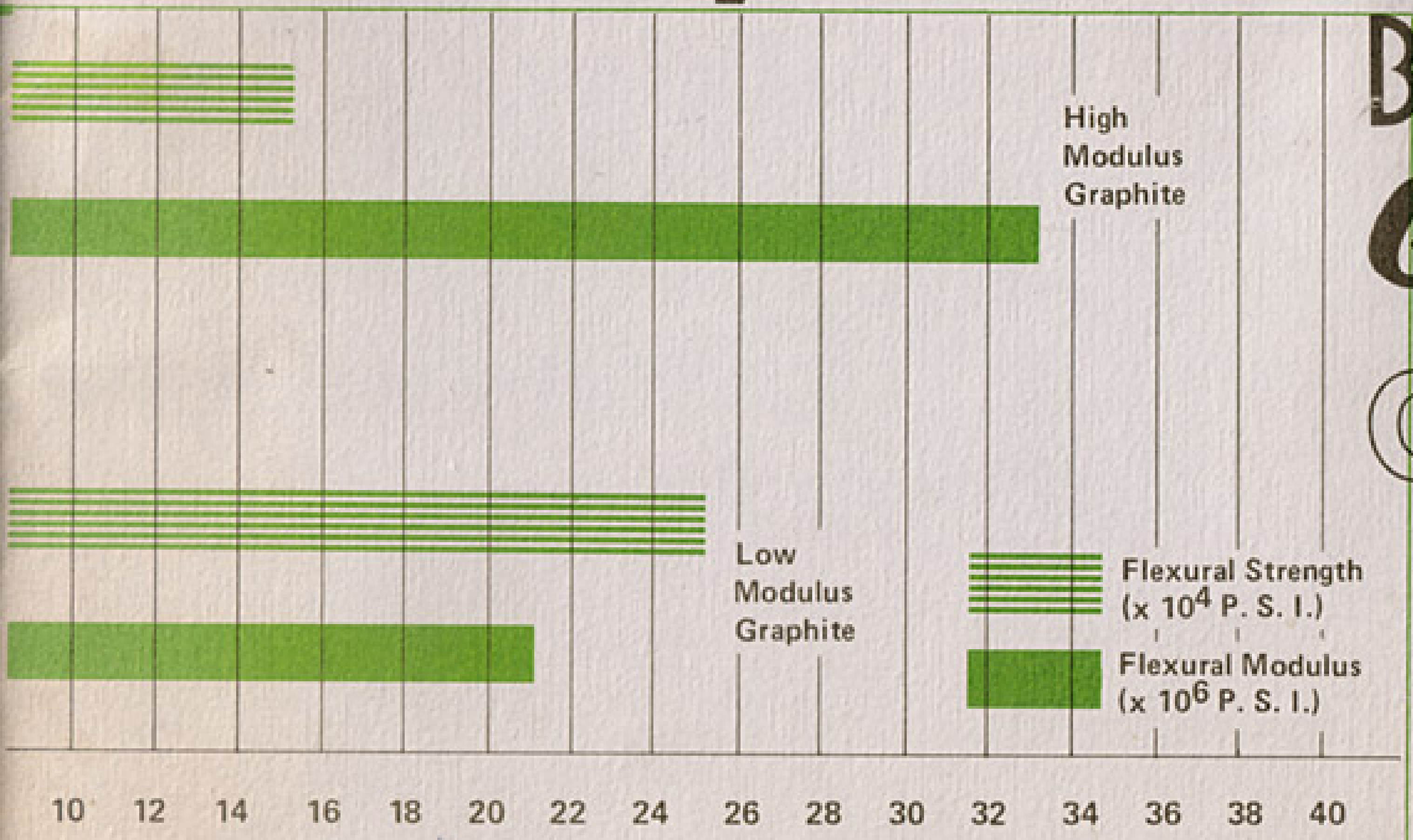
Comparison of



BAMBOO Graphite and GLASS rods

The advantages and disadvantages of each material.

Comparison of BAMBOO Graphite and GLASS rods

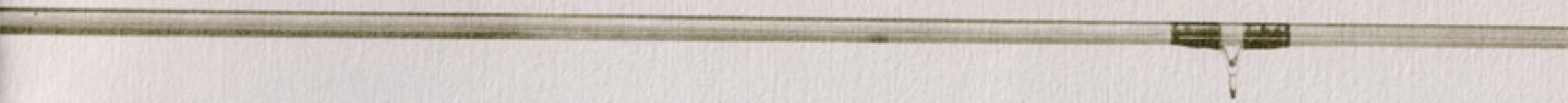
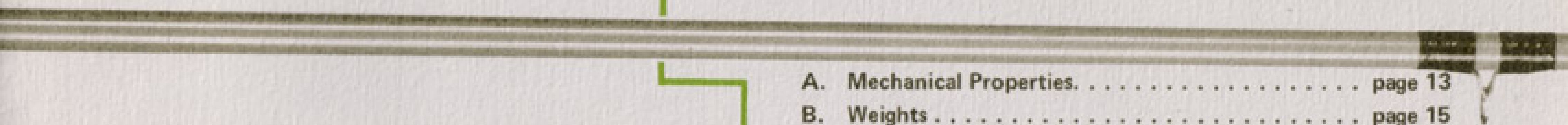


Table of Contents



I BAMBOO

is not simply bamboo

More than a hundred years ago, bamboo was settled upon by rodmakers as the ideal material for the manufacture of fly rods. Most widely used was a species known as Calcutta Cane. Then about 1890, the makers of quality bamboo rods discovered Arundinaria Amabilis, a cultivated cane with especially dense elastic fiber structure, grown in one small area of China in Kwangsi Province. All attempts to produce this particular species in Puerto Rico, Central America and our own South have so far been unsuccessful . . . the transplants grow magnificently but with a much less dense strong fiber structure.

Arundinaria Amabilis from Kwangsi, China is known locally as "tea stick bamboo" but for some strange reason lost in antiquity, it is known in export as Tonkin Cane.

