In my initial article in this series, I explained and illustrated the use of a two dimensional chart relating ERN (Effective Rod Number) and AA (Action Angle) to describe a fly rod. These numbers provided the first objective and relative means for comparing fly rod action and power. There was also an inference to the effect that for rods of the same length and weight, the closer the ERN and AA matched, the more nearly similar the two rods would feel.

I also recognized this single ERN:AA combination described only a single static situation. This led to my second article which introduced the BIG Picture (Bending Index Graph). It is essentially a plot of ERN:AA values measured along the length of the rod.

Although the BIG Picture is more complicated, it does characterize the bending characteristics of a rod to a much greater degree. Also, if so desired, one can make a three dimensional plot relating ERN, AA, and the weight of the rod.

Now, it was possible to claim that if the length, weight, ERN, AA, and The Big Picture of two rods were similar, they should indeed feel very similar. However, some rods do exist which closely match in most of the previously considered characteristics and still feel significantly different.

This difference is attributable to an additional factor called frequency. It adds yet a sixth dimension to rod characterization and is the subject of the following article. Dr. William Hanneman

# Dynamic Characterization of Fly Rods

## Frequency and More

Although "feel" has always been considered a subjective property, it can be quantified on a relative scale. Here for the first time is a practical method for quantifying rod feel and how to use it.

by Dr. William Hanneman

In previous issues of RodMaker, I introduced my Common Cents System as a simple practical method for objectively determining the intrinsic power or strength of any fly rod. This approach takes much of the guesswork out of the task of matching a fly rod with the appropriate fly line for the distance one wishes to cast. It is recognized, of course, the distance one can cast a fly line is primarily determined by the skill of the angler.

Now, ignoring the angler's input, a simple cast results from the fly rod acting as a rotating lever to accelerate the speed of the rod tip which is dragging the fly line behind. As a consequence of this acceleration and the inertia of the rod and line, the rod bends and energy is stored in the flexed rod. When the "stop" is applied, the rod begins to straighten out again and release its stored energy.

In this dynamic straightening process, the speed of the rod tip starts at zero (fully loaded) and reaches a maximum at the point the rod reaches its original "straight" position. Then, it slows and the line, now traveling faster than the tip, forms the loop and the cast is on its way. The line can never travel faster than the tip. (Hauls represent a different situation.)

The "speed of the stop" (i.e., how quickly the angler can decelerate the rod) and rod tip velocity are the critical factors in how far one can cast a line. On the other hand, from the standpoint of how a rod "feels," the most important factor is how rapidly the rod reacts to the caster's actions.

Anyone who has ever compared a boron or graphite rod to a cane or willow rod of equivalent length and power recognizes response rate is primarily a function of a rod's material of construction.

### Response Rate

Response rate is an inherent property of a fly rod—independent of the caster, but dependent on every other component of the rod and line. It is a dynamic property of the rod and can only be determined by dynamic testing.

The moment one picks up a fly rod, the process of dynamic testing is initiated. The simple act of picking up the rod will set it in motion. The tip will begin to oscillate back and forth or up and down. If one then rhythmically applies energy to the handle, the arc of the oscillatory motion can be increased to almost any degree. This is the essence of false casting a rod. It is through our interpretation of how the rod reacts or responds relative to the angler's input that determines the rod's "feel."

By one gently "wiggling" a horizontally held fly rod so as to avoid introducing any second harmonic motion, four important things can be noted.

(1) The the size of the arc (i.e., magnitude) of the oscillation can be changed at will by controlling the energy applied.

(2) Within one full oscillation or cycle, the position of the tip will fluctuate from zero (level) to a positive maximum and back again to zero before continuing to a negative minimum and returning again to the zero baseline.

(3) The speed of the tip of the rod will be zero when the tip is at the points of maximum and minimum deflection. This is where the tip changes direction. Conversely, tip speed is at a maximum at the instant the rod exhibits zero deflection.

