adjustment of the telescope in the vertical plane, an instrument should be reversed and an angle should be repeated. These remarks apply equally to transits made with the telescopes in an eccentric position. If the line of collimation is truly at right angles to the horizontal axis of revolution, the amount of the offset from the line through the center of the instrument to the line of collimation will equal the eccentricity of the latter, and will remain the same whether the sights be long or short. As a rule, however, the small geodetic instruments of the latter class cannot be constructed with the same degree of perfection as those with the telescope in the center: and in consequence the engineer using such instruments will have to rely upon methods of observing that will eliminate all instrumental errors.

In the engineer's wye level the line of collimation must be truly concentric with the object-slide and outer rings; and it is also necessary that the telescope be well balanced from the center of the instrument, in order to project a truly horizontal line.

Difficult of attainment as the foregoing conditions may seem, it is proper to say that improved tools, and a generally better understanding of the principles governing a telescope and its relation to the instrument, have done so much toward the perfection of geodetic instruments, that while it may not always be possible to make an instrument in which the line of sight for both wires remains true for all distances, that result can generally be secured, for at least the principal wire, without requiring any other but the regular cross-wire adjustment.

By the foregoing explanation it will be readily understood that it is of great importance to have the focussing slide of such a telescope *truly fitted*, in order that the optical axis of the object-glass may coincide with the geometrical axis of the telescope, whether this slide moves in the main tube and carries the object-glass, as is the custom now in the smaller instruments; or whether it moves in special rings provided for it in the main tube at the eye-end, where it will contain the eye-piece and the cross-wires, as is the case in all larger instruments. Any lateral motion in the *focussing slide* that carries the *object-glass* or the *cross-wires*, will, therefore, derange the adjustment of the line of collimation. However, it is equally as clear that a wabbling of a focussing slide carrying an eye-piece which serves only the purpose of a compound microscope for close observations of the wires and the image of an object, is of no account save that such lateral motion may be so great that the obliquity which the optical axis of the eye-piece may at times have with respect to the optical axis of the telescope, may cause some parallax, if the wire and image under observation are not sharply focussed together. In concluding, it may not be considered amiss for a full understanding of this subject, to also mention in this connection, that any transparent substance, such as *prisms,* lenses, or shade-glasses,* introduced between the object sighted at and the object-glass, will deflect the line of sight from its true course, unless such parts can be made optically and mechanically perfect, which is rarely the case without elaborate adjusting apparatus. The introduction of a lens or lenses between the object-glass and wires, or that of a glass micrometer, will also have the tendency to deflect the optical axis and affect the line of collimation. For this reason "Porro's telescope," which requires a lens between the object-glass and the wires, complicates the above conditions of a measuring telescope; and while it may prove of some value in stadia measurements, can never be adapted for the engineer's transit so long as the proper functions of the transit telescope, as explained above, are considered of the greatest importance. The successful performance of an instrument should not be sacrificed for the sake of some doubtful novelty.

The proper way of attaching prisms and colored glasses necessary to make sun and star observations is to put them upon the eye-piece of a telescope. After the rays from an object have passed through the object-glass and the plane containing the wires, the line of sight as fixed by the object, optical axis, and the wires, cannot be changed by additional refraction. The best way, therefore, is to apply prisms and shade-glasses between the eye and the lens nearest the eye.

Aluminum for Instruments of Precision.

In consequence of recent improvements in the production of pure aluminum and a corresponding great reduction in its cost, we frequently receive inquiries as to the adaptability of this metal for the manufacture of engineers' and surveyors' field instruments.

We may be permitted to say, that while we were among the earliest advocates of aluminum and its alloys for mathematical instruments (see *Scientific American*, Feb. 1, 1868), we are not so sanguine concerning its adoption for the finest class of

* The object prism, so called, attachable to the object end of a mining telescope to aid in steep sighting, from its position between the object glass and the object sighted at, must of necessity be of very limited usefulness, since the slightest change of the prism or its mounting or a change of the position of the telescope itself or of its object slide will almost certainly deflect the line of sight from its true course and give no satisfactory results.

geodetic instruments, as these inquiries would warrant us to be. There are certain advantages derived from the use of the lighter aluminum instead of copper and its alloys,—the metals now employed for field-instruments; but the disadvantages are that pure aluminum, although very rigid, is nevertheless a very soft metal like tin, and that, when alloyed with 10 per cent. copper, to make it harder, it becomes very brittle, but when alloyed with 20 per cent. or 30 per cent. of copper, it becomes so brittle as to break like glass. Therefore, we believe, in the present state of its development it is not a suitable material for precision instruments.

An alloy of 95 parts aluminum and 5 parts of silver by weight has been found to give good results, being more rigid and harder than the pure metal, and but little heavier, while it is almost as resistent to corrosion, polishes well, and is said to be better for graduation; but, the fact that it contains silver, will, of necessity, limit its use to the more exceptional class of work.

