The Audio Engineer's Handbook

GEORGE ALEXANDROVICH

The Lathe

● Of the several types of recording lathe in use today, some are no longer available new. Only a few manufacturers continue to offer new equipment, the most popular and sophisticated of which are by Scully of Bridgeport, Connecticut and Neumann of Berlin, West Germany. Both are excellent systems, offering the user a high degree of automation.

Even with the best lathes, you must know how to install a cutter properly and how to operate it. Regardless of the recording system, cutter type or lathe, certain basic tests must be performed after installation of the recording chain.

The lathe itself must be at least as good as the best playback turntables in rumble, speed constancy, and accuracy. Flatness of the platter, bearing noise, operation of the feed screw and main shaft play (the one holding the turntable), are all points of concern. Rigid standards of performance must be met for the functioning of the pitch selector mechanism. The feed screw must provide a pattern-free cut.

Testing the motion of the platter requires techniques similar to ones used in evaluating playback equipment. A flutter bridge is an invaluable tool if you are fortunate enough to have access to one. A proper signal as required by the bridge (around 3 kHz for most, there is a standard at 3150 kHz) is recorded on disc and then played back on the lathe itself. Play the disc several times, each time moving the disc in relation to the platter to check for the worst possible condition where recording and playback flutter indications are additive. This indication should be divided by two to disregard the speed error of playback.

I prefer this method of testing for flutter over the use of standard recorded test records. The test records suffer from the inherent flutter of the machine on which they were recorded; thus I feel this method to be less accurate.

Flutter can also be indicated without a bridge (albeit less conveniently). A generator and oscilloscope are necessary. With the 'scope set for identical display of vertical and horizontal inputs, a lissajous figure will be seen. This will be a slanted line when the horizontal and vertical inputs are identical. When one of the signals feeding the 'scope varies in frequency (the signal from the playback equipment) a display ranging from a slanted ellipse to a circle will be produced, depending on the phase shift between the two signals.

Using this technique for flutter measurements demands an understanding of what accuracy must be achieved. Speed constancy specifications for turntables are often quoted at 0.2 per cent maximum deviation from the nominal speed. Therefore, we should be seeking a maximum deviation at the recording lathe of 0.1 per cent.

With this in mind, some thought should be given to the selection of a suitable frequency to display a usable pattern. With the usual flutter measurement frequency of around 3 kHz, a frequency change of ±3 Hz would indicate the maximum allowable speed fluctuation. Since the most common type of flutter is once per revolution of the platter or about 1.8 sec. per cycle, our measurements using 3 kHz would be impossible to interpret. (This is because 3 Hz is 1080 degrees of phase shift while a 'scope rotates its lissajous figure every 360 degrees.)

If instead we select a lower frequency, the speed deviation of the lathe can be expressed in degrees of phase shift per revolution, not exceeding 90 degrees in 1.8 sec. This is approximately 50 degrees/sec. or 1/7 of a cycle/sec. If we want to be able to see 0.1 per cent of the nominal frequency, then this frequency should be approximately 140 Hz.

(If 50 degrees is 0.1 per cent then 100 per cent is 50,000 degrees. Frequency is 50,000:360 or 138.888 Hz—close enough to 140 Hz for practical purposes.)

This means that the maximum deviation of the 'scope's lissajous figure from a line can be 90 degrees of swing between a line and a circle and back again to a line. It may be necessary to trim the oscillator settings slightly to compensate for generator frequency drift or lathe speed variation. The phase relationship between the two signals should always produce a slanted line. Double check the 'scope by feeding the same signal to both inputs so as to obtain the proper presentation.

The speed at which the phase of the playback signal deviates from the nominal frequency is the frequency of flutter. To determine the exact phase difference from the 'scope, refer to FIGURE 1.

Cutter mounting must be done with sufficient precision so that the specified angles are not more than 2 degrees off. (Two degrees sets the limit of separation between channels to 20 dB.) The first of several critical mounting dimensions is azimuth alignment. Looking from the front of the lathe, this is the normal (perpendicular) line to the surface of the lacquer. The cutting stylus should be parallel to this line. If the stylus position creates an angle greater than ±2 degrees off 90 degrees, all attempts to achieve more than 10-15 dB separation will be futile.

