be completely scrubbed in twelve hours, and vessels drydocked after being cleaned by this method have been found to be entirely free from any marine growth. The gear itself is simple and strong. Its manipulation does not call for any special skill. This enables it to be used by a ship's company if desired; in fact, in connection with warships the sailors have successfully carried out the operation. As, however, in the case of merchantmen the services of the whole crew are generally required for other duties, small tenders equipped with the requisite gear are being stationed in ports ready for instant service. It is then only necessary for the cleaning tender and crew to make fast alongside the vessel and carry out the scrubbing operations, while the crew themselves are occupied in the loading or the unloading of the ship under treatment.

The cost of cleaning a vessel by this method is low. A 4,000-ton ship can be cleaned, inclusive of the provision of labor, current, and all gear, for $100 in approximately eight hours, though this cost would be appreciably lower were the vessel being cleaned to supply the requisite current and had steam on her own winches to operate the hawsers.

The loud and manifold complaints against the London motor omnibus have impelled the leading companies to action. A new species of inspector has been created—a speed inspector. His duty is to watch for omnibuses traveling at a speed beyond the companies' maximum of 12 miles an hour, and to report the offenders to headquarters. For purposes of identification each motor omnibus will carry a distinctive mark, a small board with certain capital letters—ON—S, for example — clearly painted upon it. This is fixed at the side of the omnibus above the window, at the end near the driver. The General and Vanguard motor omnibuses wore their identification boards for the first time last month.

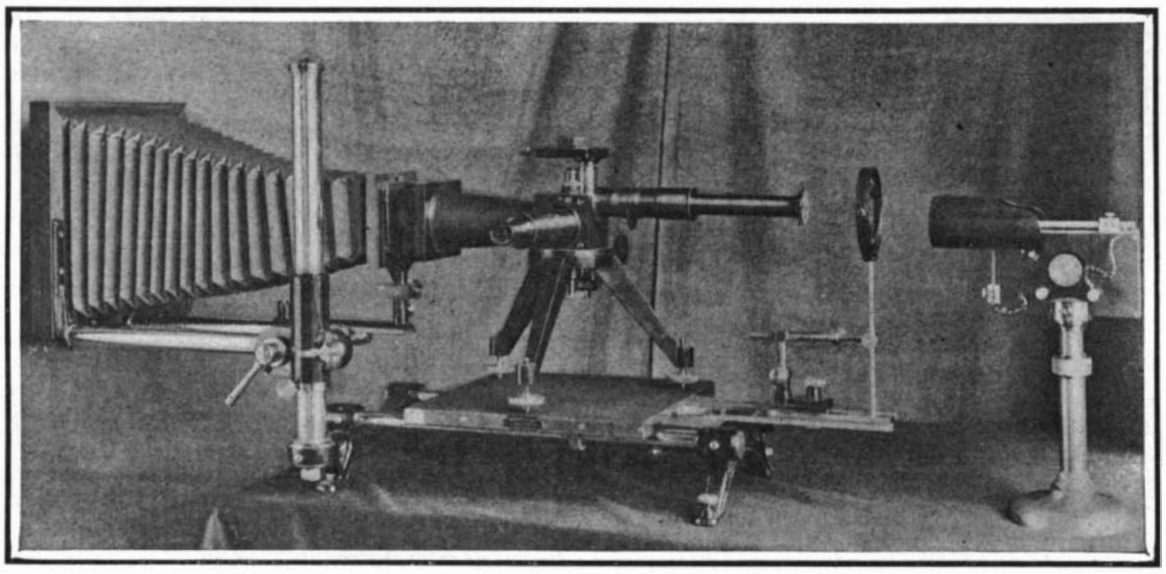
METALLOGRAPHS, OR PHOTOGRAPHS OF THE STRUCTURE OF METAL SPECIMENS.

BY J. F. SPRINGER.

