PATENT SPECIFICATION

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(19)

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(54) MAGNETIC BUBBLE DEVICE PACKAGE

(71) We, INTERNATIONAL BUSINESS MACHINES CORPORATION, a Corporation organized and existing under the laws of the State of New York in the United States of America, of Armonk, New York 10504, United States of America do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a magnetic bubble device package, for generating a rotational magnetic field.

A rotating magnetic field is a preferred method for propagation of magnetic bubbles in a magnetic bubble memory package. Customarily, this rotational magnetic field is generated using flat coils or stripline coils, one mounted on top of the other, but physically displaced 90° relative to each other, and are driven by a sinusoidal or triangular current with appropriate phase shift of 90° at a frequency of between one hundred kilohertz and one megahertz to provide the desired inplane rotational field. A typical example of such a rotational field generation package is found in the bubble devices described in the article entitled "Reflection Coil Packaging for Bubble Devices" by Masaki Takasu, Harumi Maegawa, Toshiaki Sukeda and Kazuo Yamagishi of the Fujitsu Laboratories, Ltd., Kawasaki, Japan, which was published in the IEEE Transaction on Magnetics, Volume MAG-11, Number 5, September 1975. In this package, the structure uses an upper pair of flat coils and a lower pair of flat coils, each pair being oriented orthogonal to each other. Then, by selectively varying the phase and magnitude of the current's pulse through the respective coils, an effective rotating magnetic field is produced between the pairs in the area containing the bubble memory chips. A primary difficulty encountered with these and similar prior art bubble memory coil packages are that the coils are expensive, space consuming and quite often hard to assemble. They may exhibit relatively high inductances which complicate operations at high frequencies. In addition, special high-power circuits are needed to meet the start/stop requirements of the systems without overshoot or ringing occurring, and to contain inherent high over-voltages. Generally, rather elaborate shielding of the drive lines, circuitry and coils to protect the sensitive bubble sense circuits is also required.

It is also quite important that the coil characteristics be closely matched and carefully controlled. This becomes especially difficult in that for each pair, one of the coils is further removed from the active zone of the bubble memory chips than the companion coil and therefore to provide the same effect on the rotational magnetic field, its design and/or control compensation must be carefully managed to accomplish the desired magnetic field effects.

According to the invention there is provided a modular assembly for magnetic bubble devices, comprising, first and second conductive discs, each having a plurality of contact points positioned around its circumference, said discs being arranged with their flat faces facing one another and said magnetic bubble devices being disposed betwen said conductive discs, and current switching means operative to sequentially establish electrical currents between selected pairs of said contact points on each of said discs with each current in said first disc being of approximately equal magnitude, but opposite in direction to the respective current in said second disc to thereby establish a uniform rotating magnetic field between said discs to propagate magnetic bubbles in said devices.

Embodiments of the invention utilize the fact that the magnetic field between two flat, closely spaced conductors is perpendicular to the current in the conductors which is parallel to the flat surfaces of the conductors and is homogenous between the two conductors as long as the width of the conductors is substantially greater than the spacing therebetween. Each conductor consists of a thin, solid conductive disk with a number of current contact points around its periphery. The rotation of the current is accomplished over a full 360° by consecutively advancing the current injection/extraction at contact points around the periphery. With a large enough number of contact points, a uniform field density is achievable over a relatively large centre area.

In order that the invention may be more readily understood, reference will now be made, by way of example, to the accompanying drawings, in which:

FIG. 1 is a cross-sectional view of an assembled bubble device package with the rotational field generation means embodying the present invention;

FIGS. 2-4 are top views, partially in schematic, of a disk current generator with discrete current contact points effective to generate a rotational magnetic field embodying the present invention;

FIG. 5 is a schematic diagram of a drive circuit operative to be used with the disk current generators of FIGS. 2-4; and

FIG. 6 is a partial schematic diagram showing connections of drive circuitry to a disk current generator embodying the present invention.

Referring first to FIG. 1, the bubble memory package includes a pair of oppositely disposed conductive disks 11, 13 with bubble memory devices 15, 17 attached to disk 11 via an insulative member 19 and bubble memory devices 21, 23 attached to disk 13 via insulative material 25. The lower surface 27 of insulator 19 and the upper surface 29 of insulator 25 will include appropriate circuitry (not shown) which will enable signals, power, etc. to be sent to and derived from the bubble memory devices 15, 17 21 and 23. The package will include additional shielding material, enclosures, magnetic biasing members, etc. as shown in the aforementioned publication in the IEEE Magazine and as shown in UK Patent 1 531 116.

