Equilibrium and Rest Positions

The Mechanics of Keeping One's Balance and Being Comfortable

By A. A. Somerville

FROM the standpoint of mechanics alone, and aside from physiological reasons, a man is ordinarily in the most comfortable position when he is in the most stable equilibrium and for physiological reasons when most relaxed. Comfort in its relation to equilibrium implies liability to avoid falling. A body is probably in the most stable equilibrium when its height is a minimum, the area of its base a maximum, and a vertical line drawn from the center of the mass passes through the center of the base. Reasoning from this definition would lead to the conclusion that a man lying on his back with limbs spread would comply with the conditions, and this is not infrequently the case of position for extreme relaxation. This brings out another idea, and that is that one rests only when the muscles are relaxed. Part of the body may be rested at a time. Such is the condition when one sits down in a chair. Such is also the case when one stands, bearing most of the weight of the body on one limb. Such a position also complies fairly well with the definition of stable equilibrium, which is the principal thing to be established in this article. For this purpose, several photographs have been made especially to fit the case, and others have been picked up that fill in admirably well.

To begin with, standing in a rest position betokens sociability rather than business. To this any military officer will testify. Possibly it has been fixed by custom, but more likely by efficiency. The most common illustration possible, that of a uniformed cadet at "Attention" and "At Rest," shows the idea. In the first case he is ready to "go." Here there is practically no relaxation whatever—all muscles tense; also perfectly erect, which implies that the center of gravity line falls directly between the feet or center of the base.

In the second position, "At Rest," most of the weight is thrown on one foot, the one in the rear, the other foot thrust forward, the body thrown only slightly forward, and the center of gravity line falling within or very near the rear foot. A special picture has been made to show this by hanging a plumb line directly in front of a man so posed. The limb placed forward is almost wholly relaxed. However, if this position is held very long, it becomes uncomfortable. It has been suggested that this position of rest is typified in the case of a tent pole and guy rope—one supports the weight, and the other is thrown around in any direction to balance any forces that may suddenly appear.

Note the case of a civilian (Fig. 4) in a place where he is not free to sit down, but leans instead, and he really forms a tripod. When tired one frequently makes use of this third support. An aged person may use a cane, and not be lame in either limb, but the cane is used as a prop, and so enlarges the base of the supporting body. In this case it is not for resting, but rather for stability, which indirectly leads to comfort.

Another habit which is restful in itself is that of leaning on a desk when writing, and also when eating, if the latter were only permissible in polite society. This is a case of making the elbows or arms support part of the body, or really broadening the base of support.

In reality, when one is standing erect, his form is very much like that of a top standing on a point. Fig. 5 shows that the base is really very small. The statement has also been made that by crossing the limbs at the knees, as one sometimes does when not putting up a very dignified appearance, a so-called lock is formed within the hip bones tending toward greater stability. The latter end is possibly attainable, but not by any interlocking of the bones, as the pictures probably show. But, due to the X or cross formed, if one tips either to the right or left, the center of mass of the body is lifted, which is contrary to the law of gravity, and there is a tendency to settle back to a stable position.

When a person expects a playful onslaught or attack, he braces himself or becomes more stable by placing the feet farther apart—note the common picture of the center on a football team in action. Sometimes for greater stability or for a stronger brace the hands are placed on the knees to stiffen the body, the action being the same as that of resting the arms upon the table.

