OMEGA

DRILLINGS FOR RIGHT HAND

For accurate, easy drilling, following these markings:

- ☼ Driller's Clock
- Ω Center of Gravity
- **X** Positive Axis Point (PAP)
- ● Small Pin
- ○ Extra Hole

Ball Rating System: Defining Hook in two (2) components.

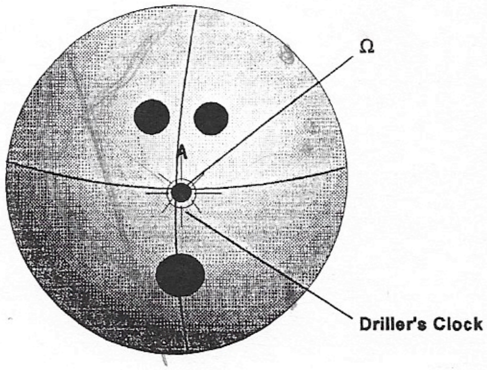
(1) Length to Breakpoint
(2) Degree of Backend Reaction

Ratings: (1) <u>Length</u> (L) --- 1 being earliest hook point to 5 being the latest hook point.

(2) <u>Backend</u> (B) --- 1 being least amount of hook to 5 being the most hook potential.

FYI: The numbers of length and backend are merely compared to each other. No quantifiable amount of length, breakpoint, nor backend hook are implied. Hook potential is a function of the oil pattern used, ball surface roughness, amount of revolutions, ball speed, axis tilt, and ball track. Label shifts will affect layout characteristics.

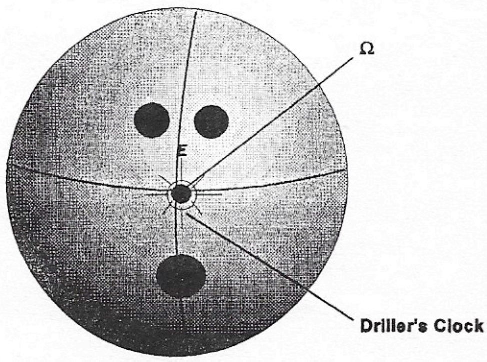
Drilling #1



RATING -- L = 4 B = 3

Select a ball that is "Pin In." Place A on Driller's Clock at 12:00 o'clock (See Diagram). The center of Driller's Clock is in the center of the grip. If the distance of the center of gravity (Ω) to the center of the Driller's Clock is greater than 1", an extra hole could be required to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 5".

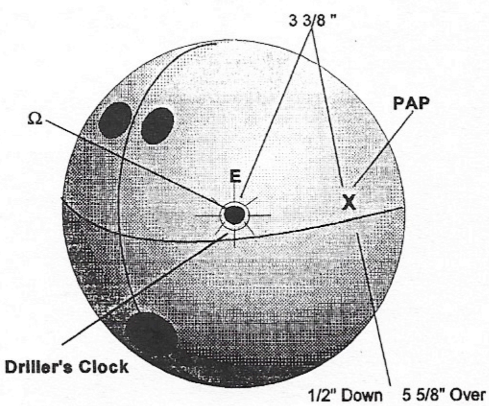
Drilling #2



RATING -- L = 2 B = 4

Select a ball that is "Pin In." Place E on Driller's Clock at 12:00 o'clock (See Diagram). The center of Driller's Clock is in the center of the grip. If the distance of the center of gravity (Ω) to the center of the Driller's Clock is greater than 1", an extra hole could be required to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 5".

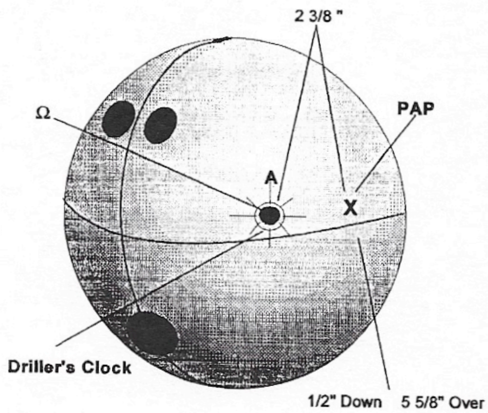
Drilling #3



RATING -- L = 3 B = 5

Select a ball that is "Pin In." Place E at 12:00 o'clock. Measure 3-3/8" to the right from the center of the Driller's Clock through G. Use this point as the bowler's positive axis point. Reverse the bowler's positive axis point coordinates to find the center of the grip. This is a drilling that could require an extra hole to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 6".

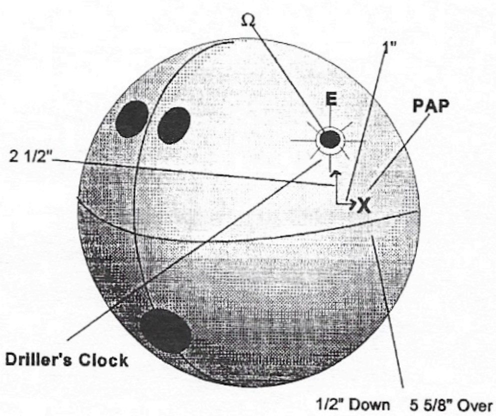
Drilling #4



RATING -- L = 5 B = 3

Select a ball that is "Pin In" with 2.70 oz. or less of top weight. Place A at 12:00 o'clock. Measure 2-3/8" to the right from the center of the Driller's Clock through "C". Use this point as the bowler's positive axis point coordinates to find the center of the grip. This drilling could require an extra hole to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 6".

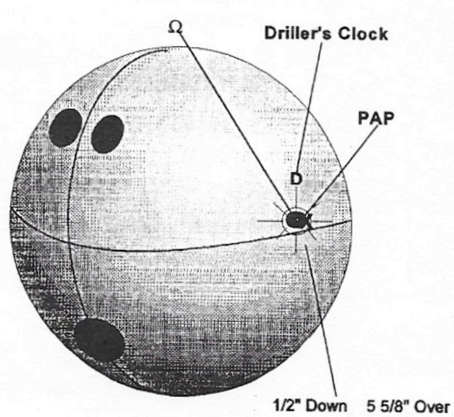
Drilling #5



RATING -- L = 4 B = 5

Select a ball that is "Pin In" with 2.50 oz. or less of top weight. Place E at 12:00 o'clock. Measure 2-1/2" down from the center of the Driller's Clock through "A". From this point, make a perpendicular line to the right 1" long. Use this point as the bowler's positive axis point. Reverse the bowler's positive axis point coordinates to find the center of the grip. This drilling could require an extra hole to meet ABC specifications. Drill the extra hole on a line from center of grip through the center of gravity at 8".

