Oct. 7, 1947. F. J. SINGER 2,428,389

DATA TRANSMISSION SYSTEM

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FIG. 1

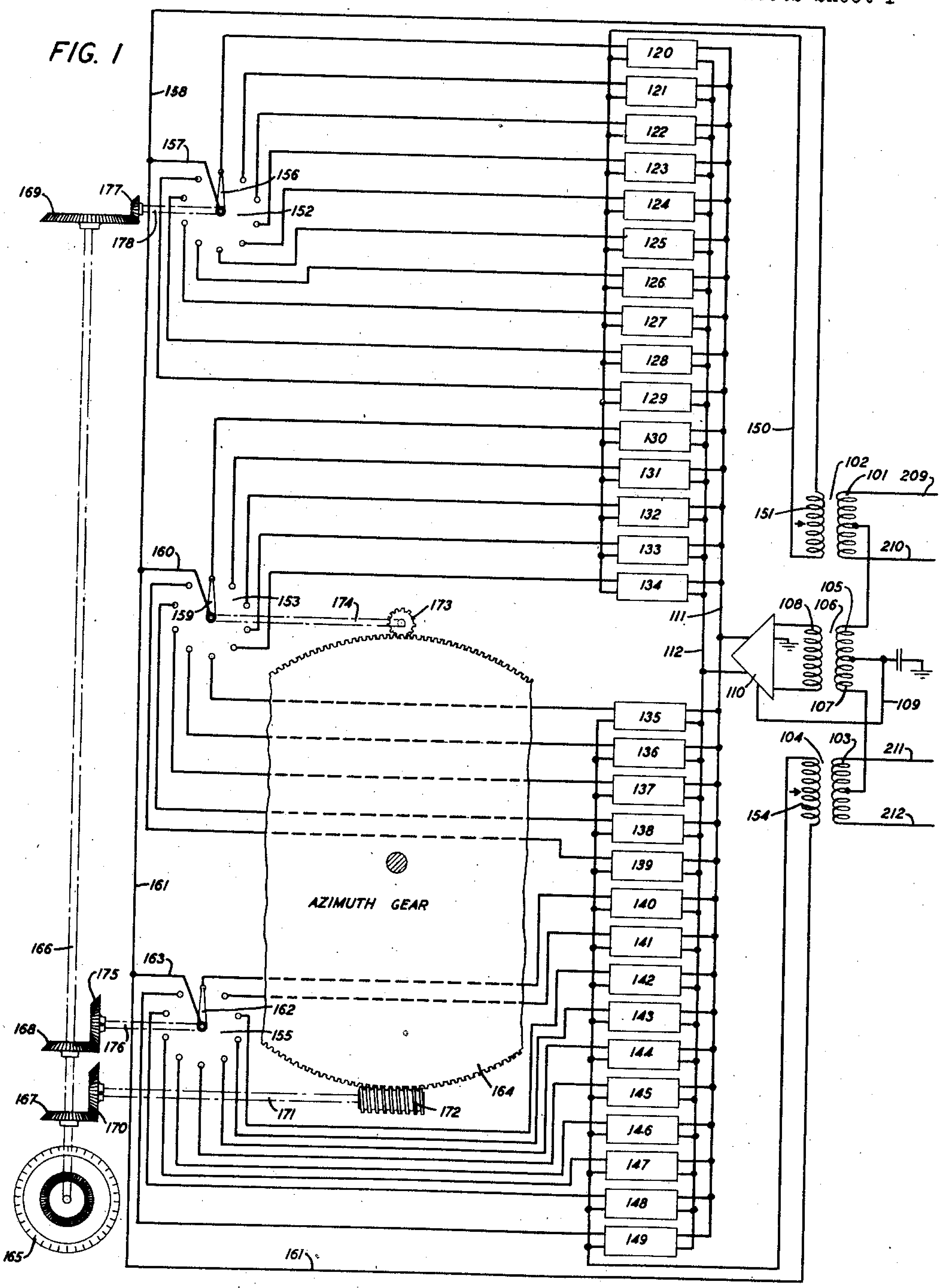

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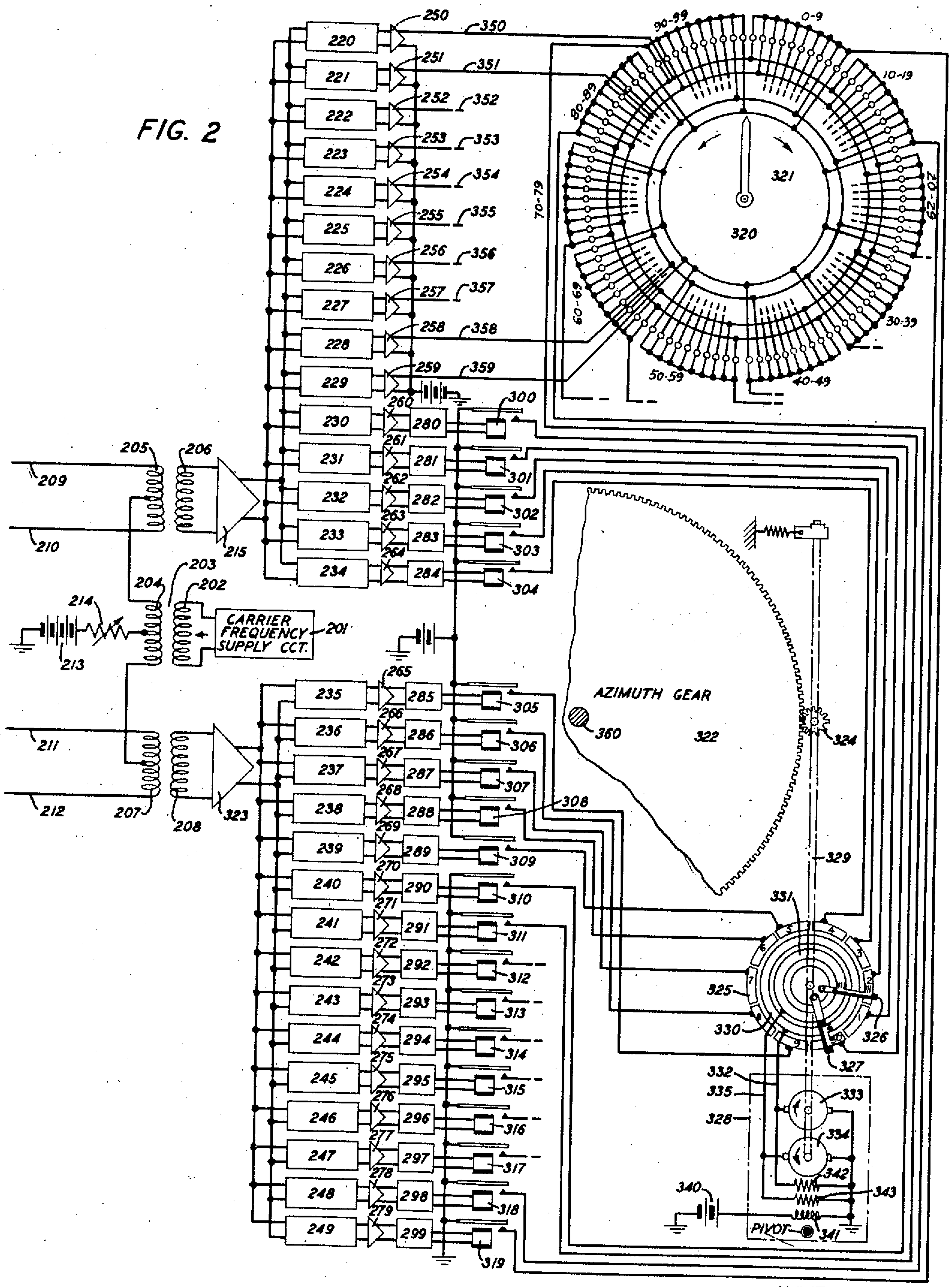
FIG. 2



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DATA TRANSMISSION SYSTEM

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8 Claims. (Cl. 177—351)

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This invention relates to data transmission systems. More particularly, this invention is a data transmission system in which alternating currents of different frequencies are transmitted between stations to define the data.