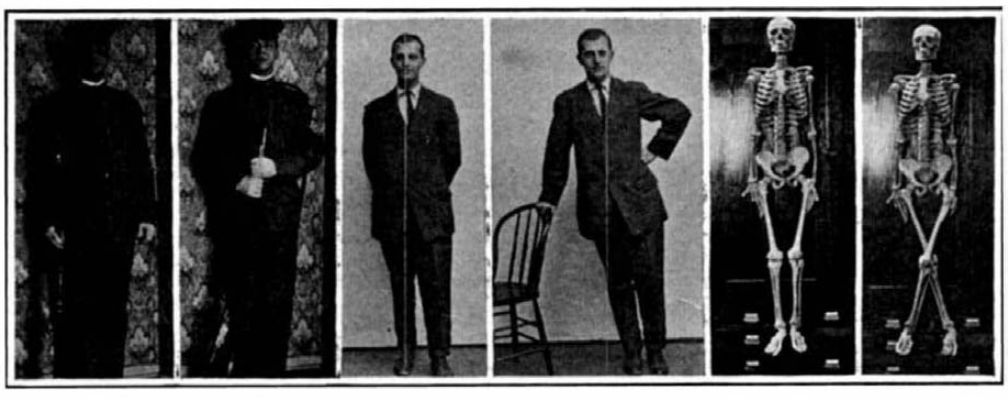
This is carried to a still greater extreme by a man in a football line, where he crouches so low as to get both hands on the ground, and so has a minimum height and maximum base. The constant training a football line receives is to get low.

The track man starts from a crouching position, but this is for the purpose of preserving kinetic or moving rather than static equilibrium, for when crouched the body may be pushed ahead, while due to its inertia one would topple over backward if he attempted to start running while in an upright position. After once started, however, the body may gradually be brought to a more nearly upright position, and now due to its own inertia it will be kept moving.

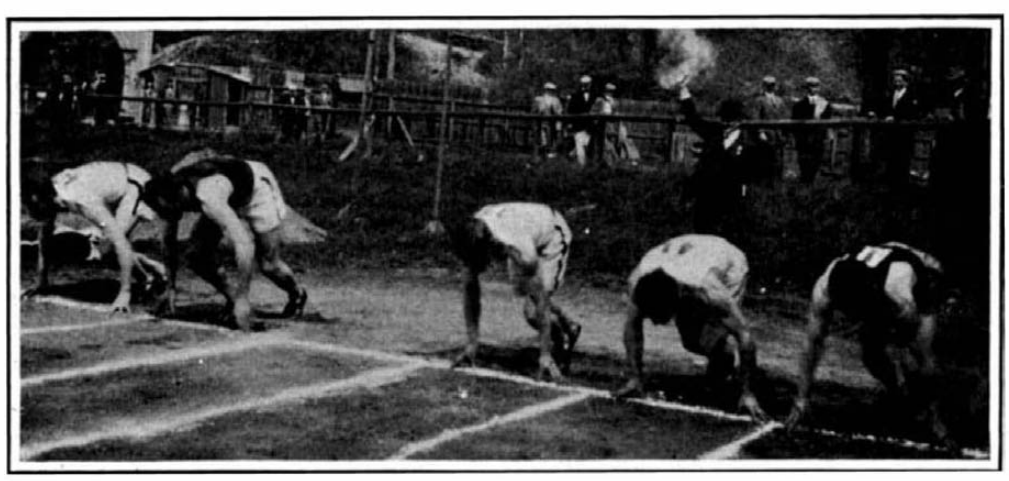
This crouching position is well shown in Fig. 7. The picture was made at a regular track meet, and was caught at such a time that the smoke of the starter's pistol is seen while the runners have not yet left their positions.

A different motion is brought out in the case of throwing. When a baseball player throws a ball, a twisting motion is used, what in mechanics is called a torque. He bears all the weight on one foot, and uses that foot as a pivot about which he swings, using the other foot and limb as a lever to push himself around. It is much on the same principle as swinging a stone in a sling, except that without the sling the man simply pushes himself part way around by taking a step forward and around the other foot upon which he is standing.

Things to be noted then are these: One unconsciously assumes a rest position; this is when most relaxed and most stable. To withstand an attack, the muscles become tense and the base broadened, that is, both feet are made to support the body. This latter is easiest noted by "attacking" a man or surprising him. If one is suddenly stopped by someone else when he least expects to be interrupted, he momentarily braces himself and assumes a position akin to that for defense. He then gradually shifts the weight to one foot, and rests while he is being detained. The length of time during which the suspense continues depends entirely on the extent of the surprise or the lack of ease which is felt, which, of course is greater among strangers than friends.



