ACES - History

By
Gideon Ariel, Ph.D.
Thailand, December 2007

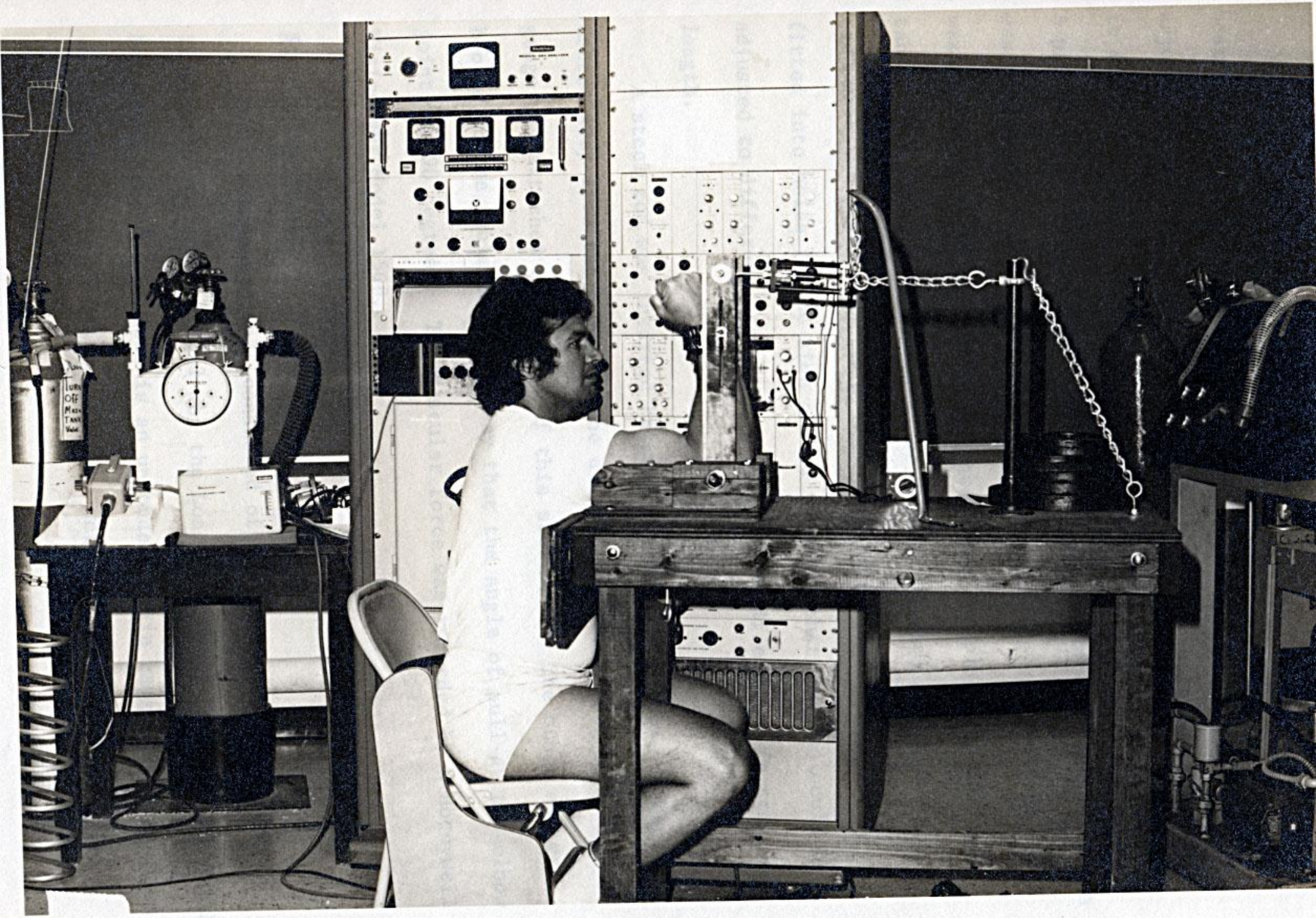


Figure 2. Contractile Force Apparatus for Isometric Contraction

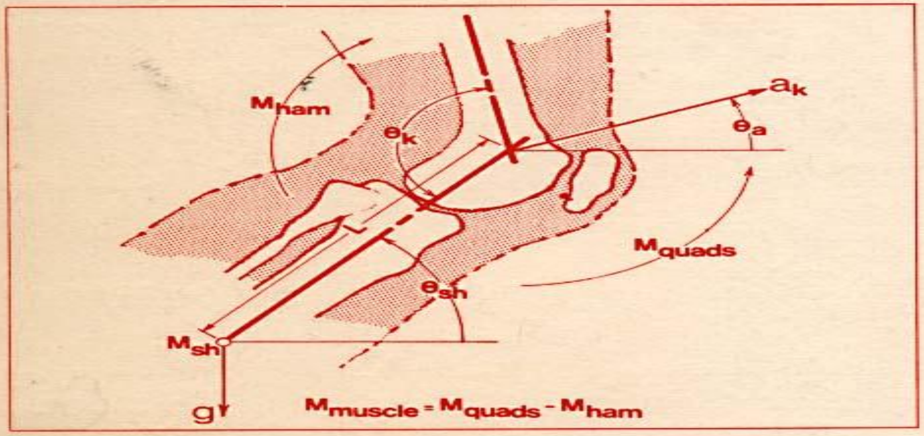
Isometric muscular effort under study in the Motor Integration Laboratory