An object of this invention is the improvement of data transmission systems.

A more particular object of this invention is the provision of a data transmission system in which alternating currents of different frequencies are employed to identify observed data.

A feature of this invention is an arrangement wherein alternating current of a plurality of frequencies is produced at the receiving station and transmitted to the observing station where various frequencies are selected and retransmitted back to the receiving station to identify data observed at the observing station.

A further feature of this invention is an arrangement in which alternating current of fifteen different frequencies is employed. Current of each of said frequencies is supplied from the receiving station. It is impressed on a phantom circuit formed by two physical transmitting circuits extending from the receiving station to the observing station. Current of some one of ten of said frequencies is conducted from said phantom circuit through a first selecting device at the observing station and returned to the receiving station over one of said physical circuits to identify a digit in the right-hand position of a multidigit number corresponding to an observation. Current of some one of the same ten frequencies is conducted from the phantom circuit through a second selecting device at the observing station and returned to the receiving station over the other of said physical circuits to identify a digit in the second position of the multidigit number. Current of some one of the remaining five frequencies is conducted from said phantom circuit through a third selecting device at the observing station and returned to the receiving station over one or the other of said physical circuits to identify digits in the remaining positions in the multidigit number.

A further feature of this invention is an arrangement wherein a phantom circuit supplies both an alternating current of a plurality of frequencies from the receiving station to the observing station for purposes of defining observations and direct current as well as to energize apparatus employed at the transmitting station.

A further feature of this invention is an arrangement wherein part of the signals defining the observed data is impressed on a motor switch

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at the receiving station which in turn controls an indicator so that it moves progressively or retrogressively in single steps as each signal is received. The range of such indicator may be unlimited but is adapted in this embodiment to defining any of three hundred and sixty observations corresponding to three hundred and sixty degrees.

These and other features will be apparent from the following description when read with reference to the associated drawings, in which:

Fig. 1 represents the apparatus associated with an observing station; and

Fig. 2 represents the apparatus associated with a receiving station.

The invention herein has wide application. In the present embodiment it is arranged particularly to define angles between a base-line and the line of sight to a target. The angle between the base-line and the target is established by rotating a telescope on an azimuth instrument until the line of sight through the telescope extends to the target. The position of the target is established by means of two telescopes, one located at each extremity of the base-line. The length of the base-line, which is fixed, and the size of the two angles between the base-line and the two lines of sight to the target fix the position of the target.

In such an arrangement two observing equipments, such as Fig. 1, and two receiving equipments, such as Fig. 2, are required. The observing equipment at each observing station would be identical with Fig. 1. The receiving equipment associated with each observing station would be identical with Fig. 2. In the description to follow the operation of the equipment at one observing station and its associated equipment at the receiving station will be described. The same description would apply to the second observing station and its associated equipment.

Refer to Figs. 1 and 2. At the receiving station, as shown in Fig. 2, a source of alternating current **201** of fifteen different frequencies is connected to winding **202** of transformer **203**. The top terminal of the winding **204** of transformer **203** is connected to the mid-point of winding **205** of transformer **206**. The bottom terminal of winding **204** of transformer **203** is connected to the mid-point of winding **207** of transformer **208**. The top and bottom terminals of the winding **205** of transformer **206** are connected by means of two conductors **209** and **210** to the top and bottom terminals of winding **101** of transformer **102** at the observing station. The top and bottom terminals of the secondary 207 of transformer 203 are connected by means of conductors 211 and 212, respectively, to the top and bottom terminals of winding 103 of transformer 104 at the observing station. The mid-point of winding 101 of transformer 102 is connected to the top terminal of winding 105 of transformer 106. The mid-point of winding 103 of transformer 104 is connected to the bottom terminal of winding 107 of transformer 106.

