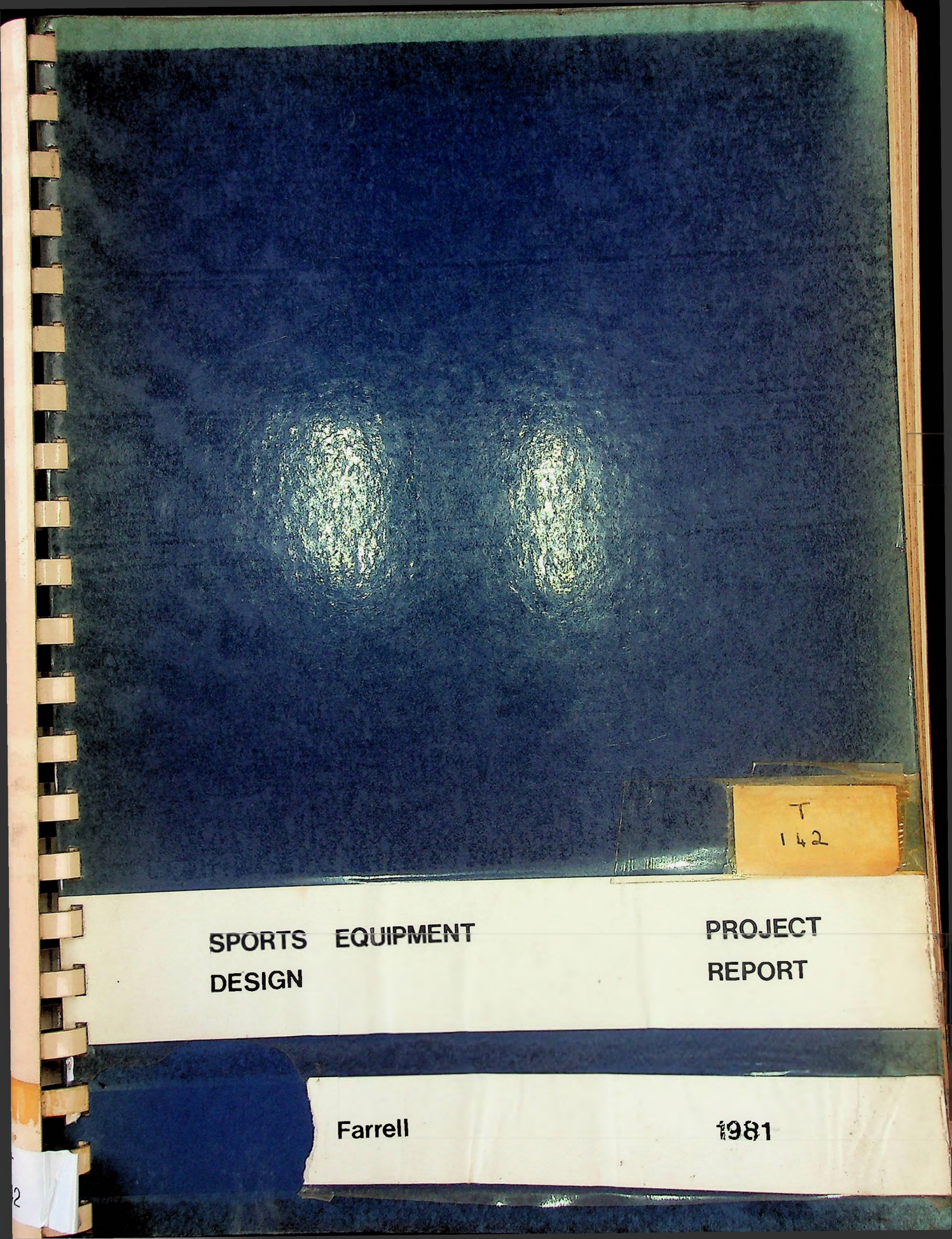


T
142

SPORTS EQUIPMENT DESIGN

PROJECT REPORT

Farrell

1981

T142

PROJECT REPORT

ISOTONIC RESISTANCE EXERCISE EQUIPMENT DESIGN

BRENDAN FARRELL - INDUSTRIAL DESIGN

TABLE OF CONTENTS

INTRODUCTION

INTRODUCTION:

1.1. The first proposal titled "POWER PACK" was concerned with developing an electrical system (portable) to be used in caravans, boats, etc., Research into the area of accumulators give litte or no information because of the nature of the product. Outline power requirements made size of system based on existing units too large. The major reason for work in this area was to try and improve safety, and reduce the risks of fire, connected with using gas. The proposed system would involve a portable power pack that would be of secondary cell nature (rechargable). The retailer would be supplied with a recharge unit and a quantity of batteries. This system would eliminate a lot of the interface between manufacturer and retailer, and allow more control over supply and demand.

Following advice from Mr. Gorman concerning the problems in Data collection the project was shelved and the new proposal submitted. The new proposal was formed from looking at the areas I have been most involved in during the past. My concern was to select an area rather than a specific product.

1.2 THE PROJECT

The nature of this project is as a result of a submitted proposal titled "SPORTS EQUIPMENT DESIGN".

The proposal outlines the area in which the design work is to be carried out. Definition of the work area is detailed in the design brief.

BRENDAN FARRELL,
FACULTY OF DESIGN
DEPARTMENT OF INDUSTRIAL DESIGN

SPORTS EQUIPMENT DESIGN

1.3 Motivation (1)

1.1 Most of my life I have been involved in sports. Without doubt it is a growing area and also an essential activity for man.

1.2 Ireland requires small, low-invested industries. My final design proposal will be developed with this in mind.

1.3 Pending my qualification I would like to diversify into as many areas of manufacturing industry as possible. In that respect I would see myself as more of a freelance than in-house designer. The eventual aim is to establish a good design consultancy that caters for both large and small industries.

1.4 Following my Co-op period and other industrial contacts I feel it essential to enhance communications with industry. Hopefully this project will cultivate a mutual benefit in this respect.

Project Aims (2)

2.1 To present my final solution in a way that will be both explanatory and informative.

2.2 To develop to a working prototype stage my final stage.

2.3 To show by ability as a designer in a real sense rather than in an ideal design situation

2.4 To achieve a good blend of engineering and design in my final solution.

Introduction to the project (3)

In any aspect of group or singular sport, physical development and training aids are always required. This area I believe has been neglected in Ireland and doubtless in many other countries. Factors such as cost, availability, and adaptability often restrict the choice of training equipment. Demands both state and social, for sports involvement and education, give rise to the need for a comprehensive range of equipment. It may well be that one design could cater for almost any sport. The design problem would then be to identify the common needs in the various sports. Aside from an effective solution, these are the important factors I am looking for in my final design

a. Safety
b. Good Ergonomics
c. Ease of Manufacture
d. Hygiene and ease of maintenance
e. East of installation

Project Procedure (4)

Jan. 1981 Research and data collection. Data analysis.

Feb. 1981 Final brief. Preliminary design stages.

Mar. 1981 Design development. First prototypes.

Apr. 1981 Final design development.
Prototype.

May. 1981 Presentation. Finalisation of prototype.

June.1981 Presentation of degree project.

Contracts (5)

5.1 C.O.S.P.O.R.

5.2 NCPE

5.3 All sports equipment manufacturers.

5.4 CTT

5.5 I.D.A.

6. Tutor Mr. Rob Umney

Introduction of Work Area

1.4 At present day man indulges in no less than seventy eight different sports. In all of these varying degrees of skill, fitness and suitability are required. Each sport has its own specialised equipment so rather than try and find the most common equipment used in sports, my attention was drawn to the requirements of man with respect to equipment. As involvement of the human body is the most common denominator in all sport, equipment which aids the adaptability and suitability of man to the sport is the largest area to work in.

Among the seventy eight sports at least fifty five involve excessive movement of the human body. Excessive in so far as the movements are outside the range of everyday movement, both in strength, time of action, and speed of action. As man may be considered as a machine, improved performance is desirable. Movement requires work which in turn requires energy. The efficiency at which man can convert chemical energy into physical energy could be described as a level of fitness. Muscle fibre through its ability to contract and relax is the interface between energy and work. In the human body muscles are connected to a series of levers called the skeletal system. This controls the power and range of mans movements, as the muscles are proportioned to the levers they are acting on.

1.5 Muscle Strength and Muscle Efficiency

A man who lifts a child in the air is lifting the weight of the child against the pull of gravity. Therefore, he is lifting against a resistance. His muscle strength and efficiency in this movement maybe defined as follows:-

MUSCLE STRENGTH:

The amount of force he is able to apply in lifting the child.

MUSCLE EFFICIENCY:

The amount of energy required to exert that force.

ENERGY IMPUT = EFFICIENCY
WORK OUTPUT

1.6 Resistance Training

There are two basic methods of resistance training, one for strength, and the other for endurance. The characteristics of the two training methods imply that, strength training produces a hypertrophy of the fibres whereas endurance exercise increases the number of capillaries. The increase in the size of fibres and in the number of capillaries is accompanied by a gain in strength. This is characterised by:-

A. The ability to produce more powerful contractions i.e. again in power.

B. The ability to repeat contractions more rapidly i.e. again in speed.

C. The ability to produce the contractions for a longer period of time i.e. again in endurance.

The strength of muscles can only be developed by exercising them against gradual increasing resistance such as pulling or pushing, lifting weights, or moving the body at increasing speed. The gains that can be made in strength are far more striking that the increase in muscle size. It is possible to increase the power of the muscle three times without a proportional increase in muscle volume. Likewise, depending on the training programme a greater amount of work can be achieved more efficiently.

1.7 Resistance Training Equipment

Resistance training equipment depends on the system being used. The three main systems are as follows:-

A. Isometric Resistance

Where the muscles are loaded statically (no Movement) and the resistance is that of the force applied in either pushing or pulling.

B. Isotonic Resistance

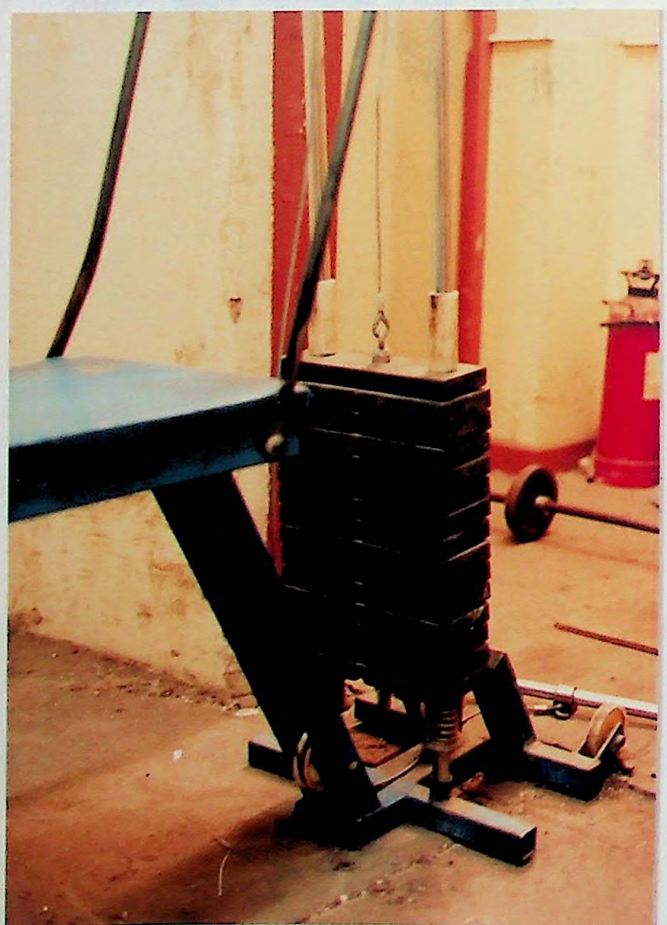
Where the muscles are loaded against a set resistance throughout a movement range.

