demand for all classes of British pottery was every year increasing in the United States, and the other English-speaking nations of the New World and the Old. Apart from this, pottery was coming into growing demand for many purposes to which it had never before been generally applied in this country. The National Liberal Club, in Whitehall Place, London, was an illustration of the pleasing effects to be obtained by covering the walls of ordinary living-rooms and house passages with enameled tiles. In the Brompton Road, London, a house is now being completed, the whole front of which is covered with enameled tiles of deep-toned brown. Nothing can be more magical than the play of the slanting shafts of the light of sunrise and sunset on these tiles. The Birkbeck Bank in Southampton Buildings, off Holborn, London, is being entirely renewed in polychrome pottery, not only the ornamentation, but the entire architectural construction, so far as it appears externally, of the building being rendered in variously and vividly colored enameled terra-cotta. Of course, pottery readily yields itself to excess of elaboration in decorative details, and some will possibly feel that this has happened with the Birkbeck Bank, both in the plastic ornamentation and the coloring of the building; but, none the less, it is a hopeful illustration of what can easily be done to render the streets of London, and other smoky cities of the United Kingdom, as clean, and bright, and cheering in the future, as at present they are dirty, dull, and depressing. The greater part of London, and of Manchester, might rapidly be rebuilt in enameled terra-cotta, and with the finest effects of both foreground and distance, and with the most charming flamboyance of softened coloring along the skylines. In Lambeth both scenic stoneware and earthenware are now being largely introduced in the internal decoration of public houses. The tap-room of one of them has lately been lined with a polychrome representation of the Lambeth bank of the Thames one hundred years ago, showing the house as it then stood. Nothing could be more attractive. There is, of course, no limit to the potential demand for enameled tiles and decorative stoneware for these and similar applications. The internal decoration of St. Paul's also at once suggests how profitable it would be for the potters of this country to take up the manufacture of earthenware and stoneware, if not of glass, mosaic cubes or "tesserae," for the external and internal decoration of public and even private buildings. A great outcry has been raised against the decoration of St. Paul's with mosaic. The practical answer to it is to visit the Cathedral as the work progresses, and I am glad to say that it is progressing without interruption, and to see it in the varying lights and shades of dewy morn and dusky eve and unclouded midday. Words cannot describe the stately splendor of the magnificent and enchanting vision that rises before you in the choir—divine in art of color and design; and when the whole work is completed, this achievement of the self-denying piety of the Dean and Chapter of the Cathedral, and of the genius of Sir William Richmond, will be regarded in all future time as the crowning architectonic glory of Victorian reign. That the outcry against it should have received any semblance of official support is nothing short of a national scandal.

I have said nothing of the use of unglazed tiles and unglazed terra-cotta mouldings in house building and decoration. There are two highly ornamental chimney-pieces, of dull brick-red terra-cotta, almost as hard, to all appearance, as unpolished jasper, in the Council Reading Room of the India Office, which deserve more attention from architects and decorators than they have received; and the Science Schools, at South Kensington, and the Natural History Gallery (British Museum), opposite to it, are two notable examples of buildings of unglazed terra-cotta. But the objection to its use in both these examples is that it is intentionally made to simulate stone, with the result of painfully disillusioning the admiring student of the noble architectural frontage of the latter building when once the imposition is exposed. The deception in this building is the more difficult of detection owing to the "bonding" of the terra-cotta blocks after the manner of stone masonry.

There is another application of pottery, in the production of bright, showy trinketry. The Egyptians were great adepts in it, enhancing the brilliance of the variegated enamels used in the first firing, by leaving depressed points on the surface of the objects [usually of a prophylactic, phalacerial, or talismanic character], into which fragments of richly-colored glass were fixed, and fused by a second firing. Gayly painted, and carefully modeled in the minutest details, this dainty trinketry was in design and subtlety of artifice a triumph of the potter's craft, and, indeed—to say so without offense—of his craftiness. Stoke might do much in this way to cut out Birmingham, and there would be nothing of the tarnish of "imitation"—of "Brummagem"—about such figural jewelry.

THE ARTISTIC EDUCATION OF THE ARTISAN.

