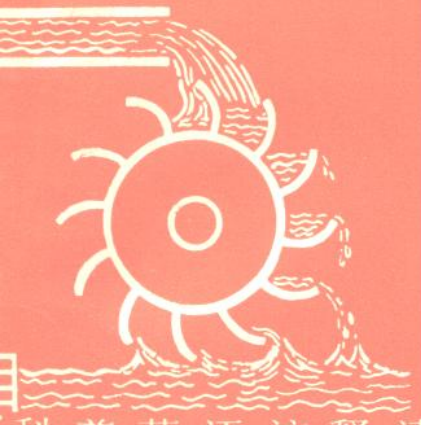
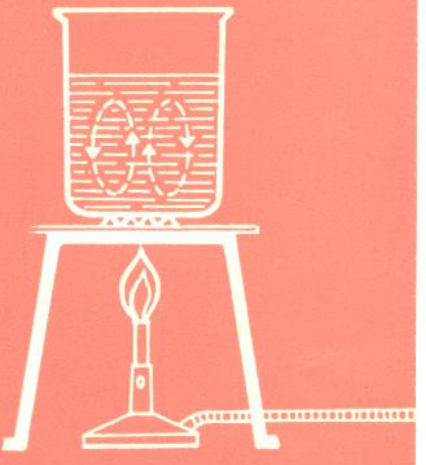


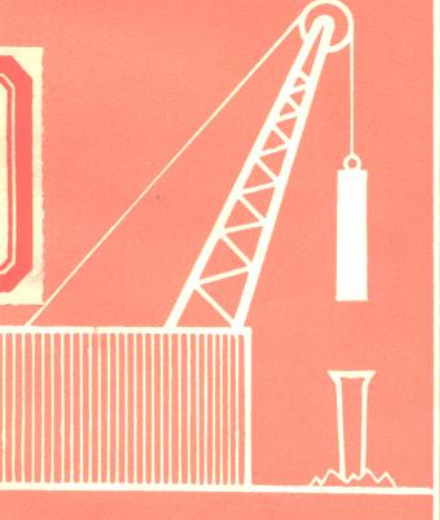


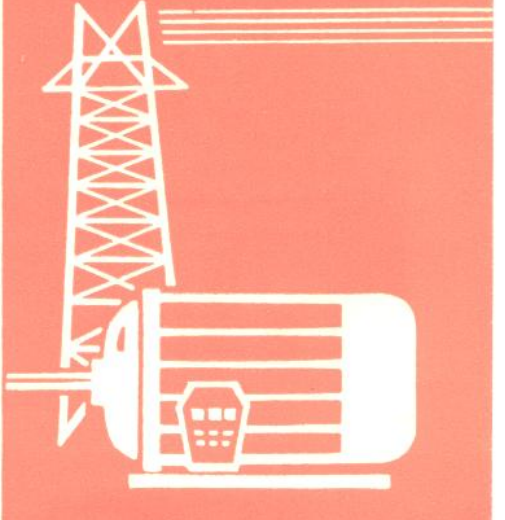
科普英语注释读物

ENERGY

能　量

〔英〕F.J.M.Laver





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〔英〕 F. J. M. Laver 著

清华大学外语教研组
课外读物注释小组 注释

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内 容 提 要

本书是一本英语科普读物，内容介绍关于能量的基本知识，包括能的各种形式、能量转化以及能与人类的关系等。我们对原书的个别段落作了删节。

本书文字浅近。为帮助读者阅读起见，每面正文下作了汉语注释，书末附有英汉对照词汇表。

本书可供学过一、二年英语的学生和相当程度的英语自学者阅读。

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CONTENTS

1. WORK AND ENERGY

WE live in a world of endless change and movement: the wind blows; rivers run; plants grow; and animals search for food. When things change, energy is used, and the larger the change the greater the amount of energy required.[1] We change things and move them about[2] as we work and play, by using our muscles to push and pull them. This gives us a feeling of effort that helps us to understand what is meant by 'a force'.[3] Forces make stationary things move,[4] and change the speeds of moving things.

