The “mustache” of the American Optical M603 Lensometer

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ABSTRACT

The American Optical Company Model M603 Lensometer is a *focimeter*, an optical instrument used to determine the “prescription” (optical specification) of corrective lenses (eyeglass lenses or contact lenses). It was made from 1938 through perhaps 1969, and was very popular among optometrists, ophthalmologists, and opticians. (Many are still in use.)

Uniquely among all American Optical focimeters (perhaps among all focimeters), the M603 (well, actually, also its short-lived predecessor the M602) has a “mustache-shaped” plate called the *lens alignment plate*. There are today many mysteries about the usage of this feature.

This report first gives some background in the operation of a focimeter, in the configuration of the M603, and in the nature of the “mustache”. Then the mysteries of its usage are discussed.

1 THE FOCIMETER

1.1 Introduction

The *focimeter* is an optical instrument used to determine the “prescription” (optical specification) of corrective lenses (eyeglass lenses or, in more modern times, contact lenses). It is typically used in the offices of optometrists, ophthalmologists, and opticians, and in corrective lens manufacturing and finishing labs.

In the case of use by optometrists and ophthalmologists, a common task is to determine the prescription of a new patient’s existing corrective lenses, to get an initial insight into the person’s previously-recognized visual defects and how they have to date been corrected.

Another important use, especially in the case of opticians, is to confirm that a newly manufactured pair of eyeglasses (or a set of contact lenses) has in fact been correctly made in accordance with the prescription issued by the optometrist or ophthalmologist.

At a lens manufacturing or finishing lab, the instrument may be used to confirm that a lens had been properly made. It may also be used for such purposes as, in the case of a not-yet shaped and mounted eyeglass lens, having a "cylinder" component, to determine and mark the orientation of the cylinder axis so that the lens can be properly oriented as it is shaped (or drilled) to fit the chosen frame.

1.2 Measurement principle

The lens under test is placed against what I call the "measurement nose" of the instrument (formally, the *measuring aperture*). In most cases, the lens is placed with its rear surface ("back vertex") against the nose.

A spring loaded arm with (typically) an open rubber-covered ring at its end presses against the lens to hold it in place. This is often called the "lens holder", but in some cases the "lens chuck".

An optical system behind the nose creates an image of an illuminated "target" (which comprises a pattern of lines at right angles) behind or in front of the lens under test at a distance controlled by a calibrated dial. (If the image is behind the lens, it is a virtual image.)

The lens under test in turn creates a virtual image of **that** image. The operator regards that virtual image through a telescope mounted in front of the lens, carefully focused at infinity.

When the movable image of the target is arranged to fall precisely at the second focal point of the lens under test, the virtual image created by that lens is "at infinity". Then, the image of the target lines will appear perfectly focused in the telescope.

When that condition obtains, the position of the movable image of the target is read from the calibrated dial. The dial actually is not calibrated in the distance of the image from the lens vertex, but rather in the inverse of that distance.

But the inverse of the distance from the lens to the target image, when that image is located at the second focal point of the lens, is by definition the *refractive power* of the lens, denominated in the unit *diopter*, which corresponds to an *inverse meter* (m^{-1}). Thus the refractive power of the lens can be read directly from the dial.[1]

It is of course that refractive power that we seek to determine by measurement with a focimeter.

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[1] Handily enough, the mathematics of the optical system are such that if the dial linearly moves the movable part of the optical system, its scale in terms of the inverse of the distance from the lens to the target image (and thus the indicated power) will be linear.

When the lens may have both “sphere” and “cylinder” components (the cylinder component being used to correct for astigmatism), special maneuvers, depending on the presence of lines in two orthogonal directions in the target pattern and the ability to change the orientation of the pattern with a second calibrated dial, are used to measure the powers of both components (and the orientation of the axis of the cylinder component). The details of this technique are beyond the scope of this article.[2]

2 The American Optical M603 Lensometer

The American Optical Company M603 Lensometer (a *focimeter*) was introduced in 1938. It was well received by the various user communities, and was commercially very successful for many years. It was superseded by a newer American Optical model in 1969.

