Mass Exp. #4

7530-286-6951
FEDERAL SUPPLY SERVICE

16—74548-1 GPO

2.0 There seem to be no fundamental theoretical difficulties so ~~that.~~ a realistic demonstration of the technique under earth conditions should be made -

(Insert Move section from P-1)

The essential components are ~~a~~ 2.1 structure to hold the mass to be weighed, 2.2 a spring assembly, 2.3 a device to determine precisely when the oscillating mass crosses point of zero displacement, [2.4] a counter for determining time periods, ~~and~~

2.5 some means of providing displacement along a given axis and [2.6] on earth some method of supporting the weight ≡ adding appreciable friction. This latter item makes the device more difficult to demonstrate under 1 G conditions than under weightless ness.

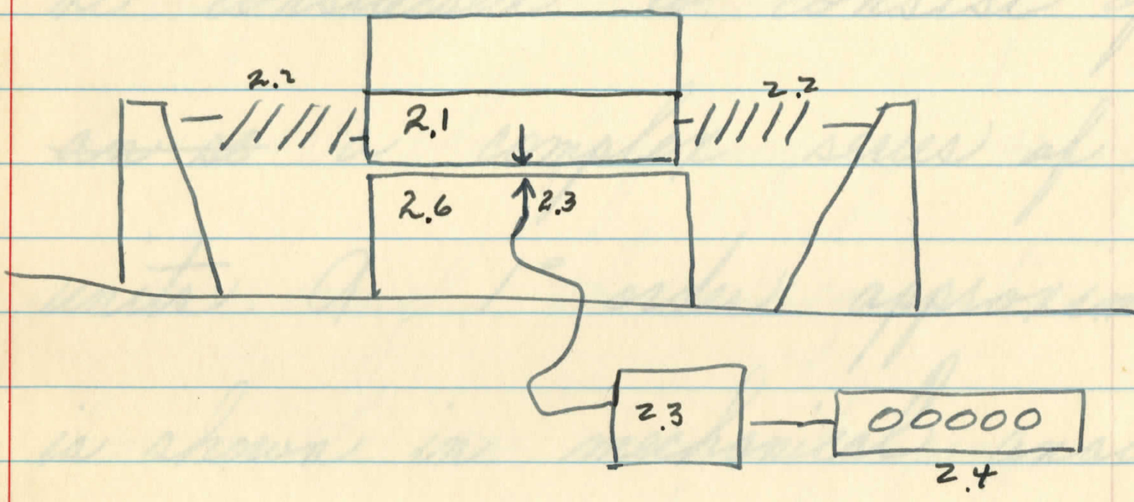
~~One of the major difficulties~~

~~This p~~ The ~~wei~~ experiment

will be ~~determined~~ described

by these sections. The basic arrangement is shown in F 2.1 -

Fig - 2.1.



2.1.1 The structure to hold

the mass is complicated by the

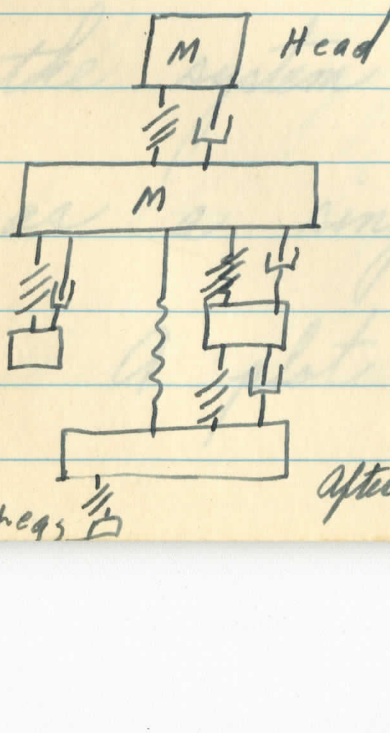
nature of the human body

and indeed the whole experiment

will be more or less influenced by these considerations.

The human body may be considered to consist of ~~an se~~ a complex series of sub-units. A 1° order approximation is shown in mechanical analogs in Fig 2.2.

p. 44.11



After Coerman, et al. Aerospace Medicine 31: 443 ('60)

~~If the frequency~~

These segments constitute a series of mechanical systems capable of ~~in~~interdependent oscillation. If however the frequency of oscillation is low enough ~~these segments may be~~ the ~~to~~ viscous damping forces become ~~great enough~~ sufficiently large to ~~cause~~ allow the system to ~~beho~~ be treated as a single mass.

A plot of ~~frequency~~ impeadance

of the body as a function of frequency of vibration is shown in Fig 2.3 - The impedance of a fixed mass is shown by the straight line. Any deviation from this line would result in an error in the proposed system. From these and a wide variety of ~~other~~ similar experiments ~~at the~~ by Coermann it appears that the maximum frequency which should be considered is ≤ 1 cps.