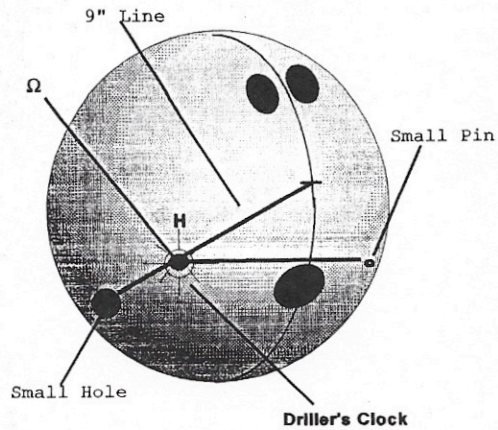
Drilling #6



RATING -- L = 1 B = 3

Select a ball that is "Pin In" with 2.50 oz. or less of top weight. Place D at 12:00 o'clock. From the center of the Driller's Clock, reverse the bowler's positive axis point coordinates to find the center of the grip. This drilling could require an extra hole to meet ABC specifications. Drill the extra hole to the right on a line from center of grip through the center of gravity at 8".

Drilling #7



This drilling is recommended for Full Roller bowlers. Select a ball that is "Pin In". Draw line through B connecting the large pin to the small pin. Locate the center of this line, keeping the large pin to the left of the center of the grip. This point becomes the top of the bowlers thumb hole. From this point, draw a 90° line up to establish the bowler's center line of grip. This drilling could require an extra hole to meet ABC specifications. To find the extra hole location, draw a line 9" long from the center of the grip through the pin.

Extra Holes:

When determining the location of the extra hole remember that a hole 5" away from the center of grip will remove some top weight. A hole 7" away from the center of the grip will maintain the top weight. A hole 9" away from the center of the grip will add some top weight.

Axis Point:

The axis point is easily attainable from the customer's old ball. Trace the track with your marking pencil. Place the ball, track side down, in your ball spinner. Adjust the ball so that the track is parallel to the ball dish. Turn on the spinner. The pencil line should be constant. If it is wobbling, turn off the spinner and readjust. When a stable line is seen, place the pencil at the top of the ball. The center of this pencil mark is your axis. This point should be equidistant to the ball track in all directions.

To get the horizontal and vertical coordinates of the axis point, draw a line down the center of the finger holes through the center of the thumb hole. Measure half the distance from the thumb to the fingers and make a mark. This is the center of the grip. Take the quarter scale and draw a horizontal line perpendicular to the grip line. Now draw a vertical line from this line through the axis point. Measure the distance from the center of the grip to the intersection of the vertical line. This is the horizontal coordinate. Now measure the length of the vertical line to the axis point. This is vertical coordinate.

OMEGA

DRILLINGS FOR LEFT HAND

For accurate, easy drilling, following these markings:

- ☼ Driller's Clock
- Ω Center of Gravity
- **X** Positive Axis Point (PAP)
- ● Small Pin
- O Extra Hole

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(2) Degree of Backend Reaction

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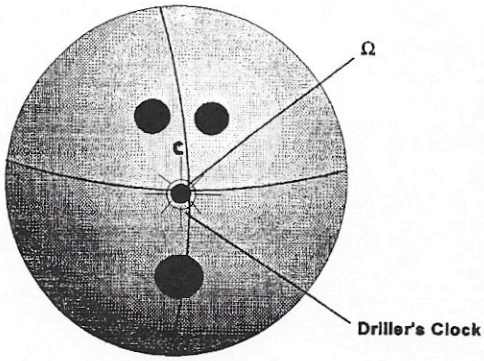
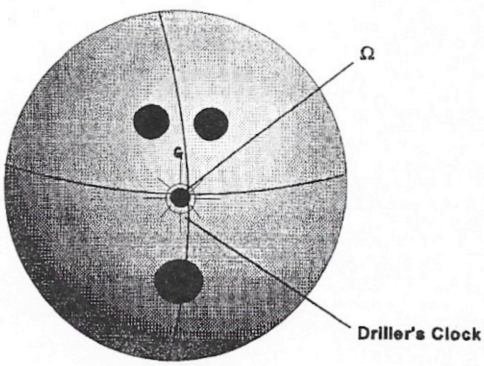


RATING -- L = 4 B = 3

Select a ball that is "Pin In." Place C on Driller's Clock at 12:00 o'clock (See Diagram). The center of Driller's Clock is in the center of the grip. If the distance of the center of gravity (Ω) to the center of the Driller's Clock is greater than 1", an extra hole could be required to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 5".

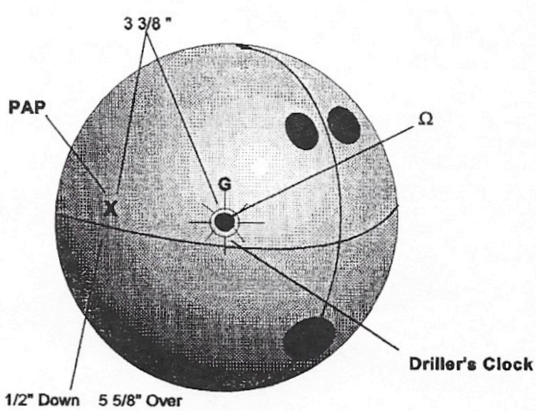
Drilling #2



RATING -- L = 2 B = 4

Select a ball that is "Pin In." Place G on Driller's Clock at 12:00 o'clock (See Diagram). The center of Driller's Clock is in the center of the grip. If the distance of the center of gravity (Ω) to the center of the Driller's Clock is greater than 1", an extra hole could be required to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 5".