To secure this future, the indispensable requirement was to advance in every way the technical and artistic education of the British potter. That is too large a subject to treat fully in bringing my remarks to a close. I will only say on the point that it is as true of pottery as of all other artistic industries, it is indeed more true, as clay responds so readily to one's mental suggestions, that the skill of the artisan can be perfected only in the education—the drawing out—of his artistic ideals; and that two things are essential to this. The first is to intimately familiarize the potter with the best examples of his art, and, above all, with the masterpieces of the Greek potters. One has to insist on this in an unhistorical age, in which men are apt, in their degrading ignorance of tradition, to rely too exclusively on their technical proficiency, and overweening conceit of themselves. The second essential, and still greater thing, is fortunately innate in all the Aryan races, and deeply implanted in the British races, and that is the simple love and diligent study of nature; the love of our green hills and dales, of the bright flowers of our fields and lanes, the birds that fill our rejoicing skies with song, and the shells and other strange sea things the surging waves wash up on our shores, the colors of sunrise and sunset, and the jeweled constellations of the midnight heavens. The love of these things must be fostered in every way; for, quoting from Longfellow, whose *Keramos* this ex-

hibition and its neighborhood have vividly recalled to my memory:

"Art is the child of Nature; yes,
Her darling child, in whom we trace
The features of the mother's face,
Her aspect and her attitude,
All her majestic loveliness
Chastened, and softened, and subdued
With a more attractive grace,
And with a human sense imbued.
He is the greatest artist then,
Whether of pencil or of pen,
Who follows Nature. Never man
As artist or as artisan,
Pursuing his own fantasies,
Can touch the human heart, or please,
Or satisfy our nobler needs,
As he who sets his willing feet
In Nature's footprints, light and fleet,
And follows fearless where She leads."

METHODS OF DETERMINING THE FREQUENCY OF ALTERNATING CURRENTS.

By CARL KINSLEY, M.E., in The Electrician, of London.

THE engineer may wish to obtain a cyclical variation of the speed of an alternator; or possibly the

FIG. 1.

exact determination of the changes of speed due to sudden variations of load may be of great importance. An experimenter with alternating currents always needs immediate and correct values of their frequency. It will be of interest to give a review of the methods that have already been used, and to suggest a new method that is easy to use and that may be employed with an error of less than one-fourth of one per cent.

FIG. 2.

The first method one considers is that of a synchronous motor and a speed indicator. If the timing is done with a watch, there is an unavoidable error of at least two per cent., and the value obtained is the total number of revolutions for, say, half a minute instead of the instantaneous value. A second method is one that has been employed by Prof. S. P. Thompson.* Several turns of wire are placed about the wire carrying

The difficulties with this method are that the forks of sufficiently slow period for the frequencies now commonly used are unwieldy, and the range that can be covered by a single fork is very limited.

A third method that has many advantages employs the resonance of an air column as the frequency indicator. A telephone is made to respond, either directly or by induction, to the alternating current. It is found that the fundamental of the telephone has a periodicity equal to that of the alternating current. There are also present all of the harmonics in succession up to the thirty-fifth, in some cases.

Fig. 1 will show how an air column may be made to respond to these notes. (A 1.5-inch drawn brass or glass tube is used. Internal diameter = 3.45 cm.) From the observed lengths of the air column find from the curve, Fig. 2, the periodicity of two successive harmonics. The greatest common divisor of the periodicities will be the frequency of the fundamental, which is the frequency of the alternating current. As an illustration:

Temperature 25° C.

Length Giving Resonance.	Frequency of the Harmonic.	
19.1	420.0	(1)
16.5	480.0	(2)

The greatest common divisor is 60. Hence the alter-

nating current has 60 periods per second, or 7,200 alternations per minute. No. 1 is then the 7th and No. 2 the 8th harmonic.* After the number of a harmonic is known, then it can be used alone to determine the variations in the frequency of the alternating current. This method can be used with an accuracy of one-half of one per cent., and is of great service, as no preliminary calibration of apparatus is needed. It is inconvenient in that the temperature must be taken, and being a sound method, upon the skill of the observer depends the accuracy with which it can be used.

A fourth method is one proposed first by Profs. Ayrton and Perry.† This includes an iron wire that is set into resonance by an electromagnet which is energized by the alternating current. The periodicity of the wire can be varied by changing the stretching load. Fig. 3 shows an arrangement of the apparatus. The period of the vibrating wire can be obtained from the equation‡

$$t = 2l\sqrt{\frac{\pi\gamma\delta}{T}} \dots\dots\dots (1)$$

t = time of one complete vibration in seconds,
 l = length of the string in centimeters,
 r = radius of the string in centimeters,
 δ = density of the material,
 T = stretching load in dynes.