(The assumption here is that the subsequent playback stylus is at 90 degrees to the disc. If both cutting and playback styli are tilted to the same degree, separation will be satisfactory. It therefore becomes important to use a carefully mounted and calibrated playback system for measurement purposes — as well as visual examination of a cut groove containing modulation applied to one channel only. *Ideal* separation produces a groove with one ridge a straight line while the other carries the modulation.)

The next vital consideration of cutter mounting is the actual orientation of the cutting stylus. Most cutters today use either tapered-shank or bare sapphire styli. In the first case you must rely on your skill for proper stylus orientation, while in the second you depend on the accuracy of the clamping device as set by the cutter manufacturer.

There are several ways to correctly position a tapered-shank stylus. Most engineers use a tweezers to grip the shank of the stylus, plus some means of optical magnification to see the cutting edge of the sapphire. I've observed some younger engineers working without magnification.

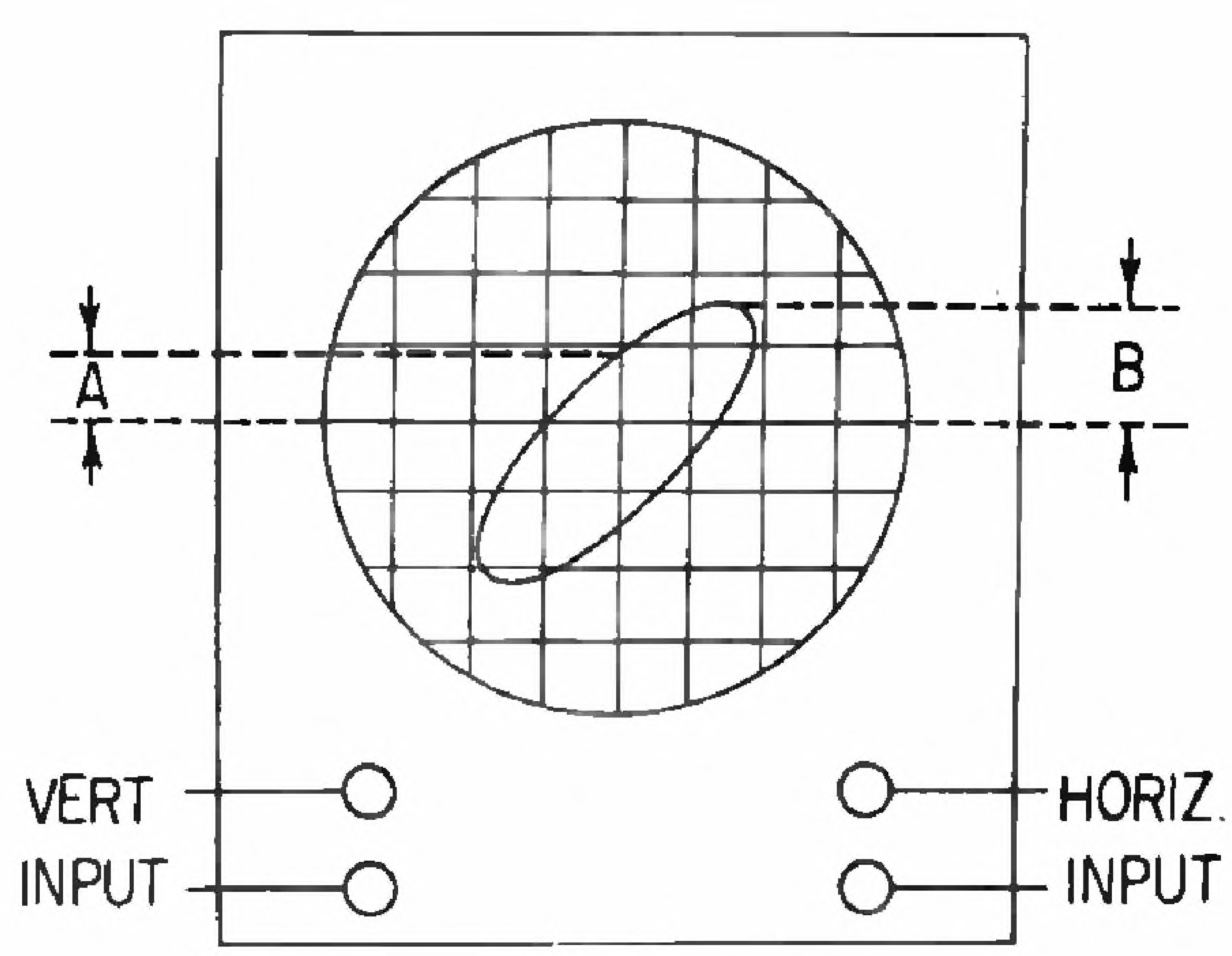

Figure 1. Use a 'scope to measure flutter. The formula is $\frac{A}{B}=\sin\theta$ where θ is the phase angle. A is the height of the y axis of the 'scope trace. B is the highest point of the lissajous figure.