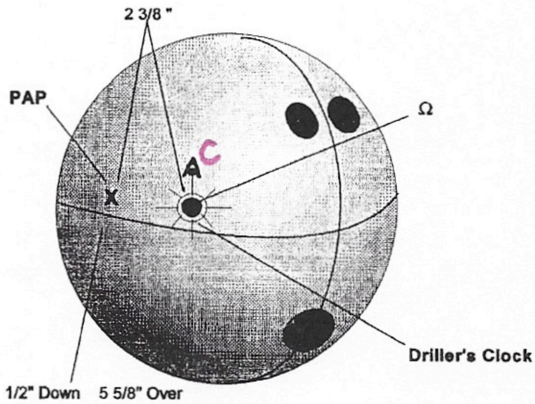
Drilling #3



RATING -- L = 3 B = 5

Select a ball that is "Pin In." Place G at 12:00 o'clock. Measure 3-3/8" to the left from the center of the Driller's Clock through E. Use this point as the bowler's positive axis point. Reverse the bowler's positive axis point coordinates to find the center of the grip. This is a drilling that could require an extra hole to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 6".

Drilling #4



RATING -- L = 5 B = 3

Select a ball that is "Pin In" with 2.70 oz. or less of top weight. Place C at 12:00 o'clock. Measure 2-3/8" to the left from the center of the Driller's Clock through "A". Use this point as the bowler's positive axis point. Reverse the bowler's positive axis point coordinates to find the center of the grip. This drilling could require an extra hole to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 6".

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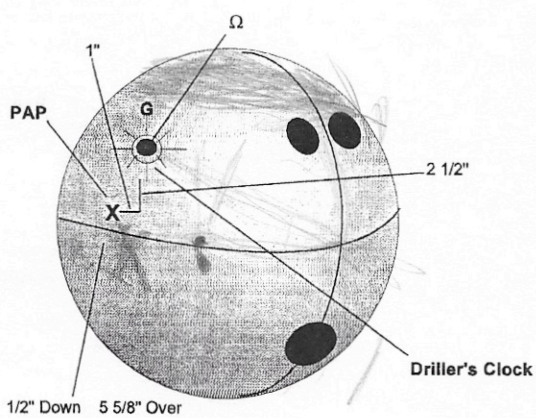

RATING -- L = 4 B = 5

Select a ball that is "Pin In" with 2.50 oz. or less of top weight. Place G at 12:00 o'clock. Measure 2-1/2" down from the center of the Driller's Clock through "C". From this point, make a perpendicular line to the left 1" long. Use this point as the bowler's positive axis point. Reverse the bowler's positive axis point coordinates to find the center of the grip. This drilling could require an extra hole to meet ABC specifications. Drill the extra hole on a line from center of grip through center of gravity at 8".

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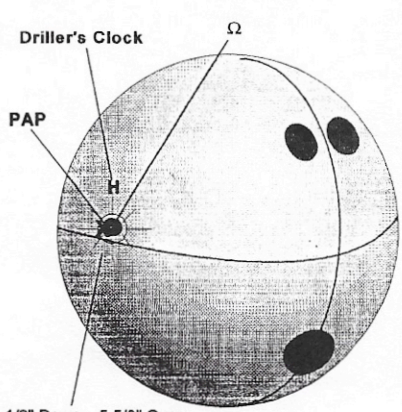
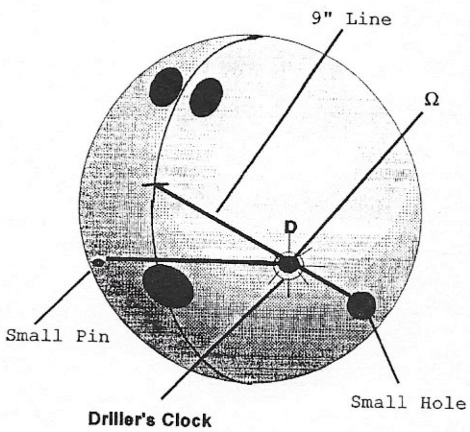


RATING -- L = 1 B = 3

Select a ball that is "Pin In" with 2.50 oz. or less of top weight. Place H at 12:00 o'clock. From the center of the Driller's Clock, reverse the bowler's positive axis point coordinates to find the center of the grip. This drilling could require an extra hole to meet ABC specifications. Drill the extra hole to the left on a line from center of grip through the center of gravity at 8".

Drilling #7



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EBONITE

Ω OMEGA BALL SEMINAR Ω

JANUARY INTRODUCTION

TOMORROW'S TECHNOLOGY TODAY

A. FUNDAMENTAL PRINCIPLES OF BALL DYNAMICS

1. FACTORS WHICH AFFECT BALL PERFORMANCE
   - a. Work applied to the ball as linear velocity -- (SPEED)
   - b. Work applied to the ball as angular velocity -- (REVS)
   - c. The axis tilt and position of the ball at release
   - d. Surface characteristics of the ball - Polished or sanded and veneer construction
   - e. Conditions of the lanes
   - f. Static imbalances present in the ball
   - g. Ball drilling with respect to dynamic positioning -- Track Flare Management
   - h. Core construction -- Mass displacement measured by Moment of Inertia, Radius of Gyration
   - i. Proper ball grip fitting

B. DESCRIPTIVE ASPECTS DEALING WITH CONCEPTS IN MOTION

1. MOMENT OF INERTIA [I] AND RADIUS OF GYRATION [RG]
   - a. Moment of Inertia -- MASS DISTRIBUTION
     1. It is the product of the mass of an object and the average of the square of the distance of the mass from the pivot point or axis of spin.
     2. Basically, it is the measure of the rotational inertia of an object which expresses opposition to change in its rotational state.
     3. The weight and distribution of mass in an object ultimately determine how easy it is to start a ball spinning and how fast it will spin. The lower the Moment of Inertia the easier it is to effect a change in the rotational characteristics of the ball, and the faster it revs. The higher the Moment of Inertia the harder it is to start a spin on the ball, and the slower the ball will rev.
     4. ABC specification limits do not directly incorporate Moment of Inertia values. Therefore, Radius of Gyration values will be used to discuss mass distribution in cores as ABC specification limits do exist for these values.
   - b. Radius of Gyration RG -- MASS DISPLACEMENT
     1. It is the numerical value equal to the radius of a thin hoop of the same mass with the same moment of inertia as the body in question.
     2. Basically, it is the measure of the average distance of the mass from the pivot point or axis of spin.
     3. In short, Radius of Gyration is an account of the displacement of mass inside a ball.
   - c. Why is RG important to bowling?
     1. Knowing the values of RG for a particular product can easily give clues to its dynamic character. In essence, RG values are the bowling ball's finger print to dynamics.
   - d. High RG vs. Low RG
     1. High RG balls are those whose mass is displaced further from the center of the ball. These balls have the tendency to skid down the lane further and have a delayed

breakpoint. Products of this type are the Gyro Pro Teal, Turbo X and Crush/R.