Figure 1 shows a typical M603 Lensometer (this one in fact from our personal collection, made in 1948).

Figure 1. American Optical M603 Lensometer

We see the observing telescope on the left, and the optical system on the right. The bullet-shaped housing at the far right contains the lamp that illuminates the target.

The large wheel on the near side (with a smaller knob to turn it) sets the position of the target and thus of the target image; the corresponding power of the lens under test is read from the scale we

[2] The reader who is interested in this may wish to read “The focimeter—measuring eyeglass lenses” by the same author, probably available wherever you get this.

see on that wheel. The wheel just in front of the lamp housing controls the orientation of the target.

A suffix letter (A or B) indicates variants equipped with certain optional features. The specimen seen in figure 1 is in fact an M603B.

3 THE "MUSTACHE"

3.1 Introduction

Many M603 Lensometers[3] were equipped with a mustache-shaped *lens alignment plate* (which for conciseness I will call here the *mustache*). In figure 2 we see close-up the one on the specimen seen above.

Figure 2. Lens alignment plate ("mustache"

It is about 6.75" in overall width. It carries horizontal and vertical reference lines.

The tube that protrudes through the mustache is the *measurement nose*, against whose end the lens under test is held. In its center is the *measuring aperture*. The intersection of the reference lines on the mustache is at the center of the measuring aperture (*i.e.*, on the axis of the optical system).

3.2 The role of the mustache

3.2.1 *Introduction*

From its name and nature, the lens alignment plate (to use, for this purpose, its actual name) would seem to be intended for us to use, if we had a partially finished lens with its optical center and horizontal axis marked in temporary ink, to:

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[3] In fact, the mustache (in exactly the form we see here) was present in the predecessor model, the Model M602, but it seems that this was very quickly superseded by the very similar Model M603, and so for conciseness I will ignore it here.

a. properly position that lens (in translation) so its optical center lies in the center of the measuring aperture, and

b. orient the lens (in rotation) so that its intended horizontal axis is parallel to the horizontal axis of the instrument.

One problem with a is that ordinarily (for a lens known to have no prism component) we locate the lens (in translation) by observing the target image in the eyepiece. When the center of the pattern lies on the center the field (and there are reticle lines to tell us where that is), the lens is properly “centered”.

But that still leaves b as a reasonable duty for the mustache.

3.2.2 *In the manual*

In the extensive 1938 manual for the Model M603, the mustache only receives a glancing mention. In the list of parts of the instrument indicated by key numbers on the figure early in the manual, we see:

> Lens aligning plate. The geometrical axis of the lens should be aligned with the 0-180 line of this plate.

Note that this speaks to the rotational orientation of the lens, and not on the location of its optical center.

There is a similar reference in the instructions for performing measurements on a basic “sphere” lens. It is probably assumed that this would also be followed for measurements of the other types of lens mentioned later.

3.2.3 *A complication*

A complication immediately arises with respect to duty a. The operator cannot look along the system axis when positing the lens against the lines on the mustache—the telescope would be where the operator’s head needed to go. And since there is a substantial distance from the lens to the mustache (as much as 1.5 cm), there would be considerable parallax.

On the other hand, with regard to duty b, parallax does not really lead to error in the visual comparison, but can make the process more difficult. Still, the operator can reasonably arrange the orientation of the lens so its “geometric axis” marking appears parallel (even if not coincident with) to the horizontal line on the mustache.

3.2.4 *A lens with a prism component*

Some eyeglass lenses have a prism component, which serves to deflect the line of sight in order to compensate for conditions in which the person’s eyes do not gladly aim at the same point.

When we measure such a lens, ordinarily, for the basic measurements, we start by positioning the lens until the center of the target pattern falls in the center of the field (as described earlier). For a lens with a prism component, this occurs with the “marked” optical center of the lens not positioned at the center of the measuring aperture.