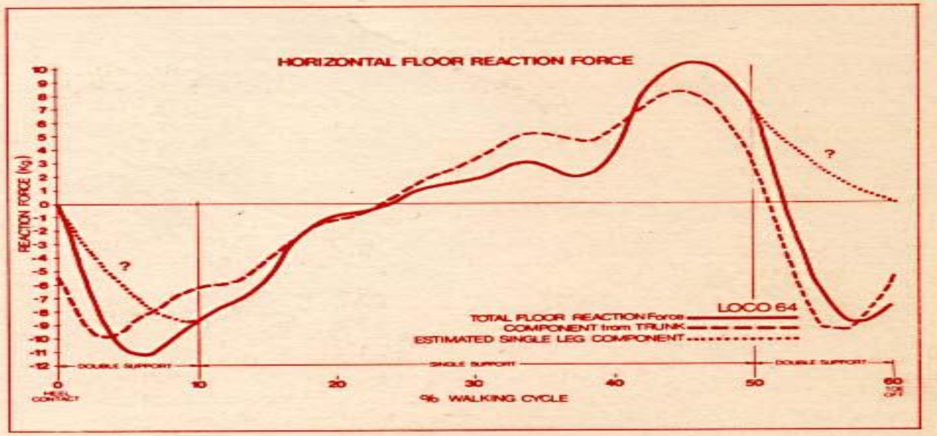
The Canadian Society
for Biomechanics

Société Canadienne
de Biomécanique

Proceedings of the 1st Annual Meeting

University of Alberta
Edmonton, Alberta
1974





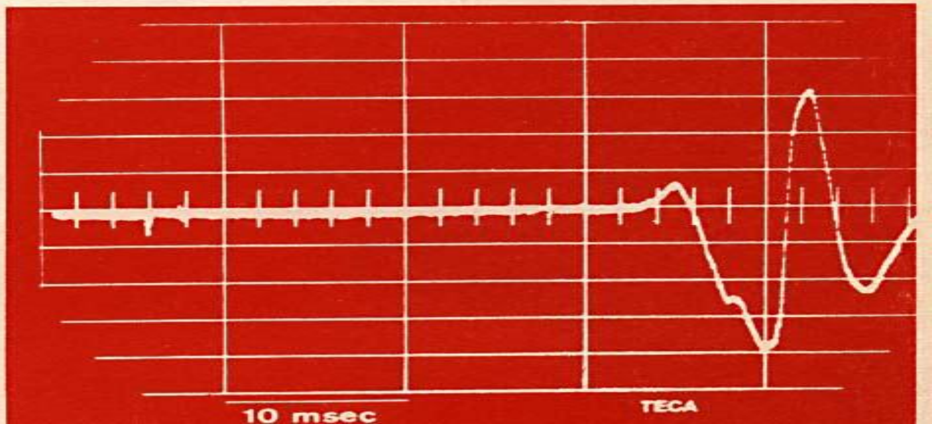
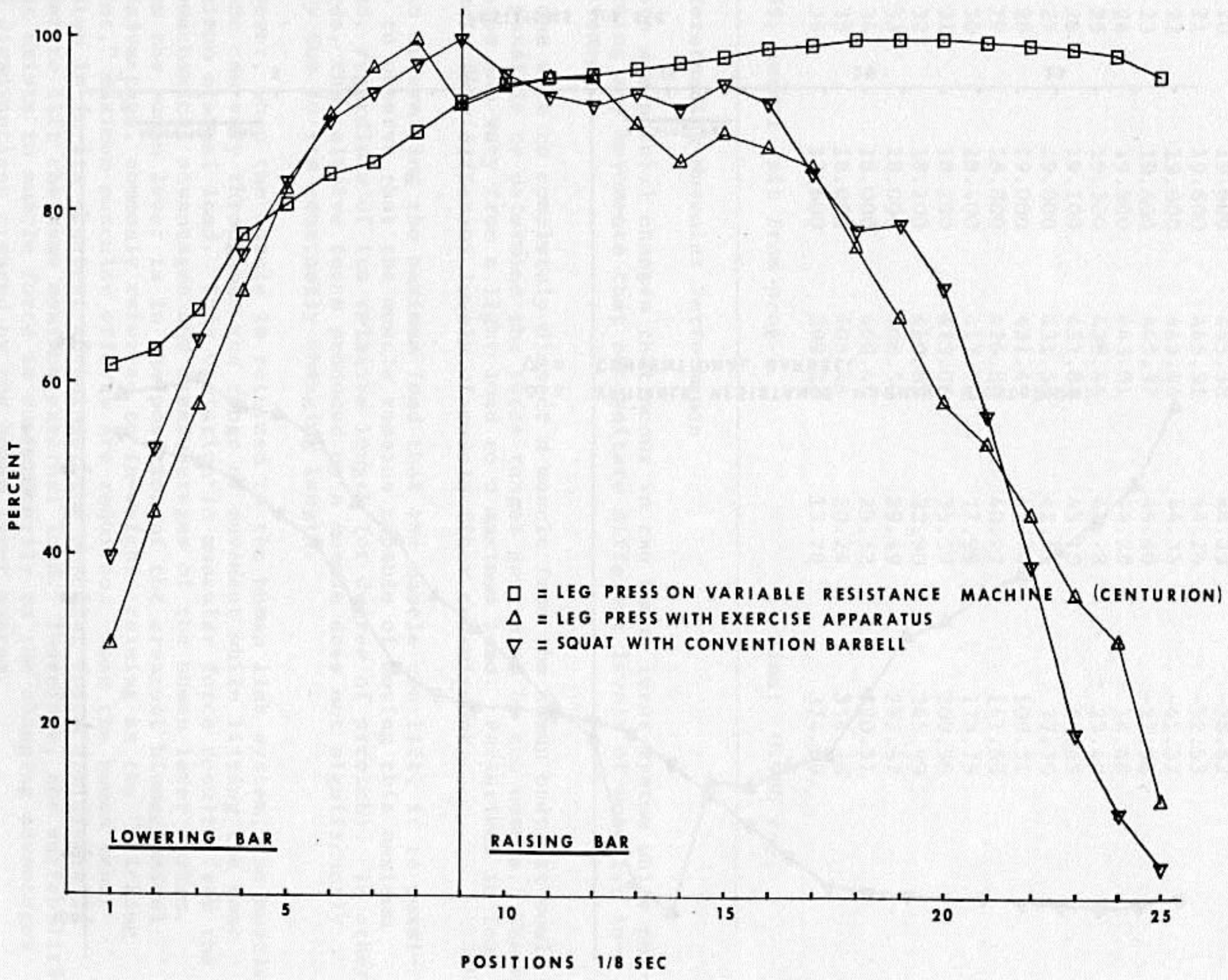


FIGURE 1. LEG PRESS: TOTAL MUSCULAR INVOLVEMENT (in percent)



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Biomechanical analysis of the knee joint during deep knee bends with heavy load

B. G. Ariel
University of Massachusetts, Amherst

The knee joint, the largest and most complex synovial joint in the human body, is an anatomical region subject to injuries from activities in various fields including athletics, industry, and recreation. Because this joint is between the longest bones in the body, the femur and the tibia, the forces and moments of force around this joint produce torques of such magnitude that injuries ensue. In athletics, various injuries may occur by overloading the knee joint (Nicholas, 1970; Peterson, 1970). In several studies (Kennedy and Fowler, 1971; Marshall and Olsson, 1971; Newman, 1969; Slocum and Larson, 1968), it was found that the instability of the knee joint was the result of the application of excessive external rotation and abduction forces to a flexed, weight-bearing knee.

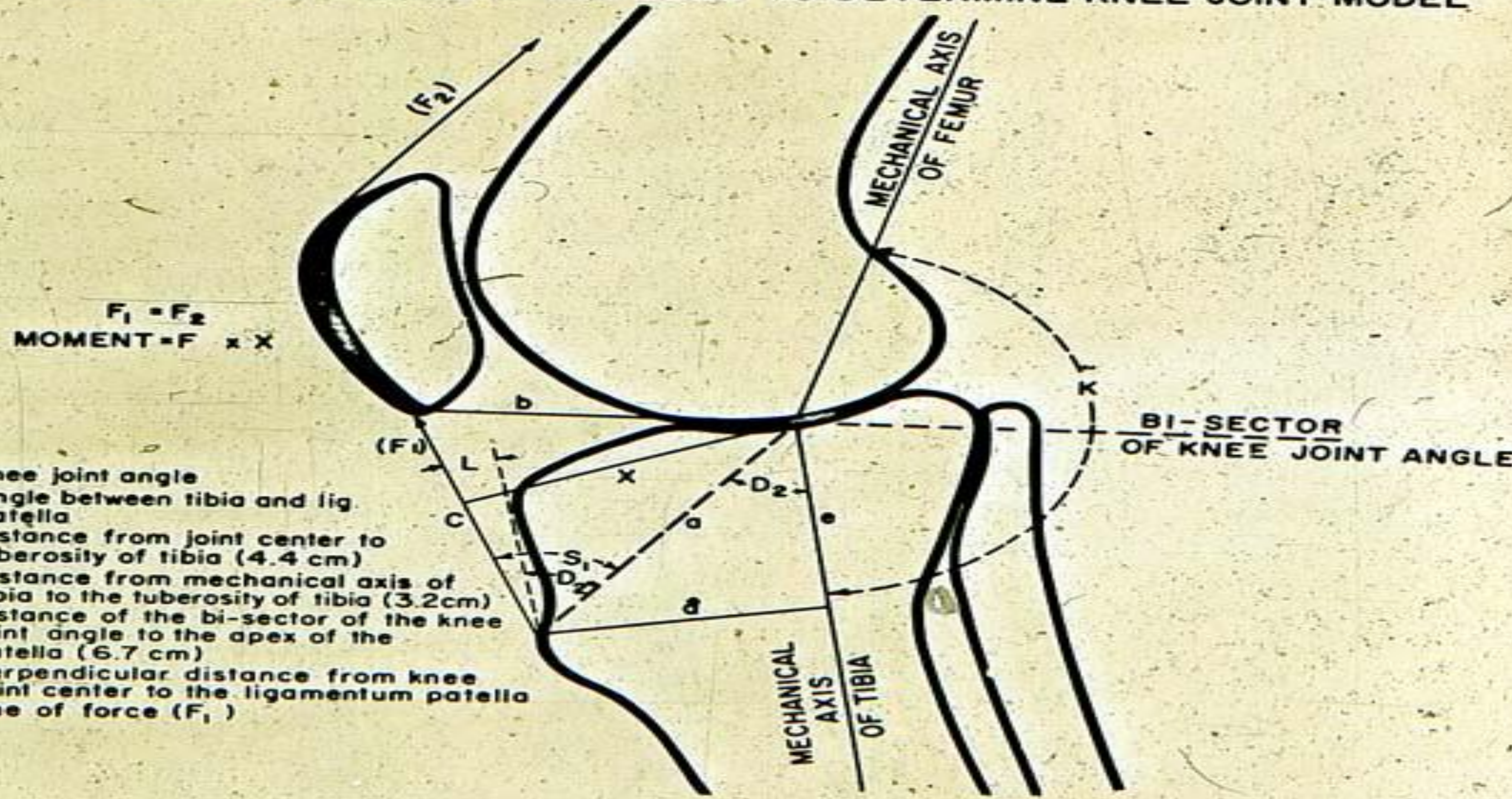
The knee joint, described as a hinge joint, is much more complex. It consists of three articulations, the surfaces of which are not mutually adapted to each other, so that movement is not simply gliding (Gray, 1954; Lockhart, Hamilton, and Fyfe, 1959). The quadriceps femoris muscle group is responsible for extension of the knee joint. The four muscles of this group pull through a common tendon and insert via the ligamentum patella, which continues from the patella to the tuberosity of the tibia. The movements of the knee joint are primarily flexion and extension and, in certain positions of the joint, internal and external rotation (Dick, 1969).

