Telescope Design — Fact And Fiction

THE DYNAMAX DIFFERENCE

Criterion Scientific Instruments is one of the oldest and most reputable telescope makers in the United States. We have been servicing the needs of the astronomical community since 1945 — more than three decades of experience in producing quality optical telescopes for both amateur and professional use.

It is this experience that enables us to know what features are the most critical in an astronomical telescope. First come precision optics. Definition and resolution of delicately shaded astronomical objects requires flawless optics and no amount of highly skilled and painstaking care and effort is spared to insure highest precision of figure and total quality for our optics.

However, we know that it does the amateur no good to have precision optics that are placed in a tube material that can hamper overall performance. We know too, that a set of optics is only as good as the mounting that supports them. In short, the total astronomical telescope is a lot more than just good optics: every seemingly trivial detail matters.

As a discriminating amateur, we know that you can appreciate this. And for this reason, we know that you will also appreciate the following information — a straight forward, factual discussion of why the Dynamax is built the way it is.

Behind each Dynamax feature, behind each seemingly abtruse specification — there lies a significant reason. And the reason is not just a result of an opinion. It is instead a *fact* of good telescope making, backed by volumes of books on the subject written by leading experts in the field. In the following discussion, we plan to show you the reasons why the Dynamax is built the way it is, and by so doing, illustrate why it constantly outperforms other telescopes on the market today. In fact, whether you ever purchase a Dynamax or not, we believe the information presented will give you a better understanding of why a telescope *must* be made in a certain way to achieve maximum performance, why results are significantly affected by material composition, and why every minute detail of optical and mechanical construction on the Dynamax telescope are standards by which other telescopes can be judged.

Selecting a telescope today is certainly difficult. There is much variety to choose from and illfounded claims seem, at times, to run rampant through the astronomical community. The wise consumer will therefore collect as many facts from as many sources as possible before making a decision. In this spirit, we would like to provide you with the facts concerning the Dynamax. We certainly hope that the facts we present will alleviate any fiction you might hear elsewhere.

THE "BAKELITE" TUBE

Many people tend to overlook the significance of a proper tube material, which will be used to hold the optical components in critical alignment. At Criterion, we feel that the material composition of the tube is a prime consideration — just as important as the optics housed within. After all, what good are precision optics if improperly mounted?

While aluminum tubes may be satisfactory for smaller apertures (4″ or less), when used in larger apertures they create problems. Properties of bakelite on the other hand, are ideal for a telescope. Bakelite composition was chosen for the Dynamax tube material for 3 very important reasons:

1. **HIGH STRENGTH:** Bakelite is a phenolic resin laminate that is, pound for pound, stronger than some metals, yet is readily machineable to fine tolerances. Since Bakelite cannot be dented (like aluminum) the optical system cannot be permanently shifted out of alignment even if the telescope is subjected to unusually rough treatment. The Dynamax tube is a rugged, thick-walled (1/8″) Bakelite impregnated cylinder that is fully weather-resistant and cannot warp, sag, shrink or distort even after a lifetime of use.

2. **DIMENSIONAL STABILITY:** Everyone knows that metal expands and contracts with temperature variations. Since the distance between the optical components is maintained by the length of the tube, doesn't it make sense to choose a tube material that remains perfectly stable and fixed in length over a wide temperature range? The *serious* amateur wouldn't want it any other way. Because the serious amateur knows that the optical spacing in a Schmidt-Cassegrain telescope is critical (largely due to the 5x secondary amplification). If the telescope tube expands and contracts with changes in temperature, the optics "move" with it, thereby seriously hampering critical observation.

The above statements are not just our biased opinion. The facts stated are irrefutable. We're sure that no one would argue the laws of physics, which clearly state that metal expands and contracts with temperature changes.

Just listen to this quote from a well-known American amateur. It appeared in *Sky and Telescope* magazine, March 1976, on page 203. We quote: "One problem with aluminum tubes is their change in length due to temperature variations. I have had to re-focus several times during a long photographic exposure. The focal-plane shift is approximately equal to the change in the tube's length multiplied by the square of the Cassegrain amplification ratio."

Before you buy a telescope, make sure the optics are mounted in a proper tube material. If you're paying for precision optics, beware of the way they are housed, so that the optical performance will be dependable at all times. We are happy to report that the Dynamax tube remains perfectly stable and fixed in length even when the temperature drops or rises sharply during the course of an evening's observing. And, keep in mind that, on most nights in many areas of the country, the temperature will in fact drop sharply when the sun goes down, and will *continue* to drop throughout the entire evening. Surely a condition that becomes a design factor in any instrument.

3. **THERMAL STABILITY:** An "insulated" optical path is a critical requirement for a well-built professional telescope. By "insulated" we simply mean that the tube material must be thermally non-conductive. Aluminum tubes are *not* insulated and will *readily* conduct heat or cold through the thin wall of the tube itself (another law of physics). This results in what is referred to by serious amateurs as "tube convection currents". Convection currents within metal tubes occur at night when the temperature is usually dropping. What basically happens is simple: Colder night air is readily conducted through the tube's metal wall, the inside of which contains warmer air. When these two layers of air mix together, the result is excessive turbulence within the tube itself due to convection currents.

The result of this turbulence is disastrous — rendering shimmering, wavy images with little or no resolution or definition. But don't take our word for it; listen to what the *experts* have to say:

Here is a quote from the book *Telescopes — How to Make Them and Use Them* available from the MacMillan Sky & Telescope Library of Astronomy. The following excerpts appear on pages 129, 130 and 131.

