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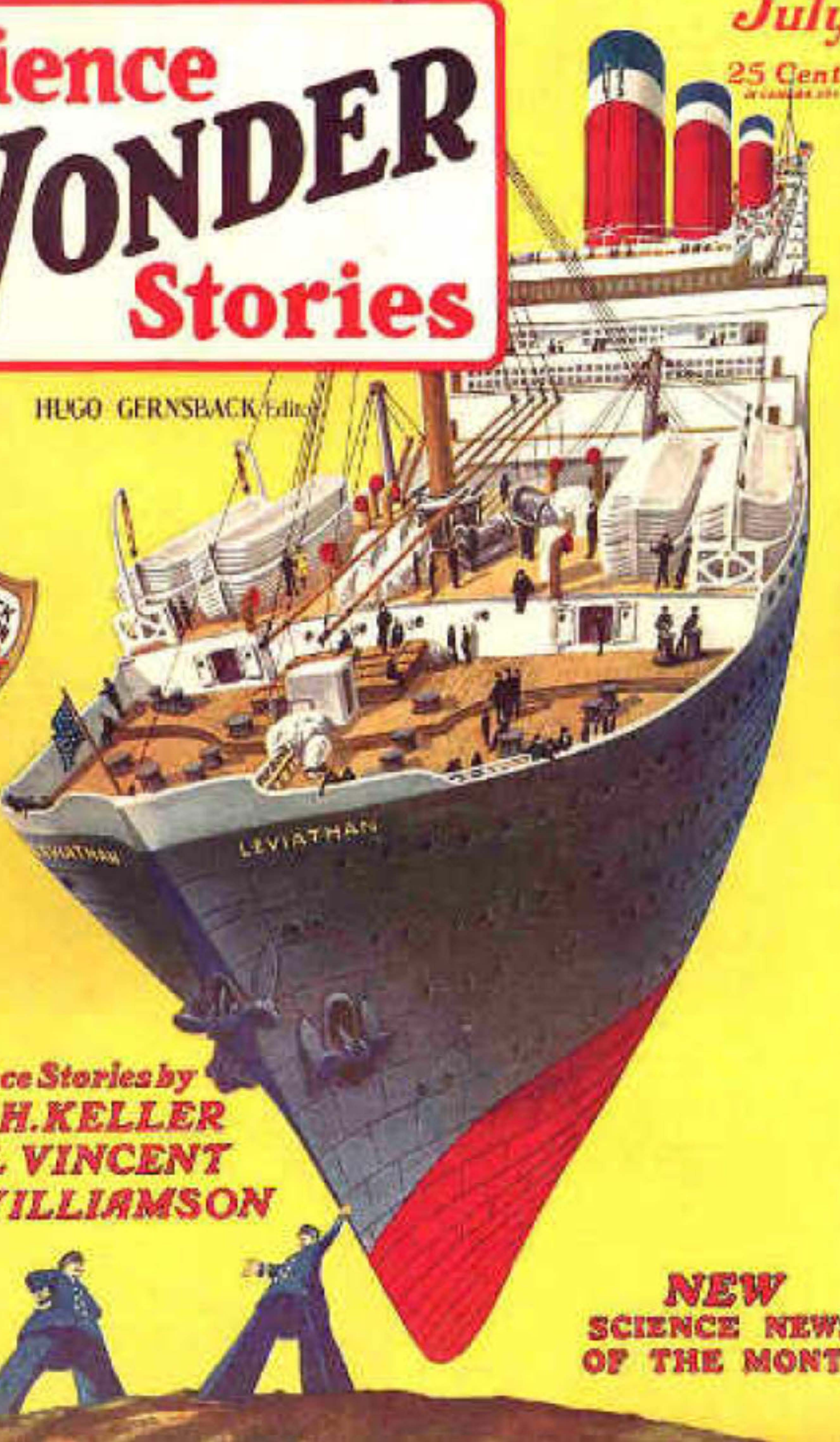

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DR. D. H. KELLER
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JACK WILLIAMSON

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The Problems of Space Flying

By

CAPTAIN HERMANN NOORDUNG, A.D., M.E., (BERLIN)

Translated from the German By Francis M. Currier

THE editor is happy to announce that we have secured the American translations rights for this important new work of Captain Noordung, well-known German engineer and authority on mechanics.

It is, we believe, the first serious work of its kind that has appeared in print, where an authority takes the problem of space flying seriously. This may be considered the most important advance step in the art of space flying because once serious-minded engineers devote their time and risk their reputations in the writing of text books on the subject, we may be sure that the translation of a former "pipe dream" into an actuality is not far away.

There is much contained in Captain Noordung's book which we have deemed wise not to include, because it goes into the realms of higher and intricate mathematics, of interest only to the engineering fraternity and mathematicians.

Captain Noordung has also considered the technicalities of the space rocket, as well as its mathematical considerations. His conclusions are, that if sufficient capital is available for building a rocket to travel into space, that it will be possible now to build one. And it seems certain that sooner or later, such a rocket will be built for exploration purposes.

In the present articles, we are mainly concerned with the more popular parts of Captain Noordung's book, which, in easy stages, acquaints the reader with the mysteries of free space, in a way that never has been done before.

In the first installment, will be found a tremendous amount of new material, which has never appeared in print.

In the second installment there will be found Captain Noordung's own description of an epoch making invention—his sun power plant, his floating observatory and his space living quarters, as well as a number of other important inventions, all of which are based on excellent science and mathematics, and which sooner or later, will be translated into actuality.

We know that every reader of SCIENCE WONDER STORIES *will be highly interested in Captain Noordung's book.*

In starting his subject Captain Noordung first considers whether we humans have a constitution enabling us to live in the strange and terrible conditions of "empty space." He attacks his subject by first considering the influence on us of "weightlessness"—the condition in empty space where there is no gravity and no weight.

PART I

The Influence of Weightlessness On The Human System

HOW does the absence of weight affect the human system? Experience in the case of a fall (such as falling in a parachute) shows that the condition of weightlessness during the fall, lasting a short time, is not injurious to health. Whether this would also be the case with lasting weightlessless cannot be foretold with certainty, since nobody has ever experienced such a thing. Yet we may most probably assume it, at least so far as its effect on our body alone are concerned; for all the physical functions result from muscular or osmotic forces and consequently do not require the assistance of gravity. In fact all the processes important to life prove to be wholly independent of the position of the body and are performed equally well in an erect or lying position or indeed any other.

Only by remaining in a weightless condition for a long time might a certain injury result. And this would be due to the fact that important groups of muscles would atrophy from disuse and would therefore refuse their services when life should return to normal conditions (for instance, after the return to the earth). It is however probable that by systematic exercises this could be successfully provided for, quite aside from the fact that it would be likewise possible to meet this circumstance by proper technical arrangements, as we shall see later.

Presumably the only organ influenced by the absence of weight is the organ of equilibrium in the inner ear. And even this would no longer be needed as before; for the idea of equilibrium ceases to exist in the absence of weight. In every position of the body we then have the same feeling; "up" and "down" lose their usual significance with regard to the surroundings; the floor, ceiling, and walls of a room may each be considered as merely a wall.

