Nautilus Bulletin #1

17

Accurately Measuring Power Production

While it is quite simple to determine the resistance employed in strength tests, accurately measuring the time and distance factors is anything but a simple procedure; for anything approaching meaningful accuracy of measurement, two high-speed, synchronous motion picture cameras are required – and it is extremely advantageous if both cameras can be mounted a rather great distance from the subject being tested. The greater the distance, the greater the degree of accuracy of measurement – and an infinite distance would be required for absolute accuracy.

However, for all practical purposes, a distance of 48 feet has proven to be sufficient for a high degree of accuracy. Both cameras should be immovably mounted on sturdy tripods, and should be locked into perfectly horizontal angles of tilt – the lower camera should be placed in line with the estimated low point of the lift, and the higher camera should be at the estimated high point of the lift; both of which points can be estimated in advance with very little error.

For clarity of detail, lenses of the longest possible focal length that will cover the required area should be employed – it being essential to cover only two small areas, not the entire area involved in the lift. It must be understood that the focal length of the lenses will have no slightest effect upon the accuracy of the results produced; perspective – and apparent distortion – are both determined by camera position. All lenses will give exactly the same perspective from a given camera position; contrary to very popular belief, wide-angle lenses do not depict distorted perspective –they merely make it possible to film from a very close position, and the close position is totally responsible for the apparent distortion. Long focal length lenses – telephoto lenses – merely show a larger image than would normally be possible, and the apparent "compression of space" is more noticeable because of the larger image; such apparent distortion exists in an exactly equal degree in pictures made with a lens of any focal length.

Both cameras should be running and "up to speed" well before the lift is attempted – and a "clap-board" must be employed for slating the scenes being filmed, and this should be done even when filming without sound; the individual frames of the two scenes being filmed must be perfectly synchronized in order to accurately measure the time factor – and this cannot be done if some method of synchronization is not employed.

In order to accurately measure both the time and distance factors, two accurately placed "position indicators" will be required; one of these should be exactly the same distance above the floor as the center line of the lowest camera's filming axis – and the other should be in line with the higher camera. Brightly colored, horizontally mounted steel rods are the tools of obvious choice; they are inexpensive and show up well in the filmed scenes.

Four such rods should be used; two low-mounted rods and two higher rods –two rods being required for each of the two "position indicators". As an additional part of the position indicators, a clearly contrasting tape measure or ruler should be vertically mounted between the two horizontal rods most distant from the camera position. This distance measuring device – tape or ruler – should be perfectly accurate, and should be mounted to one side of the centerline of the filmed scenes; otherwise, it will be hidden by the body of the test subject and no measurement of distance will be possible. It must be remembered that most commercially manufactured tape measures are not perfectly accurate – most of them are "short" by at least one-eighth of an inch per foot of length; readings produced by use of such a tape will overstate actual measurements.

Looking through the lenses of the cameras – assuming that you are using true reflex cameras, as you should – only one of the steel rods will be visible from each of the two camera positions; from the high position, you should see only the nearest of the two highest mounted rods, the more distant rod should be completely hidden from view by the closer rod. If it is not, then the rods are not mounted properly in relation to each other –or in relation to the camera. From the lower camera, only the closest of the low mounted rods should be visible. But one end of the measuring device should be clearly visible in the high-camera scene, and the other in the low-camera scene.

While the above description sounds rather involved, it has proven to be a very simple matter to set up such a measuring procedure in a matter of less than ten minutes – once all of the required tools are available. In practice, the most difficult problem proved to be locating synchronous motors for high-speed cameras; almost all synchronous motors for motion picture cameras operate at exactly 24 frames per second in this country –and at 25 frames per second in Europe – and while motors that are capable of filming at speeds of at least 186,000 frames per second are available, if certainly not inexpensive, most such motors do not operate at synchronous speeds.

Thus, if measurement of the time factor with a degree of accuracy surpassing that which is possible with time segments shorter than one forty-eighth of a second is required, it will be necessary to include a clock with a very large dial and a sweep second hand – a hand that completes a full sweep of the dial during each second – and it will be necessary to film with lenses of shorter focal length, in order to include the clock in both scenes. But finding such clocks is not very easy, either.

When filming at 24 frames per second, each second is actually being divided into forty-eight parts – or at least it is if a camera with a rotary, 180 degree shutter is employed; the shutter is closed half of the time – while the film is being transported between frames – and open half of the time, while the exposures are being made. Thus, although you will actually have only 24 frames to work with for each full second of time covered, it is easily and accurately possible to interpolate both time and distance factors during the times when the shutter was closed.

For example: if the subject was moving in a particular frame – and still moving in the next frame – then it is reasonable to assume that he was at the midpoint of both time and distance during the time that the shutter was closed; if the bar of the barbell was forty inches off the floor in one frame, and forty-two inches above the floor in the next frame – then it is probable that it was at a height of forty-one inches during the time that the shutter was closed.

If a greater degree of accuracy is desired, then the only tool that I am aware of that is capable of doing the job is a high-speed camera with a synchronous motor – but such accuracy will never be purchased inexpensively; apart from the initial cost of such cameras and camera motors, such filming consumes file at an enormous rate – some high-speed cameras require 300 feet of film, out of a roll of 400 feet, just to "come up to speed", and this first 300 feet of film will never be of any value, since the camera will not yet be operating at synchronous speed, and since the resulting scene will be overexposed because of both improper and constantly varying exposure factors.

Secondly; if your test subject hesitates even momentarily about executing the lift, the filming will be wasted – because, once up to speed, the last feet of film remaining in the magazine may be used in a matter of two or three seconds, or less.

The two higher rods of the position indicators should be located exactly six feet apart – and the two lower rods should be separated by the same distance; the lift should be performed between the rods, with the subject facing either towards or away from the cameras. For squatting, the subject should have his back to the cameras – for fast lifts involving the arms the subject should be facing the cameras. These positions are best since they permit an unobstructed view of the barbell from the camera positions.

The subject should be situated so that the bar of the barbell being lifted is as close as possible to the midpoint of a horizontal line drawn from the near position indicator rod to the most distant rod; in effect, the barbell should be three feet beyond the nearest position indicator rod and three feet closer than the most distant rod – as measured from the camera position.

This placement of the barbell is important for accurately measuring distance factors; the bar of the barbell will actually be somewhat lower than it appears to be from the low camera position – when it is above the lower position indicator rod – and higher than it appears to be when viewed from the high camera position, when it is lower than the high position indicator rod. But if the barbell is properly placed, then it will be easily possible to accurately interpolate the height of the barbell at all times during the lift.

To facilitate such interpolation, it has been found that a camera to nearest position indicator rod distance of exactly forty-eight feet should be used; but when using long focal length lenses, it must be remembered that such measurement should be from the nodal point of the lens being used – and that such measurement must be made after the lens has been focused properly. Otherwise – since most such measurements are made from the film plane of the cameras – an error of as much as a foot may be inadvertently introduced into the formula required for correct interpolation of results.