When the handle of a basket is pulled upwards with a force strong enough to[5] overcome its weight, the basket starts to rise from the ground. The basket's weight is the force with which[6] gravity pulls it towards the centre of the earth, and forces are often measured in pounds-weight, usually written lb.-wt.[7] Thus, a force of 10 lb.-wt. is needed to lift a basket weighing 10 lb. A shop's scales may be turned by a force as small as $\frac{1}{4}$ oz. -wt.,[8] and a jet engine may thrust its aircraft

1 **the larger...the greater the amount of energy required:** 变化越大，所需要的能量也就越多. 2 **move them about:** 使它们来回地运动. 3 **what is meant by 'a force':** "力"指的是什么. 4 **make...move:** 使...运动. 5 **with a force strong enough to:** 以一个大得足以...的力. enough to 译为"足以(做)". 6 **with which:** 以这个力. 7 **are often measured in pounds-weight, usually written lb.-wt.:** 常常以磅(重)来计量，磅(重)通常写成 **lb.-wt.** 8 **a force as small as** $^1/_4$ **oz.-wt.:** 一个小到 $^1/_4$ 盎司(重)的力. oz. 为 ounce 盎司(衡)的缩写.

forward with a force as large as 20,000 lb.-wt.

The force of gravity is not exactly the same in every part of the earth: when a one-pound weight is weighed on an accurate spring balance it is found to weigh slightly more in some places than in others,[1] although two one-pound weights always balance each other on a pair of scales. Thus, a weight that weighed exactly 1 lb. on a spring balance in London, would be almost $\frac{1}{100}$ oz. heavier on the same balance in Aberdeen, and about $\frac{1}{20}$ oz. lighter at the equator. These differences are small enough to be neglected for ordinary purposes,[2] but it is not good enough to measure forces in lb.-wt. for the most accurate scientific work.

We often want to raise loads that are too heavy for our muscles to move,[3] and therefore many different kinds of lifting machine have been invented to help us. One of the oldest of these is the windlass, which is shown in Fig. 1[4] raising water from a well. The well rope is wrapped around a winding drum[5] and fastened to it. The drum is turned on an axle by a handle at the end of a long crank. Experiments show that the force needed on the handle is least when the crank is long and the drum is thin. In fact, the force on the handle is:

$$\frac{\text{(weight of the bucket and water} \times \text{Radius of winding drum)}}{\text{Length of the crank}}$$

---

1 **it is found to weigh slightly more in some places than in others:** 发现它(一个一磅重物)的重量在一些地方秤起来比在另一些地方稍重一些. 2 **for ordinary purposes:** 对一般的应用来说. 3 **loads that are too heavy for our muscles to move:** 我们的臂力难于举起的重物. "too...to +不定式" 意思是 "太...(以致)不". 4 **Fig. 1:** 图 1. Fig. 为 Figure (插图)的缩写. 5 **winding drum:** 缠索轮, 鼓轮.

For example, a full bucket might weigh 24 lb., and a convenient length of crank is about 18 inches. Hence, if the radius of the winding drum is 6 inches, the force needed to turn the handle is:

$$\frac{24 \text{ lb.-wt.} \times 6 \text{ in.}}{8 \text{ in.}} = 18 \text{ lb.-wt.}$$

When we wind up[1] a full bucket from a deep well we feel that we are working hard, and the heavier the bucket and the deeper the well the more work we feel we have done.[2] Engineers and scientists measure work by multiplying the force acting on a load by the distance it moves.[3]