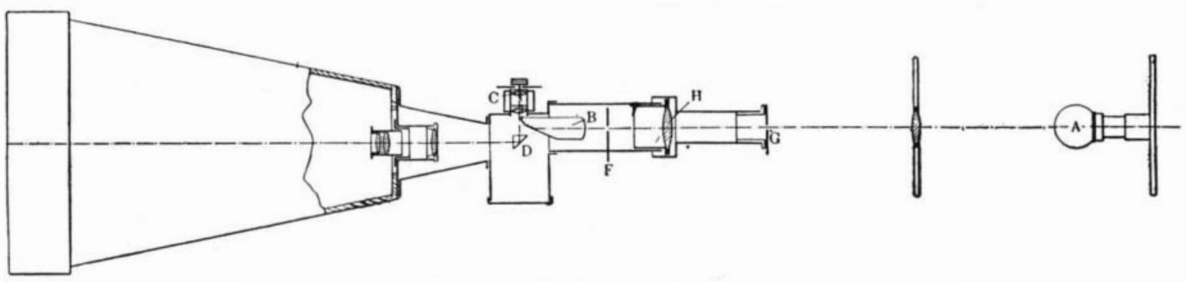
In recent years an entirely new branch of practical science has grown up, to which the name of *metallography* has been given. A *metallograph* is a pictorial representation disclosing the structure of a metal specimen. It has long been known that much might be learned of the characteristics of, say, a piece of steel by the mere optical examination of the structure disclosed by a fracture. The difference in appearance of a fresh fracture of hardened and tempered razor steel from a fracture of, say, cast iron is quite apparent to the eye. But in order to study this line of things with effectiveness, some means of recording these appearances was necessary. This has been filled by photography. An unmagnified representation — made by photography or otherwise —of a metallic fracture is called a *macrograph.* One of the illustrations shows a photographic apparatus suited to the production of macrographs. This vertical arrangement is especially desirable, as thus the sunlight may readily illumine the surface of a fracture. The specimen is seen in the figure lying—fracture side up—upon the table. The whole camera may be adjusted vertically along the post rising from the base by means of the locking arrangement. The focusing is accomplished in connection with the rod on the upper right hand.

However, while the study of macrographs is no doubt of considerable importance, the present state of the study of metallic structures would have been hardly possible of attainment through them alone. The microscope has been brought into this line of research, and with the most important results. A magnified representation of a metallic fracture is called a *micrograph.*

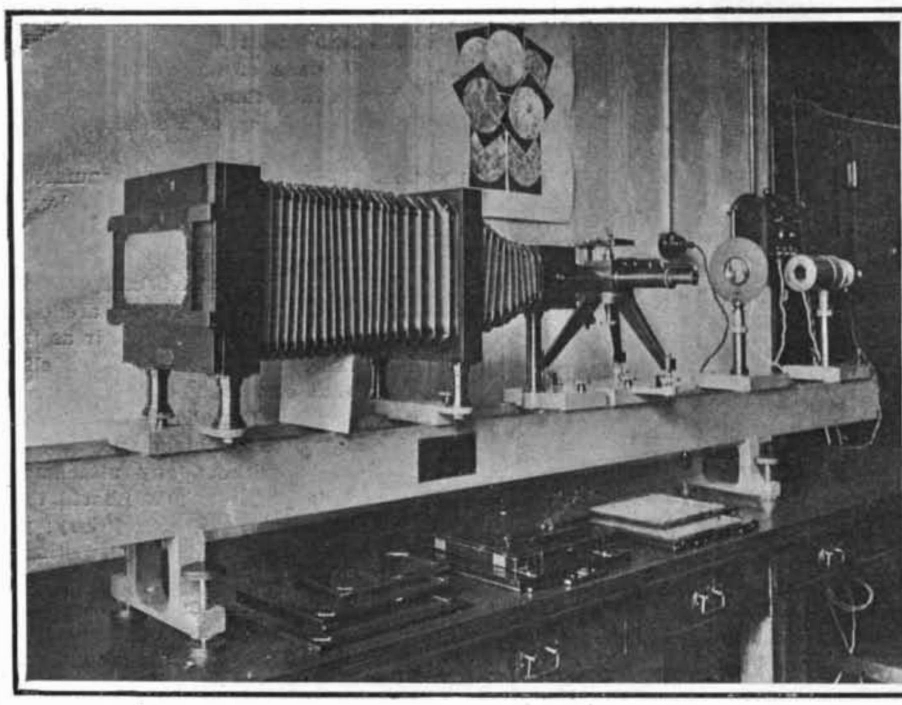
Now it might seem to some that with chemical analysis on one hand and mechanical testing on the other, there would be little that could not be learned about metals by means of one or the other of these processes. That this is not the case may be seen from the fact that metallography



