

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

A Scanning Circuit

We, WESTERN ELECTRIC COMPANY, INCORPORATED, of 195 Broadway, New York City, New York State, United States of America, a Corporation organized and existing under the laws of the State of New York, 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:—

The invention relates to scanning circuits. Scanning circuits have a variety of uses one of which is for monitoring the condition of telephone subscribers lines in a telephone system. Service is provided to a telephone subscriber in response to changes in condition of the subscriber line. There are two conditions for those lines of interest here. The first condition is an idle condition identified usually by the absence of current in an auxiliary line connected to each telephone line. This condition is termed the "on-hook" condition. The second condition is a service-request condition identified usually by a current flowing in that auxiliary line. This current is termed the "off-hook" current and the condition is termed the "off-hook" condition. Each subscriber line is associated, as is well known, with what is termed a "scan point" at which indications of the line condition are provided. The function of a scanning circuit, then, may be described as that of scanning a number of scan points and reporting changes in the electrical condition of associated lines in response to the presence or absence of off-hook currents.

One circuit designed to perform the scanning function includes, for example, a memory array comprising a "translator" core and a "memory" core associated with

each scan point. Such cores are usually magnetic storage cores driven in a conventional matrix arrangement by horizontal and vertical drivers. Thus, in response to each signal applied by those drivers a single translator core is switched providing a pulse for interrogating the associated scan point corresponding to a particular line. The translator thus serves the function of an access switch and operates in response to external energization to access sequentially all lines associated therewith. An interrogated scan point provides a signal only if it is in the off-hook condition when interrogated.

The memory core is coupled to the translator core by a transfer loop to provide a "sense" indication, in response to a switching translator core, depending on the previous state of the former. To this end, the state of the memory core is determined conveniently by controlling, via off-hook currents, the length of time during which the drive pulses for the translator core are relaxed. Such an arrangement is described in U.S. patent No. 3,349,230. The translator core, then, is switched to the same magnetic direction each time by the drive pulses and is relaxed to the opposite magnetic direction conveniently under the influence of a bias. Thus the memory core always is driven in the same direction and in being so driven functions to provide an output pulse only when a scan point interrogated in the next preceding cycle had permitted the translator core to relax sufficiently quickly to cause resetting of the memory core.

The output from the scan point and the output of the corresponding memory core are fed into present and past look detectors synchronized with an address generator controlling sequential energization of the

[Price 4s. 6d.]

translator cores. The synchronized outputs of these detectors are fed into a comparator which detects a match or mismatch therebetween. A mismatch operates to stop the address generator which, in turn, feeds the corresponding address into a message formulator. The message formulator also receives a representation of the present state of the scan point from the comparator. A system of the foregoing type is disclosed in United Kingdom patent No. 1,029,204.

According to this invention a scanning circuit for scanning a plurality of input conductors each capable of assuming a first or second of two states includes a first propagation medium having a scan position therein corresponding to each of said conductors, first and second co-acting means adapted to produce a stable condition at each of said scan positions corresponding to the input conductors which are in the first of said two states, propagation means for propagating said stable conditions along said medium, first sensing means coupled to said medium for providing an output signal in response to the arrival at said sensing means of each of said stable conditions, and means responsive to said output signal for providing an address for the input conductor corresponding thereto.

In one embodiment all the scan points are preset to unstable conditions at one time, stable conditions being set in particular positions therein only when currents appear on the associated conductors at that time. The stable conditions are propagated along the medium to a detector before unstable conditions are again preset at all the scan points. The detector provides an output pulse in response to the arrival of each stable condition there. Each output pulse gates a sequentially changing output of an address generator providing an address for the conductor associated with the corresponding position of the scan point in the medium. Means responsive to an output pulse and an address indicates the service required for that associated line.

It is thus possible to couple, for example, telephone lines to what is, essentially, a present look store for defining scan points therein. All scan points so defined may be simultaneously activated for permitting storage and then sequential generation of indications of the condition of all associated telephones as the addresses for those telephones are independently generated.

The invention will be more fully understood from a consideration of the following detailed description of embodiments thereof read in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic representation of a scanning circuit;

FIGS. 2 and 4 are schematic representa-

tions of portions of the circuit of FIG. 1;

FIG. 3 is a pulse diagram of the currents applied during the operation of the circuit of FIG. 1;

FIG. 5 is a schematic representation of an arrangement alternative to a portion of the circuit of FIG. 1; and

FIGS. 6A to 6G are illustrations of a magnetic wire of the arrangement of FIG. 5 showing various conductors coupled thereto and the magnetic condition of the magnetic wire in response to pulses applied to those conductors during operation.

