

Fig. 1.—The Creighton University, a "Field of View" in a Telescope.



Fig. 3.—Photograph of Whole Eyepiece of Transit Taken Out of the Telescope, Showing the Micrometer Box With Its Two Screws.

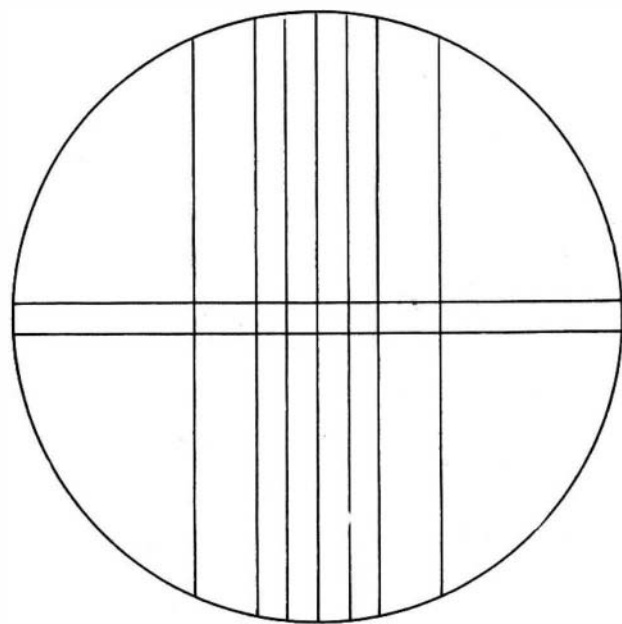


Fig. 2.—Reticle of Transit, Consisting of Seven Vertical and Two Horizontal Threads or Wires, Each System Being Moved by a Micrometer Screw.

The Value of a Cobweb*

How a Damaged Spider's Thread Paralyzed An Entire Department

William F. Rigge, S. J.

WE have often been told of the value of what are generally called trifles. We know that very great things often depend upon very small ones that, for example, the lives of many people and the safety of tons of precious merchandise may be endangered by the neglect of a bolt on a bridge, and that a spark may cause the conflagration of a city or of miles of forest lands.

While we know these things and willingly admit them, and can give illustrative examples of our own, I think most of my readers would imagine I was drawing the long bow when I tell them that a sixteen-hundred-dollar instrument was thrown completely out of use for the want of a cobweb! Yet, it was a sober fact, and was painfully in evidence to me no less than to some students of mine, one of whom had come 750 miles principally in order to use this instrument. It was about as serviceable to us as its picture would have been; and all that on account of an accident to the cobwebs it had contained. Let me explain the mystery.

THE WIRES OR THREADS IN A TELESCOPE.

If the reader has ever looked through a telescope that was on a measuring instrument such as a surveyor's transit or level, he will surely have seen in it at least two fine black lines crossing each other at right angles, one being vertical and the other horizontal. The object of these lines is to enable the observer to direct his telescope very accurately upon a given object, or conversely to find the object his telescope is directed to when it is adjusted by means of its levels or circles. The whole round picture seen in a telescope is called its field of view. As this is of some considerable size and shows quite a number of objects, it would be impossible to know which of these objects the telescope was directed to, unless we had these fine lines to point it out to us.

A telescope, as we probably know, consists essentially of at least two lenses, one at each end of a tube, each lens being itself a compound of two or more simple or elementary ones. The lens nearest the object looked at is called the objective, and is always the larger of the two. This lens forms near the other end of the tube an image of the object, in exactly the same manner that a photographic camera does. In fact, as far as the objective is concerned, there is no difference between a telescope and a camera, both have the same kind of an objective mounted at one end of a tube or box, the first having generally a cylindrical or converging tube so as to have a small field of view, and the second a diverging or expanding box so as to have a large field of view.

In the photographic camera we place a sensitized plate where we see the image of the object on the ground glass, and thus secure this image by the photographic or chemical action of the film. A photographic telescope is purely and simply a photographic camera, only that it is generally longer, that is, has a longer focus, and thus gives a larger picture.