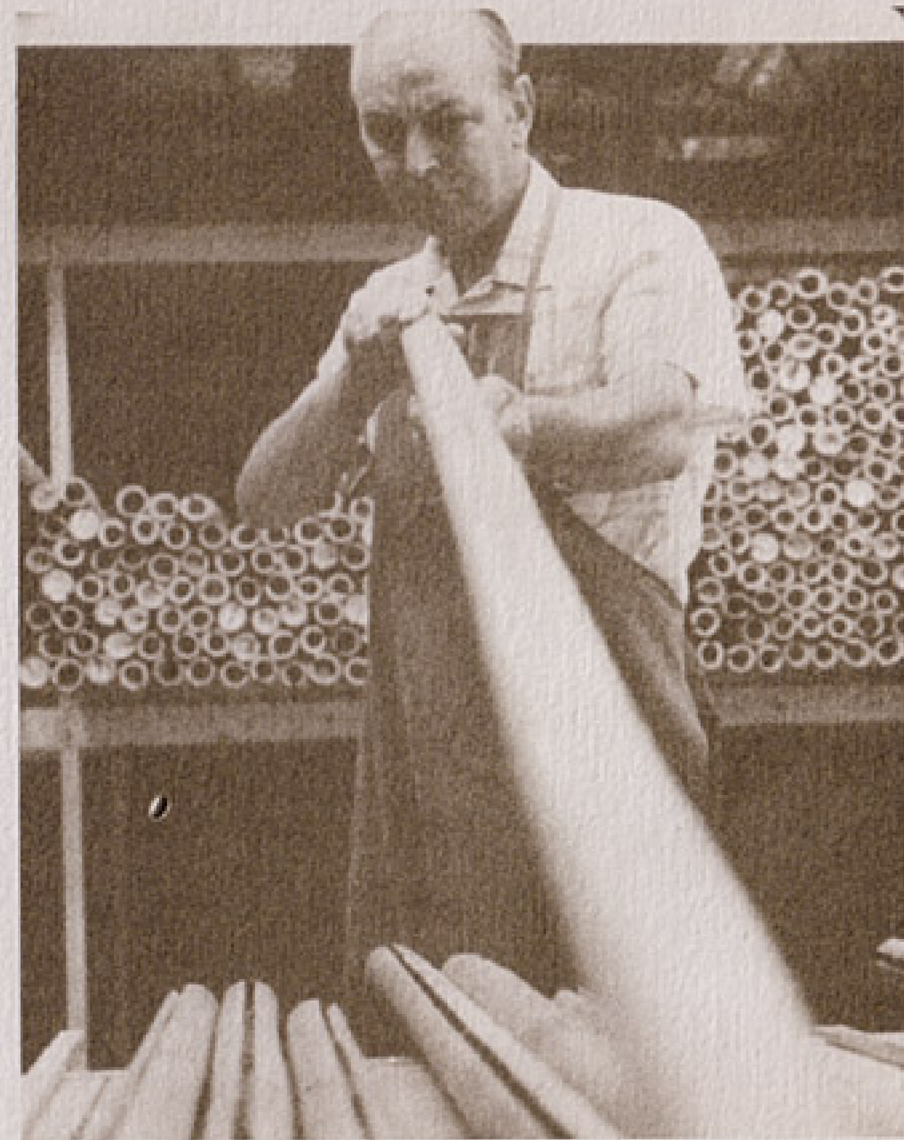
In the 1930's and 1940's most rods were made of bamboo. There was, however, a tremendous variation in quality, durability and performance. Bamboo is a natural material with a wide variance in fiber structure, density and straightness. In those early days of low priced or "general market" bamboo rods, it took a wise buyer to pick a good rod from the sporting goods rack, as virtually no two had identical characteristics.

Today, the leading manufacturer of bamboo rods uses less than 5% of their select imported Tonkin Cane in their final product. This selection of uniform fiber density and straightness AND selection of particular density for each specific rod design is extremely important. There are not too many rodmakers left today with this knowledge and talent.

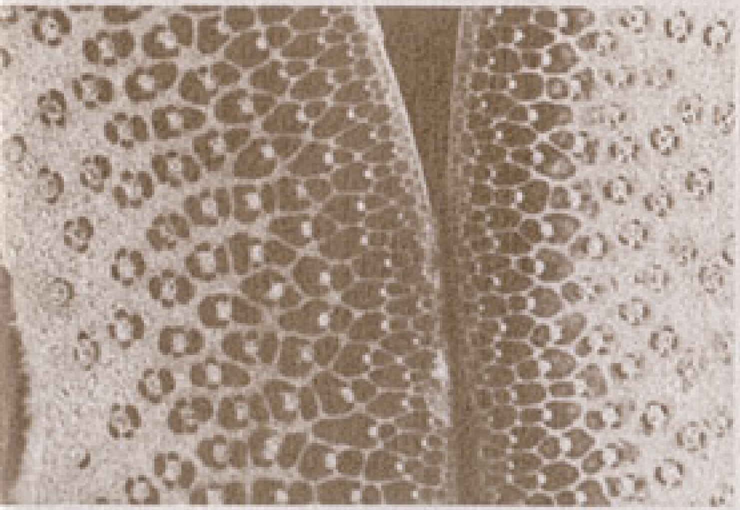
Early in the manufacture of fine bamboo rods it was learned that the bamboo could be stiffened by heat treating. This "tempering" process is an extremely critical one. It was originally done by hand over an open flame, which added the variabilities of the human element. Today, in the most modern bamboo rod processing plant, a sophisticated surface-heat-treating machine has been developed to temper each bamboo culm with precise uniformity. This tempered bamboo has a deep glowing brown shade as opposed to the straw color of untempered bamboo.

In the early manufacture of bamboo rods, animal glues were used for adhesive and exterior varnish as the rod finish. Even today some of the smaller makers of high priced rods still use these materials. The problem with animal glues and varnish is that, if the rod is subjected to high temperatures or moisture it becomes unglued . . . or if the rod is subject to extreme stress it takes a permanent bend or "set." In the 1940's an impregnated rod process was developed and patented. This has the inestimable advantage of using a phenolic resin and resorcinol glue which, in essence, makes the rod totally weatherproof, waterproof and resistant to taking a "set."

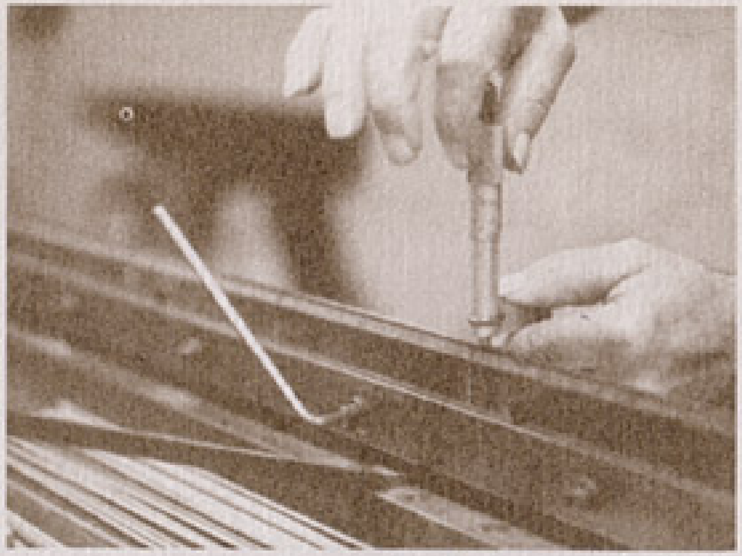
The relative mechanical characteristics on bamboo versus graphite and glass are shown in Table No. 2 on page 14.



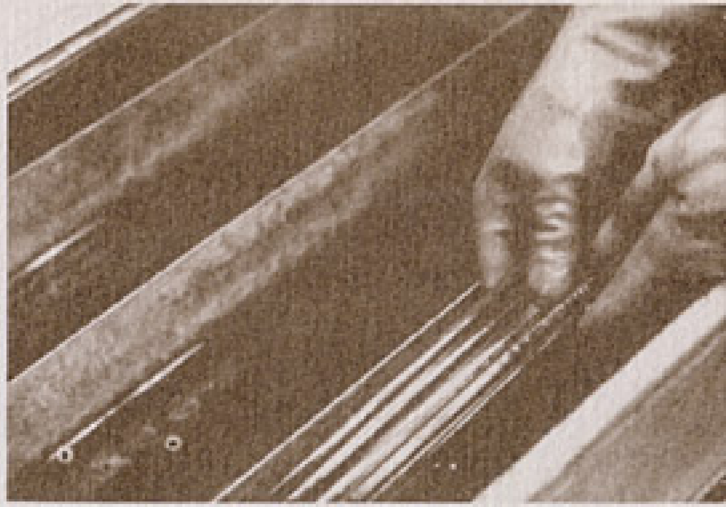
1. *Sorting cane for straightness and fiber density.*



2. *Two cross sections. At left, power fibers run nearly to center. Pole at right is rejected.*



4. *Setting up the finish milling machine for final taper. Tolerance is to 1/1000 of an inch.*

