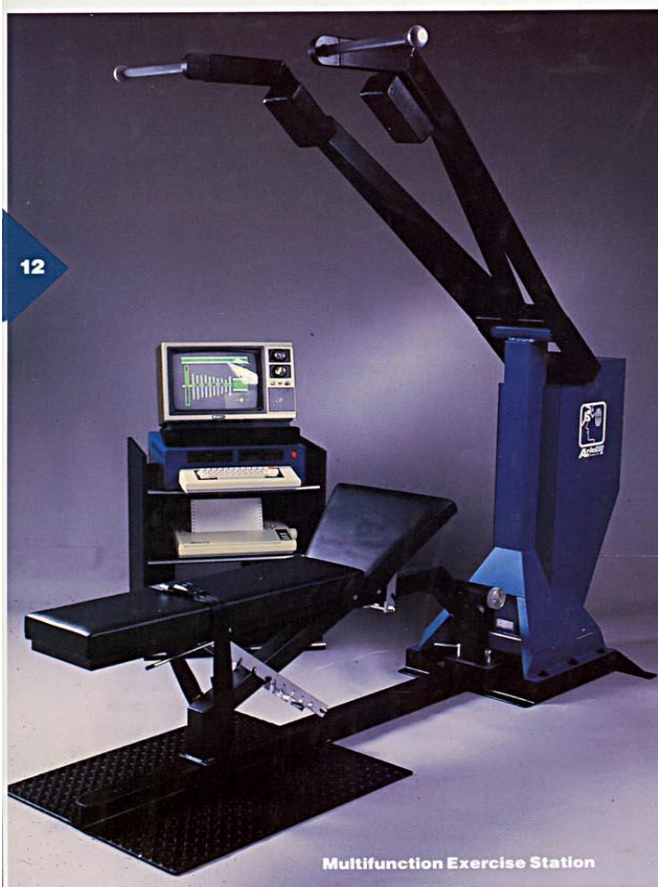# The ACES System

By

Gideon Ariel

Thailand December 2007

Multifunction Exercise Station

Arm, Leg, Back Exercise Station

With the purchase of the Ariel Computerized Exercise System you join a select group of people: The National Aeronautic and Space Agency selected the Ariel CES for research in adaptation of exercise to zero gravity. According to the experts at NASA, the Ariel CES is the only programmable modality which can provide the necessary exercise for humans in space to counteract the effects of zero gravity.

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.

CAN COMPUTERS BU

High-tech machines may provide the ultimate indivi

Principles of Training
Training for What:

•General Fitness

•Weight lost

•Good look

•Endurance Training

•Strength Training

•Athletic Training

•Specific Training

•Rehabilitation

Training with What:

- Your own body

- Swimming

- Assistance with simple equipment

- Exercise Machines

- Intelligent Exercise Machines

Definition of Terms:

- Muscular Strength
- Muscular Endurance
- Isometric Training
- Isokinetic Training
- Concentric Contraction
- Eccentric Contraction
- Muscle Overload
- Repetitions
- Sets
- Variable Resistance Exercise
- Variable Velocity Exercise
- Isokinetic Exercise
- Explosive Training Exercise
- Open loop System
- Close loop System
- Open Kinetic Chain
- Close Kinetic Chain
- Feedback Control of Exercise

1. Muscular strength: the contractile power of muscles as a result of a single maximum effort.

2. Muscular endurance: ability of the muscles to perform work by holding a maximum contraction for a given length of time or by continuing to move a submaximal load to a certain level of fatigue.

3. Isometric training: a muscular contraction of total effort but with no visible limb movement (sometimes called static training).

4. Isotonic training: raising and lowering a submaximal load, such as a weight, a given number of times (sometimes called dynamic training).

5. Isokinetic training (accomodating resistance): muscular contraction at a constant velocity. As the muscle length changes, the resistance alters in a manner that is directly proportional to the force exerted by the muscle.

6. Concentric contraction: an isotonic contraction in which the muscle length decreases (that is, the muscle primarily responsible for movement becomes shorter).

7. Eccentric contraction: an isotonic contraction in which the muscle length increases (that is, the muscle primarily responsible for movement becomes longer).

8. Muscle overload: the workload for a muscle or muscle group that is greater than that to which the muscle is accustomed.

9. Repetitions: the number of consecutive times a particular movement or exercise is performed.

10. Repetition maximum (1 RM): the maximum resistance a muscle or muscle group can overcome in a maximal effort.

11. Sets: the number of groups of repetitions of a particular movement or exercise.

12. Variable resistance exercise: as the muscle contracts, the resistance changes in a predetermined manner (linear, exponentially, or as defined by the user).

13. Variable velocity exercise: as the muscle contracts with maximal or submaximal tension, the speed of movement changes in a predetermined manner

All exercise machines are luck of intelligence. The equipment is unaware of the subject.
Only the Ariel Edge is aware of the subject using transducers and Artificial Inteligence.

Factors underlying all Athletics Performance are:

Displacement (Movement)
Velocity = Displacement/Time
Force = Mass x Accelration
Duration of Movement
Power = Force x Velocity
Technique

Integration of the Ariel Edge with the Ariel Performance Analysis System

Explosive Events

- Throwing
- Sprinting
- Jumping

Endurance Events

- Long Distance Running
- Swimming
- Cycling

- Esthetic Events
  - Figure Skating
  - Diving
- Team Sports
  - Soccer
  - Basketball
  - Ice Hockey
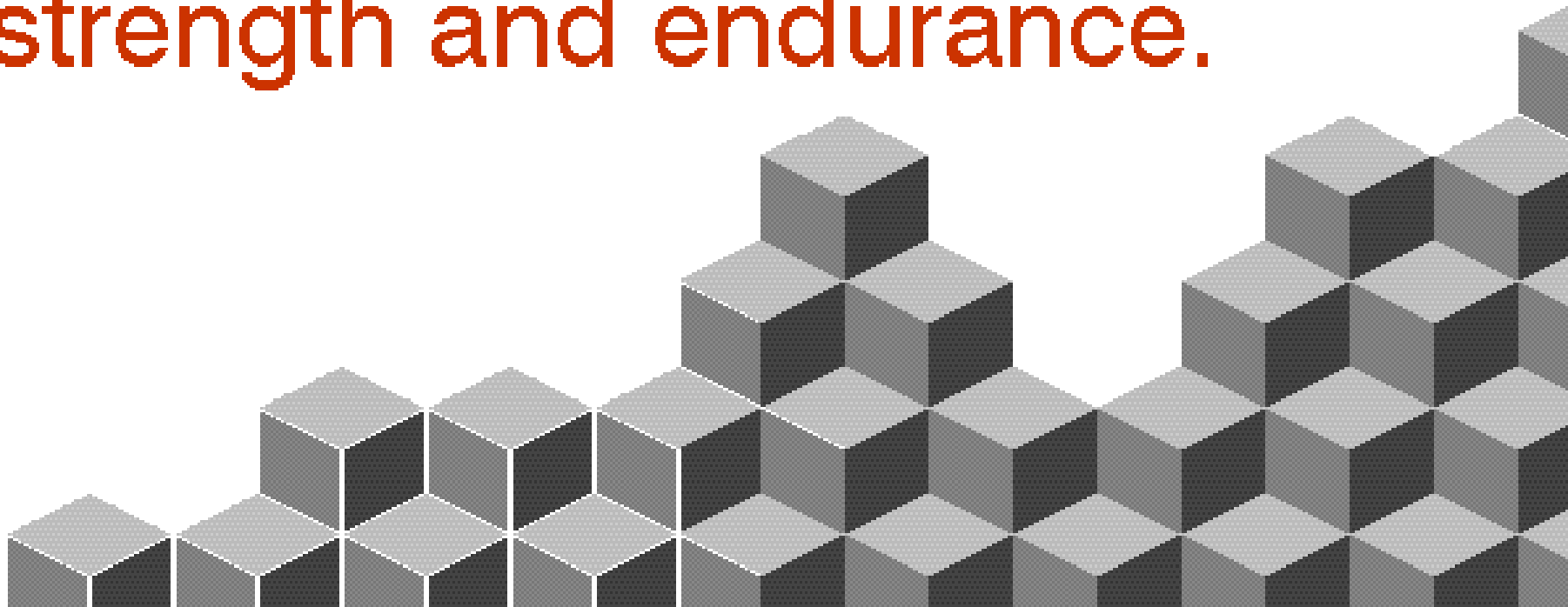- Accuracy Events
  - Archery
  - Shooting
  - Golf

The Computerized Resistive Exercise Dynamometer

By

Gideon Ariel, Ph.D.
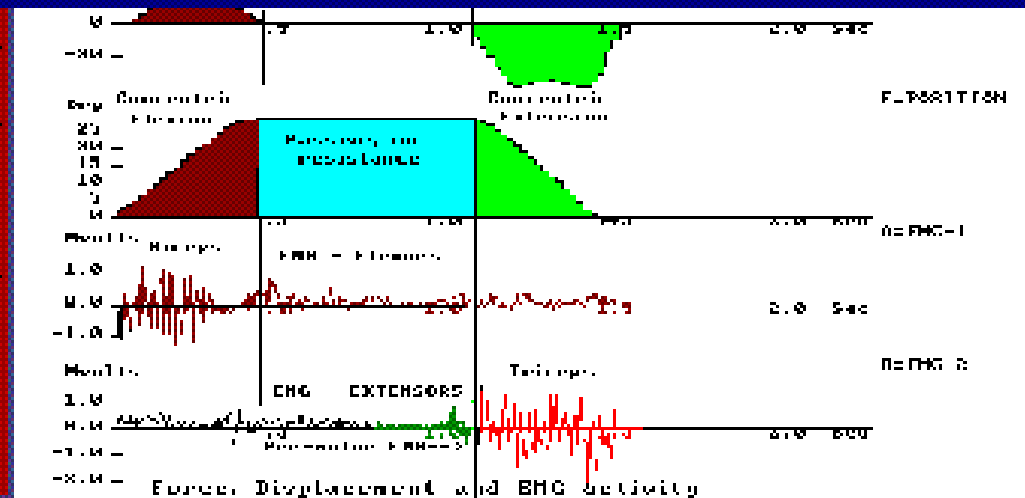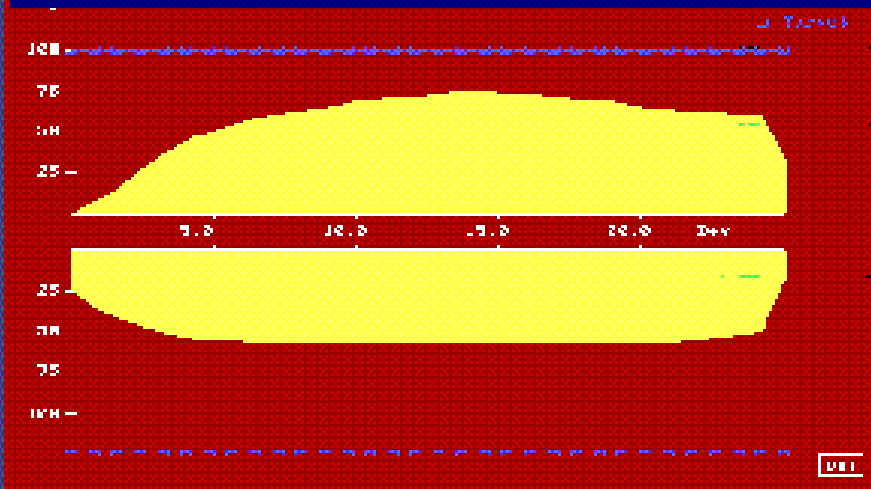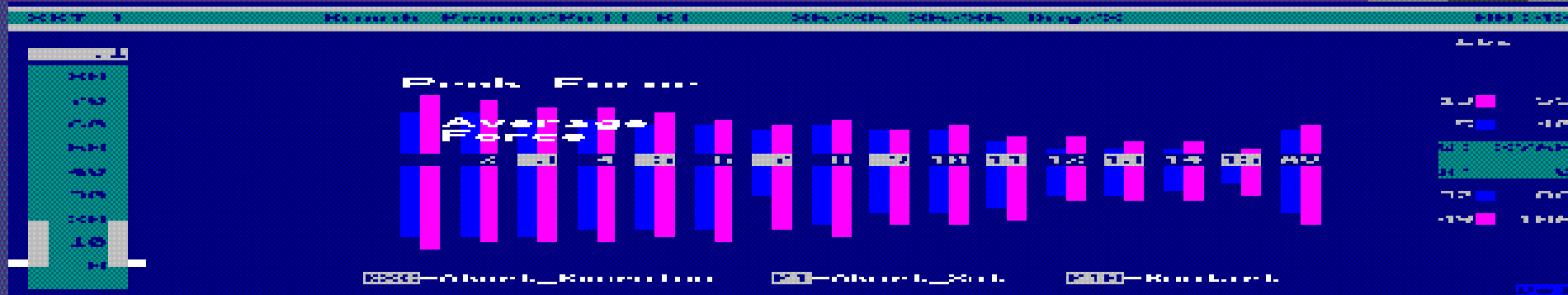
The proposed device will provide a *closed-loop feedback* system to measure and control various muscular strength and endurance.

The innovativeness of this device includes:

- The ability to measure muscular strength without the limitations imposed by traditional weight-related devices

- Computerization of both the feedback control feature, allowing adjustment of the device to the individual rather than the individual accommodating the device, and customization of the diagnostic and exercise protocols with data storage capabilities

Characteristics of the Computerized Exercise Machine?

1. Control Resistance
2. Control Velocity
3. Control Work
4. Control Power
5. Control Fatigue
6. Adapt to the user
7. Programmable
8. Interactive
9. Data Base
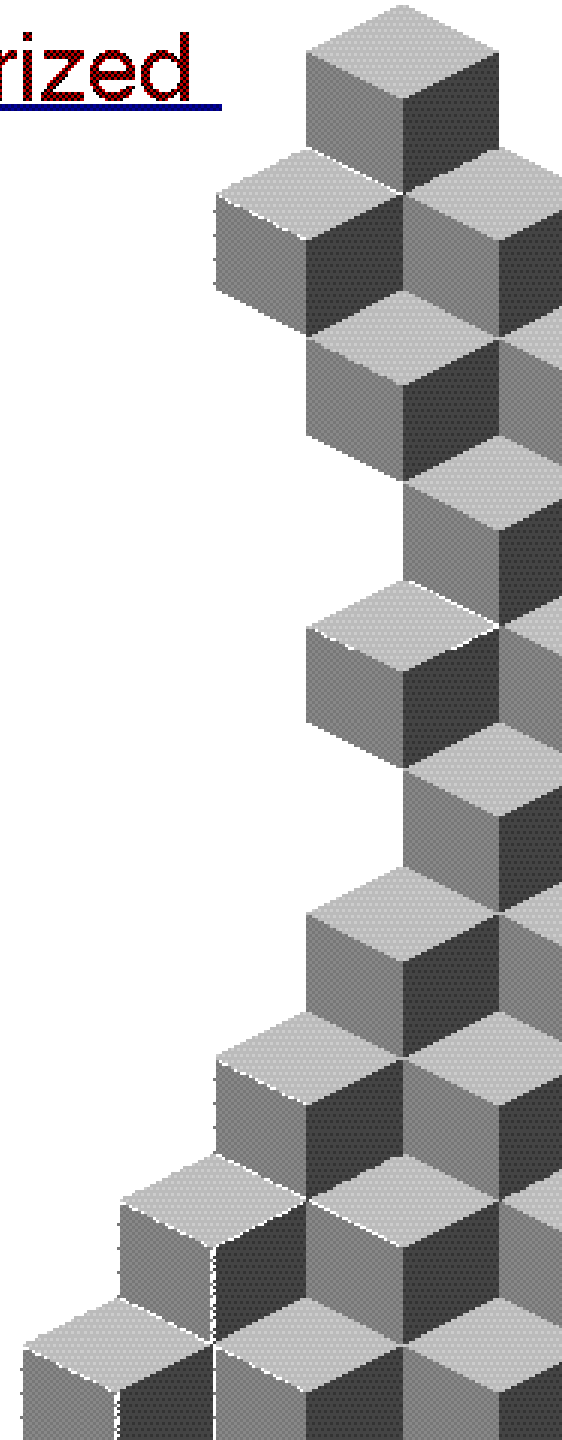
Exercise Modes:

