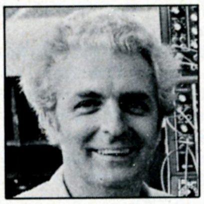

BOB MOOG ON SYNTHESIZERS

THE IDEAL SYNTHESIZER KEYBOARD, PART II: VELOCITY SENSITIVITY

IN THIS COLUMN WE pick up my discussion of synthesizer keyboards, which began in the November '84 issue. Having briefly discussed organ-style non-velocity-sensitive keyboards, we now go on to keyboards with velocity sensitivity, a feature found in many recent electronic instruments.

In nearly all velocity-sensitive keyboard instruments, electronic circuitry measures the speed of the key as it descends. This type of measurement is not a simple matter. It usually involves two sets of switch contacts per key. As the key is depressed, first one switch contact opens, then the second one closes. The circuitry actually measures the time between these two events. The accuracy of the 'velocity' information thus produced depends on how carefully the contacts are positioned, as well as the capability of the measuring circuit itself. A velocity-sensitive keyboard with well designed and carefully built 'time-of-flight' sensors will be consistent from key to key to within perhaps +20%. That is, if you depress each key with exactly the same speed, you will notice a maximum loudness variation (assuming that loudness is the parameter which is being velocity-controlled) of about 2dB from key to key. Now, the loudness difference between adjacent dynamic levels (say, between *pp* and *p*, or between *f* and *ff*) is between 4 and 6dB, depending on what kind of music you're playing. Thus, the *electrical* part of a good velocity-sensitive keyboard will be consistent to within a fraction of one dynamic level.

Why, then, are some velocity-sensitive keyboards harder to control than others? That is, why is it possible to play a scale or arpeggio with even dynamics on one instrument, but not on another? The answer lies in the mechanical feel of the key mechanism itself rather than in the way in which the velocity is detected and measured.

The conventional acoustic piano is the most controllable velocity-sensitive keyboard instrument that I know of. When we strike a piano key, we feel the inertia of the hammer as it speeds up. Because of the mechanical linkage through which the finger's force is transmitted to the hammer, the effective mass of the hammer as felt by the finger can be as high as one pound or more. This effective mass lasts only for a few milliseconds at most, while the hammer is getting up to speed. But during that short time, the finger transmits all the energy to the hammer that it needs to hit the string and sound the tone.

Why is this effective mass so important to keyboard players? And how is it related to what one feels when one plays a non-piano keyboard? To answer these questions, we have to understand what kind of control we have over our hands. Because our sense of touch is so sensitive, we are able to manipulate complex tools, accurately position objects, and feel minute differences between different surfaces. However, our sense of touch does not help us when we want to play accurate dynamics on a keyboard, because it takes several tenths of a second for us to feel what is happening at our fingertips, but only a few milliseconds to depress a key far enough to get a piano hammer moving.

Another way of saying this is that there is no feedback in effect when we play a single key on the piano. Using an engineering term, we say that we function as an open loop system when we play the piano. First we think (though not usually in words), "Next comes a C major chord played medium loud," then we bring our hand down on the keys—and loudness of the chord is completely fixed before we either hear or feel what we've done! This implies that our hand and arm must somehow be 'calibrated' or preprogrammed to accurately translate our brain's command into a physical gesture. The physical quantity that our muscles can most accurately dish out is *energy*. We can impart a precise amount of kinetic energy with our hands and arms. After a bit of practice (i.e., 'calibrating' our system), we can throw a basketball so it just goes in the basket, hit a golf ball so it lands on the green, or play a scale on the piano with near-perfect evenness.

In order to impart kinetic energy to an object, we have to set a mass in motion. If the mass (or effective mass) is too small, we will not be able to accurately control our motions. This is why unweighted velocity-sensitive keyboards are virtually impossible to control. In a real sense, our fingers expect to encounter the inertia of something massive in the key. Not finding it in an unweighted key, they depress the key in a short, uncontrolled span of time.

One of the first synthesizer keyboards equipped with velocity sensing capability and weighted keys was the Polymoog. The keyboard mechanism itself was basically a standard organ design in which the plastic part of each key was filled with a mixture of epoxy and lead shot. Today there are several instruments with high-quality plastic and metal keyboards that are specifically designed to be weighted. The keyboard of the Yamaha PF15 electronic piano, for instance, is made entirely of plastic, except for a five-ounce lead weight that hangs from the end of each key. Instruments with weighted keys (but without the action parts that simulate a piano hammer) are much more controllable than those with unweighted keyboards, even though they don't feel exactly like pianos.

About ten years ago, ARP developed a series of piano-like synthesizers. These instruments had wood keyboards with action levers at the backs of the keys that simulated the ballistic feel of hammers. That is, when you play a keyboard of this type, you get the feeling that the key is setting something in motion, and that something actually separates from the key the way a hammer does when the key bottoms out. I understand that ARP had trouble with the electrical sensors in these instruments, so the instruments were never very successful. However, the basic action concept lives on in instruments like the Rhodes Chroma and the Prophet-T8, while the Kurzweil 250 uses a specially designed, weighted, non-rigid plastic action arm to simulate both the inertial effect of a hammer and the toggling effect of a conventional piano action.

Behind all these developments lurks the question, "Is a keyboard that simulates a piano action ideal for keyboard synthesists?" The answer seems to be "yes" if you play percussively the way a conventional pianist does, and "probably not" if you are used to playing an organ or if you think in orchestral terms. Piano actions are not quite as fast as well-designed organ keyboards. This is because it takes longer to depress a weighted key than an unweighted key. In addition, a weighted component like a hammer has to fall back to its rest position, and this always takes more time than a spring-loaded key takes to come up.

An interesting alternative is a keyboard with keys that are weighted enough to provide some feeling of mass (for velocity control) but are also spring-loaded (for speed). No keyboard musician would call this an ideal keyboard for all types of playing, but it is a good compromise when your axe offers a wide variety of sustained as well as percussive voices (as most keyboard synthesizers do).

Keyboard design is every bit as subtle and complex as sound design. The funny little feelings that come through the keys and into our fingers as we play are so fleeting and fast-moving that they are almost impossible to measure, let alone analyze by scientific means. They are analogous to the subtle noises and distortions that develop in musical sounds as they make their way through electronic equipment: Sometimes the sounds become richer and more interesting, and sometimes they are degraded. To make matters more complicated, musicians frequently don't agree when they evaluate keyboards. So when you shop for your next velocity-sensitive axe, be sure to try the keyboard at length. Listen to be sure that the velocity-dependent dynamics are controllable, and play the keyboard without sound to see if it feels good to you. By all means, ignore buzzwords like "true piano feel," which are probably not true and, even if true, may not be desirable. ■