Feb. 26, 1963 C. E. SCHULTZ 3,079,535

VARIABLE STRENGTH PERMANENT MAGNETS

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Fig. 1.

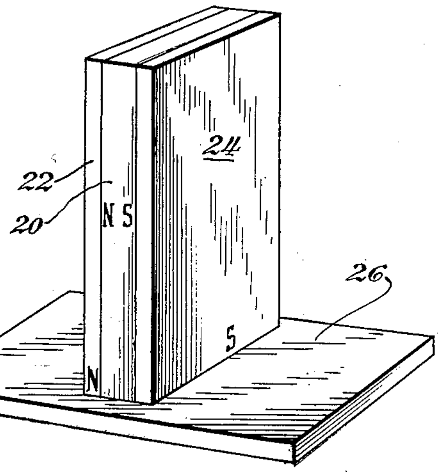


Fig. 3.

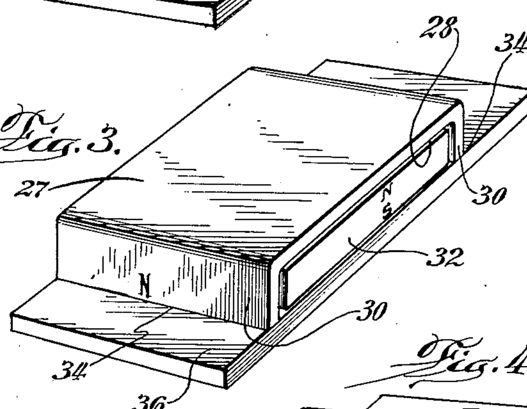


Fig. 2.

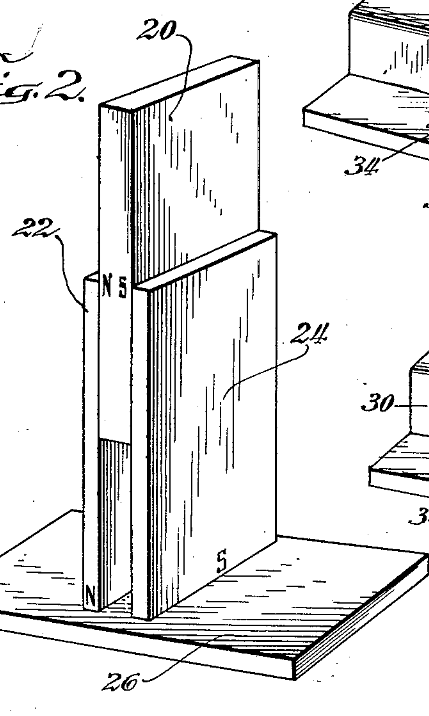
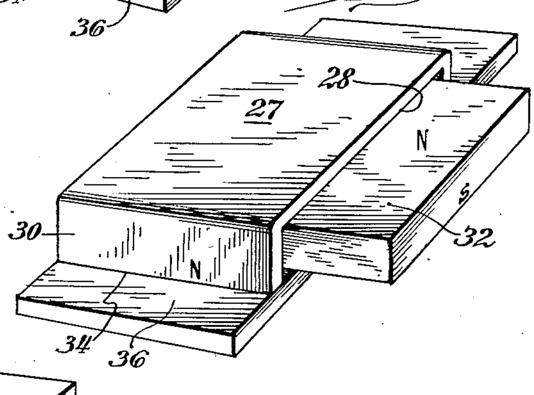


Fig. 4.



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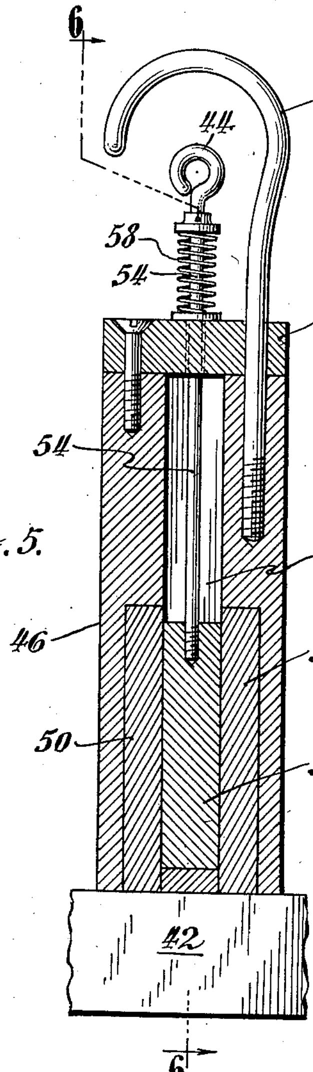


Fig. 5.