- Isotonics
- Isokinetics
- Isoacceleration
- Power
- Isometrics
- Any Combination of the Above
- Load range = 0 to >1000 Kg.
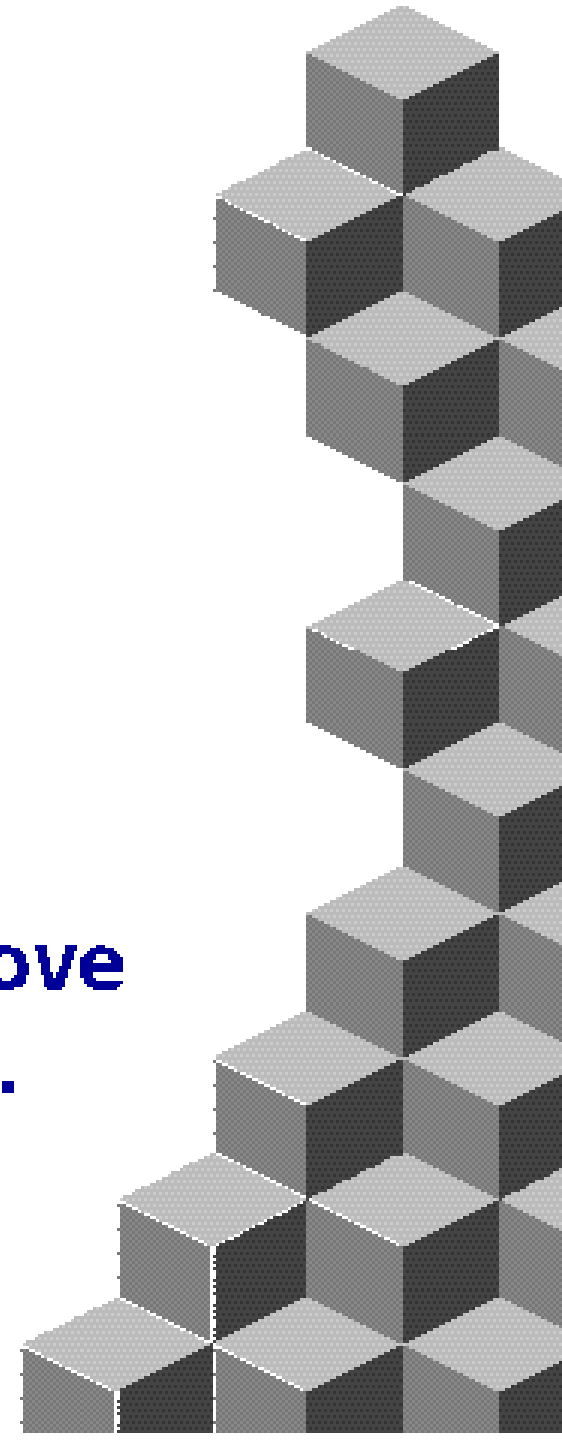
Program Modes:

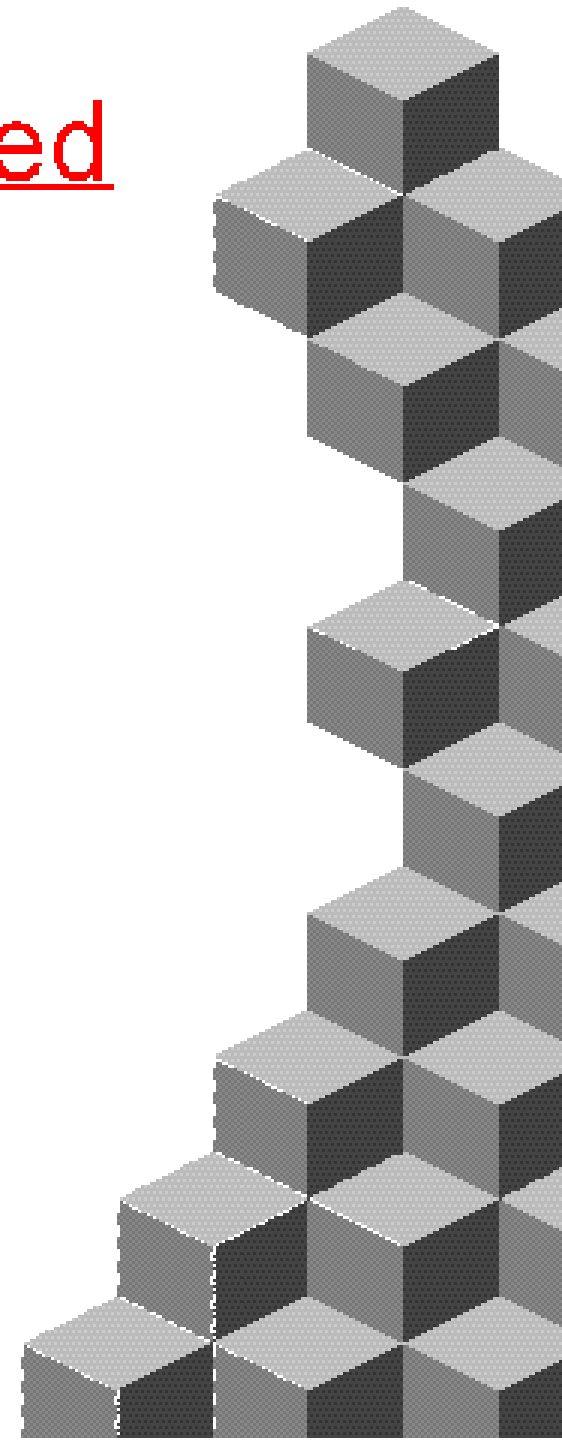- **Manual Mode (No electronics)**
- **User Mode**
- **Pre-Program Mode**
- **Internet Mode**
- **Used as Aerobic Exercise Device**
- **Used as Resistive Exercise Device**
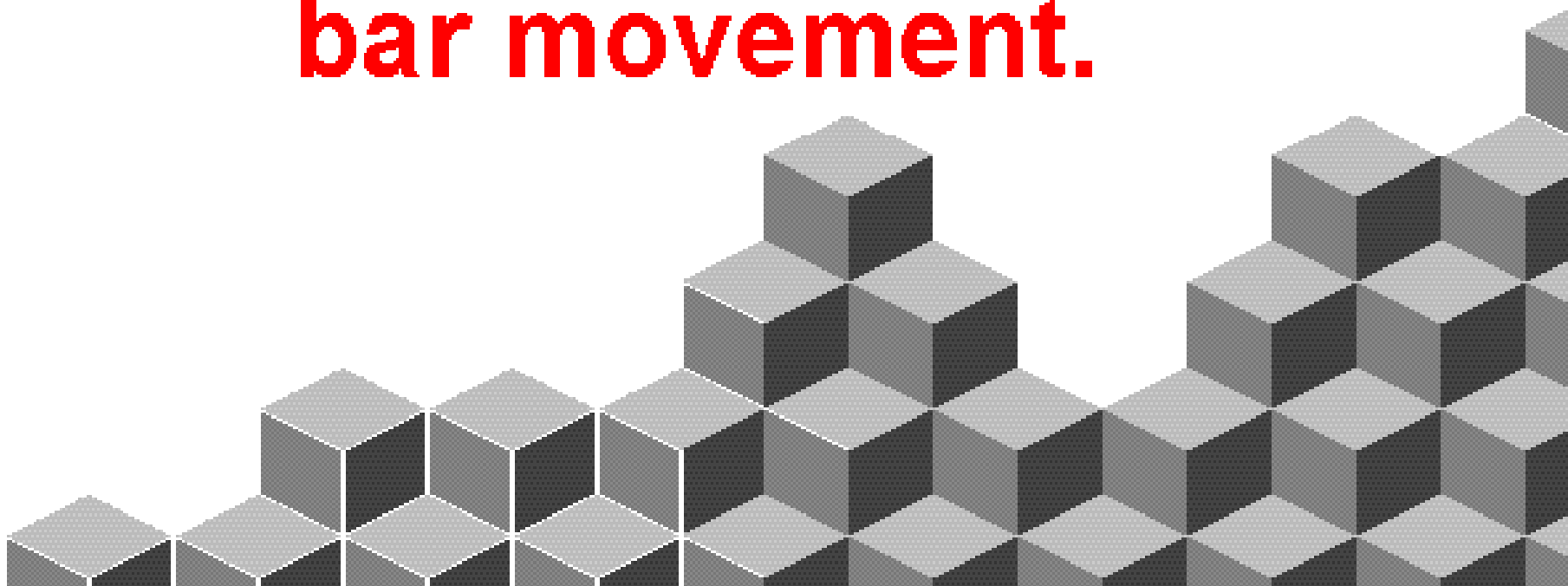- **Used as combination of the above**

Output Display and Stored

- Force Curve
- Velocity Curve
- Work
- Power
- EMG
- Fiatigue
- Historical Information
- Targets

- **Activities can be designed bi-directionally since resistance will be provided in both directions of bar movement.**

In all cases, motion will be regulated in both directions, that is, upward and downward bar movement.

- Graphic displays and audio cues will provide information to the individual with such items as current strength level, repetition number, and bar location. The sound cues will be modulated in proportion to the exerted force in order to inform the individual about his or her performance response without the need to see the computer monitor. This will simplify operation as well as providing biofeedback.
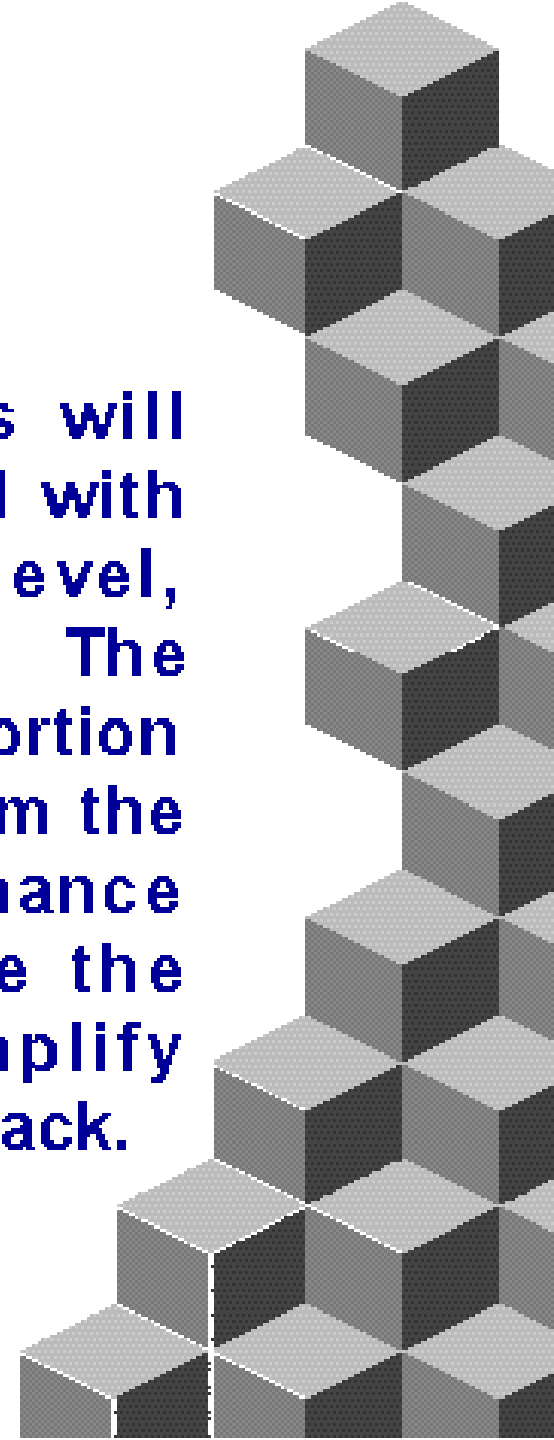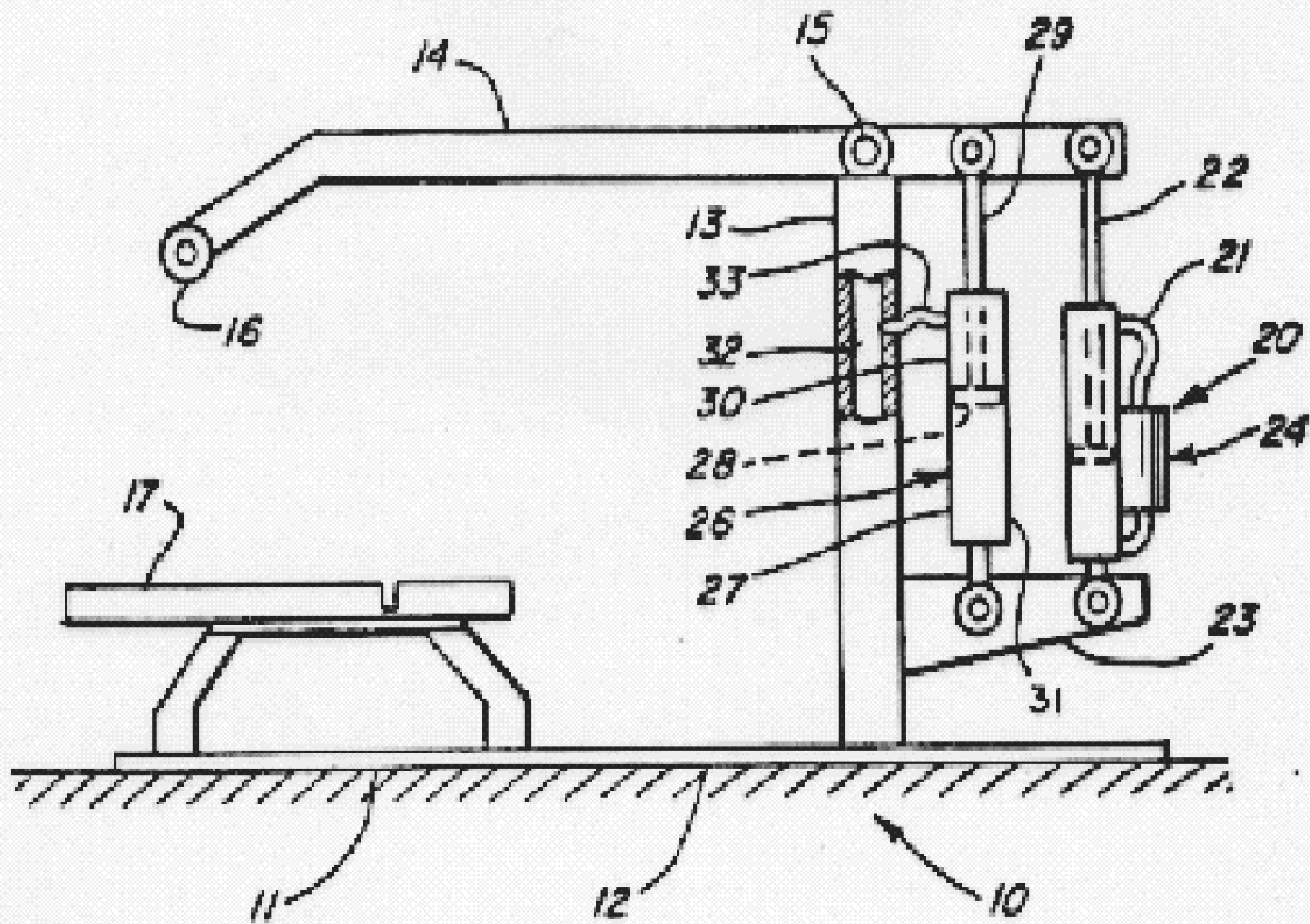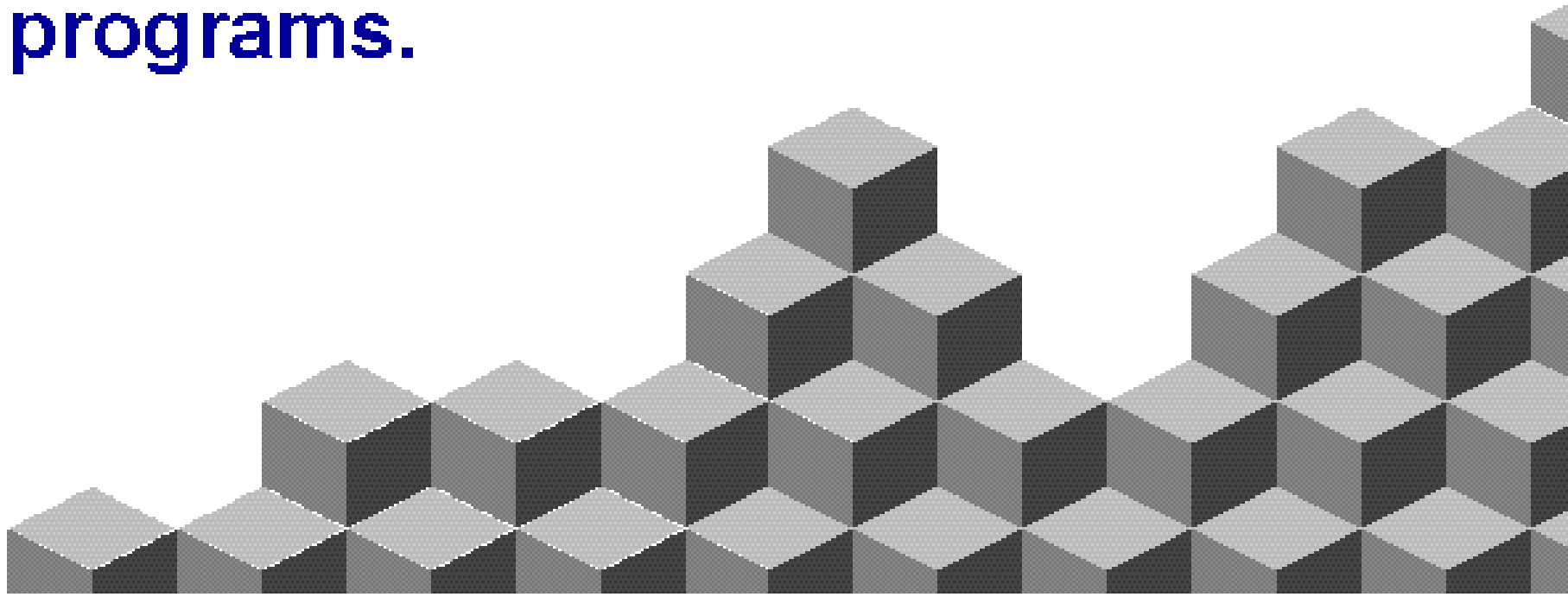
FIG. 1

