Aug. 8, 1961 J. P. SWEENEY 2,995,731

WIRING ARRANGEMENT FOR SHIFT REGISTER EMPLOYING MAGNETIC CORES

Filed Feb. 17, 1960 2 Sheets-Sheet 1

FIG. 1

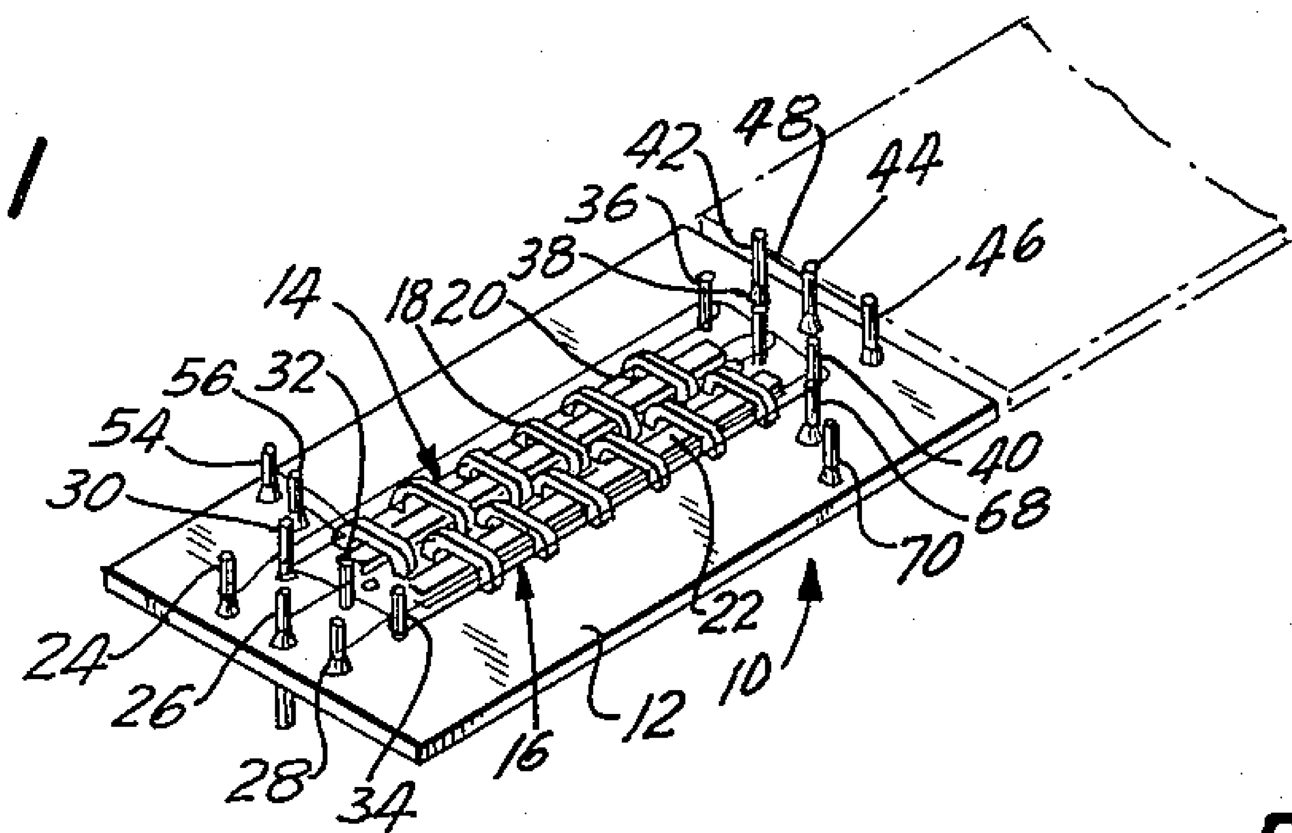


FIG. 2

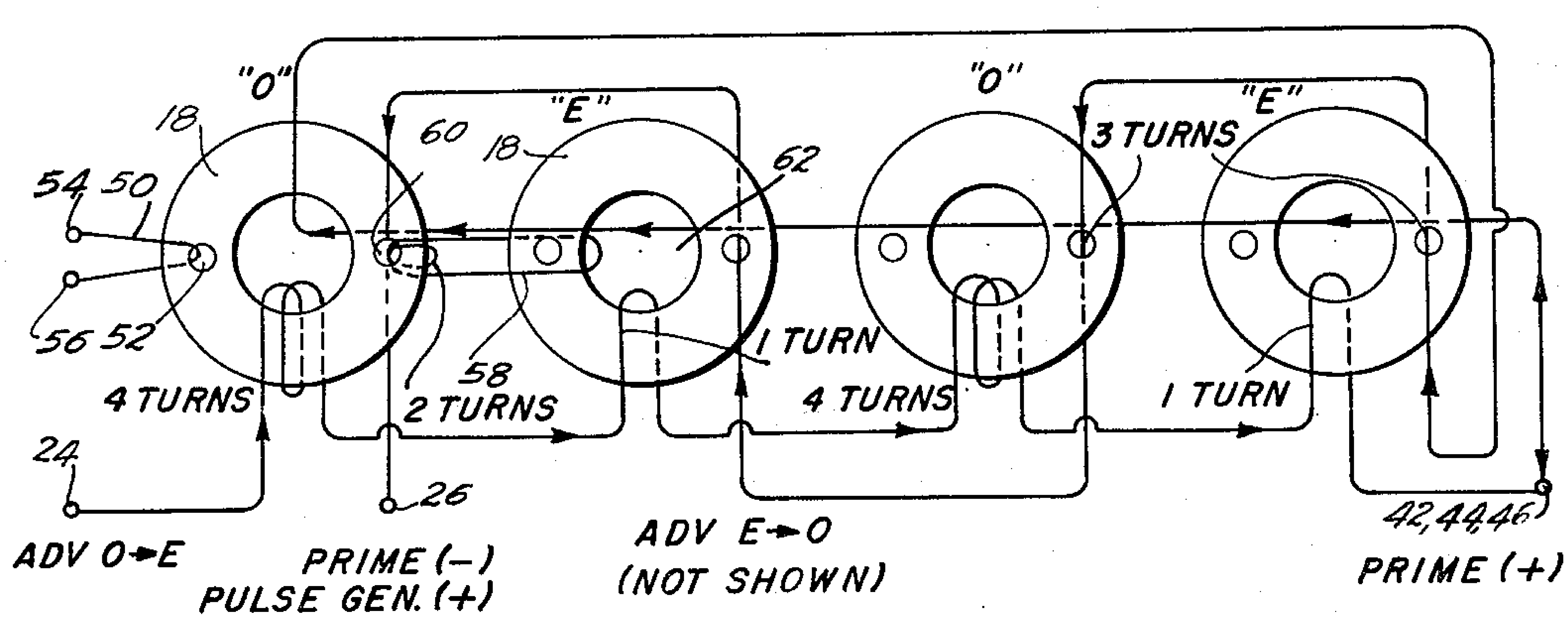
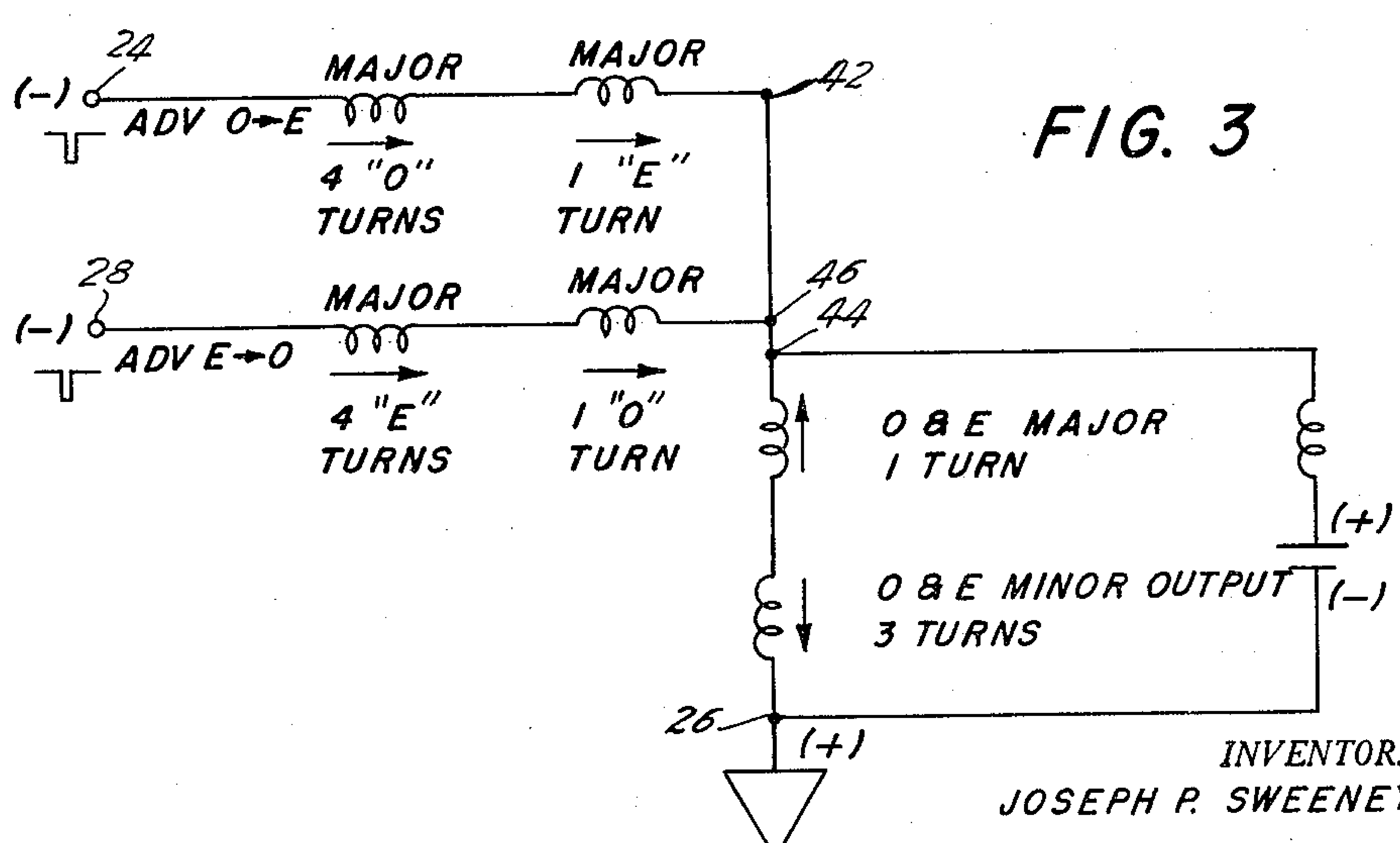