"Air, being a refracting medium, affects the path of the light rays according to its density and is as much a part of the optical system as the telescope itself. Anything that alters the homogeneity of the column of air through which the telescope looks, will distort the path of the light rays. In poor seeing of Type I, the image changes rapidly, and small objects such as stars or Jupiter's satellites occasionally appear double or triple. On the moon or planets, the disk may show two or more distinct boundaries rapidly moving or vibrating, and surface detail seems jumpy. The cause of these phenomena is air currents *within* the telescope. These moving inhomogeneities within the optical path prevent rays from all parts of the mirror from reaching the focus simultaneously. Seeing of Type I generally results from *faulty telescope design* (for example, an uninsulative metal tube). In any event, telescope tubes are best made of material with low heat conductivity and low heat capacity, to keep rapid, local variations of outside air temperature from being transmitted to the tube interior and to minimize the amount of heat so transferred."

More evidence on the use of an insulative material for a telescope tube is given by the following excerpt from *Amateur Telescope Making Advanced*, Book II. The A.T.M. series of books is considered by serious amateurs as a virtual "Bible" of telescope information. The following quote appears on page 617:

"Captain M.A. Ainslie of the British Astronomical Association writes as follows: "A very noticeable thing about American instruments is that most of them have metal tubes. Most of our telescope constructors have long abandoned the metal tube; the general experience being that the performance of a reflector in a wooden tube is distinctly better than one in a metal tube."

> Please note that a "wooden tube" is mentiond and keep in mind that the Dynamax Bakelite tube not only offers the same insulative properties of wood, but also provides much greater strength and durability characteristics as well, not to mention a better cosmetic appearance.

Or how about this quote from the world famous builder, Horace E. Dall, in the same book, page 618: "Regarding . . . wood tubes versus metal ones, my experience has shown how clearly is the superiority of the former, that I am rather surprised that the American amateurs haven't noticed it to speak of. I am speaking of moderate or large instruments and I have studied and experimented with tube currents in both kinds quite a lot, also currents induced by the body of the observer."

Another quote from the book: *How to Make a Telescope* by Jean Texereau again recommends an insulative material as follows:

"Much more damaging to image quality is the use of a metal telescope tube . . . Fluctuations are then numerous and rapid, and a permanent air sheath clinging along the metal wall, intrudes into the beam. The wooden tube of our standard telescope, on the other hand, performs well . . . This results from the fact that the plywood panels are poor heat radiators."

Indeed, few people would dispute the authority of the United States Military. The following is a quote from the U. S. Military Standardization Handbook on Optical Design, section 18.6.2:

"Thermal effects in . . . optical systems are frequently the limiting factor in the performance of these systems. Thus, tube currents . . . in astronomical and missile tracking telescopes may reduce the performance of the instrument by a factor of two or more if measures are not taken to circumvent the degradation."

Then in section 18.6.2.3: "The minimization of thermal heating of any tube is desirable from a tube deformation and image quality standpoint."

CONCLUSION

All of the quotes herein certainly indicate a unanimous agreement amongst experts that the construction of a truly high-performance, professional optical system is a lot more than just good optics. In the words of the U.S. Military: "tube currents . . . may reduce the performance of the instrument *by a factor of two or more. . . .*"

Therefore, if you plan to buy a *truly* professional instrument, don't consider just the optical quality claims of *any* manufacturer without first considering the tube in which they are mounted — unless, of course, you never plan to use your telescope for serious astronomy.

High strength, rugged durability, thermal and dimensional stability, are the simple reasons why the high performance Dynamax optical system can continue to produce razor-sharp images over an incredibly wide temperature range, and even under adverse environmental conditions.

BEWARE OF FICTION

Now that you've read the facts, be cautious of fiction.

There are some who may try to mislead you by arguing that the tube of a Schmidt-Cassegrain *should transmit* heat on the sole basis that it will take an insulated optical path much longer to reach thermal equilibrium when brought outdoors from a warm room. Contrary to what others may claim, we would like to set the record straight. The Dynamax optical system will reach thermal equilibrium in the *same time* as a telescope with a metal tube *provided* the following procedure is used: when you bring the Dynamax outdoors from a warm room, tip the tube straight up. Since warm air rises, and since the corrector plate at the top of the telescope transmits the infrared (heat), warm air inside the tube will rise and quickly escape through the front corrector plate.

The above procedure is clearly explained on page 45 of the Dynamax instruction manual. Consequently, anyone who tries to tell you that a telescope should transmit heat for the purpose of reaching equilibrium faster hasn't read our instruction manual and simply isn't aware of this easy procedure. (Obviously it only takes a second to point the tube straight up.) Moreover, such a statement illustrates a total lack of knowledge with respect to the various technical literature available on the subject of proper telescope construction, some of which we have quoted herein. Practically speaking, if you store the Dynamax in a 70°F room, and the outside temperature is 30°F, you would allow approximately 30 minutes for the optics to reach thermal equilibrium. Telescopes with metal tubes will take approximately the same amount of time to adjust to the same condition.

There are also those who may try to argue that only open-end, Newtonian-type telescopes need an insulative tube material as opposed to the sealed tube of a Schmidt-Cassegrain — another misleading statement. We call your attention to our previous quote on page 1 which appeared in *Sky and Telescope Magazine*, March 1976, page 203. If you have a copy of this issue, please refer to the article and note the type of telescope used by the author. For those who do not have a copy of the article, the telescope referred to in the quote was *not* a Newtonian, but rather a Maksutov-type whose corrector plate seals the end of the tube in the same identical manner as the Schmidt-Cassegrain. (Incidentally, the telescope pictured in the article is beautifully constructed and is clearly one of the finest examples of amateur equipment we've ever seen.)