FIG. 1 shows an illustrative scanning circuit 10, which operates as a supervisory circuit to supply a central processor with information as to the service required on telephone lines serviced thereby. This information is conventionally supplied in response to electrical conditions on auxiliary lines connected to the telephone lines. The figure shows two telephones connected to a conventional telephone switching matrix 11 by telephone lines L1 and L2. The telephone switching matrix is under the control of a central processor 12 as is well known. Auxiliary lines, designated LA1 and LA2, are coupled directly to a domain wall shift register SR1 at various positions therealong.

The basic domain wall shift register is well known and will be described briefly hereinafter. At this juncture, however, it is sufficient to state that a domain wall shift register comprises a magnetic medium, for example, a wire. A "nucleation" driver 14 is coupled to that medium at prescribed positions along its entire length, and the output of the shift register, to the right as viewed in the figure, is connected via a conductor 15 to a second domain wall shift register SR2.

The output of shift register SR1 also is connected to an EXCLUSIVE-OR circuit 20 and to an AND gate 21 via a conductor 22 connected to conductors 22a and 22b, respectively. Similarly, shift register SR2 is connected to EXCLUSIVE-OR circuit 20 and to an AND gate 23 by a conductor 24 connected to conductors 24a and 24b respectively. The EXCLUSIVE-OR circuit 20, in turn, is connected to AND gates 21 and 23 by a conductor 26 connected to conductors 26a and 26b, respectively. The AND gates 21 and 23 are connected to AND circuits 27 and 28, respectively, by conductors 29 and 30. The AND circuits 27 and 28, in turn, are connected to the central processor 12 via conductors 31 and 32, respectively. [The various logic circuitry and the connections therebetween are indicated in FIG. 1 merely as blocks and conductors, respectively. It is to be understood that these blocks and conductors are merely representative of particular func-

tions and are not necessarily meant to illustrate specific circuitry. The logic elements and the connections therebetween, however, are well known and will be discussed herein-
5 after on a functional basis, the structure thereof being described only inasmuch as it may differ from the most simple logic circuitry of like function.]

An advance clock driver 33 is coupled
10 to shift registers SR1 and SR2 via representative conductor 34. Also, advance clock driver 33 is connected to an address generator 35 via a conductor 36. Address generator 35, in turn, is connected to AND circuits
15 27 and 28 via a conductor 37 connected to conductors 37a and 37b, respectively. Nucleation driver 14 is connected to advance clock driver 33, address generator 35, and to the central processor 12 by a representative conductor 38 connected to conductors 38a, 38b, and 38c.

A simplified domain wall shift register SR is shown in FIG. 2. The shift register comprises an elongated magnetic wire 100
25 about which a narrow electrical conductor 101 is coupled at spaced apart positions therealong. The conductor 101 is connected between a driver (not shown), for example driver 14 of FIG. 1, and ground. Input
30 lines, for example auxiliary telephone lines LA1 and LA2 of FIG. 1, are coupled to the magnetic wire 100 at the above-noted positions. A sense conductor 102, coupled to the right end of magnetic wire 100, as
35 viewed in the figure, is connected between a utilization circuit (not shown), for example to EXCLUSIVE-OR circuit 20 of FIG. 1, and ground.

As is frequently the case with well known
40 magnetic wire domain wall shift registers, the magnetic wire 100 is itself helically wrapped about an elongated nonmagnetic mandrel or core. Two overlapping serpentine-like propagation conductors are arranged
45 such that elongated sections thereof, orientated along the axis of the mandrel, are connected by short sections orientated axially about the mandrel. Pulses are applied alternately to the first conductor,
50 then to the second, to step a reverse magnetic domain of stable length along the magnetic wire 100. The overlapping conductors for this purpose are well known and are not shown here. A driver such as the
55 advance clock driver 33 of FIG. 1 provides the alternate pulses thereto.

