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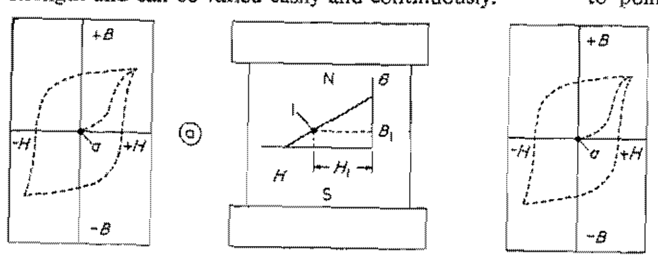
# *Permanent-Magnet Circuit using a "Flux-Transfer" Principle*

By R. J. Radus*

**As described in this article, a new magnetic circuit utilizes a special "flux-transfer" principle, in which a permanent magnet creates, without applied energy, a magnetic field which can be of any desired strength and which can be varied easily and continuously.**

Permanent magnets, as normally used for holding applications, have the inherent disadvantage that they cannot be controlled. Now, however, a new magnetic circuit, using a "flux-transfer" principle, makes it possible to utilize permanent magnets which differ from conventional permanent magnets in a number of important respects. Thus, the magnet can be made to exert a powerful magnetic force at one end and hardly any force at the other, while the strong and weak magnetic poles can be switched end-to-end, as desired, thereby turning, in effect, the magnetism on and off. Furthermore, the magnet has a "memory" which enables it to remember indefinitely its direction of greatest magnetic pull. As with any other permanent magnet, no applied energy is required to create a powerful magnetic field but, as in the case of an electromagnet, the field can be of any desired strength and can be varied easily and continuously.



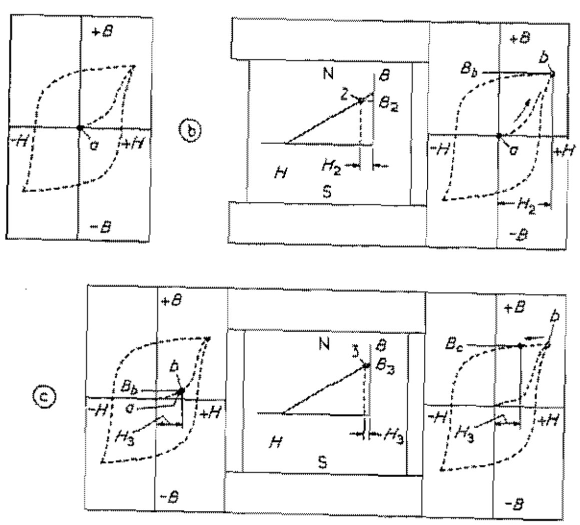




Fig. 1. Magnetic characteristics of the circuit, (a) with no keeper in position, (b) with one keeper in position, and (c) with both keepers in position.

The circuit is basically in the form of a sandwich, in which the middle layer is a ceramic magnet with its direction of magnetization through the thickness of the sandwich. The two outer layers are thinner pole pieces of soft steel, which act as magnetic "funnels" to concentrate the magnetic lines of force into the end areas, the circuit being completed by two soft-steel pieces, or keepers, one at each end.

Before either of the keepers is put into position, it will not be influenced by the permanent magnet and will therefore have zero flux density, as indicated in Fig. 1a by the points *a* on the hysteresis loops drawn within the outline of the keepers. For this condition, the permanent magnet is operating at point 1, so that the magnet supplies a magnetizing force $H_1$ in the air around the magnet and, because of this magnetizing force, a magnetic flux $B_1$ flows from one pole piece, through the air, to the other pole piece. If one of the keepers is now positioned at the edge of the sandwich magnet, as shown in Fig. 1b, the flux density in this keeper will increase from point *a* to point *b*, while the operating point of the magnet changes to point 2. It may, in this case, be assumed that most of the magnetic flux $B_2$ flows through the keeper, in which it produces a flux $B_b$. To produce this flux in the keeper requires a magnetizing force $H_2$ from the magnet and this is shown as the corresponding value $H_2$ on the demagnetizing curve in Fig. 1b, this being a steady-state condition.

If the other keeper is also put into position, as shown in Fig. 1c, it causes changes in the permanent magnet, in the first keeper put into position, and also in itself. The change in the permanent magnet results in a new operating position being established at point 3, while the amount of flux emanating from the magnet is now $B_3$ and the magnetizing force available to the parallel combination of the two keepers is now reduced to $H_3$. In the first keeper, this reduction in the magnetic force to a value of $H_3$ permits the flux to relax to point *c* at a magnetic induction of $B_c$, while the magnetizing force in the second keeper rises from its original value of zero to $H_3$. As a result, the flux in the second keeper increases along the hysteresis loop to point *b* in Fig. 1c, corresponding to a value of $B_b$.

The difference between the magnetic induction $B_c$ in the first keeper and $B_b$ in the second keeper is the basis of the "memory" mechanism of the device, which is thereby enabled to retain indefinitely an unbalance of magnetic induction between the parallel paths as a function of previous control. It should be noted that control can be effected manually or electrically. In the latter case, the basic sandwich model described is modified by extending the pole pieces to accommodate control windings.

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