FIG. 3



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Filed Feb. 17, 1960 2 Sheets-Sheet 2

FIG. 4

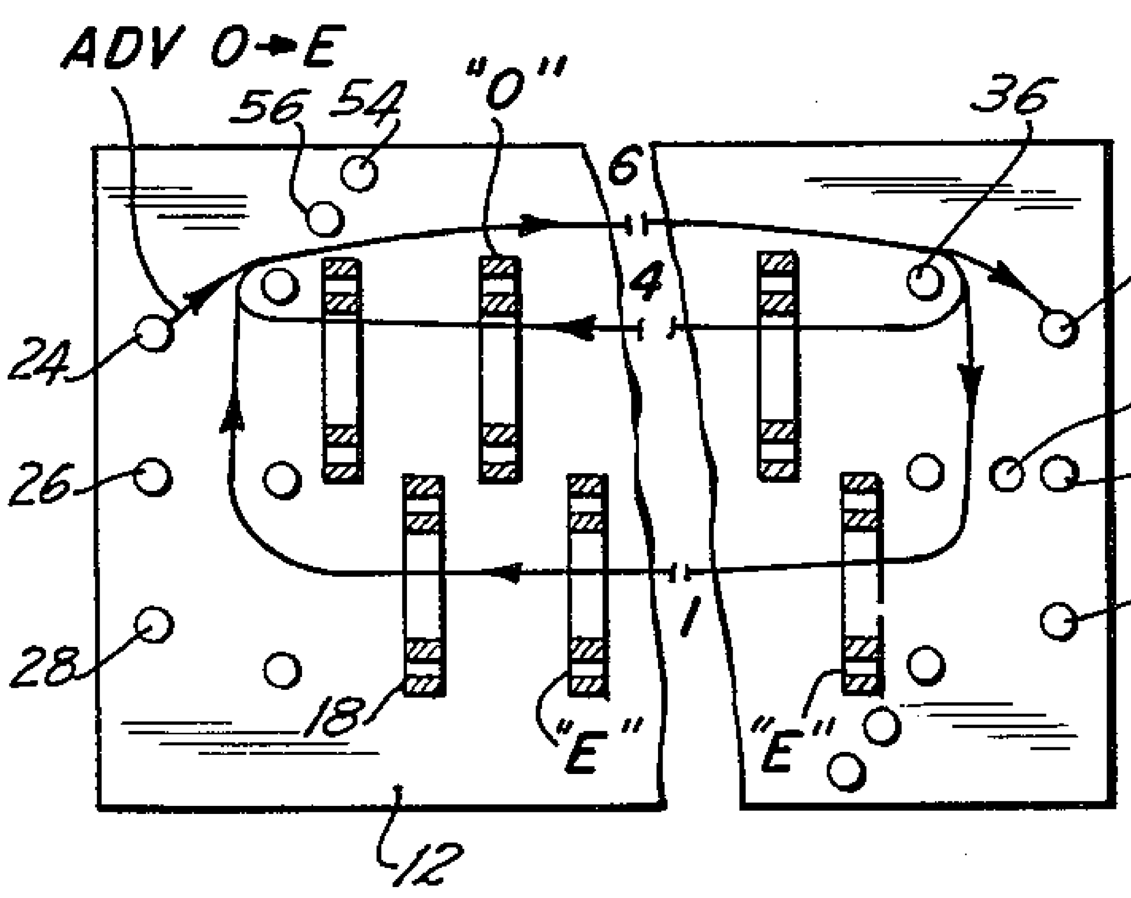


FIG. 5

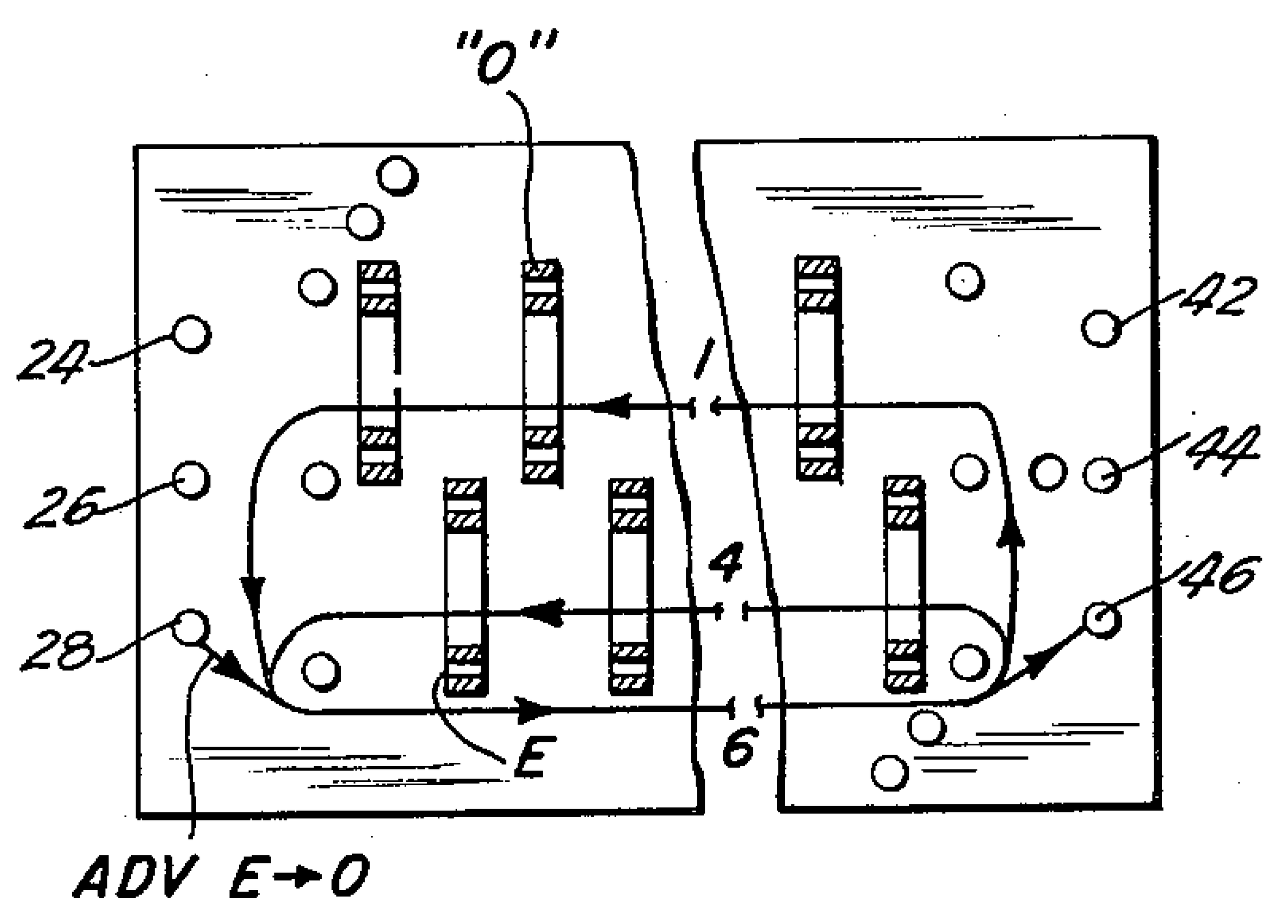


