples in the oxygenflow atmosphere customarily used, so a double-tube method was employed. The samples, in combustion boats, were heated in flowing nitrogen which swept the combustible vapor to an orifice, where oxygen was introduced. There the gas burned, providing a slower and more complete oxidation. The carbon dioxide was collected and converted in steps to a carbonate, a carbide, and purified acetylene, as described by Suess (3). The radiometric determinations were made in proportional counters of 1liter capacity at 1 atmosphere pressure, with counting times of 2 days for each sample. Results are reported in percentage of contemporary carbon, and the contemporary carbon is taken to be 95 percent of the radiocarbon oxalic acid standard, a convention agreed on by all carbon-14 laboratories.

The results of carbon-14 assays of the organic extracts, expressed as percentage of contemporary carbon, are shown in Table 1. Carbon-14 assay reveals proportions of fossil and contemporary carbon that are consistent with our knowledge of the pollution sources at the three sampling sites.

The samples from Nitro show the preponderantly industrial origin; the samples from Cincinnati show that the major portion of the organics was of biological origin. The results with the samples from Whiting clearly show two classes of pollutants, with the petroleum materials effectively concentrated in the chloroform extract.

Further applications of the method will be made. A particular effort is being directed to the assay of single classes or isolated compounds among the organic contaminants, with the objective of discerning whether specific contaminants are of natural or industrial origin when both sources are possible.

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13 February 1964

Explosive Welding with Nitroguanidine

Abstract. By using the explosive nitroguanidine, continuous welds can be made between similar and dissimilar metals. Since low detonation pressures are attainable, pressure transfer media are not required between the explosive and the metal surface. The need for either a space or an angle between the metals is eliminated, and very low atmospheric pressures are not required. Successful welds have been made between tantalum and 4140 steel, 3003H14 aluminum and 4140 steel, and 304 stainless steel and 3003H14 aluminum.

The explosive nitroguanidine (CH₄N₄O₂) has been utilized extensively at this laboratory, since 1959, for research in explosive-metal working. The primary advantage of its use in this field is its detonability in practice at bulk densities from 0.11 to 1.7 g/cm³, corresponding to computed detonation velocities from 1890 to 8270 m/sec and