1. Position at attention. 2. Position at rest. 3. Plumb line on one foot. 4. Leaning against a chair. 5. No arch here. 6. With legs crossed.



7. A crouching start.

EQUILIBRIUM AND REST POSITIONS

Metals More Precious than Gold

INASMUCH as it is the standard of currency, most persons seem to think that gold is the most precious of all the metals. This, however, is a mistaken notion. Indeed, the number of metals which, at the present time, are more valuable than gold, exceeds the number of those that are of less value.

The cheapest, but not the most plentiful of metals, is iron. In its class are lead, zinc, copper, arsenic, tin, mercury, aluminium, and nickel. In the next class, with reference to gold, we find antimony, cadmium, sodium, and bismuth. A sharp rise in the scale of prices intervenes between this class and the next approaching that of gold, i. e., that comprising magnesium, manganese, tungsten, silver, thalium, and molybdenum, all of which are sold by the ounce, the prices varying quite a good deal. Then, in a class by itself, so to speak, comes chromium, a metal whose ores occur somewhat abundantly in the Shetland Islands, but which is difficult to procure in the free state.

At this point enters gold.

Of the metals more precious than gold, there should first be mentioned that peculiar one known as platinum, found in California, Canada, Brazil, Australia, on the slopes of the Ural Mountains, and elsewhere. Platinum is said to be really an alloy of the metals platinum, palladium, iridium, osmium, rhodium, and ruthenium, together with a little gold and iron. All these, save the last, are "noble" metals. They do not tarnish in the air, and are not soluble in any single acid.

The most plentiful metal occurring in native platinum is that from which it takes its name. This is of a grayish color, and, with one exception, is the heaviest substance known. Its fusing point is extremely high, and this property, together with its freedom from tarnish, renders it available for the manufacture of crucibles and other vessels required by scientists to withstand a very high temperature. It is also sometimes used as a substitute for gold in photography; and when deposited in a thin film on the interior of the tubes of telescopes, it forms a dead-black surface that prevents the light from being reflected by the polished sides. The demand for platinum largely exceeds the supply; hence the metal is ever advancing in price.

Palladium is of a lustrous white color. It is the most easily fused of the metals found in platinum ore, and can even be volatilized. A curious quality of this metal is that, when heated to redness, it is porous to hydrogen gas, allowing it to pass through somewhat in the same manner that blotting-paper permits the passage of water. The silvery-white color of palladium and its freedom from tarnishing render it useful for making scales and division marks on scientific instruments. A mixture of this metal with mercury is sometimes used in dentistry.

Osmium is a metal that possesses two remarkable properties. In the first place, it is the most refractory of the metals, resisting fusion at the most intense heat. It is also the heaviest of the substances, being almost twenty-two and one-half times heavier than water. Together with iridium, it occurs principally in a peculiar variety of native platinum called osmiridium. This mineral differs from ordinary platinum ore in that it contains a larger proportion of osmium and iridium than platinum. Osmiridium is found in small particles varying in weight from one-sixth to one-third of a grain. These particles are extremely

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more in accord with what we now know of the laws of heredity. If we suppose that the divergent types of females arose as sudden "mutations" or *sports* from the original type, it is easy to construct a scheme of the hypothetical constitution of such individuals, from the point of view of heritable qualities, which would show not only how the new female characters would be continued in accordance with well-known Mendelian laws, but also how the original form of the female—that resembling the male—would be eliminated in the course of time. To be sure, such a scheme, being purely hypothetical, proves nothing and must be subjected to the test of experiment, which takes time. But experiments already made in the breeding of insects—some by E. B. Poulton, the most aggressive defender of the natural selection theory as applied to mimicry—are not in conflict with Punnett's theory.

If there should arise by mutation a form that was incapable of maintaining itself under the conditions of its environment, this form would of course be eliminated by the action of natural selection. But under the circumstances Prof. Punnett considers all that is required is that a mutation shall not have any characters that are harmful; it is possible to look upon the existence of the various forms as due to the *absence* of "natural selection" or any adverse conditions rather than to the operation of natural selection. In other words, natural selection may play a part in the *conservation* of new forms, but can have nothing to do with their *origin*.