(4) Irrespective of the speed of the tip at any instant or the magnitude of the arc, the rod tip will always complete the same number of oscillations over the same time period. This This number is conveniently measured in cycles per second, and this value is commonly called the resonant frequency or simply the frequency of the rod. It is an objective numerical measure of the rod's response rate.

### Regarding Resonant Frequency

The following quotations are from comments made on the rodbuilding.org web site during December 2003.

Mark Viahakis, "Can resonant frequency be measured (readily) for a fly rod? If so, what would it tell me?"

Emory Harry, "In my judgment resonant frequency is the single most important characteristic of a rod. All of the other characteristics of a rod will show up in resonant frequency, stiffness, modulus of elasticity, action, power, weight, etc. ..."

Sing-Choong Foo, "...What do you do with the number? ...That frequency number really doesn't tell you much about the performance of the rod. ..."

Christian Brink, "According to Dr. Spolek's paper 1993 "Fly Rod Performance," the rod's natural frequency is directly related to it's generated line speed. ... But I am using a frequency to derive a comparative measurement, not anything as complicated as deriving modulus of elasticity or predicted line speed."

Tom Kirkman, "... the line speed generated by a rod is dependent on the angler doing the casting. Some rods are capable of generating higher line speeds by virtue of their intrinsic properties, but no particular line speed is guaranteed with any particular rod."

Christian Brink, "... Which only makes the natural frequency of a rod useful to us as a measure of a rod's possible performance compared to other rods, not a prediction of line speed..."

Tom Kirkman, "... I have tried to stress that for any such thing to be useful, it must be converted or translated into some type of simple relative scale. With a known length, weight, power rating (ERN) and action (AA), we have most of the pieces of the puzzle. However, we're still up against what I like to call efficiency or what others may describe as feel. We have no relative scale to measure that—you have to get hold of the blank or blanks in question and use your human sense of touch to gain this last tidbit of information. It might be helpful if you didn't have to do that. ... It is in this area that a resonant frequency scale would be most helpful. It could complete the final piece of the puzzle, but again, it would have to be reduced or translated in some way to a simple relative scale in order to be widely understood and accepted. And of course, you'd have to get the manufacturers to adopt it. That would be the hardest part."

And finally, Mike McGuire, "...the basic physics we are all appealing to here (is) the mass-spring oscillator....if we up the mass load and spring constant proportionally, the frequency doesn't change. So a 10 wt rod is noticeably stiffer and heavier than a 5 wt rod of the same length, yet they can have the same frequency and thus require moves with about the same timing to cast them, This is likely as close as we can get to an objective measurement of the feel of a rod. "We already measure spring constant in the form of the CC measurement of ERN, which essentially is the spring constant scaled by the length of the rod. Combine that with resonant frequency and you really know a lot about a rod....The CC measurement makes essentially the same restriction of interest to what the tip does in response to a static load, and any number of casting gurus will tell us that it's how the tip moves is what counts."

From the preceding, we can safely conclude knowledge of the resonant frequency could be extremely useful in describing that fly rod. However first, one must be able to both easily measure it and relate it to how an angler casts and what an angler feels. Now, lets take a closer look at frequency.

### Fly Rod Frequency

This subject has been recently treated in an informative article by E. Harry and J. Hurt in the Vol.7 #1 issue of this magazine. I would strongly recommend you read the entire article. In the following paragraph, I have paraphrased some of their pertinent points.

Every blank and/or rod has a resonant or natural frequency at which it will vibrate or oscillate if excited. This frequency will have a large effect on how the rod will feel and perform. Since tip velocity and frequency are directly related, frequency is also an indication of what the casting time constant should be to take advantage of the rod's potential. A higher frequency will require a faster casting motion, and a lower frequency will require a slower casting motion.

It is important to remember all of the intrinsic properties of a rod or blank (i.e., design, materials of construction, power (ERN), length, weight, action (AA), hardware, etc.) directly affect this frequency.

The most obvious factors affecting frequency (F) are stiffness (S or ERN), length, and weight (W). Qualitatively, one might write the equation $F = S/W$ which indicates—all other things, e.g., length—being equal, frequency directly reflects the ratio of stiffness to weight. This is sometimes called "efficiency," and is why higher modulus graphites with their corresponding lower weights and greater stiffness produce rods exhibiting higher frequencies. Heavier bamboo rods exhibit lower frequencies.