The impedance of the circuit connecting the top terminal of winding 204 of transformer 203 to the top terminal of winding 105 of transformer 106 is equal to the impedance of the circuit connecting the bottom terminal of winding 204 of transformer 203 to the bottom terminal of winding 105 of transformer 106. Each of these circuits forms one side of a phantom circuit.

The fifteen carrier frequency currents impressed on winding 204 in Fig. 2 at the receiving station are impressed across winding 105 in Fig. 1 and induced in winding 108. A source of direct current 213 is connected through variable resistor 214 to the mid-point of winding 204. The four conductors 209, 210, 211 and 212 serve as parallel conductors for the direct current. The parallel branches join and the circuit extends through a single conductor 109 and through the internal connections of amplifier 110 to ground. The direct current source 213 at the receiving station serves as a battery supply for amplifier 110.

The fifteen alternating frequency currents are amplified in amplifier 110 and impressed on parallel conductors 111 and 112. Conductors 111 and 112 are connected in parallel to thirty band-pass filters 120 to 149. Each one of the fifteen band-pass filters 120 to 134 in the upper portion of the drawing is arranged to pass current of a different particular one of the fifteen frequencies and to suppress current of the fourteen other frequencies. Each one of the fifteen band-pass filters 135 to 159 shown in the lower portion of the drawing is also designed to pass current of a different particular one of the fifteen frequencies and to suppress current of the fourteen other frequencies.

The bottom terminal of the output side of each of band-pass filters 120 to 134 is connected by means of conductor 150 to the bottom terminal of winding 151 of transformer 102. The top terminal of each of the top ten band-pass filters 120 to 129 is connected to a different one of the ten terminals of the ten-point switch 152. The top terminal of each of the five band-pass filters 130 to 134 is connected to a different one of five terminals on ten-point switch 153. The bottom terminals of each of band-pass filters 135 to 149 is connected to the top terminal of winding 154 of transformer 104. The top terminal of each of band-pass filters 135 to 139 is connected to each of the five remaining terminals of ten-point switch 153. Each of the top terminals of band-pass filters 140 to 149 is connected to a different one of the ten terminals of ten-point switch 155.

Depending upon the position of rotatable arm 156 of ten-point switch 152, the circuit from some one of the ten band-pass filters 120 to 129 will be closed through arm 156 and conductor 157 to conductor 158 which connects to the top terminal of winding 151 of transformer 102. Depending upon the position of rotatable arm 159, a path will be closed from some one of filters 130 to 139 through arm 159 and conductor 160 to conductors 158 and 161. Conductor 161 connects to the bottom terminal of winding 154 of transformer 104.

Depending upon the position of rotatable arm 162 of switch 155, the circuit from some one of band-pass filters 140 to 149 will be closed through conductor 163 and conductor 161 to the bottom terminal of winding 154 of transformer 104.

The position of each of rotatable arms 156, 159 and 162 depends upon the angle between the base-line and the line of sight to the target.

The telescope, not shown, is under control of azimuth gear 164. As the azimuth gear rotates the telescope is rotated through an equal angle. Vernier 165 is rigidly secured to shaft 166. Gears 167, 168 and 169 are rigidly secured to shaft 166. The ratio of bevelled gears 167 and 170 which engage each other at right angles is such that shaft 171 rotates once for each complete revolution of venier 165. Worm gear 172 is rigidly secured to shaft 171. The ratio of worm gear 172 and azimuth spur gear 164 which engage is such that gear 164 rotates through one three-hundred and sixtieth of a revolution for each revolution of gear 172. The azimuth gear and the telescope therefore rotate through one degree for each complete revolution of vernier 165. The azimuth spur gear 164 engages spur gear 173. The ratio of gears 164 and 173 is such that gear 173 rotates thirty-six times for each rotation of gear 164. Gear 173 therefore rotates once for each ten rotations of vernier 165. Gear 173 is rigidly secured to shaft 174. Rotatable switch arm 159 is also rigidly secured to shaft 174. Rotatable switch arm 159 will therefore rotate through one revolution for each ten revolutions of vernier 165. Arm 159, will rotate from any one point on switch 153 to the next, while vernier 165 rotates once. This change in position of arm 159 therefore defines one-degree change of the position of the telescope.