The purpose of the present study was to investigate the forces and moments of force acting about the knee joint during a deep knee bend exercise with a heavy load.

METHODS

Twelve experienced weightlifters, ranging in age from 21 to 25 years, served as subjects. Their mean height was 181.5 cm and their mean weight was 90.5

TRACING OF SAMPLE X-RAY USED TO DETERMINE KNEE JOINT MODEL



K = Knee joint angle
L = Angle between tibia and lig. patella
e = Distance from joint center to tuberosity of tibia (4.4 cm)
d = Distance from mechanical axis of tibia to the tuberosity of tibia (3.2cm)
b = Distance of the bi-sector of the knee joint angle to the apex of the patella (6.7 cm)
X = Perpendicular distance from knee joint center to the ligamentum patella line of force (F_1)

Table 1. Knee joint angle, forces, and moments of force for selected subjects in the deep knee bend with heavy load

Position	Knee angle (degrees)	Moment (kg/m)	Horizontal force (kg)	Vertical force (kg)	Bone-on-bone force (kg)	Shear force (kg)	Compression force (kg)
Subject 1							
1	150.1	10.7	−145.7	−166.7	221.4	104.5	195.2
2	140.7	14.1	−197.5	−222.7	297.6	126.1	269.6
3	131.8	17.5	−252.1	−282.6	278.7	143.3	350.5
4	123.2	20.2	−298.8	−336.0	449.7	150.4	423.8
5	115.3	22.5	−340.5	−387.3	515.7	151.8	492.8
6	107.7	24.4	−377.7	−435.9	576.8	147.4	577.6
7	100.8	25.3	−399.9	−469.2	616.5	136.0	601.4
8	94.5	26.2	−421.7	−504.9	657.9	124.1	646.1
9	88.8	27.0	−440.9	−540.9	697.8	111.4	688.9
10	83.9	27.3	−451.4	−566.4	724.3	97.7	717.7
11	79.5	27.0	−451.8	−578.8	734.2	82.8	729.6
12	75.9	25.9	−437.1	−571.1	719.2	68.1	716.0
13	73.1	25.2	−427.5	−568.9	711.7	57.4	709.3
14	70.9	24.9	−424.0	−573.1	712.9	49.6	711.1
15	69.4	25.3	−432.4	−589.5	731.0	45.4	729.6
16	68.7	35.9	−612.5	−841.5	1040.8	60.8	1039.0
17	68.8	24.8	−422.7	−582.1	719.4	42.5	718.1
18	69.5	25.6	−435.4	−597.3	739.1	46.3	737.7
19	71.0	25.2	−425.9	−581.5	720.7	50.5	719.0
20	73.1	25.6	−430.2	−580.9	722.8	58.2	720.5
21	75.7	25.0	−417.9	−555.2	694.9	65.1	691.9
22	79.2	22.8	−378.0	−492.9	621.2	69.1	617.3
23	83.1	21.0	−345.6	−440.4	559.8	73.3	554.9

(continued on next page).

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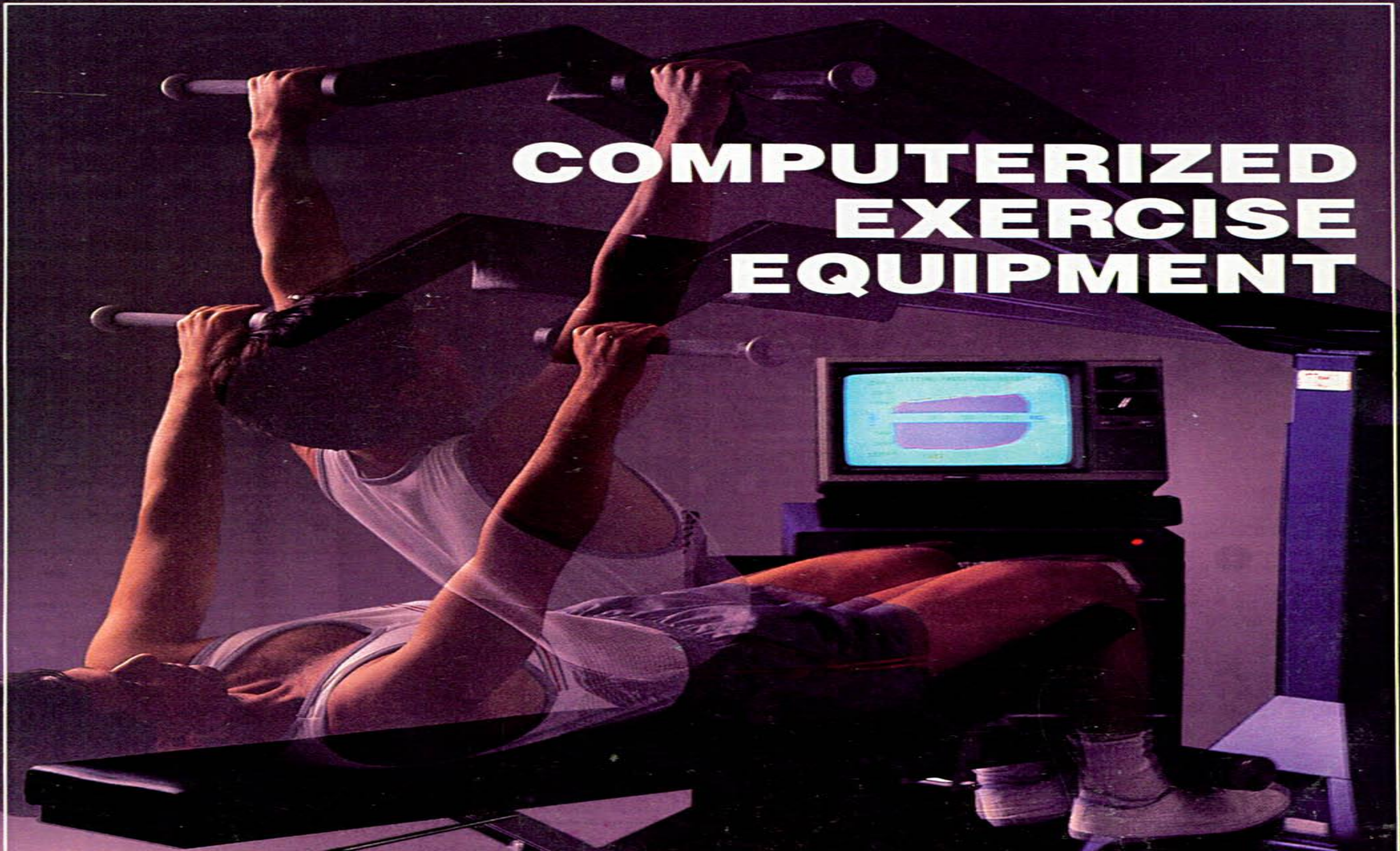


