tables made for our institutions of learning, and for surveying departments of the U. S. Government, have given absolute satisfaction, as shown by testimonials in our possession.

The modern improved plane-table alidade is a particular specialty, to which we have given considerable time and attention. This instrument has been constructed by us of aluminum, which has been a perfect success, proven by the fact that one of them has been almost daily in use for many years, under very trying conditions, without giving rise to the first complaint. Under the head of *Aluminum for Surveying Instruments,* this will be again referred to. By a combination of aluminum and aluminum bronze, the center of gravity of the alidade may be brought close to the foot of the standard, which is a very essential point in its construction.

ALUMINUM FOR SURVEYING INSTRUMENTS.

A great deal has been said and written about this comparatively new metal of late, so that its characteristics have become generally known.

Its color is a dull white, similar to silver, and rather pleasing to the eye. It embodies many qualities that make it a very valuable material in the mechanic arts. It is quite soft, but possesses malleability, tenacity and ductility, so that it may be made into very thin sheets, or drawn out into fine wire. It is a conductor of heat and electricity. One of its principal features is that it does not oxydize in the atmosphere, and that it does not lose its brightness under conditions that would tarnish silver and blacken it, for sulphuretted hydrogen or sulphide of ammonium do not influence its color. But the greatest advantage is its remarkable light weight, the specific gravity being only 2.6, or one-fourth of that of silver, and for this particular quality its use has been sought in the manufacture of articles requiring small weight, ever since the cost of its production has justified it.

One of the many alloys is the so-called aluminum bronze, which unites hardness with malleability, and is therefore extensively used for many purposes. This alloy, however, gains little in lightness as compared with the ordinary metals.

Since it has been the constant aim to produce field instruments that shall combine strength with the least practical weight, there could not have been found a better application for aluminum than in the instrument-maker's art.

It was necessary to experiment with it in different directions,

particularly as to the proper alloy—it being much too soft in its pure state—that shall give the required tensile strength and stiffness, make it workable without fretting, and yet add little to its weigh. An alloy with silver is now made that fully satisfies these conditions.

One of the principal objections urged against it in the manufacture of surveying instruments is, that on account of extreme lightness they would not be steady enough in the wind. This firm has built over 1000 transits and levels of aluminum, and, in our opinion, they are quite as rigid as any other, if properly constructed, care being taken to adhere to the old material in such details where it cannot be dispensed with.* We have found that the stability of an instrument depends more particularly upon the construction of its lower parts. If the combination of base-plate and leveling apparatus be made so that the instrument can be rigidly held, the center of gravity may be brought down lower, and that in itself would tend to increase its stability.

Aluminum transits are made by the A. Lietz Company in three sizes, being complete field instruments with every accessory. The large transit weighs 7½ pounds, and the smaller one 3 pounds, which reduces the weight about one-half. The construction is precisely the same as in the instruments already described.

The base-plate is of composition metal, the inner center of the hardest bell metal, and the outer center of bronze. The leveling screws are also of composition, as well as the telescope axis.

These transits may either be left in the beautiful natural color of the metal, or other shades may be applied. The standards are cloth-finished.

The *Saegmüller Solar Attachment* is now made of aluminum, which can only be an improvement in any direction, whether its weight be added to the top of a transit made of the red metal, or to one of the new metal. Lightness in the solar attachment is a very desirable feature, and that may be easily obtained now.

In the *Y-level* the base-plate and leveling screws and center are of composition metal; the collars, the hardest bell metal; and the rest, aluminum. It has an 18-inch telescope, its weight being 5½ pounds.

We also manufacture a *plane-table alidade* of aluminum, with a ruler of aluminum bronze. This instrument, although of the same weight as one of the ordinary metal of the same size, possesses the particular advantage of having its center of gravity as low as it can possibly be brought to the table, and that when placed upon the board

* See Testimonials for instruments made of our aluminum alloy, on fly-leaves.

it will be absolutely stable, and will not be influenced by the wind, which causes the ordinary alidade to tremble and travel on the paper.