A second aspect of the human body is that it ~~seldom~~ cannot remains fixed in one position for any great length of time and that center of mass measurements ~~would be~~ are ~~of academic interest only but of~~ of such variability as to be of academic interest only. Any mass measurement scheme should be arranged such that these changes in mass relationships ~~co~~ (movement) will cause the least possible disturbance. ~~Th~~

One approach to this is to limit the degrees of freedom to the minimum, which will be simple translatory motion ~~in a~~ along a single axis. Even so, errors will be introduced by movement, as anyone knows who has tried to weigh a child on an ordinary scale. This error will be present here only during the cycle(s) when movement occurred. By allowing the major muscles of the body to contract against a mechanism rigidly attached to the spring system

~~two~~ three benefits should accrue: 1) subject motion should be reduced to a minimum, 2) the body will be more rigidly attached to the spring system and 3) the ~~stiffness of the bod~~ compliance of the body's elasticity will be greatly reduced, i.e. the body will more nearly approximate a fixed mass. ~~I~~ Movement may be further reduced by breath holding. ~~but~~ The ballistic effects of the cardiovascular system will remain. This latter effect will be small

* ~~A second consideration of~~ The limited amount of time that a fixed position may be held is a limitation of the maximum period of time such a measurement may be made. This ~~period~~ measurement period should be as long as possible for as will be shown later, accuracy should vary as the square root of the time duration of measurement. A practical limit would seem to be 10 - 15 secs.

and will be ~~very small~~ essentially zero over a complete cardiac cycle. ~~and will in any event be small.~~ For a human mass measurement system then the "weighing pan" should have a foot board and hand holds or other arrangement to allow contraction of the major musculature. *

2.2. Spring Assembly.

~~It shoul~~ Several factors are of importance here including the

~~* This source of mo artefact will be a~~

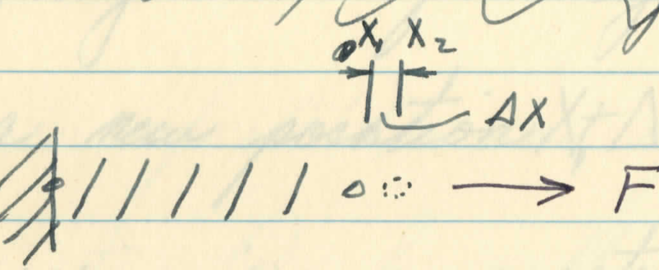
~~th~~ energy dissipative characteristics (hysteresis), linearity and time, form and temperature stability. When one speaks of springs we are referring to the precision devices which are in the majority of ~~weighing devices~~ scales in the country today rather than the crude devices used to close doors and the like.

Stability. The time stability of precision ~~scales~~ springs may be neglected for our purposes. ~~An effect called~~

~~creep~~ A spring under load will elongate slowly, ~~and for~~ an effect called "creep": ~~This effect will not is small~~

~~St is defined by $\frac{\Delta X}{X}$. St~~

~~This cont With a single~~



This effect is shown in 2. –

A spring is subjected to a fixed force F, and depending upon its constant K, it will be stretched to ~~its n~~ a position X_1 from the spring equation $F = KX$.

or $X = \frac{F}{K}$. $K = \frac{F}{X}$

~~I now~~ Depending upon

the ~~a~~ time and temperature

the spring will gradually elongate

to a new position $X + \Delta X$. If

~~the spring is now returned to~~

~~its original position X the~~

~~spring will have a new constant~~

~~force will be reduced by~~

Since the force is unchanged

this is equivalent to a new spring constant $K_2 = \frac{F}{X + \Delta X}$.

The creep of ~~the plan~~ a good spring ~~mo~~ is typically .01% /24 hrs. which results in a ~~decrease of~~ change of .01% in spring constant. Push pull springs will be use here which will double this effect to .02%. ~~Peut~~

~~Period is given by $\sqrt{\frac{\cancel{M}W}{K}}$~~

~~Since the sprin~~ Such

002
501

an effect will ~~be less than~~ ~~the~~ of the same order of magnitude as a wt. change of .1#.

However by simply unloading the spring assembly except when in actual use & this effect may be neglected. This normally occurs in spring scales which are not loaded in use.

The temperature ~~stability~~ coefficient of of the planned spring material may be varied from 0 to 15×10^{-6}

~~and made be made~~

Sherman

Temp Coeff.

Creep -

~~essentially zero~~ - The temperature variations of the lab ~~may~~ should also be small - ~~In~~ after conversation c̄ individuals ~~Mr. Gebore and others~~ c̄ extensive experience c̄ springs, there appears to be no exact expression ~~avail~~ available for the hysteresis of a spring ~~but~~ so that calculations of resistance ~~will~~ would only be estimates and will not be done here. ~~A~~ In any event this factor will be small as the hysteresis will be ~~on the~~ .02% on the

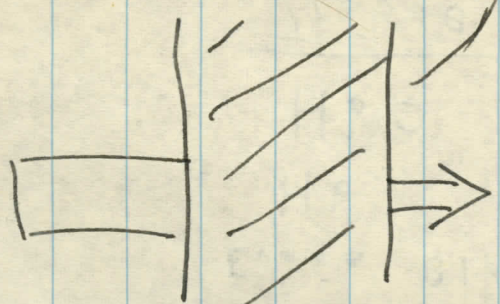
* A number of other effects might be present in a poor design (such as exceeding elastic limits) but will not be present here. A minor effect could result from twisting $\bar{c}$ displacement but this will be avoid by compound winding.