The magnetic wire for such shift registers typically comprises a ferromagnetic material having a re-entrant substantially rectangular
60 hysteresis characteristic. Such materials exhibit a stable flux state, called either a reverse domain or a stable scan point condition in the parlance of telephone scanning circuitry, when a field in excess of
65 its nucleation coercive force is applied over

a wire segment of sufficient length. A stable reverse domain in a magnetic wire is indicated by an arrow directed to the left as is shown in wire 100 in FIG. 2 and is further explained in connection with FIG. 6.
70 Since such domains and their formation are well understood, a discussion thereof is dispensed with. The normal condition of the wire is indicated by an arrow directed to the right also as discussed further in
75 connection with FIG. 6. Once the stable reverse domain is established, the domain is propagated along the magnetic wire conveniently by a relatively low amplitude polyphase propagation field generated by
80 the pulses applied to the propagation conductors as is well known. Propagation along the magnetic wire is in the direction of the sense conductor and the sense conductor provides an output pulse for each reverse
85 domain arriving there. Actually, a pulse is produced for each boundary of the reverse domain. Only the pulse for forward boundary, to the right as viewed in FIG. 2, is utilized in the illustrative embodiments.
90

The conductor 101 of FIG. 2 is pulsed periodically by a driver such as driver 14 of FIG. 1. The pulse is chosen, such that it alone cannot provide a stable reverse domain anywhere along magnetic wire 100.
95 If at the time driver 14 pulses conductor 101, an off-hook current appears in one of the auxiliary telephone lines, a stable reverse domain is provided in the corresponding portion of the magnetic wire 100.
100 Accordingly, the pulse supplied by driver 14 plus the off-hook current in an auxiliary telephone line produce fields which together create a magnetic domain over a stable length of the magnetic wire at the corresponding portion thereof. Importantly, no stable reverse domain is formed if either the field is of insufficient magnitude or, alternatively, if a field of sufficient magnitude is generated over an insufficient length of wire.
110 Both cases are contemplated; only the latter is described. To this end, conductor 101 is chosen of a geometry such that a suitable pulse therein nucleates a reverse domain of an unstable length in the corresponding portion of magnetic wire 100. In this instance, a coincident off-hook current, producing a field that exceeds the propagation field, acts to expand the reverse domain to a stable length. This mode of supplying
120 coincident fields is similar to that described for a memory matrix in U.S. patent No. 3,286,242.

In accordance with the foregoing discussion, the entire magnetic wire, for example
125 as in shift register SR1 of FIG. 1, is activated in response to a pulse in conductor 101 such that coincident off-hook currents in lines directly coupled thereto provide indications, in terms of the presence and
130

absence of stable reverse domains, of the line conditions of all the telephones connected thereto. Shift register SR1, therefore, functions as a present look store in conventional scanner circuitry. As is evident from a discussion of the operation of the circuit of FIG. 1 hereinafter, a similar shift register used as shift register SR2 in the circuit of FIG. 1 functions as a last look store.

It is convenient to mention, at this juncture, that shift register SR2 is advantageously also a domain wall shift register of the type just described, as is apparent from a consideration of the structure of such a shift register. Specifically, a second shift register of a domain wall type is provided merely by wrapping a second magnetic wire helically about the nonmagnetic mandrel about which wire 100 is wrapped or, alternatively, by merely continuing wire 100 beyond the point at which the sense conductor is coupled. If a second wire is used it is sufficiently removed from wire 100 such that there is no interaction therebetween and an amplifier (not shown) is connected between the output of the first and the input of the second wire. The second wire is provided with conventional input and output conductors to the latter of which, for example, EXCLUSIVE-OR circuit 20 of FIG. 1 is connected. The propagation circuitry for magnetic wire 100 may be shared. A continuation of wire 100 need only have an additional sense conductor which is connected, for example, to EXCLUSIVE-OR circuit 20.

The operation of the circuit of FIG. 1 may now be understood in terms of the operation of a simple domain wall shift register adapted for parallel input coincident current operation with serial output. Nucleation driver 14 periodically applied a nucleation pulse (to conductor 101 of FIG. 2) for nucleating reverse domains of unstable lengths (that is to say, for pre-setting unstable scan point conditions) along the entire magnetic wire of shift register SR1. Each telephone auxiliary line in the off-hook condition when that nucleation pulse is applied is characterized by an off-hook current which generates a field in coincidence with that of the nucleation pulse for expanding to stable lengths those reverse domains in the corresponding portions, that is, scan points, of shift register SR1. The nucleation driver, with the provision of each pulse, signals the advance clock driver 33 to initiate a sequence of propagation pulses, and, in addition, signals the address generator to generate sequentially the addresses of all telephones associated with the shift register (from right to left as viewed in the FIG.) and then to stop. The nucleation driver as well as ad-

vance clock driver 33 and address generator 35 are under the control of central processor 12.