2. Low RG balls are those whose mass is displaced closer to the center of the ball. These balls have the tendency to roll earlier and have a more balanced, smoother hook style. Products of this type are the Nitro R , Nitro R^2 and Turbo XL.

e. Static weight and its effect on RG

1. Static imbalances are in fact a mass bias toward a particular area of the ball. Since RG values are mass measurements, an imbalance left in the ball will increase the overall RG in that area. This will also create higher differentials of RG values in the ball making the product more dynamic in character.
2. Since full size 3-piece cores have RG values that are roughly similar, the impact of these imbalances is the only vehicle for creating any dynamic character in this type of product.
3. 2-piece asymmetric cores are affected by imbalances that change differentials due in part to the existence of differentials in RG values already designed into the core. The dynamics are present in this product type but are manipulated by static imbalances.
4. Static imbalances influence the dynamic character of the ball by either establishing dynamics or moving the profile of dynamics in the ball. Static imbalances are RG phenomena.

2. RG MEASUREMENTS OF THE 'XYZ' COORDINATE AXES

a. Where does a ball prefer to roll?

1. As a spinning top or gyroscope prefers to spin so that the lowest RG axis is the spin axis, a bowling ball exhibits the same charateristics as it prefers to rotate to an axis through the lowest RG value axis with the highest RG axis as the rotational plane.

b. Pin-in vs. Pin-out with regard to the 'XYZ' coordinate axes

1. One real advantage of pin-out balls is realized as the ball is drilled over the label placing the pin in an unstable axis area for greater dynamics. This is not to say that pin-in balls cannot do the same thing. In fact they can, but drilling a weight hole to make the ball legal is required.
2. The more elusive aspect of pin-out technology is the fact that pin-out balls are mass biased. If a ball is pin-in, the RG values 'XY', which are perpendicular to the 'Z' axis (Pin), have roughly the same values because of their symmetry. By shifting the core to be out of phase with the centerline of the ball, mass is biased toward either the 'X' or 'Y' axis. This creates differences in RG values between them establishing or reorienting a stronger Preferred Spin Axis [PSA] through the lowest RG axis.

c. ABC specified limits for RG values

1. ABC specification limits incorporate RG values having a maximum measured value of 2.800 and a minimum measured value of 2.430.

3. RG DIFFERENTIALS

a. What is an RG differential?

1. There are three axes in the coordinate description of a bowling ball. The three values are measured about the 'XYZ' axes where 'Z' is the axis through the pin. Differentials are the differences between the values obtained in 'XZ' and 'YZ' and 'XY'.

b. Effects of the preferred spin axis, seen as track flare, are created by differentials

1. Mentioned earlier in the section dealing with static weight imbalances, differentials between axes induce stronger dynamic potentials in ball reaction. Since a ball has an area about which it wants to rotate, creating larger differentials between the preferred axis of rotation and its rotational plane to the initial axis will give rise to a stronger PSA.
2. If two balls are drilled with all things being equal except differential RG values, (say at maximum leverage), the ball with the most differential will have more track flare potential and go into transitions quicker.
3. If a ball has the same RG values for all three axes, there will be no PSA. This results in little rotational preference and no track flare.

c. The importance of differential on High RG or Low RG balls contributors in creating hook potential. If a ball is going down the lane and has revs and axis tilt that is out of line with the linear direction of the ball, the ball will hook. If a ball has revs and an axis tilt that cause the ball to rotate in line with the ball's linear trajectory, the ball will not hook with or without friction. If a ball has proper axis tilt and revs but never encounters friction, the ball will not hook. Track flare size is dependent on the revs the bowler has, where the ball was drilled, what type of RG the ball has, amount of differential RG and how much friction is present.

The higher the revs, the wider the total track flare.

The more leveraged the ball is, the wider the total track flare will be.

The lower the moment a core has, the quicker the transitions and wider the total flare will be.

The higher the differentials, the wider the track and total track flare.

The more friction encountered, the wider the distance between track lines in flare.

Track flare has two main functions....1.) to orient the core to a more inertial position, (meaning resistance to change in rotation) 2.) to provide the ball with an oil free surface area so that when the ball hits the dry part of the lane, the friction is at its maximum potential. As discussed earlier, the greatest potential for hook is when the ball is in a high inertial position. Oddly, if the pin is in the track, the ball should hook the most evenly as this is a stable drilling pattern. Thus, the core rotation is in its highest inertial spin position. However, this is not the case as the ball will have little to no track flare. No flare means the contact area of the ball is tainted with lane oil and friction is reduced. When the ball reaches the dry area, it still has to dissipate the oil from the surface before strong hooking action can be exhibited. Very small amounts of oil on the ball's track surface will be more than enough to dampen the ball reaction significantly.

Hook is a separate aspect and is the fight between the angular velocity and the forward linear velocity of the ball. The resulting forces compromise creating rectilinear or translational motion [HOOK].