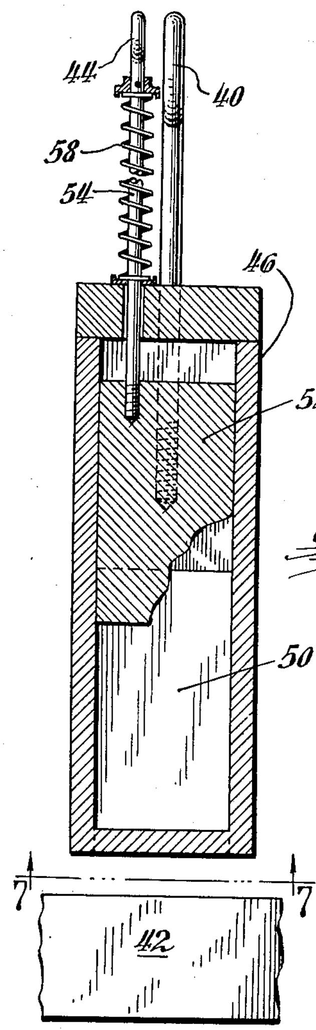
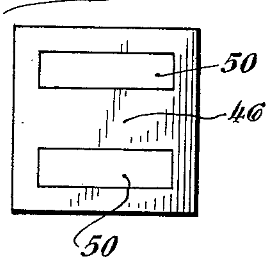


Fig. 6.

Fig. 7.



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VARIABLE STRENGTH PERMANENT MAGNETS

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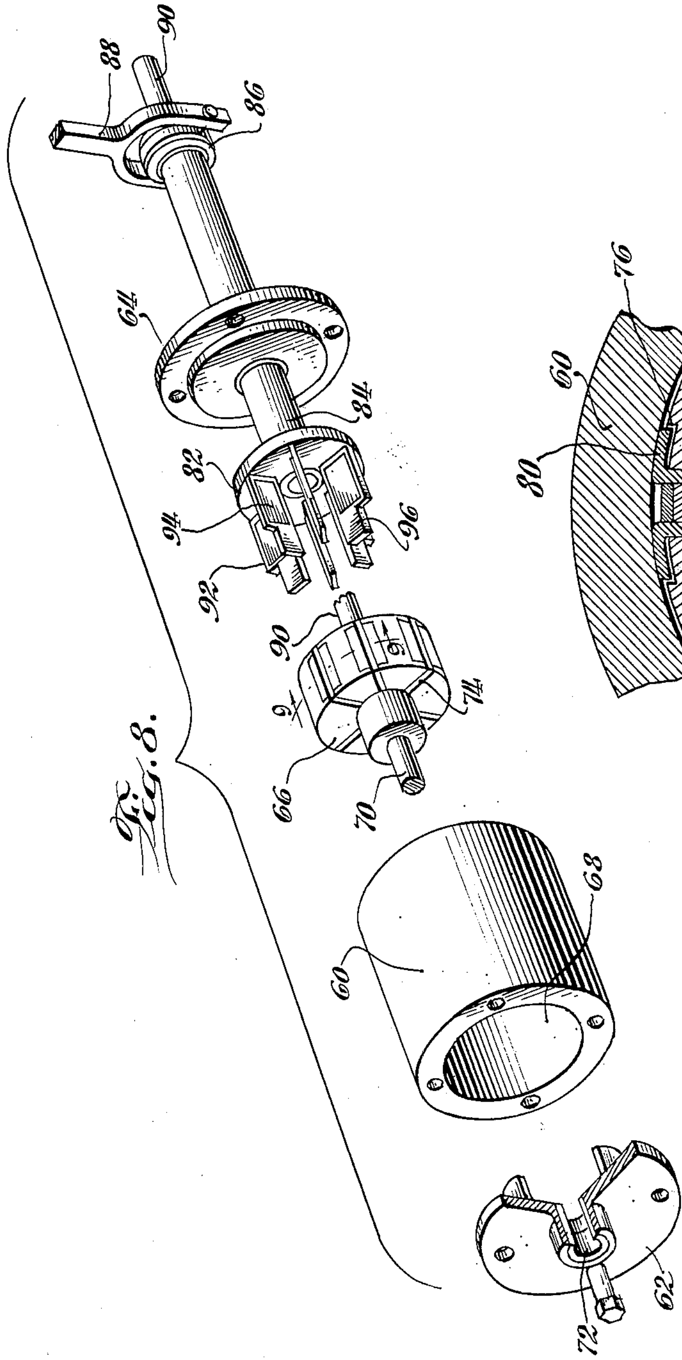