In response to the propagation pulses, stable reverse domains, that is, stable scan point conditions, are propagated through the shift register SR1 to provide pulses at the output (sense conductor) thereof as the address corresponding to the appropriate telephone line is generated by the address generator. The output of shift register SR1 is passed into shift register SR2. When shift register SR1 is free of stable reverse states and shift register SR2 includes those stable reverse states, a next nucleation pulse is applied by driver 14 under the control of the central processor 12. The stable reverse states next stored in shift register SR1 result from off-hook currents in coincidence with this next nucleation pulse. The stable reverse states in shift register SR2 are those stored in shift register SR1 during the previous nucleation pulse. Accordingly, shift register SR1 functions as a present look store and shift register SR2 functions as a last look store.

Importantly, there is no output from shift register SR2 until the contents of register SR1 are propagated through it. As shift register SR1 empties into register SR2, the former also produces an output pulse for each stable state stored there. The shift registers normally include no reverse domains unless such are deliberately stored there. Thus, in the initial operation shift register SR2 includes no such domains and propagation of such domains from shift register SR1 produces mismatches between the outputs of the two registers as follows: The outputs of the shift registers SR1 and SR2 are compared to provide an output only when there is a change in the condition of a corresponding auxiliary telephone line. Specifically, if there is a stable reverse domain in shift register SR1 and no reverse domain in the corresponding position of shift register SR2, the corresponding telephone is assumed to have gone to an off-hook condition and service is required. If the opposite situation exists, the corresponding line no longer requires service. In the initial operation, that is, in response to the propagation pulses following the first nucleation pulse from driver 14, the latter situation is not indicated. If the corresponding positions in the two registers have like indications, no service is required for the corresponding line. If an output corresponding to the arrival of a stable reverse domain (the forward boundary thereof) at the output of a shift register is represented as a "1", and the absence of such an output is represented by a "0", then Table I summarizes the possible combinations of out-

puts from shift registers SR1 and SR2.

Table I

SR1	0	1	0	1
SR2	0	0	1	1

5 The outputs of both shift registers are applied to EXCLUSIVE-OR circuit 20 of FIG. 1 which, in turn, applies an output pulse to AND gates 21 and 23 only when the outputs of the shift registers are mismatched, that is, under the condition represented by either of columns 2 and 3 of Table I. In addition, the output of shift register SR1 is applied to AND gate 21 and that of shift register SR2 is applied to AND gate 23. The AND gate 21 applies a pulse to AND circuit 27, then, only if a mismatch appears between the output of the two shift registers and shift register SR1 produces an output. This condition indicates that a line just went off-hook. The output of address generator 35 also is applied to AND circuit 27. Consequently, AND circuit 27 functions to gate an address to the central processor 12 when shift register SR1 provides an output pulse at the corresponding time and there is a mismatch between the outputs of the shift registers at that time. The pulse provided by AND circuit 27 is an indication that service is required for the telephone the address of which is gated through the AND circuit 27 at that time. Similarly, when a mismatch occurs and shift register SR2 provides an output pulse, AND circuit 28 gates through the address of the corresponding telephone indicating that a call is complete. In this connection, AND circuits 27 and 28 serve as message formulators. Central processor 12 includes well known equipment for controlling switching matrix 11 in response to a signal from either AND circuit 27 or 28.

FIG. 3 is a pulse diagram summarizing the current pulses applied to the circuit of FIG. 1, as a function of time, during operation thereof. Let us assume that a number of lines corresponding to selected scan points go off-hook at a time designated t_1 providing off-hook currents designated I_{OH} . At an arbitrary later time t_2 to t_3 a nucleation pulse, designated I_N , is applied. The pulses I_N and I_{OH} add to generate fields at the selected scan points for providing reverse domains of stable length there. At a later time designated t_4 to t_n , a sufficient number of propagation pulses, designated I_p , are applied to clear the register, that is to move the reverse domains to where the sense conductor is coupled to the magnetic wire. At a still later time, designated t_{n+1} , a next nucleation pulse is applied.