3. Revolutions -- are an essential part of creating hook in a ball as discussed earlier. As a bowler releases the ball, rotational energy is imparted to the ball. How fast the ball revs up is a result of whether the ball is a high or low RG ball. The high RG ball will rotate slower, make transitions slower and skid longer. Lower RG balls will do the opposite.
4. Axis tilt -- As discussed previously, the rotational positioning of the ball is critical to creating the potential for hook. The wider the angle between the rotational axis and the forward path of the ball, the greater potential for hook. IF THE ANGLE IS ZERO, NO HOOK WILL OCCUR.

c. Core aspects

1. Differential RG effect on hook -- The higher the differential, the stronger the PSA. The more resistant it is to change its direction from the rotational orientation, the greater the potential for hook.
2. Pin position -- The placement of pin position is basically the manipulation of the core in relation to the ball track. This also involves the movement of the PSA to effect change in ball reaction. Track flare size, focal point and direction are affected by the pin placement. Moving the pin position also moves the PSA either into the stable positions or away from them. Where the PSA plane around the ball intersects the bowler's track is the spot where the flare focal point or bow tie will be. The point where the line HD (on the bowlers clock) intersects the bowler's track is the focal point of the flare. The potential for hook is heightened when the PSA is placed several inches away from either of the stable rolling positions on the ball.

2. PERFORMANCE CONSISTENCY

a. Maintaining momentum and hitting power of light weight balls

1. A 16 lb. ball, without a doubt, is going to hit the pins with more force than lighter weight balls. This fact finds its basis in the concept of momentum, which is dependent on the mass of the ball and its velocity down the lane and into the pocket. Momentum = [velocity][mass]

16 lb. ball = [19mph][16lb] = 304

1. A spinning ball will inherently resist changes in the orientation of the axis of rotation. For high RG balls the amount of force required to exert a changing influence is greater than in low RG balls. High RG balls require large differentials to create movement of the initial axis toward the PSA or 90 degrees to the PSA. As a rule, the higher the RG differentials the the quicker the track flare transitions will be. This is one reason why low RG type balls roll out quicker.

d. ABC specified limits for Differential values

1. ABC specification limits incorporate differential values having a maximum measured value of 0.080 and no minimum measured value.

e. Ebonite pro line RG and Differential values

1. Turbo X --	RG [Z]= 2.547	RG [x,y]= 2.582		Diff [XZ]= 0.035
2. Nitro R --	RG [Z]= 2.528	RG [x,y]= 2.550		Diff [XZ]= 0.032
3. Nitro R --	RG [Z]= 2.542	RG [x,y]= 2.578		Diff [XZ]= 0.036
4. Turbo XL --	RG [Z]= 2.487	RG [x,y]= 2.534		Diff [XZ]= 0.047
5. Omega --	RG [Z]= 2.539	RG [x]= 2.556	RG [y]= 2.581	Diff [XZ]= 0.042
				Diff [XZ]= 0.025

C. TRACK FLARE MANAGEMENT AND HOOK POTENTIALS

1. WHAT CAUSES HOOK?

a. Friction

1. Without some sort of friction between the ball and the lane there would be no tendency for the ball to hook. Friction is not what causes the potential to hook, but it is the vehicle that allows the potential to be manifested. Friction is more of an aspect as to how quickly the ball is going to undergo translational movement.
2. The ball's surface is another vehicle which manipulates friction characteristics to cause directional changes in the ball trajectory. The rougher the surface the less contact there is between the ball and the lane. This creates a higher weight per unit area force at contact as well as providing a tread effect that allows for oil dispersion.
3. Veneer composition plays a big role in friction characteristics. The veneer construction dictates to a high degree what kind of friction values can be attained between the ball and the lane.

b. The creation of hook potential

1. Ball speed -- the linear velocity of the ball is another aspect. Like friction, ball speed determines how much hook will occur but does not create the potential. It is another vehicle for how much time is allotted for hooking to take place. In order to cause a ball to deviate from its linear path down the lane, a force deviating the ball away from its original direction is required. If the ball speed is increased, the force governing hook will lessen. The slower the ball rolls the stronger the influence. Conversely, the influence is weaker as the ball speed is increased.
2. Track flare and size -- this phenomenon results when a dynamic imbalance exists in a ball during motion. Essentially all balls with finger holes have a preferred spin axis. A preferred spin axis is an axis through which the ball wants to rotate. This rotational preference will place the highest RG area in either the track or on the spin axis. If the PSA is not in either of these two positions, track flare will result. The initial axis created by the bowler will seek one of these two positions in the ball. Which axial position it seeks is determined by the differential inherent in the core design and relative position of the PSA between the track and 90 degrees to the track. The closer the PSA is to either of these positions the less track flare will result. The closer to the 3 3/8 position the PSA is the more track flare will be created. The stronger the PSA the quicker the ball migrates to the stable position. Track flare creates hook potential as it allows the ball to position the core in an orientation that is very resistant to change in direction of rotation. Ball revs and axis tilt are the two most key

14 lb. ball = [19mph][14lb] = 266

The only way to get the lighter weight ball to hit the pins harder is to increase the ball's velocity into the pocket. Just throwing the ball faster will kill the angle into the pocket which is not much consolation. The only other recourse left is to design characteristics into the ball that will compensate for this problem.

b. Design parameters

1. Ebonite worked this problem to completion by offering a core design technology that keeps the RG values consistent throughout the weight range. This allows the ball to orient itself into a stronger inertial position, maximizing the entry angle. There are two ways by which this is accomplished, and both are patent pending.

D. MANIPULATION OF BALL REACTION BY DESIGN

1. CORE DESIGN PARAMETERS AND LEVELS

a. Level One

1. Level one cores have complete symmetry about all three axes. In short, the RG values for all three 'XYZ' axes are relatively the same with very small differences. Static imbalances and weight holes affect the ball reaction to a high degree by the manipulation of the PSA position. A core of this design has no particular PSA spot on the ball but is usually 6 3/4" distance from the CG. Upon drilling, ball mass is removed creating a slight mass bias in an area which results in small differentials in RG values. The ball becomes slightly dynamic if the PSA is in the right position. However, the PSA position is inconsistent and unpredictable for these type of designs. Product types -- Gyro Pro Teal, Shadow/R, Hytherm and Gyro Blue Sanded.

b. Level Two

1. This is a core that is partially asymmetric. In short, the RG values of two axes are similar and the other is different. Static imbalances and weight holes again affect the ball reaction by changing the oreintation of the PSA. A core of this design has a PSA originally by design. However, when a ball is drilled, the PSA shifts in relation to mass that has been removed. The movement of the dynamic characteristic in this type of product is random and unpredictable. The degree of movement is dependent upon the original position of the PSA and inherent process variations. Products of this type cover the range of performance balls manufactured over the past several years. Product types -- Nitro/R, Quantum, Code Red, Phantom, Hammer, Pirahana C and Ninja RPM.

