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Comparison of Active + Passive Treadmills for Space Flight -

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~~Rat~~

Design - Test -

Rationale for Passive T/M

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Introduction:

Loss of locomotor function in space flight results in rapid muscle and bone atrophy as well as ~~decond~~ loss of cardio-vascular respiratory capacity. At this time the most efficient way of ~~replacing~~ preventing such loss is c ~~a~~ a treadmill which allows resumption of locomotor activity at 1 g equivalent body weight. While treadmill ~~have been in use for many ye~~ design for 1 g - is well known there are several problems in their use in space craft including size + weight, power and absence of weight. ~~While it~~ There are frequent questions concerning their application and especially the equivalence of active + passive treadmills. The following is an attempt to answers some of the more frequent questions ~~plus giving~~ and to give a general basis for their use in the future for it seems likely that they will be ~~on a~~ the primary exercise device on space station & long after. Theory of operation, design and ~~testing~~ physiologic testing are described here.

History - Although unknown to us at the time the Russians had a small belt tread unit, ~~ex~~ both passive & motor driven, in flight by 1970 . The first American use of locomotor exercise was on SL-4 when it became obvious that such exercise was needed. Virtually no weight or space was available so a simple 'Teflon track' and elastic bungees c̄ force equivalent to body weight were sent up. This plus an on-board harness allowed a crude form of walking & jogging which was adequate to demonstrate the need for a true treadmill. A ~~unit~~ true passive T/M ~~wa~~ prototype was ~~develop~~ built within the many constraints of Shuttle ~~, including~~ and was pressed into flight service on STS-3 ~~until~~ and subsequent flights until replaced by ~~the~~ a smaller unit c̄ slightly larger tread area on STS .

— and subs. flights. ~~A~~ ~~true~~ treadmill c̄ adequate running area & other improvements is currently under construction for S.S. ¶ Rationale for design & operation, ~~&~~ test of the treadmill and physiologic testing + results follow –

Theory of operation: Fig. 3.1 shows the essential elements of any treadmill. ~~There are~~ Some replacement force for weight of the body must be provided in ~~space~~. weightlessness. ~~Note~~ A simple but not entirely satisfactory means of doing this is c̄ elastic bungees and a ~~belt~~ harness arrangement as in Fig 3.2. In human locomotion at a constant speed on level ground the net horizonal force is zero at a constant speed, for the same ~~to~~ energy is spent in the horizontal plane in accelerating + decelerating the leg & body. Thus a treadmill c̄ zero friction and large inertia to absorb.

the decelerations/accelerations of each foot could run c̄ a motor at a constant speed. At any elevation or depression energy is added to the tread by the relations shown in Fig 4.1 and the speed would increase unless the energy ~~is~~ were removed by a brake. ~~of some kind~~ The shuttle treadmill approximates this ideal as closely as possible by including a large inertia ~~in the~~ and minimum friction. The inertia ~~was~~ is obtained by a flywheel coupled to the tread through a large gear ratio and friction is minimized at every point c̄ ball bearings. This allows the treadmill to be powered by the subject at only slight elevations and a ~~variable~~ brake with onset at variable speeds controls the tread speed.

Making such a low friction device is expensive and, on earth, it is far cheaper to use a simple belt sliding over a support plate driven by a large motor which also controls the speed. However, just as in the ideal treadmill the subject adds power to the tread at any angle other than zero & motor input power decreases (Fig). Under this circumstance, power absorbed by friction of the treadmill must always exceed power generated by the subject, in order to maintain speed control. There is no difference experienced by the subject at equivalent speeds + grades on either an active or passive treadmill.

The biomechanics of locomotion is complicated by weightlessness. The first of these complications is the necessity of substituting a force for body weight. It is not practical to produce distributed forces or even load individual body segments, rather a hip and shoulder supported harness c̄