Classics of Science:

Assuming that the alloy in your ring is silver alone, you may find the proportion of gold to silver in your ring by the method Archimedes used in Hieron's crown. Divide the weight of your ring by 19.3, the specific gravity of gold, to find the apparent loss of weight in water if your ring were pure gold. Call this quantity F_1. Divide the weight of your ring by 10.5, the specific gravity of silver, to find the apparent loss of weight in water if your ring were pure silver. Call this quantity F_2. Find by experiment the actual loss of weight of your ring in water. Call this quantity F. Substitute in the equation:

$$\frac{w_1}{w_2} = \frac{F - F_1}{F_2 - F}$$

to find w_1 and w_2, the weights of gold and silver respectively in your ring.

THE WORKS OF ARCHIMEDES, On Floating Bodies, Book I. Proposition 7., Edited in Modern Notation with Introductory Chapters by T. L. Heath, Sc. D. Cambridge (England), 1897.

Weight in Water

A solid heavier than a fluid will, if placed in it, descend to the bottom of the fluid, and the solid will, when weighed in the fluid, be lighter than its true weight by the weight of the fluid displaced.

(1) The first part of the proposition is obvious, since the part of the fluid under the solid will be under greater pressure, and therefore the other parts will give way until the solid reaches the bottom.

(2) Let A be a solid heavier than the same volume of the fluid, and let $(G + H)$ represent its weight while G represents the weight of the same volume of the fluid.

Take a solid B lighter than the same volume of the fluid, and such that the weight of B is G, while the weight of the same volume of the fluid is $(G + H)$.

Let A and B be now combined into one solid and immersed. Then, since $(A + B)$ will be of the same weight as the same volume of fluid, both weights being equal to $(G + H) + G$, it follows that $(A + B)$ will remain stationary in the fluid.

Therefore the force which causes A by itself to sink must be equal to the upward force exerted by the fluid on B by itself. This latter is equal to the difference between $(G + H)$ and G [Prop. 6]. Hence A is depressed by a force equal to H, i.e. its weight in the fluid is H, or the difference between $(G + H)$ and G.

Hieron's Crown

[This proposition may, I think, safely be regarded as decisive of the question how Archimedes determined the proportions of gold and silver contained in the famous crown. The proposition suggests in fact the following method.

Let W represent the weight of the crown, w_1 and w_2 the weights of gold and silver in it respectively, so that $W = w_1 + w_2$.

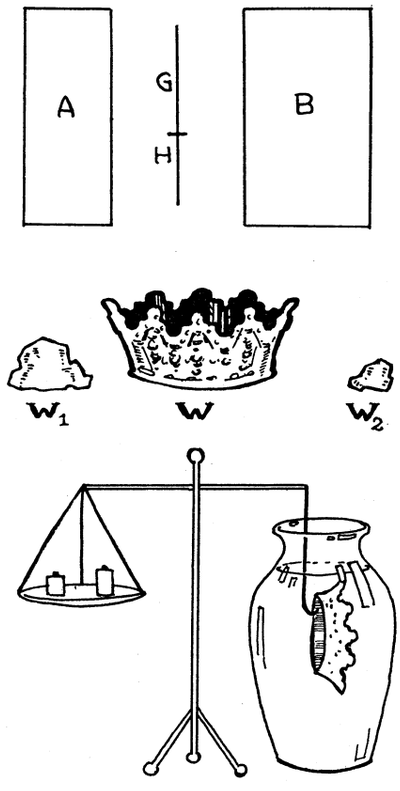
(1) Take a weight W of pure gold and weigh it in a fluid. The apparent loss of weight is then equal to the weight of the fluid displaced. If F_1 denote this weight, F_1 is thus known as the result of the operation of weighing.

It follows that the weight of fluid displaced by a weight w_1 of gold is $\frac{w_1}{W} \cdot F_1$.

(2) Take a weight W of pure silver and perform the same operation. If F_2 be the loss of weight when the silver is weighed (*Turn to next page*)

Weight in Air and Water

Physics



ARCHIMEDES' DIAGRAM is shown in the upper part of the illustration. He represented the heavier body in his proposition by the area A, the lighter by B, and let the lines G and H stand for weights, as described in the quotation. The crown W in the more modern part of the picture is supposed to be made up of a weight w_1 of gold and a less weight w_2 of silver, which was the impurity that Archimedes had to determine.

