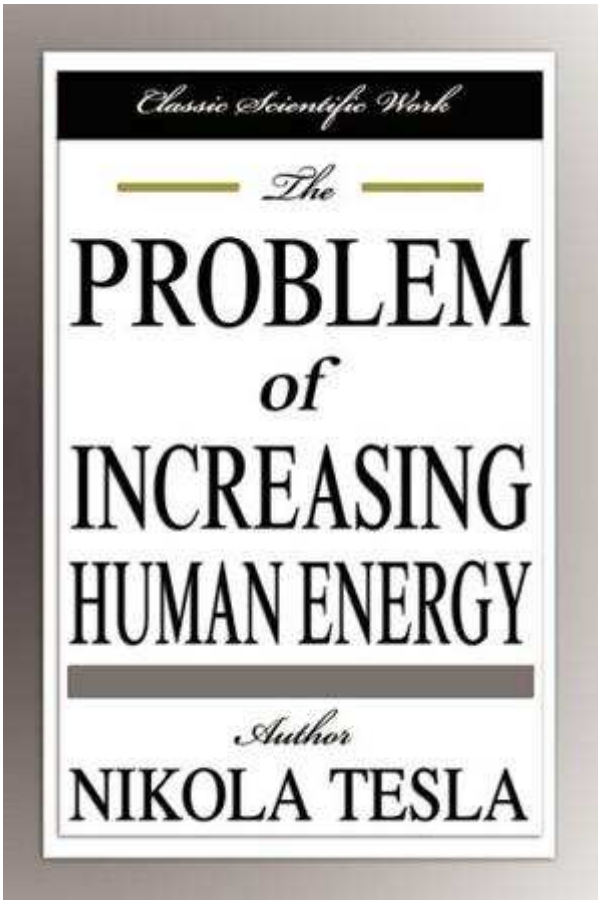
Classic Scientific Work
The
PROBLEM
of
INCREASING
HUMAN ENERGY
Author
NIKOLA TESLA

THE PROBLEM OF INCREASING
HUMAN ENERGY
人类能量的增长
WITH SPECIAL REFERENCES TO THE HARNESSING OF THE SUN'S ENERGY.
特别地提到了太阳能的利用

by Nikola Tesla
尼古拉•特斯拉

THE ONWARD MOVEMENT OF MAN•THE ENERGY OF THE MOVEMENT•THE THREE WAYS OF INCREASING
HUMAN ENERGY.
人类的发展•能量的运作•人类能量增长的三种方式

Of all the endless variety of phenomena which nature presents to our senses, there is none that fills our minds with greater wonder than that inconceivably complex movement which, in its entirety, we designate as human life; Its mysterious origin is veiled in the forever impenetrable mist of the past, its character is rendered incomprehensible by its infinite intricacy, and its destination is hidden in the unfathomable depths of the future. Whence does it come? What is it?
Whither does it tend? are the great questions which the sages of all times have endeavored to answer.
在我们感知到的所有各种无穷无尽的自然现象中，再也没有其它比不可思议的复杂运动更能让我们的头脑充满好奇，我们把它的整体性构思成人类生命；它的神秘源头，永远地被过去的面纱遮盖着，它呈现出来的无限错综复杂是难以理解的，而它的目的则被深深地埋藏在未来里。它从何而来？
它是什么？又会去哪里？无论何时，圣哲们都在努力地回答这些伟大的问题。

Modern science says: The sun is the past, the earth is the present, the moon is the future. From an incandescent mass we have originated, and into a frozen mass we shall turn. Merciless is the law of nature, and rapidly and irresistibly we are drawn to our doom. Lord Kelvin, in his profound meditations, allows us only a short span of life, something like six million years, after which time the suns bright light will have ceased to shine, and its life giving heat will have ebbed away, and our own earth will be a lump of ice, hurrying on through the eternal night. But do not let us despair. There will still be left upon it a glimmering spark of life, and there will be a chance to kindle a new fire on some distant star. This wonderful possibility seems, indeed, to exist, judging from Professor Dewar's beautiful experiments with liquid air, which show that germs of organic life are not destroyed by cold, no matter how intense; consequently they may be transmitted through the interstellar space. Meanwhile the cheering lights of science and art, ever increasing in intensity, illuminate our path, and marvels they disclose, and the enjoyments they offer, make us measurably forgetful of the gloomy future.
现代科学说：太阳是过去，地球是现在，月球是将来。我们起源于一团白炽的物质，然后我们会变成一团冰冻的物质。 自然法则是残酷的，我们很快而又无法抵抗地走向我们的末日。开尔文（物理学家，发明家）在他的深入冥想中，承认我们只是生命中很小的一部分，相当于太阳生命的六百万年。此后，太阳就会停止发光，它生命中发出的热量会渐渐消退，我们自己的地球也会结成冰块，进入暗无天日的黑夜。但我们不要失望。那里仍然会留下微弱的生命之光，会有机会在某些遥远的星球上点燃新的光芒。事实上，从杜瓦教授漂亮的液态空气实验来看，这种不可思议的可能性似乎是存在的。这表现为无论有多冷，构成有机

生命的微生物是不会被寒冷摧毁的；从而，它们会通过星际空间来传播。其间，科学与艺术令人欢呼的光芒，渐渐地变得强烈起来，照亮了我们的道路，它们在揭露奇迹，它们在提供享乐，让我们暂时地忘却了阴暗的未来。

Though we may never be able to comprehend human life, we know certainly that it is a movement, of whatever nature it be. The existence of movement unavoidably implies a body which is being moved and a force which is moving it. Hence, wherever there is life, there is a mass moved by a force. All mass possesses inertia, all force tends to persist. Owing to this universal property and condition, a body, be it at rest or in motion, tends to remain in the same state, and a force, manifesting itself anywhere and through whatever cause, produces an equivalent opposing force, and as an absolute necessity of this it follows that every movement in nature must be rhythmical. Long ago this simple truth was clearly pointed out by Herbert Spencer, who arrived at it through a somewhat different process of reasoning. It is borne out in everything we perceive•in the movement of a planet, in the surging and ebbing of the tide, in the reverberations of the air, the swinging of a pendulum, the oscillations of an electric current, and in the infinitely varied phenomena of organic life.

Does not the whole of human life attest to it? Birth, growth, old age, and death of an individual, family, race, or nation, what is it all but a rhythm? All life-manifestation, then, even in its most intricate form, as exemplified in man, however involved and inscrutable, is only a movement, to which the same general laws of movement which govern throughout the physical universe must be applicable.

尽管我们从来未能够了解人类生命，但我们当然知道它是一种运动，不管它的本质是什么。这种运动的存在，无奈地暗示着身体是运动的，有一种力量令它运动。从而，只要有了生命，就会有一种力量在推动着大量的运动。所有的力量都是惯性的，所有的力量都趋向于持续性运动。由于这种普遍的性质和条件，一个身体，不管是在休息还是在运动，都趋向于保持同一状态。有一种力量，无处不在。通过任何的原因，产生出一种相等的相反力。由此绝对必不可少地得出结论，每一种运动实质上是一种韵律。很久以前，这个简单的真理已经被赫伯特•斯宾塞明确地指出。他是通过某种稍为不同的推理过程来得出结论。它是从我们感知到的每件事物中产生，在行星的运动中，在潮汐的涨退中，在空气的回响中，在钟摆的摇动，在电流的振动，在有机生命的各种无限现象中。整个人类的一生都不是在证实它吗？个体、家族、种族或民族的出生、成长、衰老和死亡，都不只是一种韵律吗？那么，所有的生命表现，即使是最错综复杂的形式，例如是人类，都只是一种运动。然而，最棘手和难以了解的，也是运动，支配着整个物质宇宙的同一种普遍的运动法则必定适用。

[See Nikola Tesla: Colorado Springs Notes, page 334, Photograph X.]
[见尼古拉•特斯拉：科罗拉多温泉日记，334 页，图片 10]

FIG. 1. BURNING THE NITROGEN OF THE ATMOSPHERE. Note to Fig. 1.•This result is produced by the discharge of an electrical oscillator giving twelve million volts. The electrical pressure, alternating one hundred thousand times per second, excites the normally inert nitrogen, causing it to combine with the oxygen. The flame-like discharge shown in the photograph measures sixty-five feet across.

图片 1、大气中氮气的燃烧。 注：1、这是由一个振荡器放电产生出的效果，产生出一千二百万伏的电压。电压的交互频率是每秒十万次，激活了通常是惰性的氮气，引发它与氧气结合。图片上展示的火焰般的电流，跨度大概是 65 英尺。

When we speak of man, we have a conception of humanity as a whole, and before applying scientific methods to, the investigation of his movement we must accept this as a physical fact. But can anyone doubt to-day that all the millions of individuals and all the innumerable types and characters constitute an entity, a unit? Though free to think and act, we are held together, like the stars in the firmament, with ties inseparable. These ties cannot be seen, but we can feel them. I cut myself in the finger, and it pains me: this finger is a part of me. I see a friend hurt, and it hurts me, too: my friend and I are one. And now I see stricked down an enemy, a lump of matter which, of all the lumps of matter in the universe, I care least for, and it still grieves me. Does this not prove that each of us is only part of a whole?

当我们谈到了人类，我们会把人类视为一个整体的概念，在运用科学方法之前，我们必须把他的调查活动看成是一种物理事实。但是，今天有人能够怀疑所有数以亿计的个体及其属性构成一个实体，一个单元吗？通过自由地思考和行动，就会发现我们是连成一体的，就像天空里的星星，绑在一起，密不可分。这些结是看不到的，但我们能够感受到它们。我把手指切下，它让我感到痛：这只手指是我的一部分。我看到一个朋友受到伤害，也令我受到伤害。我的朋友和我是一体。现在我看见了一束能量从天而降，一大块的物质，也是宇宙中的所有大块物质。我关心它，唯恐它受损，但它仍然使我伤心。这不就是证实了我们只是宇宙中的一部分？

For ages this idea has been proclaimed in the consummately wise teachings of religion, probably not alone as a means of insuring peace and harmony among men, but as a deeply founded truth. The Buddhist expresses it in one way, the Christian in another, but both say the same: We are all one. Metaphysical proofs are, however, not the only ones which we are able to bring forth in support of this idea. Science, too, recognizes this connectedness of separate individuals, though not quite in the same sense as it admits that the suns, planets, and moons of a constellation are one body, and there can be no doubt that it will be experimentally confirmed in times to come, when our means and methods for investigating psychical and other states and phenomena shall have been brought to great perfection. Still more: this one human being lives on and on. The individual is ephemeral, races and nations come and pass away, but man remains. Therein lies the profound difference between the individual and the whole. Therein, too, is to be found the partial explanation of many of those marvelous phenomena of heredity which are the result of countless centuries of feeble but persistent influence.

很久以来，宗教的智慧教导已经完整地揭示这种思想，很可能并不是作为一种确保人类和平与融洽的方法，而是作为一种有深奥根基的真理。佛教以一种方式来解释它，基督教是另一种，但两者的说法都是一样：我们都是一体。然而，形而上学的论证并不是能够使我们支持这种观念的唯一方法。科学也一样，认可分离个体的这种连通性，尽管它并不是以相同的口吻来承认一个星座的太阳、行星和月亮是一体，但是毫无疑问，当我们研究物理和其它状态与现象的工具和方法更加完善的时候，将来的实验必定更加坚定地解释这一点。再者：这种一体的人类会继续地生活下去。个体是短暂的，种族和民族出现了又会消逝，但人类依然存在。这样，个体和整体之间存在着一种意义深远的差异。从而也会有很多对众多不可思议现象的片面解释，一个世代又一个世代地流传，微弱而有持久稳固的影响力。

Conceive, then, man as a mass urged on by a force. Though this movement is not of a translatory character, implying change of place, yet the general laws of mechanical movement are applicable to it, and the energy associated with this mass can be measured, in accordance with well-known principles, by half the product of the mass with the square of a certain velocity. So, for instance, a cannon-ball which is at rest possesses a certain amount of energy in the form of heat, which we measure in a similar way. We imagine the ball to consist of innumerable minute particles, called atoms or molecules, which vibrate or whirl around one another. We determine their masses and velocities, and from them the energy of each of these minute systems, and adding them all together, we get an idea of the total heat-energy contained

in the ball, which is only seemingly at rest. In this purely theoretical estimate this energy may then be calculated by multiplying half of the total mass•that is half of the sum of all the small masses•with the square of a velocity which is determined from the velocities of the separate particles. In like manner we may conceive of human energy being measured by half the human mass multiplied with the square of the velocity which we are not yet able to compute. But our deficiency in this knowledge will not vitiate the truth of the deductions I shall draw, which rest on the firm basis that the same laws of mass and force govern throughout nature.

构想一下，人是被一股力量拉到一起的一个大的集合。尽管这种运动并非平移运动，暗示着空间的转换，但依然适用于机械运动的普遍法则。依照著名的法则，与这个集合紧密相连的能量却是标准的，这个集合的一半等同于某种速率。那么，以一枚古代大炮为例，它以热量的形式占据了相关数目的能量，我们可以用简单的方法来测量它。我们想象一个球是由无数的微型粒子组成，称为原子或分子，一个围绕着另一个振动或旋转。我们测定了它们的质量和速度，这些微型系统产生了能量，把它们加起来，我们可以算出这个看上去是静止不运的球的热量总和。在这种纯理论的推算中，我们可以通过把总质量的一半累加来计算出能量，那是所有分子质量总和的一半乘以某个速率的平方，这个速率是取决于各个分子的速率。同样地，我们可以把人类能量构想成可以通过把人类质量的一半乘以某个速率来计算出，而这个速率目前我们还不能计算出来。但是，我们对这种知识的缺乏无损于我提出的这个真理，相同的质能法则支配着整个自然界。

Man, however, is not an ordinary mass, consisting of spinning atoms and molecules, and containing merely heat-energy.

He is a mass possessed of certain higher qualities by reason of the creative principle of life with which he is endowed. His mass, as the water in an ocean wave, is being continuously exchanged, new taking the place of the old. Not only this, but he grows propagates, and dies, thus altering his mass independently, both in bulk and density. What is most wonderful of all, he is capable of increasing or diminishing his velocity of movement by the mysterious power he possesses by appropriating more or less energy from other substance, and turning it into motive energy. But in any given moment we may ignore these slow changes and assume that human energy is measured by half the product of man's mass with the square of a certain hypothetical velocity. However we may compute this velocity, and whatever we may take as the standard of its measure, we must, in harmony with this conception, come to the conclusion that the great problem of science is, and always will be, to increase the energy thus defined. Many years ago, stimulated by the perusal of that deeply interesting work, Draper's "History of the Intellectual Development of Europe," depicting so vividly human movement, I recognized that to solve this eternal problem must ever be the chief task of the man of science. Some results of my own efforts to this end I shall endeavor briefly to describe here.

然而，人类，并不是一个普通的集合，由旋转的原子和分子组成，仅仅是包含热能。由于他被赋予了生命的创造性法则，他是一个拥有某种更高品质的集合。他的聚集，如同海浪里的水，不断地变换，新的代替老的。不仅如此，他还会生长繁殖，然后死亡，从而独立地改变了他的质量，既在容积上，也在密度上。更令人惊讶的是，他能量通过或多或少地接近其他物质，通过他拥有的神秘力量，能够逐渐增加或减少他的运动速率，把它转变成运动的能量。但是，在任何时候，我们都会忽略这些缓慢的变化，还设想人类能量是人类质量的一半乘以某个假设速率的平方。然而，我们可以计算出这个速率，不管我们是用哪种测量标准，我们必定是根据这种概念来得出结论，从而，提升限定的能量，一直是科学的重大问题。很多年以前，在德雷珀的有趣作品“欧洲智力发展史”的激励下，如此生动地描绘了人类运动。我认为解决这个永久的问题必定是科学家的首要任务。

最后，我会尽力在这里简要地讲述我自己努力的一些结果。

DIAGRAM a. THE THREE WAYS OF INCREASING HUMAN ENERGY.

图表：a、人类能量增长的三种方式

Let, then, in diagram a, M represent the mass of man. This mass is impelled in one direction by a force f, which is resisted by another partly frictional and partly negative force R, acting in a direction exactly opposite, and retarding the movement of the mass. Such an antagonistic force is present in every movement and must be taken into consideration. The difference between these two forces is the effective force which imparts a velocity V to the mass M in the direction of the arrow on the line representing the force f. In accordance with the preceding, the human energy will then be given by the product • MV2 = • MV x V, in which M is the total mass of man in the ordinary interpretation of the term "mass," and V is a certain hypothetical velocity, which, in the present state of science, we are unable exactly to define and determine. To increase the human energy is, therefore, equivalent to increasing this product, and there are, as will readily be seen, only three ways possible to attain this result, which are illustrated in the above diagram. The first way shown in the top figure, is to increase the mass (as indicated by the dotted circle), leaving the two opposing forces the same. The second way is to reduce the retarding force R to a smaller value r, leaving the mass and the impelling force the same, as diagrammatically shown in the middle figure. The third way, which is illustrated in the last figure, is to increase the impelling force f to a higher value F, while the mass and the retarding force R remain unaltered. Evidently fixed limits exist as regards increase of mass and reduction of retarding force, but the impelling force can be increased indefinitely. Each of these three possible solutions presents a different aspect of the main problem of increasing human energy, which is thus divided into three distinct problems, to be successively considered.

接着，在图表 a，M 是代表人的质量。这种质量被一种力量 f 推到一个方向，其中一部分被摩擦力，另一部分被反作用力 R 抵销，阻碍了这个人的运动。这样的反作用力在每种运动里面都会出现，必须要考虑在内。这两种力的作用产生了速率 V，通过直线上的箭头代表的力 f 来传送给质量 M。根据前述，接着人类的能量会从 MV 的乘积=•MV* V 得到。这里，在术语“质量”的通常意义下，M 是人的质量总和，V 是某个假设的速率。在科学面前，我们无法准确地定义和测定。因此，人类能量的增加，是等同于这个乘积的增加。因此，正如所看到的，只有三种方式有可能得到这种结果，画在上面的图表上。上面图片表示的第一种方式，是增加质量（用虚线的圆形来表示），抛开两种同样大小的相反力。第二种方式是把减速力 R 减到一个较小值 r ，抛开质量和同样大小的推动力，正如在中间那幅图所表示的一样。第三种方式，是最后一幅图表示的，增加推动力 f 到一个较大值 F，而质量和减速力 R 仍然不变。显然，固定的界限只存在于增加质量和减少减速力上，但推动力可以不确定地增加。这三个可能的解决方案，从不同方面表现出增加人类能量这个主要问题，因此被划分成三个截然不同的问题，相继地被考虑。

THE FIRST PROBLEM: HOW TO INCREASE THE HUMAN MASS•THE BURNING OF ATMOSPHERIC NITROGEN.

第一个问题：人类如何增加质量•气态氮的燃烧

Viewed generally, there are obviously two ways of increasing the mass of mankind: first, by aiding and maintaining those forces and conditions which tend to increase it; and, second, by opposing and reducing those which tend to diminish it. The mass will be increased by careful attention to health, by substantial food, by moderation, by regularity of habits, by promotion of marriage, by conscientious attention to children, and, generally stated, by the observance of all the many precepts and laws of religion and hygiene. But in adding new mass to the old, three cases again present themselves.

Either the mass added is of the same velocity as the old, or it is of a smaller or of a higher velocity. To

gain an idea of the relative importance of these cases, imagine a train composed of, say, one hundred locomotives running on a track, and suppose that, to increase the energy of the moving mass, four more locomotives are added to the train. If these four move at the same velocity at which the train is going, the total energy will be increased four per cent.; if they are moving at only one half of that velocity, the increase will amount to only one per cent.; if they are moving at twice that velocity, the increase of energy will be sixteen per cent. This simple illustration shows that it is of greatest importance to add mass of a higher velocity. Stated more to the point, if, for example, the children be of the same degree of enlightenment as the parents,•that is, mass of the "same velocity,"•the energy will simply increase proportionately to the number added. If they are less intelligent or advanced, or mass of "smaller velocity," there will be a very slight gain in the energy; but if they are further advanced, or mass of "higher velocity," then the new generation will add very considerably to the sum total of human energy. any addition of mass of "smaller velocity," beyond that indispensable amount required by the law expressed in the proverb, "Mens sana in corpore sano," should be strenuously opposed. For instance, the mere development of muscle, as aimed at in some of our colleges, I consider equivalent to adding mass of "smaller velocity," and I would not commend it, although my views were different when I was a student myself. Moderate exercise, insuring the right balance between mind and body, and the highest efficiency of performance, is, of course, a prime requirement. The above example shows that the most important result to be attained is the education, or the increase of the "velocity," of the mass newly added.

总体地看，显然有两种增加人类质量的方法：首先，通过支援和维持那些让质量增加的力和条件；然后，第二是通过抵销和减少那些让质量减少的力和条件。通常地说，通过细心地关注健康，通过坚固的实质，通过适度、有规律的习惯、通过促进婚姻、通过尽照顾孩子的责任；还有，是通过对所有许多规则的观察，对宗教和卫生规律的观察，会使质量增加。但是，在把大量新的质量加到旧的上面去的时候，三种情形又再次地显示出来，不管是加上同等速率的质量，还是加上更小或更大速率的。为了明白这几种情形的重要性，我们来想象一辆火车，是由一百个发动机组成，在铁路上行走，假设要增加移动车厢的能量，那样要增加另外四个发动机上去，总能量增加百分之四；如果它们每一个都只是以一半的速度移动，那样增加的能量只有百分之一；如果它们都以两倍的速度移动，那么增加的能量会是百分之十六。这个简单的例子表明，大量地增加速度是十分重要的。更加扼要地说，比如，如果孩子与父母拥有同等程度的知识，也就是说，是拥有“相同速率”的质量，能量会仅仅是随着数目的递增而成比例地增加；如果他们是智力低下或智力先进，或者是“更小速率”的质量，那样能量的增长是微小的。但是，如果他们是更加聪明，或者说是拥有“更大速率”的质量，那么新的一代会被认为是人类能量加起来的总和。任何“较小速率”能量的增加，超过了谚语“健全的精神寓于健全的身体”规定的必要数量，应该要强烈反对。例如，光是发展肌肉，正如瞄准我们的一些大学一样，我认为是等同于增加“较小速率”的质量，我不会称赞它，尽管在我是学生的时候，我的观点不同。当然，要有最高的效率，适度的练习，确保身体与头脑之间的平衡，是根本的要求。上面的例子表明，要获得成效，最重要的是教育，或者说是增加新增添质量的“速率”。

Conversely, it scarcely need be stated that everything that is against the teachings of religion and the laws of hygiene is tending to decrease the mass. Whisky, wine, tea coffee, tobacco, and other such stimulants are responsible for the shortening of the lives of many, and ought to be used with moderation. But I do not think that rigorous measures of suppression of habits followed through many generations are commendable. It is wiser to preach moderation than abstinence. We have become accustomed to these stimulants, and if such reforms are to be effected, they must be slow and gradual. Those who are devoting their energies to such ends could make themselves far more useful by turning their efforts in other directions, as, for instance, toward providing pure water.