This pulse diagram also shows a representative off-hook current I_{OH} continuing beyond time t_3 at which the nucleation pulse terminates. When the propagation pulses I_p are applied, the field generated at the selected scan point is commensurate with the pulse I_{OH} in addition to the pulse I_p . The amplitudes of these pulses are relatively small, less than one third that of the nucleation pulse, typically one tenth thereof, as shown in the figure to ensure that no additional reverse domain is provided at that scan point in the absence of a nucleation pulse. A tendency to increase propagation speeds because of the increased fields has negligible effect on the system operation because of the well known step-along nature of the fields generated by the alternately pulsed propagation conductors.

A pulsed bias current I_b may be applied (conveniently via conductor 34 of FIG. 1) concurrently with the nucleation pulse, permitting a reduction of the off-hook current I_{OH} needed to expand nucleated domains to stable lengths. Importantly, each of the off-hook currents and the propagation currents produce fields over a length of the magnetic wire at least corresponding to the length of a stable domain. This is also true of the pulsed bias current I_b . The nucleation field is restricted, in the described embodiment to a relatively short length of the magnetic wire less than the length of a stable reverse domain. The pulsed bias current is of an amplitude less than the minimum current required to generate a propagation field and serves only to permit the use of smaller off-hook currents and therefore to minimize the effect of variations in those currents. The circuits of FIGS. 1 and 2 are particularly adaptable to telephone systems such as electronic private branch exchanges (EPBX) where variations in off-hook currents are relatively small.

The various drivers, amplifiers, delay lines, logic circuits and other elements may be any elements capable of operating in the embodiment described. It is evident that AND circuits 27 and 28, for example, are not the most simple type of AND circuits as are AND gates 21 and 23. The former two circuits, however, comprise a plurality of the more simple type of AND circuit each of which is responsive to an output of address generator 35 corresponding to one bit of an address generated and to a coincident signal from AND gates 21 and 23, respectively. The details of this arrangement are shown in FIG. 4.

FIG. 4 shows address generator 35 with a plurality of outputs OL_1 to OL_n where n corresponds to the number of bits in the address. Each output connects to a corresponding AND gate A_1 to A_n , re-

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 respectively. Conductor 29 of FIG. 1, for example, has a connection to each of these AND gates A1 to An which connections and circuits are represented in FIG. 1 as a block designated 27 (and 28). The parallel output of the AND circuits A1 to An is connected to central processor 12 via representative conductor 31 (and 32).

It may be appreciated from FIG. 2 that the distance between the portion, that is, scan point, of magnetic wire 100 and the sense conductor coupling is different for each telephone auxiliary line. In effect, each line is connected to a shift register of different length. The shift registers of FIG. 1 may actually be built in this manner with each telephone line coupled to a magnetic wire of different length. Such an arrangement permits keeping the magnetic wire strongly biased into saturation except during the interval when the nucleation pulse is applied. An illustrative multiwire arrangement is discussed hereinafter in connection with FIG. 5.

Another embodiment employs the shift register arrangement shown in FIG. 5. The embodiment is illustrative of a multiwire arrangement including magnetic wires of different lengths and operates, accordingly, in a manner similar to that described hereinbefore, differing therefrom in the manner of storing information. Included in the shift register are overlapping serpentine-like conductors P1 and P2, arranged transverse to the magnetic wires, and connected between advance clock driver 133 and ground. Illustratively, four magnetic wires of different lengths are shown. These are designated 100a to 100d. Individual lines designated 40 La to Ld are coupled to corresponding magnetic wires. A "nucleation" conductor N, connected between a nucleation driver 214 and ground, couples all the magnetic wires. A "reset" conductor R, only indicated in FIG. 5 (for purposes of clarity), couples the magnetic wires over the length thereof coupled by both the nucleation conductor and the lines. The reset conductor is connected between a reset driver 215 and ground. A sense conductor S, serially coupling all the magnetic wires at a remote end (to the right as viewed in the figure) is connected between a utilization circuit U and ground. The nucleation and advance clock drivers as well as the reset driver and the utilization circuit are connected to a control circuit 312 via conductors 312a, 312b, 312c, and 312d, respectively. In this connection, the various drivers and circuits may be any such elements capable of operation in this embodiment.

