

Bob Jewett



Squirt Where it Comes From

Bob Jewett continues his discussion of squirt.

In last month's column, I went over some references in pool literature about squirt, although it didn't get that name until 1978. This month we'll look at its major characteristics and the mechanism that seems to cause it.

First, let's be clear about what we mean by squirt. In **Diagram 1** is a cue ball being hit off-center as shown from above. Rather than go along a path parallel to the axis of the cue stick, the ball starts off at an angle away from that ideal path. This angle is always away from the side of the English applied.

Although the angle shown is much larger

than you will ever see on the table, the actual angle is plenty large enough to affect normal play. If you need to hit a ball on a far cushion with lots of outside English, aiming for a thin hit may get the cue ball to land full or even on the wrong side of the object ball. An attempted thin hit with inside English is likely to miss the ball completely unless you compensate for the squirt angle. In

extreme cases, that angle is as large as three degrees. Note that this is not the change in the object-ball path; it is the error in the initial path of the cue ball. This means that the farther the cue ball has to travel to the target, the larger will be the total error in inches when it arrives.

Squirt has been found to vary due to many factors. The largest effect is from the amount of tip offset (side spin). As far we know, two tips of English will produce twice the squirt angle of one tip. Maybe there are small effects if the tip is not perfectly round, but this rule seems to hold fairly well. We'll see that it is the basis of one system of squirt compensation.

Another large contributor is the amount of mass in the front part of the cue stick.

I've reported here before on a special shaft that Jim Buss made to demonstrate this; it had a brass rod inserted in the first five inches of the shaft. It also has tremendous squirt. In experiments reported by Predator Cues, a gram of lead tape wrapped around the ferrule increased squirt significantly. (For reference, a U.S. nickel weighs about five grams.)

Perhaps the ultimate added-weight experiment was performed by Dr. Mike Page, a university professor in Fargo, N.D. In November of 2000, he took an old stick and clamped locking pliers to the shaft at various distances from the tip. When the pliers

But what, exactly, causes squirt?

While the details of the stick-ball interaction — including the main squirt-producing mechanism — seem to be obvious now, it took ultra-high-speed videos of the hit to reveal the fundamental cause of squirt. The first cue company to use such fast cameras was Meucci — well, maybe there were others, but they didn't publicize their results. Soon after Bob Meucci showed his tape at a BCA Trade Show, Predator Cues had scheduled a rental of a special camera system that works 200 times faster than normal TV cameras. Several experimenters, including myself, Mike Shamos and Jim

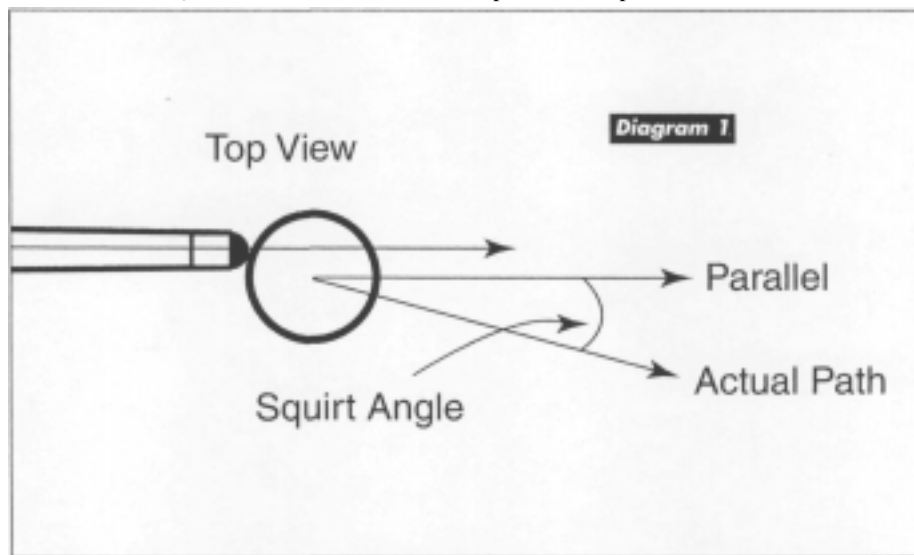
Buss (representing the American Cue Makers Association) sublet a week of the rental in

November 1998. Some of those experiments have already been reported here.

