GRASS CLIPPINGS 21 - THE DELIVERED BOWL

A player steps on to the mat, takes aim and delivers a bowl. He watches the bowl carefully as it appears to run straight for a short distance and then starts a gentle curve which gradually becomes more acute as the bowl slows down and eventually comes to rest.
The player takes note of how the bowl behaved and how far it ran. He applies that knowledge for the rest of the game.
The behaviour of the bowl depended on -

1 The configuration of the bowl itself
2 The condition of the green – it's grassy cover and the soil base
3 The human element -- the force used to propel the bowl along it's path and the direction in which it was delivered.

Of the three items mentioned above No1 (The configuration of the bowl in each set) is constant, The other two change all the time and any variation in the run of the bowl can be attributed to changes in the green or variations in the delivery.
In all the issues of Grass Clippings we have concentrated on the green (grass and soil). This and the next issue will be devoted to the bowl – it's manufacture and it's response to conditions on the green.

A SPHERE
A sphere is a perfectly round object eg a tennis ball. It can be picked up in any way and propelled on a smooth surface and it will run smoothly in a straight line without bumping or wobbling – there are an infinite number of running surfaces

A BOWL
A bowl is a sphere with a portion cut away or one side flattened. This bowl has only one running plane. If this bowl is picked up at random and propelled on a smooth surface it will start bouncing or wobbling unless it has been propelled along the true running surface.
By flattening the one side the centre of gravity has moved over from the centre of the sphere towards the wider side i.e. the side opposite to the flattened side.

THE DTNAMICS OF THE BOWLING BALL

Authors Note *The article below, written by Prof. G.P.R. von Willich is a mathematical analysis of how the biased bowl behaves .on a bowling green*
Although Prof von Willich claims that he has simplified the maths it will probably be too daunting for the average bowler but that does no mean that it dud not have to be written I am very grateful to Prof von Willich for having taken the trouble to produce this article

If the bowl is delivered on to an absolutely smooth and undeformable surface, it will continue moving (sliding) in a straight line indefinitely. Such a surface does not exist in practice, and the bowl is observed to start to spin until it rolls without slipping, its path becomes curved, and it slows down until its forward motion ceases and it falls over to one side.
This behaviour is due to the interaction between the bowl and the surface of the green. Three aspects must be considered: the vertical deformation of the green surface, the bending of the grass covering of the green, and friction. The first two may together be considered as rolling resistance.
Any surface that has a load applied to it will deform to a greater or lesser extent, the deformation will be partly elastic and partly non-elastic; it will absorb energy from the potential and kinetic energy of the rotating bowl. In effect the bowl is running uphill and therefore slowing down.
The bending of the grass (leaves and stems) by the passing bowl also absorbs energy and therefore slows the bowl down.
Friction is force acting between two surfaces which are sliding or tending to slide relatively to each other; the force acts in the plane tangential to the adjacent surfaces. The maximum size of this friction is determined by the magnitude of the normal force times the coefficient of friction, which is determined by the properties of the touching surfaces. When the force reaches this maximum value, sliding will occur. If the bowl is running freely on the surface of the green, friction may be absent. But friction has an

important role in the determination of the path of the bowl. In the first place, when the bowl is delivered, it is seldom rotating at a speed which allows forward movement without slipping at the area of contact with the green, consequently friction occurs, which has the effect of causing rotation of the bowl up to the stage where the bowl runs without slipping

The rotating bowl is, in effect, a gyroscope, and exhibits behaviour which is similar to that of a toy top spinning on its point, a rotating bullet fired from a rifle, or a bicycle in motion when the rotating wheels tend to keep it upright. The gyroscope tends to keep spinning, about an axis in a fixed direction unless there are disturbing influences. When a disturbing force is present, the axis has the rather mysterious reaction of moving not in the direction of this force, but in a direction at right angles both to its existing direction and to that force.

The bowl is then tending to rotate about an axis which is no longer at right angles to the direction of motion, and slipping tends to occur, which in turn causes friction. The friction forces have components at right angles to the direction of motion and therefore cause the path of the bowl to curve.