相反地，几乎无需说明，所有一切逆反宗教教导和卫生规则的都是减少质量。威士忌、葡萄酒、茶、咖啡、香烟和其它一些刺激性的东西，都是使很多人寿命缩短的原因，应要适度使用。但是，我不认为很多代人

流传下来的，严格压抑生活习惯是值得赞扬。
提倡适度比禁欲更加理智。我们变得对这些刺激物习以为常，如果这样的改善是有效的，那么它们必定是缓慢和渐进的。那些把自己的能量（精力）献身于某种结局的人，可以通过把他们的努力转到其它方向上去，让他们变得更加有用。这好比是饮用清澈的水。

For every person who perishes from the effects of a stimulant, at least a thousand die from the consequences of drinking impure water. This precious fluid, which daily infuses new life into us, is likewise the chief vehicle through which disease and death enter our bodies. The germs of destruction it conveys are enemies all the more terrible as they perform their fatal work unperceived. They seal our doom while we live and enjoy. The majority of people are so ignorant or careless in drinking water, and the consequences of this are so disastrous, that a philanthropist can scarcely use his efforts better than by endeavoring to enlighten those who are thus injuring themselves. By systematic purification and sterilization of the drinking water the human mass would be very considerably increased. It should be made a rigid rule•which might be enforced by law•to boil or to sterilize otherwise the drinking water in every household and public place. The mere filtering does not afford sufficient security against infection. All ice for internal uses should be artificially prepared from water thoroughly sterilized. The importance of eliminating germs of disease from the city water is generally recognized, but little is being done to improve the existing conditions, as no satisfactory method of sterilizing great quantities of water has yet been brought forward. By improved electrical appliances we are now enabled to produce ozone cheaply and in large amounts, and this ideal disinfectant seems to offer a happy solution of the important question.
对于每一个被刺激物的作用所摧毁的人而言，至少有一千个是死于饮用不洁的水的结果。水，这种宝贵的液体，每天都给予我们新的生命，同样地也是把疾病和死亡带进我们身体的主要媒介。它们把毁灭性的细菌传送给人类，更加可怕的是，它们做的可怕工作未被察觉。当我们还活着和享受生活的时候，它们注定了我们的末日。大多数的人都对饮水如此无知和疏忽，结果是损失惨重。因此，慈善家的努力工作比不上教化那些在伤害自己的人。通过有系统地净化和对饮用水杀菌，人类的质量会得到提升。
应要制造严格规定，每个家庭和每个公众地方都要煮沸或消毒饮用水，通过法律来实行。光是过滤不能确保细菌的传染。国内使用的所有冰块都要人工地通过消毒的水来制造。减少城市饮用水病茵的重要性普遍得到认可，但几乎无法改善现有环境，因为目前没有满意的方法来减少大量水源的细菌。通过改善电力设施，我们现在能够便宜地制造大量臭氧，这种理想的消毒剂看来是这个重要问题的理想解决办法。

（注：那么是否可以通过大量制造空气中的臭氧来弥补地球日益受损的臭氧层呢？
应该是通过制造闪电来制造空气中的臭氧吧。闪电能产生大量臭氧。）
Gambling, business rush, and excitement, particularly on the exchanges, are causes of much mass reduction, all the more so because the individuals concerned represent units of higher value. Incapacity of observing the first symptoms of an illness, and careless neglect of the same, are important factors of mortality. In noting carefully every new sign of approaching danger, and making conscientiously every possible effort to avert it, we are not only following wise laws of hygiene in the interest of our well-being and the success of our labors, but we are also complying with a higher moral duty. Everyone should consider his body as a priceless gift from one whom he loves above all, as a marvelous work of art,
of indescribable beauty and mastery beyond human conception, and so delicate and frail that a word, a breath, a look, nay, a thought, may injure it. Uncleanliness, which breeds disease and death, is not only a self destructive but highly immoral habit. In keeping our bodies free from infection, healthful, and pure, we are expressing our reverence for the high principle with which they are endowed. He who follows the precepts of hygiene in this spirit is proving himself, so far, truly religious. Laxity of morals is a terrible evil,

which poisons both mind and body, and which is responsible for a great reduction of the human mass in some countries. Many of the present customs and tendencies are productive of similar hurtful results. For example, the society life, modern education and pursuits of women, tending to draw them away from their household duties and make men out of them, must needs detract from the elevating ideal they represent, diminish the artistic creative power, and cause sterility and a general weakening of the race. A thousand other evils might be mentioned, but all put together, in their bearing upon the problem under discussion, they could not equal a single one, the want of food, brought on by poverty, destitution, and famine. Millions of individuals die yearly for want of food, thus keeping down the mass. Even in our enlightened communities, and not withstanding the many charitable efforts, this is still, in all probability, the chief evil. I do not mean here absolute want of food, but want of healthful nutriment.

赌博、商业投机和其它刺激，尤其是做买卖，是引发质量大量减少的原因，因为每个个体都关注自己所在单元的更高价值。

无能力观察疾病出现的首个征兆，和忽略一样，是死亡的重要因素。小心地留意走近危险的每个新征兆，有良知地用尽每种可能的办法来扭转它，我们不仅是为了我们自己的利益和我们的发财来跟随卫生学的明智法规，而且是要为了一种更高的道德责任来履行它。每一个人都应要把自己的身体视为无价的恩赐，他爱它胜过一切，是一件不可思议的艺术品，难以形容的美丽，超出了人类概念所能掌握，如此精致和脆弱，一种语言、一种呼吸、一种眼神，不，一种思想，都可以伤害它。不洁会带来疾病和死亡，不仅是一种自我毁灭，而且还是一种高度不道德的习惯。为了让我们的身体免受感染、保持健康和纯洁，我们用自己的天赋表达了对这种崇高法则的敬畏，以这种精神来遵从卫生规则的人会时时审视自己，就此而言，这是真正的宗教。道德松驰是可怕的邪恶，毒化了头脑和身体，在一些国家里，大大地降低了人类质量。现时的习俗和倾向，都会产生类似的有害结果。例如，社会生活、现代教育和对女人的追求，都倾向于让他们抛弃家庭责任，使人远离他们，必然会减损他们振奋的精神，减少了艺术般的创造力，引发思想贫乏，总的来说弱化了整个人类种族。也许我们可以提出一千种其它的罪恶（不幸），可以讨论它们引发的问题，但它们加起来，都比不上一种罪恶，那就是由贫穷、穷困和饥饿带来的食物短缺。每年都有无数人因为食物短缺而死去，因此人类也缩减了。即使在我们的文明社会，许多的慈善行为也仍然抵挡不住主要的罪恶。我在这里不仅是指食物短缺，而且还指缺乏有益的营养。

How to provide good and plentiful food is, therefore, a most important question of the day. On the general principles the raising of cattle as a means of providing food is objectionable, because, in the sense interpreted above, it must undoubtedly tend to the addition of mass of a "smaller velocity." It is certainly preferable to raise vegetables, and I think, therefore, that vegetarianism is a commendable departure from the established barbarous habit. That we can subsist on plant food and perform our work even to advantage is not a theory, but a well-demonstrated fact. Many races living almost exclusively on vegetables are of superior physique and strength. There is no doubt that some plant food, such as oatmeal, is more economical than meat, and superior to it in regard to both mechanical and mental performance. Such food, moreover, taxes our digestive organs decidedly less, and, in making us more contented and sociable, produces an amount of good difficult to estimate. In view of these facts every effort should be made to stop the wanton and cruel slaughter of animals, which must be destructive to our morals. To free ourselves from animal instincts and appetites, which keep us down, we should begin at the very root from which we spring: we should effect a radical reform in the character of the food.

因此，怎样提供大量优质的食物，是今天至关重要的问题。在普遍的法则下，通常饲养牛来提供食物是令人反感的，因为，在上述解释的意义下，它必然毫无疑问地倾向于增多“较小速率”的质量。种植蔬菜当然更加可取。我想，在违背已制定的野蛮习惯下，素食主义是值得表扬的。那样，我们可以依靠植物来生活和履行我们的工作，甚至会更加有益，这不是理论，而是一个有根据的事实。很多几乎完全地依靠蔬菜为

生的种族在体格和力量上都更为优越。毫无疑问，一些素食，例如是麦片，比肉类更经济，不管在机械上，还是在精神上，都更加优越。再者，这样的食物，大大地减轻了我们消化系统的负担，让我们更加满足和友善，带来的好处无法估计。基于这些因素，应该尽力制止挥霍和残酷的屠宰牲畜，因为那样必定会破坏我们的道德，令我们堕落。要把我们从动物本能和欲望中释放出来，我们必须从我们的根源开始：我们应该要努力从食物上进行一场激进的改革。

There seems to be no philosophical necessity for food. We can conceive of organized beings living without nourishment, and deriving all the energy they need for the performance of their life functions from the ambient medium. In a crystal we have the clear evidence of the existence of a formative life-principle, and though we cannot understand the life of a crystal, it is none the less a living being. There may be, besides crystals, other such individualized, material systems of beings, perhaps of gaseous constitution, or composed of substance still more tenuous. In view of this possibility,•nay, probability, we cannot apodictically deny the existence of organized beings on a planet merely because the conditions on the same are unsuitable for the existence of life as we conceive it. We cannot even, with positive assurance, assert that some of them might not be present here, in this our world, in the very midst of us, for their constitution and life- manifestation may be such that we are unable to perceive them.

这似乎没有哲学上的必要性。我们可以想象一下，一个没有营养的生命组织，而这都源自提供它们生命能量所需的环境介质。我们从水晶中，有明确的证据表明，存在着一种格式化的生命法则，尽管我们无法了解这颗水晶的生命，但它仍然是一种生命体。

因此，也许除了水晶以外，其它这样的个性化的物质系统，也许是气态的，或者是由更纤细的物质组成的，都是有机生命体。在这种可能的观点下，不，应该是在这种可能性下，我们无法绝然地否认，只有我们的星球才存在有组织的生命，因为正如我们设想的，同样的条件不适合生命存在。我们甚至不能够积极而又自信地声称，它们中的一些也许不在这里，不在我们的这个世界，不在我们中间，因为它们的构造和生命体征是如此，以致我们无法感知到它们。

The production of artificial food as a means for causing an increase of the human mass naturally suggests itself, but a direct attempt of this kind to provide nourishment does not appear to me rational, at least not for the present. Whether we could thrive on such food is very doubtful. We are the result of ages of continuous adaptation, and we cannot radically change without unforeseen and, in all probability, disastrous consequences. So uncertain an experiment should not be tried. By far the best way, it seems to me, to meet the ravages of the evil, would be to find ways of increasing the productivity of the soil. With this object the preservation of forests is of an importance which cannot be overestimated, and in this connection, also, the utilization of water-power for purposes of electrical transmission, dispensing in many ways with the necessity of burning wood, and tending thereby to forest preservation, is to be strongly advocated. But there are limits in the improvement to be effected in this and similar ways.

人工食物的生产，自然地显示了它本身就是引发人类质量增长的方法，但这种提供营养的直接尝试，在我们看起来似乎不是合理的，至少就现在而言。我们是否能够培育出这样的食物，也非常令人质疑。我们是世世代代积累起来的结果，也不可能作出无法预料的激进变革，因为这很可能，后果损失惨重。这样一种无法预料的实验不应去尝试。到目前为止，对我来说，是看到了罪恶带来的创伤，会去寻找提高土壤生产力的方法。这样，对森林的保护就至关重要了，就此而论，决定利用水力发电和进行电力输送，用各种方法来减少对树木的燃烧，因此强力提倡对森林的保护。但是，这种或那种类似的改进方法的效果是有限的。

To increase materially the productivity of the soil, it must be more effectively fertilized by artificial means. The question of food-production resolves itself, then, into the question how best to fertilize the soil. What

it is that made the soil is still a mystery. To explain its origin is probably equivalent to explaining the origin of life itself. The rocks, disintegrated by moisture and heat and wind and weather, were in themselves not capable of maintaining life. Some unexplained condition arose, and some new principle came into effect, and the first layer capable of sustaining low organisms, like mosses was formed. These, by their life and death, added more of the life sustaining quality to the soil, and higher organisms could then subsist, and so on and on, until at last highly developed plant and animal life could flourish. But though the theories are, even now, not in agreement as to how fertilization is effected, it is a fact, only too well ascertained, that the soil cannot indefinitely sustain life, and some way must be found to supply it with the substances which have been abstracted from it by the plants. The chief and most valuable among these substances are compounds of nitrogen, and the cheap production of these is, therefore, the key for the solution of the all-important food problem. Our atmosphere contains an inexhaustible amount of nitrogen, and could we but oxidize it and produce these compounds, an incalculable benefit for mankind would follow.

要从本质上提高土壤的生产力，必须要用人工方法来更加有效地让它肥沃。然后，解决粮食生产的问题本身也变成了如何更好地改善土壤的问题。土壤的构成依然是一个谜。要解释它的起源，很可能等同于解释生命本身的起源。岩石，本身无法维持生命，被湿气、热、风和天气分解。一些不清楚的因素出现了，一些新的法则也变得有效。第一层能够维持较低级的有机生命，比如说苔藓，就从这里形成。通过它们的生与死，再加上其它的生命，维系着土壤的质量，这样更高级的生命体也形成了，如此类推，最终滋养出高度发达的行星和动物生命。尽管有众多学说，但即使到了现在，对于如何有效地让土壤肥沃也未达成一致的共识，只有过多的探知，这是事实。土壤不能够无限地维系生命，必须要找到一些方法，从植物中提取物质来为土壤补充营养。这些物质中，主要和最重要的是由氮组成的化合物，因此，廉价地生产这些物质是解决食物问题的关键。我们的大气层是由无穷无尽的氮组成，我们是否能够氧化和生产这些化合物，对人类会是不可估计的益处。

Long ago this idea took a powerful hold on the imagination of scientific men, but an efficient means for accomplishing this result could not be devised. The problem was rendered extremely difficult by the extraordinary inertness of the nitrogen, which refuses to combine even with oxygen. But here electricity comes to our aid: the dormant affinities of the element are awakened by an electric current of the proper quality. As a lump of coal which has been in contact with oxygen for centuries without burning will combine with it when once ignited, so nitrogen, excited by electricity, will burn. I did not succeed, however, in producing electrical discharges exciting very effectively the atmospheric nitrogen until a comparatively recent date, although I showed, in May, 1891, in a scientific lecture, a novel form of discharge or electrical flame named "St. Elmo's hotfire," which, besides being capable of generating ozone in abundance, also possessed, as I pointed out on that occasion, distinctly the quality of exciting chemical affinities. This discharge or flame was then only three or four inches long, its chemical action was likewise very feeble, and consequently the process of oxidation of nitrogen was wasteful. How to intensify this action was the question. Evidently electric currents of a peculiar kind had to be produced in order to render the process of nitrogen combustion more efficient.

很久以前，这种想法在科学人的幻想里占有强而有力的地位，但却没有想出一种有效的实现方法。由于氮的不活跃性，甚至拒绝同氧结合，因而这个问题变得异常地困难。但是，电流在这里帮了我们的忙：在适当大小的电流刺激下，会把沉睡的元素唤醒。一块与氮气接触了无数个世纪而没有燃烧的煤，一点燃就马上烧起来。那么氮也一样，被电子激活，会马上烧起来。然而，直到近日，我才成功地制造出能有效地让气态氮激活的电流，尽管在 1891 年 5 月的一个科学演说中曾经演示过。小说里的电流或电火花，就像“圣艾尔摩之火”所写的一样，除了能够产生丰富的臭氧外，也像我在那次指出的一样，明显是产生出活跃的化学反应。这种电流或火花只有三四英寸长，它的化学活动同样也是非常弱，从而把氮氧化的过程是浪费的。如何加强这种活跃程度才是问题关键。显然，为了更有效地完成氮氧结合的过程，一种独特类型的电流必

须被制造出来。

The first advance was made in ascertaining that the chemical activity of the discharge was very considerably increased by using currents of extremely high frequency or rate of vibration. This was an important improvement, but practical considerations soon set a definite limit to the progress in this direction. Next, the effects of the electrical pressure of the current impulses, of their wave-form and other characteristic features, were investigated. Then the influence of the atmospheric pressure and temperature and of the presence of water and other bodies was studied, and thus the best conditions for causing the most intense chemical action of the discharge and securing the highest efficiency of the process were gradually ascertained. Naturally, the improvements were not quick in coming; still, little by little, I advanced. The flame grew larger and larger, and its oxidizing action grew more intense. From an insignificant brush-discharge a few inches long it developed into a marvelous electrical phenomenon, a roaring blaze, devouring the nitrogen of the atmosphere and measuring sixty or seventy feet across.
现在确定，首先第一步的是，通过利用极高频率或振动比率的电流来有效地提升电流的化学活跃程度。这是一个重要的进步，但实际上很快会考虑到，在此方向上，有明显的限制。下一步，在电流推动的电压作用下，产生出的波形和其它特有形态也要考虑在内。然后是大气压力和温度的影响，水和其它物体的影响也要研究，从而保证引发最强烈的电化学反应的最佳条件，渐渐地得知出确保至高效率的条件。自然地，改进不会很快地出现，它是渐进的。我开了个头。火焰渐渐地越来越大，它的氧化活动变得越来越强烈。它从一种只有几英寸长的刷形放电，发展成一种不可思议的电流现象，一种咆哮的火焰，吞吃了大气中的氮，横跨六十至七十英尺。

Thus slowly, almost imperceptibly, possibility became accomplishment. All is not yet done, by any means, but to what a degree my efforts have been rewarded an idea may be gained from an inspection of Fig. 1 (p. 176), which, with its title, is self explanatory. The flame-like discharge visible is produced by the intanse electrical oscillations which pass through the coil shown, and violently agitate the electrified molecules of the air. By this means a strong affinity is created between the two normally indifferent constituents of the atmosphere, and they combine readily, even if no further provision is made for intensifying the chemical action of the discharge. In the manufacture of nitrogen compounds by this method, of course, every possible means bearing upon the intensity of this action and the efficiency of the process will be taken advantage of, and, besides, special arrangements will be provided for the fixation of the compounds formed, as they are generally unstable, the nitrogen becoming again inert after a little lapse of time. Steam is a simple and effective means for fixing permanently the compounds. The result illustrated makes it practicable to oxidize the atmospheric nitrogen in unlimited quantities, merely by the use of cheap mechanical power and simple electrical apparatus. In this manner many compounds of nitrogen may be manufactured all over the world, at a small cost, and in any desired amount, and by means of these compounds the soil can be fertilized and its productiveness indefinitely increased. An abundance of cheap and healthful food, not artificial, but such as we are accustomed to, may thus be obtained. This new and inexhaustible source of food-supply will be of incalculable benefit to mankind, for it will enormously contribute to the increase of the human mass, and thus add immensely to human energy. Soon, I hope, the world will see the beginning of an industry which, in time to come, will, I believe, be in importance next to that if iron.
因此，很可能慢慢地，几乎不被察觉地结束。无论如何，所有这些都还没有做，但从某个程度上，我的努力已经得到回报。
从图片 1 （第 176 页），连同它的标题在表明，一种想法也许会得到实现。火焰般的可见电流经由一个强

烈的电子振荡器而产生，经过盘绕的线圈，猛烈地搅动着空气中的带电分子。用这种方法，大气中两种通常比较不活跃的成份产生了亲和力，它们乐意地结合起来，即使没有再进一步加强电流，这种电化学反应也形成。当然，用这种方法来制造氮化物，每一种可能性都意味着带来这种强烈的活动，其过程的有效性也会占了优势。此外，特别的安排也会被用作稳固这种形成的化合物，因为它们通常是不稳定的，过了少许的时间，氮又会变成惰性的。蒸汽是使这种化合物永久固化的简单而有效方法。结果表明，仅是利用便宜的化学能和简单的电子设备，把空气中无数的氮氧化是可行的。用这种方法，可以用最低的成本，把全世界的氮化物都制造出来，其数量可观。依靠这些化合物，土壤可以变得肥沃，它的赢利性也无法估计地提升了，从而可以获得丰富而便宜的健康食物。这不是假的，而是跟我们习惯的食物一样。这种新颖而无穷无尽的食物供给来源会为人类带来无可估计的益处，因为它大大地提升了人类的质量，从而也大大地增加了人类能量。我希望，很快地，这个世界会看见一种工业会很快开始。我相信，它的重要性会仅次于铁。

THE SECOND PROBLEM: HOW TO REDUCE THE FORCE RETARDING THE HUMAN MASS•THE ART OF
TELAUTOMATICS.

第二个问题：如何减少妨碍人类质量的力量•自动遥控机械学的巧妙

As before stated, the force which retards the onward movement of man is partly frictional and partly negative. To illustrate this distinction I may name, for example, ignorance, stupidity, and imbecility as some of the purely frictional forces, or resistances devoid of any directive tendency. On the other hand, visionariness, insanity, self-destructive tendency, religious fanaticism, and the like, are all forces of a negative character, acting in definite directions. To reduce or entirely overcome these dissimilar retarding forces, radically different methods must be employed. One knows, for instance, what a fanatic may do, and one can take preventive measures, can enlighten, convince, and, possibly direct him, turn his vice into virtue; but one does not know, and never can know, what a brute or an imbecile may do, and one must deal with him as with a mass, inert, without mind, let loose by the mad elements. A negative force always implies some quality, not infrequently a high one, though badly directed, which it is possible to turn to good advantage; but a directionless, frictional force involves unavoidable loss. Evidently, then, the first and general answer to the above question is: turn all negative force in the right direction and reduce all frictional force.

正如前面提到的，阻碍人类向前运动的力量部分是由于摩擦力，部分是由于反作用力。要说明这种区别，我可以举例，比如是无知、愚昧和低能，是一些纯粹的摩擦力或阻力，阻碍了任何的直线趋向。另一方面，幻想、神经错乱和自我毁灭的倾向，宗教狂热等诸如此类，是所有负面特征的力量，以一定的方向来行动。要减少或完全克服这些不同的减速力，必须采用一种完全不同的方式。例如，一个人知道狂热者通常做些什么，就可以采取预防措施，可以教化、劝服，或者可能会引导他，把他的恶习转化成美德；但是他并不知道，而且永远无法知道，一个残忍的或一个低能的人会做些什么，必定会把他视为一团物质、惰性的、没有思想的、释放疯狂元素。一种相反的力量总是暗示着某些物质，通常是高密度的，尽管没有受到引导，但有可能转变成有利的物质；但一种缺乏方向性的摩擦力会笼罩在无可避免的损耗中。那么，上述问题的首要和普遍的答案显然是：把所有负面的力量转变为正确的方向，减少所有的摩擦力。

There can be no doubt that, of all the frictional resistances, the one that most retards human movement is ignorance.

Not without reason said that man of wisdom, Buddha: "Ignorance is the greatest evil in the world." The friction which results from ignorance, and which is greatly increased owing to the numerous languages and nationalities, can be reduced only by the spread of knowledge and the unification of the heterogeneous elements of humanity. No effort could be better spent. But however ignorance may have retarded the onward movement of man in times past, it is certain that, nowadays, negative forces have become of greater importance. Among these there is one of far greater moment than any other. It is called organized warfare. When we consider the millions of individuals, often the ablest in mind and body, the flower of humanity, who are compelled to a life of inactivity and unproductiveness, the immense sums of money daily required for the maintenance of armies and war apparatus, representing ever so much of human energy, all the effort uselessly spent in the production of arms and implements of destruction, the loss of life and the fostering of a barbarous spirit, we are appalled at the inestimable loss to mankind which the existence of these deplorable conditions must involve. What can we do to combat best this great evil?

毫无疑问，在所有的摩擦性阻力中，最能阻碍人类前进的是无知。智慧的佛陀说“无知（无明）是世界上最

大的邪恶”不是没有道理的。摩擦是由无知产生，由于众多的语言和民族而大大地增加，只可以通过传播知识和统一不同种类的人类元素而减少，再也没有其它更好的办法。然而，无知也许在过去是阻碍人类的前进。当然，到了今天，负面的力量已经变得更加重要。在这些当中，有一个比其它任何的重要的多。它被称为有组织战争。当我们想到了无数的人，通常在头脑和身体方面都很能干，是人性绽放的花朵，被迫去过一种惰性而无益的生活，每天需要用大量的钱来维持军队和战争设备，表现为如此大的人类能量，所有的努力，都花在无用的武器生产和毁灭工具上，牺牲大量的生命，滋养出一种残暴的精神，我们对这些可叹情形陷入的无法估计的人类损失感到胆寒。我们怎样做才能够更好地克服这种极大的邪恶呢？

Law and order absolutely require the maintenance of organized force. No community can exist and prosper without rigid discipline. Every country must be able to defend itself, should the necessity arise. The conditions of to-day are not the result of yesterday, and a radical change cannot be effected to-morrow. If the nations would at once disarm, it is more than likely that a state of things worse than war itself would follow. Universal peace is a beautiful dream, but not at once realizable. We have seen recently that even the nobel effort of the man invested with the greatest worldly power has been virtually without effect. And no wonder, for the establishment of universal peace is, for the time being, a physical impossibility. War is a negative force, and cannot be turned in a positive direction without passing through, the intermediate phases. It is a problem of making a wheel, rotating one way, turn in the opposite direction without slowing it down, stopping it, and speeding it up again the other way.