Later when we wish to determine the power and orientation of the prism component, we reposition the lens until (by visual observation) its marked optical center indeed falls at the center of the measuring aperture.

We then ascertain, by reference to a reticle in the eyepiece, the amount and direction by which the center of the target image is displaced from the center of the field.

The positioning of the lens in this process would seem to be a natural for us to use the mustache in duty (a). But the unavoidable parallax dooms that, and so in actuality we probably position the lens until the marked optical center just is seen to lie in the center of the measuring aperture. (There is no parallax problem there, as the measuring aperture is in intimate contact with the lens.)

So in reality, the use of the mustache would seem to be limited to the rotational domain (task b).

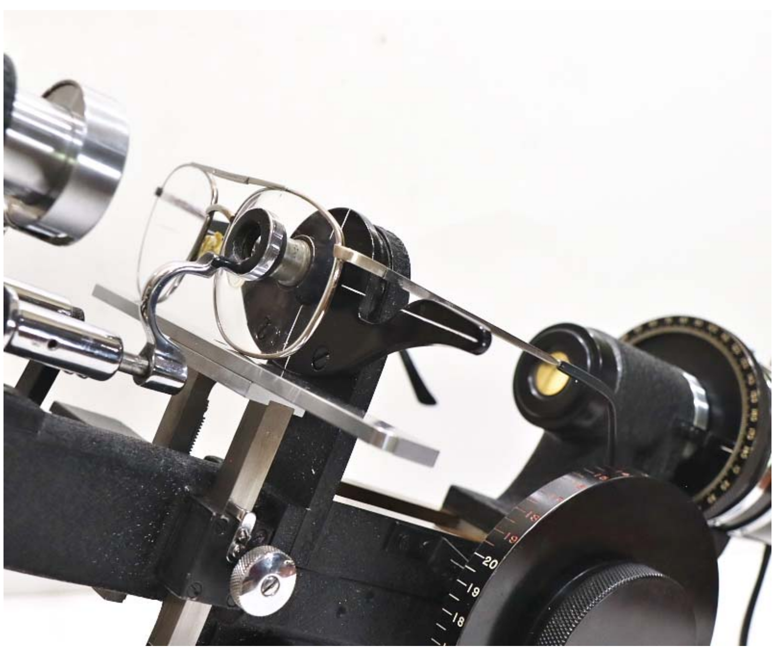

Figure 3. Eyeglasses on the spectacle table

3.3 Another player

At this point I will introduce another player in this drama, the *spectacle*[4] *table*. This is a rectangular horizontal plate that is used to support a pair of eyeglasses when one of its lenses is under measurement. It can be raised and lowered with a knob working through a rack and pinion arrangement. In the manuals for this instrument, it is called the *lens alignment table*.[5]

In figure 3, we see it (on our M603) supporting a pair of modern eyeglasses.

A friction brake holds the table in the position that is set. A scale (calibrated in mm) shows its height with respect to the center of the measuring aperture.

We also see here the mustache. In fact, we can see the reason for its unusual shape: the “dips” in its limbs are intended to provide clearance for the temple piece on a pair of eyeglasses on the same side as the lens being measured.

In the unit pictured in the 1938 manual for the M603, the spectacle table itself was just wide enough for the bottoms of the two sides of a typical eyeglass frame to fit on it. To allow either lens to be put in front of the nose for measurement, the table itself could be moved from side to side; it was mounted to a support plate on a gibway.

But from early in the production history of the model, the table proper was fixed on its support plate, and the table was made wider so that the eyeglasses can fully sit on it with either lens in front of the nose. (Ah, the great advances of science! Just make it wider!)

3.4 Why is the mustache so wide?

Why is the mustache itself so wide (as perhaps contrasted with a small circular plate carrying vertical and horizontal reference lines)?

