Some surprising discoveries about cue/cue hall interaction emerged from the Jacksonville Experiments.

FREEZE FRAME

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While the entire series of the experiment with the Kodak Ektapro Hi-Spec Motion Analyzer Model 1012 to witness cue/ball interaction is well-documented in the previous article, we now have some visual evidence of this quasi-historic event. As I have stated before, these results were compiled in the witness by five billiard enthusiasts; you must understand that the conclusions are purely our own, and not necessarily the opinion of *Billiards Digest.* That some of us write for *BD* is purely coincidental.

With that said, let's take a look at what a 12,000-frames-per-second camera could see that the naked eye cannot.

In **Figure 1,** you can see some of the features of the camera and video system that we used to record these findings. They can be found on the black border surrounding the image. (The camera itself was similar to a standard handy-cam, but it had a thick cable going over to a large box of electronics that stored the sequence of images in digital memory, or RAM. The camera was fitted with several different lenses to allow close-ups and normal views.)

The time and date (upper left-hand corner) are obvious. The ID number, 10 (right), shows which scene is being shown. Over the week-long period, we taped more than 250 different scenes.

The REC 3000 (r.) shows that the images were captured at 3,000 frames per second, which is about 100 times faster than standard video. The frame number, which gives the count from the trigger, is -606 (lower left), which means that the trigger will occur in 606 more frames. For all of the inns, the trigger — a button on the remote control —was pressed just after the action, and the camera was set to stop recording on the trigger. This is also reflected in the ET, or, elapsed time indicator (lower r.), which says there are 0.202 seconds until the trigger.

The X and Y numbers on the left show where the cross-hairs are located, and these can be moved around when viewing the video after the recording. This allows exact measurement of distances and provides a good reference.

Now that the numbers don't seem so foreign anymore, let's look at the interesting stuff: the images.

The image in Figure 1 represents one of the first tests we ran. The camera is looking down from above the table. The stick, which is moving towards the cue ball, has been caught at maximum tip compression.

The main test here was to look for bulging of the tip during the shot. In the image shown, the vertical white line or, marker, was positioned so any bulge in the right side of the tip would be highlighted. It isn't possible to see the "before" from this still picture, but the sliver to the right of the marker was only half as wide before impact.

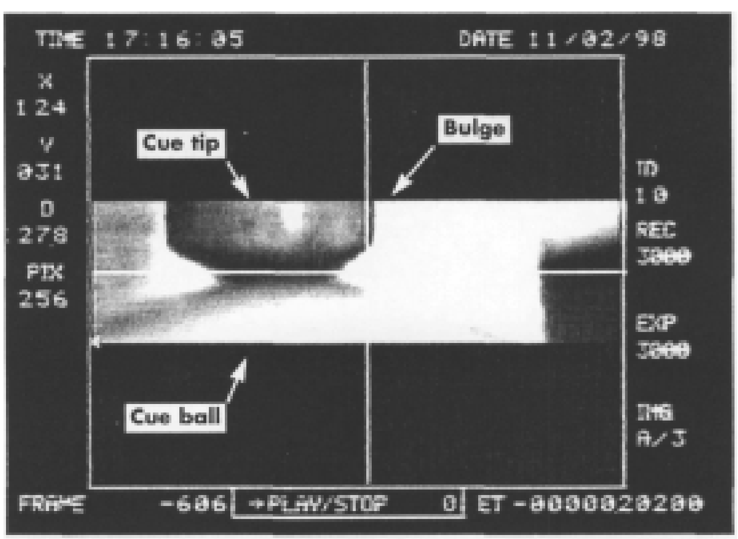

Fig. 1: A captured frame from the Ektapro 1012 at .0003 second. The image to the left of the crosshairs is the cue tip contacting the cue ball at maximum compression. From this shot, we can prove the resilient qualities of a cue tip and the camera's eye for detail.

Figure 2 is a typical view of a side-spin shot, again seen from above. The ball began with the line between the light and dark areas placed perpendicular to the stick, so it has started to rotate a little. The cue stick, which started out several millimeters closer to the center of the ball than in the image, has been moved to the side by the ball's rotation. The dark cloud which is just visible between the tip and the ball is the chalk dust that flies in all directions on spin shots. Below the ball is a grid with minor divisions every 2 millimeters and major divisions each

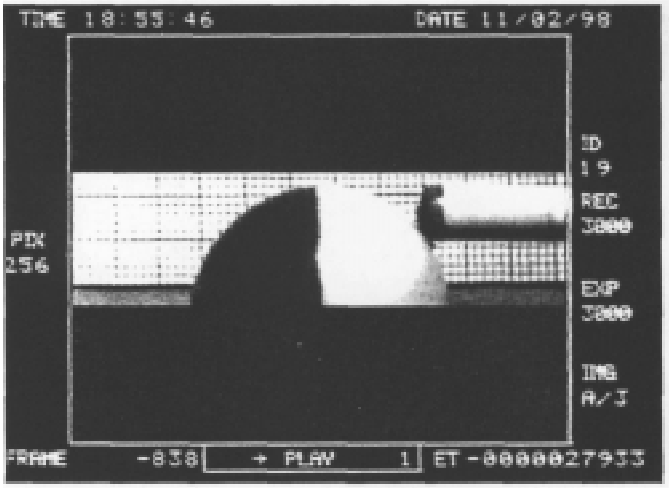

Fig. 2: This model demonstrates how the ball's rotation can throw the cue tip off-center -when English is applied.