Microsupersonics

Physics—Biology

Super-sonic waves, which are rays of sound waves vibrating too rapidly to be heard, have now been brought under such control that observers can watch their effects through a high-power microscope. Using a small electrically driven crystal to produce these waves at a rate of 406,000 a second, Prof. E. Newton Harvey of Princeton University and Alfred L. Loomis of Tuxedo Park, N. Y., have watched blood corpuscles warp, twist and disintegrate, and have seen the living protoplasm in plant cells whirl in a dance of death, faster and faster until it has separated into spinning bits, broken and disorganized.

The apparatus used in these experiments is a refinement, on almost a jeweler's scale, of an earlier form devised by Mr. Loomis and Prof. R. W. Wood of the Johns Hopkins University. It takes advantage of the fact that when a rapidly alternating electric current is fed into a quartz crystal cut in a certain fashion, the crystal vibrates at the speed of the electrical oscillations, producing sound waves. By cutting the crystal small, and using an electrical oscillator of the type employed in radio stations, it is possible to produce sound waves twenty times as fast as the 20,000-per-second ones which represent the upper limit of human hearing ability. And these extremely rapid waves, at high enough intensities, have a tearing, killing effect on living substance. They have been nick-named "the death whisper."

"Observing under a high power microscope," Prof. Harvey and Mr. Loomis state, "it has been possible to follow the progressive destruction of frog blood corpuscles. The oval cells at first become warped and twisted. Strained areas appear and the color fades, leaving a pale distorted shadow. Human blood corpuscles are likewise twisted and sometimes broken up into many small globules like an emulsion of oil."

The two scientists also tried the vibrations on the leaves of a water plant, in which the living protoplasm usually keeps up a constant circulation around the wall of each cell. "High frequency waves of low intensity passed through these cells cause the protoplasm to rotate very much as in the normal rotation," they state. "Increasing the supersonic intensity (*Turn to next page*)

Microsupersonics—*Cont.*

increases the movement until the whole cell is a rapidly whirling mass of protoplasm, fragments of which are torn loose and rotate as small balls in the vacuole. The effect is very striking.

"The microscopic method offers a promising means of attack upon the problem of influencing the development of eggs of various species, as forces can thus be applied inside an egg at different stages of its development without the necessity of puncturing the cell wall or enveloping membrane. The results immediately suggest the interesting possibility of converting an egg with determinate cleavage into an indeterminate one by thoroughly mixing and redistributing the organ-forming substances of its interior."

Science News-Letter, April 28, 1928

Importance of Roots

Plant Ecology

JOHN E. WEAVER AND WILLIAM E. BRUNER, in *Root Development of Vegetable Crops* (McGraw-Hill):

In considering the importance of root relations in crop production, it should be clearly kept in mind that the plant, the soil, and the climate, form a closely interlocking system of which no part should be overlooked or over-emphasized. It is now rather generally recognized that climate and vegetation are the most important factors determining the character of the mature soil. "The features assumed by the soil in its development from infancy, through youth, maturity, and old age, vary with the environment, especially with the climate and the vegetation." The effect of both climate and soil on the growth of aboveground plant parts has long been known. It has only recently been clearly demonstrated that the environmental factors which affect the root are not only those of the soil immediately about it but also those affecting the shoot which is rightly a part of the complex. Through the shoot the root system is influenced by the aerial environment. The amount of light or the degree of humidity, temperature, etc., and the effect of these upon food manufacture, water loss, and other activities affect root development. In fact there is a rather close correlation between shoot and root development. Whatever affects the aboveground growth of plants whether favorably or unfavorably is, in turn, very likely to exert an influence upon root development.

Science News-Letter, April 28, 1928

Weight in Air and Water—*Continued*

in the fluid, we find in like manner that the weight of fluid displaced by w_2 is $\frac{w_2}{W} \cdot F_2$.