COMPUTERIZED EXERCISE EQUIPMENT

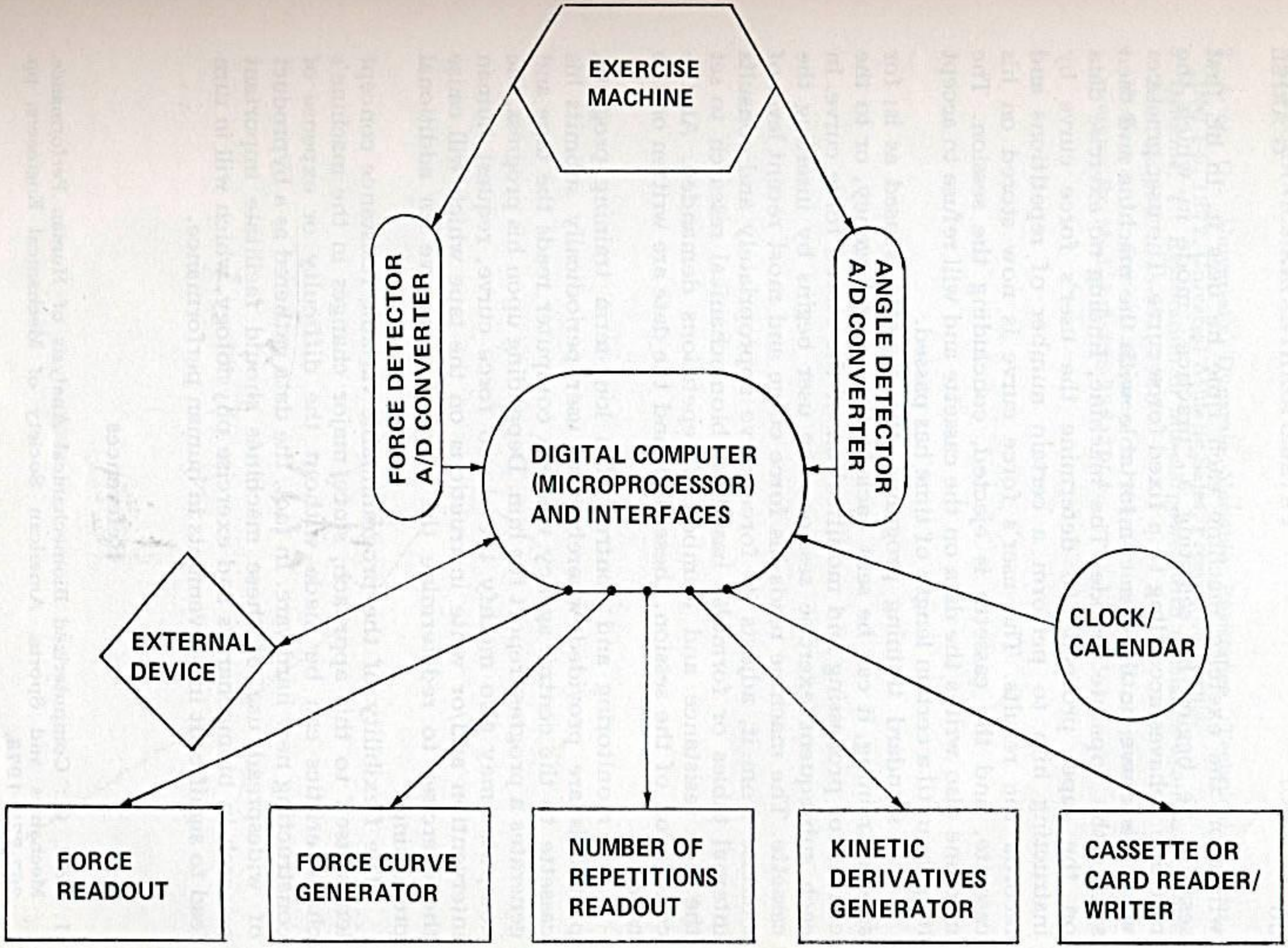
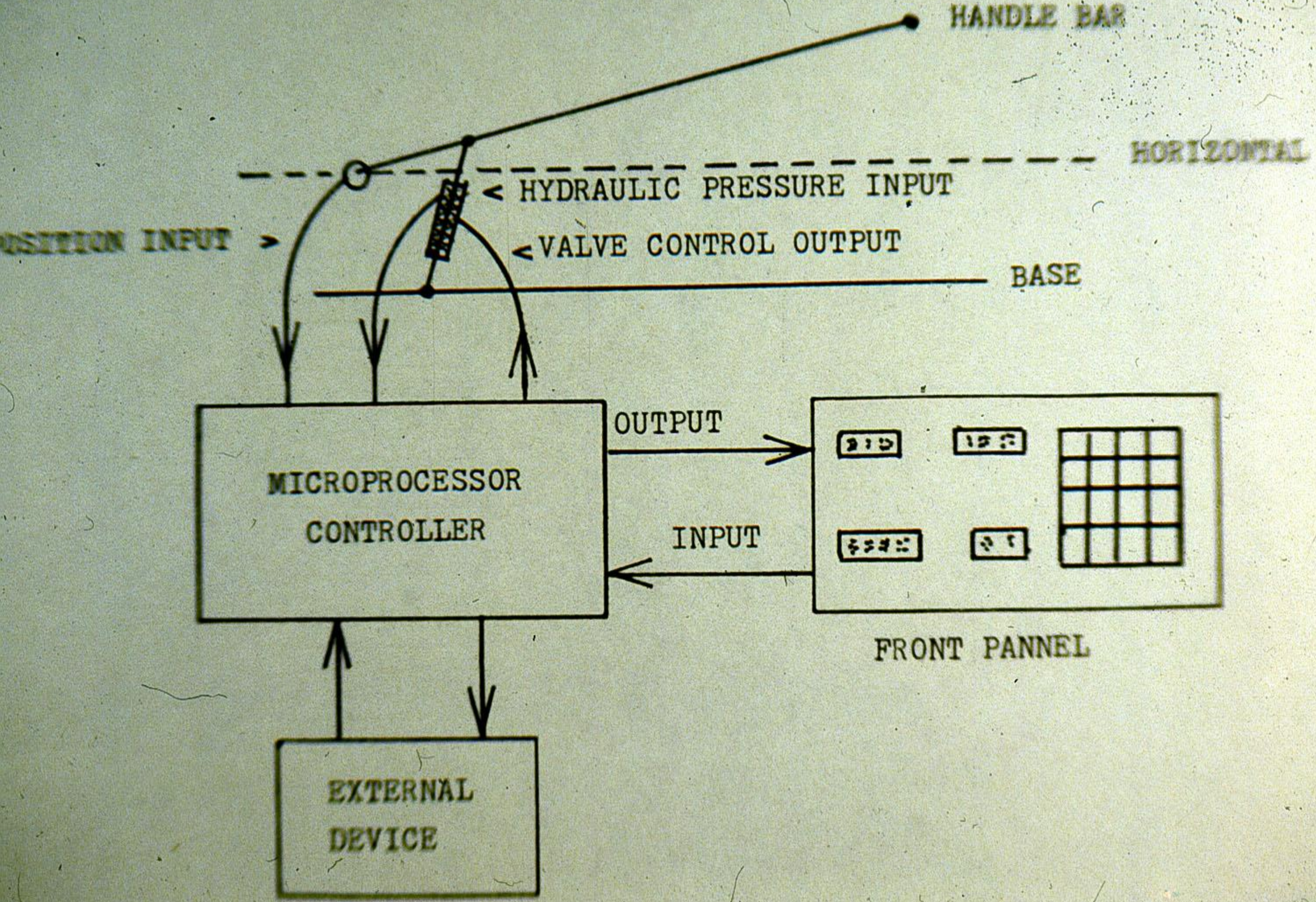


Fig. 1. The programmable variable resistance exerciser flow chart.