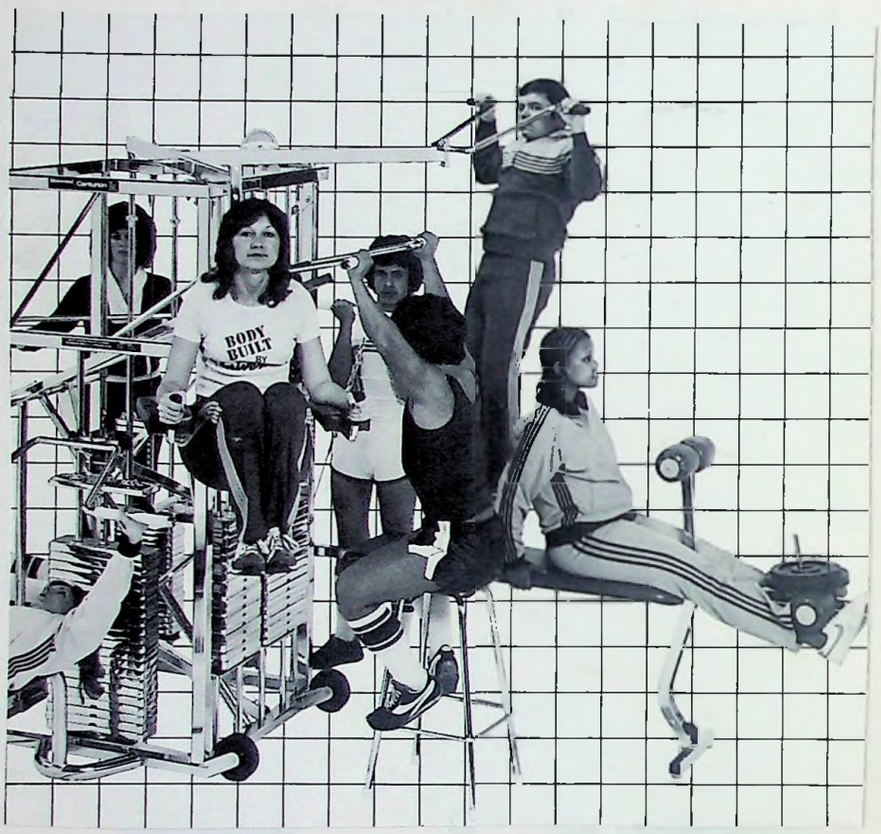
C. Isokenetic Resistance

Where the muscles are loaded with a near opposite resistance to that being applied throughout a movement.

The most favourable form of resistance training is the Isotonic method. Reasons for this will be discussed later in this report.
With all systems a large variety of equipment is available. The Isotonic equipment - this project is concerned with goes under the heading "Multi Jym" which is a multi station resistance exercise machine. The word station implys a defined set of movement ranges. Resistance is given either by weights or resistance to the weight of the body. These multi station units are designed to give a good all round conditioning machine for the sports man. Depending on the format of the machine it will cater for 4 to 16 people at a time.

1.8 EXAMPLES OF MULTI JYM RESISTANCE TRAINING UNITS




BODY
BUILT

EXAMPLES OF OTHER ISOTONIC RESISTANCE UNITS

Arm Curling Machine

Bio-mechanically Synchronized

Pat. applied for

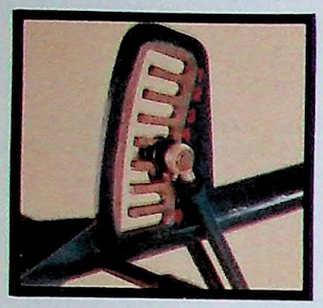
U. S. and Foreign Patents Pending

U.S. and Foreign Patents Pending

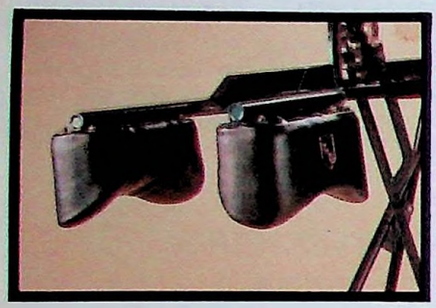
U.S. and Foreign Patents Pending

Standing Calf Machine

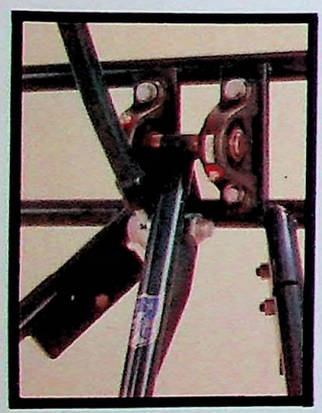
Bio-mechanically Synchronized



Quick height adjust.



No pain shoulder pads.



Ball bearing pivots.

Solid step foot rest.

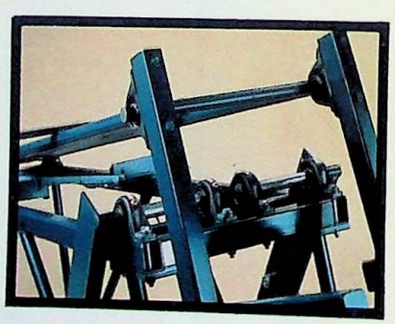
Pat. applied for.

CORBIN - GENTRY, INC.

Hack Machine

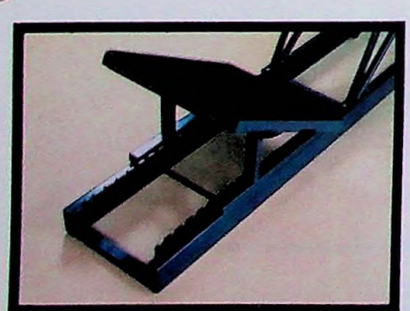
Bio-mechanically Synchronized

Pat. applied for



Ball bearing pivots.

No pain pads.



Quick height adjust.

CORBIN - GENTRY, INC.

1.9 DESIGN BRIEF

A. PRODUCT DESCRIPTION

Multi Station Isotonic Resistance Exercise Unit (Multi Gym)

Existing equipment composed of several different stations. Each station replicated a standard resistance movement or movements. Resistance is given either by opposition to a moving weight or to body weight. As resistance is progressed either by repetition or weight increase, the muscles being used are developed. The purpose of the unit is to provide a good all round conditioning apparatus for the muscular system that is safe and requires little instruction.

B. MARKET AREAS

The market areas for this product can be separated into the following categories:-

1. Institutional e.g. Colleges, Schools, Hospitals, Army, etc,.
2. Sports Play e.g. Football Clubs, Sports Centres, Health and Fitness Clubs, etc.,
3. Domestic e.g. Home Jyms.

C. THE BRIEF

This brief is concerned with a product suitable for manufacture by a low investment industry in Ireland. The product will be designed to fulfill the demands of the home market with a view to eventual export markets. The product range shall be designed with the following features in mind:

1. A Modular system to which extra stations can be added.

2. A reduction in packaging size so as to reduce transport costs.

3. An improvement in the visual aspects of the product over existing products.

4. A design to cater for as wide a market range as possible.

5. A product more competitve than existing units.

6. A more informative and easier to use machine.

7. A good blend of exercise variations.

8. A machine to suit a wider range of users.

9. A machine which may be located anywhere.

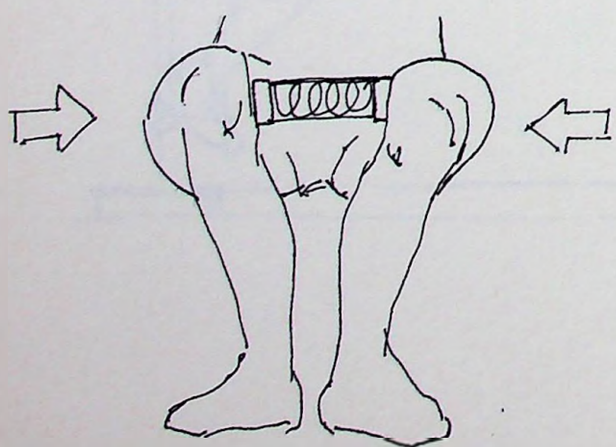
10. A unit that requires little space.

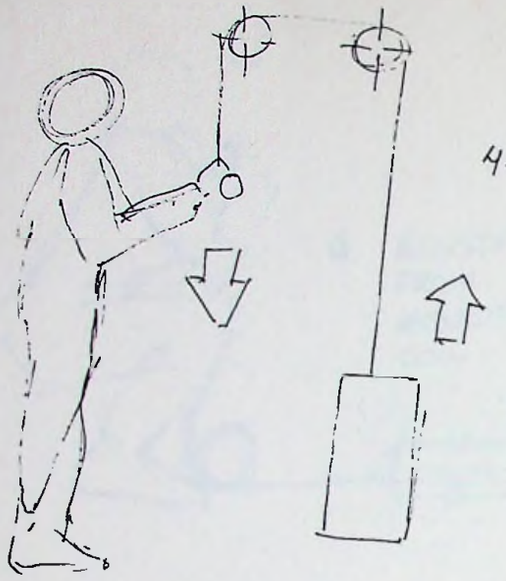
1.10 CONCEPTS

1. STATIC LOADING WHERE FORCE IS APPLIED WITHOUT MOVEMENT.

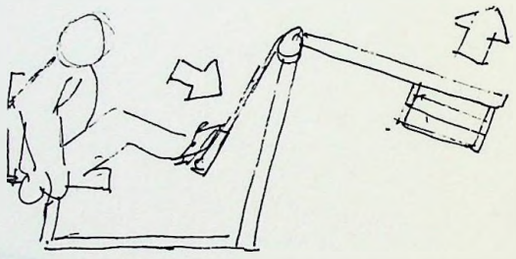
2. ISOMETRIC TYPE UNIT.

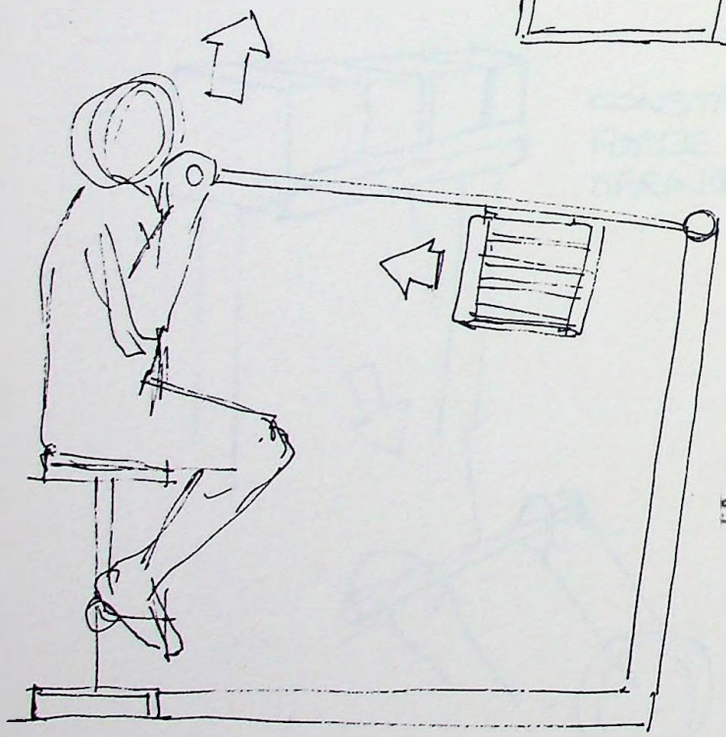
3. SPRING SYSTEM.