In fact, dimensional stability is far more important in a Schmidt-Cassegrain than in a Newtonian by merit of the 5x amplification found on the secondary mirror of a Schmidt-Cassegrain, which greatly magnifies even the most minute shifts in tube length. By comparison, the diagonal mirror of a Newtonian does not magnify errors *at all*, being perfectly flat, and for this reason, a Newtonian is significantly less affected by dimensional stability of the tube.

Furthermore, we again quote the U.S. Military Handbook on Optical Design, section 18.6.2.3 as follows:

"The minimization of thermal heating of *any* tube is desirable from a tube deformation and image quality standpoint."

From the same book, section 18.6.2.1:

"Any telescope exposed to thermal radiation or temperature differences of any kind will have variations in density of the air within itself."

Please note that the underlined word "any" is the key word here. Clearly, *any* telescope — Newtonian, Schmidt-Cassegrain, Maksutov, etc., should have an insulative tube material.

Thus ends the argument that only open-end tubes dictate an insulated tube. As you can see, the truth of the matter is that *all* telescopes should follow the same standards concerning material construction. (For further proof also see the previous quote on page 2 taken from section 18.6.2. which clearly mentions missile tracking telescopes. Then note that the vast majority of missile trackers are closed-tube catadioptrics — not open-end Newtonians.)

Finally, it's significant that, in making a literature search to gather information for this piece, we could not find even one textbook on the subject that recommended the use of a metal tube, by comparison to the many that specifically recommended an insulated tube.

ACTUAL PROOF WILL BE IN THE USING:

We contend that, in actual practice, many amateurs presently owning telescopes with metal tubes are not even aware that their optical performance suffers due to thermal effects. That is, until their telescopes are compared, side by side, to a Dynamax optical system (especially on nights when the temperature is constantly dropping).

Why? The answer is somewhat elusive, yet simple, once explained. On page 2 we provided the reader with a quote from *Telescopes — How to Make and Use Them*. Refer to this quote and note that tube currents affect optical performance so severly that they are actually classified as a "bad seeing" condition (specifically Type I seeing, which is due to "faulty telescope design", such as an uninsulative metal tube).

This is certainly logical, as one must realize that seeing conditions inside the tube are just as damaging to image quality as seeing conditions encountered in the earth's atmosphere. In the words of the U.S. Military Handbook on Optical Design, section 18.6.2.1, "Insofar as the final image is concerned, it matters little whether the density discontinuity occurs without or within the tube of the optical instrument itself." However, a point that is overlooked by most is that *it is virtually impossible to determine whether the bad seeing is inside — or outside of the telescope tube.* In fact, for most observers, it is impossible.

We wonder then, how many owners of telescopes with metal tubes go out to observe, look into the eyepiece, see shimmering, wavy images, then quickly proclaim "The seeing is poor tonight." Consequently, the telescope is packed up, put away, and the owner retires to a good night's sleep.

The point we're trying to make here is that if the same telescope owner had a Dynamax side by side with the metal telescope tube, he might quickly see that the atmospheric seeing is good — it's the seeing conditions *inside* the metal telescope tube that are actually at fault! And we reiterate that for most observers, there is virtually no way of determining whether the poor seeing is inside or outside of the tube unless a Dynamax telescope is being used as a standard of reference.

This surely must be an obvious reason why our files are filled with complimentary letters from enthusiastic Dynamax owners who have compared their instruments to others at star parties and local amateur gatherings. It seems that the compliment we hear often (too frequently to call it "coincidence") is "The image in my Dynamax seemed much steadier by comparison with similar instruments we tested it against." Some owners have even told us that other telescopes were packed up and put away while their Dynamax went on observing. One proud owner in particular proclaimed his Dynamax is consistently "The Star of the Star Party"!

All of this is just one reason why the Criterion Dynamax telescope is rapidly becoming the number one choice of serious amateurs worldwide — an instrument so precise and well-constructed that superior performance cannot help but follow.

THE RUGGED FORK MOUNT

Precision optics are of no use to the amateur astronomer if housed in an improper tube material. But a factor that is just as critical to successful observing is the mounting that supports the complete optical system itself. The rugged Dynamax fork mount is truly a mounting worthy of the optical system it supports, for very good reasons:

SAND CAST CONSTRUCTION

When exceptional rigidity in supporting a large mass is required, there is no better structural method than sand castings. Die castings, a high production technique, are generally used when the mass supported is small. Die castings are best suited for telescopes of 4″ aperture or less; Telescopes of 6″ aperture or larger may not be adequately supported by die castings. This is due to the fact that die castings must necessarily utilize thin walls in order for the part to cool quickly while it is within the die itself; otherwise the part will not cast properly. The sand cast components of the Dynamax fork mount, on the other hand, can be cast with greater thickness and therefore offer greater strength than the components found on die cast telescopes.

HEAVY DUTY BEARINGS:

If you are paying for a truly high quality astronomical fork mounting, make sure you get it in the form of heavy duty precision bearings.

By comparison to other Schmidt-Cassegrains on the market, the Dynamax fork mount offers a far superior bearing system. How important are the bearings in a particular telescope design? The design (correct or incorrect) of the bearing system of a telescope mount will directly affect the overall stability of the system while you are observing. And, as the experienced observer knows all too well, a stable, steady image at high power is an absolute necessity for serious observation and research. But size and strength is not the only consideration in the proper selection of a bearing for a given application. Other details are also important (such as bearing type), the determination of which is correlative to achievement of the most desirable balance between capacity, endurance and reliability.