Is it vaguely suggested in the manual that this is so the mustache can be used to attain proper orientation of a completed pair of eyeglasses. Presumably this would depend on each of the lenses still having in place a visible (but temporary) mark at the location of the optical center of that lens. Despite the matter of parallax, the operator could presumably visually orient the glasses so that a line imagined between

[4] In much writing in this area, the otherwise-archaic term “spectacles” is often used to refer to eyeglasses,

[5] Often the name conferred on some new thing reflects the preoccupation of the inventor at the time rather than describing the thing in a more “universal” way.

the optical center marks on both lenses would seem parallel to the horizontal line on the mustache.

But there is no suggestion of this procedure in the 1938 manual. Rather, the manual describes the use of the spectacle table to not only support and position vertically the complete pair of glasses but as well to properly orient them in rotation.

So the reason that the mustache is not merely a circular crosshair plate, surrounding the measurement nose, remains a mystery to me.

4 THE SUPPORT PLATE

In all M602 focimeters, an important ingredient is what I will call here the *support plate*. This is a bulkhead that arises from the bed of the instrument about halfway along its length. Its primary duty is to support a cylindrical assembly which, at its distant end, carries the standard lens and whose near end is the measurement nose, against whose end the lens under test is seated.

A secondary job, where applicable, was to support the mustache.

Over the life of the M603, two different designs of this plate were used. We see these two designs in figure 4 (both on instruments that, at least at the time the photos were taken, did not have a mustache).

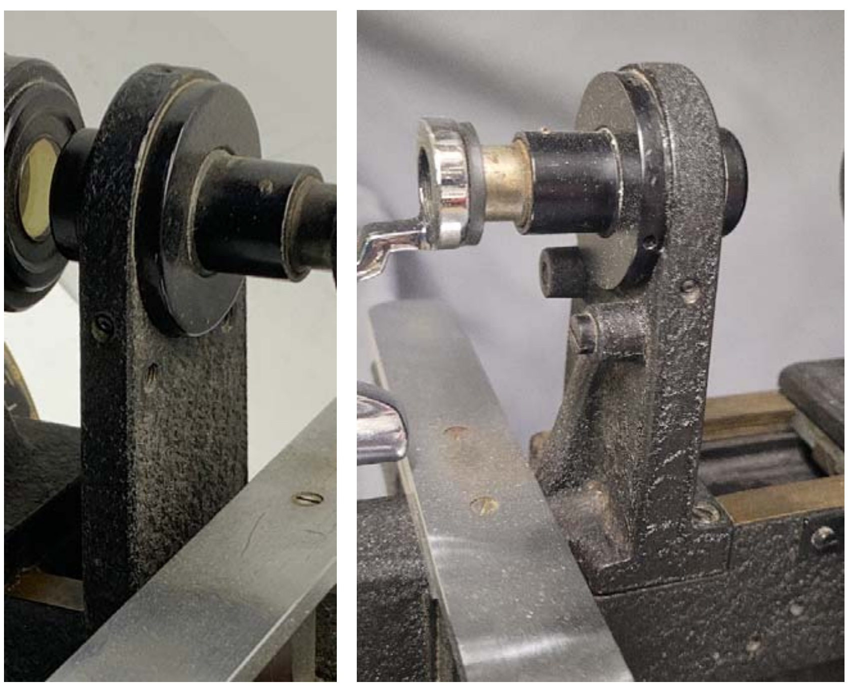

Figure 4. Support plate
(L: no buttresses or bosses; R: buttresses and bosses)

In particular, seemingly starting in 1951 (although one example is seen on a 1948 specimen), the support plate had a buttress on each side, presumably intended to strengthen the plate against possible deformation or breakage were it to be struck. This difference also involved a different way that the support plate was fastened into the bed of the instrument, and in turn some considerable differences in the details of the bed itself. I think that the support plate itself also got a little thicker with that design.

The left hand picture shows the design of a support plate without buttresses. We see two tapped holes that would be used to mount the mustache, if one were provided. Spacers would then be used to set the mustache out from the surface of the mounting plate to the proper location. (That “proper location” seems to have varied over the life of this model.)