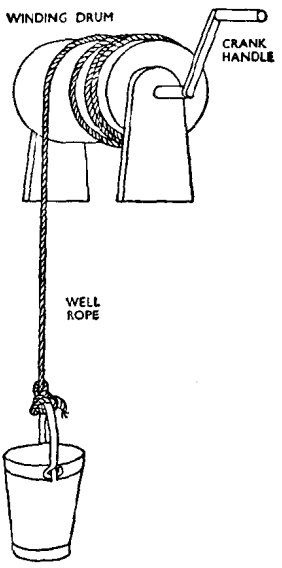

FIG. 1. *A windlass*

When a full bucket weighing 24 lb. is raised from a well 30 feet deep, the amount of work done is 30 ft. × 24 lb. = 720 ft. lb.[4]

This amount of work has to be done to raise the bucket, and we do not escape doing it by using[5] a windlass to reduce the force required. Thus, in our example, each turn of the handle turns the drum once, and so winds up a length of rope

---

1 **wind up:** 绞起，吊起. 2 **the heavier...and the deeper...the more work we feel we have done:** 水桶越重，井越深，那么我们感到我们所做的功越多. 当句中有三个 the...and the...the... 并列时，就要根据 and 的位置来判断三者的关系. 本句中 and 连接第一个 the... 和第二个 the...，因此译为"...越重，...越深，则...". 如果 and 连接第二个 the... 和第三个 the...，如 the..., the...and the..., 则译为"...越...，则...越..., ...也就越...." 3 **multiplying the force...by the distance it moves:** 把...的力乘以它所经过的距离. 4 **ft. lb.** = foot pound 呎磅. 5 **we do not escape doing it by using...:** 我们并不因为使用...而不用作这么多的功.

equal to[1] one wrap around the drum, that is[2] about 3 feet. Ten turns are needed to raise the bucket 30 feet (*see* Fig. 1). The handle at the end of the crank moves around a circle 18 inches radius, and so for each turn[3] the 8 lb.-wt. force acting on the handle moves about 9 feet. The work done in turning the handle round once is therefore 9 ft. $\times$ 8 lb. = 72 ft. lb., so that for the 10 turns needed to raise the bucket the work done would be $72 \times 10 = 720$ ft. lb., as before.

The windlass does no work for us: it simply allows us to choose to do the work by using a small force over a long distance, instead of[4] a larger force over a shorter distance. This is true of all such machines as levers, pulley blocks and tackles, and the jacks used to lift motor cars.[5] Indeed, all of these machines waste some work by friction between their moving parts. Many inventors have tried to make a machine that would give out more work than was put into it,[6] but we now know that such a 'perpetual motion' machine[7] cannot be made.

In calculating the work done in lifting a weight it is only the vertical distance travelled that matters.[8] Suppose that a hill is 300 feet high, with a steep slope of 1 in 5 on one side

---

1 **equal to:** 等于. 作定语说明 a length of rope. 2 **that is:** 即, 也就是. 3 **and so for each turn...:** 因此, 每绕一圈.... 4 **it simply allows us to choose...instead of...:** 它 (windlass) 只是便于我们选择作功的办法, 即用一个小力通过一段长的距离而不是(用).... 5 **This is true of all such machines as levers, pulley blocks and tackles, ... cars.** 这一点对杠杆、滑车组和滑车以及用来顶起汽车的千斤顶这样一类机械也是正确的. 6 **that would give out more work than was put into it:** 输出的功可以大于输入的功的(机器). 7 **'perpetual motion' machine:** 永动机. 8 **it is only the vertical distance travelled that matters:** 只有所通过的垂直距离才是有关紧要的. it is... that... 是强调句型, 此处强调名词 the vertical distance.

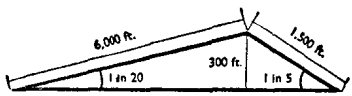

FIG. 2.