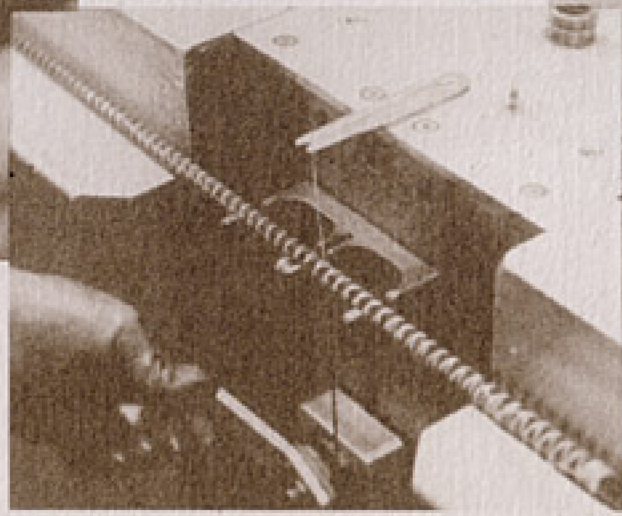


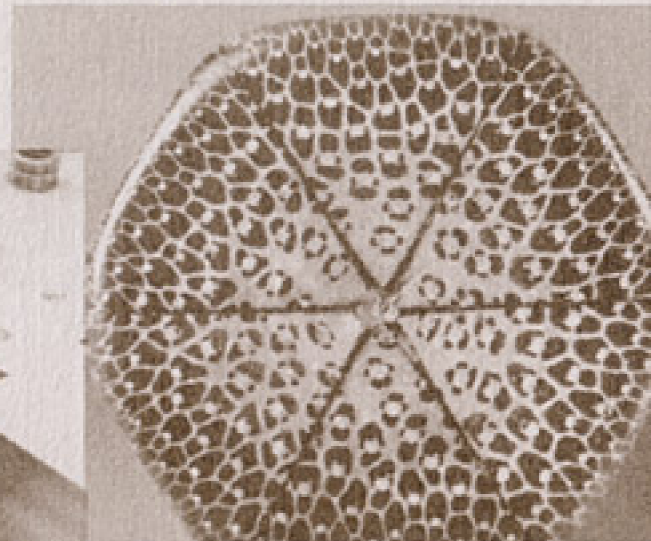
7. *Sections spend 7 days in the impregnation tanks.*

3. *Cane poles take on a glowing brown after tempering.*

5. *Mismatched segments sorted into bundles of six.*

6. *Glueing together the six segments.*





8. *Cross section of a glued, impregnated section.*

II The GLASS rod revolution of 1950

Fiberglass rods came on the market in the United States in a big way in 1950. This fortunate development of fiberglass rod technology coincided with the embargo against the direct importation of market bamboo from China. Almost immediately all major mass production manufacturers of fishing rods converted to fiberglass.

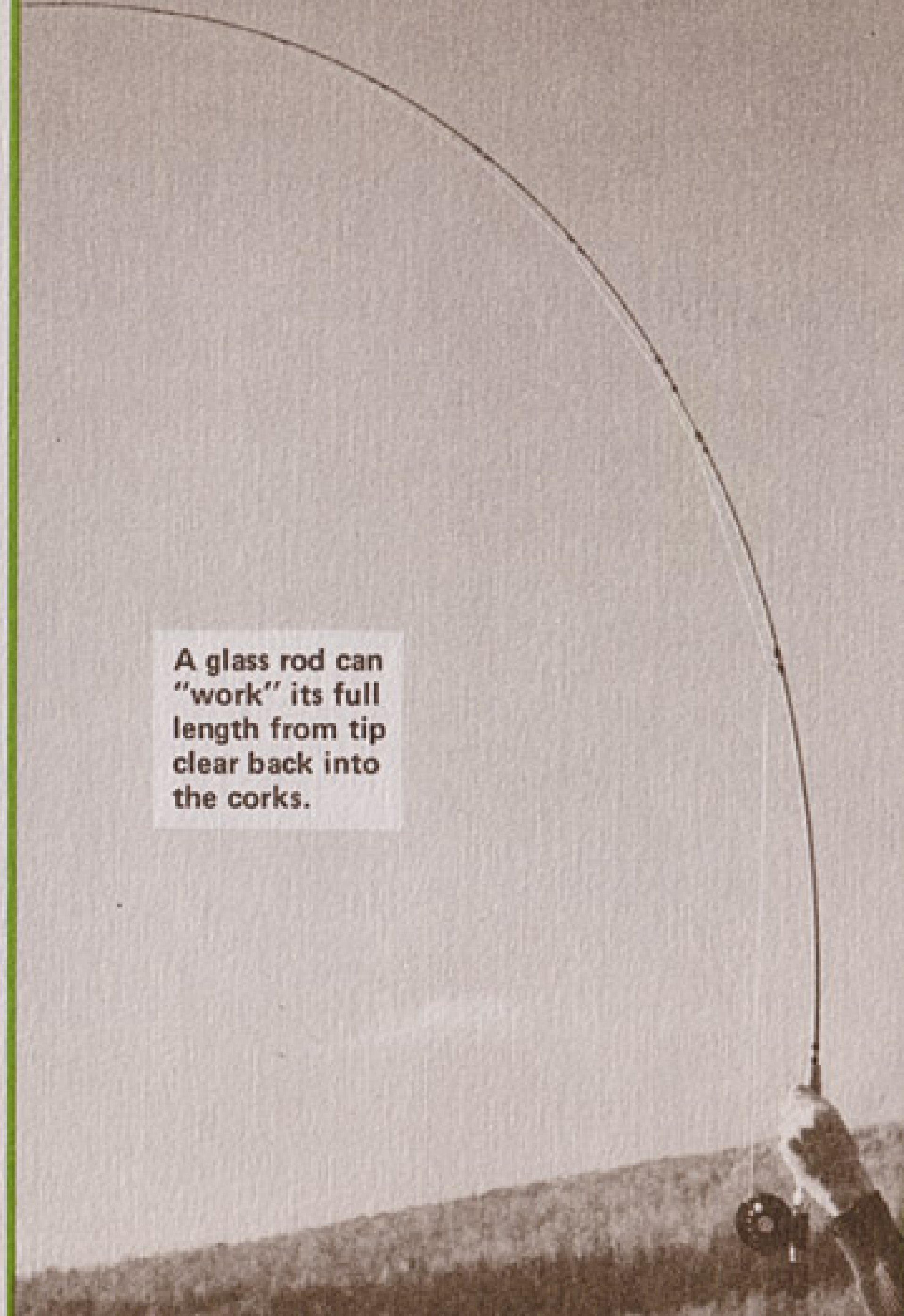
Here was a synthetic material, inexpensive and with reasonably consistent characteristics. Of course, there are numerous potential variables in the manufacture of glass rods. There are various types and diameters of glass fiber. There are unidirectional fiberglass rods and cross-weave fiberglass rods with varying percentages of longitudinal and latitudinal fibers. There are design variables in the tapers and shapes of the steel mandrels on which a fiberglass rod is made. There are variables in the amounts of glass material (wall thickness) used for the rod. There are important variables in the percentages of glass fibers to resins. And there are variables in the density of the fiber-resin composite, based on the pressure to which it is subjected in manufacture.

The test of 25 years time and experience has shown that fiberglass rod blanks of primarily longitudinal fiber

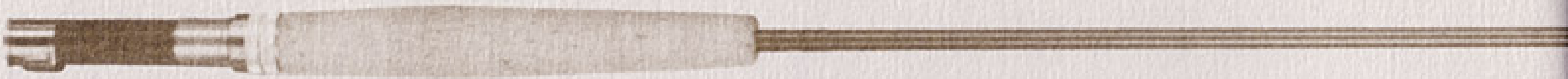
structure (like the longitudinal fibers of bamboo), and the use of phenolic or epoxy resin have proven the most satisfactory for fly rod design. Fiberglass is lighter than bamboo but with a lower modulus of elasticity, so a fiberglass rod had to be made with larger diameter and with hollow construction to produce a similar flex profile.