Fig. 8.

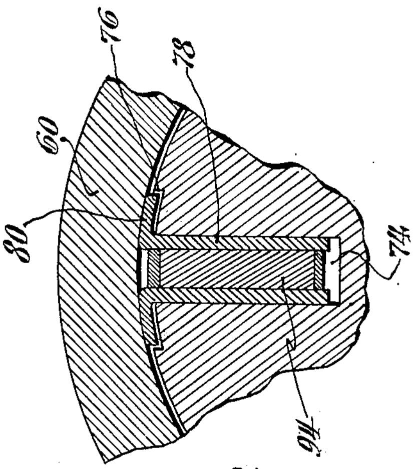

Fig. 9.

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VARIABLE STRENGTH PERMANENT MAGNETS

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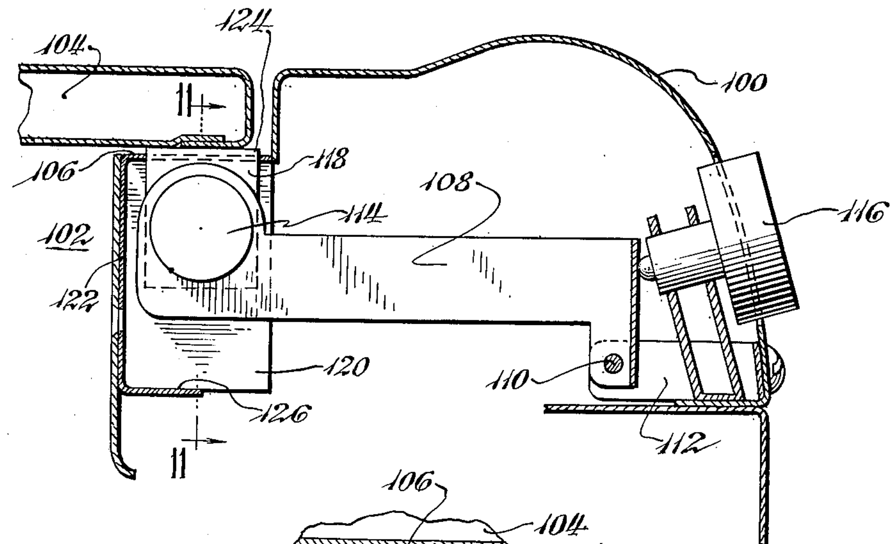
Fig. 10.



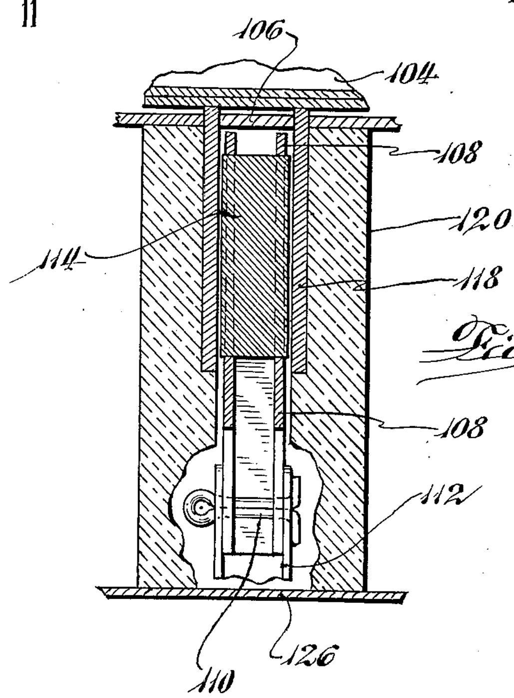


Fig. 11.