The Dynamax fork mount offers the amateur astronomer not only the largest and strongest bearings of any comparable telescope, but also offers the correct choice of bearing design for the given engineering application.

LOAD RATINGS OF THE DYNAMAX BEARINGS:

The Dynamax design incorporates a polar axle of *hardened steel* that has an axial deformation limit of 10 tons! This is the heart of the Dynamax Bearing Support System. At the north end of the polar axle is a precision Timken tapered roller bearing 1.63″ in diameter. This particular bearing has a load rating of better than 375 lbs! The south end of the polar axle boasts a massive Sealmaster bearing almost 2″ in diameter fully capable of supporting over 800 lbs! *No other commercially available Schmidt-Cassegrain can offer you this kind of bearing system.* Incredible, isn't it? A bearing system this strong and massive supporting a tube weighing less than 15 lbs? Overdesigned? Maybe. But the truly serious amateur astronomer knows that an overdesigned fork mount can only add up to one thing: pillar-like stability so necessary for steady views even at extreme magnifications. In this respect, we submit that an astronomical telescope cannot ever be overdesigned in terms of stability.

Our engineers were recently shocked upon inspecting another Schmidt-Cassegrain instrument currently on the market. Upon disassembling the instrument, they found only *one* very small, imported, ball bearing in the entire telescope mount! Needless to say, such a design can in no way compare to the massive bearing support system offered by the Dynamax telescope.

So once again we see that a truly precise and well designed astronomical telescope involves much more than good optics alone. In comparing telescopes, be sure to compare internal clock-drive specifications — especially those relating to the structure and design of the bearing support system. We believe that in this respect the Dynamax stands out from all others, and superior performance will become clearly evident in the actual "side by side" comparisons to other telescopes of this type.

DESIGN OF THE DYNAMAX BEARINGS

Not only are the Dynamax bearings strong, but they are also of the correct design for their particular application — an astronomical fork mount. Why is this important? Before we answer that question, we must first investigate the stresses a telescope is subjected to. All compact, portable telescopes made today, including the Dynamax, are intended for use in either of two modes: the equatorial mode for astronomical observation using the clock drive, or the altazimuth mode for terrestrial observation.

In the altazimuth mode, the correct choice of bearing design calls for a *thrust* bearing because the force exerted by the telescope requires vertical support only. The exerted force is also concentric with the bearing so that no radial load exists. On the other hand, a telescope used in the equatorial position is tilted back to an angle equal to the angle of latitude at the observing site. In this position, the telescope is literally "hanging" off the polar axle at an angle that exerts not one, but *two* forms of load stress: both *radial and thrust.* The radial load results from the "sideways" force being exerted on the outer races of the bearing; the thrust load is caused by the "up and down" stress concentric with the *bearing's* center.

Thus we can now see from a good engineering standpoint, that truly adequate support of a fork mounted instrument in the equatorial position calls for a bearing that supports *both* radial as well as thrust loads. The best bearing for this application is a tapered bearing design. The north (top) bearing of the Dynamax fork mount is a precision Timken tapered roller bearing — probably the finest bearing of its kind (it is interesting to note that this particular type of bearing is widely used by automobile manufacturers to support the front wheels of cars).

The tapered Dynamax bearing insures smoother overall performance of the fork mounted clock drive. It additionally assures greater stability and load carrying capacity due to the fact that both forms of load exerted in an equatorially positioned fork mount are fully and properly compensated. In short, the Dynamax bearing system properly supports your telescope when it is tilted back as well as when it is standing up!

Most other telescopes of this type utilize either a simple thrust or radial bearing to support the instrument in both altazimuth and equatorial positions. No other telescope of this type that we know of offers you the superior quality and performance of the Timken tapered bearing found in the Dynamax.

The reason for this may well stem from the fact that the Dynamax bearing system is very expensive by comparison to the simple bearings found on other telescopes. Criterion, however, feels that the quality of a truly precision astronomical telescope should never, under any circumstances, be compromised for the sake of price. Also, because you buy the Dynamax directly from the factory, we can afford to give you more quality for less price. And, when you compare the Dynamax to other similar telescopes using simple, inexpensive bearings, we can guarantee that the bearing system of the Dynamax will clearly result in superior performance that will be evident the first night out.

METALLURGICAL COMPATABILITY

If you live in a geographical area in which the temperature ranges are severe, metallurgical compatibility becomes an important consideration. If incompatible metals are used in the design of a telescope mount, severe changes in temperature can possibly cause the clock drive mechanism and/or other components to malfunction or even cease operation entirely as one metal expands (or contracts) more than another.

The Dynamax catalog on page 13, refers to the Dynamax as "a telescope for all seasons", and rightfully so. All moving parts have been carefully designed to be metalurgically compatible. The polar axle is hardened steel, as well as the heavy duty bearings described previously. This eliminates differential expansion and rotational irregularities due to changes in temperature.

THE CRITERION TRIPOD:

The optional Criterion Golden Pyramid Field Tripod is without a doubt the finest support system found on the market today. It incorporates many exclusive design features not found on any other tripod of this type.

Specifically, the Golden Pyramid Tripod is supplied with telescoping legs, which accomplish three important goals, important to every observer:

(1) *Quickly adjusts* to a comfortable height for any observer, even children. Also, the tripod may be used whether seated or standing. (We recommend that a portable, folding lawnchair be used for a seated position when used in the field.)