One of the major problems that still persists today is that most of the mass manufacturers of glass rods are heavily oriented toward spinning and bait casting rods, and so have a tendency toward producing rods with stiff unyielding butts and whippy flip-flop tips. The dynamics of fly rod design are immensely complex. With a century of bamboo rod design experience and a quarter century of glass rod experience, it is possible to produce a really fine glass rod with the full length flex action for smooth, easy, long casts . . . a rod that "works" its full length from tip clear back into the corks.

Again, the relative mechanical characteristics on glass versus bamboo and graphite are shown in Table No. 2, page 14.



A glass rod can "work" its full length from tip clear back into the corks.



What exactly is Graphite?

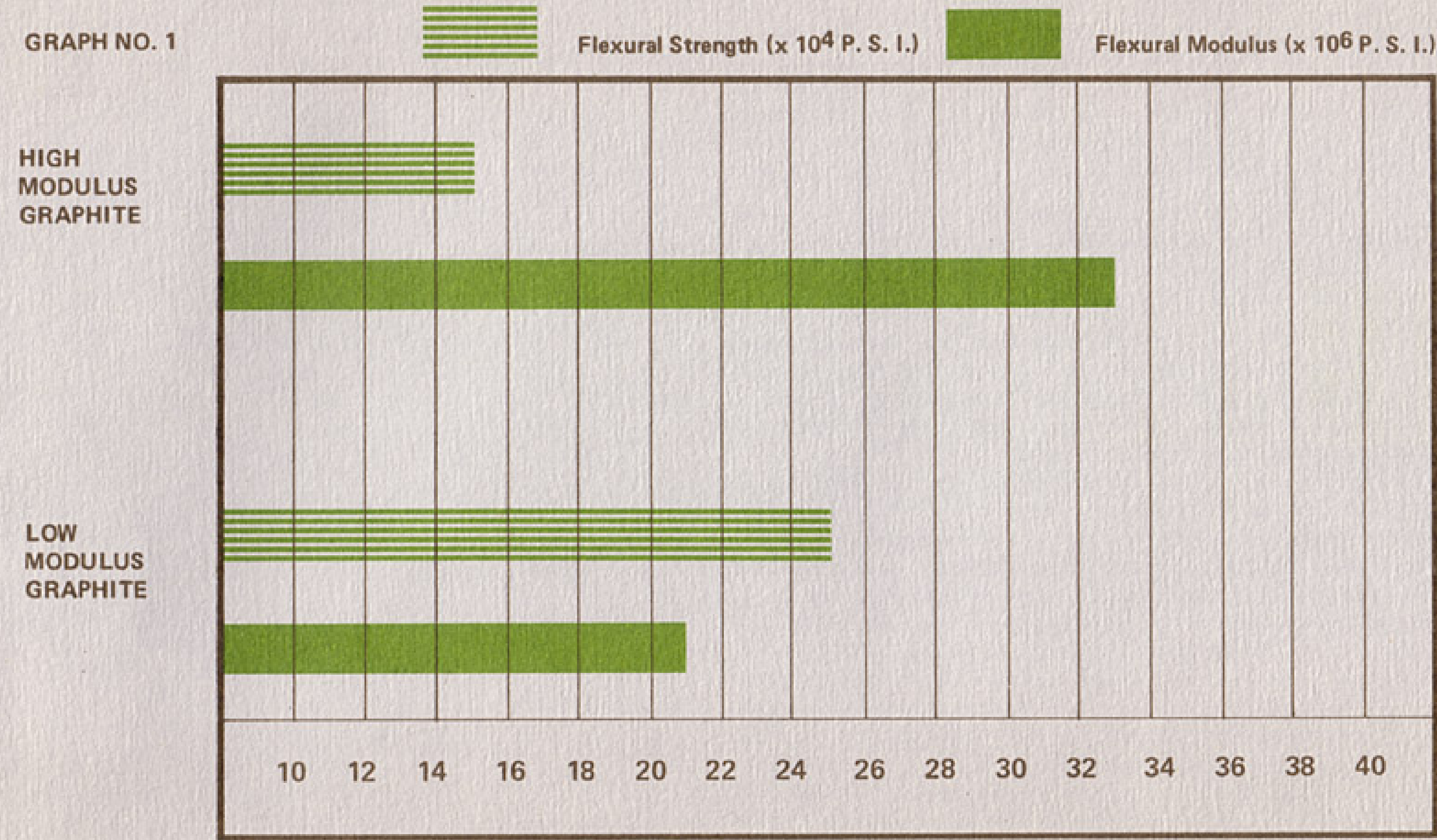
A continuous length of synthetic polyacrylonitrile (a type of polyester fiber) is oxidized at 300°, then carbonized at 1500°, then graphitized at 3000° in complete absence of oxygen. The resultant filaments are extremely fine . . . as small as .0003 inches thickness. As many as 10,000 are made up into yarn (called a "toe") in continuous lengths up to 5,000 feet.

The precise mechanical properties of these graphite fibers can be regulated by varying tensions, speed of processing, oven temperature and surface treatment. In simplest terms, the variance differentiates between "High Modulus Graphite" (very stiff) with "Low Specific Strength" (less strong), OR "Low Modulus Graphite" (more flexible) with "High Specific Strength" (more break strength).

Graph No. 1, on opposite page, illustrates this relationship between break strength and modulus of elasticity. You can see the increasing break strength at the less stiff modulus fibers.

All graphite has a much higher modulus of elasticity (is much stiffer) than the fibers of bamboo or fiberglass, so a graphite rod uses much less diameter than a bamboo or glass rod for a corresponding weight fly line. That is, if a graphite rod were built to the same length, diameter, taper and wall thickness as a glass rod, the graphite would be three times stiffer than the best of the glass. So, of course, the graphite rod is designed with smaller diameter.

GRAPH NO. 1


Flexural Strength (x 10⁴ P. S. I.)
Flexural Modulus (x 10⁶ P. S. I.)
HIGH MODULUS GRAPHITE
LOW MODULUS GRAPHITE
10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40

Long experience of fly rod design dictates the use of Low Modulus Graphite. This provides the maximum of break strength for the smaller diameter while still taking advantage of the extremely high modulus of elasticity of all graphite fibers. In other words, the use of Low Modulus Graphite produces an almost incredibly light, slim, powerful rod which still has great break strength.

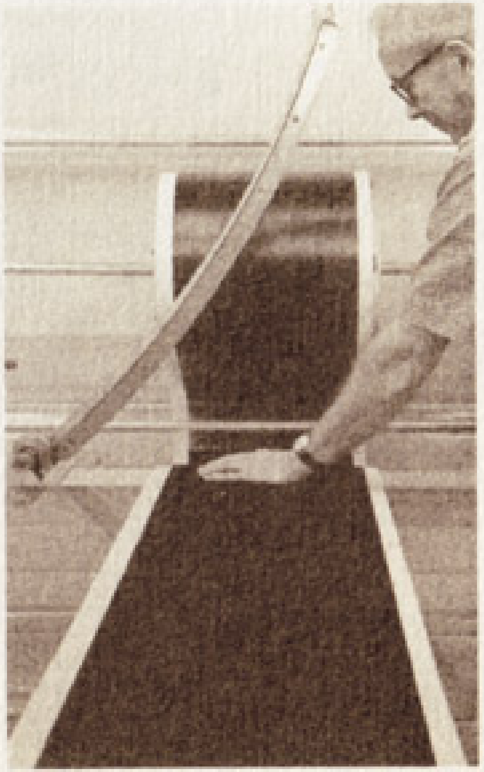
Some so-called "graphite rods" are being built with a considerable admixture of glass fiber to achieve flexibility, sufficient break strength AND because raw graphite fiber costs as much as $100 per pound while glass costs less than $1 per pound.