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United States Patent Office

3,079,535

Patented Feb. 26, 1963

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VARIABLE STRENGTH PERMANENT MAGNETS

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Filed Nov. 22, 1955, Ser. No. 548,327
3 Claims. (Cl. 317—201)

The present invention relates to permanent magnets and to various devices which include permanent magnets as elements thereof and this application is a continuation-in-part of my copending application Ser. No. 475,177, filed December 14, 1954, for "Releasable Magnetic Holder," and now abandoned.

It is an object of my invention to employ permanent magnets, particularly permanent magnets of a particular type as will appear, in a novel manner which greatly increases their efficiency and usefulness.

Yet another object is to provide a novel magnetic circuit of high magnetic induction which can be made or broken or varied in strength in an extremely simple fashion and by the application thereto of only an extremely small force.

Still another object is to provide a novel magnetic circuit which takes special advantage of the unusual properties of ferrite magnets of the alkaline earth ceramic type.

Yet another object is to provide a novel magnetic circuit which has special utility when it includes a magnetic slug or wafer having a very short length as compared with its pole face area.

Still another object is to provide a novel magnetic circuit which has special utility when it includes a magnetic slug or wafer having extremely high coercive force and relatively low residual induction.

Other objects and advantages will become apparent from the following description of a preferred embodiment of my invention which is illustrated in several alternative arrangements.

In the drawings:

FIG. 1 is a perspective view of a simple device illustrating a principle of operation of devices of the present invention;

FIG. 2 is similar to FIG. 1, but shows one of the elements thereof in an alternative position;

FIG. 3 is a perspective view of a simple device which may be considered as an alternative embodiment of the device of FIG. 1;

FIG. 4 is similar to FIG. 3, but shows one of the elements thereof in an alternative position;

FIG. 5 is a vertical medial sectional view of a releasable lifting magnet embodying principles of the invention;

FIG. 6 is a vertical sectional view which may be considered as taken substantially along the line **6—6** of FIG. 5 in the direction indicated by the arrows;

FIG. 7 is a bottom view of the lifting magnet of FIGS. 5 and 6 as indicated by the arrows along the line **7—7** of FIG. 6;

FIG. 8 is an exploded perspective view of a variable slip clutch embodying the present invention;

FIG. 9 is a fractional sectional view of a portion of the assembled clutch taken in the direction of the arrows so as to fall along the line **9—9** of FIG. 8;

FIG. 10 is a somewhat diagrammatic representation in vertical section of a portion of a sheet metal cabinet and cover showing a magnetic latch embodying the present invention in longitudinal vertical section associated therewith for holding the cover in closed position; and

FIG. 11 is a vertical transverse sectional view which may be considered as taken in the direction of the arrows substantially along the line **11** of FIG. 10.

Relatively recently a class of magnetic materials of

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high energy have become available which have rather unusual properties. These materials are ceramic in nature rather than metallic and are alkaline earth ferrites or ferramics. A typical substance of this nature is formed by sintering a mixture of ferric oxide and barium carbonate in an oxidizing atmosphere to obtain crystals which are finely ground, mixed with a binder, molded under high pressure to the desired shape and then reheated and cooled in a magnetic field since the materials are highly anisotropic. A magnetic material of this type is manufactured and marketed under the name "Indox" by The Indiana Steel Products Company, Valparaiso, Indiana, and has the general chemical formula $BaFe_{12}O_{19}$. Similar materials are prepared from ferric oxide and calcium oxide, or from ferric and ferrous oxides and cobalt oxide, the latter being known as Vectolite.