In a visual telescope the image is looked at through an eyepiece, which is the second of the two lenses we mentioned before, and derives its name from the fact

of its being nearest the eye of the observer. This eyepiece is a magnifying glass in principle, and makes the image look larger. It is often easily removable and replaceable by another, which has a different magnifying power, so that one may examine the object he is looking at under various degrees of magnification. The higher the power, the fainter is the image, because the eyepiece receives only a definite amount of light from the objective, and the more the image is magnified, the more this light is spread, so that the highest powers of a telescope can seldom be used to advantage except on a bright object and in a clear sky.

CHARACTER OF THE LINES.

The fine black lines we have mentioned before are at the same place in the tube where the objective forms

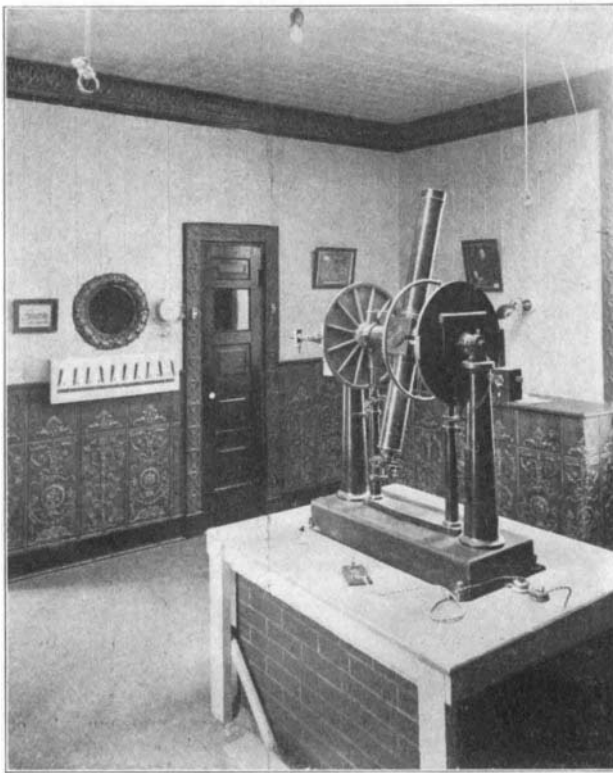


Fig. 5.—The Sixteen-hundred Dollar Transit Instrument, Which Was Rendered Perfectly Useless for the Want of a Few Cobwebs.

the image, so that both image and lines are viewed together through the eyepiece. For very accurate work it is evident that these lines should be very fine and smooth, so that they may be looked at through eyepieces of the highest magnifying power. They ought also to be perfectly straight and taut, and sufficiently elastic to remain straight and taut, no matter how much the tube of the telescope and the frame on which they are fixed, expands and contracts with the temperature, or is moved about in various positions. And lastly, they should not be hygroscopic, that is, should not be affected by wet weather.

COBWEB.

Very few substances possess all these qualifications in a higher degree than the commonest kind of cobweb, simple ordinary spider's web, which tidy people abhor so much in the corners of their rooms. A spider line is perfectly smooth under the highest magnifying power. It is perfectly black in a bright field, and may be made bright in a dark field. It is also elastic, and may therefore be stretched perfectly straight, its weight being so insignificant that in short lengths there can be no danger whatever of sagging.

Cobweb is inexpensive, to be sure, but so delicate, that it is quite an accomplishment to know how to handle it. Perhaps the reader would like to know how this is done, and how spider lines are actually put into a telescope.

HOW SPIDER LINES ARE PUT IN.

The first thing to do is to get the cobweb. This is not as easy as it looks. Not every spider gives a web that can be used. Some lines are altogether too fine to be readily seen even with a magnifying glass, and too trying on the eyes. Some consist of loose strands not sufficient knit together, they are not one line but many of them and absolutely unfit for the purpose. Some have beads strung upon them, or are otherwise of varying thickness. It took us actually a whole week to find the cobweb we wanted. This may be a powerful proof of the cleanliness of our buildings and premises, but it was a fact notwithstanding, and was responsible for 90 per cent of the inactivity of our telescope.