In the operation of the circuit of FIG. 5, nucleation driver 214 applies a nucleation pulse to nucleation conductor N, under the control of control circuit 312, which pulse

reverses flux in the coupled portion of each wire providing stable reverse domains there. Off-hook currents in ones of the lines La to Ld coincident with that nucleation pulse are coupled in a manner to expand existing stable reverse domains to the right as viewed in the figure. The propagation conductors P1 and P2 are arranged such that the polyphase field produced in response to alternate pulses applied thereto by advance clock driver 133 is spaced apart from unexpanded stable reverse domains. In this manner, unexpanded reverse domains are not propagated by the propagating fields while expanded ones are so propagated. The manner and amount of expansion of reverse domains by the propagation field are consistent with that provided by the first phase of the well known polyphase propagation field. As is well known, that polyphase field expands the reverse domain to the right (as viewed in the figure) during a first phase, then not only expands it to the right but also contracts it from the left during the later phases. In the present embodiment, the initial reverse domains are not contracted from the left during the propagation operation. This contraction is done by a separate reset operation, comprising the activation of conductor R by reset driver 215 under the control of control circuit 312, before the reverse domain is completely propagated through the shift register.

The foregoing operation is detailed in connection with FIGS. 6A to 6G. The figures show a representative magnetic wire 100 illustrating the magnetic condition thereof in response to the various fields generated therein by the pulses applied during operation. Initially, the magnetic wire has all its flux aligned in one direction as illustrated by the arrow, directed to the right, as shown in FIG. 6A. Nucleation conductor N is shown coupled to a first portion of the wire 100. FIG. 6B shows wire 100 with a representative line La coupled thereto over a second portion thereof next adjacent the first portion as viewed in the figure. In response to a nucleation pulse I_N applied to conductor N, a stable reverse domain is provided in the first portion. This is illustrated by the arrow directed to the left as viewed in FIG. 6C. The presence of an off-hook current I_{OH} on the line La coincident with the nucleation pulse causes the domain wall, defined between the two oppositely poled domains, to move to the right to occupy the first and second portions of wire 100 as is clear from a comparison of FIGS. 6C and 6D.

FIG. 6D illustrates the two propagation conductors, in cross section, as well as the wire 100. The propagation conductors are labelled P1 and P2; the current pulses applied thereto are designated I_{P1} and I_{P2} .

respectively. The expanded reverse domain shown in FIG. 6D is bounded to the right by a domain wall which can be seen to lie over a section of propagation conductor P2. The propagation conductors P2 and P1, thus, are positioned such that, when activated, they affect no domain wall to the left of the domain wall bounding the expanded domain and may be described as spaced apart from the first portion described. Importantly, the right boundary of the first portion coincides with a domain wall bounding the reverse domain generated there in response to a nucleation pulse in the absence of an off-hook pulse. Thus, the propagation means is spaced apart from the last mentioned domain wall and has a negligible effect thereon. A pulse I_{P2} then is applied to propagation conductor P2 to move to the right the domain wall aligned with conductor P2 until that domain wall is in a position aligned with the propagation conductor P1. This movement is illustrated by a comparison of FIGS. 6D and 6E.

FIG. 6F shows the reset conductor R coupled to wire 100 over the first and second portions described. In practice conductor R wraps a mandrel on which all the wires are positioned and thus couples all wires at once rather than coupling them individually as shown. A pulse I_R is applied to the reset conductor switching to a forward direction the flux in the first and second portions of wire 100 as illustrated by the arrow directed to the right there as shown in FIG. 6F. A reverse domain D of stable length remains to be propagated along the wire 100 in response to alternate pulses I_{P1} and I_{P2} applied to conductors P1 and P2, respectively. Propagation due to a (later) pulse I_{P1} applied to conductor P1 is illustrated in FIG. 6G which also shows the stable reverse domain expanded to the right. Further propagation maintains constant this expanded length for the reverse domain D.

It may be appreciated that this type of arrangement is operable also if the nucleation pulse is applied to provide a reverse domain of unstable length. In this latter arrangement, a coincident off-hook current expands the domain to a stable length which domain then is propagated as described in connection with the embodiment of FIG. 5. The operation of the circuit of FIG. 5 within the larger circuit as shown in FIG. 1 is apparent when it is realized that the various blocks of FIG. 5 function as do similarly designated blocks of FIG. 1. Thus, nucleation driver 214 functions as does nucleation driver 14 of FIG. 1, and advance clock driver 133 functions as does advance clock driver 33 of FIG. 1. Utilization circuit U is a generalized designation which includes, for example, the logic circuitry and

the address generator 35 of FIG. 1. The various lines described in FIG. 5 correspond to the auxiliary telephone lines of FIG. 1. Of course, two shift registers of the type described in FIG. 5 may be used to fully implement the circuit of FIG. 1 alternative to the shift registers described in connection with FIG. 2. Then, control circuit 312 may be understood as functioning as does central processor 12 of FIG. 1.