The preceding reinforces the conclusion that knowledge of the natural frequency of a fly rod would be extremely useful in describing that fly rod—but, is that really true?

### What Frequency Should We Determine?

It's all well and good to aspire to measure the intrinsic frequencies of rods or rod blanks and use those values as an indicator of the relative timing required for pleasurable casting. However, assuming one could make these measurements and establish the frequencies of two rods, would this knowledge be useful?

Rod Blanks: Studies have shown the natural frequencies of fly rod blanks range from about 120 to 600 cycles per minute (cpm). However, there is no evidence to support the idea that knowing the frequency of a rod blank will allow one to precisely predict the properties of the finished rod.

While a rod maker might determine the frequencies of two blanks, the frequencies of both will decrease with every guide, wrap, tip top, or layer of finish added to complete them.

In the final analysis, the originally faster responding (higher frequency) blank might well produce the slower responding rod. Dr. G. Spolek has shown that starting with two blanks having essentially the same frequencies (216 cpm), the addition of different guides, etc. reduced the frequency of one of the finished rods to 209 cpm and the other to 181 cpm.

Finished Rods: The preceding logically raises the next question. Should one ignore the frequency of the blank and measure the frequency of the finished rod. The answer to that question is either Yes or No—depending on your situation.

Knowing the frequency of a finished rod would indeed be useful for those who understand the significance of that number. Unfortunately, there is no easy way to make this determination without employing some rather sophisticated instrumentation. Consequently this value would have to be supplied by the rod manufacturers, and presently, they have little incentive to do so.

Rod manufacturers appear to believe the typical angler can learn enough about the feel of a rod to allow him to make a choice by simply wiggling those few rods available to him at his local dealer.

However, such an approach is not satisfactory for the conscientious custom rod builder. He, having access to any number of fly rod blanks, recognizes that knowledge of the frequency of each would allow him to construct a rod to more precisely match the predetermined desire of even the most demanding of clients.

Fly Fishing Outfits: As alluded to above, before using any fly rod, one must first put a fly line on it. While each and every rod does have a measurable intrinsic frequency, putting any fly line on any rod will produce a new combination having a much lower frequency, i.e., a longer response time.

Consequently, if the customer is still not completely satisfied, a dealer can play the game of adjusting the feel of his available rods by changing the weight of the line.

We know stiffer rods have higher frequency values and also know manufacturers now produce "heavier" lines to "sweeten the action" of these stiffer rods.

By such a trial and error approach, a fly shop dealer can adjust the feel of almost any rod sufficiently to make the immediate sale. However, such an adjustment comes at a cost the buyer might not recognize until much later, when, under different circumstances, his rod fails to perform as expected.

The practical problem confronting the custom rod builder is that he must work in reverse of the fly shop. Instead of offering a selection of finished rods from which the client can choose, he must be able to construct a rod which, when fitted with the "correct" line, matches the response rate or "feel" the client desires.

To successfully accomplish this task, the rod builder must have some means whereby the client can adequately transmit his desires to the builder and the builder can objectively demonstrate these desires have been fulfilled.

This brings us to the subject of "feel."

### Quantitating Feel

Imagine overhearing this conversation at your favorite rod builder's shop.

Joe: "Hey Charlie, I'm in the market for two new rods. One with a CCF of 100 and the other 55. Can you help me?

Charlie: "Well, I should be able to build that cannon for you, but I can't help you with the cane one."

While one might well wonder what language they were speaking, they were discussing feel.

Lord Kelvin said "If you cannot measure it, if you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind." Joe and Charlie were simply using numbers to describe feel, and both understood each other perfectly.

Fly rod builders need some means of describing the feel of a fly rod in other than purely subjective terms and in terms which can be clearly understood by all. To that end, in this piece, I propose a new language or vocabulary of feel which incorporates objective definitions of the familiar terms used in describing feel. Granted, the words themselves are insufficient for describing feel. However, they serve to establish the base necessary for an objective numerical scale of feel.