The continual exchange of data between input sensors and the regulation of the hydraulic system is one of the most crucial segments of the software programs.

Hydraulic Valve, Pack, and Cylinder Unit and Stepper Motor

A stepper motor is attached to a hydraulic valve assembly which opens and closes an orifice regulating the flow of hydraulic fluid, thus controlling the amount of force needed to push or pull the piston within the cylinder.

Lbs

−.1

Peak Force

Average Force

80

70

60

50

40

30

20

10

0

2 3 4 5 6 7 8 9 10 11 12 13 14 15 AV
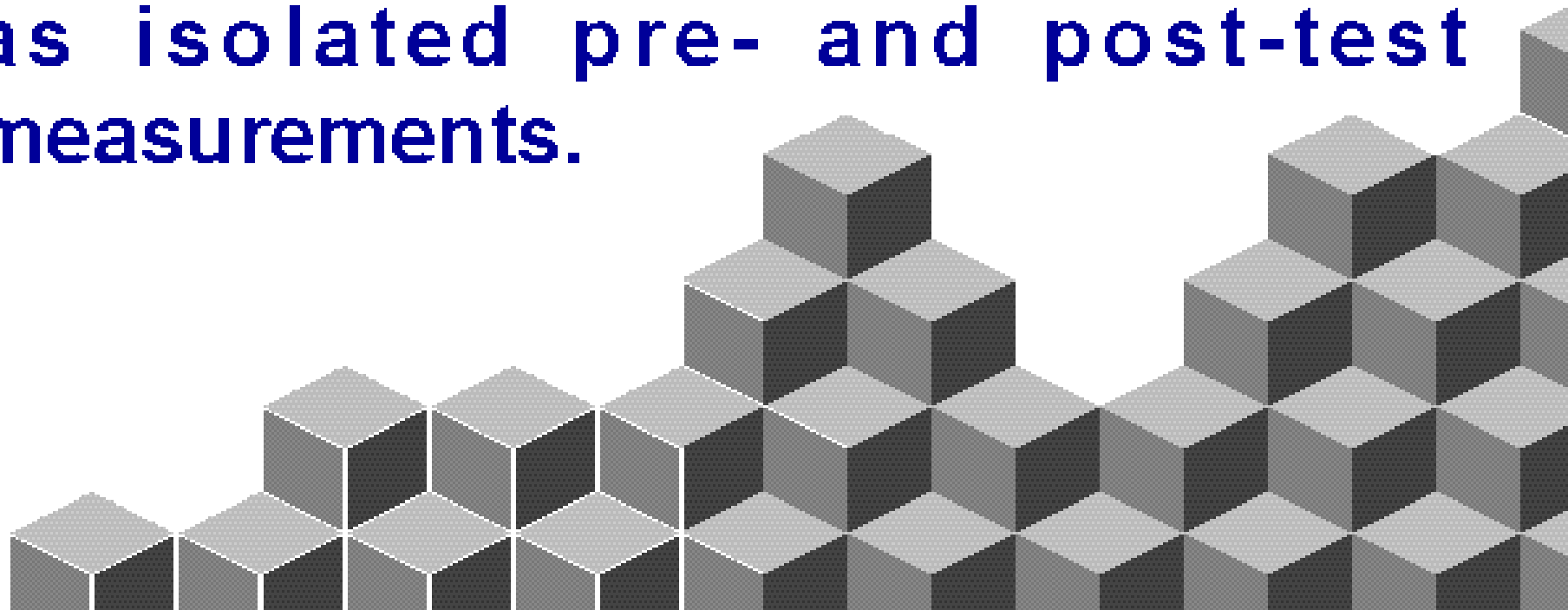
13   55

5   40

J: 2765

R: 0

32   86

49   106

ESC-Abort_Exercise   F1-Abort_Set   F10-Restart

The maximum force and maximum speed data will be determined at each discrete point in the range of movement as well as the average across the entire range. The diagnostic data could be used solely as isolated pre- and post-test measurements.

In addition, the person will be able to choose either velocity or resistance as the method for controlling the bar movement. As with the previous options, bi-directional control will be possible.
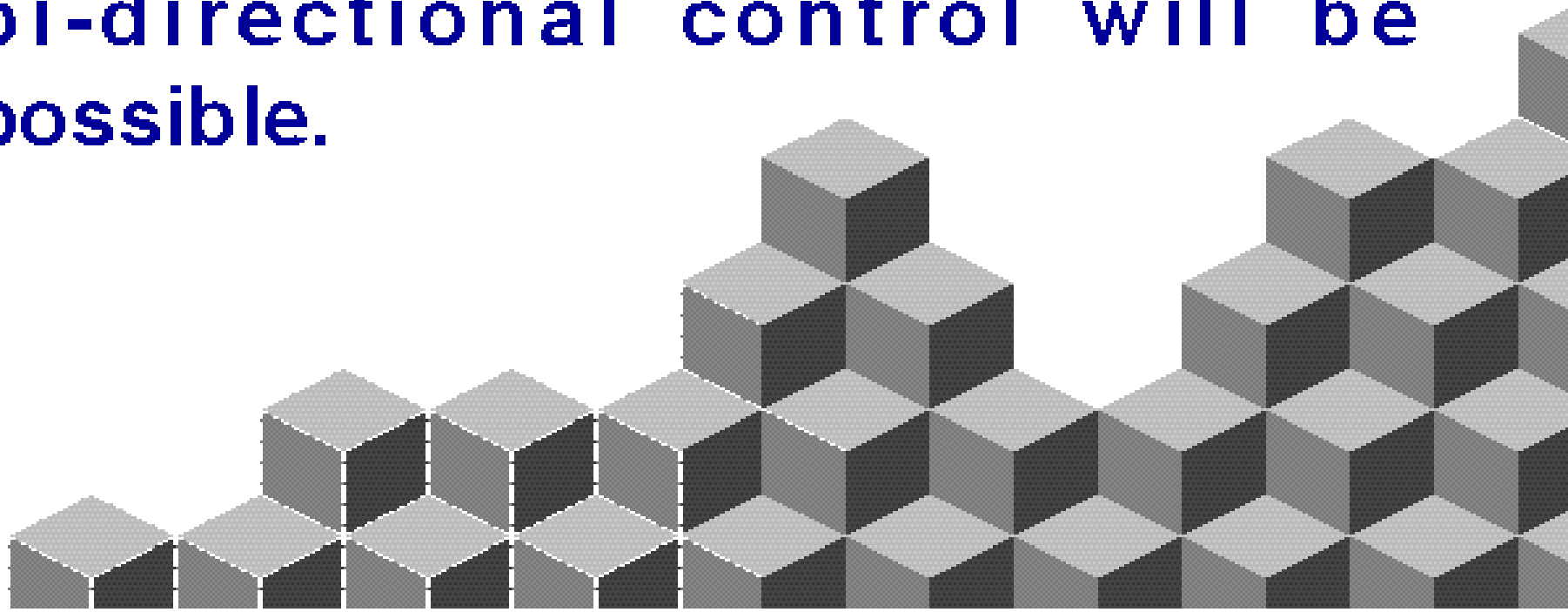
However, the data can also be stored within the person's profile so that subsequent actions and tests performed on the equipment can be customized to adjust to that specific individual's characteristics.
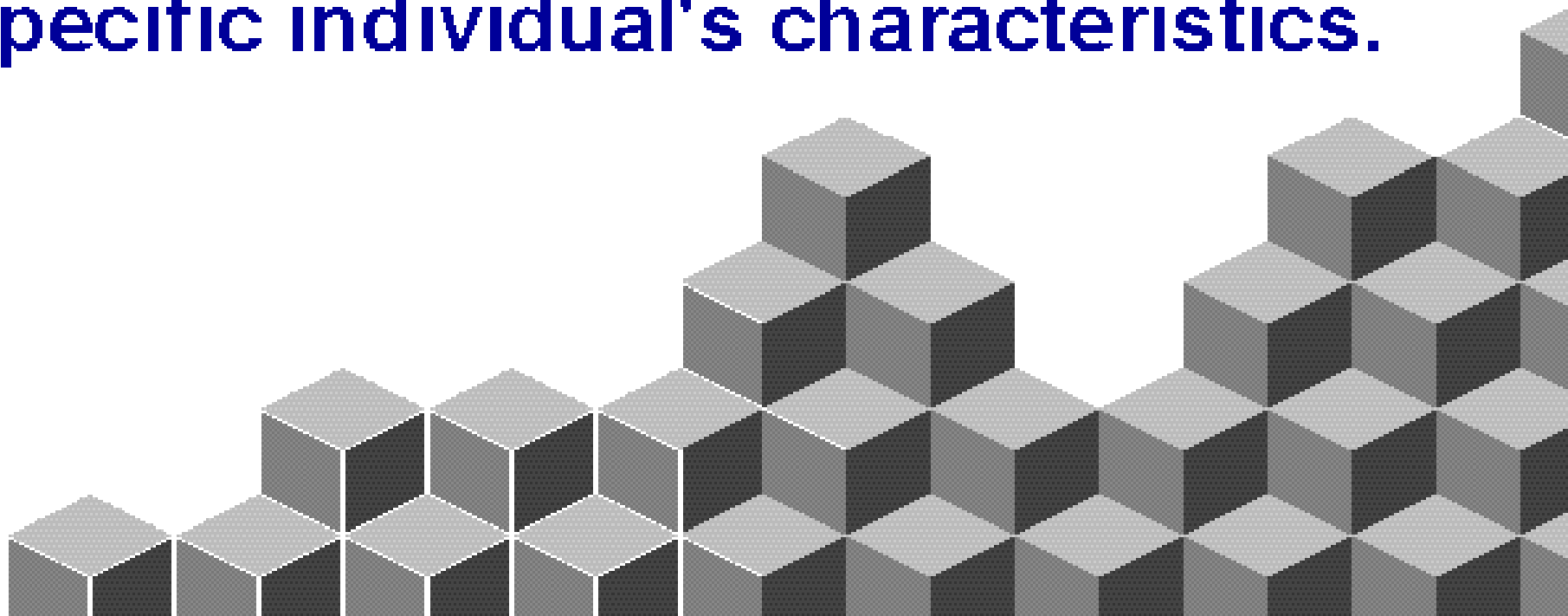
The data storage capability will be useful in the design of research protocols. The software will be designed to allow an investigator to "program" a specific series of exercises and the precise manner in which they are to be performed, e.g. number of repetitions, amount of work, etc.