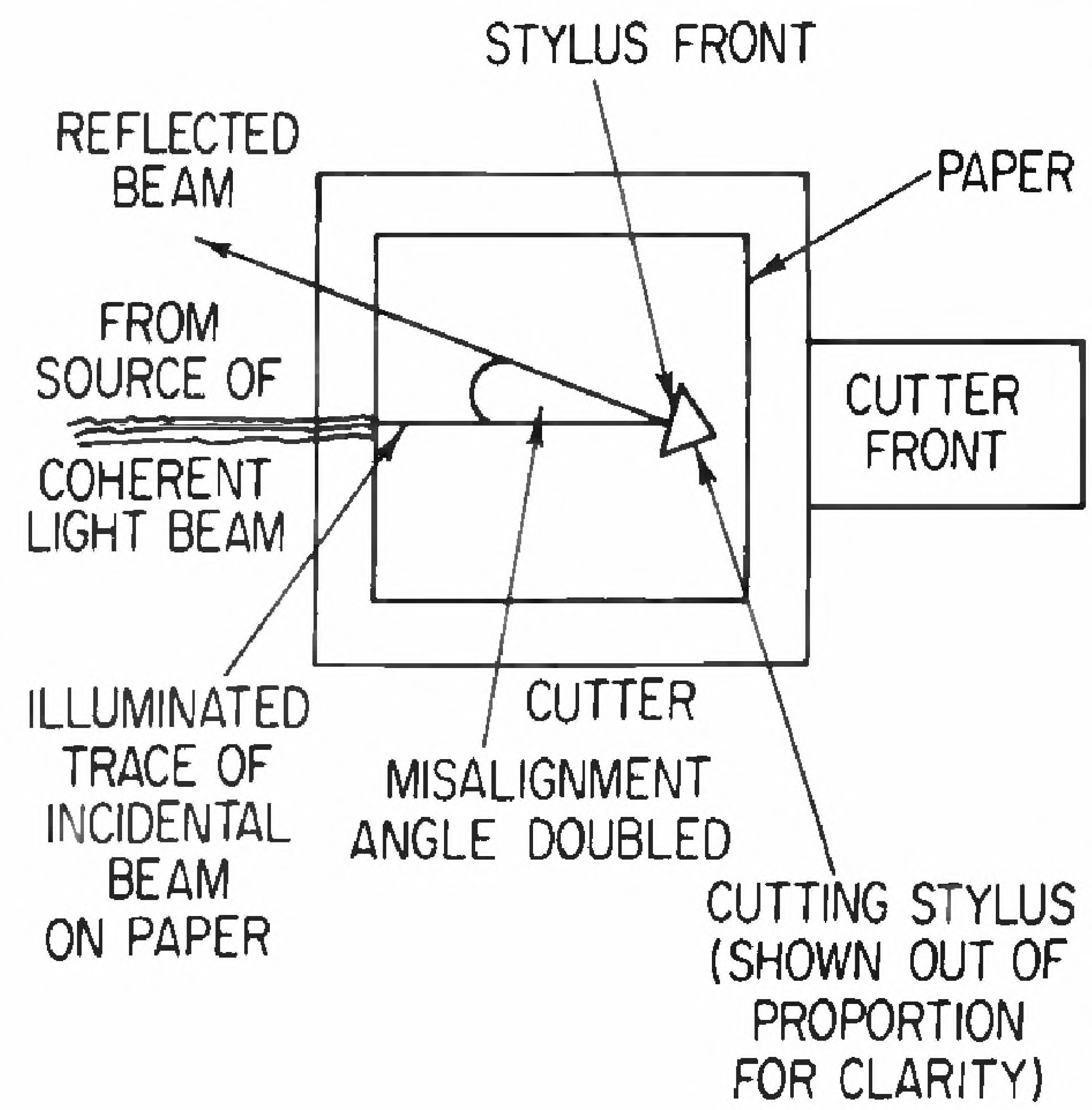

Figure 2. A coherent light beam coming from exactly 90° off where the flat of the stylus belongs will be deflected if the stylus is improperly oriented.

I prefer a method that is harder to use but far more accurate. It utilizes a narrow beam of light reflected off the surface of the sapphire's flat front. A narrow beam can be obtained from a focused flashlight or microscope light. Place a square of paper over the stylus tip so that the beam touches the paper indicating the direction of the source and the reflection. Rotate the stylus in its seat until both beams coincide. (See FIGURE 2.)

Since the angle of incidence is equal to the angle of reflection, the observed error is doubled. This makes alignment that much more accurate.

When a cutter is mounted particular attention must be given to the positioning of the leads to the head. In addition to the signal wires, there are heater wires supplying current to the stylus heater. There must be enough slack for them to flex without interfering with the vertical motion of the cutter. This also applies to the suction-pipe hose. It is recommended that all of these be fastened to the carriage itself so that regardless of the position of the cutter over the platter, the same vertical bias force is always present.

Quite often recording systems use an advance ball with the cutter to assure constant groove depth. The choice of using an advance ball or not depends on cutter construction, cutter cable flexibility, as well as the mechanical suspension of the cutter mount. When an advance ball is used, groove depth can be closely controlled because of the rigid coupling between the lacquer surface and the cutter body. A sapphire ball (actually a sapphire stud with a highly polished base) can accumulate considerable dust while it is riding the surface of a disc. This can cause lacquer smear and it can also change the actual groove depth if dust finds its way between the ball and the lacquer. Cleanliness, therefore, is of utmost importance if an advance ball is used.