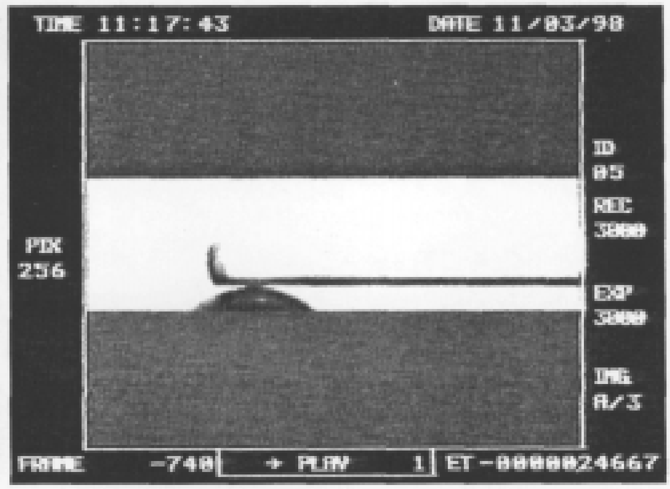

Fig. 3: The most surprising result: On just one miscue, the tip, the ferrule and even the shaft can all contact the cue ball.

centimeter, which allowed accurate measurements of speed and deflection. As we tried more and more English, it wasn't long before we started miscuing.

Figure 3 is the surprising result. In many but not all miscues, the ferrule — or in extreme cases, the shaft — slaps the cue ball several times during the motion.

In **Figure 4,** the speed of the camera has been set to its maximum: 12,000 frames per second. At this rate, each image is a short horizontal slice, and the display stacks twelve of them vertically, reading from top to bottom, giving the history of one-thousandth of a second. This is a close-up of a graphite cue hitting a ball. You can roughly estimate the speed of the stick by noting that in the first 12 frames (.001 second) the stick moves about 3 millimeters, or about 3 meters per second. A grid would have helped, but there was no room in this picture for one. The main point of this test was to see whether the stick hit the ball multiple times. It is pretty clear that the tip makes only one contact. By counting the number of slices in which the tip is touching the ball, you can get the total contact time. It appears that the tip is touching in twelve consecutive frames, which would give a time of .001 seconds. In the last few frames, it's hard to say whether the tip is still touching the ball or not, because the chalk cloud obscures things. Other tests which didn't require side-spin were done without chalk for a clearer view.

Conclusions: How can the above ideas or insights be applied to a game? Here's one example: As predicted by physics, the ball moves off the tip at a speed faster than the incoming stick.

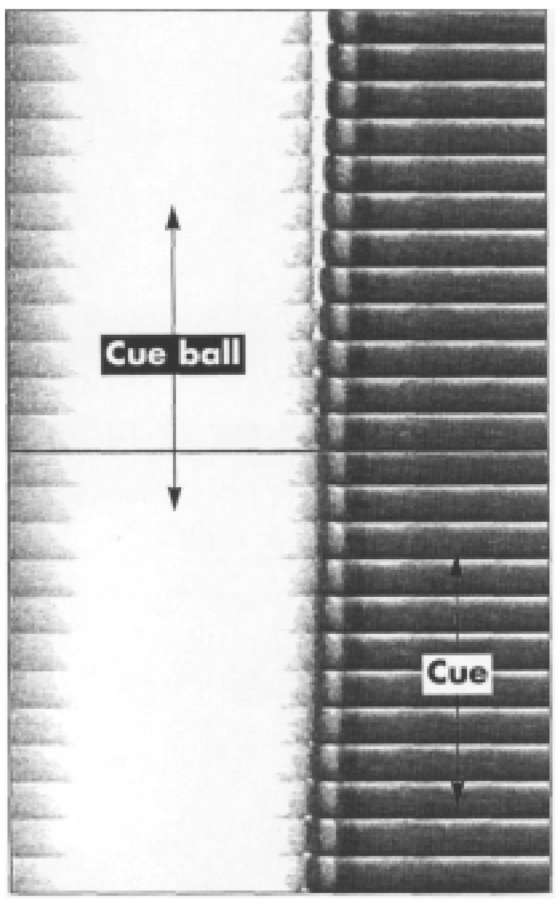

Fig. 4 proves that the cue makes only one contact with the cue ball. Total contact time: .001 seconds.

What is not directly predicted is that this speed-up, which is caused by the springiness of the tip, is not as large as the simple calculation says.

Presumably, significant energy is lost in the tip, perhaps as much as 30 percent. For a break stick, you want to lose as little energy as possible. The suggestion from the video is that work on the tip is more likely to improve a break stick than anything else.

Another major contribution of the tape is an improved understanding of how squirt develops. It is clear now that all sticks must have squirt or deflection on spin shots, because movement of the front part of the stick to the side as the tip rotates sideways with the spinning ball must have an equal and opposite motion to the other side by the cue ball.

However, there is no way to control how much sideways speed the stick gets — that's determined by the amount of spin used — but it is certainly possible to reduce the effect by reducing the weight of the front part of the stick. This result bears out what a lot of people have been saying for some time: balance, length and weight aside, all of the playability of a stick is in the shaft. «d

To obtain your own copy of the Jacksonville Experiment tapes, along with a copy of the notes that were made during the experiments, send $30 ($35 for S-VHS) to Bob Jewett at 962 Stony Hill Road, Redwood City, CA 94061.