The impression of these very unusual conditions might indeed, especially at first, produce a serious mental injury however. There is also the influence directly exerted on the nervous system by the absence of weight. The chief sense-impressions involved are as follows: the effect already mentioned on the organ of equilibrium, the feeling that there is no longer a supporting pressure against the body, and certain changes in the sensations of the muscles and joints.

Now this complexity of feeling is thus far known to us on earth only when we fall, since (as has been pointed out) here on earth we can only experience weightlessness in falling. Therefore in space we shall feel, with the ceasing of weight, the same anxiety that is connected with falling, as well as all the other mental states caused by this extraordinary situation. And this is true even though the absence of weight is not caused by falling but is caused in other ways (as for example in the space flyer through centrifugal force to be described later.)

Certainly it is to be expected from previous experience (of such persons as aviators, ski-jumpers, etc.) that through habit it will be possible to endure weightlessness even in its mental relations, more and more as one realizes that "weightlessness" and "falling" need not be connected. It may even be assumed that the feeling of worry may be entirely eliminated by a gradual diminution of the feeling of weight.

The German scientist Oberth has made a deep study of all these questions. Using his results, we may summarize as follows: though the absence of weight may be endured for a long and maybe infinite time without serious physical injury, this cannot be stated with certainty regarding mental effects, but it may be considered probable, at least. The course of mental impressions is presumably approximately as follows: first, a feeling of worry (at least in the case of rapid and direct entrance into weightlessness); the brain and the sense organs act extremely intensively, all thoughts being strictly objective and both quick and logical; time seems to pass more slowly; then there sets in a peculiar lack of sensitiveness to pain and discomfort. Later these phenomena grow less and there remains only a certain feeling of increased buoyancy and freshness, perhaps as after taking a drug which stimulates the nerves, until at last after long habituation the mental condition also becomes entirely normal.

CHAPTER II

The Physical Behavior of Bodies In The Absence Of Weight.

TO be able to form an idea of the general physical relations prevailing in the obsence of weight, one must remember this: the force of gravity of the earth, which draws all masses down to the ground and thus "arranges" them with a certain regularity, is no longer effective. Therefore bodies move in their accidental course, following only the law of inertia, in an absolutely straight line, until some resistance stops them. They "arrange" themselves, therefore, only according to the forces operating between them, in them, and actually pertaining to them (molecular, electric, and magnetic force, mass attraction, etc.)

As a result of these extraordinary suppositions we must conclude that all bodies unaffected by gravity show an entirely different behavior and that our own acts in consequence must be performed in a manner entirely unlike that used hitherto.

Thus human locomotion can no longer take place by "walking." The feet have lost their usual purpose. In the absence of the pressure of weight there is no friction under the soles of the shoes. Therefore they stick to the floor much less than they normally stick even to the smoothest ice. To proceed ahead one must either pull one's self along a surface by the hands, for which purpose the walls of a space flyer must be provided so far as possible with proper holds (presumably straps like those in street cars), or else it is necessary to jump in the direction of the goal or to float to it.

At the same time it may be hard for the novice to conserve his strength properly. This is however necessary. Since a person strikes the opposite wall of the room with the full force of the initial push, too much zeal in this will lead to painful bruises.

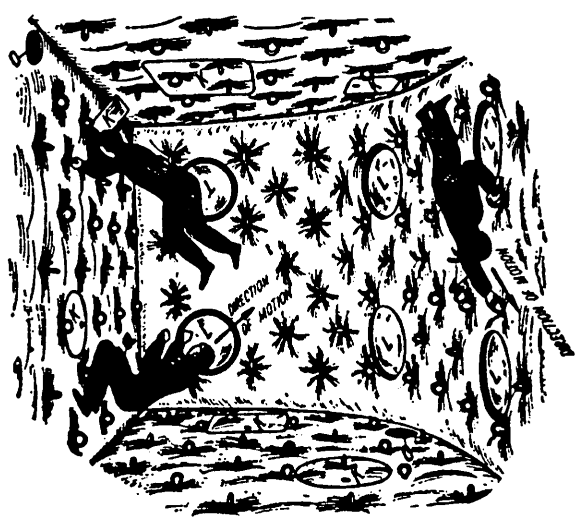


Fig. 1—A room in the observatory in space, in which weightlessness prevails and which is equipped accordingly. The walls are completely padded and provided with hand-holds. No loose object is present. K—Boxes with fastenings for keeping utensils, etc. L—Windows to admit the light. O—Openings for the conduction of air. Z—Motion by pulling along. A—Motion by pushing off.

Therefore all the rooms used by persons, more especially in the corners and on all sharp edges, must be very well padded.

Motion by pushing can also be dangerous to life, especially if it occurs in the open, that is to say outside the observatory, (to be described later). For if one in jumping fails to take proper precautions and misses the goal, the result will be continuous and eternal travel in the deadly emptiness of space. Thus, there threatens as a counterpart to the terrestrial danger of falling of from a height the no less terrible possibility of floating away into open space. The cry of "Man overboard!" on a space flyer has its meaning even in the absence of weight, though certainly in a different sense than on earth.

Bodies Inside a Room

SINCE bodies now cannot be pressed on their supports by their weight, it is of course useless to "hang up" or "lay down" an object anywhere. It would have to be guided to its support or held by magnetism or some other forces. A body can be kept in position only if it is fastened somewhere or still better if it is shut up. Therefore the rooms of the space flyer must be fitted out with easily fastened boxes suitably placed about the walls.

Clothes racks, stands, etc., likewise tables, at least for laying objects down, become useless pieces of furniture. But also seats, benches, and beds can no longer fulfill their purpose; a person would have to tie himself to them in order not to float away from them into some corner at the least movement. Without weight there is neither "standing," "sitting," nor "lying down." To do any work it is necessary to be fastened to the site of activity: for instance, to the table, if desirous of writing or drawing. Sleeping does not require lying down: it is possible to rest in any position, in any part of the room.