An unusual property of these magnetic materials is reflected in the fact that when in bar form the length of the bar can be extremely short as compared with the areas of the poles. For instance, a typical Indox magnetic bar or slug is $\frac{3}{16}''$ thick between the pole faces, and the pole faces, which are rectangular, have a width of $1\frac{5}{8}''$ and a length of $1\frac{13}{16}''$. The poles in this typical example therefore each have an area of almost 3 sq. inches whereas the distance between the parallel pole faces is $\frac{3}{16}''$. This relationship is more commonly expressed as the ratio of the length to the diameter of a circle having the same area as the pole faces. As the above example indicates, the l./d. ratio of magnets formed of these substances may be of the order of 0.1 which is of course extremely low. Although this ratio will vary somewhat with different magnetic slugs or wafers formed for different purposes, the figure given may be considered as typical.

The reason why this unusual ratio prevails is that these materials have an extremely high coercive force as compared with their residual induction. As an example, Alnico 5 has a coercive force of about 580 oersteds and a residual induction of about 12,000 gausses which is a numerical ratio of about 1 to 20. For Indox the equivalent figures are about 1600 oersteds and 2000 gausses, or about 4 to 5 which is 16 times as high. For Vectolite they are about 900 oersteds and 1600 gausses which is about 3 to 4. Similarly, the energy product of these materials is very low as compared with their coercive force and the permeability is extremely low. Furthermore, they do not readily form consequent poles or become appreciably demagnetized through treatment which would ordinarily be considered as abusive.

The properties of these ferramic materials are such that if one of the poles of an Indox slug **20** of the size and shape described above is brought against an iron or steel plate, the magnetic wafer can be pulled away by the application thereto of a force of only about ten ounces applied in a direction perpendicular to the pole face. I have discovered, however, that if a pair of iron plates **22** and **24** (FIG. 1) are put one each against the pole faces of this wafer **20** and a third plate **26** is attached to the aligned ends of this pair it will take a pull of about fifty pounds to separate the third plate **26** from the pair **22** and **24** in contact with the poles of the wafer **20**. Surprisingly enough, however, even with the third plate in place as in the above example, I have discovered that the magnetized wafer can be slid from between its pair of pole plates, as indicated in FIG. 2, by the application thereto of very little force, of the order of four ounces for instance, depending upon mechanical friction. Also important is the fact that the force needed to move the wafer is almost constant throughout its range of movement from completely in to completely out.

This ratio of the tractive force available when one of these wafers is equipped wtih pole pieces of low energy magnetic material, to the force required to remove the wafer, and in a practical sense to destroy the magnetic effect, is enormous and so far as I have been able to learn, this has never been recognized.

By the application of this discovery, permanent magnets, particularly of the ceramic type, can be made to perform most of the duties usually assigned to electromagnets, but without the use of an electric current. The efficiency of the operation is therefore greatly increased and the cost, and complexity thereof reduced. The similarity to electromagnets goes beyond simply turning off and on the magnetomotive force by removing and replacing a magnetic wafer in an appropriate magnetic circuit, which is similar to switching the current off and on to an electromagnet. In the same fashion that the current in an electromagnet can be varied in order to vary the magnetomotive force, so can the magnetomotive force of the magnet of the present invention be varied by shifting the magnetic wafer in the circuit to a position somewhere intermediate the completely in and the completely out position as shown in FIG. 2.

In the above example, for instance, the magnetomotive force can be varied gradually from that which will lift 50 pounds down to substantially zero by the application of a force of about four ounces acting to position the magnetic slug to a desired location within a range of movement which is considerably less than two inches. This four ounce control force, since it is remarkably constant and acts in one direction only (providing that the wafer is always pulled out in the same direction) can largely be counterbalanced, as by spring or gravity action, so that the control force required to position the magnetic wafer is almost nothing.

Shown in FIG. 3 is a generally similar arrangement which has proved to be highly advantageous and which illustrates a useful variation. In this simplified circuit a mild steel plate **27** has been bent downwardly at its ends and the ends finished so as to lie in the same plane. The flat central inside surface **28** is somewhat longer between the downturned portions **30** than is the width of the magnetic wafer **32**. The distance between the inside surface **28** and the plane of the ends **34** of the downturned portions **30** is slightly greater than the thickness of the wafer **32**. Now if the ends **34** are placed against a flat surface of an object of low energy magnetic material, such as the mild steel plate shown at **36**, and the wafer **32** is inserted into the loose fitting opening thus formed, the U-shaped member **27** will be held to the plate **36** by a force of the order of 50 lbs. or so, but the wafer **32** can be pulled out by the application thereto of a very small force (four ounces or so) as is indicated in FIG. 4.

