MK I EXERCISER

This device consists of two components 1) a load or force generator 2) means of 'coupling' the forces to the human body.

The value of this device is in the concept of the force generator. Little or no attention had been paid to the nature of the load applied to muscle, i.e. a pound of force was a pound of force. Muscle, like most other body system, was evolved in response to particular needs. It makes a great deal of difference, particulary for sustained performance, whether the body is acting against a purely resistive force or whether other force-types are present. The exerciser in existence allows both selection of up to three force-types ($F_1 = K_1$; $F_2 = K_2 \dot{X}$; $F_3 = K_3 \ddot{X}$; where F=force, K-constant, and X=displacement ≥ 0) and independently ajustable magnitude. This allows simulation of earth forces such as bar bells, tightening a bolt, pushing a sledge or what-have-you.

The coupling systems on the exerciser may be arranged to satisfy almost any requirement for loading any muscle or muscle systems. It's present configuration is simply a round bar constrained to travel in a vertical plane of some eight feet.

Photo S-68-18112 shows the device mounted in a wooden stand with guy wires for restraint of the vertical number. This was prototype which has been considerably improved but demonstrates features of one configuration. The force generator is beneath the foot board and controlled by levers between the feet. Obviously some form of "boot" is required for zero G flight. The force generators shown in #1017 is research prototype but again demonstrates principles. A series of constant forces (F) are generated by constant force (almost) "Negator" springs.

These springs have been the limiting feature of the system since their working life is some 6,000 to 8,000 cycles at present stresses. (They are, however easily replaced) Inertial loads ($F_3 = K_3 \ddot{X}$) are provided by the rotating discs in the upper portion. Not shown is the resistive force generator ($F_2 = K_2 \dot{X}$) a continuously variable faraday disc eddy current generator.

At this point a brief history of who and why may be useful as a background for future work. A number of persons (Col. John Ord, USAF School of Aerospace Medicine, Brook AFB Texas was most pertinently involved) involved with MOL were concerned that bicycle type exercisers, while excellent for cardio-vascular conditioning, might allow marked atrophy of truncal and upper extremity musculature. It was also felt that some form of "total body exercise" would conserve skeletal integrity. This proposal & rational is contained in a number of USAF, Aerospace & Douglas documents and Douglas was directed to develop a device. The proposed development followed fairly conventional electrical generator-variable load arrangements but development was not successful and we begain a parallel effort at the School of Aerospace Medicine. Mr. Donald McDougall of the schools instrument shop was primarily involved in fabrication and test of the devices. Our interest at the time was provision of moderately heavy work (including the upper extremeties) which could be maintained for periods long enough to accrue cardio-vascular benefit. A prototype was designed which allowed the comparison of a variety of ranges and types of forces which were investigated using respiratory gas studies and subject performance.

These studies were confirmed in Dr. K. Cooper's lab with a larger number and variety of subjects. It was obvious that sustained high work loads could be obtained with "total body exercise" using a combination of gravitational & inertial forces. Other forces would fatigue the muscles too rapidly, which is not surprising when one looks at evolutinary developmental conditions. Bed rest studies were started and continue under Col. Ord's direction.

In an attempt to simulate and later confirm under flight conditions the biomechanics involved, a zero G simulartor was devised after zero G studies in the KC-135 (see unmarked photo) using an instrumented prototype and photo-recordings. This zero G simulator is shown in #0752 & 0754 and is still being extensively used in bed rest studies. * This work was also to provide a point of departure for comprehensive studies of the cost of work in space in general. While it does not directly concern the immediate goal of putting the exercise device aboard, these studies have provided an extensive experience.
Further, H.Q. NASA is apparently considering the inclusion of an instrumented version of the device to allow continuation of the MOL studies.

As to the use of the device for crew of-duty fun & games: Some two years ago a prototype was taken to the astronaut gym and various exercises explored with Joe Garino. A wide variety of standard lifts, presses and the like are possible. A few of these are pictured. In one mode it can be considered a set of bar-bells, constrained to one plane. "Weights" ranging 15# to 65# in 10# increments are available (other ranges up to 100# are practical, though I've seen little use for weights above this, except in bench presses, in the astronaut gym.) The zero or rest point of the bar may be set at any desired position. The grivitational forces may be set for either direction down or up. In the latter case some additional form of restraint of the subject to the base must be considered for large forces. It must not be forgotten that this is a good simulation of a bar-bell which, if dropped, will accelerate and acquire kinetic energy capable of mashing things. A clutch provides some but far from complete protection. Other type combinations of useful forces are available but probably of less benefit.

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*Southwest Research Institute: Mr. Bill Oakey & Wray Fogwell were involved in various aspects of these studies & machine design.

Current status: the device has gone through several prototypes with consideration given to flight use. A final flight prototype & design should be made which after life & preliminary tests could be frozen and flight qualified. Cost of the unit will be direct function of the Q & A. If an enlightened approach could be taken (I've heard rumors of such) then a reliable and useful device (one flight, one backup, one training, and one prototype) will probably cost $60,000. If the whole Apollo Q & A game is played, who knows. The only inherent limit is the $5\text{-}6X10^{3}$ cycle life of the springs but this should be adequate for intermittant use for 60-120 days. These are ways of circumventing this problem which have been studied & tested.

Weight, depending upon maximum loads desired, should be 30-35#. This has been demonstrated.

Operable prototypes are available for study and some drawings are available but not complete.

Time is a function of contractor & program director but could be as short as 6 months or 9 months with full Q & A.

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