c. Level Three

1. This is a core that is totally asymmetric. In short, the RG values of all axes are different and will exhibit stronger PSA potentials. Static imbalances and weight holes affect the ball reaction to a lesser degree. A core of this type has a strong PSA by design. When this ball is drilled, the PSA shifts very little as it is becoming more mass biased. The dynamic signature of this ball type is more predictable than a ball with a level one or level two core. Degree of movement is dependent upon the original position of the PSA and inherent process variations. Very weak attempts at creating a level three core are possible with 2-piece pin-out type products.

d. Level Four

1. This is a core that is more than just asymmetric. The dynamic characteristics are frozen in this ball. The PSA will not change position in the ball much regardless of where it is drilled. It is the most consistent design parameter possible. This aspect of frozen dynamics affords the most hook poential and track manageability versus previous design parameters. This technology and product design are both patent pending. Until the introduction of the Omega there has been no other ball designed with this technology.

E. THE OMEGA

1. ASPECTS OF TH DESIGN
   a. Core design paramters
      1. Level 4 core design
   b. The veneer
      1. Introducing [ACRYLLIUM] - the latest advance in polymer science that incorporates the tackified hook potential of standard reactive resins without the inherent durability problem. This veneer does not soak up lane oil, and it is not reactive. Testing at the ABC research headquarters established that the potentials for the carry down of lane oil fall between that of urethane and reactive type veneers. This will keep lane transitions down while maintaining more consistent lane conditions. Acryllium is a complex array of polymer alloys that provide substantial lane gripping action. Its smooth but powerful arc style hook and breakpoint are predictable and consistent. Independent lab testing of the Omega revealed that the wear and tendency toward tracking up are similar to that of durable urethanes. Two versions of this veneer are available depending on needs. The Omega is an aggressive coverstock with strong lane grip characteristics, whereas the Omega Dry is designed to dampen the hook power of this veneer to accomodate dry lane conditions.

OMEGA

COMPUTER GENERATED

TRACK FLARE

RESULTS

Ω

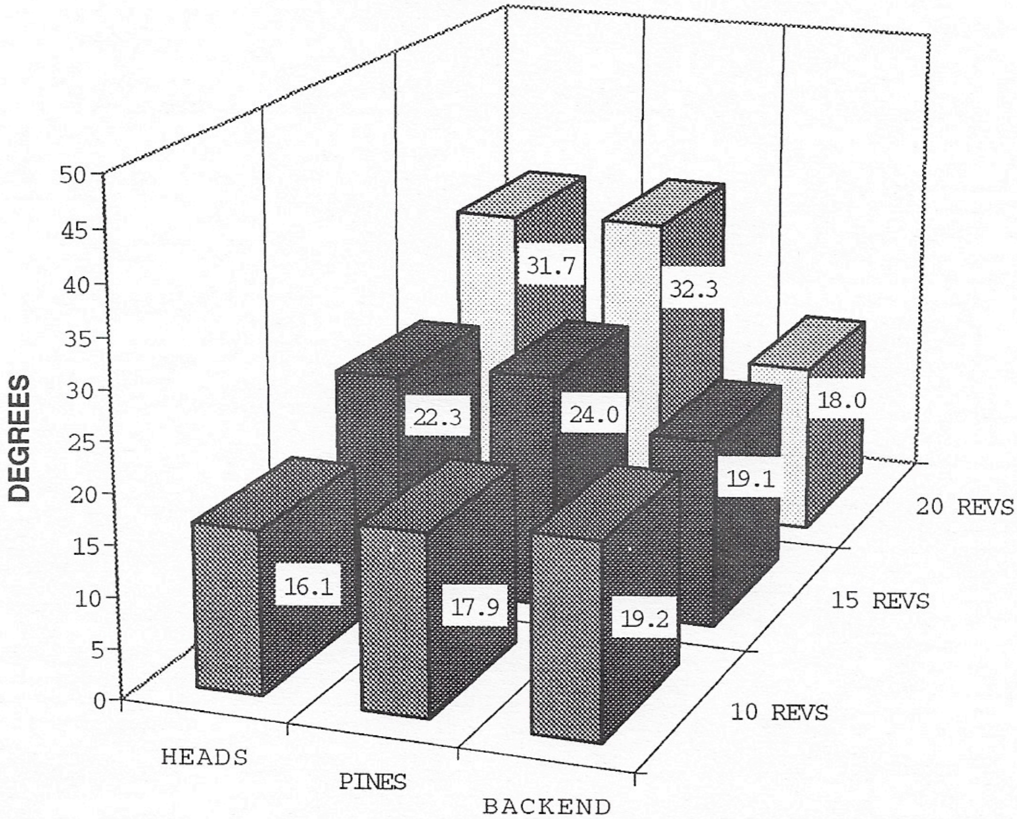
TRACK FLARE MEASURED IN ANGULAR MOVEMENT ON THE BALL'S SURFACE

1" TRACK = 13 degrees
2" TRACK = 26 degrees
3" TRACK = 40 degrees
4" TRACK = 53 degrees
5" TRACK = 66 degrees