The subject need only select his or her name from the graphic menu and the computer will then guide the procedures.
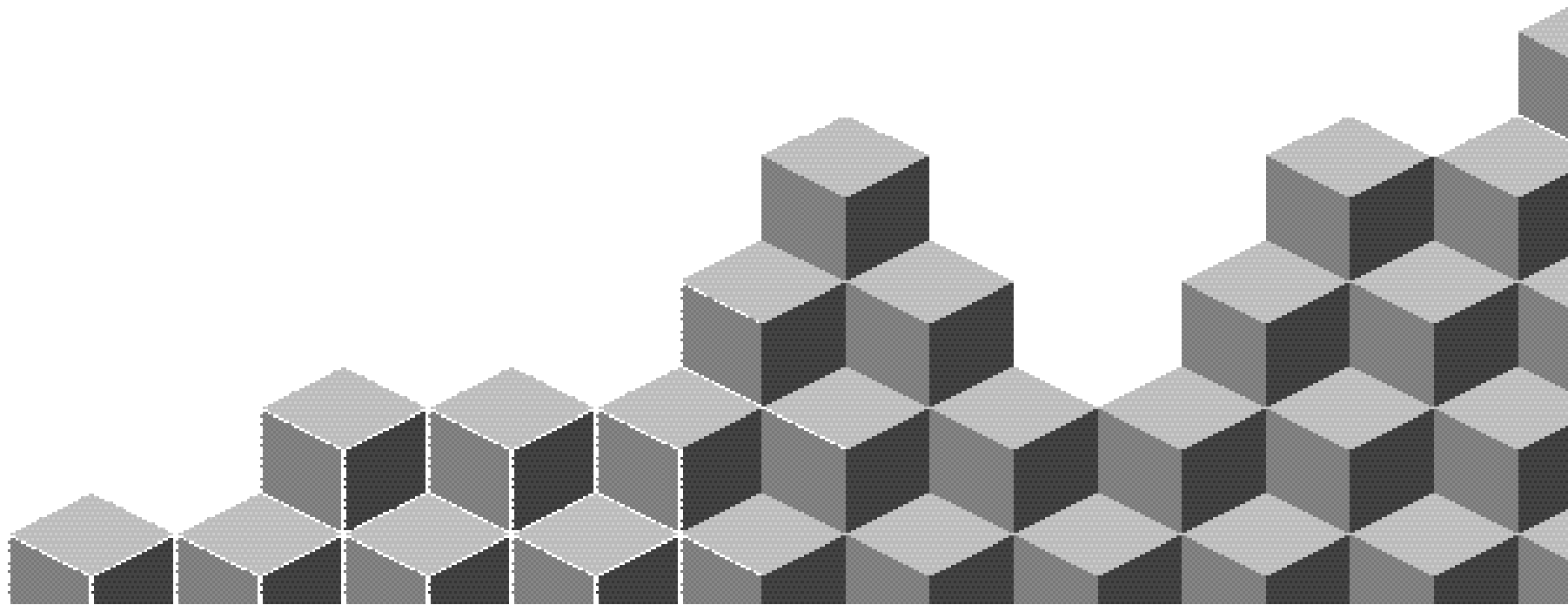
The controlled velocity option will permit the individual to control the speed of bar movement. The pattern of the velocity will be determined by the person using the equipment and these choices of velocity patterns will include:
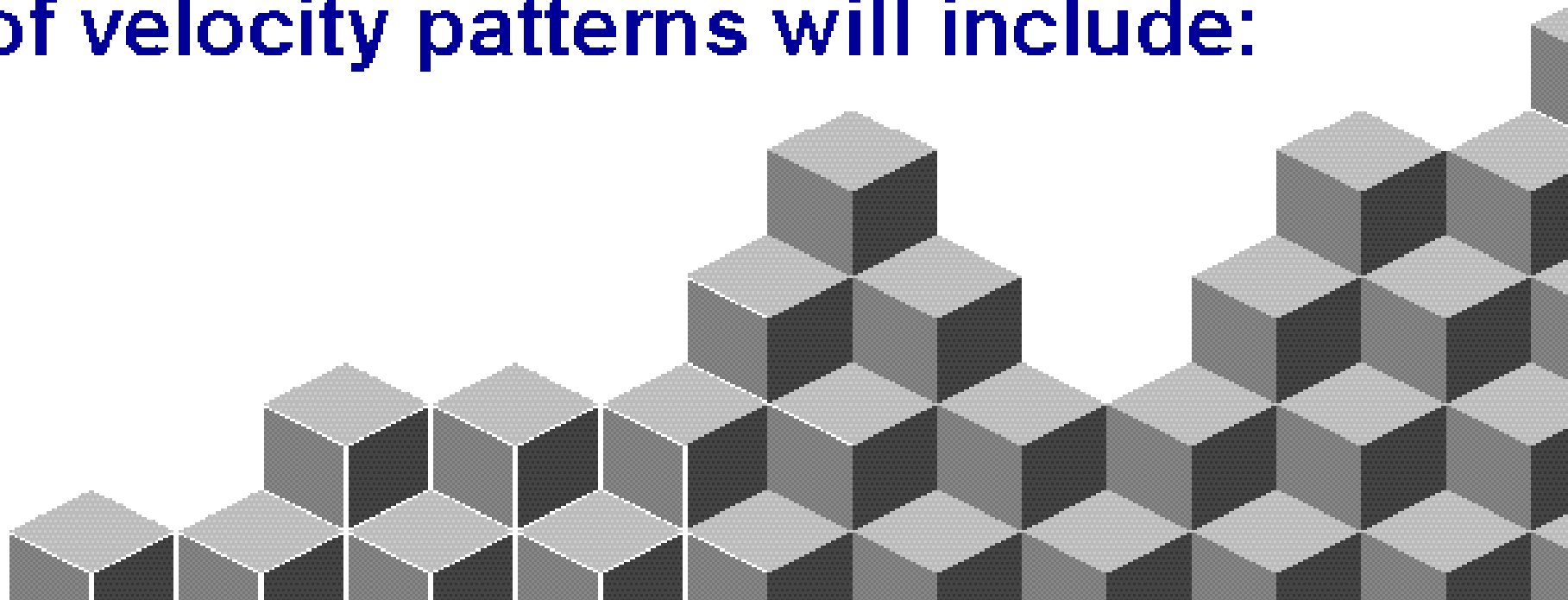
Velocity Mode:

- **Isokinetic,** which will provide a constant speed throughout the range of motion;
- **Variable speed,** in which the speed at the beginning of the motion and the speed at the end of the stroke are different with the computer regulating a smooth transition between the two values;
- **Programmed speed,** which will allow the user to specify a unique velocity pattern throughout the range of movement.

ISOKINETIC RESISTANCE CURVE OF A BENCH PRESS
PUSHING/PULLING MOVEMENT
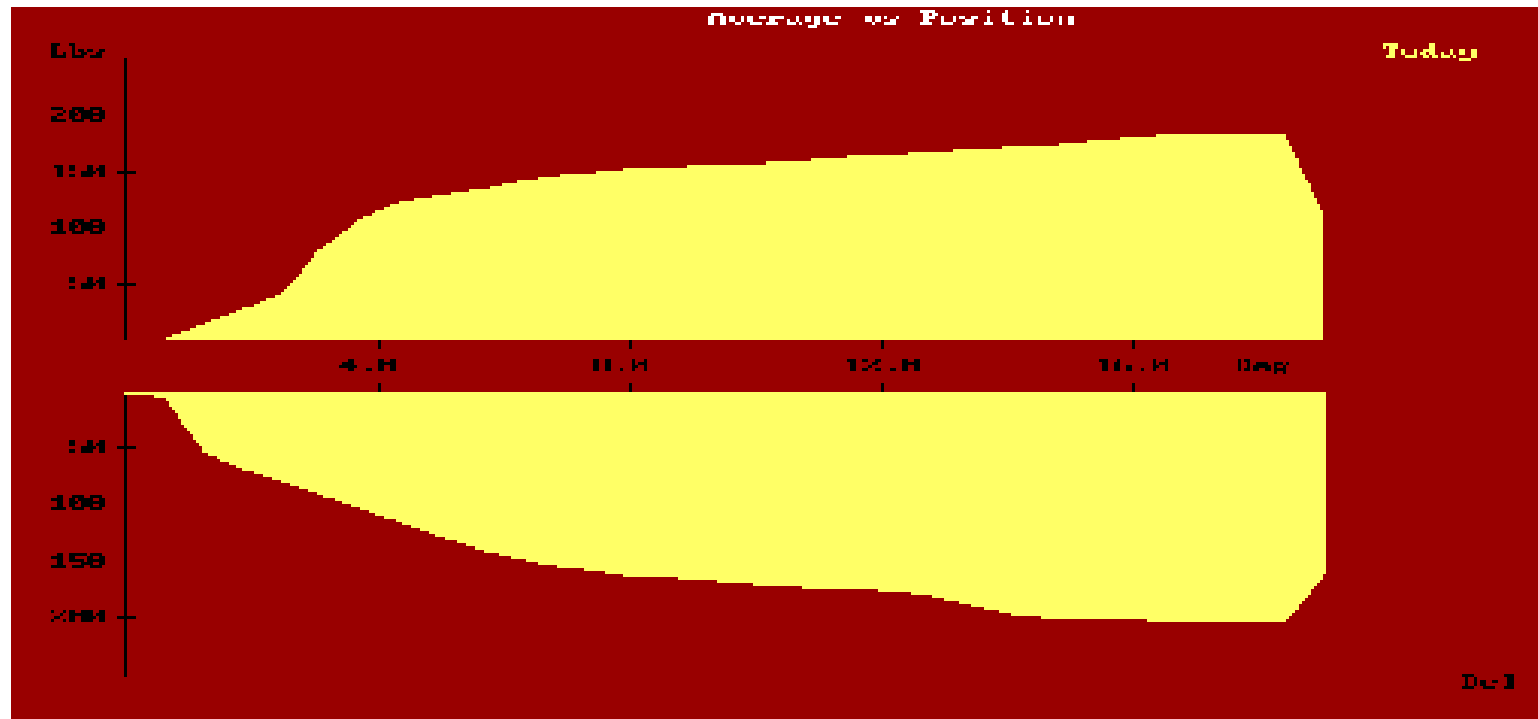
This graph displays the strength curve of an isokinetic (constant velocity) bench press pushing/pulling movement. Note that the is different shape and magnitude for the upper (pushing) curve when compared to the lower (pulling) curve. The force expression of the pushing curve is greater as the user moves through the range of motion (left to right in upper curve) The force expression of the pulling curve is very high at the start of the movement and falls off at the end of the movement (right to left in the lower curve).

Average vs Position
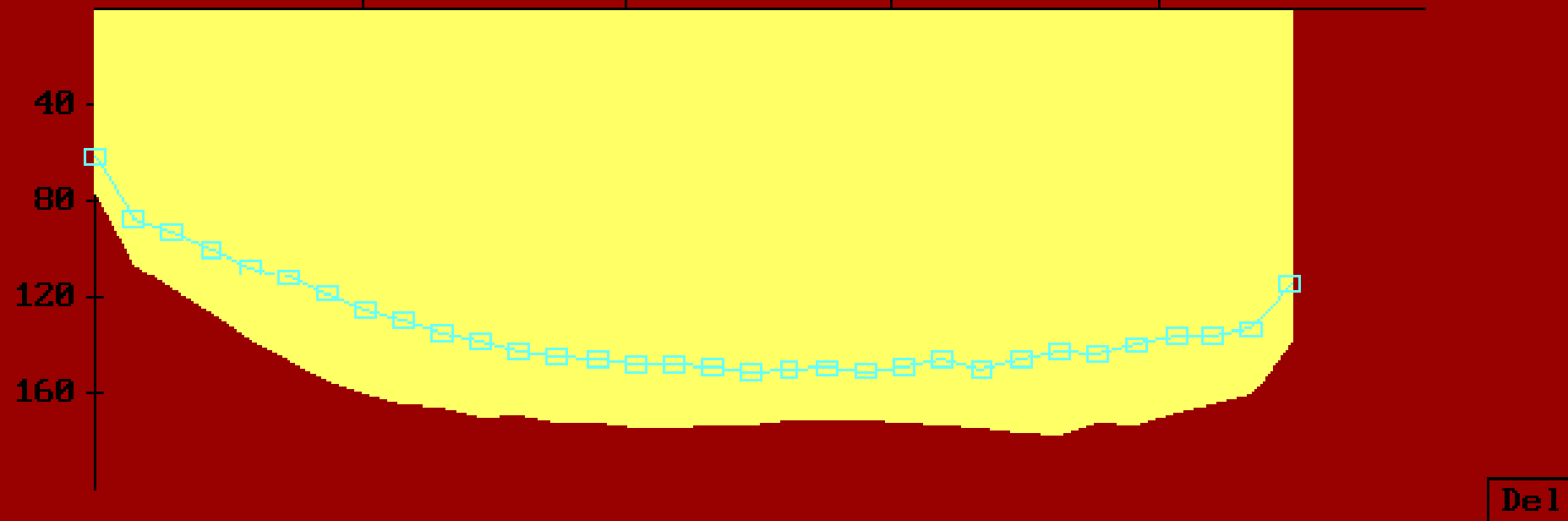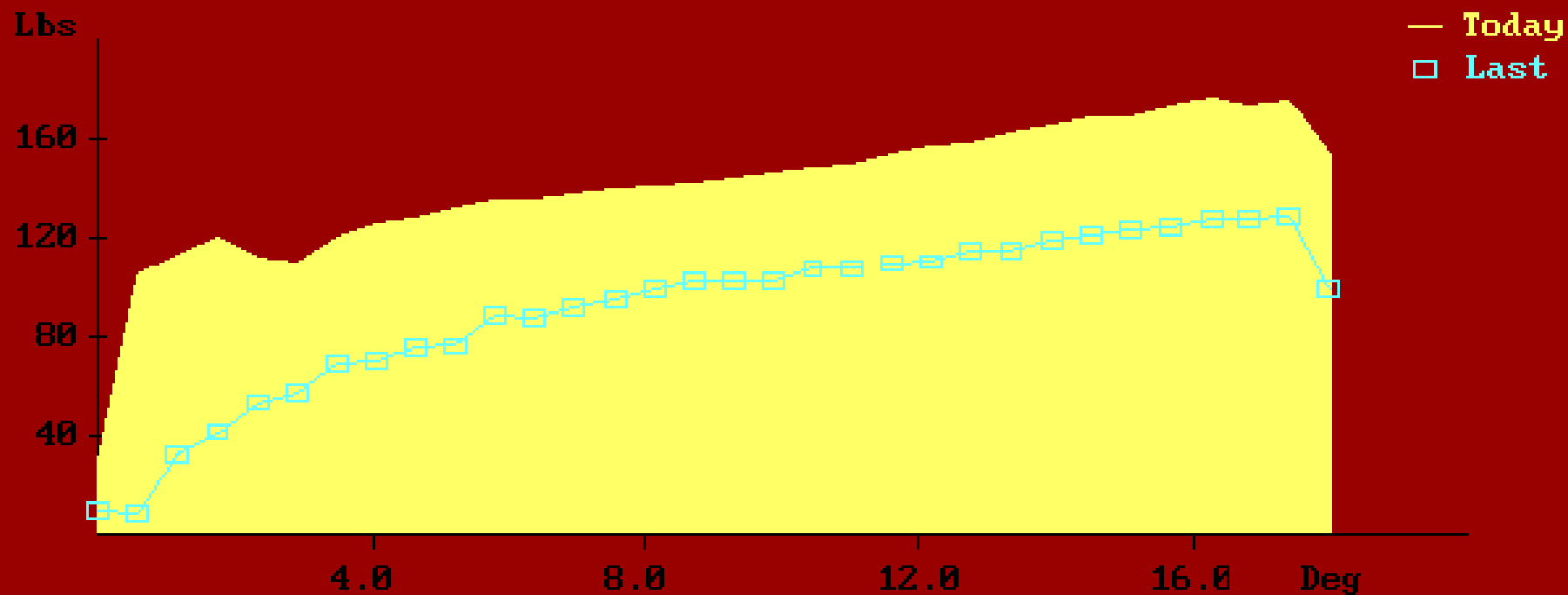
ACCOMMODATING VELOCITY CURVE FOR
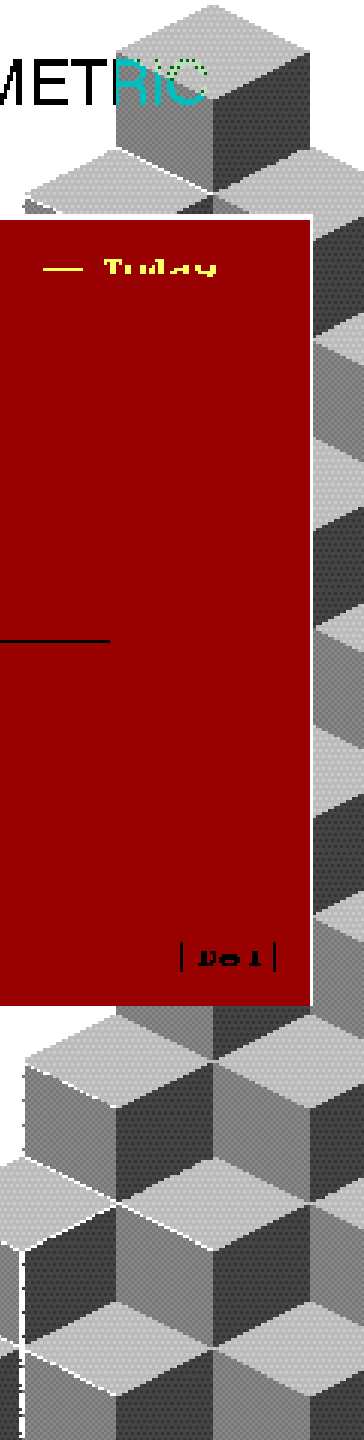# A BENCH PRESS PUSHING/PULLING MOVEMENT

This figure shows the velocity of the bench press/pull movement. The upper figure is the push part and the bottom figure represents the pull part of the bench press movement. The start of the push is at the left and the finish of the pushing movement is on the right. The start of the pull is at the right and the finish of the pulling movement is on the left. The velocity of the pressing movement increases throughout the movement until it reaches near the top where it naturally drops off sharply in anticipation of stopping the action. The pulling action graph of this body builder displays a small increase throughout the movement with an abrupt stop at the end of the pulling movement.