要维系有组织的力量，法律和秩序必不可少。没有了严格的纪律，没有社会能够存在和繁荣。每一个国家都必须能够有一些必要的自我防卫。今天的状况不是昨天的结果，激进的变革无法有效地影响明天。如果国家立即解除武装，那么更加可能的是，一种比战争更糟糕的状态会随之而来。世界的和平是一种美丽的梦想，但不是立即实现。我们最近已经看到，即使是世界最强大的国家投入宝贵的努力，最终事实上是没有成效。这也不足为奇，因为世界和平的建立，是暂时性的，物理上是不可能的。战争是一种负面的力量，不经历过中间状态，是无法转变成正面力量的。这个问题好比是让一个轮子沿着一个方向滚动，无需把它减速，或者让它停下来而转到了另一个方向，然后在另一个方向再次地加速。

It has been argued that the perfection of guns of great destructive power will stop warfare. So I myself thought for a long time, but now I believe this to be a profound mistake. Such developments will greatly modify, but not arrest it. On the contrary, I think that every new arm that is invented, every new departure that is made in this direction, merely invites new talent and skill, engages new effort, offers new incentive, and so only gives a fresh impetus to further development. Think of the discovery of gun-powder. Can we conceive of any more radical departure than was effected by this innovation? Let us imagine ourselves living in that period: would we not have thought then that warfare was at an end, when the armor of the knight became an object of ridicule, when bodily strength and skill, meaning so much before, became of comparatively little value? Yet gunpowder did not stop warfare: quite the opposite•it acted as a most powerful incentive. Nor do I believe that warfare can ever be arrested by any scientific or ideal development, so long as similar conditions to those prevailing now exist, because war has itself become a science, and because war involves some of the most sacred sentiments of which man is capable. In fact, it is doubtful whether men who would not be ready to fight for a high principle would be good for anything at all. It is not the mind which makes man, nor is it the body; it is mind and body. Our virtues and our failings are inseparable, like force and matter. When they separate, man is no more.

有人一直在争论，枪炮的强大破坏力会完美地结束战争。所以我自己考虑了很长时间，但现在我相信这是一个深刻的错误。这样的发展会是大大地改变了它，而不是阻止它。相反地，我认为每发明一种新的武器，每一种新的旅程就会以这个方向来展开，仅是激起了新的才干和技能，忙碌于新的努力，构想新的动机，这样只会给进一步的发展给予了一种新的推动力。想一想火药的发明。我们能够想象比这种创新的影响力

更激进的开启旅程吗？让我们来想象自己是生活在那个时期：当武士的盔甲变成了受奚落的对象的时候；当体力和技能，意味着成为过去，变成相对较少价值的时候，我们可否想到战争即将会结束？火药依然没有停止战争：十分相反，它变成了一种最有力的动机。我也不相信任何的科学或思想的发展会制止战争，只要占优势的类似条件还存在，战争就会出现；因为战争本身已经成为了一种科学，也因为战争笼罩着人类某些最神圣的情感。事实上，人类准备去为某种崇高的法则而斗争是否有好处，是值得怀疑的。既不是思想，也不是身体组成了人类；而是思想和身体共同组成了人类。我们的美德和我们的过失是密不可分的，就像力量和物质一样。当它们分离的时候，人就不复存在了。

Another argument, which carries considerable force, is frequently made, namely, that war must soon become impossible be cause the means of defense are outstripping the means of attack. This is only in accordance with a fundamental law which may be expressed by the statement that it is easier to destroy than to build. This law defines human capacities and human conditions. Were these such that it would be easier build than to destroy, man would go on unresisted, creating and accumulating without limit. Such conditions are not of this earth. A being which could do this would not be a man: it might be a god. Defense will always have the advantage over attack, but this alone, it seems to me, can never stop war. By the use of new principles of defense we can render harbors impregnable against attack, but we cannot by such means prevent two warships meeting in battle on the high sea. And then, if we follow this idea to its ultimate development, we are led to the conclusion that it would be better for mankind if attack and defense were just oppositely related; for if every country, even the smallest, could surround itself with a wall absolutely impenetrable, and could defy the rest of the world, a state of things would surely be brought on which would be extremely unfavorable to human progress. It is by abolishing all the barriers which separate nations and countries that civilization is best furthered.
另一个争论就是，携带相当的力量，通常是制造出来的，那样战争很快就不可能发生，因为过量的防卫就意味着进攻。那只是与陈述的一个基本法则相一致，那就是毁坏比建设更容易。这个法则明确定义了人类能力和人类状况。当满足这些条件的时候，会是建设比毁坏更容易，人类继续是自由的，持续地创造和累加而不受限制。这样的条件并不在这个地球上。一种生命也许会这样做，但不会是人，也许是神。防卫通常胜于进攻，但这个是例外，在我看来，不能够停止战争。通过使用新的防卫法则，我们可以建造坚不可摧的港口，使之无法攻取，但我们无法用这样的手段来阻止两艘船在公海上相遇而发生战争。于是，如果我们按照这种想法去发展，会导致这样的结局，那就是如果进攻和防守只是两个相对的对立面，那么人性胜于战争，因为每一个国家，即使是最小的国家，都可以用一堵绝对坚不可摧的墙来把自己包围着，并且可以公然藐视世界上的其它国家，那么无疑会产生这样一种情形，极为不利于人类进步。只有把分离国家与国家、民族与民族的屏障废除，文明社会才会更进一步发展。

Again, it is contended by some that the advent of the flying-machine must bring on universal peace. This, too, I believe to be an entirely erroneous view. The flying-machine is certainly coming, and very soon, but the conditions will remain the same as before. In fact, I see no reason why a ruling power, like Great Britain, might not govern the air as well as the sea. Without wishing to put myself on record as a prophet, I do not hesitate to say that the next years will see the establishment of an "air-power," and its center may be not far from New York. But, for all that, men will fight on merrily.
另外，还有一些人主张，飞行器的发展必定会带来宇宙和平。 我相信这也是一个完全错误的观点。飞行器当然很快会出现，但情形仍然和以前的一样。事实上，我看不到有什么理由要让一种统治力量，比如是大英帝国，既要支配空中，也要支配海洋。我不希望有人把我视为先知而把我记起来，但我毫不犹豫地说，在随后的几年会看到一种“空军力量”的建立，它的中心也许离纽约市不远。但是，尽管如此，人类还是会尽情地战争。

The ideal development of the war principle would ultimately lead to the transformation of the whole energy of war into purely potential, explosive energy, like that of an electrical condenser. In this form the war-energy could be maintained without effort; it would need to be much smaller in amount, while incomparably more effective.
发展战争法则的想法最终会导致战争的能量转变成纯粹潜在的、爆炸性的能量，就像一个电容一样。在这种形式下，可以毫不努力地维持着战争的能量；它需要变得更加小规模，同时也变得更为有效。

As regards the security of a country against foreign invasion, it is interesting to note that it depends only on the relative, and not the absolute, number of the individuals or magnitude of the forces, and that, if every country should reduce the war-force in the same ratio, the security would remain unaltered. An international agreement with the object of reducing to a minimum the war-force which, in view of the present still imperfect education of the masses, is absolutely indispensable, would, therefore, seem to be the first rational step to take toward diminishing the force retarding human movement.
至于保卫国家完全免受外国入侵，有趣的是要注意，它只取决于相对，而不是绝对，而且还取决于军队的人数或量级。
如果每个国家都以同等的比例来削减战斗力量，安全性的考虑仍然是不变的。一份国际裁军协议，在现时对质 / 能的不完善认识下，是绝对地不可缺少的，因此，阻碍人类进展，逐步裁减军队似乎是合理的第一步。

Fortunately, the existing conditions cannot continue indefinitely, for a new element is beginning to assert itself. A change for the better is eminent, and I shall now endeavor to show what, according to my ideas, will be the first advance toward the establishment of peaceful relations between nations, and by what means it will eventually be accomplished.
幸运的是，现存的情况不会是持续地无法确定，因为一种新的因素开始在浮现。一种有利的变化在显赫发生，现在我要尽力地向大家展示这种变化。根据我的想法，它会是国与国之间建立和平关系的第一步，无论怎么样，它最终将会完成。

Let us go back to the early beginning, when the law of the stronger was the only law. The light of reason was not yet kindled, and the weak was entirely at the mercy of the strong. The weak individual then began to learn how to defend himself. He made use of a club, stone, spear, sling, or bow and arrow, and in the course of time, instead of physical strength, intelligence became the chief deciding factor in the battle. The wild character was gradually softened by the awakening of noble sentiments, and so, imperceptibly, after ages of continued progress, we have come from the brutal fight of the unreasoning animal to what we call the "civilized warfare" of to-day, in which the combatants shake hands, talk in a friendly way, and smoke cigars in the entr'actes, ready to engage again in deadly conflict at a signal. Let pessimists say what they like, here is an absolute evidence of great and gratifying advance.

让我们回到较早时说过的，无论什么时候，更强大的法律也只不过是法律。理性之光并没有点燃，弱者完全受强者支配。然后弱者开始学习如何保护自己。他会利用棍棒、石头、弹弓，或者弓和箭来防卫，随着时间的推移，他会发现是智力，而不是体力，成为了战斗中的决定性因素。这种野蛮的特性渐渐地被唤起的高尚情操软化了，于是，不知不觉间，在经历了几个时代的进步后，我们从盲目冲动的动物间的残忍格斗变成了今天称为的“文明战争”。在这种战争中，战士们握着手，友好地交谈，在休战期间抽着雪茄，在一声令下，又准备下一轮的垂死搏斗。让悲观主义者们去说他们爱说的吧，这是伟大而又悦人的进步的绝

对证据。

But now, what is the next phase in this evolution? Not peace as yet, by any means. The next change which should naturally follow from modern developments should be the continuous diminution of the number of individuals engaged in battle. The apparatus will be one of specifically great power, but only a few individuals will be required to operate it. This evolution will bring more and more into prominence a machine or mechanism with the fewest individuals as an element of warfare, and the absolutely unavoidable consequence of this will be the abandonment of large, clumsy, slowly moving, and unmanageable units. Greatest possible speed and maximum rate of energy-delivery by the war apparatus will be the main object. The loss of life will become smaller and smaller, and finally, the number of the individuals continuously diminishing, merely machines will meet in a contest without blood-shed, the nations being simply interested, ambitious spectators. When this happy condition is realized, peace will be assured. But, no matter to what degree of perfection rapid-fire guns, high-power cannon, explosive projectiles, torpedo-boats, or other implements of war may be brought, no matter how destructive they may be made, that condition can never be reached through any such development. All such implements require men for their operation; men are indispensable parts of the machinery. Their object is to kill and to destroy. Their power resides in their capacity for doing evil. So long as men meet in battle, there will be bloodshed. Bloodshed will ever keep up barbarous passion. To break this fierce spirit, a radical departure must be made, an entirely new principle must be introduced, something that never existed before in warfare•a principle which will forcibly, unavoidably, turn the battle into a mere spectacle, a play, a contest without loss of blood. To bring on this result men must be dispensed with: machine must fight machine. But how accomplish that which seems impossible? The answer is simple enough: produce a machine capable of acting as though it were part of a human being•no mere mechanical contrivance, comprising levers, screws, wheels, clutches, and nothing more, but a machine embodying a higher principle, which will enable it to per form its duties as though it had intelligence, experience, judgment, a mind! This conclusion is the result of my thoughts and observations which have extended through virtually my whole life, and I shall now briefly describe how I came to accomplish that which at first seemed an unrealizable dream.

可是现在，这种进展的下一步会是什么呢？无论用什么办法，都依然没有和平。自然地，从现代世界发展出来的接下来下一个变化应该是通过战争来持续减少人口数目。器械会是其中一种特别的强大力量，但只有少数的人允许去操作它们。这种发展会越来越多地产生一种用最少的人操纵的机器或机械装置，成为了战争的一个因素，结果是绝对无可避免地放弃庞大、笨拙和运作缓慢，以及难以管理的单元。最大可能地加快和加大能量的效率——主要是通过战争器械来表现出来，仅仅是机器的竞赛而不流血。失去生命的人越来越年轻，最后，个体的数目会不断地缩小，国家之间会变得只是对竞赛有兴趣，并且完全投入。一旦意识到这种幸福的条件，和平会是确定的。但是，不管是何种程度的速射手枪、高能大炮、爆炸性射弹、鱼雷艇，还是其它的战争武器，不管它们的破坏力有多大，都无法通过这样的发展来达到那种幸福状态。所有这些工具都要求人类去操作；人是机器中不可缺少的部分。他们的目标就是去杀戮和摧毁。他们把力量驻留在邪恶的事上。只要人类遇上了战争，那么将会是流血的。血不断地维系着野蛮的欲望。要打破这种残暴的精神，一种激进的旅程必须被展开，一种全新的法则必须被引入，那是某些在战争发生之前从未有过的东西。一种强制的、不得已的法则，把战争变成仅是一种观览物、一场戏、一场竞赛而不流血。要带来这种结果，人必须被省却：机器必须与机器作战。但是，如何去完成这件似乎是不可能的事？答案很简单：制造一种能够承担思考角色的机器，仿佛它就是人类的一部分，而不仅仅是发明出来的机器，由控制杆、螺丝钉、离合器和其它无关紧要的东西组成，而是一部包含更高法则的机器，能够承担各种各样的任务，就像是拥有智力、经验、判断力和头脑一样！这个结论是我的思考和观察的结果，事实上已经透过我的整个生命来延伸。现在我会简单地描述一下如何去完成这个看上去是不真实的梦想。

A long time ago, when I was a boy, I was afflicted with a singular trouble, which seems to have been due to an extraordinary excitability of the retina. It was the appearance of images which, by their persistence, marred the vision of real objects and interfered with thought. When a word was said to me, the image of the object which it designated would appear vividly before my eyes, and many times it was impossible for me to tell whether the object I saw was real or not. This caused me great discomfort and anxiety, and I tried hard to free myself of the spell. But for a long time I tried in vain, and it was not, as I clearly recollect, until I was about twelve years old that I succeeded for the first time, by an effort of the will, in banishing an image which presented itself. My happiness will never be as complete as it was then, but, unfortunately (as I thought at that time), the old trouble returned, and with it my anxiety. Here it was that the observations to which I refer began. I noted, namely, that whenever the image of an object appeared before my eyes I had seen something that reminded me of it. In the first instances I thought this to be purely accidental, but soon I convinced myself that it was not so. A visual impression, consciously or unconsciously received, invariably preceded the appearance of the image. Gradually the desire arose in me to find out, every time, what caused the images to appear, and the satisfaction of this desire soon became a necessity. The next observation I made was that, just as these images followed as a result of something I had seen, so also the thoughts which I conceived were suggested in like manner. Again, I experienced the same desire to locate the image which caused the thought, and this search for the original visual impression soon grew to be a second nature. Mt mind became automatic, as it were, and in the course of years of continued, almost unconscious performance, I acquired the ability of locating every time and, as a rule, instantly the visual impression which started the thought. Nor is this all. It was not long before I was aware that also all my movements were prompted in the same way, and so, searching, observing, and verifying continuously, year by year, I have, by every thought and every act of mine, demonstrated, and do so daily, to my absolute satisfaction, that I am an automaton endowed with power of movement, which merely responds to external stimuli beating upon my sense organs, and thinks and acts and moves accordingly. I remember only one or two cases in all my life in which I was unable to locate the first impression which prompted a movement or a thought, or even a dream.

很久以前，当我还是一个小孩的时候，我受到一种烦恼困扰，似乎是由于视网膜的过度兴奋而产生的。这些图像持续地出现，破坏了正常的视觉，扰乱了思想。当有人告诉我一个词的时候，这个物体的影像会生动地出现在我的眼前，很多时候我都不能确定我看到的这个图像是真还是假，因为我能够清晰地记起来，直到我大约在十二岁的时候，第一次通过意志力来成功地消除出现的图像。从那时候起，我感到一种从来没有得到过的幸福，可是，不幸的是（我想是从那时候起），旧有的烦恼又出现了，还夹杂着我的焦虑。现在我开始把我的观察说出来。我注意到，只要一个物体的图像出现在我的眼前，我就看见一些东西，它不断地使我回想。起初，我想这纯粹是意外，但很快我确信它并非如此。一个视觉印象，有意识或无意识地被获取，总是先于图像而出现。渐渐地，这唤起了我寻找的欲望，每一次，不管是什么原因引起图像的出现，对这种欲望的满足很快变成一种需要。下一次我观察发现，这些图像的出现是伴随着我看到的某些东西的结果而来，那样我持有的种种想法也以这种方式来暗示。另外，我同样经历过搜查引发思想的图像的欲望，这种对最初视觉印象的搜查很快变成了一种习性。我的头脑好像变成自动机器一样，随着年龄的增长，几乎变成了一种无意识的性能。我获得了搜查每个时间的能力，通常，一开始思考，就立郎是成为了一种视觉印象。也不完全如此。在不久以前，我也意识到我自己很迅速地向同一方向运动，因此，我一年又一年不断地搜索、观察和校验自己的每一种思想和每一种行动。那样，我是一台自动机器，被赋予了运动的力量，只不过是外部的刺激敲响了我的感觉器官，思想和行动也因此而活动，每天都在这样演示，直到我绝对地满足为止。我只记起我整个一生中的一两个情形，那是我能够定位预示一种活动，或一种思想，

甚至一个梦的第一印象的情形。
[See Tesla•Man Out of Time photograph section.]
[见 特斯拉•超越时间 图片部分]

FIG. 2. THE FIRST PRACTICAL TELAUTOMATON. A machine having all the bodily or translatory movements and the operations of the interior mechanism controlled from a distance without wires. The crewless boat shown in the photograph contains its own motive power, propelling and steering machinery, and numerous other accessories, all of which are controlled by transmitting from a distance, without wires, electrical oscillations to a circuit carried by the boat and adjusted to respond only to these oscillations.
图画 2 首个实践组织 一部全身运动或平移运动的机器，内部机械装置的操作者在远处利用无线电来控制机器。图片上展示一艘无人乘坐的船，装有动力装置、推动和操纵机器，还有众多其它的附件，控制者在远处利用发射信号来控制。无线电和电子振荡器形成了一个电路，只需用这些机械就可以调节船的运动。

With these experiences it was only natural that, long ago, I conceived the idea of constructing an automaton which would mechanically represent me, and which would respond, as I do myself, but, of course, in a much more primitive manner, to external influences. Such an automaton evidently had to have motive power, organs for locomotion, directive organs, and one or more sensitive organs so adapted as to be excited by external stimuli. This machine would, I reasoned, perform its movements in the manner of a living being, for it would have all the chief mechanical characteristics or elements of the same. There was still the capacity for growth, propagation, and, above all, the mind which would be wanting to make the model complete. But growth was not necessary in this case, since a machine could be manufactured full grown, so to speak. As to the capacity for propagation, it could likewise be left out of consideration, for in the mechanical model it merely signified a process of manufacture. Whether the automation be of flesh and bone, or of wood and steel, it mattered little, provided it could perform all the duties required of it like an intelligent being. To do so, it had to have an element corresponding to the mind, which would effect the control of all its movements and operations, and cause it to act, in any unforeseen case that might present itself, with knowledge, reason, judgment, and experience. But this element I could easily embody in it by conveying to it my own intelligence, my own understanding. So this invention was evolved, and so a new art came into existence, for which the name "telautomatics" has been suggested, which means the art of controlling the movements and operations of distant automatons. This principle evidently was applicable to any kind of machine that moves on land or in the water or in the air. In applying it practically for the first time, I selected a boat (see Fig. 2).
这些实践只是很普通的。很久以前，我在构想建立一种自动机器的想法，这种机器能够机械地自我表达，还会作出回应，于是我自己动手去做，当然，是以一种更加粗糙的方式来影响着外界。这样一种自动机器显然是有自己的驱动力、运动的元件、引导的元件和一两个感应的元件，在外界的刺激下会作出反应。我推测，这种机器会以一种生命体的方式来转动，因为它会拥有所有机器的主要特征或相同的原理，却依然有生长、繁殖，更重要的是，它应该能够完全模仿大脑。这样，成长不是必要的，因为可以说是人工地让机器完全成长。至于繁殖能力，可以完全不用考虑，因为在机器的模式中，它仅仅是象征一种制造的过程。倘若它能够像智慧生物一样完全各种任务，不管自动机器是有肉和骨头，还是有木头和钢筋，都无关紧要。要实现它，就必须要有一种与大脑相应的原理，可以有效地控制它的运动和运作。但是通过把它输送入我的智慧里，我可以轻易地具体描述这种原理。一旦这种发明得到发展，一种新的技术会出现，我建议取名

为“自动遥控机械学”，意思是远程自动控制运动与操作的技术。这种法则显然是应用在任何类型的机器上，不管是在陆地上，在水上，还是在天空上的。实际上这是第一次应用它，我选择了一艘船（见 图片 2）。
A storage battery placed within it furnished the motive power. The propeller, driven by a motor, represented the locomotive organs. The rudder, controlled by another motor likewise driven by the battery, took the place of the directive organs. As to the sensitive organ, obviously the first thought was to utilize a device responsive to rays of light, like a selenium cell, to represent the human eye. But upon closer inquiry I found that, owing to experimental and other difficulties, no thoroughly satisfactory control of the automaton could be effected by light, radiant heat, hertzian radiations, or by rays in general, that is, disturbances which pass in straight lines through space. One of the reasons was that any obstacle coming between the operator and the distant automaton would place it beyond his control. Another reason was that the sensitive device representing the eye would have to be in a definite position with respect to the distant controlling apparatus, and this necessity would impose great limitations in the control. Still another and very important reason was that, in using rays, it would be difficult, if not impossible, to give to the automaton individual features or characteristics distinguishing it from other machines of this kind. Evidently the automaton should respond only to an individual call, as a person responds to a name. Such considerations led me to conclude that the sensitive device of the machine should correspond to the ear rather than the eye of a human being, for in this case its actions could be controlled irrespective of intervening obstacles, regardless of its position relative to the distant controlling apparatus, and, last, but not least, it would remain deaf and unresponsive, like a faithful servant, to all calls but that of its master. These requirements made it imperative to use, in the control of the automaton, instead of light or other rays, waves or disturbances which propagate in all directions through space, like sound, or which follow a path of least resistance, however curved. I attained the result aimed at by means of an electric circuit placed within the boat, and adjusted, or "tuned," exactly to electrical vibrations of the proper kind transmitted to it from a distant "electrical oscillator." This circuit, in responding, however feebly, to the transmitted vibrations, affected magnets and other contrivances, through the medium of which were controlled the movements of the propeller and rudder, and also the operations of numerous other appliances.
船里放置了蓄电池，用来提供动力。推进器受到发动机的驱动，是代表了动力装置。方向舵，受到另一个发动机控制，同样是以电池为动力，是用来代替指引装置。至于感应装置，显然首先要考虑的是一种能够对光线作出反应的设备，例如是硒光电管，用来代表人的眼睛。但是在更仔细的质询下，我发现由于实验的缘故和其它的困难，受到光和热辐射影响的设备不可能完全满意地控制自动机器。原因之一是操作者和自动机器之间的任何障碍物都可以影响了对它的控制。另一个原因是，对于遥距控制，代表眼睛的感应装置都必须要处于确定的位置，这是必要的，否则会大大地限制了对机器的控制。还有一个，也是非常重要的原因是，很难选用发射的射线。如果可能的话，要给予自动机器个别特征，使它有别于其它同类型的机器。显然，自动机器只会对个别的呼叫作出回应，就像有人叫它的名字，它就回答一样。这样的考虑使我推断出，机器的感应装置应该更加像人的耳朵，而不是人的眼睛。这样，它的行动都可以受到控制而不受干扰，不管干扰物是远还是近。至少它不会变聋或反应迟钝，就像一个忠实的仆人一样，随时听候主人的吩咐。在控制自动机器中，需要的是制造命令，而不是光或其它射线，电磁波或来自四面八方、穿越空间的干扰，例如是声音；或者是沿着一条最少干扰的线走，不管它有多弯曲。我通过调节或“调谐”放置在船上的电子电路来达到效果。正确地说，是通过在远处的“电子振荡器”发送适当的电子振动来达到效果。这种电路，对传送来的振荡波作出回应，然而是微弱的，影响着磁铁和其它的发明物，通过介质来控制导管螺旋桨舵的运动，也可以用来操作无数其它的设备。
By the simple means described the knowledge, experience, judgment•the mind, so to speak•of the distant operator were embodied in that machine, which was thus enabled to move and to perform all its

operations with reason and intelligence. It behaved just like a blindfolded person obeying directions received through the ear.
可以说，这是用简单的工具来描述知识、经验和判断。操作者在远处的操作，都在机器上具体表现出来，因此机器能够移动和用理性和智慧来履行它的所有操作。它的举止就像一个盲人通过耳朵获取信息来辨别方向。