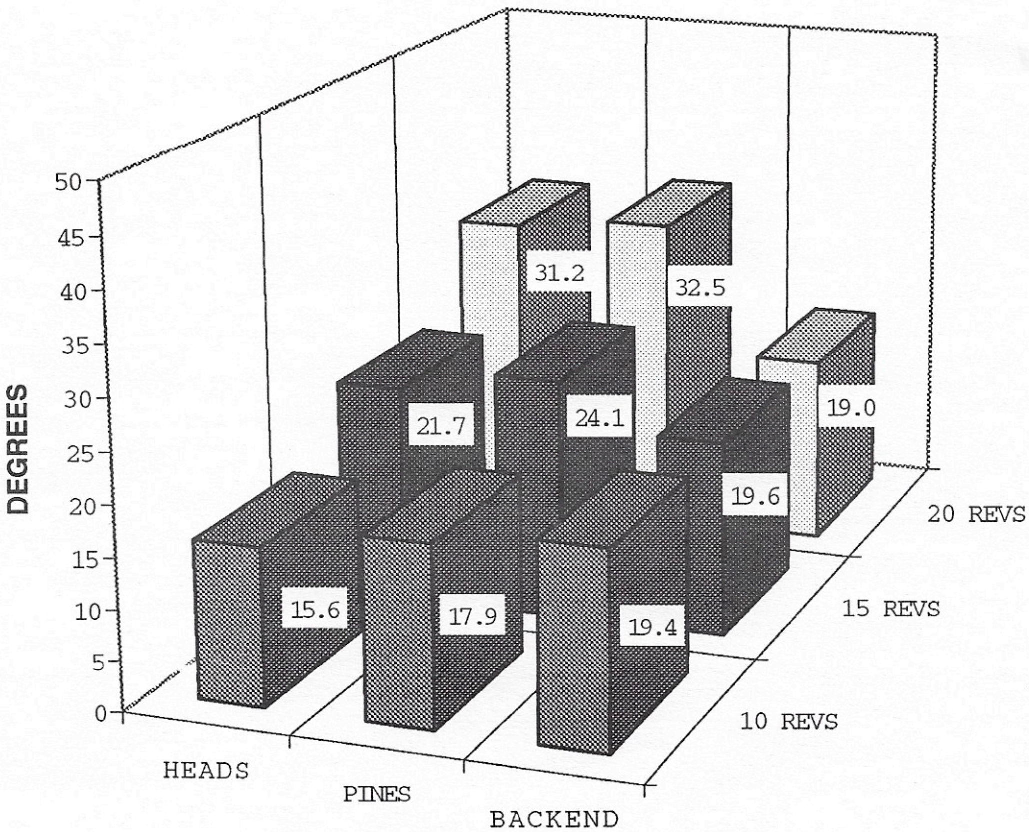
RESULTS ARE SHOWN AS GRAPHS

TRACK FLARE RESULTS

DRILLING #1

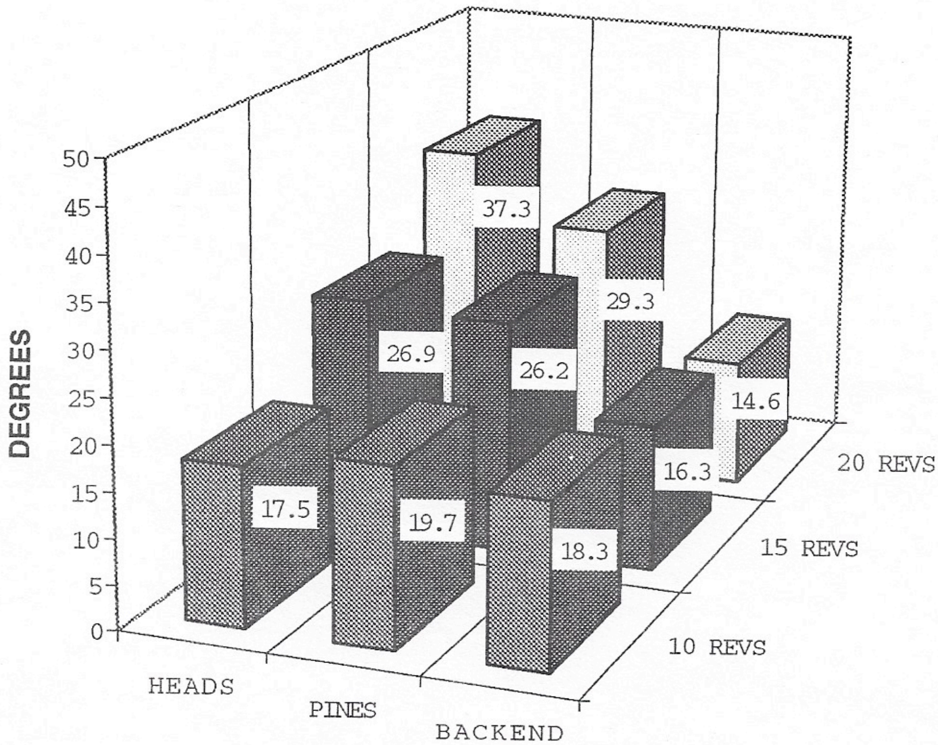


DRILLING #2

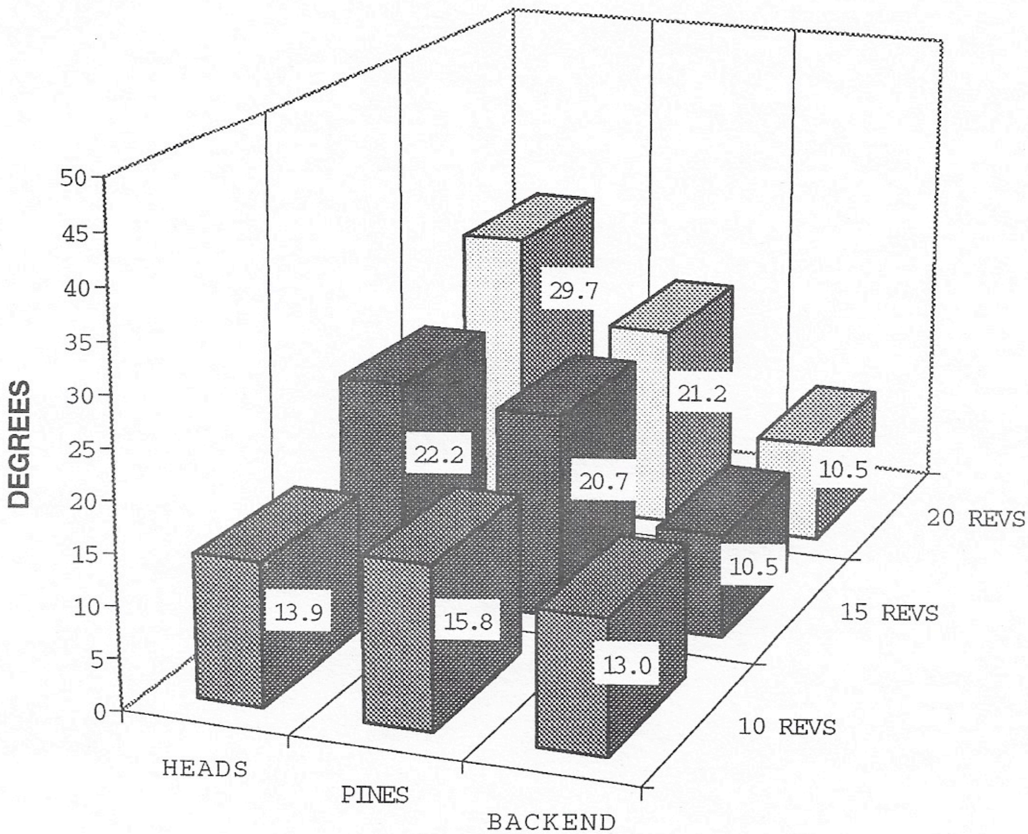