Simplified Mathematical Analysis.

Newton's first law of motion states: a body remains at rest or in uniform motion in a straight line unless a force acts on it.

Newton's second law states: the rate of change of momentum of a body is

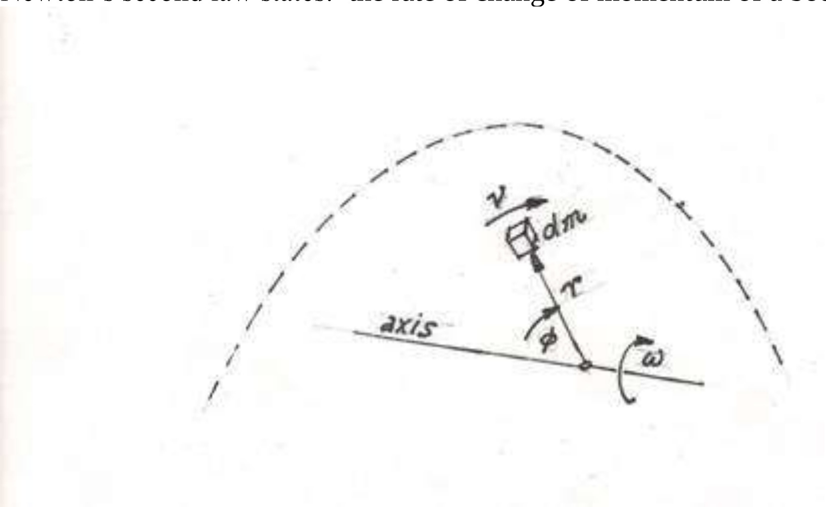

Fig 1

equal to the force acting on it, and is in the same direction as the force.

Momentum = mass times velocity $= Mv$

Or with acceleration $a = \frac{dv}{dt}$, $F = \frac{d}{dt}(Mv) = M\frac{dv}{dt} = Ma$

These laws are applicable to whole bodies, and also to any portions of bodies, including portions of infinitesimal size..

A body of finite size can possess linear momentum due to its motion as a whole, and also angular momentum due to rotation about an axis.

ω is the rate of rotation of the bowl about the y –axis as it rolls over the green.

Ψ is the rate of rotation of the axis of rotation of the bowl, about the vertical z - axis

A displacement, force, moment, angular momentum, velocity and acceleration are all vectors; i e they possess both magnitude and direction. A moment, change in angle and angular moment may all be represented by line vectors. The line coincides with the relevant axis, with the direction given by the right-hand rule: if the fingers of the right hand point in the direction of the relative quantity, the thumb points in the direction of the vector. (Alternatively, the corkscrew rule also applies: if the handle of a corkscrew is turned in the direction of the quantity, the corkscrew's point moves in the direction of the vector).