Very little is gained in the way of reducing the weight of an instrument by employing aluminum bronze (90 per cent. copper and 10 per cent. aluminum). The parts of instruments made of the latter metal might be easily reduced somewhat in thickness on account of its greater rigidity as compared with copper alloys; yet to lessen the tendency to vibration, and also in order to withstand the wear and tear of the field use of an instrument, such parts need a little more mass, or dead weight as it may be called. It is then found that the weight of an instrument remains materially the same as ever. An exception to the rule may exist in the construction of the larger and stationary astronomical instruments, where aluminum bronze may be used to a certain extent to advantage. Its adoption is, however, restricted to non-revolving parts, since, when closely fitted into bearings made of the softer copper and tin alloys, the friction and wear of these parts is so marked that we would never think of substituting it for steel, bell metal or phosphor-bronze, or for any work requiring a smooth and accurate motion.

There can be no doubt that aluminum possesses great utility over brass in the construction of instruments of minor importance. Sextants, reflecting circles, and the more ordinary compasses,* parts of plane-tables, etc., can be made of it with propriety. We have used it occasionally for many years, but for reasons already stated above, we are not prepared to advocate its general adoption for instruments requiring greater precision, such as the finer transits, theodolites, etc. It is only in rare cases when a judicious use of this metal may be a necessity for the successful construction of an instrument, as for instance in our new style of mining transit, permitting of vertical sights up and down a shaft without the use of an extra side telescope, where certain detachable parts of the instruments are mounted in an excentric position, and unless such parts are made of aluminum they would require a heavy counterpoise.

It is principally the indiscriminate use of aluminum that we would warn against. We are aware that transits have been made of aluminum, but aside from their novelty as such, little or no merit can be claimed for them. To make this fully understood, it will be necessary to explain that all the finer bearings of an instrument made of aluminum, such as *centers*, *object slides*, *leveling* and *micrometer screws*, etc., will have to be *bushed* with a harder and non-friction metal, to guard against friction and wear and to obtain the close fitting of such parts, and permanency of adjustments so necessary in instruments of precision. Now, to make the principal bearings of an instrument of different metals will have the tendency to weaken the parts so treated, to make them less secure, and to render the adjustments more liable to derangement on account of unequal contraction and expansion between the two metals. It simply means, then, that the present high state of perfection in geodetic instruments, which retain their adjustment in the varying temperatures and climes of our zone, shall be abandoned, and we go back many years to when the indiscriminate use of widely different metals often made an instrument entirely unreliable, except when used in the temperature in which it was adjusted.

Modern instrument-making has, however, already achieved great results in reducing the weight of field instruments. By improved designs and by the use of harder metals in place of the soft brass, remarkable changes have been brought about in the weight of instruments. They are no longer the heavy and formless structures of soft or hammered brass as of yore, but are of the type and character of a long-span steel bridge, as compared with an old-fashioned wooden structure. Every important member of an instrument is now calculated with regard to its strength, and the materials are particularly chosen for the part they are to perform.

* Commercial Aluminum, unless obtained from reliable sources, often contains a small amount of iron.

Owing to the many improvements made in the designs, to the use of better materials, by the application of specially designed tools and machinery, there is no need any more to use large and heavy instruments. An instrument of about two-thirds of the size and weight of those made ten or fifteen years ago will do now the same class of work.

It is by these methods that lightness has been gained, and even must be looked for to some extent in the future. Unless the size of an instrument is decreased, the resistance of its exposed surfaces to wind pressure, causing sudden vibrations or tremor in the instrument, will of necessity require a certain amount of weight to secure the needed steadiness, and if this weight is not in the instrument proper, it will have to be in its tripod legs. This is especially true in this era of high telescope powers and sensitive spirit-levels. What is needed is that engineers and surveyors should have more confidence in instruments of smaller size as made by the best makers.

There are other reasons why makers should be somewhat conservative in the adoption of aluminum as a material for the finer class of surveying instruments, but as they relate principally to the treatment of aluminum during construction graduating process, etc., they may be omitted here.

In conclusion we wish to say that the future developments, in alloying it as a base with other metals or combination of metals, will be watched by us with due care, and that whenever such developments will warrant their adoption in the various parts of our instruments, we will only be too glad to avail ourselves of any superiority such alloys may possess.

Repair of Instruments.

We are often applied to for correcting new and repairing old instruments made by other makers. We will here remark, that as workmanship, material and construction of different makers' instruments vary from one another, it is oftentimes impossible to repair them in an entirely satisfactory manner without going into an unwarrantably great expense, or without making such alterations as would practically make a new one. We will always guarantee in such cases to put the instrument in as good order and adjustment as the character of its construction, workmanship and material, the extent of damage and the general wear will permit, and that all repairs are promptly and conscientiously made. The charges will be according to time consumed, and as low as is consistent with good work. Parties sending instruments should point out in detail whatever parts they wish to have repaired; but the best course to be pursued is to have the instrument *put in thorough order and adjustment*, implying, as it does, that the firm should make such warrantable repairs as will make it as serviceable as possible. This course is always more expensive, but the most satisfactory to insure good work, and it is also the cheapest in the end.