When the right spider has been found, his thread is caught as he spins it and before it touches anything, and wrapped on a branching twig or stiff wire shaped like the letter Y. Having then made ready the frame work on which the threads are to be fastened, we take a compass or dividers, such as is used for drawing circles, put a drop of shellac or other sticky substance at the points, and pick up a suitable spider line longer than is finally needed. Stretching this by opening the compass a trifle, we place the line in position, using a magnifying glass if necessary, and press it down so that it touches the shellac we have placed on the outside, on the lateral sides as we might call them, of the frame work, make sure that it is caught there, and cut it off with a penknife. We next put the second thread in position in the same way, and all the others that we may need. We then with a clean pin or needle adjust them cautiously under a magnifying glass, and when everything is satisfactory we drop a little shellac on all the threads on the front side of the frame work, and the job is done.

DIFFICULTIES.

Yes, when everything is satisfactory—has the reader ever tried it? We think not, for it takes a long time and infinite patience before everything is satisfactory. Cobweb is extremely delicate. The least false movement will tear the thread. Removing the loose ends may ruin two or three neighboring threads. Patience, try again. Sometimes the final drop of shellac may be too wet with alcohol and may so affect the threads that they curl up and stick together. Unraveling then is almost sure disaster. Flies must not witness the

* By courtesy of St. Michael's Almanac.

work, for they may spoil the threads directly as well as indirectly by annoying the operator. A breeze is almost as objectionable. Altogether it is as trying a piece of work as one could well imagine, trying to hands and eyes and much more so to patience. The material is not worth much, but the skill is, and when one has tried it for the first time, he will admit that the two dollars that a professional instrument maker charges in his catalogue for only two threads at right angles, are far from being an unfair price. But if there had to be nine wires, one hundredth of an

more durable, although our cobwebs were all that could be desired for 21 years, until they were destroyed by an accident. This accident consisted in one of my students inserting an eyepiece that was scarcely ever used. The lens went into the tube too far and tore two of the threads. These could not be replaced without renewing the whole set, or reticle, as it is called. Whatever fault there was, ought to be laid upon the instrument maker, who should have prevented such a possibility. If it was the student's, he nobly made amends for it by spending a whole week upon the new

sit, the exact fraction of a second that a star crosses them is carefully noted. Knowing the intervals between the threads, we can reduce the observed transits to the middle wire, and thus practically have as many chances at the middle wire as there are threads in the field.

MICROMETER.

And again, by having the whole reticle, or at least one wire of it, movable, we can place a thread wherever we please, and thus observe and measure the positions of stars or objects anywhere in the field of view, in the Creighton University transit the whole reticle is moved by means of a screw which has a hundred threads or turns to the inch. The head of the screw is divided into a hundred parts, and these parts are read by estimation to tenths, so that we may measure down to one-tenth of one-hundredth of one-hundredth, that is, to one hundred-thousandth of an inch. There are two such micrometer screws in the eyepiece, one moving the seven vertical threads, and the other the two horizontal ones. Their accuracy is such that one could measure inches on a stake 80 miles away.

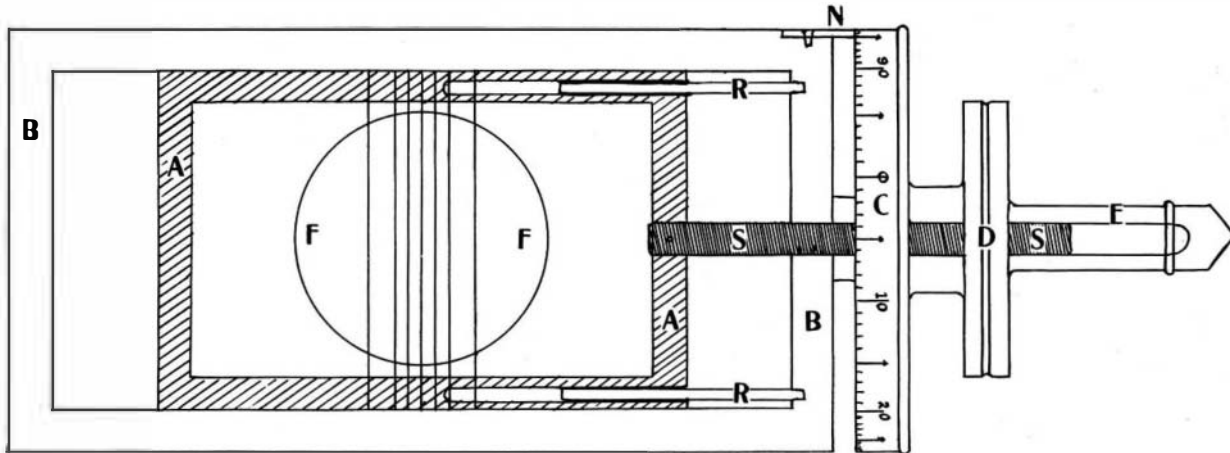
The finely divided circle on this instrument is read by two micrometer microscopes, which also use spider lines. These came with the instrument 25 years ago, and are so well protected that there is no likelihood of their ever being damaged.