Bevelled gear 168 engages bevelled gear 175 at right angles. The ratio is such that gear 175 rotates once for each revolution of gear 168. Gear 175 is rigidly secured to shaft 176. Rotatable switch arm 162 of switch 155 is rigidly secured to shaft 176. Rotatable switch arm 162 therefore turns through one complete revolution for each revolution of vernier 165. A change in the position of arm 162 from one point to the next represents a change of a tenth of a degree in the position of the telescope.

Bevelled gear 169 engages bevelled gear 177 at right angles. The gear ratio is such that gear 177 rotates ten times for each revolution of gear 169. Gear 177 is rigidly secured to shaft 178. Rotatable switch arm 156 is also rigidly secured to shaft 178. Arm 156 will rotate once in one-tenth of a degree. The displacement of rotatable arm 156 from one contact to the next succeeding contact corresponds, therefore, to a change in the position of the telescope of one-hundredth of a degree.

When rotatable arm 156 engages a particular point on switch 152 alternating current of the particular frequency passed by the corresponding band-pass filter will be impressed across winding 151 of transformer 102 and induced in winding 101 of transformer 102. The current will be conducted back to the receiving station and impressed through transformer winding 206 on amplifier 215. The output of amplifier 215 is connected in parallel to filters 220 to 234 which correspond to filters 120 to 134 at the observing station. The particular frequency which has been selected by switch 152 will be passed through some one filter of band-pass filters 220 to 229 and will be suppressed by all of the others. After passing through the particular filter, current of the particular frequency will be amplified by a corresponding amplifier in the amplifier group 250 to 259.

The output of each one of amplifiers 250 to 259 is connected in parallel to a different ten lamps in the display unit 320. Display unit 320 comprises one hundred lamps equally spaced on the circumference of a circle. The lamps are numbered consecutively from 0 to 99. Conductor 350 is connected from amplifier 250 in parallel to the inner terminal of lamps numbered 0, 10, 20, 30, 40, etc. Conductor 351 is connected from amplifier 251 in parallel to the inner terminal of lamps numbered 1, 11, 21, 31, 41, etc. Each of the other eight of the ten conductors 350 to 359 is connected in parallel to the inner terminal of a corresponding group of ten lamps. Depending, therefore, upon the position of the telescope and the contact of switch 152 engaged by arm 156, alternating current will be connected to the inner terminal of a particular group of ten of the hundred lamps in the display unit 320.

Depending upon the setting of switch 155, alternating current of some particular frequency will be impressed on winding 154 of transformer 104 to identify the particular tenth degree zone in which the target is located at the moment. The current will be induced in winding 103 of transformer 104 and conducted to the receiving station by means of conductors 211 and 212. It will pass through transformer winding 208 and through amplifier 323 and will be impressed on the input of filters 235 to 249. Some one of filters 240 to 249 will pass current of this particular frequency. All other filters of the group 235 to 249 will suppress current of this particular frequency.

An individual amplifier 265 to 279 is connected to each of filters 235 to 249. An individual detector 285 to 299 is connected in series with each of amplifiers 265 to 279 and an individual relay 305 to 319 is connected to the output of each of detectors 285 to 299. Current of the particular frequency which has been selected by switch 155 after passing through some one of the band-pass filters 240 to 249 and being amplified by the corresponding amplifier 270 to 279 and detected by the corresponding detector 290 to 299 will operate a corresponding relay of the group 310 to 319. The operation of the particular relay will connect direct ground through a corresponding contact to the outer terminal of a particular group of ten lamps in the display unit. Thus the operation of relay 319 will supply ground through its contact to the outer terminals of lamps 0 to 9 in parallel. The operation of relay 318 will supply ground through its contact to the outer terminal of lamps 10 to 19 in parallel, etc.

Some particular lamp of the one hundred lamps on the display unit 320 will therefore light to indicate the location of the line of sight to the nearest hundredth of a degree. The manner in which the particular degree is defined will now be described.