Metals More Precious than Gold

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hard, and are used for pointing pens. Metallic iridium possesses a white, steel-like appearance. The knife edges of delicate balances and other bearings that require extreme hardness are often made of it. An alloy of ten per cent iridium and ninety per cent platinum has been found to be little affected in volume by changes of temperature, and is the substance of which the standard meter, kept in the International Metric Bureau at Paris, is made.

Rhodium and ruthenium are metals of comparatively little practical use. The former occurs in platinum ore to the extent of five per cent. The latter is found only in osmiridium, and averages about five per cent of that metal.

The six metals mentioned are generally treated of together because of their resemblance to one another.

The metal that really ranks next to platinum in value is zirconium, which occurs in hyacinth and some other rare minerals. Titanium and uranium, whose ores are found in Cornwall, England, and some other places, are slightly more costly than zirconium. Uranium is remarkable for its high atomic weight.

Another costly metal is lithium. Its salts are widely distributed, being found in very minute quantities in the ashes of many plants, especially tobacco.

Vanadium, the ores of which are also very widely distributed, occurs, according to one authority, in all primitive granite rocks, but in small quantity. It is difficult to obtain in a state of purity, and is of value in processes connected with the manufacture of steel.

The next metal is barium, concerning the appearance and properties of which much difference exists among chemists.

Rubidium and cæsium were the first of a number of elements whose discovery was directly due to the introduction of spectroscopic analysis. They are widely diffused, but in such small quantities that their presence has been undetected by the methods of analysis previously in use. One mineral spring in Cornwall was shown to contain about one and one-half parts of cæsium in one million. A similar spring in Durkheim, Bavaria, contains one and one-half parts in ten millions, and these have been regarded as the richest sources of cæsium until recently, when both it and rubidium were found in Vulcano, one of the Lipari Isles. Rubidium occurs as silver-white globules of metal. Cæsium is also of a silver-white color, and is soft at ordinary temperatures.

Another metal whose discovery is due to the spectroscope is gallium. It is bluish-white in appearance, and is easily fused. In fact, it can be liquefied by rolling it between the fingers. When rubbed on glass it forms a mirror much superior to the ordinary mercurial one.

Next may be mentioned a group of fifteen metals, usually known from their analogy to the most important of their number as the cerium metals, many of which are extremely rare and valuable. They are cerium, yttrium, lanthanum, præseodymium, neodymium, terbium, ytterbium, erbium, holmium, thulium, dysprosium, decipium, samarium, scandium, and victorium. The cerium metals are chiefly associated in groups in minerals that occur in Sweden, Greenland, and some parts of Siberia. Three metals that sometimes accompany them are thorium, niobium, and tantalum; but they are not classified with them because of the dissimilarity of their properties. These metals do not occur in commerce to any extent, with the notable exception of tantalum, which has been utilized in the manufacture of electric lamp filaments. Generally speaking, the cerium metals may be held to be mere chemical curiosities.

Within recent years the most notable additions to the catalogue of metallic elements are radium, actinium, and polonium, whose existence remained unsuspected until science began to experiment with the Röntgen and Becquerel rays. So much has been written of these, that it were superfluous to treat of them, especially radium.

American Aborigines

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stature, yet possessing remarkable strength and endurance. Their skin is a light brownish yellow with a ruddy tint on the exposed parts. Their hands and feet are small and well formed. Their eyes resemble those of the Mongols, and this fact has induced many students to classify them with Asiatic peoples.