The detailed construction of the micrometer can be gathered from one of the accompanying illustrations.

IMPORTANCE OF THE SPIDER LINES.

All the refinements of this sixteen-hundred-dollar instrument were lost on account of the want of the few cobwebs which constituted its reticle. Stars could not be timed, the micrometers had no employment, and the circle could not be used. Nor is this all. Several connected instruments were rendered idle. The chronograph, upon which star transits are recorded, and the sidereal and solar clocks as well, were all out of commission on account of that apparently most insignificant accident to a few cobwebs. Even our great equatorial telescope was only a seeing instrument, and had lost a great part of its power of measurement, because the error of our time-pieces could not be ascertained. In a word, it was an actual fact, and, as I said, painfully in evidence, that all measuring power of our observatory was ruined on account of the want of a few cobwebs. It was a great object lesson, which the reader may turn to his profit in his own way, and thus form a much higher estimate than he has ever done before of the value of trifles, and especially of the value of a cobweb.

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The framework A, which carries the reticle, is moved in the box B by means of the Screw S, which has a hundred threads or turns to the inch. The nut, head or drum C of this screw is divided into a hundred parts, tenths of which are indicated by the pointer N. The reticle is moved slowly by turning the milled head B, which forms one piece with the drum C and the shank E. Turning the shank E moves the reticle rapidly across the field of view. The number of whole turns is indicated by a cogwheel gearing into a short spiral screw on the lateral face of the drum. It is not represented on the diagram. There is a second and similar micrometer at right angles to the one shown. It moves two parallel horizontal threads, which are supported by two short rods or studs, and brought as close to as possible without touching the seven vertical threads, so as to be in the same focus with them.

Fig. 4.—The Micrometer for Adjusting and Reading the Position of the Reticle.

inch apart, what would the charge be then? That was exactly our case. And we did not have the time to send the eyepiece to a professional and wait for its return, whatever the item of cost might be.

PLATINUM WIRES AND RULED GLASS.

Spider lines are so delicate that some makers use very fine platinum wires. One of the greatest firms in the country says in its catalogue: "No one but a workman with practiced hand and provided with the best facilities can properly set the platinum wires in a cross-wire diaphragm, and it is useless, therefore, for us to send a parcel of wires for that purpose." Platinum wires are, however, harder to set close and parallel and straight, than spider lines. They may be

reticle, and finally delivering one in every respect as good as the one he had injured.

Some makers use ruled glass. But glass intercepts some light, and may become soiled by age or dust, when it would be difficult to clean. Whatever its advantages may be, it could not be used in our instrument on account of its peculiar construction, as its maker himself personally affirmed. I have never yet found anything superior to common spider's web.

USES OF A RETICLE.

The spider lines in a telescope serve also other purposes besides merely indicating the center of the field of view by means of a simple cross. When there are many wires, as there are in every astronomical tran-

Wasted Mathematical Energy

The Futility of Some Efforts of the Amateur Mathematician

THE thirst for truth and the impulse to accomplish the solution of problems are human traits that can hardly be too strongly encouraged. The greater pity is it that occasionally a man thus endowed turns his faculties into barren channels, and seeks to achieve the impossible. There is the perpetual motion crank, who imagines that he can construct a machine that will yield up an unlimited amount of work for nothing; others, of a less mechanical turn of mind, bury themselves with certain outstanding problems of mathematics. The case of the latter is ably discussed in the *Queens Quarterly* by N. F. Dupuis, who shows clearly the nature of the insurmountable obstacles which stand in the way of the solutions sought. It is not so much that the "trisection of the angle" for example is impossible, but that it requires auxiliaries beyond the two admitted by Euclid—the straight line and the circle. But we will let Mr. Dupuis state the case in his own words:

The average man is not a mathematician, except in the lowest and most fundamental portions, and does not, with very few exceptions, pretend to be; possibly because there is nothing in the subject calculated to excite his cupidity or to lead to his preferment. The mathematical attainments of the man of the street consist usually of a small amount of arithmetic sufficient for the common transactions of business, possibly a remote knowledge of elementary algebra, and a meager acquaintance with the elementary principles of geometry. When it comes to the higher branches of the subject, he is usually ignorant of even the nomenclature and notation, and his speculations in this field are more likely to be wrong than right. But this statement has some peculiar partial exceptions. Some people, believing themselves to be mathematicians, overrate their mathematical powers to the extent of assuming that it has been reserved to them to find solutions to those famous "problems" which have been handed down from ancient times and which have so far appeared to baffle the mathematical

world. Such are the *Trisectors of the Angle*, the *Duplicators of the Cube*, and the *Squarers of the Circle*.

The accomplished mathematician long ago proved to his own satisfaction that the trisection of an angle by the machinery of Euclid's elements is an impossibility. And that being for once established there is no reason, but rather folly, in his returning to the problem again, or in seeking to discover errors in the attempts of others along this line. The results of mathematics are absolute, and there is no more sense in trying to trisect an angle by Euclid's figures than there would be in attempting to prove that the sum of 2 and 3 is 6. The mathematician knows too well the limitations of his work, and the futility of spending time over that which cannot lead to any definite result. In fact, the "problems" in question have long ago ceased to be problems to the mathematician inasmuch as he knows exactly under what conditions they admit of solution and the means necessary to be employed in their solution. As the carpenter would find it impossible to bore a round hole through a plank if supplied with a hammer alone, but would experience no difficulty when furnished with an auger, so somewhat in like manner these problems become impossible of solution when restricted to the employment of certain fundamental principles, but yield easily enough when all restrictions are removed. It is considerations of this kind that have influenced the writer in preparing the present article. If it has any effect in preventing the waste of time and energy and money in following after a mere chimera, it will do some good.

Let us consider first the *Trisection of an Angle*.

This famous old problem has come into our mathematical horizon as a curiosity rather than as a problem to be solved. The older mathematicians gave a great amount of thought to it and undoubtedly wasted much time in futile attempts to solve it, but the modern and accomplished mathematician knows the limitations of his subject too well to waste valuable time

in trying to do the impossible. The problem is as follows: "Given an angle, to construct an angle having one-third its magnitude, using nothing beyond Euclid's elements."

In his elements Euclid employs only straight lines and circles, and he assumes the power to draw a straight line between any two given points, and to draw a circle with a given radius and having any given point as a center. This then is the problem: and any process or method which goes outside these elements or brings in other means than those laid down, does not solve the problem. Thus, one gentleman, forgetting or ignoring the conditions, employs a string, or the properties of a string in his solution, and as a consequence the so-called "solution" is worthless, although he prided himself very much upon having obtained it.

A few years ago the writer was asked to pronounce upon the merits of the attempt where the solver had assumed the authority to draw a certain line to assist in the solution, and had laid it down as an axiom that this line could be drawn. The solution then became simple enough, as he had, in fact, "assumed" himself out of the difficulty. But if he had tried to draw the line by means of Euclid's elements, he would very soon have discovered that the drawing of this line, instead of being axiomatic, was a problem of the same order of difficulty as the original one. Many other attempts have come under the notice of the writer, but in every case any apparent solution obtained was due to a misunderstanding of the problem, or a misconception of the conditions by which it is surrounded. And it may be here pointed out definitely, that any departure from Euclid's elements in the attempt at solution vitiates the whole problem; and that if a person is allowed to assume the properties of the hyperbola, or of some other particular curve, the trisection of an angle becomes simple enough. The writer does not, therefore, propose to make any attempt at solving the problem, but rather