The automatons so far constructed had "borrowed minds," so to speak, as each merely formed part of the distant operator who conveyed to it his intelligent orders; but this art is only in the beginning. I purpose to show that, however impossible it may now seem, an automaton may be contrived which will have its "own mind," and by this I mean that it will be able, independent of any operator, left entirely to itself, to perform, in response to external influences affecting its sensitive organs, a great variety of acts and operations as if it had intelligence. It will be able to follow a course laid out or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do, and of making experiences or, otherwise stated, of recording impressions which will definitely affect its subsequent actions. In fact, I have already conceived such a plan.
迄今为止，自动机器人可以说是一颗“借来的头脑”，因为它的每一个运作都表现了操作者从远处传达的智慧指令；但这种工艺只是个开端。无论现在看上去是多么地不可能，我也打算要展示它。一架人造的自动机器会有它“自己的头脑”，这样我指的是它将来能够不需要任何操作者而完全独立运作，它的元件能够对外界的影响作出回应，履行多种多样的行动和操作，就像它已经拥有了智慧一样。它将能够沿着指定的路线，或者是按照事先给予的指命来行动；它将能够在“是什么”和“不是什么”之间进行辩别，会制造经历，或者是把将会明确影响后继操作的印象记下来。事实上，我已经构想出这样一个计划。
Had I accomplished nothing more than this, I should have made a small advance indeed. But the art I have evolved does not contemplate merely the change of direction of a moving vessel; it affords means of absolutely controlling, in every respect, all the innumerable translatory movements, as well as the operations of all the internal organs, no matter how many, of an individualized automaton. Criticisms to the effect that the control of the automaton could be interfered with were made by people who do not even dream of the wonderful results which can be accomplished by use of electrical vibrations. The world moves slowly, and new truths are difficult to see. Certainly, by the use of this principle, an arm for attack as well as defense may be provided, of a destructiveness all the greater as the principle is applicable to submarine and aerial vessels. There is virtually no restriction as to the amount of explosive it can carry, or as to the distance at which it can strike, and failure is almost impossible. But the force of this new principle does not wholly reside in its destructiveness. Its advent introduces into warfare an element which never existed before•a fighting-machine without men as a means of attack and defense. The continuous development in this direction must ultimately make war a mere contest of machines without men and without loss of life•a condition which would have been impossible without this new departure, and which, in my opinion, must be reached as preliminary to permanent peace. The future will either bear out or disprove these views. My ideas on this subject have been put forth with deep conviction, but in a humble spirit.
我完成的不仅仅是这个，事实上我还应该做小小的改进。但是我改进的这种工艺不仅仅是让一个移动的容器改变；它还提供了绝对控制的工具，在每一方面上，包括所有数不清的平移运动，也包括所有内部零件的运作，不管一个自动化机器里有多少个零件。那些批评自动化机器会受到干扰的人做梦也没有想到，这样令人惊奇的结果可以通过运用电子振荡来完成。世界的运作是缓慢的，新的真理很难看得到。当然，通过运用这种原理，可以制造一种可以进攻，同时又可以防御的武器，如果应用到潜水艇和航天飞机上，破坏性甚至会更大。它携带的炸药事实上是不受限制的，它能够攻击的距离也是不受限制，失败几乎是不

可能的。但是这种新原理制成的武器，并不完全在于它的破坏力。它的进步性，让战争引入一种前所未有的元素，一种无人驾驶的战斗机，用作进攻和防卫。持续不断地向这个方面发展，必定让战争变成一种纯粹的机械竞赛，没有人，也不会有伤亡。没有这个新的开端，这种情形就不可能实现。以我的观点，它必定是达到永久科平的初步阶段。将来要么是证实，要么是反驳这些观点。我深信这一点。我对这个计划的想法是在这种确信下提出，但以一种谦逊的精神来提出。

The establishment of permanent peaceful relations between nations would most effectively reduce the force retarding the human mass, and would be the best solution of this great human problem. But will the dream of universal peace ever be realized? Let us hope that it will. When all darkness shall be dissipated by the light of science, when all nations shall be merged into one, and patriotism shall be identical with religion, when there shall be one language, one country, one end, then the dream will have become reality.

要让国与国之间达到永久和平，最有效的方法就是让人类走在一起，这会是解决人类这个重大问题的最好办法。

但是，宇宙和平的梦想会实现吗？我们希望它会。当所有的黑暗被科学的光芒驱散的时候，当所有的国家会融为一体的时候，当所有的爱国精神都变成同一种宗教的时候，当只有一种语言、一个国家和一种结局的时候，这个梦想就会成为现实。

THE THIRD PROBLEM: HOW TO INCREASE THE FORCE ACCELERATING THE HUMAN MASS•THE HARNESSING OF THE SUN'S ENERGY.

第三个问题：如何加快提升人类的质量•太阳能的利用

Of the three possible solutions of the main problem of increasing human energy, this is by far the most important to consider, not only because of its intrinsic significance, but also because of its intimate bearing on all the many elements and conditions which determine the movement of humanity. In order to proceed systematically, it would be necessary for me to dwell on all those considerations which have guided me from the outset in my efforts to arrive at a solution, and which have led me, step by step, to the results I shall now describe. As a preliminary study of the problem an analytical investigation, such as I have made, of the chief forces which determine the onward movement, would be of advantage, particularly in conveying an idea of that hypothetical "velocity" which, as explained in the beginning, is a measure of human energy; but to deal with this specifically here, as I would desire, would lead me far beyond the scope of the present subject. Suffice it to state that the resultant of all these forces is always in the direction of reason, which therefore, determines, at any time, the direction of human movement. This is to say that every effort which is scientifically applied, rational, useful, or practical, must be in the direction in which the mass is moving. The practical, rational man, the observer, the man of business, he who reasons, calculates, or determines in advance, carefully applies his effort so that when coming into effect it will be in the direction of the movement, making it thus most efficient, and in this knowledge and ability lies the secret of his success. Every new fact discovered, every new experience or new element added to our knowledge and entering into the domain of reason, affects the same and, therefore, changes the direction of movement, which, however, must always take place along the resultant of all those efforts which, at that time, we designate as reasonable, that is, self-preserving, useful, profitable, or practical. These efforts concern our daily life, our necessities and comforts, our work and business, and it is these which drive man onward.

在增加人类能量这个主要问题中的这三种可能解决方案，是目前为止的考虑重点，不仅是因为它的内在意义，而且还因为它与决定人类活动的许多因素和条件有着密切关系。为了有系统地继续下去，它在指导我仔细思考从开始努力到得到解决方案的所有需要考虑的事项中，是必不可少的。在初步研究问题的时候，一种对推动向前运动的主要力量的分析性调查，是十分有用的，比如象我做的那样，尤其是在传送一种假定为“速度”的思想中，也就是说，跟开始时解释的一样，是对人类能量的测量；但是在处理这种特定情形的时候，正如我要求的那样，会让我严重偏离现时研究的问题范畴。有足够理由说明，这些力量的得出的结果总是朝着某种思考的方向，所以，它在任何时候，都决定着人类运动的方向。这就是说，每一种科学的运用、推理、应用，或者是实践，都必须是朝着总体上移动的方向。有实践经验的人，理性思考的人，观察者和商人，只要事先经过仔细推理、计算或测定，在开始实施的时候，都总会朝着运动的方向前进，因而变得最有效率。这种知识和能力之下隐藏的是他成功的秘密。每一个新实相的发现，每一种新的经验或新的元素都会被加进我们的知识里，进入了理性的领域，因此，它对于改变运动的方向而言，其影响力是相同的。这些结果都随着所有的努力而来。然而，这都被我们指定为合理的，那就是，自我的保存、利用、获利或实践。这些努力涉及到我们的日常生活，我们的需求和舒适环境，我们的工作和商业，这些都驱动着人类前进。

But looking at all this busy world about us, on all this complex mass as it daily throbs and moves, what is it but an immense clock-work driven by a spring? In the morning, when we rise, we cannot fail to note that all the objects about us are manufactured by machinery: the water we use is lifted by steam-power; the

trains bring our breakfast from distant localities; the elevators in our dwelling and our office building, the cars that carry us there, are all driven by power; in all our daily errands, and in our very life-pursuit, we depend upon it; all the objects we see tell us of it; and when we return to our machine-made dwelling at night, lest we should forget it, all the material comforts of our home, our cheering stove and lamp, remind us of how much we depend on power. And when there is an accidental stoppage of the machinery, when the city is snowbound, or the life sustaining movement otherwise temporarily arrested, we are affrighted to realize how impossible it would be for us to live the life we live without motive power. Motive power means work. To increase the force accelerating human movement means, therefore, to perform more work.

但是，看看我们这个忙碌的世界，所有这些复杂的东西，还有它每日的脉搏和运动，是不是像一个上紧了发条的大钟呢？早上我们起来的时候，我们未能注意到我们周围的所有物体都由机械制造出的：我们用的水是通过蒸汽来蒸馏的；火车从远处的地方为我们运送早餐；还有我们乘坐的电梯和我们建造的办公室，接送我们的汽车，都由动力驱使的，全部出现在我们的日常生活中，也是我们每日生活所追求的，我们所依赖的；我们看到的所有物件都告诉了我们那样的信息；当我们回到那千篇一律的夜间生活的时候，我们享受着家里的舒适生活，享受着家里的炉子和油灯，都时时提醒着我们，我们是多么依赖能量，以免我们会忘记它。当这些机械意外地停止了运作，当城市被雪困住，或者是生活补给品的运输突然间被中断了，我们都惧怕去意识到过着没有动力的生活是多么不可能。动力即意味着工作。因此，加大力量去加快人类的运动就意味着去做更多的工作。

So we find that the three possible solutions of the great problem of increasing human energy are answered by the three words: food, peace, work. Many a year I have thought and pondered, lost myself in speculations and theories, considering man as a mass moved by a force, viewing his inexplicable movement in the light of a mechanical one, and applying the simple principles of mechanics to the analysis of the same until I arrived at these solutions, only to realize that they were taught to me in my early childhood. These three words sound the key-notes of the Christian religion. Their scientific meaning and purpose now clear to me: food to increase the mass, peace to diminish the retarding force, and work to increase the force accelerating human movement. These are the only three solutions which are possible of that great problem, and all of them have one object, one end, namely, to increase human energy. When we recognize this, we cannot help wondering how profoundly wise and scientific and how immensely practical the Christian religion is, and in what a marked contrast it stands in this respect to other religions. It is unmistakably the result of practical experiment and scientific observation which have extended through the ages, while other religions seem to be the outcome of merely abstract reasoning. Work, untiring effort, useful and accumulative, with periods of rest and recuperation aiming at higher efficiency, is its chief and ever-recurring command. Thus we are inspired both by Christianity and Science to do our utmost toward increasing the performance of mankind. This most important of human problems I shall now specifically consider.

所以我们发现，增加人类能量这个重大问题的三个可能的解决方案都可以用三个字来回答：食物、和平、工作。很多年以来，我一直在思考和寻找，在思索和理论中迷惑了自己，认为人是被一股力量驱使的一团物质，在一束机械似的光里看着自己那无法说清的运动，并且应用简单的机械法则去分析相同的事物，直到我得到这些解答，没想到在我年幼的时候，大人们就已经教会了我。这三个词听起来就像是基督宗教的三个关键词。它们的科学含义和目的现在清晰地在我眼前：食物是提升质量，和平是减少减速力，还有工作是提升加快人类运动的力量。这些是那个大问题的三种唯一可能解决的方法，它们都有一个对象、一个结果，也就是，提升人类的能量。当我们认识到这一点，我们就不禁对基督宗教拥有多么深奥的智慧和科学性，多么广泛地具有可实践性而感到惊讶，它在这一方面与其它宗教形成鲜明的对照，而其它宗教似乎

都仅仅是通过抽象的推理来得出结果。不知疲倦地努力工作是有益的，主要是为了能量的积累和不断重现地支配能量，周期性地休息和恢复是为了更高的效率。因此，我们既从基督教上，也从科学上获得灵感，最大限度地利用那日渐递增的人类性能。现在我应该特别地考虑人类这个最重要的问题。

THE SOURCE OF HUMAN ENERGY•THE THREE WAYS OF DRAWING ENERGY FROM THE SUN.
人类能源的来源•提取太阳能的三种方式

First let us ask: Whence comes all the motive power? What is the spring that drives all? We see the ocean rise and fall, the rivers flow, the wind, rain, hail, and snow beat on our windows, the trains and steamers come and go; we here the rattling noise of carriages, the voices from the street; we feel, smell, and taste; and we think of all this. And all this movement, from the surging of the mighty ocean to that subtle movement concerned in our thought, has but one common cause. All this energy emanates from one single center, one single source•the sun. The sun is the spring that drives all. The sun maintains all human life and supplies all human energy. Another answer we have now found to the above great question: To increase the force accelerating human movement means to turn to the uses of man more of the sun's energy. We honor and revere those great men of bygone times whose names are linked with immortal achievements, who have proved themselves benefactors of humanity•the religious reformer with his wise maxims of life, the philosopher with his deep truths, the mathematician with his formul•, the physicist with his laws, the discover with his principles and secrets wrested from nature, the artist with his forms of the beautiful; but who honors him, the greatest of all,•who can tell the name of him,•who first turned to use the sun's energy to save the effort of a weak fellow-creature? That was man's first act of scientific philanthropy, and its consequences have been incalculable.

首先我们来问：所有的动力是从何而来？一切动力的源头是什么？我们看见海水的涨退，河水的流动，风、雨、冰雹和雪像波浪似地扑向我们的窗户，火车和汽船在来来往往；车厢里的吵杂声，还有从大街而来的声音；我们摸到的、闻到的和尝到的；我们考虑的所有这一切。所有的运动，从波涛汹涌的海浪冲击到周旋在我们的思想周期的微妙运动，都只有一种共同的源头。所有的能量都从一个单一的中心散发出去。那个单一的源头就是太阳。太阳是推动一切的源头。太阳维持所有人的生命，向所有人提供能量。我们发现上述主要问题的另一个答案是：提升能量，加快人类运动即意味着让人类更多地利用太阳能。我们对过去这些伟大的人表示敬意，他们的名字与不朽的功绩连在一起，被证明是人类的恩人。宗教改革家有他智慧的人生格言，哲学家有他深渊的真理，数学家有他的公式，物理学家有他的定律，发现者也有他费力地从大自然取得的原理和奥秘，艺术家有他美丽的作品；可是谁会荣耀他，一切中的至伟大者；谁能说出他的名字，谁首先会利用太阳的能量来把一个虚弱的人的努力成果保存起来？那是人类的首个科学性的慈善举动，它的一系列后果无法计算得出来。

From the very beginning three ways of drawing energy from the sun were open to man. The savage, when he warmed his frozen limbs at a fire kindled in some way, availed himself of the energy of the sun stored in the burning material. When he carried a bundle of branches to his cave and burned them there, he made use of the sun's stored energy transported from one to another locality. When he set sail to his canoe, he utilized the energy of the sun applied to the atmosphere or the ambient medium. There can be no doubt that the first is the oldest way. A fire, found accidentally, taught the savage to appreciate its beneficial heat. He then very likely conceived of the idea of carrying the glowing members to his abode. Finally he learned to use the force of a swift current of water or air. It is characteristic of modern development that progress has been effected in the same order. The utilization of the energy stored in

wood or coal, or, generally speaking,
fuel, led to the steam-engine. Next a great stride in advance was made in energy-transportation by the use of electricity, which permitted the transfer of energy from one locality to another without transporting the material. But as to the utilization of the energy of the ambient medium, no radical step forward has as yet been made known.
从一开始的时候，太阳的能量以三种方式来向人类敞开。原始人以某种方式在火堆下取暖的时候，能够通过燃烧的材料把太阳的能量贮存到自己身上。当他把一大堆柴带到洞穴，然后把它们点燃的时候，他是在利用太阳的贮存能量，从一个地方传到另一个地方去。当他扬起独木舟起航的时候，他是利用太阳的能量，把它运用在大气层或环境介质上。毫无疑问，首先出现的是最古老的方式。火偶尔地被发现，教会了原始人运用火来得到热量。然后他很可能会构想着如何去把炽热的火搬到他的住处。最后他学会了利用水或空气急速流动的力量。现代化发展的过程也同样具有这样的次序。一般来说，是利用贮存在木头或煤炭里的能量，或者说是燃料的利用，导致了蒸汽机的出现。下一个向前迈进的更大步伐，就是通过利用电流来进行能量传输，不需要输送的材料而把能量从一个地方传到另一个地方。但是，对于环境介质的能量运用，现在仍旧还没有更有效的办法。

The ultimate results of development in these three directions are: first, the burning of coal by a cold process in a battery; second, the efficient utilization of the energy of the ambient medium; and, third the transmission without wires of electrical energy to any distance. In whatever way these results may be arrived at, their practical application will necessarily involve an extensive use of iron, and this invaluable metal will undoubtedly be an essential element in the further development along these three lines. If we succeed in burning coal by a cold process and thus obtain electrical energy in an efficient and inexpensive manner, we shall require in many practical uses of this energy electric motors•that is, iron. If we are successful in deriving energy from the ambient medium, we shall need, both in the obtainment and utilization of the energy, machinery•again, iron. If we realize the transmission of electrical energy without wires on an industrial scale, we shall be compelled to use extensively electric generators•once more, iron. Whatever we may do, iron will probably be the chief means of accomplishment in the near future, possibly more so than in the past. How long its reign will last is difficult to tell, for even now aluminium is looming up as a threatening competitor. But for the time being, next to providing new resources of energy, it is of the greatest importance to making improvements in the manufacture and utilization of iron. Great advances are possible in these latter directions, which, if brought about, would enormously increase the useful performance of mankind.
这三个方向发展的最终结果是：第一，燃烧的煤炭通过一种冷加工而贮藏在电池里。第二，有效地利用环境介质的能量；第三，是实行无线电力传输，把能量传送到任何距离。不管怎样，这三种方式都可以得到同样结果，它们的实际应用，会无可避免地牵涉到对铁的广泛应用。毫无疑问，铁这种价值无法衡量的金属在朝这三个方向的更进一步发展中是必要的元素。如果我们能够成功地燃烧经过冷加工的煤，从而更便宜、更有效地获取电能，我们就需要大力地运用这种电动机，也就是铁。如果我们能够成功地从环境介质获取能量，那么我们既在能量的获取上，也在能量的利用上，都需要这种机器，那又是铁。如果我们在生产规模上实现了电力的无线输送，那么我们就要被迫去广泛地使用电力发动机，那也是使用铁。不管我们做什么，铁在不久的将来很可能完成这些的主要方法，而且比过去更有可能使用铁。很难说铁会在多长时间里占有支配地位，因为尽管是现在，铝还是一个有力的竞争者。但是随着时间的过去，新能源在不断地被运用，改进对铁的加工和利用将是至关重要的。伟大的进步很可能是按照后者的趋势来进行。如果能带来进步的话，那将会是大大提高了人类性能的利用。

GREAT POSSIBILITIES OFFERED BY IRON FOR INCREASING HUMAN PERFORMANCE•ENORMOUS WASTE IN IRON MANUFACTURE.

非常大可能利用铁来增加人的工作效率•铁加工业的巨大浪费

Iron is by far the most important factor in modern progress. It contributes more than any other industrial product to the force accelerating human movement. So general is the use of this metal, and so intimately is it connected with all that concerns our life, that it has become as indispensable to us as the very air we breathe. Its name is synonymous with usefulness. But, however great the influence of iron may be on the present human development, it does not add to the force urging man onward nearly as much as it might. First of all, its manufacture as now carried on is connected with an appalling waste of fuel•that is, waste of energy. Then, again, only a part of all the iron produced is applied for useful purposes. A good part of it goes to create frictional resistances, while still another large part is the means of developing negative forces greatly retarding human movement. Thus the negative force of war is almost wholly represented in iron. It is impossible to estimate with any degree of accuracy the magnitude of this greatest of all retarding forces, but it is certainly very considerable. If the present positive impelling force due to all useful applications of iron be represented by ten, for instance, I should not think it exaggeration to estimate the negative force of war, with due consideration of all its retarding influences and results, at, say, six. On the basis of this estimate the effective impelling force of iron in the positive direction would be measured by the difference of these two numbers, which is four. But if, through the establishment of universal peace, the manufacture of war machinery should cease, and all struggle for supremacy between nations should be turned into healthful, ever active and productive commercial competition, then the positive impelling force due to iron would be measured by the sum of those two, numbers, which is sixteen•that is, this force would have four times its present value. This example is, of course, merely intended to give an idea of the immense increase in the useful performance of mankind which would result from a radical reform of the iron industries supplying the implements of warfare.

到目前为止，铁是现代进步中的最重要因素。它比任何其它工业产品产生更大的力量，加速人类的运动。它的使用是如此普遍，它与我们生活中的关系是如此密切。对于我们来说，它已经变得不可缺少，就跟我们呼吸的空气一样。它的名字与有效性是同义词。但是，不管铁对现时人类发展有多大的影响，它都几乎不可能增加促使人类前进的力量。首先，它的加工，跟现在的一样，是对燃烧的极大浪费。也就是，浪费能量。此外，在产生的铁中，只有一部分是用作有用的目的。质量较好的部分会产生摩擦性的阻力，而其它大部分都是要来发展负面力量，大大地阻碍了人类运动。因此，战争的负面力量几乎完整地表现在铁上。用任何的精确度去估计所有的负面力量最大有多少是不可能的，但它确实是非常值得考虑的。例如，在对铁的充分利用下，产生出的当前正面推动力是用“十”来代表的话，由于充分地考虑所有的负面影响和结果，也就是“六”，那么我不认为对战争等的负面力量的估计是夸大的。基于此，铁带来的正向推动力可以用“十”和“六”这两个数字相减来估算，也就是“四”。但是，如果要建立宇宙和平的法则，战争机器的制造应该停止，国与国之间为了争取至高地位的努力也要转化成良性的、积极的和多产的商业竞争，然后是由铁带来的正面推动力会是等于“十”和“六”这两个数字的总和，也就是“十六”。那就是说，这种力量会是现有价值的四倍。当然，这个例子仅是意在表述大力地提升人性有用价值这种想法，是由对制造战争工具的铁工业激进改革而产生。

A similar inestimable advantage in the saving of energy available to man would be secured by obviating the great waste of coal which is inseparably connected with the present methods of manufacturing iron. In some countries, such as Great Britain, the hurtful effects of this squandering of fuel are beginning to be

felt. The price of coal is constantly rising, and the poor are made to suffer more and more. Though we are still far from the dreaded "exhaustion of the coalfields," philanthropy commands us to invent novel methods of manufacturing iron, which will not involve such barbarous waste of this valuable material from which we derive at present most of our energy. It is our duty to coming generations to leave this store of energy intact for them, or at least not to touch it until we shall have perfected processes for burning coal more efficiently. Those who are coming after us will need fuel more than we do. We should be able to manufacture the iron we require by using the sun's energy, without wasting any coal at all. As an effort to this end the idea of smelting iron ores by electric currents obtained from the energy of falling water has naturally suggested itself to many. I have myself spent much time in endeavoring to evolve such a practical process, which would enable iron to be manufactured at small cost. After a prolonged investigation of the subject, finding that it was unprofitable to use the currents generated directly for smelting the ore, I devised a method which is far more economical.