It has been long recognized that there is a definite relationship between the feel of a fly rod and the frequency at which it vibrates. Consequently, any quantitation of feel must incorporate the concept of frequency.

### How Does That Feel?

Suppose I hand you a fly rod and ask, "How does that feel?" Before you can give me a meaningful answer, you must ask the question, "Compared to what?"

Your conception of feel must always have a reference point. Hot or cold, heavy or light, rough or smooth, hard or soft, and better or worse are all relative terms—meaningless without a reference point. The better you can objectively describe your reference point, the more meaningful will be your assessment of feel.

When buying shoes, you are frequently asked, "How does that feel?" A good clerk does not simply hand you shoes to try on without first determining the reference point from which your decision will be based, e.g., material of construction (cloth, leather, rubber), style (ballet, tennis, work boot), or fastenings (laces, buckles, straps).

These are all things you have subjective feelings about. They will determine what, at this particular point in time, will constitute a good feeling shoe. Only then will the clerk bring you shoes to try on. Now, the major concern is whether the shoe is of the right size and width.

So it is when you go to your local fly shop to purchase a new fly rod. Unless you are simply killing time or seeking free entertainment through wiggling their rods, you will specify the material of construction (bamboo, fiberglass, graphite), length, weight, color, guides, handle, reel seat, action, and any other details you have a strong feeling about. Now, when the clerk hands you a rod and asks how it feels, he is seeking to ascertain if the stiffness and frequency of that rod are compatible with your present casting stroke or the one you might wish to develop.

We recognize the feel of a fly rod depends upon the many factors listed above. While each of those individual factors could be objectively measured or defined, it is that “undefinable combined effect” of all these interacting factors which creates what we call the feel of that rod. Nevertheless, we can instantly determine whether that “feel” is more or less pleasurable than that of a different rod.

Remember, it is imperative one distinguish between the intrinsic reel of the fly rod, itself, and any resultant feel due to the installation of a fly reel. A rod feeling tip heavy with one reel might well feel butt heavy with a different reel.

### Fly Rod Feel

The subjective concept of feel can be expressed in terms relating to what I call the intrinsic feels of familiar objects. The Hanneman Fly Rod Scale of Intrinsic Feels is summarized in the first column of Table A. It ranges from “like a wet noodle” to “like a broomstick.” In comparing the relative feels of any two rods, one can easily say one feels more like a noodle than the other, or the other feels more like a broomstick.

Even without the use of objective numerical values or any precise definitions of the physical limits of the different categories, anyone having the slightest familiarity with fly rods can easily take any group of rods and rate them relative to each other on the basis of feel. This is because feel is primarily a function of the length and strength of each rod. These are also the major factors determining its frequency. Rod action also affects what we subjectively call feel. This factor is addressed through the determination of Action Angle.

While this approach is sufficient for simple comparative purposes it tells little about how near or far two rods are from each other or from the extremes of the scale. This can only be done by the use of numerical values and an objective relative numerical scale.

Table A

**Correlation of Intrinsic Feels with Values of CCF**

| Intrinsic Feel | CCF, cpm |
|---|---|
| Broomstick | 200 |
| Cannon | >100 |
| Graphite (typical) | 66 - 90 |
| Fiberglass | 60 - 85 |
| Bamboo | 30 - 75 |
| Greenheart | <30 |
| Wet Noodle | 0 |

To accomplish this, a new term and numerical scale called CCF (Common Cents Frequency) must be introduced. This CCF scale is presented in the second column of Table 1. It provides the necessary objective link between frequency and feel.

Now, returning to the opening paragraph, when Joe asks about making a rod with a CCF of 100, Charlie immediately understands that Joe wants a very, very fast responding rod made from the latest “space age” material. The reference to a rod with CCF of 55 indicated a typical mid-range bamboo rod. Note: It is important that one does not confuse rod response time with rod action. A rod’s response time is a function of the frequency at which the rod oscillates. This is entirely different from a rod’s action which is a function of where the rod first bends. It is possible to construct rods with fast actions and slow response times, and visa versa. The numerical value of CCF will vary directly with the speed of response, irrespective of action.