Orvis Graphite Rods are built with better than 94% of the fiber pure graphite . . . LOW MODULUS graphite, to provide highest break strength and the flexibility for smooth casting and protection of finest tippets plus graphite's almost incredible lightness, slim profile and power.

All the problems of fly rod design mentioned in connection with fiberglass certainly apply to graphite and then some. For instance, graphite's very high modulus of elasticity means much tighter tolerances of manufacture to produce a consistent product . . . .5% variation of graphite material on a graphite fly rod tip will make the difference between good or poor fly presentation . . . whereas, with fiberglass, plus or minus 12.0% variation is generally acceptable. In the manufacture of a quality graphite rod, extremely close tolerances must be held in heat, pressure, feed, tension and taper . . . even a slight difference of .003 of an inch per foot of taper in a mandrel could mean a 20% variation of the flexural profile. In short, a manufacturer who attempts to make a highly critical graphite rod on the same equipment by the same methods as a medium priced glass rod is very likely to end up with inconsistent quality and performance.

Naturally, one might expect rodmakers with many years of successful experience in fine bamboo and high quality fiberglass rods to be most likely to come up with the most pleasing and functional actions in a graphite rod. Certainly one might be cautious of purchasing a graphite rod from any manufacturer with little or no prior experience in designing rods . . . and this quite apart from the human temptation to adulterate $100-a-pound fiber with $ .87-a-pound fiber.

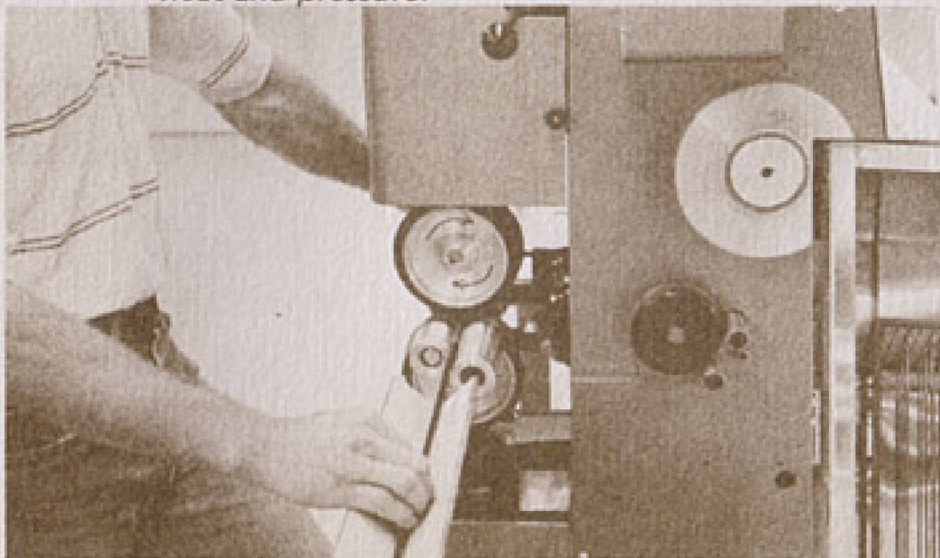
Synthetic Fabrication



1. *Unidirectional graphite fibers are spread in thin layer, held in place by inert epoxy resin on a paper backing . . . forming a strip 12 inches wide by 100 feet long, on a roll. Each fiber carries the entire 100 foot length. Pictured here is the roll, with a rod-length section being cut for wrapping on a mandrel, with the paper backing being stripped away.*

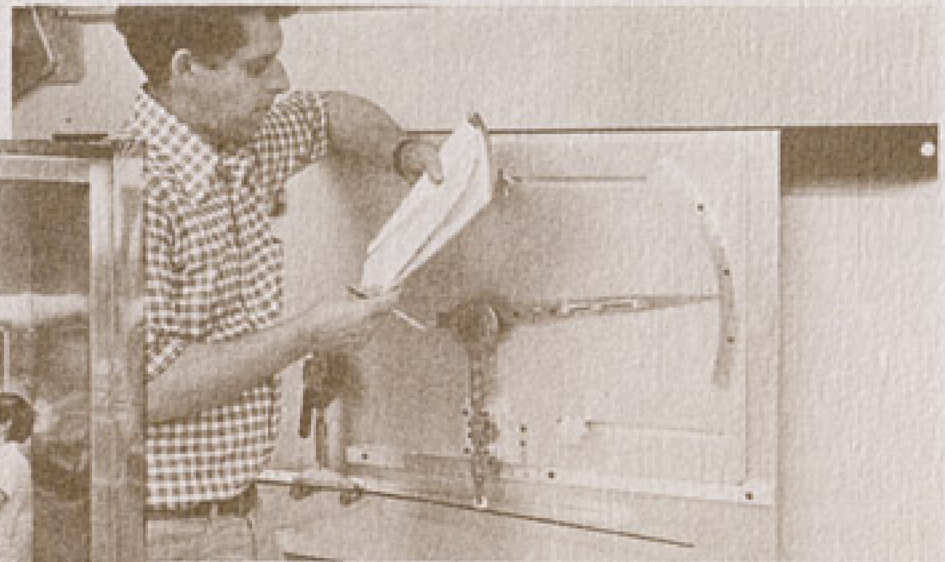
2. Pattern being wrapped on mandrel under controlled heat and pressure.

5. Mandrel being withdrawn from rod blank.



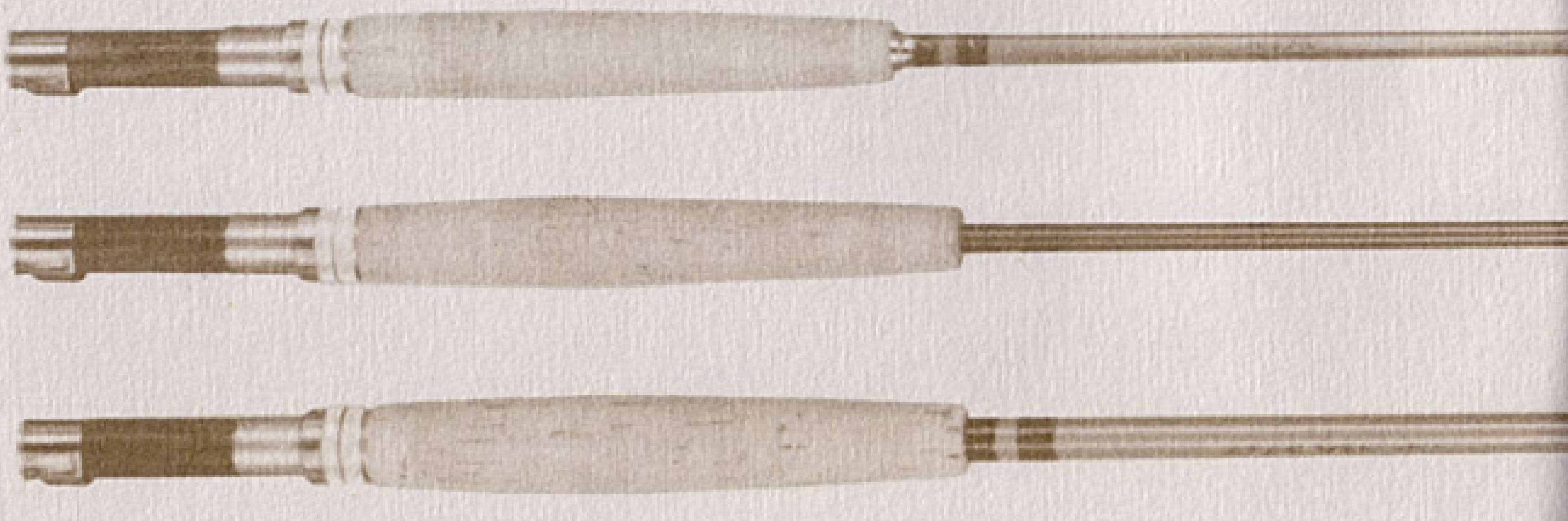
3. Heat shrink film being applied.