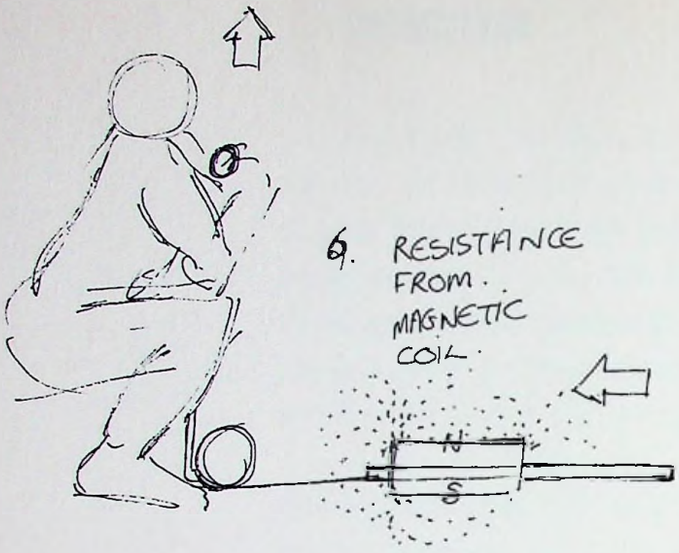


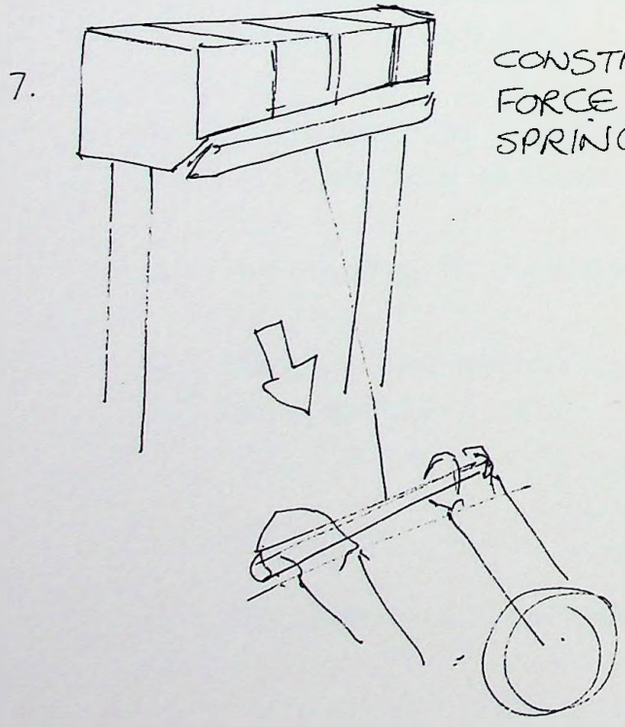
4. RESISTANCE AGAINST GRAVITY THROUGH PULLEY MECHANISMS.





5. USE OF LEVERS TO GAIN MECHANICAL ADVANTAGE IN WEIGHT MEDIUM.


6. RESISTANCE FROM MAGNETIC COIL.
N
S


7. CONSTANT FORCE SPRINGS.

OBJECTIVES

2.1 OBJECTIVES

In the term of this project, it is hoped to fulfill the objectives laid down in this section. All efforts will be made to work to a correctly proportioned time table of study. In the event that one area exceeds its alloted time, its importance in the final solution will be evaluated, and if felt necessary will be extended.

The objectives of this project maybe outined as follows:-

1. To complete the project in the time alloted.

2. To gain a good understanding of the work area.

3. To product a design that fulfills the criteria laid down.

4. To present my final solution in a way that will be both explanatory and informative.

5. To develop to prototype stage my final design.

6. To give the consumer as much value for money as possible i.e

$$\frac{\text{FUNCTIONS}}{\text{COST}}$$

7. To produce a good functional design.

2.2. DESIGN CRITERIA

A. Utility and Safety

To provide a solution that will not fail in operation so as to cause serious injury, or death. To use materials that are safe in use, and hygienic for user. To allow for an acceptable range of user sizes, so as not to place undue strain outside a movement range. To provide a design that, when not in use will be of no danger by way of obstruction or other. All relevent British standards should be applied.

B. Maintenance

The solution should be relatively maintenance free, easy to keep clean, require little or no adjustments, and it should not require sundry maintenance which through neglect would cause failure. Replacement of parts should be done by dealer so as to allow complete check of apparatus. Change of weight stack should be done by manufacturer. Simple componants like pins, wheels and pulleys should be available from manufacturer, and be easily replaced by customer. Tools to carry out these operations should be provided.

C. Cost and Value

The final solution should provide more functions for less money than other products in the field. The cost of the product should be priced to suit the market area it is aimed at. The product should have an acceptable life span, either the same or longer that its competitors.

D. Appearance Design

The design should compliment the environment it is being placed in. Colour and form should be complimentry. Design should be of an aggressive nature to match area of activity. Colour should not cause distress or distraction to user. Form should be functional and informative in mechanical uses. Styling should be modern and clean. The structure should look solid and secure. Styling should be aimed at the market area but give a leading edge in appearance or a market edge in appeal. Areas of colour should not be subject to deterioration through use, there by visually making the product look shabby. Visual information should be easy to read or interpret and should also not be subject to deterioration with time.

E. "Sales Appeal Design"

The sales appeal of the final solution should appeal to the three basis needs. The features required to satisfy the needs are as follows:-

1. BASIS NEEDS

Design should fulfill the basic needs, both functionally and cost effectively for the buyer. The value of money element here is an important feature.

2. INTRINSIC NEEDS

The psychological impact of the design to create a need should compliment the image of the area for the buyer. Intrinsic needs should be satisfying by a suggestive design. Here colour, form and graphics require a close connection between medial interpretation and visual presentation.

3. STATUS NEEDS

A certain element of "snob" value maybe incorporated into the design by way of "Quality Item" portrayal. Design should be functional, but also a show piece when not in use. Status need may also be created by brand name or celebrity name i.e. "Charles Atlas" this'Loud' or 'Aggressive' design should also aid the basic and intrinsic needs.

2.3 PROPOSED TIME TABLE OF PROJECT WORK

Date	Work Area
January '81	Data Collection and Research Conceptual Outline. Thesis Research.
February '81	Data Collection and Market Evaluation.
March ' 81	Data Analysis and Conceptual Development.
April ' 81	Design development and Data Presentation.
May '81	Protptype and Final Design Development.
June '81	Final Prototype and Presentation.

2.4 OBJECTIVES OR DATA COLLECTION

1. To gain a good understanding of the skeletal muscular system, muscle work and movement.

2. To scan market for similar type machines. (Isotonic Resistance Machines)

3. To establish a good blend of exercises for development of muscular system.

4. To evaluate the concepts in terms of cost versus performance.

5. To establish a price range for product.

6. To analyse existing equipment in terms of suitability to application in proposed market.

7. To determine materials and manufacturing methods of final design.

PROCEDURE

PROCEDURE

3.1 Data Collection from Manufacturers

To obtain literature on existing resistance apparatus, prices and methods used, a standardised format for a letter was written up. This letter was then sent to all amnufacturers, persons or bodies connected with the research area. A list of contacts is given in the bibliography.

The following is the standard letter used.

30 January 1981

Dear Sir,

I am a final year student of Industrial Design (Engineering) in the National College of Art & Design. Presently, I am working on my final year Degree Project for a B.Sc. Degree.

My major project involves the area of resistance exercise equipment for sport. I write to you in the hope that you may be able to aid me in my data collection on the above. My area of research involves the following:

The history and development of resistance exercise and related equipment

The relationship between exercise movements and resultant physiological effects on the muscular system. (i.e. what exercises develop which muscles)

Information relating to the production processes, materials, weights and physical dimensions involved in multi-gym and similar equipment.

I should also be grateful if you would send me any brochures, price lists or catalogues related to my topic.

Thanking you in anticipation of an early reply.

Yours sincerely,

Brendan Farrell
Fourth Year Industrial Design Student
Faculty of Design

PLEASE REPLY TO: Department of Industrial Design
Princes Street
(Off Townsend Street)
DUBLIN 2

3.2 DATA PROCESSING OR MARKET INFORMATION

A. Price Ranges.

Equipment was divided into multi station, and single station units. A table indicating the cost of multi station units, and the number of stations per price was drawn up. A second table giving the average price of the single station units (of which there is a range) was also formed giving the number of variations available in the range.

It must be noted that all prices were not subject to V.A.T. and were for the country of origin as no resistance equipment of this nature is manufactured in Ireland one must allow for import costs.

B. Apparatus Type

Short description given of apparatus types available, and relative costs, indicating market areas.

3.3 RESEARCH AREAS

AREA 1.

Man and Movement

Data for this section was compiled mostly through reading. Once an understanding of movement had been reached the mechanics could be examined. Here the muscles and their actions in movement could be connected to basic movements used in weight training and resistance training.

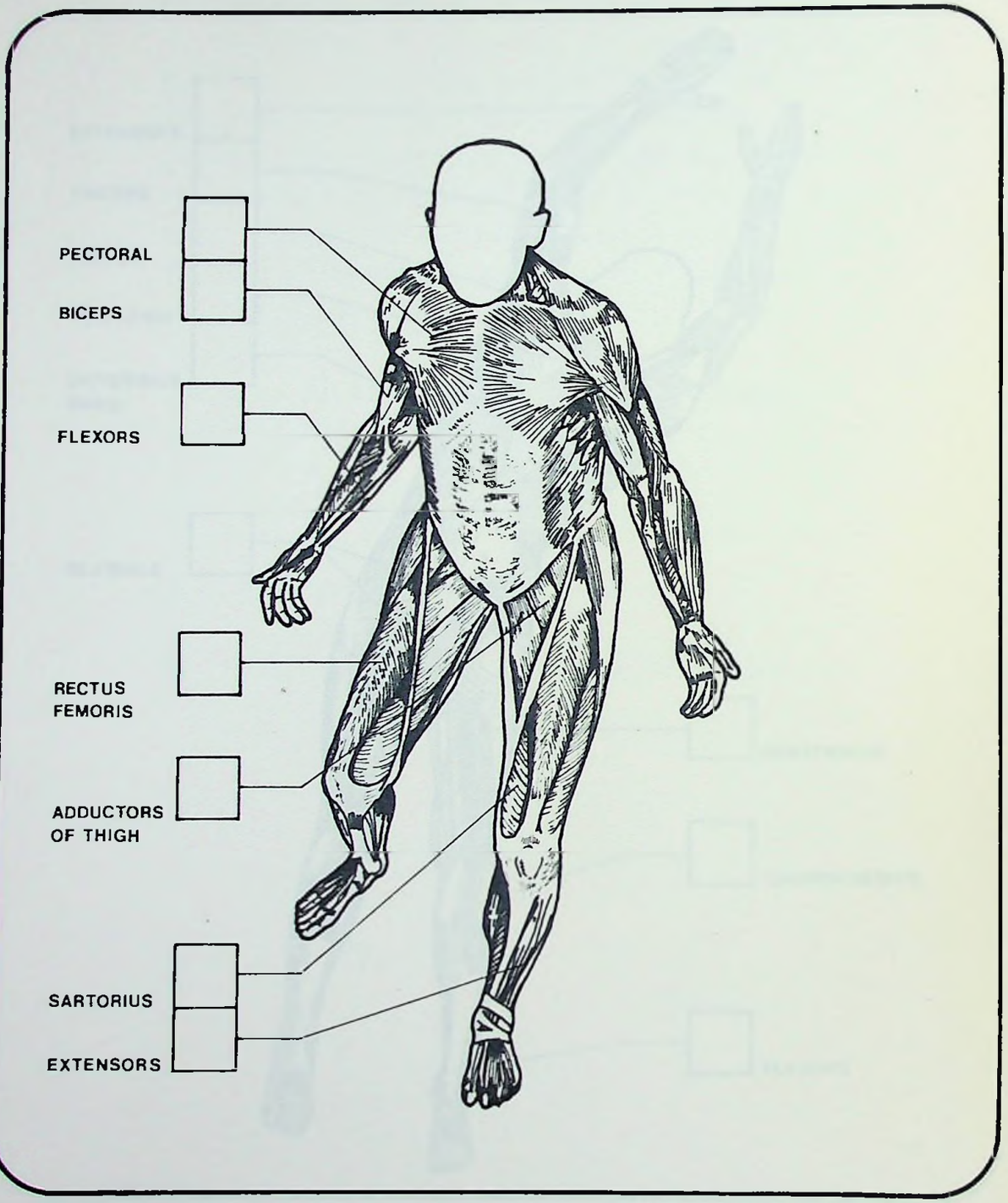
AREA 2.