Some of the difficulties accompanying the use of this method are mentioned by Lord Rayleigh.§ The periodicity cannot be determined with precision without a refinement of apparatus and manipulation—including temperature determinations and calibration of the wire—that makes its use inadvisable.

A fifth method|| was proposed by Mr. Albert Campbell, who used a vibrating iron strip, whose periodicity was varied by changing its length. Fig. 4 gives his arrangement of apparatus. The length of the strip was changed until the rod vibrated in synchronism with the alternating field of the magnet. The periodicity of the rod can be computed from the equation¶

$$t = \frac{2\pi l^2}{k\delta m^2}$$

FIG. 3.

the alternating current. A hand telephone connected to these turns then gives a note which has twice the periodicity of the alternating current. If a tuning fork of known period, which is about the same as that of the alternating current, is now sounded near the telephone, there will be heard a succession of beats which in number will equal the difference in frequency between the telephone and the tuning fork. For instance, let

f = number of complete vibrations per second = 240.
 b = number of beats per second = 2.
 n = telephone frequency.
 p = alternator frequency.

Assume that the frequency of the fork is less than that of the telephone. With a little practice it is easy to tell whether the frequency is greater or less.

$$n = f + b = 242.$$

$$p = n/2 = 121 \text{ periods per second.}$$

* Proc. Phys. Soc., vol. xiv., p. 270.

l = length of the bar in cm.,
 k = radius of gyration,
 τ = thickness, $\tau^2 = 12k^2$,
 δ depends on the material of the bar,
 m is an abstract number.

This equation may be written—

$$t = \sqrt{B/T}.$$

For band iron rods, $\sqrt{B} = 1.459 \times 10^{-5} \dots$

* A more complete discussion of this method, giving correction tables for various temperatures and sizes of tubes, I have published in the Phil. Mag., April, 1898.

† See The Electrician, vol. xxiii., p. 219.

‡ "Theory of Sound," by Lord Rayleigh, second edition, p. 180.

§ "Theory of Sound," second edition, p. 184.

|| Phil. Mag., August, 1896.

¶ "Theory of Sound," second edition, p. 273.

** "Theory of Sound," second edition, p. 274, gives the equation for steel bars $t = 1.182 \times 10^{-4}/T$.

For tool steel I have found the value

$$t = 1.003 \times 10^{-5} l^2 / r.$$

In order to get absolute values it is necessary to determine the constant as is explained in connection with the following method:

The constants for iron are very nearly the same for different specimens, while in the case of steels they vary widely. If exact values are desired it is not sufficient to use the equation, but the periodicity must in the first place be determined directly for varying lengths on account of the uncertainty in regard to the modulus of elasticity. By this method determinations cannot be made quickly, as the changes of length must be made with great care, for the least difference in the way in which the bar is clamped makes a large difference in the periodicity of the bar. The position for resonance must be sought for with great care on account of the effect of small changes of length. A bar 5.36 cm. long, 0.056 cm. thick, and 0.94 cm. wide will have a periodicity of 16,100 periods per minute. A change in length of only 0.007 cm. gives a change of $\frac{1}{4}$ of 1 per cent. in its frequency.

The sixth method is one that I have been using for about a year, and I find it free from most of the difficulties and errors of the preceding methods. A flat iron bar is made to vibrate in unison with the varying field of an electromagnet energized by the alternating current. This is accomplished by varying the periodicity of the bar by means of a non-magnetic rider.* Fig. 5 shows the arrangement of the apparatus. The principal advantages are seen to be: 1. The invariable condition of the bar on account of its unchanged length. 2. The sensitiveness of the resonator can be changed at will by varying the mass of the rider. 3. The adjustments can be made with such rapidity that practically instantaneous values of the periodicity can be obtained. 4. The determination can be made without special skill with an error of less than $\frac{1}{4}$ of 1 per cent. I have found that thin rods are most easily used. If, then, a rod of band iron is employed 7.7 cm. long, 1 cm. wide, and 0.056 cm. thick, with a rider of 0.27 gramme, then Fig. 6 will show the relation between the distance of the rider from the fixed end of the bar and the alternations per minute of the alternating current. If, for instance, the rider stood at 6 cm. when the rod was vibrating synchronously with the alternating current, the frequency of the current would be 7,195 alternations per minute. The difficulty that accompanies the use of this method, in common with the two preceding, is caused by the trouble necessary to get the calibration curve for the particular rod being used. The curve may be obtained either by calculation or experiment, as follows. For the lateral vibration of a bar loaded at the end Lord Rayleigh proposes the equation which was obtained by means of a series of approximations.†

$$\frac{1}{p^2} = \frac{l^3}{3q\kappa^2\omega} \left(m + \frac{33}{140} \rho \omega l \right) \dots \dots \dots (2)$$

p = number of complete periods per second.

l = length of bar in centimeters.

q = (Young's modulus) modulus of elasticity.

