TECHNICAL TIDBITS

This section has been added to open a channel of communication for the personnel of the several laboratories in this field. Its purpose is to provide a link for the informal exchange of ideas on technically interesting matters which do not ordinarily find their way into published reports.

Engineers, technicians, physiologists, physicians, and others engaged in the technical aspects of testing, development, and research are welcome to share their views on specific problems or to report their solutions, elegant or otherwise.

LET'S TAKE A WALK

Measuring blood pressure, or for that matter, instantaneous velocity of the CG, angular velocities, accelerations of major joints, and oxygen consumption while the subject displaces at one to four m.p.h., can be troublesome. Instruments are jiggled, lead wires break, and like the rest of us, telemetric devices shudder when a subway train passes.

To reduce the relative velocity of subjects in gait studies, the civilized thing to use is a treadmill. The patient displaces furiously with respect to the treadmill belt but negligibly with respect to the rest of the environment including the data gathering instruments; we can also control velocities, employ sophisticated instruments, and obtain highly reproducible test procedures. These delights may not soften the heart of a purse string holding administrator, but the effect of respectable results on obtaining project funds often will. Loosening the purse strings is only half the battle; selection of an adequate commercially available treadmill is like negotiating the Minoan labyrinth.

Commercial treadmills are notoriously underpowered, and the belt velocity changes under load making it extremely difficult to estimate subject velocity accurately. They are too narrow, ranging from 16 to 18 in., inducing the feeling of tight-rope walking. This results in abnormal gait patterns and reduces the similarity between treadmill and level floor walking. They are too short, ranging in length from 40 to 54 in., and they frequently cause subjects to mince their stride length in fear of disappearing over the edge. The treadmill walking surfaces are constructed of rollers covered by a tread or belt; a fact which causes an abnormal heel-toe transition since in one step the heel may strike the tread between two rollers and in the next step it may strike one roller tangentially. Only discrete velocity changes of relatively large increments are possible. Finally, their minimum velocities are frequently too high for disabled and/or aged patients.

Avoiding any possible confrontation with the Minotaur, we obtained a commercial belt conveyor 11 ft. long (lengths up to 13 ft. were available at the same price) with a 38-in.-wide walking surface (widths up to 48 in. were available at no extra cost), a 3-ply neoprene belt that slides over a solid metal bed (no rollers), and all this driven by a 5-hp. Reeves motor with an ∞ velocity adjustment from 1 to 7 m.p.h. The price tag, motor included, was actually cheaper than Brand X.

HOW TO SAVE $2(10^{3.079})

With all the prosthetic and orthotic gadgetry being designed to modulate, influence, affect, alter, control, regulate, etc. hip, knee, and ankle motion, it seems that every third person walking through our doors is getting into the business of measuring angular displacement about the lower-extremity joints. His brother, on the other hand, is concentrating on the upper-extremity joints.

Measuring real time angular displacement is not a stylish sort of problem. *Strategically* placed, a precision potentiometer faithfully indicates the peregrinations of one limb segment with respect to another. That's what a pot is for. However, to make its message perfectly clear (linear), the potentiometer needs the support of an amplifier before its output is committed to paper (oscillographic). To make sense in a kinematic analysis, it is usually necessary to measure the angular displacement of more than one joint and, therefore, three to six amplifiers at approximately $600 a unit may be required in such a system. The amplifiers are needed only because a galvanometer does not speak the same language as a potentiometer. Although both are from the same family of Ohmic tongues, something is lost in the translation of the *Hoch*-impedance spoken by the pot to the *Platt*-impedance understood by the galvanometer; sometimes the pot says ten chart lines of angular displacement but the galvanometer hears only seven chart lines, sometimes only four. The strange thing about this foreign language business is that while low impedance devices can understand high impedance inputs, a high impedance instrument understands both.

Armed with this secret of nature, we are teaching the potentiometer to speak low impedance and the galvanometer to speak high impedance, and the middleman, Mr. Amplifier, is being eliminated at a savings of approximately 2.4 Kilobucks (Fig. 1).

KNEE NEWS

The other day, we just got plain tired of all the base-10 arithmetic involved in reducing force plate and photometric data every time we needed to measure moments about the knee. So, we ran off a little beauty which takes care of that and several other things, leaving us time to contemplate the uncertainties of life, love, and the quantum theory.