Weight Training

A list of the number of weight training and resistance movements was compiled. By means of movement analysis, the relevant muscles used were mapped on standardised data collection sheets. The following are samples of the sheets used in this area:

Data Collection

DATE SHEET NUMBER PART



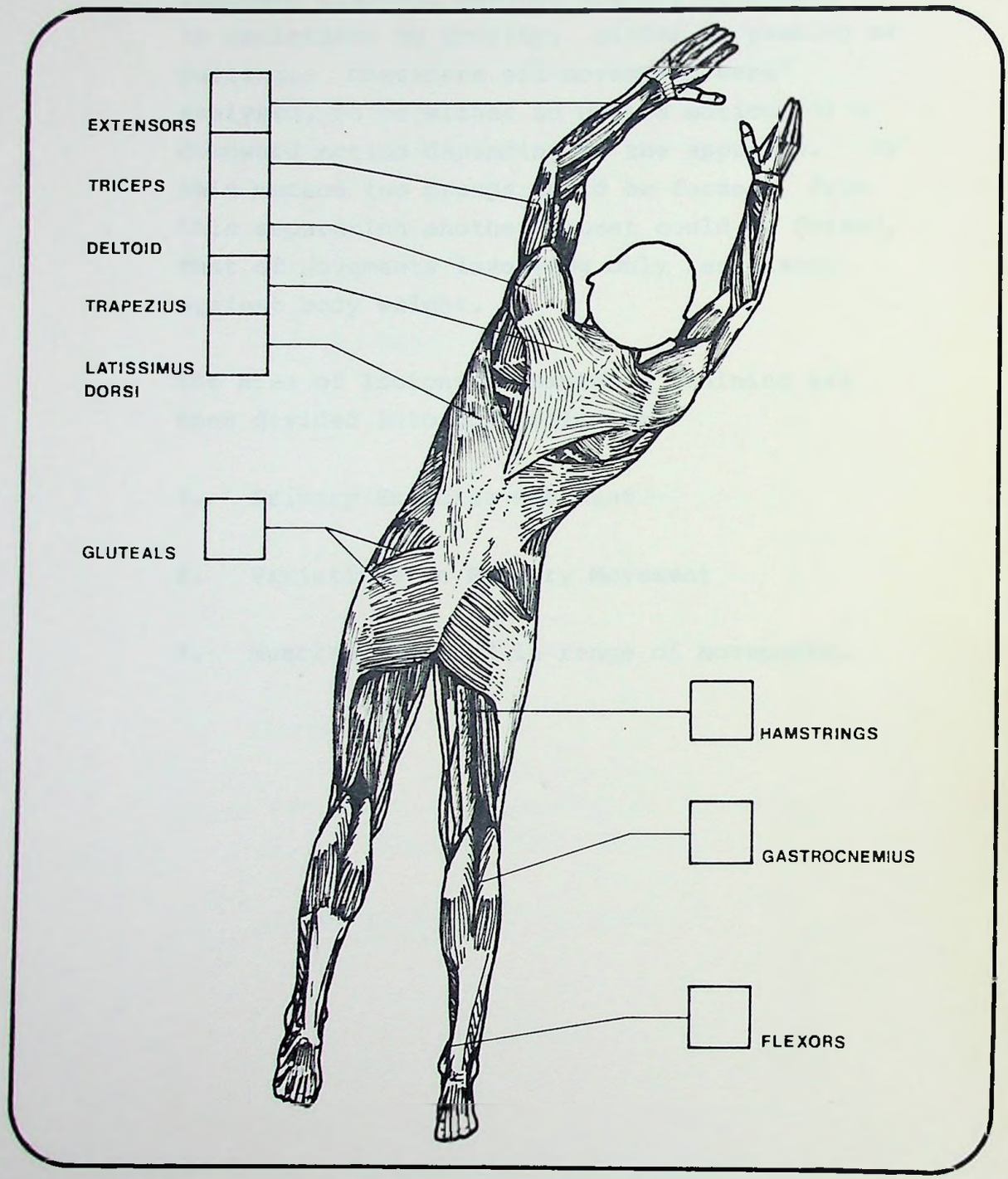
ACTIVITY

DISCRIPTION

NOTES

Data Collection

DATE SHEET NUMBER PART



PRIME MOVERS 1 SECONDARY 2

WEIGHT RANGE

NOTES

3.4 FUNCTIONAL ANALYSIS OF RESISTANCE MOVEMENTS

Isotonic Training Methods are all connected to resistance to gravity, either by pushing or pulling. Therefore all movements were analysed, to be wither an upward motion, or a downward motion depending on the appratus. By this method two groups could be formed. From this separation another subset could be formed, that of movements involving only resistance against body weight.

The area of Isotonic Resistance Training was then divided into the following:-

1. Primary Exercise Movement

2. Variations on Primary Movement

3. Muscles effected in range of movements.

3.5 EVALUATION OF EXISTING SYSTEMS AND NEW SYSTEMS

Through a morphology chart the old systems in use and newly proposed systems were compared and evaluated. The areas of consideration were as follows:-

1. Quality of Resistance
2. Cost of Apparatus
3. Suitability to market aimed at
4. Life expectancy and accuracy
5. Ease of use
6. Ease of installation
7. Space requirements
8. Flexaility of apparatus in operation (i.e. number of variations etc.)
9. Aesthetic quality of system.

3.6 EVALUATION OF WEIGHT MEDIUMS

Selection of materials to be used in production of weight medium were selected through a morphology system. Each material was considered with respect to the relevant qualities required. Those are:-

1. Cost of Material
2. Formability of Material
3. Cost of Manufacture
4. Density of Material
5. Compressive strength of material
6. Impact resistance of material
7. Accuracy in weight
8. Aesthetic qualities of material (finished)

Through a points system awarded by way of the perticular quality of the material by comparison to the others, a final selection was made.

The idea of a combination of materials was also considered. This is described in the discussion section.

The points system was:-

Very bad	1 point
Bad or low	2 points
Fair	3 points
Good	4 points
V/Good/High	5 points
Excellent	6 points

3.7 DESIGN EZPERIMENTS

Two types of experiment were formed to establish the movement ranges involved in the design.

EXPERIMENT 1. - Photographic Method

Apparatus Used:- Standard Free.
Weight Barbell. 35 m.m. Canon A.e1
TRIPOD. BENCH. Subject of 95%ile
(Great Britan) Slide Film.
Slide Projector.
HUMAN SCALE CHARTS.

Procedure:- The subject was instructed to perform a set number of resistance movements. Movements were photographed at the beginning, and end of each movement. The film having been processed and mounted in slide mounts was then projected on to a drawing board, and brought to scale.
Through varying the distance of the projector from the board, the subject could be changed from 95%ile to 50%ile. The link measurements of the projection were noted and the ranges established.

Due to reasons such as focal length, and perspective effect the resultant dimensions were not felt accurate enough. Therefore a second experiment was carried out.

EXPERIMENT 2. Tracer Method

Apparatus used:-

Standard length fee weight barbell.
Large roll of paper 1 m wide.
Bench. Pantone Tracer markers
(2 Colours)

Procedure:

In this experiment the subjects were asked to be seated or to stand in pre set positions on the floor. Tracer markers were fixed to the barbell. The subject was then asked to perform a selected number of resistance exercises, the result being that the movement was traced on to the area of paper on the wall.
Exercises were traced for both 50%ile and 95%ile. Measurements were then taken and the results gave the distance travelled or range of the movements from beginning to end. These were then mapped given a common ground line.

RESULTS

RESULTS

4.1 Active Sports

The following is a list of active sports in which resistance training could be used to aid the sportsman or sportswoman.

1. Aerobatics.
2. Archery
3. Association Football (Soccer)
4. Athletics (Track and Field)
5. Badminton
6. Baseball
7. Basketball
8. Bobsleigh
9. Boxing
10. Canoeing
11. Cricket
12. Cross-Country Running
13. Cycling
14. Equestrian Sports
15. Fell Running (Mountaineering)
16. Fencing
17. Football (Association, Gaelic, Rugby League, Rugby Union, American)
18. Gymnastics
19. Handball (Court and Field)
20. Hockey
21. Horse Racing
22. Hurling
23. Ice Hockey
24. Ice Skating (Figure and Speed)
25. Judo (Ju-Jitsu)
26. Karate
27. Lacrosse
28. Lawn Tennis
29. Modern Pentathlon
30. Mountaineering

31. Pelota Vasca
32. Polo
33. Rackets
34. Rodeo
35. Roller cycling
36. Roller Skating
37. Rowing
38. Shinty
39. Skiing
40. Softball
41. Speedway
42. Squash
43. Surfing
44. Swimming
45. Table Tennis
46. Tennis (Real & Royal)
47. Tobogganing
48. Trampolining
49. Tug of War
50. Volleyball
51. Water Polo
52. Water Skiing
53. Weight Lifting
54. Wrestling

COMPETITIVE SPORT DIVIDED INTO THREE AREAS

(a) Co-operative Team Competition (versus other teams)

(b) Individual Competition (versus other individuals)

(c) Personal Competition (Versus self in time and distance or versus nature)

PHYSICAL ADVANTAGES OF COMPETITIVE GAMES AND SPORTS

1. Satisfy basic need for physical activity
2. Offers outlets for the release of surplus energy
3. Are an asset to anatomical development (Joints and Muscles)
4. Stimulate the physiological systems of the body (Heart and Longs etc.)
5. Are likely to increase strength and endurance
6. Serve an an avenue for the acquisition of basic skills (Foot/Eye and Hand/Eye Co-ordinations)
7. Offer opportunity for all to participate at their own level.
8. Offer opportunity to try out physical skills
9. Provide a yard-stick for the measurement of ability and skill against peers.
10. Act as an incentive to participate in vigorous physical activity.
11. Act as an incentive to training.
12. Lead to improvement in standards.
13. Offer worthwhile outlets for the physically gifted
14. Inculcate good habits of hygiene.

4.2 MARKET INFORMATION

Compiled from Major Manufacturers.