FIG. 6

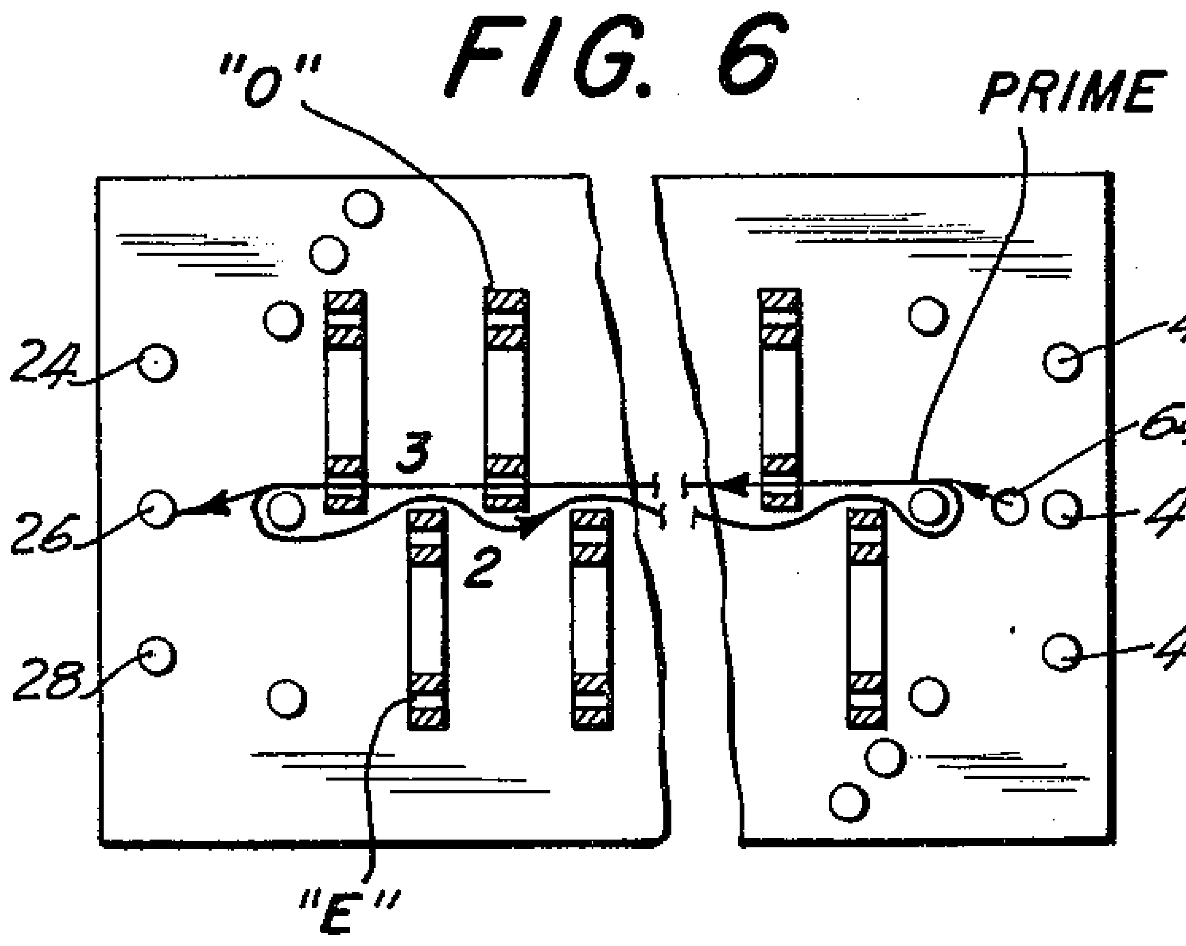


FIG. 8

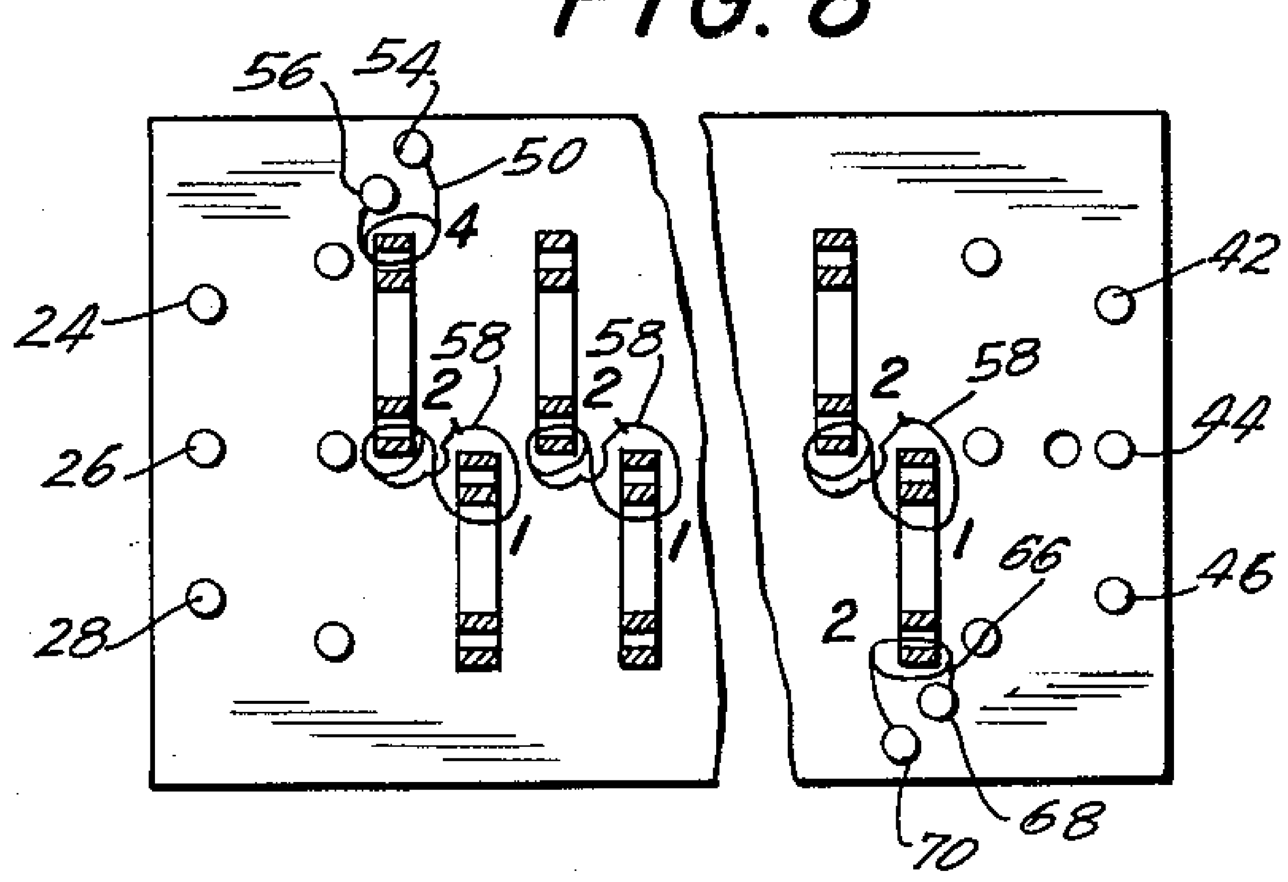


FIG. 7

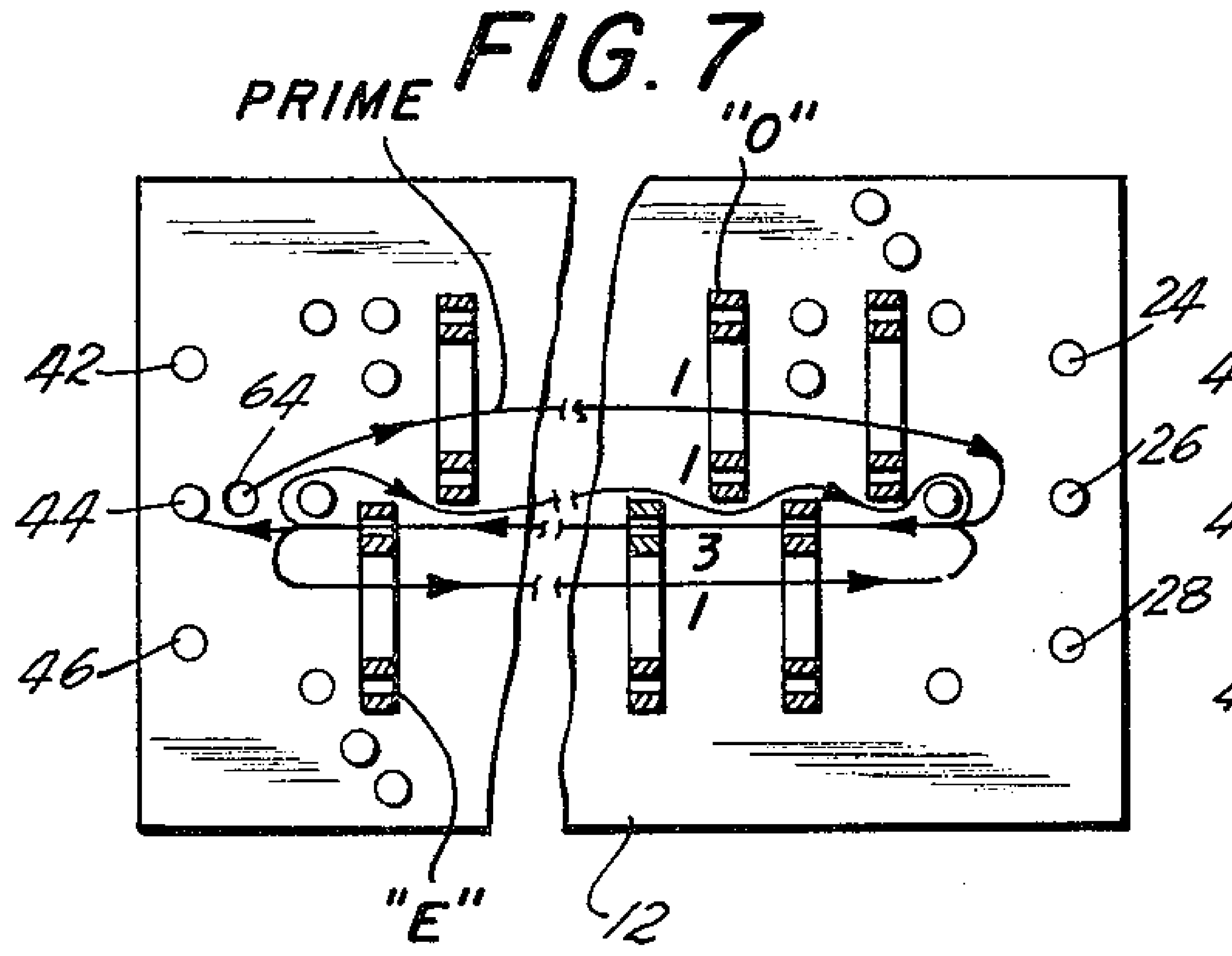
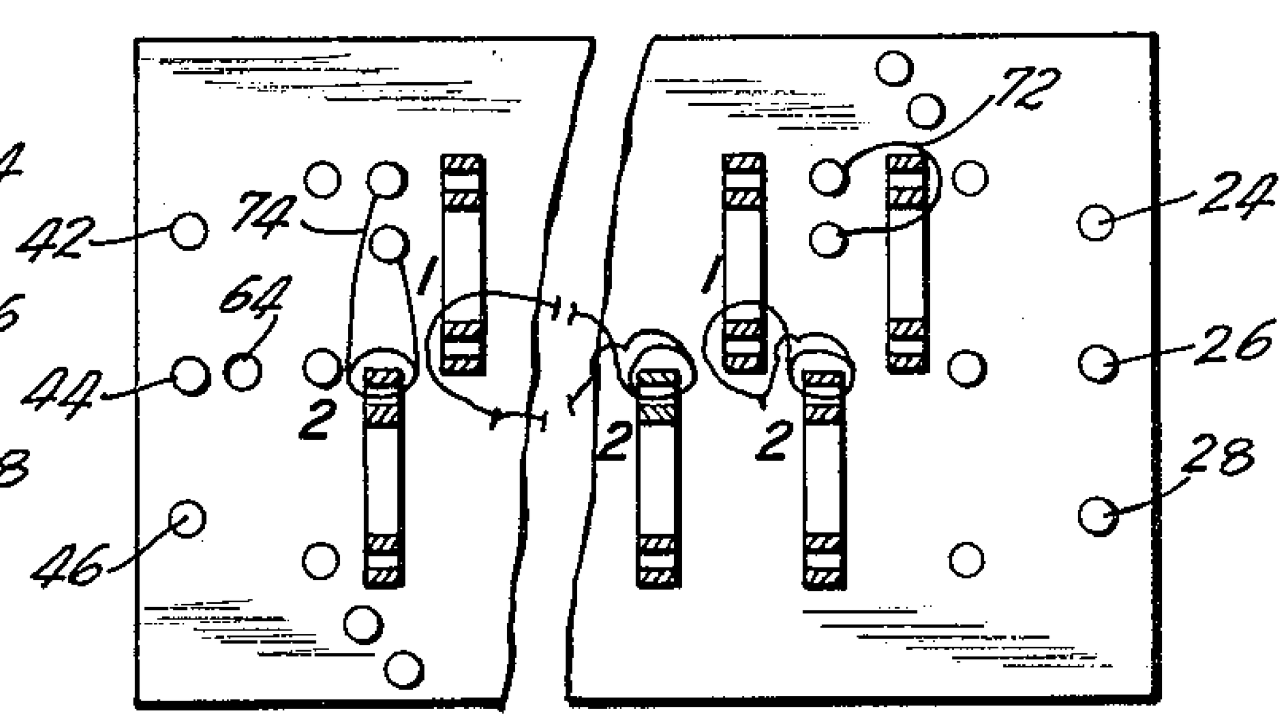


FIG. 9



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5 Claims. (Cl. 340—174)

This invention relates to an improved and simplified wiring arrangement and layout for a shift register employing magnetic cores.

An object of this invention is to provide a shift register which can be more easily wired on a mass production basis than comparable units previously known.