EXERCISE SYSTEM DIAGRAM




1 Constant Force
2 Constant Velocity
3 Linear Force
4 Linear Velocity
5 Measured Force
6 Measured Velocity
7
8
9
Stop
4
5
6
Go
1
2
3
No
Entr
0
Rub out
Yes


SPRAGUE
ATOM®
TVA-1175
3000UF-16VDC

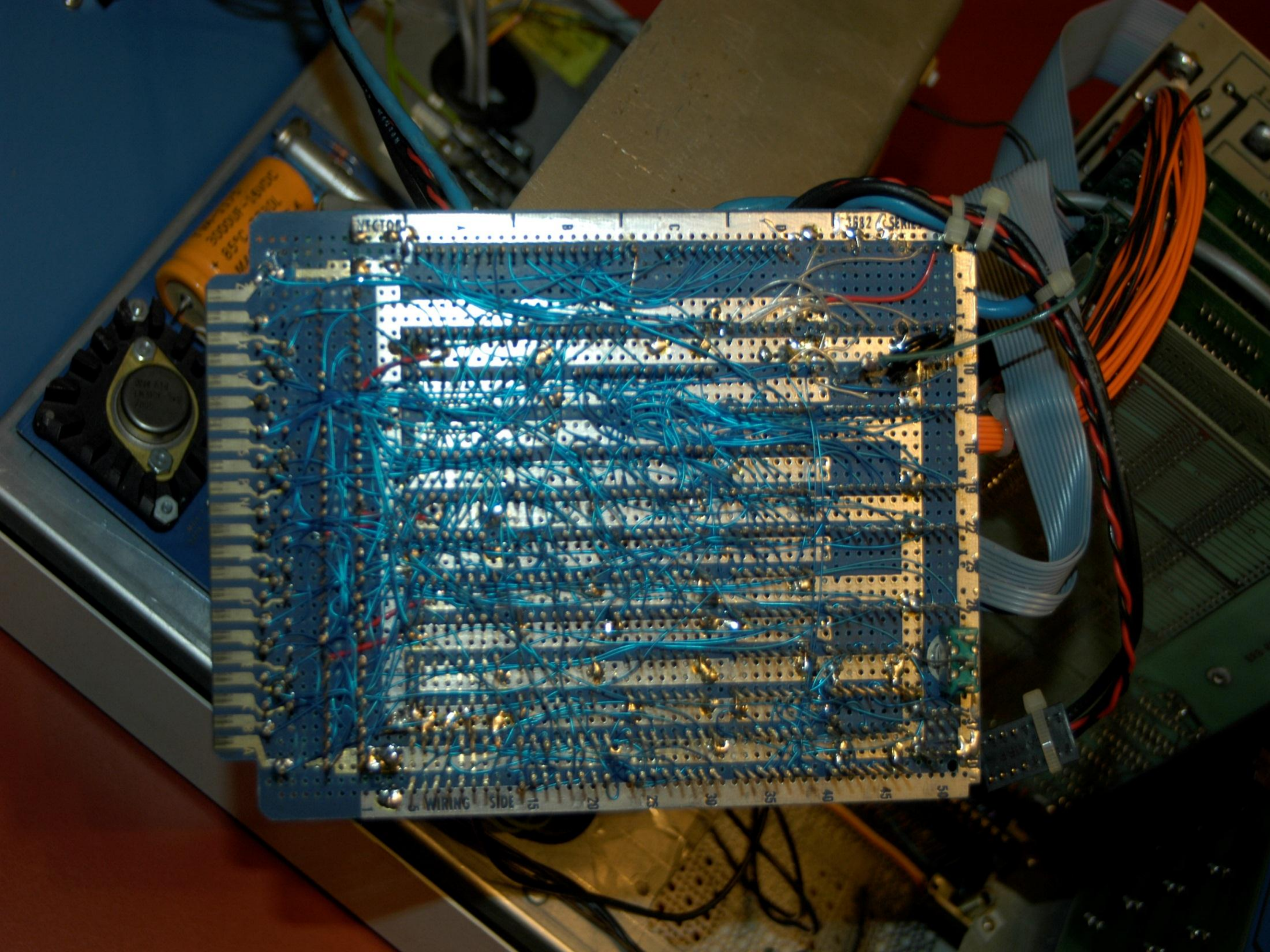
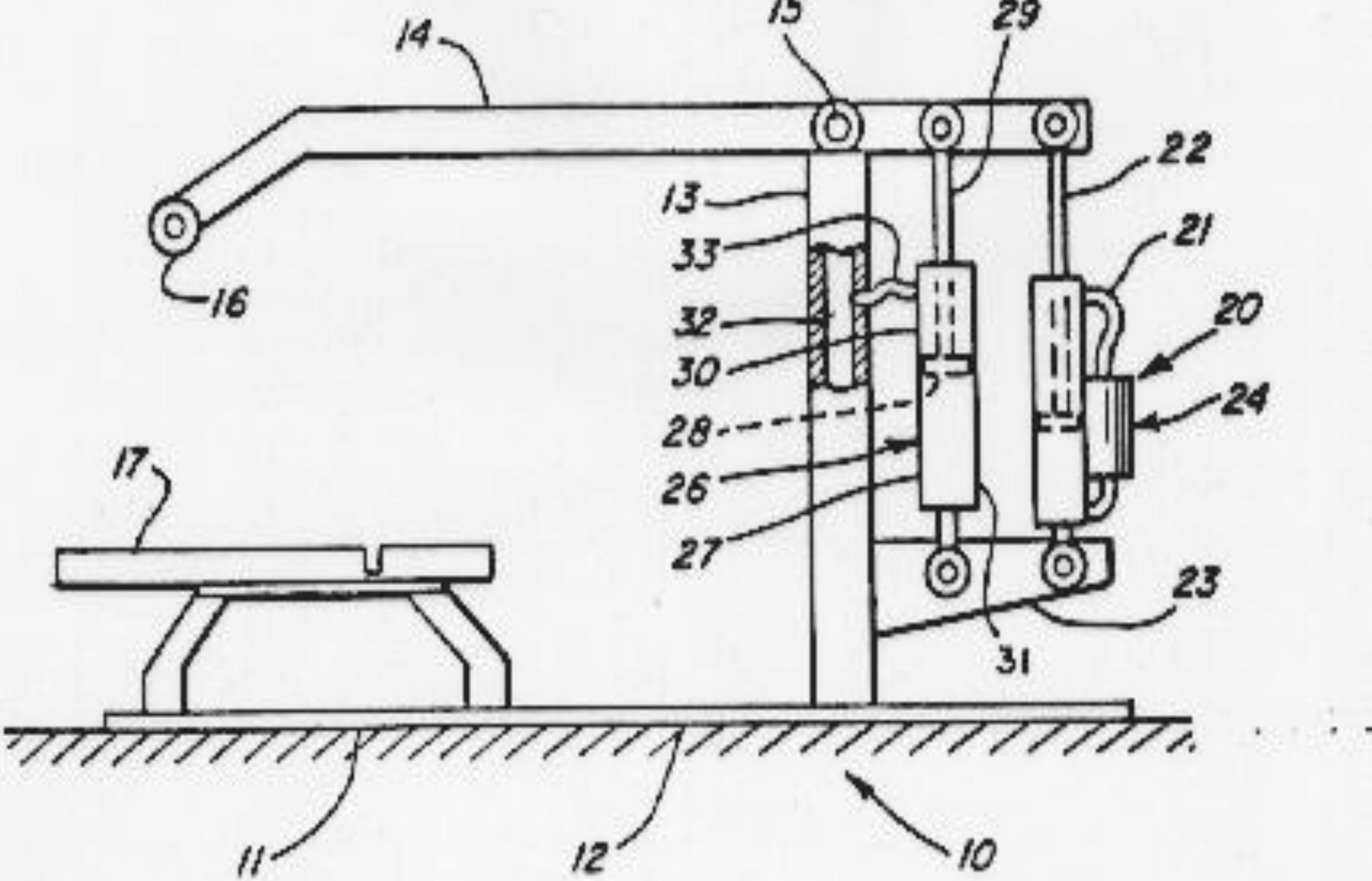
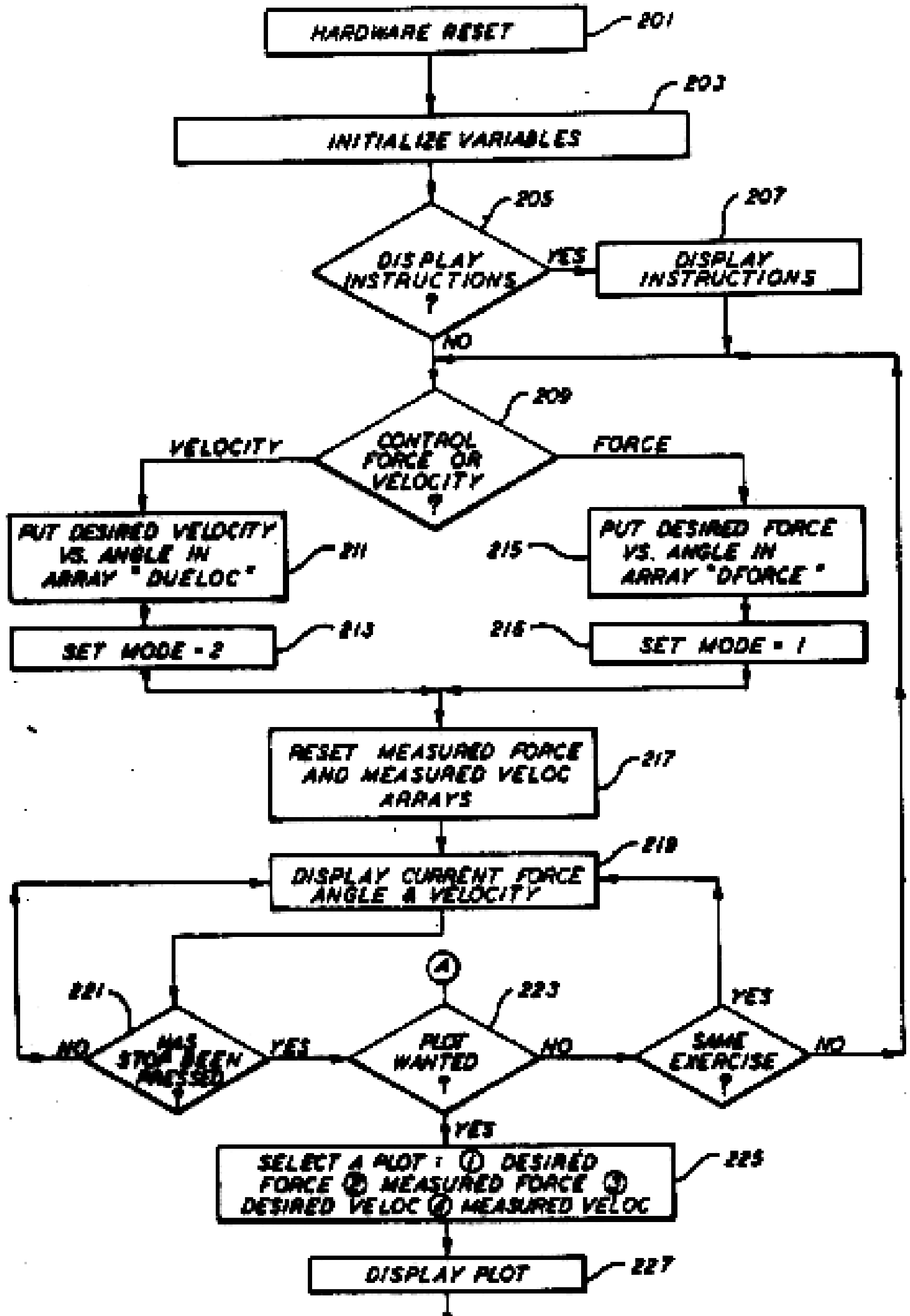