The information received from Manufacturers was designed into the following areas.

1. Type of Equipment. Isotonic, Isometric or Isokinetic.
2. Multi station or single station
3. Types of Resistance used.

The following price list formed from ex-factory prices is evidence of the high cost equipment available on the market.
Price List is formed of:

	Name of Manufacturer
"MULTI GYMS"	Number of exercise stations (Either on the unit or in separate machines)
"SINGLE STATION MACHINES"	Number of exercise stations available in the range of equipment
	Cost in pounds sterling or American Dollars.

NOTE:- All prices are not inclusive of import costs or V.A.T.

COST OF OTHER MULTI GYM MACHINES ON MARKET

NAME	NO OF STATIONS	COST STERLING £	COST AMERICAN $
Lodge Sports	12	2885.00	
"	8	2220.00	
"	6	1825.00	
"	5	1444.00	
Universal Centurion	16		7014.00
"	15		6364.00
"	10		5595.00
"	9		5418.00
"	8		5160.00
"	6		4408.00
"	5		4219.00
"	4		4150.00
Universal Gladiator	16		6455.00
"	15		5805.00
"	10		5063.00
"	9		4886.00
"	8		4624.00
"	5		3881.00
"	4		3623.00
Universal Maximus	4		2569.00
"	3		2435.00
"	2		1398.00
Universal Power-Pak	2		2670.00
"	4		3691.00

AVERAGE COST OF SINGLE STATION MACHINES

NAME	RANGE OF STATIONS	AVERAGE COST £	$
Universal Maximus	3		1241.00
Universal DVR	8		1490.00
REM Isokinetic	8	440.00	
Corbin Gentry	10		1670.00
Keiser	14		2035.00
John Terry Isokinetic	7	998.00	

4.3 RESEARCH RESULTS

Body contains three types of muscle.

1. Voluntary skeletal muscles
2. Involuntary muscles i.e. digestive tract
3. Heart muscle.

Exercise primarily concerned with skeletal muscles because when they are contracted they cause movement.
Movement potential is brought into action by 434 skeletal muscles.

They are composed of 250 million smaller units, the muscle fibres. These constitute 40 per cent of the average males body weight.

Weight composition of average American male

Muscle Fibres	40%	ESTIMATE ON A CELLULAR LEVEL
Body Fat	20%	
Bone and Other	40%	

Exercise does not increase the number of cells, but increases the cell size.

i.e. Hypertrophy instead of Hyperplasia.

MUSCLE GROWTH

Muscle growth consists of two parts:-

1. Growth stimulation within the body itself at the basic cellular level.
   Best results in this area are achieved just after puberty by high intensity exercise.

2. Providing large amounts of nutrients, in excess of what the body requires will not necessarly promote growth. Providing the correct blend of nutrients will activate growth machinery within the cell.
   Muscle stimulation must always precede nutrition.

MUSCLE CONTRACTION

Muscle contraction results from formation of a chemical called creatine. Creatine stimulates muscle to form more myosin, one of the contraction proteins within the muscle fibre.

Creatine has been identified as the messenger substance which turns on the RNA (Ribonucleic Acid) processing line to produce muscle growth. RNA fibres within the cell act as an assembly line and hook together various combinations of amino acids. This along with complex sugars and fats for the compounds that result in increased size of certain muscle cells.

WEIGHT TRAINING AND OTHER EXERCISES

in alphabetical order.

4.4 Abdominal Curl
Abdominal Curl with Trunk Twisting
Abdominal Knees Curl
Alternate Dumbbells Curl
Alternate Dumbbells Press
Alternate Forward Raise with Dumbbells
Alternate Pull Over in Back Bridge
Barbell One Hand See-Saw Movement
Barbell Windmill Rotating
Bench Jump
Bent-over Rowing
Bouncing Split Squat
Chair Dips with Raised Legs
Cheat Curl
Chinning the Bar
Flying Movement
Flying Movement in Back Bridge
Flying Movement in Front Bridge
Front Bridge with Neck Rotating
Front Squat
Good Morning Exercise
Hack Lift
Halting dead Lift
Head Strap Exercise
Heels Raised
High Pull Up
Jump Squat
Lat Machine Pull Down
Lateral Raise - Bent Forward
Lateral Raise - Lying
Lateral Raise - Lying (Bent Arms)
Leg Circling
Leg Lunge
Leg Press
Leg Extensions
Legs Raise
Neider Press
One Arm Lift Over
One Arm Press

One Hand Clean with Dumbbell
One Hand Swing
Overhead Roll
Parallel Bar Dips
Power Clean
Press Behind Neck
Power Clean with Dumbbells
Press on Bench
Press out from Neck
Pull Back
Pull Over
Pull Over in Back Bridge
Pull Over with Bent Arms
Pull Round Sideways and Over
Roller Bar Winding
Side Press
Single Arm Rowing
Squat (Deep Knees Bend)
Step up on Bench
Straddle Lift
Swing Bell Curn - Seated
Triceps Press
Trunk Side Bends
Trunk Twisting
Two Hands Clean
Two Hands Clean from Hang
Two Hands Clean with Dumbbells
Two Hands Curl
Two Hands Dead Lift
Two Hands Press
Two Hands Press with Dumbbells
Two Hands Swing
Upright Rowing
Wrist Curl
Zottman Curl

Analysis in respect to the muscles used in each exercise is given in a separate book titled "RESISTANCE EXERCISE MOVEMENT ANALYSIS"

4.5

EXERCISE NAME	DEVELOPMENT AREA PURPOSE
High Pull Up	All round power builder
Two Hand Press	Shoulders upper back muscles at rear of upper arm
Two Hand Curl	To develop muscles at front of upper arm
Squat	To develop chest, back legs, improve condition of heart and lungs.
Bench Press	To develop chest muscles, front shoulder, back of upper arm
Straight Legged Deadlift	Develop muscles which extend Spine, and hip joints, Hamstring group at back of leg (upper)
Bent forward Rowing	Develop Upper back muscles, and with variation the lower back muscles.
Close Grip Bent Forward Rowing	Upper back, Front of upper arms
Heels Raising	Develop Calf Muscles
Straight Arm Pull Over	To enlarge Thorax, develop muscles of shoulder girdle, Front Chest Muscles, Large muscles of lower back.
Bent Arm Pull Over	Stretch and mobilize thorax. Develop Chest Muscles. Large of lower back.
Upright Rowing	Muscles surrounding shoulders and upper back, also muscles which flex the elbow.

NAME	PURPOSE
Dumbbell Press	Shoulder Muscles, Upper back Muscles, back of upper arm.
Straight Arm Lateral	Chest Muscles, front of shoulder
Raise Lying	" "
Bent Arm Lateral	" "
Raise Lying	" "
Dumbbell Screw Curl	Front of Upper Arm
Side to Side Bend	Mid section and side of trunk
Tricep Bench Press with Dumbbells	Back, and Upper Arm
Seated Dumbbell Curl	Front Upper Arm
Press Behind Neck	Upper Back, Shoulder, Rear of Upper Arm
Standing Triceps Press with Dumbbells	Rear of Upper Arm
Walk Standing Heel Raising	Calf Muscles
Hack Lift	Leg and Hip Muscles
Single Arm Rowing	Upper back muscles, Trunk muscles, Upper Arm Front
Trunk Forward Bend	Develop Muscles at rear of thigh, hip, Lower back.
Bent Arm Lateral Raise standing with Dumbbells	Shoulder and Upper Back
Bent forward tricep press with Dumbbells	Rear of Upper Arm
See-Saw press with Dumbbells	Shoulder, Upper Back, waist muscles. Rear upper arm.
High Kick with Legbell	Abdominal muscles and those that cross front of hip joint, Front of thigh muscles.

NAME	PURPOSE
Cheating Single Arm Rowing	Muscles which rotate trunk, shoulder and upper back.
Shot Side Bend	Muscles responsible for sideways movement of trunk. Muscles which rotate the spine.
Leverage side bend	Lateral flexors of spine.
Inclined Bench Leg Raising with Trunk Twisting	Abdominal muscles spinal flexors and rotators.
Inclined Leg Raising	Abdominal muscles hip, and spinal flexors.
Inclined Sit-Ups	Abdominal (Hip Spinal Flexors)
Alternative Press on inclined bench	Front of shoulders, back of upper arm.
Dumbbell Inclined Press	Extensions of elbow, flexors or shoulders and abductors of the scapula. Upper back, Front shoulder, back of upper arm.
Declined Barbell Press	Protractors of shoulders, extentions of elbow. Front shoulder upper arm.
Heave Press with two dumbbells	Same as barbell heave. Extensors of arms, legs, shoulder flexors. Extensors of shoulder girdle.
Heave Press with Barbell	" " "
Inclined Barbell Press	Arm, shoulder, and chest.
Inclined Dumbbell Press	Elevators and abductors of shoulder, extensors of elbows.

NAME	PURPOSE
Seated Press with Barbell	Arms, shoulders. Arm extensors elevators of shoulder girdle.
Bent arm pull over with swing bell	Mobilise thorax and develop surrounding muscles.
Cheat bent forward lateral raise standing	Abductors of scapula muscles which cap shoulder joint.
Bent forward swingball curl	Flexors of arm
Bent arm declined lateral raise with Dumbbells	Front of chest and shoulder joints
Bent arm inclined lateral raise with Dumbbells	Abductors of scapula. Front of chest, shoulder.
Vertical Jumps	Hips, front of thigs, calf muscles. Explosive action.
Split Squats	All major leg muscles.
Front Squat	Front of thigh hip muscles.
Halting dead lift	Legs back grip, extensors of leg and spine, flexors of arm shoulder girdle, shoulder abductors.
Power clean with Dumbbells	All around.
Squat balance Press	Legs arms extensors, shoulder flexors, elevators of shoulder girdle.
Snatch Balance Press ↑	Arm leg extensors of shoulder girdle
Jerk Balance	Arm leg extensors of shoulder girdle
Free Upward Leaps	Leg Spring

SOURCE:- MODERN WEIGHT TRAINING - ALISTAIR MURRAY,
KAYE/WARD - LONDON 1976

4.6 BASIC EXERCISE STATIONS AND VARIATIONS

STATIONS

Chest Press
Abdominal Board
Dipping
Leg Press
High Lat Pull
Leg Extension/Leg Curl
Low Pulley
Back Pyperextension
Wrist Conditioner
Chinning
Shoulder Press
Rowing

MOVEMENT VARIATIONS: TOTAL NO. OF VARIATIONS = 80

Chest Press No. of Variations = 9.

1. Bench Press. 2. Side Bend. 3. Shoulder Shrug. 4. Arm Curl. 5. Squat Clean. 6. Calf Raise on Blocks. 7. Leg Raise/Chest Press Combination. 8. Single Arm Side Bench Press. 9. Dead Lift.

Abdominal Board No. of Variations = 13.

1. Straight Sit Up. 2. Twisting Sit Up. 3. Douldbe Twisting Sit Up. 4. Alternate Bent Knee Leg Raises. 5. Double Bent Knee Leg Raises. 6. Alternate Leg Raises. 7. Double Straight Leg Raises. 8. Side Leg Raises. 9. Side Leg Raises with Knee Rotation. 10. Double Knee Leg Raises with Trunk Twisting. 11. Back Arch. 12. Single Back Leg Raises. 13. Double Back Leg Raises.

Dipping No. of Variations = 3.

1. Dipping. 2. Reverse Grip Dipping. 3. Seated Pull-Up.

Movement Variations - Cont/d

Leg Press No. of Variations = 3.