(2) *Leveling* — is easily accomplished on unlevel ground.

(3) *Collapses* — down to a compact package for unprecedented portability in a heavy duty tripod.

Another convenient feature found on the Criterion tripod is a built-in azimuth adjustment which makes adjustment to Polaris as easy as pointing your finder.

The range of latitude adjustment is an incredible 0° - 90° — a range not found on any other tripod. Additionally, the wedge section folds down flat so you can mount your telescope in the altazimuth position for terrestrial observing or photography. It is also interesting to note that the Criterion Field Tripod is ideal for supporting other compact telescopes and special mounting holes are in-

corporated in the design which accommodate portable telescopes made by other manufacturers.

TRIPOD LEVELING UNNECESSARY?

The discriminating telescope buyer must be forwarned against a misleading statement regarding tripod leveling.

You may be told, or see in a dealer's pamphlet, that tripod leveling is unnecessary. Although this statement is basically true, it is deceptive in the respect that it requires further qualification. Aside from the fact that simple, elementary tripods are not equipped with levels, and professional caliber tripods are, here are the *real* facts concerning this issue.

The Criterion field tripod incorporates a bubble-type level which is precision machined into its base. Although it is true that the level is not an absolute necessity in achieving polar alignment, the specific purpose of the level is to enable the amateur astronomer to spend more time observing and less time setting up — a most desirable aspect for every observer. Here's how it works:

The Criterion tripod is set up with special attention paid to having the bubble level indicate a perfectly level condition of the tripod's base. (We should remind you that the "telescoping leg" feature enables leveling of the tripod even if the tripod is on completely unlevel ground — another important aspect to consider for field use.) The next step is to carefully align the telescope to Polaris with the greatest possible degree of accuracy. (Several easy methods of accomplishing this are given in our 90 page instruction manual.) From this point on, you will *never again* have to adjust the latitude adjustment of the tripod, provided you do not move to a new latitude (a move of considerable mileage) or, of course, disturb the initial setting. Instead, each time you want to observe, you will merely set up the tripod so that the bubble level indicates a precisely level condition of the tripod head, and your latitude adjustment will be automatically accomplished to the same degree of accuracy as previously established in your initial setting. You will now have only *one* quick adjustment to make each time you set up — the azimuth adjustment (by far the easiest adjustment to make).

Thus we can see that having a built-in bubble level is really no small matter in terms of ease, reliability and rapidity of set-up. Is it necessary? Not at all — that is, if you want to spend a lot of time setting up each night, making two adjustments instead of one over and over again. On the other hand, it *is* absolutely necessary if you want to avoid a nightly repeat of the laborious latitude adjustment that will be necessary without a level.

The bubble level on the Criterion tripod enables rapid, and most importantly, *repetitively accurate* setup of your instrument. That way, you can spend more time observing and less time adjusting.

On a final note, we might also be able to say that a built-in bubble level on a tripod is as necessary as having a radio, air conditioning, reclining seats, etc., etc., in a new automobile. The car will work without them, just as a tripod will indeed work without a level. But we pose the question: "which is more desirable?" And since our tripod is supplied with a precision level at *no extra cost*, who would argue that this represents extra value?

RESOLVING THE QUESTION OF APERTURE:

The potential telescope buyer in today's market faces an interesting question in the selection of a proper telescope for his needs: the question of aperture (size of the main telescope lens). Manufacturers of large aperture instruments claim that larger aperture is more desirable, while manufacturers of smaller aperture instruments claim that large aperture can actually hamper performance for many observers (depending upon atmospheric conditions).

What statements are fact, and which ones are fiction? We hope that after reading the following, the question of aperture will be resolved once and for all.

The final resolution of *any* telescope, regardless of design, expense, or manufacture, is determined mathematically by the formula:

Resolving Power: (in seconds of arc) $= \frac{4.56}{D}$ where D is the diameter of the objective lens. Thus we can easily see that the resolving power of a telescope becomes greater as diameter increases. A 3″ telescope yields a resolution of $4.56/3 = 1.52$ seconds of arc and a 6″ telescope will resolve to .76 seconds of arc. This means that a 6″ telescope will resolve *twice as well* as a 3″ telescope, all other factors being equal. This means you'll see twice the detail in a 6″ as in a 3″. And, we reiterate, that this law applies to *all* telescopes, with *no* exceptions. Whether the instrument is a Maksutov, Newtonian, Schmidt-Cassegrain or other type of design is irrelevant. The same law is irrefutable and can be found in virtually any textbook on the subject of telescopes.

And yet, there are suppliers of expensive smaller instruments who will actually tell you that their smaller catadioptric telescope will indeed out-resolve larger instruments. They argue that atmospheric "seeing" conditions adversely affect the performance of larger telescopes to such an extent that better views will be achieved by using smaller aperture. Such a statement can be misleading for several reasons and requires further qualification. Briefly, there are *two* kinds of atmospheric conditions to consider when observing through any telescope: turbulence and transparency.

On nights of gross turbulence, the stars appear to be "twinkling"; when the stars shine with a steady light, the atmosphere is quiet. Good transparency, on the other hand, simply means the air is clear and free from clouds, haze, fog and smog.

At this Point, the most important factor you should know is that *atmospheric turbulence is only crucial to detailed observations of the Sun, Moon and Planets. Faint, low contrast objects, such as Galaxies, Nebulae and Star Clusters are virtually unaffected by turbulence in the atmosphere.*

In summary, observations of the Moon and Planets require extremely *steady* air, while transparency is of far less importance. (In fact, many well-known amateurs have noted that a slight haze is actually *preferable* for planetary observation.) Galaxies, Nebulae and Star Clusters, on the other hand, require perfect *transparency*, while steadiness is not at all a prime concern.