The right hand picture shows the design with the buttresses. The buttress on the face to our right is small, and can’t be seen in this photo. Note that the plate also has two integral bosses, on which the mustache (when provided) would be fastened. We even see one of what is probably a mustache mounting screw in place on one of the bosses. We note the “foot” by which this style of support plate is fastened to the instrument bed (with four screws). (The type with no buttresses is fastened by screws through it into the end of one section of the bed.)

5 OPTIONALITY

After considerable study of photos of M603 Lensometers offered for sale on eBay, and of the specimen in our personal collection, I suspect that, at least later in the life of the model, the mustache was an optional feature (perhaps only by way of a special order). (Not every user might have fully appreciated its talents, in particular, optometrists and ophthalmologists, who, especially in “modern” times, would rarely work with individual loose lenses.) This option is, however, not listed on the catalog sheets we have from 1947 and 1958.

6 IN A LATER MODEL

Figure 5 shows the measurement nose of an American Optical Model 12603 Lensometer, the successor (in 1969) to the Model 603.

Figure 5. American Optical Model 12603—measurement nose

We see the white lines that radiate from the center of the measuring aperture. We presume these are to support the same lens locating and orienting maneuvers that were facilitated in a more ornate way by the mustache of model M603.

Again, here substantial parallax would be unavoidable, and would be problematical if using these lines as a reference for adjusting the translational position of the lens under test. The fact that these lines are on a conical surface would seem to aggravate that problem.

7 AN ALTERNATE APPROACH

Several patents by Edgar Tillyer, for many years American Optical's lens wizard, provide for (in different ways) changing the focus of the observing telescope so that, rather than it being prepared to properly focus on an image at infinity (as when it is used for the measurement of the power of the lens under test), it would be refocused on a plane about at the measurement nose, thus providing a view of the lens under test itself. In this mode, additionally, the view would be "erect", whereas when operating in the measurement mode the view is "inverted" And in the alternate mode, the field of view is substantially wider than in the measurement mode.

The purpose of this alternate mode of viewing was so that the operator could see the position of the lens (and any markings on it), and in fact the entire lens, without moving his eye from the observing telescope, this view also being free from parallax.

We believe that this was in fact implemented on the earliest commercial American Optical Lensometer, the Wellsworth Lensometer, seen in figure 6 in a charming photo from a catalog *ca*. 1920:

Figure 6. American Optical Wellsworth Lensometer

The knob atop the telescope puts into play a secondary lens cell that produces the alternate viewing mode described above.

We believe that this alternate viewing mode disappeared after this model.

8 ABOUT OUR M603B AND ITS MUSTACHE

The M603B in our personal collection (made in 1948, according to the serial number) had no mustache as we received it. It has the earlier style of support plate (with no buttresses or mustache mounting bosses).

The holes in the plate where mustache mounting screws would go had paint on the threads, suggesting that there had never been screws in them. It may well be that this specimen never had a mustache (perhaps by dint of a special order).

But, given that the mustache was "normal" on this model, we felt it would be legitimate to retrofit ours with one.

We were very fortunate to obtain a mustache (unpainted, with the reference lines embossed) on eBay, with two screws of the proper type. We applied what we considered to be an appropriate finish (satin black, oven cured) and filled the reference lines with white acrylic paint. We made appropriate spacers (the way we did it made their outside surface black), and put the mustache in place. I have to say it looks quite splendid. (We see it in figures 1, 2 and 3.)

9 COMMENTARY

The mustache was conceived a long time ago (about the same time as *moi*), and I have no information on the thinking behind it.

From an archeological perspective, I get the feeling that this was an "invention" that was never fully invented, and which arrived when one of its purposes (facilitating rotational alignment of a pair of eyeglasses) had already been overtaken by another invention, the spectacle table.

Clearly there was at American Optical Company a culture that included almost a supernatural respect for its key technical people (several product lines were in fact labeled with the name of [Edgar] Tillyer, one on the company's most brilliant technical innovators and leaders). It is always possible that the mustache carried some "blessing" that made it inextinguishable.

Just sayin'.

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