Whether a single wire or a multiple wire arrangement is used in the circuit of FIG. 1, stable reverse domains therein may have lengths of as little as about 100 mils with even shorter stable lengths provided by additional well known expedients. In the embodiment where a plurality of such domains are stored in one wire the domains are spaced apart typically by like lengths. For compatibility with existing telephone equipment, 1024 reverse domain positions, that is, scan points, are defined, for example, along a single magnetic wire in the embodiment of FIGS. 1 and 2. If the nonmagnetic wires are coiled about a nonmagnetic mandrel, then adjacent coils are spaced apart distances of about 50 mils. A suitable magnetic wire for such a shift register is a niobium-silver doped nickel-iron permalloy as described in U.S. Patent No. 3,350,199. Suitable registers of the domain wall magnetic wire type presently operate at speeds up to about 100 kilocycles. Suitable nucleation fields are about ten oersteds, propagation fields about one oersted accommodating off-hook currents varying from ten milliamperes to 100 milliamperes. The electrical loading, during the propagation operation, due to the coupling of even 1024 telephone auxiliary lines is negligible. The nucleation pulses typically have a duration of about ten microseconds and the propagation pulses have durations of about 25 microseconds, 4096 (4x1024) propagation pulses (1024 for multiple wire embodiment) being applied before the next subsequent nucleation pulse is applied. The inductances required for coupling to the magnetic wire of the shift register are so small that the telephone lines, in contradistinction with the auxiliary lines, may be coupled directly to the shift register. In this case, care is taken to avoid imbalance in the lines.

Rather than direct coupling between input lines and a magnetic wire herein, the input wires may be wrapped about for example, a saturable magnetic element and the appropriate portion of the magnetic wire positioned within the field generated about the magnetic element.

In addition, it may be advantageous to gang shift registers, of the type shown in FIG. 2, in parallel on a mandrel for providing parallel read out. It may be appreciated that such an arrangement is

very inexpensive since the cost of additional shift registers is little more than the cost of the magnetic wire used.

WHAT WE CLAIM IS:—

1. A scanning circuit for scanning a plurality of input conductors each capable of assuming a first or a second of two states, the circuit including a first propagation medium having a scan position therein corresponding to each of said conductors, first and second co-acting means adapted to produce a stable condition at each of said scan positions corresponding to the input conductors which are in the first of said two states, propagation means for propagating said stable conditions along said medium, first sensing means coupled to said medium for providing an output signal in response to the arrival at said sensing means of each of said stable conditions, and means responsive to said output signal for providing an address for the input conductor corresponding thereto.
2. A scanning circuit according to claim 1 wherein the first of said two states is a current-carrying state.
3. A scanning circuit as claimed in claims 1 or 2 wherein said first propagation medium comprises material able to sustain a reverse-magnetized domain therein in response to a magnetic field greater than a first value and to propagate at least one wall of said domain therealong in response to a magnetic field of a second value less than said first value.
4. A scanning circuit as claimed in claim 3 wherein said first co-acting means is adapted to produce a domain of unstable length in said first propagation medium and said second co-acting means is adapted to expand said domain to a stable length whereby it can be propagated by said propagation means.
5. A scanning circuit as claimed in claim 3 wherein said first co-acting means and said second co-acting means are so adapted as to be individually incapable but collectively capable of providing a reverse-magnetized domain in said first propagation medium.
6. A scanning circuit as claimed in claim 3 wherein said first co-acting means is adapted to produce a stable reverse-magnetized domain and said second co-acting means is adapted to expand the domain so produced to a length such as to enable said propagation means to propagate at least one wall of said domain along said first propagation medium.
7. A scanning circuit as claimed in any of claims 3 to 6 wherein said first propagation medium comprises a single magnetic

wire.

8. A scanning circuit as claimed in any of claims 3 to 6 wherein said first propagation medium comprises a plurality of magnetic wires of different lengths.

9. A scanning circuit according to any preceding claim including a second propagation medium, means responsive to the arrival of the said stable conditions at said first sensing means for introducing stable conditions into said second propagation medium, means for propagating the stable conditions along the second medium, and second sensing means coupled to the second medium.