The same amount of work is done by the engine when the car climbs the hill, whether it climbs the gentle (1 in 20) or the steep (1 in 5) slope

and a gentle slope of 1 in 20 on the other,[1] as in Fig. 2. When a motor car climbs to the top of this hill it does not matter whether it travelled $(5 \times 300 \text{ ft.}) = 1500$ ft. along the steep road or[2] $(20 \times 300 \text{ ft.}) = 6{,}000$ ft. along the gentle slope, the same amount of useful work is done, namely: the amount needed to raise the car through 300 feet.

We have been using the word 'work' with a meaning which is rather different from that of ordinary speech.[3] When we stand still[4] holding a heavy basket in one hand we are doing no 'work', because although we are exerting a lifting force on the handle, this force produces no movement. This is surprising at first,[5] because holding a heavy basket would certainly make us feel tired. However, the basket might equally well have rested on a chair,[6] and we have done no useful work — produced no useful changes — by holding it. Again,[7] the amount of work done by a force on a load is the same whether the load

---

1 **with a steep slope of 1 in 5 on one side and...on the other:** 山的一边是一个陡坡，坡度是 1:5 (高:斜)，山的另一边是一个平缓的坡，坡度是 1:20 (高:斜). 2 **it does not matter whether...or...:** 无论是...，还是...，都无关紧要 (都没有关系). 3 **which is rather different from that of ordinary speech:** 这个意思颇不同于普通语言中 "work (工作)"的意义. that 用来代替前面提到的东西，以避免重复，此处 that 代替 meaning. 4 **stand still:** 一动也不动地站着. 5 **at first:** 最初，起先. 6 **the basket might... on a chair:** 这篮子完全同样可以是放在一张椅子上. might well... 译为 "完全可以". 7 **Again:** 还有，此外.

moves quickly or slowly: work equals distance multiplied by force, and time does not come into it.[1] The speed with which the work is done depends on the 'power' employed. In ordinary speech the words 'power' and 'force' have very similar meanings, but engineers and scientists use them with quite different meanings: force has been discussed above, and 'power' is described in Chapter 5.

The action of the windlass shows that when an object moves, it is the work done that measures how much change has taken place, rather than the force or the distance by themselves.[2] Energy is used when changes happen, and it is convenient to measure the amount of energy used by the amount of change, that is by the amount of work done. Indeed, the word 'energy' comes from two Greek words meaning 'in' and 'work'. Work and energy can both be measured in ft. lb., and energy is often said to be 'the capacity for doing work'.[3]

Forces are measured in lb.-wt. and work and energy are measured in ft. lb. in English-speaking countries. In European countries using the metric system, and for scientific work in all countries, forces are measured in grammes-weight or kilogrammes-weight,[4] and work and energy are measured in centimetre-gramme or metre-kilogramme units.[5]

---

1 **and time does not come into it:** (而功) 不包括时间在内. 2 **it is the work done that...by themselves:** 用以度量发生的变化有多大的是所作的功，而不是单独以力或距离来度量. rather than 译为"而不是". 3 **energy is often said to be 'the capacity for doing work':** (我们)经常说能是作功的能力. 句中 to be... 是主语补足语. 4 **grammes-weight or kilogrammes-weight:** 克(重)或千克(重). 5 **centimetre-gramme or metre-kilogramme units:** 厘米-克或米-千克这种单位.

2. ENERGY IN STORE

GRANDFATHER clocks[1] are often driven by heavy weights hanging from cords. As the clock ticks, its weights descend, and from time to time they have to be wound up again[2] by turning the handle of a small windlass. Work is done in winding up the weights, and the energy used to do it comes from the muscles of the man who turns the handle. This energy is stored in the raised weights, and as the weights descend their stored energy is slowly used to do the work of driving the clock. The energy stored in the weights is called 'potential energy',[3] because it makes it possible to do work.[4] Potential energy is rather like[5] money in the bank, which might be called potential purchases,[6] because it makes it possible for us to buy things. Work done corresponds to[7] money spent, that is to actual purchases.