# A BENCH PRESS PUSHING/PULLING DYNAMIC-ISOMETRIC ISOMETRIC POINTS CURVE

This curve shows three sticking point isometric force applications coupled within a series of dynamic repetitions of the bench press/pull movement. Note the different shape of the push curve (top) compared to the shape of the pulling curve (bottom). The magnitude of the pushing sticking point forces is higher than the sticking point forces of the pulling action. This is to be expected in most people.

A "Fatigue" mode will allow the person to specify a decrement level so that when the performance deteriorates to the predefined value, the computer will terminate the exercise.
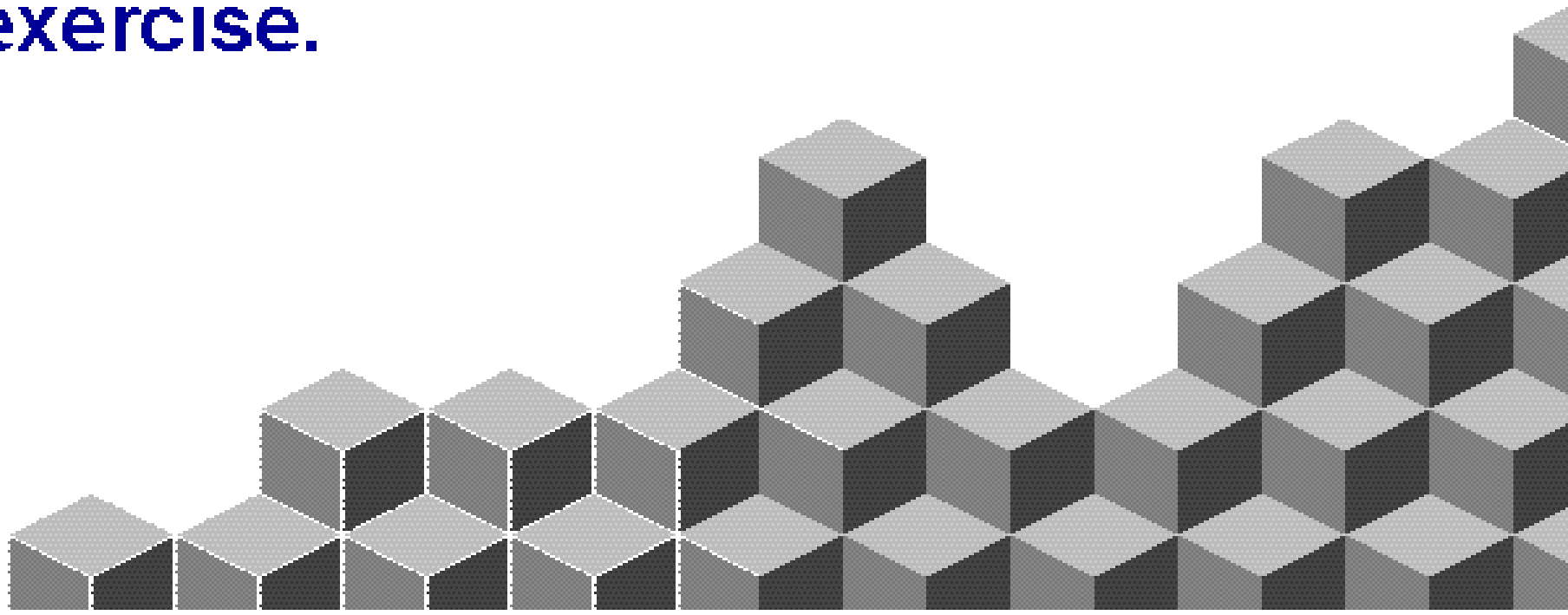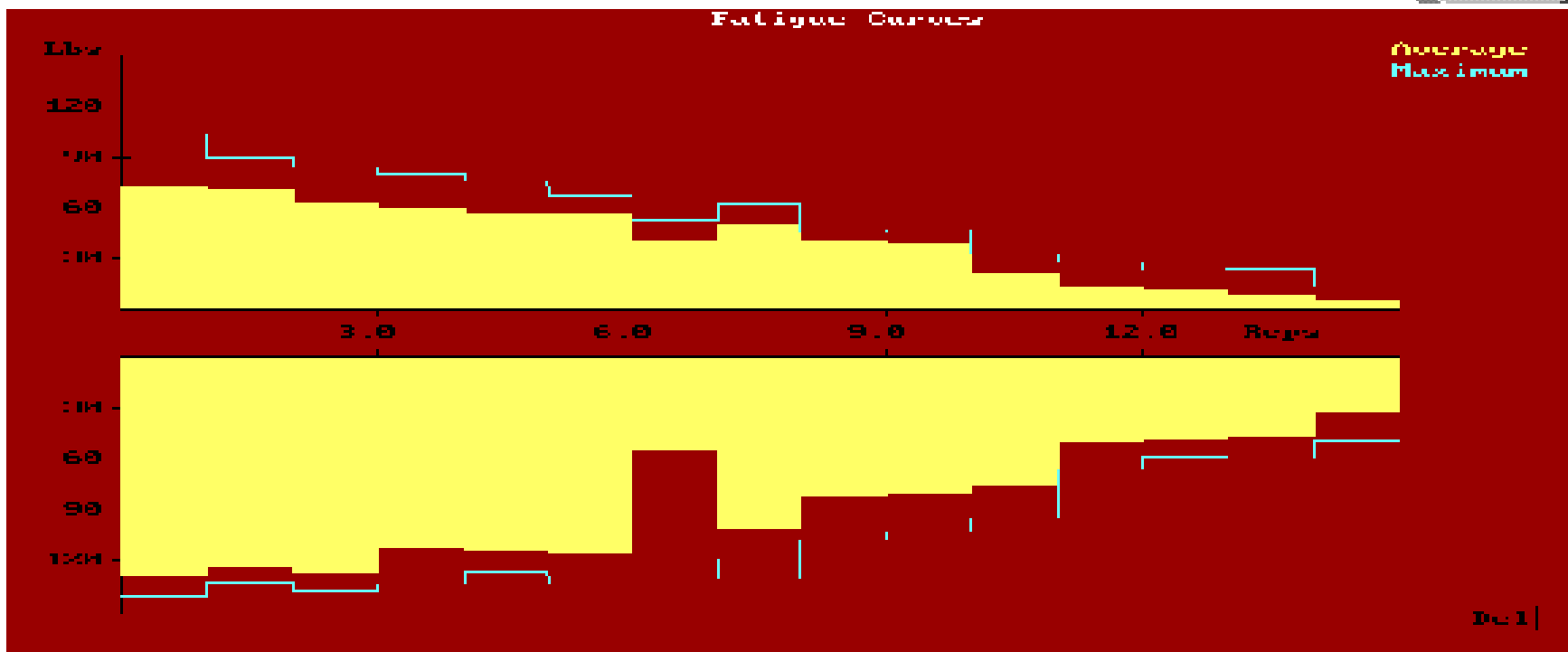
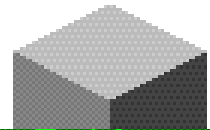# FATIGUE CURVE FOR A BENCH PRESS PUSHING/PULLING MOVEMENT
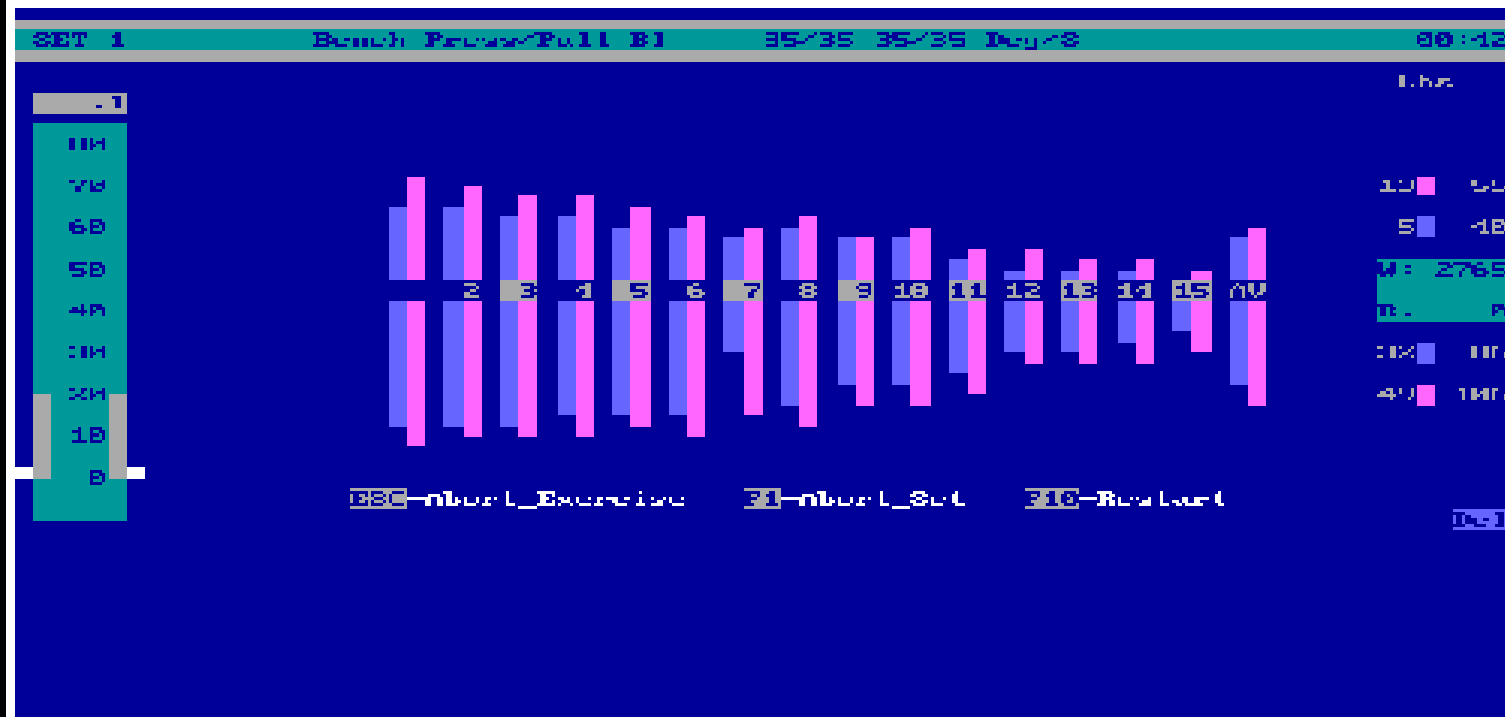
This bar graph displays a fatigue curve of a bench press/pull movement. There is a strength decrement as displayed on the bar graph moving from left to the right. The pushing action is represented by the bars on the top of the graph. The pulling action is depicted by the bottoms of the graph. The body builder can set the level of fatigue as they desire to insure that a specific objective (strength, mass, cutting or shaping) will be obtained.

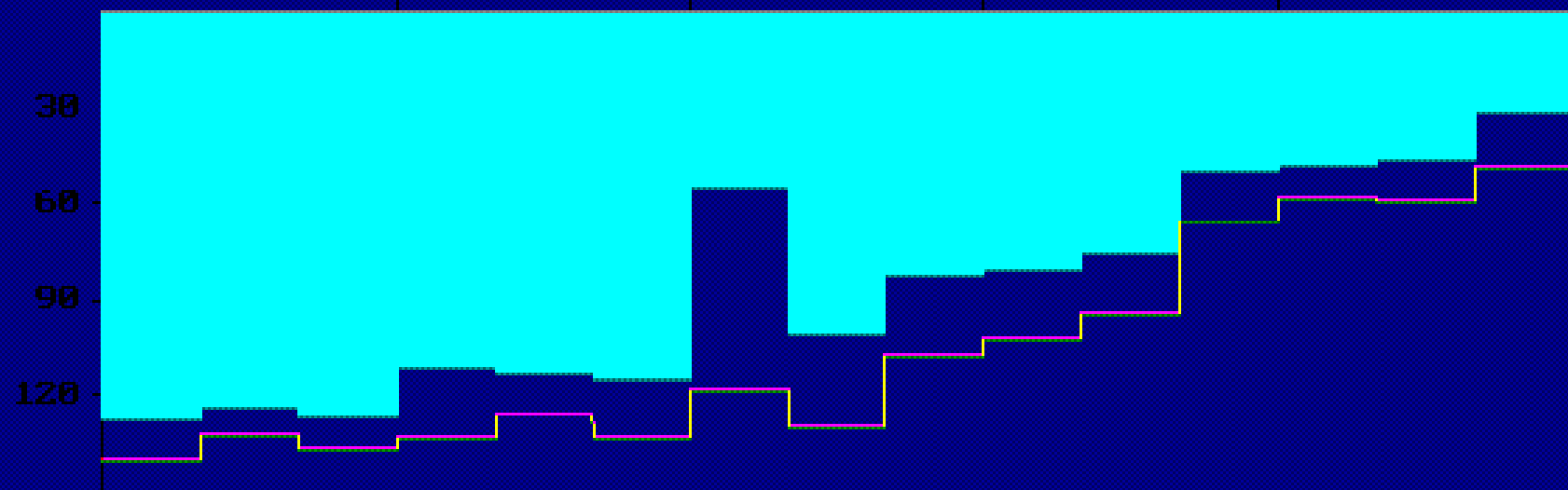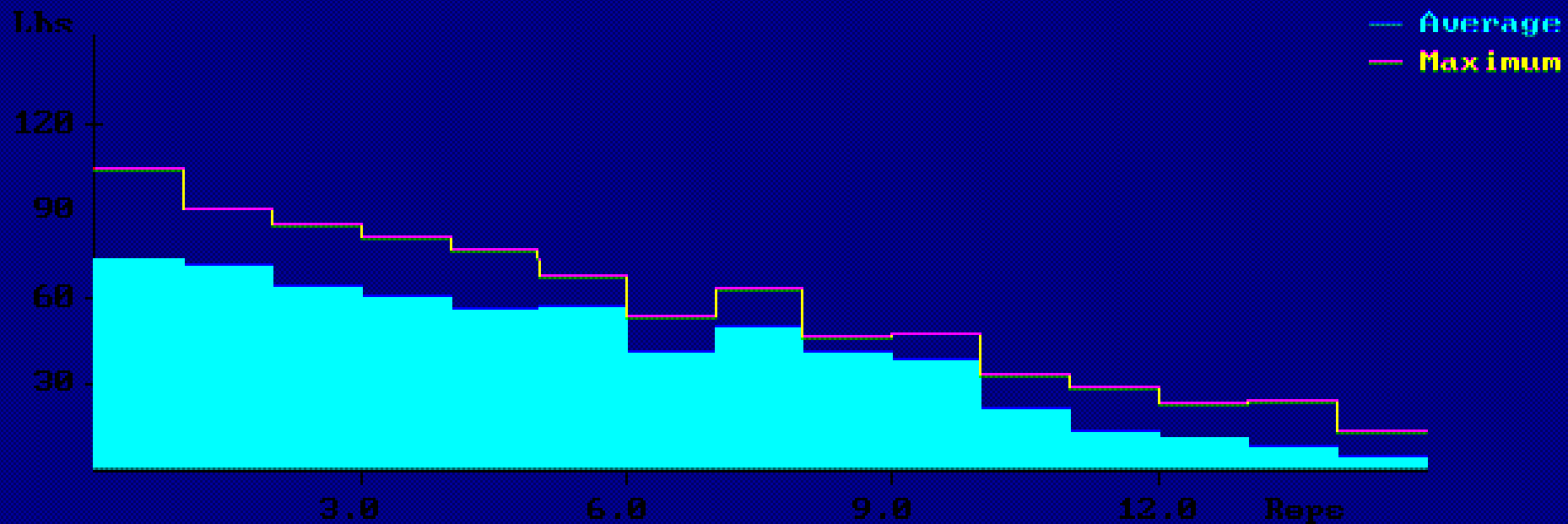# FATIGUE CURVE FOR A BENCH PRESS PUSHING/PULLING MOVEMENT

This graph displays a fatigue curve of a bench press/pull movement. The top graph is for the pushing action. The lower graph is for the pulling movement. There is a strength decrement as displayed on the graph moving from left to the right. The solid yellow displays the fatigue level and the white line show the maximum strength at each succeeding repetition. The body builder can set the level of fatigue as they desire to insure that a specific objective (strength, mass, cutting or shaping) will be obtained.