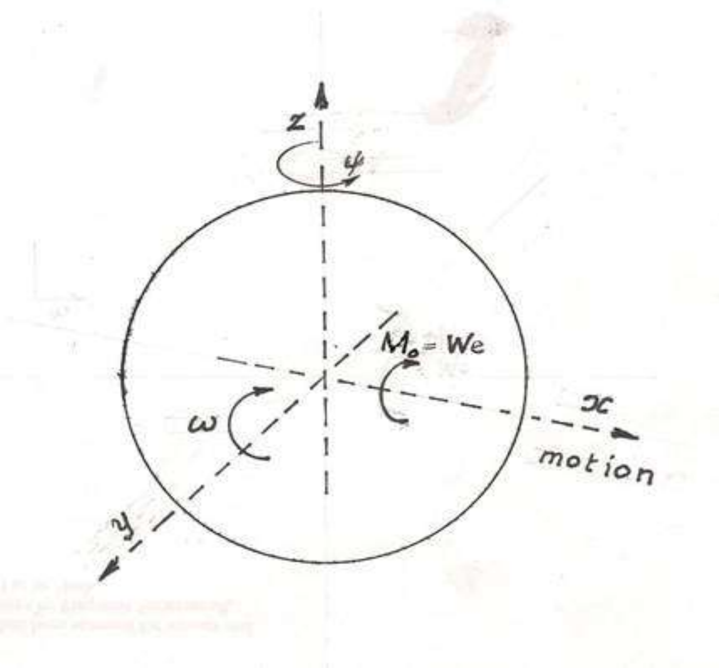

Fig 2a

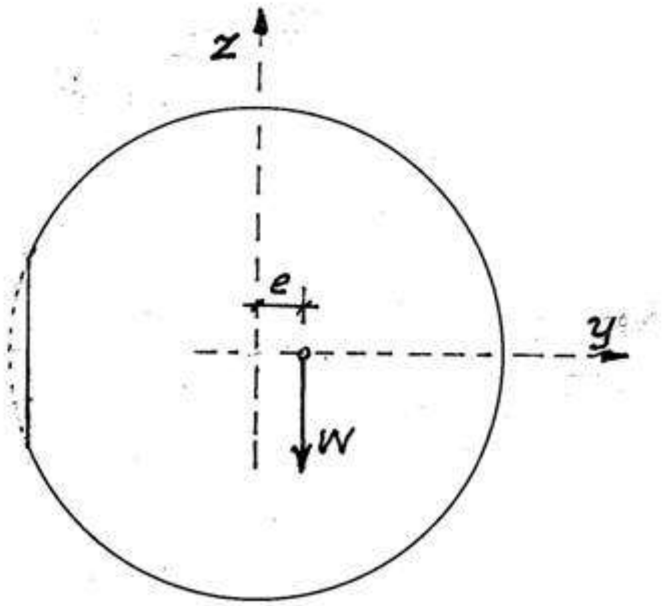

Fig 2b

Consider a small element of a body which is rotating with angular velocity ω about a given axis. The element is at a distance r from the axis of rotation. The velocity is the element is then $v = r\omega$ and if the mass is dm, the angular moment about the axis is $r\omega dm$. Integrating over the volume of the body, the total angular momentum is $\int vrdm = \omega \int r^2 dm = \omega I$ where I is moment of inertia of the body about the axis. The rate of change of angular momentum is then $I\frac{d\omega}{di}$.

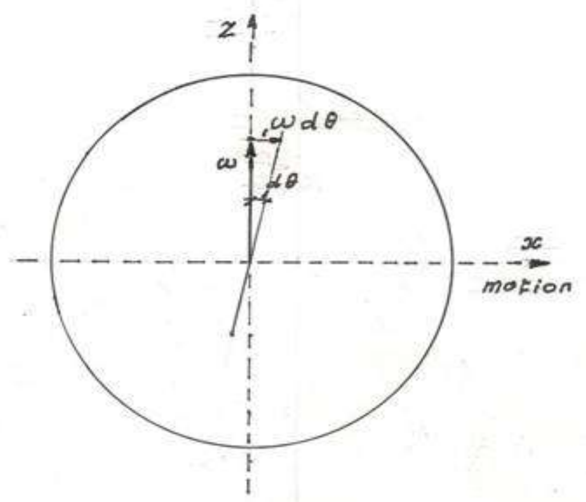

Fig 2c

Note that $d\omega$ is in the *x*-direction, i e it is at right angles to the directions y and *z*

If dF is the component of the force perpendicular to the radius *r* acting on the element *dm*, then by Newton 's second law, $dF = \frac{dv}{dt}\ dm = r\frac{d\omega}{dt}\ dm$.

The moment of the force dF about the axis is then $r^2\frac{d\omega}{dt}\ dm$.

For the body as a whole the resultant moment is

$$M_o = \int r^2\frac{d\omega}{dt}\ dm = I\frac{d\omega}{dt}$$

Where I is the moment of inertia of the body
Thus the applied moment is equal to the rate of change of angular momentum.