Alternating current of ten of the fifteen frequencies impressed on conductors 111 and 112 is employed to define the digits in the two right-hand positions of the multidigit number corresponding to the observed data. Depending upon the position of the rotatable arm 159 of switch 153, alternating current of some one of the five remaining frequencies selected by filters 130 to 134, inclusive, will be conducted to the receiving station over conductors 209 and 210, or current of some one of the same five frequencies will be selected by some one of filters 135 to 139 and conducted through switch 153 over conductors 211 and 212 to the receiving station. Depending upon the transmitting circuit over which the current is transmitted, it will be amplified by either amplifier 215 or 323 and selected by some one of band-pass filters 230 to 234 or 235 to 239. It will be amplified by some one of the corresponding amplifiers 260 to 269, detected by some one of detectors 280 to 289, and will operate some one of relays 300 to 309. Depending upon which relay is operated, battery will be connected through a corresponding relay contact to some particular one of the ten conducting segments of distributor 325.

Distributor 325 is equipped with two rotatable arms 326 and 327. The arms are rigidly secured to a rotatable core which is secured rigidly to shaft 329. Shaft 329 is under control of motor assembly 328 and is conditioned to be rotated in either of two directions. Distributor 325 is equipped with a segmented outer ring having ten conducting segments separated by insulators and two individually insulated solid inner conducting rings 330 and 331. Rotatable arm 327 is equipped with two interconnecting conducting brushes. The outer brush engages the outer segmented ring. The inner brush engages conducting ring 330. Rotatable arm 326 is also equipped with two interconnecting conducting brushes. The outer brush engages the outer segmented ring. The inner brush engages conducting ring 331. Brushes 326 and 327 are angularly spaced so that they will just straddle any segment of the outer ring of distributor 325. Conducting ring 330 is connected by means of conductor 332 to the left-hand brush of armature 333, the right-hand brush of which is connected to ground. Conducting ring 331 is connected by means of conductor 335 to the left-hand brush of armature 334, the right-hand brush of which is connected to ground.

A circuit may be traced from grounded battery 340 through the motor field windings 341 to ground. Connected between the brushes of armatures 333 and 334 are antihunting resistances 342 and 343, respectively.

The segments of the outer segmented ring of distributor 325 are numbered from 1 to 10. It will be assumed that relay 301 has been operated and that battery is connected therefore to segment 1 of distributor 325. A circuit may then be traced from battery through the contact of relay 301, segment 1 of distributor 325, outer brush of rotatable arm 326, inner brush of rotatable arm 326, conducting ring 331, conductor 335 and armature 334 to ground. In response to this armature 334 will rotate in a counter-clockwise direction, rotating shaft 329 which in turn rotates both rotatable arms 326 and 327 in unison in a counter-clockwise direction until brush 326 has moved off segment 1 to which battery has been connected and engages the lower portion of segment 2. Due to the spacing of arms 326 and 327 arm 327 will be rotated simultaneously to a position in which it is stopped just short of segment 1 or at the right-hand end of segment 0. Segment 1 will thus be straddled by brushes 326 and 327.

If it is now assumed that relay 300 operates a circuit may be traced from battery through the contact of relay 300 to segment 0 of distributor 325, outer brush of rotatable arm 327, inner brush of arm 327, conducting ring 330, conductor 332 and armature 333 to ground. In response to this, armature 333 will be rotated in a clockwise direction. Shaft 329 will rotate brushes 326 and 327 in unison in a clockwise direction until brush 327 has moved off segment 0 and engages the right-hand end of segment 9. Brush 326 will be rotated simultaneously to the extreme lower portion of segment 1. Segment 0 will thus be straddled by the brushes. It should be clear from the foregoing description of the operation of the apparatus comprising the motor switch that the segment to which battery is connected will always be straddled by rotatable arms 326 and 327.

Attention is called to the fact that the movement of the telescope is from one degree position to the next higher or next lower degree position. As a result of this, when battery has been connected to a particular segment of distributor 325 the movement of the telescope in either of the possible directions through a degree transition will result in the connection of battery to an adjoining segment on distributor 325 in a clockwise or counter-clockwise direction, corresponding to the movement of the telescope. As a result of this, one or the other of brushes 326 or 327 will always be in position to activate armature 333 or 334 to move brushes 326 and 327 into positions such that one or the other will engage a segment to which battery will be connected when the position of the telescope is moved forward or retrogressively into the next degree zone.