But in spite of this irregularity in the behavior of freely movable bodies caused by the absence of weight, the manner in which they come to rest is not absolutely arbitrary. The general law of mass attraction is valid even in the observatory in

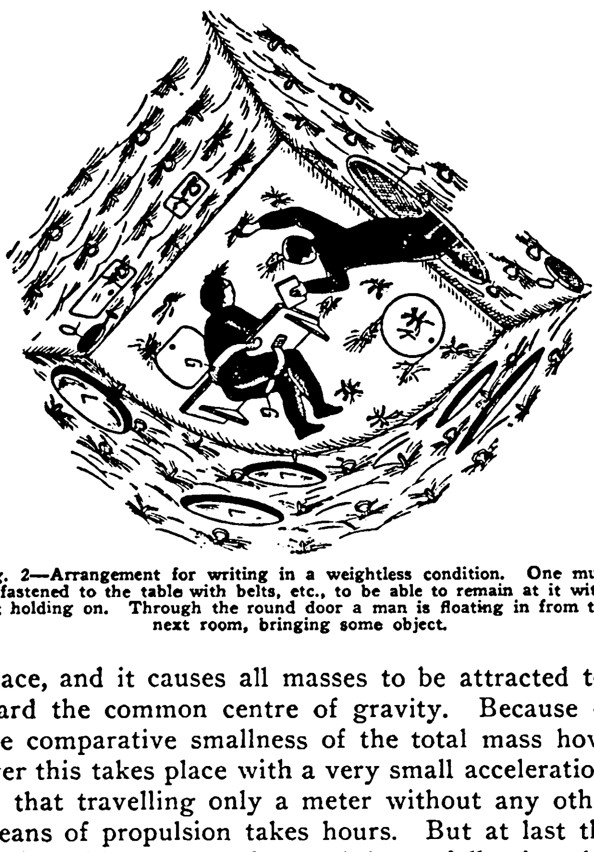


Fig. 2—Arrangement for writing in a weightless condition. One must be fastened to the table with belts, etc., to be able to remain at it without holding on. Through the round door a man is floating in from the next room, bringing some object.

space, and it causes all masses to be attracted toward the common centre of gravity. Because of the comparative smallness of the total mass however this takes place with a very small acceleration, so that travelling only a meter without any other means of propulsion takes hours. But at last the bodies which are not fastened down, following this force or their own accidental motion, will meet on one of the walls and either remain there or, if their speed was great enough, float back and forth between the walls, constantly repelled according to the degree of elasticity, until their energy of motion is gradually exhausted and they come to rest at one of the walls. Thus, in the course of time, all bodies freely floating within the limits of the space flyer will settle at the walls and particularly as near as possible to the common centre of gravity.

Since this process however may extend over

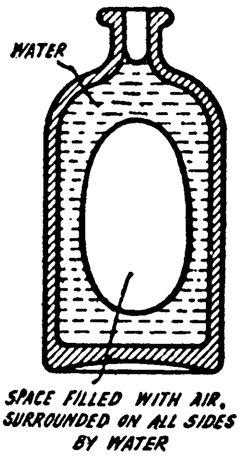


FIG. 3

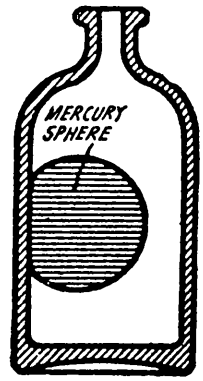


FIG. 4

Fig. 3—How water spreads out in a partly filled bottle in the absence of weight.

Fig. 4—Behavior of mercury in a bottle, in the absence of weight.

hours or even days and since even a weak current of air would suffice to disturb it or to dislodge and mix up again the bodies already come to rest (but clinging only very loosely to the walls), from a practical standpoint there is really no regularity in the motion of the weightless masses.

This last point becomes noticeable in an especially unpleasant manner when it is a question of bodies which get into a room in considerable numbers. If these are powdery, they can be collected and removed in a comparatively simple manner by filtering the air through vacuum cleaners or similar devices. But if they are somewhat larger, for instance if anyone thoughtlessly emptied a bag of apples in a room, there would be no other method than catching them in nets. In fact, all bodies must be very well cared for; the arranging power of weight has ceased to operate: *matter is free.*

The articles of clothing also go on a strike; for they no longer hang down, even if made of the heaviest fabric. Therefore cloaks, dresses, aprons, and the like are useless as clothing. At any movement of the body they would flow quite irregularly in all directions.

In the weightless condition, the behavior of liquids is especially peculiar. Under normal conditions, following the force of gravity, they of course seek the deepest places and then fit themselves completely into whatever holds them (the vessel, the ground, etc.). But when there is no weight, the separate particles can follow their molecular forces unhindered and arrange themselves according to the effect of the latter.

The Behavior of Liquids

LIQUIDS in a weightless condition therefore take on an independent form, indeed the simplest form known to geometry, the sphere. This requires the assumption that they are subject only to their own force of cohesion, that is to say, that they touch no body which they can "wet."

It is now clear why water, in falling, forms exactly in drops: for in this condition, as was said before, it is weightless and therefore takes on a spherical form, which the resistance of the air distorts into elongated drops.

If the liquid is in contact with a body which it

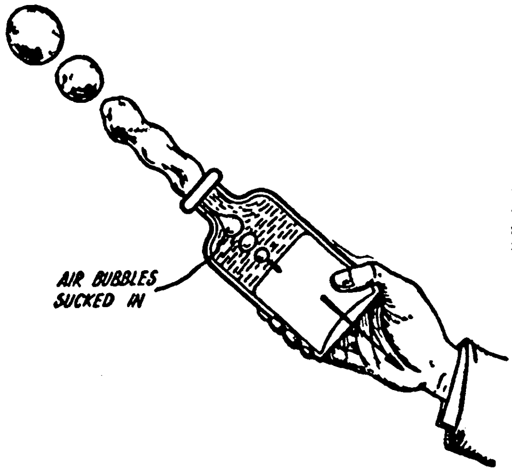


Fig. 5—Emptying a bottle in weightlessness by pulling back.

wets, besides the forces of cohesion (the tendency of the particles of water to cling together) there are also forces of adhesion (the tendency of the water to cling to a surface that it "wets") of much greater power. The liquid will then be inclined to follow the latter and to spread out over the surface of the body, in other words to cover it with a more or less thick layer.

Accordingly, in space, for example the water in a partly filled bottle will not occupy the bottom of it but, leaving the centre empty, will seek to spread out over all the walls of the vessel. Mercury, on the other hand, which does not wet glass, forms in a ball and remains floating in the vessel.

In both cases it makes absolutely no difference in what position the bottle is held. Therefore it cannot be emptied in the usual manner by simply tipping it. For this purpose it is necessary to do one of the following things: either pull it back quickly (that is, accelerate it backward); or push it forward in the direction of its mouth and suddenly check it (that is, retard the forward motion); or lastly swing it in a circle.

In these cases the liquid will come out of the bottle because of its force of inertia (in the last instance because of the centrifugal force), while the air is sucked in at the same time, just as in the gurgling in the normal pouring from a bottle. It must be assumed that the neck of the bottle is sufficiently wide or that the motion takes place with sufficient force so that the entrance of air can actually take place while the water is streaming out.

It is interesting to note that the above described method of emptying a bottle by pulling it back or stopping it, there being no weight, is fundamentally no different from the pouring out by turning the bottle upside down in the case of the normal condition of weight on earth. Indeed, from a physical standpoint, these processes are absolutely identical, if the motion of pulling back or stopping is exactly the speed of the acceleration of gravity (with us, 9.81 meters a second); for according to the general theory of relativity it is well known that a system in accelerated or retarded motion is exactly equivalent to a field of gravity of the same acceleration. We can therefore say that in the process of emptying I have described, there comes to replace the missing gravity those forces of mass inertia which were brought to life in the system of bottle plus contents by the pulling back or stopping.