贮存能量，确保人类拥有足够的能量，避免大量浪费煤炭，与现时的铁加工方法具有不可分割的关系。类似的价值也是无法估计的。在一些国家，例如是英国，开始感受到大量浪费煤的恶果。煤的价格在不断上升，穷人在忍受越来越多的痛苦。尽管我们还远远未达到“煤田枯竭”的恐惧，慈善事业命令我们去发明新颖的铁加工方法，不会牵涉到对现时大多数能源的巨大浪费。我们的责任是要把这种能源贮存起来，留给下一代，或者至少是不要碰它们，直到我们拥有更加有效的煤炭处理方法。紧跟着我们的下一代会比我们需要更多的煤。我们需要利用太阳能来加工铁，而不需要浪费任何的煤。这样的努力结果是，通过瀑布的水来获取电流，再用电流来把铁矿熔炼的想法不断地浮现在脑海里。我已经花了大量的时间去致力于发展这样一种实用的加工过程，能够以最低的成本来制造出铁。经过了长期调查以后，发现利用电流来直接地熔炼铁矿是无利可图的。我建议采用另一种更加经济的方法。

ECONOMICAL PRODUCTION OF IRON BY A NEW PROCESS.

铁的经济生产的新过程

The industrial project, as I worked it out six years ago, contemplated the employment of the electric currents derived from the energy of a waterfall, not directly for smelting the ore, but for decomposing water for a preliminary step. To lessen the cost of the plant, I proposed to generate the currents in exceptionally cheap and simple dynamos, which I designed for this sole purpose. The hydrogen liberated in the electrolytic decomposition was to be burned or recombined with oxygen, not with that from which it was separated, but with that of the atmosphere. Thus very nearly the total electrical energy used up in the decomposition of the water would be recovered in the form of heat resulting from the recombination of the hydrogen. This heat was to be applied to the smelting of ore. The oxygen gained as a by-product of the decomposition of the water I intended to use for certain other industrial purposes, which would probably yield good financial returns, inasmuch as this is the cheapest way of obtaining this gas in large quantities. In any event, it could be employed to burn all kinds of refuse, cheap hydrocarbon, or coal of the most inferior quality which could not be burned in air or be otherwise utilized to advantage, and thus again a considerable amount of heat would be made available for the smelting of the ore. To increase the economy of the process I contemplated, furthermore, using an arrangement such that the hot metal and the products of combustion, coming out of the furnace, would give up their heat upon the cold ore going into the furnace, so that comparatively little of the heat energy would be lost in the smelting. I calculated that probably forty thousand pounds of iron could be produced per horse-power per annum by this method. Liberal allowances were made for those losses which are unavoidable, the above quantity being about half of that theoretically obtainable. Relying on this estimate and on practical data with reference to

a certain kind of sand ore existing in abundance in the region of the Great Lakes, including cost of transportation and labor, I found that in some localities iron could be manufactured in this manner cheaper than by any of the adopted methods. This result would be obtained all the more surely if the oxygen obtained from the water, instead of being used for smelting of ore,

这个工业项目的设计，就像我在六年前构思的一样，是利用源自瀑布能量而来的电流，但不是直接地用来熔炼铁矿，是根据预设的步骤把水分解。为了减少计划的成本，我建议使用异常便宜和简单的发电机来产生电流。这是我为了这个唯一目的而设计的。电分解分离出氢气，用作燃烧，或者是与氧气结合。它不是和分离的氧气结合，而是和大气层的氢气结合。因此，由于发电而几乎用光的水，可以通过跟氢气的再度结合而重新获得。产生出来的热量可以用来熔炼铁矿。我打算把从水分解出来的氧气用作其它的工业用途，由于这是用最便宜的方法来大量获取这种气体，因此很可能会产生很好的财政收益。无论如何，通过燃烧各种各样的废物、廉价的碳氢化合物、或者是在空气中烧不着的最劣质的煤，否则是充分利用有利条件，获得相当可观的热量，能够使铁矿熔解。此外，为了提高其加工过程的经济效益，我作出了这样的安排，利用烧热的金属以及由炉子产生的、燃烧而来的产物，把它们的热传到冰冷的铁矿，使它们燃烧起来，这样在熔炼时丢失的热量会相对地少一些。我计算过，用这种方法，很可能每年每马力的电能够生产出四万磅的铁。用慷慨的补助来填补损失是无可避免的。从理论上来说，是可以得到上述热量的一半。以北美洲五大湖地区大量存在的某种沙岩（包括运输和劳动费用）为参考，根据这种估计和实际数据，我发现在一些地方，可以用这种方式来生产铁，比用其它任何方式还便宜。

This result would be obtained all the more surely if the oxygen obtained from the water, instead of being used for smelting of ore, as assumed, should be more profitably employed. Any new demand for this gas would secure a higher revenue from the plant, thus cheapening the iron. This project was advanced merely in the interest of industry. Some day, I hope, a beautiful industrial butterfly will come out of the dusty and shriveled chrysalis.

正如所设想的，如果是从水中提取氧气，而不是从熔化的铁矿来提取，那么更加确信会得到这样的结果，也更加获利。

对这种气体的任何新需求，都会从这个计划里面确保更高的收入，从而铁也会降价。对于工业利益来说，这个计划无疑是先进的。我希望有一天，美丽的工业蝴蝶从垃圾和废墟里破茧而出。

The production of iron from sand ores by a process of magnetic separation is highly commendable in principle, since it involves no waste of coal; but the usefulness of this method is largely reduced by the necessity of melting the iron afterward. As to the crushing of iron ore, I would consider it rational only if done by water-power, or by energy otherwise obtained without consumption of fuel. An electrolytic cold process, which would make it possible to extract iron cheaply, and also to mold it into the required forms without any fuel consumption, would, in my opinion, be a very great advance in iron manufacture. In common with some other metals, iron has so far resisted electrolytic treatment, but there can be no doubt that such a cold process will ultimately replace in metallurgy the present crude method of casting, and thus obviating the enormous waste of fuel necessitated by the repeated heating of metal in the foundries.

利用磁力从砂岩中分离出铁矿的计划原则上也是相当值得推广的，因为它不浪费煤；但是使用这种方法，随后是大大地降低了熔铁的必要性。至于把铁矿石碾碎，我认为这是合理的，只是需要用水力，或者是用其它不从煤炭中产生的能源来完成。一种由电解产生的冷加工过程，可以便宜地提取出铁，也可以不需要浪费任何的煤而把铁铸造成需要的各种模型。依我来看，这在铁加工业里是非常先进的。与其它一些金属一样，铁迄今为止是能够强经受得住电解处理的金属，但毫无疑问，这样的冷处理方法最终会取代现时粗糙的铸造方法，在铸造中重复地使用加过热的金属，可以大大地减少对煤的浪费。

Up to a few decades ago the usefulness of iron was based almost wholly on its remarkable mechanical properties, but since the advent of the commercial dynamo and electric motor its value to mankind has been greatly increased by its unique magnetic qualities. As regards the latter, iron has been greatly improved of late. The signal progress began about thirteen years ago, when I discovered that in using soft Bessemer steel instead of wrought iron, as then customary, in an alternating motor, the performance of the machine was doubled. I brought this fact to the attention of Mr. Albert Schmid, to whose untiring efforts and ability is largely due the supremacy of American electrical machinery, and who was then superintendent of an industrial corporation engaged in this field. Following my suggestion, he constructed transformers of steel, and they showed the same marked improvement. The investigation was then systematically continued under Mr. Schmid's guidance, the impurities being gradually eliminated from the "steel" (which was only such in name, for in reality it was pure soft iron), and soon a product resulted which admitted of little further improvement.

直到几十年以前，铁的使用几乎完全是基于它不可思议的力学性质，但自从商用发电机和电动机的出现，由于它独一无二的磁性，它的价值已经大大地被提高。关于后者，铁在近代已经被大大地改进了。标志性的进步大约在十三年前，在我发现贝西默（首创酸性炉钢的英国工程师）在使用软钢，而不是熟铁的时候开始。在当时来看，在交互式发动机中使用软钢，其性能会双倍增加。我不知疲倦的努力，其能力在美国电机界中首屈一指的事实，已经受到了阿尔伯特•斯密特先生的关注，他当时是从事这个领域的工业集团负责人。他依照我的建议，建造了钢铁变压器，它们同样表现出显著的改进。在斯密特先生的指引下，这个调查当时是有系统地进行，杂质渐渐地从“钢铁”（只能这样叫法，事实上是纯净的软铁）中去除，很快就得出结果，承认有少许的改进。

THE COMING OF AGE OF ALUMINIUM•DOOM OF THE COPPER INDUSTRY•THE GREAT CIVILIZING POTENCY OF THE NEW METAL.

铝时代的到来•铜工业的末日•新金属的大开采

With the advances made in iron of late years we have arrived virtually at the limits of improvement. We cannot hope to increase very materially its tensile strength, elasticity, hardness, or malleability, nor can we expect to make it much better as regards its magnetic qualities. More recently a notable gain was secured by the mixture of a small percentage of nickel with the iron, but there is not much room for further advance in this direction. New discoveries may be expected, but they cannot greatly add to the valuable properties of the metal, though they may considerably reduce the cost of manufacture.

The immediate future of iron is assured by its cheapness and its unrivaled mechanical and magneticqualities. These are such that no other product can compete with it now. But there can be no doubt that, at a time not very distant, iron, in many of its now uncontested domains, will have to pass the scepter to another: the coming age will be the age of aluminium. It is only seventy years since this wonderful metal was discovered by Woehler, and the aluminium industry, scarcely forty years old, commands already the attention of the entire world. Such rapid growth has not been recorded in the history of civilization before. Not long ago aluminium was sold at the fanciful price of thirty or forty dollars per pound; to-day it can be had in any desired amount for as many cents. What is more, the time is not far off when this price, too, will be considered fanciful, for great improvements are possible in the methods of its manufacture. Most of the metal is now produced in the electric furnace by a process combining fusion and electrolysis, which offers a number of advantageous features, but involves naturally

a great waste of the electrical energy of the current. My estimates show that the price of aluminium could be considerably reduced by adopting in its manufacture a method similar to that proposed by me for the production of iron. A pound of aluminium requires for fusion only about seventy per cent. of the heat needed for melting a pound of iron, and inasmuch as its weight is only about one third of that of the latter, a volume of aluminium four times thatof iron could be obtained from a given amount of heat-energy. But a cold electrolytic process of manufacture is the ideal solution, and on this I have placed my hope.

尽管近年来铁的冶炼技术取得了进展，可我们实质上只取得了有限的进步。我们不指望能从根本上增加它的抗张强度、弹性、硬度或柔韧性，也不能够期待去把它的磁性变得更强。最近，一个值得注意的发现就是，把少量比例的镍混在铁里面，就会确保获取更多的铁，但这个方向没有太多的发展空间。我们也许在期待着新的发现，但它们不能够大大地增加金属的价值，尽管它们能够相当大地减少制造的费用。铁的价格便宜，又有无可比拟的机械性和磁性，确定了铁在不久将来的价值。现在再也没有其它的产品与之匹敌。但是毫无疑问的是，在不久的将来，铁在很多方面占有的支配地位，将会被另一种金属所取代：铝时代的到来。自从这种奇妙的金属被维勒发现以来，只有七十年的时间。而铝工业也只有短短四十年，但它已经在整个世界上占有了支配地位。如此快速的增长是史无前例。不久以前，每镑的铝在市场的售价是惊人的三十至四十元不等，今天合计只有几元钱。更有甚者，过了不久，这个价格也跌得相当惊人，因为它的制造方法可能会有极大的改进。现在，大多数的金属都是在电炉里通过熔炼和电解而产生，有了许多好处，但很自然地又卷进了对电能的极大浪费。我的估计是，通过采用新的冶炼方法，类似于我提议过的炼铁方法，铝的价格也会大幅度下降。提炼一英磅的铝需要的热量大约只是提炼同等质量的铁的百分之七十，也由于它的重量大约只有后者的三分之一，同等的热能提炼出来的铝是铁的四倍。但是，冷电解的制造过程是理想的解决方法，我对此抱有希望。

The absolutely unavoidable consequence of the advancement of the aluminium industry will be the annihilation of the copper industry. They cannot exist and prosper together, and the latter is doomed beyond any hope of recovery. Even now it is cheaper to convey an electric current through aluminium wires than through copper wires; aluminium castings cost less, and in many domestic and other uses copper has no chance of successfully competing. A further material reduction of the price of aluminium cannot but be fatal to copper. But the progress of the former will not go on unchecked, for, as it ever happens in such cases, the larger industry will absorb the smaller one: the giant copper interests will control the pygmy aluminium interests, and the slow-pacing copper will reduce the lively gait of aluminium. This will only delay, not avoid the impending catastrophe.

铝工业进步中绝对无可避免的过程就是铜工业的灭亡。它们不可能同时存在和兴盛，后者注定没有任何复原的希望。即使是现在，用铝线输送电流比用铜线更加便宜；铝的造价更加便宜，在室内和其它地方使用的铜再也没有机会与铝竞争。材料的改进必然让铝的价钱降低，对铜是致命的打击。但是，前者的发展也不会受到阻碍，因为会有这样的情形，就是大型的产业会吸收小型的产业：铜巨头的利益会控制着铝的利益，步阀缓慢的铜工业会让位于步阀灵活的铝工业。这只是迟早问题，但无可避免会发生。

Aluminium, however, will not stop at downing copper. Before many years have passed it will be engaged in a fierce struggle with iron, and in the latter it will find an adversary not easy to conquer. The issue of the contest will largely depend on whether iron shall be indispensable in electric machinery. This the future alone can decide. The magnetism as exhibited in iron is an isolated phenomenon in nature. What it is that makes this metal behave so radically different from all other materials in this respect has not yet been ascertained, though many theories have been suggested. As regards magnetism, the molecules of the various bodies behave like hollow beams partly filled with a heavy fluid and balanced in the middle in the manner of a see-saw. Evidently some disturbing influence exists in nature which causes each molecule, like such a beam, to tilt either one or the other way. If the molecules are tilted one way, the body is

magnetic; if they are tilted the other way, the body is non-magnetic; but both positions are stable, as they would be in the case of the hollow beam, owing to the rush of the fluid to the lower end. Now, the wonderful thing is that the molecules of all known bodies went one way, while those of iron went the other way. This metal, it would seem, has an origin entirely different from that of the rest of the globe. It is highly improbable that we shall discover some other and cheaper material which will equal or surpass iron in magnetic qualities.

然而，铝工业并不能阻止铜工业的衰落。在很多年以前，它已经卷入了与铜的激烈竞争之中，后来它又发现它的对手不容易被征服。争论的焦点很大程度上是取决于铁在电机里是否不可缺少。只有未来才能够作出决定。铁表现出来的磁性是自然界绝无仅有的现象。这又使得铁完全不同于所有其它金属。尽管很多理论已经暗示过这一点，但是什么原因致使铁这种金属在这一方面与所有其它金属完全不同却还没有确定。至于磁性，各种不同物体的分子结构就像一条空心管，里面充满了巨大的流动性，像秋千那样，中间保持着平衡。很明显地，实际上是存在着一些干扰，使得每一个分子，就像一束电波一样，不是以一个，就是以另一个方向倾斜。如果这种分子是以某一个方向倾斜，物体就带有磁性，如果是以另一个方向倾斜，那么物体就不带磁性；但是两种方向都是稳定的，就像它们在空心管里的情形一样，那是由于流动是从高端急速流向低端的缘故。现在，令人惊讶的是，所有已知物体的分子都是以一个方向倾斜，而铁分子是以另一个方向。似乎是，铁的起源完全不同于地球上所有其它金属。要发现其它更便宜的金属，在磁性这一方面相当于铁，甚至超超于铁，是非常不可能的。

Unless we should make a radical departure in the character of the electric currents employed, iron will be indispensable. Yet the advantages it offers are only apparent. So long as we use feeble magnetic forces it is by far superior to any other material; but if we find ways of producing great magnetic forces, than better results will be obtainable without it. In fact, I have already produced electric transformers in which no iron is employed, and which are capable of performing ten times as much work per pound of weight as those of iron. This result is attained by using electric currents of a very high rate of vibration, produced in novel ways, instead of the ordinary currents now employed in the industries. I have also succeeded in operating electric motors without iron by such rapidly vibrating currents, but the results, so far, have been inferior to those obtained with ordinary motors constructed of iron, although theoretically the former should be capable of performing incomparably more work per unit of weight than the latter. But the seemingly insuperable difficulties which are now in the way may be overcome in the end, and then iron will be done away with, and all electric machinery will be manufactured of aluminium, in all probability, at prices ridiculously low. This would be a severe, if not fatal, blow to iron. In many other branches of industry, as ship-building, or wherever lightness of structure is required, the progress of the new metal will be much quicker. For such uses it is eminently suitable, and is sure to supersede iron sooner or later. It is highly probable that in the course of time we shall be able to give it many of those qualities which make iron so valuable.

除非我们完全不使用电，否则铁将会是不可缺少。它的优势是显然的。只要我们还利用着微弱的磁力，它就远远超越于其它任何金属；但是如果我们找到了产生强磁力的方法，那么最好是不需要铁来获取它。事实上，我已经能够不需要使用铁来制造出变压器，它能够产生出比一磅重的铁多出十倍的功率。这是通过使用一种非常高频的电流，用一种新颖的方式来达到，而不是使用现在工业用的普通电流。我也不需要铁，用这种高频电流来成功地让电动机运作，但产生出来的效果，至今为止也仍然不如用铁做的普遍电动机，尽管从理论上说，前者每一重量单位产生出来的功率远远优越于后者。但是，现在不可克服的困难最终会克服，那样铁会完全地被取代，所有的电机都很可能用铝来制造，价格会迅速降低。这对铁的打击，如果不是致命的话，也是严峻的。在工业的许多其它分支，例如是造船业，轻盈的构造不管怎样都是必需的，新金属的发展将会更加迅速。铁无疑很快地会被铝取代，因为这样的效用会使船变得不寻常地稳定。随着

时间的推移，我们非常有可能看到铁的许多贵重性会让位于铝。

While it is impossible to tell when this industrial revolution will be consummated, there can be no doubt that the future belongs to aluminium, and that in times to come it will be the chief means of increasing human performance. It has in this respect capacities greater by far than those of any other metal. I should estimate its civilizing potency at fully one hundred times that of iron. This estimate, though it may astonish, is not at all exaggerated. First of all, we must remember that there is thirty times as much aluminium as iron in bulk, available for the uses of man. This in itself offers great possibilities. Then, again, the new metal is much more easily workable, which adds to its value. In many of its properties it partakes of the character of a precious metal, which gives it additional worth. Its electric conductivity, which, for a given weight, is greater than that of any other metal, would be alone sufficient to make it one of the most important factors in future human progress. Its extreme lightness makes it far more easy to transport the objects manufactured. By virtue of this property it will revolutionize naval construction, and in facilitating transport and travel it will add enormously to the useful performance of mankind. But its greatest civilizing property will be, I believe, in arial travel, which is sure to be brought about by means of it. Telegraphic instruments will slowly enlighten the barbarian. Electric motors and lamps will do it more quickly, but quicker than anything else the flying-machine will do it. By rendering travel ideally easy it will be the best means for unifying the heterogeneous elements of humanity. As the first step toward this realization we should produce a lighter storage-battery or get more energy from coal.

虽然很难说得清这场工业革命会在何时完成，但毫无疑问的是，将来必定属于铝，铝将会是提升人类性能的主要工具。在这一方面，铝的地位会远远高于目前为止的任何其它金属。我估计它的潜力至少胜过铁的一百倍。这种估计，也许会令人惊讶，但并不是完全夸大。首先的是，我们要记住，在同等重量下，铝的体积比铁大三十倍。这样，它本身就有可能为人类提供更大的使用空间。其次，这种新金属更加容易使用，这无疑又增加了它的价值。从严格意义上，它的很多特性都扮演着一种贵金属的角色，这又添加了它的额外价值。在同等重量下，它的电导性远远大于任何其它金属，这足以令它成为人类未来发展的最重要因素。铝极度轻盈，使得铝制品更加容易运送。由于这种特性，它将使舰艇（船）的建造产生革命，也让船变得容易运送和行进，大大地加大了人类性能的利用。由于铝的这种优越性，我相信，在远程航行中，将会依靠它。电信工具会慢慢地开启着野蛮的文明。电动机和电灯会更快地开启这个步阀，但是飞机比任何其它的都还要快。通过理想地远程航行，使它将会成为统一人类不同种类要素的最佳工具。迈向这种文明的第一步，我们要生产出一种能够打火的畜电池，或者从煤中提取更多能量。

DEVELOPMENT OF A NEW PRINCIPLE•THE ELECTRICAL OSCILLATOR•PRODUCTION OF IMMENSE

一种新原理的发展•电子振荡器•无限的生产力

ELECTRICAL MOVEMENTS•THE EARTH RESPONDS TO MAN•INTERPLANETARY COMMUNICATION NOW PROBABLE.

电子运动•地球对人类的回应•星际间的通讯现在变得可行

I resolved to concentrate my efforts upon this venturesome task, though it involved great sacrifice, for the difficulties to be mastered were such that I could hope to consummate it only after years of labor. It meant delay of other work to which I would have preferred to devote myself, but I gained the conviction that my energies could not be more usefully employed; for I recognized that an efficient apparatus for, the production of powerful electrical oscillations, as was needed for that specific purpose, was the key to the solution of other most important electrical and, in fact, human problems. Not only was communication, to

any distance, without wires possible by its means, but, likewise, the transmission of energy in great amounts, the burning of the atmospheric nitrogen, the production of an efficient illuminant, and many other results of inestimable scientific and industrial value. Finally, however, I had the satisfaction of accomplishing the task undertaken by the use of a new principle, the virtue of which is based on the marvelous properties of the electrical condenser. One of these is that it can discharge or explode its stored energy in an inconceivably short time. Owing to this it is unequaled in explosive violence. The explosion of dynamite is only the breath of a consumptive compared with its discharge. It is the means of producing the strongest current, the highest electrical pressure, the greatest commotion in the medium. Another of its properties, equally valuable, is that its discharge may vibrate at any rate desired up to many millions per second.