Note in Fig 2c that that dω is acting about the *y*-direcion, i.e at right angles to the direction *z* about which the bowl is rotating and to the direction *x* about which the moment *We* is applied.

The moment is $M_o = We$ See Fig 2(b)

In time dt this causes a change in angular momentum about the *y*-axis, $I\omega\ d\theta,$ and the rate of change of angular momentum is

$$I\omega\frac{d\theta}{dt} = I\omega\psi = M_o \qquad \text{See Fig 2(c)}$$

Hence $$\psi = \frac{M_o}{I\ \omega}$$

This shows that the slower the bowl revolves, I e the smaller the value of ω, the greater is the rate of rate of change of the direction of the axis of rotation, ψ. When the rate of the rotation of the bowl, ω, become very small, the value of ψ becomes large and the equation is no longer applicable. The axis of symmetry (the same axis about which the bowl started its rotation) now rotates about a horizontal axis until the bowl becomes stationary with its centre of gravity more or less vertically about the point of contact with the bowling green.

Summary of Symbols used

a	acceleration	r	distance from axis of rotation
F	force	t	time
e	eccentricity	vc	velocity
I	moment of inertia	θ	angle
M, m	mass	ω, ψ	rate of rotation
M_0	moment		

Note: regarding the Greek letters used as symbols
θ = *theta,* ω = *omega (last letter of the alphabet);*
ψ = *psi (second last letter)*

` The above article serves to identify the various forces which act on the bowl in it's passage across the green.It does not really matter how much of the bowl has been sliced off the one side because the mathematical formula will apply whatever the configuration as long as there is some bias.
What Prof . Von Willich has stressed is that on a theoretically undeformable surface the bowl could slide forever but as such a surface does not exist we have to deal with the surface on which the bowl will slide at first and then start rotating i.e. the surface of the green..

THE CONFIGURATION OF THE BOWL

1 <u>Historical</u>

Although little is known of the manufacture of the type of bowl used by Sir Francis Drake in 1588 many clubs still have in their museum samples of the bowls used in the early 20 th century where the bowls were numbered 1 – 4 and each had a different bias.
The old wooden bowls were too light to use effectively and lead weights were incorporated into the bowl - somewhere off centre. This not only made the bowl heavier but also made one side heavier and created a bias which would make the bowl in motion lean and draw to one side.
In a set of bowls the amount of lead varied which meant that each bowl would have a greater or lesser bias – they were numbered I – 4 to indicate which bowls would have the most bias.
(To-day all the bowls in a set of four must be identical and all exhibit the same characteristics.)
In the period between 1912 and 1939 some companies experimented with rubber bowls
The rubber bowl was abandoned by 1930 and the firm Henselite turned their attention to developing bowls made from a new kind of material which would not expand and contract with temperature changes. After much experimentation they decided upon a plastic called Phenolformaldehyde and in 1931 the first solid plastic bowl was produced, changing the face of bowls as it was known then.

In 1959, Henselite introduced an improved powder compound with a 'Super Grip' additive, designed to give the plastic bowl a better feel in the hand and provide bowlers with a better grip on the bowl. Bowls with 'Super Grip' were called the Henselite **Championship** model. The additive has remained a feature of all subsequent models.

Up to this point bowls were not machined with a dimple grip. In the late 1960's there was popular demand for a gripped bowl with many bowlers looking for a firmer, more reliable grip on the bowl.

Henselite brought out the **Deluxe** bowl the first Henselite bowl with a dimple grip. This grip feature continued to be extremely popular and today it appears on approximately 90% of bowls produced. Since its innovation, all subsequent Henselite models have been available in gripped or non-gripped variations.

1988 was a turning point for bowls. This year saw the introduction of the World Biased Bowls (W.B.B.) Rules for the game of lawn bowls. These rules allowed the introduction of 'narrow biased bowls', and also called for bowls manufacturers to identify their biases by a specific model name.

Consequently, the **Henselite Standard Bias**, the bias used from 1930 to 1988 on the original Henselites, Uni-disc, Standard, Championship and Deluxe models, was renamed the **Classic Bias**.