In **Diagram 2** is an illustration of what the tape showed about the tip-to-ball contact on a spin shot. At the start of this shot with left-side spin, the stick is coming straight forward and the

cue ball is at rest. In the middle of the contact time — which lasts about one thousandth of a second — the tip has compressed some onto the ball, and the ball has started to move forward and has some spin, as shown by the arrows. The critical point for understanding squirt is that the tip is no longer moving straight forward. Because it doesn't slip on the ball, the tip must follow the rotation of the ball, and move to the side. At the end of the shot, the tip has uncompressed and leaves the ball. The ball has its full spin, and the stick has slowed and is moving partly sideways, away from the ball.

At this point we can apply the Law of Conservation of Momentum. At the start of the shot, nothing was moving sideways. At



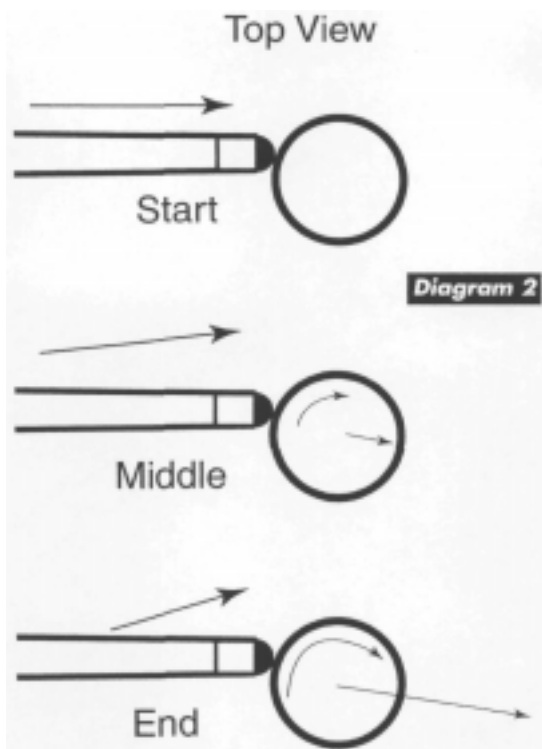
were near the tip, the squirt was huge. As the pliers were moved back, the squirt reduced, so that with the pliers even five inches back from the tip, the stick played nearly normally.

Dr. Page also noticed a considerable change in squirt with the speed of the shot. For normal cues, this change is not clearly evident. Many people seem to notice that there is less squirt for softer shots. It may just seem that way because at slower speeds, the cue ball will have time to swerve back and cancel some of the squirt. This is an experiment that should be fairly easy to do, except that it takes a perfectly level cue stick to avoid contaminating the results. It is nearly impossible to hit the cue ball on its equator with a truly level stick.

the end of the shot, the stick — or at least the front part of the stick — is moving to the left. The Law requires that something must be moving to the right at least partly to cancel the momentum of the stick to the left, and that something is the cue ball.

You could say that the ball pushes the tip to the side, but it is equally correct to say that the tip pushes the ball to the side. In fact you can't have one without the other; "for every action there is an equal and opposite reaction." A physicist would say that there is a sideways force between the tip and the ball without imputing motive to either one.

With the realization that it is this "pushing the tip to the side" on spin shots that causes squirt, most or all of the phenomena are explained. When mass is added to the ferrule or front of the stick, there will be more momentum in the thing that's pushed aside by the ball, so there'll be more squirt. Similarly, more spin means more squirt because with a more eccentric hit, the stick will be moving faster to the side at the end of contact than for a more centered hit. Sadly for those of us who would like to try a squirtless stick, such an ideal now looks impossible; it



would require a stick without any mass at all.

Page's pliers experiment brings up an interesting question: How much of the stick is pushed aside? If you go through the numbers, if the whole stick were involved, the squirt would be much larger than observed. If moving the pliers five inches (or so) back reduces their effect, maybe it's only the first five inches of the stick that are involved. It's pretty clear that the stick must bend some during the hit, but this hasn't been measured. Ron Shepard, a researcher at Argonne National Labs and serious pool-physics fanatic, has worked out a lot of the math behind squirt, and in the end, arrives at an "effective mass" for the stick. This represents the fraction of the stick that you could say was involved if it all moved sideways together at the speed of the tip. Interestingly, this works out to be the mass in the front several inches of the stick.

A possible design path is now clear to reduce squirt: reduce the mass near the tip. Next month we'll see what has been done so far along this course, and how you can deal with whatever squirt your stick happens to have.