VECTOR
WIRING SIDE

FIG. 1




HARDWARE RESET
201
INITIALIZE VARIABLES
203
DISPLAY INSTRUCTIONS ?
205
YES
NO
DISPLAY INSTRUCTIONS
207
CONTROL FORCE OR VELOCITY ?
209
VELOCITY
FORCE
PUT DESIRED VELOCITY VS. ANGLE IN ARRAY "DVELOC"
211
SET MODE = 2
213
PUT DESIRED FORCE VS. ANGLE IN ARRAY "DFORCE"
215
SET MODE = 1
216
RESET MEASURED FORCE AND MEASURED VELOC ARRAYS
217
DISPLAY CURRENT FORCE ANGLE & VELOCITY
219
A
HAS STOP BEEN PRESSED
221
NO
YES
PLOT WANTED ?
223
NO
YES
SAME EXERCISE ?
YES
NO
SELECT A PLOT : ① DESIRED FORCE ② MEASURED FORCE ③ DESIRED VELOC ④ MEASURED VELOC
225
DISPLAY PLOT
227

Gideon Ariel, Computernik-Biomechanist

Gideon Ariel is a single-minded problem-solver, calling on the disciplines of exercise science (in which he received his doctorate at at the University of Massachusetts), computer science, mechanics, and engineering to provide solutions for the problems of athletic performance. As biomechanics and computer science chairman for the US Olympic Committee he recently helped the women's volleyball team at Squaw Valley, who weren't jumping high enough. Using computer analysis of their movements, he and colleagues found that the volleyballers didn't have sufficient weight and strength in their arms, as compared with their legs, for the work of leaping. "They worked on it for six weeks," recalls the biomechanist, "increased their arm strength, and increased their jumping capacity quite a bit."

Dr. Ariel gets to the heart of challenges like these by using the data-gobbling, data-juggling talents of the computer, which if properly programmed, can analyze and manipulate data concerning the complex motions and interactions of human-body segments and athletic gear. Originally he labored to reduce limb and trunk movements to stick-figure representations from motion-picture photographs superimposed on each other. Finding the conventional ways tedious and time-consuming, he experimented with shortcuts. Now he feeds coordinates of points on a body into computers by several methods.

In one of them, a scanning device glances over a photographic image projected on a screen, responding to its light and dark areas. A computer connected to the scanner then plots the positions of joints to produce stick-figure tracings. Two other gadgets depend on sound rather than light to position body segments on a cathode-ray tube or paper printout. In one technique, Dr. Ariel touches a "sonic pen" to a photographic image displayed over a kind of grid with tiny microphones around the edges. The microphones pick up sound impulses and measure how far away the source is; the computer converts the coordinates to visual images. From this, says Dr. Ariel, he can calculate the forces, velocities, and accelerations, if given the segment weights and distribution of body mass.