One must recognize that while the material of construction produces general references (primarily a result of stiffness/weight), design (particularly length, action, and weight) accounts for variations within each grouping. Consequently, as one might expect, there is an overlapping of the numerical values. Differentiating the groups can generally be done by sight or weight (e.g. bamboo/fiberglass).

It must be stressed and remembered, individual values of CCF are neither good nor bad. They are simply objective relative numbers. Their practical value lies in describing the CCF of any rod—or for comparing the CCF values of two or more rods.

### CCF, So What?

While the above paragraphs may have made interesting reading and provided some food for thought for those sincerely interested in characterizing fly rod performance, I am certain that astute readers are now asking questions like, “What does the CCF physically represent?” and “How does one make and use CCF measurements?” These questions will be addressed next.

### CCF — Common Cents Frequency

In the Common Cents System (CCS), I introduced a unique, simple, and easy to perform method for characterizing fly rods. It was based on a set of objective static measurements related to the intrinsic power or ERN (effective rod number) and action of the rod.

Any further characterization of fly rods, addressing what is commonly referred to as *feel*, requires the introduction of a dynamic test which reflects the properties of the fly rod in motion. The Common Cents Frequency (CCF) determination described in this paper is proposed to supply that dynamic test.

Historically, anglers have shown great interest in determining the frequency at which a fly rod oscillates and trying to relate that frequency to how that rod feels. However, without a working definition of the term "feel" and an objective means of relating frequency to feel, all previous efforts have been doomed to failure.

This paper proposes a new approach to the problem. It incorporates a new relative numerical scale for frequency and a new relative subjective scale for feel, as well as relating the two scales in a useful fashion. Details for the experimental determination of frequency values are provided.

The significant aspect of this new approach is recognition that the feel or frequency of the fly rod, itself, addresses only part of the fly angler's problem. Now, a new term which I have called the "fly rod outfit" includes both the rod and the line. It is the frequency of this "outfit" which dictates feel, is measured in this approach, and is called CCF (Common Cents Frequency).

## Frequency and Feel

It is generally conceded the *feel* of a fly rod can be defined to a great extent by a determination of its static properties (i.e., length, weight, action, and intrinsic power) coupled with a determination of the frequency at which the rod oscillates. While measurements of the first four factors are relatively straight forward, my task lay in developing a useful scale relating frequency to feel.

To accomplish this, it was necessary to do three things:

(1) Develop a relative subjective scale for feel.

(2) Develop a relative numerical scale for frequency.

(3) Relate the two scales in a useful fashion.

## Understanding CCF

Determining the frequency of a fly rod blank or a finished fly rod using very simple or inexpensive instruments has so far proven to be impossible. This is due to the high frequencies (100 to 600 cycles per minute) they exhibit. Also, while the characterization of bare blanks or rods can produce some interesting data, there is really very little one can do with them.

This raised the question, "Could there be a more fruitful approach?"

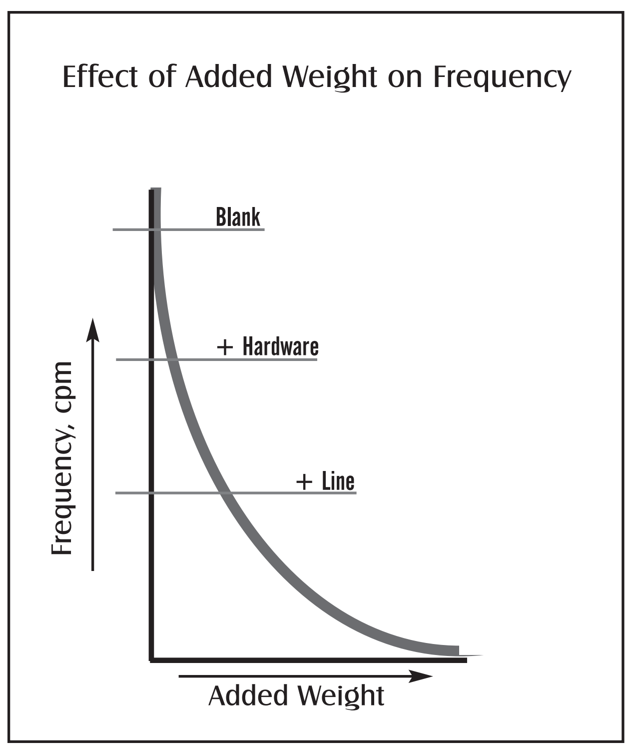
We all recognize that if one intends to cast a line and fish, it is necessary to first put a line on the rod. A bit earlier in this article, I wrote, "While each and every rod does have a measurable intrinsic frequency, putting any fly line on any rod will produce a new combination of rod and line having a much lower frequency, i.e., a longer response time."