我下定决心集中精力去完成这项危险的任务，尽管它涉及到极大的牺牲，由于要控制它极为困难，我希望只花数年的时间就把它 完成。这意味着把我宁可投身于的其它工作耽搁，但我确信我的精力已经不够用了；因为我验证过的高效率设备产生出的强烈电子振动，是解决其它最重要的电学问题，事实上也是人类问题的关键，现在却需要它们来完成那个特殊的目的。利用它，不仅在任何距离实现无线通讯变得可能，而且还类似地，能够传送极大总量的能量，把大气中的氮气燃烧，产生出一种高效的发光体，许多其它成果在科学上和工业上的价值是无法估计的。然而，最后我采用了一种新的原理来满意地完成任务，其优点是基于电容器不可思议的特性。其中之一就是它可以在相当短时间里放出或激发贮存的能量。由于这个属性，它威力无比。与它的放电相比，炸药的爆炸只是小巫见大巫。这意味着它能在介质里产生出最强的电流，最高的电压，最大的暴乱。它的另一个特性，同样是非常有价值，就是无论如何，它放出的电的振动频率至少达到每秒钟数百万次。

[See Nikola Tesla: Colorado Springs Notes, page 324, Photograph III.]
[见 尼古拉•特斯拉：科罗拉多温泉日记，324 页，图 3]

FIG. 6. PHOTOGRAPHIC VIEW OF THE ESSENTIAL PARTS OF THE ELECTRICAL OSCILLATOR USED IN THE EXPERIMENTS DESCRIBED

图片 6 实验中，用照相机的观点来描述电子振荡器的基本部分

I had arrived at the limit of rates obtainable in other ways when the happy idea presented itself to me to resort to the condenser. I arranged such an instrument so as to be charged and discharged alternately in rapid succession through a coil with a few turns of stout wire, forming the primary of a transformer or induction-coil. Each time the condenser was discharged the current would quiver in the primary wire and induce corresponding oscillations in the secondary. Thus a transformer or induction-coil on new principles was evolved, which I have called "the electrical oscillator," partaking of those unique qualities which characterize the condenser, and enabling results to be attained impossible by other means.

Electrical effects of any desired character and of intensities undreamed of before are now easily producible by perfected apparatus of this kind, to which frequent reference has been made, and the essential parts of which are shown in Fig. 6. For certain purposes a strong inductive effect is required; for others the greatest possible suddenness; for others again, an exceptionally high rate of vibration or extreme pressure; while for certain other objects immense electrical movements are necessary. The photographs in Figs. 7, 8, 9, and 10, of experiments performed with such an oscillator, may serve to illustrate some of these features and convey an idea of the magnitude of the effects actually produced. The completeness of the titles of the figures referred to makes a further description of them unnecessary.

其它能够使用的方法都飞快地在我头脑闪过。这时一种愉快的想法出现在我眼前，驱使我决定使用电容器。

我用结实的金属丝绕成一个线圈，形成一个原始的变压器或感应线圈，然后安排使用这样一种器具，它通过这样一个线圈便可以在非常短的瞬间内交替地充电和放电。电容器每次放出的电流都在初级电路里震动，导致相应的二级谐振。从而，一个变压器或感应线圈涉及到一种新原理的发展，我称它为“电子振荡器”，拥有的那些独特性质都表现为电容器的特性，导致了用其它方法无法达到的结果。任何想要得到的电子效应特性和强度，在以前是不可想象的，现在通过完善这种设备便可轻易地产生。图 5 已经展示出经常提到的重要组成部分。为了某些目的，需要一种强烈的感应作用；而对于其它某些目的，极大量的电子运动却是不可缺少。图 7，8，9 和 10 的图片已经展示了这样一种振动器的实验，可以用作阐明其中的一些特性，传达出这样一种思想，即巨大的电子效应事实上已经产生了。图上的题目已经清楚说明，进一步的描述是不必要的。

[See Nikola Tesla: Colorado Springs Notes, page 344, Photograph XVII.]
[见 尼古拉•特斯拉：科罗拉多温泉日记，第 344 页，图 17]
FIG. 7. EXPERIMENT TO ILLUSTRATE AN INDUCTIVE EFFECT OF AN ELECTRICAL OSCILLATOR OF GREAT POWER.
图 7 实验阐明一种极高能量的电子振荡器在起着感应作用（诱导效应）
The photograph shows three ordinary incandescent lamps lighted to full candle-power by currents induced in a local loop consisting of a single wire forming a square of fifty feet each side, which includes the lamps, and which is at a distance of one hundred feet from the primary circuit energized by the oscillator. The loop likewise includes an electrical condenser, and is exactly attuned to the vibrations of the oscillator, which is worked at less than five percent of its total capacity.
上图展示了三个普通的白炽灯在本地回路的感应下被点着了，充分地发光。本地回路由一条线组成，形成了一个边长五十英尺的正方形，在距离被振荡器激活的初级电路一百英尺远的地方。那个回路同样也包括一个电容器在内，准确地调谐到和振荡器的频率协调，在用电量小于电容总容量的百分之五的状态下工作。

[See Nikola Tesla: Colorado Springs Notes, page 335, Photograph XI.]
[见 尼古拉•特斯拉：科罗拉多温泉日记，第 335 页，图 9]

FIG. 8. EXPERIMENT TO ILLUSTRATE THE CAPACITY OF THE OSCILLATOR FOR PRODUCING ELECTRICAL EXPLOSIONS OF GREAT POWER.
图 8 用实验阐明振荡器能够产生能量极大的电子爆破

Note to Fig. 8.•The coil, partly shown in the photograph, creates an alternative
movement of electricity from the earth into a large reservoir and back at a rate of one hundred thousand alternations per second. The adjustments are such that the reservoir is filled full and bursts at each alternation just at the moment when the electrical pressure reaches the maximum. The discharge escapes with a deafening noise, striking an unconnected coil twenty-two feet away, and creating such a commotion of electricity in the earth that sparks an inch long can be drawn from a water main at a distance of three hundred feet from the laboratory.
图 8 的注释：线圈（在图片中显示出其中一部分）创造出一种交替式的电流运动，在每秒中十万次的交换频率下从地面进入一个巨大的蓄水池，然后回到地面。
在这样的调整下，蓄水池被灌满了水，在电压来到最大值的时候，交替地发出爆炸声，放出的电在震耳欲聋的响声中逃离出来，打击着二十二英尺远的一个没有连接的线圈，在地上产生了这样一种电子骚动，一英寸长的火花可以从离实验室三百英尺远的总水管伸展出来。

[See Nikola Tesla: Colorado Springs Notes, page 390, Photograph LXII.]
[见 尼古拉•特斯拉：科罗拉多温泉日记，第 390 页，图片 LXII]

FIG. 9. EXPERIMENT TO ILLUSTRATE THE CAPACITY ON THE OSCILLATOR FOR CREATING A GREAT ELECTRICAL MOVEMENT.
图 9 实验阐明电子振荡器能够产生极大的电子运动

The ball shown in the photograph, covered with a polished metallic coating of twenty square feet of surface, represents a large reservoir of electricity, and the inverted tin pan underneath, with a sharp rim, a big opening through which the electricity can escape before filling the reservoir. The quantity of electricity set in movement is so great that, although most of it escapes through the rim of the pan or opening provided, the ball or reservoir is nevertheless alternately emptied and filled to over-flowing (as is evident from the discharge escaping on the top of the ball) one hundred and fifty thousand times per second.
图中显示的一个球体，二十平方英尺的表面上镀上了一层磨光的金属，代表了一个巨大的电子蓄水池，下面是翻转的锡盘子，有锋利的边缘，上面有一个大缺口，电流可以在装满蓄水池之前逃脱。运动中的电量是如此之大，尽管大多数都通过盘子的边缘或打开的缺口逃脱了，然而球体或蓄水池却交替地变空或变得满得溢出（明显地是来自球体顶部逃离出的电），其次数是每秒十五万次。

[See Nikola Tesla: Colorado Springs Notes, page 332, Photograph IX.]
[见 尼古拉•特斯拉：科罗拉多温泉日记，332 页，图片 9]

FIG. 10. PHOTOGRAPHIC VIEW OF AN EXPERIMENT TO ILLUSTRATE AN EFFECT OF AN ELECTRICAL OSCILLATOR DELIVERING ENERGY AT A RATE OF SEVENTY-FIVE THOUSAND HORSE-POWER.
图片 10. 图片演示一个实验来说明一个功率为七万五千马力的电子振荡器产生出的效果
The discharge, creating a strong draft owing to the heating of the air, is carried upward through the open roof of the building. The greatest width across is nearly seventy feet. The pressure is over twelve million volts, and the current alternates one hundred and thirty thousand times per second.
放电，由于空气中的热，产生出强烈的痕迹，向上提升，穿过屋顶。最大的宽度是横跨将近七十英尺。电压超过一千二百万伏特，电流的交替频率是每秒十五万次。
However extraordinary the results shown may appear, they are but trifling compared with those which are attainable by apparatus designed on these same principles. I have produced electrical discharges the actual path of which, from end to end, was probably more than one hundred feet long; but it would not be difficult to reach lengths one hundred times as great. I have produced electrical movements occurring at the rate of approximately one hundred thousand horsepower, but rates of one, five, or ten million horse-power are easily practicable. In these experiments effects were developed incomparably greater than any ever produced by human agencies, and yet these results are but an embryo of what is to be.
无论结果表现得多么不寻常，它们比起那些由相同原理设计的设备而得到的结果，都视同如戏。我已经制造出一种放电，从末端到末端的真正路径很可能超过一百英尺长；达到比这还要长一百倍的长度也不难。我已经制造出一种大约十万马力功率的电子运动，但是一百万、五百万或一千万马力的也轻易得到。这些产生出的实验结果，远比任何人类机构产生出的大得多，但这些结果都只不过是处于萌芽状态。

That communication without wires to any point of the globe is practicable with such apparatus would need no demonstration, but through a discovery which I made I obtained absolute certitude. Popularly

explained, it is exactly this: When we raise the voice and hear an echo in reply, we know that the sound of the voice must have reached a distant wall, or boundary, and must have been reflected from the same. Exactly as the sound, so an electrical wave is reflected, and the same evidence which is afforded by an echo is offered by an electrical phenomenon known as a "stationary" wave•that is, a wave with fixed nodal and ventral regions. Instead of sending sound-vibrations toward a distant wall, I have sent electrical vibrations toward the remote boundaries of the earth, and instead of the wall the earth has replied. In place of an echo I have obtained a stationary electrical wave, a wave reflected from afar.
利用这些设备实现全球任何地方的无线通讯是可能的，我是通常一种发现而绝对确信这一点，无需论证。普遍的解释确实是这样：每当我们提高嗓门的时候会听到回声，我们知道所发出的声音必定来到远处的一堵墙，或者是边界，同样也会反射回来。声音会反射，电子波也是如此。由回波产生的电子现象是一种“固定”的波，那就是说，一种固定在结点和腹侧区域的波。我把一束电子振动发送到遥远的地球边界处，而不是发送声音振动。我得到的是一种固定的电子波（现在称为“驻波”），而不是一种回声，那是从远处反射回来的波。

Stationary waves in the earth mean something more than mere telegraphy without wires to any distance. They will enable us to attain many important specific results impossible otherwise. For instance, by their use we may produce at will, from a sending-station, an electrical effect in any particular region of the globe; we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, or its speed; or we may send over the earth a wave of electricity traveling at any rate we desire, from the pace of a turtle up to lightning speed.
地球上的驻波远远不只是实现任何距离的无线通讯。它们能够使我们获得许多重要的特别成果，否则的话不可能。比如，通过利用它们，我们可以随意地在发送站把一个电子效应发送到地球上任何地方去；我们可以决定物体的相关位置或移动路线，比如是海上的一艘船，它横经的距离，或者是它的速度；或者我们可以向地球发送一束电子波，让它们以任意速度去我们想要的地方，从海龟般的慢速到闪电般的快速不等。
I have observed the above effects so far only up to a limited distance of about six hundred miles, but inasmuch as there is virtually no limit to the power of the vibrations producible with such an oscillator, I feel quite confident of the success of such a plant for effecting transoceanic communication. Nor is this all. My measurements and calculations have shown that it is perfectly practicable to produce on our globe, by the use of these principles, an electrical movement of such magnitude that, without the slightest doubt, its effect will be perceptible on some of our nearer planets, as Venus and Mars. Thus from mere possibility interplanetary communication has entered the stage of probability. In fact, that we can produce a distinct effect on one of these planets in this novel manner, namely, by disturbing the electrical condition of the earth, is beyond any doubt. This way of effecting such communication is, however, essentially different from all others which have so far been proposed by scientific men. In all the previous instances only a minute fraction of the total energy reaching the planet•as much as it would be possible to concentrate in a reflector•could be utilized by the supposed observer in his instrument. But by the means I have developed he would be enabled to concentrate the larger portion of the entire energy transmitted to the planet in his instrument, and the chances of affecting the latter are thereby increased many millionfold.
我观察过上述的效应，至今为止只局限于六百英里的距离，但事实上由于这样一个振荡器振动产生的能量是无限的，我相当确信这个计划的成功结果是导致远洋通信的出现。事实也远远不止如此。我的测量和计算也表明，通过利用这些原理，在我们的地球上产生这样一种巨大的电子运动是完全可能的，它的影响会在我们附近的一些行星察觉到，比如是金星和火星，从而也为我们的行星通信提供更大的可能性。事实上，毫无疑问，我们可以用这种奇异的方法，也就是说，通过干扰地球上的电子状态，来在其中一个星球上产

生一种截然不同的效果。然而，这样的通讯方式的实现本质上是与目前为止所有其它科学家主张的完全不同。在以前的所有实例里，所有能量中只有很微小的一部分能够来到这个星球，假设观察者在使用他的器具的话，很可能只有集中在反射镜里的能量被利用。但是使用我发展出的方法，他的器具能够把大得多的能量传送到行星上，从而后者影响行星的机会也增加许多百万倍。

Besides machinery for producing vibrations of the required power, we must have delicate means capable of revealing the effects of feeble influences exerted upon the earth. For such purposes, too, I have perfected new methods. By their use we shall likewise be able, among other things, to detect at considerable distance the presence of an iceberg or other object at sea. By their use, also, I have discovered some terrestrial phenomena still unexplained. That we can send a message to a planet is certain, that we can get an answer is probable: man is not the only being in the Infinite gifted with a mind.

除了用机械振动产生需用功率以外，我们必须也拥有精密的器具，能够显示反射到地球上的微弱影响带来的效果。为了这样的目的， 我也完善了一些新的方法。通过使用它们，我们也同样能够在其它东西中，探测出远处海洋上的冰山或其它物体。通过对它们的使 用，我也发现了一些陆地现象，仍然无法解释。那样，我们无疑可以向一颗行星发送信息，那样我们很可能会得到答案；人类不仅 只有无限的构想。

TRANSMISSION OF ELECTRICAL ENERGY TO ANY DISTANCE WITHOUT WIRES•NOW PRACTICABLE•THE BEST MEANS OF INCREASING THE FORCE ACCELERATING THE HUMAN MASS.

无线传送电能到任何遥远的地方•现在能实行•促进人类质量增长的最佳工具

The most valuable observation made in the course of these investigations was the extraordinary behavior of the atmosphere toward electric impulses of excessive electromotive force. The experiments showed that the air at the ordinary pressure became distinctly conducting, and this opened up the wonderful prospect of transmitting large amounts of electrical energy for industrial purposes to great distances without wires, a possibility which, up to that time, was thought of only as a scientific dream. Further investigation revealed the important fact that the conductivity imparted to the air by these electrical impulses of many millions of volts increased very rapidly with the degree of rarefaction, so that air strata at very moderate altitudes, which are easily accessible, offer, to all experimental evidence, a perfect conducting path, better than a copper wire, for currents of this character.

在这些研究期间，最有价值的观察要数是在强大电动势的脉冲下，大气层的不寻常行为。这个实验表明，在普通压力下，空气变得有明显的传导性，这为实现远距离无线传电，传送大量的电能作工业之用敞开了美妙的前景。目前为止，这样的想法还是一个科学上的梦想。进一步的研究揭示了，要让空气变得具有传导性，一个重要的因素就是以非常快的速度把数百亿伏特的电子脉冲加在稀薄的空气上，这样海拔适中的大气层会非常容易地受到影响。所有的实验证据表明，它是一个完美的导体，表现出电流属性，更胜于一根铜线。

Thus the discovery of these new properties of the atmosphere not only opened up the possibility of transmitting, without wires, energy in large amounts, but, what was still more significant, it afforded the certitude that energy could be transmitted in this manner economically. In this new system it matters little•in fact, almost nothing•whether the transmission is effected at a distance of a few miles or of a few thousand miles.

因此大气层这些新属性的发现，不仅为现实无线输送巨大能量敞开了可能，而且有更重要意义的是，它使我们确信，利用这种经济的方式来输电是可以的。在这种新的系统中，距离只是一个小问题，事实上几乎

不存在距离问题，不管传送的影响达到几英里还是几千英里。

While I have not, as yet, actually effected a transmission of a considerable amount of energy, such as would be of industrial importance, to a great distance by this new method, I have operated several model plants under exactly the same conditions which will exist in a large plant of this kind, and the practicability of the system is thoroughly demonstrated. The experiments have shown conclusively that, with two terminals maintained at an elevation of not more than thirty thousand to thirty-five thousand feet above sea-level, and with an electrical pressure of fifteen to twenty million volts, the energy of thousands of horse-power can be transmitted over distances which may be hundreds and, if necessary, thousands of miles. I am hopeful, however, that I may be able to reduce very considerably the elevation of the terminals now required, and with this object I am following up an idea which promises such a realization. There is, of course, a popular prejudice against using an electrical pressure of millions of volts, which may cause sparks to fly at distances of hundreds of feet, but, paradoxical as it may seem, the system, as I have described it in a technical publication, offers greater personal safety than most of the ordinary distribution circuits now used in the cities. This is, in a measure, borne out by the fact that, although I have carried on such experiments for a number of years, no injury has been sustained either by me or any of my assistants.

到现在为止，我事实上还没有用这种方法来实现相当大量的远距离能量传输，这在工业上是很重要的。我已经在完全相同的环境下模拟操作过几种方法，它们将会存在于这一类的巨大计划里面，彻底地证明了这个系统有实行可能。实验最后总结出，把两个终端维持在大约海拔三万到三万五千英尺的高度上，再加上一个十五千万伏特到二十千万伏特的电压，如果有需要的话，就可以把数以千计马力的能量传送到数百英里，甚至数千英里的距离。然而，我希望能够把现在终端需要的海拔高度大大减低。我沿着这个目标探究到底，一种想法会实现。当然，流行的偏见是反对使用数百万伏特的电压，因为这样会产生火花，飞到数百英尺以外的距离，但是荒谬的是，这个系统，正如我在一本技术刊物描述的那样，比现在城市使用的大多数普通分布式电路有更大的人身安全。这就是说，在某个尺度上，事实是尽管我已经持续展开这样的实验数年了，但是我和我的任何助手都没有发生过任何伤害。

But to enable a practical introduction of the system, a number of essential requirements are still to be fulfilled. It is not enough to develop appliances by means of which such a transmission can be effected. The machinery must be such as to allow the transformation and transmission, of electrical energy under highly economic and practical conditions. Furthermore, an inducement must be offered to those who are engaged in the industrial exploitation of natural sources of power, as waterfalls, by guaranteeing greater returns on the capital invested than they can secure by local development of the property.

但是，为了能够实际引进这个系统，许多基本需要还有待实现。光是发展这样一种能够实现传送的器具是不够的。这种机器必须在高度节省成本下，能够在实际条件里实现电能的转换和传送。此外，还要为致力于工业开采自然动力资源，例如是瀑布的人提供指引，确保他们比投资开发地方财富有更大得多的回报。

From that moment when it was observed that, contrary to the established opinion, low and easily accessible strata of the atmosphere are capable of conducting electricity, the transmission of electrical energy without wires has become a rational task of the engineer, and one surpassing all others in importance. Its practical consummation would mean that energy would be available for the uses of man at any point of the globe, not in small amounts such as might be derived from the ambient medium by suitable machinery, but in quantities virtually unlimited, from waterfalls. Export of power would then become the chief source of income for many happily situated countries, as the United States, Canada, Central and South America, Switzerland, and Sweden. Men could settle down everywhere, fertilize and irrigate the soil with little effort, and convert barren deserts into gardens, and thus the entire globe could

be transformed and made a fitter abode for mankind. It is highly probable that if there are intelligent beings on Mars they have long ago realized this very idea, which would explain the changes on its surface noted by astronomers. The atmosphere on that planet, being of considerably smaller density than that of the earth, would make the task much more easy.

与已制定的观点相反，从一观察到能够廉价而轻易地让大气层变成导电那一刻起，无线电力输送已经成为了工程师们的首要任务，其重要性超过了所有其它东西。它的实际成就是意味着能量可以被地球上任何地方的人们使用，而不再是局限于一小处地方，比如是用适当的机器从环境介质、从瀑布似的东西中获得，但是数量事实上是无限的。能量的输出对于很多适合的国家会是收入的主要来源，例如是美国、加拿大、中美洲和南美洲、瑞士和瑞典。人类可以在各处定居，只用少许的工夫就可以施肥和灌溉，把沙漠变成绿洲，全球也因此而得到改变，为人类打造一个适合的住所。如果火星上有智慧生命的话，他们很有可能在很久以前就实现这种想法，这样可以解释得到天文学家记录下来的他们星球表面的变化。那颗行星上的大气层密度比地球小得多，也让任务变得更加容易。

It is probable that we shall soon have a self-acting heat-engine capable of deriving moderate amounts of energy from the ambient medium. There is also a possibility•though a small one•that we may obtain electrical energy direct from the sun.

This might be the case if the Maxwellian theory is true, according to which electrical vibrations of all rates should emanate from the sun. I am still investigating this subject. Sir William Crookes has shown in his beautiful invention known as the "radiometer" that rays may produce by impact a mechanical effect, and this may lead to some important revelation as to the utilization of the sun's rays in novel ways. Other sources of energy may be opened up, and new methods of deriving energy from the sun discovered, but none of these or similar achievements would equal in importance the transmission of power to any distance through the medium. I can conceive of no technical advance which would tend to unite the various elements of humanity more effectively than this one, or of one which would more add to and more economize human energy. It would be the best means of increasing the force accelerating the human mass. The mere moral influence of such a radical departure would be incalculable. On the other hand if at any point of the globe energy can be obtained in limited quantities from the ambient medium by means of a self-acting heat-engine or otherwise, the conditions will remain the same as before. Human performance will be increased, but men will remain strangers as they were.

很可能我们很快将会拥有自动的热力发动机，能够从环境介质中提取数量适中的能量。也有可能通过小小的发电机，我们就可以直接地从太阳中获取电能。如果麦克斯韦的理论是对的话，这也许是一种情形，因为所有频率的电子振动都是从太阳中散发的。我仍然在研究这个课题。威廉•克鲁克斯爵士展示了他的美丽发明，称为“辐射计”，通过一种机械效应的影响会产生出射线，这会导致一些重要的新发现，例如是以新奇的方式来利用太阳射线。其它的能量来源也会敞开，从太阳中提取能量的新方式也被发现，但这些或类似的成就都比不上通过介质把能量传送到任何距离的重要性。我可以想象，没有其它技术上的进步会比这个更有效地趋向于人类各种不同元素的统一，或者能够为人类获取更经济的能量。它是促进人类质量的最佳方法。这样一个激进的里程碑，光是道德方面的影响也是不可计算的。另一方面，如果依靠自动热力发动机或其它机器，可以在地球任何地方的环境介质中获取数量有限的能量，那么受制条件就和过去没有两样。人类性能会提升，但人类依然和以往一样地陌生。

I anticipate that any, unprepared for these results, which, through long familiarity, appear to me simple and obvious, will consider them still far from practical application. Such reserve, and even opposition, of some is as useful a quality and as necessary an element in human progress as the quick receptivity and enthusiasm of others. Thus, a mass which resists the force at first, once set in movement, adds to the energy. The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of the planter•for the future. His duty is to lay the

foundation for those who are to come, and point the way. He lives and labors and hopes with the poet who says:
我预料，任何这些尚未准备好的结局，经由长期亲密接触，对我而言是简单而显而易见，但会被认为是离实际应用还远。
这样的一些保留，甚至是相反观点，是有用的，在人类进步中是必不可少的因素，因为一些人很快地接受，同时又刺激了另一些人。因此，起初是大量力量聚集起来，一旦开始运动，能量便会递增。科学工作者不应把目光瞄准一个立即的结果。他并不期待他的先进想法被乐意地采用。他的工作就像是为未来而耕作。他的责任是为那些后继者打下基础和指出道路。他的生活、劳动和希望可以用以下一首诗来概括：

Schaff' das Tagwerk meiner H•nde, Hohes
Gl•ck, dass ich's vollende! Lass, o lass
mich nicht ermatten! Nein, es sind nicht
leere Tr•ume: Jetzt nur Stangen, diese
B•ume Geben einst noch Frucht und
Schatten. [1] （这段可能是塞尔维亚语）

1 Daily work•my hands' employment, To
complete is pure enjoyment! Let, oh, let
me never falter! No! there is no empty
dreaming: Lo! these trees, but bare poles
seeming, Yet will yield both food and
shelter!
我手上的工作，
让我享受着每天的快乐！
噢，我决不会蹒跚踉跄！
那里没有空想：
看看这些树！
它们表面看上去是赤裸的电极，
但依然会提供食物和庇护所！

Goethe's "Hope" Translated by William
Gibson, Com. U. S. N.
歌德的“希望”，威廉•吉布森 翻译

EFFORTS TOWARD OBTAINING MORE ENERGY FROM COAL•THE ELECTRIC TRANSMISSION•THE GAS- ENGINE•THE COLD-COAL BATTERY.
努力地从煤炭中提取更多的能量•电力传输•气体能量•冷-煤电池

I remember that at one time I considered the production of electricity by burning coal in a battery as the greatest achievement toward the advancing civilization, and I am surprised to find how much the continuous study of these subjects has modified my views. It now seems to me that to burn coal, however efficiently, in a battery would be a mere makeshift, a phase in the evolution toward something much more perfect. After all, in generating electricity in this manner, we should be destroying material, and this would be a barbarous process. We ought to be able to obtain the energy we need without consumption of

material. But I am far from underrating the value of such an efficient method of burning fuel.