And this is the reason why we should object very strongly to an aluminum rule in a plane-table alidade. This part of the alidade should be of heavy material, as well as the lower part of the standard, while the rest may be constructed as lightly as possible. In this case little or nothing may be gained in the weight, but very much is gained in stability, when compared with an instrument made of one metal throughout. Under no condition should the RULE, which is the BASE of the structure, be made of a light material.

After fifteen years of experience in the construction of aluminum surveying instruments, we are ready to advocate the *judicious* use of this material. We have applied it in transits and levels, and have accomplished a saving in weight of about 50 per cent. Great care is exercised in the proper distribution of the metal. We have already stated that in a transit aluminum is never used in the construction of the base-plate, centers, leveling screws, telescope axes and all minor parts having threads. The principal horizontal members, the plates, are of aluminum, strongly ribbed.

Much has been written about its high coefficient of expansion, and particular stress has been laid upon the effect of unequal expansion necessarily induced by the use of different metals. If this matter be considered for one moment, however, it will soon be seen that practically there can be no serious result from this source. In the first place, the difference between the coefficients of brass and aluminum is altogether too small* that the effect of any possible distortion in material judiciously placed need necessarily be feared. Glass plays a very important part in the make-up of a transit. The coefficient of expansion in glass is very low (0.8 mm. per meter, raised 100° C) and a metal best adapted for our purpose would be one having the same coefficient. Now, as far as brass and aluminum are concerned, it is readily seen that there is practically no difference in them when compared with glass. As long as glass is used, one may as well employ aluminum as brass for the constructive parts, for while the expansion of the latter exceeds that of glass 0.000072 inches per linear foot for 1° Fahrenheit, that of the former does so only by 0.000103. Unequal expansion, therefore, is not a source of error that need reasonably be feared.

The more vital objection to a light instrument—its greater un-

* (The Physical Laboratory of the German Empire has established the following: For brass 1.88 mm. per meter of length, raised in temperature 100° C; for aluminum 2.34. Our reductions are made from these data.)

steadiness in the wind when compared with a heavier make—is something we have already referred to. We have made and sold over 1000 aluminum transits and levels, and every one has been a proof of our statement made fifteen years ago: that the stability depends more upon the construction of its base and connection with the tripod than it does upon the weight of what may be called its superstructure—the part above the leveling head.

It may also be mentioned incidentally that a fall will injure an aluminum instrument less than if made of red metal. Not only is this theoretically correct, but our actual experience in this line has proven to us the fact that from ordinary accidents the lighter instruments are always less seriously injured than the heavier ones.

The testimonials from our customers will show the public that the aluminum instruments made by our firm have given the fullest satisfaction, and have not disappointed our expectations.

We are firmly convinced of the adaptability of aluminum for surveying instruments, and for that reason our firm has gone extensively into that branch of manufacture, for which every facility has been added recently to the capacities of the shop. The aluminum instrument is fifty per cent. lighter than the other, is just as strong, is just as precise in its workings, possesses every requisite detail of a complete field instrument, and, *we claim,* is just as stable. Those of the engineering fraternity who have to carry the transit all day, the mining and railway men, who climb the mountain sides during the long summer days from early until dark, will not be long in finding out these advantages and in putting them to a severe test in every direction. After manufacturing aluminum instruments for fifteen years we have had no occasion to regret it, and find constant encouragement from the best professional men.

CARE OF INSTRUMENTS.

The greatest source of danger to a delicate instrument is *careless handling*. It is often subjected to violent usages for which there is absolutely no need. The rude way of manipulating its delicate parts; the unnecessary display of digital strength in operating a clamp; the useless strain applied to the leveling screws; the careless manner of carrying it; the rough method of taking it out of its case, or replacing it; and the incautious closing of a lid or door of a box by force, before the instrument is somewhat adjusted to its position; all these are sources of danger that vitiate its adjustments and cause no end of