A similar object is to provide a shift register which can be manufactured in less time and at lower cost than previously known registers.

A further object is to provide a register of this kind which can be wired with less chance of error, and which will operate with a higher degree of reliability than previously known units.

These and other objects will in part be understood from and in part pointed out in the description given hereinafter.

In co-pending U.S. Patent application Serial No. 855,-335, there is disclosed a shift register comprising an array of multi-aperture magnetic cores arranged in two columns and wired in unique configuration to give a shift register unit which is relatively simple in construction, yet highly effective in its operation. The construction of this shift register and the way it is operated make possible considerable simplification in the wiring and assembly of the various parts, but it has been found that further simplification and improvement in the wiring arrangement and general layout are desirable to fully adapt this unit to mass production.

In this general type of shift register, the cores are in the forms of toroids with a large central aperture and with additional minor apertures at various points around the body of the toroid. These cores are about the size of a small shirt button and the minor apertures are not much larger than the size of a needle. Accordingly, a considerable problem is presented in passing the necessary wires through the various ones of the apertures of the cores. The present invention among other things provides a simplified wiring arrangement which nonetheless gives the improved electrical performance of units disclosed and claimed in the aforesaid co-pending application.

In accordance with the present invention, three sets of windings, two comprising "advance" windings to be energized by short electric pulses, and a "prime" winding to be energized by direct current, or by a suitable current pulse, are separately wound upon the cores, each winding being a continuous strand threaded back and forth in a unique pattern through respective apertures of the cores to establish the required turns ratios for the winding on the cores. The invention makes it possible for a person in assembling the shift register to thread each of these windings in accordance with its predetermined pattern back and forth without having to make splices or electrical connections at various points in the winding. Consequently, the wiring of the unit is con-

siderably simplified and since the number of electrical splices which must be made is reduced, the reliability of the unit is improved and the danger of error in manufacture is considerably reduced.

In accordance with another aspect of the invention, the various windings are terminated at each end of the unit on posts arranged so that the output of one unit can be connected to the input of an identical unit, and so on, to give a shift register of twice, three times, etc., the length of the original. Thus, starting from a basic shift register assembly of say 10 bits it is possible simply by connecting two or more such units in series to obtain as many bits in a given shift register as desired. The electrical connections between basic units are quickly and easily made so that only a single basic one need be manufactured to supply the needs of many different customers.

A better understanding of the invention together with a full appreciation of its many advantages will best be gained from the following description given in connection with the accompanying drawings wherein:

FIGURE 1 is a perspective view of a shift register embodying the invention and showing its actual physical appearance;

FIGURE 2 is a schematic diagram showing several cores of the unit of FIGURE 1 and various windings thereon;

FIGURE 3 is a schematic diagram showing in shorthand fashion the wiring configuration of various windings with respect to the various apertures of the cores of the unit; and

FIGURES 4 through 9 show respectively the winding sequences and configurations of various windings on the cores and illustrate a preferred procedure followed during the mass production of these shift register units.

The shift register **10** shown in FIGURE 1 includes an insulating base board **12** on which are mounted two parallel and somewhat interleaved columns **14** and **16** of multi-aperture cores **18**. Column **14** will be designated the "O" (odd numbered) cores and column **16** the "E" (even numbered) cores. Each core is mounted on edge and projects through a corresponding transverse slot in board **12**. Each column of cores is aligned and held in place by a respective one of the flat insulating strips **20** and **22** glued to board **12** and passing through the center or major apertures of the cores.

At the near or input end of unit **10** are three upstanding electrical terminal posts **24**, **26** and **28** rigidly fixed to board **12**. As will appear, these posts comprise the input connections to the unit for various drive currents supplied from an external power source (not shown) during operation of the unit. Immediately behind these electrical posts are three insulating pins **30**, **32** and **34** which serve to support the near ends of the drive windings on the cores. A similar set of insulating pins **36**, **38** and **40** is positioned at the far end of the core assembly, and near the rear edge of board **12** are three conductive posts **42**, **44** and **46**. The latter are normally shorted together by a conductor **48**. When desired, however, an identical shift register unit as indicated by dotted lines can be connected in series with unit **10** by removing conductor **48** and by connecting output posts **42**, **44** and **46** to respective ones of the input posts, corresponding to input posts **24**, **26** and **28**, of the next unit. Also, as will be explained shortly, the signal output of unit **10** would be connected to the signal input of the next unit.

FIGURE 2 is a schematic circuit representation of the cores and windings of unit **10**. Counting the cores from left to right, the first core **18** is designated an "O" core and has an input signal winding **50** passing through a minor aperture **52** of the core and, as seen also in FIGURE 1, terminating at conductive posts **54** and **56**. An output signal from this core is obtained from a signal winding **58** passing twice through a second or output minor aperture **60** of the core and encircling once the second core **18**, an "E" core, through its major aperture **62**. The latter core is similarly coupled through its output minor aperture **60** to the third core by a signal winding (not shown), and so on to the end of the register. It should be noted that signal winding **58** passes through the major aperture of the receiving core, an input minor aperture in this core being shown but not used.