This new lower frequency now reflects the response time and feel of one's "fishing outfit" rather than just the rod. Consequently, it appeared to make more sense to measure the frequency of this rod and line combination. For the sake of simplicity and ease, the weight of the fly line is simulated by the use of weight attached to the tip top of the rod.

In order to clearly distinguish the results obtained by use of this new approach from the work and results of previous investigators, a new term "CCF" (Common Cents Frequency) has been invoked.

Fortuitously, the added weight of the fly line had the effect of reducing the frequency of the combination to a value which in most cases could be easily measured. The relationship between frequency and added weight is schematically illustrated in Figure 1, below.

Figure 1



It is important to remember, as shown in Figure 1, the mere addition of weight to the tip decreases the measured frequency. This means that one can produce any value of frequency by simply controlling the applied weight.

Therefore, the first step in developing my method entailed making the arbitrary decision as to how much weight should be added to the blank.

Since this added weight serves to simulate the weight of the fly line which would be used on that rod, it seemed logical to relate the amount of weight added to the intrinsic power or strength of the fly rod.

In the parlance of the "average" fly angler, what I appear to be saying is, if one is testing a "6-weight" rod, the added weight should equal the weight of an AFTMA No. 6 line.

However rod builders are well aware that since a 6-weight rod has never been defined, there actually is no such thing as a 6-weight rod. Consequently what one company calls a "6-wt" rod may be the equivalent of another company's "5-wt" rod or a third company's "7-wt" rod. Also, all AFTMA No. 6 lines do not weight the same.

To obviate the above unresolvable confusion, rod builders have embraced the Common Cents System (CCS) and now discuss the intrinsic power of fly rods in terms of Effective Rod Number (ERN) and the weight of lines in terms of Effective Line Number (ELN). The derivation of the term CCF (Common Cents Frequency) is now apparent.

## Defining CCF

In as few words as possible, the CCF is defined below.

CCF is the fundamental frequency, expressed in units of cycles per minute, of a fly rod bearing a specified weight (X gr.) attached to its tip top. X is defined by the ERN of the rod in the table below.

| ERN | gr. | ERN | gr. | ERN | gr. |
|---|---|---|---|---|---|
| 0 | 40 | 6 | 160 | 12 | 380 |
| 1 | 60 | 7 | 185 | 13 | 450 |
| 2 | 80 | 8 | 210 | 14 | 500 |
| 3 | 100 | 9 | 240 | 15 | 550 |
| 4 | 120 | 10 | 280 | | |
| 5 | 140 | 11 | 330 | | |

## Determination of CCF

The determination of CCF is briefly summarized directly below. Following it, a number of clarifications and suggestions for making the measurements are offered.