1. Regular Leg Press. 2. Calf, Ankle, Arch Press.
3. Single Leg Press.

High Lat. Pull No. of Variations = 6.

1. Back Pull Down. 2. Front Pull Down
3. Good Morning Exercise. 4. Triceps Extension.
5. Discolate Pull Down. 6. High Lat. Row.

Leg Extension and Leg Curl No. of Variations = 4.

1. Double Leg Extension. 2. Single Leg Extension
3. Double Leg Curl 4. Single Leg Curl.

Rowing and Low Pulley No. of Variations = 25.

1. Bent over Rowing. 2. Upright Rowing.
3. Double Arm Curl. 4. Alternate Arm Curl.
5. Reverse Arm Curl. 6. Rip-Up.
7. Sit-Up 8. Trunk Twisting Sit-Up. 9. Pull Over.
10. Bent Arm Pull-Over. 11. Front Raise.
12. Alternate Front Raises. 13. Lateral Raise.
14. Side Bend. 15. Abductor Kick. 16.Abductor Kick. 17. Back Extension Kick. 18. Hip Flexor.
19. Wrist Curl. 20. Reverse Wrist Curl.
21. Dead Lift. 22. Neck Extension. 23. Right Side Neck Extension. 24. Left Side Neck Extension.
25. Front Neck Curl.

Back Hyperextension No. of Variations = 4.

1. Back Arch. 2. Double Leg Raise. 3. Alternate Back Leg Raise. 4. Roman Chair Sit Up.

Wrist Conditioner No. of Variations = 2.

1. Wrist Curl. 2. Reverse Wrist Curl.

Movement Variations - Cont/d

Chinning No. of Variations = 6.

1. Reverse Grip Chin. 2. Regular Chin Grip.
3. Shoulder Broadener. 4. Hip Flexor.
5. Leg Raises. 6. Alternate Leg Raises.

Shoulder Press No. of Variations = 5.

1. Forward Shoulder Press. 2. Back Shoulder Press.
3. Calf Raise. 4. French Curl. 5. Single Hand Press.

47

SPACE REQUIREMENTS FROM MANUFACTURERS GUIDES

STATION	INCHES WIDTH	INCHES LENGTH	INCHES HEIGHT	LBS WEIGHT MAX
Chest Press	36	75	79	1260
Abdominal Board	31	44	65	
Dipping	30	28	41	
Leg Press	20	58	61	1527
High Lat Pull	36	40	79	580
Leg Extension & Leg Curl	36	82	65	870
Low Pulley	24	38	72	580
Back Hyperextension	36	72	40	
Wrist Conditioner				
Chinning	36	28	82	
Shoulder Press	41	26	61	1050
Rowing				

TOTAL WORKING SPACE REQUIREMENTS OF MULTI GYM UNITS

WORKING SPACE 12 X 17 X 8 Feet.

4.8 EXPERIMENTAL RESULTS 1.

These results were not valid due to too large an error in processing, thus experiment number two was formed

MALE

Exercise Movement		95% ile CMS	50% ile CMS
	Arm Curl 1	80	90
	Arm Curl 2	140	150
	Bench Press 1	60	61
	Bench Press 2	106	111

BENCH HEIGHT 38 CMS

MALE

Exercise Movement		95%ile	50%ile
		CMS	CMS
 Shoulder Press	1	96	103
 Shoulder Press	2	161	166
 Bent Over Rowing	1	76	76
 Bent Over Rowing	2	146	151
 Squat Clean	1	100	105
 Squat Clean	2	150	160

BENCH HEIGHT 38 CMS

Exercise Movement	CMS	CMS
Upright Rowing 1	80	82
Upright Rowing 2	130	135
Leg Press 1	92	100
Leg Press 2	152	161
Chinning Position	202	202

BENCH HEIGHT 38 CMS

4.9 STANDARDS

British Standards relating to the design of weight training Equipment:-

WEIGHT TRAINING EQUIPMENT: BS 1892 PART 2: SECTION 2.6 : 1972

1. The weights shall be of cast iron, in conformity to BS 1452, or of mild steel and marked in kilograms, and.....

2. The weights shall be manufactured to within 3% of the stated weight.

3. The bar shall be manufactured from 25 m.m (1 Inch) diameter steel rod to BS 970, PART 1, 07 OM 20.

4.10

EVALUATION OF WEIGHT MEDIUMS

Material	Cost P.	Formability	Manu Cost	Compressive Strength	Density	Impact Resistance	Accuracy in Weight	Aesthetic Qualities of material	SCORE
Mild Steel	£500/Tonne	V. Good	Fair	Good	V/Good	Very Good	Very Good	Very Good	
Lead	£400/Tonne	V. Good	Fair	Low	Excellent	Low	Excellent	Good	
Aluminium	£550/Tonne	V. Good	Fair	Good	Low	Fair	Very Good	Excellent	
Concrete	£120/Tonne	Good	Very Good	Very Good	Good	Low	Fair	Fair	
Clay	£100/Tonne	Fair	Fair	Very bad	Good	Very Bad	Fair	Low	
Cast Iron	£210/Tonne	V. Good	Fair	Very Good	Very Good	Very Good	Good	Very Good	
Water	/Tonne	V. Bad	Excellent	Very Bad	Low	Very Bad	Very Good	Fair	

Points System

1. Very Bad
2. Bad or Low
3. Fair
4. Good
5. Very Good/High
6. Excellent

Mild Steel	34
Lead	31
Aluminium	30
Concrete	30
Clay	21
Cast Iron	35
Water	25

SELECTION : Cast Iron

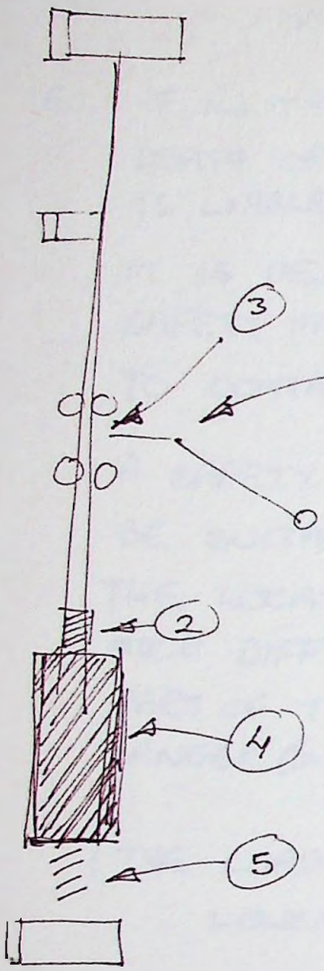
Conforms to British Standards.

4.11 DESIGN DEVEPOMENTS

The following section is a free hand.

Design development outline including

1. Structural Analysis
2. Manufacturing Considerations
3. Cost Effectiveness
4. Styling.

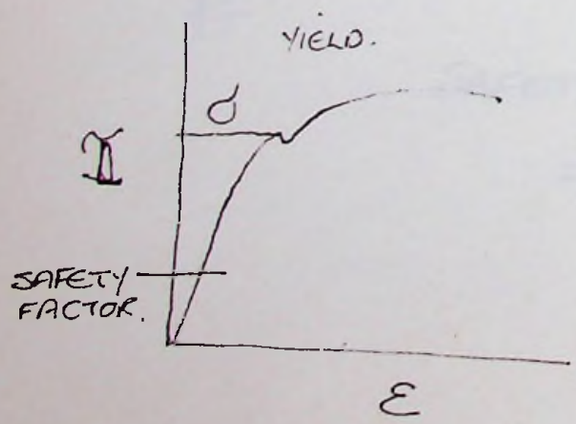


AREAS TO BE CONSIDERED.

1. BENDING MOMENT.
2. STRESS OR REQ.D PERFORMANCE OF CENTRE SPRING.
3. SHEAR STRESS ON CENTRE PIN
4. SHEAR STRESS ON LOADING PIN.
5. STRESS ON WEIGHT STACK. SPRINGS.

IT IS DESIRABLE IN A DESIGN LIKE THE ABOVE TO DESIGN TO A SAFETY MARGIN OF 8:1.

SAFETY FACTOR OF 8 IT TAKEN FROM THE YEILD POINT OF THE MATERIAL IN USE.



ANOTHER FACTOR IN THE DESIGN IS A CONTROLLED SYSTEM OF FAILURE.

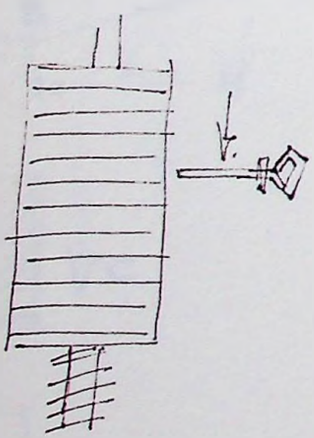
IE. IF IN THE EVENT OF FAILURE, A RESULT OF DEATH OR INJURY OCCURS THEN THE DESIGNER IS LIABLE.

IT IS DESIRED THROUGH REDUCING THE SAFETY FACTOR IN ONE POINT OF THE DESIGN TO CONTROL THE FAILURE.

A SAFETY FACTOR OF 5:1 OR 6:1 WOULD BE SUITABLE.

THE LOCATION SHOULD BE REPLACEABLE WITHOUT MUCH DIFFICULTY. (IE THE ITEM IS A SMALL PART OF THE MACHINE THAT WILL CAUSE NO DANGER ON FAILURE, TO THE USER.)

(THE LOADING PIN IS THE BEST AREA FOR THIS LOWER SAFETY FACTOR)



SHEAR STRESS ON LOADING PIN

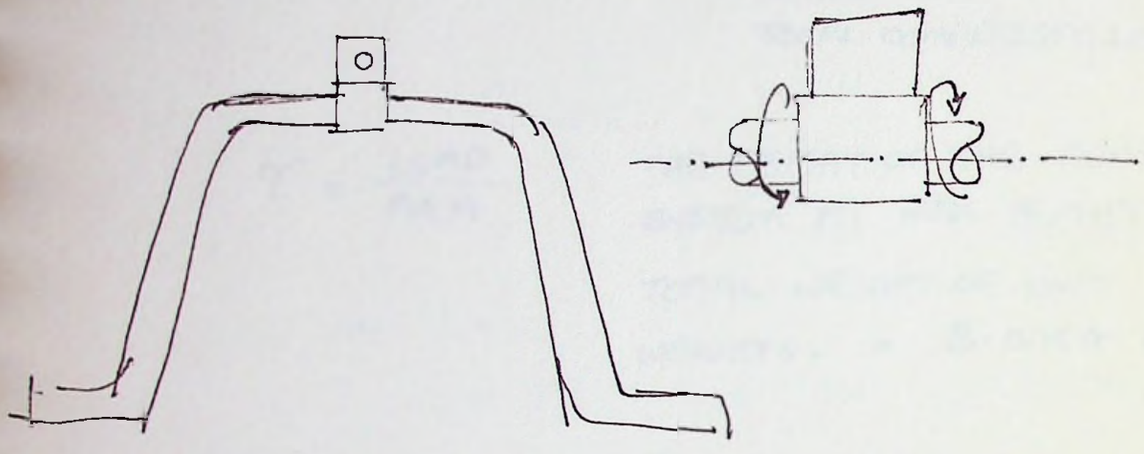
$$= \frac{\text{LOAD}}{\text{AREA.}}$$

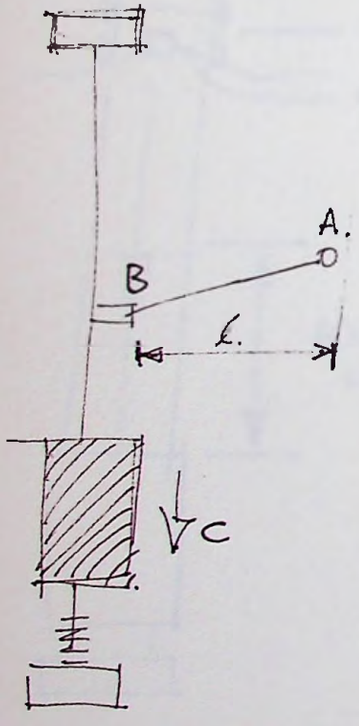
$$\tau = \frac{L}{A} \quad \frac{(N)}{(M^2)}$$

$$\text{SAFETY FACTOR} = \frac{\tau_{YIELD}}{\tau}$$

STRUCTURAL STRESS ANALYSIS.