The circuit shown in FIGURE 2 includes a first drive winding, designated "ADV O to E" whose input end is connected to terminal **24** and which is adapted to receive a negative current pulse of relatively short duration. This winding as indicated also in FIGURE 3, encircles in the same sense, each "O" core four turns and each "E" core one turn through their major apertures. The other end of the winding is connected to terminal **42**. Similarly a second winding, "ADV E to O," (not shown in FIGURE 2) extends from terminal **28** and encircles each "E" core four turns and each "O" core one turn, the other end of the winding ending at terminal **46**. Finally, the cores are threaded with a "Prime" winding, extending between terminals **26** and **44**, and which encircles with one turn, in opposite sense from the advance windings, each major aperture of the cores, and with three turns each output minor aperture. The relative winding senses of the advance and prime windings are indicated by the arrows in FIGURE 3. The Prime winding is common to a portion of the advance windings and is independently energized, as indicated in FIGURE 3, by a battery in series with an isolating inductor.

It will be noted that the single "O and E Major" turn of the prime winding cancels one turn of the four turn "O" portion of the ADV O to E winding between terminals **24** and **42** and the entire single "E" turn portion. Thus the net ADV O to E winding constitutes three turns through the major apertures of the "O" cores. Similarly, the net ADV E to O winding constitutes three turns through the major apertures of the "E" cores. However, as will appear from FIGURES 4 through 7, this winding arrangement simplifies the layout of the advance and prime windings and makes possible the easy interconnection of two or more units in sequence.

The physical wiring pattern of the ADV O to E winding is shown in FIGURE 4. This winding, on the top side of board, extends from terminal **24** and makes four turns through the major aperture of the "O" cores, one turn through the "E" cores, and six turns on the outside and is then connected to terminal **42**. The ADV E to O winding, as shown in FIGURE 5 is the mirror image of this.

As shown in FIGURE 6, the Prime winding near the right end of board **12** extends upward through a hole **64** and passes on the top side of board **12** three turns through the output minor apertures of the "O" cores and two turns on the outside before ending at terminal **26**. The bottom portion of the Prime winding, seen in FIGURE 7 which shows the underside of board **12**, extends from the hole **64** one turn through the major apertures of the "O" cores, three turns through the output minor apertures of the "E" cores, one turn through the major apertures of the "E" cores, one turn outside of the cores, and ends at terminal **44**.

FIGURE 8 is a top view of board **12** and shows input winding **50** and those of the signal windings **58** which extend from the "O" to the "E" cores. Also shown is an output signal winding **66** which encircles twice the minor output aperture of the last "E" core and is connected to terminals **68** and **70** (see also FIGURE 1). FIGURE 9 which is a bottom view of board **12**, shows the signal windings **58** extending from the "E" to the "O" cores. The first "O" core has an auxiliary input winding **72** encircling its major aperture and the last "E" core has an auxiliary output winding **74** passing twice through its minor output aperture. To provide for circulation of the information stored in the cores, these windings can be connected together by suitable jumpers, not shown. Where a second unit is connected in sequence, output winding **74** of the first unit is connected to the input winding of the second corresponding to winding **72**.

In an actual unit, substantially identical to unit **10**, which has been built and successfully operated, each core had a diameter of about 1/4 inch and a body about 3/64 inch thick in each direction. They were made by General Ceramics Corporation of Keasbey, New Jersey and identified as "5209–FG96" material.

The above description of the invention is intended in illustration and not in limitation thereof. Various changes may occur to those skilled in the art and these may be made without departing from the spirit or scope of the invention as set forth.

I claim:

1. An improved shift register comprising two parallel columns of magnetic cores each having a central aperture and at least one minor aperture, said apertures of the cores in each respective column being aligned with each other, a plurality of windings disposed on said cores, said windings including a first advance winding looped in one direction a plurality of times through the major apertures of the cores of one column, and looped once in said direction through the major apertures of the cores of the other column, a second advance winding disposed on said cores symmetrically with the first, a prime winding looped a plurality of times in the same sense through the minor apertures of said cores and also looped once in a direction opposite to said one direction through the major apertures of said cores, three input terminals connected to the inputs of said windings at one end of said columns, and three output terminals connected to the other ends of said windings at the opposite end of said columns, said output terminals comprising intermediate connections for said windings whereby said register can be used by itself or connected in sequence with a similar unit.

2. The arrangement as in claim 1 wherein said output terminals are shorted together.

3. The arrangement as in claim 1 wherein said prime winding is connected in series with each of said advance windings.

4. An improved shift register construction comprising an insulating base, two parallel columns of magnetic cores each core having a central aperture and at least one minor aperture, said cores being mounted perpendicular to said base with the apertures of the cores in a column aligned with each other, a first drive winding looped in one direction a plurality of times through the major apertures of the cores in one column, and looped at least once in said direction through the major apertures of the cores in the other column, said winding having an input end at one end of said columns and a second end at the opposite end of said columns, a second drive winding disposed in mirror image relation to the first on said cores, and a third drive winding looped a plurality of times in the same sense through the minor apertures of said cores and looped once opposite to said one direction through the major apertures of said cores, said third drive winding having an input at said one end of said columns and having at the other end of said columns a common connection to said first and second drive windings.

5. A magnetic core unit of the character described comprising a plurality of multi-aperture magnetic cores, said cores being arranged in two aligned groups side-by-side, each core having a major aperture and at least one minor aperture, a first drive winding looped a plurality of times through the major apertures of the cores in one group from one end thereof to the other, a second drive winding similar to the first and looped a plurality of times through the major apertures of the cores in the other group from one end thereof to the other, and a third drive winding looped through the minor apertures of all said cores and looped at least once through the major apertures of all said cores, said third winding being connected in series with said first winding and in series with said second winding, said portion of said third winding through said major apertures opposing said first and second windings.

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