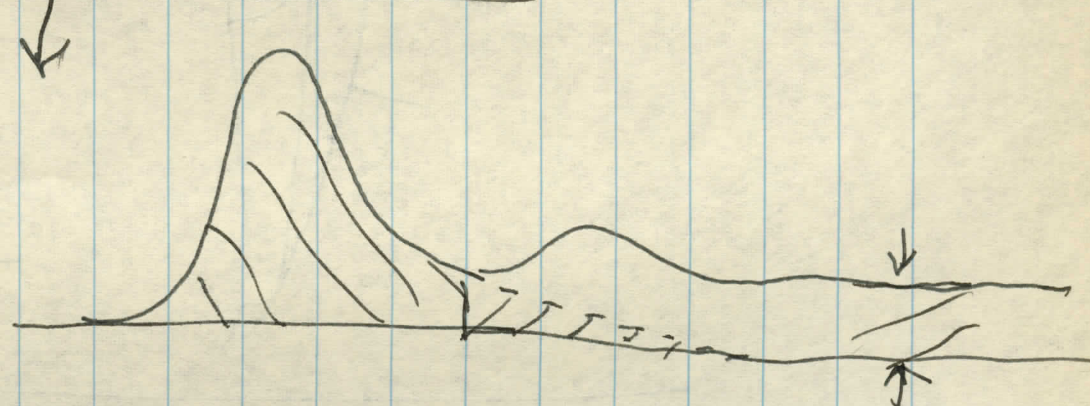
TP Some measurements recently made here on the resistance losses (hysteresis) show that these losses are very neglegible.

units to be used. * To summarize,
the springs should not present a problem
if the best material available is used.

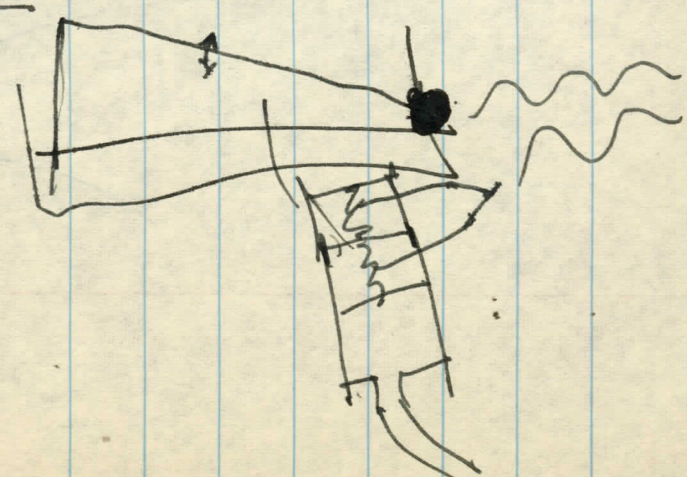
2.3 Insert 2.3 here

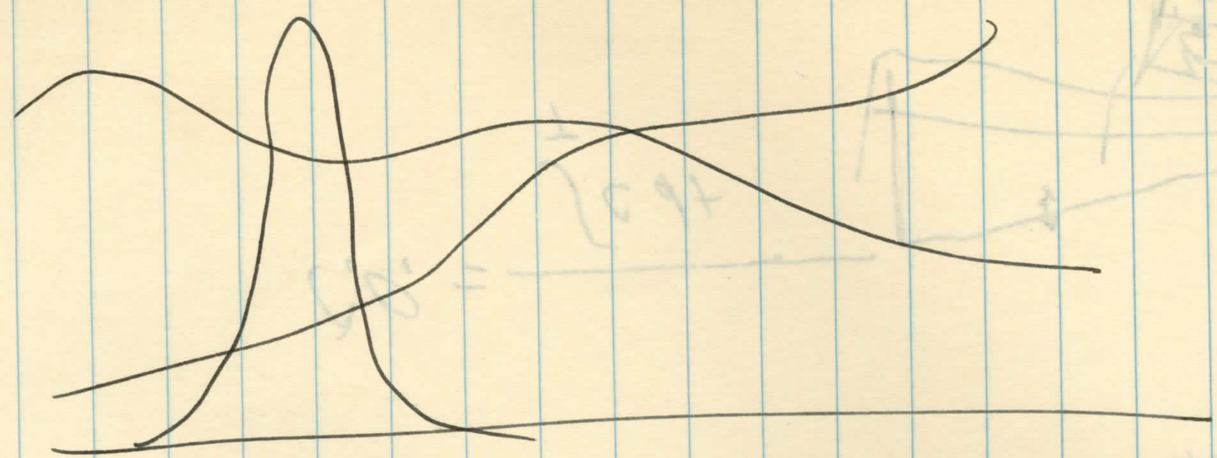
$$E = \mathrm{Log}\,\frac{I_0}{I} = \epsilon\,[c]\,L$$





$$C.O. = \frac{}{\int_T c\,dt}$$





Evans Blue —

Hb —

HbO —

Tissue