Henselite was also producing a bowl with a narrower bias for faster, New Zealand greens which at this point, was renamed the **Masters Bias**.

In 1989 due to the adoption of the new W.B.B. Rules, Henselite developed and released the **Classic II** model bowl with a narrower bias than the Classic.

As a result of its release and subsequent success on the greens it became the most popular narrow biased bowl in Australia and New Zealand.

The decade between 1992 and 2002 saw an increase in demand for bowls with varying bias profiles and Henselite began to manufacturer a number of different bowls for the different greens around Australia and the World, beginning with the **Maestro** bowl in 1992.

In 1994 the Maestro was superseded by the **ABT-2000**. The ABT-2000 used the latest precision manufacturing technology at the time, hence the name Advanced Bias Technology (ABT). This bowl combined the best features of the Classic II and the Maestro and was released only after extensive field testing by some of Australia's best bowlers. In their hands it achieved outstanding success on the greens. By 1995 Henselite had produced 6,000000 bowls.

The millennium year saw the introduction of the **Eureka Gold** model and the **Sapphire** model - a bowl with a narrower girth, designed to accommodate bowlers with smaller hands.

In July 2009 Henselite released its newest and brightest bowl **- ALPHA**. Designed specifically for fast, free-running greens and synthetics, the **ALPHA** is distinguished by its steady curved arc and flat finish into the head. It also features a unique non-slip grip. Within weeks of its release, Australia's top bowlers enjoyed immediate success with the ALPHA featuring in finals

Coloured BowlsColoured bowls have recently appeared on the bowling scene. Their behaviour on the green is the dame as the black or brown bowls but the Black and brown is harder, more wear-resistant and more colour stable. Coloured bowls are made from a different material.

2 The Bowl

The main characteristic of a bowl is the fact that after delivery it does not travel in a straight line on a bowling green but will turn (draw) to one side with the degree of "turn" increasing as the bowl slows down and eventually comes to rest. This "drawing characteristic "is built into the bowl and is called "bias"

3 Bias

The practice of adding lead weights to the bowl to produce a bias was discarded many years ago Bias is now produced entirely by the shape of the bowl. Regulations determine the minimum bias allowed and the bowl diameter (11.6 to 13.1 cm).

Bowls were originally made from lignum vitae, a dense wood, but are now more typically made of a hard plastic composite material.

In simple language a bowl starts off by being a perfect sphere. By removing a portion from one side and leaving the other side untouched the one side would weigh more and the centre of gravity would have shifted over to the untouched side.

If the bowl is propelled so that it runs smoothly the additional weight on the one side will cause the bowl in motion to "swing" to that side.

In the 1980's better greens management (especially in Australia and New Zealand) produced faster greens – so much so that with the standard bowls being used the track of the bowl over a full end would go over the boundaries of the rink into the adjacent rink. This caused undue delay with players waiting for their neighbours to play their shots.

There were two alternatives –

- Either make the rinks wider – a proposal opposed by the Green keepers because it limited rink movement.

- Amend the Specifications regarding the draw of a bowl and permit a narrow bias bowl to be introduced

In 1988 the World Bowls Board allowed the manufacturers of bowls to introduce a narrower bias bowl with an alternative narrower draw. The new rules specified the maximum and minimum bias which would be allowed.

A new addition to the manufacturers armamentarium is that they start with a sphere and remove a small portion from both sides and then remove a little more from one side. This will create a narrower bowl which is easier to handle.

In addition to all this the manufacturers can alter the curve of the running edge to create a bowl which runs straight for longer and then suddenly turns sharply – called a hockey-stick turn.

In the RSA there are about 11-12 kinds of bowls on the market which gives the bowler ample opportunity to select a bowl to suit his needs

The diagram below indicates the number of options available to a player from one manufacturer.

PS To be continued – In the next issue we will discuss the various changes on the green which will influence the run of the bowl and the speed of the green. CHL