We can thus conclude that the arguments over "seeing" conditions that supposedly favor smaller aperture, made by those who sell small telescopes, pertain only to observations of extended objects such as the Sun, Moon and Planets. The same arguments cannot be applied to point source objects such as Galaxies, Nebulae and Clusters. To better aid you in understanding all of the facts, we will therefore discuss these two categories of celestial observation on a separate basis.

OBSERVING EXTENDED OBJECTS (SUN, MOON, PLANETS)

We will agree that, on rare nights of gross turbulence, a smaller telescope will show greater detail in extended objects. This is due to the fact that the smaller instrument has inferior resolving power (resolving power is limited only by aperture no matter how well the optics are made). As a result, the smaller tele-

scope is incapable of resolving turbulence as well as the larger telescope. However, there are two remedies that owners of large telescopes can apply, which will promptly correct the situation:

(1) Lower the magnification of the larger telescope to a point where turbulence remains unresolved. By doing so, you will now still enjoy all the benefits of larger aperture, specifically greater brilliance and far better contrast in the final image.

(2) Another solution that seems to be conveniently overlooked by suppliers of smaller instruments is that, when grossly turbulent conditions do exist, the larger telescope can be "stopped down" to whatever diameter seems appropriate. Simply cut a piece of cardboard so that it fits inside the front of the telescope tube. Then cut a circular, central hole 3″ or 4″ in diameter, or whatever size seems appropriate, and you now own a smaller telescope! Remember — you can always make a larger telescope smaller, but you cannot ever make a smaller telescope bigger!

And, as every experienced amateur astronomer knows, when steady seeing conditions do exist, and these conditions are not as rare as some would lead you to believe, no small telescope could ever possibly produce the spectacular views afforded only by larger aperture.

Do the experts agree? Listen to these quotes from the famous astronomer/astrophotographer, George Keene, from his book *Star Gazing with Telescope and Camera*, page 62: "The image in a smaller telescope looks steadier only because there is less detail in it to be affected by air currents. When the air does settle down, the larger aperture will *always* show a better view."

On the same page, "Wilkins and Moore, using professional telescopes of 30″ to 60″ aperture always found a better image in a bigger telescope."

Another quote from the book, *Observational Astronomy for Amateurs*, by J.B. Sidgwick, reads as follows: "Planetary observations worth recording can be made with a 4 inch, though the desirable minimum is one or two inches larger than this. With 6 inches, full participation in the observing programs of the Planetary sections of the B.A.A. is possible; for regular work on the inner planets; 8 inches is the useful minimum. Summarily: for regular planetary work in this country, less than 5 inches provides insufficient resolving power."

Finally, with respect to our previous statement concerning "stopping down" the larger instrument on those rare nights when seeing is excessively turbulent, we find the following quote of interest. It appears in *Amateur Telescope Making* Book II, page 603: "We conclude, then, that, as well as improving the seeing, diaphragming may improve the contrast, and that diaphragming a large telescope is better than using a smaller instrument."

OBSERVING POINT SOURCE OBJECTS (GALAXIES, NEBULAE & CLUSTERS)

When it comes to observing Galaxies, Nebulae and Clusters, there is unanimous agreement amongst experts and amateur astronomers in general that there is simply no substitute for large aperture. Such objects are extremely faint and require the greatest possible amount of light-gathering power. And since these objects are, for all practical purposes, unaffected by turbulence within the atmosphere, there can be no further argument that "seeing" favors the smaller aperture.

The simple truth of the matter is that the light-gathering power of any telescope is directly proportional to the square of the aperture. Additionally, the brightness of a point source image is proportional to the fourth power of aperture.

Put simply, this means that an 8 inch telescope gathers 4 times more light than a 4 inch telescope and its images are 16 times brighter as well! Therefore, under no circumstances can a 4″ telescope ever give better views than a 6″ or 8″ on faint objects such as galaxies and nebulae. In fact, hundreds of interesting objects that are clearly visible in an 8″ telescope are totally *invisible* in a 4″. From page 80 of *Star Gazing with Telescope and Camera* we quote: "You will soon appreciate the advantage of large telescope aperture because these objects (Galaxies, Nebulae and Clusters), faint and of appreciable area, rapidly disappear against the night sky in a small instrument."

And remember, *all telescopes* are subject to the same laws of physics governing light-gathering power. A smaller telescope cannot possibly collect more light than a larger telescope, no matter what the design (Maksutov, Newtonian, Schmidt-Cassegrain etc.), how well it is made, or how much it costs.

CONCLUSION:

According to firmly established optical laws governing all telescopes, large aperture provides greater resolving power, light-gathering power and image brightness than small aperture.

Arguments referring to "seeing" conditions favoring smaller aperture can be applied only to observations of the Sun, Moon and Planets. And even then, as we have previously established, the magnification can be lowered, or the larger telescope can be "stopped down", when severe conditions exist. Yet when good to moderately good seeing prevails, the larger telescope will always outperform the smaller by a wide margin.

Observations of deep sky objects, since they are extremely faint, low contrast subjects, are unaffected by turbulence and will always be viewed better in a larger telescope because the larger telescope has greater light gathering capability.

So, with all due respect to those few amateurs who exclusively observe *only* the Moon and Planets, as spectacular as they are, we wish to remind the potential telescope buyer that these are not the only objects in the heavens. There are literally *thousands* of exciting Galaxies, Nebulae and Clusters that can only be successfully viewed with large aperture instrumentation.