Referring next to FIGS. 2-4, there is shown a sequential current switching mode of operation which has the effect of providing a rotational electric field across the surface of the disk, which will in turn effect a rotational magnetic field in the space 31 of FIG. 1 between the two disks and approximate the surfaces of the magnetic bubble memory devices 15, 17, 21 and 23. As seen in FIG. 2, there are a number of current injection points 33, 35, 37, 39, 41, 43, 45 and 47. Attached to each of the signal injection points is a respective control member 53, 55, 57, 59, 61, 63, 65 and 67. Illustrated in FIG. 2, control members 67 and 55 are gated such that current will flow as indicated by the lines between injection point 47 and point 35. Similarly, control members 65 and 57 are gated to yield a current flow between injection point 45 and point 37 and control members 63 and 59 are gated to yield a current flow between point 43 and point 39. In the next sequence shown in FIG. 3, the switching points have been changed so that devices 53 and 57 are selectively activated to provide a current path between points 33 and 37; devices 67 and 59 are activated to provide current paths between points 47 and 39; and, devices 65 and 61 are activated to provide current paths between points 45 and 41. Then, in the next sequence shown in FIG. 4, the devices 55 and 59 are activated to provide current paths between points 35 and 39; devices 53 and 61 are activated to provide current paths between points 33 and 41; and devices 67 and 63 are activated to provide current paths between points 47 and 43. Therefore, in the sequence occurring from FIG. 2 to FIG. 4, the current path across the surface of the disk has been rotated by 90°. By continuing the selective activation of the control devices, the surface currents can be continually rotated through an effective 360° pattern.

The switching circuit devices, shown as "black boxes" in FIGS. 2-4, being operative to produce the rotational field can utilize any switching device which provides the desired speed, space, power dissipation and control necessary to affect the rotational electric field. Solid state switches, possibly combined with an amplified and selection circuitry, would be appropriate or in the alternative thyratron type semiconductor switches can be used. A particular circuit arrangement is shown in FIG. 5 which uses a pair of oppositely poled SCR devices as the switching apparatus. As illustrated, SCR 71 has its anode connetced to the lead going to an injection point under the control of its gate 73 with the input being applied at terminal 75 to the SCR cathode. The oppositely poled SCR 77 has its cathode connected to the lead going to the injection point and its anode connected to an output terminal 79 under the control of a gate 81. A more specific implementation of the circuit of FIG. 5 is illustrated in FIG. 6. For simplicity, the controls going to only two injection points are illustrated but it will be understood that similar pairs will be connected to the remaining injection points. In FIG. 6, the injection point 45 is connected to the anode of SCR 83 and to the cathode of SCR 85. The cathode of SCR 83 is connected to a terminal 87 going to a suitable source of energizing potential. SCR 83 is adapted to receive suitable control signals at its gate 89 and similarly, SCR 85 is adapted to receive suitable control signals at its gate 91. The anode of

SCR 85 is connected to a suitable return signal potential via terminal 93. Similarly, injection point 37 is connected to the cathode of SCR 101 and to the anode of SCR 103 with their respective gates 105 and 107 under the control of suitable gating pulses. The cathode of SCR 103 is connected via terminal 109 to a suitable source of energizing potential and the anode of SCR 101 is connected via terminal 110 to a suitable source of return potential.

In order to generate a unidirectional signal across the surface of the disk 12 between points 45 and 37, one of each pair of the SCRs in the control devices 65 and 57 are selectively activated. For example, to provide a unilateral signal current running from point 45 to point 37, a suitable gating pulse is applied to the gates 89 of SCR 83 and a similar gating pulse is applied to the gate 105 of SCR 101. Simultaneously, a suitable potential is applied between the terminal 111 going to the anode of SCR 101 and terminal 87 going to the cathode of SCR 83. This can be in the form of a predetermined pulse amplitude of proscribed duration which will therefore induce a unilateral current going from injection point 45 to point 37 and provide the desired current and resultant magnetic field. To reverse the current by 180°, SCRs 103 and 85 are activated in the same fashion, but with reversed polarities applied to the terminals 93 and 109.

In this fashion by selectively controlling the gates of the switching devices connected to the various signal injection points on the periphery of the conductive disk 12, a rotational electrical field with the incident rotational magnetic field is generated.

The generator makes use of the fact that the magnetic field strength between two flat, closely spaced conductors is perpendicular to the current in the conductor, parallel to the flat surface of the conductor and homogenous between the two conductors, so long as the width of the conductor is very much greater than the spacing between the conductors. For example, referring back to FIG. 1, it is apparent that the spacing between the disk 11 and 13 is very much smaller than the width of the two conductors. In order to reduce skin effects in the system, the thickness of the disk will be on the order of a few mils thick.

With the configuration of FIG. 1, the current switching devices are activated in such a manner that the currents through disk 11 are substantially equal in magnitude, but opposite in direction to the currents in disk 13. Therefore, as the currents are switched by sequential rotational activation, they produce substantially the same effect as a rotating field coil generating the rotational magnetic field in the plane of the bubble memory devices. The rotational uniformity of the magnetic field can be increased by increasing the number of current contact points around the circumferences of the disks.

Several disk/bubble-memory layers can be stacked on the top of one another, providing a compact package design with a maximum containment of the magnetic fields, with an efficient use of the drive current and high volumetric memory capacity.