In this circuit it will be noticed that one pole S of the wafer **32** attracts the plate **36** or its equivalent directly, whereas the other pole N is formed by the two ends **34** of the U-shaped member. Also, note that the wafer **32** floats in the space between the inside surface **28** and the surface of the plate **36**, since it is substantially equally attracted to each and mechanical friction is therefore reduced to incidental contact. Thus, no relatively movable members are held into firm engagement by magnetic attraction.

This circuit arrangement is extremely useful for simple magnetic chucks and avoids the usual complexity associated with such devices and furthermore there is no necessity for the use of special leverage compounding arrangements for applying a high order of force to shift portions of the magnetic circuit to release the object held to the chuck surface as is customary.

The important thing to be noticed here is that the magnetized wafer is free to move without substantial frictional engagement and that the wafer is formed so as to have a very large pole area and very short length (low l./d. ratio) of a material of extremely high coercive force as numerically compared with its residual induction, and that this wafer is used in a circuit of material of low magnetic energy which includes pole pieces which can substantially cover the pole faces of the wafer when in one position.

Referring now to FIGS. 5, 6 and 7, which illustrate a practical although simple embodiment of the principles just disclosed, this device may be considered as a lifting magnet for ferromagnetic materials. The lifting magnet is connected by a hook **40** to any convenient suspending and lifting means and the object to be lifted is represented by the block or plate at **42**. The control means, such as a line, for the magnet is connected to an eye **44** and is used for turning on and off or varying the tractive force as between the magnet and the member **42** to be lifted.

The lifting magnet includes a housing **46** formed of nonmagnetic material which is connected to the hook **40**. It is generally rectangular with a rectangular enclosed slot **48** therein. This slot is lined at each side at its lower end by iron pole-forming members **50**, the ends of which are flush with the lower end of the housing as is best seen in FIG. 7. Conveniently the housing can be cast with the members **50** as inserts in the mold. A magnetized wafer **52** of the type discussed above fits loosely into the slot **48** with its poles toward the plates **50**. It is proportioned so that it is free to slide upwardly approximately to the ends of the pole-forming members **50** or downwardly into a position completely therebetween as shown in FIG. 5.

The wafer **52** is connected to an upwardly extending control rod **54** which extends through the cover **56** for the housing and terminates in the eye **44** previously mentioned. By lifting the eye **44** upwardly the wafer **52** can be raised from a position between the pole pieces **50**, thereby substantially turning off the flux through these members so as to turn off the tractive force as between the lifting magnet and the block **42**. To attract the block **42** it is necessary merely to move the eye **44** downwardly to the position shown in FIG. 5.

Since ordinarily the wafer **52** will tend to seek the position shown in FIG. 5, both because of the gravity effect thereon and also because of the few ounces of tractive force tending to urge the wafer into this position, a coil spring **58** is shown surrounding the portion of the stem **54** above the cover **56** so as to tend to urge the control rod **54** in an upwardly direction.

From the previous discussion it will be apparent that by the application of a very small force to the eye **44** in either an upwardly or a downwardly direction, depending upon the strength of the spring **58**, the tractive force of the lifting magnet shown can be turned on or off, and that when in the "on" position the magnet shown will have a capability of lifting approximately fifty pounds of steel plate or the like if it is assumed that the wafer **52** is of the size previously discussed. By increasing the size of the device including the wafer **52**, or by using more than one wafer, the lifting ability of the magnet can of course be increased as desired.

A variable slip magnetic clutch or coupling is illustrated in FIGS. 8 and 9. This clutch includes an annular sleeve **60** formed of steel, which is provided with end caps **62** and **64**. A relatively rotatable drum **66** is loosely fitted to the cavity **68** within the sleeve **60** and has a shaft **70** coaxial therewith which extends outwardly through a bearing **72** in the center of the left hand end closure plate **62**.