Furthermore, one must also realize that the planets are not always positioned properly for observation — there are indeed several months out of every year when the sky overhead is conspicuously bare of planets. During this same period, however, there remains a countless number of deep sky objects for your observing pleasure.

We therefore conclude that if you are buying a telescope for general use that will be used to observe the *thousands* of splendors the Universe has to offer, not just the moon and planets, do not choose anything less than a 6″ aperture. If portability is a prime consideration, the Criterion Dynamax 6 is the most compact and portable 6″ telescope in the world. And if you're truly serious about astronomy, the Dynamax 8 should be your ultimate choice.

BUY YOUR DYNAMAX DIRECTLY FROM CRITERION—AND SAVE!

Other manufacturers currently have telescope dealers throughout the country, and most of these dealers operate on a 40% discount. With this kind of huge commission, a dealer can even afford to sell a $1,000.00 telescope for a "discount" price of $800.00, and still make $200.00 on the sale.

This is why the pages of today's astronomy oriented magazines are filled with ads from telescope dealers, each one exclaiming "Buy from me! I have the lowest price!"

The Dynamax, on the other hand, is only sold directly from our factory, as Criterion prefers to eliminate this dealer profit, which would otherwise add *hundreds* of dollars to our price tag. There is only one "factory direct" price to you. And you also get Criterion's own, unconditional, money back guarantee, which takes the "worry" out of buying through direct mail. If you buy a Dynamax, compare it to other telescopes on the market, and don't find it to be as superior as we claim it to be, or simply don't like it for any reason, your money will be refunded in full and you can buy any other brand you feel is better. Our guarantee is your assurance that the Dynamax is the best choice of a compact, portable telescope today. To make such a guarantee illustrates how sure we are that the Dynamax will provide 100% satisfaction in every respect.

Because of Criterion's direct mail policy which eliminates dealer profit, we can afford to offer you more features and quality at the lowest possible price. Indeed, the Dynamax bearing support system alone is far more expensive that that found on competing models. Countless other Dynamax components represent far greater product expense (consider, for instance, the use of solid brass in many areas, or the precision *engraving* found on many parts). Unfortunately, a summary of all the areas of greater quality found on the Dynamax is too lengthy to list here.

In summary, the Dynamax is probably the most expensive telescope on today's market, even though its price tag may seem lower than some competing models.

BUYER BEWARE!

Fortunately, most of today's manufacturers represent their products honestly and without exaggerations. Also, most telescope dealers in today's market seem to do their best in supplying the amateur with truthful, correct information. Unfortunately, there may be some who unknowingly or otherwise may misinform, being more concerned with "making the sale" which leads to the big profits we've already mentioned.

This issue has been brought to our attention by Dynamax owners as well as potential telescope buyers who have heard all kinds of stories from various dealers when comparing telescopes.

For instance, one customer who called our factory had just spoken to a telescope dealer. Believe it or not, he was actually told that the Dynamax had *no bearings* at all and he wanted to know if this was true.

Other customers who have called us were told that the Dynamax bearings were "much smaller" than the bearings found on competing models. As we mentioned earlier, the exact opposite is true.

Aside from such outrageous statements, there are the more subtle cases of fiction. These are the cases where you are only being told one side of the story and the opposing viewpoint is conveniently ignored.

A case in point is a pamphlet recently published by a certain dealer, which states that tripod leveling is unnecessary — an issue we have hopefully clarified in this piece. The same pamphlet also states that an aluminum tube is better than a Bakelite tube — a statement which stands in bold defiance to the recommendations of experts we have already quoted. It causes one to wonder why unsupported statements such as these can be made. And yet, when you read or hear only *one* side of the story, such statements may in fact sound convincing.

Other statements concerning aperture requirements can also be deceptively misleading. Consider, for instance, customers who are told "seeing" favors smaller aperture — a point that conveniently overlooks the fact that a larger telescope can be made smaller by diaphraming. The same statement also ignores the fact that seeing is not bad *all* the time, and when it is good, the larger aperture will *always excel.*

When comparing various telescopes, you may or may not be subjected to the kinds of fictitious statements we have mentioned. But we do want you to know that we have spoken with enough customers to know that misconceptions and misstatements do exist in such numbers that we couldn't possibly list all of the rumors we've heard. No wonder it becomes difficult for a potential telescope owner to separate fact from fiction. We want you to feel free to contact us any time you have a question regarding Dynamax. For instance, the customers who consulted Criterion after hearing that Dynamax had no bearings or tiny ones were indeed happy that they did.

If you are comparing telescopes, you should carefully investigate all brands. And if by any chance you should visit a dealer who sells telescopes that compete with the Dynamax, just remember that he is going to try to sell you the telescopes he has. And, after all, he must sell very hard in trying to overcome all the advantages and features of the Dynamax.

In your shopping for a telescope, here is a check list of questions you should ask:

1. What is the guarantee you get?
2. Does the telescope have substantial bearings in the mount?
3. Does it have a switch so it can be shut off and on without pulling the plug from the wall?
4. Does it have a pilot light that will indicate the drive is running when in the dark?
5. Does it have a non-metallic, insulated tube, or does it have a metal tube that can contract or expand or be dented?
6. What about the metals used?
7. In the case of 8" diameter, is it equipped with large 8x50 that collects more light and is more powerful than a 6x30?
8. What types of eyepieces are provided?
9. What equipment is standard, and what is charged extra? For instance, will I have to buy a wedge or latitude extra just to make the telescope usable as an astronomical telescope?
10. Is the electric drive train fully enclosed to protect the unit from dust and moisture and possible electric shock?
11. Is the Dec. setting circle a *solid engraved* dial or a single round plate? How accurately can you read the R. A. circle.
12. How does the telescope compare feature by feature with the specifications listed on pages 12, 13 and 16 of the Dynamax color brochure?