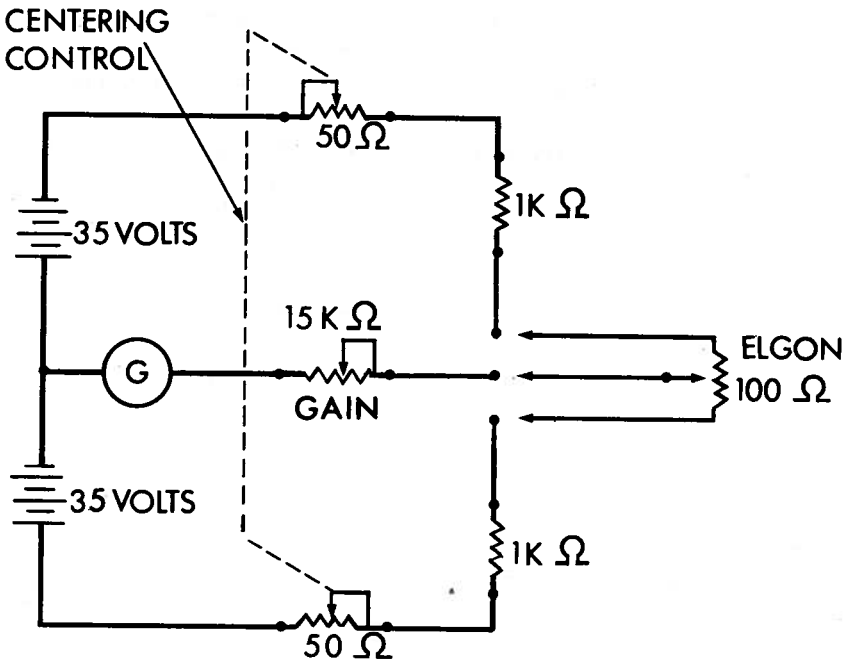

FIGURE 1. As shown, the 15k-ohm gain control is what makes the galvanometer talk high impedance. The 100-ohm "elgon" talks low impedance (high resolution). The two 1k-ohm resistors let the 100-ohm elgon ends float freely and the ganged 50-ohm pots help center the elgon.

A little thought, a few assumptions and, presto—a gadget that gives us the real lowdown on all that hurly-burly around the knee joint: moment and shear in not one but two planes (AP and ML), torque, axial load, and three other measures (X and Y positions and torque couple) to boot.

Since knee moment represents a linear function, we intrepidly assumed a massless condition between the knee center and the instrument. It really wasn't very courageous because the thing only weighs about 2 lb., a very small mass in comparison to the 100–200 lb. force of the ground reaction vector.

From then on it was only necessary to determine the *absolute magnitude* of the moment at one point and the *slope* of the moment curve to find the value of the moment at any other point.

Because the gages are a precisely fixed distance apart, we are in fact measuring $\frac{dm}{dx}$, the slope of the moment curve. This is also signal conditioned; it is multiplied by the distance (L) from the point of absolute measurement to the knee center.

Conditioned and summed, the total output ($M + L \frac{dm}{dx}$ = the knee moment) is read on an oscillograph. Thus, from one of the four instrumented sections we have knee moment in one plane. A second section on the instrument provides similar information in a plane perpendicular to the first. Axial load is read on a third section of gages. The fourth section reads the total axial torque (Fig. 2).

As soon as we get it completely checked out in a BK and AK pylon, it goes on the payroll.

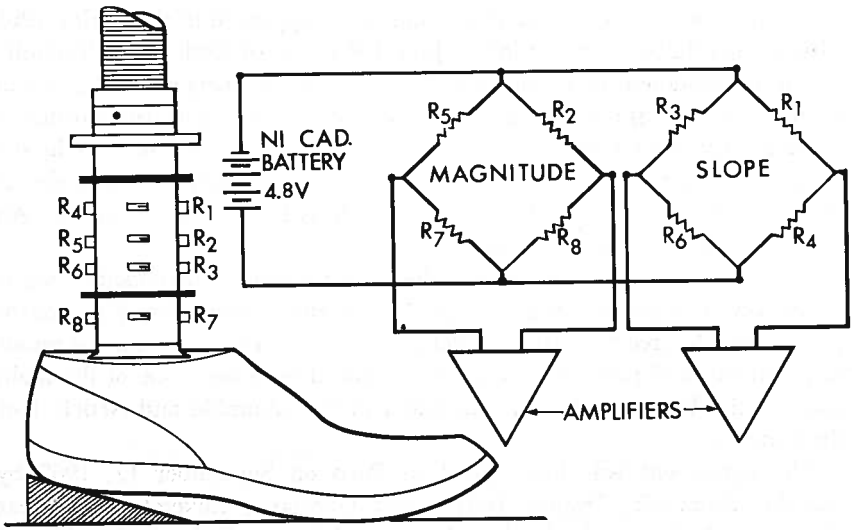

FIGURE 2. Gages 2, 5, 7, and 8 in a Standard Wheatstone bridge configuration give the absolute magnitude of the moment in one plane (M). Fed into an amplifier this signal is amplified and demodulated. Gages, 1, 3, 4, and 6 in a unique differencing circuit give the difference in moment between the two levels of gage placement.