After coming out of the bottle the liquid will float off in the room in the form of one or more spheres, similar in appearance perhaps to soap-bubbles moving through the air. Finally such floating spheres of liquid must strike one of the walls.

If they can wet it, they will seek to spread out over it.

Otherwise a sphere will be broken up by the shock, like a falling drop of mercury, into numerous smaller spheres which will float along the walls or sometimes perhaps out in the room, sometimes joining again and breaking up, until their force is finally exhausted and the entire amount of liquid comes to rest, united into one or more spheres remaining on the walls. (Compare the previous remarks regarding processes taking place in a bottle).

In view of this unusual behavior of liquids it is impossible to use any of the ordinary vessels, such

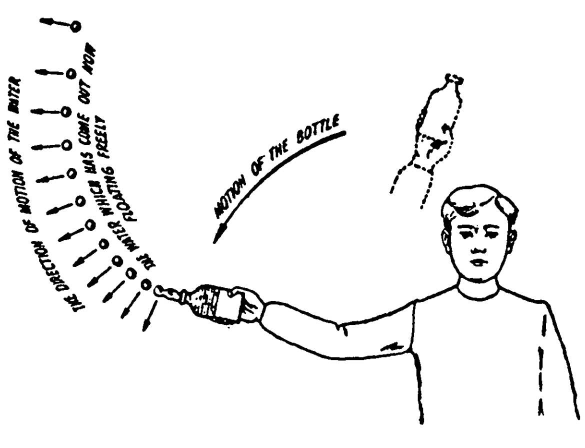


Fig. 6—Swinging a water bottle in a circle to empty it in the absence of weight. (In reality the liquid coming out would not distribute itself so equally on the indicated curve of flowing out.)

as bottles, drinking glasses, sauce pans, jugs, wash basins, etc. In fact it would be hardly possible to fill them. But even if this could be done, for example if a bath were prepared, we could not use it; *in a very short time the water would disappoint us by spreading from the tub to the walls of the room or by settling on them in spheres.*

For holding liquids, the only suitable devices would be tubes or balloons made of rubber, with some sort of stop-cock, or vessels with a bottom moving like a piston, similar to a squirt-gun; for only such can be filled in a simple manner and conveniently emptied. This last is accomplished by squeezing them or by pushing the plunger, to force out the contents. In the case of elastic balloons filled so as to expand the covering, the tension of the latter alone would suffice to expel the liquid on the opening of the stop-cock.

Cooking and Eating

SUCH compressible vessels (provided with a suitable mouthpiece) would have to be used for drinking, instead of the useless vessels of ordinary life.

Furthermore the different implements used in eating, such as plates, dishes, spoons, etc., would

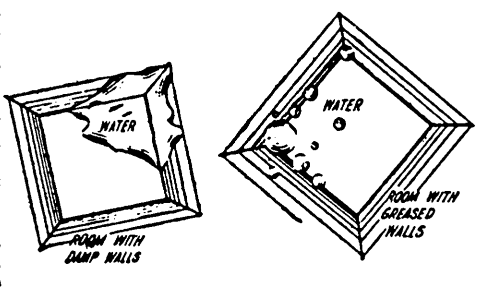


Fig. 7—In the absence of weight water released in a room with walls it can wet well (e.g. rather damp ones) would spread out over them, as shown at the left; in a room with walls it cannot wet (e.g. greased ones) it would collect in spheres and rest by the walls, as shown at the right.

be worthless. One careless movement, and we would have to chase their perhaps precious contents, which would be floating through the room. Eating would be possible in only two ways, either by consuming the food in solid form like bread or by drinking it in liquid or semi-liquid condition by means of the compressible vessels just mentioned. The cook accordingly would have to prepare the food in these ways.

And assuredly the cook would have particularly great difficulties to overcome in his important work. Even these, however, could be conquered. Thus, for example, electric cooking vessels with locks could be used, to be kept in constant rotation during use, so that the centrifugal force thus produced would replace the missing gravity and press the contents against the walls of the vessels—and there are other similar devices. At any rate, the cooking would be very inconvenient, but this as well as eating and drinking would be possible in some manner.

It would be absolutely necessary to give up washing or bathing in the usual manner! Cleaning could be done only by rubbing with damp cloths, sponges, and the like, rubbed with soap in case of need, however satisfactory or not this way might be.

The more closely we regard the matter, the more clearly we must recognize that *it is far from an unalloyed pleasure to be able to float about like an angel,* freed of all burdensome weight—even if we ourselves find this condition pleasant. For weight does not simply hold us down, it forces down all other bodies as well and keeps them from moving about in confusion, without any regularity, if chance has set them free. The force of gravity is perhaps the most important power for order in our existence. Where it is absent, everything is, in the truest sense of the words, upside down, and has lost its hold.

CHAPTER III

The Necessity of Readjustment

HUMAN life can exist only in the presence of properly composed gaseous air. In the first place, the process of living is a process of combustion and therefore requires for its continuance a constant source of oxygen, which the human system can only take up by breathing from gaseous air. Secondly, the human body must always be surrounded by a certain pressure, for without it, our water content would evaporate and the vessels of our bodies would burst. It is therefore necessary to provide for the artificial preparation of air, if our life is to be made possible in empty space.

To accomplish this the human beings in space must always be surrounded by a room of some sort shut in on all sides and absolutely air-tight, since only in such an arrangement can the air be kept at the proper pressure and in the proper composition. This must be done by artificial means and actually can be done by automatic devices.

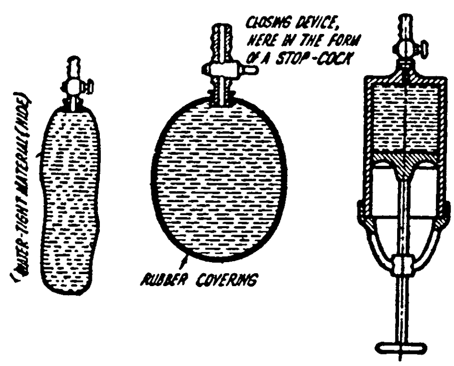


Fig. 8—In the absence of weight the usual vessels for liquids must be replaced by sealable tubes (left), rubber balloons (centre), or vessels like squirt guns (right).

In substance it is a question of nothing but a rather large enclosed space, ranging in size from a room to a group of whole buildings, such as might be needed for a rather long sojourn. The walls would have to be built on the principle of a steam boiler, since they must resist an interior air pressure of one atmosphere (14.7 lbs. per square inch) in excess of the empty space outside. They should therefore not only have the requisite thickness but should also present so far as possible only curved surfaces, since flat ones need a special strengthening or reinforcing on account of the pressure. The nitrogen and especially the oxygen needed for the artificial preparation of air would have to be kept on hand in large quantities in special tanks in a liquid condition and be continually replaced from the earth.