The drum **66** has a plurality of radial rectangular slots **74** best seen in FIG. 9 which communicate at their outer ends with circumferentially extending grooves **76**. These grooves are quite shallow although considerably wider than the slots **74**. A generally L-shaped steel pole-forming member **78** extends into the slots **74** on each side thereof so as to provide a space therebetween, the upper ends of these pole-forming members being bent outwardly as at 80 so as to lie within the grooves 76. The outer faces of these out-turned portions 80 have a cylindrical contour to fit the inside surface of the sleeve 60.

A disc 82 is carried at the end of a quill shaft 84 which extends through the center of the right hand end plate 64. This shaft is adapted for rotational and sliding movement relative to the sleeve 60. The outward end of the quill shaft 84 is connected to a circumferentially grooved collar 86 adapted to be moved forwardly and backwardly by means of a fork 88 while permitting relative rotation as between the collar 86 and the fork.

The shaft 70 previously mentioned as being connected to the center of the drum 66, extends therethrough toward the right as at 90 so as to be piloted at the center of the quill shaft 84. If desired it may extend through the quill shaft so as to project, as shown, beyond the collar 86. A power coupling means connected to the end of the shaft 90 or to its counterpart 70 at the other end of the device rotates with the drum 66.

The disc 82 carries a plurality of longitudinally extending fingers 92 which are adapted to slide in an endwise direction in the spaces between the pole plates 78 in the drum 66. Each of these fingers is formed of non-magnetic material and carries a magnetized wafer 94 of the type previously described. The non-magnetic portion of these fingers extends sufficiently to the left of the wafers as is indicated at 96, so that as the fingers are moved within the slots in the drum 66 in an axial direction, the projections 96 are sufficient to prevent uncoupling as between these fingers and the drum 66 even though the disc 82 has been moved to the right sufficiently to withdraw the wafers 94 substantially completely from these slots.

In operation, one of the drive or driven members is connected to the drum 66 either by means of a connection to the shaft end 70 or to the shaft end 90. The other drive or driven member is connected to one of the end plates 62 or 64. When the magnetic wafers 94 are inserted all of the way into the drum 66, the pole pieces 78 will be magnetized and will be attracted against the inside surface of the sleeve 60. Rotation of one of the drive or driven members, therefore, transfers drive to the other member by way of the magnetically induced engagement between the outer surfaces 80 of the pole pieces 78 and the inside surface of the drum 60. As the fork 88 is moved so as to shift its lower end toward the right, the fingers 92 are withdrawn to any desired degree from the slots in the drum 66, thereby reducing the magnetic attraction of the pole pieces 78 for the inner surface of the sleeve 60. The torque transmitting capability of the coupling is therefore reduced until when the wafers 94 are all the way out of the slots between the pole pieces 78 substantially no drive is transmitted as between the drive and driven members. At any particular setting, the clutch will drive as a solid coupling until some torque level is reached. Thereafter it will slip while transmitting substantially constant torque. In operation, engagement, disengagement, and adjustment of the torque transmitting capability of the coupling is extremely easy since almost no effort is required to move the magnetic wafers.

In FIGS. 10 and 11 I have shown the invention as embodied in a latching mechanism. In this particular embodiment the latch has the purpose of holding the cover of an appliance, such as a washing machine for instance, in closed position until manually released.

The top front portion of the washing machine cabinet is indicated at 100. The top is open to give access to the inside as at 102 and this opening is closed by a sheet steel cover 104 which is spring loaded to open or partially open position. When in closed position, the cover rests around its periphery against a depressed ledge 106 so as to present a comparatively smooth top surface. Such construction is common and customarily a mechanical top latch is provided. These latches must be fitted rather closely and they release with a jar or shock which is rather unpleasant, particularly since it produces vibration and noise which causes reverberation of the cabinet sheet metal structure.

The latch shown holds the cover tightly and can be released completely silently and smoothly with a very light touch.