κ = radius of gyration of the bar about an axis perpendicular to the plane of bending.

h = width of the bar in centimeters.

ω = cross section of the bar in square centimeters.

m = mass of the rider in grammes.

ρ = density of the material of the bar.

The values of A and B will be given, and then, for any particular bar using a single rider, the equation may be written

$$t^2 = Cr^3 + K \dots \dots \dots (4)$$

I have experimentally verified the equations determining the time of a period, t , by autographic chronographic records.* The experimental work is too extensive to be given in this paper. The results are of great interest, as they give the modulus of elasticity of bending, instead of Young's modulus, which is usually employed.

It is sufficient to say that the period of vibration of every bar can be obtained from equation (3) for all values of m , r , h , and l , as soon as the constants A and B have been found. The error due to the approximations is not greater than $\frac{1}{10}$ of 1 per cent. Band iron is a convenient material, and for the four specimens

FIG. 6.

tested, varying in thickness from 0.0285 to 0.115 cm.,

$$A = 1.17 \times 10^{-10} \quad B = 2.13 \times 10^{-10} \quad A/B = 0.549.$$

The ratio A/B is independent of the modulus of elasticity, and consequently it can be employed in the experimental determination of the constants for the particular rod that is to be used. If, for instance, we consider the rod mentioned in connection with Fig. 6. When no rider is used ($r = 0$) it is found that

$$t = 0.01546 \text{ sec.} \quad t^2 = K = 2.39 \times 10^{-4}.$$

From the preceding equations it is found that C of equation (4) can be obtained by substituting in the following equation the dimension of the rod being used, as follows:

$$C = 0.549 \frac{K m}{h r t^4} = 1.80 \times 10^{-7}.$$

Equation (4) becomes

$$t = 1.80 \times 10^{-7} r^3 + 2.39 \times 10^{-4} \dots \dots \dots (5)$$

The alternations per minute = $120/t$.

Equation (5) was thus used in getting the calibration

FIG. 4.

FIG. 5.

If the rider is not at the end of the bar, the equation may be written

$$\frac{1}{p^2} = \frac{1}{3q\kappa^2\omega} m r^3 + \frac{33}{140} \frac{\rho}{3q\kappa^2} l^4;$$

r = distance of the rider from the fixed end of the bar. Also let τ = thickness of the bar in centimeters. Then

$$\kappa^2 = \frac{1}{12} \tau^2.$$

t = time of one complete period.

For iron bars the equation becomes

$$t^2 = A \frac{m r^3}{h \tau^3} + B \frac{l^4}{\tau^3} \dots \dots \dots (3)$$

* Since writing this paper I have found that Profs. Ayrton and Perry, while using the vibrating string method, suggested that a magnetic tongue, whose moment of inertia was varied, could be employed. This method was apparently neither used nor further considered.

† "Theory of Sound," second edition, vol. I, p. 239.

* Physical Review, March, 1899.

FLUORSPAR MINING.

FLUORSPAR occurs in the United States only in Crittenden County, Kentucky, and Hardin County, Illinois. It is found in veins in connection with limestone and yellow clay, a small amount of lead, calcspar and feldspar being present. The fluorspar found in Kentucky is a pure white massive variety, and is found in veins ranging from 6 to 30 feet in width and varying greatly in length. The largest vein so far discovered in the State is owned by the Fluorspar Company, of St. Louis, Mo., and is known as Mine No. 1. It is situated on the side of a hill and runs almost due north and south from 25 to 50 feet below the ridge. It has been prospected a distance of over 1,200 feet, and the width varies from 15 to 30 feet. In this case the spar is found from the grass roots down.

The main shaft on this vein is 13 feet square and has reached a depth of 96 feet. At this level two drifts, each 6 feet high by 7 feet wide, are being run north and south along the vein, cutting through an almost solid mass of pure white fluorspar. Heavy timbers are necessary to support the roofs. When a drift has been run far enough, a narrow track is laid, upon which small four-wheeled flat cars are run. The buckets are placed on these, and when loaded at the end of the drift are wheeled to the foot of the shaft. They are then hoisted to the top by a horse power whim, so arranged that while one bucket is being brought up, another is going down.