To be able to remain *outside* such enclosed rooms in space, one would have to use an air-tight suit, the inside of which is automatically provided with air by an apparatus carried along. The devices, that is, would be somewhat like the well-known diving

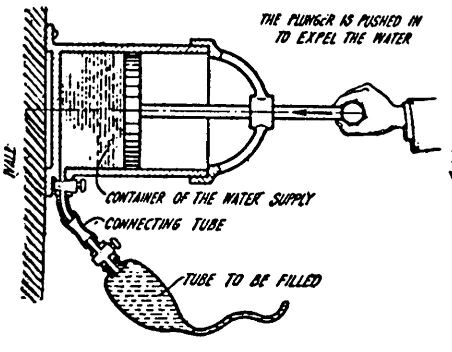


Fig. 9—Filling a water container in weightlessness.

suits used under water. More details about these will be given later.

It is clear that the problem at hand concerns much the same things as remaining under water, in submarines and in diving. On the basis of ample experience already collected in the matter of artificial production of air we may say that this question is completely answerable, beyond a doubt, for a sojourn in space.

Eternal Silence Prevails in Space

THE air has not merely a direct importance for life, (for breathing and the production of a suitable pressure) indirectly it also has the greatest significance, since it influences the natural phenomena most important for the development of life—heat, light, and sound—in the highest degree.

Sound is a vibratory process of the air and can never occur in a vacuum. Therefore eternal silence prevails in space. The firing of the heaviest cannon could not be heard, even at the slightest distance. Likewise normal communication by speech would be impossible. Of course this is not true of enclosed, air-filled rooms, within which the properties of the air can be artificially maintained as on

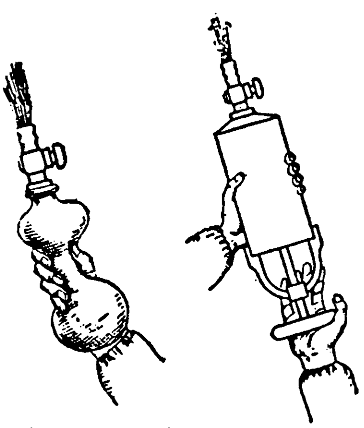


Fig. 10—Emptying a liquid container in the absence of weight can be done satisfactorily only by squeezing out or pressing out the contents.

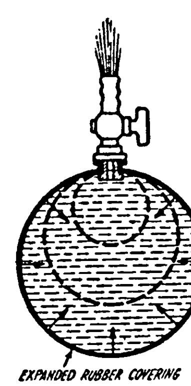


Fig. 11—In elastic rubber balloons filled under pressure the contents flow out themselves when the stop-cock is opened.

earth. But it is true when one is out "in the open" (in the space suit). There, communication by speech would be possible only by telephonic means.

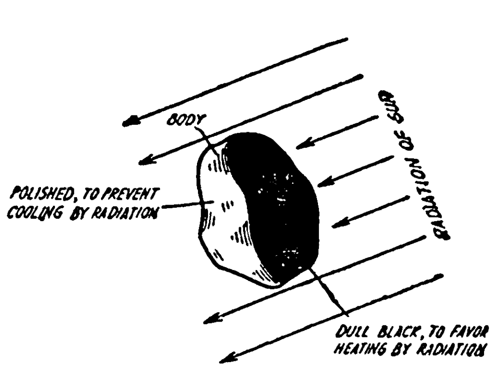
Sunshine in the Darkness of Night

LIKEWISE the conditions of light are now essentially altered. Naturally the idea of day is connected with the notion of a blue sky or illuminated clouds and of light diverging in all directions, without the necessity of direct sunshine to produce them. But all these phenomena are simply a consequence of the presence of the earth's layer of air. In this, a part of the sun's rays is divided, repelled, and thereby diverged in all directions, producing at the same time the impression of the blue coloring of the sky. Thus the air provides a manifold and beneficial gradation between the brilliance of sunlight and darkness.

In space all this is not possible because air is lacking there. At the same time there is an end to the idea of day, taken in the strict sense of the word. The firmament at all times appears in deepest black, out of which the countless stars shine extraordinarily brilliantly with an even calm light, while the indescribably blinding power of the sun far surpasses everything else.

Yet, once we turn our backs to the sun, we have the impression of night, though our backs are flooded with its light; while under its rays the side of a body turned toward it (consider, for example, an umbrella) shines brilliantly, on the side turned away the darkness of night prevails. Not absolute darkness! On all sides the stars are shining, even if the earth or moon do not light up by their

Fig. 12—Warming a body in space by the sun's rays by proper choice of surface conditions.



reflected light the side of the body lying in the sun's shadow. Still the light that is obtained is always harsh and direct light, never mild and diverging as on earth.

Unlimited Vision

IN many respects, however, the absence of air has advantages for the conditions of visibility in space. It is indeed generally known what a great influence the composition of the air exercises on distant vision (e.g. in the mountains, on the ocean, etc.). Even on clear days some of the light rays are always lost in it, or, because of the tiny particles of dust and vapor always floating in it, vision is obscured.

This last circumstance is very disadvantageous on earth, for the carrying out of distant observations of all kinds, especially in astronomy. Therefore observatories are erected whenever possible on high points on mountains, because at such points the air is relatively the clearest. But even then the limitations are soon reached. It is not possible on earth to keep the fixed stars from twinkling, (which is caused by nothing but the presence of our air). Similarly it is not possible to eliminate the diverging sunlight (the blue of the sky), caused also by the layer of air and very troublesome for

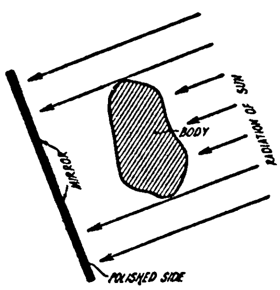


Fig. 13—Heating a body by shielding its shady side against space by means of a mirror.

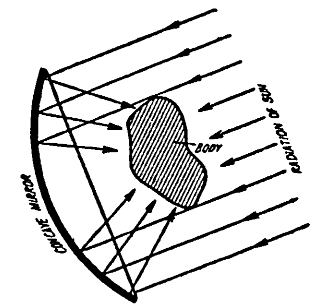


Fig. 14—Powerful heating of a body by concentrating the sun's rays on it by a concave mirror.

observations during the day. This latter difficulty greatly impedes the study of such heavenly bodies as are not visible in absolute night, such as Mercury, and Venus, and by no means lastly the sun itself.

All these disadvantageous circumstances cease in the empty space of the universe: nothing now weakens the luminosity of the heavenly bodies, the fixed stars no longer twinkle, observations are not impeded by the blue of the sky. At any time, equally favorable and practically limitless possibilities are offered; for now that there is no optical hindrance, we could use telescopes of as great a size as we desire.

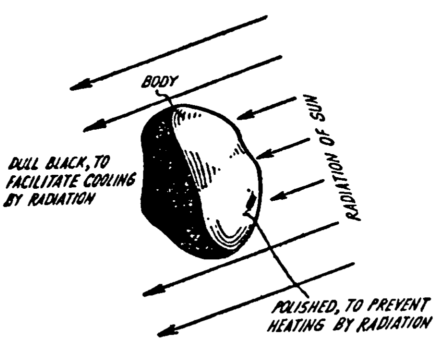


Fig. 15—Cooling a body in space by proper choice of surface conditions.