(1.) BENDING MOMENT ON LIFTING ARM.





CONSIDERATIONS.

(1) DISTANCE FROM FULCRUM POINT. A → B.

(2) LOAD AT POINT

(3) MODULUS OF REGIDITY OF POINT B.

IS POSSIBLE TO WORK OUT ANGLE OF TWIST IN RADS.

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L} = \frac{\text{ANGLE OF TWIST}}{\text{LENGTH.}}$$

MODULUS OF REGIDITY FOR MILD STEEL APROX 80×10^9 N/M^2

STRESS ON SPRINGS.

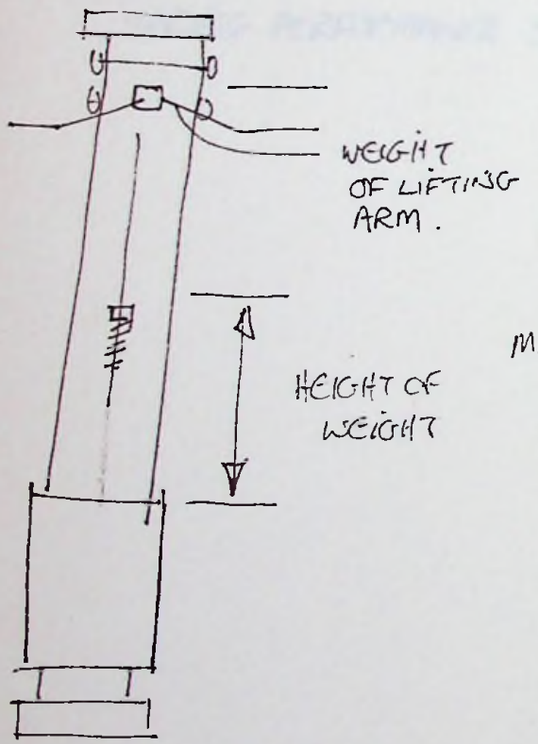
FOR (2) REQUIRED COMPRESSION SPRING

TOTAL LENGTH l.
ACTIVE LENGTH L
TOTAL COMPRESSED LENGTH

$\tau = \frac{\text{LOAD}}{\text{AREA}}$.

THE HEIGHT OF THE RUNNER SYSTEM AT MAX HEIGHT.

TOTAL WEIGHT OF UNIT WITHOUT WEIGHTS. = 8.5KG APROX.



MASS X ACC = FORCE N

STRESS ON WEIGHT STACK SPRINGS.

IMPACT STRESS. COMPRESSION SPRINGS.

GIVEN BY TOTAL LIFTING WEIGHT
DROPING FROM MAX HEIGHT

$$\tau_{MAX} = \frac{\frac{LOAD}{AREA}}{2.}$$ FOR TWO SPRINGS.

LOAD MAX L_{MAX}

$= 75\,KG + 8.5\,KG = 83.5\,KG.$

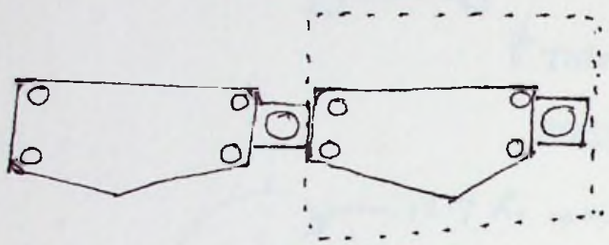
SPRING PERFORMANCE SPECK FROM STANDARD WIRE GUAGE.

SUPPORT PLATE — CENTRE COLUMN

MATERIAL — MILD STEEL SHEET. 2 MM GUAGE.

FORMING PROCESS. — PUNCH PRESS.

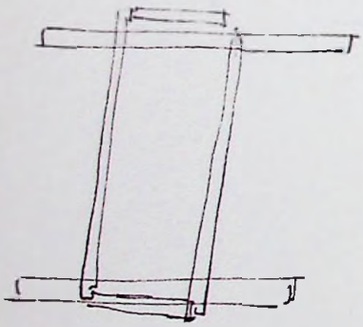
PATTERN.



CONTINUOUS FEED FROM ROLL OF FLAT STRIP

CROPPING EVERY 2ND IMPRESSION.

PLATE BENT 3/90° BENDS WITH BOX AND PAN FOLDERS.



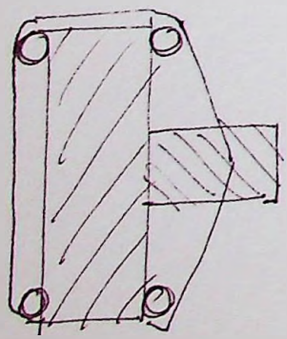
FUNCTIONS.

ALLOWS SHAFTS TO BE CENTRED. BEFORE ASSEMBLY.

IS SUPPORTIVE TO "T" SECTION

IS A FAILSAFE IN THE EVENT OF A WELD BRAKEING FROM THE T. (SHAFTS)

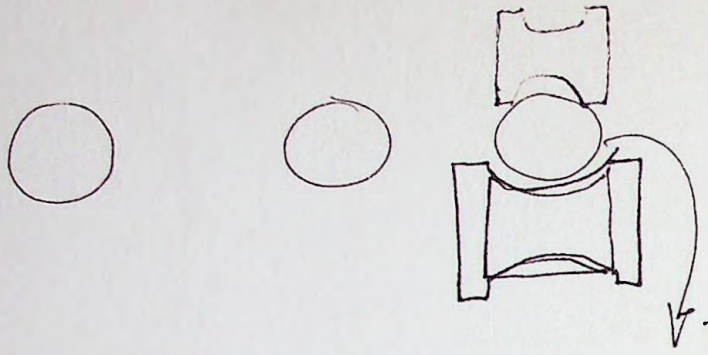
IS A DESIGN FEATURE TO LOOK FUNCTIONALLY STRONG AND VISUALLY SUPPORTING.



"T" SECTION.

ROLLER SYSTEM

MATL : NYLON.

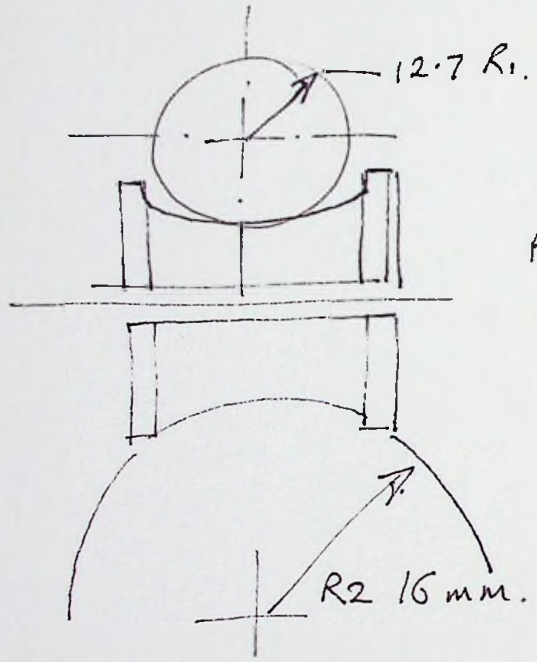


3 CENTRES.

1" SOLID ROUND BMS.

TIGHT TOL REQ.

APROX .5MM → 1MM.



LOWER SURFACE AREA CONTACT LESS FRICTION.

4.12 PERFORMANCE SPECIFICATION

The resistance exercise machine must.....

1. Be able to give resistance in SKG incriments.
2. Be stable when in use.
3. Be able to allow full range of movements.
4. Cost between £400 and £550
5. Be accurate to 3% of stated lifting weight
6. Be structurally sound.
7. Be suitable for manufacture by a low investment industry.
8. Be durable and give a life span of 8-10 yrs.
9. Provide a good range to exercise movement
10. Be safe for user (Not fail in use)
11. Easy to operate
12. Require no more than 4' X 7' of floor space when working and less when stored.
13. Provide a weight guard
14. Be installable anywhere
15. Be adjustable to suit stature of user range (25-30 Height Measurements)
16. Be easy to adjust
17. Be serviceable by Manufacturer.
18. Conform to B.S. 1892 PART 2 SECTION 2.6
19. Complimentry to its environment (Colour Form)
20. Be theft and vandal resistant.
21. Require little or no service by user (Other than oiling or similar)
22. Provide resistance up to 150 KG in weight
23. Allow smooth movement of weights (Low friction co-efficient)
24. Hygienic, easy to clean
25. Have a high resistance to corrosion that might lead to failure.
26. Compliment visual and structural strength of area.

DISCUSSION

5.1 DISCUSSION

Comparison of resistance exercise.

Isokinetic Exercises

The claims made for isokinetic exercise maybe shortened into

1. It provides full range exercise
2. It provides a high intensity of muscular contraction
3. It provides a very safe form of exercise

These claims maybe disputed by the following:-

1. Full range exercise is not possible without a "Back Pressure" of a force pulling against your muscles prior to the start of movement. Nor is it possible without resistance at the far end of the movement. Therefore isokinetic is not a full range exercise.

2. Isokinetics providing high intensity is true one to a certain extent. Without "Back Pressure" there is no pre-stretching the involved muscles. Pre-stretching is required for maximum muscle contraction.

3. Isokinetics is unsafe because:

   A. It results in greatly elevated blood pressure.

   B. Involved forces are far higher than either necessary or desirable.

MAJOR DISADVANTAGE

Isokenetic provides no eccentric contraction

(negative work)

ISOMETRIC EXERCISES

Advantages maybe outlined as follows:-

1. Isometric work involves no weights.
2. Equipment is cheap
3. Exercise periods are short

Disadvantages

1. Requires instruction
2. No negative work
3. Not possible to work muscles through full movement range.
4. Exercises must be made more frequently.
5. Development potential is limited
6. No visual representation of work
7. Low Cardiovascular activity

Reasons for Selecting Isotonic

1. Provides both positive and negative work
2. Measurable resistance is given.
3. Resistance is fixed throughout movement
4. Requires little or no instruction
5. No development limit of muscles
6. Suitable for circuit training systems

Disadvantages

1. Requires weight or mechanical resistance
2. Equipment is usually high cost.
3. Requires more space than isometric.

The points outlined are the reason why Isotonic was selected over the other two basic forms of Resistance Exercise.

5.2 REASONS FOR SELECTION OF WALL MOUNTED MODULES OVER FREE STANDING MULTI GYMS

Advantages of Wall Mounted Units

1. Low space requirement
2. Could be locked away in presses
3. Places little stress in floor
4. Better distribution of weight
5. Modular units give larger market range
6. Require Less material than free-standing units
7. Less susceptible to vandalism
8. No limit to number of modules
9. Multi function stations.