Fatigue Curves
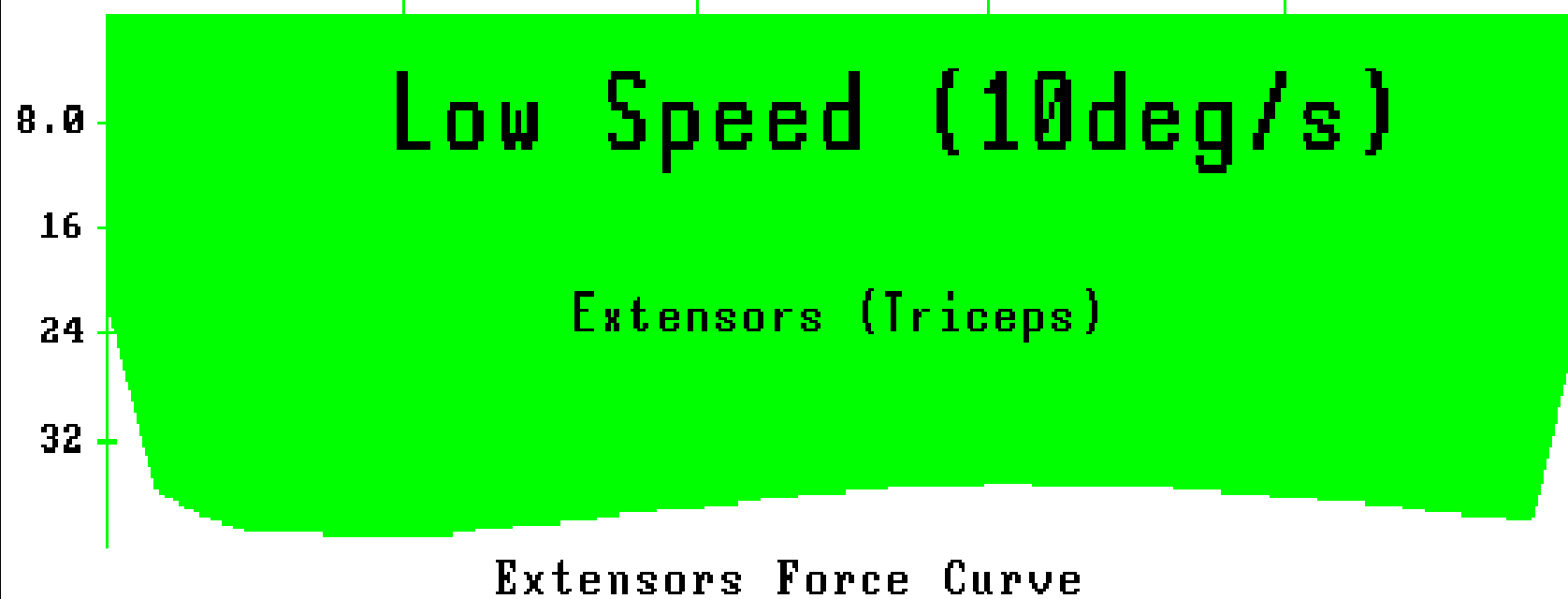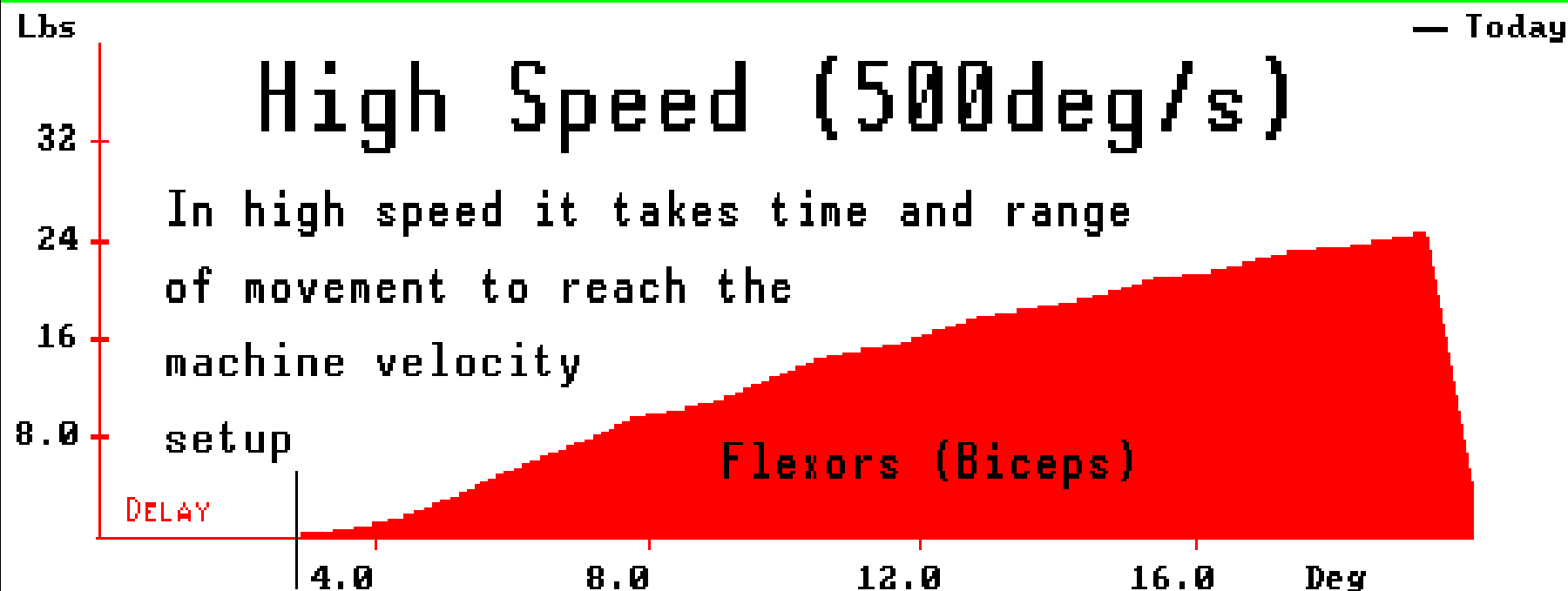
— Today

Lbs

High Speed (500deg/s)

In high speed it takes time and range
of movement to reach the
machine velocity
setup

DELAY

Flexors (Biceps)

32
24
16
8.0

4.0   8.0   12.0   16.0   Deg

Low Speed (10deg/s)

Extensors (Triceps)

8.0
16
24
32

Extensors Force Curve

Del

File: D:\USERFILES\GIDEON   Maxf Up: 200   Dn: 200   Ex#: 1/ 1

User: Gideon Ariel   Maxv Up: 75   Dn: 75   Range: 0

Stick[F1] Ideal[F2] Target[F3] Pyramid[F4] Power[F5] Dip[F6] Emg[F7] Last[F8]

Station: ↑↓ Multi   Exercise: ↑↓ BENCH PRESS   Limbs: ↑↓ Bi

Start_Pos: ↑↓ Low   Mode: ↑↓ VARIABLE VELOCITY   Start_Type: ↑↓ Float

Ctl_Curve: ↑↓ Linear   UP: 25/100   DN: 25/ 25   Rep/Time: ↑↓ Reps

Reps: 5   #Sets: 1   Time_Between: 0

Plot 1st: ↑↓ 1st   Plot 2nd: ↑↓ 2nd   Plot 3rd: ↑↓ 3rd

Del-Delete   Esc-Abort   PgUp-Last   PgDn-Next   F9-Diag   End-Done

Use ← → Keys to Highlight Desired Field, Then Enter a Number. ↑↓
Indicates a Rotating Field. Active Special Keys Are Listed Above.

Force Mode

The controlled resistance option will enable the person to control the resistance or amount of force required to move the bar. The alternatives will include:
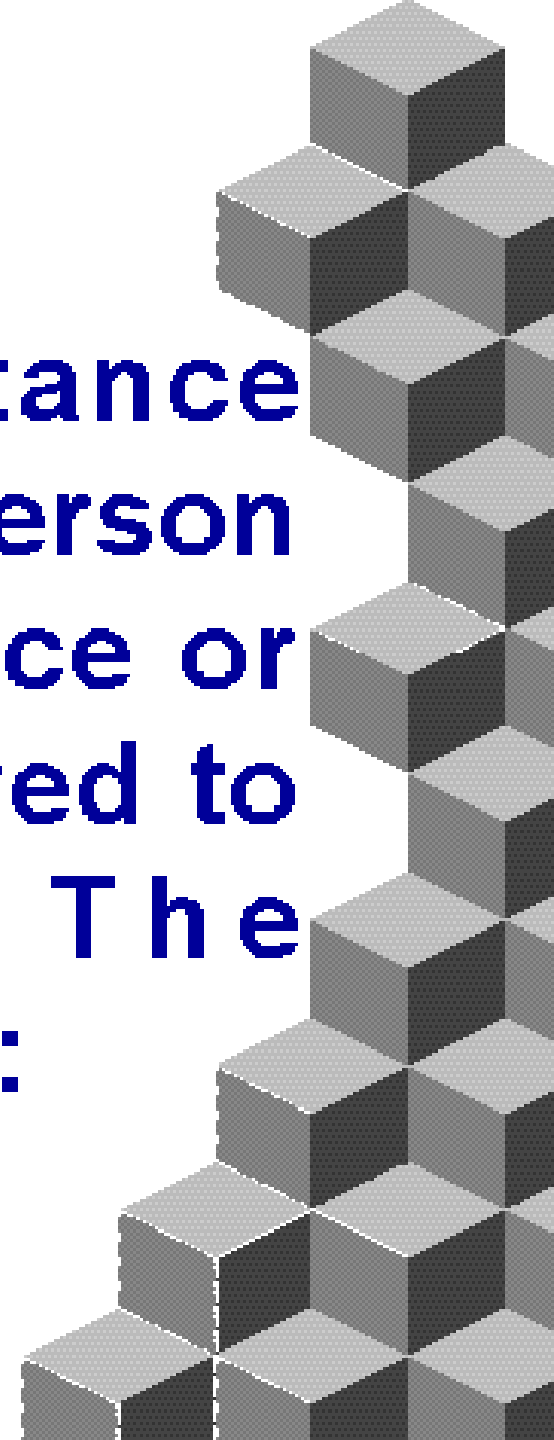
Variable Force Mode:

- **The controlled resistance** option will enable the person to control the resistance or amount of force required to move the bar.
- **Variable resistance,** in which the force at the beginning of the motion and the force at the end of the movement are different with the computer regulating a smooth transition between the two values;
- **Programmed resistance,** which will permit the individual to specify a unique force pattern throughout the range of movement.
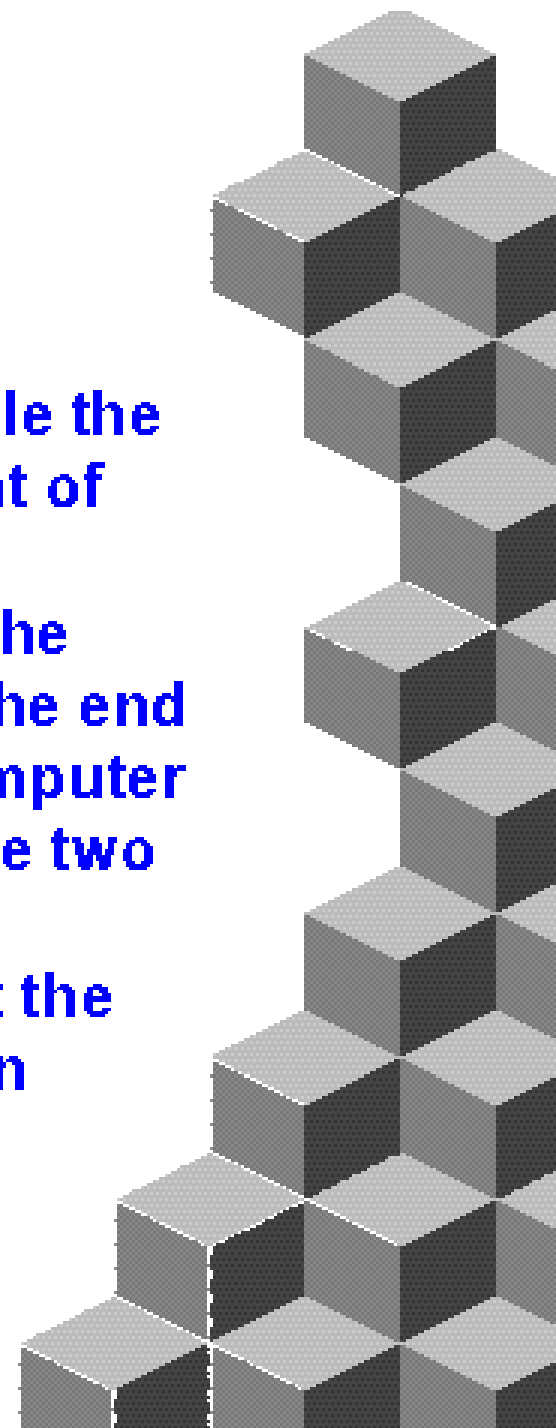
File: D:\USERFILES\GIDEON   Maxf Up: 200   Dn: 200   Ex#: 1/ 1

User: Gideon Ariel   Maxv Up: 75   Dn: 75   Range: 0

Stick[F1] Ideal[F2] Target[F3] Pyramid[F4] Power[F5] Dip[F6] Emg[F7] Last[F8]

Station: ↑↓ Multi   Exercise: ↑↓ BENCH PRESS   Limbs: ↑↓ Bi

Start_Pos: ↑↓ Low   Mode: ↑↓ VARIABLE RESISTANCE   Start_Type: ↑↓ Float

Ctl_Curve: ↑↓ Linear   UP: 25/100   DN: 25/ 25   Rep/Time: ↑↓ Reps

Reps: 5   #Sets: 1   Time_Between: 0

Plot 1st: ↑↓ 1st   Plot 2nd: ↑↓ 2nd   Plot 3rd: ↑↓ 3rd

Del-Delete Esc-Abort PgUp-Last PgDn-Next F9-Diag End-Done

Use ← → Keys to Highlight Desired Field, Then Enter a Number. ↑↓
Indicates a Rotating Field. Active Special Keys Are Listed Above.

