

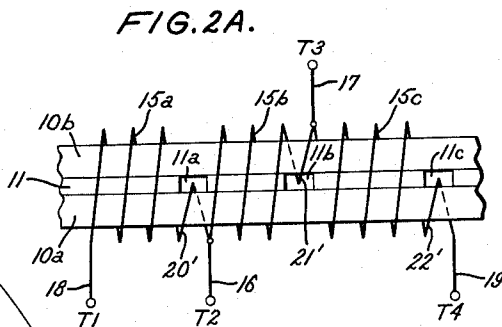
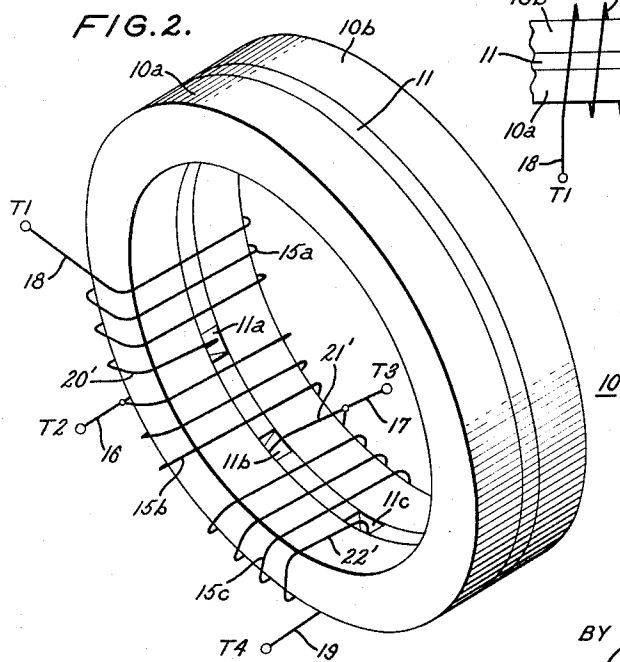
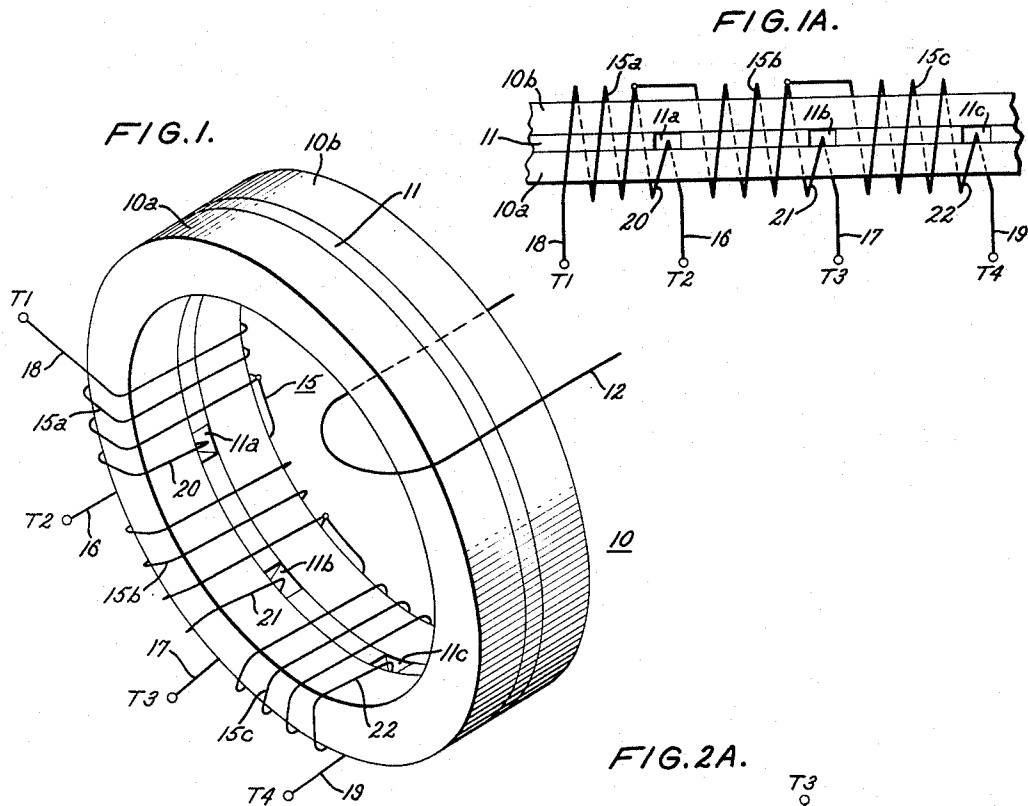
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CURRENT TRANSFORMER

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1

3,260,976

CURRENT TRANSFORMER

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My invention relates to electric current transformers, and more particularly it relates to ratio control and phase angle compensation for multiple ratio current transformers. The invention is especially adapted for application to such transformers when designed for current measurement, recording or metering wherein it is desirable that each selectable primary to secondary current ratio be accurately predetermined and remain substantially constant throughout the operating range of the transformer.