Any object supported above the ground has a potential energy equal to the work done in lifting it to where it now is.[8] For instance,[9] in lifting a book weighing 2 lb. from the floor to a library shelf 6 feet high (6 ft. × 2 lb.)=12 ft. lb. of work is done, and this increases the potential energy of the book by 12 ft. lb.[10] If the book had been resting on a table,

---

1 **Grandfather clocks:** 落地式立钟，有摆的大座钟. 2 **from time to time they have to be wound up again:** 必须经常上(钟)弦. wound 为 wind 的过去分词. 3 **'potential energy':** 势能，位能. 4 **makes it possible to do work:** 使有可能作功. 句中 it 是引词，代替不定式 to do work. 5 **rather like:** 颇象. 6 **potential purchases:** 潜在的购买(力). 7 **corresponds to:** 相当于.... 8 **the work done...it now is:** 把该物举到它现在的位置时所作的功. 9 **For instance:** 例如. 10 **increases...by 12 ft. lb.:** 给...增加 12 呎磅(的能量). by 表示差额.

$2\frac{1}{2}$ feet high, instead of lying on the floor, the work done would have been ($3\frac{1}{2}$ ft.×2 lb)=7 ft. lb., and its potential energy would have increased by 7 ft. lb. only. But when it was resting on the table it already had a potential energy of ($2\frac{1}{2}$ ft.×2 lb.)=5 ft. lb. relative to[1] the floor (*see* Fig. 3). This example shows that the potential energy of a raised weight depends not only on how high it is, but also on how far it can fall.

A tennis ball weighs 2 ounces, that is $\frac{1}{8}$ lb., and when it is held 2 feet above the deck of an aircraft flying at 16,000 ft. above the ground, it has a potential energy of 2 ft.×$\frac{1}{8}$lb.=$\frac{1}{4}$ ft. lb. relative to the deck. But when it is resting on the deck its potential energy relative to the ground is 16,000 ft.×$\frac{1}{8}$ lb.=2,000 ft. lb. And, clearly, dropping it 2 feet to the deck would produce much less effect than dropping it 16,000 ft. to the ground.[2]

Although grandfather clocks are driven by weights, many modern clocks are driven by springs. Force has to be used to turn the key to wind a spring, and the work done by this force is stored as potential energy[3] in the spring. The stored energy is used gradually as the clockwork turns. It is often said

---

1 **relative to...**: 相对于...(来说)的. 2 **dropping it 2 feet...to the ground:** 使它(网球)下落二呎落到(飞机)舱板上所产生的效应，会比它下落16,000 呎落到地面上所产生的效应要小得多. dropping 是动名词，在句中作主语. 3 **is stored as potential energy...**: 作为势能而储藏(在...中).

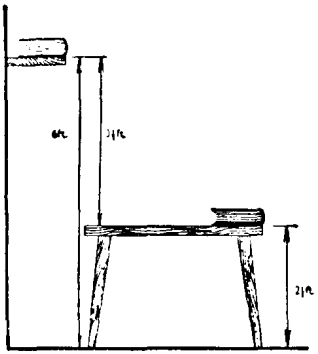

FIG. 3. *Potential energy*
A book weighing 2 lb. has a potential energy of (6 ft. × 2 lb.) = 12 ft lb. when resting on a shelf 6 ft. high, and (2½ ft. × 2 lb.) = 5 ft. lb. when resting on the table

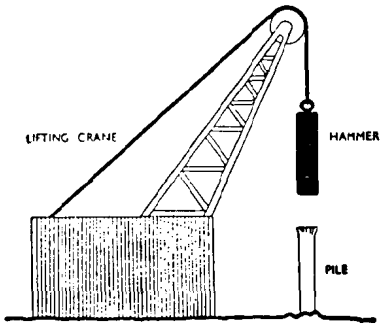

FIG. 4. *Pile driver*
The heavy hammer is lifted slowly by the crane, and is then dropped suddenly, hitting the pile and driving it into the ground

that[1] the energy stored in the spring drives the clock; this is true enough for ordinary purposes, but it is worth remembering that[2] it is forces that make things move, not energy.[3] It is the force exerted by the wound-up spring that drives the clockwork, and the work done by this force uses up[4] the spring's store of potential energy.