Shaft 329 and gear 324, rigidly secured to shaft 329, will occupy a different definite position for each segment to which battery is connected.

Azimuth gear 322 engages spur gear 324. The ratio of the gears is thirty-six to one. Gear 324 rotates thirty-six times for each revolution of gear 322. Gear 324 rotates once for each ten-degree change of azimuth. Gear 322 rotates once for each three-hundred-sixty-degree change of azimuth. Gear 322 is rigidly secured to shaft 360. A scale numbered from 0 to 360, not shown, may be attached to gear 322 or separately mounted on shaft 360. A suitable fixed reference point will indicate the particular degree position.

It is particularly pointed out that the degree switch 153 is arranged so that it will identify any one of ten degree positions within any ten-degree zone. However, the system is not limited to defining positions within a ten-degree zone only. Any degree position in the full three-hundred-sixty-degree range can be defined by this system. Due to the arrangement of the degree recording mechanism, degree information recorded is cumulative. As shaft 329 and gear 324 are rotated a complete rotation will define a change of ten degrees which will be imparted to azimuth gear 322. Gear 322 will be moved through ten degrees for each revolution of shaft 329 and gear 324. For each of the three hundred and sixty positions of azimuth gear 164 at the observing station there will be a corresponding position of azimuth gear 322 at the receiving station.

Gear 324 may be arranged in any convenient manner so that it can be disengaged from gear 322 so that gear 322 and gear 164 may be fixed in corresponding positions at convenient times to care for any variation in transmission.

Variable resistance 214 regulates the direct current supplied to amplifier 110 at the observing station.

If it is desired, relays such as relays 300 to 319 may be connected to amplifiers 250 to 259 and direct current may be supplied to light the lamps in display unit 320.

The display unit may be equipped with a tracking mechanism as it is known in the art to transfer the observed data to an automatic computing mechanism.

What is claimed is:

1. In a data transmission system, an observing station, a receiving station, a pair of electrical transmission paths interconnecting said stations, means for coupling said pair of paths to form a phantom circuit, means at said receiving station for impressing on said phantom circuit a plurality of alternating currents of different frequencies, means at said observing station for selecting from said plurality alternating current of a particular frequency to define an observation at said observing station, and means at said observing station for impressing said current on a selected one of said paths.

2. In a data transmission system, an observing station, a receiving station, an electrical signal transmission circuit interconnecting said stations, said circuit having a first and a second path, a supply of alternating current of fifteen different frequencies at said observing station, means at said observing station for making three separate selections from among said frequencies to define simultaneously all of the separate parts of any number in the range from 0 to 36,000 corresponding to a particular setting of a measuring instrument at said observing station, means at said observing station, responsive to the setting of said instrument, for impressing current of one of a first group of ten of said fifteen frequencies on said first path, means at said observing station, responsive to said setting, for impressing current of one of a second group, different from said first group, of ten of said fifteen frequencies on said second path, means at said observing station, responsive to said setting, for impressing current of one of either of two groups of five of said fifteen frequencies on a selected one of said two paths, and means at said receiving station responsive to the reception of current of said three frequencies impressed on said paths for indicating said number corresponding to said setting.

3. In a data transmission system, an observing station, a receiving station, a first and a second separate electrical transmission circuit interconnecting said stations, instrumentalities in said system for transmitting signals between said stations to define multidigit numbers corresponding to observed data, said instrumentalities comprising means for supplying alternating current of fifteen different frequencies, frequencies numbered 1 to 15, to said observing station, means at said observing station for selecting a first current of any one of ten of said frequencies, frequencies numbered 1 to 10, and impressing said first current on said first circuit to define a first portion of said number, means at said observing station for selecting a second current of any one of ten of said frequencies, frequencies numbered 6 to 15, and impressing said second current on said second circuit to define a second portion of said number, means at said observing station for selecting a third current of any one of five of said frequencies, frequencies numbered 11 to 15 and impressing said third current on said first circuit or for selecting a fourth current of any one of five of said frequencies, frequencies numbered 1 to 5, and impressing said fourth current on said second circuit, so as to define a third portion of said number with either said third or said fourth cur-

rent, dependent on the magnitude of said third portion.