ACCOMMODATING RESISTANCE CURVE OF A BENCH PRESS PUSHING/PULLING MOVEMENT WITH COMPARISON OF DIFFERENT TRAINING SESSIONS
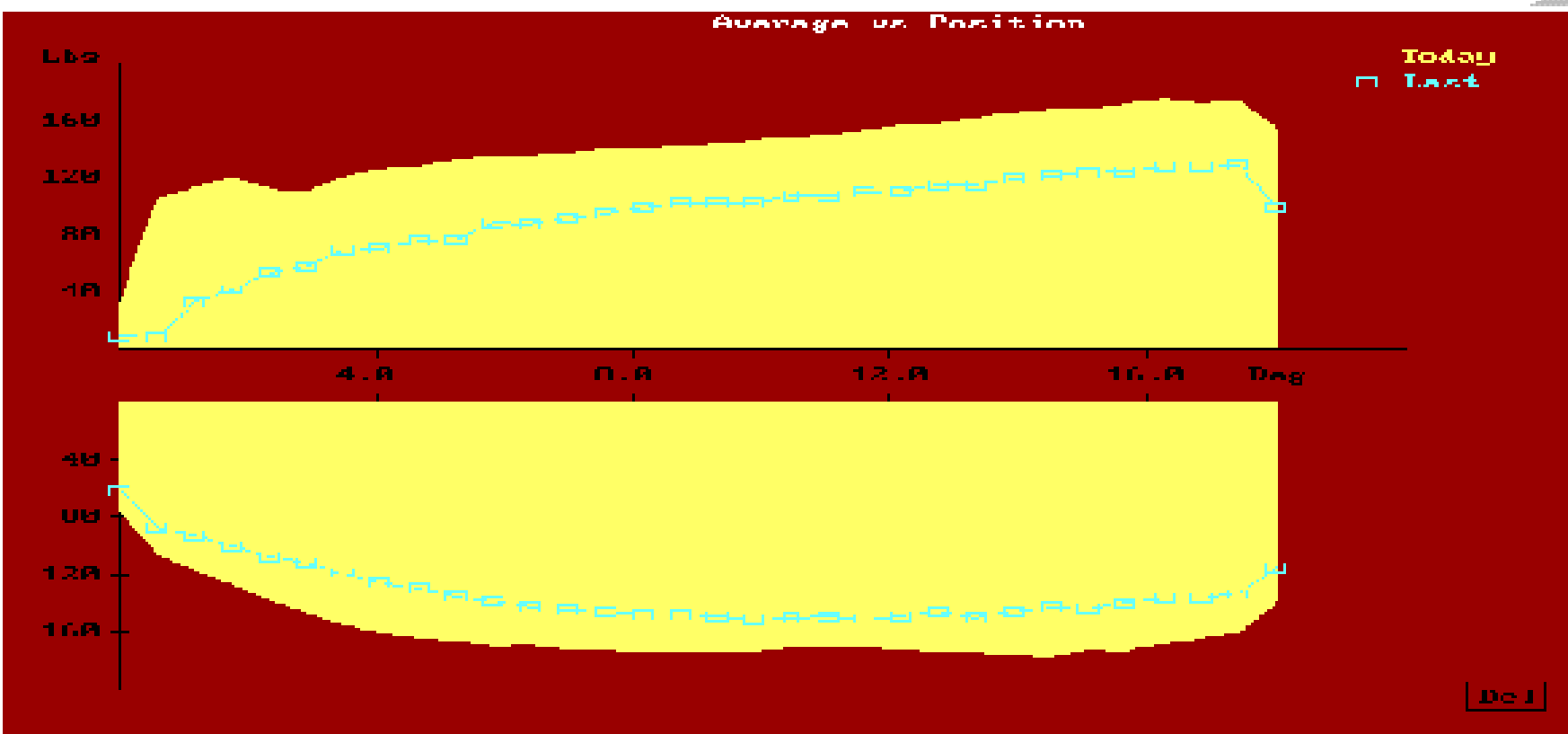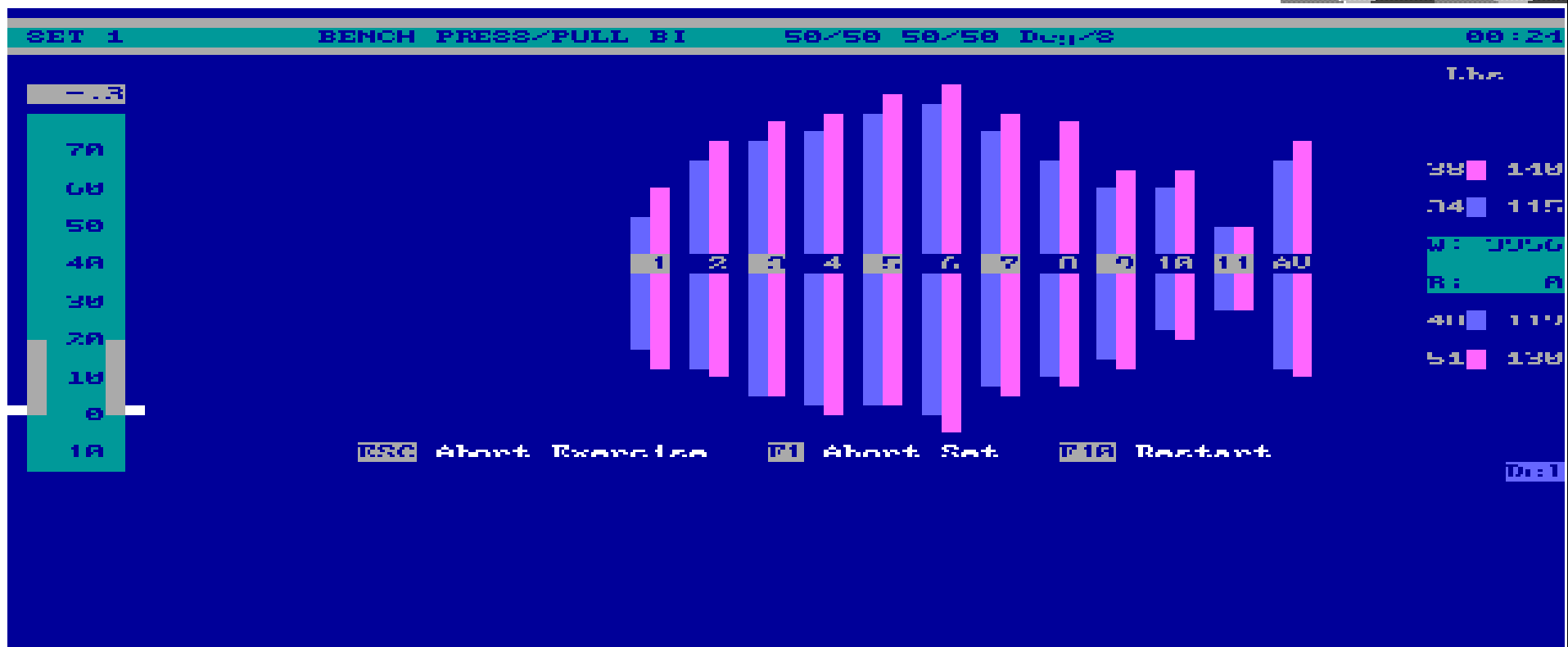
A BAR GRAPH OF A BENCH PRESS PUSHING/PULLING ACTION DEMONSTRATING AN ASCENDING PYRAMID IN SPECTRUM TRAINING
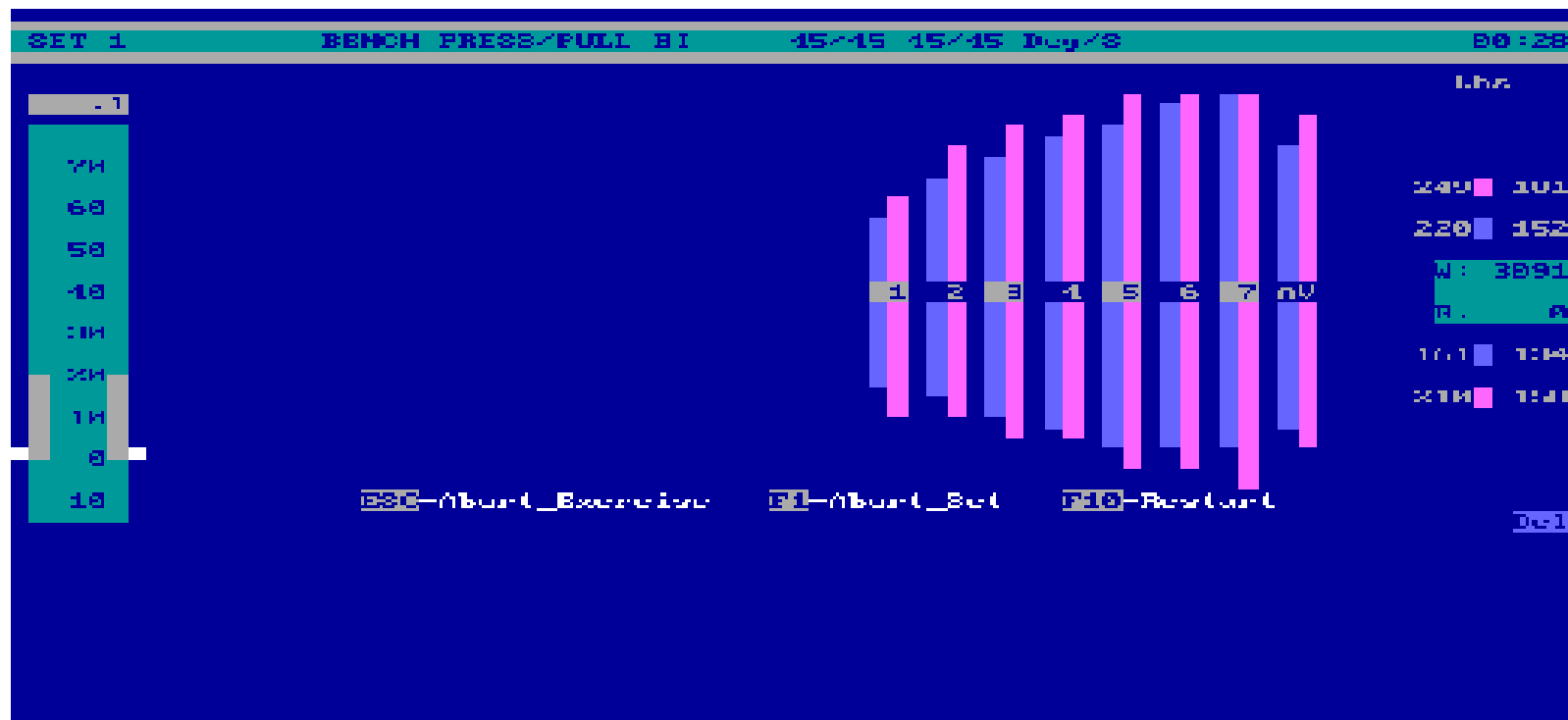
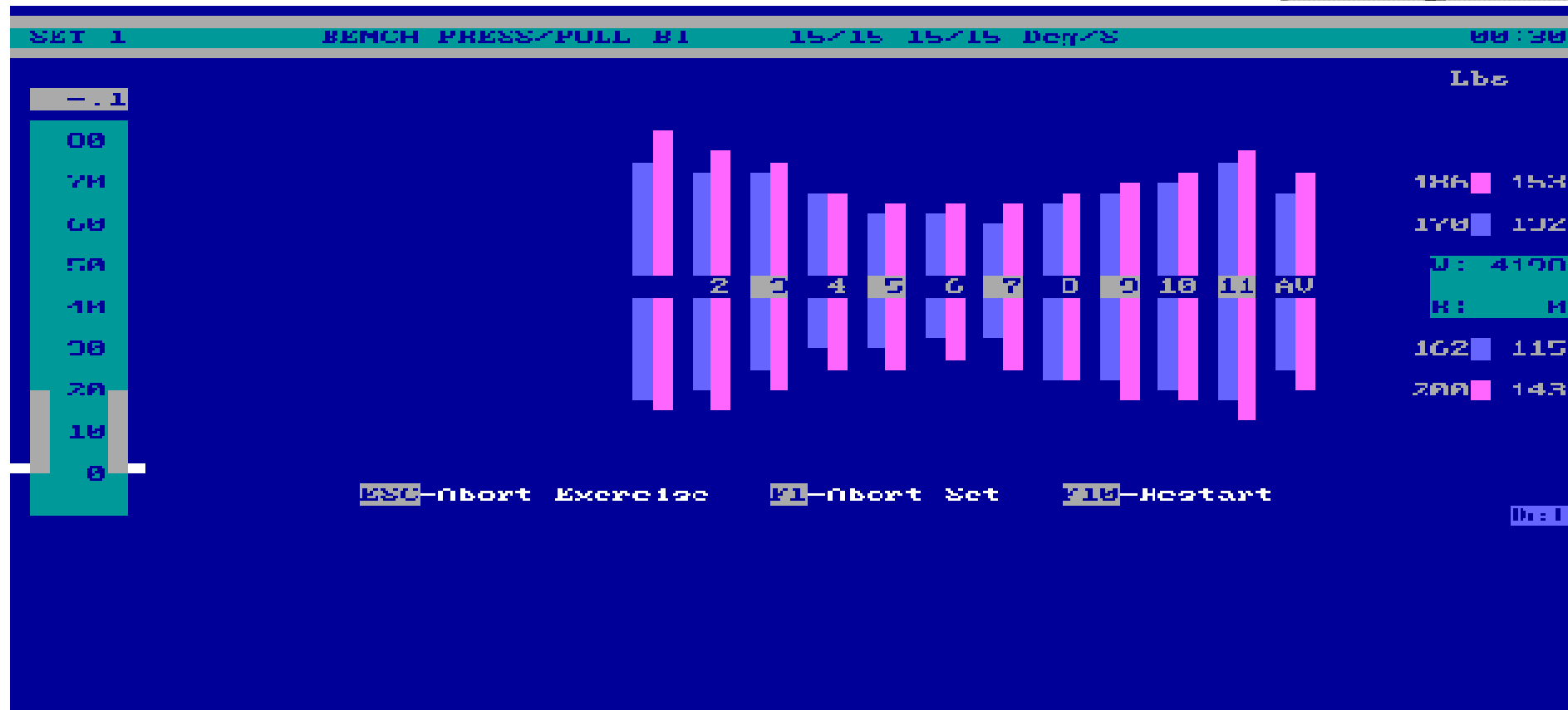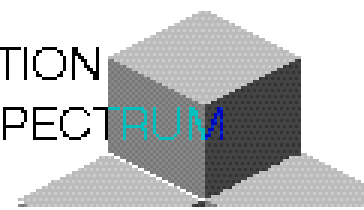

This graph displays the computer programing of increasing resistance of the pushing and pulling actions of the bench press/pulling movement for each succeeding repetition of an ascending pyramid in spectrum training. The graph shows the pushing movement force on the top and the pulling movement force underneath. Work, range of motion and average force for each repetition are also displayed.

A BAR GRAPH OF A BENCH PRESS PUSHING/PULLING ACTION DEMONSTRATING AN ASCENDING/DESCENDING PYRAMID IN SPECTRUM TRAINING
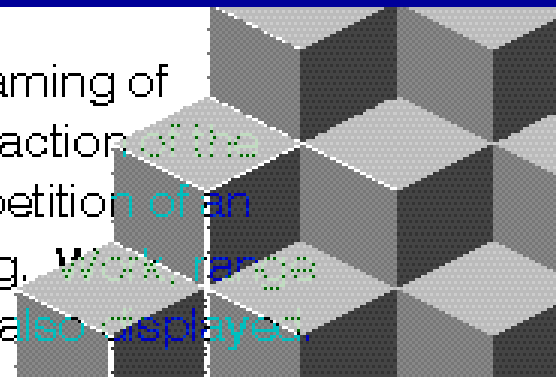

This bar graph displays the computer programing of increasing/decreasing resistance of the pushing action of the bench press movement and the pulling movement for each succeeding repetition of an ascending/descending pyramid in spectrum training. Work, range of motion and average force for each repetition are also displayed.

A BAR GRAPH OF A BENCH PRESS PUSHING/PULLING ACTION DEMONSTRATING AN DESCENDING/ASCENDING PYRAMID IN SPECTRUM TRAINING

This bar graph displays the computer programing of decreasing/increasing resistance of the pushing action of the bench press movement for each succeeding repetition of an descending/ascending pyramid in spectrum training. Work range of motion and average force for each repetition are also displayed.

