

Mass Exp. #4

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

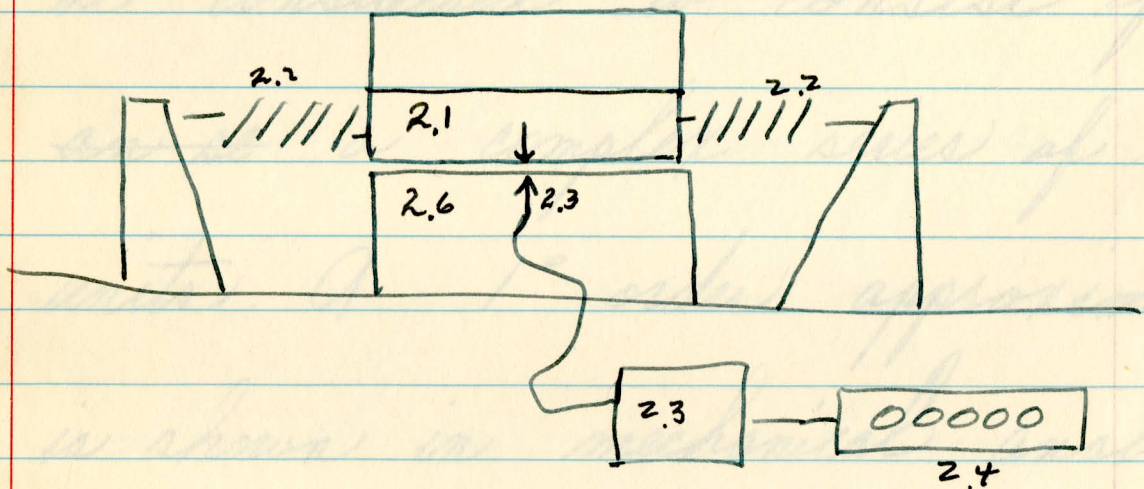
(Insert movie section from P-1)

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} one
earth some method of supporting
the weight $\equiv$ adding appreciable
friction. This latter item makes
the device more difficult to demonstrate
under 1 G conditions than under
weightlessness.

One of the major difficulties
This is the experiment

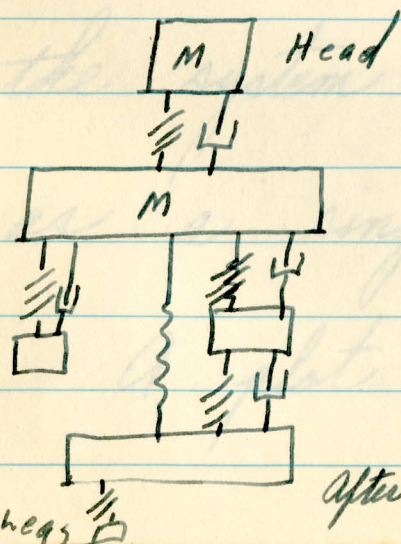
will be determined described
by these sections. The basic
arrangement is shown in F 2.1 -
Fig - 2.1.



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~~ a complex series of sub-units. A 1st order approximation is shown in mechanical analogs in Fig 2.2.



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

~~If the frequency~~

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

A plot of frequency ^{impedance}

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 g.p.s.

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

least possible disturbance. ~~It~~

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 this error will be present ^{here} only during the cycle(s) an ordinary scale. By allowing when movement occurred 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 body compliance of the body's elasticity will be i.e. the body will more nearly approximate a fixed mass. greatly reduced. ~~Its~~ 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 $\sqrt{t}$ the square root
of the time duration of measurement.

A practical limit would seem to
be 10 - 15 secs.

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

2.2. Spring Assembly -

~~It should~~ Several factors are of
importance here including the
* This source of ~~no~~ artefact will be a
~~an~~ energy dissipative characteristic

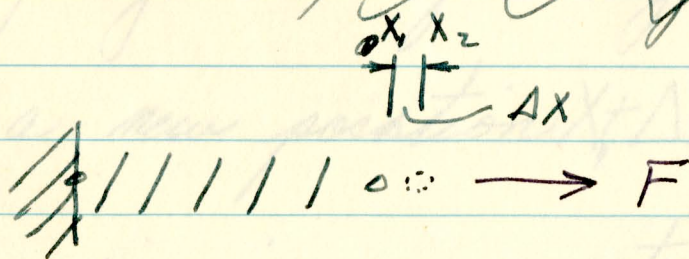
(hysteresis), linearity and time, form and temperature stability - when one speaks of springs we are referring to the precision devices which are in the majority of scales weighing devices in the country today rather than the crude devices used to close doors and the like.

Stability - The time stability of ^{springs} precision ~~scales~~ 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

It is defined by $\frac{\Delta X}{X}$ It

This can't it 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 ~~in~~ a position X_2 from

the spring equation $F = KX$.

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

~~I now~~ Depending upon
the ~~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 0.01% / 24 hrs.
which results in a decrease of
change of 0.01% in spring
constant. Push pull springs
will be use here which will double
this effect to 0.02% . Period

Period is given by $\sqrt{\frac{MBW}{K}}$

Since the spin Such

an effect will be less than
the of the same order of magnitude
as a wt. change of 0.1 #.

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

~~essentially zero~~ The temperature variations of the lake ~~may~~ should also be small. ^{After} ~~In~~ conversation ^{individuals} ~~in~~ Mr. Shore and others ~~is~~ extensive experience ~~in~~ springs, there appears to be ^{exact} no expression ~~with~~ available for the hysteresis of a spring but so that calculations ^{of resistance} ~~will~~ would only be estimates and will not be done here. ~~If~~ 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 & displacement but this will be avoided by compound winding.

1. If some measurements, ^{recently} made ^{here} on the resistance losses (hysteresis) show that these losses are very negligible.

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

2.3 I insert 2.3 here