4. In a data transmission system means for impressing alternating current of two different frequencies, selected from fifteen different frequencies, simultaneously on a selected first circuit of a first and second circuit, said circuit depending upon the frequencies of the current selected, and means for impressing an alternating current of a single frequency, selected from ten of said fifteen frequencies, on said second circuit, simultaneously with the impressing of said current on said first circuit, to define substantially instantaneously three separate digits of a single multidigit number corresponding to an observation at an observing station.

5. A data transmission system for defining all of the digits of a multidigit number simultaneously, two separate transmission circuits and current frequency discriminating means both in said system, means, connected to said discriminating means, for impressing on a first one of said circuits a first alternating current of a particular one of ten selected frequencies, of a first group of fifteen frequencies, to define a first portion of said number, means, connected to said discriminating means for impressing on the second one of said circuits a second alternating current of a particular one of ten selected frequencies of a second group of said same fifteen frequencies, to define a second portion of said number, and means, connected to said discriminating means, for impressing a third alternating current, of a particular one of the five remaining frequencies of said first group, on said first circuit, or of a particular one of the five remaining frequencies of said second group, on said second circuit, to define a third portion of said number.

6. In a data transmission system, an observing station, a receiving station, a first and a second separate electrical transmission circuit interconnecting said stations, means in said system for supplying alternating current of fifteen different frequencies, frequencies numbered one to fifteen, to said observing station, means at said observing station for selecting a first current of any of ten of said frequencies, frequencies numbered one to ten, and impressing said first current on said first circuit to define a first portion of a multidigit number corresponding to a measurement at said observing station, means at said observing station for selecting a second current of any of ten of said frequencies, frequencies numbered six to fifteen and impressing said second current on said second circuit to define a second portion of said number, and means at said observing station for selecting a third current of any of the five frequencies, frequencies numbered eleven to fifteen, and impressing it on said first circuit, or for selecting a third current of any of the five frequencies, frequencies numbered one to five, and impressing it on said second circuit, to define a third portion of said number.

7. In a data transmission system, an observing station, a receiving station, a first and a second electrical transmission path interconnecing said stations, means in each of said paths for selectively conducting current of any of fifteen different frequencies between said stations, a first selecting and transmitting means, responsive to a measuring means, at said observing station for selecting and transmitting a current of a particular one of the ten lowest frequencies of said fifteen frequencies through said first path, a second selecting and transmitting means, responsive to said measuring means, at said observing station for selecting and transmitting current of a particular one of the ten highest frequencies of said fifteen frequencies through said second path, and a third selecting and transmitting means, responsive to measuring means, at said observing station for selecting and transmitting current of a particular one of the five highest of said fifteen frequencies through said first path or current of a particular one of the five lowest of said fifteen frequencies through said second path, to define substantially instantaneously, three separate portions of a multidigit number, corresponding to a measurement at said observing station.

8. In a data transmission system, means for separating currents of n different frequencies into currents of two different first groups each of a frequencies, means for selecting current of one of said a frequencies in each of said groups to define each of two portions of a multidigit number, means for separating current of said n frequencies into currents of two different second groups each of $(n-a)$ frequencies, means for selecting current of one of said $(n-a)$ frequencies in one or the other of said groups of $(n-a)$ frequencies to define a third portion of said multidigit number an observing station, a receiving station, a first and a second transmission path interconnecting said stations, means at said observing station for impressing said selected current of one of said a frequencies of one of said first groups on said first path, means at said observing station for impressing said selected current of one of said a frequencies of the other of said first groups on said second path and means at said observing station for impressing said selected current of one or the other of said groups of $(n-a)$ frequencies on said first path or on said second path depending upon the frequency selected.

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