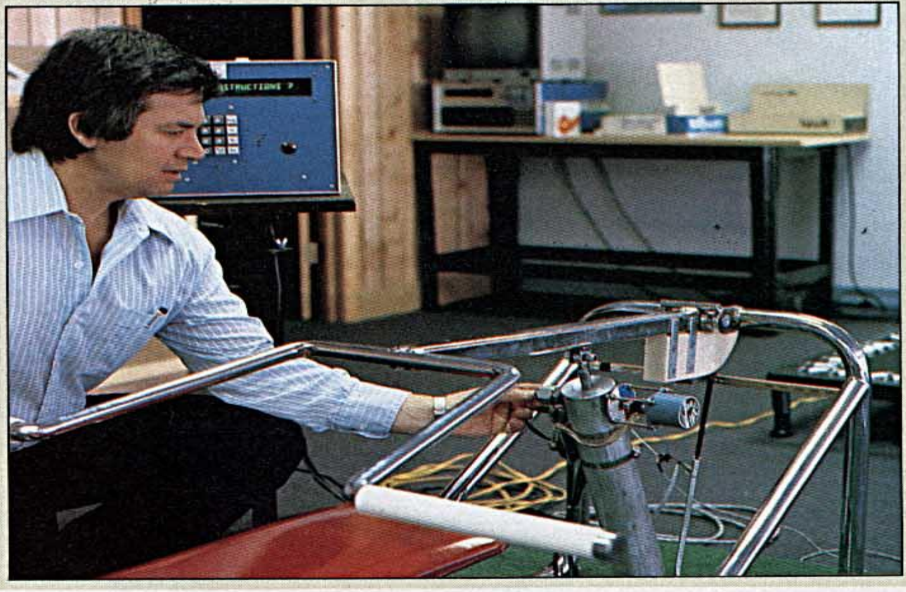
Restless and curious, Dr. Ariel has explored a broad spectrum of athletic activities—running, field events, diving, golf, basketball, football, ice skating, and tennis—at Computerized Biomechanical Analysis, Inc (CBA), his private company.

Although still an adjunct professor of computer science at the University of Massachusetts, he presently has little to do with pure research, having made a conscious decision in 1971 to steer a commercial course. CBA has taken on a number of projects for manufacturers so Dr. Ariel can recover his investment in facilities. "The money has to come from somewhere," he laments.

Although he's been consulted by professional teams in the past, he's not currently active in such work. He is, however, busy dealing with tennis rackets, golf clubs, and football helmets and jackets newly conceived to prevent injuries. Furthermore, he's absorbed in developing new, large exercise devices—he has contributed to the Universal, Nautilus, and Paramount equipment—perhaps even for home use. Someday, he speculates, the exercise machine's computer will describe how to work out to be a better tennis player, bowler, or orienteerer, and in addition, tell the athlete what to eat and how much.

David Whieldon

Dr. Ariel with a computerized exercise machine.



Book 6

Biomechanics of Sports and Kinanthropometry

Compiled and edited by

Volume 6

Biomécanique du sport et kinanthropométrie

Recueilli et édité par

FERNAND LANDRY, Ph. D.
WILLIAM A.R. ORBAN, Ph. D.

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Computerized Dynamic Resistive Exercise

Gideon Ariel

Introduction

The relationship between resistance exercises and muscle strength has been known for a long time. Muscular strength may be defined as the force a muscle group can exert against a resistance in a maximal effort, and any motion by the human requires muscular involvement. Forty to sixty percent of the human body is composed of contractile tissue forming 437 different voluntary muscles, and the most fundamental function of these muscles is the ability to produce motion by their own contraction. The action of these muscles on the bones, which provides the leverage system, permits man to stand erect, carry out activities of daily living and participate in athletic performances requiring optimal efficiency in muscular contraction and coordination. This motion of the musculoskeletal system is governed by the strength of the muscles and skeletal structure.

In 1948 Delorme [3] adopted the name "progressive resistance exercise" for his method of developing muscular strength through the utilization of counterbalancing the weight of the extremity with a cable and pulley arrangement and, thus, gave load-assisting exercise to muscle groups which would not perform antigravity motions. McQueen [4] distinguished between exercise regimens for producing muscle hypertrophy and for producing muscle power. He concluded that the number of repetitions for each set of exercises determines the different characteristics of the exercise. Based on evidence presented in these early studies, hundreds of investigations have been published relative to muscular development through resistance exercise with various methods being introduced. Techniques for muscular development include isotonic, isometric, isokinetic, eccentric, concentric and many other exercise techniques. Each system has been supported and refuted by numerous investigations.

Gideon Ariel, Computerized Biomechanical Analysis Inc., Amherst, Massachusetts, U.S.A.


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Ariel
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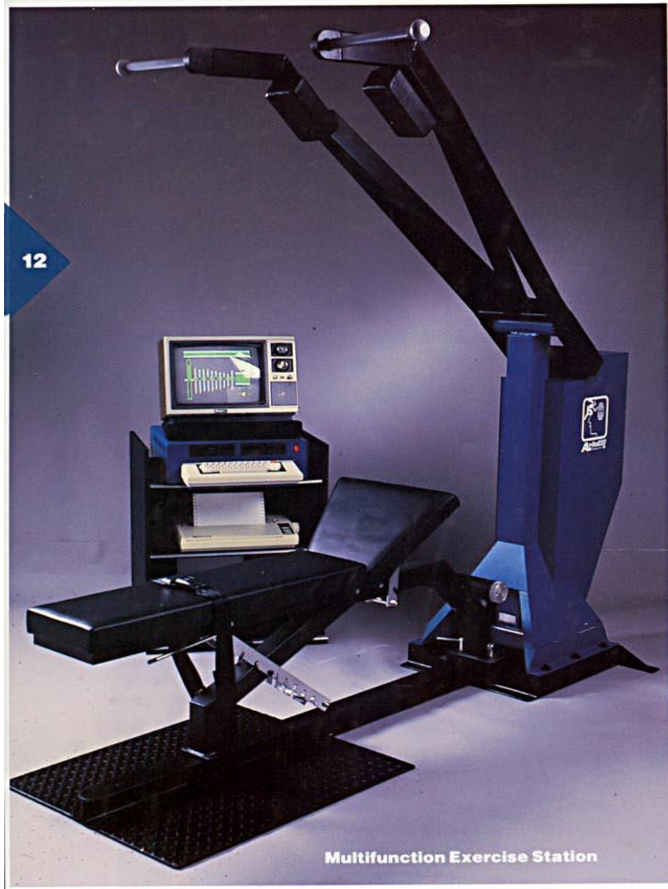

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In a laboratory at Harvard Medical School, studies are being conducted with the Ariel CES to determine human adaptation to physical stress, lack of sleep, and exercise on various biochemical processes.

The United States Olympic Committee purchased the Ariel CES to assist in research for appropriate alternates to anabolic steroids or other ergognic aids for athletes.

Hospitals and rehabilitation centers have purchased the Ariel CES to enhance the traditional methods of diagnoses, research, and rehabilitation protocols.

Health and fitness clubs have selected the Ariel CES because it allows both instructors and members to assess performance levels, follow changes, a well as tailoring special exercise regimens.