Men have known for many hundreds of years how to store and use energy. One of their earliest uses for stored energy was for working the weapons and traps they had made.[5] Thus, when an archer bends his bow he slowly stores energy in the springy wood, and when he releases the bowstring, this energy

---

1 **It is often said that...:** 人们常说.... it 是引词，代替由 that 引出的主语从句. 2 **it is worth remembering that:** 值得记住的是.... it 是引词，代替由 that 引出的主语从句. be worth + ing 意思是: 值得(做). 3 **it is... energy:** 使得物体运动的是力，而不是能. it is... that... 是强调句型. 4 **uses up:** 消耗尽.... 5 **was for working...they had made:** 是用于开动他们所制造的武器和夹兽机(的机关).

is used very quickly to speed the arrow in its flight. A more modern example, in which energy is stored slowly and used quickly, is the piledriver. A piledriver (*see* Fig. 4) is a machine for driving large steel or wooden beams into soft ground: these beams are called piles and are used to make a firm foundation for a building. The pile is driven by a very large hammer which is slowly lifted, and then dropped to strike a sudden heavy blow on the end of the pile. In other machines potential energy is stored quickly by working hard for a short time, so that it can be used slowly over a much longer time. An eight-day clock,[1] for example, can be wound in half a minute.

Sometimes potential energy is stored and used at the same rate,[2] as in the lift shown in Fig. 5. The lift cage and its counterweight hang from opposite ends of a steel rope which passes over a pulley at the top of the lift shaft.[3] As the lift rises, the counterweight falls through an equal distance. If the counterweight and the cage are equal in weight, then the work of lifting the cage can just be done by the potential energy given up by[4] the counterweight. The electric motor that turns the pulley has only to supply the small amount of energy needed to overcome friction. Of course, when passengers enter the lift, their weight is not balanced by the counterweight, and the motor then has to do the extra work needed to lift them; but it still does not have to do the much larger amount of work needed to lift the heavy cage.

It is very convenient to speak as if the potential energy of a raised weight were somehow stored inside the weight

---

1 **eight-day clock:** (上一次弦能走)八天的时钟. 2 **at the same rate:** 以同样的速度. 3 **lift shaft:** 升降机井. 4 **given up by:** 由...所释放的.

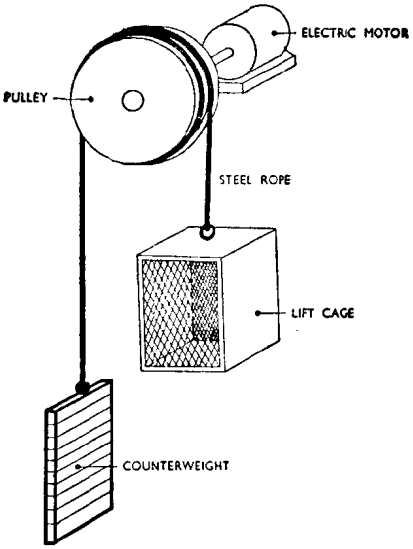

FIG. 5. *Electric lift*

The counterweight balances the weight of the lift cage, so that the electric motor does not have to lift the heavy cage, which greatly reduces the work it has to do

itself.[1] But, a weight held 10 feet above the ground is not noticeably different from the same weight held 3 feet above the ground, although it certainly has more potential energy. Energy is stored when a force is prevented from making something move,[2] for instance, when a weight is held up against[3] the force of gravity, or when a tightly wound spring is prevented from uncoiling. Therefore, strictly speaking,[4] it is the whole arrangement of a moving force and a checking force that stores potential energy.