1. Support the rod in a horizontal position and determine the ERN according to the Common Cents System.

2. Determine the amount of weight (X) to be added, as derived from the table above.

3. Attach the weight (X) to the rod tip top.

4. Depress and quickly release the rod tip to start it oscillating up and down.

5. Use a stopwatch to determine the number of seconds required for the rod tip to make 20 complete oscillations.

6. Calculate CCF: CCF = 1200 / (number of seconds for 20 cycles) e.g. If it takes 16.46 seconds for 20 oscillations, then CCF = 1200 / 16.5 = 73 cycles per minute (cpm)

Note: This technique was originally conceived and developed for trout rods (ERN=<6). As the strength of the rod increases, the frequency increases and one's ability to visually count the number of oscillations becomes more difficult. One solution recommended to solve this problem is to place the rod in front of a clock having a large second hand, video tape the oscillating rod and replay it at a slower speed.

If one's only concern is comparing the relative recovery speeds of two rods of similar ERN, the exact amount of weight to be added is not critical, however, it must be the same for both rods. Use enough weight to slow the frequencies so they can be easily measured. Remember, wuch values do not equal the CCF values.

## Clarifications and Suggestions

It is important that the rod handle be firmly supported. Any looseness of support will cause the CCF value to be low.

The value of X is derived from the whole integer of the measured ERN. For example, if the ERN of a rod falls between 5.00 and 5.99, then X = 5 and the attached weight = 140 grains.

The weights must first be constructed, then adjusted to their precise value, and finally attached to the tip top. I have found the following approach to be simple yet adequate for this task.

The weight is composed primarily (on a weight basis) of a common fishing sinker. About one quarter or less of the total weight is composed of Duco Stik-Tak or an equivalent tacky substance which adheres tightly to metal. For the serious investigator, making a complete set of standard weights covering his range of interest will in the long run save much time and effort.

Each weight is adjusted to match the desired value by the addition or removal of some of the adhesive. This will require the use of some sort of weighing device such as Dr. Bill's Fly Rod Analyzer (see RodMaker Vol. 6 , No. 4).

A weight can be easily attached and secured to the tip top by means of the adhesive. It is important to remember that this adhesive is an integral part of the weight. Therefore, when removing the weight from the rod after the measurement has been made, one must be certain to retrieve all of the adhesive and recombine it on the weight. Otherwise, one will have to recalibrate the weight before using it again.

Another approach, utilizing a few common cents and BB size split shot lead sinkers is described in Box A.

**Box A**

**Alternative Weights for CCF Determinations**

| ERN | Stik Tak* grams | Cents No. | Lead BB weights, No. | Total Wt. grains (approx) |
|---|---|---|---|---|
| 3 | 5 | 0 | 3 | 100 |
| 4 | 5 | 1 | 0.5 | 120 |
| 5 | 5 | 1 | 3 | 140 |
| 6 | 5 | 2 | 3 | 160 |
| 7 | 5 | 2 | 4 | 185 |
| 8 | 5 | 3 | 2 | 210 |

*equivilent to one half of one stick - 5g. or 2 cents in weight.

### Changing Frequency

Since it is now possible to quantitate frequency, it is also possible to precisely determine the change in frequency or response time of a fly fishing outfit as a result of altering the weight of the line used or the length of line aerialized.

Qualitatively, we all recognize that increasing the weight on the tip of the rod will decrease the response rate or frequency of that rod and decreasing the weight will speed it up. This changes the feel of the rod and is the basis for the practice whereby anglers "soften" fast responding rods. The same effect can be obtained by changing the length of line aerialized in a cast. A rod which feels too stiff with 20 feet of line out may well feel great with 50 feet of line out.

Carrying this idea to extremes, one could take almost any fly rod and, by simply changing the weight of the aerialized line, make it feel like anything from a broomstick to a noodle. Of course, the pleasure derived from fishing these two extremes would be significant.

On a more practical level, we recognize that any fly rod can satisfactorily cast a fly line which is one AFTMA Line No. greater or less than what the rod was designed to optimally cast. We also know that changing lines will alter the feel of the resulting fishing outfit. The question I want to address next is how much of a change might one expect? To do this, I must introduce two new terms.

### CCF+1 and CCF-1

The terms CCF plus or minus one are intended for use in describing the effects on frequency due to over-lining or under-lining a rod by one AFTMA line number. The terms CCF+1 and CCF-1 have been defined as the CCF determined using an added weight equal to the weight of 30 feet of line of one line number higher or lower than that specified by the measured ERN.