4. Rack of cured rod sections ready for removal from oven.



6. Checking flexural profile of completed tip section.

IV Direct comparison of BAMBOO GLASS Graphite



A. Mechanical properties

Orvis, as stated earlier, uses Low Modulus graphite for maximum break strength with a still tremendously high elastic modulus. Resin binder for the fiber structure could be polyester (soft) or phenolic (medium) or epoxite (hard) . . . Orvis uses epoxite as it is closest in flex and strength to the graphite fibers.

This tremendously high elastic modulus of all graphite provides increased line speed on the forward cast, a tight loop on the backcast. It also provides a very high "damping ratio" . . . that is, the rod does not "flutter" and oscillate at the completion of the cast. Yet the LOW modulus graphite is sufficiently flexible to protect your fine tippets.

It can certainly be said that a graphite rod, with proper timing, will lay out the longest cast with the least effort. Also, if wind resistance against a moving fly rod seems to you a petty matter, just bear in-mind that your rod on a forward cast is moving very fast indeed . . . and imagine holding your fly rod extended out the open window of a fast moving automobile. You would be very conscious of back-push. So, the fact that a bamboo rod has much slimmer profile than does glass and a graphite rod much the slimmest profile of all, does effect forward line speed.

The hands and eye of a fly caster have developed a good sense of when his rod is at maximum curvature, providing this action takes place relatively slowly. The extra quickness of graphite may require a little adjustment of your sense to this new material. But this tighter, faster reaction of graphite provides some real advantage in striking and playing a fish. Your strike reaction moves a shade more quickly to your hook. And every move of your fighting fish is telegraphed more quickly to your rod hand.

TABLE NO. 2

Base Material	Resin Binder	Material Pattern	Elastic Modulus P. S. I. x 10^6	Flexural Break Strength
Fiberglass	Polyester	Crossweave	2.5	59,000
Fiberglass	Phenolic	Crossweave	5.0	110,000
Fiberglass	Epoxite	Crossweave	5.3	120,000
Fiberglass	Epoxite	Unidirectional	5.7	160,000
Bamboo	—	Unidirectional	6.4	165,000
(Low Modulus) Graphite	Epoxite	Unidirectional	19.0	250,000
(High Modulus) Graphite	Epoxite	Unidirectional	33.0 (too stiff)	148,000 (less strength)

B

Weights of Graphite, Glass, Bamboo

TABLE NO. 3

Rod Length	Rod Material	For Line Wgt.	Rod Weight
	CLASS NO. 1		
7½ ft.	Graphite	6 wgt. Line	2 oz.
7½ ft.	Glass	6 wgt. Line	2-3/4 oz.
7½ ft.	Bamboo	6 wgt. Line	3-3/8 oz.
	CLASS NO. 2		
9 ft.	Graphite	9 wgt. Line	4 oz.
9 ft.	Glass	9 wgt. Line	5-3/8 oz.
9 ft.	Bamboo	9 wgt. Line	6-5/8 oz.

Rods compared have the same hardware and the same flex profile for their class.

The extremely light weight of all delicate fly rods for lines from 3-weight through 6-weight means that the slight differences between bamboo, graphite and glass can hardly be considered critical. But as we move on up to the longer rods for heavier lines, graphite's almost incredible ratio of weight to thrust does begin to show as an advantage. For instance, Orvis Graphite S/S/S Rod, 8 ft. 9 in. to lay out 10-weight fly line a country mile at a mere 4 ounces is less tiring through long hours of casting for salmon, steelhead or in the salt.

C. Relative durability of Bamboo, Graphite, Glass

Because a fine bamboo fly rod has a beautiful, exquisitely delicate appearance, it is often assumed to be very frail. This is not strictly the fact. Bamboo is almost incredibly tough. You can whack a dainty bamboo rod against an alder, on a careless backcast, with a blow which would fatally dent a synthetic rod's hollow tube construction, without damage to the bamboo.

And again, if the bamboo is heat tempered AND impregnated, it is absolutely impervious to rain, snow, ice, broiling sun, humidity. The finish is IN the rod, not just on it. After 20 years hard service, an impregnated bamboo rod can simply be buffed up to the same deep glowing shine as the day it was made. Graphite and glass are also impervious to moisture, so on the score of the care required for maintenance, there is no particular choice between the three materials.

In passing, it might be remarked that NO material can be expected to withstand the lethal slicing action of a slammed car door.

When it comes to the break strength comparison between a bamboo rod, a glass rod and a graphite rod, Table No. 2 back on page 14 could be slightly misleading. This table is the scientific engineering analysis of the actual structural modulus of the three fibers. Bear in mind, however, that a finished fishing rod is, in the case of bamboo, a solid section . . . in the cases of graphite and glass it is a tubular section (of variable wall thickness and diameter). As pointed out earlier, a graphite rod of the same length, diameter, taper and wall thickness as a glass rod, the graphite would be three times stiffer than the glass. This would be unacceptable for practical fly rod action. So, less graphite fiber is used for a particular action, resulting in a much slimmer lighter rod.

The actual comparison of the break point of a finished bamboo rod section, a graphite rod section and a glass rod section is illustrated in Graph No. 4 on page 17.

Another factor in the "durability" of a rod is, of course, its life in action. Constant flexing will, obviously, ultimately break down the fiber structure of any material on earth.

In the case of a fishing rod, this gradual breakdown of fiber structure means a gradual reduction of the flexural strength . . . a "softening" of the rod's action, less speed of recovery, less forward line thrust for a given weight fly line, or reduction of the weight (line size) which the rod will cast satisfactorily.

Graph No. 5 on page 18 compares this factor of durability for glass, bamboo and graphite.