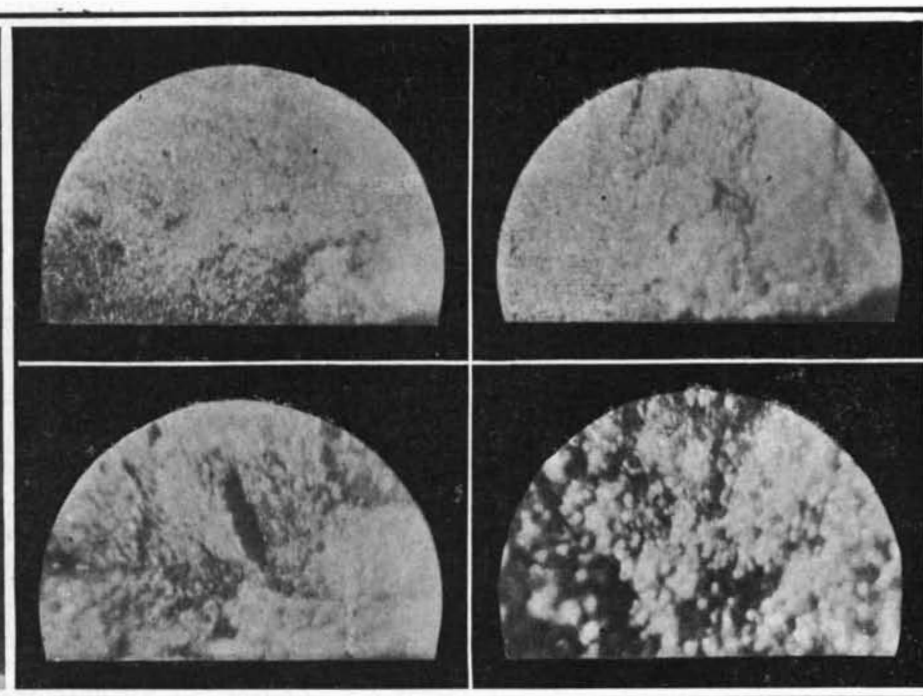
Chatelier apparatus for making metallographs using "Liliput" focusing arc lamp as source of light.



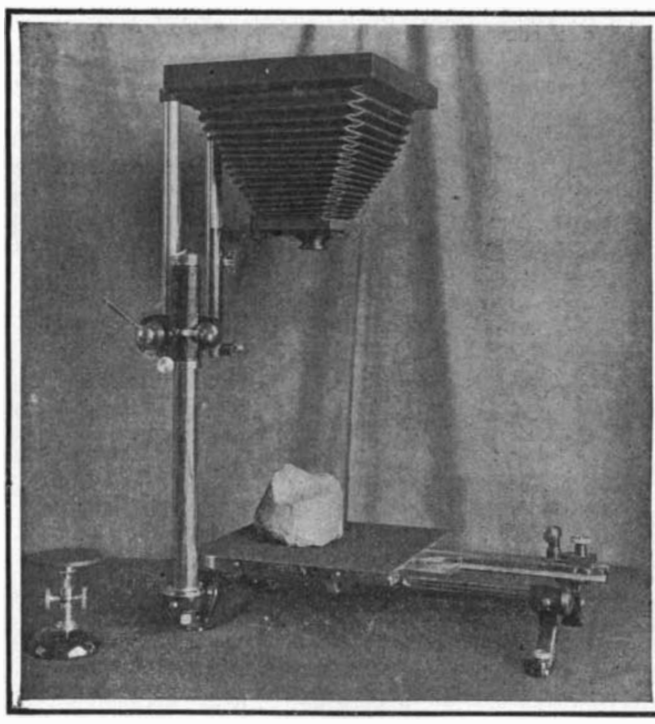
Diagrammatic view of the Chatelier system of microphotography.