10. A scanning circuit as claimed in claim 9 wherein said second propagation medium comprises material able to sustain a reverse-magnetized domain therein in response to a magnetic field greater than a first value and to propagate at least one wall of said domain therealong in response to a magnetic field of a second value less than said first value.

11. A scanning circuit as claimed in claims 9 or 10 including means responsive to mismatches between the outputs of said first and second sensing means for signalling the condition of the corresponding conductor.

12. A scanning circuit as claimed in claim 11 including an address generator and first and second AND circuits, said address generator applying sequentially to said first and second AND circuits multibit addresses of all conductors coupled to said first medium, said first AND circuit being responsive to a first mismatch between said outputs for indicating a service request for the corresponding conductor, said second AND circuit being responsive to an alternative second mismatch different from said first mismatch between said outputs for indicating the termination of service for the corresponding conductor.

13. A scanning circuit as claimed in any preceding claim in which each of said conductors comprises a conductor connected to a telephone subscriber line such that off-hook currents in each subscriber line flow through the corresponding conductor.

14. A scanning circuit constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawings.

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very inexpensive since the cost of additional shift registers is little more than the cost of the magnetic wire used.

WHAT WE CLAIM IS:—

1. A scanning circuit for scanning a plurality of input conductors each capable of assuming a first or a second of two states, the circuit including a first propagation medium having a scan position therein corresponding to each of said conductors, first and second co-acting means adapted to produce a stable condition at each of said scan positions corresponding to the input conductors which are in the first of said two states, propagation means for propagating said stable conditions along said medium, first sensing means coupled to said medium for providing an output signal in response to the arrival at said sensing means of each of said stable conditions, and means responsive to said output signal for providing an address for the input conductor corresponding thereto.
2. A scanning circuit according to claim 1 wherein the first of said two states is a current-carrying state.
3. A scanning circuit as claimed in claims 1 or 2 wherein said first propagation medium comprises material able to sustain a reverse-magnetized domain therein in response to a magnetic field greater than a first value and to propagate at least one wall of said domain therealong in response to a magnetic field of a second value less than said first value.
4. A scanning circuit as claimed in claim 3 wherein said first co-acting means is adapted to produce a domain of unstable length in said first propagation medium and said second co-acting means is adapted to expand said domain to a stable length whereby it can be propagated by said propagation means.
5. A scanning circuit as claimed in claim 3 wherein said first co-acting means and said second co-acting means are so adapted as to be individually incapable but collectively capable of providing a reverse-magnetized domain in said first propagation medium.
6. A scanning circuit as claimed in claim 3 wherein said first co-acting means is adapted to produce a stable reverse-magnetized domain and said second co-acting means is adapted to expand the domain so produced to a length such as to enable said propagation means to propagate at least one wall of said domain along said first propagation medium.
7. A scanning circuit as claimed in any of claims 3 to 6 wherein said first propagation medium comprises a single magnetic

wire.

8. A scanning circuit as claimed in any of claims 3 to 6 wherein said first propagation medium comprises a plurality of magnetic wires of different lengths.

9. A scanning circuit according to any preceding claim including a second propagation medium, means responsive to the arrival of the said stable conditions at said first sensing means for introducing stable conditions into said second propagation medium, means for propagating the stable conditions along the second medium, and second sensing means coupled to the second medium.

10. A scanning circuit as claimed in claim 9 wherein said second propagation medium comprises material able to sustain a reverse-magnetized domain therein in response to a magnetic field greater than a first value and to propagate at least one wall of said domain therealong in response to a magnetic field of a second value less than said first value.

11. A scanning circuit as claimed in claims 9 or 10 including means responsive to mismatches between the outputs of said first and second sensing means for signalling the condition of the corresponding conductor.

12. A scanning circuit as claimed in claim 11 including an address generator and first and second AND circuits, said address generator applying sequentially to said first and second AND circuits multibit addresses of all conductors coupled to said first medium, said first AND circuit being responsive to a first mismatch between said outputs for indicating a service request for the corresponding conductor, said second AND circuit being responsive to an alternative second mismatch different from said first mismatch between said outputs for indicating the termination of service for the corresponding conductor.

13. A scanning circuit as claimed in any preceding claim in which each of said conductors comprises a conductor connected to a telephone subscriber line such that off-hook currents in each subscriber line flow through the corresponding conductor.

14. A scanning circuit constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawings.

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