Heatless

ESPECIALLY significant is the influence exerted by the absence of air on the heat conditions of empty space. Since heat, as is known today, is nothing but a definite condition of motion of the smallest material particles of which the substance of the body is formed, this presupposes that there is no heat unless some matter is present. Where there is none, there can therefore be no heat: from a practical standpoint space is "heatless," because there is no air. Whether this is also absolutely correct theoretically depends on the accuracy of the widely held opinion that space is filled with real matter, even though divided extremely finely. If space is absolutely empty of material, the idea of temperature accordingly loses its significance.

This view does not contradict the fact that the heat rays of the sun and of the various fixed stars traverse space in tremendous quantity: *for heat rays themselves are not heat!* They are nothing but electromagnetic waves of the same kind as light waves or radio waves; they have, however, the special characteristic of being able to produce that molecular motion which we call heat, *when they strike anything material.* This occurs only when they are taken up (that is, destroyed) by the matter in question, for only in this case does their energy pass over to the body and transform into heat.*

Thus the temperatures of transparent or highly polished bodies are raised only a little even with strong heat radiation and appear almost insensitive to heat rays. For in the case of transparent bodies the rays for the most part pass through the body, in the case of polished bodies the rays are repelled.

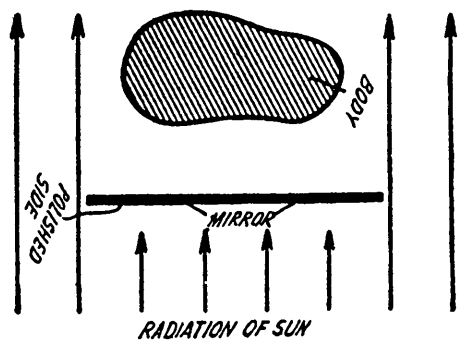


Fig. 16 — Cooling a body by shielding it from the sun's rays by a mirror.

In either case the rays are not weakened or destroyed, therefore they do not give up any of their energy. On the contrary, if the surface of the body is dark and rough, it can neither allow the rays which strike it to pass through nor reflect them; in this case they must be taken up and cause therefore the heating of the body.

This phenomenon, however, holds, not only for the reception of heat, but also for emitting it by radiation: the brighter and more polished the surface of a body is, the less its power of radiation, therefore the longer it retains its heat; with a dark rough surface it can cool off very rapidly by radiation.

The processes of heat radiation of different types occur chiefly on dull black surfaces and least on bright polished ones. This circumstance would make it possible to influence the temperature of bodies in space at will, simply and extensively.

If an object in space is to be heated, the side toward the sun is made dull black and the opposite side bright and polished; or the shady side (the side away from the sun) is screened from space by

* *What Mr. Noordung means in this paragraph is that space cannot of itself hold heat (as our air does) because space has no material in it which can transmit the molecular action (there is nothing to be heated). But heat can be transferred across space from the sun or a star to a material body by heat waves—Editor.*

means of a mirror. If a concave mirror is used for this purpose (concave to the sun), which directs the sun's rays on the body in proper intensity, its temperature can be raised to a very high point.

If, on the contrary, a body in space is to be cooled, its sunny side must be made reflecting and its shady side dull black; or it can be screened altogether by means of a mirror, from the action of the sun. In this case it loses its heat into space constantly by radiation. There would be no replacement of this heat conduction from the vicinity (as happens on earth from contact with the surrounding air). In this way by reflecting all heat and receiving none a body could be cooled to almost absolute zero (—273 degrees Centigrade). In practice however this point could not be quite reached, because on the shady side a certain amount of heat is radiated by the fixed stars, and anyway the mirrors could not absolutely shut out the sun.

By using the above described phenomena of radiation it would be possible not only to obtain and preserve in the observatory in space the heat necessary for life but also to produce extremely high and low temperatures and accordingly very violent changes in heat.

CHAPTER IV

The Observatory in Space

THE physical hypotheses and possibilities of space are now known to us. Now for a description of the manner in which our observatory in space must be arranged.

In order to simplify as much as possible the amount of work to be done in space during the construction of it (which can be done only in space suits), the whole structure and its equipment must first be entirely completed on earth and tested as to its dependability. Furthermore it must be so

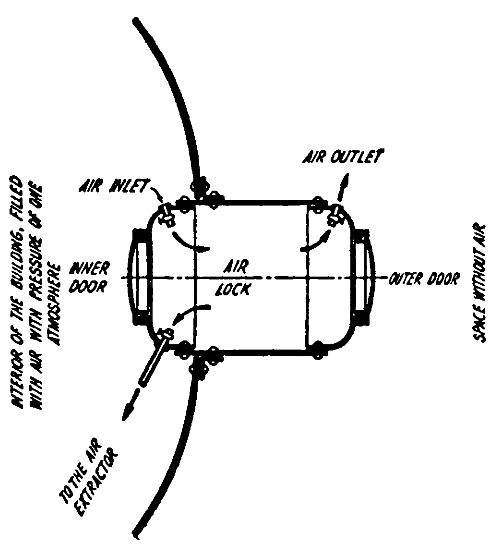


Fig. 17—Fundamental arrangement of an air lock for passage from an air-filled room (e.g. the inside of the observatory) to space. Removing the air when "locking out" is done on economic grounds chiefly by drawing the air into the interior of the building; only the last bit of the air content of the lock is released into space.

constructed that it can be separated into its component parts very easily, if possible into single completely equipped cells, which then can be taken by space ships into space and there be assembled again without too much difficulty. The materials used must be as light as possible, to lessen the cost of lifting them into space.

The structure ready for use would in general appear as follows: primarily, it must be capable of being made air-tight, against space, so that normal

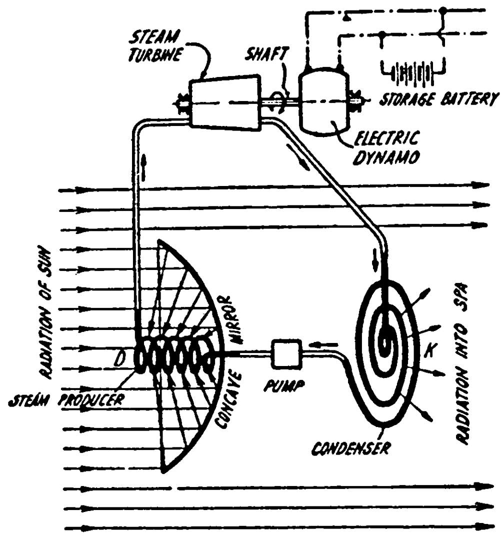


Fig. 18—Scheme of the sun - power plant of the observatory.

air conditions may be artificially maintained within. To be able to localize the hazard of the escape of air, which would take place in the event of a leak (due for example to a blow from a meteor), proper use is made of division into compartments as in ship-building.