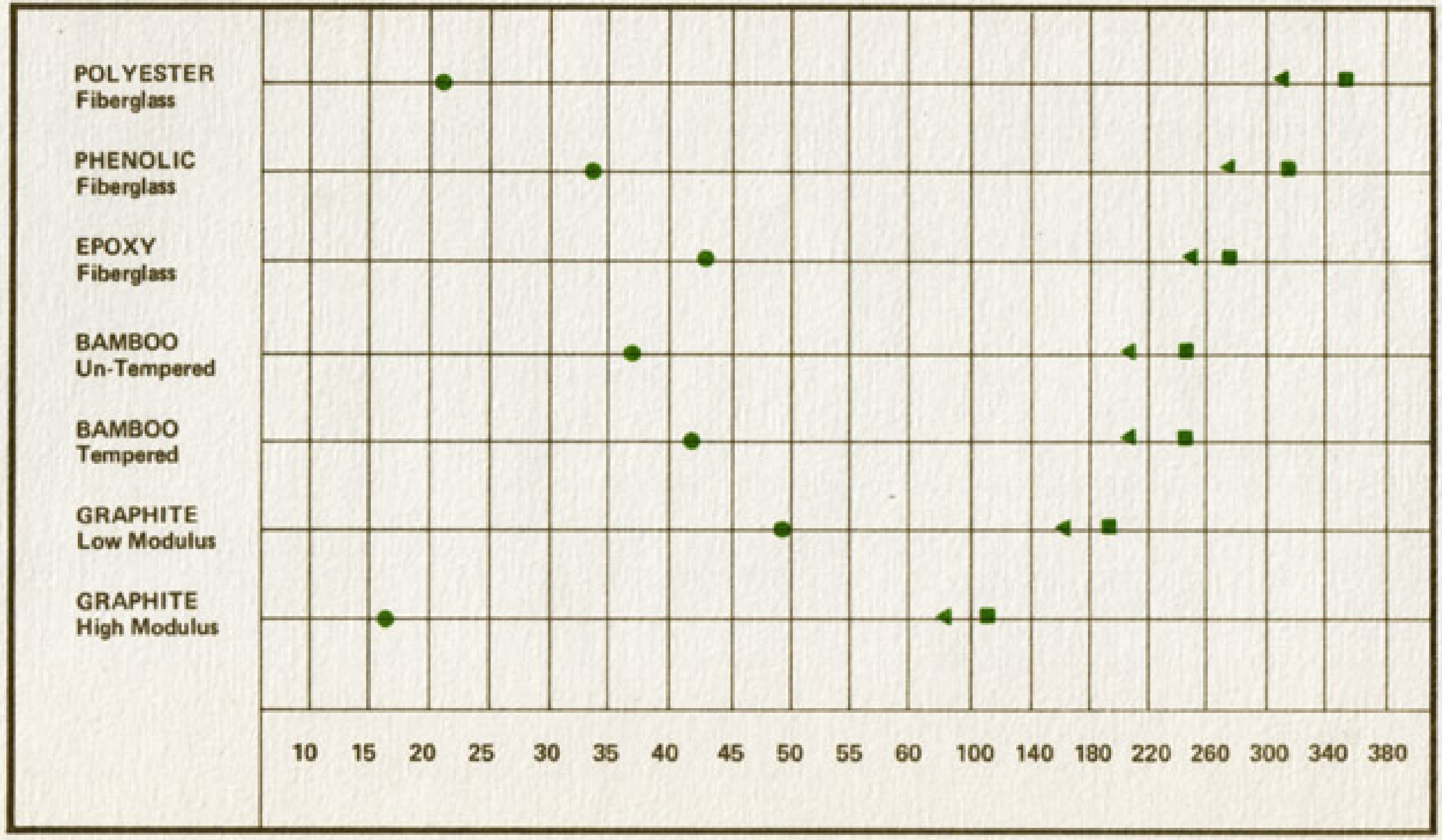
Flexural Profile For The Same Weight Load

■ OUTSIDE DIAMETER — Expressed - Thousandths of an Inch

◀ MATERIAL AREA "Sq. In." — Expressed - 10 Thousandths of an Inch

● FLEXURAL STRENGTH — Expressed - Thousand P. S. I.

GRAPH NO. 4



This graph was prepared from rod sections of the various materials listed, each section designed for the exact same flexural profile under load.

It will be seen that the polyester fiberglass rod has to have the largest outside diameter [■] and the largest amount of fiber material [◀], and still provides the least break strength [●] . . . while the low modulus graphite rod has very slim outside diameter [■], very small amount of fiber material [◀], and provides the greatest break strength of all the materials.

As you can see, a fiberglass-polyester rod softens 6.4% after 13,600 casts and 13.6% after 27,200 casts . . . whereas Low Modulus Graphite softens only 1.1% after 13,600 casts and 1.4% after 27,200 casts, an amazing durability.

These tests were made by mechanical flexing of actual rod sections with, of course, identical flex profiles under the identical same stress. You are indeed a dedicated and fortunate fisherman if you do actually manage to fish 226 hours with one cast (counting false-casts) per minute in a season. The relative comparisons are valid, however, whether you fish this much or much less.

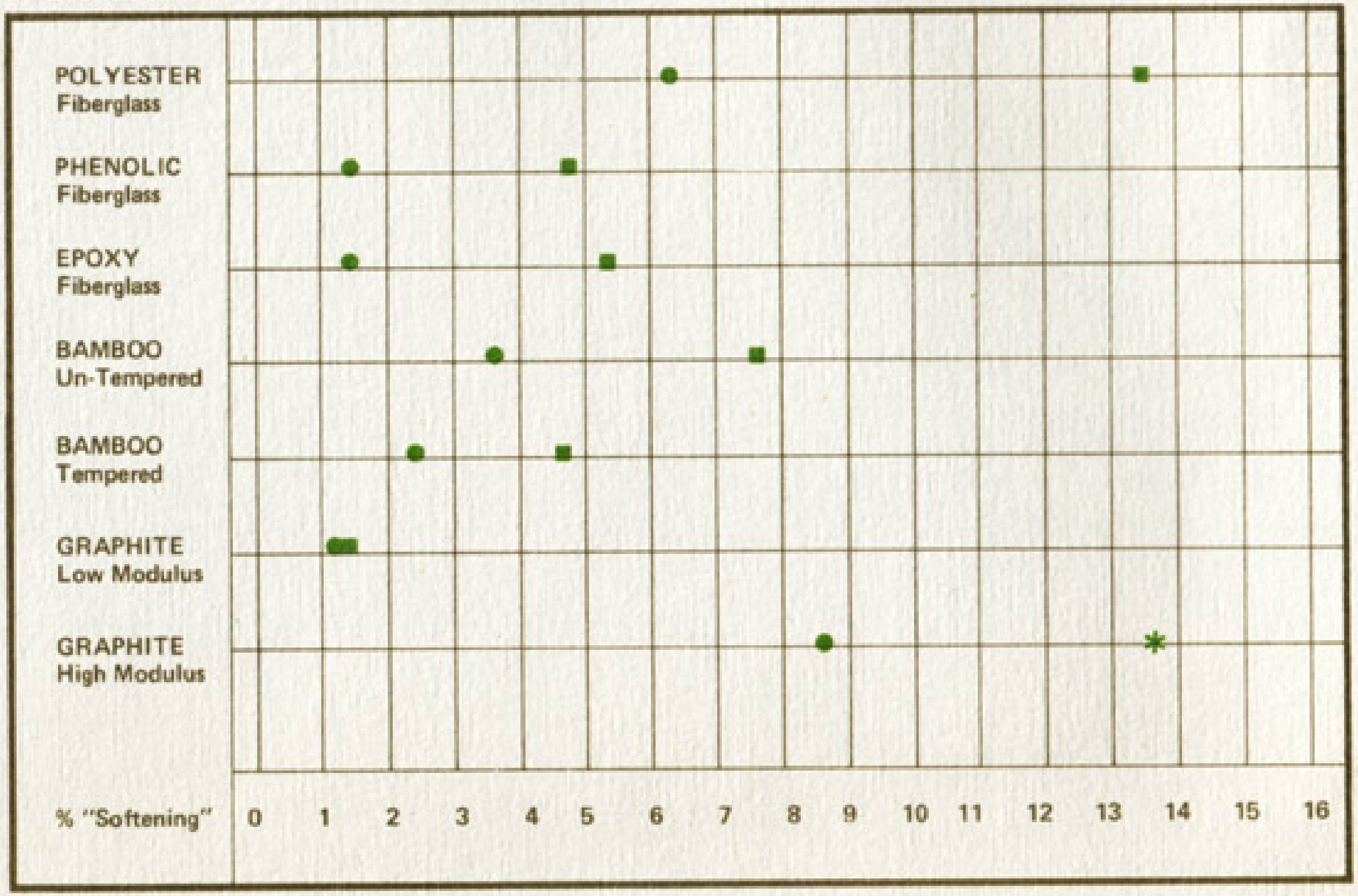
In other words, after the 27,200 double flexes, graphite has softened only 1.4% tempered bamboo next at 4.8%, and fiberglass phenolic in third place with 4.9%.