A horizontally extending arm 108 is bent from aluminum or other nonmagnetic sheet material and is pivoted as by a transverse cotter pin 110 to a bracket 112 secured to the cabinet structure near the front thereof. The opposite end of this arm carries a magnetic wafer 114 of the type previously mentioned so that the wafer swings upwardly and downwardly with the arm 108. The wafer when in the up position lies directly beneath the ledge 106. It may be secured to the arm in any suitable manner. As shown it is simply pressed into die cut openings in the end of the arm.

A release button 116 extends through an opening in the front of the cabinet and is so mounted that when it is pressed inwardly it engages a portion of the arm 108 above the pivot 110 and swings the free end of the arm downwardly.

When in the up position the magnetic wafer 114 is between, but spaced from, a pair of vertically oriented sheet iron pole pieces 118. These pole pieces 118 are secured in the faces of a pair of plastic blocks 120 which in turn are secured to an aluminum sheet metal partial case 122 through which the top ends 124 of the pole pieces 118 extend. The case 122 with the pole pieces and supporting structure therein is mounted to the cabinet structure so that the top of the case 122 is substantially flush with the ledge 106.

When the button 116 is pushed, the wafer 114 is swung downwardly so as to be almost completely out of the space between the pole plates 118 and such downward movement is limited by a portion 126 of the case which acts as a stop for the free end of the arm 108.

The device operates as follows: The slight tractive force acting between the magnetic wafer 114 and the pole pieces 118 is enough to cause the wafer so swing upwardly to the position shown. The plates 118 therefore act as the poles of a magnet and as soon as the cover 104 is closed it will be retained tightly by these magnet members.

Whenever the button 116 is lightly touched, the arm 108 and wafer 114 will be swung downwardly smoothly, thereby gradually decreasing the tractive force of the pole pieces 118 until the cover is released and swings upwardly, as soon as the button 116 is released, the tractive force of the wafer for the pole pieces 118 restores the wafer to the up position as shown.

From the above description of my discovery and of several representative embodiments thereof in various devices which have been illustrated and described for the purpose of clarifying the nature of the invention it will be seen that variations and modifications may be made without exceeding the scope of the invention. The scope of the invention is therefore to be measured by the scope of the following claims.

Having described my invention, what I claim as new and useful and desire to secure by Letters Patent of the United States is:

1. A magnetic device comprising: a thin wafer of alkaline earth magnetic ferrite ceramic material of extremely high coercive force, said wafer being magnetized so as to have opposite poles upon opposite large area surfaces thereof, a pair of magnet pole forming members of low energy magnetic material having a pair of faces separated by a distance sufficient to permit the insertion therebetween of said ceramic wafer but not substantially greater, said faces having opposed areas which substantially encompass said wafer large area surfaces when said wafer is between said pole faces, means for shifting the position of said wafer relative to said faces, and said magnet pole forming members being arranged to provide flux conducting elements of a magnetic circuit.

2. A magnetic device comprising: a thin wafer of alkaline earth magnetic ferrite ceramic material of high coercive force, said wafer being magnetized so as to have opposite poles upon opposite large area surfaces thereof, a pair of magnet pole forming members of low energy magnetic material having a pair of faces separated by a distance sufficient to permit the insertion therebetween of said ceramic wafer but not substantially greater, said faces having opposed areas which substantially encompass said wafer large area surfaces when said wafer is between said faces, means for inserting said wafer between said faces and for removing said wafer therefrom, said magnet pole forming members being arranged to provide flux conducting elements of a magnetic circuit.

3. A magnetic device comprising: a thin wafer of high energy magnetic alkaline earth ferrite ceramic material, said wafer having a l./d. ratio of less than 0.5, said wafer being magnetized so as to have opposite poles upon opposite large area surfaces thereof, a pair of magnet pole forming members of low energy magnetic material having a pair of faces separated by a distance sufficient to permit the free insertion therebetween of said ceramic wafer but not substantially greater, said faces having opposed areas which substantially encompass said wafer large area surfaces when said wafer is between said faces, means for altering the position of said wafer with respect to said faces, said magnet pole forming members being arranged to provide flux conducting elements of a magnetic circuit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,286,238	Simmons	June 16, 1942
2,346,193	Simmons	Apr. 1, 1944
2,715,109	Albers	Aug. 9, 1955