If, by chance, the dealer gives you questionable information pertaining to the Dynamax telescope, please remember that ONLY Criterion is qualified to discuss Criterion products in detail. At this point, please call us for our side of the story. And, after all, if you're planning to purchase a telescope that costs at least $600.00, it could prove to be a wise decision to call us in order to assure yourself of the best choice in a precision instrument. So why not call us today and let us know what you've heard or what you'd like to know about our fine line of precision telescopes. We'll be more than happy to supply you with the facts — not the fiction — concerning our Dynamax telescope. Only then, after hearing both sides of the story, and after gathering all of the *correct* facts, will the wise consumer be able to make an intelligent decision.

CONCLUSION:

We have tried to cover several main differences between the Dynamax telescope and other telescopes available today. However, by no means are the points we covered the *only* features that set the Dynamax apart from competing models. For instance, we didn't mention that the

Dynamax is the only Schmidt-Cassegrain that utilizes an oversized primary mirror (Dx8 = 8.3″ dia.; Dx6 = 6.25″ dia.) and is supplied with Achromatized Symmetrical (Plossl) eyepieces. Nor did we mention the large 8x50 finder (not 6x30) found on the Dynamax 8, another important feature greatly appreciated by serious astronomers, nor that the R.A. circle has finer increments (one line = 4 minutes or 1 degree unlike competing models where one line = 5 minutes), as well as verniers for greater precision. (Using the verniers, you can read the R.A. circle to one minute; competing models do not offer verniers.) Likewise, there was no mention of the convenient on-off switch and indicator light, the fully enclosed drive train which protects the gears and motors from dust and moisture, the eccentrically located slant thrust motors for uniform power transmission, the latitude adjusters for equatorial table-top use that come included at no extra cost, and many other features. For further information on all of the outstanding qualities that make the Dynamax a superior instrument, consult pages 12, 13 and 16 of our color brochure.

In addition to all of these features, the Dynamax Schmidt-Cassegrain offers unsurpassed optical quality. Each of the optical elements is precision ground and superbly polished to optical perfection on the most advanced of today's modern machinery. Each is then tested with the most technologically sophisticated equipment available for state of the art optical testing. After final assembly, the entire optical system is subjected to rigid performance tests, possibly far more severe than it may ever experience in actual use. But then, in order to preserve the optical quality so that it can give high performance to the practicing amateur, the optical system is mounted in a proper tube which prevents dimensional and thermal distortion of the critical light rays which must all reach the eye at a simultaneous focus. The entire tube is then placed onto a mounting truly capable of rigidly supporting its powerful optical assembly without excess mechanical vibration.

The result of all of this is a professional telescope of such high caliber and superior quality that it will be treasured by its owner for a lifetime. Such a telescope is the Dynamax and its razor-sharp image quality constantly astonishes everyone who has experienced it. We call this experience "The Dynamax Difference". Why not discover it for yourself — we can guarantee you won't be disappointed.

IF, AFTER READING THIS LITERATURE, YOU HAVE ANY ADDITIONAL QUESTIONS, WE'LL BE DELIGHTED TO ANSWER THEM FOR YOU. PLEASE DO NOT HESITATE TO CALL US TODAY AT 203-247-1696. ASK FOR EXTENSION 21.

FULL ONE-YEAR WARRANTY

WITH NO-RISK, 30-DAY FREE TRIAL OFFER

And Additional Full 10-Year Clock-Drive Warranty

This warranty supersedes all others. It is effective from the date the product is received, and its provisions are transferable for the period of the warranty. This warranty gives you specific legal rights. You may also have other rights which vary from state to state.

NO-RISK, 30-DAY FREE TRIAL OFFER

If within a period of 30 days, you are not completely satisfied with the Dynamax telescope — for whatever reason — return the instrument to us and we will promptly refund your money in full.

FULL ONE-YEAR TELESCOPE AND ACCESSORY WARRANTY

The Dynamax telescope and all Dynamax accessories are warranted to be free from defects in materials and workmanship for a period of one year.

Further, barring defects in materials and workmanship, the optical system of the Dynamax, when properly tested, is warranted to:

(1) be diffraction-limited and equal or exceed all theoretical limits of definition and resolution.

(2) equal or surpass the overall optical performance of any comparable telescope, and

(3) surpass the overall optical performance of any telescope of smaller aperture.

FULL 10-YEAR CLOCK-DRIVE WARRANTY

The electric clock drive of the Dynamax is warranted to be free from defects in materials and workmanship for a period of 10 years.

If, during the warranty period specified, the Dynamax or any of its accessories fails to operate properly, or is found to be defective, return the product to us and we will repair or replace it, at our option, free of charge.

THIS WARRANTY DOES NOT APPLY IN CASES OF ABUSE, MISHANDLING AND UNAUTHORIZED REPAIR OR MODIFICATION BY ANY PERSON OR COMPANY NOT ASSOCIATED WITH CRITERION SCIENTIFIC INSTRUMENTS.

Return all products freight-prepaid to:

Criterion Scientific Instruments
620 Oakwood Avenue
West Hartford, CT 06110
Telephone (203) 247-1696

CSI

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620 Oakwood Avenue
West Hartford, CT 06110