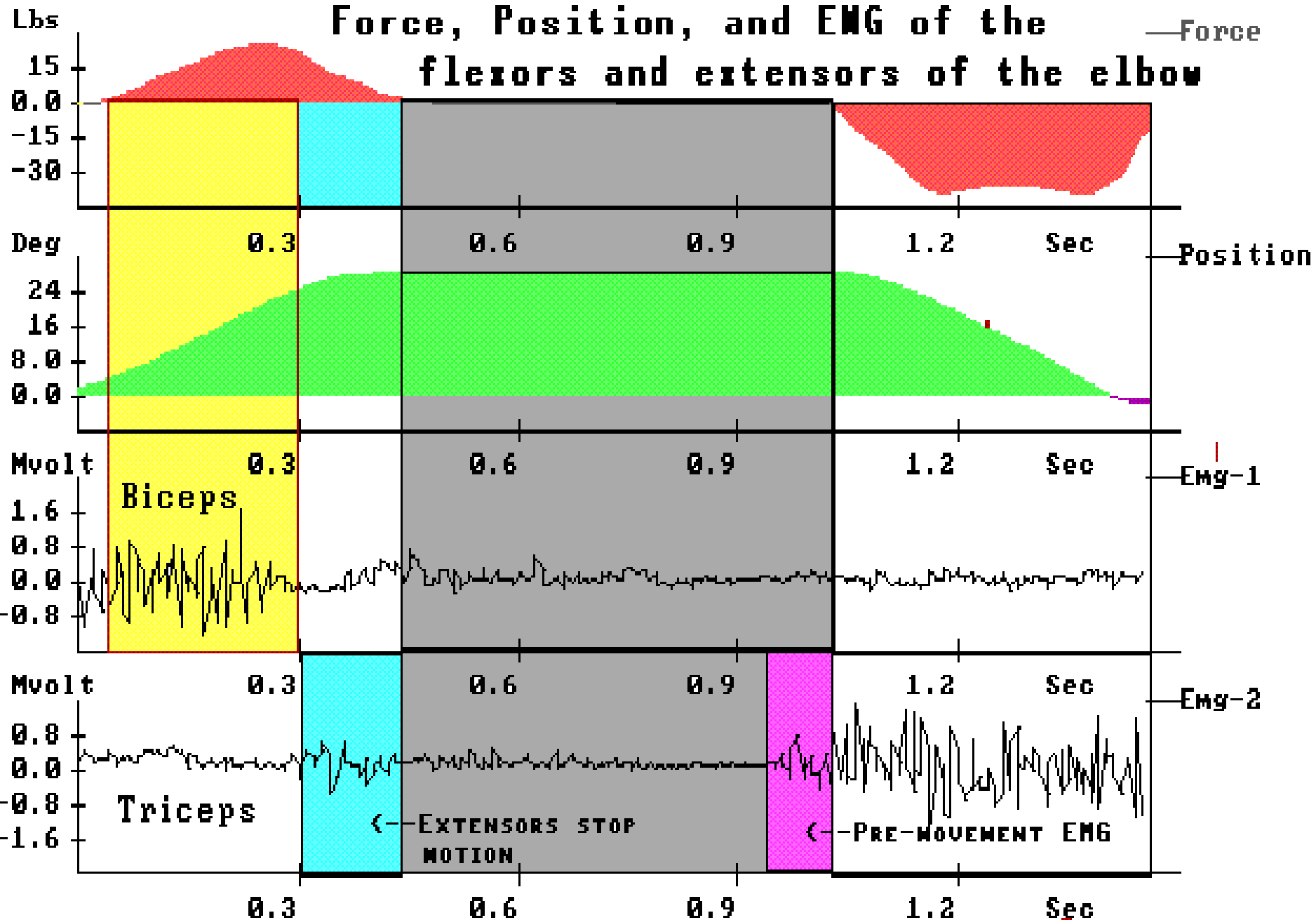# CURVE PLOTS FOR SUCCEEDING REPETITIONS OF A BENCH PRESS PUSHING ACTION IS AN ASCENDING PYRAMIDING PROGRAM IN SPECTRUM TRAINING
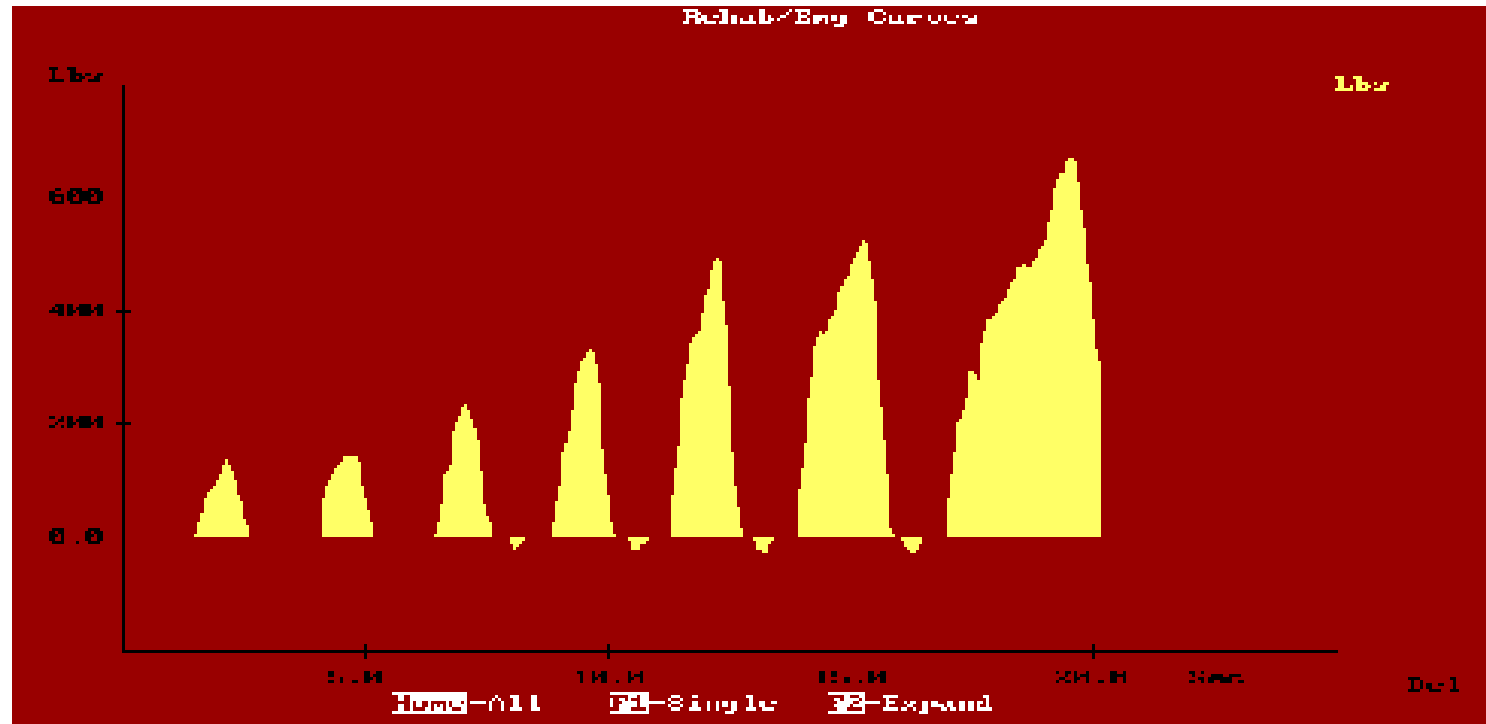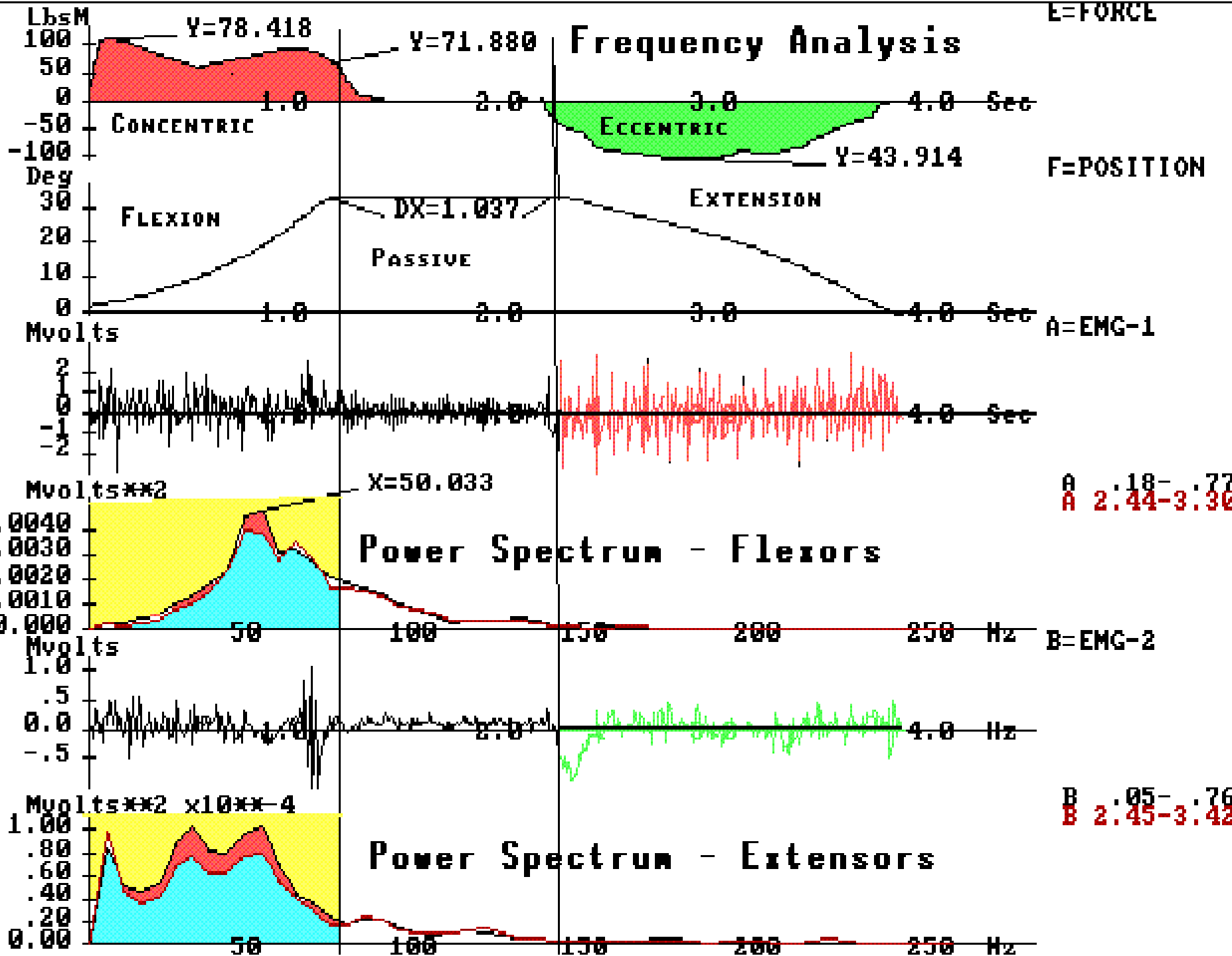

This graph displays the curve plots of the computer programing of increasing resistance of the pushing action of the bench press movement for each succeeding repetition of an ascending pyramid in spectrum training.

Force, Position, and EMG of the flexors and extensors of the elbow

Frequency Analysis

E=FORCE

LbsM
Y=78.418
Y=71.880

CONCENTRIC
ECCENTRIC
Y=43.914

F=POSITION

Deg
FLEXION
DX=1.037
EXTENSION
PASSIVE

A=EMG-1

Mvolts

A 2:18-2:77
A 2:44-3:30

Mvolts**2
X=50.033

Power Spectrum - Flexors

B=EMG-2

Mvolts

B 2:05-2:76
B 2:45-3:42

Mvolts**2 x10**-4

Power Spectrum - Extensors
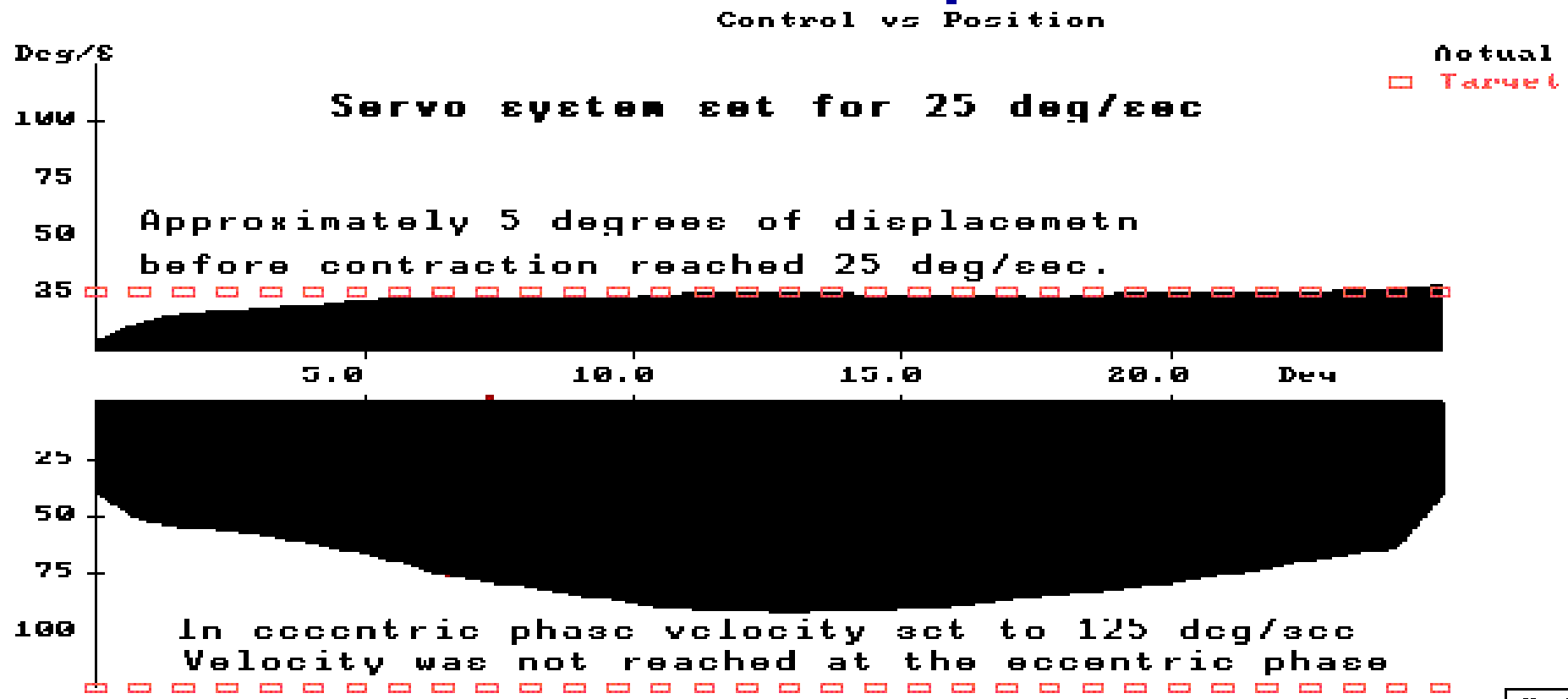
Calibration

Accuracy of measurement is essential and it is deemed as one of the most important considerations in the software development.

Control vs Position

Deg/S

Actual
☐ Target

100

75

Servo system set for 25 deg/sec

50

Approximately 5 degrees of displacemetn
before contraction reached 25 deg/sec.

35

5.0   10.0   15.0   20.0   Deg

25

50

75

100

In eccentric phase velocity set to 125 deg/sec
Velocity was not reached at the eccentric phase

Del

Versatility

* **Bidirectional**