Upon reaching the top the bucket is put on another car, wheeled to the sorting and cleaning sheds, dumped and returned for another load. At the sheds the spar is taken in hand by the sorters, hackers, screeners and barrelers. The large pure white lumps from 5 to 150 pounds in weight are first selected and turned over to the hackers, who chop off with hatchets the small amount of dirt adhering. It is then graded as No. 1 pure white lump fluorspar and is used for the manufacture of hydrofluoric acid and for grinding and for the use of glass manufacturers, enamellers, etc. The slightly off or mixed colored lumps are also separated and cleaned, and known as lump fluorspar. This grade is used by steel manufacturers.

After taking out the large lumps the spar passes to the screeners, who separate the fine or gravel spar from the crushed or small lump fluorspar by the use of coarse screens. The crushed fluorspar is passed to the barrelers, who grade it into Nos. 1 and 2 qualities, according to color and at the same time barrel it. When filled the barrels are headed up and loaded into wagons or placed in the warehouse. Barreled fluorspar is also used by acid makers, iron and steel manufacturers, blast furnaces, foundries and furnaces. Very little fluorspar of any grade is kept at the mines; it is hauled to the railroad and loaded on the cars or stored in the warehouse and on platforms as fast as it is taken out.

The demand for all grades of fluorspar has been steadily increasing during the past year, as the iron and steel makers are beginning to realize the benefits derived from its use.

Besides the above described Mine No. 1, the Fluorspar Company is developing mines Nos. 2 and 3, which bid fair to equal No. 1. The company also owns or controls 2,000 acres of mining lands, which, although not now worked, are known to contain a fine grade of fluorspar.

In Illinois the fluorspar is found under the same general conditions as in Kentucky. It is also of the massive variety, but is of a mottled color and not as pure. The Fluorspar Company owns or controls extensive deposits at Karber's Ridge, Cypress Junction, and Shawneetown, in Illinois, which are worked on the same plan as in Kentucky.—E. E. Squier, Jr., in Engineering and Mining Journal.

AGRICULTURAL UTILIZATION OF DISEASED AND PUTRID MEATS.

In 1883 M. Aimé Girard suggested an easy and advantageous process for utilizing the dead bodies of animals and rejected meats. The lamented professor advised the dissolution of the remains in sulphuric acid and the utilization of the nitrogenous product in the fabrication of superphosphates.

The process is of great utility. Every dangerous germ is destroyed by the acid of 66° Baumé which is employed for dissolving the meats and dead bodies. The nitrogen of the flesh and the phosphate of the bones are preserved and utilized.

Certain individuals availed themselves speedily of M. Girard's suggestions.

In 1884 M. Picard, manager of the estate of M. Houette at Lamothe-Jarry (Yonne), installed on his farm a working place for treating animal remains by sulphuric acid. These are thrown into vats constructed of wood with a lining of lead. In a day or two the fat alone remains, and the dissolved portion serves for the manufacture of animalized superphosphates. From 1884 to 1892 M. Picard treated more than 70,000 kilos.

In 1893 a manufacturer obtained authorization to work the Girard processes at Rouen. Here 15,000 to 20,000 kilos are treated yearly.

At Marseilles an establishment of the same kind, recently started, has treated 150,000 kilos during the first year.

Similar enterprises have been inaugurated at Beaulieu (Indre-et-Loire), at Saint Martin d'Hères near Grenoble, at Romans (Drôme) and Nantes.

Recently Mr. Lindet, Professor of Technology at the National Agricultural Institute, has prepared an interesting paper on the establishment at Geneva, also of recent foundation.

The animals, seized meats, etc., are brought in covered vehicles, which are disinfected as soon as they are unloaded. The carcasses immediately after being cut up, and even before if the animals have died of glanders or anthrax, are immersed in sulphuric acid.

The vats have a capacity of more than two square meters (1 meter deep by 2.20 meters long and 1.10 meters wide). They are constructed of spruce lined with lead 5 millimeters thick, and have on the top a wooden trough of 0.15 meter width and depth sustained by iron supports, in which the flanges of the cover sink. The cover is furnished with hinges and can be readily raised by a pulley.

The remains to be treated are put into the vat to the amount of 1,500 kilogrammes. To prevent the cor-