Disadvantages of Wall Mounted Units

1. Must be mounted or fixed to wall
2. Require sound wall for fixing
3. Require more frequent servicing
4. Module is not mobile.

Advantages of Multi Gym, Free Standing

1. Mobile Unit
2. Requires no Fixing (Free Standing)
3. Centralised exercise area
4. Caters for more than one person at a time
5. No change exercise change station i.e No adjusting required.

Disadvantages of Multi Gym (Free Standing)

1. Requires large amount of space (Minimum room size 13' X 17')
2. High concentration of stress on central floor area.
3. Cost range, gives lower marker range.
4. Requires large storage area
5. More susceptible to vandalism
6. Uneven distribution of weight in room
7. Limit to number of stations per multi Gym.

5.3 MANUFACTURING CONSIDERATIONS

Because weight medium should conform to B.S.1892 the following production processes were considered

1. MILD STEEL PRESSED PLATE

Material Cost £500 per tonne
Machine Cost £10 per hour
@ 1 plate per minute.

2 X ½ in plate or 1 X 1" in Plate
Cost per 5 KG WGHT £4.02 plus V.A.T.

Pressed mild steel would give a good finish with high dimensional accuracy. Little finish would be required other than bush insert and accuracy in weight would fall to within the 3% required. Some protective coating maybe required to avoid rusting or corrosion. High Impace resistance and material strength would give long life.

2. MILD STEEL CASTING

Material Cost £500 per tonne
Casting Cost £2.20 per Wght.
IVI Foundries Athy.

Cast mild steel weights are in line with qualities above for mild steel plates. The main argument against casting in mild steel is cost of casting. Otherwise it could be said to be a suitable material. The cast weights would also require bushes or inserts.

3. CAST IRON

Unit Cost £2.87 + V.A.T.
IVI Foundries Athy.

Cast iron weights would conform to the requirements of the weight medium. Cost is low. Finish is good but may require some painting or finish treatment.

5.4 EVALUATION OF OTHER RESISTANCE FORMS

Types required:-

1. Springs
2. Hydraulics
3. Electromagnetism
4. Levers.

1. SPRINGS (EXTENSION)

Springs restrict movement to a certain range. Extension spring resistance is not constant. These two factors alone would eliminate extensions and compression springs.

SPRINGS (CONSTANT FORCE)

Would give range of movement from two variables
1. Number of Coils
2. Diameter of Coil.
Maximum size available 7' diameter.

De Souter Constant Force Springs London
Maximum Resistance Available = 22 lbs
Cost per 22 lbs = £24.70 per spring.

On this basis and due to the fact that springs are sometimes subject to mechanical failure their use in the final design was ignored. Another factor against the use of springs is that with time the tempering of the spring would decrease and become inaccurate. This would not comply with BS 1892.

2. HYDRAULICS

Fluid Hydraulics can displace very high pressures but require tight tollerenceing. They are restrictive in movement range only by the proportional length of the piston shaft. In a closed system they would not give a constant resistance. In an open one they would but only in one direction i.e. There would be no negative work.

Hydraulics Cont/d.....

Unless aided by a compressor hydraulics would work in only one direction. This in both respects is underirable.

3. ELECTROMAGNETISM

Electrical instillations are an insurance risk in institutional and leisure centres. System would cost consumer money in operation. Risk of shock to user through conducted currents water vapour. Medical effects of strong magnetic fields not clear enough in safety.

4. LEVERS

The use of levers may well provide advantages in weight saving, but are restrictive in the range of movement that they allow. They also require more operating space which by the outlines of the brief is important.

5.5 COSTING ESTIMATE

The below costing is an estimate for a low estimate industry. Equipment on site would be as follows:-

1. ARC Welding Plants
2. Benders forming Machine Rollers
3. Gringing Machines hand held
4. Box and Pan Folders
5. Stove enammeling plant
6. Compressor. Spray Gun.
7. Centre Lathe or Capstan Lathe.

Not all componants will be manufactured on site. Bought in 'Off the Shelf' componants will be prices according to buying price and shall not be given a manufacturing cost break down. Sundries implys , nuts rivets washers etc.,

BOUGHT IN COMPONANTS

Componant	QTY	Cost P/O	Material	TOTAL COST
Weights	15	3.65	Grey Cast Iron	54.75
Weight Bushes	45	.06	Poly Prop	2.70
Weight Rollers	8	.40	Nylon	3.20
Roller Collars	8	.02	Chrome Tube	.16
Compression Springs	3	2.00	Spring Steel	6.00
Wall Bolts	6	.40	Steel bolt	2.40
Pressed Plate	1	1.80	Mild Steel	1.80
Bushes/Bungs	2	.30	Nylon	.60
Sundries				1.50

BOUGHT IN COSTS £73.11

FABRICATED COMPONANTS

COMPONANT	MATERIAL COST
Top and Bottom Brackets 2 off	2.60
Support Plate	1.00
Handles	4.12
Runner Column	2.76
Weight Guard	3.30
Centre Pole	2.28
	16.06

Fabrication Cost 8 hours Two Men
1 Fitter @ £5.50 /hour
1 Apprentice @ £4.00 /hour

LABOUR COSTS

£44.00 Fitter
£32.00 Apprentice

£73.11	Bought in cost
£16.06	Material Costs
£76.00	Labour Costs
	TOTAL COSTS = £165.

Assume 125% mark up
for profit margin

SALE PRICE £371.25 (Estimate Only)

CONCLUSION

CONCLUSION

1. At an approximate cost of under £400 the design is within the market range aimed at.

2. A compliment of extras would be made available to develop the range.

3. Structural stress analysis would be required to specify material qualities and degrees of yield required.

4. Final design prototype should be subject to a distructive test to establish experimental performance rather than calculated performance.

5. Colour of unit should be modern to suit design

6. A book or wall chart should accompany the final design.

7. Design activieies should be concentrated on the actual working mechanism. Casing and extras may be designed later to compliment basic unit.

BIBLIOGRAPHY

CONTACTS

1. Dublin Steel Stockholders - Dublin.

2. Tonge and Tagart - Dublin.

3. Abbicoil Springs Ltd - Portadown

4. British Spring Research and Manf. Assoc. - Sheffield.

5. Tensator Constant Force Springs

CONTACTS

1. Magnet Wicksteed Ltd. Clonroadmore Ennis
   Tom Bourke Financial Controller (065) 24611
2. Sauda Distributors, Rathcoole, Co. Dublin
   (01) 589464
3. Shannon Development (061)61555
4. Gym Sports Eng. Rush (01) 437010
5. CONSPOR Dept. of Education - Hawkins House
6. Lodge Sports, Trading Est. West Molesey
   Surrey Engineering London.
   (031) 941-2555 KT80UH
7. Industrial Development Authority
8. Matchmakers Shannon Development (061) 62888
9. Michael McDonagh. Insp. of Phis. Ed.
   Dept. of Education REP,
   Sports Council
10. Paddy McCann, Ballinteer Community School
    (Palmerston R.F.C.)
11. Oliver Marshall, Chief Librarian, Dept of Ed.
    Malborough St
    Library Phis. Educ. Section.
12. Mr. Tony Watson - NCPE Limerick
13. English Sports Council - Michael Collins
    031-431,589,3411
14. Star Plastics - Ballyconnelly - Cavan
15. Multi Station Exerciser - George Dudley
    Sports Technology Ltd.
    130 Lancaster Road, New Barnet,
    Herts, EN. 48AL.
16. Mulit Gym Equipment, John Terry Isokinetic Eqp.
    21 Derwent Road, Castbourne, East Sussex.
    0323 - 638851.
17. Ergo-Gym 4-12 Station. H. Hunt Ltd., Wood End
    Avenue, Speke, Liverpoof L249JW
    051-486-1994

18. Olympic Gymnasium Co.Ltd. Olympic Works,
Great Suffolk Street,
London SE1 OBN 01-928, 3633

19. R.W.Writtle Ltd., P.V. Works Monton Eccles,
Manchester M30 8 AX,
061-789-1607

20. Niels Larsen & Sons Ltd.
Richmond Works,
Selbyrd, Garforth Leeds,
LS 25ILY.

21. C.G. DAVIES & SON
46 Smithford Way,
Coventry. CV1 1 FW.

22. Gym Sports Ire Ltd.,
Iona Main Street Lr.,
Rush, Co. Dublin.
437010

23. British Amateur Weightlifting Association.

LETTERS - Universal Gym Machine

1. Univeral Athletic Sales Co. Inc. Fresno,
California, U.S.A.

16 Stations 1. Leg Press

2. Ravelle Wright Weight Ltd.,
28-30 Rivington Street
London EC2 A3DU. 01-735,9089

3. Nautilus Sports/Medical Industries
P.O. Bos 1783,
Deland Florida, 32720 U.S.A.

4. Harry Gill Company, 201 Courtesy Road,
Urbana, ILL. 61801

5. Grandsteam Ltd. Phoenix Way, Carngogh Ind. Est.
Gorseinon, Swansea.

5. Physique Internation, 39. Penryn Isaf Road.
Penryn Bay,
Llandudno, Gwynedd.

6. Universal Box 1270 - Cedar Rapids, IOWA 52406

7. Keiser Sports Health Equipment
1603 'E' St. Fresno,
California 93706.

8. Hydra-Gym Athletics Inc. 2121 Indust. Road,
Belton,
Texas, 76513.

9. AFM American Jefferson IOWA 50129.

10. Corbin Gentry Inc.
40 Mapel Street,
Conneciticut 06072.

READING REFERENCES

1. Effects of Competitive Sport on young children in Ireland.
   An Roinn Oideachais. Discussion Document, Government Publications.

2. The Manual of Weight Training - George Kirkley
   John Goodbody - 1967

3. Anatomy for Students and Teachers of Physical Education. J. W. Perrott. 1974.
   PUB. EDWARD ARNOLD LTD.

4. Athletics for Student and Coach. Ian Ward/Denis Watts
   PELHAM BOOKS LTD. 1967.

5. Manual of Structural/Kinesiology CLEM W. THOMPSON
   C.V. Mosby Company Saint Lois 1977

6. Kinesiology Fundementals of Motion Description
   DAVID L. KELLY, (Prentice Hall, New Jersey.)

7. Experiments in Physiology of Exercise
   LARRY G. SHAVER. (Burgless Pub.)

REFERENCE BOOKS

1. The Physiology of Human Survival
   O.G. EDHOLM AND A.L BACHARACH.
2. Modern Weightlifting and Powerlifting
   GEORGE POPPLEWELL
3. Physical Education in England since 1800
   PETER C. MCINTOSH. G. Bell & Son London 1972.
4. Greek Physical Education
   CLARENCE A. FORBES.
5. History of Physical Education
   HARPER/ROW New York 1966.
6. A Brief History of Physical Education
   EMMET A. RICE. JOHN L. HUTCHINSON. 1969
   THE RONALD PRESS CO. NEW YORK. MABEL LEE.
7. Physical Education an Overview
   SEIDEL/RESICK ADDISON- WESLEY PUB. CO. 1972 London
8. Kinesiology Fundamentals of Motion Description
   DAVID L. KELLY, PRENTICE HALL INC. New Jersey
   1971.
9. Kinesiology and Applied Anatomy
   RASCH/BOURKE. LEA/FEBIGER PHILADELPHIA 1971.
10. Biomechanics of Human Motion.
    WILLIAMS/LISSNER.
    W.B. SAUNDER COL PHIL-LONDON 1962.
    12. DYOTT STREET,
    LONDON WCIA 1DB.