At the present time most motive power comes from coal, and, either directly or by its products, it adds vastly to human energy. Unfortunately, in all the process now adopted, the larger portion of the energy of the coal is uselessly dissipated.

The best steam-engines utilize only a small part of the total energy. Even in gas-engines, in which, particularly of late, better results are obtainable, there is still a barbarous waste going on. In our electric-lighting systems we scarcely utilize one third of one per cent., and in lighting by gas a much smaller fraction, of the total energy of the coal. Considering the various uses of coal throughout the world, we certainly do not utilize more than two per cent. of its energy theoretically available. The man who should stop this senseless waste would be a great benefactor of humanity, though the solution he would offer could not be a permanent one, since it would ultimately lead to the exhaustion of the store of material. Efforts toward obtaining more energy from coal are now being made chiefly in two directions•by generating electricity and by producing gas for motive-power purposes. In both of these lines notable success has already been achieved.

我记得曾经有一次，我认为把煤燃烧时产生的电能贮存在电池里是迈向这种先进文明的第一步，然而我感到惊讶的是，经过再三研究这个问题，我改变了原有的看法。现在对我来说，要把燃烧的煤贮存在电池中，不管多么有效，都只不过是一个权宜之计，采用渐进式的方法来迈向这个目标会是更加理想。毕竟，总的来说，以这种方式来贮存电能，我们会破坏原料，这会是一种粗野的过程。我们应该能够获得这种能量而无需浪费原料。但是，我远远没有低估这样一种高效燃料的价值。目前为止，大多数的动力都来自于煤，直接的或间接的。它大大地增加了人类能量。不幸的是，在现在采用的所有加工方法中，煤能量的更大一部分是闲置的。最好的蒸汽机也只是利用了全部能量的小小一部分。即使在内燃机里，尤其是后期的，可以得到较佳的效果，但仍然有大部分是处于浪费。在我们的电灯系统，我们很少用到百分之三分之一的煤，仍然有大量的浪费在里面，用气体来照明，消耗的煤能量还会更少。考虑到在世界各地，煤的各种各样用途，无疑地，使用不超过百分之二的煤能量在理论上是可行的。人们应要停止这种无谓的浪费，这将对人类有极大的益处，尽管他提出的解决方法并非持久，因为这样最终会导致原料贮存的枯竭。现在主要是通过两个方向来尽力从煤中获取更多的能量：通过发电；以及用产生的气体作为动力。这两种方法都已经获得了显著的成效。

The advent of the alternating-current system of electric power-transmission marks an epoch in the economy of energy available to man from coal. Evidently all electrical energy obtained from a waterfall, saving so much fuel, is a net gain to mankind, which is all the more effective as it is secured with little expenditure of human effort, and as this most perfect of all known methods of deriving energy from the sun contributes in many ways to the advancement of civilization. But electricity enables us also to get from coal much more energy than was practicable in the old ways. Instead of transporting the coal to distant places of consumption, we burn it near the mine, develop electricity in the dynamos, and transmit the current to remote localities, thus effecting a considerable saving. Instead of driving the machinery in a factory in the old wasteful way of belts and shafting, we generate electricity by steam-power and operate electric motors. In this manner it is not uncommon to obtain two or three times as much effective motive power from the fuel, besides securing many other important advantages. It is in this field as much as in the transmission of energy to great distance that the alternating system, with its ideally simple machinery, is bringing about an industrial revolution. But in many lines this progress has not been yet fully felt. For example, steamers and trains are still being propelled by the direct application of steam-power to shafts or axles. A much greater percentage of the heat-energy of the fuel could be transformed into motive energy by using, in place of the adopted marine engines and locomotives, dynamos driven by specially designed high-pressure steam- or gas-engines and by utilizing the electricity generated for the propulsion.

A gain of fifty to one hundred per cent. in the effective energy derived from the coal could be secured in this manner. It is difficulty to understand why a fact so plain and obvious is not receiving more attention from engineers. In ocean steamers such an improvement would be particularly desirable, as it would do away with noise and increase materially the speed and the carrying capacity of the liners.
交流电输送系统的进步，标致着人类利用煤能源的经济新纪元。显然，所有的电能都是来自于爆布，它贮存了大量燃料，对人类是一种净利，并且会更加有效，事实上它几乎不需要人类努力付出，因为源自太阳的能量最为完美，它在许多方面为文明进步作出了贡献。但是，电力能够使我们从煤炭中获取更多的能量，比以往的任何方式还要多。我们只需在煤矿附近燃烧煤，用发电机来发电，然后把电流传送到远方，而不是花钱去把煤运到远方，从而相当有效地节省能量。我们利用蒸汽和电动机来产生电流，而不是在工厂里利用输送带和轴承的旧有耗能方式来操练机器。用这种方式，从燃料中获取二至三倍有效动力是不平凡的，此外安全性也是重要的有利条件。在远程输送能量这一领域，它的功率差不多相当于交流电系统。利用理想的简单机器，会带来一场工业的革命。但在许多方面，这一过程仍然没有充分地完成。例如，汽船和火车仍然是直接应用蒸汽推动轴承或轮轴来前进。燃烧的热能更加多的可以转化成动能，取代了船用柴油机和火车头，发动机是用特别设计的高压蒸汽机或内燃机来制造，通过产生出的电流来推动。照这样，源自煤炭的有效能量会从百分之五十提升到百分之一百。真不明白，如此显而易见的事实为什么不会引起工程师们更多的注意。在远洋轮船，这样的改进会是显著地悦人心意的，因为它可以消除噪音，从本质上提升速度和船的承载能力。

Still more energy is now being obtained from coal by the latest improved gas-engine, the economy of which is, on the average, probably twice that of the best steam-engine. The introduction of the gas-engine is very much facilitated by the importance of the gas industry. With the increasing use of the electric light more and more of the gas is utilized for heating and motive-power purposes. In many instances gas is manufactured close to the coal-mine and conveyed to distant places of consumption, a considerable saving both in cost of transportation and in utilization of the energy of the fuel being thus effected. In the present state of the mechanical and electrical arts the most rational way of deriving energy from coal is evidently to manufacture gas close to the coal store, and to utilize it, either on the spot or elsewhere, to generate electricity for industrial uses in dynamos driven by gas engines. The commercial success of such a plant is largely dependent upon the production of gas-engines of great nominal horse-power, which, judging from the keen activity in this field will soon be forthcoming. Instead of consuming coal directly, as usual, gas should be manufactured from it and burned to economize energy.
利用近年改进了的内燃机，还可以从煤中获取更多的能量，很可能是最佳的蒸汽机的两倍。内燃机的引入会大大地推动煤气工业。随着电灯的普及，越来越多的煤气用于提供热能和动力。在许多例子里，煤气是在煤矿附近制造出来的，被运送到远处，既在运输的花费上，也在能源的有效利用上，都有相当大的节约。在现阶段，机械和电气工艺，显然是从煤中提取能量，在煤矿附近提取气体的合理方法，然后利用它，或者在某一地点，或者在其它地方，用内燃机驱动的发电机来产生工业用电。这种设备在商业上获取的成功，主要是决取于超大马力的内燃机生产，对这个领域的敏锐判断很快会来到。跟以往一样，煤气是从煤中提取，然后燃烧来节省能源，而不是直接地把煤燃烧。

But all such improvements cannot be more than passing phases in the evolution toward something far more perfect, for ultimately we must succeed in obtaining electricity from coal in a more direct way, involving no great loss of heat-energy. Whether coal can be oxidized by a cold process is still a question. Its combination with oxygen always involves heat, and whether the energy of the combination of the

carbon with another element can be turned directly into electrical energy has not yet been determined. Under certain conditions nitric acid will burn the carbon, generating an electric current, but the solution does not remain cold. Other means of oxidizing coal have been proposed, but they have offered no promise of leading to an efficient process. My own lack of success has been complete, though perhaps not quite so complete as that of some who have "perfected" the cold-coal battery. This problem is essentially one for the chemist to solve. It is not for the physicist, who determines all his results in advance, so that, when the experiment is tried, it cannot fail. Chemistry, though a positive science, does not yet admit of a solution by such positive methods as those which are available in the treatment of many physical problems. The result, if possible, will be arrived at through patent trying rather than through deduction or calculation. The time will soon come, however, when the chemist will be able to follow a course clearly mapped out beforehand, and when the process of his arriving at a desired result will be purely constructive. The cold-coal battery would give a great impetus to electrical development; it would lead very shortly to a practical flying-machine, and would enormously enhance the introduction of the automobile. But these and many other problems will be better solved, and in a more scientific manner, by a light storage battery.

但是，这样的改进都比不上随着时间流逝而逐渐改进，迈向某种更完美的状态，因为最终我们必须要成功地以一种更加直接的方式从煤中获取电，包括不损失过多的热能。煤是否可以通过冷加工过程而被氧化还是个问题。它与氧结合总是产生出热。碳和其它元素结合而产生出的能量是否可以直接地转变成电也是一个未知数。在某种情况下，硝酸会把碳燃烧，产生一种电流，但产生出的溶液不会冷却。把煤氧化的其它方法也被提议过，但他们还没有提供一种有效的处理方法。我自己完全缺乏成功的经验，尽管也许不是完全地缺乏，还有某些冷煤电池的“完美”想法。这个问题本质上是由化学家去解决，而不是由预先确定结果的物理学家去做。所以，当实验是可靠的时候，它不可能会失败。化学，尽管是一门实际的科学，但仍然不承认用这样的实际的方法来得到一种溶液，因为那样会涉及到很多物理方面的问题。如果可能的话，可以通过专有的试验来得到结果，而不是通过推论或计算。然而，当化学能够通过一个明确的过程来事先制订的时候，当得到预期效果的过程变得完全有建设性的时候，这很快会来到。冷煤电池会为电力的发展提供极大的推动力；它很快地会导致一种实用的飞行机器出现；也会大大地提高汽车的性能。但是，以一种更为科学的方式，通过利用一种可点燃的蓄电池，这些和其它很多问题都会得到更好的解决。

ENERGY FROM THE MEDIUM•THE WINDMILL AND THE SOLAR ENGINE,•MOTIVE POWER FROM TERRESTRIAL HEAT•ELECTRICITY FROM NATURAL SOURCES.

来自介质的能量•风车与太阳能•来自陆地热量的动力•来自自然资源的电能

Besides fuel, there is abundant material from which we might eventually derive power. An immense amount of energy is locked up in limestone, for instance, and machines can be driven by liberating the carbonic acid through sulphuric acid or otherwise. I once constructed such an engine, and it operated satisfactorily.

除了燃料，还有足够的原料，使我们最终能够获得能量。例如，许许多多的能量被封藏在石灰石里，通过利用硫酸或其它东西，把里面的碳酸释放，能够让机器起动。我曾经制造过这样一座发动机，它运作得很好。

But, whatever our resources of primary energy may be in the future, we must, to be rational, obtain it without consumption of any material. Long ago I came to this conclusion, and to arrive at this result only two ways, as before indicated, appeared possible•either to turn to use the energy of the sun stored in the ambient medium, or to transmit, through the medium, the sun's energy to distant places from some locality where it was obtainable without consumption of material. At that time I at once rejected the latter

method as entirely impracticable, and turned to examine the possibilities of the former.
可是，在将来，不管我们的原始能量的资源是什么，我们都必须要合理地开采而不浪费任何原料。很久以前，我得出这个结论，要达到这种效果只有两种方法，就跟前面指出的那样，只有两种可能，一是利用贮藏在环境介质里的太阳能；二是利用介质把太阳能从某些地区传送到较远的地方而不需要浪费原料。那时候，我立即拒绝了后者，认为它是完全不可能，而致力于检验前者的可能性。

It is difficult to believe, but it is, nevertheless, a fact, that since time immemorial man has had at his disposal a fairly good machine which has enabled him to utilize the energy of the ambient medium. This machine is the windmill. Contrary to popular belief, the power obtainable from wind is very considerable. Many a deluded inventor has spent years of his life in endeavoring to "harness the tides," and some have even proposed to compress air by tide- or wave-power for supplying energy, never understanding the signs of the old windmill on the hill, as it sorrowfully waved its arms about and bade them stop. The fact is that a wave- or tide-motor would have, as a rule, but a small chance of competing commercially with the windmill, which is by far the better machine, allowing a much greater amount of energy to be obtained in a simpler way. Wind-power has been, in old times, of inestimable value to man, if for nothing else but for enabling him, to cross the seas, and it is even now a very important factor in travel and transportation. But there are great limitations in this ideally simple method of utilizing the sun's energy. The machines are large for a given output, and the power is intermittent, thus necessitating the storage of energy and increasing the cost of the plant.
很难相信，但却是事实，那就是自古以来，人类就已经配置了相当良好的机器，能够使他利用环境介质的能量。这种机器是风车。与大众认为的相反，从风里得到的能量是相当多的。许多被迷惑的发明家花了一生的大部分时间致力于“利用潮汐（势能）产生的动力”，一些甚至还主张利用潮汐或波浪的力量来压缩空气，用于供给能量，却从来不明白山丘上古老的风车的作用，它在悲哀地挥动着它的叶轮，示意他们要停止。实情是通常，一个波浪—或潮汐的电动机，在商业上只有很少的机会与一个风车竞争，而后者毕竟是更好的机器，允许以简单的方式获取更加多的能量。在古时候，风车对于人类有难以估量的价值，因为除此之外，再也没有其它东西能够帮他渡过海洋，即使到了现在，它还是旅行和运输的一个非常重要因素。但是，这种理想的简单方式却大大限制了太阳能的利用。这种机器的输出是巨大的，动能是间歇的，因此贮藏能量必不可少，增加了设备的成本。

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Besides fuel, there is abundant material from which we might eventually derive power. An immense amount of energy is locked up in limestone, for instance, and machines can be driven by liberating the carbonic acid through sulphuric acid or otherwise. I once constructed such an engine, and it operated satisfactorily.
除了燃料，还有足够的原料，使我们最终能够获得能量。例如，许许多多的能量被封藏在石灰石里，通过利用硫酸或其它东西，把里面的碳酸释放，能够让机器起动。我曾经制造过这样一座发动机，它运作得很好。

But, whatever our resources of primary energy may be in the future, we must, to be rational, obtain it without consumption of any material. Long ago I came to this conclusion, and to arrive at this result only two ways, as before indicated, appeared possible•either to turn to use the energy of the sun stored in the ambient medium, or to transmit, through the medium, the sun's energy to distant places from some

locality where it was obtainable without consumption of material. At that time I at once rejected the latter method as entirely impracticable, and turned to examine the possibilities of the former.
可是，在将来，不管我们的原始能量的资源是什么，我们都必须要合理地开采而不浪费任何原料。很久以前，我得出这个结论，要达到这种效果只有两种方法，就跟前面指出的那样，只有两种可能，一是利用贮藏在环境介质里的太阳能；二是利用介质把太阳能从某些地区传送到较远的地方而不需要浪费原料。那时候，我立即拒绝了后者，认为它是完全不可能，而致力于检验前者的可能性。

It is difficult to believe, but it is, nevertheless, a fact, that since time immemorial man has had at his disposal a fairly good machine which has enabled him to utilize the energy of the ambient medium. This machine is the windmill. Contrary to popular belief, the power obtainable from wind is very considerable. Many a deluded inventor has spent years of his life in endeavoring to "harness the tides," and some have even proposed to compress air by tide- or wave-power for supplying energy, never understanding the signs of the old windmill on the hill, as it sorrowfully waved its arms about and bade them stop. The fact is that a wave- or tide-motor would have, as a rule, but a small chance of competing commercially with the windmill, which is by far the better machine, allowing a much greater amount of energy to be obtained in a simpler way. Wind-power has been, in old times, of inestimable value to man, if for nothing else but for enabling him, to cross the seas, and it is even now a very important factor in travel and transportation. But there are great limitations in this ideally simple method of utilizing the sun's energy. The machines are large for a given output, and the power is intermittent, thus necessitating the storage of energy and increasing the cost of the plant.
很难相信，但却是事实，那就是自古以来，人类就已经配置了相当良好的机器，能够使他利用环境介质的能量。这种机器是风车。与大众认为的相反，从风里得到的能量是相当多的。许多被迷惑的发明家花了一生的大部分时间致力于“利用潮汐（势能）产生的动力”，一些甚至还主张利用潮汐或波浪的力量来压缩空气，用于供给能量，却从来不明白山丘上古老的风车的作用，它在悲哀地挥动着它的叶轮，示意他们要停止。实情是通常，一个波浪—或潮汐的电动机，在商业上只有很少的机会与一个风车竞争，而后者毕竟是更好的机器，允许以简单的方式获取更加多的能量。在古时候，风车对于人类有难以估量的价值，因为除此之外，再也没有其它东西能够帮他渡过海洋，即使到了现在，它还是旅行和运输的一个非常重要因素。但是，这种理想的简单方式却大大限制了太阳能的利用。这种机器的输出是巨大的，动能是间歇的，因此贮藏能量必不可少，增加了设备的成本。

A far better way, however, to obtain power would be to avail ourselves of the sun's rays, which beat the earth incessantly and supply energy at a maximum rate of over four million horsepower per square mile. Although the average energy received per square mile in any locality during the year is only a small fraction of that amount, yet an inexhaustible source of power would be opened up by the discovery of some efficient method of utilizing the energy of the rays. The only rational way known to me at the time when I began the study of this subject was to employ some kind of heat- or thermodynamic-engine, driven by a volatile fluid evaporate in a boiler by the heat of the rays. But closer investigation of this method, and calculation, showed that, notwithstanding the apparently vast amount of energy received from the sun's rays, only a small fraction of that energy could be actually utilized in this manner. Furthermore, the energy supplied through the sun's radiations is periodical, and the same limitations as in the use of the windmill I found to exist here also. After a long study of this mode of obtaining motive power from the sun, taking into account the necessarily large bulk of the boiler, the low efficiency of the heat-engine, the additional cost of storing the energy and other drawbacks, I came to the conclusion that the "solar engine," a few instances excepted, could not be industrially exploited with success.

然而，更好的办法是，从太阳射线中获取能量。太阳射线不停地敲打着地球，以每平方哩超过四百万马力的最大功率来提供能量。尽管在每处地方，每平方里接受的平均能量只有总数的一小部分，但是随着一些新的发现，射线能量被有效地使用，无穷无尽的能量来源在向我们敞开。当我开始研究这个课题的时候，我那时候所知的唯一合理方式，就是使用一些热能，或者热动力的引擎，通过利用太阳射线对锅炉里的一种挥发性流体进行加热产生的蒸气来驱动。但是，最近的研究表明，这种方法和计算，尽管从太阳射线那里显然地可以获取大量的能量，可是实际上只有其中很小的一部分能够被利用。另外，通过太阳射线提供的能量是定期的，我发现，利用风车发电的局限性，也同样出现在这里。经过了长期的研究，发现这种从太阳获取动力的方式，也需要用大批巨大的锅炉，低效的热力发动机，再加上贮存能量的额外费用和其它缺点，我得出的结论是，除了少数情况以外，“太阳能发动机”在工业上不能够成功地大批开发。

Another way of getting motive power from the medium without consuming any material would be to utilize the heat contained in the earth, the water, or the air for driving an engine. It is a well-known fact that the interior portions of the globe are very hot, the temperature rising, as observations show, with the approach to the center at the rate of approximately 1 degree C. for every hundred feet of depth. The difficulties of sinking shafts and placing boilers at depths of, say, twelve thousand feet, corresponding to an increase in temperature of about 120 degrees C., are not insuperable, and we could certainly avail ourselves in this way of the internal heat of the globe. In fact, it would not be necessary to go to any depth at all in order to derive energy from the stored terrestrial heat. The superficial layers of the earth and the air strata close to the same are at a temperature sufficiently high to evaporate some extremely volatile substances, which we might use in our boilers instead of water. There is no doubt that a vessel might be propelled on the ocean by an engine driven by such a volatile fluid, no other energy being used but the heat abstracted from the water. But the amount of power which could be obtained in this manner would be, without further provision, very small.

从介质中提取动力而不浪费任何原料的另一种方式是利用蕴含在地下、水源，或者是空气中的热能来操纵机器。一个众所周知的事实就是，地球内部非常热，温度在上升，正如观察所得，每靠近地心一百英尺，就增加一摄氏度。无法克服的困难是，如何通过升降轴来把锅炉放到地底下一万二千英尺的深处去，相对应的温度是 120 摄氏度。事实上，要获取贮藏在地球内部的能量，进入这么深的地方是完全没有必要的。地球的表层和大气层的温度接近，足以让一些极度不稳定的物质挥发，我们在锅炉里是使用这种物质，而不是水。毫无疑问，一个放在海洋里的容器，可以用这样一种挥发性流体驱动的发动机来驱动，除了从水里获取热能以外，不浪费其它的能量。但是，没有更进一步的供应，以这种方式获取的能量总计是非常少的。

Electricity produced by natural causes is another source of energy which might be rendered available.Lightning discharges involve great amounts of electrical energy, which we could utilize by transforming and storing it. Some years ago I made known a method of electrical transformation which renders the first part of this task easy, but the storing of the energy of lightning discharges will be difficult to accomplish. It is well known, furthermore, that electric currents circulate constantly through the earth, and that there exists between the earth and any air stratum a difference of electrical pressure, which varies in proportion to the height.