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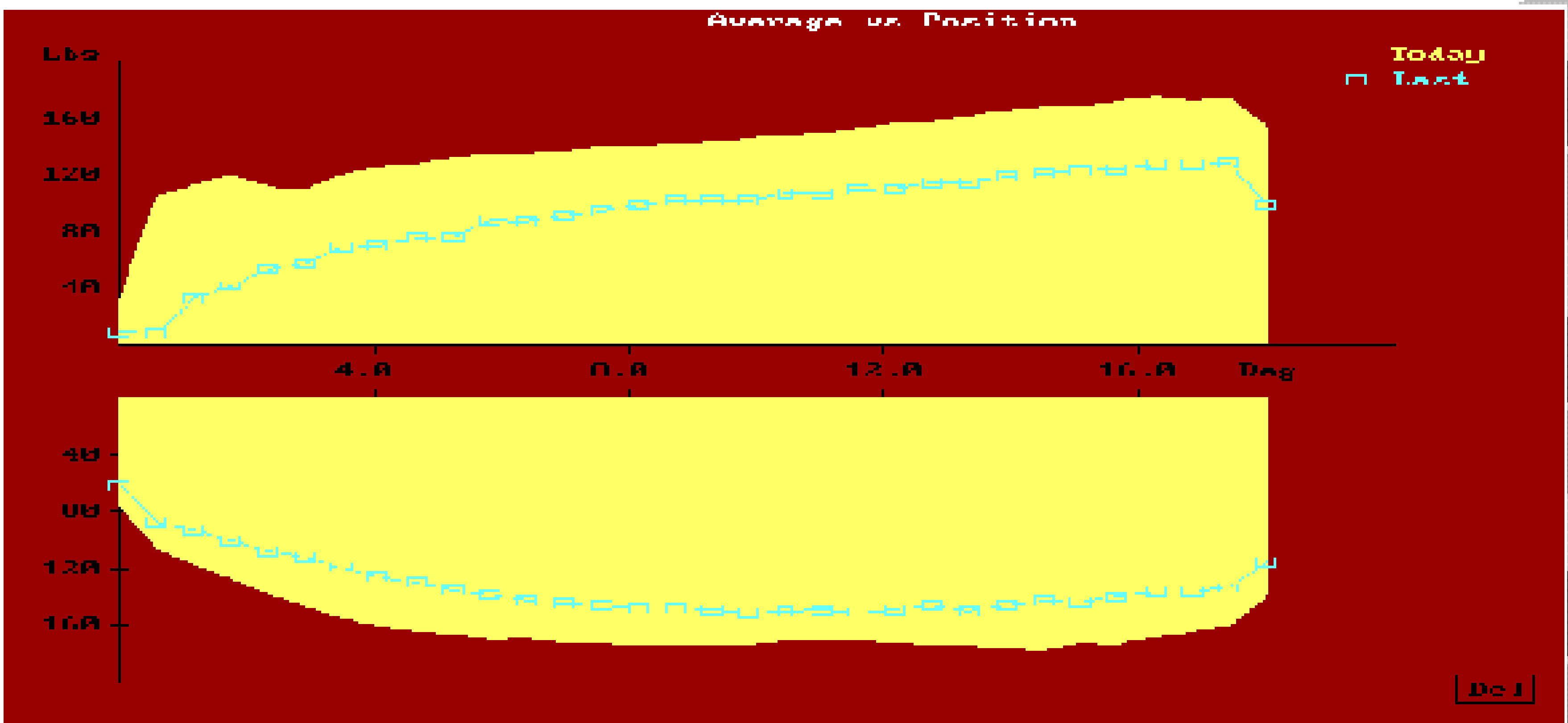
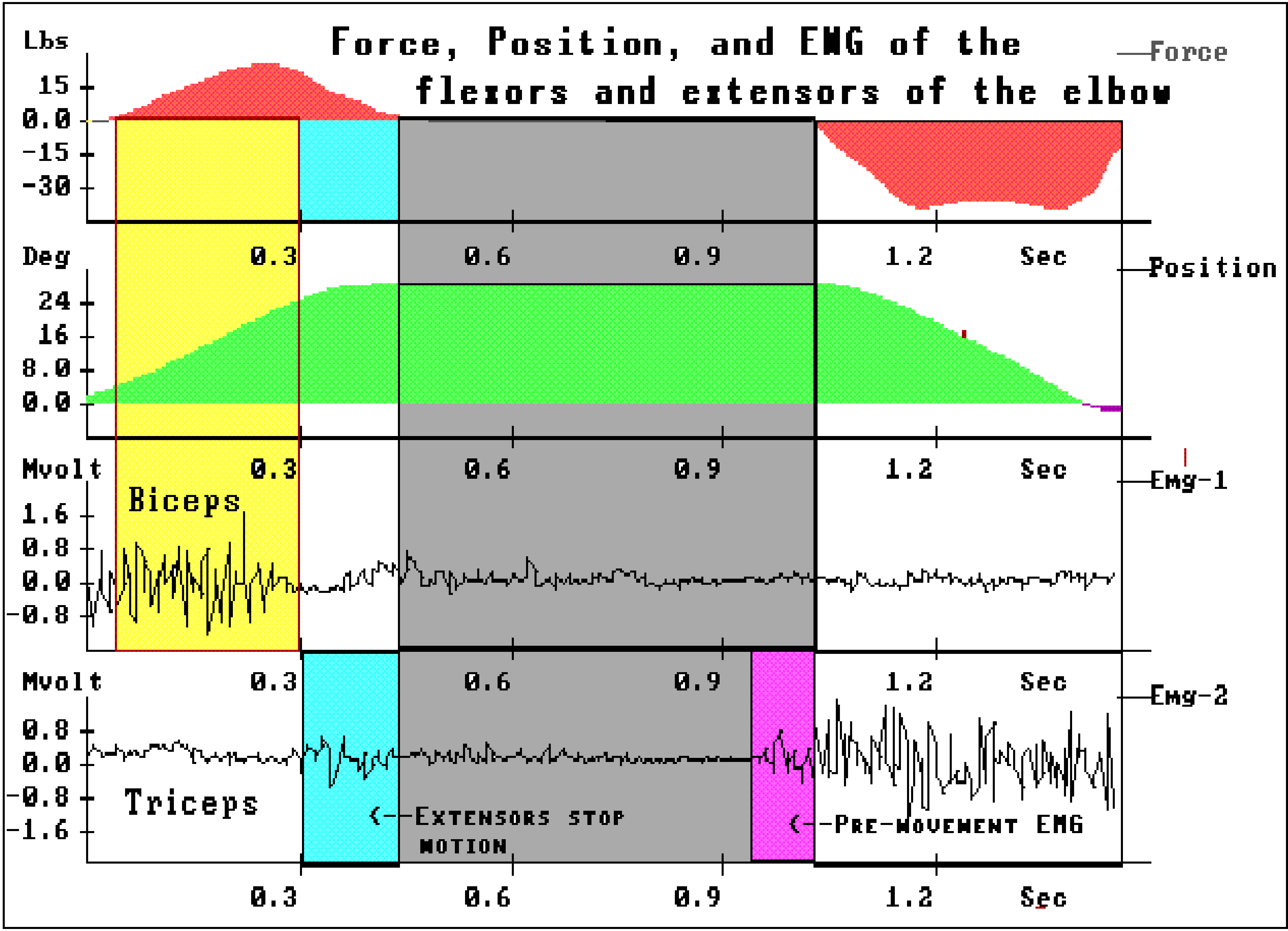
- **No pain, all gain.** When using the ARIEL Edge there is no eccentric (negative) resistance applied to the muscle, therefore no muscle tear down, which causes DOMS (Delayed Onset Muscle Soreness).

ACCOMMODATING RESISTANCE CURVE OF A BENCH PRESS PUSHING/PULLING MOVEMENT WITH COMPARISON OF DIFFERENT TRAINING SESSIONS




Force, Position, and EMG of the
flexors and extensors of the elbow
Lbs
15
0.0
-15
-30
Force
Deg
0.3
0.6
0.9
1.2
Sec
Position
24
16
8.0
0.0
Mvolt
Biceps
1.6
0.8
0.0
-0.8
Emg-1
Mvolt
0.8
0.0
-0.8
-1.6
Triceps
Emg-2
<--Extensors stop motion
<--Pre-movement EMG

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