In an ideal current transformer, the ratio of transformation of primary to secondary current is equal to the ratio of the primary and secondary turns. However, due to the exciting current drawn by the transformer, the true ratio of transformation does not in fact equal the turn ratio, and the secondary current will not be in phase with the primary current. It has been known heretofore that the turn ratio may be more accurately adjusted and may be compensated for variations in core permeability throughout the operating range of the transformer by connecting in series with the secondary winding one or more so-called fractional winding turns. Such fractional turns are wound upon the core in such a way as to link only a portion of the cross-section of the magnetic circuit.

As illustrated in Patent 1,722,167—Wilson issued July 23, 1929 and Patent 2,391,229—D'Entremont issued December 18, 1945, it has previously been the practice to attain ratio compensation in current transformers by taking the last several turns of the secondary winding through one or more gaps or apertures in the core so that compensation is effected only when the whole or a final part of the secondary winding is connected in circuit. A single group of compensating fractional turns therefore can optimally compensate for only a single secondary connection, i.e. a single transformer ratio. Such an arrangement is not adequate to properly compensate all the available ratios, or secondary connections, of a tapped or multi-ratio current transformer when it is desired to provide measuring or metering accuracy.

It is therefore a general object of my invention to provide an improved multi-ratio current transformer having adequate turn ratio compensation in each of its several selectable secondary winding connections.

It is a more particular object of my invention to provide a measuring or metering type current transformer of the multi-ratio type having fractional turn ratio compensation in each of its available secondary winding connections.

In carrying out my invention in one preferred embodiment, I provide a current transformer having a tapped multi-ratio secondary winding including several groups of one or more fractional compensating turns. The secondary winding tap leads are so connected that one or more such groups of fractional turns are connected in circuit with the main full turn winding sections included between any selectable pair of secondary winding terminals. Preferably a separate group of fractional turns is associated with each full turn section of the secondary winding, as by series connection at one end of each full turn section or by connection in the tap leads.

My invention will be more fully understood and its various objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective and partially schematic view of a current transformer embodying my invention;

2

FIG. 1A is a linear development of the core and secondary winding of the transformer shown at FIG. 1;

FIG. 2 is a partially schematic perspective view of a current transformer embodying my invention in modified form, and

FIG. 2A is a linear development of the core and secondary winding of the transformer shown at FIG. 2.

Referring now to the drawing and more particularly to FIGS. 1 and 1A, I have illustrated a current transformer having a magnetizable core 10 formed as a closed loop or ring. The core loop as illustrated is of circular configuration, but it is evident that rectangular or other loop configurations may be used. The core 10 is built of two similar circular sections 10a and 10b each formed of magnetizable material, preferably laminated, and assembled together in spaced-apart relation with a circular spacer 11 of non-magnetic material therebetween. At several convenient points around the periphery of the core the spacer 11 is slotted or apertured, as at 11a, 11b and 11c, to provide radial passageways or gaps through the core. As will appear more clearly hereinafter, it is not essential to my invention that the core be sectionalized nor that the core gaps be radial. If desired the core may be formed of one integral section of magnetizable material, preferably laminated, and core gaps or apertures may be provided either radially or axially so long as the parallel flux paths provided through the core are discretely spaced apart at least in the regions of the core apertures. These regions are referred to herein as fractional core portions. The primary winding of the current transformer is illustrated as a single central conductor 12 passing axially through the core loop. It will of course be understood that if desired one or more winding turns around the entire flux path of the core may be provided in the primary winding.

For clarity of the illustration, I have shown in schematic form only a secondary winding 15 on the core 10. To this end the winding 15 is represented by a relatively few widely spaced turns encircling only a portion of the core at FIG. 1. The secondary winding extends between end terminals T1 and T4 and is provided with several intermediate tap terminals T2 and T3. It will of course be understood that in practice the secondary winding will ordinarily comprise a large number of turns, will encircle the entire core and may be laid upon the core in several layers, as illustrated in the foregoing Patent 2,391,229—D'Entremont. In any event, the secondary winding 15 is divided into several main full turn sections 15a, 15b and 15c connected in series circuit relation and having intermediate points connected by tap leads 16 and 17 to the intermediate terminals T2 and T3 respectively. The end leads to the terminals T1 and T4 are identified as 18 and 19 respectively.

In order to predetermine with accuracy and precision each of the several selectable current ratios of the transformer shown at FIG. 1, and in order to compensate for the non-linear permeability characteristic of the core material, I provide several separate groups of fractional winding turns 20, 21 and 22. By a fractional winding turn I mean to identify a turn in the secondary winding which links less than all of the parallel flux paths through the core. In the illustrated embodiments where the core is composed of two similar sections spaced apart to provide a window the fractional winding turns 20, 21 and 22 link approximately half of the core flux. It will of course be evident to those skilled in the art that if desired the core may be made up of unequal sections, or of more than two sections, so that the fractional winding turns link any desired fraction of the total core flux. Similarly an integral single section core provided with an aperture or window such as shown in Patent 2,391,229—

D'Entremont may be utilized to provide for fractional turn linking of any desired fractional portion of the total core flux. As shown schematically at FIG. 1 the fractional winding turns 20, 21 and 22 each comprise a single turn only. It will of course be understood that each of these separate groups of fractional winding turns may comprise more than a single fractional turn as determined by the requirements for adequate compensation in particular transformer designs.