---

1 **It is very convenient to speak... itself.** 很方便的说法是：一个被举起的重物的势能说成好象就是以某种形式储藏在这一重物本身之内似的. 2 **when a force is prevented from making something move:** 当一个力受到阻碍不能使某物运动时. 3 **is held up against:** 克服...而被举起. 4 **strictly speaking:** 严格地说.

3. ENERGY AND MOVEMENT

A BALL at rest on the ground has no surplus energy to give to other objects on or above the ground, and produces no changes in them, but when picked up and thrown[1] it can break a window or scatter a set of skittle pins.[2] The energy that an object has because it is moving is called its 'kinetic energy'.[3] The faster the object moves, and the heavier it is, the greater[4] is its kinetic energy. It is the kinetic energy of the wind that drives a windmill, and the kinetic energy of a fast motor car that does so much damage in a crash.

Flint axes, made by men who lived perhaps half a million years ago, are the earliest tools that have been discovered. With these simple implements early men were able to put the kinetic energy of a heavy piece of stone to work.[5] This discovery is ancient but it is not yet old-fashioned for,[6] although flint has been replaced by steel, the same principle is used in hand axes and hammers today. Hammers and axes work by using up their kinetic energy very rapidly to produce a large force acting over a very short distance. In other examples the kinetic energy is used more slowly. When a cyclist reaches the bottom of a steep hill he has a considerable amount of kinetic energy, and he can then freewheel for some time[7] using

---

1 **but when picked up and thrown...:** 但当把它(球)拾起并掷出时. 2 **a set of skittle pins:** 一套九柱戏的木柱. 3 **'kinetic energy':** 动能. 4 **The faster..., and the heavier..., the greater...:** ...越快,...越重,则...越大. (见 P. 3 注 2) 5 **put... to work:** 使...作功. 6 **for:** 因为. 这连接词引出的从句是 the same... today. 7 **freewheel for some time:** 滑行(不蹬车轮)一段时间.

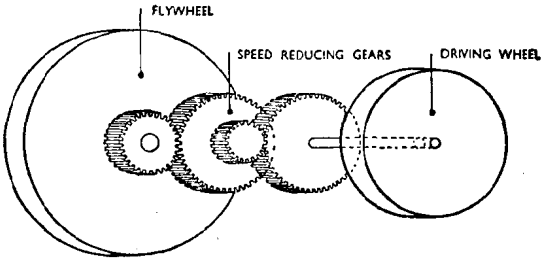

FIG. 6. *Push-and-go motor*

Push-and-go toys have a fly-wheel geared to their driving wheels. When the toy is pushed, the driving wheels turn the fly-wheel rapidly, through the gears. When the toy is released the kinetic energy stored in the fly-wheel turns the driving wheels and makes the toy go

this energy to work against the friction forces that slow him down.

Again, kinetic energy can be stored in a fly-wheel, and many kinds of 'push-and-go' toys[1] are driven by the energy of a small fly-wheel. The fly-wheel is geared down to the driving wheels,[2] as shown in Fig. 6, and when the toy is pushed the driving wheels spin the fly-wheel. Spinning the fly-wheel makes the toy harder to push and the extra work that has to be done is stored as kinetic energy in the fly-wheel. In the cheaper toys the fly-wheel is made of some plastic material, and as this is rather light,[3] the amount of kinetic energy stored is small, and the toy only goes for a short time. The same principle is used in a full-sized shunting engine called an electrogyro locomotive,[4] but its steel fly-wheel is large and weighs

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1 **'push-and-go' toys:** 一推就动的玩具. 2 **the fly-wheel is geared down to the driving wheels:** 飞轮一直联到主动轮上. 3 **as this is rather light:** 由于塑料制飞轮相当轻. 4 **a full-sized shunting engine called an electrogyro** [i'lektroudʒirə] **locomotive:** 一个实际尺寸的、称为电动回转轮蓄能机车的调车机车.