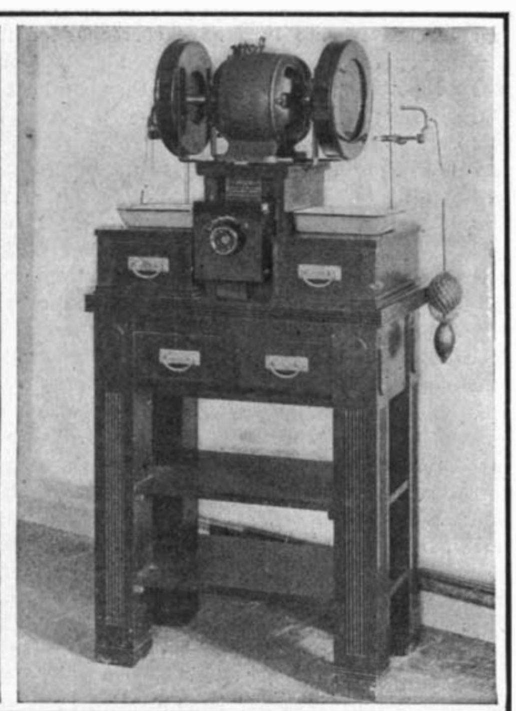
Nernst lamp used with the Chatelier microphotographic apparatus.



Micrographs of 1.65 per cent carbon steel, showing effects of overheating.



Camera taking macrograph of a fracture of specimen.



Electric polishing machine for preparing specimens to be microphotographed.

METALLOGRAPHS, OR PHOTOGRAPHS OF THE STRUCTURE OF METAL SPECIMENS.

is making a place for itself by the intrinsic value and uniqueness of its information. The chemist could tell us, no doubt, that a given specimen of steel contained just so much iron, so much carbon, so much silicon, and so on to the last minute impurity. The mechanical tester could inform us as to its capability of withstanding compression, of its resistance to tension, of its degree of hardness, and so on. Now if our piece of steel were an absolutely homogeneous, noncrystalline substance, the metallographist would probably have nothing to add. But steel and many other metals have a definite structure. In fact, the micrographs show that it is a most complex substance—not complex merely from the fact that it contains quite a number of different substances, but because it is an aggregation of substances which differ from each other in form and characteristics. In other words, steel is not a perfect chemical compound. Metallography not only informs us of this fact, but instructs us as to the form of the structure.

It is found, particularly with steels, that the structure varies with the heat treatment to which the specimen may have been subjected, with its chemical constitution, and with the mechanical operations which it has undergone. Thus, the percentage of carbon influences the structure. A great variety of structural changes is brought about by heating, chilling, overheating, and the like. Cast steel, steel hot forged under the hammer, and steel cold rolled, all differ in structure. The expert metallographist is able, in fact, to discern from his metallographs a good deal as to what has happened to the steel under inspection.

Now it is not quite so easy a matter to make a micrograph as it is to make a macrograph. It is necessary to prepare the specimen for microscopic inspection; and it must be flat and highly polished as a preliminary to the final processes.

There are four methods of preparing the test piece: (1) it may be etched with acids and the like; (2) it may be polished in bas relief; (3) it may be polished by "polish attack"; or (4) it may be tinted by heating.

To etch the surface, nitric acid, iodine, or picric acid may be used. The object is to affect differently the different substances making up the complex structure exposed by the fracture, with a view of creating different optical conditions, so that when exposed to a strong light the etched surface will disclose in the microphotograph light and dark effects corresponding to the structure. Ordinarily, the surface should be carefully polished before etching.

Polishing in bas relief depends for its success upon differences in hardness of the different parts of the complex. Upon treating the specimen to a series of polishing operations—proceeding from a rough polishing with files to that obtainable with emery papers and rouge—it is possible to produce a surface free even from microscopic scratches, which will yet be unequally worn in detail although flat as a whole. This is considered a very fine method—especially applicable to certain cases. Thus, Prof. Stoughton points out that this method is particularly advantageous in differentiating the graphite in pig iron, as it does not produce the discolorations to which an acid etching might give rise. In preparing his own specimens, he performs all the polishing operations, except that with the rouge, by hand. There are, however, one or more varieties of apparatus for accomplishing this by mechanical means.

The method of preparation called "polish attack," as used by F. Osmond, of Paris, consists in performing polishing operations by means of parchment which has been treated with a little ammonium nitrate in solution. This method is a finishing operation, and is performed after coarser means of polishing have been used.