Since all the rooms are connected and filled with air, travel within offers no difficulties. The outside, empty space, may only be reached by means of the so-called "air lock." This device, which is well known in submarine use (in caissons, diving bells, etc.), consists essentially of a small chamber between two doors made air-tight. One door leads to the interior of the structure and the other leads to the outside.

If a person for example wishes to leave the observatory (to "lock out"); then, wearing a space suit, he passes through the inner door into the lock, (the outside door of which must at this time be closed). Now the inner door is closed and the air present in the lock is either drawn off or let out, after which the outer door may be opened and the person may float out into the open. To reach the inside of the observatory (to "lock in"), the opposite process is necessary.

The determining factor for the operation, and accordingly for the equipping of the observatory is the fact that there will be absolutely nothing available for heat or power but the rays of the heavenly bodies, principally the sun. But these however will be available at almost any time and in any amount. All materials, especially those necessary for life, such as air and water, must therefore be brought constantly from the earth. Hence the fundamental principles of management in the observatory are clear: rigid economy must be used with all materials, and from the sun's rays must be obtained the energy available on the spot in great amounts and utilizing it in most extensive fashion to operate technical devices of all sorts, especially such as make it possible to make the exhausted materials again available for use.

This can be done either directly, by use of the lighting and heating power of the sun, or indirectly, by changing its radiated heat into electrical energy.

The Sun Power Plant

THE sun power plant serving for this last purpose forms one of the most important parts of the equipment of the observatory in space. It provides direct current, is furnished with a storage battery, and resembles in principle a normal steam turbine system of the same kind. There is however this difference, that in the case of our sun plant the steam producer is heated with the sun's rays which are concentrated by concave mirrors to attain sufficiently high temperatures, and the cooling of the condenser takes place merely by radiation of heat into space, for which reason it must be exposed to space and shielded from the sun.

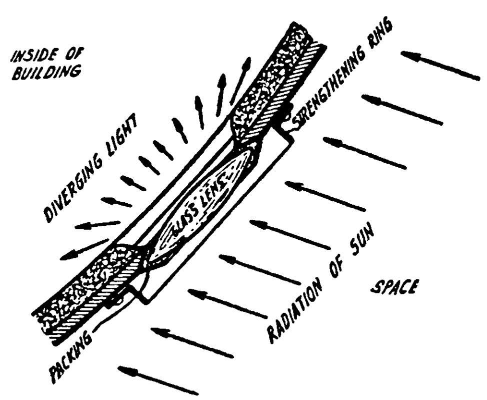


Fig. 19—Diagram of port-hole.

According to what was said before, this requires that both the steam producer and the condenser be colored dull black on the outside. Essentially they both consist only of suitably long metal pipes twisted everywhere, so that even in the weightless condition the inner surfaces are constantly and sufficiently touched by the liquid flowing through.

The liquid is in constant circulation. Unlike the ordinary procedure, the liquid used here is not water (or steam, as the case may be) but a medium easily liquified, namely nitrogen. This renders it possible to keep the temperature of the condensers so low that the extraordinary cooling power of space can be really utilized; also any chance escape of it into the rooms of the observatory would not make the precious air there impure.

Since it depends only on the size of the concave mirrors used how much energy is taken from the radiation of the sun, a suitably efficient construction of the power plant is alone enough to provide the observatory with constant and tremendous amounts of electrical (and therefore mechanical) energy. Since also heat, even in great amounts, may be obtained directly from the sun's rays, and even the lowest temperatures of cold may very simply be reached by radiation into space, all the prerequisites are available for operating technical devices of all sorts.

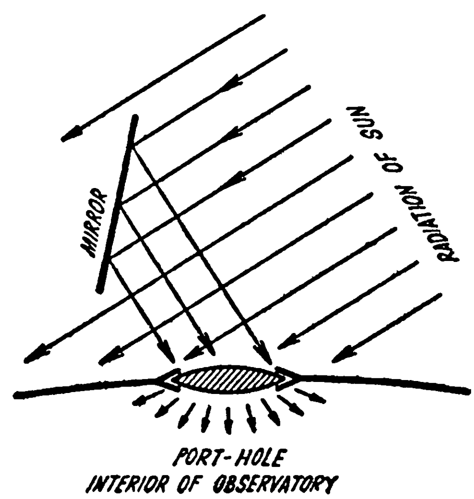


Fig. 20—The mirror expressly directs tht sun's ray's at the port-hole.

The Light Supply

THE illumination of the observatory is most simple to arrange; this requires almost no mechanical devices but can chiefly be accomplished by the direct action of the sun which indeed shines there all of the time, barring occasional brief passages of the observatory through the shadow of the earth.

For this purpose the walls have round openings like the port-holes of a ship, glassed in air-tight by strong-lens-shaped windows. By having these milky white or opaque and by properly selecting the kind of glass care may be taken to free the sunlight of all injurious combinations of rays, just as it

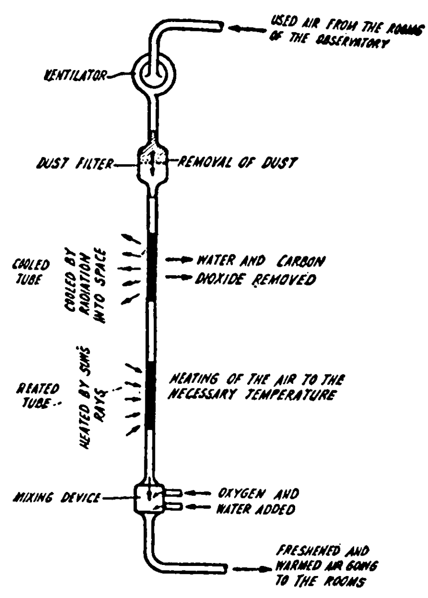


Fig. 21 — Schematic diagram of ventilating system. The cooled and heated tubing can be similar to Fig. 18 D & K.

is filtered by the layer of air. It then enters the observatory in a divergent condition and lights the inside with normal daylight.

Many of the port-holes are provided with special mirrors by which the rays may be directed at will on the ports in question.

There is also arrangement for electric lighting, using the current from the sun power plant.

The Air and Heat Supply

THE heating of the observatory also takes place by direct use of the sun's rays, indeed on the principle of heating the air as it is prepared for use.

For this purpose all the air in the observatory is in constant circulation between the rooms in which it is needed and a purifying apparatus, where it is cleaned, made fresh again, and warmed. A great electric ventilator provides for the maintaining of this motion. There are also pipe-lines which are necessary for this. They enter the different rooms by small screened openings.

The airing system like the apparatus for renewing air is suggested by Oberth. First the air flows through a dust filter. Then it reaches a pipe, cooled by radiation, into space, in which its temperature is gradually reduced below -78 degrees Centigrade, a process during which the gaseous components separate out, first the water vapor and afterward the carbon dioxide. Then the air flows through a heating pipe, heated by the concentrated rays of the sun, to be brought to the proper temperature for the warming of the rooms. Finally the proper proportions of oxygen and moisture are added, after which it flows back again into the rooms of the observatory.