由自然产生的电流是另一种可利用能源的来源。闪电释放出大量电能，我们可以通过把它转变成另一种能量，然后贮存起来，再利用它。几年以前，我因为一种转化电能的方法而变得出名，这种做法的开头很容易，但要把闪电释放出的能量贮存起来却很难完成。另外，众所周知，电的流通贯穿整个地球，在地球和不同大气层之间存在着电压，其变化与海拔高度成比例。

The second fact which I have ascertained is that the upper air strata are permanently charged with electricity opposite to that of the earth. So, at least, I have interpreted my observations, from which it appears that the earth, with its adjacent insulating and outer conducting envelope, constitutes a highly charged electrical condenser containing, in all probability, a great amount of electrical energy which might be turned to the uses of man, if it were possible to reach with a wire to great altitudes.
我确认的第二个事实是，上空的大气层带有与地面完全相反的电荷。所以，至少地，我已经对我的观察作出了解释：地球、还有它邻近的绝缘体和外面的包壳，组成了一个充满了电的大电容。如果有一根线通往海拔高处，很可能地，大量的电能都可以转成人类之用。

It is possible, and even probable, that there will be, in time, other resources of energy opened up, of which we have no knowledge now. We may even find ways of applying forces such as magnetism or gravity for driving machinery without using any other means. Such realizations, though highly improbable, are not impossible. An example will best convey an idea of what we can hope to attain and what we can never attain. Imagine a disk of some homogeneous material turned perfectly true and arranged to turn in frictionless bearings on a horizontal shaft above the ground. This disk, being under the above conditions perfectly balanced, would rest in any position. Now, it is possible that we may learn how to make such a disk rotate continuously and perform work by the force of gravity without any further effort on our part; but it is perfectly impossible for the disk to turn and to do work without any force from the outside. If it could do so, it would be what is designated scientifically as a "perpetuum mobile," a machine creating its own motive power. To make the disk rotate by the force of gravity we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one half of the disk, and the rotation of the latter would follow. At least, we cannot deny such a possibility until we know exactly the nature of the force of gravity. Suppose that this force were due to a movement comparable to that of a stream of air passing from above toward the center of the earth. The effect of such a stream upon both halves of the disk would be equal, and the latter would not rotate ordinarily; but if one half should be guarded by a plate arresting the movement, then it would turn.
有可能，甚至很可能，在不久的将来，我们现在还不知道的其它能源会被发现。我们甚至还可以想方设法把磁力或重力等力量应用到机器动力上而无需使用其它任何方法。尽管现实中这是非常不可能的，但并不是完全没有可能。一个例子将会最好地表达了“什么是我们希望能够得到的”，“什么是我们不可能得到的”。想象一个由某些同类材料材料造成的碟子，它完全是真实的，在地面上沿着水平方向来转动而不产生摩擦。这个碟子，在上述条件下是完全平衡的，无论在任何位置都是静止状态。现在，我们来研究一下如何让一个碟子不断地旋转，只需利用引力来运作而无需我们额外添加其它动力是可能的，但是要研究如何让一个碟子不需要任何外在力量而旋转和运作是完全不可能的。如果是可能的话，这样的科学设计应该被称为“永动机”，一种能够自己产生动力的机器。要让碟子在引力的驱使下旋转，我们只能发明一种屏罩，抵抗这种力量。通过这样一种屏罩，我们可以阻挡这种力量对半边碟子的影响，另一半随之会旋转。至少地，我们无法否认有这样一种可能性，直到我们完全了解引力的本质为止。假设这样一种力量是由一种运动所致，可比作大气层上空流向地球中心的气流。这样一种气流对两半碟子的影响是相同的，下半部分通常不会旋转；但是如果镀上了金属的另一半能够捕获能量，那么它就会旋转。

A DEPARTURE FROM KNOWN METHODS•POSSIBILITY OF A "SELF-ACTING" ENGINE OR MACHINE, INANIMATE, YET CAPABLE, LIKE A LIVING BEING, OF DERIVING ENERGY FROM THE MEDIUM•THE IDEAL WAY OF OBTAINING MOTIVE POWER.
与已知的方法相违背•“自动”引擎或机器的可能性•非生命，却能够像生命那样，从介质中衍生出能量•获得动力的理想方法

When I began the investigation of the subject under consideration, and when the preceding or similar

ideas presented themselves to me for the first time, though I was then unacquainted with a number of the facts mentioned, a survey of the various ways of utilizing the energy of the medium convinced me, nevertheless, that to arrive at a thoroughly satisfactory practical solution a radical departure from the methods then known had to be made. The windmill, the solar engine, the engine driven by terrestrial heat, had their limitations in the amount of power obtainable. Some new way had to be discovered which would enable us to get more energy. There was enough heat-energy in the medium, but only a small part of it was available for the operation of an engine in the ways then known. Besides, the energy was obtainable only at a very slow rate. Clearly, then, the problem was to discover some new method which would make it possible both to utilize more of the heat-energy of the medium and also to draw it away from the same at a more rapid rate.

虽然那时我对提及过的许多事实并不熟悉；然而，当我在再三考虑下开始研究这个课题的时候，当前述或类似的想法首次呈现在我眼前的时候，经过对利用介质能量的各种方式的考察，使我深信要得到一种完全满意的实际解决方案，就要有一种与已知截然不同的方法。风车，太阳能，以及由地热驱动的引擎，在获取大功率的能量上，都有它们的局限性。必须发明一些新的方法，使我们能够得到更多的能量。介质里面有足够多的热能，但是利用已知的方法，只有其中的一小部分能够用于操作机器。此外，只能以非常低的效率来获取能量。显然地，问题是：要发现一些新的方法，即能够充分地利用介质的热能，同样也要以更快的效率把它拉走。

I was vainly endeavoring to form an idea of how this might be accomplished, when I read some statements from Carnot and Lord Kelvin (then Sir William Thomson) which meant virtually that it is impossible for an inanimate mechanism or self- acting machine to cool a portion of the medium below the temperature of the surrounding, and operate by the heat abstracted. These statements interested me intensely. Evidently a living being could do this very thing, and since the experiences of my early life which I have related had convinced me that a living being is only an automaton, or, otherwise stated, a "self-acting-engine," I came to the conclusion that it was possible to construct a machine which would do the same. As the first step toward this realization I conceived the following mechanism. Imagine a thermopile consisting of a number of bars of metal extending from the earth to the outer space beyond the atmosphere. The heat from below, conducted upward along these metal bars, would cool the earth or the sea or the air, according to the location of the lower parts of the bars, and the result, as is well known, would be an electric current circulating in these bars. The two terminals of the thermopile could now be joined through an electric motor, and, theoretically, this motor would run on and on, until the media below would be cooled down to the temperature of the outer space. This would be an inanimate engine which, to all evidence, would be cooling a portion of the medium below the temperature of the surrounding, and operating by the heat abstracted.

我曾经努力地去想如何能够把它实现，但始终是徒劳无功。我读到了卡尔诺和开尔文爵士（他当时是威廉•托马斯先生）的一些论述，意思是说在低于周围环境的温度下，让一部无生命的或自动的机器去把介质的一部分冷却下来，用抽出来的热来运作事实上是不可能的。这些论述深深地使我感兴趣。显然地，生命体完全可以这样做，因为我讲述过的早年实验已经使我确信，一个生命体只是一部自动机器，或者说是一个“自动引擎”，我得出一个结论，就是构建一部同样的机器是可能的。实现这个目标的第一步，我构想出以下的机械装置。想象一个热电堆，是从地球伸出来的数个金属棒组成，依照金属棒较低部分所处的位置，会把地球，或者海洋和空气冷却。而结果，正如很多人所知道的，会产生出一种电流，在这些金属棒中间流通。热电堆的两个接线端现在透过一个发电机而连接在一起，理论上，这个发电机会连续不断地运作，直到下面的介质会冷却到外太空的温度为止。这将会是一个无生命的引擎，显然地，会把介质的一部分冷却到周

围温度以下，又以抽取出来的热量来运作。

DIAGRAM b. OBTAINING ENERGY FROM THE AMBIENT MEDIUM A,
图表 b 从环境介质中获取能量
medium with little energy; ambient medium with much energy; O, path of the energy.
带有少量能量的介质；B, B,有大量能量的环境介质；O, 能量的路径

But was it not possible to realize a similar condition without necessarily going to a height? Conceive, for the sake of illustration, [a cylindrical] enclosure T, as illustrated in diagram b, such that energy could not be transferred across it except through a channel or path O, and that, by some means or other, in this enclosure a medium were maintained which would have little energy, and that on the outer side of the same there would be the ordinary ambient medium with much energy. Under these assumptions the energy would flow through the path O, as indicated by the arrow, and might then be converted on its passage into some other form of energy. The question was, Could such a condition be attained? Could we produce artificially such a "sink" for the energy of the ambient medium to flow in? Suppose that an extremely low temperature could be maintained by some process in a given space; the surrounding medium would then be compelled to give off heat, which could be converted into mechanical or other form of energy, and utilized. By realizing such a plan, we should be enabled to get at any point of the globe a continuous supply of energy, day and night. More than this, reasoning in the abstract, it would seem possible to cause a quick circulation of the medium, and thus draw the energy at a very rapid rate.
但是，有可能无需把电线架到海拔高处而实现类似状态吗？为了把问题阐明，构想一下，[一根圆柱]被围栏 T 包围着，正如图解 b 所述的那样，这样，除了经过一根导线或路径 0 以外，能量不会流经圆柱体。用某种方法，让围栏里面的介质持有少许的能量，而同一围栏外面的普通环境介质却拥有非常多的能量。在这样的设定下，能量会流经路径 0，正如箭头所指出的那样，然后它会在流经的通路上转变成其它形式的能量。问题是，可以实现这样一种状态吗？我们能够人为地制造这样一道“水槽”，让环境介质的能量经过吗？假设能够运用一些方法让某个空间维持极端低温；那么周围的介质就会被迫放出热能，热能可以转变成机械能或其它形式的能量，然后利用它。通过实现这样的计划，我们在地球的任何地方日日夜夜都可以得到持续供应的能源。此外，通过抽象的推理，我确信，让电流在介质快速地流通似乎是可能的，那样会让能量以非常高的速率来流动。

Here, then, was an idea which, if realizable, afforded a happy solution of the problem of getting energy from the medium. But was it realizable? I convinced myself that it was so in a number of ways, of which one is the following. As regards heat, we are at a high level, which may be represented by the surface of a mountain lake considerably above the sea, the level of which may mark the absolute zero of temperature existing in the interstellar space. Heat, like water, flows from high to low level, and, consequently, just as we can let the water of the lake run down to the sea, so we are able to let heat from the earth's surface travel up into the cold region above. Heat, like water, can perform work in flowing down, and if we had any doubt as to whether we could derive energy from the medium by means of a thermopile, as before described, it would be dispelled by this analogue. But can we produce cold in a given portion of the space and cause the heat to flow in continually? To create such a "sink," or "cold hole," as we might say, in the medium, would be equivalent to producing in the lake a space either empty or filled with something much lighter than water. This we could do by placing in the lake a tank, and pumping all the water out of the latter. We know, then, that the water, if allowed to flow back into the tank,

would, theoretically, be able to perform exactly the same amount of work which was used in pumping it out, but not a bit more. Consequently nothing could be gained in this double operation of first raising the water and then letting it fall down. This would mean that it is impossible to create such a sink in the medium.

于是，有了这样的想法，如果能做得到，那么就为如何从介质中获取能量的问题提供了令人愉快的解决方案。但是，它真的能做到吗？我深信会有许许多多的方法，以下是其中一种。说起热量，我们来作个类比。假定我们是处于一个高海拔的地方，可以比作一个山顶上的湖，位于海面以上很高的地方，海拔高度标志着存在于星际空间的绝对零度。热量，像水一样，从高处流向低处，从而，正如我们可以让湖水流入海洋里一样，我们也可以让热能从地球表面上升到高处寒冷的地方。热能，像水一样，可以在流动的过程中做功。如果我们对利用热电堆（温差电堆）是否能够从介质中提取能量有任何疑惑，就象先前所述的那样，那么在此种类似情形下，疑惑也被消除。但是，我们是否能够利用其中一部分的特定空间来产生冷却，然后促使热能源源不断的流动呢？要在介质中创造这样一个“水槽”，或者“冷洞”，相当于在湖里制造一个空间，要么是真空，要么是装满一些比水轻得多的物质。我们可以做得到，在湖里放一个水箱，然后把里面的水完全抽出来。接着，我们得知，如果让水流回水箱里，从理论上说，能够得到与使用水泵把水抽走时完全相同的功，但不会得到更多。因此，先把水抽走，然后让它往下流的这种双重运作什么也得不到。那意味着要在介质中创造这样一个“水槽”是不可能的。

FIRST EFFORTS TO PRODUCE THE SELF-ACTING ENGINE•THE MECHANICAL OSCILLATOR•WORK OF DEWAR AND LINDE•LIQUID AIR.

制造自动引擎的首个成就•机械振荡器•迪尤尔和林德的工作•液化气体

Having recognized this truth, I began to devise means for carrying out my idea, and, after long thought, I finally conceived a combination of apparatus which should make possible the obtaining of power from the medium by a process of continuous cooling of atmospheric air. This apparatus, by continually transforming heat into mechanical work, tended to become colder and colder, and if it only were practicable to reach a very low temperature in this manner, then a sink for the heat could be produced, and energy could be derived from the medium. This seemed to be contrary to the statements of Carnot and Lord Kelvin before referred to, but I concluded from the theory of the process that such a result could be attained. This conclusion I reached, I think, in the latter part of 1883, when I was in Paris, and it was at a time when my mind was being more and more dominated by an invention which I had evolved during the preceding year, and which has since become known under the name of the "rotating magnetic field."

认识了这个真理以后，我开始想办法把我的想法实现。经过了长时间的思考，我最后构想出了一组机械设备，通过一系列的步骤把大气冷却，从而能够从介质中获取能量。这种设备，通过不断地把热能转变为机械功，使温度变得越来越低，如果能够用这种方法来制造出非常低的气温，那么一个装载热能的“水槽”便会产生，也可以从介质中得到能量。这似乎与卡诺特和开尔文爵士的观点相反，但我从整个过程中得出结论：这样的结果能够达到。我想，在 1883 年的下半年，我在巴黎的时候，每当我的头脑越来越多地被先前构想的发明所占据，我便得出这样的结论，自此以后它便以“转动式磁场”名字为人所知。

During the few years which followed I elaborated further the plan I had imagined, and studied the working conditions, but made little headway. The commercial introduction in this country of the invention before referred to required most of my energies until 1889, when I again took up the idea of the self-acting machine. A closer investigation of the principles involved, and calculation, now showed that the result I aimed at could not be reached in a practical manner by ordinary machinery, as I had in the beginning expected. This led me, as a next step, to the study of a type of engine generally designated as "turbine," which at first seemed to offer better chances for a realization of the idea. Soon I found, however, that the turbine, too, was unsuitable. But my conclusions showed that if an engine of a peculiar kind could be brought to a high degree of perfection, the plan I had conceived was realizable, and I resolved to proceed

with the development of such an engine, the primary object of which was to secure the greatest economy of transformation of heat into mechanical energy. A characteristic feature of the engine was that the work-performing piston was not connected with anything else, but was perfectly free to vibrate at an enormous rate. The mechanical difficulties encountered in the construction of this engine were greater than I had anticipated, and I made slow progress.

在随后的几年，我进一步地具体实现先前构想好的计划，还研究了它的运作状况，但几乎毫无进展。但是在这个国家里，对发明的商业引进耗费了我的大量精力，直至 1889 年，我才重新拾起自动机器的想法。最近对相关原理的研究和计算表明，用普通的机械，以实际的方式根本无法得到我期待的结果，跟我开始的时候想的一样。这导致我下一步去研究一种通常被称为“涡轮”的机器，它似乎更有可能实现我的想法。然而，我很快发现，涡轮同样也不适合。但是我的结论表明，如果有种特殊的发动机（引擎）是高度完美的话，那么我构想的计划便会实现。于是我下决心去发展这样的发动机，这个计划的首要任务就是确保以最经济的方式来把热能转化成机械能。发动机的一个显著特征就是活塞的做功无不与其它东西相关，而是完全能够自由地高速振动。在构建这种发动机中遇到机械方面的困难比我预期的要大得多，我的计划进展缓慢。

This work was continued until early in 1892, when I went to London, where I saw Professor Dewar's admirable experiments with liquefied gases. Others had liquefied gases before, and notably Ozlewski and Pictet had performed creditable early experiments in this line, but there was such a vigor about the work of Dewar that even the old appeared new. His experiments showed, though in a way different from that I had imagined, that it was possible to reach a very low temperature by transforming heat into mechanical work, and I returned, deeply impressed with what I had seen, and more than ever convinced that my plan was practicable. The work temporarily interrupted was taken up anew, and soon I had in a fair state of perfection the engine which I have named "the mechanical oscillator." In this machine I succeeded in doing away with all packings, valves, and lubrication, and in producing so rapid a vibration of the piston that shafts of tough steel, fastened to the same and vibrated longitudinally, were torn asunder. By combining this engine with a dynamo of special design I produced a highly efficient electrical generator, invaluable in measurements and determinations of physical quantities on account of the unvarying rate of oscillation obtainable by its means. I exhibited several types of this machine, named "mechanical and electrical oscillator," before the Electrical Congress at the World's Fair in Chicago during the summer of 1893, in a lecture which, on account of other pressing work, I was unable to prepare for publication. On that occasion I exposed the principles of the mechanical oscillator, but the original purpose of this machine is explained here for the first time.

这个工作一直持续到 1892 年，我来到了伦敦，见到了迪尤尔教授那美妙绝伦的液化气体实验。之前其它人曾经成功地把气体液化，尤其是奥兹韦斯基和皮斯特，已经在这一方面成功做过了早期实验，但是迪尤尔对这样的工作充满了干劲，使得这位老人看上去像年轻一样。他的实验，虽然异于我想象的，然而却表明，通过把热能转化成机械能来把气温降到非常低是可能的。我对自己所见到的留有非常深刻的印象。回去以后，我更加深信我的计划是能实行的。这项暂时被打断了的工作又重新展开。很快地，我想出了这种相当完美的发动机，取名为“机械振荡器”。接着，我成功地为这种机器摆脱了所有的包装、阀门和润滑油，使活塞产生了非常高频率的振动，坚硬钢铁做的、以相同的频率纵向地振动的轴承也被分离成碎片。籍着这种由特殊设计的发电机组合的引擎，我制造出一种非常高效率的电动机，由于振动频率保持不变，无法估计产生出的物理量，价值无法衡量。在 1893 年夏天的芝加哥国际电学大会开办之前，我展出过几类这样的机器，命名为“机械和电子振荡器”。在国际电学大会的演讲上，由于其它紧迫的工作，我无法为向公众公开作准备。在那个场合上，我解释了机械振荡器的原理，但这种机械的最初目的是在这里首次解释。

In the process, as I had primarily conceived it, for the utilization of the energy of the ambient medium,

there were five essential elements in combination, and each of these had to be newly designed and perfected, as no such machines existed. The mechanical oscillator was the first element of this combination, and having perfected this, I turned to the next, which was an air-compressor of a design in certain respects resembling that of the mechanical oscillator. Similar difficulties in the construction were again encountered, but the work was pushed vigorously, and at the close of 1894 I had completed these two elements of the combination, and thus produced an apparatus for compressing air, virtually to any desired pressure, incomparably simpler, smaller, and more efficient than the ordinary. I was just beginning work on the third element, which together with the first two would give a refrigerating machine of exceptional efficiency and simplicity, when a misfortune befell me in the burning of my laboratory, which crippled my labors and delayed me. Shortly afterward Dr. Carl Linde announced the liquefaction of air by a self-cooling process, demonstrating that it was practicable to proceed with the cooling until liquefaction of the air took place. This was the only experimental proof which I was still wanting that energy was obtainable from the medium in the manner contemplated by me.

从环境介质中提取能源的过程，就跟我起初构思的一样，是由五个基本要素相结合，每一个都被重新设计和完善，因为没有这样的机器存在。这种组合的首个要素是机械振荡器，把它完善以后，我转向了下一个要素，是设计一个空气压缩机，在某些方面与机械振荡器相似。在构建的过程中也遇到类似的困难，但是充沛的精力推动了工作的进展，在 1894 年底，我已经完成了这个组合里的两个要素，从而产生了一种压缩空气的机械，事实上能够压缩到任何想要的压力，相当简单、轻巧，比普通的更加有效。我开始着手设计第三项要素，再加上头两项要素，组成了一种制冷的机器，异常地有效率和简单。这时候不幸降临在我身上，烧毁了我的实验室，我的实验付诸一炬，也耽搁了我的进度。不久以后，卡尔•林德博士宣告成功地用自我制冷的过程把空气液化，演示了用冷却的方法让空气液化是可行的。这个实验唯一地证实了我仍然在想的用我预期的方式来从介质中获取能量。

The liquefaction of air by a self-cooling process was not, as popularly believed, an accidental discovery, but a scientific result which could not have been delayed much longer, and which, in all probability, could not have escaped Dewar. This fascinating advance, I believe, is largely due to the powerful work of this great Scotchman. Nevertheless, Linde's is an immortal achievement. The manufacture of liquid air has been carried on for four years in Germany, on a scale much larger than in any other country, and this strange product has been applied for a variety of purposes. Much was expected of it in the beginning, but so far it has been an industrial ignis fatuus. By the use of such machinery as I am perfecting, its cost will probably be greatly lessened, but even then its commercial success will be questionable. When, used as a refrigerant it is uneconomical, as its temperature is unnecessarily low. It is as expensive to maintain a body at a very low temperature as it is to keep it very hot; it takes coal to keep air cold. In oxygen manufacture it cannot yet compete with the electrolytic method. For use as an explosive it is unsuitable, because its low temperature again condemns it to a small efficiency, and for motive-power purposes its cost is still by far too high. It is of interest to note, however, that in driving an engine by liquid air a certain amount of energy may be gained from the engine, or, stated otherwise, from the ambient medium which keeps the engine warm, each two hundred pounds of iron-casting of the latter contributing energy at the rate of about one effective horsepower during one hour. But this gain of the consumer is offset by an equal loss of the producer.

跟普遍认为的一样，利用冷冻加工来把空气液化的技术并非偶然的发现，而是一种长期积聚的科学结晶，迪瓦尔的工作很可能不可缺少。我相信，在这醉人的进展中，很大程度上是归功于这位伟大的苏格兰人强而有力的工作。然而，林德取得的是不朽的成就。液化空气的制造在德国已经持续展开了四年，在更大的尺度上，比任何其它国家要先进。这种前所未知的产物已经运用于不同的目的。大多数人一开始的时候都对它充满了期待，就此范围来说，它已经成为了工业的“鬼火”。通过使用这样的机器，跟我改进的一样，

成本很可能会大大降低，但尽管如此，它商业上的成功也是令人质疑的。作为制冷，它是不经济的，因为没有必要把温度降到这么低。要让机件的主体部分维持非常低的温度，跟维持高温一样，是非常昂贵的；它需要利用煤炭来让空气保持低温。在氧气制造中，它也依然无法与电解的方法竞争。作为一种炸药来使用，它是不适合的，因为它的低温又使它只能以低效率来运作，它使用的动力决定了它的花费非常高。然而，它引起了人们的注意，促使一种由液态空气驱动的发动机诞生，所有的能量都可以从那种发动机中获取，否则的话，就是通过环境介质来使发动机保持运转。后者需要用二百磅的铁铸成，每部这样的发动机能够在一小时内以一有效马力的速度来提供能量。但是，消费者得到的这种收益也只是刚好弥补生产者的损失。

Much of this task on which I have labored so long remains to be done. A number of mechanical details are still to be perfected and some difficulties of a different nature to be mastered, and I cannot hope to produce a self-acting machine deriving energy from the ambient medium for a long time yet, even if all my expectations should materialize. Many circumstances have occurred which have retarded my work of late, but for several reasons the delay was beneficial.

我一直在努力做的大量工作，至今依然还继续进行。 大量机械方面的细节还有待完善，一些困难有待克服。即使我的所有期待都会在物质上实现，但我还依然不能够指望会产生一种自动机器，长久地从环境介质中获取能量。很多情况已经发生，把我的工作耽搁了，但是因为几个理由，我觉得这种耽搁是有益的。

One of these reasons was that I had ample time to consider what the ultimate possibilities of this development might be. I worked for a long time fully convinced that the practical realization of this method of obtaining energy from the sun would be of incalculable industrial value, but the continued study of the subject revealed the fact that while it will be

commercially profitable if my expectations are well founded, it will not be so to an extraordinary degree.

其中之一就是我有充足的时间来思考这种发展的最终可能是什么。我为此工作了很长时间，最后完全确信从太阳中获取能量的方法在工业上的价值是无法估计的，但是继续研究这个课题，发现如果我的期待是完全有根据的话，从商业利润的角度来看，它事实上是不那么有利可图的。

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