If no advance ball is used, the depth of the groove is dependent on the lacquer resistance offered to the cutting edge of the stylus. This is a function of the lacquer hardness, stylus heat, recording speed, and the amount of suction. Suction affects the groove depth indirectly. Since the cutterhead is floating freely above the disc surface, positioned only by the tip of the stylus, every change in the amount of suction alters the vacuum or atmospheric pressure between the cutter and disc surface. However, the effect is partially offset by the stylus heat. This heater current is fairly constant so the actual heat at the stylus tip is dependent on the cooling effect of the suction. The more suction — the more cooling. The more cooling — the colder the stylus tip. The colder the stylus tip — the shallower the cut.

I suggest that an advance ball be used even with a free-floating cutter. Adjust it so that it rides 2-3 mils *above* the surface of the disc, without touching it. This will prevent the stylus from being broken if the cutter is dropped to the lacquer too fast.

Once the stylus is seated and adjusted properly, the heater wires must be dressed with a proper amount of slack to prevent biasing of the stylus movement at low frequencies.

(I once had to make a cross-country trip for the sole purpose — it turned out — of loosening heater wires which were causing a system to malfunction.) Let me hasten to point out that too much wire slack is also dangerous; wires may touch metal parts of the cutter and short out— with heater burn-out as the result.

Usually Nicrome V AWG 40 is used for heater windings. Wind four or five turns of wire around the sapphire and use a small amount of liquid ceramic to cement the wire in place.

Wire can be purchased from Industrial Heater in New York City and liquid ceramic from Sauereisen Corp. of Pittsburgh, Pa. The ceramic is available in paste form premixed, or in powder and liquid form ready to be mixed.

(To be continued next month.)