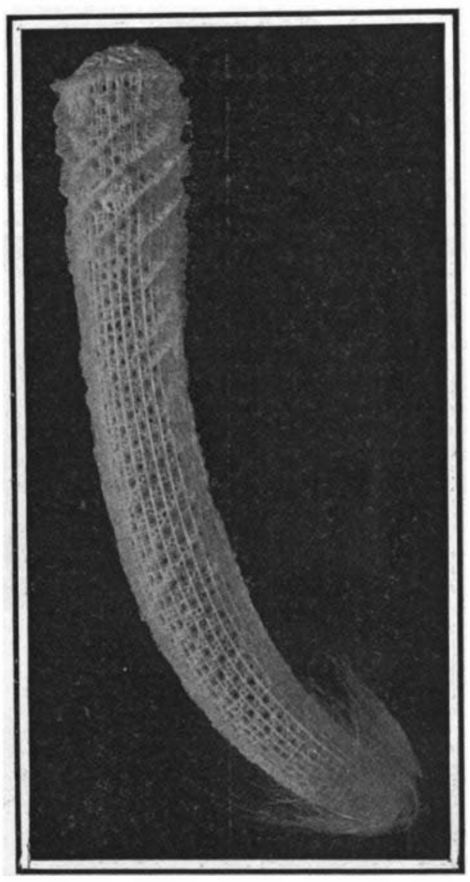
The process of tinting by heat depends upon the fact that upon application of warmth the different constituents of the polished surface will oxidize differently, thus producing differentiating effects discernible by the photographic plate.

F. Osmond, of Paris, is one of the leading metallographers. He recommends the application of a series of finishing operations. Thus, after the preliminary preparation of the specimen, it may be treated to polishing in the bas relief, then to "polish attack," and finally to the action of chemicals. Photomicrographs may be made after each stage.

However, whatever process or combination of processes is employed, the problem of preserving a record is solved by the use of a magnifying apparatus in combination with a photographic camera. In the line cut we have a diagrammatic representation of the method of Le Chatelier. The microscope is at *C*. The specimen may be seen almost in contact with the outer—or object—glass of the microscope. The great difficulty in this application of photography is the illumination of the object. In micrography the specimens are seldom, if ever, transparent, so that the light must fall upon them on the same side as that which is presented to the object glass of the microscope. In the Le Chatelier process of microphotography, an artificial light is set up at *A*. There is a diaphragm at *G*, but intervening between *A* and *G* a condensing lens is set up. Its office is to gather a multitude of rays and focus them at *G*. This condensing lens may be seen in the half-tone engravings as a separate piece of apparatus, off to the right. The light next falls upon the lens *H*, whence it passes through the diaphragm *F*. The prism *B* now receives the light, and totally reflects it through the microscope upon the specimen. Thence it is reflected back through the microscope to the prism *D*, whence it is totally reflected into the object glass of the camera.

One of the engravings shows a series of photomicrographs. These all relate to the same piece of steel, although the micrographs were made from different portions. One part of the whole specimen was overheated and then quenched. As the piece was unequally heated, the temperatures at quenching varied. These have been estimated. This specimen was a pure carbon steel of 1.65 per cent carbon. Notice the size of the grains in the last of the series. That these changes in appearance correspond to variations in physical properties will be understood from the fact that the hardness numbers corresponding to the portion represented by the micrographs varied from 105 for the first down to 70 for the last. The tests for hardness were performed by the scleroscope—the hardness-testing instrument described in the Scientific American for August 29, 1908. It will be seen that metallography affords a precise method of determining what has been the heat treatment of steel whose chemical analysis is already known.

This brings us to another point. If the specimen just described had been a steel of, say, a different



GLASS-SPONGE.

percentage of carbon, it would have disclosed a variation in its structure, but this line of variation would have corresponded to its own composition. We could not say merely from observation of the size of the grains to what heat the steel had been heated. It is necessary to know its chemical constitution in addition.

It seems to have been pretty well ascertained that the finest grain of pure carbon steels is developed at about the temperature of 1,300 deg. F. As this temperature is exceeded the size of the grain continually increases, and apparently with great regularity. If the steel has been overheated, and has consequently developed a large grain, this serious fault may usually be corrected by cooling below the temperature just mentioned and then reheating to some point above it. When the heat of 1,300 deg. F. is just reached, the fine grain begins to form. If the steel has a carbon percentage of precisely 0.9, a few degrees in excess will be sufficient ordinarily to cure the large-grained structure. But if the carbon is much below 0.9, then the heating will have to go considerably beyond, 0.4 carbon requiring a temperature of about 1,470 deg. F. If the carbon percentage is quite low it may be necessary to heat to 1,600 deg. F. or somewhat beyond. The reason for heating beyond 1,300 deg. F. is that steels having less than 0.9 carbon are composite in their structure, and heating to 1,300 deg. F. does not uniformly affect the whole mass. The old grain size (developed by the overheating) tends to persist. If the steel has more than 0.9 carbon, the necessity for heating above about 1,300 deg. F. to effect restoration is not pressing—the imperfection from want of uniformity being but slight. It is evident that the new science of metallography is eminently adapted for investigation into this whole matter of size of grain.