TRACK FLARE RESULTS

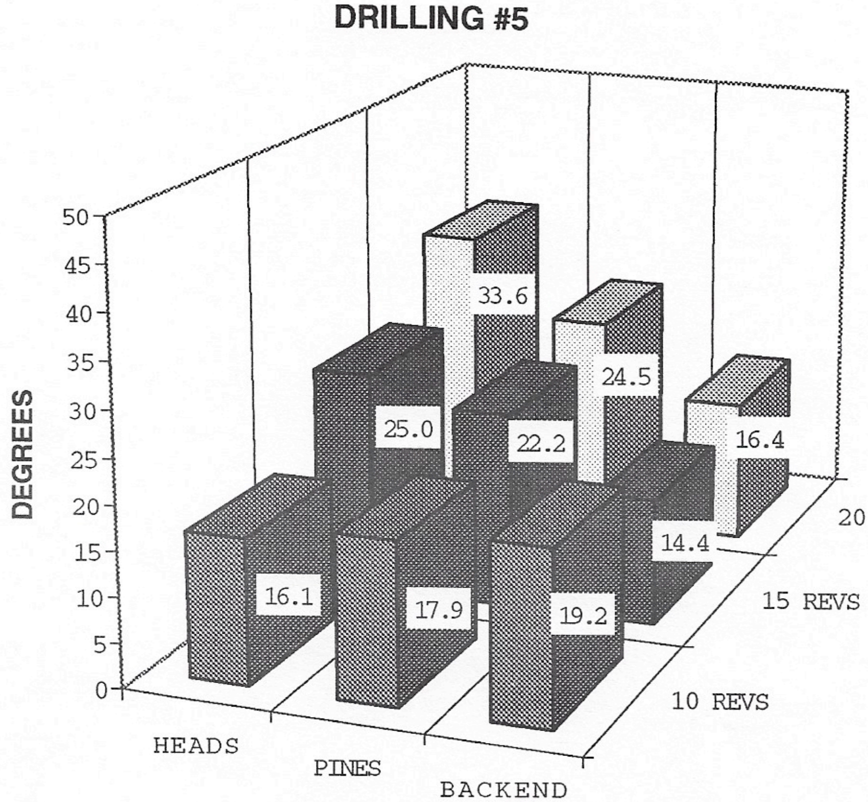
DRILLING #3

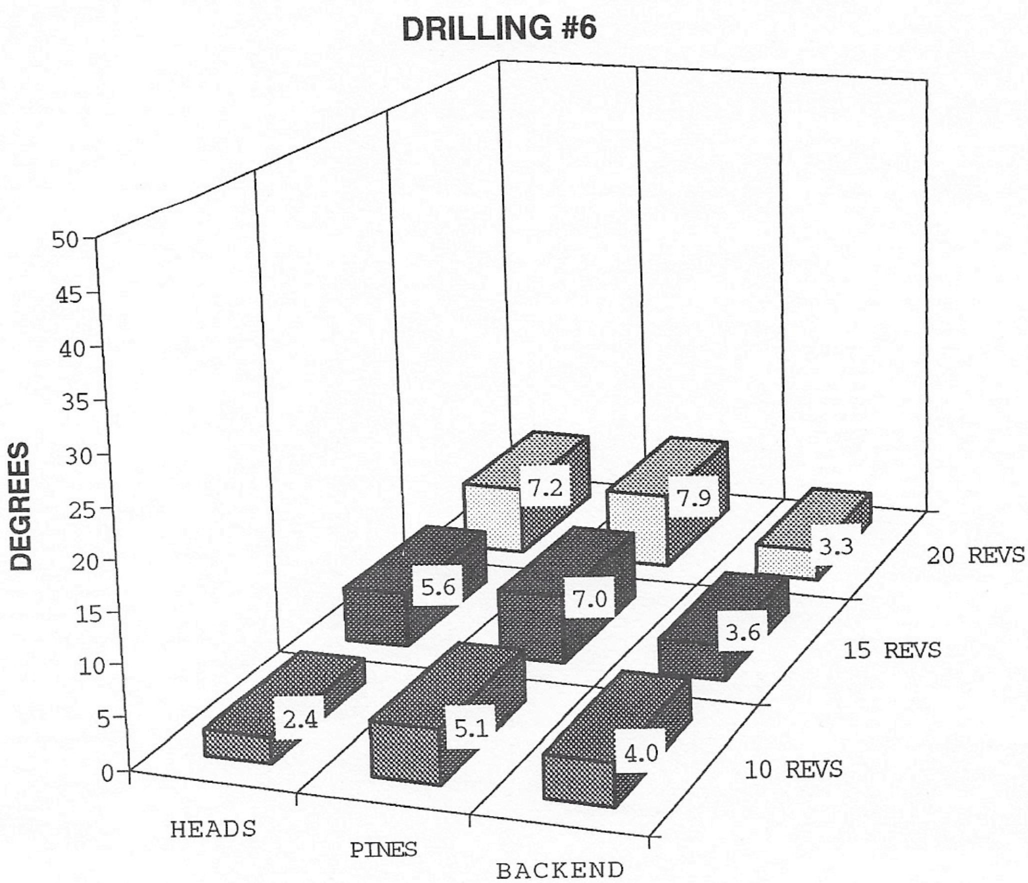


DRILLING #4



TRACK FLARE RESULTS





TRACK FLARE RESULTS