Among most Eskimo tribes the women tattoo their faces, and some of the Alaskan tribes wear studs in openings through their cheeks. To a certain extent the Eskimos practise both polygamy and polyandry, but a second marriage is unusual where children have been born of the first wife. Their religious cult is curious. They believe in spirits inhabiting animals and inanimate objects, but their chief deity is an old woman who is said to reside in the ocean and has the power of wreaking vengeance on her mortal subjects by causing storms to arise, etc., if any of her laws are infringed. The central tribes believe that a man's body is inhabited by two spirits, one of which stays with it when it dies and may temporarily enter the body of some child, who is then named after the deceased, while the other spirit wings its flight to one of the many lands reserved for the souls of the departed.

Groups of North Greenland Eskimo (Smith Sound) and western (Alaskan) Eskimo are here illustrated.

The first depicts a phase of family life at Smith Sound as it might appear in the spring, moving across the ice fields. The young man, having clubbed a small seal, has called on the sledge party to haul it home. He is laughed at by the elder man, who doubtless asked him jokingly why he couldn't have carried it home on his back. The fact that they were unnecessarily called out to perform the task of bringing this little seal home on a sledge did not irritate them; for, strange as it may seem, these people, living farther north than any other tribe, isolated from everything that we regard as making life pleasant and comfortable, are exceptionally cheerful. The woman, who carries a baby in her hood, is about to help in attaching the seal to the sledge. A girl is playing with the dogs, while a little boy is seen clinging to the back of the sledge.

The second picture shows the typical western Eskimos, who inhabit the shores of the northwestern seas from the mouth of the Mackenzie River around Alaska to Mount St. Elias. The woman with a child is dressed in caribou skins, while the one on the right, from Bristol Bay, is clad in marmot skins. The man, from the region of Norton Sound, is dressed in caribou and holds a barbed harpoon in his hand.

We now take quite a jump, from Eskimo land to the Great Plains, where live the Sioux, Algonkin, and Kiowa tribes.

In taking this leap we pass over, with only a sentence or two, the Chilkat Indians of southeastern Alaska and the Hupa Indians of northwestern California, as it is impossible to notice every type in a brief article of this kind. The former do commerce with the Athapascan tribes to their east, from whom they obtain the horns and wool of the Arctic goat. The women weave the wool into the famous Chilkat blankets, the designs of which are inserted separately, as in the Gobelin tapestry. The Hupa Indians live on a mixed diet of meat, fish, and acorns; they dress in deerskins and are very fond of personal adornment. One of their most important industries is the harvesting, transporting, storing, and milling of acorns, as well as the preparation of food from the meal.

The next picture shows a Sioux family, whose activities depended largely on the buffalo, from which were derived their food, dress, tents, tools, and even their folk-lore and religion. In this picture is seen a man returning from the chase; his wife is dressing a hide; the young girl is beading a moccasin for her sister, while the small boy, with a bow and arrow, is toddling forward to welcome his father.

In the Pueblo province the Navahos are conspicuous. They are especially interesting, since it was under Spanish direction that they laid aside their wild hunting habits and became herdsmen of sheep and other domestic animals, and learned to weave and work in metals. A man may busy himself with implements of iron, shaping some silver ornaments, which they are very skillful in working. The women engage in their most notable industry, i. e., spinning yarn from native wool and weaving blankets. As intimated, the Navahos have become adept in various industrial occupations. An interesting account of their work in tanning and shoe making was published in Volume XI. of the Proceedings of the National Museum, while their skill in belt weaving is described in Volume XIV. of that series, and their advance in house-building methods is the subject of an article in Volume XV.

We next come to the Zuñi Indians, who live in pueblos on the tablelands of western New Mexico. They were visited at the beginning of the sixteenth century by the earliest Spanish explorers, and their arts and industries, religion, etc., were critically studied some years ago by Mr. Cushing and Major Stevenson of the Bureau of American Ethnology. Later, Mrs. M. E. Stevenson has continued these studies, and a number of excellent papers on this tribe, by these investigators, have been published in Volumes II., III., IV., V., XII., and XVIII. of the Reports of the Bureau of American Ethnology. A group not represented here includes in the foreground a young woman engaged in weaving an artistic belt. At the right is seen an old man drilling a bit of stone with a pump-drill. His costume is that worn during the Spanish period. Near the middle of the group stands a