By this process nothing is replaced but the oxygen consumed in breathing, consequently noth-

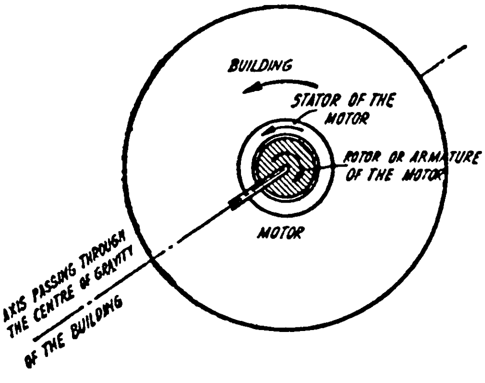


Fig. 22—Operation of a rotary motor.

ing else has to be supplied from the earth. The unused constituents of the air (especially the entire nitrogen content) remain in constant use. Since the outer walls of the observatory have no share in the heating which takes place at the same time, they must be prevented, so far as possible, from giving off heat by radiation into space, for which reason the outside of the entire structure is made absolutely mirror-like.

The water supply, too, must be used as economically as the air. All the water after use is collected and purified for re-use. Great distillation apparatus serves for this purpose, the vaporizing and later condensing of the water being effected in a similar manner as was described in the account of the sun power plant: that is to say, in pipes, some heated by concentrated sunbeams, some cooled by radiation into space.

Distant Communication

THE arrangements for long distance communication are also very important. This may be effected either by phototelegraphy, by means of blinkers, electric lights, search lights, colored

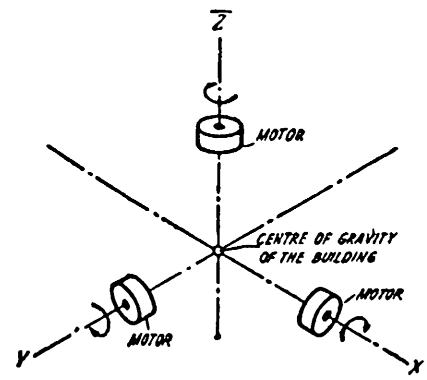


Fig. 23 — Arrangement of the rotary motors. The three axes are perpendicular to each other and pass through the centre of gravity of the building.

slides, etc., or electrically by radio, or even over wires, within the limits of the observatory.

In communication with the earth the use of phototelegraphy has the disadvantage of being unreliable, since its use depends on the station on earth being free from clouds.

Therefore the observatory possesses also a powerful radio station, making possible at any time telegraphic or telephonic communication with the earth. The overcoming of the comparatively great distance as well as the screening effect of the layer of air on radio waves is accomplished by using (with the proper choice of direction of radiation) short directed waves and sufficiently high transmission energy. This appears to offer no great difficulty, since electrical energy can be produced by the sun power plant in any desired amounts, and also the construction of any type of antenna offers no serious trouble, in view of the prevailing absence of weight.

The Means of Establishing the Observatory

FINALLY, special rotary motors and recoil devices are provided, which serve both to turn the observatory in any desired direction and to influence its condition of motion as needed.

This possibility must exist in the first place in order that the observatory may be kept in the desired relation to the earth or in the necessary position with respect to the sun's rays. For this purpose not only must all impulses to motion, (coming from outside the system,) which are inevitable in the case of visits by space flyers, be balanced at all times, but also the influence of the earth's rotation about the sun must constantly be kept in account.

On the other hand this is also necessary in order to allow the observatory to perform its special duties, which will be spoken of later, since for many of these its position in space must be changeable at will. Lastly, at times there may occur the necessity of changing position as regards the surface of the earth.

The rotary motors are normal direct current electric motors, but they have the highest possible number of turns and a relatively large armature. Special brakes make it possible to decrease or check their speed as quickly as may be desired. They are built into the observatory in such a way that their prolonged axis of rotation passes through the centre of gravity of the building.

If such a rotary motor is started, at the same time as the rotor (or armature) the stator (the part of an electric motor ordinarily motionless), can be made to turn and along with this (if they are fixed) the entire building connected with it. The movement will then be around the axis of the motor—of course in the opposite direction to the rotor and much more slowly, because of the difference in mass—this motion will continue until the motor is stopped again. The general rate of motion will vary with the number of turns given. (In the previous case it is a question of a "free system" in which only the inner forces operate.) Since motors can be so arranged with axes at right angles to each other, like the coordinates in a right-angle system of three dimensions, by their cooperation it is possible to swing the building in any desired direction.

(To be concluded)

The Boneless Horror

(Continued from page 141)

interesting levers and mechanisms, the use of which was hard to determine.

Taking a lot of the jewelry with them, they sought civilization to secure help in the exploration of the city. When they returned, a freshet of the Colorado had covered the opening of the tunnel with sand, and they were unable to locate it.

Thus died the great land of Mo.

The fair country of Atlantis had no enemies. It lived only for pleasure and art. From Ireland to the shores of America it lay in the sunshine. Then one day a continent across the globe was destroyed. A terrific shifting of balance of weight took place; large tidal waves rolled from one sea to the other and suddenly the continent of Atlantis was swallowed up by the water of the Atlantic Ocean, and, thus, a kindly lovable people paid the price of the hatred between two nations that they had never harmed. So perished the second of these great lands.

Where Gobi once ruled supreme, now rule the Himalayas. These mountains, the greatest in the world, run nineteen hundred miles from east to west and an average of ninety miles from north to south. They cover a total of one hundred and sixty thousand square miles. Of these mountains, the greatest peak, Mount Everest, reaches upward to the sky twenty-nine thousand one hundred and forty feet above the sea level. Immense sections of these mountains are inaccessible to modern man. Mount Everest remains unconquered.

Hidden in the tops of these mountains, unknown to man save by tradition, lies the ancient capitol of the lost Empire of Gobi. Half frozen Tartars, insect ridden Lamas, barbarians of every description remain as the sole descendants of what was once a great people. Even the memory of their former greatness has been lost in the changing struggles of fourteen thousand years. If they are asked how old these mountains are, they will reply that they have always been there. How could they know that once all this land was lowland, forest land, a pleasant country for rich folk to live in? How could they know of the physician from Mo and his magical table and map thereon?

Yet, amid those mountains, lies the ancient city and the Hall of Dragons. There, on their silken cushions, their beds of goosefeather, lie the boneless Emperor and the boneless Seven Wise Men, and, though their bodies are chilled with the frost of centuries, yet, would there come a pleasant day of springtime, with blossoming almond trees and a warm, gentle shower, those frozen hearts would once again send pulsing life through those boneless sacks, for full of the Jelly food of the Queen-bee they can never die, at least, not for a long, long time.

On the floor in front of the Emperor, lies the body of Heracles, dead of a dagger, thrust by the nervous hand of the woman beloved by the Emperor. The body of the physician, frozen, decays not.

Neither does the body of the beloved woman.

And, frozen in her body, lies the unborn Prince of Gobi, last of a royal line that dared all for their hatred of a bitter enemy.

Thus perished Gobi.

THE END