For example: For a rod having a measured ERN of 5.3, the CCF is determined using a weight of 140 grains, the CCF+1 is determined using a weight of 160 grains, and the CCF-1 is determined using a weight of 120 grains.

## CCF and Choosing a Fly Rod Outfit

### Know your favorite CCF!

1. If an angler knows the CCF which produces the feel he desires and also knows the CCF of a fly rod outfit (rod+line) he is considering purchasing, he can immediately predict—without touching rod or line—the degree to which that outfit is likely to satisfy his desires in regards to feel.

2. If an angler also knows the values of CCF+1 and CCF-1 of the rod in question, he can accurately pre-

dict whether or not he can satisfactorily adjust the feel of that rod to meet his requirements by over-lining or under-lining the rod.

### Rod Tip Speed

While the angler supplies all of the energy required to make a cast, a portion of this energy is momentarily stored in the form of the loaded (deflected) rod and released at the time of the "stop." This contributes to the total speed of the rod tip and the line. Essentially, we can consider this analogous to adding a bow and arrow cast to the speed of the line produced by a rigid rod and the angler's arm motion.

How much additional speed can be added is a function of how far the rod has been deflected and the speed at which the rod straightens. The former is a subjective decision of the angler which allows him to alter the length of his cast to fit the occasion. The latter is a function of the frequency of the rod, an intrinsic property which can be measured.

If desired, one can approximate the maximum rod tip speed attributable to the straightening rod by use of the following formula:

Maximum tip speed = 8 D F ft./sec.
Where D - deflected distance
and F is the frequency.

The chart in Box B shows the maximum rod tip speed (in feet/second) as a function of the CCF of the rod and the distance in feet the rod tip is deflected.

**Box B**

**Tip Speed Formula**

Maximum tip speed = 8 D F ft.sec.
Where D - deflected distance and F is the Frequency (c.p.s.)

**The chart below shows the maximum rod tip speed (in feet/second) as a function of the CCF of the rod and the distance in feet the rod tip is deflected.**

| CCF | 1 ft. | 2 ft. | 3 ft. | 4 ft. |
|---|---|---|---|---|
| 90 | 12 | 24 | 36 | 48 |
| 80 | 11 | 21 | 32 | 43 |
| 70 | 9 | 19 | 28 | 37 |
| 60 | 8 | 16 | 24 | 32 |
| 50 | 7 | 13 | 20 | 26 |
| 40 | 5 | 11 | 16 | 21 |

### Summary

For the first time, fly rod builders and anglers alike have a means by which they can objectively characterize the dynamic property of feel and numerically express it in unambiguous terms.

CCF values provide the dynamic characterization , while rod strength (ERN) and action angle (AA) provide the static characterization. Together they complete the Common Cents System. The DBI (Defined Bending Index) can now be written in the form of ERN/AA/CCF. It should be inscribed on every flyrod. ✍

Editor's Note: Until the advent of the complete Common Cents System, the only relative measurements available for rods and blanks concerned length and weight, and only those two. Any other rod or blank "properties" were listed according to the subjective opinions of the respective designer or maker and were not accountable to any across the board standards or constants.

Now, with the advent of Dr. Hanneman's latest work, the CCF and Rod Tip Speed Analysis, rod builders and fishermen have, for the first time ever, a totally objective and relative means of measuring and comparing nearly all of the most important intrinsic properties of a rod or blank - Action, Power, Speed, Frequency or Feel.

Along with this issue, these previous issues of RodMaker contain the complete system as presented by the inventor.

Volume 6 #2 • The Common Cents System - Determining power (ERN) and action (AA).

Volume 6 #3 • The Big Picture - Using the Common Cents System to further analyze rod power and action.

Volume 6 #4 • The Common Cents System - Dr. Bill's Fly Line Analyzer and The Rosetta Stone Chart.

Volume 6 #5 • The Common Cents System - Balancing fly rods and reels.

Volume 7 #2 • The Common Cents System - Updated Rosetta Stone Chart.