Material Fatigue Test - % of Break Down

● Represents 1 year's fishing (13,600 double flexes - 226 hours @ 1 cast per minute)

■ Represents 2 years' fishing (27,200 double flexes - 532 hours @ 1 cast per minute)

GRAPH NO. 5



* Rod Section Broke 2nd Year Test

D.

Cost comparison... and the WHY

On the score of price comparison, fiberglass wins by a wide margin. In the Spring of 1976, an Orvis Fullflex A Glass 7½ ft. Rod for 6-weight line costs $66.50. The corresponding Orvis Graphite 7½ ft. Rod for 6-weight line costs $155.00. The Orvis Bamboo Battenkill 7½ ft. Rod for 6-weight line costs $180.00.

The difference between glass and graphite is partly in the fact that, as previously stated, raw graphite fiber costs 100 times as much as raw fiberglass . . . and 94% of the fiber content of an Orvis Graphite Rod is pure graphite. Also, as explained earlier, the manufacturing tolerances in working with graphite are vastly more critical than with glass. The even higher cost of an Orvis Bamboo Rod is because each of these rods is largely the personal, individual hand work of a skilled rodmaker rather than a "manufactured product."

This is not to deny the skill, judgment and experience required to "manufacture" a fine Graphite or fine Glass Rod. Not all graphite and glass rods are alike by any means. Quite apart from the 120 years of expertise in designing fine fly rod "action," great skill and care are required to lay up the man-made graphite and glass fibers on their designed mandrels. 41 highly critical operations are involved in the production of each of these rods.

But, the patient hours a trained rodmaker must devote to inspecting, selecting, sizing, glueing, sanding, impregnating and finishing a six-segment bamboo "section" are obviously a greater expense.

E.

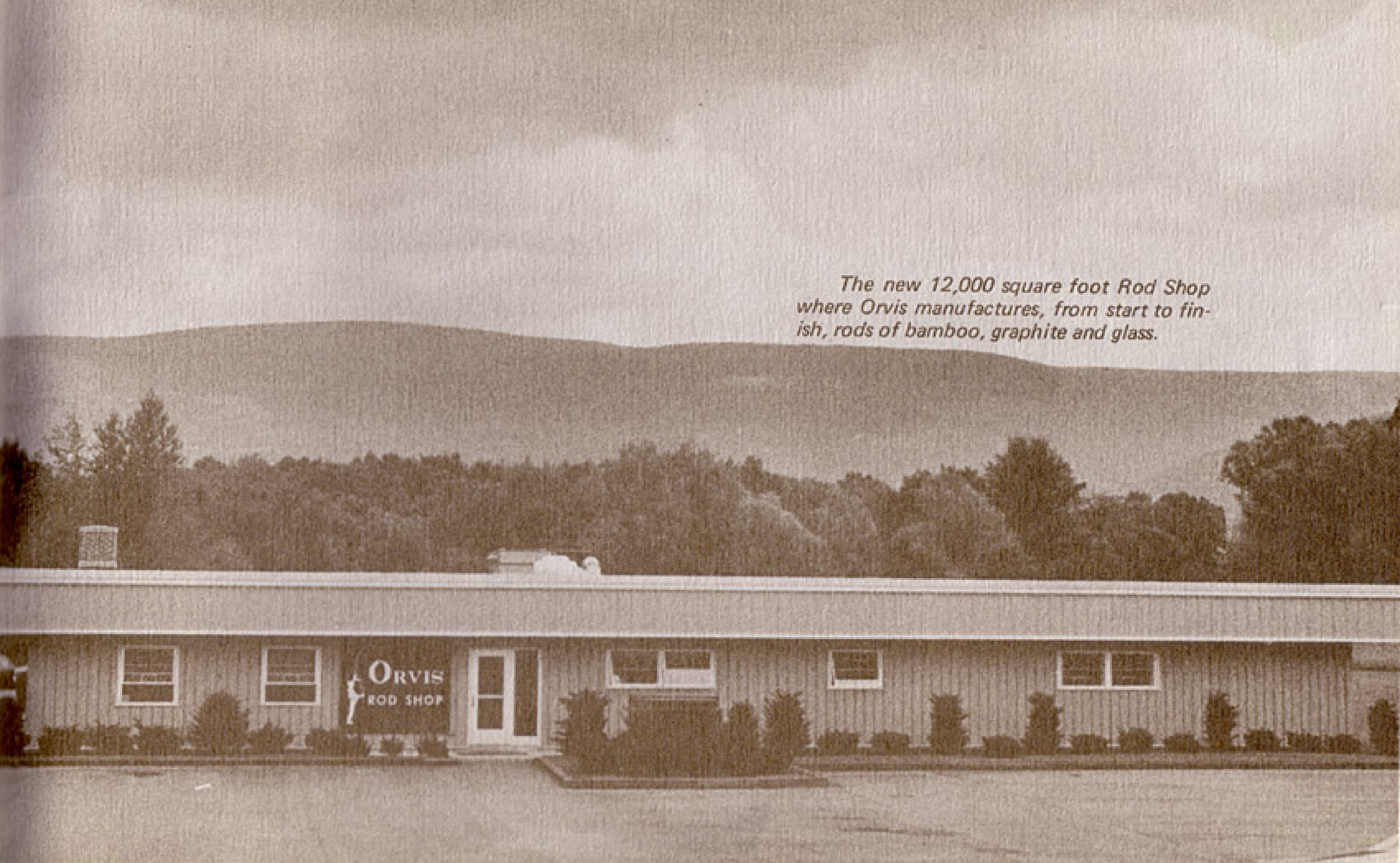
In Conclusion, then...

Is any ONE material the obvious choice for all fly rods? No, it really is not. Bamboo, graphite and glass all have their specific advantages and disadvantages. Choice of a fly rod is definitely a matter of the personal tastes and requirements of each individual fisherman. And that is why Orvis rodmakers work in all three materials . . . Bamboo, Graphite and Glass.

An Orvis Glass Rod is a beautiful and efficient tool. Its full length flex from tip clear back into the cork is sound "Orvis action" design. The quality, care and expertise of its manufacture and finish make it an Orvis Rod of which a fisherman can be justly proud. And its much lower price for a fly rod of this quality can well be a deciding factor in its favor.

An Orvis Graphite Rod is an almost incredible, new experience. It lays out longer casts with less effort, throws the narrowest of backcast loops, damps its end-of-cast oscillation almost instantly, is much the lightest fly rod ever made, has the greatest break strength. It sets a hook instantly and telegraphs every move of a fighting fish. Uniquely, each Low Modulus Graphite Rod has the ability to handle 2 to 4 line sizes comfortably and efficiently. It is certainly a rod that every fly fishing enthusiast will want to fish . . . and not too briefly because the "feel" and action of a graphite rod is quite different from any other rod you have ever fished.

An Orvis Bamboo Fly Rod is the great tradition. And justly so. The soft glowing beauty of natural bamboo, its "personality," will not be replaced by any synthetic. Even more to the point, the flowing, "forgiving," easy "feel" of a bamboo rod makes fly casting a special pleasure. Bamboo action has a definite and distinctive quality all its own. When a man is fishing a lovely quiet stream, he will select his bamboo fly rod as his preference still.



The new 12,000 square foot Rod Shop where Orvis manufactures, from start to finish, rods of bamboo, graphite and glass.

ORVIS®

10 River Road
Manchester, Vermont
05254

Orvis Fishing Tackle Catalog . . . sent you without charge on request . . . 128 pages full color of rods, reels, lines, flies, fishing vests, waders, all accessories . . . the "bible of serious fishermen since 1856." It's a good book. Just drop a card to Bruce Bowlen at Orvis, 10 River Road, Manchester, Vermont 05254.