It may, however, be gathered from the foregoing that no method of investigation—whether chemical, metallographic, or mechanical—stands absolutely alone. To have full and definite information, it is necessary to have the co-operation of all. And even then, we may fall short of having a complete statement; for none of these practical sciences is to be regarded as having reached its final stage. Science is ever going on to a higher goal.

SOME COMMERCIAL USES OF THE GLASS-SPONGES.

BY L. LODIAN.

The glass-sponges of the Oriental tropical seas were first described among spongiæ as a curiosity about a century ago; but their commercial uses in the far East are unknown to the Western world even to this day.

What asbestos is to us, the glass-sponge débris is to the Asiatic. In fact, asbestos is not found in the far East, if we except the poor short-fiber mineral mined on the Asiatic versant of the Ural range—many thousands of miles distant from the habitat of its marine competitors, the uplektela, or glass-sponges.

These odd glass-silk sponges grow in the warm tropical seas of the Pacific like ordinary sponges, from the Fujiyama region to the Indian Ocean. Specimens have even been fished up in our own Antilles. The Japanese call them mineral-silk sponges; and some are a mere bunch of cords like a skein of twine, with none of the exquisite, complex, snow-white, built-up lacework of the cornucopia-shaped glass-sponge. However, they are all allied to the homely sponge which is used in our bath-tubs. But with what widely-variant, different uses! The far-eastern article is raked up for its fiber and débris, the latter forming a heat-insulator for steam pipes. In recent years it has been used with even better results in cold-storage insulation, and is considered as efficient as magnesia or asbestos. It is of course cheaper. The separated fiber is woven into chemical filter-cloths, which would be destroyed if made of animal or vegetable fibers; into fireproof candle-shades; and even into delicate fireproof chintz curtains, of a dazzling, glossy white.

Whether the fiber can be used in the manufacture of gas-mantles, is a matter to be determined by experiment. The idea apparently has never been carried out.

Specimens of the glass-sponges which escape breakage, and are secured intact from the sea, are occasionally sold to tourists, or woven in the hair as fantastic ornaments by the natives. The sponges cling so readily to fabrics, that sometimes they are merely laid on the breast as decorations. Thus they have a singular habit of clinging to clothing, and may be carried around for hours without any attachment other than their own natural fastening. Should they fall on a stone floor, they would suffer no injury; yet if stepped on, they would be crushed to destruction—leaving, however, the long fiber fairly intact.

Some of the glass-sponges reach an extreme length of nearly forty inches and a diameter of four inches. Broken and trimmed-up pieces of the big growths are used as lamp-globes and shades; and whole plants have been used in some of the city homes of the natives for receiving two or three bulb-lights. A very charming effect is the result.

They are easily cleaned by simply holding them under the faucet of running water.

The specimen of the glass-sponge here illustrated was originally enveloped (as an ear of Indian corn is enveloped by its husks) in silky fibers, a tuft of which remains at the base. These glossy and almost indestructible fibers are prized too much by the Orientals to be allowed to remain. Moreover, they would completely obscure the marvelous serrated corrugations, like little flounces with delicate frilled edges, terminating the upper part of the sponge, as here illustrated. The fibers are especially valued for spinning and weaving (mingled with the yet longer fibers of the twine-sponges—also pure silica) into the beautiful silk-gauze zephyr-cloths of Chinese inland commerce.

German Picture Post Card Industry.

Consul-General T. St. John Gaffney, of Dresden, states that the exportation of German picture post cards has recently diminished considerably. The foreign demand is, however, still great, amounting to about 500,000,000 since the beginning of the year to July 1. Compared with the previous year, this shows a diminution of 150,000,000. The United States is said to be Germany's best customer, followed by England. Asia and Australia are also good patrons of this form of art industry.

Safe flywheel diameter in feet equals 6,000 ÷ (3.1416 × revolutions per minute).