In order to produce a uniform field of between 30 and 50 oersted, for example, between the disks 11, 13, a current of about 24 to 40 amperes per centimetre disk diameter has to flow through each disk. However, this current is distributed among the switching devices that are on at any one time and each device switches on and off once during each rotational period with a proscribed duty cycle. Obviously since the total amount of current stays constant, several disks can be connected in series and stacked, since the power supply has to deliver a d.c. current only.

Although a particular embodiment has been shown and described, it will be understood that certain changes can be made depending on system requirements or design preference. For example, an increase in the number of injection points and the integration of the switching components on a semiconductor layer attached to the conductor are examples of such changes. Also, it may be possible in a given system configuration to use only one conductive disk to generate the desired rotational field, effectively replacing the second conductive disk with a suitable reflection plate.

WHAT WE CLAIM IS:—

1. A modular assembly for magnetic bubble devices, comprising, first and second conductive discs, each having a plurality of contact points poistioned around its circumference, said discs being arranged with their flat faces facing one another and said magnetic bubble devices being disposed between said conductive discs, and current switching means operative to sequentially establish electrical currents between selected pairs of said contact points on each of said discs with each current in said first disc being of approximately equal magnitude, but opposite in direction to the respective current in said second disc to thereby establish a uniform rotating magnetic field between said discs to propagate magnetic bubbles in said devices.

2. An assembly as claimed in claim 1, in which said devices are mounted on both of said disc on their flat surfaces facing one another.

3. An assembly as claimed in claim 1, including a third similar disc, and magnetic

bubble devices disposed between said second and third discs, said third disc having a like plurality of contact points positioned around its circumference and said switching means being operative to sequentially establish electrical currents between selected pairs of said contact points on said third disc with each current in said third disc being of approximately equal magnitude, but opposite in direction to the respective current in said second disc.

4. A modular assembly substantially as described herein with reference to Figures 1, 2, 3 and 4 or Figures 5 and 6 of the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

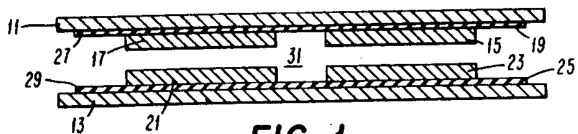

FIG. 1

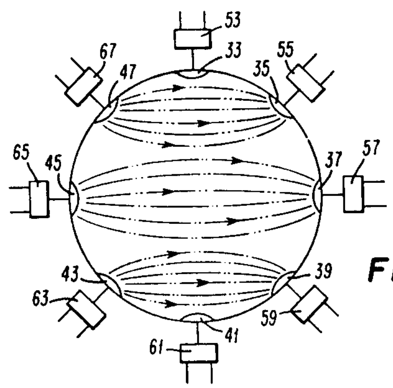

FIG. 2

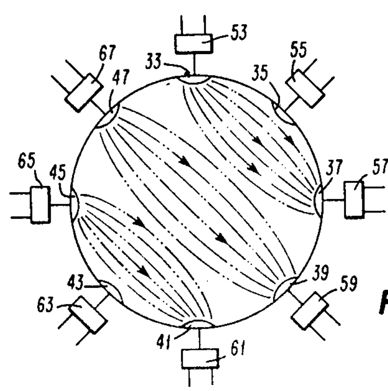

FIG. 3

1583903 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

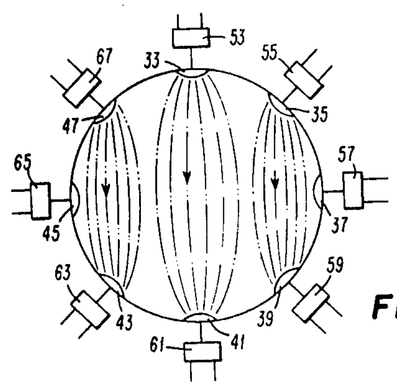

FIG. 4

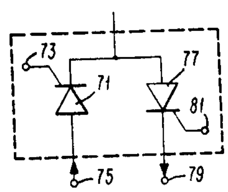

FIG. 5

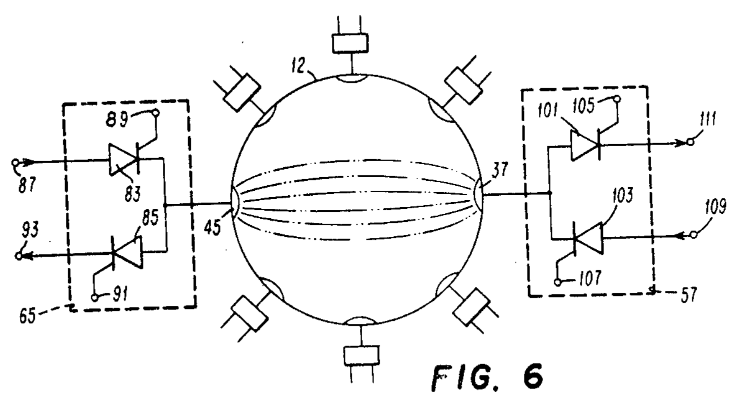

FIG. 6