In the transformer shown at FIG. 1, and as more clearly illustrated in the linear diagrammatic development of FIG. 1A, the fractional winding turns 20, 21 and 22 are connected in the several tap leads 16, 17 and 19 respectively. Thus each intermediate tap lead 16, 17 and one terminal lead 19 are connected to their associated secondary winding terminals through a compensating fractional winding turn or group of turns. It will of course be understood that the other terminal winding lead 18 and its terminal T1 are common to the several selectable secondary winding connections. The connections ordinarily contemplated are T1-T2 or T1-T3, or T1-T4. As will be most readily evident from FIG. 1A, there is included in any one of these selectable secondary winding connections at least one group of compensating fractional winding turns. This is also true however if connection is made to any other available pair of secondary winding terminals excluding T1.

At FIGS. 2 and 2A I have illustrated another embodiment of my invention similar in most respects to the embodiment shown at FIGS. 1 and 1A, and like parts have been identified with the same reference numerals. In the embodiment of FIG. 2, however, the fractional winding turns, identified as 20', 21' and 22' are not connected in the secondary tap leads but are connected instead directly in series with the serially connected full turn secondary winding sections 15a, 15b and 15c. As will be most clearly evident from FIG. 2A, the fractional winding turns of FIGS. 2 and 2A are separately associated each with one of the full turn sections of the secondary winding by connection of a fractional turn, or fractional turn group, at one end of each full turn section intermediate the tap leads. By this arrangement, if the terminal T1 is considered a common terminal, connection to T2 will include one fractional turn group whereas connections to T3 and T4 include more than one fractional turn group. In this respect FIG. 2 differs from FIG. 1 wherein any connection including T1 as a common terminal includes only a single fractional turn group. For this reason it is necessary to differently proportion and arrange the fractional turn groups of FIG. 2 as compared with those at FIG. 1. Specifically it is desirable in the embodiment of the FIGS. 2 and 2A to place the fractional winding turns 20', 21' and 22' alternately on opposite fractional portions of the core 10.

In both embodiments of my invention shown in the drawing I have illustrated each of the several groups of fractional winding turns 20, 21, 22 or 20', 21', 22' as wound upon a separate one of several fractional core portions spaced apart around the core 10. It will of course be understood by those skilled in the art that if desired more than one such group of fractional turns may be wound upon a single fractional core portion.

While I have shown and described certain preferred embodiments of my invention by way of illustration, other modifications will occur to those skilled in the art. I therefore wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a current transformer, a magnetizable core having a plurality of flux paths disposed in parallel spatial relation to define a single closed magnetic circuit, said flux paths being discretely spaced apart at at least one fractional portion of said core, a tapped secondary winding comprising a plurality of full turn sections each having a plurality of turns surrounding and linking all said parallel flux paths, a plurality of fractional winding turns disposed on said core at fractional portions of said core and each surrounding and linking less than all said parallel flux paths, means connecting said full turn sections and said fractional winding turns in series circuit relation, terminal leads connected to intermediate and end points of said winding and including between each predetermined selectable pair of leads at least one full turn section and at least one fractional winding turn.

2. In a current transformer, a magnetizable core having a plurality of flux paths disposed in parallel spatial relation to define a single closed magnetic circuit, said flux paths being discretely spaced apart at at least one fractional portion of said core, a tapped secondary winding comprising a plurality of full turn sections each having a plurality of turns surrounding and linking all said parallel flux paths, a plurality of fractional winding turns disposed on said core at spaced-apart fractional portions of said core and each surrounding and linking less than all said parallel flux paths, means connecting said full turn sections and said fractional winding turns in series circuit relation with at least one fractional winding turn between each electrically adjacent pair of full turn sections and at one end of said winding, and selectable terminal leads connected to the opposite ends of said winding and to one end of each said fractional winding turn.

3. A current transformer according to claim 1 wherein each said parallel flux path is linked by at least some of said fractional winding turns.

4. A current transformer according to claim 1 wherein said fractional winding turns are divided among the several said parallel flux paths in optimally balanced linking relation.

5. A current transformer according to claim 2 wherein said parallel flux paths are two in number, and serially consecutive groups of said series-connected fractional winding turns are positioned in alternate linking relation with said two parallel flux paths.

6. A current transformer according to claim 2 wherein the several groups of fractional winding turns serially connected between adjacent full turn sections are distributed in substantially balanced linking relation with each of said parallel flux paths.

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