(3) Lastly, weigh the crown itself in the fluid, and let F be the loss of weight. Therefore the weight of fluid displaced by the crown is F.

It follows that

$$\frac{w_1}{W} \cdot F_1 + \frac{w_2}{W} \cdot F_2 = F,$$

or $$w_1F_1 + w_2F_2 = (w_1 + w_2)\ F.$$

whence $$\frac{w_1}{w_2} = \frac{F_2 - F}{F - F_1}.$$

This procedure corresponds pretty closely to that described in the poem *de ponderibus et mensuris* (written probably about 500 A.D.) purporting to explain Archimedes' method. According to the author of this poem, we first take two equal weights of pure gold and pure silver respectively and weight them against each other when both immersed in water; this gives the relation between their weights in water and therefore between their loss of weight in water. Next we take the mixture of gold and silver and an equal weight of pure silver and weigh them against each other in water in the same manner.

The other version of the method used by Archimedes is that given by Vitruvius, according to which he measured successively the *volumes* of fluid displaced by three equal weights, (1) the crown, (2) the same weight of gold, (3) the same weight of silver, respectively. Thus, if as before the weight of the crown is W, and it contains weights w_1 and w_2 of gold and silver respectively,

(1) the crown displaces a certain quantity of fluid, V say,

(2) the weight W of gold displaces a certain volume of fluid, V_1 say; therefore a weight w_1 of gold displaces a volume of $\frac{w_2}{W} \cdot V_1$ of fluid.

(3) the weight W of silver displaces a certain volume of fluid, say V_2; therefore a weight w_2 of silver displaces a volume $\frac{w_2}{W} \cdot V_2$ of fluid.

It follows that

$$V = \frac{w_1}{W} \cdot V_1 + \frac{w_2}{W} \cdot V_2.$$

whence, since $W = w_1 + w_2$,

$$\frac{w_1}{w_2} = \frac{V_2 - V}{V - V_1};$$

and this ratio is obviously equal to that before obtained, viz. $\frac{F_2 - F}{F - F_1}$.]

Archimedes was born about 287 B. C., and was killed in 212 B. C. by a Roman soldier during the sack of Syracuse. He was the son of Pheidias, a Syracusan astronomer. He spent some time inAlexandria, then one of the principal seats of learning of the world. While there he is said to have invented a water-screw, which was used in the irrigation system of Egypt. After returning to his native city, Archimedes devoted himself to the study of problems in mathematics and physics with such concentration that he would often forget to eat. Any handy material served him for drawing his diagrams, even the ashes in the fireplace or the oil upon his body when he bathed. He was an intimate friend of King Hieron and his son Gelon, and dedicated some of his books to them. The problem of finding out whether a new crown was pure gold or adulterated with silver was given him by Hieron, and Archimedes got the clew to the method by seeing the water-level rise when he entered the bath. He jumped out and ran through the streets, shouting: "Eureka!" Levers also engaged the philosopher's admiration, causing him to exclaim: "Give me a place to stand on, and I can move the earth!" His book "On Levers," however, is lost. Archimedes constructed many scientific toys, one of which, an astronomical sphere showing the motions of the sun, moon and five planets in the heavens with such accuracy that it would illustrate the eclipses, survived to the time of Cicero, who saw and described it. During the siege of Syracuse, Archimedes devised catapults and other engines of war, which terrorized the besieging Romans. The Romans were, nevertheless, successful. After the capture of the city, Archimedes was sitting as usual before his sand table, working out a diagram, oblivious to what was going on about him, when he was run through the body by the sword of a Roman soldier. Some say that the soldier was annoyed because Archimedes asked him to step out of the light. Marcellus, commander of the Roman forces, seems to have grieved that one of his men inadvertently killed the greatest mathematicians of his time.

Science News-Letter, April 28, 1928

The Magic Box

Mathematical Physics

W. R. BAKER, in *Harper's Magazine*:

Length, breadth and depth are said
to be
The limits of man's comprehension,
But when I see the pile of junk
That she can get into a trunk
The mystery convinces me
That woman knows a fourth dimension.

Science News-Letter, April 28, 1928

Minnesota ranks first among the states in production of potatoes.